11 NOISE AND VIBRATION

11.1 INTRODUCTION

This chapter of the EIAR assesses the effects of the Project from noise impacts. The Project refers to all elements of the application for the proposed Wind Farm (**Chapter 2: Project Description**). The assessment considers the potential effects during the following phases of the Project:

- Construction of the Project
- Operation of the Project
- Decommissioning of the Project

Any effects arising as a result of the future decommissioning of the Project, are considered to be no greater than the effects arising during construction.

Common acronyms used throughout this EIAR can be found in **Appendix 1.2**. This chapter of the EIAR is supported by the Figures in Volume III and the following Appendices documents provided in Volume IV of this EIAR:

- **Appendix 11.1: Wind Speed Calculations for Hub Height**
- **Appendix 11.2: Calibration Certificates of Noise Instruments**
- **Appendix 11.3: Candidate Turbine Manufacturer's Noise Emission Data**

11.1.1 Statement of Authority

This section of the EIAR has been prepared by Brendan O'Reilly of Noise and Vibration Consultants Ltd and Shane Carr of Irwin Carr Ltd. Brendan has a Master's degree in noise and vibration from Liverpool University and over 40 years' experience in noise and vibration control (many years' experience in preparation of noise impact statements) and have been a member of a number of professional organisations including the SFA, ISEE and IMQS. Brendan was a co-author and project partner (as a senior noise consultant) in 'Environmental Quality Objectives, Noise in Quiet Areas' administered by the EPA. Brendan has considerable experience in the assessment of noise impact and has compiled studies for more than 100 wind farm developments. Brendan carried out the baseline study and contributed to the report.

Irwin Carr Consulting is based in Northern Ireland. The company has a proven track record in noise impact assessments throughout the UK and Ireland, with extensive knowledge of the issues in relation to noise from wind energy developments.

Shane Carr carried out the noise modelling in this assessment and contributed to the report. Shane is a Director in Irwin Carr Consulting, primarily responsible for environmental noise and noise modelling. He has over 22 years' experience working in both the public and private sectors having previously obtained a BSc (Hons) Degree in Environmental Health and a Post-Graduate Diploma in Acoustics. Shane has been responsible for undertaking and reviewing noise impact assessments on numerous large scale wind farms throughout the UK and Ireland.

11.1.2 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 3dB (A) is 'barely perceptible', while an increase in noise level of 10dB (A) is perceived as a twofold increase in loudness. A noise level in excess of 85dB (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 standard industry practice applied in wind farm 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 are reached at between 5 to 9m/s wind speed at 10m height depending on turbine

[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 wind farm noise the interval used is 10 minutes.

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

type chosen. The larger turbines reach maximum sound power level output at lower wind speeds. **Table 11.1** gives a comparison of noise levels in our everyday environment.

Table 11.1: 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
Wind farm at 350m	**35-45**
Busy road at 5km	35-45
Car at 65km/hr at 100m	55
Busy general office	60
Conversation	60
Truck at 50km/hr at 100m	65
Inside a typical shopping centre	70-75
Inside a modern car at around 90km/hr	75-80
Passenger cabin of jet aircraft	85
City Traffic	90
Pneumatic drill at 7m	95
Jet aircraft at 250m	105
Threshold of pain	140

11.2 ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

11.2.1 Assessment Methodology

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

- Legislation and guidance review
- Desktop 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

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

11.2.2 Description of Effects

The significance of effects of the proposed development is described in accordance with the EPA guidance document '*Guidelines on the information to be contained in the Environmental Impact Assessment Reports (EIAR), EPA May 2022'*. The details of the methodology for describing the significance of effects are provided in Table 3.4: Section 3.7.3 of the aforementioned EPA 2022 document.

11.2.3 Relevant Legislation and Guidance

The noise assessment is carried out in accordance with the guidance and consideration of the following documents, with references given where relevant in the various Sections of the report:

- Wind Energy Development Guidelines[5] (the 2006 Guidelines)
- Recent 2021 An Bord Pleanála Decisions on Noise Limits
- ETSU-R-97[6]: The Assessment & Rating of Noise from Wind Farms (ETSU-R-97)
- 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'[7] (the IOA Good Practice Guide)
- ISO 1996[8]Acoustics-Description and Measurement of Environmental Noise - Part 1: Basic Quantities and Procedures (ISO 1996)
- World Health Organisation (WHO) 2018 Environmental Noise Guidelines for European Region (WHO 2018)
- Draft Revised Wind Energy Development Guidelines December 2019 (DRWEDG, 2019)
- National Roads Authority (NRA) Guidelines for Treatment of Noise and Vibration in National Road Schemes, 2004.

11.2.3.1 Wind Energy Development Guidelines 2006

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

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

General Noise Impact

"*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."

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

"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.

However, in very quiet areas, the use of the margin of 5dB(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 30dB(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 35-40dB(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 43dB(A) L90,10min 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 23:00hrs
- Saturday afternoon from 13:00 to 18:00hrs and all-day Sunday 07:00 to 18:00hrs
- Night-time is defined as 23:00 to 07:00hrs

11.2.3.2 An Bord Pleanála

2021 An Bord Pleanála Decisions

Recent decision by ABP gave limits (ABP-309306-21, dated 26th September 2022) in accordance with the 2006 Guidelines and were as follows:

(a) between 7am and 11pm:

  (i) the greater of 5 dB(A) L90,10min above background noise levels, or 45 dB(A) L90, 10min, at wind speeds of 5m/s or greater,

  (ii) 40 dB(A) L90, 10min, at all other wind speeds.

(b) 43 dB(A) L90,10min at all other times

where wind speeds are measured at 10 metres above ground level.

11.2.3.3 WHO 2018 Guidelines

The most recent WHO 2018 Guidelines: 'Environmental Noise Guidelines for the European Region' gives a conditional recommendation requiring substantial debate with a limit of 45 dB Lden which is based on low quality evidence. This is an annual average noise level, based on wind speed and direction in the vicinity of the site with no specific limits for night.

11.2.3.4 DRWEDG 2019

Draft Revised Wind Energy Development December 2019 (DRWEDG 2019)

There have been a number of draft guidelines over the years with the latest one being the *Draft Revised Wind Energy Guidelines December 2019.* These guidelines, currently in draft format are subject to significant public and stakeholder consultation and liable to change. In line with best practice, this assessment is based on the current guidance outlined in Section 11.2.2.

11.2.4 Desktop Study

The Study Area has been defined such that the predicted noise results have been included for all the residential receptors within 1.5km of the wind farm. Where the noise levels meet the relevant noise limits at the nearest locations, it will also meet the relevant noise limits at more distant residential locations. On this basis three locations for noise monitoring were selected by inspection of site maps and by identifying the nearest receptors surrounding the wind turbines. The validation of selected locations was made with a visit to the Noise Study Area. The three locations selected are considered representative of the local noise environment and are as shown in **Figure 11.1**.

11.2.5 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. The IOA Good Practice Guide Supplementary Guidance Note 4[9] (**Appendix 11.1**) gives the methodology to account for wind shear, calculation to hub height and to standardise 10m height wind speed.

A LiDAR unit was located within the Site during the noise survey which was used for wind data measurements at height of 91m with wind shear derived and used to calculate the hub height wind speed of 91.5m.

The 91.5m hub height wind speed was then standardised to 10m height wind speed with the wind speed plotted against the 10minute background noise data to derive a best fit polynomial curve.

11.2.6 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[10] which provides a prediction of noise levels likely to occur under worst-case down-wind conditions.

SoundPLAN version 8.2 software package, produced by Braunstein & Berndt GmbH 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 formula:

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

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

It is not necessary to make an allowance for the character of noise emitted by the turbines as is normal practice for most sound sources, however in general the emissions from wind turbines are broadband in nature. In the unlikely event of a turbine exhibiting clearly tonal components as a result of a turbine malfunction at any receptor, the turbine would be turned

[9] 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

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

down or stopped until such tonality is ameliorated. A guarantee will also be sought in the procurements of the turbine to be used in the Development, 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 result in attenuation over distance according to:

$$Lp = Lw – (20 \log R + 11)$$

Where:

Lp = sound pressure level

Lw = sound power level

R = distance from the turbine to receiver

D – Directivity Factor

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 4m and an assumed ground factor of G=0.5 as recommended in the IOA Good Practice Guide. Using a receiver height of 4m equates to first floor height resulting in a higher predicted noise level.

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 energy 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 10^0C and a relative humidity of 70% has been used for these predictions and are given in **Table 11.2** below. These values are recommended in the IOA Good Practice Guide.

Table 11.2: 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 at the same time. The prediction model is thus calculated as a worst-case scenario.

11.2.7 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 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 wind farms including the proposed wind farm 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 i.e.. the blade swish mentioned above.

The Temple Group[11] 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."*

[11] 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 Effect*, Dec'2013.

Based on the evidence available, it was recognised that even at those wind farm 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[12] 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 wind farm being installed. In the very unlikely event that OAM arises then appropriate mitigation measures will be put in place,

Salford University in 2007, found that out of 133 operational wind farms 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 research has shown that OAM is a rare and unlikely occurrence at operational wind farms.

11.2.8 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 distant road traffic, wind effects through air and vegetation, wave motion, 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, air conditioners, fridges, heating systems, extraction systems, electric or battery clocks), water flowing through pipes within the home and in water flow from municipal water supply. Vibration of elements of structures (low frequency) is generated in one's home by way of normal routine activity, like climbing stairs and closing doors, 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 with infrasound being the term for low frequency noise typically of

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

frequencies below 20Hz. There appears to be little or no agreement about the biological effects of low frequency noise on human health and there is strong 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 wind farm was carried out for ETSU and reported in ETSU W/13/00392/REP – '*Low Frequency Noise and Vibration Measurements at a Modern Wind Farm*'[13]. 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'.*

Significant research carried out on low frequency noise has been in the area of blasting (air overpressure) which falls into a very low frequency range (2-20Hz), although with a considerably higher magnitude – typically in a range of 110-125dB. Interestingly most microphones recording air-overpressure (low frequency sound) is linear down to 2Hz with a range that does not go below 88dB, as below that value trigger will occur by relatively low wind speeds (a gust of wind at 9m/s equates to an air overpressure of 133dB). Wind in the natural environment, along with streams and rivers, generates elevated levels of low frequency (infrasound) yet nobody complains from about these sources being the cause of sickness. Low frequency sound is generated from wind effects on vegetation close to receptors in the wind speed range that turbines operate in, yet nobody complains about wind being the cause of sickness.

<u>South Australian Environment Protection Authority (EPA) Infrasound Study</u>

A report released in January 2013 by the South Australian EPA[14] found that the level of infrasound from wind turbines is insignificant and no different to any other sources 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, houses both adjacent to a wind farm, away from turbines and measured the levels of infrasound with the wind farms operating and also switched off. There were no noticeable differences in the level 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 South Australian study found: '*the contribution of wind turbines to the measured infrasound levels is insignificant in comparison with the background level of infrasound in the environment*'.

[13] ETSU W/13/00392/REP – '*Low Frequency Noise and Vibration Measurements at a Modern Wind Farm'.*
[14] http://www.epa.sa.gov.au/environmental_info/noise/wind_farms

Massachusetts Institute of Technology (MIT)

A report by an Independent Expert Panel prepared for Massachusetts Department of Health (2012)[15] which consisted of a panel that included seven individuals with backgrounds in public health, epidemiology, toxicology, neurology and sleep medicine, neuroscience, and mechanical engineering, all considered independent experts from academic institutions. The report found that *'there is insufficient evidence that the noise from wind turbines is directly (i.e., independent from an effect on annoyance or sleep) causing health problems or disease'* and '*available evidence shows that infrasound levels near wind turbines cannot impact the vestibular system'*.

Technical Research Centre of Finland

A long-term study into so-called "wind turbine syndrome"[16] health problems supposedly caused by low-frequency sound from spinning blades has concluded that this "infrasound" has absolutely no physical impact on the human body.

The study conducted by the Technical Research Centre of Finland (VTT) and others, commissioned by the Finnish government, found that infrasound sound waves with frequencies below the range of human hearing cause no measurable changes in the human body, and cannot in any way be detected by the human ear.

Infrasound measurements were taken inside and outside local dwellings near two Finnish wind farms, as well as inside the facilities and beyond them, for 308 days.
"Infrasound samples representing the worst-case scenarios were picked out from the measurement data and used in the listening tests," said VTT.

"The participants in the listening tests were divided into two groups based on how they reported wind turbine infrasound related symptoms: people who suffered from those and people who never had symptoms.

"The participants were unable to make out infrasonic frequencies in wind turbine noise, and the presence of infrasound made no difference to how annoying the participants perceived the noise, and their autonomous nervous system did not respond to it. There were no

[15] A Wind Turbine Health Impact Study: Report of Independent Expert Panel in January 2012. Prepared for: the Massachusetts Department of Environmental Protection, Massachusetts Department of Public Health.
[16] Infrasound Does Not Explain Symptoms Related to Wind Turbines, Finnish Government, June 2020, https://www.vttresearch.com/en/news-and-ideas/vtt-studied-health-effects-infrasound-wind-turbine-noise-multidisciplinary.

differences between the results of the two groups". "No evidence of health effects of wind turbine infrasound was found."

11.2.9 Field Work

Baseline noise monitoring was undertaken at three locations between 24th June and 22nd July 2021. 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.

11.2.10 Consultation

Consultation was initiated by the Developer's Community Liaison Officer with local residents to obtain permission to install noise monitors at three locations for baseline noise monitoring (see **Section 11.3** of this EIAR). Access to the nearest dwellings was carried out with permission from the householders and landowners.

11.2.11 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 noise levels from construction and from wind turbines
- Comparison of the predicted levels with noise limits
- The 20kV substation is considered. However, it is discounted from the noise assessment as the noise emissions are very low compared to the wind turbines i.e., less than 30dBA at 150m and will have negligible impact at the nearest noise sensitive receptor H2 which is 495m south of the substation.

Potential receptors in the area around the Development Area were initially identified from Ordnance Survey maps, google maps, EPA maps, Site visits and Eircode's. Background measurements were carried out at three locations as shown in **Figure 11.1**.

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 at minimum 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 10m/s at standardised 10m height wind speed.

The method of predicting noise levels of wind turbines at receptors is discussed in **Section 11.2.3.2**. 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. For EIA purposes, hypothetical candidate turbine, the Vestas V117-4.2 megawatts (MW) has been selected as it reflects a worst-case scenario for the technical assessment as it generates the highest sound power levels of all turbines within the proposed range. For the purposes of assessment, the turbine was assessed operating in restricted sound optimised mode SO2 with serrated trailing edge (STE). The tip of the blades with STE lowers noise emissions without reducing energy output, and the selected turbine will have STE as standard. The worst-case sound power level at each wind speed from 4m/s to 12m/s was input into the noise model.

All turbines to be used will have a best practice Serrations Trailing Edge (STE) fitted as standard, which reduces the sound power levels of each turbine. **Table 11.3** provides details of the candidate turbine used for the noise assessment.

Table 11.3: Candidate Turbine Assessed

Turbine Manufacturer	Model	Turbine Output (MW)	Sound Power Level at Source dB LWA
Vestas	117-Mode SO2	4.2	103

The Vestas V117 turbine has a range of hub heights, however the proposed hub height is 91.5m. A wind farm noise assessment is based on a standardised noise level referenced to a wind speed at 10m height. A change in hub height does not therefore change the maximum sound power level of any specific turbine.

The maximum sound power level of the Vestas V117 in Mode SO2 is similar for hub heights up to 91.5m. At lower wind speeds there is a small variation in the sound power levels due to variation in hub height when it is standardised to a 10m wind speed. The manufacturer's data gives the sound power levels at hub height and at varying wind speeds. **Table 11.4** gives the sound power levels at varying wind speeds at standardised 10m height wind speed using the methodology given the IOA Good Practice Guide.

The prediction modelling is based on all the turbines operating at full power (maximum sound power output) in standard Mode S02. 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 manufacturer's data, the uncertainty value will range from 0 to 2dBA. However, for the Vestas V117 in Mode SO2 an uncertainty value of 2dBA is added in line with guidance. **Table 11.4** gives the maximum sound power levels at varying wind speeds (presented at standardised 10m height) for the Vestas V117 with a hub height of 91.5m.

Table 11.4: Noise Emission Levels, Vestas V117 with STE in Mode SO2

Standardised 10m height Wind Speed, ms^{-1}	3	4	5	6	7	8	9	10+
Sound Power Level, dB LWA, derived from 91.5m hub height	93.1	96	100.1	101.9	102.3	102.5	102.9	103
Uncertainty added and conversion of LAeq to LA90 made	93.1	96	100.1	101.9	102.3	102.5	102.9	103

The octave band values at maximum sound power levels are given in **Table 11.5** with uncertainty values of 2dB added and conversion of LAeq to LA90 added as input to the prediction model.

Table 11.5: Octave Band Spectrum of Vestas V117 with STE in Mode S02

Octave Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level, dB LWA 10 ms^{-1}	82.9	90.3	95.3	97.7	97.5	94.7	89.4	81.4
Uncertainty added to octaves and conversion of LAeq to LA90	82.9	90.3	95.3	97.7	97.5	94.7	89.4	81.4

11.2.11.1 Cumulative Assessment

Cumulative effects from any existing, consented or application-stage wind farms within 3km of the wind farm 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 operational Garvagh Glebe Wind Farm located 1,100m southwest of the nearest turbine, and Black Banks I&II Wind Farm located 1,685m south-southwest of the nearest turbine was assessed (**Figure 11.2**). The operational Garvagh Glebe Wind Farm comprises thirteen no. Vestas V80 each rated at 2MW, and the operational Black Bank I&II Wind Farm comprises 12 no. Vestas V52 each rated at 850 kW. The maximum noise emission data at varying wind speeds (at standardised 10m height) is presented for both the Vestas V80, 2MW wind turbines of 70m hub height, and Vestas V52, 850kW wind turbines of 49m hub height is given in **Table 11.6** and **Table 11.7**.

Table 11.6: Noise Emission Levels of Vestas V80, 2MW w/ 1dB uncertainty

Standardised 10m height Wind Speed, ms^{-1}	3	4	5	6	7	8	9+
Sound Power Level, dB LWA 8 ms^{-1} derived from 70m hub height	95	94	99.3	103	104.5	105.2	105.2
Uncertainty added and conversion of LAeq to LA90	94	93	98.3	102	103.5	104.2	104.2

Table 11.7: Noise Emission Levels of Vestas V52, 850kW w/ 0.9dB uncertainty

Standardised 10m height Wind Speed, ms^{-1}	3	4	5	6	7	8	9	10+
Sound Power Level, dB LWA 8 ms^{-1} derived from 49m hub height	90.9	90.9	94.9	99.4	102.6	103.4	103.4	103.4
Uncertainty added and conversion of LAeq to LA90	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1

The octave band values at maximum sound power output are given in **Table 11.8** and **Table 11.9** with uncertainty values and conversion for LAeq to LA90 added as input to the prediction model.

Table 11.8: Octave Band Spectrum of Vestas V80, 2MW

Octave Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level, dB LWA 9 ms^{-1}	86.6	95.5	101.2	101.4	97.4	96.2	87.8	74.1
Uncertainty added to octaves and conversion of LAeq to LA90	85.6	94.5	100.2	100.4	96.4	95.2	86.8	73.1

Table 11.9: Octave Band Spectrum of Vestas V52, 850kW

Octave Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level, dB LWA 9 ms^{-1}	72.7	80.7	88.2	92.9	94.3	93.4	89.4	83.8
Uncertainty added to octaves and conversion of LAeq to LA90	71.6	79.6	87.1	91.8	93.2	92.3	88.3	82.7

11.2.11.2 Noise Limits

The method of deriving operational noise limits is described in Section 11.2.2.1 based on the Wind Energy Development Guidelines 2006 and lower limits specified in recent An Bord Pleanála decisions, and taking into account the cumulative effects and noise limits given for the Garvagh Glebe and Black Banks I&II Wind Farms. The noise limits for the Letter Wind Farm are designed to meet:

'Wind turbine noise arising from the proposed development, by itself or in combination with other existing or permitted wind energy development in the vicinity, shall not exceed the greater of:

43dB(A) L90,10min for day and night at wind speeds of 5m/s or greater, and

40 dB(A) L90, 10min at all other wind speeds

where wind speeds are measured at 10 metres above ground level. Where properties are financially involved, a 45dB(A) L90,10min limit can be applied.'

11.2.12 Construction Assessment Methodology

11.2.12.1 Relevant Guidance

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. However, the National Roads Authority (NRA) give guideline limit values which are widely used (NRA

Guidelines)[17]. Guidance to predict and control noise is also given in BS 5228:2009-1+A1:2014[18].

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

The NRA Guidelines provide noise maximum permissible noise levels at façade of dwellings during construction and where it is considered necessary to predict noise levels associated with construction noise that this can be done in accordance with BS 5228:2009-1+A1:2014.

11.2.12.3 BS 5228:2009-1+A1;2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites

Part 1 of BS 5228 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

[17] National Roads Authority, *2004, Guidelines for the Treatment of Noise and Vibration in National Road Schemes.*
[18] British Standard (BS) 5228-1: 2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites: *Code of Practice for Basic Information and Procedures for Noise Control*.

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.

11.2.12.4 Construction and Decommissioning Noise Assessment Methodology

The NRA guidelines for construction noise are given in **Table 11.10**.

Table 11.10: NRA Guidelines for Construction Noise

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.

<u>Construction Times for Development</u>

The construction for this Development is:

Monday to Friday: 07.00 to 19.00hrs, Saturday 08.00 to 13.00hrs with no work on Sunday, or Bank Holidays.

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

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

Construction noise from wind farm development, or decommissioning is not considered an intensive activity. The main noise sources will be associated with the excavation of the borrow pit including crushing, construction of the turbine foundations and hardstands, while lower levels are generated by activity such as access roads, temporary construction compound and a 20kV substation (construction of a substation would generate no more noise than construction of a bungalow). Grid connection from the substation on site will involve cable being laid underground to connect to the 20kV Substation. The overhead lines portion of the grid connection route will involve the installation of two standard ESB Networks 20kV wooden poles.

Road widening and other works are required for part of the Turbine Delivery Route which are works of low noise intensity, of short duration and expected to be of less than one week's duration at any single location.

All workers associated with development will be subject to the Health and Safety Authority Guidance[19] which states that for noise exposure noise levels likely to exceed 80dBA (expressed as Lep,d 8 hour dBA) that there is the potential of risk of damage to hearing. All workers on site will be given guidance on how to comply with the 'First Action Level'.

11.2.13 Evaluation of Potential Effects

The potential impacts of construction are evaluated by comparing the predicted noise and vibration levels against the guideline limits given in **Table 11.10**, **Table 11.11**.

The potential operational impacts are evaluated by comparing the predicted noise levels against the day and night-time noise limits given in **Table 11.12**. The assessment of effects is made according to Section 11.2.2.

11.2.13.1 Sensitivity

The sensitivity of the Development during construction is based on the guideline values in **Table 11.10, Table 11.11** and sample criteria in Part 1 of BS 5228. The sensitivity of the Development during operation is based on the guideline values in Section 11.3.6.

11.2.13.2 Magnitude

The magnitude of potential impacts of construction is based on the values in **Table 11.15.** and compliance with the values given in **Table 11.10**. The magnitude of the Development during operation is based on the values in **Table 11.16 and 11.18.**

11.2.13.3 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 11.10, Table 11.11** and sample criteria of in Part 1 of BS 5228.

[19] Noise - Frequently Asked Questions - Health and Safety Authority (hsa.ie)

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.

11.3 BASELINE DESCRIPTION

11.3.1 Identification of Potential Receptors

A number of predictions were prepared for layout of the 4 turbine Development. Based on layout, potential noise-sensitive receptors including occupied and un-occupied were identified from maps. Receptor locations were verified through visits to the area surrounding the Development and are shown in **Figure 11.1**.

11.3.2 Selection of Baseline Noise Survey Locations

Three baseline noise survey locations were selected on the basis of their location relative to the turbine layout, their location with respect to large trees, streams, rivers and access to properties as outlined in **Table 11.11** and shown in **Figure 11.1.**

11.3.3 Baseline Noise Survey

Baseline noise measurements were carried out from 24th June to 22nd July 2021 at locations given in **Table 11.11**. The baseline survey monitoring locations were carried out at receptor houses H5, H8, and H10.

Table 11.11: Baseline Noise Survey Locations

Location	ITM Reference	Description of Location
H5	588599, 823681	Microphone 1.2-1.5m height, 20m from front corner of facing towards house and towards Development
H8	588125, 825399	Microphone 1.2-1.5m height, 15m from rear of house and also facing towards the Development
H10	588587, 824530	Microphone 1.2-1.5m height, 23m from rear of house

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 using LiDAR. The methodology is given in **Section 11.2.3.1.**
- 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 1.2-1.5m above ground level and more than 5m from any reflective surface.
- An electronic rain gauge was installed onsite at receptor H10 to monitor rainfall at 10-minute intervals over the duration of the noise survey. Rain data (including effects of small streams) which impacted on noise levels were removed from the noise data set prior to analysis.
- The standardised 10m height wind speed was plotted against the background noise levels using a best-fit polynomial line.

11.3.3.1 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[22]
- 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 0.3dB. Survey measurement data and calibration certificates of the acoustic instruments are included in **Appendix 11.2.**

11.3.4 Prevailing Background Noise Levels

Table 11.12 gives the background noise levels obtained from quiet daytime and night-time measurement periods at the five baseline measurement locations. The WEDG06 states:

In general, a lower fixed limit of 45 dB(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. 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 30 dB(A), it is recommended that the daytime level of the LA90, 10min of the wind energy development noise be limited to an absolute level within the range of 35-40 dB(A).

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

In order to screen out the requirements to assess the site as a low noise environment, a 16hr daytime noise level was calculated for each day with the average level for each location presented below:

H5 – 33.4dB LA90

H8 – 32.3dB LA90

H10 – 34.2dB LA90

The daytime background noise levels are above LA30dB as per the requirements of the WEDG06, therefore the site was not considered a low noise environment.

Table 11.12: Prevailing Background Noise Levels

Monitoring Location		Prevailing Background (B/G) noise levels LA90dB, 10min Standardised Mean 10 m Height Wind Speed, (m/s)					
		4	5	6	7	8	9
H5	Day	27.1	27.8	28.6	30.1	32.3	35.7
	B/G+5	32.1	32.8	33.6	35.1	37.3	40.7
H5	Night	22.8	24.5	26.4	28.2	29.7	30.6
	B/G+5	27.8	29.5	31.4	33.2	34.7	35.6
H8	Day	29.6	31.0	32.6	34.2	35.8	37.2
	B/G+5	34.6	36.0	37.6	39.2	40.8	42.2
H8	Night	29.6	31.5	33.4	35.1	36.2	36.4
	B/G+5	34.6	36.5	38.4	40.1	41.2	41.4
H10	Day	26.4	27.7	29.5	31.7	34.4	37.6
	B/G+5	31.4	32.7	34.5	36.7	39.4	42.6
H10	Night	27.7	28.8	30.6	32.9	35.4	38.1
	B/G+5	32.7	33.8	35.6	37.9	40.4	43.1

Location H5

The house is located on the side of a slope close to the local road. The noise monitor was located at the corner of the house on slightly elevated ground. The main source of noise was from local domestic activity, wind effects on vegetation and from very low levels of road traffic.

Location H8

The house is located approximately 30m from a small local road. The noise monitor was located in the rear garden facing toward to the development. The main source of noise was from a river, local domestic activity, wind effects on vegetation and from very low levels of road traffic.

Location H10

The house is located close to a small local road. The noise monitor was located at the rear of the house facing toward to the development. The main source of noise was from local domestic activity, wind effects on vegetation and from very low levels of road traffic.

11.3.5 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 are representative of the background noise environments surrounding the development.

Should the predicted noise levels from the Development comply with the requirements of the WEDG06 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 of all receptors assessed are given in **Figure 11.1**.

11.3.6 Noise Limits

The noise limits for the Development are based on the limits contained within the Wind Energy Development Guidelines 2006 and on the background levels obtained in **Table 11.13.** A lower fixed limit of 45dBA for daytime could be applied, however a more stringent limit is applied with the lowest background noise levels obtained at location H8 used as the basis for the assessment at all receptors with a limit of 43dBA being applied for day and night.

Table 11.13: Derived Background Night Noise Levels Used in Assessment (H8)

Monitoring Location	Prevailing Background (B/G) noise levels LA90dB, 10min Standardised Mean 10m Height Wind Speed, (m/s)									
		4	5	6	7	8	9	10	11	12
H8	Day	29.6	31.0	32.6	34.2	35.8	37.2	37.2	37.2	37.2
	B/G+5	34.6	36.0	37.6	39.2	40.8	42.2	42.2	42.2	42.2
Noise Limit		43	43	43	43	43	43	43	43	43
H8	Night	29.6	31.5	33.4	35.1	36.2	36.4	36.4	36.4	36.4
	B/G+5	34.6	36.5	38.4	40.1	41.2	41.4	41.4	41.4	41.4
Noise Limit		43	43	43	43	43	43	43	43	43

11.3.7 Development Design Mitigation

The preferred turbine model will be fitted with STE. 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, STE is only installed on the outer rotor blade area where the rotary speed is highest. Typically, STE reduces the noise levels by 2 to 3dBA without reducing the energy output.

11.4 ASSESSMENT OF POTENTIAL EFFECTS

11.4.1 Construction Noise and Decommissioning Noise Levels

As has been previously stated, the construction process associated with wind farms is not considered intensive and is temporary works most of which is carried out a considerable distance from receptors. The main noise sources will be associated with the construction of the turbine foundations, turbine hardstands, grid connection, processing in the borrow pit location, with lesser sources being site access roads and construction of a 20kV substation. Accessing stone material from the borrow pit will significantly reduce road traffic flow on local roads. The main construction traffic to Site will be due to a very short period where ready-mix trucks deliver concrete for the turbine bases. The delivery of turbines by large trucks travelling at very low speed will generate very low levels of noise.

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 11.14** indicates typical construction range of noise levels for this type of activity (levels from author's database and BS 5228). Predictions are made for receptors nearest to the borrow pit processing, turbine bases / hardstands activity and for receptors at varying distance from the grid connection route. The construction of a substation is considerably less intensive than the construction of a small bungalow.

Decommissioning noise levels are expected to be similar to construction levels, but for a shorter period.

Table 11.14: Typical Noise Levels from Construction Works

Activity	L_{Aeq} at 10m
Pile driving, ready-mix trucks pouring concrete).	70-84dBA
Large tracked excavator removing topsoil, subsoil for foundation.	80- 87dBA
Rock breaker, vibrating rollers, trucks loading and tipping material	76-89dBA
Grid Connection: Trenching, Tracked excavator 14t, pneumatic breaker, vibratory roller 71t. Horizontal Drilling: Rig HPU* (diesel), mud pump, diesel generator /tractor/dumper.	70-74dBA 70-86dBA
Borrow Pit Processing (Portable crusher, screener, truck loading by excavator, front end loader, dump truck)	78-86dBA

* Hydraulic power unit (for horizontal drilling)

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

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

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

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 3dBA.

Table 11.15 gives the noise levels predicted from construction activity at the nearest receptor to the borrow excavation and at varying distances due to the development of the Grid Connection. The maximum construction noise levels will be at the receptor listed in **Table 11.15.** At receptor locations further away, noise levels will be less than that predicted.

Table 11.15: Predicted Construction Noise Levels

Receptor	Activity	Distance of Activity (m)	LAeq dB 1hr range
H3	Foundation works: trucks pouring concrete, large tracked excavator moving topsoil/subsoil	712	46-53
H3	Rock breaking, vibratory roller, trucks loading/tipping	712	42-55
Grid connection Receptors at varying distances	Excavator removing material, Pneumatic breaker, truck loading	20 40 80	72-80 66-78 60-68

NB: Predicted noise levels assumes that there are no barrier/berm attenuation effects

Construction Traffic

The delivery of turbines to the site will generate low level traffic noise as the vehicles carrying the turbines will move slowly along the local roads where impact is expected to be greatest. The main construction noise generated by traffic to the Site will be due to ready-mix trucks delivering concrete. The concrete pour for each individual turbine will be required to be completed in a short a period as possible (usually within 10 hours).

It is estimated that 840 m^3 of structural concrete and 60 m3 of blinding concrete will be required for each Turbine Foundation and that an additional $122.4m^3$ will be required for the substation building and plinths and other miscellaneous works. This gives a total volume of concrete of 3,722 m^3. Based on 6 m^3 per concrete truck, some 620 loads will be required.

The general expression for predicting the 1 hr LAeq alongside a haul road used by single engine items of mobile plant is:

$L_{Aeq} = L_{WA} - 33 + 10\log_{10}Q - 10\log_{10}V - 10\log_{10}d$

where:

L_{WA} is the sound power level of the truck, in decibels (dB);

Q is 15 the number of vehicles per hour;

V is 30, the average vehicle speed, in kilometres per hour (km/h);

d is the distance of receiving position from the centre of haul road, in metres (m).

LAeq = 105-33 + 10log 15 – 10log30 – 10log20 = 54.8 Laeq 1hr.

At 10m from the roadside the noise levels equate to 57.8 LAeq 1hr. The concrete pour trucking will extend for a total of 4 days (1 day for each turbine). In practice the levels generated by truck movement should be lower than predicted due to the smooth surface on the local roads.

Grid Connection-Cable laying in fields and along road by trenching

Cable laying and trenching will move along the grid route from the substation on site to the Corderry 110kV Substation which means maximum levels will pertain to no more than one day equivalent (8 hours) at any single receptor except where horizontal drilling is required.

Construction noise levels are based on continuous operation. In practice most plant will operate at a maximum level for short intervals. If required, at distances within 20m of a receptor an acoustic barrier can be provided which can be placed close to the source giving maximum attenuation (refer to BS 5228 for guidance on screening / barrier effects). For dwellings that are within 20m from the grid route, an acoustic barrier can be installed to provide a minimum 10dBA attenuation. When a noise source is completely obscured from a receptor by an acoustic barrier a 10dBA reduction is obtained.

The predicted construction noise levels are within the NRA guidelines for daytime for all activity and within the lower threshold of 65 dBA, as defined in BS 5228-1:2009, the noise levels are therefore considered as not significant.

11.4.2 Assessment of Construction Noise

The maximum predicted noise levels from construction of the turbine foundations and hardstands will be at 43dB while lower levels will be experienced at all other receptors which are located further away. Most of the activity close to turbine bases will be invisible to the nearest inhabited houses thereby providing significant additional attenuation (in excess of 10dBA above that predicted) due to topographic screening effects. All activity is predicted without additional mufflers, or without topographic screening. The level of ground vibration generated by truck movement along roadways at receptors will be below the threshold of sensitivity to humans, at less than 0.2mm/s peak particle velocity[23] at all receptors. The maximum road traffic noise which is generated by readymix trucks will be short term and of duration of 4 days with noise levels within NRA guidelines and is therefore considered not significant.

[23] 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

11.4.2.1 Description of Effects

The criteria for description of effects for all construction noise activity and the potential worst-case effects, at the nearest receptors is given below.

Quality	Significance	Duration
Negative	Not significant	Temporary

11.4.2.2 Decommissioning

Noise effects during decommissioning of the Development are likely to be of a similar nature to that during construction but of shorter duration. Turbine bases (excluding plinths) will be left in place and revegetated. It is proposed to leave roadways and drainage in place. It is likely that the duration of decommissioning will be less intensive and of shorter duration than that during construction. Any legislation, guidance or best practice relevant at the time of decommissioning will be complied with.

11.4.2.3 Decommissioning

The criteria for description of effects for all decommissioning noise activity and the potential worst-case effect at the nearest receptors is given below.

Quality	Significance	Duration
Negative	Not significant	Temporary

11.4.3 Predicted Operational Noise Levels

Table 11.16 gives the predicted noise levels at the nearest receptors to the Development at varying wind speeds.

A noise contour map of the 4-no. turbine Development at maximum sound power output at a wind speed of 10m/s at 10m height is presented in **Figure 11.1**. The contour map in **Figure 11.1** assumes that all turbines are simultaneously downwind at the same time to each location which results in an overprediction of the noise levels.

Table 11.16: Predicted Noise Levels from the Development as LA90 at Varying Wind Speeds from the Development

House ID	ITM Easting	ITM Northing	3m/s dBA	4m/s dBA	5m/s dBA	6m/s dBA	7m/s dBA	8m/s dBA	9m/s dBA	10+m/s dBA
H1	587495	823063	26.7	29.6	33.7	35.5	35.9	36.1	36.5	36.6
H2	587972	822926	25.6	28.5	32.6	34.4	34.8	35	35.4	35.5

House ID	ITM Easting	ITM Northing	3m/s dBA	4m/s dBA	5m/s dBA	6m/s dBA	7m/s dBA	8m/s dBA	9m/s dBA	10+m/s dBA
H3	588550	823532	26.7	29.6	33.7	35.5	35.9	36.1	36.5	36.6
H4	588584	823583	26.5	29.4	33.5	35.3	35.7	35.9	36.3	36.4
H5	588599	823681	26.6	29.5	33.6	35.4	35.8	36	36.4	36.5
H6	588756	823642	24.8	27.7	31.8	33.6	34	34.2	34.6	34.7
H7	588841	823710	24.1	27	31.1	32.9	33.3	33.5	33.9	34
H8	588125	825399	23.9	26.8	30.9	32.7	33.1	33.3	33.7	33.8
H9	588700	824266	25.2	28.1	32.2	34	34.4	34.6	35	35.1
H10	588587	824530	25.5	28.4	32.5	34.3	34.7	34.9	35.3	35.4
H11	588452	825457	21.8	24.7	28.8	30.6	31	31.2	31.6	31.7
H12	588261	825511	22.4	25.3	29.4	31.2	31.6	31.8	32.2	32.3
H13	588687	825627	19.7	22.6	26.7	28.5	28.9	29.1	29.5	29.6
H14	587934	825595	23	25.9	30	31.8	32.2	32.4	32.8	32.9
H15	587946	825648	22.5	25.4	29.5	31.3	31.7	31.9	32.3	32.4
H16	588676	823513	25.2	28.1	32.2	34	34.4	34.6	35	35.1
H17	588841	823890	23.7	26.6	30.7	32.5	32.9	33.1	33.5	33.6

11.4.4 Operational Noise Assessment

The assessment was made with predicted operational noise levels from the Development against noise limits in the Wind Energy Development Guidelines 2006 and taking into consideration recent 2021 An Bord Pleanála decisions.

As can be seen from **Table 11.17** the predicted noise levels at all receptors are lower than the noise limits in all cases are therefore compliant with the noise limits and are not significant in terms of EIAR Regulations.

The predicted noise levels assume that all 4 No. Turbines are directly down-wind. The potential for negative impacts is negligible.

Table 11.17: Margin between Predicted Noise Levels and Noise limits

House ID	ITM Easting	ITM Northing	3m/s dBA	4m/s dBA	5m/s dBA	6m/s dBA	7m/s dBA	8m/s dBA	9m/s dBA	10+m/s dBA
H1	587495	823063	-13.3	-10.4	-9.3	-7.5	-7.1	-6.9	-6.5	-6.4
H2	587972	822926	-14.4	-11.5	-10.4	-8.6	-8.2	-8	-7.6	-7.5
H3	588550	823532	-13.3	-10.4	-9.3	-7.5	-7.1	-6.9	-6.5	-6.4
H4	588584	823583	-13.5	-10.6	-9.5	-7.7	-7.3	-7.1	-6.7	-6.6
H5	588599	823681	-13.4	-10.5	-9.4	-7.6	-7.2	-7	-6.6	-6.5

House ID	ITM	ITM	3m/s	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10+m/s
	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA	dBA	dBA
H6	588756	823642	-15.2	-12.3	-11.2	-9.4	-9	-8.8	-8.4	-8.3
H7	588841	823710	-15.9	-13	-11.9	-10.1	-9.7	-9.5	-9.1	-9
H8	588125	825399	-16.1	-13.2	-12.1	-10.3	-9.9	-9.7	-9.3	-9.2
H9	588700	824266	-14.8	-11.9	-10.8	-9	-8.6	-8.4	-8	-7.9
H10	588587	824530	-14.5	-11.6	-10.5	-8.7	-8.3	-8.1	-7.7	-7.6
H11	588452	825457	-18.2	-15.3	-14.2	-12.4	-12	-11.8	-11.4	-11.3
H12	588261	825511	-17.6	-14.7	-13.6	-11.8	-11.4	-11.2	-10.8	-10.7
H13	588687	825627	-20.3	-17.4	-16.3	-14.5	-14.1	-13.9	-13.5	-13.4
H14	587934	825595	-17	-14.1	-13	-11.2	-10.8	-10.6	-10.2	-10.1
H15	587946	825648	-17.5	-14.6	-13.5	-11.7	-11.3	-11.1	-10.7	-10.6
H16	588676	823513	-14.8	-11.9	-10.8	-9	-8.6	-8.4	-8	-7.9
H17	588841	823890	-16.3	-13.4	-12.3	-10.5	-10.1	-9.9	-9.5	-9.4

Substation 20kV

The on-site substation will operate during the life of the turbines. Noise levels taken outside an existing 20kV substation was measured at less than 32dBA at 150m and inaudible, thus it has no potential for impact on the nearest receptor H2 which is 495m away.

Charts 11.1 to **11.6** (outlined below) of this section plots the derived background noise levels at the three receptors where monitoring was carried out, with the predicted noise levels for that location and a lower fixed limit of 43 dBA.

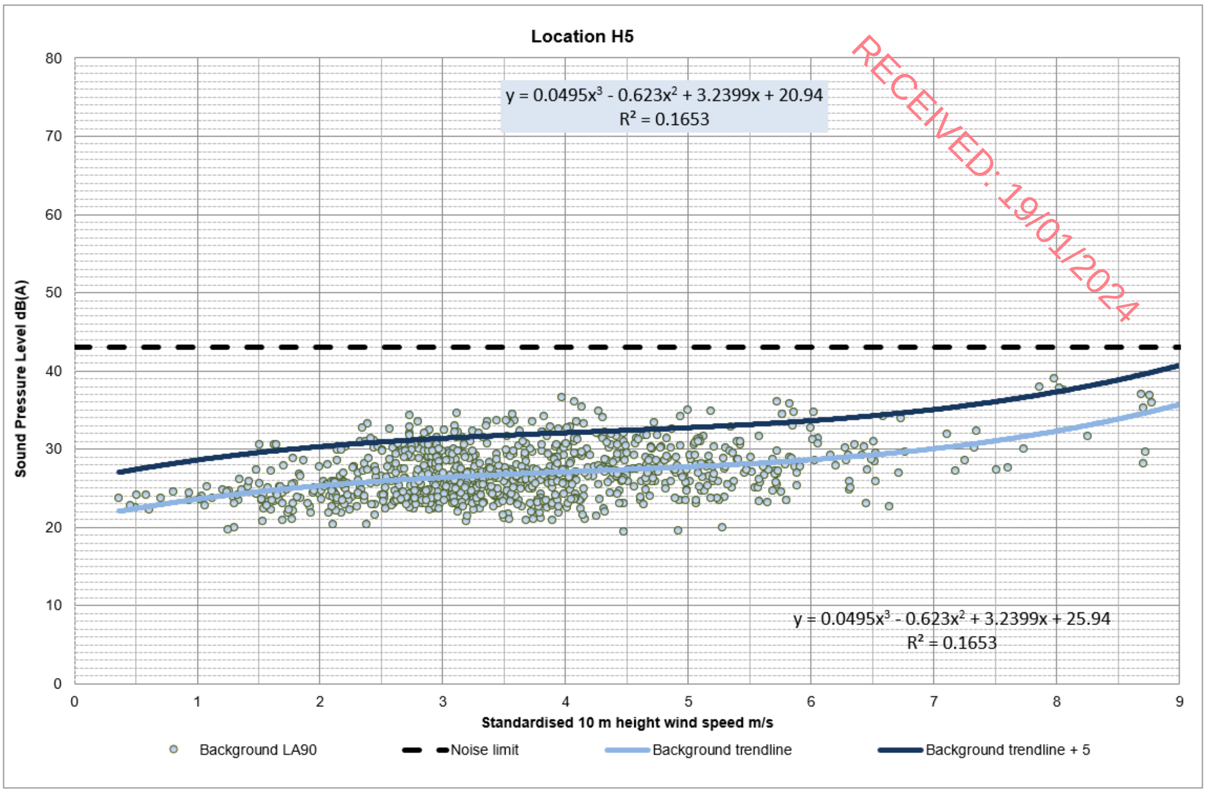

Chart 11.1: Quiet Daytime Background and Predicted Noise Levels at House H5

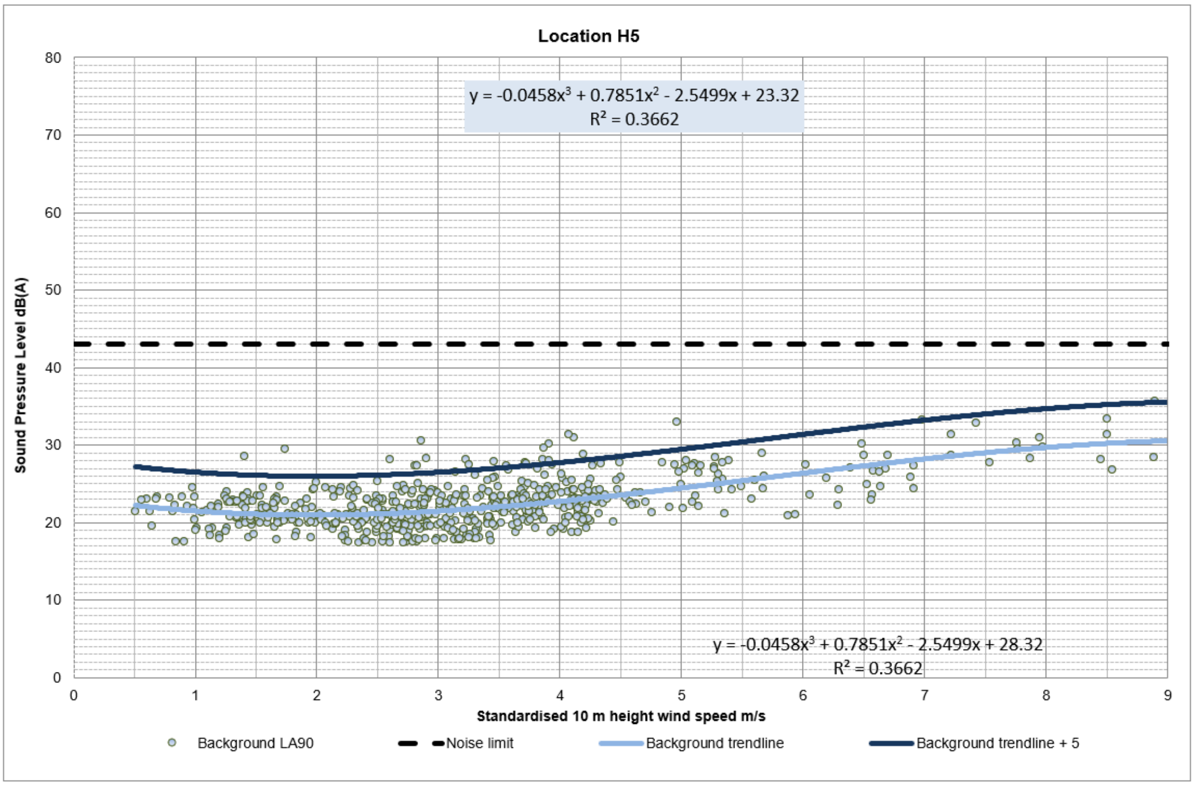

Chart 11.2: Night-time Background and Predicted Noise Levels at House H5

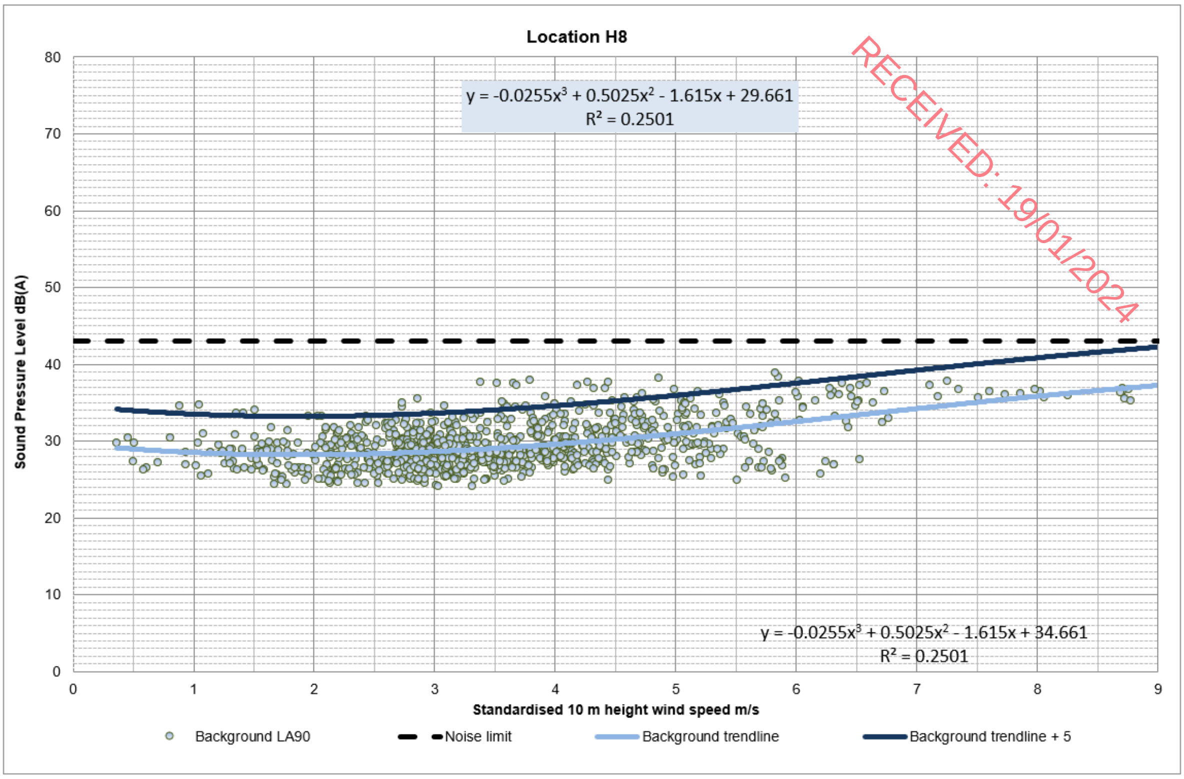

Chart 11.3: Quiet Daytime Background and Predicted Noise Levels at House H8

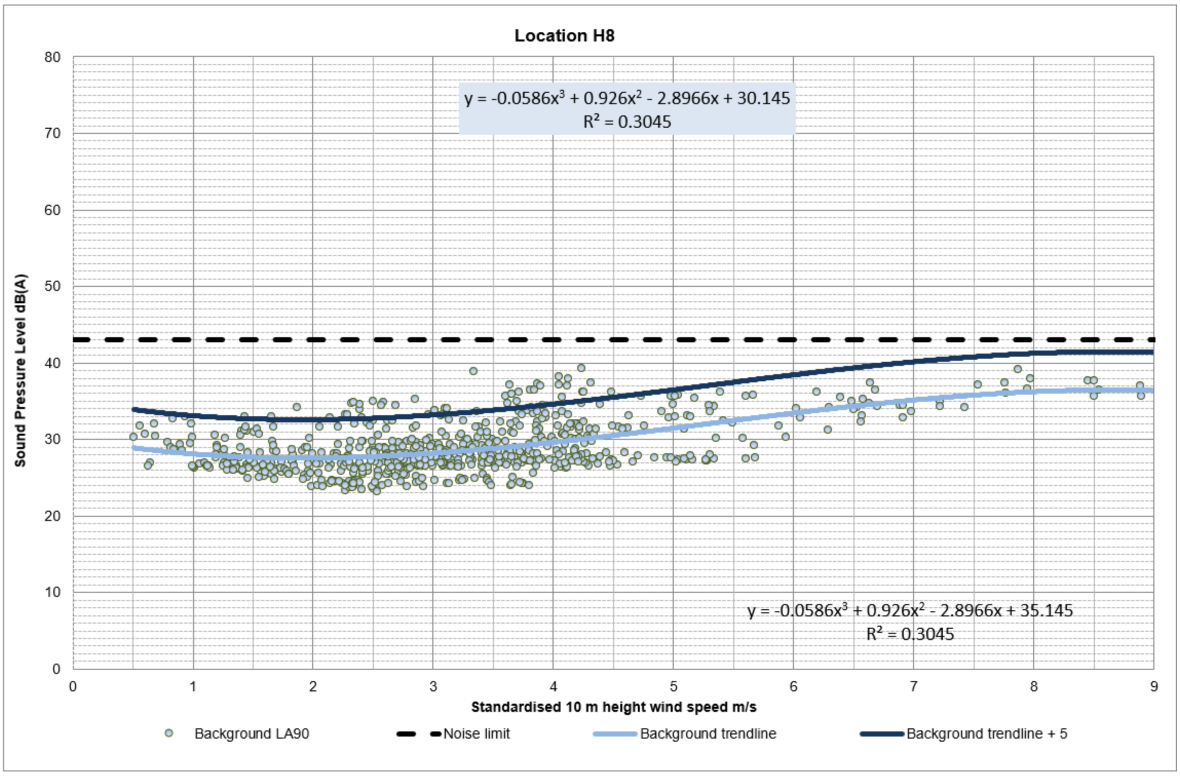

Chart 11.4: Night-time Background and Predicted Noise Levels at House H8

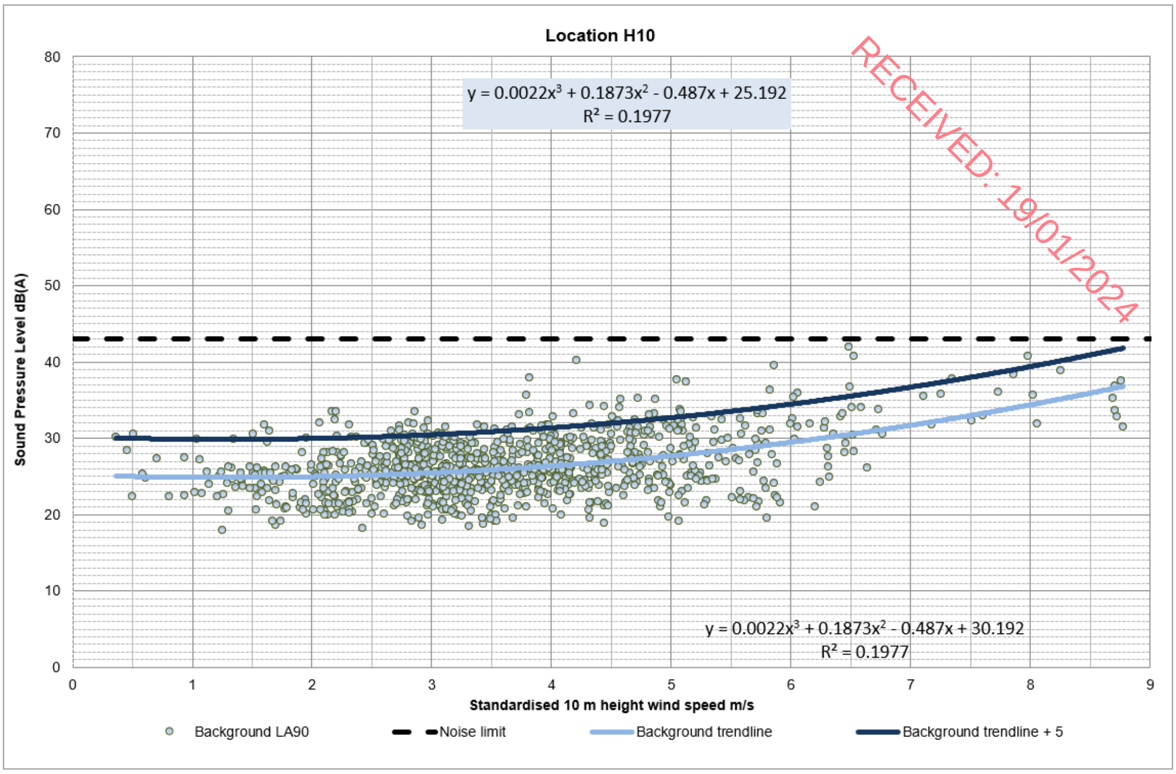

Chart 11.5: Quiet Daytime Background and Predicted Noise Levels at House H10

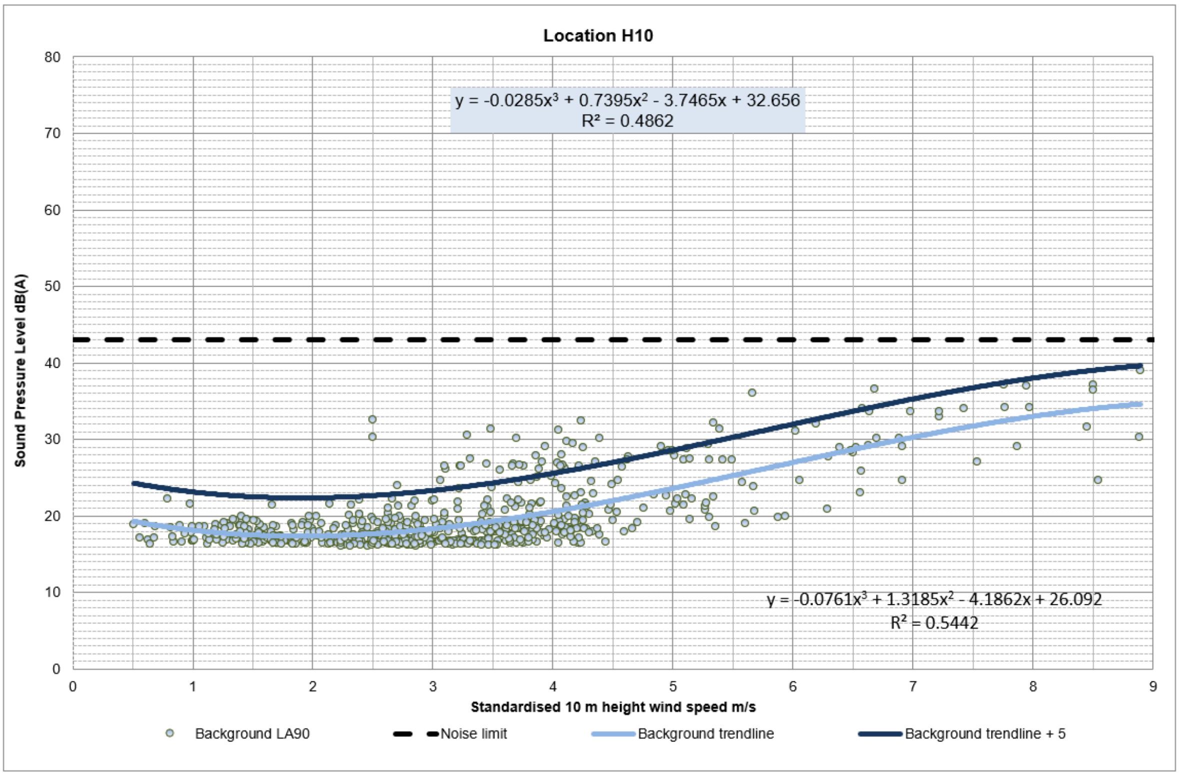

Chart 11.6: Night-time Background and Predicted Noise Levels at House H10

11.4.5 Cumulative Effects Assessment

Wind Farms

An assessment of the cumulative effects of noise from the Development together with both the nearby thirteen turbine operational Garvagh Glebe Wind Farm, and twelve turbine operational Black Banks I&II Wind Farm, located south-southwest of the Development has been undertaken (**Figure 11.2**).

It is noted that the Garvagh Glebe Wind Farm has a planning condition which differs from the requirements of the WEDG06. Condition 3 of the planning permission P.03/257 states:

> *"At the critical wind speed (that is, the speed at which the noise of wind turbines and blades is most in excess of ambient noise levels), the noise from the proposed development shall not, when measured externally at the nearest occupied house, exceed 45 dB(A)Leq, when measured over any five minute period. Within six months of commissioning the turbines, the developer shall undertake the measurement of noise levels in order to determine the extent and characteristics of noise levels arising from the wind farm in the vicinity of the nearest two occupied residential properties. The results of such noise measurements shall be forwarded to the planning authority. In the event of a failure to meet the above limit, the wind farm operation shall be stopped until written agreement is reached with the planning authority on design or operational alterations intended to reduce the noise accordingly."*

Battery Storage

The application will include the installation of battery arrays located within container units. However, the impact from this development would be negligible in comparison to the wind farm for a number of reasons. The wind farm subjects the closest properties to higher noise limits. The noise limits for properties in close proximity to the wind farm, as per ETSU-R-97, are stated as 35dB for the daytime period and 43dB for night-time, or background +5dB. In consideration of the lower fixed limits, the noise levels from the battery storage development on the nearest receptor properties would be negligible in comparison to the operational wind farm. Furthermore, it is a requirement within NG4 to exclude from the assessment any sound measurements where the wind speed is above 5m/s. Therefore, the background noise levels used in the assessment of the battery storage would be particularly low in comparison to what is typical for the area.

The wind farm is situated in a mountainous area where the wind generally blows at high wind speeds. Therefore, it is assumed that the background sound level would be higher than what has been employed in this assessment. Moreover, the noise from the wind turbines increase as the wind speed increases, further reducing the potential impact of the battery storage development.

11.4.5.1 Cumulative Assessment locations

The same receptor locations used for the Development are also 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 both wind farms and individual turbines at the same time, a scenario that cannot occur in practice.

11.4.5.2 Noise Limits

The noise limits are the same as that used in **Table 11.13**, a limit of LA90 43dB for day and night.

11.4.5.3 Cumulative Noise levels

Table 11.18 gives details of the predicted cumulative noise levels for the nearest receptors to the Development.

Table 11.18: Predicted Cumulative Noise Levels for each Receptor

	ITM	ITM	3m/s	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10+m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA	dBA	dBA
H1	587495	823063	32.7	33.6	38.4	41.6	43.0	43.6	43.6	43.6
H2	587972	822926	29.4	30.9	35.4	38.3	39.5	40.1	40.1	40.1
H3	588550	823532	28.2	30.4	34.7	37.0	37.9	38.2	38.5	38.5
H4	588584	823583	28.0	30.2	34.5	36.8	37.6	38.0	38.2	38.3
H5	588599	823681	28.0	30.3	34.6	36.8	37.6	38.0	38.2	38.3
H6	588756	823642	26.6	28.7	33.1	35.4	36.3	36.7	36.9	37.0
H7	588841	823710	26.0	28.1	32.4	34.8	35.7	36.1	36.3	36.4
H8	588125	825399	25.2	27.5	31.8	34.0	34.7	35.1	35.4	35.4
H9	588700	824266	26.5	28.8	33.1	35.4	36.1	36.5	36.7	36.8
H10	588587	824530	26.7	29.0	33.3	35.5	36.2	36.6	36.8	36.9
H11	588452	825457	23.4	25.6	29.9	32.3	33.1	33.5	33.7	33.7
H12	588261	825511	23.9	26.1	30.4	32.7	33.5	33.9	34.1	34.2
H13	588687	825627	21.7	23.7	28.1	30.5	31.4	31.8	32.0	32.1
H14	587934	825595	24.4	26.7	31.0	33.3	34.0	34.4	34.6	34.7
H15	587946	825648	24.0	26.2	30.6	32.9	33.6	34.0	34.3	34.3
H16	588676	823513	27.2	29.2	33.6	36.0	36.9	37.4	37.6	37.6
H17	588841	823890	26.0	27.9	32.4	34.9	35.9	36.3	36.5	36.5

A noise contour map of the cumulative effects of all turbines is presented with a maximum sound power output at a wind speed of 8m/s at 10m height in **Figure 11.2**. The contour map assumes that all turbines are simultaneously downwind at the same time to each location which results in an overprediction of the noise levels.

11.4.5.4 Cumulative Noise Assessment

The assessment was made with predicted operational noise levels from the Development against noise limits in the Wind Energy Development Guidelines 2006. All predicted noise levels are within the noise limits. **Table 11.19** gives the difference between the predicted cumulative noise levels in **Table 11.18** and noise limits for each receptor. A negative margin indicates that the predicted noise levels are within the limit which means the levels are within the day and night limits.

Table 11.19: Margin between Predicted Cumulative Noise Levels and Noise Limits

	ITM	ITM	3m/s	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10+m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA	dBA	dBA
H1	587495	823063	-7.3	-6.4	-4.6	-1.4	0.0	0.6	0.6	0.6
H2	587972	822926	-10.6	-9.1	-7.6	-4.7	-3.5	-2.9	-2.9	-2.9
H3	588550	823532	-11.8	-9.6	-8.3	-6.0	-5.1	-4.8	-4.5	-4.5
H4	588584	823583	-12.0	-9.8	-8.5	-6.2	-5.4	-5.0	-4.8	-4.7
H5	588599	823681	-12.0	-9.7	-8.4	-6.2	-5.4	-5.0	-4.8	-4.7
H6	588756	823642	-13.4	-11.3	-9.9	-7.6	-6.7	-6.3	-6.1	-6.0
H7	588841	823710	-14.0	-11.9	-10.6	-8.2	-7.3	-6.9	-6.7	-6.6
H8	588125	825399	-14.8	-12.5	-11.2	-9.0	-8.3	-7.9	-7.6	-7.6
H9	588700	824266	-13.5	-11.2	-9.9	-7.6	-6.9	-6.5	-6.3	-6.2
H10	588587	824530	-13.3	-11.0	-9.7	-7.5	-6.8	-6.4	-6.2	-6.1
H11	588452	825457	-16.6	-14.4	-13.1	-10.7	-9.9	-9.5	-9.3	-9.3
H12	588261	825511	-16.1	-13.9	-12.6	-10.3	-9.5	-9.1	-8.9	-8.8
H13	588687	825627	-18.3	-16.3	-14.9	-12.5	-11.6	-11.2	-11.0	-10.9
H14	587934	825595	-15.6	-13.3	-12.0	-9.7	-9.0	-8.6	-8.4	-8.3
H15	587946	825648	-16.0	-13.8	-12.4	-10.1	-9.4	-9.0	-8.7	-8.7
H16	588676	823513	-12.8	-10.8	-9.4	-7.0	-6.1	-5.6	-5.4	-5.4
H17	588841	823890	-14.0	-12.1	-10.6	-8.1	-7.1	-6.7	-6.5	-6.5

It can be seen that the predicted noise level at receptor H1 exceeds the 43dB limit applicable within the WEDG. This considers the predicted noise levels from all of the cumulative turbines to equivalent of the noise level in a downwind direction from the turbine to the receptor simultaneously. In practice this is not possible due to the locations of the turbines.

11.5 DIRECTIVITY

The predictions made using ISO 9613-2 are "worst-case" conditions, which reflect the scenario where the source to receiver propagation is always in a downwind direction. When considering cumulative impacts from wind turbines the IOA GPG, the predicted noise levels were reduced by 2dB when the wind was in the region 80-90° from downwind, with a 10dB reduction to the predicted noise levels when in an upwind direction. A typical directivity plot is presented in Chart 11.7.

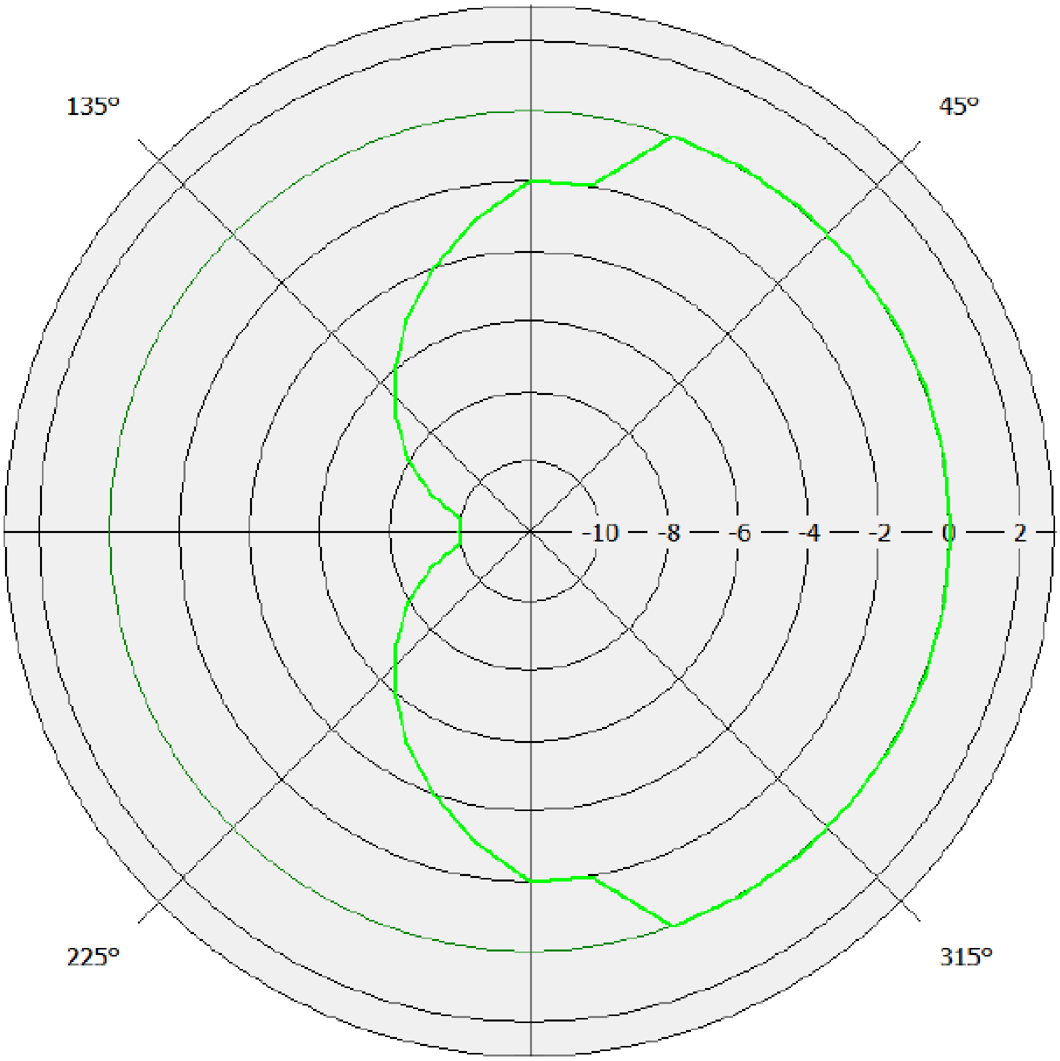

Chart 11.7: Directivity plot for Westerly wind direction

The predicted noise levels from the proposed and cumulative turbines were previously assessed with a slight downward breeze in all directions. However, it would be rational to predict the impact of the turbines when the wind is blowing from certain wind directions as it is possible that the predicted levels may not exceed the noise limits at receptor properties, particularly when the turbines are downwind from the properties.

Table 11.20: Impact of Directionality Assessment at H1

Wind Direction (Blowing from)	Noise levels (cumulative initial assessment)	Noise levels (cumulative considering directionality)	Total Reduction due to directivity	Predicted Noise levels (Letter WF only)	Contribution below Cumulative Level
West	43.6	43.3	0.3	32.1	11.2
South West	43.6	43.2	0.4	27.7	15.6
South	43.6	42.2	1.4	-	-
South East	43.6	40	3.6	-	-
East	43.6	38.7	4.9	-	-
North East	43.6	39	4.6	-	-
North	43.6	41.2	2.4	-	-
North West	43.6	42.9	0.7	-	-

It can be seen that in all but two wind directions, the noise level is below 43dB when directivity is accounted for. In both of these wind directions the contribution of the Letter WF is more than 10dB below the overall predicted noise levels.

The IOA GPG states:

> *"….planning permission noise limits set at any future neighbouring wind farm would have to be at least 10 dB lower than the limits set for the existing wind farm to ensure there is no potential for cumulative noise impacts…."*

The Letter WF complies with these requirements in the wind directions where the noise limits exceed the 43dB noise level within the WEDG06. Therefore, the Letter WF does not contribute to the combined noise levels in these wind directions.

11.6 MITIGATION MEASURES AND RESIDUAL EFFECTS

11.6.1 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. Construction and Decommissioning of the Development shall be limited to working times given and any controls incorporated in any planning permission.

During the Decommissioning phase of the Development, noise levels are likely be no more than predicted in **Table 11.15,** however, it is envisaged that decommissioning will be of shorter duration. Any legislation, guidance or best practice relevant at the time of decommissioning will be complied with. Construction and decommissioning are a temporary day time activity.

11.6.1.1 Residual Construction and Decommissioning Effects

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

11.6.2 Operational Noise Mitigation

The Development has been designed to comply with best practice guidelines, the Wind Energy Development Guidelines 2006 and the noise limits given in the planning conditions for the adjoining wind farm which is dealt with in cumulative impacts. All 4 No. turbines in the Development will have as standard STE to reduce noise levels, so no mitigation is required.

A warranty will be provided by the manufacturer of the turbine selected for the Development in order to ensure that the turbine selected does not require a tonal noise correction under best practice.

11.6.2.1 Residual Operational Effects

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

11.6.3 Cumulative Effects

The cumulative effects of the permitted Garvagh Glebe and Black Banks I&II Wind Farms, located within 3km have been predicted and assessed and found to be in compliance with the noise limits set in the Wind Energy Development Guidelines 2006.

11.7 SUMMARY OF EFFECTS

Table 11.21 below summarises the Effects.

Table 11.21: Summary of Effects

	Quality	Significance	Duration
Construction Noise	Negative	Not Significant	Temporary
Operational Noise	Negative	Not Significant	Long Term
Decommissioning Noise	Negative	Not Significant	Temporary

11.8 STATEMENT OF SIGNIFICANCE

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

The effects of noise from the operation of the Development have been assessed using the methodology in the 2006 Guidelines, 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 the 2006 Guidelines and recent 2021 An Bord Pleanála limits and found to be compliant.

There has been a consultation process in relation to the revision of the 2019 Wind Energy Development Guidelines. This document provided the basis for a discussion on amendments of the noise limits applicable to wind turbine developments. It is understood that there could be revisions to the draft consultation documents, however a mitigation strategy to incorporate a reduction in sound power level outputs with respect to directionality can be put in place to comply with any specific variation in noise limit levels if new guidelines are adopted. All turbines have software control incorporated so that the sound power levels can be reduced by direction and energy output.

The noise levels predicted at the nearest receptors are orders of magnitude below the level at which risk of hearing damage, or indeed negative health effects are possible.

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