11 NOISE AND VIBRATION

11.1 INTRODUCTION

This Chapter of the EIAR assesses the potentially significant issues associated with noise and vibration due to the Project as described in **Chapter 2: Project Description**. **Sections 11.1 to 11.17** of this Chapter deals with all elements of the Wind Farm Site, Grid Connection and Construction Delivery Routes. **Sections 11.18 to 11.28** deals with all elements of the Hydrogen Plant Site, Interconnector from the Wind Farm Site to the Hydrogen Plant Site, Construction and Operational Delivery Routes. The assessment considers the potential effects during the following phases of the Proposed Development:

- Construction
- Operation
- Decommissioning

Any effects arising from the future decommissioning of the Proposed Development, are considered no greater than the effects arising during construction.

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

- **Appendix 11.1**: Photos of noise monitors in-situ for Wind Farm
- **Appendix11.2**: Method for calculating wind shear from different hub heights, calculating to hub height and standardising hub height wind speed to 10 m height
- **Appendix 11.3**: Calibration certificates of noise instruments
- **Appendix 11.4**: Candidate turbine manufacturer's noise emission data.
- **Appendix 11.5:** Predicted noise levels for 102.5 m hub height
- **Appendix 11.6**: Photos of noise monitors in-situ for the Hydrogen Plant Site

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 and vibration 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 compiled studies for numerous wind farms and many large scale industrial developments. Brendan carried out the baseline studies 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 Ireland and the UK with extensive knowledge of the issues in relation to noise from wind energy developments.

Shane Carr carried out all 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 25 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 and many noise and vibration impact statements on large scale developments throughout Ireland and the UK and has completed a noise impact report on a hydrogen plant in Northern 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 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 dB).

Sound Power Level (L_{WA} dB) is a measure of the acoustic energy emitted from a source of noise, expressed in decibels. Sound power level refers to the source and sound pressure level is measured by a sound level meter at a distance from a source. Sound power is distance independent, whereas sound pressure is the distance-dependent effect.

[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.

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 level which are usually reached at between 6 and 10 m/s wind speed at 10 m height depending on turbine type chosen. **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 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

11.1.3 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.
- Baseline Description - a description of the noise baseline of the receiving environment based on the results of surveys, desk information, consultations, and a summary of any information required for the assessment that could not be obtained.

[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

- Assessment of Potential Effects - identifying the ways in which noise receptors could be affected by the Project, including a summary of the measures taken during design of the Project to minimise noise and vibration 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 Project after mitigation measures have been implemented.
- Cumulative Effects – identifying the potential for effects of the Project to combine with those from other windfarm developments and Hydrogen Plant.
- Summary of Significant Effects.
- Statement of Significance.

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
- 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

11.2.2 Description of Effects

The significance of effects of the proposed Projects 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.

11.3 RELEVANT LEGISLATION AND GUIDANCE

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

- Wind Energy Development Guidelines (WEDG)[5] (the 2006 Guidelines)
- An Bord Pleanála Decisions on Noise Limits for Carrowleagh Site 2013 (Now called the Firlough Site 2013)

[5] Department of Environment, Heritage and Local Government: Wind Energy Development Guidelines, Guidelines for Planning Authorities 2006 Energy

- WHO 2018 Environmental Noise Guidelines for European Region (WHO 2018)
- Draft Revised Wind Energy Development Guidelines December 2019 (DRWEDG 2019).
- 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)
- ISO 1996[7] Acoustics-Description and Measurement of Environmental Noise - Part 1: Basic Quantities and Procedures (ISO 1996)
- ETSU-R-97[8]: The Assessment & Rating of Noise from Wind Farms (ETSU-R-97)
- Recent (September 2022-309306-21) An Bord Pleanála Decision

A discussion on interrelationship between the Wind Energy Development Guidelines 2006, the WHO 2018 document and the Draft Revised Wind Energy Development Guidelines December 2019, is provided below.

11.3.1 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."

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."

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

Specific Noise Limits

"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.

[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] ISO 1996/1- Acoustics-Description and Measurement of Environmental Noise - Part 1: Basic Quantities and Procedures
[8] ETSU-R-97: Acoustics-The Assessment & Rating of Noise from Wind Farms: ETSU for the DTI, UK, 1996

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

11.3.2 An Bord Pleanála Reference Number: PL 16.241592 (Planning Register Reference Number: P. 11/495

<u>Carrowleagh Site 2013 (now referred as the Firlough Wind Farm)</u>

Planning permission was granted for this site by An Bord Pleanála for a 21 turbine Wind Farm where, Condition 9 stated:

"*Noise levels emanating from the proposed development following commissioning when measured externally at a noise sensitive location shall not exceed the greater of 43dB(A) L90, or 5dB(A) above background levels. If the noise contains a discrete, continuous note (whine, hiss, screech, hum, etc.), or if there are distinct impulses in the noise (bangs, clicks, clatters or thumps), or if the noise is irregular enough in character to attract attention, a penalty of +5 dB(A) shall be applied to the measured noise level and this increased level shall be used in assessing compliance with the specified levels. All noise measurements shall be made in accordance with I.S.O. Recommendations R1996/1 and 2 "Acoustics – Description and measurement of Environmental noise"*

Recent 2022 An Bord Pleanála permissions for wind farms have included an additional limit of 40dB(A) L90 10min below wind speeds of 5 m/s.

11.3.3 WHO 2018

The most recent WHO 2018 Guidelines: 'Environmental Noise Guidelines for the European Region' recommends a limit of 45 dB Lden which is based on low quality evidence. This is an annual average noise level, or exposure level and is determined by the wind speed and directionality on a yearly basis in the vicinity of the site, however it does not give specific limits for night.

11.3.4 DRWEDG 2019

There have been a number of draft guidelines over the years with the latest one being in December 2019. The DRWEDG 2019 guidelines currently in draft format are the subject of significant public and stakeholder consultation and is in the process of review. In line with best practice, the assessment is based on the current guidelines outlined in **Section 11.3.1** and **Section 11.3.2**.

11.4 DESK STUDY

The four 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 Study Area. The Study Area has been defined such that the predicted noise levels have been included for all receptors within 2 km 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 four locations for noise monitoring were selected by inspection of site maps and by identifying the nearest receptors surrounding the Wind Farm.

11.5 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 11.2**) gives the methodology to account for wind shear, calculation to hub height and standardise to 10 m height wind speed.

A meteorological mast located within the Wind Farm Site during the noise survey was used for wind data measurements at heights of 80 m and 50 m with wind shear derived and used to calculate to the expected turbine hub height range of 102.5 m to 110.5 m. The assessment is based on the higher hub height of 110.5 m standardised to 10 m height that gives

[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

marginally higher noise levels at the wind speeds below the maximum sound power level. The maximum sound power level of the turbine does not change by variation of hub height.

The 110.5 m hub height wind speed was then standardised to 10 m height wind speed with the wind speed plotted against the 10 minute background noise data to derive a best fit polynomial curve.

When compiling the baseline data directional filtering was carried out so that downwind noise from the existing Windfarms south and north-east were excluded.

11.6 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.

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. 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:

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.

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

A_{geo} –Geometric Spreading

Geometric (spherical) spreading from a simple free-field point source results 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 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 10^0C 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. 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 which is best practice.

11.7 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 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[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.

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.

[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 Effec*t, Dec'2013.

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 windfarm being installed.

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.

11.8 INFRASOUND AND LOW FREQUENCY NOISE AND VIBRATION

There is always low frequency (or infrasound) noise present in the ambient and quiet background. It is generated by distant road traffic, natural sources such as, wind effects thru 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, boilers, burners, heat pumps, extraction systems, electric or battery clocks, sky box, etc.), Other sources include water flowing through pipes within your home and in water flow from municipal water supply. Vibration of elements of structures (low frequency, less than 20Hz) can be generated by local activity in one's home by way of normal routine activity, like climbing stairs, walking on the floor, closing doors etc. When sitting in a moving vehicle very high levels of low frequency vibration/sound is generated.

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 typically of 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 evidence to suggest that there are no serious consequences to people's health from infrasound exposure.

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

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*'[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 of these low frequency microphones recording air-overpressure (low frequency sound) are 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 9 m/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 (or rivers or streams) being the cause of sickness.

The level of ground vibration from the operation of the windfarms is below human threshold of 0.2 mm/s[14] at the base of a turbine.

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

A report released in January 2013 by the South Australian EPA[15] 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 and 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 a 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] 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
[15] 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)[16] 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"[17] 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.

Measurements showed that the infrasound levels in rural areas with wind farms were about the same as levels in a regular urban environment.
"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 differences between the results of the two groups."

[16] 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 Health
[17] 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.

11.9 FIELD WORK

Baseline noise monitoring was undertaken at four locations from 12th March to 8th April 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 period.

11.10 CONSULTATION

Consultation was initiated by the Developer's representative liaising with local residents to obtain permission to install noise monitors at four locations for baseline noise monitoring. Access to the nearest dwellings was carried out with permission from the householders and landowners.

11.11 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 Wind Farm
- Prediction of noise levels from the wind turbines including cumulative noise levels
- Comparison of the predicted levels with noise limits; and
- Description of the effects

The 110kV Wind Farm Substation is considered. However, it is discounted from the noise assessment as the noise emissions from the operation are very low compared to the wind turbines (recorded levels of similar substation by author of report gave noise levels of less than 30 dBA at 120 m) and will have negligible impact at the nearest noise sensitive receptor H3 which is 505 m away resulting in a noise level of less than 17 dBA.

Potential receptors in the area around the Wind Farm were initially identified from Ordnance Survey maps, Google maps, EPA maps, Site visits and Eircode's. Background measurements were carried out at four 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 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 5 m/s at standardised 10 m height wind speed.

The method of predicting noise levels from turbines at receptors is discussed in **Section 11.6.** 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 turbines that fit within the proposed range available on the market. The final turbine choice will be made through a commercial tender process. For EIA noise assessment purposes, a hypothetical candidate turbine, the Nordex N149 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 being considered.

All turbines to be used will as best practice have Serrated Trailing Edge (STE) fitted as industry standard, which reduces the sound power level of each turbine. The tip of the blades with STE reduces noise emissions without compromising on energy output.

A copy of the manufacturers noise specification for the turbines used in the assessment is given in the **Appendix 11.4**.

The Nordex N149 turbine has a range of hub heights, however the proposed hub heights range between 102.5 m and 110.5 m. A wind farm noise assessment is based on a noise level referenced to a standardised wind speed at 10 m height. The change in hub height does not therefore change the maximum sound power level of any specific turbine, however a change in hub height may marginally change the noise level at wind speeds below the maximum sound power level. The maximum sound power level for the Nordex N149 in Mode 0 is 105.6dBA and similar for all hub heights.

The prediction modelling is based on the turbines operating at full power in Mode 0 at maximum sound power level (LWA dB**)** fitted with STE as industry standard which is good practice. 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 2d BA. However, as no uncertainty is given it is standard practise to add an uncertainty value of 2 dBA which is given in both tables. **Table 11.3** gives maximum sound power level of the N149 turbine at varying wind speed (presented at standardised 10 m height) for hub height of 110.5 m. An uncertainty value of 2 dBA is added to the data and a value of 2 dBA subtracted to account for conversion from LAeq to LA90 which is considered best practice and recommended by ETSU-R-97.

Table 11.3: Noise Emission Levels, Nordex N149 with STE at Maximum Sound Power Levels in Mode 0

Standardised 10 m height Wind Speed, ms^{-1}	3	4	5	6	7	8	9+
Sound Power Level, dB L_{WA} derived from 110.5 m hub height	97.4	103.8	105.6	105.6	105.6	105.6	105.6
Uncertainty added and conversion of LAeq to LA90	97.4	103.8	105.6	105.6	105.6	105.6	105.6

A Wind Farm noise assessment is based on noise levels referenced to standardised wind speed at 10 m height. The maximum sound power level of the Nordex N149 is similar for hub heights of 102.5 m and 110.5 m at 105.6 dBA. At lower wind speeds there is a small variation (0.8dB at 3 m/s and 0.7dB at 4 m/s) in the sound power levels due to variation in hub height when standardised to a 10 m wind speed. The predicted noise levels for the hub height of 102.5 m standardised to 10 m height is given in **Appendix 11.5**.

Table 11.4 gives the maximum sound power output at varying wind speed (presented at standardised 10 m height) for the Nordex N149 with a hub height of 102.5 m. An uncertainty value of 2 dBA is subtracted to account for conversion from LAeq to LA90 which is best practise.

Table 11.4: Noise Emission Levels, Nordex N149 with STE at Maximum Sound Power Levels in Mode 0

Standardised 10 m Height Wind Speed, ms^{-1}	3	4	5	6	7	8	9+
Sound Power Level, dB L_{WA} at varying wind speed derived from 102.5 m hub height	96.6	103.1	105.6	105.6	105.6	105.6	105.6
Uncertainty added and conversion of LAeq to LA90	96.6	103.1	105.6	105.6	105.6	105.6	105.6

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

Table 11.5: Octave Band Spectrum of Nordex N149 with STE at Maximum Sound Power Level (LWA dB) at 8 m/s wind speed

Octave Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level, dB L_{WA} 8 ms^{-1}	86.9	93.5	97.2	99.3	100.6	98.7	89.1	81.2
Uncertainty added to octaves and conversion of LAeq to LA90	86.9	93.5	97.2	99.3	100.6	98.7	89.1	81.2

11.11.1 Cumulative Assessment

Cumulative effects from any existing, consented or application-stage windfarms within 5 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 6 No. Enercon E92 turbines in Blacklough WF, 17 No. Enercon E70's in Carrowleagh WF, 13 No. Enercon E70's in the Ballyconnellan WF, single Enercon E138 permitted Glenree WF and the single E92 permitted Stokane WF are assessed. All E70's have a hub height of 64 m, the Blacklough WF has E92's with a hub height of 78 m, the single E138 Glenree WF has a hub height of 81 m while the permitted single turbine Stokane WF has an E92 with hub height of 104 m. All sound power levels given for the Enercon (E) turbines are for standardised 10 m height wind speed. The Enercon E70's, E92's turbines give an uncertainty value of 1 dBA so to convert from LAeq to LA90 results in 1 dBA being subtracted from the values given in **Table 11.6** and **Table 11.7** when modelling. The single E138 Glenree WF has an uncertainty value of 1.7 dBA resulting in 0.3 dBA being subtracted from the values in **Table 11.8.**

The octave band spectrum of the Enercon E70's wind turbine at maximum sound power level is given in **Table 11.6**.

Table 11.6: Octave Band Spectrum of E70's at Maximum Sound Power (L_{WA})

Octave Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000	L_{WA}dB
Sound Power Level, dB L_{WA} 9 ms^{-1}	88.3	96.9	99.4	98.0	96.5	93.2	86.3	78.7	104.4

The octave band spectrum of the Enercon E92's wind turbine at maximum sound power level is given in **Table 11.7**. The maximum sound power level of the E92 is at a wind speed of 10 m/s at 10 m height.

Table 11.7: Octave Band Spectrum of E92's at Maximum Sound Power (L_{WA})

Octave Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000	L_{WA}dB
Sound Power Level, dB L_{WA} 9 ms^{-1}	85.7	92.9	94.0	95.8	98.3	98.9	97.1	86.6	104.7

Table 11.8: Octave Band Spectrum of E138 EP3 at Maximum Sound Power (L_{WA})

Octave Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000	L_{WA}dB
Sound Power Level, dB LWA 9 ms-1	86.9	92.6	95.4	98.0	99.9	101.0	97.2	83.8	106.0

11.11.2Noise Limits

The method of deriving operational noise limits is described in Section 11.2.2.1 and is based on the current 2006 guidelines, background noise levels, the 2013 An Bord Pleanála limits a that were applied to the Wind Farm Site and recent 2022 (26th September-309306-21) An Bord Pleanála Decisions introduced an additional limit of 40 dBA for wind speeds below 5 m/s.

The cumulative noise limits proposed are:

'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:

(a) 5 dB(A) above background noise levels or

(b) 43 dB(A) L90,10min and for wind speeds less than 5 m/s a limit of 40 dB(A) L90,10min when measured externally at dwellings or other sensitive receptors and where wind speeds are measured at standardised wind speed of 10 m/s'.

The assessment is made against a 43 dB(A) L90,10min limit for all wind speeds at 5 m/s and above and 40dBA for wind speeds below 5 m/s. A 43 dB(A) L90,10min limit protects sleep at night.

11.12 CONSTRUCTION ASSESSMENT METHODOLOGY

11.12.1 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 acceptable (the NRA Guidelines)[18]. Guidance to predict and control noise is also given in BS 5228:2009, *Code of Practice for*

[18] National Roads Authority, *Guidelines for Noise and Vibration in National Road Schemes.*

Noise and Vibration Control on Construction and Open Sites (two parts) where Part 1 deal with Noise[19].

11.12.2 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.

11.12.3 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 Proposed 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

[19] 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*.

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.

11.12.4 Construction and Decommissioning Noise Limits

The NRA guidelines for construction noise which are considered typically acceptable are given in **Table 11.9**.

Table 11.9: Noise levels that are 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.

<u>Construction times for the Wind Farm</u>

The construction times for the Wind Farm are:

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 the 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 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 Wind Farm, or decommissioning is not considered an intensive activity. The main noise sources will be associated with the construction of the Turbine Foundations and Turbine Hardstands. Lesser noise source activity will be construction and upgrading of access roads, a temporary construction compound, felling of trees in forest and relocating on site of peat. The maximum road traffic noise levels will be generated by delivery of concrete for Turbine Foundations of the turbines, with lower noise levels generated by less intensity delivery of material for Turbine Hardstands / access roads and turbine delivery.

The grid connection from the Wind Farm Substation will be along public roads to the Glenree – Moy 110kV over-head line in the townland of Carrowleagh, and will involve horizontal drilling at four locations along this route (construction of the onsite Wind Farm Substation will generate no more noise than construction of a bungalow).

Road widening and other works are required for part of the Turbine Delivery Route. Road widening activity will be of short duration of less than a week with low level noise emissions at any receptor.

Decommissioning could include removal of turbines off site for recycling. The Turbine Foundations and site roads will be left in-situ. Underground cabling will be removed but ducting will be left in place. Noise levels are expected to be no more than during construction noise but of shorter duration.

All workers associated with Proposed Development will be subject to the Health and Safety Authority Guidance[20] which states that for noise exposure noise levels likely to exceed 80 dBA (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'.

11.12.5 Evaluation of Potential Effects

The potential impacts of construction are evaluated by comparing the predicted noise levels against the guideline values given in **Table 11.9:** Noise levels that are acceptable are based on the NRA guidelines**.**

The potential operational impacts are evaluated by comparing the predicted noise levels against the noise limits given in **Section 11.12**. The predicted noise levels are carried out according to the IOA Good Practice Guide as detailed in **Section 11.6** and potential impacts are assessed against the noise limits at the nearest receptors.

11.12.6 Sensitivity

The sensitivity of the Wind Farm during construction is based on the guideline values in **Table 11.9.** The sensitivity of the Proposed Development during operation is based on the noise limits in **Sections 11.12** and **11.17**.

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

11.12.7 Magnitude

The magnitude of potential impacts of construction is based on the values in **Table 11.111**. The magnitude of the Wind Farm during operation is based on the values in **Table 11.13 and Table 11.15.**

11.12.8 Significance Criteria

The significance of construction is based on the potential impacts based on the predicted levels and compliance with the guideline values in **Table 11.9** and sample criteria of in Part 1 of BS 5228.

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

11.13 BASELINE DESCRIPTION

11.13.1 Identification of Potential Receptors

A number of predictions were prepared for the layout of the Wind Farm. Based on initial 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 Wind Farm Site.

Four baseline noise survey locations were selected on the basis of their location relative to the Wind Farm Site as outlined in **Table 11.10** and shown in noise contour map in **Figure 11.1**.

11.13.2 Baseline Noise Survey

Baseline noise measurements were derived from a noise survey carried out from 21st March to 18th April 2020 at locations outlined in **Table 11.10**. The baseline survey monitoring locations were carried out at, or close to receptor houses H3, H5, H7 and H28 (photos of monitors in-situ in **Appendix 11.1**).

To avoid any noise contribution from existing windfarms located east, north-east and south from survey locations the recorded data was subsequently filtered so that the data was devoid of turbine noise.

Table 11.10: Baseline Noise Survey

Location	ITM Reference	Description of Location
H3	535188E, 821210N	Microphone at 1.2-1.5 m height, at 20 m from rear of dwelling facing the Wind Farm Site
H5	535061E, 823316N	Microphone at 1.5 m height, 10 m from corner of dwelling in rear garden facing the Wind Farm Site
H7	535387E, 820024N	Microphone at 1.2-1.5 m height, at 60 m in front of dwelling away from trees facing the Wind Farm Site.
H28	536542E, 819091N	Microphone at 1.2-1.5 m height, at 10 m from end of house facing the Wind Farm 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 noise measurements with 10-minute interval mean wind speed were recorded from wind mast on the Wind Farm Site. 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 1.2-1.5 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 close to H3 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 measurements prior to analysis.
- The standardised 10 m wind speed was plotted against the filtered background noise levels to exclude directly downwind form the other windfarm, using a best-fit polynomial line.

<u>Instrumentation Used</u>

The following instrumentation was used in the baseline survey measurements:

- Four 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[21]'.

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

- Calibration Type: Larson Davis Precision Acoustic Calibrator.
- Rain Gauge Type: TR-525met tipping bucket rain gauge, 0.2 mm pulse with LOGBOX datalogger.

All acoustic instrumentation was calibrated before and after each survey and the drift of calibration was less than 0.2dB within accepted guidelines.

11.13.3 Prevailing Background Noise Levels

Table 11.11 gives the background noise levels obtained from quiet daytime and night-time measurement periods at the four baseline measurement locations H3, H5, H7 and H28. Direct downwind noise levels were filtered from the data prior to analysis.

Table 11.11: 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	10
H3	Day	24.5	27.0	30.0	33.3	36.9	40.4	43.9
	B/G+5	29.5	32.0	35.0	38.3	41.9	45.4	48.9
H3	Night	21.6	23.7	26.4	29.6	33.1	36.6	40.1
	B/G+5	26.6	28.7	31.4	34.6	38.1	41.6	45.1
H5	Day	23.3	25.6	28.3	31.2	34.3	37.4	40.5
	B/G+5	28.3	30.6	33.3	36.2	39.3	42.4	45.5
H5	Night	21.9	23.9	26.4	29.2	32.3	35.4	38.4
	B/G+5	26.9	28.9	31.4	34.2	37.3	40.4	43.4
H7	Day	25.7	28.1	30.8	33.9	37.2	40.5	44.0
	B/G+5	30.7	33.1	35.8	38.9	42.2	45.5	49
H7	Night	22.4	24.8	27.8	31.2	34.7	37.7	40.1
	B/G+5	27.4	29.8	32.8	36.2	39.7	42.7	45.1
H28	Day	32.2	33.0	34.0	35.2	36.5	37.9	39.2
	B/G+5	37.2	38.0	39.0	40.2	41.5	42.9	44.2
H28	Night	33.3	34.3	35.5	36.7	37.9	38.7	39.2
	B/G+5	38.3	39.3	40.5	41.7	42.9	43.7	44.2

Location H3

The noise monitor was located 15 m in front the house close to local road, facing towards the Wind Farm Site. Existing turbines were inaudible on all my visits to this site. Main noise sources would be generated by wind effects on vegetation, local domestic activity and low-level traffic on the local roads. For analysis of data only wind direction between 215 and 340 degrees was analysed.

Location H5

The noise monitor was located 10 m from end of house, facing towards the Wind Farm Site. Existing turbines were inaudible on all my visits to this site. Main noise sources would be generated by wind effects on vegetation, local domestic activity and low-level traffic flow on the local roads. For analysis of data only wind direction between 225 and 340 degrees was analysed.

Location H7

The noise monitor was located 60 m east of the house and away from local trees, facing towards the Wind Farm Site. Existing turbines were inaudible on all my visits to this site. Main noise sources would be generated by wind effects on vegetation, distant river, local domestic activity and low-level traffic flow on the local roads. For analysis of data only wind direction between 225 and 340 degrees was analysed.

Location H28

The noise monitor was located 10 m east of the house and away from local trees, facing towards the Wind Farm Site. Existing turbines were inaudible on all my visits to this site. Main noise sources would be generated by a stream which flows close to the main road, wind effects on vegetation, local domestic activity and low-level traffic flow on local roads. For analysis of data only wind direction between 240 and 340 degrees was analysed.

11.13.4 Noise Assessment Locations

The nearest receptors to the Wind Farm Site 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 at the nearest properties to each monitoring location.

Should the predicted operational noise levels comply with the requirements of the 2006 Guidelines at the closest receptors, it may be assumed that the predicted noise levels at receptors further away will also comply, due to the attenuation of turbine noise levels with distance. The locations of the four baseline locations are given in **Table 11.10**.

11.13.5 Noise Limits

The noise limits for the Wind Farm Site (and cumulative levels) are designed to comply with the limits in the 2006 Guidelines, background noise levels, the limits already given for this site and recent 2022 An Bord Pleanála limits.

The assessment (including cumulative assessment) is made against a 43 dB(A) L90,10min limit for wind speeds at 5 m/s and above and 40dBA for wind speeds below 5 m/s.

11.13.6 Proposed Development Design Mitigation

The turbine model assessed, the N149 will be fitted with STE as industrial standard as will all chosen turbines for the project. 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 are only installed on the outer rotor blade area where the rotary speed is the highest. Typically, STE reduces the noise levels by 2 to 3dBA.

11.14 ASSESSMENT OF POTENTIAL EFFECTS

11.14.1 Construction 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, compound, felling of trees, with lesser sources being the development and upgrade of existing site access roads and construction of the onsite 110kV Wind Farm Substation. Other noise sources which will generate very low levels of noise include the construction of the end masts at the grid connection loop-in location, the sheds and house to be demolished and the construction of a new house and shed (close to the entrance to the Hydrogen Plant Site) is not considered to increase noise levels at receptors. The main construction traffic to the Wind Farm Site will be due to a very short period where ready-mix trucks deliver concrete for the turbine bases while delivery of material from local quarries for upgrade of site roads, Turbine Hardstands, compound and Wind Farm Substation will prolong for longer periods but will be of less intensity generating lower levels of noise along the routes. During delivery of materials trucks will access the Wind Farm Site from a different route than leaving the Site, thereby reducing traffic noise at receptors along the local road network. The delivery of turbines by large trucks travelling at very low speed will generate very low levels of noise at receptors along the route.

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 11.12** 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 turbine bases / Turbine Hardstands activity, compound development, felling of tree and for receptors at varying distance from the Grid Connection Route including horizontal drilling. Predictions are made for the nearest receptors to the Proposed Development.

Table 11.12: Typical Noise Levels from Construction Works

Activity	Range L_{Aeq} dB at 10 m
General Construction (pile driving, ready-mix trucks pouring concrete)	70-84
Tracked excavator removing topsoil, subsoil for foundation	80- 87
Rock breaker and excavator loading	82-89
Vibrating rollers including tipping material	76-86
Grid Connection: Trenching, Tracked excavator 14t, Hydraulic breaker, vibratory roller	70-73
Horizontal Directional Drilling, Rig HPU(Diesel) mud pump, diesel generator with tractor	71-75
Excavator loading / tipping, excavator and Vibratory roller	80- 87
Removal of peat to laydown area (Loading tipping, excavator, dumper)	70- 83
Felling of trees in Forest- Chain-saw cutting trees[22]	60-66

* Hydraulic power unit (measurements taken on 22nd March 2022 with HDD giving 71dBA without tractor).

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

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

[22] Inac TAS, Abdulllah E, AKAY, 2018, Bursa Technical University, Bursa Turkey Analysis of Noise level caused by a chainsaw during tree felling operations, IARC

A_{mis} = Attenuation provided by miscellaneous other effects

In the calculation attenuation by A_{atm}, A_{gr} and A_{mis} is conservatively assumed as 3dBA with no correction made for plant at distances less than 100 m.

Table 11.13 gives the predicted noise levels from construction activity at the nearest receptors while for grid connection noise levels are given at varying distances from receptors along the Grid Connection Route. With Grid Connection the activity moves continuously along the route which means that maximum levels will be for no more than 4 hours at any receptor except where horizontal direction drilling is required. Horizontal directional drilling (HDD) will occur at 4 four locations (Stafaungal stream, Fiddaun stream, Glenree stream and the Loughnagore stream. It is anticipated that HDD will be of duration of less than one week at each location.

The maximum construction noise levels are listed in **Table 11.13.** At receptor locations further away, noise levels will be less than predicted.

Table 11.13: Predicted Construction Noise Levels

Activity	Distance calculated in metres (m) to nearest receptor	L_{Aeq} dB 1hr Range
General Construction (pile driving, ready-mix trucks pouring concrete) at nearest turbine T6	810 m to H5	29-43
Tracked excavator removing topsoil, subsoil for nearest turbine T6 foundation	810 m to H5	39-46
Rock breaker and excavator loading at nearest turbine T6	810 m to H5	41-48
Vibrating rollers including tipping material sit down area close to T6	810 m to H5	33-43
Grid Connection: Trenching, Tracked excavator 14t, Hydraulic breaker, vibratory roller	At varying distances along route 15 m 20 m 40 m 80 m	 67-70 64-67 58-61 52-55
Horizontal Drilling, Rig HPU(Diesel) mud pump, diesel generator /tractor /dumper	45 m Loughnagore Stream 178 m Glenree Stream 70 m Fiddaun Stream 47 m Srafaungal Stream	58-62 42-47 54-58 58-62
Construction of compound (Loading / tipping, excavator and Vibratory roller	989 m to H17	37-44

Activity	Distance calculated in metres (m) to nearest receptor	L_{Aeq} dB 1hr Range
Removal of peat to spreading area (Loading tipping, excavator, dumper	1223 m to H5	25-38
Felling of trees in Forest- Chain-saw cutting trees assuming two saws in operation	503 m to H3	23-29

NB: Assumes plant operating at 100% capacity (no down time) which generally does not occur in practice

<u>Construction Traffic</u>

The delivery of turbines to the Wind Farm 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 most intensive construction noise generated by traffic to the Wind Farm 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).

Each turbine will require a pour of 900 m^3 of concrete while each ready-mix truck has a capacity of 8 m^3. This results in 113 loads of concrete resulting in 226 truck movements for each turbine. To reduce traffic flow delivery and departure will be by different routes (refer to **Chapter 2**) so this means 113 movements on each road. For delivery of concrete the time frame envisaged for each turbine concrete pour is taken as 10 hrs. This equates to an average of 11.3 movements per hour (12 movements used in calculations).

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 12, the number of vehicles per hour; V is 50, the average vehicle speed, in kilometres per hour (km/h); d is the distance of receiving position at 20 m from the centre of haul road, in metres (m). LAeq = 105-33 + 10log 12 – 10log50 – 10log20 = 52.8 LAeq 1hr. At 10 m from the roadside the noise levels from delivery equates to 55.8 LAeq 1hr. The trucking for the concrete pour will extend for a total of 13 days (1 day for each Turbine Foundation). In practice the levels generated by truck movement should be lower than predicted due to the smooth surface on the local roads.

There will be an increase in road traffic on the N59 due to delivery of crushed stone for site tracks and for engineering fill. Traffic will also be generated by material associated with the Grid Connection. There is a logarithmic relationship between road traffic flow and noise levels.

Typically doubling the traffic flow will result in a 3 dBA increase in noise level[23] and a 30% increase will increase noise levels by 1 dBA while a 50% increase results in a 2 dBA increase. The peak road traffic flow on the N59 is 433 veh/hr with the average daily flow between 06:00 to 18:00hrs at 215 veh /hr. The increase in traffic flow on the N59 is from construction will be negligible (Refer to Chapter 15, Traffic and Transport). The road traffic noise impact will be imperceptible along the N59 National Road.

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

Cable laying and trenching will move along the Grid Connection Route from the Wind Farm Substation to the Glenree – Moy 110kV over-head line is in the townland of Carrowleagh. The maximum predicted noise levels will pertain for less than 0.5 days equivalent (4 hours) at any single receptor, except with horizontal drilling where the period could be in the region of up to a week.

Construction noise levels are based on continuous operation. In practice most plant will operate at a maximum level for short intervals.

11.14.2 Assessment of Construction Noise and Vibration

The maximum predicted noise levels from construction will be from the development of the Grid Connection Route, however these effects will be short term at no more than 4 hours at all locations except at stream crossings where this activity could be of duration of one week. In terms of construction duration, the longer periods will from the development of Turbine Foundations and Turbine Hardstands, however this activity is more than 0.8 km from the nearest receptors.

All activity is predicted without additional mufflers, or without topographic screening. The maximum road traffic noise which is generated by ready-mix trucks delivering concrete for Turbine Foundations will be short term and of 13 days duration. The predicted noise levels are within the NRA guidelines given as acceptable and are therefore considered as not significant.

Ground vibration from construction traffic will be below the threshold of sensitivity to humans of 0.2 mm/s peak particle velocity[24] at all receptors.

[23] 1998, Dept of Transport Welsh Office, Calculation of Road Traffic Noise
[24] 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

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

11.14.3 Decommissioning

Noise and vibration effects during decommissioning are likely to be of a similar nature to that during construction but of shorter duration. There will be no blasting during decommissioning. 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.

11.14.4 Description of Effects

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

Quality	Significance	Duration
Negative	Not significant	Temporary

11.14.5 Predicted Operational Noise Levels

Table 11.14 gives the predicted noise levels at the nearest receptors at varying wind speeds for each receptor location. A noise contour map of the 13 No. turbine Wind Farm at maximum sound power output at a wind speed of 8 m/s at 10 m height is presented in **Figure 11.2**. The contour map in **Figure 11.2** assumes that all turbines are simultaneously downwind to each location all of the time (continuously) which results is an overprediction of the noise levels.

Table 11.14: Predicted Noise Levels as LA90 at Varying Wind Speeds

	ITM	ITM	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA	dBA
H1	535070	822103	41.6	43.4	43.4	43.4	43.4	43.4	43.4
H2	535267	821598	41.5	43.3	43.3	43.3	43.3	43.3	43.3
H3	535188	821210	39.8	41.6	41.6	41.6	41.6	41.6	41.6
H4	535124	823263	37.3	39.1	39.1	39.1	39.1	39.1	39.1
H5	535061	823316	36.5	38.3	38.3	38.3	38.3	38.3	38.3
H6	535574	819899	36.8	38.6	38.6	38.6	38.6	38.6	38.6

House ID	ITM Easting	ITM Northing	4m/s dBA	5m/s dBA	6m/s dBA	7m/s dBA	8m/s dBA	9m/s dBA	10m/s dBA
H7	535387	820024	36.6	38.4	38.4	38.4	38.4	38.4	38.4
H8	535857	819660	36.1	37.9	37.9	37.9	37.9	37.9	37.9
H9	535644	819809	36.5	38.3	38.3	38.3	38.3	38.3	38.3
H10	535747	819724	36.3	38.1	38.1	38.1	38.1	38.1	38.1
H11	535966	819584	35.8	37.6	37.6	37.6	37.6	37.6	37.6
H12	535210	820136	36.2	38	38	38	38	38	38
H13	534401	822381	35.3	37.1	37.1	37.1	37.1	37.1	37.1
H14	534306	822410	34.6	36.4	36.4	36.4	36.4	36.4	36.4
H15	534999	823644	33.9	35.7	35.7	35.7	35.7	35.7	35.7
H16	534907	820371	35.3	37.1	37.1	37.1	37.1	37.1	37.1
H17	534321	822162	34.7	36.5	36.5	36.5	36.5	36.5	36.5
H18	534233	822602	33.8	35.6	35.6	35.6	35.6	35.6	35.6
H19	536282	819253	33.6	35.4	35.4	35.4	35.4	35.4	35.4
H20	534230	822231	34.1	35.9	35.9	35.9	35.9	35.9	35.9
H21	535711	819425	34	35.8	35.8	35.8	35.8	35.8	35.8
H22	534198	822255	33.9	35.7	35.7	35.7	35.7	35.7	35.7
H23	535670	819393	33.7	35.5	35.5	35.5	35.5	35.5	35.5
H24	534175	822187	33.7	35.5	35.5	35.5	35.5	35.5	35.5
H25	534988	823817	32.8	34.6	34.6	34.6	34.6	34.6	34.6
H26	534775	820212	33.9	35.7	35.7	35.7	35.7	35.7	35.7
H27	535082	823941	32.3	34.1	34.1	34.1	34.1	34.1	34.1
H28	536542	819091	32.5	34.3	34.3	34.3	34.3	34.3	34.3
H29	534421	820709	33.4	35.2	35.2	35.2	35.2	35.2	35.2
H30	536673	818878	31.1	32.9	32.9	32.9	32.9	32.9	32.9
H31	534352	820705	33	34.8	34.8	34.8	34.8	34.8	34.8
H32	534961	824183	30.8	32.6	32.6	32.6	32.6	32.6	32.6
H33	533812	822112	31.5	33.3	33.3	33.3	33.3	33.3	33.3
H34	533788	822143	31.4	33.2	33.2	33.2	33.2	33.2	33.2
H35	535220	824333	30.5	32.3	32.3	32.3	32.3	32.3	32.3
H36	534326	820215	31.7	33.5	33.5	33.5	33.5	33.5	33.5

House ID	ITM Easting	ITM Northing	4m/s dBA	5m/s dBA	6m/s dBA	7m/s dBA	8m/s dBA	9m/s dBA	10m/s dBA
H37	536569	818707	30.3	32.1	32.1	32.1	32.1	32.1	32.1
H38	534868	824326	29.9	31.7	31.7	31.7	31.7	31.7	31.7
H39	534270	820167	31.3	33.1	33.1	33.1	33.1	33.1	33.1
H40	534280	820106	31.1	32.9	32.9	32.9	32.9	32.9	32.9
H41	536492	818590	29.7	31.5	31.5	31.5	31.5	31.5	31.5
H42	535188	824469	29.8	31.6	31.6	31.6	31.6	31.6	31.6
H43	536527	818584	29.6	31.4	31.4	31.4	31.4	31.4	31.4
H44	533553	822169	30.2	32	32	32	32	32	32
H45	534052	820668	31.4	33.2	33.2	33.2	33.2	33.2	33.2
H46	533495	822184	29.9	31.7	31.7	31.7	31.7	31.7	31.7

NB: H1 and H2 are derelict buildings.

11.14.6 Operational Noise Assessment

The assessment was made of the predicted operational noise levels from the Wind Farm based on the limits described in **Section 11.13.** in the 2006 Guidelines and taking into account the previous 2013 An Bord Pleanála permission for the Wind Farm Site. All predicted noise levels are within the assessment noise limit of 43dB(A) L90,10min at a wind speed of 5 m/s and above and 40 dB(A) L90,10min at all wind speeds below 5 m/s except for two derelict properties where the limit is marginally exceeded at derelict buildings H1 and H2. As can be seen from **Table 11.15** 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 EIA Regulations. The predicted noise levels assume that all 13 turbines are directly down-wind to nearest receptors.

Table 11.15: Margin between Predicted Noise Levels and Assessment Noise Limit of 43 dB(A) L90,10min at wind speeds of 5 m/s and above and of 40 dB(A) L90,10min at wind speeds below 5 m/s.

House ID	ITM Easting	ITM Northing	4m/s dBA	5m/s dBA	6m/s dBA	7m/s dBA	8m/s dBA	9m/s dBA	10m/s dBA
H1	535070	822103	1.6	0.4	0.4	0.4	0.4	0.4	0.4
H2	535267	821598	1.5	0.3	0.3	0.3	0.3	0.3	0.3
H3	535188	821210	-0.2	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4

	ITM	ITM	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA	dBA
H4	535124	823263	-2.7	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9
H5	535061	823316	-3.5	-4.7	-4.7	-4.7	-4.7	-4.7	-4.7
H6	535574	819899	-3.2	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4
H7	535387	820024	-3.4	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6
H8	535857	819660	-3.9	-5.1	-5.1	-5.1	-5.1	-5.1	-5.1
H9	535644	819809	-3.5	-4.7	-4.7	-4.7	-4.7	-4.7	-4.7
H10	535747	819724	-3.7	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9
H11	535966	819584	-4.2	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4
H12	535210	820136	-3.8	-5	-5	-5	-5	-5	-5
H13	534401	822381	-4.7	-5.9	-5.9	-5.9	-5.9	-5.9	-5.9
H14	534306	822410	-5.4	-6.6	-6.6	-6.6	-6.6	-6.6	-6.6
H15	534999	823644	-9.1	-7.3	-7.3	-7.3	-7.3	-7.3	-7.3
H16	534907	820371	-4.7	-5.9	-5.9	-5.9	-5.9	-5.9	-5.9
H17	534321	822162	-5.3	-6.5	-6.5	-6.5	-6.5	-6.5	-6.5
H18	534233	822602	-6.2	-7.4	-7.4	-7.4	-7.4	-7.4	-7.4
H19	536282	819253	-6.4	-7.6	-7.6	-7.6	-7.6	-7.6	-7.6
H20	534230	822231	-5.9	-7.1	-7.1	-7.1	-7.1	-7.1	-7.1
H21	535711	819425	-6	-7.2	-7.2	-7.2	-7.2	-7.2	-7.2
H22	534198	822255	-6.1	-7.3	-7.3	-7.3	-7.3	-7.3	-7.3
H23	535670	819393	-6.3	-7.5	-7.5	-7.5	-7.5	-7.5	-7.5
H24	534175	822187	-6.3	-7.5	-7.5	-7.5	-7.5	-7.5	-7.5
H25	534988	823817	-7.2	-8.4	-8.4	-8.4	-8.4	-8.4	-8.4
H26	534775	820212	-6.1	-7.3	-7.3	-7.3	-7.3	-7.3	-7.3
H27	535082	823941	-7.7	-8.9	-8.9	-8.9	-8.9	-8.9	-8.9
H28	536542	819091	-7.5	-8.7	-8.7	-8.7	-8.7	-8.7	-8.7
H29	534421	820709	-6.6	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8
H30	536673	818878	-8.9	-10.1	-10.1	-10.1	-10.1	-10.1	-10.1
H31	534352	820705	-7	-8.2	-8.2	-8.2	-8.2	-8.2	-8.2
H32	534961	824183	-9.2	-10.4	-10.4	-10.4	-10.4	-10.4	-10.4
H33	533812	822112	-8.5	-9.7	-9.7	-9.7	-9.7	-9.7	-9.7

House ID	ITM Easting	ITM Northing	4m/s dBA	5m/s dBA	6m/s dBA	7m/s dBA	8m/s dBA	9m/s dBA	10m/s dBA
H34	533788	822143	-8.6	-9.8	-9.8	-9.8	-9.8	-9.8	-9.8
H35	535220	824333	-9.5	-10.7	-10.7	-10.7	-10.7	-10.7	-10.7
H36	534326	820215	-8.3	-9.5	-9.5	-9.5	-9.5	-9.5	-9.5
H37	536569	818707	-9.7	-10.9	-10.9	-10.9	-10.9	-10.9	-10.9
H38	534868	824326	-10.1	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3
H39	534270	820167	-8.7	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9
H40	534280	820106	-8.9	-10.1	-10.1	-10.1	-10.1	-10.1	-10.1
H41	536492	818590	-10.3	-11.5	-11.5	-11.5	-11.5	-11.5	-11.5
H42	535188	824469	-10.2	-11.4	-11.4	-11.4	-11.4	-11.4	-11.4
H43	536527	818584	-10.4	-11.6	-11.6	-11.6	-11.6	-11.6	-11.6
H44	533553	822169	-9.8	-11	-11	-11	-11	-11	-11
H45	534052	820668	-8.6	-9.8	-9.8	-9.8	-9.8	-9.8	-9.8
H46	533495	822184	-10.1	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3

NB: H1 and H2 are derelict buildings

A noise contour map of the cumulative effects of all turbines is presented with a maximum sound power output at a wind speed of 10 m/s at 10 m height in **Figure 11.3**. The contour map in **Figure 11.3** assumes that all turbines are simultaneously downwind at the same time to each location which results in an overprediction of the noise levels.

Charts 11.1 to **11.8** of this section plots the derived background noise levels, background plus 5 trendline plotted against a noise limit of 43 dB(A) L90,10min for wind speeds at 5 m/s and above with 40 dB(A) L90,10min at wind speeds below 5 m/s. The derived background noise levels exclude downwind data from the wind farms located north-east and south of the monitoring locations.

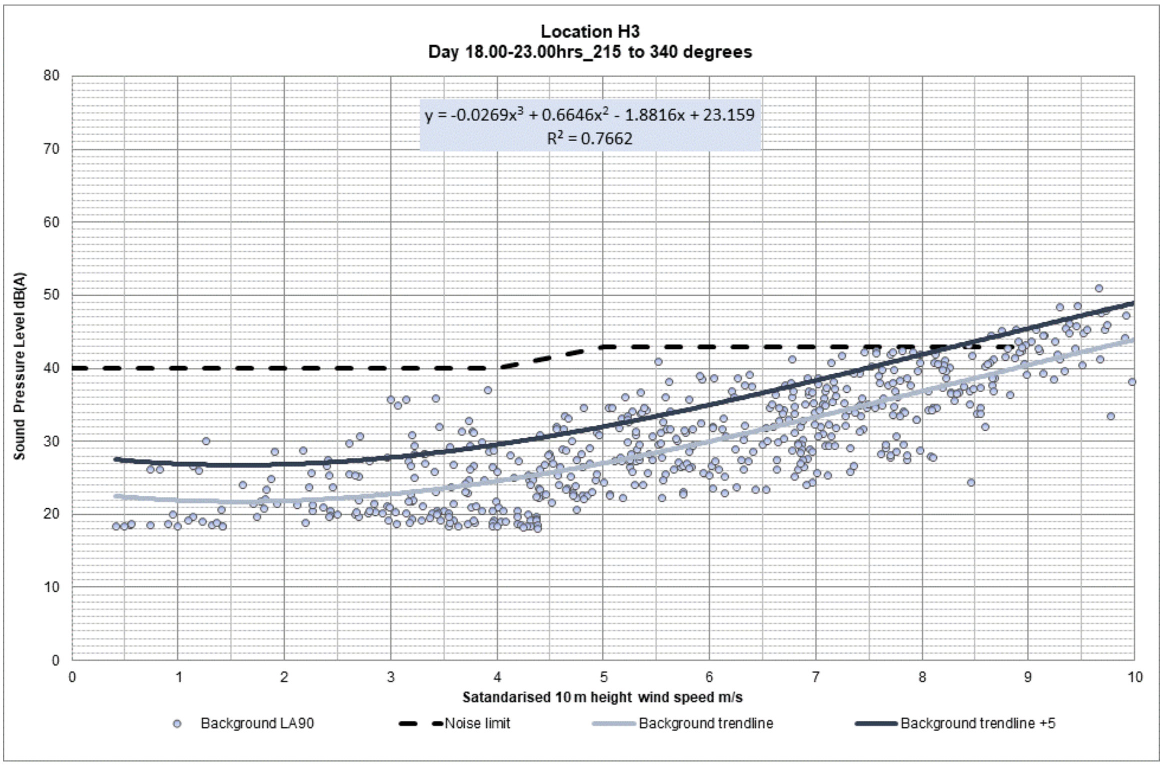

Chart 11.1: Quiet daytime background and background plus 5dBA with noise limit for H3

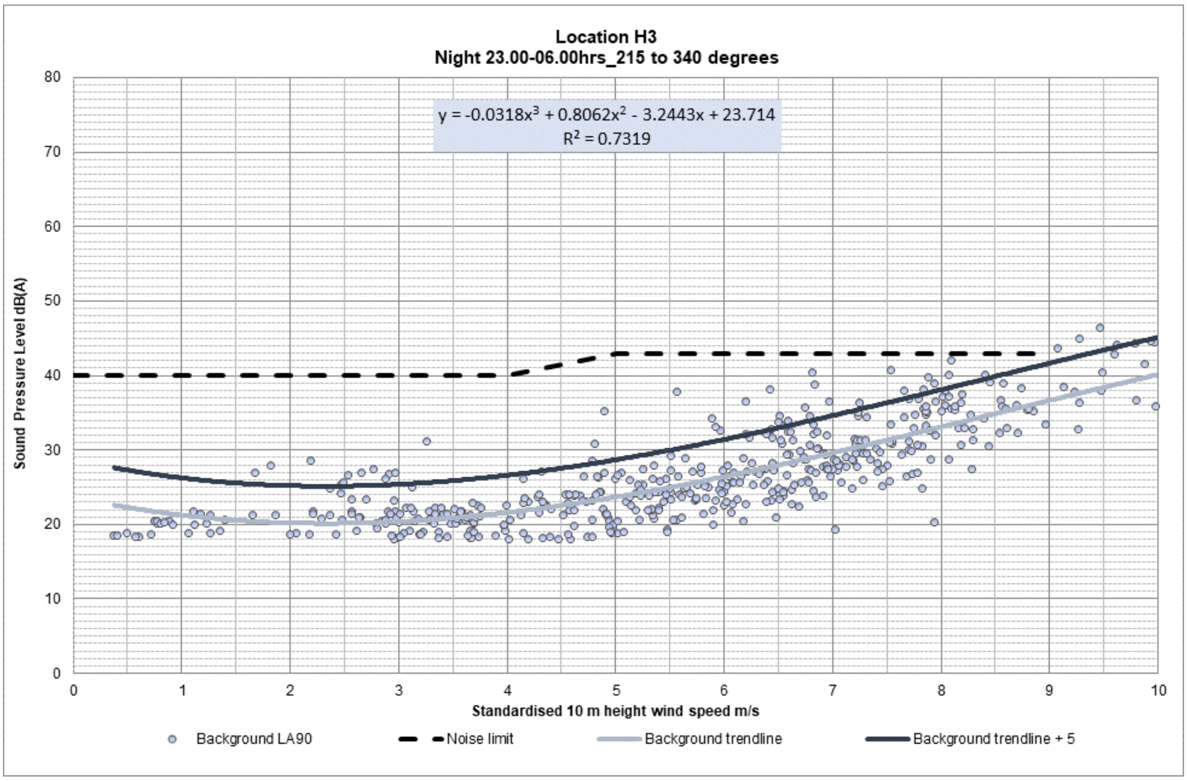

Chart 11.2: Night-time background and background plus 5dBA with noise limit for H3

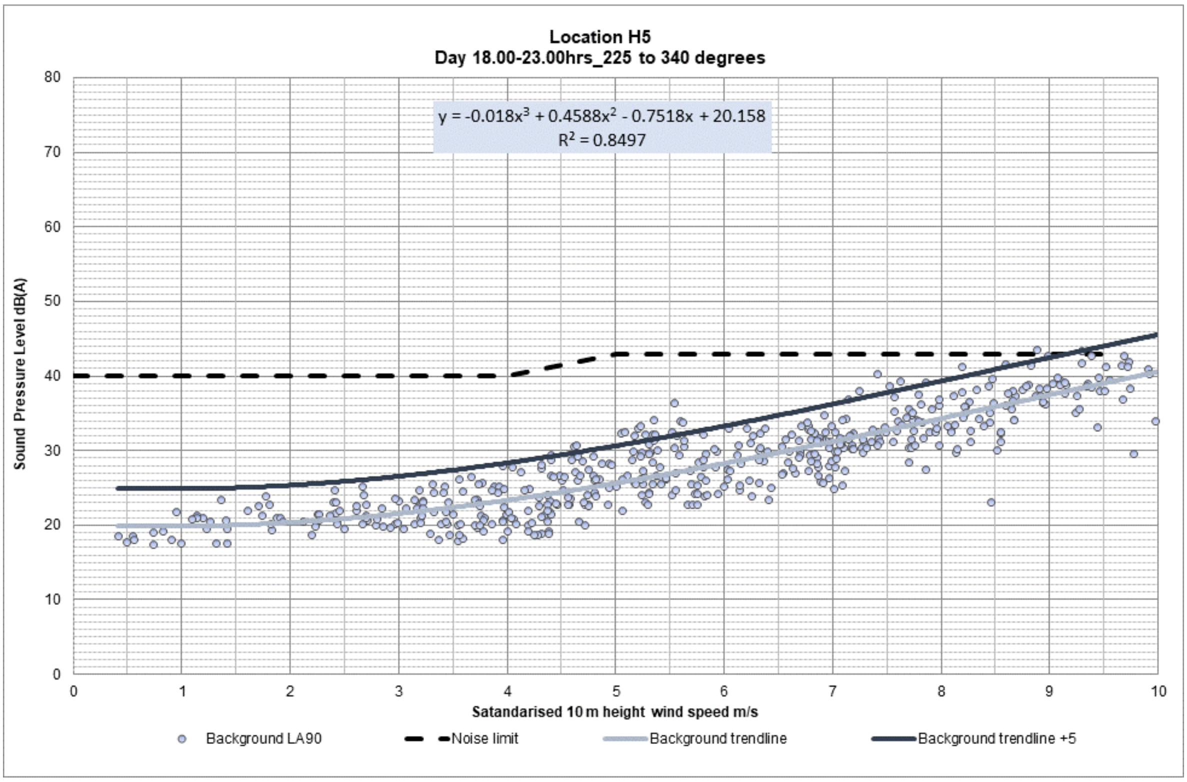

Chart 11.3: Quiet Daytime background and background plus 5dBA with noise limit for H5

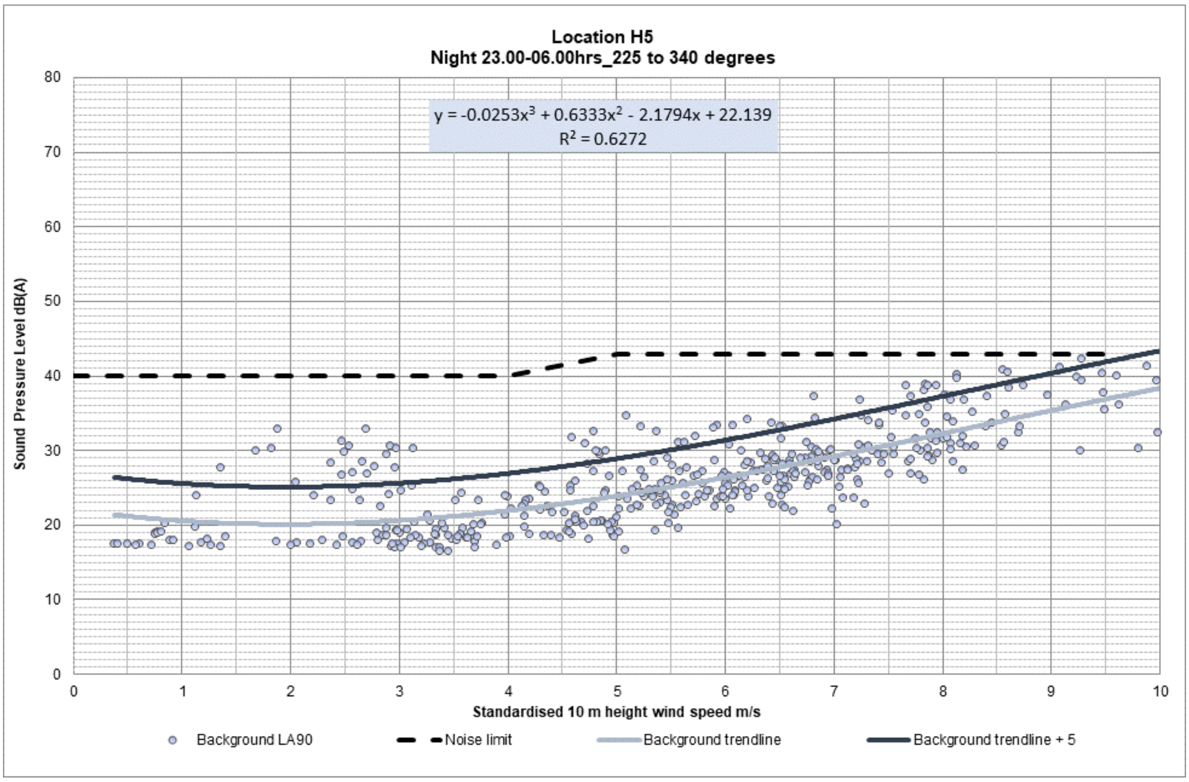

Chart 11.4: Night-time background and background plus 5dBA with noise limit for H5

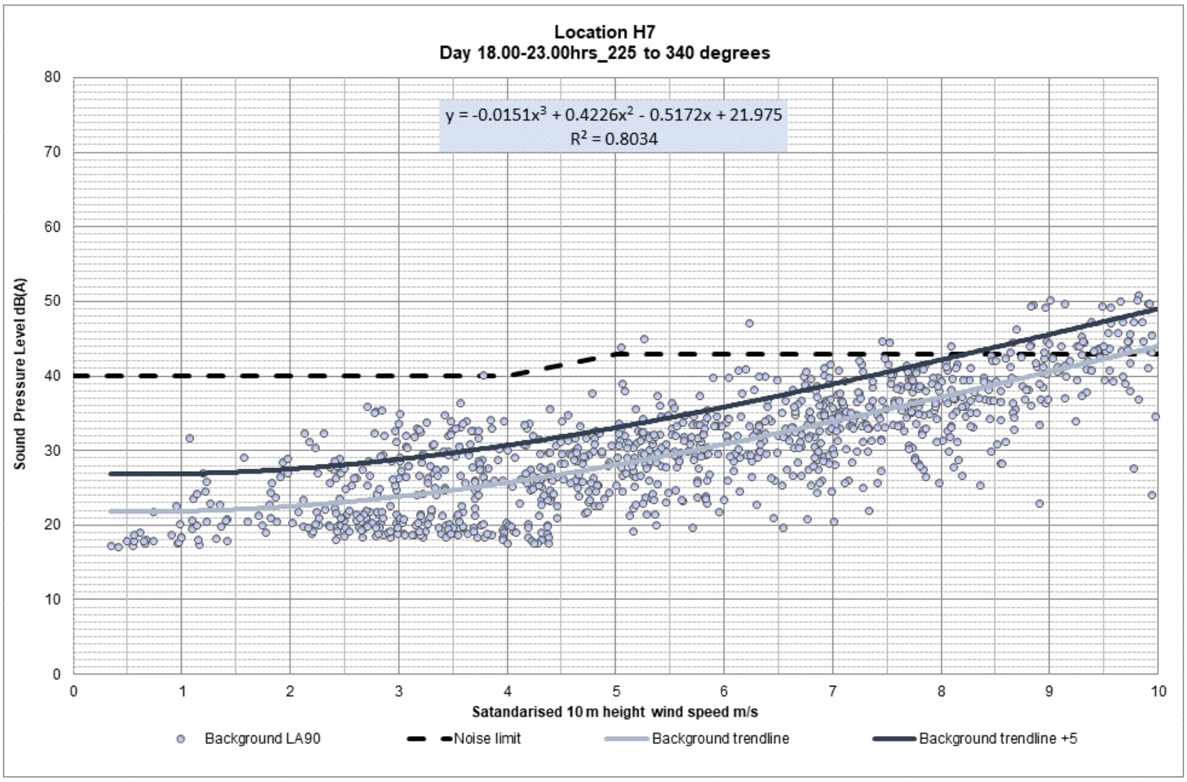

Chart 11.5: Quiet Daytime background and background plus 5dBA with noise limit for H7

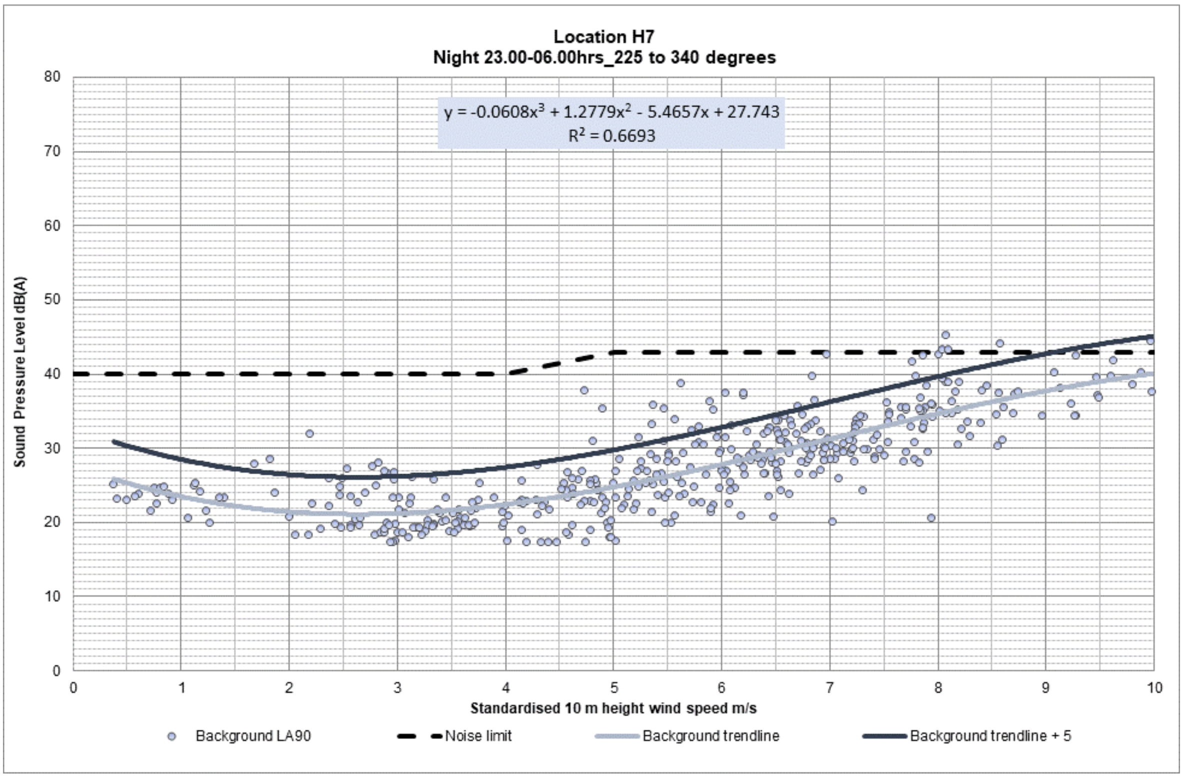

Chart 11.6: Night-time background and background plus 5dBA with noise limit for H7

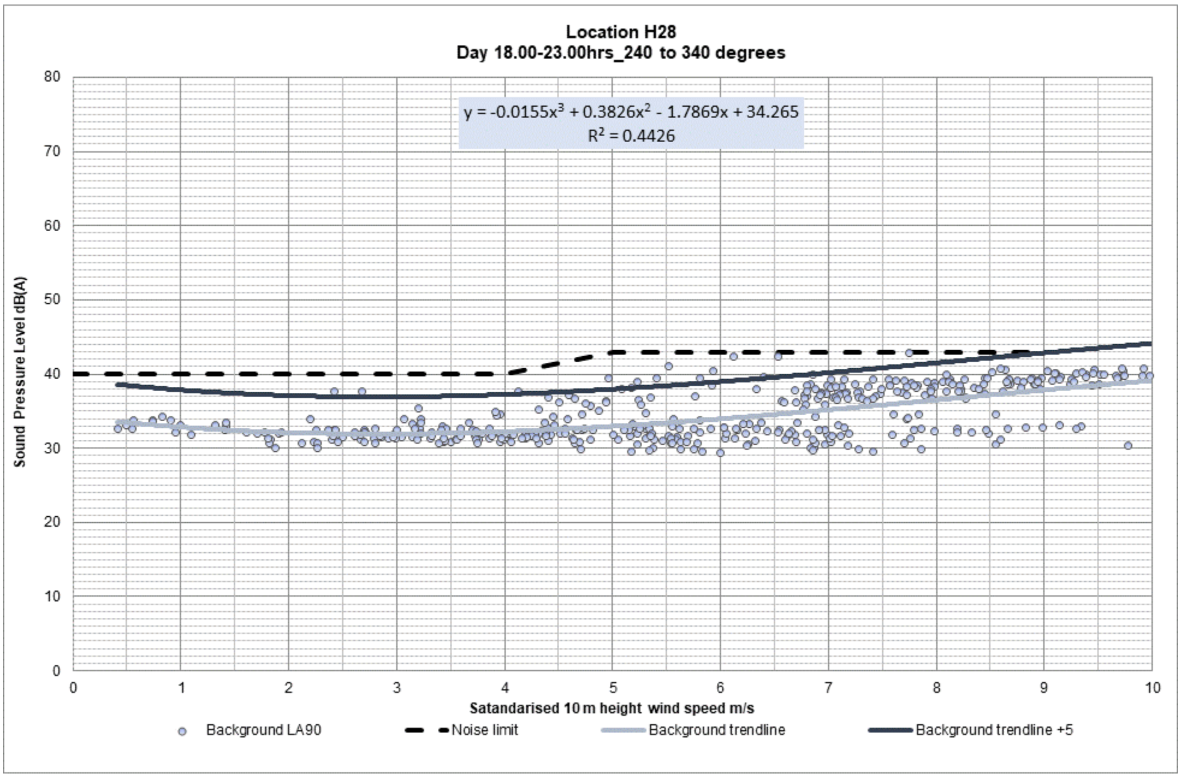

Chart 11.7: Quiet Daytime background and background plus 5dBA with noise limit for H28

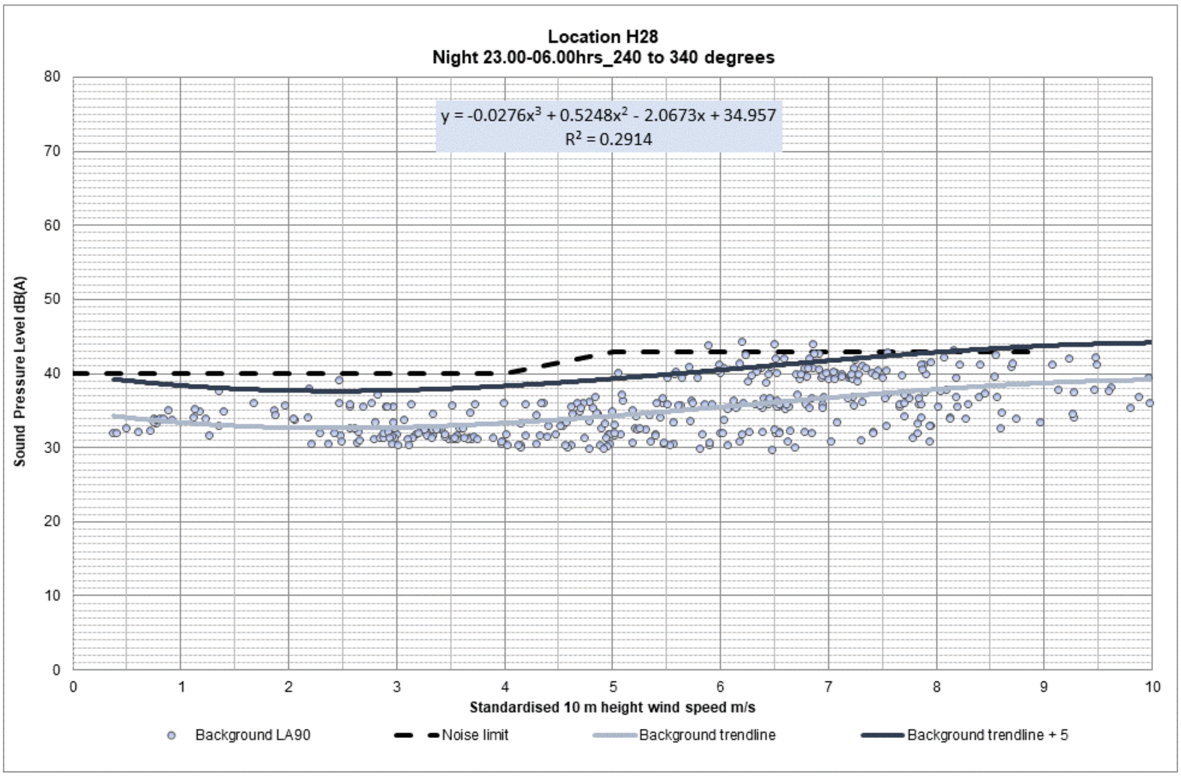

Chart 11.8: Night-time background and background plus 5dBA with noise limit for H28

11.14.7 Cumulative Effects Assessment

An assessment of the cumulative effects of noise from the Wind Farm together with 17 No. Carrowleagh WF, 6 No. Blacklough WF, 12 No. Bunnyconnellan WF, 1 No. Glenree WF and 1 No. Stokeane W F has been undertaken.

11.14.7.1 Cumulative Assessment locations

The same receptor locations 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 will not occur in practice.

11.14.7.2 Noise Limits

The noise limits are the same as that used for the Firlough Wind Farm.

11.14.7.3 Cumulative Noise levels

Table 11.16 gives details of the predicted cumulative noise levels as LA90 at Varying Wind Speeds for each of the nearest receptors.

Table 11.16: Predicted Cumulative Noise Levels as LA90 at Varying Wind Speeds

	ITM	ITM	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA	dBA
H1	535070	822103	41.7	43.5	43.5	43.6	43.6	43.7	43.8
H2	535267	821598	41.6	43.4	43.4	43.5	43.6	43.7	43.8
H3	535188	821210	39.9	41.7	41.8	41.9	42.0	42.2	42.3
H4	535124	823263	37.6	39.3	39.4	39.5	39.7	39.8	39.9
H5	535061	823316	36.8	38.5	38.6	38.7	38.9	39.1	39.2
H6	535574	819899	37.1	38.8	39.0	39.2	39.6	39.9	40.1
H7	535387	820024	36.8	38.6	38.8	39.0	39.3	39.7	39.9
H8	535857	819660	36.4	38.1	38.4	38.7	39.2	39.6	39.8
H9	535644	819809	36.8	38.5	38.7	39.0	39.4	39.7	40.0
H10	535747	819724	36.6	38.3	38.6	38.8	39.3	39.7	39.9
H11	535966	819584	36.2	37.8	38.2	38.5	39.0	39.5	39.8
H12	535210	820136	36.4	38.2	38.4	38.6	38.9	39.2	39.5
H13	534401	822381	35.5	37.2	37.3	37.5	37.7	37.9	38.0

House ID	ITM Easting	ITM Northing	4m/s dBA	5m/s dBA	6m/s dBA	7m/s dBA	8m/s dBA	9m/s dBA	10m/s dBA
H14	534306	822410	34.8	36.5	36.7	36.8	37.0	37.2	37.4
H15	534999	823644	34.4	36.0	36.2	36.4	36.7	37.0	37.1
H16	534907	820371	35.5	37.2	37.4	37.6	37.8	38.1	38.2
H17	534321	822162	34.9	36.6	36.8	36.9	37.1	37.3	37.5
H18	534233	822602	34.0	35.8	35.9	36.1	36.3	36.5	36.7
H19	536282	819253	34.2	35.8	36.3	36.9	37.6	38.3	38.7
H20	534230	822231	34.3	36.0	36.2	36.3	36.6	36.8	36.9
H21	535711	819425	34.3	36.0	36.3	36.4	36.7	36.9	37.0
H22	534198	822255	34.1	35.9	36.0	36.1	36.4	36.6	36.7
H23	535670	819393	34.0	35.7	36.0	36.3	36.7	37.1	37.4
H24	534175	822187	33.9	35.7	35.8	36.0	36.2	36.4	36.6
H25	534988	823817	33.4	35.0	35.2	35.4	35.8	36.1	36.3
H26	534775	820212	34.1	35.9	36.0	36.2	36.5	36.8	37.0
H27	535082	823941	33.0	34.6	34.8	35.1	35.4	35.8	36.0
H28	536542	819091	33.1	34.7	35.2	35.7	36.4	37.1	37.4
H29	534421	820709	33.6	35.4	35.5	35.7	36.0	36.3	36.5
H30	536673	818878	31.8	33.4	34.0	34.5	35.3	36.0	36.5
H31	534352	820705	33.3	35.0	35.2	35.4	35.7	36.0	36.1
H32	534961	824183	31.6	33.2	33.4	33.7	34.2	34.5	34.8
H33	533812	822112	31.8	33.5	33.7	33.9	34.2	34.5	34.7
H34	533788	822143	31.7	33.4	33.6	33.8	34.1	34.4	34.6
H35	535220	824333	31.5	33.0	33.3	33.7	34.1	34.6	34.8
H36	534326	820215	32.0	33.7	33.9	34.2	34.5	34.9	35.1
H37	536569	818707	31.0	32.5	33.1	33.7	34.5	35.2	35.6
H38	534868	824326	30.8	32.3	32.6	32.9	33.4	33.8	34.0
H39	534270	820167	31.8	33.4	33.8	34.2	34.7	35.3	35.6
H40	534280	820106	31.4	33.1	33.4	33.6	34.0	34.4	34.6
H41	536492	818590	30.9	32.3	33.4	34.3	35.4	36.4	36.9
H42	535188	824469	30.9	32.4	32.7	33.1	33.6	34.0	34.3
H43	536527	818584	30.3	31.9	32.5	33.0	33.8	34.5	35.0

House ID	ITM Easting	ITM Northing	4m/s dBA	5m/s dBA	6m/s dBA	7m/s dBA	8m/s dBA	9m/s dBA	10m/s dBA
H44	533553	822169	30.5	32.2	32.4	32.7	33.0	33.3	33.5
H45	534052	820668	31.8	33.5	33.8	34.1	34.6	35.0	35.3
H46	533495	822184	30.3	31.9	32.2	32.4	32.8	33.1	33.3

NB: H1 and H2 are derelict buildings

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

11.14.7.4 Cumulative Noise Assessment

Table 11.17 details the margin between the predicted cumulative noise levels and assessment 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 2006 Guidelines and noise limits given for the Wind Farm Site by An Bord Pleanála in 2013.

Table 11.17: Margins between Predicted Cumulative Turbine Noise for Nearest Receptors and Assessment Noise Limit of 43dB(A) L90,10min

House ID	ITM Easting	ITM Northing	4m/s dBA	5m/s dBA	6m/s dBA	7m/s dBA	8m/s dBA	9m/s dBA	10m/s dBA
H1	535070	822103	1.6	0.5	0.5	0.6	0.6	0.7	0.8
H2	535267	821598	1.7	0.4	0.4	0.5	0.6	0.7	0.8
H3	535188	821210	-0.1	-1.3	-1.2	-1.1	-1.0	-0.8	-0.7
H4	535124	823263	-2.4	-3.7	-3.6	-3.5	-3.3	-3.2	-3.1
H5	535061	823316	-3.2	-4.5	-4.4	-4.3	-4.1	-3.9	-3.8
H6	535574	819899	-2.9	-4.2	-4.0	-3.8	-3.4	-3.1	-2.9
H7	535387	820024	-3.2	-4.4	-4.2	-4.0	-3.7	-3.3	-3.1
H8	535857	819660	-3.6	-4.9	-4.6	-4.3	-3.8	-3.4	-3.2
H9	535644	819809	-3.2	-4.5	-4.3	-4.0	-3.6	-3.3	-3.0
H10	535747	819724	-3.4	-4.7	-4.4	-4.2	-3.7	-3.3	-3.1
H11	535966	819584	-3.8	-5.2	-4.8	-4.5	-4.0	-3.5	-3.2

House ID	ITM Easting	ITM Northing	4m/s dBA	5m/s dBA	6m/s dBA	7m/s dBA	8m/s dBA	9m/s dBA	10m/s dBA
H12	535210	820136	-3.6	-4.8	-4.6	-4.4	-4.1	-3.8	-3.5
H13	534401	822381	-4.5	-5.8	-5.7	-5.5	-5.3	-5.1	-5.0
H14	534306	822410	-5.2	-6.5	-6.3	-6.2	-6.0	-5.8	-5.6
H15	534999	823644	-5.6	-7.0	-6.8	-6.6	-6.3	-6.0	-5.9
H16	534907	820371	-4.5	-5.8	-5.6	-5.4	-5.2	-4.9	-4.8
H17	534321	822162	-5.1	-6.4	-6.2	-6.1	-5.9	-5.7	-5.5
H18	534233	822602	-6.0	-7.2	-7.1	-6.9	-6.7	-6.5	-6.3
H19	536282	819253	-5.8	-7.2	-6.7	-6.1	-5.4	-4.7	-4.3
H20	534230	822231	-5.7	-7.0	-6.8	-6.7	-6.4	-6.2	-6.1
H21	535711	819425	-5.7	-7.0	-6.7	-6.6	-6.3	-6.1	-6.0
H22	534198	822255	-5.9	-7.1	-7.0	-6.9	-6.6	-6.4	-6.3
H23	535670	819393	-6.0	-7.3	-7.0	-6.7	-6.3	-5.9	-5.6
H24	534175	822187	-6.1	-7.3	-7.2	-7.0	-6.8	-6.6	-6.4
H25	534988	823817	-6.6	-8.0	-7.8	-7.6	-7.2	-6.9	-6.7
H26	534775	820212	-3.9	-7.1	-7.0	-6.8	-6.5	-6.2	-6.0
H27	535082	823941	-7.0	-8.4	-8.2	-7.9	-7.6	-7.2	-7.0
H28	536542	819091	-6.9	-8.3	-7.8	-7.3	-6.6	-5.9	-5.6
H29	534421	820709	-6.4	-7.6	-7.5	-7.3	-7.0	-6.7	-6.5
H30	536673	818878	-8.2	-9.6	-9.0	-8.5	-7.7	-7.0	-6.5
H31	534352	820705	-6.7	-8.0	-7.8	-7.6	-7.3	-7.0	-6.9
H32	534961	824183	-8.4	-9.8	-9.6	-9.3	-8.8	-8.5	-8.2
H33	533812	822112	-8.2	-9.5	-9.3	-9.1	-8.8	-8.5	-8.3
H34	533788	822143	-8.3	-9.6	-9.4	-9.2	-8.9	-8.6	-8.4
H35	535220	824333	-8.5	-10.0	-9.7	-9.3	-8.9	-8.4	-8.2
H36	534326	820215	-8.0	-9.3	-9.1	-8.8	-8.5	-8.1	-7.9
H37	536569	818707	-9.0	-10.5	-9.9	-9.3	-8.5	-7.8	-7.4
H38	534868	824326	-9.2	-10.7	-10.4	-10.1	-9.6	-9.2	-9.0
H39	534270	820167	-8.2	-9.6	-9.2	-8.8	-8.3	-7.7	-7.4
H40	534280	820106	-8.6	-9.9	-9.6	-9.4	-9.0	-8.6	-8.4
H41	536492	818590	-9.1	-10.7	-9.6	-8.7	-7.6	-6.6	-6.1

	ITM	ITM	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA	dBA
H42	535188	824469	-9.1	-10.6	-10.3	-9.9	-9.4	-9.0	-8.7
H43	536527	818584	-9.7	-11.1	-10.5	-10.0	-9.2	-8.5	-8.0
H44	533553	822169	-9.5	-10.8	-10.6	-10.3	-10.0	-9.7	-9.5
H45	534052	820668	-8.2	-9.5	-9.2	-8.9	-8.4	-8.0	-7.7
H46	533495	822184	-9.7	-11.1	-10.8	-10.6	-10.2	-9.9	-9.7

NB: H1 and H2 are derelict buildings

11.15 MITIGATION MEASURES AND RESIDUAL EFFECTS

11.15.1 Construction Noise Mitigation

No significant construction noise effects have been identified so no specific mitigation measures are required. General guidance for controlling construction noise through the use of good practice given in BS 5228 will be followed. During construction, activity shall be limited to daytime, except where delivery of large transport loads such as turbines, where it may be necessary to transport outside of daytime hours.

During decommissioning noise levels are likely be no more than predicted in **Table 11.12** as similar plant will be utilised. Any legislation, guidance or best practice relevant at the time of decommissioning should be complied with.

11.15.2 Residual Construction and Decommissioning Effects

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

11.15.3 Operational Noise Mitigation

The Wind Farm has been designed to comply with the Wind Energy Development Guidelines 2006, background noise levels and recent 2022 An Bord Pleanála decision.

All turbines will have STE fitted as industrial standard to reduce noise emission levels. No other mitigation is considered necessary.

11.15.4 Residual Operational Effects

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

11.15.5 Cumulative Effects

An assessment of the cumulative effects of noise from all windfarms within 3 km have been predicted and assessed and found to be in compliance with limits set in the Wind Energy Development Guidelines 2006 and recent An Bord Pleanála decision.

11.16 SUMMARY OF SIGNIFICANT EFFECTS

Table 11.18 below summarises the effects.

Table 11.18: Summary of Significant Effects

	Quality	Significance	Duration
Construction Noise Ground vibration	Negative Neutral	Not significant Imperceptible	Temporary Temporary
Operational Noise incl. Cumulative	Negative	Not Significant	Long Term

11.17 STATEMENT OF SIGNIFICANCE

The statement of significance has assessed the potential effects of the Wind Farm during operation, construction and decommissioning in **Sections 11.0 to 11.7**.

The effects of noise from the operation of the Wind Farm have been assessed using the 2006 Guidelines, the methodology described in ETSU-R-97 and the IOA Good Practice Guide. Noise levels during operation have been predicted using the best practice calculation technique, compared with the noise limits in the 2006 Guidelines and the 2013 An Bord Pleanála limits for the Wind Farm Site where a permit was granted for 21 turbines. At two derelict properties H1 and H2 the cumulative noise levels are marginally above (by less than 1dBA) the limit but this assumes that the wind is blowing from the wind farms south and north-east of the Proposed Development at the same time, which is an event that cannot occur. The reduction from the consented 21 turbine Wind Farm to the proposed 13 No. turbines reduces marginally the noise footprint.

Noise during construction and decommissioning will be managed to comply with best practice, legislation and guidelines current at that time so that effects are not significant. It is important to point out that construction is a short-term temporary activity.

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. There is now a review of this draft consultation document, 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 more restrictive guidelines are put in place.

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.

11.18 HYDROGEN PLANT

11.18.1 Introduction

The Hydrogen Plant is located in Castleconnor, Co. Sligo, approximately 4 km north-east of Ballina, 5.5 km west of the wind farm and within 0.6 km of the N59 National Primary Road.

The assessment considers the potential effects during the following phases:

- Construction
- Operation
- Decommissioning

Any effects arising from the future decommissioning are considered to be no greater than the effects arising during construction.

This section of the EIAR is also supported by the Figures in **Volume III** and the Appendices documents provided in **Volume IV** as stated in **Section 11.1**

11.19 DESCRIPTION OF THE PROPOSED DEVELOPMENT

The Hydrogen Plant will generate green hydrogen via electrolysis of water, splitting water into hydrogen and oxygen using electricity in an electrochemical cell. The electricity generated to power the Hydrogen Plant is proposed to come from the Firlough Windfarm, therefore the hydrogen produced will be green, with zero emissions.

The proposed Firlough Wind Farm configuration consists of 13 No. wind turbines, giving an overall installed capacity in the region of 78 MW. The electrolyser has been designed to match the size of the wind farm. Once hydrogen is produced, it can then be utilised as fuel, potentially benefitting Ireland's economy, while adhering to the country's net zero commitment. Plate 11.1 gives a generalised schematic of the hydrogen process.

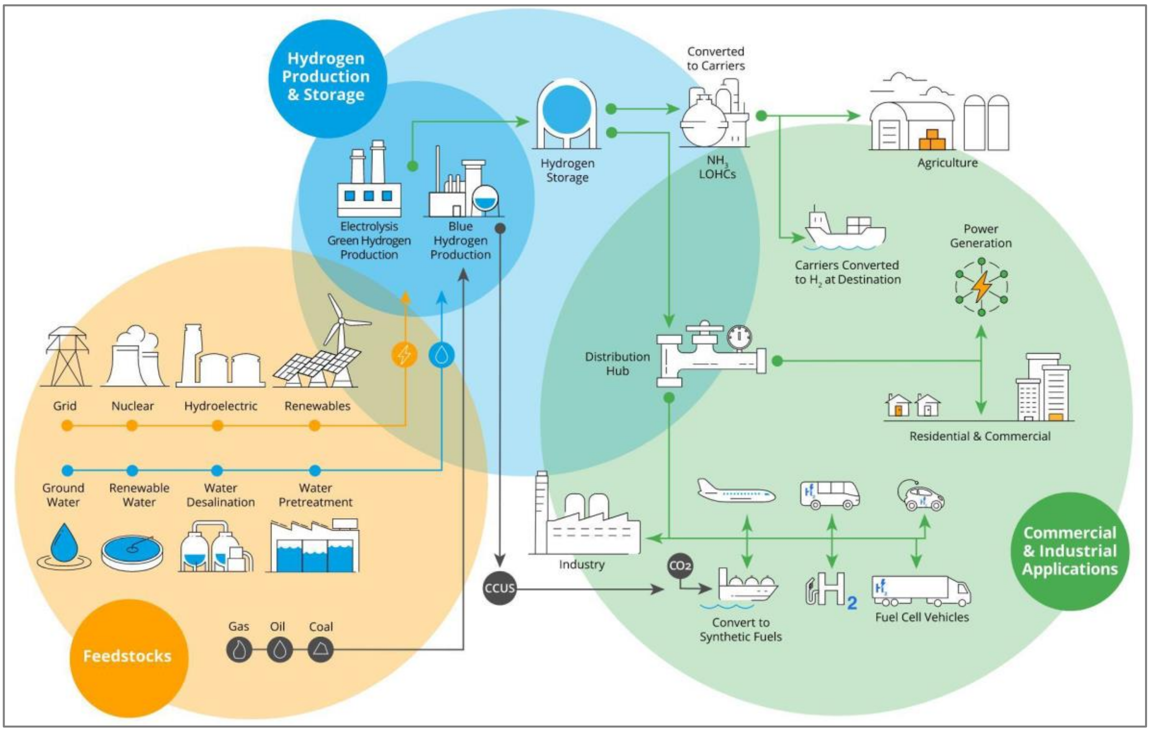

Plate 11.1: Hydrogen Generation Schematic

The assessment also includes the 110 kV interconnector between the Wind Farm Site and the Hydrogen Plant Substation. The site location and locations of baseline noise monitoring are shown in **Figure 11.4**.

11.20 ASSESSMENT STRUCTURE

The assessment structure is the same as given in **Section 11.1.3**. The description of effects is the same as that given in **Section 11.2.2**.

11.21 ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

The assessment methodology and significant criteria is the same as **Section 11.2.1** and **Section 11.2.2**.

11.22 LEGISLATION AND GUIDANCE

The Hydrogen Plant Site noise and vibration assessment is carried out in accordance with the guidance contained in the following documents:

- EPA Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4) (Jan 2016).
- ISO 1996-1-2016: Acoustics: Description and Measurement of Environmental Noise-Basic Quantities and Assessment Procedures.

- ISO 9613-2, First Edition 1996-12-15. Acoustics-Attenuation of sound during propagation outdoors-Part 2: General method of calculations
- Guidelines for the Treatment of Noise and Vibration in National Road Schemes
- BS5228, 2009 Code of Practice for Noise Control on Construction and Open Sites: Part 1: Noise.
- EPA, 2003, Environmental Quality Objectives-Noise in Quiet Areas
- HMSO, Department of Transport Welsh Office, 1988. Calculation of Road Traffic Noise
- World Health Organisation (WHO) publication Guidelines for Community Noise, 1999

11.22.1 EPA NG4

It is a requirement of the Environmental Protection Agency (EPA) to ensure that relevant licensed activities do not result in significant impact on the environment; this includes noise impact on the human environment. The EPA has produced a relevant guidance document NG4[25].

When the EPA Agency licence includes conditions relating to noise emissions, this would normally entail specified numerical noise limits which are not to be exceeded. These limits may apply to individual sources of noise on the site itself, at the boundary of the site or at the nearest Noise Sensitive Location (NSL).

The setting of noise limits at any or all of these locations may be required, and the assignment of such limits will be decided during the licensing process for the facility. All reasonably practicable measures should be adopted at licensed facilities to minimise the noise impact of the activity, and best avail technology (BAT) should be used in the selection and implementation of appropriate noise mitigation measures and controls.

While BAT must be applied on a case-by-case basis, the noise attributable solely to on-site activities, expressed as a free field value at any NSL, should not generally exceed the values given below.

- Daytime (07:00 to 19:00hrs) – 55dB $L_{Ar,T}$
- Evening (19:00 to 23:00hrs) – 50dB $L_{Ar,T}$
- Night-time (23:00 to 07:00hrs) – 45dB $L_{Aeq,T}$

11.22.2 World Health Organisation (WHO)

Example noise limits can be found in World Health Organisation (WHO) publication Guidelines for Community Noise, 1999 which states the following:

[25] Guidance Note for Noise: Licence Application, Survey and Assessments in relation to Scheduled Activities (NG4), Environmental Protection Agency Office of Environmental Enforcement (OEE), January 2016

"To protect the majority of people from being seriously annoyed during the daytime, the sound pressure level on balconies, terraces and outdoor living areas should not exceed 55 dB L_{Aeq} for a steady, continuous noise."

and

"For a good night's sleep, the equivalent sound level should not exceed 30dB(A) for continuous background noise, and individual noise events exceeding 45dB(A) should be avoided."

The good night sleep noise limits are for inside a room.

11.23 CONSTRUCTION AND DECOMMISSIONING ASSESSMENT METHODOLOGY

The guidelines for construction and decommissioning are the same as that given in **Section 11.12.4**, and **Table 11.9.**

11.23.1 Evaluation of Potential Effects

The potential impacts of construction are evaluated by comparing the predicted noise levels against the guideline values given in **Table 11.9** and sample criteria in Part 1 of BS 5228.

The potential operational impacts are evaluated by comparing the predicted noise levels against the daytime, evening and night-time noise limits given in **Table 11.20**.

11.24 BASELINE DESCRIPTION

11.24.1 Selection of Baseline Noise Survey Locations

Noise levels were measured at four locations surrounding the Hydrogen Plant Site between 29th July and 12th August 2022. The data was filtered to exclude the period between 29th July and 3rd August up to 08.00hrs when there was a generator operating which would have a small impact on the baseline measurements. The baseline noise monitoring locations are given in **Table 11.19.**

The instruments used in the noise survey were the same as used in **Section 11.13.2.**

Table 11.19: Noise Monitoring Locations

Description	Location (ITM)
NML1	529267, 823067
NML2	529639, 822657
NML3	529141, 822458

Description	Location (ITM)
NML4	528953, 822817

All acoustic instrumentation was calibrated before and after each survey and the drift of calibration was less than 0.3dB within accepted guidelines.

Weather during the surveys was dry and calm with wind speeds typically less than 5 m/s. Any periods or rainfall, or wind mean wind speed over 5 m/s were excluded for the dataset.

11.24.2 Noise Survey Results

The results of the noise measurements over the period between 08.00hrs on 3rd August to 12th August 2022 are given in **Figure 11.5** to **Figure 11.8** incl.

For the purposes of the NG4 assessment the measured daytime, evening and night-time ambient and background noise levels are presented in **Table 11.20**. The noise levels include the mean ambient (Leq dBA) and mean background (L90 dBA) levels measured in 30-minute intervals over the period given to the nearest whole number for each of the four locations.

Table 11.20: Summary of ambient and background noise levels from 3rd to 12th August 2022

Location NML1	Leq dBA	Lmax dBA	Lmin dBA	LA90 dBA
Day time	40	57	29	34
Evening	38	55	26	31
Night-time	31	50	19	21

Location NML2	Leq dBA	Lmax dBA	Lmin dBA	LA90 dBA
Day time	38	55	28	32
Evening	34	50	24	29
Night-time	31	47	19	21

Location NML3	Leq dBA	Lmax dBA	Lmin dBA	LA90 dBA
Day time	41	57	29	35
Evening	37	53	26	32
Night-time	31	51	19	22

Location NML4	Leq dBA	Lmax dBA	Lmin dBA	LA90 dBA
Day time	44	59	32	38

Location NML4	Leq dBA	Lmax dBA	Lmin dBA	LA90 dBA
Evening	44	60	28	36
Night-time	35	55	20	24

The baseline monitoring locations are considered representative of the environment surrounding the Proposed Development. Locations closer to the N59 are exposed to higher daytime noise levels from the traffic flow.

11.25 NOISE LIMITS

There are a number of steps involved in confirming the assessment under the NG4 guidance:

Step 1: Quiet Area Screening of the Development Location

The location of the Proposed Development should be screened in order to determine if it is to be located in or near an area that could be considered a 'Quiet Area' in open country according to the Agency publication Environmental Quality Objectives - Noise in Quiet Areas. This will involve determining if the following criteria are satisfied:

- At least 3 km from urban areas with a population >1,000 people;
- At least 10 km from any urban areas with a population >5,000 people;
- At least 15 km from any urban areas with a population >10,000 people;
- At least 3 km from any local industry;
- At least 10 km from any major industry centre;
- At least 5 km from any National Primary Route, and;
- At least 7.5 km from any Motorway or Dual Carriageway

The proposed site located within 1 km of the N59 National Primary Route and therefore not considered a quiet area.

Step 2: Baseline Environmental Noise Survey

Noise measurements were carried as detailed in **Section 11.23.1**.

Step 3: Screen Areas of Low Background Noise

For all areas not identified as Quiet Areas in Step 1, the existing background noise levels measured during the environmental noise survey should be examined to determine if they satisfy the following criteria:

- Average Daytime Background Noise Level ≤40dB L_{AF90}, and;
- Average Evening Background Noise Level ≤35dB L_{AF90}, and;
- Average Night-time Background Noise Level ≤30dB L_{AF90}.

If all three of the above criteria are satisfied for any of the measurement locations, then those locations are deemed to be in areas of low background noise and reduced noise limits apply. Three of the four locations satisfy the criteria of low background noise. NML 4 is marginally above the criteria for evening time as can be seen in **Table 11.20**. However, the lower criterion given for '*areas of low background noise'* will apply for all receptors surrounding the site.

Step 4: Determine Appropriate Noise Criteria

Based on the information in Step 1-3 above the site is not a quiet area but assumed as an area of low background noise level at all four locations.

The recommended noise for the site is defined within the "Areas of Low Background Noise" criteria as shown in **Table 11.21** below.

Table 11.21: Recommended Noise Limit Criteria Given by NG4

Scenario	Daytime Noise Criterion, dB $L_{Ar,T}$ (07:00 to 19:00hrs)	Evening Noise Criterion, dB $L_{Ar,T}$ (19:00 to 23:00hrs)	Night-time Noise Criterion, dB $L_{Aeq,T}$ (23:00 to 07:00hrs)
Quiet Area	Noise from the licensed site to be at least 10dB below the average daytime background noise level measured during the baseline noise survey	Noise from the licensed site to be at least 10dB below the average evening background noise level measured during the baseline noise survey	Noise from the licensed site to be at least 10dB below the average night-time background noise level measured during the baseline noise survey
"Areas of Low Background Noise"	**45dB**	**40dB**	**35dB**
All other Areas	55dB	50dB	45dB

It should be noted that the criteria specifies that there should be no clear tonal or impulsive noise audible at night-time and accordingly no rating level is applied.

11.26 DEVELOPMENT DESIGN MITIGATION

There are number of mitigation measures to be incorporated into the design of the Hydrogen Plant as specified in **Section 11.25.4.4**.

11.27 ASSESSMENT OF POTENTIAL EFFECTS

11.27.1 Construction and Decommissioning Noise Levels

The main construction noise sources associated with the Proposed Development will be the levelling of the site which involves cutting into the side of a hill and removing material to the lower elevation of the site increasing the level above adjoining ground. This activity involves removing the topsoil, levelling and compacting the site. A 110 kV interconnector will be made between the Wind Farm Substation and the Hydrogen Plant Substation which will involve trenching activity similar to the grid connection. Other noise sources will involve construction of walls (including retaining walls) and floors, placement of pillars and beams to form the fabric of the Electrolyser Building. Construction noise associated with access road to the site is not considered as significant as the nearest receptors are closer to the N59. 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 11.22** indicates typical construction range of noise levels for this type of activity (levels from author's database and BS 5228). Predictions are made for the nearest receptors surrounding the Proposed Development.

Table 11.22: Typical Construction Noise Levels

Activity	L_{Aeq} dB at 10 m
Tower Crane, Dump truck, Tracked excavator (C.2.13)	72-78dBA
Large tracked excavator removing topsoil, subsoil for Site preparation	80- 87dBA
Rock breaker, vibrating rollers, trucks loading and tipping material	76-89dBA
Rotary bored piling rig, Tracked excavator, Articulated lorry (C11.19)	72-83 dBA
Loading / Tipping, Excavator, Dozer and Vibratory roller	80- 87dBA
General Construction: Grinders, circular saw, hand tools, Poker vibrator, Teleporter, Forklift, Articulated Lorry	71-77dBA
Trucks pouring concrete, Concrete pump, Screeding concrete	78-84dBA
Tracked Mobile Crusher (C9.14)	90dBA
Interconnector: Trenching, Tracked excavator 14t, Pneumatic breaker, vibratory roller	70-73

Construction noise levels from site activity are predicted according to the methodology in **Section 11.14.1**. Noise levels are predicted for receptors within 650 m of the Hydrogen Plant Site using a range of noise levels given in **Table 11.23** (71-90 dBA). Predictions are also made at varying distances for the interconnector between the Wind Farm Substation and the Hydrogen Plant. Substation using the similar noise levels as associated with grid connection in **Table 11.12**. Predictions are made to the nearest whole number.

Table 11.23: Predicted Construction Noise Levels

Nearest Receptor	Activity Range at 10 m LAeq dB 1hr	Distance to Activity (m)	L_{Aeq} dB 1hr Range
HH 1	71-90	294	39-58
HH 2	71-90	353	37-56
HH 3	71-90	352	37-56
HH 4	71-90	368	37-56
HH 5	71-90	399	36-55
HH 6	71-90	458	35-54
HH 7	71-90	453	35-54
HH 8	71-90	524	34-53
HH 9	71-90	542	33-52
HH 11	71-90	593	32-51
HH 12	71-90	626	32-51
HH 14	71-90	640	32-51
Varying distance	70-73	15 m 20 m 40 m 80 m	67-70 64-67 58-61 52-55

The predicted site noise levels are well within the NRA guidelines and considered not significant. From monitoring intensive construction activity on other sites over a number of years it is expected that the maximum noise levels predicted would be experienced for less than 2 days equivalent (16 hours) for the duration of the construction period.

<u>Construction Traffic</u>

The main construction traffic to the site will be delivery of materials such as hardcore, concrete, building materials for building construction and construction staff. Construction is expected to extend for a period of 21 months. There are two receptors HH11 and HH6 within 150 m of the access road. HH6 is at 30 m to the access road while HH11 is at 14 m. HH11 is only 10 m from the N59 Regional Road which has an average traffic flow of 215 veh/hr and in a location where the Hydrogen Plant Site access /departing trucks will be moving at a very slow speed thereby generating very low levels of noise.

There will be an increase in road traffic on the N59 due to delivery of crushed stone for site tracks and for engineering fill. Traffic will also be generated by material associated with the interconnector. There is a logarithmic relationship between road traffic flow and noise levels. Typically doubling the traffic flow will result in a 3 dBA increase in noise level and a 30% increase will increase noise levels by 1 dBA while a 50% increase results in a 2 dBA increase. The peak road traffic flow on the N59 is 433 veh/hr with the average daily flow between 06:00 to 18:00hrs at 215 veh /hr. The increase in traffic flow on the N59 is from construction will be negligible. The road traffic noise impact will be imperceptible along the N59 National Road.

Ground Vibration

Ground vibration from construction traffic and site works will be well below the threshold of sensitivity to humans of 0.2 mm/s peak particle velocity at all receptors.

11.27.2 Description of Effects

The criteria for description of effects for all construction and vibration activity and the potential worst-case effects at the nearest receptors are given **Table 11.24**.

Table 11.24: Description of Effects

	Quality	Significance	Duration
Construction noise	Negative	Not Significant	Temporary
Ground vibration	Neutral	Imperceptible	Temporary
Construction Traffic	Negative	Not Significant	Temporary

11.27.3 Decommissioning

Should any element of the Hydrogen Plant be decommissioned, the noise effects during decommissioning of the Hydrogen Plant are likely to be of a similar nature to that during construction but of shorter duration. Any legislation, guidance or best practice relevant at the time of decommissioning will be complied with.

11.27.4 Predicted Operational Noise Levels

The inputs for the noise modelling assessment are described in detail in this Section. The layout of the Hydrogen Plant Site, including all receptors within 1 km is shown in **Figure 11.9**. A detailed site layout is given in **Figure 2.2** in **Chapter 2**.

11.27.4.1 Noise Modelling

For the purposes of this assessment, computer modelling has been undertaken to accurately predict noise emissions at the nearest residential properties due to the Proposed Development. The model was implemented in SoundPLAN version 8.2, which is produced by Braunstein & Berndt GmbH. The SoundPLAN implementation of ISO9613 has been tested in-house by SoundPLAN developers to ensure calculated results are within 0.2dB of the standard.

The model is integrated, allowing noise from all sources, with prediction methodologies to be undertaken simultaneously. The noise model takes into consideration the following parameters:

- Topographical effects
- Atmospheric absorption
- Ground absorption
- Screening effects
- Reflections
- Focusing effects
- Metrological conditions

The model predicts the propagation of noise in each octave-band for source-receiver pair and produces a noise level contour map. The noise level contour map is given in **Figure 11.9**.

11.27.4.2 Source Noise Levels and Noise Model Inputs

The main components onsite which will generate noise are presented in **Table 11.25**.

Table 11.25: Frequency spectrum octave data

Source	Octave Band Sound Power Level dB (Lin)								Sound Power Level dB(A)
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	
Inside Electrolyser Building (Lp)	90.6	90.6	85.6	80.6	75.6	70.6	68.6	62.6	**83***
Water Treatment Pumps	75.4	76.5	78.4	78.4	81.4	78.4	74.4	68.4	**85**
Fin-Fan Coolers	110	105	100	96	97	94	92	91	**102**
Compressor	75.4	76.4	78.4	81.1	78.4	78.4	74.4	68.4	**85**
Transformer	90.6	92.6	87.6	87.6	81.6	76.6	71.6	64.5	**88**
Other Pumps, fans, etc.	75.4	76.4	78.4	81.1	78.4	78.4	74.4	68.4	**85**

***** Inside building (sound pressure level)

All site components have been modelled with a 100% on-time.

Digital mapping was used to present the site layout and the closest residential properties in the vicinity of the site.

The noise model accounts for the topography of the existing and proposed land in the vicinity of the site, where it is proposed that the Proposed Development will sit at a lower ground level in comparison to the existing land, where the raised land surrounding the site effectively acts as a barrier.

11.27.4.3 Receptor Locations

The twenty-two closest sensitive residential properties to the site have been deemed representative of the worst-case scenario for the noise assessment and are the receptors within 1 km of the Proposed Development. Receptor locations are shown on **Figure 11.9** with co-ordinates given in **Table 11.26**.

11.27.4.4 Mitigation Measures

There are number of mitigation measures to be incorporated into the design of the site:

- The metal clad insulation within the Electrolyser Building will have a minimum Rw of 35dB.
- The enclosure to the fin fans will reduce the noise level by 12dB, or alternatively low noise designs with low face velocities with an increase in surface area could also be considered.
- The housing envelope enclosing the Compressor and Standby Compressor will have a minimum Rw of 25dB.

11.27.4.5 Predicted Noise Levels

The predicted noise levels (L_{Aeq} to the nearest dBA) at each receptor location are presented in **Table 11.26**. The predicted levels assume that the Hydrogen Plant is operating at maximum capacity. A noise contour map of the predicted noise levels is presented in **Figure 11.9**.

Table 11.26: Predicted Noise levels from Hydrogen Plant Operating at Maximum Capacity

House ID	ITM Easting	ITM Northing	LAeq,1hr, dB dBA
HH1	529794	822941	31
HH2	529380	823058	29
HH3	529988	822739	30
HH4	529326	823086	27
HH5	529094	822988	24
HH6	528985	822881	22
HH7	529027	822993	23
HH8	530147	822846	27

	ITM	ITM	LAeq,1hr, dB
House ID	Easting	Northing	dBA
HH9	528798	822416	21
HH10	529036	822007	21
HH11	528806	822829	20
HH12	530271	822500	24
HH13	529195	821845	21
HH14	530041	821965	21
HH15	528639	822567	19
HH16	528650	822820	19
HH17	529908	821735	21
HH18	528512	822829	17
HH19	528512	822831	17
HH20	528437	822247	17
HH21	528872	821600	17
HH22	528415	822856	16

11.27.4.6 Road Traffic

Site Access Road

During operations, the maximum number of trucks to the Hydrogen Plant Site will be 26 per day which equates to 52 movements per day. Distributed over a 12-hour period (07.00-19.00hrs) this equates to 4.3 movements per hour. The average movement is taken as 5 trucks per hour. There are two receptors within 150 m of the access road HH11 and HH6. HH6 is at 30 m to the access road while HH11 is at 14 m. HH11 is only 15 m from the N59 which has an average traffic flow of 215 veh/hr and at a location where access road trucking will generate very low levels of noise. The mean traffic flow at 15 m from the N59 would generate noise levels in the region of 60-65 dB L_{Aeq} 1hr.

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 travelling downhill, in decibels (dB); Q is 5, the number of vehicles per hour; V is 40, the average vehicle speed, in kilometres per hour (km/h); d is the distance of receiving position at 30 m from the centre of haul road, in metres (m).

L_{Aeq} = 105-33 + 10log 5 – 10log40 – 10log20 = 50 dB L_{Aeq} 1hr. A lower sound power level is expected by a truck loaded going down hill on a smooth surface. The noise level generated by trucking along the access road to the Hydrogen Plant is predicted at 50 dB L_{Aeq} 1hr. In practice the levels generated by truck movement will be lower than predicted due to the smooth surface on the access road.

Additional Traffic on N59

There is a logarithmic relationship between road traffic flow and noise levels. Typically doubling the traffic flow will result in a 3 dBA increase in noise level and a 25% increase will increase noise levels by 1 dBA. The peak road traffic flow on the N59 is 433 veh/hr with the average daily flow between 06:00 to 18:00hrs at 215 veh /hr. The average flow from the operating site is 5 veh/hr which may go in a NE or SW direction. Assuming that all traffic goes in the same direction (10 movements/hr) results in an increase of less than 5%.

The increase in traffic flow on the N59 is negligible. The road traffic noise impact will be imperceptible along the N59 National Road.

Ground Vibration from Operation of Hydrogen Plant and Traffic Flow

The level of ground vibration from the operation of the Hydrogen Plant is below human threshold of 0.2 mm/s for the operation of the plant including trucking from same.

11.27.4.7 Operational Noise Assessment

The maximum predicted noise levels are well within the noise limits for areas of low background as recommended by the EPA's NG4 for day, evening and night-time. The predicted noise levels include the ameliorative measures specified in **Section 11.25.4.4**.

The assessment is based on the Hydrogen Plant operating at maximum capacity. It should be noted that when turbine wind speeds (which generates the energy to operate the plant) are below the cut-in speed of 3 m/s then the Hydrogen Plant does not operate and when below wind speeds of 5 m/s the plant will operate at lower capacity thereby generating lower noise levels at all receptors.

11.28 MITIGATION MEASURES AND RESIDUAL EFFECTS

11.28.1 Construction Noise Mitigation

No significant construction effects have been identified. General guidance for controlling construction noise through the use of good practice given in BS 5228 will be followed. During construction of the Proposed Development, activity generated noise shall be limited to daytime guidance given in the NRA guidelines, except where delivery of large transport loads such as the turbines, where it may be necessary to transport outside of daytime hours. During decommissioning of the Hydrogen Plant, if applicable, noise levels are unlikely to be more than predicted in **Table 11.23** as similar plant will be utilised. Any legislation, guidance or best practice relevant at the time of decommissioning will be complied with.

11.28.2 Residual Construction and Decommissioning Effects

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

11.28.3 Operational Mitigation

The Hydrogen Plant has been designed to comply with a low background site according to the EPA's NG4 guidelines. A number of mitigation measures are specified in **Section 11.25.4.4** to be incorporated into the design of the Hydrogen Plant Site.

11.28.4 Residual Operational Effects

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

11.28.5 Cumulative Effects

The Firlough Wind Farm and cumulative effects of five other wind farms have been assessed. Firlough Wind Farm is the nearest wind farm at over 5.5 km from the Hydrogen Plant, so the potential for cumulative effects do not exist.

11.29 SUMMARY OF EFFECTS

Using the EPA criteria for description of effects, the potential worst-case associated effects at the nearest noise sensitive receptors associated with the operation of the Hydrogen Plant is described in **Table 11.27**. The description includes the ameliorative measures in **Section 11.25.4.4**. The summary effects also include the wind farm and cumulative wind farms.

Table 11.27: Summary of Effects

	Quality	Significance	Duration
Firlough WF: Construction Noise Operational Noise Cumulative Noise	 Negative Negative Negative	 Not significant Not Significant Not Significant	 Temporary Long Term Long Term
Hydrogen Plant:			

	Quality	Significance	Duration
Construction Noise	Negative	Not Significant	Temporary
Construction Ground Vibration	Negative	Imperceptible	Temporary
Operational Noise	Negative	Not Significant	Long Term
Operational Road Traffic	Negative	Not Significant	Long Term
Operational Ground Vibration	Neutral	Imperceptible	Long Term

11.30 STATEMENT OF SIGNIFICANCE

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

The effects of noise from the operation of the Wind Farm 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 including the cumulative effects have been predicted using the best practice calculation technique and compared with the noise limits in the 2006 Guidelines, the existing limits for the Wind Farm Site and recent 2022 noise limits in An Bord Pleanála Decisions.

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 effects of noise and vibration from the operation of the Hydrogen Plant have been assessed using the methodology given in the EPA's NG4. Noise levels have been predicted using best practice calculation technique with mitigation design measures incorporated.

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.