10 NOISE

10.1 Introduction

This Chapter of the EIAR assesses the effects of the Development from noise impacts. This assessment was undertaken by Noise & Vibration Consultants Limited.

The assessment will consider the potential effects during the following phases of the Development:

- Decommissioning of the Operational Barnesmore Windfarm (initial phase of the Development)
- Construction of the Development (likely to occur in tandem with the above phase)
- Operation of the Development
- Decommissioning of the Development (final phase)

The decommissioning of the Operational Barnesmore Windfarm and the construction of the Development are likely to occur partly in tandem and would have a greater effect than if the two processes were to arise at different times. This represents a worst-case scenario for assessment purposes. Any effects arising as a result of the future decommissioning of the Development, are considered to be no greater than the effects arising when these two phases are combined. As a result, the final decommissioning phase has not been considered further in this assessment.

The Development refers to all elements of the application for the repowering of the Operational Barnesmore Windfarm (**Chapter 2: Development Description**). The repower design layout has provision for the retention and re-use of existing footprint locations, in part, of the Operational Barnesmore Windfarm.

Common acronyms used throughout this EIAR can be found in **Technical Appendix 1.4**.

This chapter of the EIAR is supported by the Figures in Volume III and following Technical Appendices documents provided in Volume IV of this EIAR:

- **Technical Appendix 10.1**: Photos of noise monitors in-situ
- **Technical Appendix 10.2**: Wind speed calculations for Hub Height
- **Technical Appendix 10.3**: Calibration certificates of noise instruments
- **Technical Appendix 10.4**: Noise survey data (files 1, 2 and 3)
- **Technical Appendix 10.5**: Candidate turbine manufacturer's noise emission data

This chapter includes the following elements:

- Assessment Methodology and Significance Criteria – a description of the methods used in baseline surveys and in the assessment of the significance of effects.
- Baseline Description - a description of the noise baseline of the Development based on the results of surveys, desk information and consultations, and a summary of any information required for the assessment that could not be obtained.
- Assessment of Potential Effects - identifying the ways in which noise receptors could be affected by the Development, including a summary of the measures taken during design of the Development to minimise noise effects.
- Mitigation Measures and Residual Effects - a description of measures recommended to offset potential negative effects and a summary of the significance of the effects of the Development after mitigation measures have been implemented.
- Cumulative Effects – identifying the potential for effects of the Development to combine with those from other windfarm developments.
- Summary of Significant Effects
- Statement of Significance

10.1.1 Acoustic Terminology

Sound is simply the pressure oscillations that reach our ears. These are characterised by their amplitude, measured in decibels (dB), and their frequency, measured in Hertz (Hz). Noise is unwanted or undesirable sound, it does not accumulate in the environment, is transitory, fluctuates, and is normally localised. Environmental noise is normally assessed in terms of A-weighted decibels, dB (A), when the 'A weighted' filter in the measuring device elicits a response which provides a good correlation with the human ear. The criteria for environmental noise control are of annoyance or nuisance rather than damage. In general, a noise level is liable to provoke a complaint whenever its level exceeds by a certain margin, the pre-existing noise level or when it attains an absolute level. A change in noise level of 3 dB (A) is 'barely perceptible', while an increase in noise level of 10 dB (A) is perceived as a twofold increase in loudness. A noise level in excess of 85 dB (A) gives a significant risk of hearing damage. Construction and industrial noise sources are normally assessed and expressed using equivalent continuous levels, LAeq[1]. Wind turbine source noise is generally expressed in Leq dBA and in sound power levels (LWA).

Operational wind turbine noise is assessed using the LA90[2] descriptor, which allows reliable measurements to be made without corruption from relatively loud transitory noise events from other sources. The LA90 should be used for assessing both the wind energy development noise and background noise. As discussed in ETSU-R-97[3] the LA90 is 1.5-2.5dBA less than the LAeq measured over the same period. In this assessment, the difference between LAeq and LA90 is assumed to be 2dBA, which is the value most commonly applied in windfarm assessments in Ireland. Wind turbine noise levels are given as sound power levels (LWA) in dB at integer wind speeds up to maximum LWA levels which is no more than 10m/s wind speed at 10 m height. **Table 10.1** gives a comparison of noise levels in our everyday environment.

Table 10.1: Comparison of sound pressure level in our Environment[4]

Source/Activity	Indicative noise level dBA
Threshold of hearing	0
Rural night-time background	20-50
Quiet bedroom	35
Windfarm at 350 m	**35-45**
Busy road at 5 km	35-45
Car at 65 km/hr at 100 m	55
Busy general office	60
Conversation	60
Truck at 50 km/hr at 100 m	65
Inside a typical shopping centre	70-75
Inside a modern car at around 90 km/hr	75-80
Passenger cabin of jet aircraft	85
City Traffic	90
Pneumatic drill at 7 m	95
Jet aircraft at 250 m	105
Threshold of pain	140

10.1.2 Assessment Structure

This Chapter contains the following sections:

- Assessment Methodology and Significance Criteria – a description of the methods used in baseline surveys and in the assessment of the significance of effects

[1] L_{Aeq} is defined as being the A-weighted equivalent continuous steady sound level that has the same sound energy as the real fluctuating sound during the sample period and effectively represents a type of average value.

[2] LA90, or L90dBA is defined as the noise level equaled or exceeded for 90% of the measurement interval and with windfarm noise the interval used is 10 minutes.

[3] ETSU-R-97, The Assessment & Rating of Noise from Wind Farms, June 1996

[4] Fact sheet published by the Australian Government (Greenhouse Office) and the Australian Wind Energy Association

- Baseline Description - a description of the noise baseline of the Development based on the results of surveys, desk information and consultations, and a summary of any information required for the assessment that could not be obtained
- Assessment of Potential Effects - identifying the ways in which noise receptors could be affected by the EIA Development, including a summary of the measures taken during design of the EIA Development to minimise noise effects
- Mitigation Measures and Residual Effects - a description of measures recommended to off-set potential negative effects and a summary of the significance of the effects of the EIA Development after mitigation measures have been implemented
- Cumulative Effects – identifying the potential for effects of the EIA Development to combine with those from other windfarm developments
- Summary of Significant Effects
- Statement of Significance

10.2 Assessment Methodology and Significance Criteria

10.2.1 Assessment Methodology

This assessment has involved the following elements, further details of which are provided in the following sections:

- Legislation and guidance review
- Desk study, including review of available maps and published information
- Site walkover
- Evaluation of potential effects
- Evaluation of the significance of these effects
- Identification of measures to avoid and mitigate potential effects

10.2.2 Relevant Legislation and Guidance

The noise assessment is carried out in accordance with the guidance contained in the following documents:

- Wind Energy Development Guidelines[5] (the 2006 Guidelines)
- A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise including Supplementary Guidance Note 4: Wind Shear'[6] (the IOA Good Practice Guide)
- Proposed Revisions to Wind Energy Development Guidelines, 2006[7] (the Proposed Revisions 2013)
- Review of the Wind Energy Development Guidelines 2006 - "Preferred Draft Approach 2017 (Preferred Draft Approach 2017)
- ISO 1996[8]Acoustics-Description and Measurement of Environmental Noise - Part 1: Basic Quantities and Procedures (ISO 1996)
- ETSU-R-97[9]: The Assessment & Rating of Noise from Wind Farms (ETSU-R-97)

10.2.2.1 Wind Energy Development Guidelines 2006

The following are a number of key extracts from the 2006 Guidelines in relation to noise impact:

<u>General Noise Impact</u>

> "*Noise impact should be assessed by reference to the nature and character of noise sensitive locations*."
>
> "*Separate noise limits should apply for day-time and for night-time*"
>
> *"Noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed."*

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[5] Department of Environment, Heritage and Local Government: Wind Energy Development Guidelines, Guidelines for Planning Authorities 2006 Energy
[6] Institute of Acoustics (2013) A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise
[7] Proposed Revisions to Wind Energy Development Guidelines, Targeted Review in Relation to Noise, Proximity and Shadow Flicker- December 11th 2013
[8] ISO 1996/1- Acoustics-Description and Measurement of Environmental Noise - Part 1: Basic Quantities and Procedures
[9] ETSU-R-97: Acoustics-The Assessment & Rating of Noise from Wind Farms: ETSU for the DTI, UK, 1996

Measurement Units

> *"The descriptor [LA90 10min] which allows reliable measurements to be made without corruption from relatively loud transitory noise events from other sources, should be used for assessing both wind energy development noise and background noise."*

Specific Noise Limits

"Noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed."

> *"In general, a lower fixed limit of 45 dB(A) or a maximum increase of 5 dB(A) above background noise at nearby noise sensitive locations is considered appropriate to provide protection to wind energy development neighbours.*
>
> *However, in very quiet areas, the use of the margin of 5 dB(A) above the background noise at nearby noise sensitive properties is not necessary to offer a reasonable degree of protection and may unduly restrict wind energy developments. Instead in low noise environments where background noise is less than 30 dB(A), it is recommended that the daytime level of LA90,10min of the wind energy development noise should be limited to an absolute level within the range 35-40 dB(A)".*
>
> *"During the night the protection of external amenity becomes less important and the emphasis should be on preventing sleep disturbance. A fixed limit of 43 dB(A) L90,10min which will protect sleep inside properties during the night"*

The 2006 Guidelines do not specify daytime or night-time hours. However, it is considered good practice to follow the framework given in ETSU-R-97 and IOA Good Practice Guide where daytime and night-time hours are specified. The limits are based on the prevailing background noise level for 'quiet daytime' periods, defined in ETSU-R-97 as:

- Quiet waking hours or quiet day-time periods are defined as:
    - All evenings from 18.00 to 23.00 hrs
    - Saturday afternoon from 13.00 to 18.00 hrs and all-day Sunday 07.00 to 18.00 hrs
- Night-time is defined as 23.00 to 07.00 hrs

10.2.2.2 Proposed Revisions to the 2006 Guidelines dated 2013

The Proposed Revisions 2013 specifies a limit of 40dBA for day and night expressed in terms of dB LA90 10min, determined as best practice. The limit applies irrespective of time of day or night and applies to any wind speed within the operational range of any turbine. There are exceptions when the relevant properties are supportive of the development. Under these circumstances the owner of the property or properties must provide written confirmation to the satisfaction of the planning authority that they understand that their property may experience noise levels higher than the 40 dBA limit and that they have no objection to the proposed wind energy development.

10.2.2.3 Preferred Draft Approach 2017

The proposed new robust noise restriction limits are consistent with World Health Organisation standards, proposing a relative rated noise limit of 5 dB(A) above existing background noise within the range of 35 to 43 dB(A) for both day and night, with 43 dB(A) being the maximum noise limit permitted. The rated limit will take account of certain noise characteristics specific to wind turbines (e.g. tonal, low frequency and amplitude modulation) and, where identified, the noise limit permitted will be further reduced to mitigate for these noise characteristics.

10.2.2.4 Desk Study

The three locations for noise monitoring were selected by inspection of site maps and by identifying the nearest receptors to the wind turbines. The validation of selected locations was made with a visit to the Operational Noise Study Area (within 2.5 km of the Site). The three locations are considered representative of the local noise environment. When compiling the baseline data only upwind noise data to the Operational Barnesmore Windfarm was considered so that noise contribution was omitted.

Construction and decommissioning noise have been assessed by comparing predicted construction activity against relevant noise limits at the nearest residential properties. As such, if the construction noise levels meet the relevant noise limits at the nearest locations, it will also meet the relevant guidance at more distant residential locations.

There will be additional temporary delivery vehicles on the local roads to the Development generated by construction and decommissioning of Operational Barnesmore Windfarm. However, materials to the Site will be minimised by the use of existing Site tracks and all vehicles will be moving at low speed on the local roads generating low level noise emissions.

The operational noise study area has been defined such that the operational noise prediction results have been included for all the nearest residential receptors within 2.5 km to the Development turbines. Where the operational noise levels meet the relevant noise limits at the nearest locations, it will also meet the relevant noise limits at more distant residential locations.

10.2.2.5 Acquisition and Analysis of Background Noise Data

The 2006 Guidelines, ETSU-R-97 and the IOA Good Practice Guide recommend the measurement and use of wind speed data, against which background noise measurements are correlated. However, there is no guidance in the 2006 Guidelines to account for wind shear. There was a wind mast centrally located within the Site during the noise survey, which has 10-minute interval mean wind speed at hub heights of 70.2 m and 50 m. The wind speed at these heights were used to determine the wind shear. Wind direction was taken from the met mast at a height of 68 m.

For each 10-minute interval, the mean wind speed was calculated to the 109 m hub height of the proposed turbine wind speed using a specified procedure, which takes account of the wind shear with the result then standardised to 10 m height wind speed. The procedures to calculate wind shear hub height wind speed and to calculate standardised 10 m height wind speed is according to the method given in the Supplementary Guidance Note 4[10].

10.2.2.6 Prediction of Wind Turbine Noise Levels

The predicted noise levels are based on the methodology given in the IOA Good Practice Guide. Noise level calculations are based on ISO 9613-2[11] which provides a prediction of noise levels likely to occur under worst-case down-wind conditions.

There are numerous models for predicting noise from a point source and some of these models are specifically used for the prediction of noise from windfarms. WindFarm V4 wind energy development software package was used to calculate the noise level at the receptors. The propagation model calculates the predicted sound pressure levels by taking the source sound power level for each turbine in their respective octave bands and subtracting a number of attenuation factors according to the following formulae:

Predicted Octave Band Noise level = $LW + D - (A_{geo} + A_{atm} + A_{gr} + A_{br} + A_{mis})$

The predicted octaves from each of the turbines are summed to give the predicted noise level expressed as dBA.

No allowance has been made for the character of noise emitted by the turbines, however in general the emissions from wind turbines are broadband in nature. In the unlikely event of a turbine exhibiting clearly tonal components at any receptor, the turbine would be turned down or stopped until such tonality is ameliorated. A guarantee will be sought in the procurements of the turbine to be used onsite, stating that there should be no clearly tonal or impulsive components audible at any noise sensitive receptor location.

A_{geo} –Geometric Spreading

Geometric (spherical) spreading from a simple free-field point source results in attenuation over distance according to:

$$L_p = L_w - (20 \log R + 11)$$

Where:

L_p = sound pressure level

L_w = sound power level

[10] IOA, A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise- Supplementary Guidance Note 4: Wind Shear

[11] ISO 9613-2 Acoustics -Attenuation of sound during propagation outdoors, Part 2: General Method of Calculation

R = distance from the turbine to receiver

D – Directivity Factor

The directivity factor allows for adjustment where the sound radiated in the direction of the receptor is higher than that for which the sound power level is specified. In this case, the sound power levels are predicted as worst case propagation conditions, i.e. all receptors are assumed to be in downwind conditions.

A_{gr} - Ground Effects

Ground effect is the result of sound reflected by the ground interfering with the sound propagating directly from the turbine to receiver. The prediction of ground effects is complex and depends on the source height, receiver height, propagation height between the source and receiver and the intervening ground conditions.

Ground conditions are described according to a variable defined as G, which varies between 0 for hard ground and 1 for soft ground. Although in reality the ground is predominately porous, it has been modelled as mixed 50% hard and 50% porous corresponding to a ground absorption coefficient of 0.5. Our predictions have been carried out using a source height corresponding to the proposed height of the turbine nacelle, a receiver height of 4 m and an assumed ground factor of G=0.5 as recommended in the IOA Good Practice Guide.

A_{bar}- Barrier Attenuation

The effect of a barrier (including a natural barrier) between a noise source and receptor is that noise will be reduced according to the path difference (difference between the direct distance between source to receptor and distance between source and receptor over the barrier). The reduction is relative to the frequency spectrum of the sound and may be predicted according to the method given in ISO 9613. In practice, barriers can become less effective in downwind conditions. A barrier can be very effective when it lies within a few metres of the receptor. In the prediction model, zero attenuation is given for barrier effects, which is a worst case scenario setting.

A_{atm} - Atmospheric Absorption

Sound emergency through the atmosphere is attenuated by conversion of sound energy to heat. This energy is dependent on the temperature and relative humidity of the air, but only weakly on ambient pressure through which the sound is travelling and is frequency dependent with increasing attenuation towards higher frequencies. The attenuation by atmospheric absorption A_{atm} in decibels during propagation through distance in metres is given by:

$A_{atm} = d \times \alpha$,

α = atmospheric absorption coefficient in dBm^{-1}

d = distance from turbine

Values of α from ISO 9613 Part 1, corresponding to a temperature of $10^{0}C$ and a relative humidity of 70% has been used for these predictions and are given in **Table 10.2** below. These values are recommended in the IOA Good Practice Guide.

Table 10.2: Frequency dependent atmospheric attenuation coefficients (dB/m)

Octave Band Centre Frequency (Hz)	63	125	250	500	1k	2k	4k	8k
Atmospheric Absorption Coefficient (dB/m)	0.0001	0.0004	0.001	0.0019	0.0037	0.0097	0.0328	0.117

A_{misc} – Miscellaneous Other Effects

ISO 9613 includes effects of propagation through foliage, industrial plants and housing as additional attenuation effects. These have not been included here and any such effects are unlikely to significantly reduce noise levels below those predicted.

The ISO 9613-2 standard calculates under downwind propagation conditions and therefore predicts the average downwind sound pressure level at each dwelling. The model assumes that the wind is directly downwind from each turbine to each dwelling. The prediction model is calculated as a worst-case scenario.

The predicted noise levels $L_{Aeq\ 10min}$ are converted to the required $L_{A90,10min}$ by subtracting 2 dBA.

10.2.3 Aerodynamic Modulation or Aerodynamic Noise

Aerodynamic noise originates from the flow of air over, under and around the blades and is generally broadband in character. It is directly linked to the movement of the rotors through the air and will occur to varying degrees whenever the turbine blades move. Aerodynamic noise is generally both broadband i.e. it does not contain a distinguishable note or tone, and of random character, although the level is not constant and fluctuates in time with the movement of the blades. The dominant character of such aerodynamic noise is therefore normally a 'swish' type of sound, which is familiar to most people who have stood near to a large wind turbine.

The sound level of aerodynamic noise from wind turbine blades is not completely steady, but is modulated (fluctuates) in a cycle of increased and then reduced level, sometimes called "*blade swish*", typically occurring in step with the angle of rotation of the blades and so being periodic at the rotor's rotational speed – for typical commercial turbines, this is at a rate of around once or twice per second. This phenomenon is known as Amplitude Modulation of Aerodynamic Noise or more succinctly by the acronym AM. In some situations, however, the modulation characteristics can change in character to the point where it can potentially give rise to increased annoyance.

In early wind turbine designs, where the rotor was positioned downwind of the tower, a pronounced 'beat' was audible as each blade passed through the turbulent wake shed from the tower. However, this effect does not exist for the upwind rotor designs found on the majority of modern windfarms where the air flow to the blades is not interrupted by the tower structure. Instead, it seems that aerodynamic modulation is due to fluctuation of the primary mechanisms of aerodynamic noise generation.

The Temple Group[12] undertook a review of Renewable UK's Research into Amplitude Modulation and concluded the following:

The distinction between normal AM i.e. blade swish (NAM) and other AM (OAM) is important as they are caused by different mechanisms and have separate impacts. Normal AM (NAM) is a commonly occurring typical characteristic of wind turbine noise that occurs persistently for long periods. NAM or "swish" usually disappears at around 3 to 4 rotor lengths from the turbines, except in crosswind conditions.

Based on the evidence available, it was recognised that even at those windfarm sites where OAM has been reported to be an issue, its occurrence may be relatively infrequent.

The study reports that the occurrence and intensity of OAM is dependent on a number of interacting factors that are specific to a location and it is not feasible to reliably predict the occurrence of OAM at another location simply by cross checking whether similar conditions that arise at a location where OAM has occurred might arise at the new location.

Normal Amplitude Modulation (NAM) is a fundamental component of wind turbine noise and can be heard in proximity to virtually all wind turbine installations. The 2007[13] Salford University Report found instances of "enhanced" AM which occurred at larger distances, but relatively infrequently and at only a small minority of sites. These characteristics are consistent with and can be explained by OAM.

As described previously, many risk factors have been considered for OAM. However, no single item or specific combination of items have been found to be the controlling factors whereby the occurrence, duration and intensity of OAM at a particular location can be reliably predicted in advance of a wind turbine or windfarm being installed.

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[12] Report for Renewable UK by Temple Group (Dani Fliumicelli). *Summary of Research into Amplitude Modulation of Aerodynamic Noise from Wind Turbines*, Wind Turbine Amplitude Modulation: *Research to Improve Understanding as to the cause and Effec*t, Dec'2013.

[13] Research into Aerodynamic Modulation of Wind Turbine Noise. Report by University of Salford

Salford University in 2007, found that out of 133 operational windfarms investigated, 27 were associated with noise complaints, but OAM was considered to be a factor in noise complaints at only four sites and a possible factor in a further eight locations.

The existing 25 turbine Operational Barnesmore Windfarm has been operating for 22 years with no OAM reported.

10.2.4 Low Frequency Noise and Vibration

There is always low frequency (or infrasound) noise present in the ambient quiet background. It is generated by natural sources such as road traffic, wind, water flow in streams and rivers. There are also low frequency emissions from many sources found in modern life, such as household appliances (e.g. washing machines), water flowing through pipes within your home and in water flow from municipal water supply. Vibration of elements of structures (low frequency) can be generated by local activity in one's home by way of normal routine activity, like climbing stairs, closing doors, traveling in a car, etc.

The frequency range of audible noise is in the range of 20 to 20,000Hz and low frequency noise is generally from about 2 to 200Hz. Researchers such as Leventhall have studied low frequency noise, however, most of the research carried out on low frequency noise (and not alluded to by Leventhall) has been in the area of blasting (air overpressure) which falls into the same frequency range, although with a considerably higher magnitude. There appears to be little or no agreement about the biological effects of low frequency noise on human health and there is evidence to suggest that there are no serious consequences to people's health from infrasound exposure.

A study of low frequency noise (infrasound) and vibration around a modern windfarm was carried out for ETSU and reported in ETSU W/13/00392/REP – '*Low Frequency Noise and Vibration Measurements at a Modern Wind Farm*'[14]. The results showed levels of infrasound to be below accepted thresholds of perception even on the Site. Furthermore, a document prepared for the World Health Organisation, states that *'there is no reliable evidence that infrasound below the hearing threshold produce physiological or psychological effects'.*

The level of ground vibration from the operation of the windfarms is below human threshold (0.13mm/s) at distances greater than 100 m. The level of ground vibration from construction activity is below human threshold at the nearest activity which is at distances greater than 200 m.

10.2.5 Field Work

Baseline noise monitoring was undertaken at three locations between 2 April and 3 May 2019. The continuous monitoring period coincided with the wind speed monitoring over the same period and at the same 10-minute intervals. Noise data was recorded for a representative range of wind speeds during this four week+ period.

10.2.6 Consultation

Consultation was carried out with personnel familiar with the Site and locality. Access to the nearest dwellings was carried out with permission from the householders / landowners. There was correspondence received from An Bord Pleanála and the EHO in Northern Ireland.

10.2.7 Operational Noise Assessment Methodology

In summary, the assessment process comprises:

- Identification of potential receptors, i.e. houses and other potentially noise-sensitive locations
- Measurement of existing background noise levels at representative locations close to the Site
- Prediction of the likely noise levels of wind turbines received at each receptor
- Comparison of the predicted levels with noise limits
- The energy storage facility and new substation is considered. However, it is discounted from the noise assessment as the noise emissions are very low compared to the wind turbines.

Potential receptors in the area around the Development were initially identified from Ordnance Survey maps, google maps, EPA maps and Site visits. Background measurements were carried out at three locations as detailed in **Figure 10.1**.

The method of measuring background noise is described in ISO 1996 and ETSU-R-97. In practice, it means carrying out continuous monitoring of background noise levels at receptors for a period that includes a range of wind speeds which

[14] ETSU W/13/00392/REP – '*Low Frequency Noise and Vibration Measurements at a Modern Wind Farm'.*

correspond to the maximum sound power of the candidate turbines being proposed which is usually 3 to 4 weeks duration. The candidate turbine assessed reaches maximum sound power level at a mean wind speed of 8 m/s at 10 m height.

The method of predicting noise levels of wind turbines at receptors is discussed in **Section 10.2.2.5**. This method was applied to the calculations for both contour plots and individual receptor predictions.

It is standard practice to predict noise levels for a reference wind speed and to adjust these for other wind speeds, according to the variation in sound power level with wind speed.

There are a range of turbine options available for the Site, the final turbine choice will be made through a commercial tender process. **Table 10.3** lists a number of potential turbines assessed with no favoured model at this stage. For EIA purposes hypothetical candidate turbine, the ENERCON E-136 EP5/4650 kilowatts (4.65 MW) has been selected as it reflects the worst case scenario for each EIA technical assessment**.**

A copy of the manufacturers noise specification of all turbines used in the assessment are given in the **Technical Appendix 10.5**.

Table 10.3: List of Turbines Assessed

Turbine Manufacturer	Model	Turbine Output (MW)	Sound Power Level at Source dB LWA
Enercon	E136 EP5-4,65 E-147 EP5-5.0	4.65 5.00	93.8 - 107.2 95.5 - 106.4
SGRE	SWT 4.1-142 SG 6.0-155	4.10 6.00	107 105
GE	GE 5.3-158	5.30	106
Goldwind	GW136/4200	4.20	106
Nordex	N133/4.8	4.80	103
Vestas	V136-4.2 V150	4.20 5.60	105.5 104.9

The ENERCON E-136 EP5/4650 kilowatts (4.65MW) has a hub height of 109 m. The prediction modelling is based on the turbines operating at full power in Mode O's and all turbines will be fitted with Trailing Edge Serrations (TES) which reduces the sound power levels of each turbine. The IOA Good Practice Guide recommends that an uncertainty value is required to be added to the turbine emission data prior to modelling. Depending on the type of manufactures data, the uncertainty value will range from 0 to 2dBA. However, for the ENERCON E136 EP5 an uncertainty value of 1.2 dBA is given in the data sheet. **Table 10.4** gives the noise emission data of the ENERCON turbine at a wind speed of 9 m/s at standardised10 m height as inputted into prediction model. An uncertainty value of 1.2 dBA is added to the data and a value of 2dBA subtracted to convert from LAeq to LA90.

Table 10.4: Noise Emission Data, ENERCON E-136 EP5 4.65 MW with TES in Mode 0's

Standardised 10 m height Wind Speed, ms^{-1}	4	5	6	7	8	9	10	10+
Sound Power Level, dB LWA 8 ms^{-1}	97.5	102.9	105.9	107.1	107.2	107.2	107.2	107.2
Uncertainty added and conversion of LAeq to LA90	96.7	102.1	104.1	106.3	106.4	106.4	106.4	106.4

The octave band values are given in **Table 10.5** with uncertainty values and conversion for LAeq to LA90 added as input to the prediction model.

Table 10.5: Octave Band Spectrum of ENERCON E-136 EPS 4.65 MW with TES in Mode 0's

Octave Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level, dB LWA 8 ms^{-1}	84.6	93.4	100.5	102.4	100.9	98.4	93.3	85.9
Uncertainty added to octaves and conversion of LAeq to LA90	83.8	92.6	99.7	101.6	100.1	97.6	92.5	85.1

10.2.7.1 Cumulative Assessment

Cumulative effects from any existing, consented or application-stage windfarms within 3 km of identified noise-sensitive receptors have been taken into consideration as the potential for cumulative effects beyond this distance is considered negligible. On this basis, the cumulative effect of the operating group of Windfarm's located south of Barnesmore WF known as the Meenadreen Group of Windfarm's comprising Straness Windfarm (21 Nordex turbines, HH of 70m), Meenadreen Windfarm Extension (2 Nordex turbines, HH of 70m), Lough Cuill Windfarm (8 Nordex turbines, HH of 70m) and Meenadreen Windfarm (4 Vestas turbines, HH of 60m) along with the permitted Meenbog Windfarm (19 turbines) located north of the Development. Assessment of noise impacts in Northern Ireland are also considered.

The octave band spectrum of the 31 No. Nordex N90, 2.5 MW wind turbines (70m HH) is given in **Table 10.6**. The octave band spectrum for the 4 No Vestas V52-850 Kilowatt is given in **Table 10.7**. The octave band spectrum of the 19 No. turbines permitted for the Meenbog Windfarm is given in **Table 10.8**.

Table 10.6: Octave Band Spectrum of Nordex N90, 2.5 MW at maximum LWA

Octave Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000	L_{WA}
Sound Power Level, dB LWA 9 ms^{-1}	90.7	94.8	99.2	99.6	98.1	97.0	93.0	85.4	105.5

Table 10.7: Octave Band Spectrum of Vestas V52-850 Kilowatt **at maximum LWA**

Octave Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000	L_{WA}
Sound Power Level, dB LWA 9 ms^{-1}	83	90.0	96.7	102.3	102.0	98.1	91.7	81.5	106.8

Table 10.8: Octave Band Spectrum of unknown turbine used in the Meenbog EIAR[15]

Octave Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000	L_{WA}
Sound Power Level, dB L_{WA} 9m/s	89.1	95.8	98.3	99.8	100.6	98.5	94.7	84	106.3

10.2.7.2 Noise Limits

The method of deriving operational noise limits is described in Section 10.2.2.3 and is based on the Preferred Draft Approach 2017. The noise limits proposed are:

- Lower limit of 40 dB(A), or 5 dB(A) above existing background noise with a maximum limit of 43 dB(A) for day and night

10.2.8 Construction Methodology

10.2.8.1 Relevant Guidance

There is no published national guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project. However National Roads Authority (NRA) give limit values which are deemed

[15] Meenbog Wind Farm-EIAR, McCarthy, Keville, O'Sullivan, 2017.11.22-F, Pages 11-32.

acceptable (the NRA Guidelines)[16]. Guidance to predict and control noise is also given in BS 5228:2009, *Code of Practice for Noise and Vibration Control on Construction and Open Sites* (two parts) where Part 1 deal with Noise[17].

10.2.8.1.1 NRA Guidelines for the Treatment of Noise and Vibration in National Road Schemes

The NRA Guidelines provide noise limits which are typically acceptable and states that where it is deemed necessary to predict noise levels associated with construction noise that this should be done in accordance with BS 5228.

10.2.8.1.2 BS 5228:2009 Code of Practice for Noise and Vibration Control on Construction and Open Sites

Part 1 of BS5228 deals with noise prediction and control. It recommends procedures for noise control in respect of construction operations. The standard stresses the importance of community relations, and states that early establishment and maintenance of the relations throughout the carrying out of Site operations will go some way towards allaying people's concerns. Some of the more relevant factors that are likely to affect the acceptability of construction noise are:

- The attitude of local receptors to the Development
- Site location relevant to noise sensitive receptors
- Duration of Site operations
- Hours of work
- The characteristics of the noise produced.

Recommendations are made regarding the supervision, planning, preparation and execution of works, emphasising the need to consider noise at every stage of the activity. Measures to control noise are described including:

- Control of noise at source by, e.g.
  - Substitution of plant or activities by less noisy ones
  - Modification of plant or equipment by less noisy ones
  - Using noise control enclosures
  - Siting of equipment and its method of use
  - Maintenance of equipment
  - Controlling the spread of noise by increasing distance between plant and receptors, or by the provision of acoustic screening

Example criteria for the assessment of the significance of noise effects are also given, although these are not mandatory.

Methods of calculating the levels of noise resulting from construction activities are provided, as are updated source levels for various plant, equipment and construction activities.

10.2.8.2 Construction and Decommissioning Noise Assessment Methodology

The NRA guidelines for construction noise which are considered typically acceptable are given in **Table 10.9**.

Table 10.9: Noise levels that are typically acceptable based on the NRA guidelines

Day / Times	Guideline Limits
Monday to Friday 07:00 – 19:00hrs 19:00 – 22:00hrs	 70dB LAeq, (1h) and LAmax 80dB *60dB LAeq, (1h) and LAmax 65dB*
Saturday 08:00 – 16:30hrs	 65dB LAeq,1h and LAmax75dB
Sunday and Bank Holidays 08:00 – 16:00hrs	 *60dB LAeq,1h and LAmax 65dB*

*Construction at these times, other than required by an emergency works, will normally require explicit permission from the relevant local authority.

Part 1 of BS 5228 provides several example criteria for the assessment of the significance of noise effects from construction activities. Noise levels generated by construction activities are considered significant if:

[16] National Roads Authority, *Guidelines for Noise and Vibration in National Road Schemes.*
[17] BS 5228-1: 2009 Code of Practice for Noise and Vibration Control on Construction and Open Sites: *Code of Practice for Basic Information and Procedures for Noise Control*.

- The LAeq, period level of construction noise exceeds lower threshold values of 65 dB during daytime, 55 dB during evenings and weekends or 45 dB at night.
- The total noise level (pre-construction ambient noise plus construction noise) exceeds the pre-construction noise level by 5 dB or more for a period of one month or more.

Construction noise from windfarm development, or decommissioning is not considered an intensive activity. The main noise sources will be associated with the construction of the turbine foundations and hardstands. Additional Site tracks, energy storage and a temporary construction compound will also be put in place. Decommissioning could include removal of construction bases and removal of excess roadways. Turbine erection gives negligible noise emissions while the power generated from the turbines will be directed to a nearby permitted sub-station.

10.2.9 Evaluation of Potential Effects

The potential impacts of construction are evaluated by comparing the predicted noise levels against the guideline limits given in **Table 10.9: Noise levels that are typically acceptable based on the NRA guidelines,** and sample criteria in Part 1 of BS 5228 in Section 10.2.8.2.

The potential operational impacts are evaluated by comparing the predicted noise levels against the day and night-time noise limit given in Section 10.2.7.2. The predicted noise levels are carried out according to the IOA Good Practice Guide as detailed in Section 10.2.2.4 and potential impacts are assessed against the noise limits at the nearest receptors.

10.2.9.1 Sensitivity

The sensitivity of the Development during construction is based on the guideline values in **Table 10.9: Noise levels that are typically acceptable based on the NRA guidelines,** and sample criteria in Part 1 of BS 5228. The sensitivity of the Development during operation is based on the guideline values in Section 10.2.7.1.

10.2.9.2 Magnitude

The magnitude of potential impacts of construction is based on the values in **Table 10.13**: **Typical Noise Levels from Construction Works.** The magnitude of the Development during operation is based on the values in **Table 10.9: Noise levels that are typically acceptable based on the NRA guidelines**.

10.2.9.3 Significance Criteria

The significance of construction is based on the potential impacts based on the predicted values and compliance with the guideline limits in **Table 10.9: Noise levels that are typically acceptable based on the NRA guidelines**, and sample criteria of in Part 1 of BS 5228.

The significance of the potential impacts of the Development have been assessed by taking into account the noise limits at receptors and the degree to which compliance has been met.

10.3 Baseline Description

10.3.1 Identification of Potential Receptors

A number of predictions were prepared for the layout of the 13-turbine windfarm. Based on initial layout, potential noise-sensitive receptors including occupied and un-occupied were identified from maps. Receptor locations were verified through Site visits.

10.3.2 Selection of Baseline Noise Survey Locations

Three baseline noise survey locations were selected on the basis of their location relative to the Development are shown in **Table 10.10: Baseline Noise Survey**. **Figure 10.1** shows the three noise monitoring locations in relation to the Development.

10.3.3 Baseline Noise Survey

Baseline noise measurements were carried out from 2 April to 3 May 2019 at locations outlined in **Table 10.10: Baseline Noise Survey** and shown in **Figure 10.1**. To avoid any noise contribution from the existing Barnesmore turbines the measurement data was filtered so that only upwind data was used in the analysis. The baseline survey monitoring locations were carried out at receptor houses H1, H17, and H19 (photos of monitors in-situ in **Technical Appendix 10.1)**.

Table 10.10: Baseline Noise Survey

Location	Irish Grid Reference	Description of Location
H1	202146E,384425N	Microphone at 1.2-1.5 m height, at front of dwelling facing Site
H17	201089E, 382715N	Microphone at 1.2-1.5 m height, at rear of dwelling facing Site
H19	201753E, 381258N	Microphone at 1.5 m height, at side dwelling facing Site

The survey was carried out in accordance with ISO 1996, ETSU-R-97 and the IOA Good Practice Guide with the following implemented:

- Measurement of background noise levels at 10-minute intervals was undertaken using Type 1 instruments.
- Concurrent measurements of 10-minute interval mean wind speed / direction were recorded from Existing Met Mast located on the Site. The methodology is given in Section 10.2.2.4.
- The background noise measurement recorded continuously included 10-minute intervals, as LA90, 10min along with a series of other parameters including LAeq,10min.
- Noise measurements were recorded at a height of 1.2-1.5 m above ground level and more than 5 m from any reflective surface other than the porous ground.
- An electronic rain gauge was installed onsite at House 17 to monitor rainfall at 10-minute intervals over the duration of the noise survey. Rain data which impacted on noise levels were removed from the noise data set prior to analysis.
- The wind speed was taken from the existing Met Mast (located onsite which has anemometers at 70.2 m and 50 m height.
- Wind shear calculated from the two different wind speed heights at 10 min intervals was used to extrapolate to the hub height wind speed followed by calculation to standardised 10 m height using the methodology given in the IOA Supplementary Guidance Note 4.
- The standardised 10 m wind speed was plotted against the filtered background noise levels to exclude directly downwind form the Operational Barnesmore Windfarm using a best-fit polynomial line.

10.3.3.1 Instrumentation Used

The following instrumentation was used in the baseline survey measurements:

- Three Larson Davis Precision Integrating Sound Level Analyser/Data logger with 1/2" Condenser Microphones. All microphones were fitted with double skin windscreens based on that specified in W/31/00386/REP 'Noise Measurements in Windy Conditions[18]'.
- Calibration Type: Larson Davis Precision Acoustic Calibrator
- Rain Gauge Type: Davis Instruments Vantage Pro2 weather station

All acoustic instrumentation was calibrated before and after each survey and the drift of calibration was less than 0.2dB. Survey measurement data and calibration certificates of the acoustic instruments are included in **Technical Appendix 10.3**.

10.3.4 Prevailing Background Noise Levels

Table 10.11 gives the background noise levels obtained from quiet daytime and night-time measurement periods at the three baseline measurement locations. H01, H17 and H19. Direct downwind noise levels were filtered from the data prior to analysis.

[18] W/31/00386/REP 'Noise Measurements in Windy Conditions'.

Table 10.11: Prevailing Background Noise Levels

Monitoring Location	Prevailing Background (B/G) noise levels LA90dB, 10min Standardised Mean 10 m Height Wind Speed, (m/s)										
		3	4	5	6	7	8	9	10	11	12
H1	Day	40.2	40.4	41.1	42.0	43.2	44.6	45.9	47.3	49.7	48.6
	B/G+5	45.2	45.4	46.1	47.0	48.2	49.6	50.9	52.3	54.7	53.6
H1	Night	35.2	36.8	38.2	39.4	40.5	41.5	42.4	43.1	43.7	44.2
	B/G+5	40.2	41.8	43.2	44.4	45.5	46.5	47.4	48.1	48.7	49.2
H17	Day	33.1	32.8	33.3	34.5	36.3	38.5	41.0	43.7	46.5	49.2
	B/G+5	38.1	37.8	38.3	39.5	41.3	43.5	46.0	48.7	51.5	54.2
H17	Night	26.9	26.4	26.7	27.6	29.1	31.1	33.3	35.8	38.2	40.7
	B/G+5	31.9	31.4	31.7	32.6	34.1	36.1	38.3	40.8	43.2	45.7
H19	Day	27.8	27.1	29.1	31.1	33.5	36.3	39.4	42.8	46.3	49.8
	B/G+5	32.8	32.1	34.1	36.1	38.5	41.3	44.4	47.8	51.3	54.8
H19	Night	27.3	27.7	28.8	30.6	32.9	35.4	38.1	40.6	43.0	44.9
	B/G+5	32.3	32.7	33.8	35.6	37.9	40.4	43.1	45.6	48.0	49.9

Location H01

This is a holiday house located in low elevation area. The noise monitor was located in the front garden close to trees but away from local mountain stream noise and facing towards the Operational Barnesmore Windfarm which is not visible. The main source of noise which dominated the environment is from the busy National Primary Route (N15) located approximately 270 m away. The nearby river running through flat ground along the N15 was not audible at this location.

Location H17

This is a residential home on an elevated site in a low-level farming area. The noise monitor was located in the rear garden of the residence facing towards the Operational Barnesmore Windfarm. The main source of noise is from distant N15 road traffic, local road network and wind effects on vegetation.

Location H19

This building presented in **Technical Appendix 10.1**, Plate 4 is currently devoid of doors and has signs of being frequented by sheep. The noise monitor was located in the front of the residence facing towards the Operational Barnesmore Windfarm The building is inaccessible by car. The main noise sources are a local mountain river which is approximately 80 m away, sheep and wind effects on vegetation.

The Operational Barnesmore Windfarm was not audible at any location even when wind was directly downwind on any of six visits to the monitoring locations.

10.3.5 Noise Assessment Locations

The nearest receptors to the Development were selected for assessment and represent the properties most likely to be affected by potential effects. Measured background noise levels have been assumed to be representative of the background noise environments at the nearest properties to each monitoring location.

Should the predicted operational noise levels from the Development comply with the requirements of the Preferred Draft Approach 2017 at the closest receptors, it may be assumed that the predicted noise levels at receptors further away from the Development will also comply, due to the attenuation of turbine noise levels with distance. The locations are given in **Table 10.10: Baseline Noise Survey**.

10.3.6 Noise Limits

The noise limits for the Development are based on the limits recommended by the Preferred Draft Approach 2017 and on the background levels obtained in **Table 10.11: Prevailing Background Noise Levels.** To obtain a more robust assessment the lower background noise levels obtained at location H19 is used as the basis for the assessment at all receptors. The **Table 10.12** gives the derived noise limits.

Table 10.12: Derived Background Noise Levels Used in Assessment (H19 night-time)

Monitoring Location		Prevailing Background (B/G) noise levels LA90dB, 10min Standardised Mean 10 m Height Wind Speed, (m/s)									
		3	4	5	6	7	8	9	10	11	12
H19	Day	27.8	27.1	29.1	31.1	33.5	36.3	39.4	42.8	46.3	49.8
	B/G+5	32.8	32.1	34.1	36.1	38.5	41.3	44.4	47.8	51.3	54.8
Noise Limit		40.0	40.0	40.0	40.0	40.0	41.3	43.0	43.0	43.0	43.0
H19	Night	27.3	27.7	28.8	30.6	32.9	35.4	38.1	40.6	43.0	44.9
	B/G+5	32.3	32.7	33.8	35.6	37.9	40.4	43.1	45.6	48.0	49.9
Noise Limit		40.0	40.0	40.0	40.0	40.0	40.4	43.0	43.0	43.0	43.0

10.3.7 Development Design Mitigation

The preferred turbine model, yet to be decided will be fitted with trailing edge serrations (TES). A serrated extension of the trailing edge to the rotor blades mitigates noise emission by effectively breaking up the turbulence on the tooth flanks into smaller eddies. The intensity of the pressure fluctuations is reduced which mitigates the noise emissions. Since the intensity of the noise emissions is largely dependent on the flow speed, TES are only installed on the outer rotor blade area where the rotary speed is the highest. Typically, TES will reduce the noise levels by 2-3 dBA.

10.4 Assessment of Potential Effects

10.4.1 Construction Noise

10.4.1.1 Typical Construction and Decommissioning Noise Levels

As has been previously stated, the construction process associated with windfarms is not considered intensive and is temporary works. The main noise sources will be associated with the construction of the turbine foundations and hardstands. Upgrade of existing Site tracks, upgrade of the 110 kV substation, energy storage facility and a temporary construction compound will also be put in place. Decommissioning of the existing turbines will be carried out and will run in parallel with construction activity. Decommissioning noise levels are assumed to be in the same order as construction levels. All extra Site tracks and turbine base material will be imported to the Site avoiding the need to quarry or blast for stone. Every effort will be made to utilise as much as possible existing hardstands.

It is not possible to specify the precise noise levels of emissions from the construction equipment until such time as a contractor is chosen and construction plant has been selected, however **Table 10.13** indicates typical construction related noise levels for this type of activity (levels from author's database). Predictions are made for the nearest receptors to the Development.

Table 10.13: Typical Noise Levels from Construction Works

Activity	L_{Aeq} at 10m
General Construction (pile driving, ready-mix trucks pouring concrete)	70-84 dBA
Tracked excavator removing topsoil, subsoil for foundation	80- 87 dBA
Rock breaker	82-89 dBA
Vibrating rollers and trucks loading and tipping material	76-86 dBA

The difference in noise levels between two locations can be calculated as:

$$L_{p2} - L_{p1} = 10 \log (R_2 / R_1)^2 - (A_{atm} + A_{gr} + A_{br} + A_{mis})$$

$$= 20 \log (R_2 / R_1) - (A_{atm} + A_{gr} + A_{br} + A_{mis})$$

where:

L_{p1} = sound pressure level at location 1

L_{p2} = sound pressure level at location 2

R_1 = distance from source to location 1

R_2 = distance from source to location 2

and where:

A_{atm} = Attenuation due to air absorption

A_{gr} = Attenuation due to ground absorption

A_{br} = Attenuation provided by a barrier

A_{mis} = Attenuation provided by miscellaneous other effects

In the calculation attenuation by A_{atm}, A_{gr} and A_{mis} is assumed as 0.

Table 10.14 gives the noise levels predicted from construction activity at the nearest receptors. The main noise sources are assumed to be in the construction of the turbine foundations and turbine hardstands. Additional Site tracks, energy storage and a temporary construction compound will be put in place, however the noise levels associated with this activity will be no more than that associated with construction of turbine foundations and hardstands. The maximum construction noise levels are at receptors listed in **Table 10.14.** At receptor location further away, noise levels will be less than that predicted.

Table 10.14: Predicted Construction Noise Levels

Receptor	Activity	Distance of Activity to Nearest Turbine	LAeq dB 1hr range
H19 Un-habited	General construction Foundation works (excavation / concreting) Rock breaking Vibratory rollers and trucks loading / tipping	1300 1300 1300 1300	27.7-41.7 37.7-44.7 39.7-46.7 30.7-40.7
H1	General construction Foundation works (excavation / concreting) Rock breaking Vibratory rollers and trucks loading / tipping	1800 1800 1800 1800	24.9-38.9 37.7-41.9 39.7-43.9 30.7-37.9

10.4.1.2 Assessment of Construction Noise

The highest predicted noise levels are at H19 which is un-habited and frequented by sheep. The maximum predicted noise levels will exist for no more than one week equivalent (12 hours x 5 days). The predicted noise levels are well within the NRA guidelines given as generally acceptable and well below the lower threshold of 65 dBA, as defined in BS 5228-1:2009 and are therefore considered as not significant**.** At all other receptors the noise levels will be well below that predicted for H19 as the next closest receptor H1 is more than 1.8 km away. Furthermore, all ground level activity close to turbines will be invisible to all inhabited houses thereby providing significant additional attenuation due to topographic screening effects.

Ground vibration from rock breaking will be below the threshold of sensitivity to humans of 0.2 mm/s peak particle velocity at all receptors[19].

The effects of noise and vibration from onsite construction activities are therefore considered not significant.

10.4.1.3 Decommissioning

Noise effects during decommissioning of both the Operational Barnesmore Windfarm and the repower are likely to be of a similar nature to that during construction. It is likely that the duration of decommissioning will be shorter duration than that during construction. It is likely that existing roadways will be left in place unless there are environmental reasons to remove. Any legislation, guidance or best practice relevant at the time of decommissioning will be complied with.

10.4.2 Predicted Operational Noise Levels

Table 10.15 gives the predicted noise levels at the nearest receptors to the Development at varying wind speeds for each receptor location. A noise contour map of the 13 no. turbine Development at maximum sound power output at a wind speed of 9 ms^{-1} at 10 m height is presented in **Figure 10.2**. The contour map in **Figure 10.2** assumes that all turbines are simultaneously downwind at the same time to each location which results is an overprediction of the noise levels.

Table 10.15: Predicted Noise Levels as LA90 at Varying Wind Speeds from the Development

	IGR	IGR		4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	10+m/s
House ID	Easting	Northing	Altitude	dBA	dBA	dBA	dBA	dBA	dBA	dBA	dBA
1	202104	384453	94	24.3	29.7	32.7	33.9	34.0	34.0	34.0	34.0
1a	202144	384431	103	24.4	29.8	32.8	34.0	34.1	34.1	34.1	34.1
2	201928	384606	90	23.1	28.5	31.5	32.7	32.8	32.8	32.8	32.8
3	201733	384688	106	22.2	27.6	30.6	31.8	31.9	31.9	31.9	31.9
4	201879	384921	122	22.0	27.4	30.4	31.6	31.7	31.7	31.7	31.7
5	201589	384468	92	22.3	27.7	30.7	31.9	32.0	32.0	32.0	32.0
6	201543	384434	91	22.2	27.6	30.6	31.8	31.9	31.9	31.9	31.9
7	201492	384422	92	22.0	27.4	30.4	31.6	31.7	31.7	31.7	31.7
8	201476	384323	91	22.2	27.6	30.6	31.8	31.9	31.9	31.9	31.9
9	201347	384298	93	21.8	27.2	30.2	31.4	31.5	31.5	31.5	31.5
10	201335	384155	90	22.0	27.4	30.4	31.6	31.7	31.7	31.7	31.7
11	201287	384112	93	22.0	27.4	30.4	31.6	31.7	31.7	31.7	31.7
12	201152	384171	103	21.3	26.7	29.7	30.9	31.0	31.0	31.0	31.0
13	201037	383992	104	21.2	26.6	29.6	30.8	30.9	30.9	30.9	30.9
14	201161	383916	88	21.8	27.2	30.2	31.4	31.5	31.5	31.5	31.5
15	201051	383809	84	21.6	27.0	30.0	31.2	31.3	31.3	31.3	31.3
16	200991	383913	99	21.2	26.6	29.6	30.8	30.9	30.9	30.9	30.9
17	201092	382715	138	22.9	28.3	31.3	32.5	32.6	32.6	32.6	32.6
18	200990	382645	134	22.4	27.8	30.8	32.0	32.1	32.1	32.1	32.1
19	201755	381260	231	25.3	30.7	33.7	34.9	35.0	35.0	35.0	35.0
20	201061	383754	86	21.7	27.1	30.1	31.3	31.4	31.4	31.4	31.4

[19] Wiss, J. F., and Parmelee, R. A. (1974) Human Perception of Transient Vibrations, "*Journal of Structural Division*", ASCE, Vol 100, No. S74, PP. 773-787

10.4.3 Operational Noise Assessment

The assessment was made of the predicted operational noise levels from the Development against noise limits in the Preferred Draft Approach 2017. All predicted noise levels are within limits. **Table 10.16** gives the difference (margin) between the predicted noise level in **Table 10.15: Predicted Noise Levels as LA90 at Varying Wind Speeds from the Development,** and noise limits for each receptor. A negative margin indicates that the predicted noise levels are within the lower 40 dBA, background plus 5 dBA and maximum 43 dBA noise limits.

As can be seen from **Table 10.16** the predicted noise levels at all receptors are lower than the noise limits in all cases, at all wind speeds, and are therefore compliant with the noise limits and are not significant in terms of EIAR Regulations.

The predicted noise levels assume that all 13 turbines are directly down-wind.

There are no noise sensitive receptors in NI within 6 km of the Development which is proposed to replace the existing operational 25 no. turbines, so the potential for negative impacts is negligible.

Table 10.16: Margin between Predicted Noise Levels and Noise Limit

	IGR	IGR		4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	10+m/s
House ID	Easting	Northing	Altitude	dBA	dBA	dBA	dBA	dBA	dBA	dBA	dBA
1	202104	384453	94	-15.7	-10.3	-7.3	-6.1	-6.4	-9.0	-9.0	-9.0
1a	202144	384431	103	-15.6	-10.2	-7.2	-6.0	-6.3	-8.9	-8.9	-8.9
2	201928	384606	90	-16.9	-11.5	-8.5	-7.3	-7.6	-10.2	-10.2	-10.2
3	201733	384688	106	-17.8	-12.4	-9.4	-8.2	-8.5	-11.1	-11.1	-11.1
4	201879	384921	122	-18.1	-12.7	-9.7	-8.5	-8.8	-11.4	-11.4	-11.4
5	201589	384468	92	-17.7	-12.3	-9.3	-8.1	-8.4	-11.0	-11.0	-11.0
6	201543	384434	91	-17.8	-12.4	-9.4	-8.2	-8.5	-11.1	-11.1	-11.1
7	201492	384422	92	-18.0	-12.6	-9.6	-8.4	-8.7	-11.3	-11.3	-11.3
8	201476	384323	91	-17.8	-12.4	-9.4	-8.2	-8.5	-11.1	-11.1	-11.1
9	201347	384298	93	-18.2	-12.8	-9.8	-8.6	-8.9	-11.5	-11.5	-11.5
10	201335	384155	90	-18.0	-12.6	-9.6	-8.4	-8.7	-11.3	-11.3	-11.3
11	201287	384112	93	-18.1	-12.7	-9.7	-8.5	-8.8	-11.4	-11.4	-11.4
12	201152	384171	103	-18.7	-13.3	-10.3	-9.1	-9.4	-12.0	-12.0	-12.0
13	201037	383992	104	-18.8	-13.4	-10.4	-9.2	-9.5	-12.1	-12.1	-12.1
14	201161	383916	88	-18.2	-12.8	-9.8	-8.6	-8.9	-11.5	-11.5	-11.5
15	201051	383809	84	-18.4	-13.0	-10.0	-8.8	-9.1	-11.7	-11.7	-11.7
16	200991	383913	99	-18.8	-13.4	-10.4	-9.2	-9.5	-12.1	-12.1	-12.1
17	201092	382715	138	-17.1	-11.7	-8.7	-7.5	-7.8	-10.4	-10.4	-10.4
18	200990	382645	134	-17.7	-12.3	-9.3	-8.1	-8.4	-11.0	-11.0	-11.0
19	201755	381260	231	-14.7	-9.3	-6.3	-5.1	-5.4	-8.0	-8.0	-8.0
20	201061	383754	86	-18.3	-12.9	-9.9	-8.7	-9.0	-11.6	-11.6	-11.6

Charts 10.1 to **10.6** (outlined below) of this section plots the derived background noise levels with the predicted noise levels and a lower noise limits of 40 dBA, or background plus 5 dBA with 43dB(A) being the maximum noise limit (**Table 10.12: Derived Background Noise Levels Used in Assessment (H19 night-time)**). The derived background noise levels exclude direct downwind data from the Operational Barnesmore Windfarm. The charts are used by way of examples for the receptors that have the highest predicted noise levels.

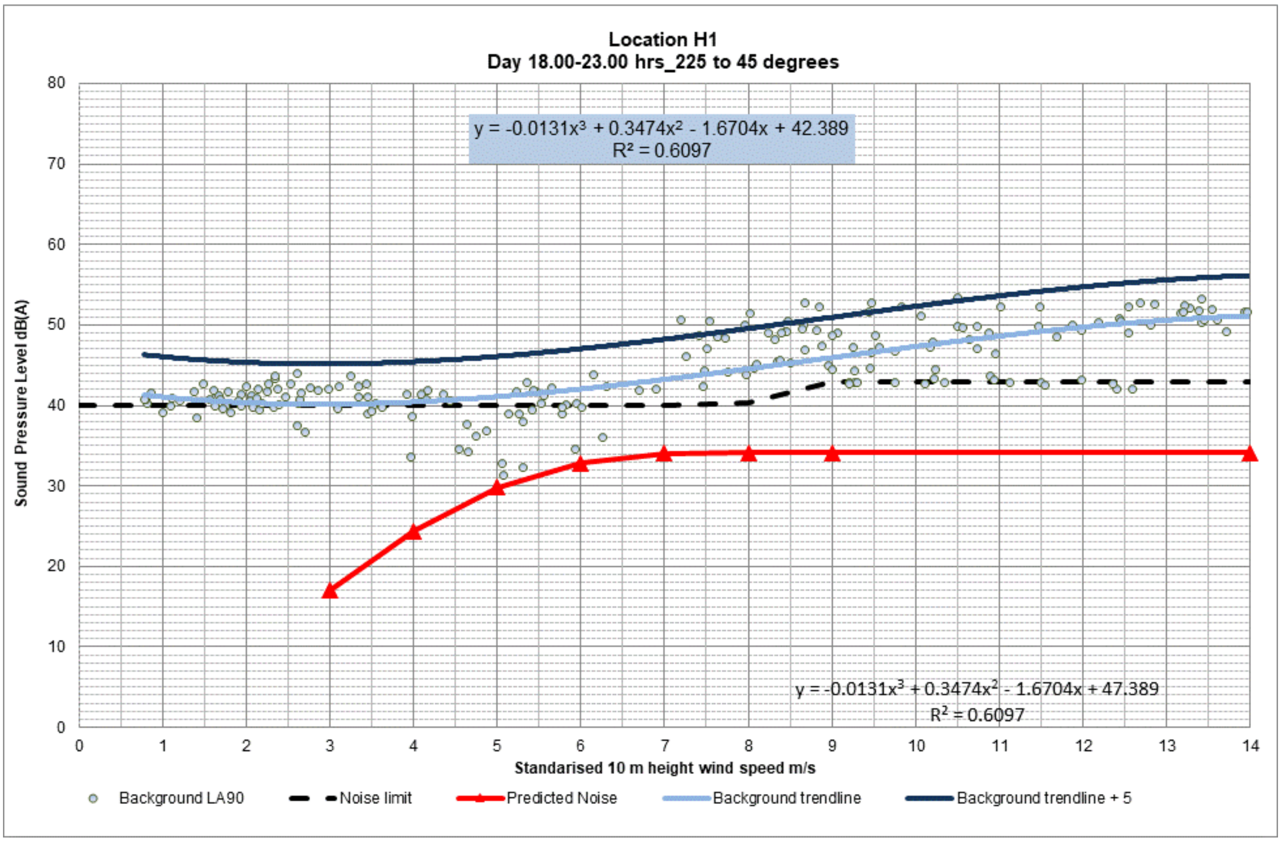

Chart 10.1: Quiet Daytime Predicted Assessment for House 1

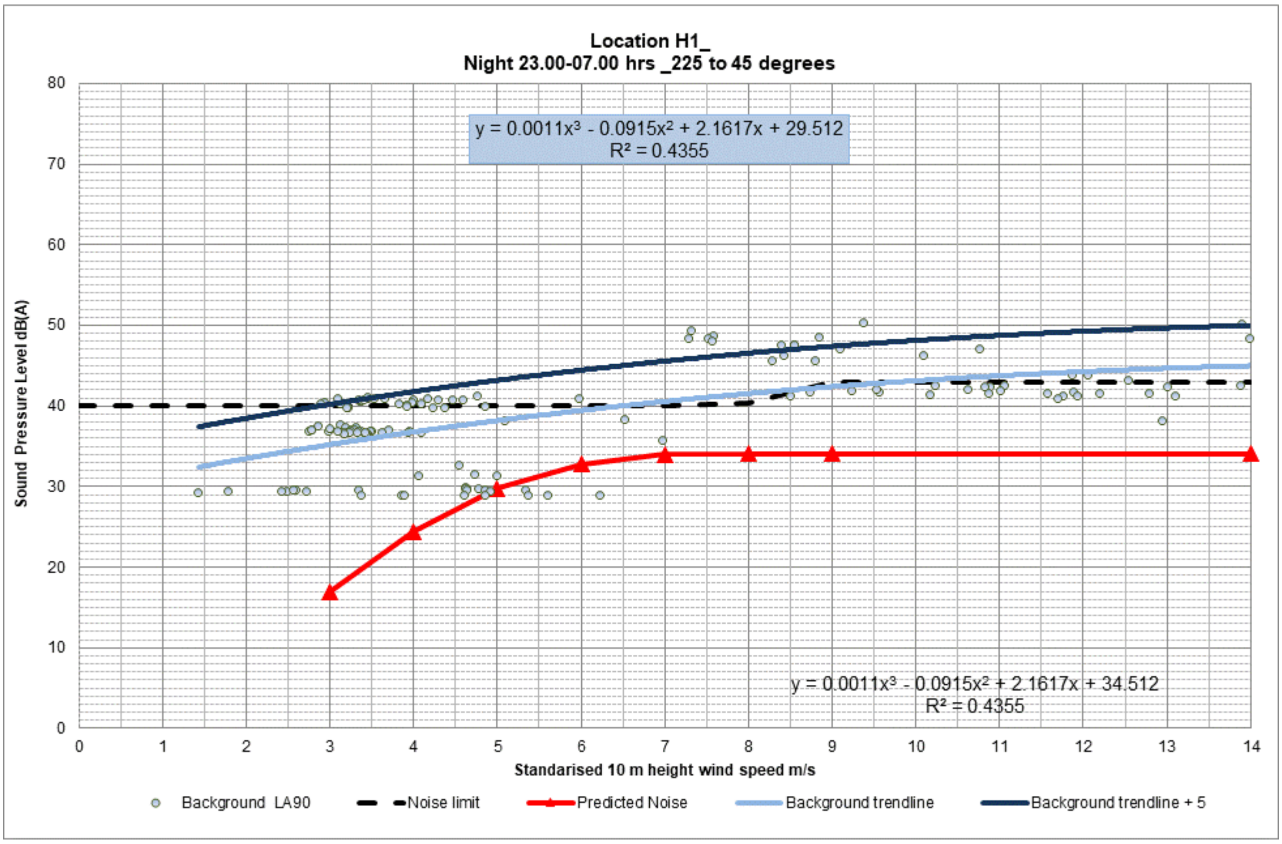

Chart 10.2: Night-time Predicted Assessment for House 1

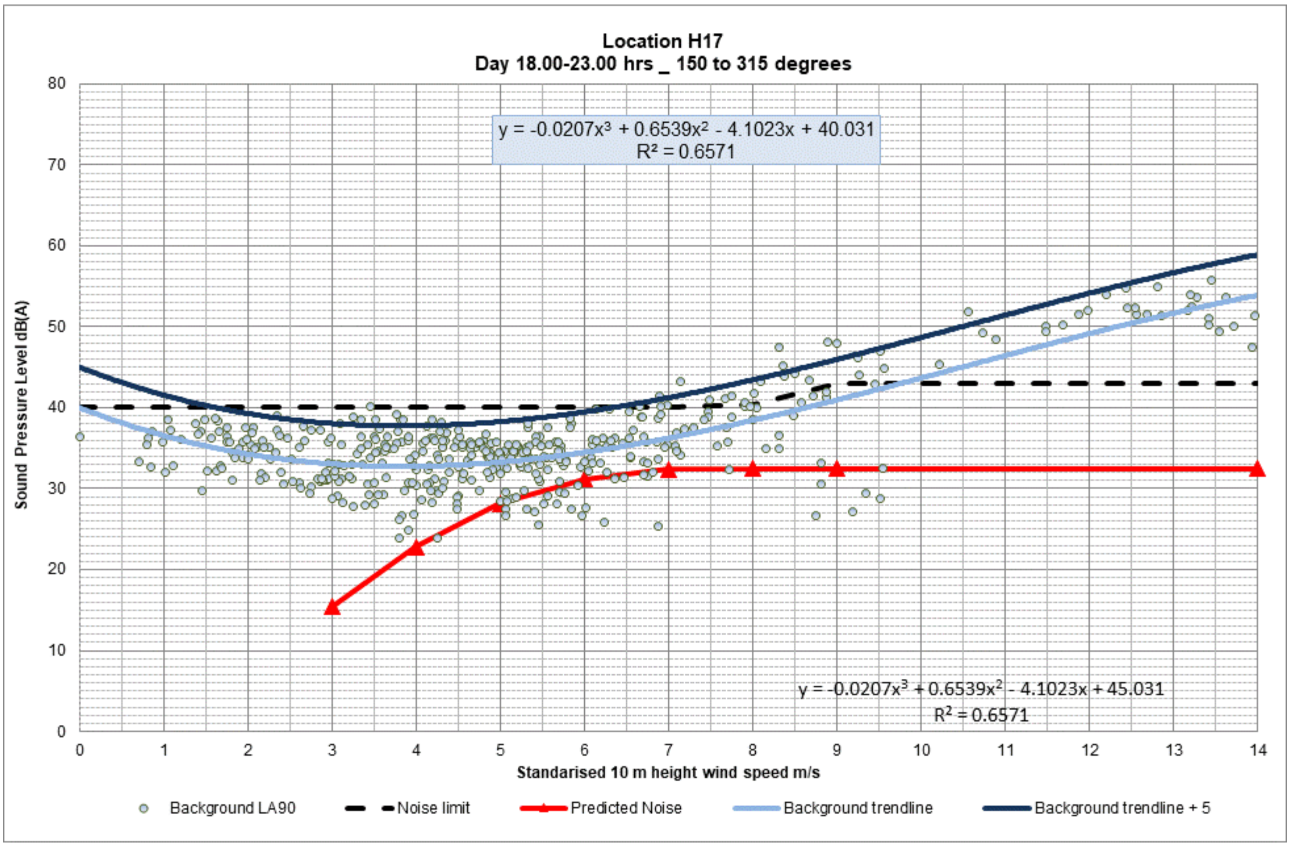

Chart 10.3: Quiet Daytime Predicted Assessment for House 17

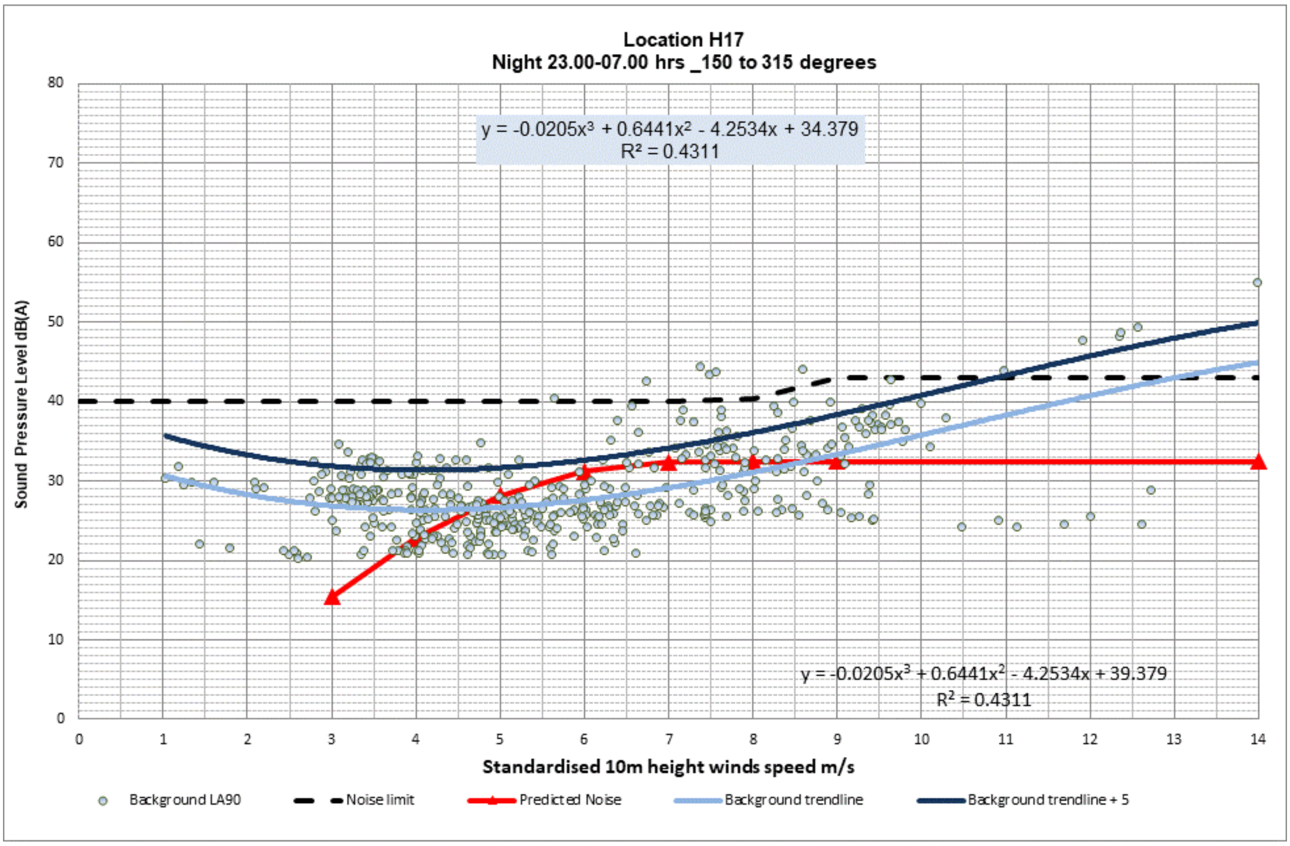

Chart 10.4: Night-time Predicted Assessment for House 17

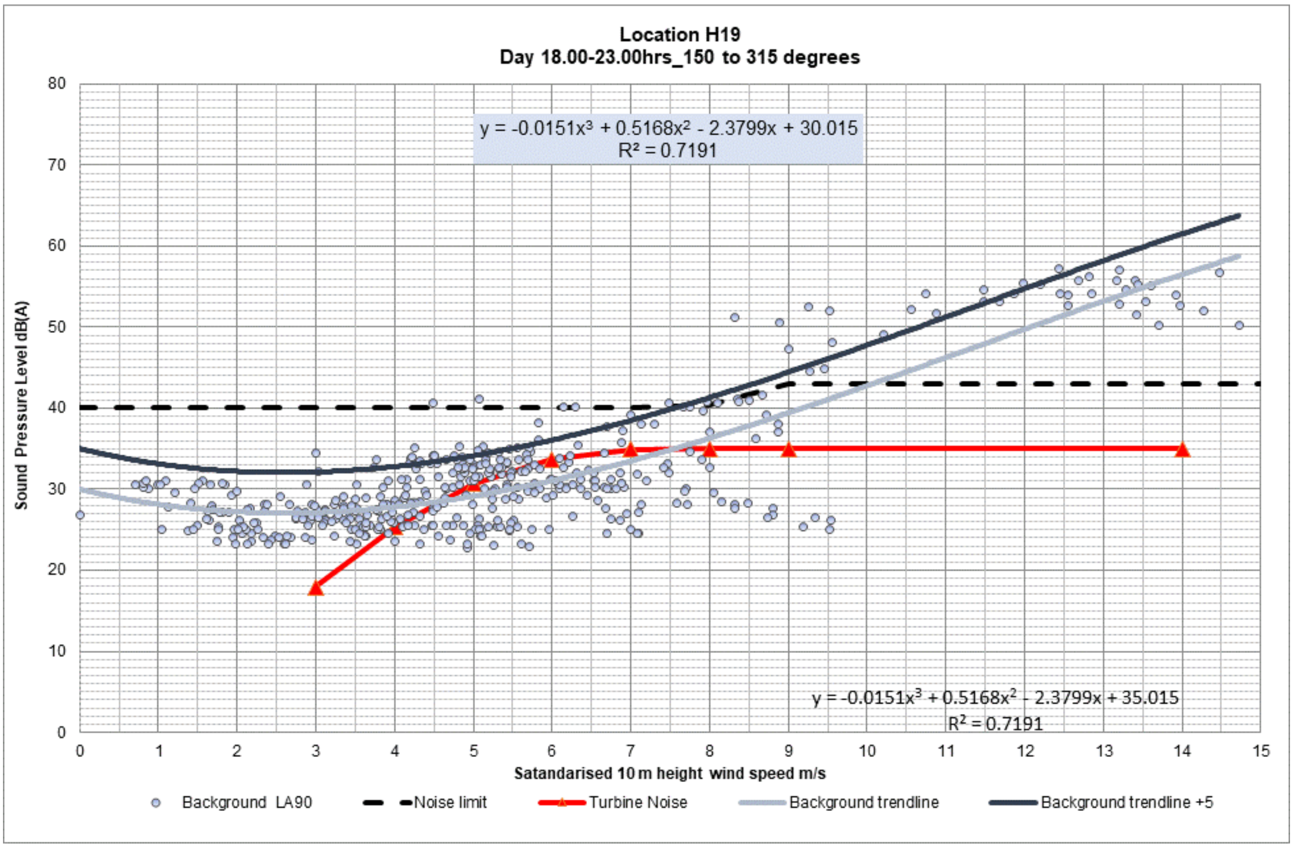

Chart 10.5: Quiet daytime Predicted Assessment for Derelict House H19

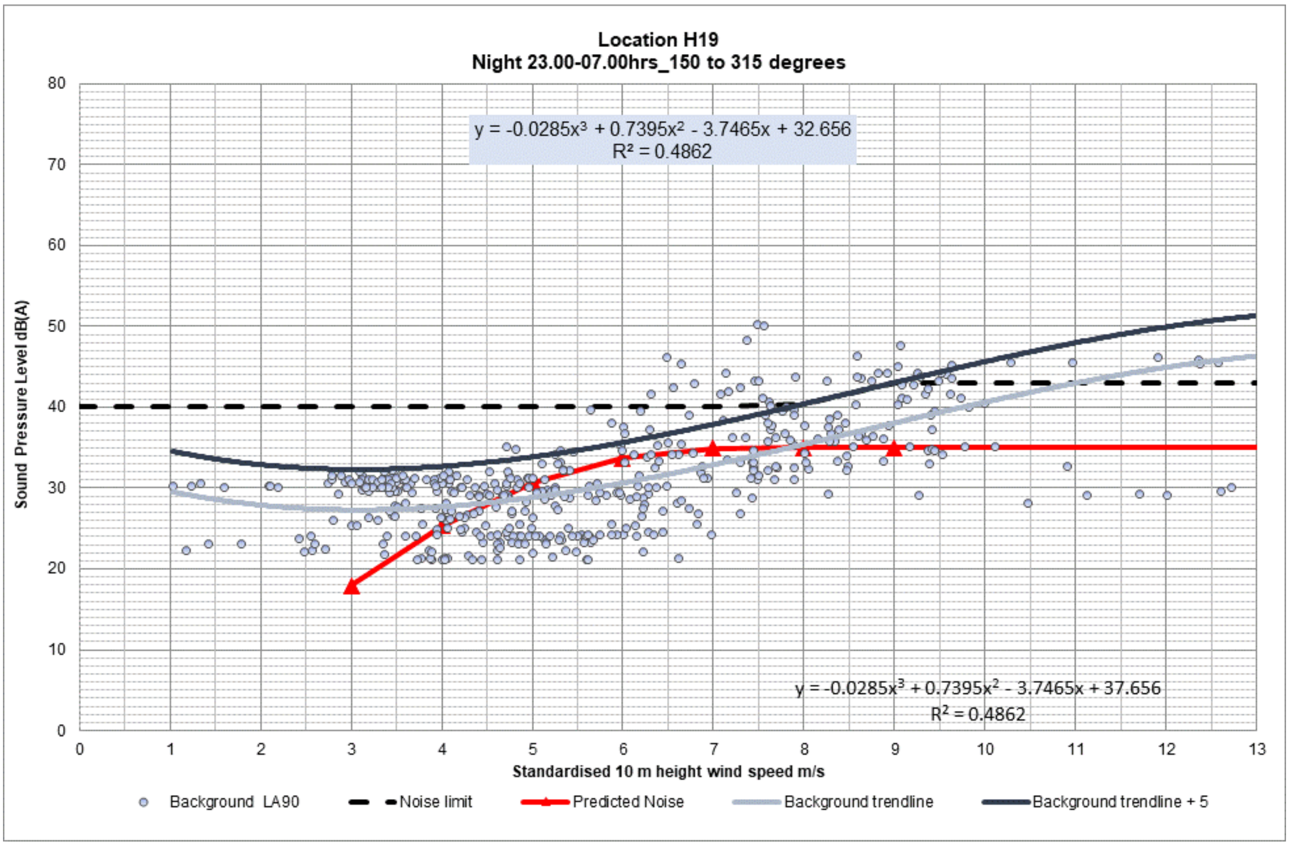

Chart 10.6: Night-time Predicted Assessment for Derelict House H19

10.4.4 Cumulative Effects Assessment

An assessment of the cumulative effects of noise from the Development together with the 38 no. turbines in the operational Meenadreen Group WF south of the Development and the permitted 19 no. turbines Meenbog WF north of the Development has been undertaken.

10.4.4.1 Cumulative Assessment locations

The same receptor locations as used in the Development are used in the cumulative assessment. The assessment is a worst-case scenario with the assumption made that the predicted noise levels to receptors are downwind from all wind farms and individual turbines at the same time, a scenario that cannot occur in practice.

10.4.4.2 Noise Limits

The noise limits are similar to that used in Section 10.3.6, **Table 10.12: Derived Background Noise Levels Used in Assessment (H19 night-time)**. The lower baseline measurements derived for night-time are used for all receptors.

10.4.4.3 Cumulative Noise levels

Table 10.17 gives details of the predicted cumulative noise levels for each of the nearest receptors to the Development as presented in **Figure 10.1**.

Table 10.17: Predicted Cumulative Noise Levels for each Receptor

	IGR	IGR		4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	10+m/s
House ID	Easting	Northing	Altitude	dBA	dBA	dBA	dBA	dBA	dBA	dBA	dBA
1	202104	384453	94	27.1	31.9	34.5	35.3	35.6	35.6	35.6	35.6
1a	202144	384431	103	27.1	31.9	34.5	35.3	35.6	35.6	35.6	35.6
2	201928	384606	90	26.3	31.1	33.7	34.5	34.8	34.8	34.8	34.8
3	201733	384688	106	25.6	30.4	33.0	33.8	34.1	34.1	34.1	34.1
4	201879	384921	122	25.5	30.3	32.9	33.7	34.0	34.0	34.0	34.0
5	201589	384468	92	25.7	30.5	33.1	33.9	34.2	34.2	34.2	34.2
6	201543	384434	91	25.7	30.5	33.1	33.9	34.2	34.2	34.2	34.2
7	201492	384422	92	25.6	30.4	33.0	33.8	34.1	34.1	34.1	34.1
8	201476	384323	91	25.8	30.6	33.2	34.0	34.3	34.3	34.3	34.3
9	201347	384298	93	25.5	30.3	32.9	33.7	34.0	34.0	34.0	34.0
10	201335	384155	90	25.7	30.5	33.1	33.9	34.2	34.2	34.2	34.2
11	201287	384112	93	25.7	30.5	33.1	33.9	34.2	34.2	34.2	34.2
12	201152	384171	103	25.2	30.0	32.6	33.4	33.7	33.7	33.7	33.7
13	201037	383992	104	25.3	30.1	32.7	33.5	33.8	33.8	33.8	33.8
14	201161	383916	88	25.7	30.5	33.1	33.9	34.2	34.2	34.2	34.2
15	201051	383809	84	25.6	30.4	33.0	33.8	34.1	34.1	34.1	34.1
16	200991	383913	99	25.3	30.1	32.7	33.5	33.8	33.8	33.8	33.8
17	201092	382715	138	27.3	32.1	34.7	35.5	35.8	35.8	35.8	35.8
18	200990	382645	134	27.2	32.0	34.6	35.4	35.7	35.7	35.7	35.7
19	201755	381260	231	31.6	36.4	39.0	39.8	40.1	40.1	40.1	40.1
20	201061	383754	86	25.7	30.5	33.1	33.9	34.2	34.2	34.2	34.2

A noise contour map of the cumulative effects of all turbines is presented with a maximum sound power output at a wind speed of 9 ms^{-1} at 10 m height in **Figure 10.3.** The contour map in **Figure 10.3** assumes that all turbines are simultaneously downwind at the same time to each location which results in an overprediction of the noise levels. Directly downwind to the nearest receptor H19 is partially upwind to the turbines south of the Development.

10.4.4.4 Cumulative Noise Assessment

Table 10.18 details the margin between the predicted cumulative noise levels and derived noise limits. A negative margin or Zero indicates that the predicted cumulative noise level is within the limit. The predicted cumulative noise levels are therefore considered acceptable within the terms of the Preferred Draft Approach 2017.

There are no noise sensitive receptors in NI within 6 km of the Development which is proposed to replace the existing operational 25 turbines, so the potential for negative impacts is negligible with no increase in existing noise levels at any receptor.

Table 10.18: Margins between Predicted Cumulative Turbine Noise for Receptors and Noise Limits

	IGR	IGR		4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	10+m/s
House ID	Easting	Northing	Altitude	dBA	dBA	dBA	dBA	dBA	dBA	dBA	dBA
1	202104	384453	94	-12.9	-8.1	-5.5	-4.7	-4.8	-7.4	-7.4	-7.4
1a	202144	384431	103	-12.9	-8.1	-5.5	-4.7	-4.8	-7.4	-7.4	-7.4
2	201928	384606	90	-13.7	-8.9	-6.3	-5.5	-5.6	-8.2	-8.2	-8.2
3	201733	384688	106	-14.4	-9.6	-7.0	-6.2	-6.3	-8.9	-8.9	-8.9
4	201879	384921	122	-14.6	-9.7	-7.1	-6.3	-6.5	-9.1	-9.1	-9.1
5	201589	384468	92	-14.3	-9.5	-6.9	-6.1	-6.2	-8.8	-8.8	-8.8
6	201543	384434	91	-14.3	-9.5	-6.9	-6.1	-6.2	-8.8	-8.8	-8.8
7	201492	384422	92	-14.4	-9.6	-7.0	-6.2	-6.3	-8.9	-8.9	-8.9
8	201476	384323	91	-14.3	-9.5	-6.8	-6.1	-6.2	-8.8	-8.8	-8.8
9	201347	384298	93	-14.5	-9.7	-7.1	-6.3	-6.4	-9.0	-9.0	-9.0
10	201335	384155	90	-14.3	-9.5	-6.9	-6.1	-6.2	-8.8	-8.8	-8.8
11	201287	384112	93	-14.3	-9.5	-6.9	-6.1	-6.2	-8.8	-8.8	-8.8
12	201152	384171	103	-14.8	-10.0	-7.4	-6.6	-6.7	-9.3	-9.3	-9.3
13	201037	383992	104	-14.7	-9.9	-7.3	-6.5	-6.6	-9.2	-9.2	-9.2
14	201161	383916	88	-14.3	-9.5	-6.9	-6.1	-6.2	-8.8	-8.8	-8.8
15	201051	383809	84	-14.4	-9.6	-7.0	-6.2	-6.3	-8.9	-8.9	-8.9
16	200991	383913	99	-14.7	-9.9	-7.3	-6.5	-6.6	-9.2	-9.2	-9.2
17	201092	382715	138	-12.7	-7.9	-5.3	-4.5	-4.6	-7.2	-7.2	-7.2
18	200990	382645	134	-12.9	-8.1	-5.5	-4.7	-4.8	-7.4	-7.4	-7.4
19	201755	381260	231	-8.4	-3.6	-1.0	-0.2	-0.3	-2.9	-2.9	-2.9
20	201061	383754	86	-14.3	-9.5	-6.9	-6.1	-6.2	-8.8	-8.8	-8.8

NB:H19 is derelict and unlikely to be in-habited.

10.5 Mitigation Measures and Residual Effects

10.5.1 Construction Noise Mitigation

No significant construction noise effects have been identified. Therefore, no specific mitigation measures are required. However, general guidance for controlling construction noise through the use of good practice given in BS 5228 will be followed. During decommissioning of the Operational Barnesmore Windfarm and construction of the Development, operations shall be limited to working times incorporated in any planning permission.

During decommissioning prior to repowering and decommissioning of the repowered Windfarm, noise levels are likely be no more than predicted in **Table 10.14: Predicted Construction Noise Levels**, as similar plant will be utilised. Any legislation, guidance or best practice relevant at the time of decommissioning should be complied with. All construction is a temporary day time activity.

10.5.1.1 Residual Construction and Decommissioning Effects

The residual effects are the same as the construction and decommissioning effects identified in this assessment.

10.5.2 Operational Noise Mitigation

The Development has been designed to comply with the Deferred Draft Approach 2017 noise limits. The operational noise emissions are predicted to be compliant with the Deferred Draft Approach 2017.

All 13 turbines will have Trailing Edge Serrations fitted to reduce noise levels. No other mitigation is considered necessary.

A warranty will be sought from the manufacturer of the turbine selected for the Development in order to confirm that an assessment of noise would result in noise levels at all receptor locations being less than or equal to the noise limits set out in this section. The warranty will include the provision that there will be no clear tonal components audible at any receptor.

10.5.2.1 Residual Operational Effects

The residual effects are the same as the operational effects identified in this assessment.

10.5.3 Cumulative Effects

The cumulative effects of all windfarms within 3 km have been predicted and assessed and found to be in compliance with limits set in the Deferred Draft Approach 2017.

10.6 Summary of Significant Effects

Table 10.19 below summarises the Significant Effects.

Table 10.19: Summary of Significant Effects

Potential Effect	Mitigation	Residual Effect
Construction noise	Implementation of good practice measures	Not Significant
Operational Noise	Designed to meet the limits in the Deferred Draft Approach 2017	Within guideline limits, no more than Operational Barnesmore Windfarm and not significant

10.7 Statement of Significance

This Section has assessed the significance of the potential effects of the Development during operation, construction and decommissioning

The effects of noise from the operation of the Development has been assessed using the methodology in the 2006 Guidelines, the Deferred Draft Approach 2017, the methodology described in ETSU-R-97 and the IOA Good Practice Guide. Noise levels during operation of the Development have been predicted using the best practice calculation technique, compared with the noise limits in both the 2006 Guidelines and the Deferred Draft Approach 2017 and found to be compliant.

An assessment was made of the cumulative effects which was found to be in compliance with 2006 Guidelines and the Deferred Draft Approach 2017.

Noise during decommissioning of the existing windfarm and construction of the proposed windfarm will be managed to comply with best practice, legislation and guidelines current at that time so that effects are not significant.