MWP

Chapter 10 Noise and Vibration

Ballycar Wind Farm

10. Noise and Vibration

10.1 Introduction

This chapter of the Environmental Impact Assessment Report (EIAR) describes the potential noise and vibration effect from the proposed development. The overall project is described in **Chapters 1** and **2** of this EIAR.

Once operational there will be noise from the wind turbines and associated substation. There will be noise from plant and machinery during the construction phase of the project. The noise associated with felling is typical of forestry operations and will be carried out in accordance with Forest Service Guidance and the felling licence approval.

Noise and vibration assessments were undertaken for the construction, operational and decommissioning phases of the proposed development and the grid connection route. It is worth noting that construction noise from the wind farm itself is the worst-case scenario as the works along the grid connection route are of a much less scale and duration. Accordingly, the noise sensitive receptors relate to the construction and operation of the wind turbines.

10.1.1 Noise and Vibration Emissions from a Wind Farm Development

The main sources of noise from a wind turbine include aerodynamic noise (rotating blades in the air) and mechanical noise (gearbox (if not a direct drive system) and generator).

Noise only occurs above the 'cut-in' wind speed and below the 'cut-out' wind speed. The typical 'cut in' wind speed of a modern turbine is 3 meters per second (m/s) and the 'cut-out' wind speed is approximately 25 to 30 m/s.

The Vestas V136, 4.5 MW wind turbine, has been modelled in the proceeding analyses as the turbine candidate. This turbine is a pitch regulated upwind turbine.

Construction noise will occur during excavation and earth moving, laying of access tracks and hard standings, transportation of materials and erection of the wind turbines. The construction phase will be phased and temporary. The decommissioning phase works will be similar in magnitude to the construction phase.

Blasting, instead of rock breaking may be required in the proposed borrow pit as an alternative to rock breaking. Noise and vibration will be controlled by prescribed measures to ensure there will be no significant effects on sensitive receptors. Once operational, there will be no significant vibrations from the proposed development.

10.1.1.1 2006 Wind Energy Guidelines

The noise assessment has been based on guidance in relation to acceptable levels of noise from wind farms as contained in the document "Wind Energy Development Guidelines" published by the Department of the Environment, Heritage and Local Government in 2006. These guidelines are in turn based on detailed recommendations set out in the Department of Trade & Industry (UK) Energy Technology Support Unit (ETSU) publication "The Assessment and Rating of Noise from Wind Farms" (1996). The ETSU document has been used to supplement the guidance contained within the "Wind Energy Development Guidelines" publication.

The noise limits set out in the 2006 guidelines are currently the guidelines which An Bord Pleanála must have regard to and which are adopted by the expert community when assessing the potential effect from wind farm noise.

It is noted that three recent wind farm grants of permission from ABP utilise the existing 2006 Guidelines, specifically:

- ABP-313750-22 Seven Hills Wind Farm (23rd November 2023);
- ABP-308799-20 Carrownagowan Wind Farm (29th September 2022);
- ABP-309306-21 Castleblaney Wind Farm (22nd September 2022).

10.1.2 Fundamentals of Noise

Fundamentally, noise is vibrations of the air which are detectable by the ear. Sound waves radiate out spherically from a sound source in three dimensions.

The human ear can detect a very wide range of pressure variations. In order to cope with this wide range, a logarithmic scale (decibel (dB) scale) is used to translate pressure values into manageable numbers from 0dB to 140 dB. 0 dB is the threshold of hearing and 120 dB is the threshold of pain.

Measuring in decibels means that a 3 dB increase is equivalent to a doubling of the sound energy and a 10 dB increase is a tenfold increase in energy. For broadband sounds which are very similar in all but magnitude, a change or difference in noise level of 1 dB is just perceptible under laboratory conditions, 3 dB is perceptible under most normal conditions and a 10 dB increase generally appears twice as loud.

A healthy human ear is also sensitive to a large range of frequencies (approximately 20 Hz to 20,000 Hz) and varies in sensitivity depending on the frequency.

The human ear is not equally sensitive to sound at all frequencies and is less sensitive to sound at low frequencies and high frequencies. A -weighting (dB A) is the main way of adjusting measured sound pressure levels (noise) to take account of the uneven human response to frequencies.

Figure 10-1 illustrates some everyday sounds on the dB(A) scale. A quiet bedroom is around 35 dB(A), a busy office around 60dB(A) and a rock concert around 100 dB(A). The illustration is extracted from draft Wind Energy Development Guidelines 2019.

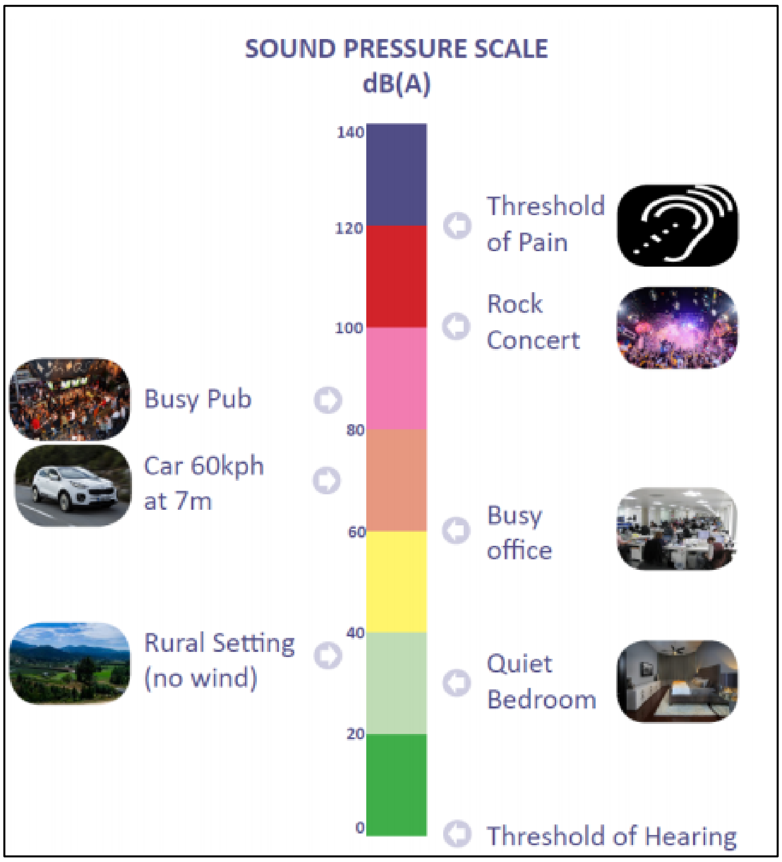

Figure 10-1: The Level of Typical Common Sounds on the dB(A) Scale

10.2 Methodology

In general, the methodology used to assess the noise effect from wind farms includes extended measurements of the existing background noise levels (across a range of wind speeds) at nearby representative locations and comparisons against the predicted noise output from the wind farm, which also varies with wind speed. The methodology and planning guidance framework are described in the following sections.

10.2.1 Operational Wind Farm Noise Policy and Guidance

As with any development, a balance must be struck between the noise restrictions placed on a wind farm, the protection of amenity and the national and global benefits of renewable energy development. This Noise Assessment has been prepared in accordance with the following guidance documents:

EPA Guidelines on the information to be contained in Environmental Impact Assessment Reports, 2022

A description and significance of the effects of the proposed development are described in accordance with this document as outlined in Table 5-5 (Chapter 05 Population and Human Health).

Guidance on the preparation of the Environmental Impact Assessment Report (Directive 2011/92/EU as amended by 2014/52/EU)

The assessment was carried out in accordance with the above EIA report guidance which aims to help developers and consultants alike prepare good quality environmental impact assessment reports. The guidelines were considered and consulted for the purposes of this chapter.

Department of the Environment, Heritage, and Local Government (DoEHLG) – Wind Energy Development Guidelines (2006)

This document provides the framework for wind farm noise assessment in Ireland. The noise limit thresholds in this publication are those currently endorsed by the Irish Government and deemed to strike the balance between the protection of residential amenity and renewable energy developments. These guidelines remain in force until the final version of the replacement WEDGs is published.

Information Note Review of the Wind Energy Development Guidelines 2006 "Preferred Draft Approach" 2017

Following detailed engagement between the Department of Housing, Planning, Community and Local Government (DHPCLG) and the Department of Communications, Climate Action and Environment (DCCAE), an emerging "preferred draft approach" to the Review of the 2006 Wind Energy Development Guidelines was jointly announced on 13 June 2017.

The 2017 Information Note, "*preferred draft approach*" proposes noise restriction limits in broad terms consistent with World Health Organisation standards, proposing a relative rated noise limit of 5dB(A) above existing background noise within the range of 35 to 43dB(A), with 43dB(A) being the maximum noise limit permitted, day or night. The details surrounding the derivation of the proposed noise limit criteria was not published in this document.

ETSU-R-97 – The Assessment and Rating of Wind Farm Noise (1997)

The assessment related to the proposed development was undertaken with regard to ETSU-R-97 – The Assessment and Rating of Wind Farm Noise (1997). The noise levels contained within the DoEHLG Wind Energy Development Guidelines 2006 are adapted from this document.

A Good Practice Guide (GPG) to the application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (Institute of Acoustics 2013)

This publication which was issued by the Institute of Acoustics in May 2013, is endorsed by the UK, Department of Energy and Climate Change (DECC), the Northern Ireland Executive, the Scottish Executive and the Welsh Assembly, and provides guidance on all aspects of the use of ETSU-R-97. The assessment presented herein adopts the recommendations of the GPG.

10.2.2 Construction and Decommissioning Phases Impact Assessment – Best Practice and Guidance

There are no mandatory noise limits for construction noise in Ireland. The most recent revision of *British Standard 5228-1:2009+A1:2014, Code of practice for noise and vibration control on construction and open sites* outlines noise thresholds for significant effects.

The Irish National Roads Authority (NRA) (now TII) - *Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes*, March 2014 was also consulted for noise and vibration related effects.

The construction and decommissioning works will be broadly similar, with comparable plant and machinery involved. The assessment criteria will be the same and both will be temporary effects of short duration. Therefore, for the purpose of this assessment the conclusions of the construction phase effects can be assumed for the decommissioning phase.

10.2.3 Criteria for Evaluating the Operational Phase Impact from Wind Turbines

Current wind farm noise limit thresholds are described in the Department of Environment Heritage and Local Government (DoEHLG), Wind Energy Development Guidelines, 2006.

It recommends that noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed. Wind turbine noise is directly related to wind speed. Therefore, the guidelines are based on the principle that turbine noise should be controlled with reference to fixed limits when background noise is low, or relative to background noise itself as it increases with wind speed, whichever is greater. The interpretation of these limits is that turbine-attributable noise should be limited to:

- 43 dB LA90 10min for night-time hours;
- 45 dB LA90 10 min or 5 dB above background noise, whichever is greater, at the noise sensitive receptor for daytime hours;
- 35 to 40 dB LA90 10 min or 5 dB above background noise, whichever is greater, at the noise sensitive receptor where background noise is less than 30 dB LA90.

For the purpose of this assessment, the fixed lower limit has been set at L90 40dB(A). This lower limit value for areas of low background noise is lower than typical noise limits (LA90 43dB or 5 dB above background) set down in recent planning conditions for similar developments. It is also lower than the lower limit value (45dB(A) for daytime in the EPA document '*Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities*' (NG4). The aforementioned noise criteria have been adopted in recent An Bord Pleanála Conditions including:

- ABP-313750-22 Seven Hills Wind Farm (23rd November 2023);
- ABP-308799-20 Carrownagowan Wind Farm (29th September 2022);
- ABP-309306-21 Castleblaney Wind Farm (22nd September 2022).

10.2.4 Criteria for Evaluating Construction and Decommissioning Noise Effects

There is no statutory guidance in Ireland relating to the maximum noise levels permitted during construction (and decommissioning in this instance) works. In the absence of statutory guidance or other specific limits prescribed by local authorities, the thresholds outlined in the *British Standard 5228-12009+A1:2009, Code of Practice for Noise and Vibration Control on Construction and Open Sites - Noise* has been adopted in this assessment, as they are recognised by the expert community as the most appropriate in the assessment of construction noise. The noise levels, which are reproduced in **Table 10-1**, are typically deemed acceptable.

Table 10-1: Construction Stage Noise Level Thresholds

Assessment category and threshold value period (T)	Threshold values, LAeqT dB		
	Category A Note A	Category B Note B	Category C Note C
Night-time (23:00 to 07:00hrs)	45	50	55
Evening and Weekends Note D	55	60	65
Daytime (07:00 – 19:00hrs) and Saturdays (07:00 - 13:00hrs)	65	70	75

Note A: Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values.
Note B: Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as category A values.
Note C: Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are higher than category A values.
Note D: 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays.

Given the rural nature of the site, all properties will be afforded a Category A designation. Therefore, if the predicted construction noise exceeds 65dB LAeq(T), this is assessed as a significant effect.

10.2.5 Criteria for Evaluating Construction and Operational Vibration Effects

Vibration emissions are limited to the construction phase of the proposed development and the grid connection route.

According to NRA's (now TII) 2014 *Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes*, there are two separate considerations for vibration during the construction phase namely 1) that which affects human comfort and 2) that which affects cosmetic or structural damage to buildings.

The guidelines suggest that human tolerance for daytime blasting and piling, two of the primary sources of construction vibration, limits vibration levels to a peak particle velocity (ppv) of 12mm/s and 2.5mm/s respectively.

To avoid the risk of even cosmetic damage to buildings, the guidelines suggest that vibration levels should be limited to 8mm/s at frequencies of less than 10Hz, to 12.5mm/s for frequencies of 10 to 50Hz, and to 20mm/s at frequencies of 50Hz and above.

10.2.6 Scope of the Assessment

The scope of the assessment has been defined by industry standard best practice and guidance (Section 10.2) used in Ireland. In general, this includes:

- Establishing the existing or baseline noise conditions at representative noise sensitive receptors.
- Establishing noise limits based on the measured baseline noise levels in accordance with best practice and guidance.
- Using computer software, predict the noise emissions from the proposed wind farm and associated infrastructure at the noise sensitive receptors.
- Comparing the wind farm noise emissions against the noise limit criteria. The predicted wind farm noise emissions must not exceed the noise limit criteria.

10.2.7 Statement on Limitations and Difficulties Encountered

There has been some difficulty surrounding the uncertainty of the assessment criteria. The current 2006 Guidelines remain in force until the revised Guidelines are published in final form and therefore are used for this assessment.

It is acknowledged that the 2006 Wind Energy Development Guidelines are currently being revised. A draft version of the replacement Wind Energy Development Guidelines (WEDG) was published in December 2019. At the time of writing this chapter, submissions were being received on the draft document. There is no timeline on the publication of the finalised document and at the time of writing, the 2006 Guidelines are in force until the new WEDGs are published in final form. As the 2019 Draft WEDGs have undergone further consultation and have yet to be finalised, they are subject to further change. The core of this assessment is based on the only Irish guidelines currently in force, which are the 2006 WEDGs. At this point it is not known what the specific parameters for assessment will be provided in the final version of the revised Wind Energy Guidelines. A large volume of submissions has been received regarding the draft document and due consideration must be given to these submissions.

Therefore, in line with best practice, which includes ESTU and IoA methodologies as described, the assessment presented in the EIAR is based on the current best practice guidance outlined in Section 5.6 of the Wind Energy Development Guidelines for Planning Authorities, 2006. The original ETSU-R-97 concepts on which both the WEDG06 and DRWEDG19 are based underwent a thorough standardisation and modernisation in 2013 with the Institute of Acoustics publication of 'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise' including 6 Supplementary Guidance Notes, all of which bring together the combined experience of acoustic consultants in the UK and Ireland in the application of these methods. Numerous improvements in the accuracy and robustness are described, in particular the treatment of wind shear and the general adaptation to larger wind turbines. The assessment in the EIAR is therefore in full accordance with the latest best-practice methods.

10.3 Existing Environment

This section describes the existing environment in terms of the noise monitoring locations, existing noise sources at these locations and the prevailing background noise levels.

The wind farm is to be developed in a rural area of county Clare, with all proposed wind turbines situated within a "Strategic" area for wind farm development as per the Clare County Development Plan 2023-2029. A detailed description of the locality is provided in Chapter 2 of this EIAR. The land use in the immediate area is mainly agricultural and forestry related. This also applies to the work areas of the grid connection route.

The main sources of noise in the area include traffic on the local and regional road network, and machinery involved in working agricultural land and forestry. Natural noise sources include wind borne noise in vegetation and water in streams and rivers. Limerick city and suburbs are approximately 3km south of the proposed development.

The following sections describe how the existing pre-development noise environment was measured and characterised.

10.3.1 Noise Sensitive Receptors

At the start of the noise assessment, a preliminary desktop modelling exercise was undertaken using computer software to locate noise sensitive receptors (NSR's) and to identify suitable locations at which to monitor background noise. The first iteration of the wind turbine layout was input into the software using noise data for the candidate turbine representative of the type that could be installed on the site.

The noise contour plot predicted wind turbine noise levels at the NSR's surrounding the proposed development with predicted turbine noise (measured in dB(A), L_{90}) decreasing with distance from the proposed development. All properties or clusters of properties within or close to the 35dB(A) contour were then identified and assessed to determine which NSR's would provide representative background noise data for others in the area. Irrespective of the 35dB(A) contour, noise level predictions for all receptors numbered in Figure 10-2 were calculated.

In accordance with the *Institute of Acoustics Good Practice Guide (IOA GPG)*, the noise contour plot is based on a noise level at a wind speed of 8 m/s (as standardised to 10m height) as the manufacturer determined that this is the wind speed with the highest predicted noise level for the candidate turbine, namely the Vestas V136, 4.5MW turbine.

The EPA's Guidance Note for Noise: *Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (2016)*, defines a noise sensitive location as "any dwelling house, hotel or hostel, health building, educational establishment, place of worship or entertainment, or any other facility or other area of high amenity which for its proper enjoyment requires the absence of noise at nuisance levels".

In total, five (5) noise monitoring locations (NML) were selected to characterise the existing noise environment and derive the noise limit criteria for potentially effected locations. These locations were carefully selected in accordance with guidelines, to characterise the existing local noise environment. A description of the noise monitoring locations is presented in Table 10-2. Noise monitoring was carried out between the 21st October 2021 and 21st November 2021.

Table 10-2: Noise Monitoring Locations

NML Number	Receptor	Approximate GPS	Photograph
NML 1	Rural location. Generally quiet. Birdsong, livestock, and windborne noise contributed to ambient noise levels. Occasional aircraft noise.	52.731586, -8.661610	
NML 2	Occupied farmhouse. Rural location. Generally quiet. Birdsong, livestock, and windborne noise contributed to ambient noise levels. Occasional aircraft noise. Low level background noise from Limerick City.	52.725240, -8.678633	
NML 3	Occupied farmhouse. Rural location. Generally quiet. Birdsong, livestock, and windborne noise contributed to ambient noise levels. Occasional aircraft noise. Low level background noise from Limerick City.	52.711993, -8.666404	
NML 4	Field (proxy location for nearest dwelling). Rural location. Generally quiet. Birdsong, livestock, and windborne noise contributed to ambient noise levels. Occasional aircraft noise. Low level background noise from Limerick City. Traffic on local road.	52.704607, -8.643759	

NML Number	Receptor	Approximate GPS	Photograph
NML 5	Dwelling. Rural location. Generally quiet. Birdsong, livestock, and windborne noise contributed to ambient noise levels. Occasional aircraft noise. Low level background noise from Limerick City. Traffic on local road including quarry HGV's.	52.721650, -8.645234	

10.3.2 Background Noise Monitoring

Background noise monitoring was undertaken over a four week period commencing on the 22nd October 2021. The chosen locations are rural in nature and soundscape characteristics will be representative of present day. The relative locations of the NML's, dwellings and proposed development infrastructure are illustrated on **Figure 10-2**. It is not practical, feasible or recommended by the guidelines to measure background noise at every single location within the study area. Rather, representative locations are selected to characterise the existing noise environment of the wider area. For this assessment a study area of 1.36 km or 10 times the rotor diameter was adopted. The predicted noise emissions for each of these locations has been calculated. All dwellings identified within this zone are illustrated in **Figure 10-2**, more zoomed illustrations are presented in **Figures 10-3** to **10-7**. If for whatever reason a dwelling is not obvious from the mapping, calculations for all dwellings within this zone have been undertaken. The software calculated the noise levels on a grid across the whole area. Even future receptors can be determined or even estimated with a high degree of accuracy by extrapolating from the results of the nearest point identified in the following figures.

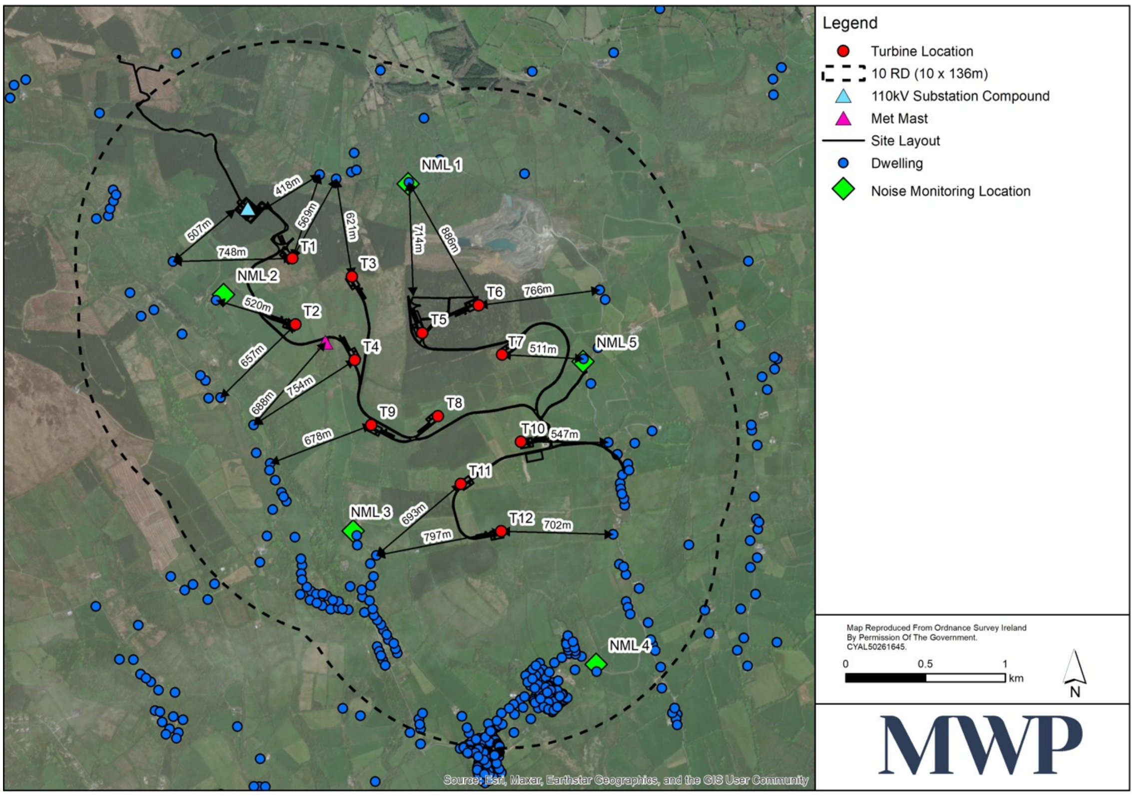

Figure 10-2: Noise Monitoring Locations, Noise Sensitive Receptors and Proximity to Project Infrastructure

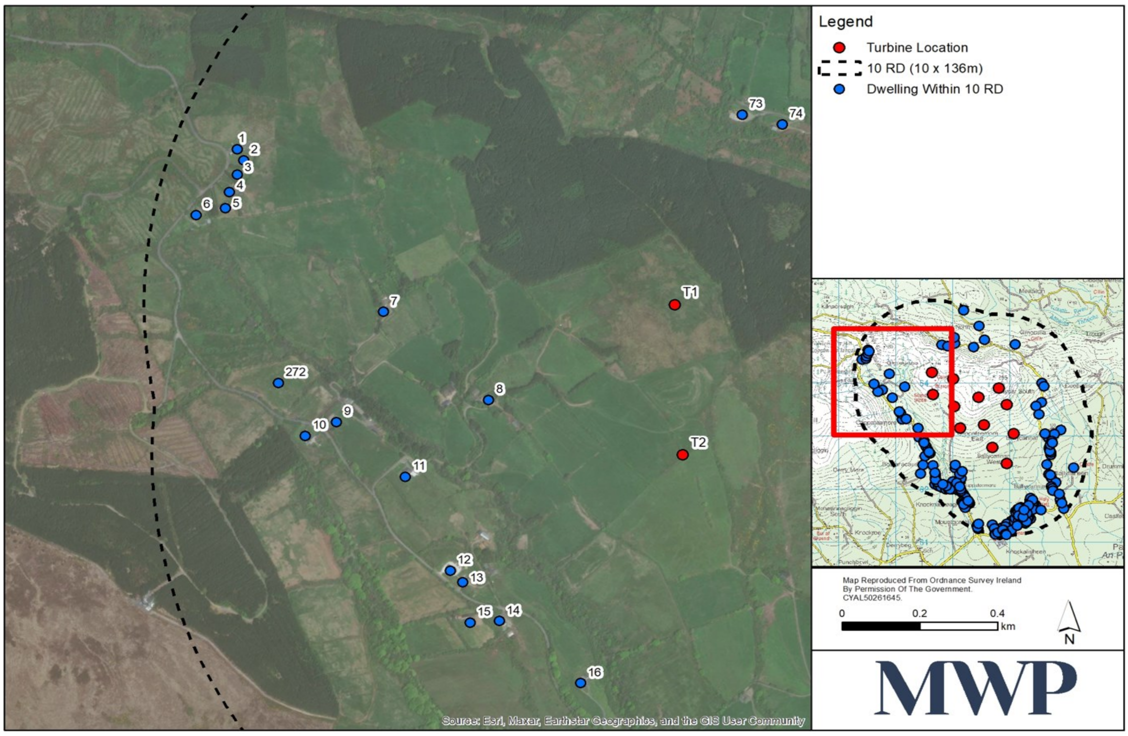

Figure 10-3: Noise Sensitive Number and Identification (northwest)

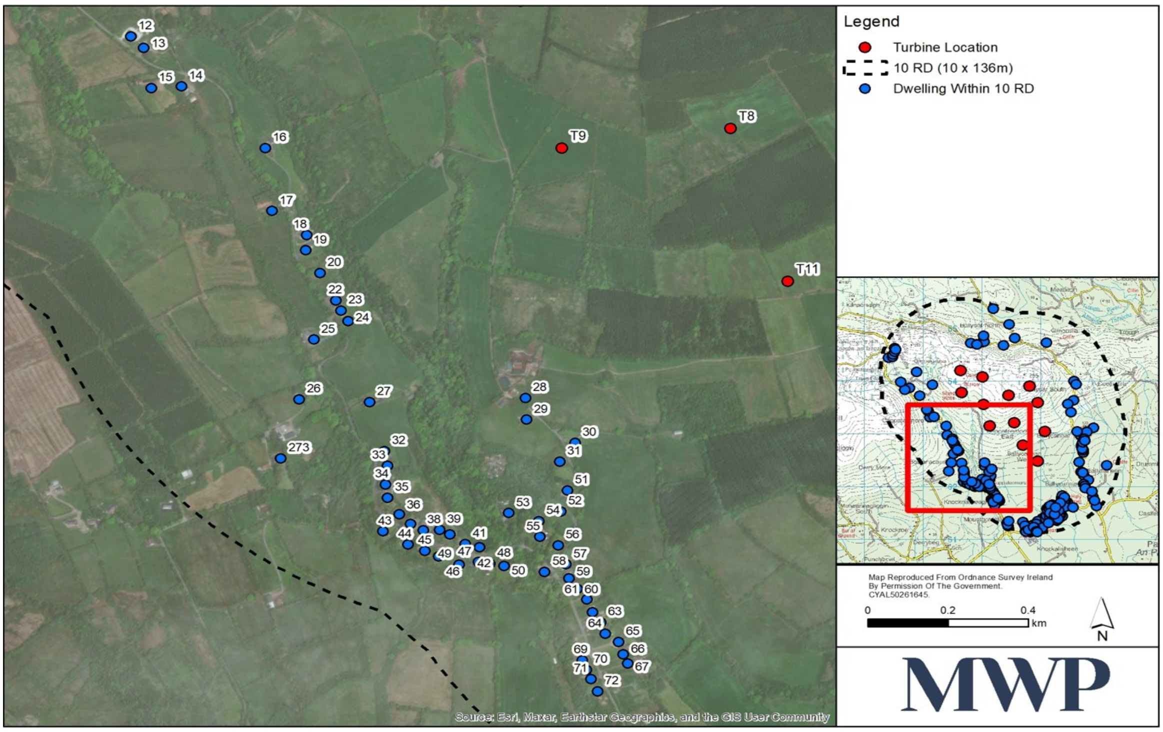

Figure 10-4: Noise Sensitive Numbering and Identification (west/southwest)

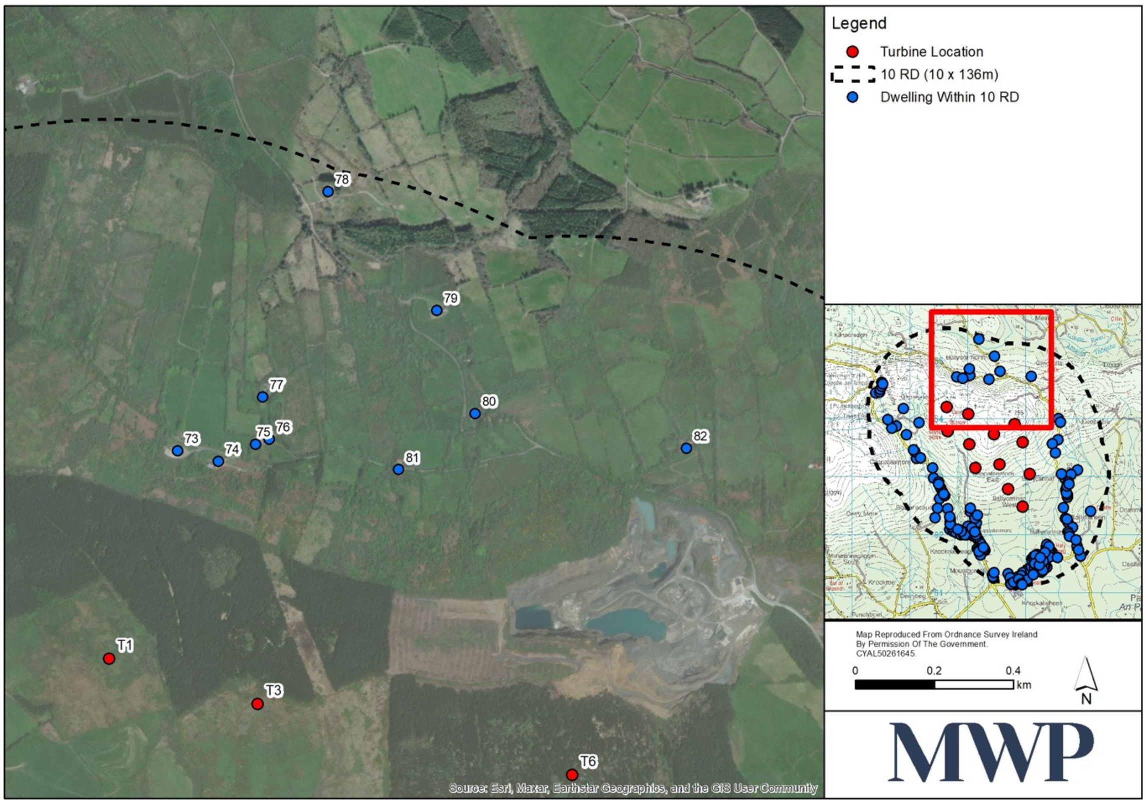

Figure 10-5: Noise Sensitive Numbering and Identification (north)

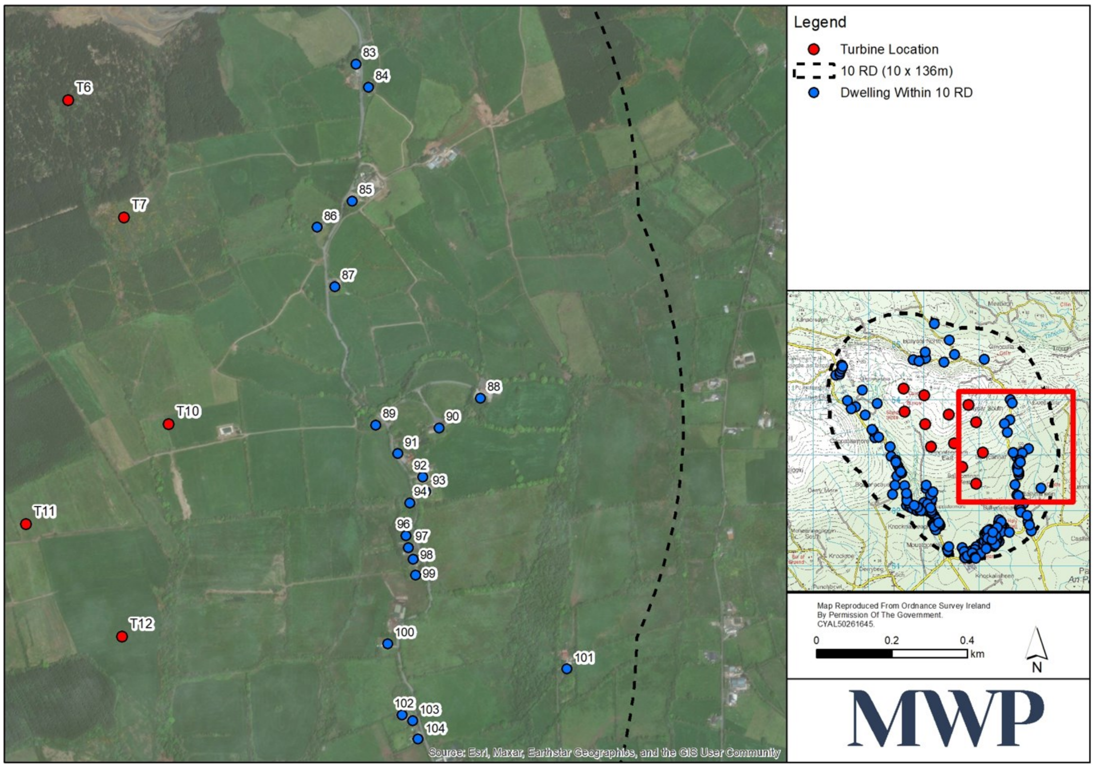

Figure 10-6: Noise Sensitive Numbering and Identification (east)

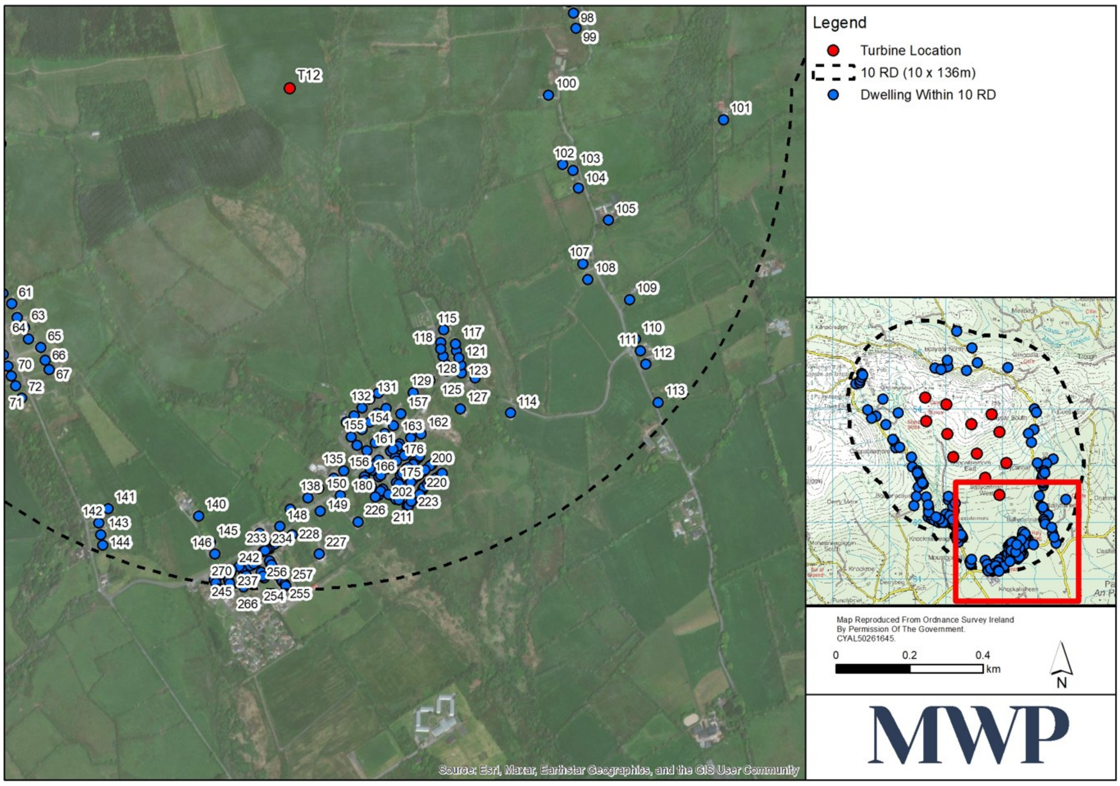

Figure 10-7: Noise Sensitive Numbering and Identification (south)

10.3.3 Noise Monitoring Equipment

Section 2.4 of the IOA GPG, includes information on the type and specification of noise monitoring equipment which should be used for background noise surveys and states:

Noise measurement equipment and calibrators used on site should comply with Class 1/ Type 1 of the relevant standard(s). Enhanced microphone windscreens should be used. Standard windshields of a diameter of less than 100 mm cannot be relied upon to provide sufficient reduction of wind noise in most circumstances.

The noise monitoring equipment used for the background noise survey meets with the requirements of the IOA GPG. Details of the noise monitoring equipment, the calibration drift recorded and photographs at each NML are detailed in the field data sheets (FDS). There was no significant calibration drift.

Expert judgement was used when locating the noise monitoring equipment. The microphones were all mounted between 1.2 m and 1.5 m above ground level and situated between 3.5 and 20m from a dwelling where practical. The noise meters were located away from obvious sources of noise such as boiler flues, fans and ephemeral running water. The meters were situated away from hard reflective surfaces such as fences and walls.

Copies of the calibration certificates with serial numbers for the sound level meters and sound level calibrator are attached as Appendix 10A.

10.3.4 Meteorological Data

In accordance with the IOA GOG:

Background noise measurements should be correlated with wind speed measurements performed at the proposed site, such that actual operating noise levels from the turbines may be compared with the noise levels that would otherwise be experienced at a dwelling.

The IOA GPG states that three methods of wind speed measurement may be adopted.

A) Direct measurement at hub height using a large mast or LiDAR/ Sodar unit;
B) A meteorological mast lower than hub height but carrying anemometers at two different heights; these are then used to calculate hub height wind speed; and
C) A meteorological mast carrying an anemometer at 10 metres height.

The IOA GPG states that Methods A and B are preferred, and that Method C should only be adopted for smaller-scale developments for which the installation of a tall meteorological mast or deployment of a SODAR or LiDAR system at the planning stage might not be justified economically.

For this assessment, wind speeds were recorded using Method A.

A tipping bucket rain gauge was installed at NML 5 for the duration of the noise survey to record periods of rainfall.

10.3.5 Wind Shear

Wind shear can be defined as the changes in the relationship between wind speed at different heights. Due to wind shear, wind speeds recorded on one meteorological mast, at different heights, are usually different. Generally, the higher the anemometer the higher the wind speed recorded. For example, if a wind speed of 4 m/s is recorded at 80 m height, 3.5 m/s may be recorded at 40 m and 2.5 m/s may be recorded at 10 m.

The issue of wind shear has been considered in accordance with the IOA GPG, Supplementary Guidance Note (SGN) 4: Wind Shear, July 2014. Wind speed measurements at two different heights from the on-site LiDAR unit were standardised to 10 m using the following equations. The Performance Verification Certificate for Lidar Unit is included in Appendix 10A

Equation A

Shear Exponent Profile - this uses the following equation:

$$U = U_{ref} \times (H \div H_{ref})^m$$

Where:

U	=	calculated wind speed
Uref	=	measured wind speed
H	=	height at which the wind speed will be calculated
Href	=	height at which the wind speed is measured
m	=	shear exponent

Equation B

Roughness Length Shear Profile – this uses the following equation:

$$U1 = U2 \times [(\ln (H_1 \div z))/ (\ln (H_2 \div z))]$$

Where:

H_1	=	The height of the wind speed to be calculated (10m)
H_2	=	The height of the measured wind speed
U_1	=	The wind speed to be calculated
U_2	=	The measured wind speed
z	=	The roughness length

Note: A roughness length of 0.05m is used to standardise hub height wind speeds to 10m height in the IEC 61400-11:2003 standard, regardless of what the actual roughness length seen on a site may have been. This 'normalisation' procedure was adopted for comparability between test results for different turbines.

A data set from the LiDAR was available for the duration of the baseline noise survey undertaken. This data set was used to perform a calculation of the shear exponent found between the highest two wind speed measurements for every ten-minute period using the equation;

$$M = \ln (v_2 \div v_1) / \ln (h_2 \div h_1)$$

Where:

V_1 = wind speed at lower anemometer h_1

V_2 = wind speed at higher anemometer h_2

The shear exponents calculated for every ten-minute period were then used to calculate the hub height wind speed from that measured at the relevant hub height proposed, using equation B. Equation A was then used to calculate a ten-metre height wind speed from the hub height wind speed every ten minutes, assuming the reference roughness length of 0.05 m.

10.3.6 Filtering and Analysis of Data

Analysis of the measured data has been undertaken in accordance with the recommendations in ETSU-R-97 and the IOA GPG.

The purpose of data analysis is to provide a representative background noise level across a range of wind speeds for Amenity and Night-time Hours and thereby help define appropriate noise limits for a proposed wind energy development.

To obtain a typical representation of the existing noise environment, analysis of the collected data should minimise the influence of atypical sources for a representative location (or other locations for which a proxy is being applied) during the period of noise measurement.

ETSU – R- 97 requires the filtering of noise, wind and rain data for Amenity and Night-time hours which are defined as follows:

Amenity hours
18:00 to 23:00 hrs. Monday to Sunday
13:00 to 18:00 Saturday and 07:00 to 18:00 Sunday.

Night-time
23:00 to 07:00 (weekday and weekend)

Raw meteorological data was screened upon receipt and where rainfall occurred, the noise and wind speed data has been excluded from the assessment. The potential impact of a dawn chorus was also removed by filtering night-time hours to 23:00 to 04:00.

10.3.7 Prevailing Background Noise Level

The prevailing measured background noise levels have been calculated using a best fit polynomial regression line of no more than a fourth order through the measured LA90 10 min noise data, as required by ETSU-R-97 and the IOA GPG. The regression analysis curve is shown as a continuous black line on the following series of graphs. The graphs show the 10-minute average wind speeds plotted against the 10-minute average recorded noise levels at the noise monitoring locations, along with a calculated best fit for the quiet daytime and night-time periods.

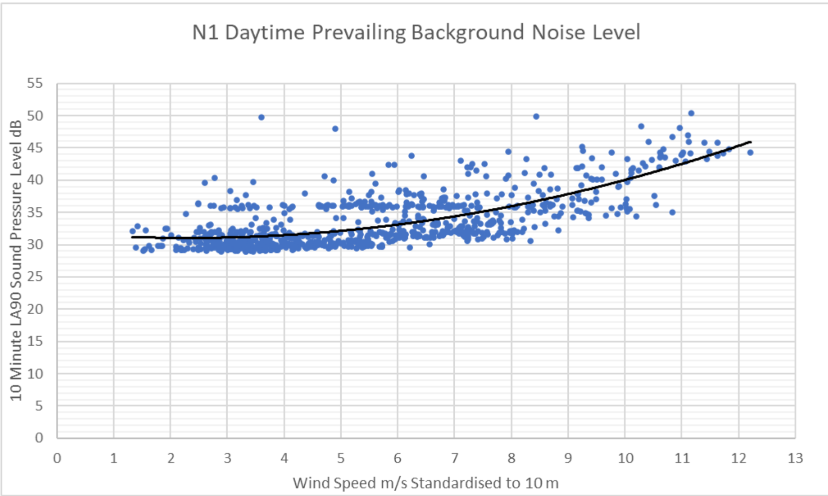

Figure 10-8: N1 Daytime Prevailing Background Noise Level

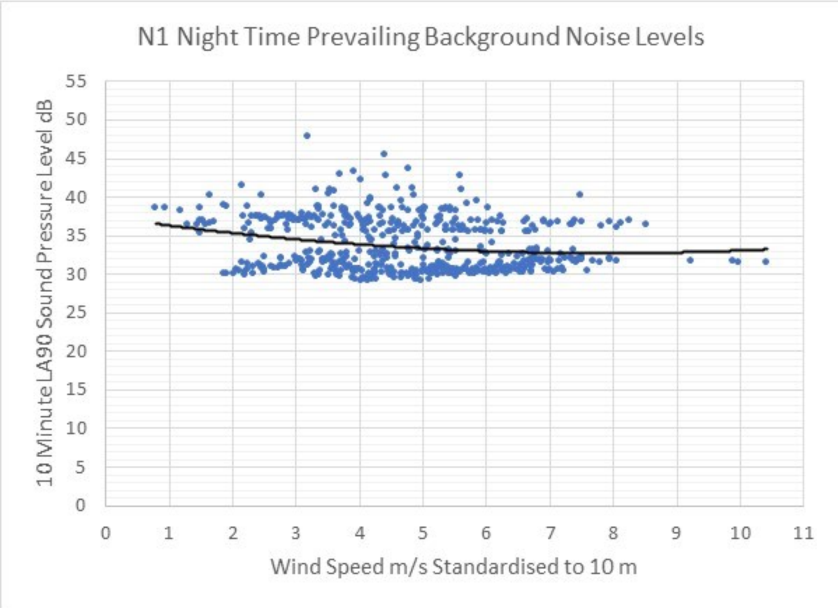

Figure 10-9: N1 Night Time Prevailing Background Noise Level

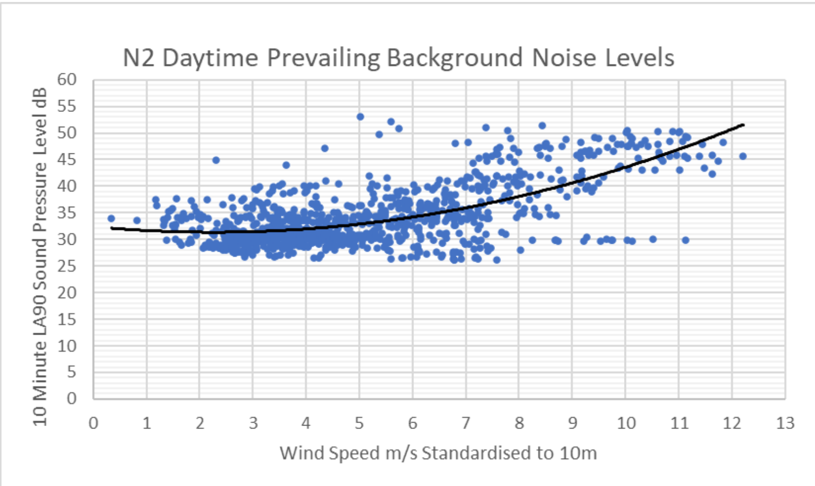

Figure 10-10: N2 Daytime Prevailing Background Noise Levels

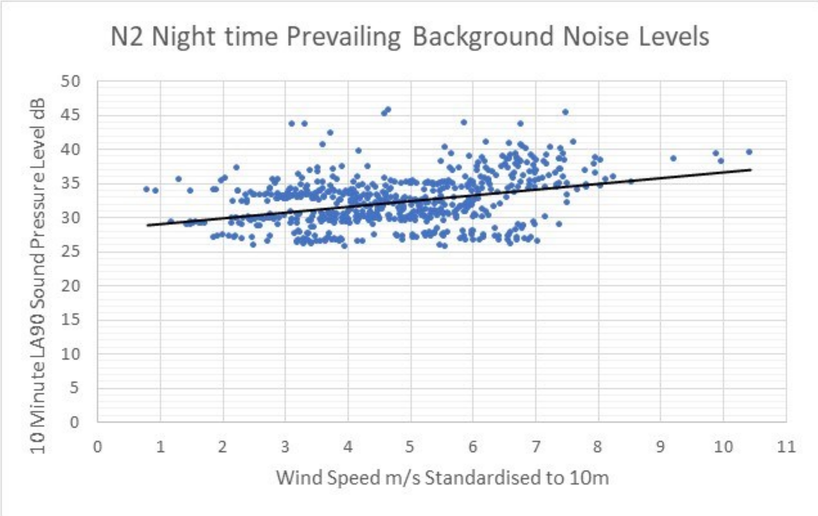

Figure 10-11: N2 Night Time Prevailing Noise Levels

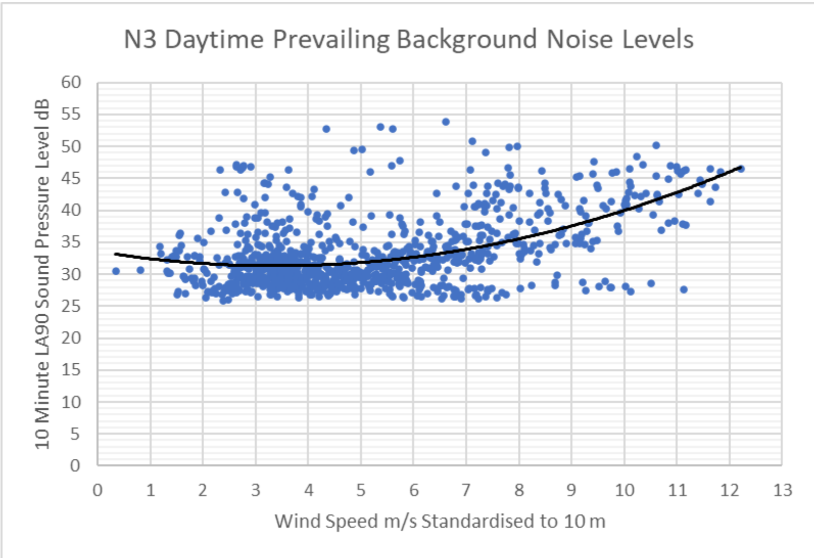

Figure 10-12: N3 Daytime Prevailing Noise Levels

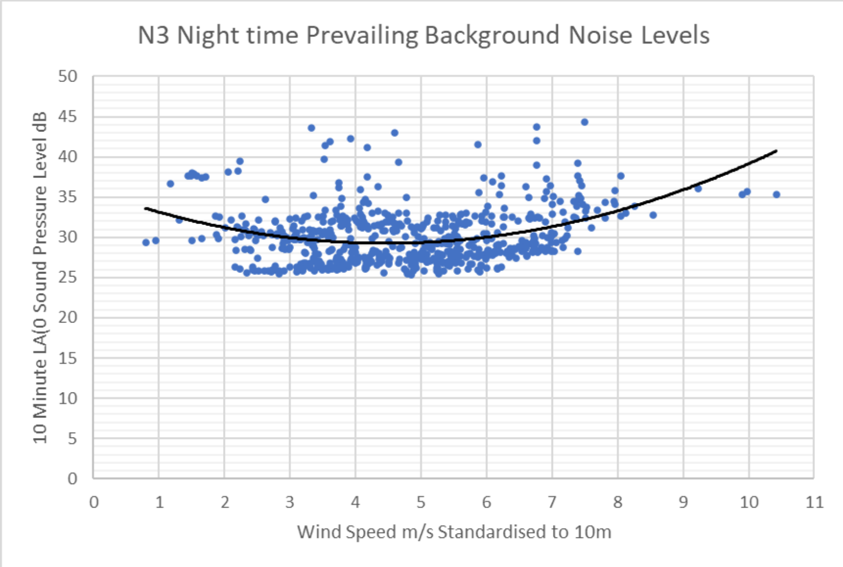

Figure 10-13: N3 Night Time Prevailing Background Noise Levels

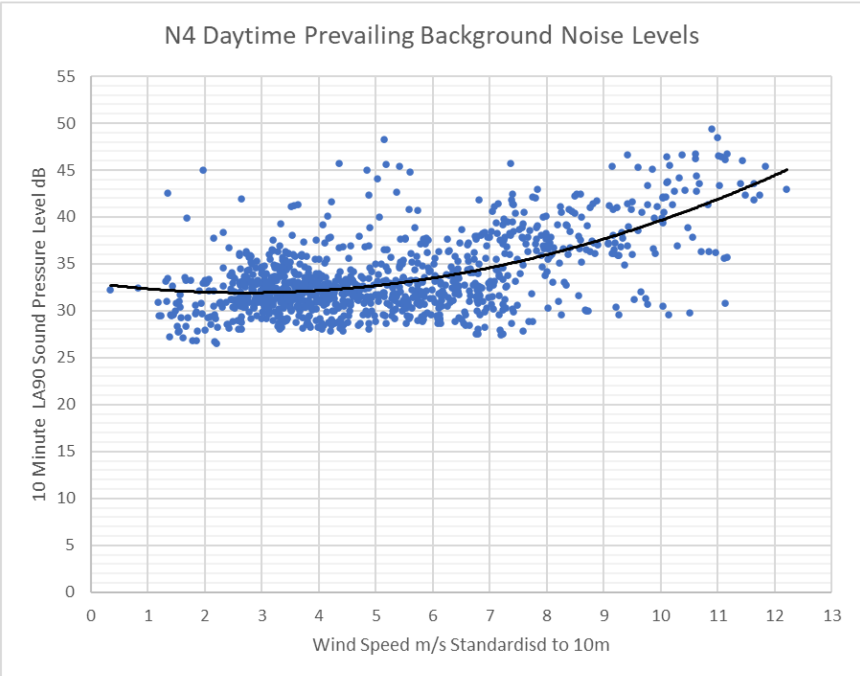

Figure 10-14: N4 Daytime Prevailing Background Noise Levels

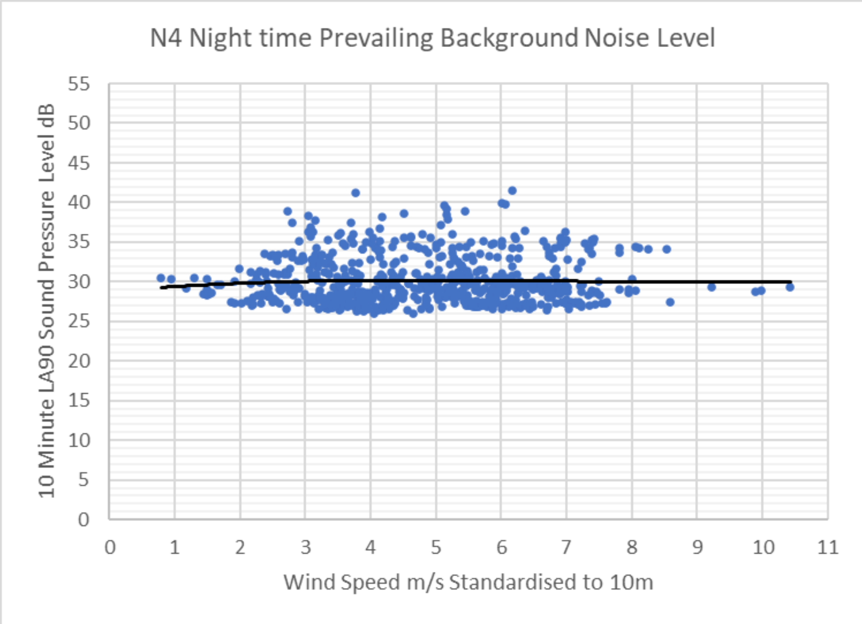

Figure 10-15: N4 Night Time Prevailing Background Noise Levels

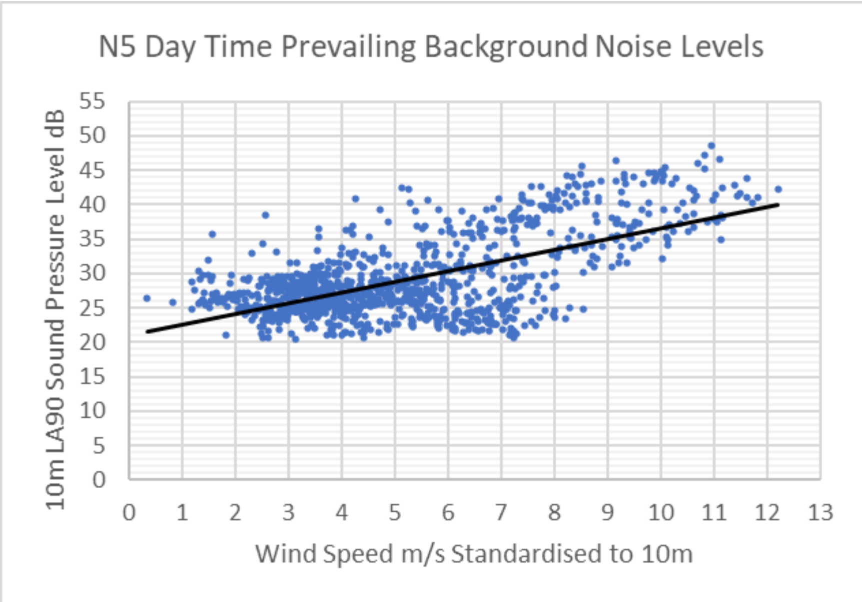

Figure 10-16: N5 Daytime Prevailing Background Noise Levels

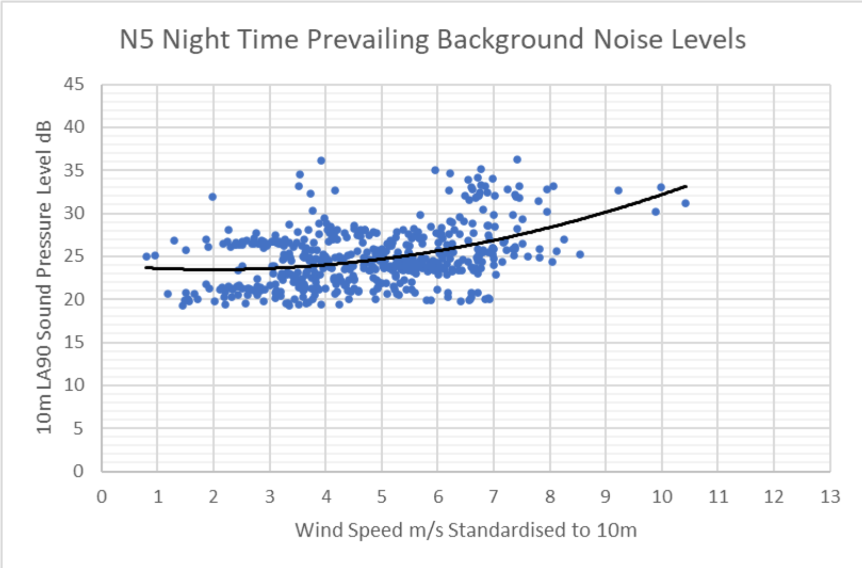

Figure 10-17: N5 Night Time Prevailing Background Noise Levels

Tables 10-3 & **10-4** presents the derived L_{A90} 10 min noise levels for the monitoring locations for both the amenity hours and night-time periods. These levels have been derived using regression analysis carried out on the data sets and presented on **Figures 10-8** to **10-17** above.

Table 10-3: Prevailing Background Noise Levels – Amenity Hours

Monitoring Location	Wind Speed Standardised to 10m (m/s)							
	3	4	5	6	7	8	9	10
	Prevailing Background L_{90}dB(A)							
NML 1	31	32	32	33	34	36	38	40
NML 2	31	32	33	34	35	38	41	44
NML 3	31	31	31	33	34	35	37	40
NML 4	32	32	33	34	35	36	38	40
NML 5	26	27	29	30	31	33	36	39
Lowest Measured Background Noise Level	26	27	29	30	31	33	36	39

Table 10-4: Prevailing Background Noise Levels - Night Hours

Monitoring Location	Wind Speed Standardised to 10m (m/s)							
	3	4	5	6	7	8	9	10
	Prevailing Background L_{90}dB(A)							
NML 1	34	34	33	33	33	33	33	33
NML 2	30	31	32	33	34	35	36	37
NML 3	30	29	29	30	31	33	36	39
NML 4	31	31	31	31	31	31	31	31
NML 5	23	24	25	26	27	28	30	32
Lowest Measured Background Noise Level	23	24	25	26	27	28	30	32

10.3.7.2 Do Nothing Scenario

Should the proposed development not proceed it is likely that noise and vibration levels will remain unchanged. However, the local, regional and national benefits which accompany the proposed development associated with the replacement of fossil fuels with renewable energy will be lost.

10.4 Likely Significant Effects

The following sections describe the potential noise and vibration effect from the proposed development and associated infrastructure. The construction, operational and decommissioning phases are assessed.

10.4.1 Construction Phase – Assessment of Noise Effects.

The construction phase entails the building of the wind farm infrastructure including access tracks, hard standings, turbine bases, drainage system, substation, control buildings, and borrow pit, and also the grid connection route works areas. The main noise sources include heavy machinery and support equipment used to construct the various elements. This typically means heavy earth moving machinery, generators, and material transport trucks. For the purpose of assessing the likely construction phase impacts, the construction phase has been separated into separate categories as described in the following sections.

The noise levels described in the following sections for the various construction phases are based on theoretical worst-case assumptions, in order to demonstrate that it will be possible to undertake the works without significant noise effects. By their nature, the works are temporary and will only potentially impact on a small number of receptors at any one time. In reality, construction noise levels will be lower than those presented.

10.4.1.3 Access Tracks, Cabling and Turbine Erection

In this category, the construction of the wind farm access tracks will include the noisiest plant and machinery.

Construction of the wind farm tracks is by its nature linear and will move from the outside in towards the inner infrastructure relatively quickly and away from receptors. Therefore, the noise effect will decrease quickly as the works progress into the wind farm.

The most intense areas of activity will be during the excavation and construction of the turbine bases and hardstands. This will require a concentration of stationary equipment. If poor ground conditions are encountered during excavation and a significant depth to sub-formation is required, a piled foundation may be considered. A piled foundation requires the use of a piling machine equipped with an auger drill to rotary bore a number of holes around the area of the turbine base to the sub-formation depth determined at construction stage. Once all the holes have been bored, reinforcement steel is inserted into each hole with concrete poured afterwards. The potential effects associated with piling are not considered significant in terms of noise or vibration given that the nearest turbine base/ hardstand is approximately 512m from a sensitive receptor.

The exact equipment to be used is not known at this stage, however the plant and machinery outlined in **Table 10-5** are typical of plant that are commonly used in wind farm construction and can provide an accurate assessment of construction noise emissions during the construction of the turbine hardstand/ base.

The associated noise levels have been sourced from *BS 5228 Noise and Vibration from open and construction sites*, totalled, and extrapolated to the nearest noise sensitive location. The resultant noise level is then compared against the relevant noise threshold. The result is a theoretical worst case, as it assumes all machinery will be operating simultaneously which will not be the case and accounts for attenuation due to distance only. In reality there will be further noise attenuation due to atmospheric absorption, ground absorption, and landform screening. Therefore, the noise levels presented herein are overestimated.

The formula, as shown below, to calculate sound attenuation over distance for a point source is based on the inverse square law[1]. Using the following equation, noise emissions from the construction site are extrapolated to the nearest noise sensitive receptor.

$$SPL_2 = SPL_1 - 20\log(r2/r1)$$

Where:

- Sound Pressure Level 1 (SPL1) = Known noise level at 10m from construction site;
- Sound Pressure Level 2 (SPL2) = Unknown noise level at nearest receptor;
- R2 = Distance between noise sensitive receptor and construction site.

Table 10-5: Plant and Machinery and associated noise levels to be used in Wind Farm Track Construction

Activity	BS 5228, 2014 Sound Pressure Level (@10m (r1) Leq dB(A)	Predicted Sound Pressure Level @ 512 m (r2), Leq dB(A).
Dozer (35 tonne) – ground excavation earthworks	86	37 (SPL2)
Wheeled loader – loading lorries	80	
Dump truck (40 tonne) empty	81	
Backhoe mounted hydraulic breaker -Breaking-road surface	73	

[1] https://www.wkcgroup.com/tools-room/inverse-square-law-sound-calculator/#:~:text=According%20to%20the%20inverse%20square,valves%2C%20small%20pumps%20and%20motors.

Dozer (14 tonne) – spreading chipping/ fill	82
Road planer (17 tonne) road planing	82
Road roller (22 tonne) – rolling and compaction	80
Asphalt paver (and tipper lorry) – Paving	84
Total	91 (SPL1)

Applying guidance and professional judgement, the worst case predicted noise level at the nearest noise sensitive location during the construction stage of turbine base and hardstand is 37 dB(A), which does not exceed the construction noise threshold of 65dB (A). Noise dissipates over distance and will therefore reduce further below construction noise thresholds at receptors further from nearest sensitive location.

Construction noise from the proposed development will result in a ***temporary short term moderate adverse effect*** at noise sensitive locations, therefore there will be no significant effect.

10.4.1.4 Borrow Pit

One borrow pit which will also act as a spoil deposition area has been identified to facilitate the extraction of hardcore material for the construction phase of the project. Rock from the borrow pit may be broken out using a rock breaker or blasting. For the purpose of this assessment, both scenarios have been assessed. Scenario 1 assumes rock breaking operations and Scenario 2 assumes blasting operations. The location of the borrow pit in relation to the nearest noise sensitive receptors in illustrated in **Figure 10-2.**

Scenario 1: Rock Breaking Operations

The noisiest items of plant to be used during rock breaking operations will include a rock breaker and a crusher to process the material, refer to **Table 10-6**. For this assessment a rock breaker and crusher has been assumed to be in operation simultaneously. Site activities will be staggered and therefore rock breaking plant has been assumed to be in operation for 70% of a typical working day of 7 am to 7 pm. The noise emission from the rock breaker and crusher have been sourced from *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration on construction and open sites – Noise*.

Using iNoise software, the noise levels predicted at the nearest noise sensitive locations to the borrow pit have been calculated. These include H74 to the north, H8 to the west, H28 the south and H83 to the east. A noise level of 38dB(A) is predicted at H74, 34dB(A) at H8, 33dB(A) at H28 and 38 dB(A) at H83. These are all well within the construction noise limit criteria.

This will be a ***likely adverse moderate localised temporary direct effect,*** therefore there will be no significant effect.

Table 10-6: Borrow Pit Plant Noise Emissions

Item	BS 5228 Ref:	dB Lw Octave band (Hz)								Lw Total dB(A)
		63	120	250	500	1000	2000	4000	8000	
Rock Breaker	C9.11	119	117	113	117	115	115	112	108	121
Crusher	C1.14	121	114	107	108	103	99	94	87	110

Scenario 2: Blasting Operations

Blasting largely reduces the use of a rock breaker. The potential noise of blasting will be less than the prolonged daily use of a backhoe mounted rock breaker. Blasting will be a once off event which will occur approximately once or twice per month. Blast events will be controlled in accordance with measures outlined in Section 10.5.4.

The noise emissions of the blast itself have not been calculated as there are too many variables to accurately calculate. It will most likely be audible but will be a single instantaneous event on the day. Residents will be notified in advance of any blasting. The extent of blasting will depend on the rock type and depth in the borrow pit area. Blasting breaks significant more rock than rock breaking and therefore will be an intermittent occurrence. Blasting will be coordinated with the neighbouring quarry to ensure that blasts do not coincide.

Noise and vibration limit values for blasting will be set out in accordance with the Environmental Protection Agency's, *Environmental Management in the Extractive Industry* in addition to the mitigation measures which are described in Section 10.5.4.

Given the advance warning required and infrequency of occurrence, i.e., there will be no more than 1 blast in a day, blasting will be a ***likely adverse moderate localised temporary direct effect***, therefore there will be no significant effect.

10.4.1.5 Substation Construction

Table 10-7 below is a typical list of plant and machinery involved in substation construction activities. Noise levels from the equipment identified below have been sourced from *BS5228 Noise Database for Noise and Vibration Control on Construction and Open Site 1& 2: 2014+A1*.

Table 10-7: Typical Construction Plant and Machinery which will be used during the Substation Construction

Activity	BS 5228, 2014 Sound Pressure Level (@10m (r1) Leq dB(A)	Predicted Sound Pressure Level @ 418m (r2), Leq dB(A).
Telescopic Handler	71	54 (SPL2)
Mobile Crane	70	
30-50T Excavator	79	
15-30T Excavator	78	
12T Roller	80	
Dump truck	78	
Tractor & Trailer	79	
15-20T Rubber Tired Excavator	68	
3-10T mini digger	69	
Diesel Generator	61	
Total	86	

The construction works will be sequenced and all the noise sources in Table 10-7 above will not be in operation continuously or simultaneously for the duration of the construction. The substation location is approximately over 418m from the nearest noise sensitive receptor. The resultant theoretical worst-case noise emission level at the nearest receptor is 54 dB(A). This is below the construction noise threshold.

This will be a ***likely adverse moderate localised temporary direct effect***, therefore there will be no significant effect.

10.4.1.6 Grid Connection Cable Trenching and Jointing Bays

The majority of the proposed underground grid connection route will be located within an area of coniferous forestry and also land comprising pasture. A small section of the grid will be located within the curtilage of an existing public road within an excavated trench.

In general, the construction takes place in distinct stages including:

1) the excavation of the trench using an excavator machine, typically a back hoe loader, tracked machine, or directional drilling machine for water crossings;

2) a dump truck to take away any spoil which is not used for back fill;

3) the trench surface receives a temporary surface dressing of either spray and chip or macadam on pubic roads; and

4) once the overall scheme is completed, the cable route and associated road areas on the public road will receive a finish as agreed with Clare County Council.

Construction will be phased so therefore, all the machinery above will not be in operation simultaneously. The full resurfacing works will take place some-time after the cabling works are completed.

Given the very short time frame, the temporary and minor nature of the works and machinery, in combination with the low number of receptors impacted at any one time, the potential effect of noise, based on professional judgement, is considered **not significant**.

Significant vibrations are not expected from the types of equipment to be used, i.e., backhoe loader, track machine and dumper. This will be a ***likely adverse moderate localised temporary direct effect***, therefore there will be no significant effect**.**

10.4.1.7 Forestry Felling

The work will consist of removing trees to allow construction of elements of the proposed development required for T5, T6 and the location of the substation and grid route. Most of the proposed forestry felling activities will occur at such distances from noise sensitive receptors that no significant noise effects are likely to occur. The nearest NSL to the proposed felling is approximately 300 m from the felling works area. **Table 10-8** outlines the typical construction noise levels associated with the proposed works for this element of the construction. Calculations have assumed an on-time of 100% for each item of plant, which is a worst case scenario as all equipment may not be in operation simultaneously.

Table 10-8: Forestry Felling

Activity	Sound Pressure Level (@10m (r1) Leq dB(A)	Predicted Sound Pressure Level @ 300 m (r2), Leq dB(A).
Forwarder	79	56 (SPL2)
30-50T Excavator	79	
Chainsaw	83	
Total	**86**	

The resultant theoretical worst-case noise emission level at the nearest receptor is 56 dB(A). This is below the construction noise threshold of 65 dB (A). There will be no significant vibrations effects. No mitigation measures are required.

This will be a likely **adverse not significant localised temporary direct effect**, therefore there will be no significant effect**.**

10.4.1.8 Construction Traffic

On a wind farm, the most intense period of construction traffic activity takes place during the pouring of the concrete for the turbine bases. This is because all the concrete required for a turbine base must be poured on a single day. **Chapter 15 Material Assets** considers the traffic and transport aspects of the project.

For mobile items of plant that pass at intervals, it is possible to predict an equivalent continuous sound level using the following expression for predicting LAeq alongside a haul road used by single engine items of mobile plant:

LAeq = Lwa – 33 + 10log10Q – 10log10V – 10log10d,

Where

- Lwa is the sound power of the plant in decibels (dB);
- Q is the number of vehicles per hour;
- V is the average vehicle speed, in kilometres per hour (km/h);
- d is the distance of receiving position from the centre of the haul road, in metres (m).

Therefore

LAeq = 118[Note 1] – 33 + 10Log 24 – 10log50 – 10log20 = 69 dB(A).

Note 1: Source, Maximum drive by sound power level (Table C.2 BS 5228 Part 1).

The averaged L_{Aeq} over the course of an hour from passing HGV's (as calculated above) is predicted to be 69 dBA. The base pours will only occur 12 times (12 turbines) and typically these days will not occur concurrently. In that regard, the noise effect from the HGV concrete deliveries, based on professional judgement, is considered **not significant**. These noise levels are typical of any HGV traffic which already uses the road network.

This will be a ***likely adverse not significant localised temporary direct effect***, therefore there will be no significant effect***.***

10.4.1.9 Summary – Assessment of Noise Effects

The associated construction phase noise effect is dependent on a multitude of variables and is predicted to range from a short term moderate adverse localised direct effect to not significant, depending on the timing, location and phase of the construction works, refer to **Table 10-9**. Mitigation measures described in **Section 10.5** will reduce the potential for significant adverse effect. The construction phase is expected to last approximately 18 months.

Table 10-9: Assessment of Construction Effects as per EPA Guidelines

Effect: Construction Noise						
	Quality of Effect	Significance	Spatial Extent	Duration	Other Relevant Criteria	Likelihood
Pre - Mitigation	Adverse	Moderate to not significant	Localised	Short- term	Direct	Likely

10.4.2 Construction Phase Vibrations

10.4.2.10 Wind Farm Works Vibration

The nearest sensitive location is 512m from the closest turbine base location. At this distance, vibrations from the construction plant and activities involved will not be perceptible or cause structural or cosmetic damage. Vibration levels dissipate further due to distance beyond the nearest receptor.

This will be a ***likely adverse imperceptible localised temporary direct effect***, therefore there will be no significant effect.

10.4.2.11 Substation Works Vibration

The nearest sensitive location is at a distance of 418m from the substation location. At this distance, vibrations from the construction plant and activities involved will not be perceptible or cause structural or cosmetic damage. Vibration levels dissipate further due to distance beyond the nearest receptor.

This will be a ***likely adverse imperceptible localised temporary direct effect***, therefore there will be no significant effect.

10.4.2.12 Borrow Pit Works Vibration

During rock breaking, there is potential for vibration to be generated through the ground. Empirical data for this activity is not provided in BS 5228 – 2:2009+A1:2014 standard, however the likely levels of vibration are expected to be orders of magnitude below the relevant criteria to avoid cosmetic damage to buildings based on experience from other sites and the significant distances between the works and the nearest sensitive buildings. Notwithstanding the above, any construction activities undertaken on the site will be required to operate below the recommended vibration criteria set out in Section 10.2.5.

The level of vibration at a receiver location from a blast depends predominantly on the distance from the blast, the maximum instantaneous charge (MIC), sequencing of charges and ground conditions between the blast and the receiver location.

The closest properties to the nearest point of the borrow pit and potential blast site are at a distance of 721m. Due to the relatively large distance to receptors, ground borne vibration from blast events are predicted to be minor at the nearest NSLs due to the ground vibration levels and the duration of the effects are intermittent. These potential impacts will be appropriately mitigated through the implementation of control measures as outlined in Section 10.5.4.

There are no significant controlled vibration effects anticipated at sensitive locations during the construction phase from blasting. Notwithstanding the above, any construction activities undertaken on the site will be required to operate below the recommended vibration criteria set out in Table 10-3.

Borrow works blasting and rock breaking will ***likely*** *be an* ***adverse not significant localised temporary direct effect***, therefore there will be no significant effect.

10.4.3 Operational Phase Noise– Assessment of Effects

Once operational, the wind turbines and the substation will generate noise which will propagate into the receiving environment. The potential effects are described in the following sections.

10.4.3.1 Wind Turbines

Noise prediction computer software was used to quantify the effect of the proposed development. The noise predictions were undertaken using noise prediction software, specifically Bruel & Kjaer's Predictor software (iNoise 2019.1 V1). The software calculations are based on *ISO 9613, Attenuation of sound during propagation outdoors, Part 2, General Method* *of Calculation*. This is the standard recommended by the IOA GPG. The ISO 9613-2 model can take account of the following factors that influence sound propagation outdoors:

- Geometric divergence;
- Air Absorption;
- Reflecting obstacles;
- Screening;
- Vegetation; and
- Ground reflections.

The model uses as its acoustic input data the octave band sound power of the turbine and calculates, on an octave band basis, attenuation due to factors above, as appropriate. The data input into the model was also defined by the IOA GPG and is presented in **Table 10-10**.

Table 10-10: Model Input Data

Item	Description
Turbine Locations	Irish grid 1965 (Appendix 10-B)
House Locations	Irish grid 1965 (Figure 10-18)
Acoustic Emission	Turbine Sound Power Levels
Hub Height	90 + 82 m (T10 only)
Landform	10m contours
Ground Factor	0.5 (Note 1)
Receptor Height	4m
Wind Direction	Downwind
Relative Humidity	70%
Temperature	10^oC

Note 1: Ground Factor is a value between 0 and 1, where 0 represents hard/ reflective surfaces and 1, represents soft absorbent surfaces.

The following sections detail the noise spectra for the wind turbines under consideration for the proposed wind farm.

The Vestas V136, 4.5 MW (with serrated trailing edge) has been modelled in the proceeding analyses. This turbine is a pitch regulated upwind turbine. The maximum operating sound power level of the candidate turbine, namely the Vestas V136 is 103.9dB(A). The sound power levels (SWL) are presented with reference to code IEC 61400-11 ed. 2.1, Wind turbine generator systems, Acoustic noise measurement techniques, (2006) based on a hub height of 100 m and a roughness length of 0.05 m as described in the IEC code. The SWL presented are valid for the corresponding wind speeds referenced to the height of 10 m above ground level in normal operating mode.

The IOA GPG states that it should be ensured that a margin of uncertainty is included within source wind turbine noise data used in noise predictions. There is uncertainty associated with the measurement of wind turbine noise. This is sometimes included in the warranted noise levels from the turbine manufacturer however, if not the IOA GPG guidelines recommends:

If no data on uncertainty or test reports are available for the turbine then a factor of +2dB should be added.

For the purposes of all predictions presented in this report to account for various uncertainties in the measurement of turbine source levels, a factor of +2dB has been added to the manufacturer's values.

Table 10-11: V136 (Serrated Edge) – Total Sound Power Levels - dB

Wind Speed (m/s)	dB LwA	dB LwA (+2dBA)
3	91.4	93.4
4	94.6	96.6
5	99.7	101.7
6	103.5	105.5
7	103.9	105.9

Table 10-12: V136 (Serrated Edge) – Total Sound Power Levels – Octave Band

Wind Speed referenced to 10m height w/s	dB Lw Octave band (Hz)								Lw Total dB(A)
	63	120	250	500	1000	2000	4000	8000	
7 m/s	86	90.9	96.3	98.8	98.5	95.3	89.3	80.3	103.9
6 m/s	85.6	90.5	95.9	98.4	98.1	94.9	88.9	79.9	103.5
5 m/s	82.6	87.5	92.7	94.9	94	90	83.1	73	99.7
4 m/s	77.6	82.5	87.8	90	89.3	85.5	78.8	69.1	94.6
3 m/s	74	80.9	79.9	87.5	85.4	82.8	76.5	65.8	91.4

10.4.3.2 Noise Assessment Results, DoEHLG 2006

Table 10-13 outlines the derived noise limit criteria based on the lowest measured prevailing background noise levels in **Tables 10-3** and **10-4**. This is a robust approach.

Table 10-13: Noise Limits - Amenity and Night-time Hours

Wind Speed referenced to 10m height w/s	LA90, 10 min (dB) Limits at Standardised 10m Height Wind Speed (m/s)							
	3	4	5	6	7	8	9	10
Amenity Hours - Background Noise Level	26	27	29	30	31	33	36	39
Day LA90 10min dB Limit	**40**	**40**	**40**	**45**	**45**	**45**	**45**	**45**
Night-time - Background Noise Level	23	24	25	26	27	28	30	32
Night LA90 10min dB Limit	**43**	**43**	**43**	**43**	**43**	**43**	**43**	**43**

The results of the assessment shown in tabular form in **Table 10-14** show that the proposed development will not exceed the noise limit criteria as set out in the 2006 DoEHLG Wind Energy Guidelines. The margin above (+) or below (-) the noise limit criteria for the day and night-time periods are presented. At all noise sensitive locations (**Figures 10-3** to **10-7**) and at all wind speeds, the predicted noise emissions do not exceed the derived limit criteria for both the quiet daytime and night-time periods.

The wind turbine noise emission levels included in **Table 10-14** below are based on the $L_{A90,\ 10\ minute}$ noise indicator in accordance with the recommendations in ETSU-R-97, which were obtained by subtracting 2dB(A) from the calculated L_{AeqT} noise levels based on the turbine sound power level data used.

Figure 10-18 illustrates the theoretical maximum noise emissions from the wind farm. Noise levels at receptors may be lower due to attenuation because of local landform, natural screening and wind direction effects.

Table 10-14: Ballycar Wind Farm predicted noise levels and noise limit comparison

NSL	Description	dB LA90 Standardised wind Speeds (m/s)						
		3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s
1 (H81)	Predicted	28	31	36	40	40	40	40
	Day Limit	40	40	40	45	45	45	45
	Margin Day	-12	-9	-4	-5	-5	-5	-5
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-15	-12	-7	-3	-3	-3	-3
2 (H8)	Predicted	30	33	39	42	43	43	43
	Day Limit	40	40	40	45	45	45	45
	Margin Day	-10	-7	-1	-3	-2	-2	-2
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-13	-10	-4	-1	0	0	0
3 (H28)	Predicted	29	32	37	41	41	41	41
	Day Limit	40	40	40	45	45	45	45
	Margin Day	-11	-8	-3	-4	-4	-4	-4
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-14	-11	-6	-2	-2	-2	-2
4 (H115)	Predicted	26	29	34	38	38	38	38
	Day Limit	40	40	40	45	45	45	45
	Margin Day	-14	-11	-6	-7	-7	-7	-7
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-17	-14	-9	-5	-5	-5	-5
5 (H86)	Predicted	30	34	39	42	43	43	43
	Day Limit	40	40	40	45	45	45	45

NSL	Description	dB LA90 Standardised wind Speeds (m/s)						
		3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s
	Margin Day	-10	-6	-1	-3	-2	-2	-2
	Night Limit	43	43	43	43	43	43	43
	Margin Night	-13	-9	-4	-1	0	0	0

The predicted noise emissions from the wind farm development at all receptors within the study area of 1.36km is illustrated in **Figure 10-18**. The results show that the operational assessment criteria will not be exceeded at any location.

MWP

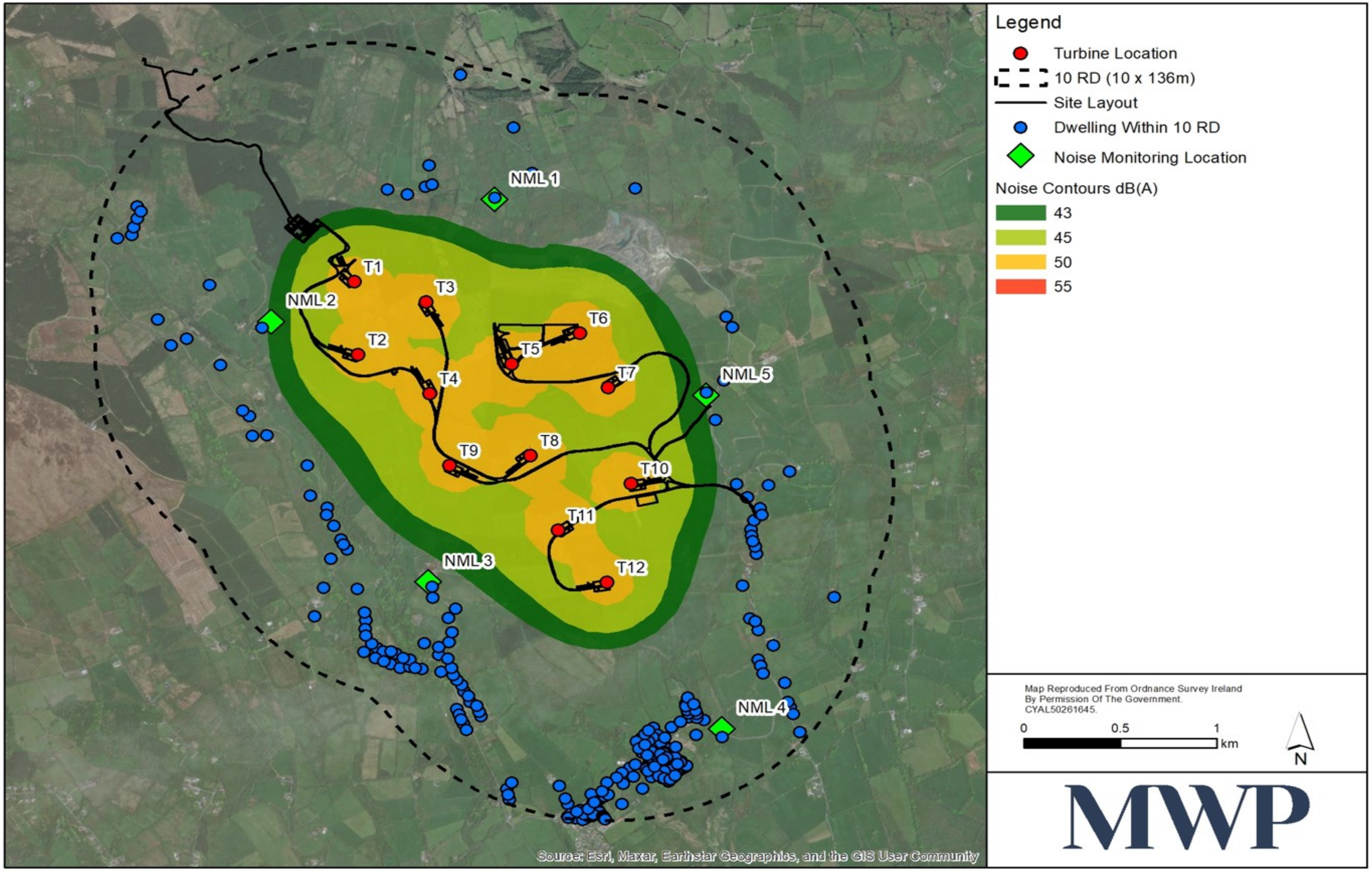

Figure 10-18: Predicted Noise Emissions from Wind Farm Development (Operational Phase)

10.4.3.3 Special Audible Characteristics

There are three categories of special audible characteristics that may arise from wind turbines:

1. Tonal Noise;
2. Amplitude Modulation;
3. Low Frequency Noise.

These are discussed in the following sections.

Tonal Noise

A tone can be described as an identifiable characteristic from a particular sound. It can be commonly described as a whine, hum or hiss. Tonal wind turbine noise can generally be attributed to gearbox related noise. Improvements in turbine design have greatly reduced potential tonal noise.

Such characteristics incur an additional acoustic penalty to the wind turbine noise emission. Typically wind turbines are broadband in nature and there are no clearly audible tones when operating normally, therefore no penalty has been included.

A warranty will be sought from the turbine manufacturer guaranteeing no tonal content at the nearest noise sensitive receptors.

Amplitude Modulation

The variation in noise level associated with turbine operation, at the rate at which turbine blades pass any fixed point of their rotation (the blade passing frequency), is often referred to as blade swish and amplitude or aerodynamic modulation (AM). It is often referred to as a 'whooming' or 'thumping' noise which may cause disturbance at a considerable distance from the wind energy development.

The Institute of Acoustics (IoA) Working Group defined wind turbine amplitude modulation as follows:

"*Wind turbine amplitude modulation is defined as periodic fluctuations in the level of audible noise from a wind turbine (or wind turbines), the frequency of the fluctuations being related to the blade passing frequency of the turbine rotor(s*)."

This effect is identified within the UK document *ETSU-R-97, The Assessment and Rating of Noise from Wind Farms (1996)*, upon which the Department of the Environment, Heritage, and Local Government, Wind Energy Planning Guidelines, 2006, noise limits are based. ETSU-R-97 states that '*… modulation of blade noise may result in variation of the overall A-Weighted noise level by as much as 3 dB(A) (peak to trough) when measured close to a wind turbine... '* and that at distances further from the turbine where there are '*… more than two hard, reflective surfaces, then the increase in modulation depth may be as much as 6 dB(A) (peak to trough)*'. It concludes that '*the noise levels (i.e. limits) recommended in this report take into account the character of noise described ... as blade swish*'.

Modern wind turbines can generate normal AM but this usually disappears at 3 to 4 rotor lengths (with the exception of cross wind conditions). Where the modulation characteristics change, AM can potentially give rise to disturbance. Research into AM was conducted by Renewable UK, published as '*Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect' (December 2013)*. This research focused on the less understood 'Other AM' where reported incidents are relatively limited and infrequent but is a recognised phenomenon. However, the occurrence and intensity of OAM is specific to a location and its likelihood of occurrence cannot be reliably predicted.

Section 6 of the '*Summary of Research into Amplitude Modulation of Aerodynamic Noise from Wind Turbines- Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect'* states that "*At present there is no way of predicting OAM at any particular location before turbines begin operation due to the general features of a site or the known attributes of a particular turbine*".

Should AM arise it will be investigated thoroughly and if a complaint is justified, the required mitigation measures will be undertaken.

Infrasound and Low Frequency Noise

Low frequency noise is noise that is dominated by frequencies less than 200 Hz. It is audible to the human ear, can travel large distances and is difficult to attenuate.

Infrasound is typically described as sound at frequencies below 20 Hz. This is below the threshold of human hearing.

Further information on Infrasound and its potential effect is provided in the *EPA document Guidance Note for Noise Assessment of Wind Turbine Operations at EPA Licenced Sites (NG3)*. The document states:

"*There is similarly no significant infrasound from wind turbines. Infrasound is high level sound at frequencies below 20 Hz. This was a prominent feature of passive yaw "downwind" turbines where the blades were positioned downwind of the tower which resulted in a characteristic "thump" as each blade passed through the wake caused by the turbine tower. With modern active yaw turbines (i.e. the blades are upwind of the tower and the turbine is turned to face into the wind by a wind direction sensor on the nacelle activating a yaw motor) this is no longer a significant feature*."

The turbine selected for the site is a modern active yaw turbine.

The Draft 2019 WEDGs state "*There is no evidence that wind turbines generate perceptible infrasound".* It also states the following with regard to low frequency sound*:*

"Natural levels of low frequency noise arise in the environment. Regular environmental low frequency noise sources include rivers, waterfalls, waves on the sea, and air turbulence from the wind. Occasional short duration sources include thunder, landslides, avalanches and earthquakes. Low frequency noise from man-made sources includes industrial facilities, transportation, mechanical ventilation systems and some household tools and appliances".

If a complaint arises regarding Low Frequency Sound, it will be investigated in accordance with the most appropriate guidance at the time and corrective action will be taken if the complaint is found to be justified.

10.4.3.4 Substation

The proposed substation is approximately 418m from the nearest noise sensitive receptor. The substation will typically be in operation 24 hours a day, 7 days a week. The noise emission from a substation required for a wind farm development of this size would be in the order of 93 dB(A) Lw.

The noise level associated with the operation of the substation at the nearest noise sensitive receptor is predicted to be 28dB(A). This accounts for attenuation due to distance, ground absorption and landform screening.

28dB(A) noise is equivalent to quiet rural noise, refer to Figure 10-1 and therefore will not cause cumulative effect with wind turbine operations, therefore there will be no significant effect.

10.4.3.5 Significance of Effect

The effect of the operational wind turbines will vary depending on a number of variables including wind speed and direction and proximity of receptors relative to the wind turbines. The effect will be most noticeable to those closest to the site, however the effect will be slight, based on the margin between the predicted noise and the limits as per Table 10-14. The same applies to the substation, therefore there will be no significant effect.

As the proposed turbines are predicted not to exceed DoEHLG noise limit criteria in standard operating mode, mitigation measures are not required.

Table 10-15: Operational Phase Assessment of Noise Effects (Pre-Mitigation)

Effect: Operational Noise						
	Quality of Effect	Significance	Spatial Extent	Duration	Other Relevant Criteria	Likelihood
Wind turbines	Adverse	Slight	Localised	Long-term	Direct	Likely
Substation	Adverse	Slight to not significant	Localised	Long-term	Direct	Likely

10.4.3.6 Vibration

Once operational, there will be no significant sources of vibration from the wind farm development or the substation. There will be no significant sources of vibration from the ongoing maintenance through the lifetime of the wind farm, therefore no mitigation measures are required.

Table 10-16: Operational Phase Assessment of Vibration Effects (Pre-Mitigation)

Effect: Operational Vibration						
	Quality of Effect	Significance	Spatial Extent	Duration	Other Relevant Criteria	Likelihood
Wind turbines	Adverse	Imperceptible	Localised	Long-term	Direct	Likely
Substation	Adverse	Imperceptible	Localised	Long-term	Direct	Likely

10.4.3.7 Cumulative Effects

Other Wind Farm Developments

There are no other operational, permitted, or proposed wind farm developments which may impact cumulatively with the proposed development. The nearest wind turbines are the single turbine at Limerick Blow Moulding Ltd. at Parteen which is approximately 4 kilometres from the proposed development, and the Johnson and Johnson wind turbine in the University of Limerick campus which is approximately 8.5 km from the proposed development. The permitted 19 turbine Carrownagowan wind farm (currently under Judicial Review) is approximately 12 kilometres northeast of the proposed development. The proposed Fahy Beg Development approximately 8.5 km northeast of the proposed development is currently under consideration by An Bord Pleanála, following planning refusal by Clare County Council. This assessment has shown no significant noise or vibration effects to receptors closest to the proposed wind farm. Given the significant separation distances of the proposed development to other farms and geographical positioning, there will be no cumulative noise or vibration effects, therefore there will be no significant effect.

O Connell's Quarry

Planning conditions for the quarry restrict noise emissions to 55dB(A) at the quarry boundaries. Results show that the noise contribution to the local environment as a result of the usual operational activities at the quarry does not exceed the daytime limit of 55dB(A).

A review of the EIAR for the proposed quarry expansion indicates that the proposed development will not result in an increase in noise levels as all plant will remain in the same location except when the fixed processing plant is decommissioned. Mobile plant will be deployed at the quarry face to process material. The quarry void created will aid in retaining emissions associated with the quarry.

Allowing the quarry to operate to its maximum allowable noise limits of 55dB(A) at 10m from quarry boundaries, it can be extrapolated to the nearest noise sensitive receptors which have been identified as H80, H81, H82, H83 and H84, allowing for attenuation due to distance only. The results in **Table 10-17** show that quarry operations is not a major contributor to ambient noise levels at the nearest noise sensitive receptors to the quarry. The quarry will not cause wind farm noise criteria to be exceeded. The calculations in **Table 10-17** assume both developments are operating at maximum allowable noise limit criteria 100% of the time, which in reality will not be the case. Therefore, the results are very likely overestimated.

The cumulative effect is not considered a significant effect.

Table 10-17: Cumulative Noise Emissions Calculations

Location	Proximity to closest quarry boundary (m)	Extrapolated Quarry Noise Levels dB(A)	Predicted maximum wind farm noise levels (dBA)	Cumulative dB(A)
H80	400	23	41	41
H81	390	23	42	42
H82	150	31	39	40
H83	390	23	42	42
H84	450	22	42	42

Forestry Felling Operations

There will be felling activities in the commercial stand of forestry when the existing crop is scheduled for felling. The noise emissions associated with these operations have been assessed in **Section 10.4.1.5**. The noise emissions are low and will not be significant when in combination with the operational wind farm. Any forestry felling works will be temporary and of short duration, therefore the cumulative effect is not considered a significant effect.

10.5 Mitigation

10.5.1 Construction Phase Noise

The contract documents shall specify that the Contractor undertaking the construction of the works will be obliged to take specific noise abatement measures when deemed necessary to comply with recommendations of BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise. The following list of measures will be implemented, where necessary, to ensure compliance with the relevant construction noise criteria:

- No plant used on site will be permitted to cause an on-going public nuisance due to noise.
- The best means practicable, including proper maintenance of plant, will be employed to minimise the noise produced by on site operations.
- All vehicles and mechanical plant will be fitted with effective exhaust silencers and maintained in good working order for the duration of the contract.
- Compressors will be attenuated models, fitted with properly lined and sealed acoustic covers which will be kept closed whenever the machines are in use and all ancillary pneumatic tools shall be fitted with suitable silencers.
- Machinery that is used intermittently will be shut down or throttled back to a minimum during periods when not in use.
- Any plant, such as generators or pumps, which is required to operate before 07:00hrs or after 19:00hrs will be surrounded by an acoustic enclosure or portable screen.
- During the construction programme, supervision of the works will include ensuring compliance with the construction limits using methods outlined in BS 5228- 1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise.
- The hours of construction activity will be limited to avoid unsociable hours where possible. Construction operations shall generally be restricted to between 7:00hrs and 19:00hrs weekdays and between 7:00hrs and 14:00hrs on Saturdays. However, to ensure that optimal use is made of good weather period or at critical periods within the programme (i.e. concrete pours) or to accommodate delivery of large turbine component along public routes it could be necessary on occasion to work outside of these hours. Any such out of hours working will be agreed in advance with the local Planning Authority.
- Where rock breaking is employed, the following are examples of measures that will be implemented, where necessary, to mitigate noise emissions from these activities:
    - Fit suitably designed muffler or sound reduction equipment to the rock breaking tool to reduce noise without impairing machine efficiency.
    - Ensure all leaks in air lines are sealed.
    - Erect acoustic screen between compressor or generator and noise sensitive area. When possible, line of sight between top of machine and reception point needs to be obscured.
    - Enclose breaker or rock drill in portable or fixed acoustic enclosure with suitable ventilation.

Vibration levels will not exceed those described in BS5228 –1&2:2009 + A1 2014, *Code of Practice for the Control of Noise and Vibration on Construction and Open Sites* and this chapter. The contractor undertaking the construction works will be responsible for construction phase noise mitigation.

10.5.2 Construction Phase Vibration

Vibration associated with construction activities will be limited to the values set out in Section 10.2.5. It should be noted that these limits are not absolute but provide guidance as to magnitudes of vibration that are very unlikely to cause damage.

Although the assessment concluded that the proposed development is not predicted to give rise to vibration that is either significantly intrusive or capable of giving rise to structural or cosmetic damage to buildings, the following measures shall be implemented during the construction period:

- A clear communication programme will be established to inform closest building occupants in advance of any potential intrusive works which may give rise to vibration levels likely to exceed perceptible levels. The nature and duration of the works will be clearly set out in all communication circulars.
- Alternative less intensive working methods and/or plant items shall be employed, where feasible.
- Appropriate vibration isolation shall be applied to plant, where feasible.
- Cut off trenches to isolate the vibration transmission path shall be installed where required.

- Monitoring will be undertaken at identified sensitive buildings, where proposed works have the potential to be at or exceed the vibration limit values.

Vibration levels will not exceed those described in BS5228 –1&2:2009 + A1 2014, *Code of Practice for the Control of Noise and Vibration on Construction and Open Sites* and this chapter. The contractor undertaking the construction works will be responsible for construction phase vibration mitigation.

10.5.3 Construction Phase Blast Management

A Blast Management Plan will be prepared and implemented during the construction phase. The following mitigation measures will be incorporated into the Blast Management Plan and complied with during blasting operations:

- The appointed contractor will liaise with O' Connells quarry to ensure blasting that may be required are carried out for the proposed development at different times to blasting at O' Connell Quarry.
- Trial blasts will be carried out in less sensitive areas to assist in blast designs and identify potential zones of influence.
- An appropriate burden will be ensured to avoid over or under confinement of the charge.
- Accurate setting out and drilling will be implemented.
- Appropriate charging will be implemented.
- Appropriate stemming with appropriate material such as sized gravel or stone chipping will be implemented.
- Detonation will be delayed to ensure small maximum instantaneous charges.
- Decked charges and in-hole delays will be implemented.
- Blast monitoring will be carried out to enable adjustment of subsequent charges.
- Good blast design will be ensured to maximise efficiency and reduce vibration.
- Using exposed detonating cord on the surface will be avoided.
- Hours within which blasting can be conducted will be restricted.
- A publicity campaign will be undertaken before any work and blasting starts (e.g. 48 hours written notification).
- The firing of blasts at similar times will be implemented to reduce the 'startle' effect.
- On-going circulars informing people of the progress of the works will be issued.
- An onsite documented complaints procedure will be implemented.
- Independent monitoring by external bodies for verification of results will be implemented.

The contractor undertaking the construction works will be responsible for blast management and mitigation.

10.5.4 Operational Phase Noise

As the proposed turbines are predicted not to exceed DoEHLG noise limit criteria in standard operating mode, mitigation measures are not required.

In the unlikely event that a complaint of Amplitude Modulation arises during the operation of the wind farm, an investigation into the phenomenon will be carried out in accordance with best practice, specifically the Institute of Acoustics' (IoA) Noise working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG), *Method for Rating Amplitude Modulation in Wind Turbine Noise (August 2016)*. If required, mitigation measures will be put in place to eliminate any disturbance that is found to occur. These mitigation measures will be applied during the specific meteorological conditions which causes the AM to happen and typically involve one or more of the following:

- slowing down or stopping the relevant wind turbine;
- altering the pitch of the blades (i.e. changing the amount of rotation of the blade along its length);
- realigning the yaw of the rotor (i.e. changing the angle at which the turbine rotor faces into the wind).

In the unlikely event an issue regarding low frequency arises, the matter will be fully investigated with regard to best practice and guidance at the time. Currently guidance is outlined in Appendix VI of the EPA document entitled *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities* (NG4) (EPA, 2016).

There are no significant vibrations predicted with the operational phase of the proposed development, therefore no vibration mitigations are recommended. The operator of the development will be responsible for the implementation of any mitigation measures which may be required.

10.5.5 Decommissioning Phase Noise

In all instances, the total predicted construction and decommissioning noise levels are expected to be below construction noise thresholds of 65 dB (A). The mitigation measures that will be considered in relation to any decommissioning of the site are the same as those proposed for the construction phase of the development i.e as per **Section 10.5.1**. The contractor undertaking the decommissioning works will be responsible for mitigation measures.

10.5.6 Decommissioning Phase Vibration

There will be no significant vibration during the decommissioning phase.

Vibration levels will not exceed those described in BS5228 –1&2:2009 + A1 2014, *Code of Practice for the Control of Noise and Vibration on Construction and Open Sites* and this chapter.

10.6 Residual Effects

With the outlined mitigation in place, there will be no significant adverse residual noise and vibration effects at sensitive receptors as a result of the proposed development.

10.6.7 Construction and Decommissioning Phase

The construction phase noise effect is dependent on a multitude of variables and is predicted to range from a short term moderate adverse localised direct effect to not significant, depending on the timing, location and phase of the construction works. Based on the assessments undertaken, the construction noise threshold criteria are not expected to be exceeded, therefore no specific mitigation measures are required. However, best practice will be applied to minimise construction noise.

Best practice measures described in **Section 10.5.1** will reduce the potential for significant adverse effect. The construction phase is expected to last approximately 18 months.

Table 10-18: Construction Phase Noise Residual Effects

Effect: Construction Noise						
	Quality of Effect	Significance	Spatial Extent	Duration	Other Relevant Criteria	Likelihood
Wind Farm Development	Adverse	Moderate to not significant	Localised	Short- term	Direct	Likely

The residual adverse vibration effects on receptors from the proposed development will be not significant with the implementation of the mitigation measures outlined in **Section 10.5.2**, associated with rock breaking, blasting and construction activities.

Table 10-19: Construction Phase Vibration Residual Effects

Effect: Construction Vibration						
	Quality of Effect	Significance	Spatial Extent	Duration	Other Relevant Criteria	Likelihood
Wind Farm Development	Adverse	Moderate to not significant	Localised	Short- term	Direct	Likely

10.6.8 Operational Phase

The residual effect of the operational wind turbines will vary depending on a number of variables including wind speed and direction and proximity of receptors relative to the wind turbines. The effect will be most noticeable to those closest to the site. For the majority of receptors, the effect will be slight. The same applies to the substation.

Table 10-20: Operational Phase Noise Residual Effects

Effect: Operational Noise						
	Quality of Effect	Significance	Spatial Extent	Duration	Other Relevant Criteria	Likelihood
Wind turbines	Adverse	Slight	Localised	Long-term	Direct	Likely
Substation	Adverse	Slight	Localised	Long-term	Direct	Likely

Once operational, there will be no significant sources of vibration from the wind farm development or the substation.

Table 10-21: Operational Phase Vibration Residual Effects

Effect: Operational Vibration						
	Quality of Effect	Significance	Spatial Extent	Duration	Other Relevant Criteria	Likelihood
Wind turbines	Adverse	Imperceptible	Localised	Long-term	Direct	Likely
Substation	Adverse	Imperceptible	Localised	Long-term	Direct	Likely

10.7 References

Attenuation of sound during propagation outdoors –Part 2: General method of calculation, ISO 9613-2-1996- Acoustics.

Code of Practice for Noise and Vibration Control on Construction and Open Sites + A1 2014 British Standard 5228 Parts 1 & 2.

Environmental Management in the Extractive Industry (Non-Scheduled Minerals), Environmental Protection Agency, 2006.

Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise, Institute of Acoustics, 2013.

Guidelines for Environmental Noise Impact Assessment, Institute of Environmental Management and Assessment (IEMA), 2014.

Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4), Environmental Protection Agency, (EPA, 2016).

EPA Guidelines on the information to be contained in Environmental Impact Assessment Reports 2022.

Department of the Environment, Heritage, and Local Government (DoEHLG) – Wind Energy Development Guidelines (2006).

ETSU-R-97 – The Assessment and Rating of Wind Farm Noise (1997).

A Good Practice Guide (GPG) to the application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (Institute of Acoustics 2013).

EU Commission (2014) – Guidance on the preparation of the Environmental Impact Assessment Report (Directive 2011/92/EU as amended by 2014/52/EU).