11. NOISE AND VIBRATION

11.1 Introduction

11.1.1 Background & Objectives

This chapter of the EIAR describes the assessment undertaken of the potential noise and vibration impacts associated with the proposed Glenard Wind Farm Development (the 'Proposed Development'). The Proposed Development comprises up to 15 no. wind turbines with a maximum overall ground level to blade tip height of up to 173 metres, an electricity substation, construction compound and all ancillary infrastructure. A full description of the proposed development is provided in Chapter 4 of this EIAR. There are 93 no. noise sensitive locations (NSLs) within 3.5 km of the proposed turbine locations. The nearest NSL is H077 being 723 m from turbine T11.

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

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

11.1.2 Statement of Authority

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

Mike Simms

Mike Simms (Senior Acoustic Consultant) holds a BE and MEngSc in Mechanical Engineering, and is a member of the Institute of Acoustics (MIOA) and of the Institution of Engineering and Technology (MIEI). Mike has worked in the field of acoustics for over 19 years. He has extensive experience in all aspects of environmental surveying, noise modelling and impact assessment for various sectors including, wind energy, industrial, commercial and residential.

Dermot Blunnie

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

11.2 Fundamentals of Acoustics

A sound wave travelling through the air is a regular disturbance of the atmospheric pressure. These pressure fluctuations are detected by the human ear, producing the sensation of hearing. To take account of the vast range of pressure levels that can be detected by the ear, it is convenient to measure sound in terms of a logarithmic ratio of sound pressures. These values are expressed as Sound Pressure Levels (SPL) in decibels (dB).

The audible range of sounds expressed in terms of Sound Pressure Levels (SPL) is 0dB (for the threshold of hearing) to 120dB (for the threshold of pain). In general, a subjective impression of doubling of loudness corresponds to a tenfold increase in sound energy which conveniently equates to a 10dB increase in SPL. It should be noted that a doubling in sound energy (such as may be caused by a doubling of traffic flows) increases the SPL by 3 dB.

The frequency of sound is the rate at which a sound wave oscillates is expressed in Hertz (Hz). The sensitivity of the human ear to different frequencies in the audible range is not uniform. For example, hearing sensitivity decreases markedly as frequency falls below 250Hz. In order to rank the SPL of various noise sources, the measured level has to be adjusted to give comparatively more weight to the frequencies that are readily detected by the human ear. The ‘A-weighting’ system defined in the international standard, BS ISO 226:2003 Acoustics. Normal Equal-loudness Level Contours has been found to provide the best correlations with human response to perceived loudness. SPL’s measured using ‘A-weighting’ are expressed in terms of dB(A).

An indication of the level of some common sounds on the dB(A) scale is presented in Figure 11-1.

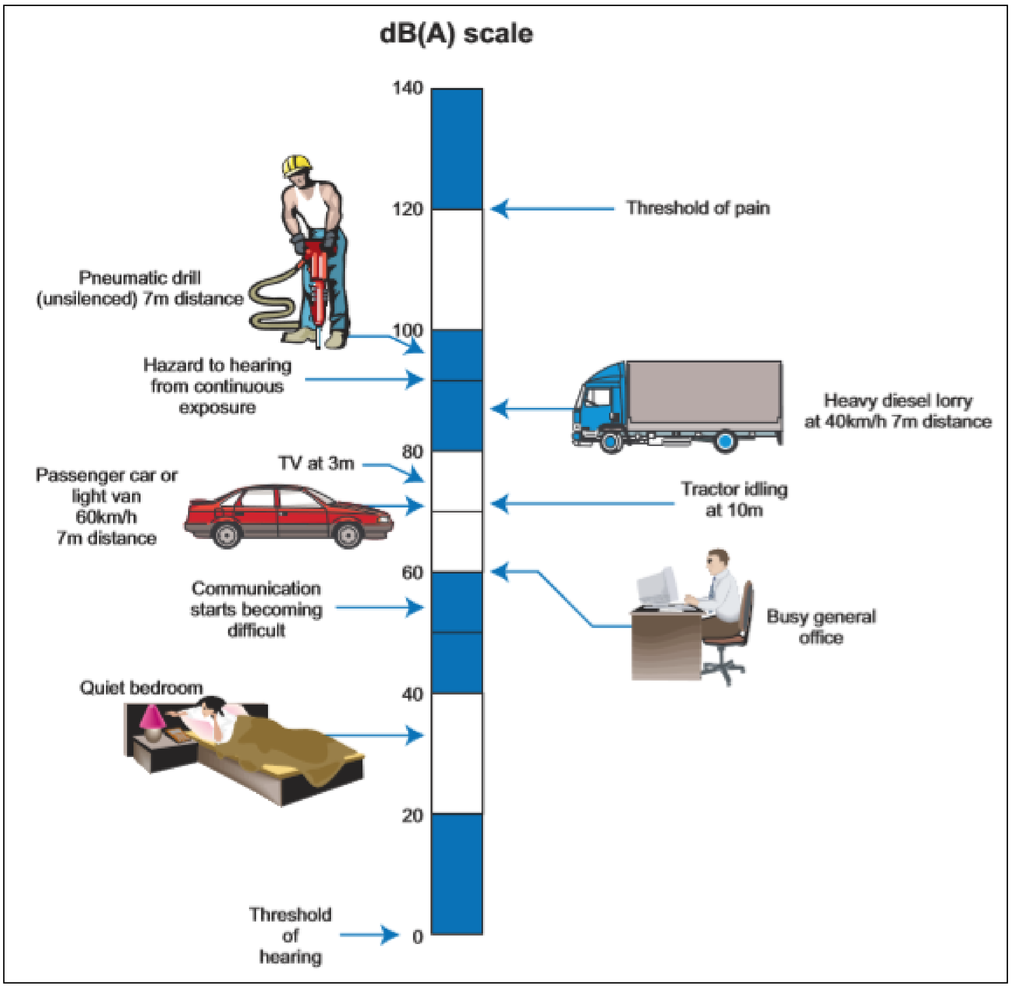

Figure 11-1 The level of typical common sounds on the dB(A) scale (NRA Guidelines for the Treatment of Noise and Vibration in National Road Schemes, 2004)

For a glossary of terms used in this chapter please refer to Appendix 11-1.

11.3 Assessment Methodology

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

In addition to the specific guidance documents outlined below, the Environmental Impact Assessment (EIA) guidelines listed in Section 1.7.1 of Chapter 1 were considered and consulted for the purposes of preparing this EIAR chapter.

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

- Review of appropriate guidance to identify appropriate noise and vibration criteria for both the construction and operational phases;
- Characterise the receiving environment through baseline noise surveys at various NSLs surrounding the proposed development;
- Undertake predictive calculations to assess the potential impacts associated with the construction phase of the proposed development at NSLs;
- Undertake predictive calculations to assess the potential impacts associated with the operational of the proposed development at NSLs; evaluate the potential noise and vibration impacts and effects;

- Specify mitigation measures to reduce, where necessary, the identified potential outward impacts relating to noise and vibration from the proposed development; and
- Describe the significance of the residual noise and vibration effects associated with the proposed development.

11.3.1 EPA Description of Effects

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

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

11.3.2 Guidance Documents and Assessment Criteria

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

11.3.2.1 Construction Phase

11.3.2.1.1 *Construction Noise*

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

In the absence of specific noise limits, appropriate criteria relating to permissible construction noise levels for a development of this scale may be found in the *British Standard 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise.*

The approach adopted here calls for the designation of a NSL into a specific category (A, B or C) based on existing ambient noise levels in the absence of construction noise. This then sets a threshold noise value that, if exceeded (construction noise only) at the façade of residential, noise sensitive locations, indicates a potential significant noise impact is associated with the construction activities.

Table 11-1 sets out the values which, when exceeded, potentially signify a significant effect at the facades of residential receptors as recommended by BS 5228 – 1. These levels relate to construction noise only.

Table 11-1 Example Threshold of Potential Significant Effect at Noise Sensitive Locations

Assessment category and threshold value period (T)	Threshold values, $L_{Aeq,T}$ dB		
	Category A Note A	Category B Note B	Category C Note C
Night-time (23:00 to 07:00hrs)	45	50	55
Evenings 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.

The following assessment method is only valid for residential properties.

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

See Section 11.5.2 for the detailed assessment in relation to this site. If the specific construction noise level exceeds the appropriate category value (e.g. 65 dB $L_{Aeq,T}$ during daytime periods) then a significant effect is deemed to have occurred.

11.3.2.1.2 Additional Vehicular Activity on Public Roads

There are no specific guidelines or limits relating to traffic related sources along the local or surrounding roads. Given that traffic from the development will make use of existing roads already carrying traffic volumes, it is appropriate to assess the calculated increase in traffic noise levels that will arise because of vehicular movements associated with the development. To assist with the interpretation of the noise associated with additional vehicular traffic on public roads, Table 11-2, adapted from *Design Manual for Roads and Bridges (DMRB*), Highways England Company Limited, Transport Scotland, The Welsh Government and The Department for Regional Development (Northern Ireland), 2019, offers guidance as to the likely impact in the long-term associated with any change in traffic noise level.

Table 11-2 Likely Impacts Associated with Change in Traffic Noise Level (Source DMRB, 2019)

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

The guidance outlined in Table 11-2 will be used to assess the predicted increases in traffic levels on public roads associated with the construction of the Proposed Development. Where an impact is identified due to the change in traffic noise level, reference will be made to the overall predicted noise level from construction traffic in the context of the construction noise criteria outlined in Section 11.4.1.1.

11.3.2.1.3 Construction Vibration

Vibration standards come in two varieties: those dealing with human comfort and those dealing with cosmetic or structural damage to buildings. With respect to this development, the range of relevant criteria used for building protection is expressed in terms of Peak Particle Velocity (PPV) in mm/s.

Guidance relevant to acceptable vibration within buildings is contained in the following documents:

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

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

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

The Transport Infrastructure Ireland (TII) (formerly National Roads Authority (NRA)) document *Guidelines for the Treatment of Noise and Vibration in National Road Schemes* (NRA, 2004) also contains information on the permissible construction vibration levels during the construction phase as shown in Table 11-3.

Table 11-3 Allowable Transient Vibration at Properties

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

11.3.2.2 Operational Phase

11.3.2.2.1 *Noise*

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

11.3.2.2.2 *Wind Energy Development Guidelines*

Section 5.6 of the *Wind Energy Development Guidelines* published by the Department of the Environment, Heritage and Local Government (2006) addresses noise and outlines the appropriate noise criteria in relation to wind farm developments.

The following extracts from this document should be considered:

> *"An appropriate balance must be achieved between power generation and noise impact."*

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

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

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

> *"In general, a lower fixed limit of 45dB(A) or a maximum increase of 5dB(A) above background noise at nearby noise sensitive locations is considered appropriate to provide protection to wind energy development neighbours."*

This represents the commonly adopted daytime noise criterion curve in relation to wind farm developments. However, an important caveat should be noted as detailed in the following extract.

> *"However, in very quiet areas, the use of a margin of 5dB(A) above background noise at nearby noise sensitive properties is not necessary to offer a reasonable degree of protection and may unduly restrict wind energy developments which should be recognised as having wider national and global benefits. Instead, in low noise environments where background noise is less than 30dB(A), it is recommended that the daytime level of the LA90, 10min of the wind energy development be limited to an absolute level within the range of 35 – 40dB(A)."*

In relation to night-time periods the following guidance is given:

> *"A fixed limit of 43dB(A) will protect sleep inside properties during the night."*

This limit is defined in terms of the $L_{A90,10min}$ parameter. This represents the commonly adopted night-time lower limit noise criterion curve in relation to wind farm developments.

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

- an appropriate absolute limit level for quiet daytime environments with background noise levels of less than 30 dB $L_{A90,10min}$;
- 45 dB $L_{A90,10min}$ for daytime environments with background noise levels of greater than 30 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher), and;
- 43 dB $L_{A90,10min}$ for night time periods.

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

This set of criteria has been chosen as it is in line with the intent of the relevant Irish guidance. The proposed operational noise criteria curves for wind turbine noise at various noise sensitive locations are presented in Section 11.4.2.

11.3.2.2.3 The Assessment and Rating of Noise from Wind Farms – ETSU-R-97

As stated previously the core of the noise guidance contained within the Wind Energy Development Guidelines guidance document is based on the 1996 ETSU publication *The Assessment and Rating of Noise from Wind Farms (ETSU-R-97).*

ETSU-R-97 calls for the control of wind turbine noise by the application of noise limits at the nearest noise sensitive properties. ETSU-R-97 considers that absolute noise limits applied at all wind speeds are not suited to wind turbine developments and recommends that noise limits should be set relative to the existing background noise levels at noise sensitive locations. A critical aspect of the noise assessment of wind energy proposals relates to the identification of baseline noise levels through on-site noise surveys.

ETSU-R-97 states on page 58, "*...absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area which contribute to the noise received at the properties in question...".* Therefore, the noise contribution from all wind turbine developments in the area should be included in the assessment.

11.3.2.2.4 Institute of Acoustics Good Practice Guide

The guidance contained within the institute of Acoustics (IoA) document *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (2013) (IOA GPG) and Supplementary Guidance Notes are considered to represent best practice and have been adopted for this assessment. The IOA GPG states, that at a minimum continuous baseline noise monitoring should be carried out at the nearest noise sensitive locations for typically a two-week period and should capture a representative sample of wind speeds in the area (i.e. cut in speeds to wind speed of rated sound power of the proposed turbine). Background noise measurements (i.e. $L_{A90,10min}$) should be related to wind speed measurements that are collated at the site of the wind turbine development. Regression analysis is then conducted on the data sets to derive background noise levels at various wind speeds to establish the appropriate day and night-time noise criterion curves.

Noise emissions associated with the wind turbine can be predicted in accordance with ISO 9613: *Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation* (1996). This is a noise prediction standard that considers noise attenuation offered, amongst others, by distance, ground absorption, directivity and atmospheric absorption. Noise predictions and contours are typically prepared for various wind speeds and the predicted levels are compared against the relevant noise criterion curve to demonstrate compliance with the appropriate noise criteria.

Where noise predictions indicate that reductions in noise emissions are required in order to satisfy any adopted criteria, consideration can be given to detailed downwind analysis and operating turbines in low noise mode, which is typically offered by modern wind turbine units.

Reference has been made to the IoA GPG for guidance on the methodology for the background noise survey and operation impact assessment for wind turbine noise.

11.3.2.2.5 World Health Organisation (WHO) Noise Guidelines for the European Region)

The WHO *Environmental Noise Guidelines for the European Region* (2018) provide guidance on protecting human health from exposure to environmental noise. They set health-based recommendations based on average environmental noise exposure of several sources of environmental noise, including wind turbine noise. Recommendations are rated as either 'strong' or 'conditional'. A strong recommendation, "*can be adopted as policy in most situations*" whereas a conditional recommendation, "*requires a policy-making process with substantial debate and involvement of various stakeholders. There is less certainty of its efficacy owing to lower quality of evidence of a net benefit, opposing values and preferences of individuals and populations affected or the high resource implications of the recommendation, meaning there may be circumstances or settings in which it will not apply*".

The objective of the World Health Organisation (WHO) Environmental Noise Guidelines for the European Region that was published in October 2018 is to provide recommendations for protecting human health from exposure to environmental noise from transportation, wind farm and leisure sources of noise. The guidelines present recommendations for each noise source type in terms of L_{den} and L_{night} levels above which there is potential for adverse health risks.

In relation to wind turbine noise, the WHO Guideline Development Group (GDG) state the following:

> *"For average noise exposure, the GDG **conditionally** recommends reducing noise levels produced by wind turbines below 45 dB L_{den}, as wind turbine noise above this level is associated with adverse health effects.*
>
> *No recommendation is made for average night noise exposure L_{night} of wind turbines. The quality of evidence of night-time exposure to wind turbine noise is too low to allow a recommendation.*
>
> *To reduce health effects, the GDG **conditionally** recommends that policymakers implement suitable measures to reduce noise exposure from wind turbines in the population exposed to levels above the guideline values for average noise exposure. No evidence is available, however, to facilitate the recommendation of one particular type of intervention over another."*

The quality of evidence used for the WHO research is stated as being 'Low', the recommendations are therefore conditional.

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

There is potential increased uncertainty due to the parameter used by the WHO for assessment of exposure (i.e. L_{den}), which it is acknowledged may be a poor characterisation of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes, as stated below.

> *"Even though correlations between noise indicators tend to be high (especially between LAeq-like indicators) and conversions between indicators do not normally influence the correlations between the noise indicator and a particular health effect, important assumptions remain when exposure to wind turbine noise in L_{den} is converted from original sound pressure level values. The conversion requires, as variable, the statistical distribution of annual wind speed at a particular height, which depends on the type of wind turbine and meteorological conditions at a particular geographical location. Such input variables may not be directly applicable for use in other sites. They are sometimes used without specific validation for a particular area, however, because of practical limitations or lack of data and resources. This can lead to increased uncertainty in the assessment of the relationship between wind turbine noise exposure and health outcomes. Based on all these factors, it may be concluded that the acoustical description of wind turbine noise by means of L_{den} or L_{night} may be a poor characterization of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes...*
>
> *...Further work is required to assess fully the benefits and harms of exposure to environmental noise from wind turbines and to clarify whether the potential benefits associated with reducing exposure to environmental noise for individuals living in the vicinity of wind turbines outweigh the impact on the development of renewable energy policies in the WHO European Region."*

Based upon the review set out above, it is concluded that the conditional WHO recommended average noise exposure level (i.e. 45dB L_{den}) should not currently be applied as target noise criteria for an existing or proposed wind turbine development in Ireland.

11.3.2.2.6 Future Potential Guidance Change

In December 2019, the Draft Revised Wind Energy Development Guidelines December 2019 (DRWEDG19) were published for consultation and therefore have yet to be finalised. It is important to note that as part of the public consultation a number of concerns in relation to the proposed approach have been expressed by various parties and it is the opinion of the authors' of this assessment that the DRWEDG19 document does not outline a best practice approach in terms of the assessment of wind turbine noise. Specific concerns expressed by a cross party group of interested professionals can be reviewed at:

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

The following statement is of note from the above submission:

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

Therefore, in line with best practice, which includes ESTU and IoA methodologies as described above the assessment presented in the 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 the 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.

In the event that updated Wind Energy Guidelines are published during the application process for the Proposed Development it is anticipated that any relevant changes affecting the noise will be addressed through an appropriate planning condition, or where a supplementary assessment is necessary, through provision of additional information.

11.3.3 Special Characteristics of Turbine Noise

11.3.3.1 Infrasound/Low Frequency Noise

Low Frequency Noise is noise that is dominated by frequency components less than approximately 200Hz whereas Infrasound is typically described as sound at frequencies below 20Hz. In relation to Infrasound, the following extract from the EPA document *Guidance Note for Noise Assessment of Wind Turbine Operations at EPA Licensed Sites* (NG3) (EPA, 2011) is noted here:

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

With respect to infrasonic noise levels below the hearing threshold, the World Health Organisation (WHO) document Community Noise (WHO, 1995) has stated that:

> *"There is no reliable evidence that infrasounds below the hearing threshold produce physiological or psychological effects."*

In 2010, the UK Health Protection Agency published a report entitled *Health Effects of Exposure to Ultrasound and Infrasound*, Report of the independent Advisory Group on Non-ionising Radiation. The exposures considered in the report related to medical applications and general environmental exposure. The report notes:

> *"Infrasound is widespread in modern society, being generated by cars, trains and aircraft, and by industrial machinery, pumps, compressors and low speed fans. Under these circumstances, infrasound is usually accompanied by the generation of audible, low frequency noise. Natural sources of infrasound include thunderstorms and fluctuations in atmospheric pressure, wind and waves, and volcanoes; running and swimming also generate changes in air pressure at infrasonic frequencies.*
>
> *For infrasound, aural pain and damage can occur at exposures above about 140 dB, the threshold depending on the frequency. The best-established responses occur following acute exposures at intensities great enough to be heard and may possibly lead to a decrease in wakefulness. The available evidence is inadequate to draw firm conclusions about potential health effects associated with exposure at the levels normally experienced in the environment, especially the effects of long-term exposures. The available data do not suggest that exposure to infrasound below the hearing threshold levels is capable of causing adverse effects."*

The UK Institute of Acoustics Bulletin in March 2009 included a statement of agreement between acoustic consultants regularly employed on behalf of wind farm developers, and conversely acoustic consultants regularly employed on behalf of community groups campaigning against wind farm developments (IAO JS2009). The intent of the article was to promote consistent assessment practices, and to assist in restricting wind farm noise disputes to legitimate matters of concern. In relation to the issue of infrasound, the article states the following:

> *"Infrasound is the term generally used to describe sound at frequencies below 20 Hz. At separation distances from wind turbines which are typical of residential locations the levels of infrasound from wind turbines are well below the human perception level. Infrasound from wind turbines is often at levels below that of the noise generated by wind around buildings and other obstacles.*
>
> *Sounds at frequencies from about 20 Hz to 200 Hz are conventionally referred to as low-frequency sounds. A report for the DTI in 2006 by Hayes McKenzie concluded that neither infrasound nor low frequency noise was a significant factor at the separation distances at which people lived. This was confirmed by a peer review by a number of consultants working in this field. We concur with this view."*

The article concludes that:

> *"from examination of reports of the studies referred to above, and other reports widely available on internet sites, we conclude that there is no robust evidence that low frequency noise (including 'infrasound') or ground-borne vibration from wind farms, generally has adverse effects on wind farm neighbours".*

A report released in January 2013 by the South Australian Environment Protection Authority namely, *Infrasound levels near windfarms and in other environments* (EPA, 2013)[1] found that the level of infrasound from wind turbines is insignificant and no different to any other source of noise, and that the worst contributors to household infrasound are air-conditioners, traffic and noise generated by people.

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

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

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

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

A German report[2], titled "*Low Frequency Noise incl. Infrasound from Wind Turbines and Other Sources*" presents the details of a measurement project which ran from 2013. The report was published by the State Office for the Environment, Measurement and Nature Conservation of the Federal State of Baden-Württemberg in 2016 and concluded the following in relation to infrasound from wind turbines:

> *"The measured infrasound levels (G levels) at a distance of approx. 150 m from the turbine were between 55 and 80 dB(G) with the turbine running. With the turbine switched off, they were between 50 and 75 dB(G). At distances of 650 to 700 m, the G levels were between 55 and 75 dB(G) with the turbine switched on as well as off."*

> *"For the measurements carried out even at close range, the infrasound levels in the vicinity of wind turbines – at distances between 150 and 300 m – were well below the threshold of what humans can perceive in accordance with DIN 45680 (2013 Draft) [3]"*

> *"The results of this measurement project comply with the results of similar investigations on a national and international level."*

In summary, considering the modernisation of wind turbines and the conclusions of the studies quoted above, infrasound associated with wind turbines is insignificant in comparison to typical prevailing levels of infrasound and is below the threshold of hearing for humans even in proximity to turbines before set back distances of hundreds of meters are taken into account.

11.3.3.2 Amplitude Modulation

In the context of this assessment, amplitude modulation (AM) is defined in the IOA Noise Working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) document A Method for Rating Amplitude Modulation in Wind Turbine Noise (IOA, 2016) as:

> *"Periodic fluctuations in the level of audible noise from a wind turbine (or wind turbines), the frequency of the fluctuations being related to the blade passing frequency (BPF) of the turbine rotor(s)."*

It is now generally accepted that there are two mechanisms which can cause amplitude modulation:

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[1] EPA South Australia, 2013, Wind farms https://www.epa.sa.gov.au/files/477912_infrasound.pdf
[2] Report available at https://www4.lubw.baden-wuerttemberg.de/servlet/is/262445/low-frequency_noise_incl_infrasound.pdf?command=downloadContent&filename=low-frequency_noise_incl_infrasound.pdf
[3] DIN 45680:2013-09 – Draft "Measurement and Assessment of Low-frequency Noise Emissions" November 2013

- 'Normal' AM, and;
- 'Other' AM (sometimes referred to 'Excessive' AM).

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

'Normal' AM

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

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

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

'Other' AM

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

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

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

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

The RenewableUK AM project report adopted the term 'Other AM' (OAM) for this characteristic. The terms 'enhanced' or 'excess' AM (EAM) have been used by others, although such definitions do not distinguish between the source mechanisms and presuppose a 'normal' level of AM, presumably relating back to blade swish as described in ETSU-R-97.

11.3.3.2.1 Frequency of Occurrence of AM

Research by Salford University commissioned by the Department of Environment Food and Rural Affairs (DEFRA), the Department of Business, Enterprise and Regulatory Reform (BERR) and the Department of Communities and Local Government (CLG) investigated the issue of AM associated with wind turbine noise. The results were reviewed and published in the report *Research into Aerodynamic Modulation of Wind Turbine Noise* (2007). The broad conclusions of this report were that aerodynamic modulation was only considered to be an issue at 4, and a possible issue at a further 8, of 133 sites in the UK that were operational at the time of the study and considered within the review. At the 4 sites where AM was confirmed as an issue, it was considered that conditions associated with AM might occur between about 7 and 15% of the time. It also emerged that for three out of the four sites the complaints have subsided, in one case due to the introduction of a turbine control system. The research has shown that AM is a rare and unlikely occurrence at operational wind farms.

It should be noted that AM is associated with wind turbine operation and it is not possible to predict an occurrence of AM at the planning stage. It should also be noted that it is a rare event associated with a limited number of wind farms. While it can occur, it is the exception rather than the rule.

RenewableUK Research Document states the following in relation to matter:

Page 68 Module F	*"even on those limited sites where it has been reported, its frequency of occurrence appears to be at best infrequent and intermittent."*
Page 6 Module F	*"It has also been the experience of the project team that, even at those wind farm sites where AM has been reported or identified to be an issue, its occurrence may be relatively infrequent. Thus, the capture of time periods when subjectively significant AM occurs may involve elapsed periods of several weeks or even months."*
Page 61 Module F	*"There is nothing at the planning stage that can presently be used to indicate a positive likelihood of OAM occurring at any given proposed wind farm site, based either on the site's general characteristics or on the known characteristics of the wind turbines to be installed."*

11.3.3.2.2 Assessment of AM

Research and Guidance in the area is ongoing with recent publications being issued by the Institute of Acoustics (IoA) Noise working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) namely, *A Method for Rating Amplitude Modulation in Wind Turbine Noise* (August 2016) (The Reference Method). The document proposes an objective method for measuring and rating AM. The AMWG does not propose what level of AM is likely to result in adverse community response or propose any limits for AM. The purpose of the group is simply to use existing research to develop a Reference Methodology for the measurement and rating of amplitude modulation.

The definition of any limits of acceptability for AM, or consideration of how such limits might be incorporated into a wind farm planning condition, is outside the scope of the AMWG's work and is currently the subject of a separate UK Government funded study. In the absence of published guidance to date, it is considered best practice to adopt the penalty rating and assessment scheme contained in an article published in the Institute of Acoustics publication Acoustics Bulletin (Vol. 42 No. 2 March/April 2017) titled, *Perception and Control of Amplitude Modulation in Wind Turbines Noise*.

Where it occurs, AM is typically an intermittent occurrence, therefore assessment may involve long-term measurements during the operational phase of the proposed development. The 'Reference Method' for measuring AM outlined in the IoA AMWG document will provide a robust and reliable indicator of AM and yield important information on the frequency and duration of occurrence, which can be used to evaluate different operational conditions including mitigation.

11.3.4 Comments on Human Health Impacts

11.3.4.1 The National Health & Medical Research Council

The relevant Australian authority on health issues, the National Health and Medical Research Council (NHMRC), conducted a comprehensive independent assessment of the scientific evidence on wind farms and human health, the findings are contained in the NHMRC Information Paper: *Evidence on Wind Farms and Human Health* 2015, this report concluded:

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

11.3.4.2 Health Canada

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

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

11.3.4.3 New South Wales Health Department

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

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

11.3.4.4 The Australian Medical Association

The Australian Medical Association put out a position statement, Wind Farms and Health 2014[5]. The statement said:

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

11.3.4.5 Journal of Occupational and Environmental Medicine

The review titled, Wind Turbines and Health: A Critical Review of the Scientific Literature was published in the Journal of Occupational and Environmental Medicine, 2014. An independent review of the literature was undertaken by the he Department of Biological Engineering of the Massachusetts Institute of Technology (MIT). The review took into consideration health effects such as stress,

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[4] *Health Canada 2014, Wind Turbine Noise and Health Study: Summary of Results. Available at https://www.canada.ca/en/health-canada/services/environmental-workplace-health/noise/wind-turbine-noise/wind-turbine-noise-health-study-summary-results.html*
[5] *Australian Medical Association, 2014, Wind farms and health. Available at https://ama.com.au/position-statement/wind-farms-and-health-2014*

annoyance and sleep disturbance, as well as other effects that have been raised in association with living close to wind turbines. The study found that:

> *"No clear or consistent association is seen between noise from wind turbines and any reported disease or other indicator of harm to human health."*

The report concluded that living near wind farms does not result in the worsening of the quality of life in that region.

11.3.4.6 Summary

The peer reviewed research outlined in the preceding sections supports that there are no negative health effects on people with long term exposure to wind turbine noise. Please refer to Chapter 5 of the EIAR for further details of potential health impacts associated with the Proposed Development.

11.3.5 Vibration

A recent report published in Germany by the State Office for the Environment, Measurement and Nature Conservation of the Federal State of Baden-Württemberg in 2016, "*Low Frequency Noise incl. Infrasound from Wind Turbines and Other Sources*", Conducted vibration measurements study for an operational Nordex N117 – 2.4 MW wind turbine. The report concluded that at distances of less than 300m from the turbine vibration levels had dropped so far that they could no longer be differentiated from the background vibration levels.

Considering the distances from nearest NSL's to any of the turbines in the Proposed Development (>740m) the level of vibration will be significantly below any thresholds for perceptibility. Therefore, vibration criteria have not been specified for the operational phase of the Proposed Development.

11.3.6 Noise Conditions for Other Wind Farm Developments

The 5 wind farms Glackmore 2, Three Trees, Aught, Malkell and J McCarron have a noise condition in the following form:

> *Noise levels from the proposed development when measured at the nearest noise sensitive location or dwelling house shall not exceed 43dB (A) L Aeq (15 mins). Measurements shall be carried out in accordance with ISO Recommendations R 1996-1 (Acoustics Description and Measurement of Environmental Noise – Part 1: Basic Qualities and Procedures).*

6 no. wind farms Sorne Hill, Flughland, Crockahenny, Glackmore 1, Meenkeeragh II and III, and Colpey Rock have no planning condition attached to their respective grants of planning permission.

11.3.7 Background Noise Assessment

An environmental noise survey was undertaken to determine typical background noise levels at representative NSLs surrounding the development site. The background noise survey was conducted through installing unattended sound level meters at 9 no. representative locations in the surrounding area.

All measurement data collected during the background noise surveys has been carried out in accordance with the Institute to Acoustic's Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (IoA GPG, 2013) and accompanying, Supplementary Guidance Note 1: Data Collection (2014) discussed in the following Section.

The NSLs are located within 3km of the proposed turbine locations. The noise monitoring locations were selected to obtain background noise levels representative of the noise environments at noise sensitive locations surrounding the site. Consideration was also given to the potential for noise from existing turbines effecting the survey when selecting the locations.

As set out in the IOA GPG:

> *"Where a new wind farm is proposed and a receptor is also within the area acoustically affected by an already operational wind farm, then noise from the existing wind farm must not be allowed to influence the background noise measurements for the proposed development."*

For each measurement location, noise data collected during the survey has been filtered to exclude periods where the measurement locations were downwind of existing operational wind turbines.

11.3.7.1 Choice of Measurement Locations

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

The selected locations for the noise monitoring are outlined in the following sections. Coordinates for the noise monitoring locations are detailed in

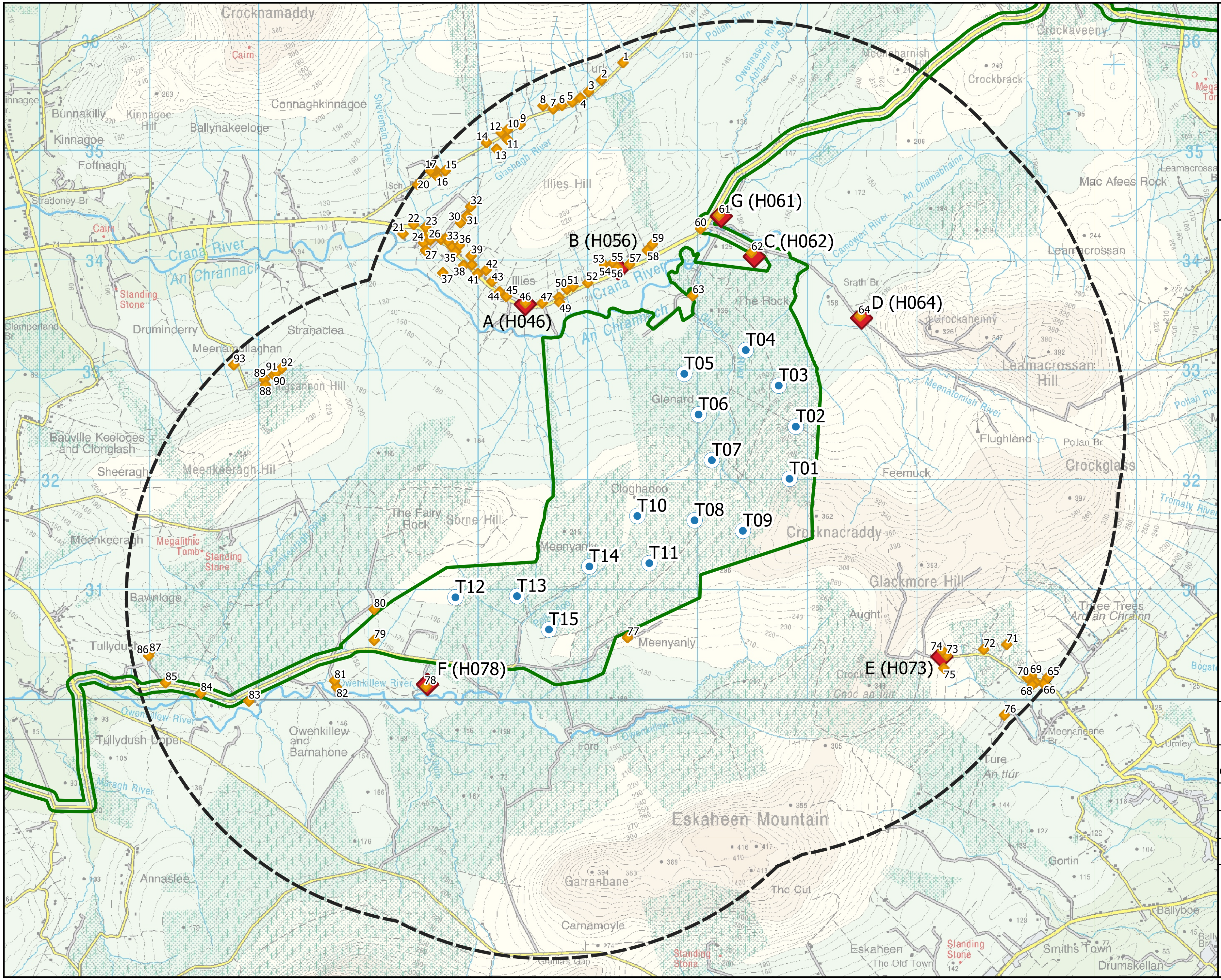
Table 11-4 and illustrated in Figure 11-2 as well as the Noise Sensitive Locations.

Table 11-4 Measurement Location Coordinates

Location	Coordinates – Irish Transverse Mercator (ITM)	
	Easting	Northing
A (H046)	642374	933582
B (H056)	643219	933905
C (H062)	644461	934016
D (H064)	645440	933456
E (H073)	646172	930370
F (H078)	641482	930117
G (H061)	644160	934384
H (H063)	643895	933635

Significant noise sources in this area were noted to be distant traffic movements, activity in and around the residences and wind generated noise from local foliage and other typical anthropogenic sources typically found in such rural settings. Flowing water was audible at some locations.

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



Map Legend

- EIAR Site Boundary
- Proposed Turbine Layout (15 no. turbines)
- Sensitive Receptors
- Noise Monitoring Locations
- Noise Monitoring Study Area 3km Turbine Buffer

Drawing Title	Noise Monitoring Locations
Project Title	Glenard Wind Farm, Co. Donegal
Drawn By: SD	Checked By: EMC
Project No.: 190114	Drawing No.: Figure 11-2
Scale: 1:45000	Date: 27.01.2022

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Plate 11-1 to Plate 11-9 illustrate the installed noise monitoring kits. In the descriptions that follow, all distances are approximate.

Location A

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

Plate 11-1 Location A (H046)

Location B

Location B was positioned on a lawn 15m southeast of the dwelling, 20m northeast from a local road and 1.5m above the low-level surrounding grass.

Plate 11-2 Location B (H056)

Location C

Location C was positioned 10m southwest of the dwelling and 1.5m above the low-level vegetation in the immediate area.

Plate 11-3 Location C (H062)

Location D

Location D was positioned on grassy area at 20m to the east of the dwelling. at 15m from a local road and 1.5m above the surrounding grass.

Plate 11-4 Location D (H064)

Location E

Location E was positioned on grassy area at 20m to the north of the dwelling, at 10m from a local road and 1.5m above the low-level vegetation in the surrounding area.

Plate 11-5 Location E (H073)

Location F

Location F was positioned on grassy area at 15m to the north of the dwelling at 30m from a local road and 1.5m above the surrounding grass.

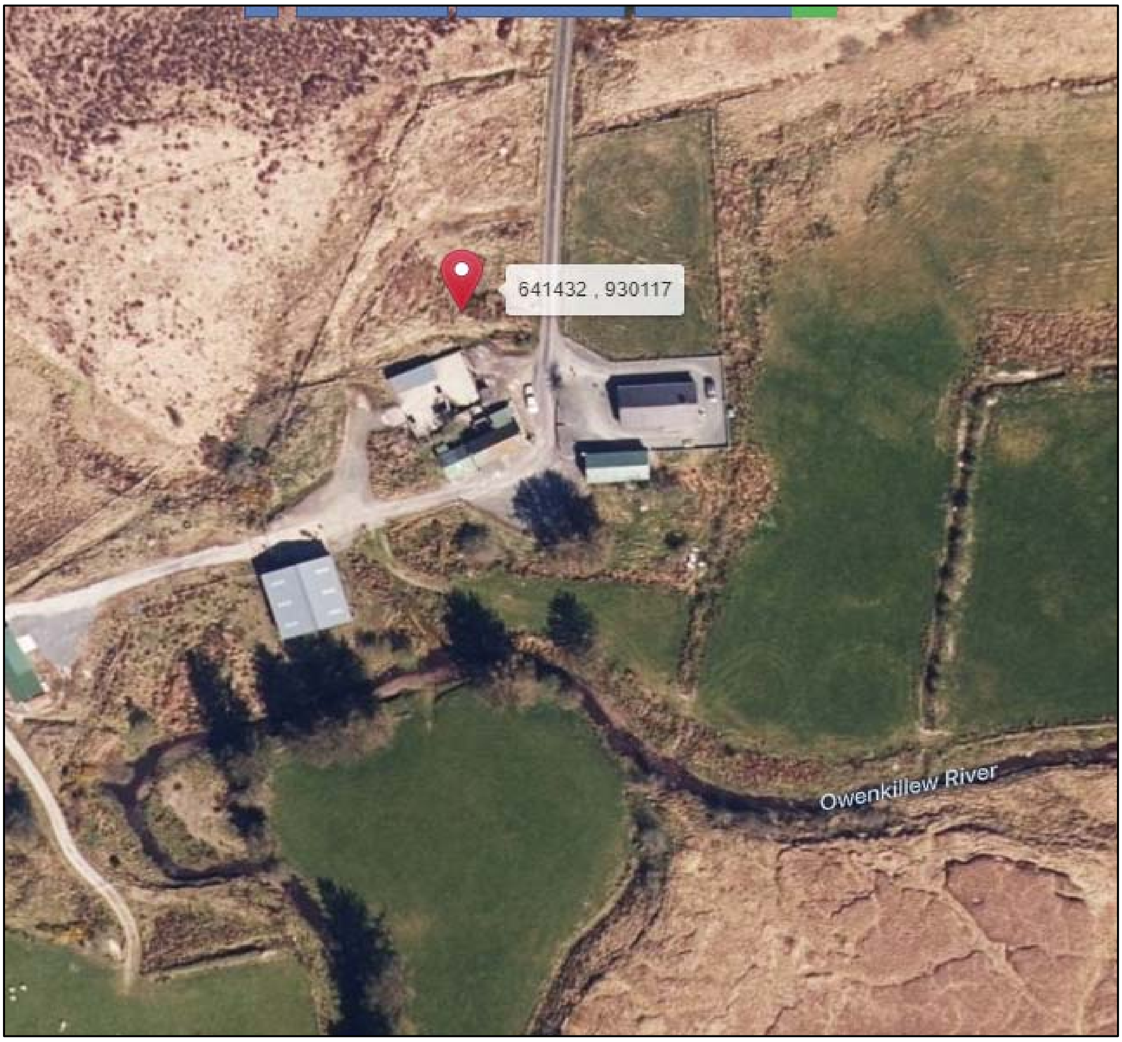

Plate 11-6 Location F (H078)

Location G

Location G was positioned on a lawn at 20m to the southeast of the dwelling, at 90m from a local road and 1.5m above the surrounding grass.

Plate 11-7 Location G (H061)

Location H

Location H was positioned on grassy area at 20m to the southeast of the vacant house, at 10m from a the local road and 1.5m above the low-level vegetations in the surrounding area.

Plate 11-8 Location H (H063)

11.3.7.2 Measurement Periods

Noise measurements were conducted at each of the monitoring locations over the periods outlined in Table 11-5.

Table 11-5 Measurement Periods

Location	Start Date	End Date
A (H046)	26 September 2019	4 November 2019
B (H056)	5 September 2019	10 October 2019
C (H062)	5 September 2019	10 October 2019
D (H064)	5 September 2019	10 October 2019
E (H073)	5 September 2019	10 October 2019
F (H078)	5 September 2019	10 October 2019
G (H061)	11 September 2019	4 November 2019
H (H063)	11 September 2019	4 November 2019

A variety of wind speed and weather conditions were encountered over the survey periods in question. Figure 11-3 illustrates the distributions of wind speed and wind direction standardised to 10 metre height over the survey period detailed in Table 11-5.

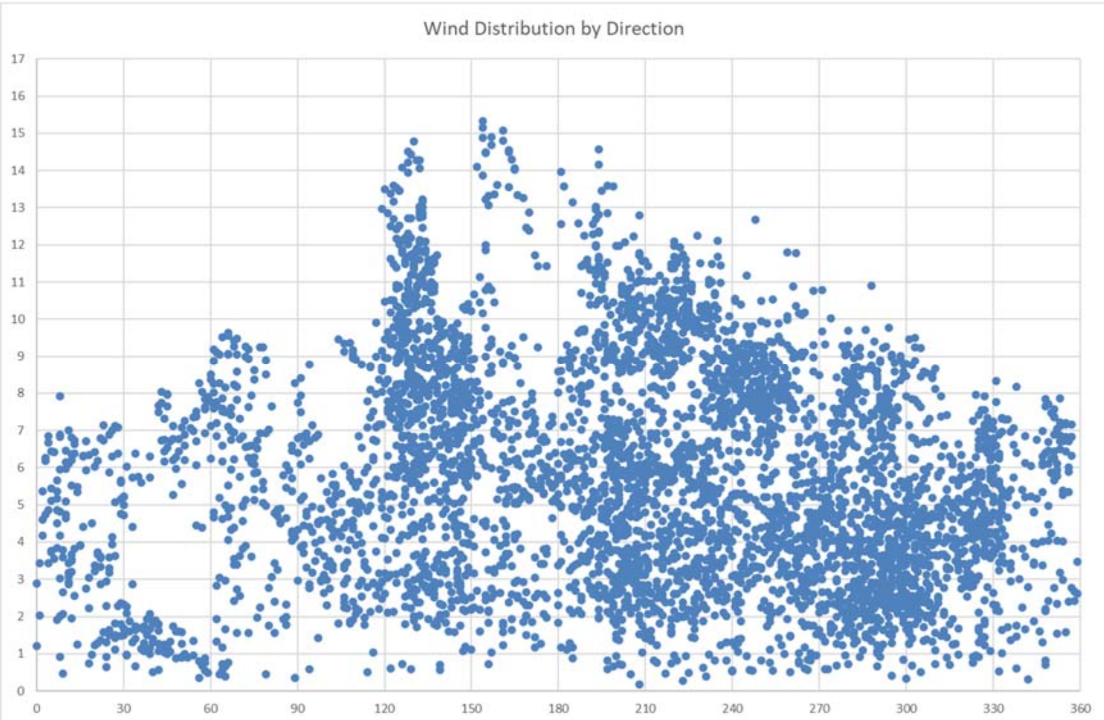

Figure 11-2 Distributions of Wind Speeds and Directions Over the Survey Period

11.3.7.3 Personnel and Instrumentation

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

Table 11-6 Instrumentation Details

Location	Equipment	Serial Number
A (H046)	Rion NL-52	186668
B (H056)	Rion NL-52	586944
C (H062)	Rion NL-52	186667
D (H064)	Rion NL-52	186669
E (H073)	Rion NL-52	575802
F (H078)	Rion NL-52	186671
G (H061)	Rion NL-52	586940
H (H063)	Rion NL-52	575785

Before and after the survey the measurement apparatus was check calibrated using a Bruel & Kjaer type 4231 Sound Level Calibrator where appropriate. Instruments were calibrated on each interim visit and any drift noted. Relevant calibration certificates are presented in Appendix 11-2.

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

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

Table 11-7 Met Mast Details

Description	Coordinates (ITM)	
	Easting	Northing
Met Mast	643,946	931,844

11.3.7.4 Procedure

Measurements were conducted at ten locations over the survey periods outlined in Table 11-5. Data samples for all measurements (noise, rainfall and wind) were logged continuously at 10-minute interval periods for the duration of the survey.

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

11.3.7.5 Analysis of Background Noise Data

The data sets have been filtered to remove issues such as the dawn chorus and the influence of other atypical noise sources. An example of atypical sources would be short isolated periods of raised noise levels attributable to local sources, agricultural activity, boiler flues, operation of gardening equipment etc. In addition, sample periods affected by rainfall or when rainfall resulted in prolonged periods of atypical noise levels have also been screened form the data sets. The assessment methods outlined above are in line with the guidance contained in the IoA *GPG*.

Consideration has been given to removing contributing noise from the existing turbines for the measured noise data. For guidance, reference has been made to Section 5.2.3 of the IOA GPG which states:

> *"5.2.3 In the presence of an existing wind farm, suitable background noise levels can be derived by one of the following methods:*
>
> - *switching off the existing wind farm during the background noise level survey (with associated cost implications);*
> - *accounting for the contribution of the existing wind farm in the measurement data e.g. directional filtering (only including background data when it is not influenced by the existing turbines e.g. upwind of the receptor, but mindful of other extraneous noise sources e.g. motorways) or subtracting a prediction of noise from the existing wind farm from the measured noise levels;*
> - *utilising an agreed proxy location removed from the area acoustically affected by the existing wind farm/s; or utilising background noise level data as presented within the Environmental Statement/s for the original wind farm/s (the suitability of the background noise level data should be established)."*

The approach adopted here is to apply wind directional filtering to the measured data in order to assess background noise data when it was not influenced by the existing turbines e.g. upwind of the NSL.

The results presented in the following sections refer to the noise data collated during 'quiet periods' of the day and night as defined in the IoA *GPG*. These periods are defined as follows:

- Daytime Amenity hours are:
  - all evenings from 18:00 to 23:00hrs;
  - Saturday afternoons from 13:00 to 18:00hrs, and;
  - all day Sunday from 07:00 to 18:00hrs.
- Night-time hours are 23:00 to 07:00hrs.

11.3.7.5.1 *Consideration of Wind Shear*

Wind shear is defined as the increase of wind speed with height above ground. As part of a robust wind farm noise assessment due consideration should be given to the issue of wind shear. The issue of wind shear has been considered in this assessment and followed relevant guidance as outlined in the IoA GPG. It is standard procedure to reference noise data to standardised 10 metre height wind speed.

Wind speed measurements at 80m and 60m heights have been corrected to a height of 105m (the intermediate hub height adopted for the noise assessment) in accordance with Method B of Section 2.6 of the IOA GPG. The calculated hub height wind speeds were then corrected to standardised 10 metre height wind speed.

The IoA GPG presents the following equations in relation to the derivation of a standardised wind speed at 10m above ground level:

Shear Exponent Profile:

$$U = U_{ref}\left(\frac{H}{H_{ref}}\right)^{m}$$

Where:

U Calculated wind speed

U_{ref} Measured wind speed.

H Height at which the wind speed will be calculated.

H_{ref} Height at which the wind speed was measured.

m shear exponent = $\frac{\log_{10}\frac{U}{Uref}}{\log_{10}\frac{H}{Href}}$

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

Roughness Length Shear Profile:

$$U_1 = U_2\left(\frac{\ln\frac{10}{z}}{\ln\frac{H_2}{z}}\right)$$

Where:

H_1 The height of the wind speed to be calculated (10m)

H_2 The height of the measured or calculated HH wind speed.

U_1 The wind speed to be calculated.

U_2 The measured or calculated HH wind speed.

~~Z~~z The roughness length.

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

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

11.3.8 Turbine Noise Calculations

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

11.3.8.1 Noise Modelling Software

Proprietary noise calculation software was used for the purposes of this impact assessment. The selected software, DGMR iNoise Enterprise, calculates noise levels in accordance with ISO 9613: *Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation*, (ISO, 1996).

iNoise is a proprietary noise calculation package for computing noise levels and propagation of noise sources. iNoise calculates noise levels in different ways depending on the selected prediction standard. In general, however, the resultant noise level is calculated considering a range of factors affecting the propagation of sound, including:

- the magnitude of the noise source in terms of A weighted sound power levels (L_{WA});
- the distance between the source and receiver;
- the presence of obstacles such as screens or barriers in the propagation path;
- the presence of reflecting surfaces;
- the hardness of the ground between the source and receiver;
- Attenuation due to atmospheric absorption; and
- Meteorological effects such as wind gradient, temperature gradient and humidity (these have significant impact at distances greater than approximately 400m).

11.3.8.2 Input Data and Assumptions

The calculation settings, input data and any assumptions made in the assessment are described in the following sections. Additional information relating to the noise model inputs and calculation settings is provided in Appendix 11-3.

11.3.8.2.1 *Turbine Details*

Table 11-1 details the co-ordinates of the 15 no. proposed turbines that are being considered in this assessment.

Table 11-8 Proposed Glenard Turbine Co-ordinates

Turbine Ref.	Coordinates – Irish Transverse Mercator (ITM)	
	Easting	Northing
T1	644783	931991
T2	644840	932467
T3	644684	932840
T4	644384	933164
T5	643824	932948
T6	643953	932577
T7	644075	932161
T8	643927	931653
T9	644357	931517

Turbine Ref.	Coordinates – Irish Transverse Mercator (ITM)	
	Easting	Northing
T10	643370	931654
T11	643505	931222
T12	641736	930911
T13	642298	930922
T14	642958	931192
T15	642589	930617

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

Sound power levels (L_{WA}) have been supplied for the various turbines under consideration. These levels have been reviewed and an envelope method used whereby the worst case, i.e. highest noise levels, for the proposed turbine models have been selected and input into the noise model. For the purposes of this assessment, calculations are based on a turbine HH of 105m above ground. However, in order to assess the proposed maximum and minimum turbine dimensions, a range of turbine dimensions has also been considered. The methodology is described in Section 11.3.8.2.2 below and related sound power levels of the various scenarios assessed are presented in Appendix 11-4.

Table 11-9 details the noise spectra used for noise modelling purposes for the proposed Glenard Wind Farm.

Table 11-9 Sound Power Level Spectra Used for Prediction Model – Glenard Wind Farm

Wind Speed (m/s)	Octave Band Centre Frequency (Hz)								dB L_{WA}
	63	125	250	500	1000	2000	4000	8000	
4	74.7	81.7	85.5	86.9	86.9	85.6	81.3	72.1	93.1
5	76.7	83.8	88.6	90.5	89.3	87.6	83.3	74.1	95.8
6	82.3	89.3	93.8	95.6	94.4	93.2	88.9	79.7	101.1
7	85.9	92.9	96.8	98.6	98.1	96.8	92.5	83.3	104.4
8	86.2	93.2	97.2	99.0	98.4	97.1	92.8	83.6	104.8
≥9	86.2	93.2	97.2	99.0	98.4	97.1	92.8	83.6	104.8

An appraisal of the wider study area around the site identified the potential for cumulative impacts from the operation of the Proposed Development in combination with other wind farms in the surrounding area as detailed in Section 11.7.5 of this report as listed below:

- Aught wind farm to the southwest;
- Carrowglen wind farm to the northeast;
- Crockahenny wind farm to the northeast;
- Flughland wind farm to the east;
- Glackmore wind farm to the southwest;
- Sorne Hill wind farm to the west;
- Colpey wind turbine to the northwest;
- McCarron wind farm to the west;
- Malkell wind farm to the west;
- Meenkragh wind farm to the west; and
- Three Trees wind farm to the east.

Sound power levels used for the turbines in these wind farms are presented in Appendix 11-5.

The manufacturer's turbine sound power levels in Table 11-2 to and in Appendices 11-4 and 11-5 are derived based on measurements in terms of the L_{Aeq} acoustic parameter[6]. In accordance with best practice guidance contained within the Institute of Acoustics Good Practice Guide (IoA GPG), an allowance for uncertainty in the measurement of turbine source levels of +2dB is added to all turbine sound power levels presented in the tables above.

Moreover, as explained below in Section 11.3.2.2.1, appropriate guidance is couched in terms of a L_{A90} criterion. Best practice guidance in the IoA GPG states that "*L_{A90} levels should be determined from calculated L_{Aeq} levels by subtraction of 2 dB*". Therefore, a 2dB reduction has been applied to the noise model output. All predicted noise levels in this chapter are presented in terms of L_{A90}, i.e. this reduction of 2dB is included the values presented. In the interest of clarity, the levels presented in the tables above are the corrected levels following the adding and subtracting of 2dB.

Finally, best practice specifies that should any tonal component be present, a penalty shall be added to the predicted noise levels. The level of this penalty is described in ETSU-R-97[7], and is related to the level by which any tonal components exceed audibility. For the purposes of this assessment a tonal penalty has not been included within the predicted noise levels. A warranty will be provided by the manufacturers of the selected turbine to ensure that the noise output will not require a tonal noise correction under best practice guidance.

11.3.8.2.2 Assessment a of Range of Possible Turbine Dimensions

In order to assess the noise effects of a possible range of turbine dimensions, the following three scenarios are evaluated:

- A lowest hub height of 96 m;
- An intermediate hub height of 105 m, and
- A highest hub height of 107 m.

A set of noise calculations for each scenario is prepared. Each scenario results in a table of noise levels for wind speeds from 4 to 9 m/s for each of the 93 locations. Then, a single table of noise levels made from the highest value from each scenario for each wind speed and house combination separately. This table of highest values is then used in the assessment, i.e. the comparison against the noise criteria.

[6] *For details, see IEC 61400 Wind turbine generator systems – Part 11: Acoustic noise measurement techniques.*

[7] *UK Department of Trade and Industry: ETSU-R-97 The assessment of rating of Noise from wind farms, 1996*

Full details of the sound power levels for each scenario are presented in Appendix 11.4. The predicted noise levels for each of the three scenarios (for omni-directional propagation) are presented in Appendix 11.6. The table of highest values used in the assessment is presented in Appendix 11-7.

11.3.8.3 Consideration of Wind Direction and Noise Propagation

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

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

- Downwind (i.e. 0° ±80°);
- Crosswind (i.e. 90° ±10° and 270° ±10°);
- Upwind (i.e. 180° ±70°).

Figure 11.3 illustrates the directivity attenuation factor that has been applied to turbines when considering noise propagation in downwind conditions (downwind is represented by 0° with upwind being 180°).

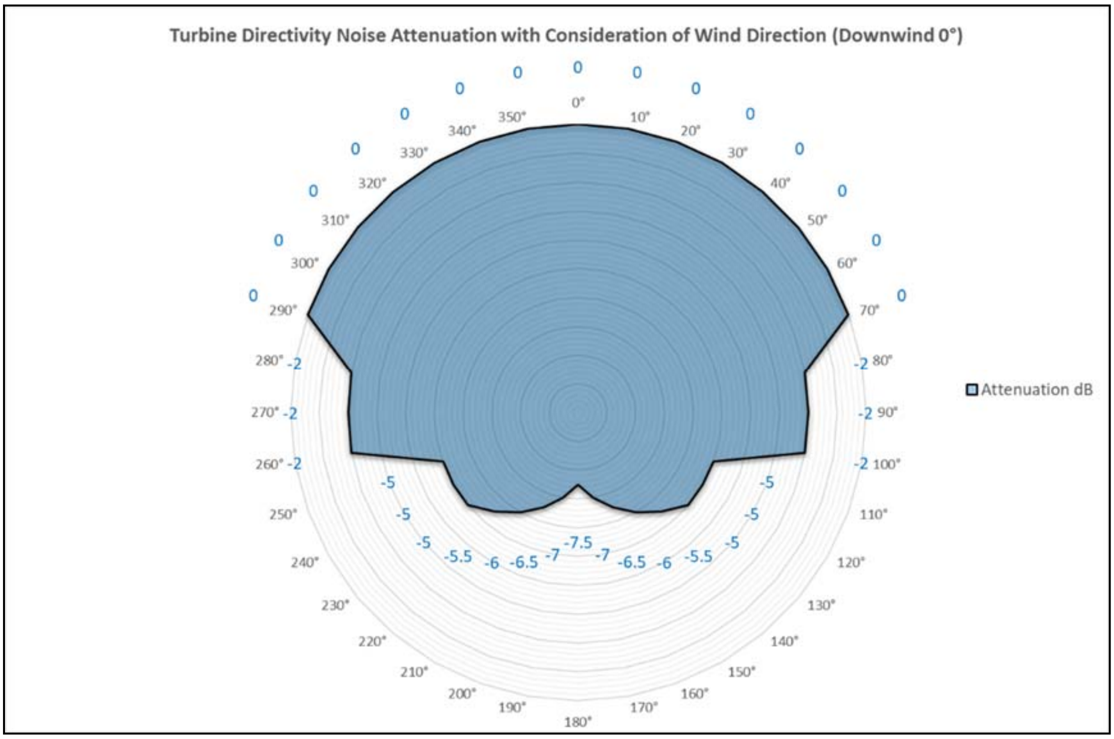

Figure 11.3 Turbine Directivity Attenuation with Consideration of Wind Direction

11.3.8.4 Assessment of Turbine Noise Levels

The predicted cumulative turbine noise level from the proposed development, and contributing permitted and proposed developments in the area will be compared against the derived turbine noise limits and any exceedances of the limits will be identified and assessed. Where necessary, appropriate mitigation measures will be outlined.

The following presents a breakdown of the various steps involved in the assessment of operational turbine noise level:

- Screen the cumulative turbine noise predictions against the lowest potential (worst-case) criteria outlined in Section 11.3.2.2.2 to identify any locations with a potential exceedance.
- Undertake directional noise prediction calculations to refine the noise prediction results as presented in Table 11-20.
- Identify any locations with potential cumulative exceedances that occur as result of the proposed development only (i.e. Glenard turbines).
- Calculate the level of attenuation required from the Glenard turbines to achieve the adopted turbine noise criteria or the attenuation required to Glenard such that the predicted contribution of the Glenard turbines is 10 dB below the cumulative turbine limit value in accordance with best practice guidance.

11.3.9 Assessments of Construction Impacts

The potential impacts of the construction phase noise and vibration in addition to the potential impacts from additional vehicular activity on public roads will be assessed in accordance with best practice guidance as outlined in Section 11.3.2.1.

11.4 Receiving Environment

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

11.4.1 Background Noise Levels

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

11.4.1.1 Location A (H046)

11.4.1.1.1 *Daytime Quiet Periods*

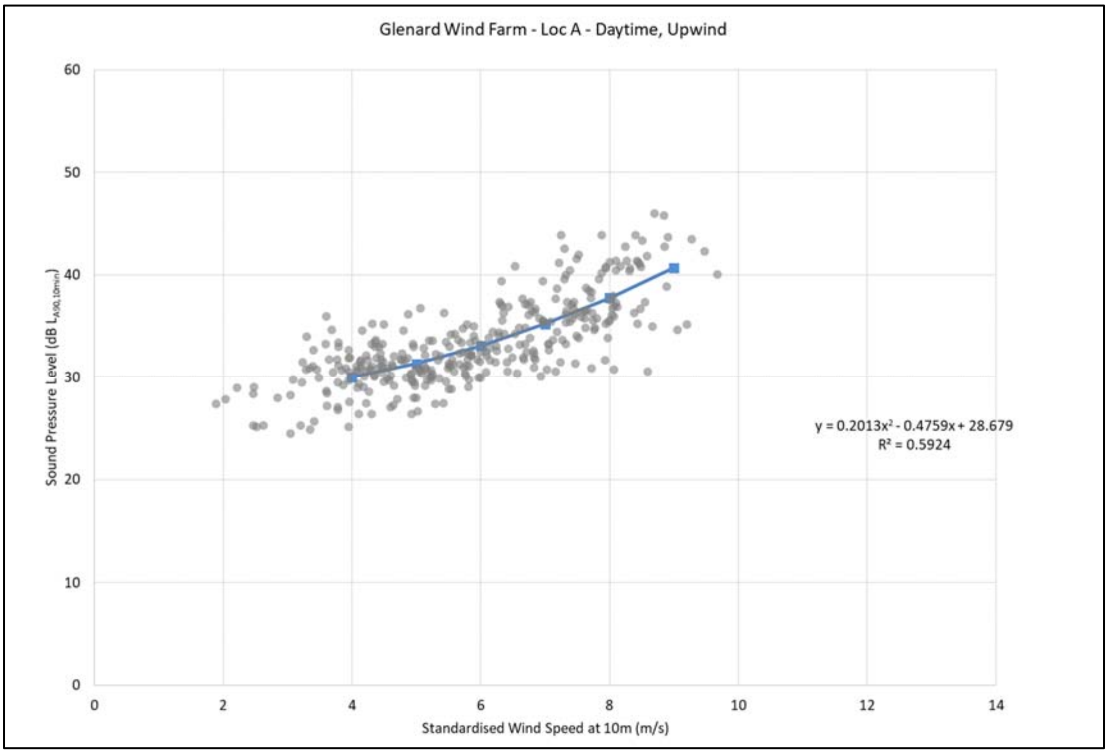

Figure 11-4 Location A (H046) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Daytime

11.4.1.1.2 *Night-time Periods*

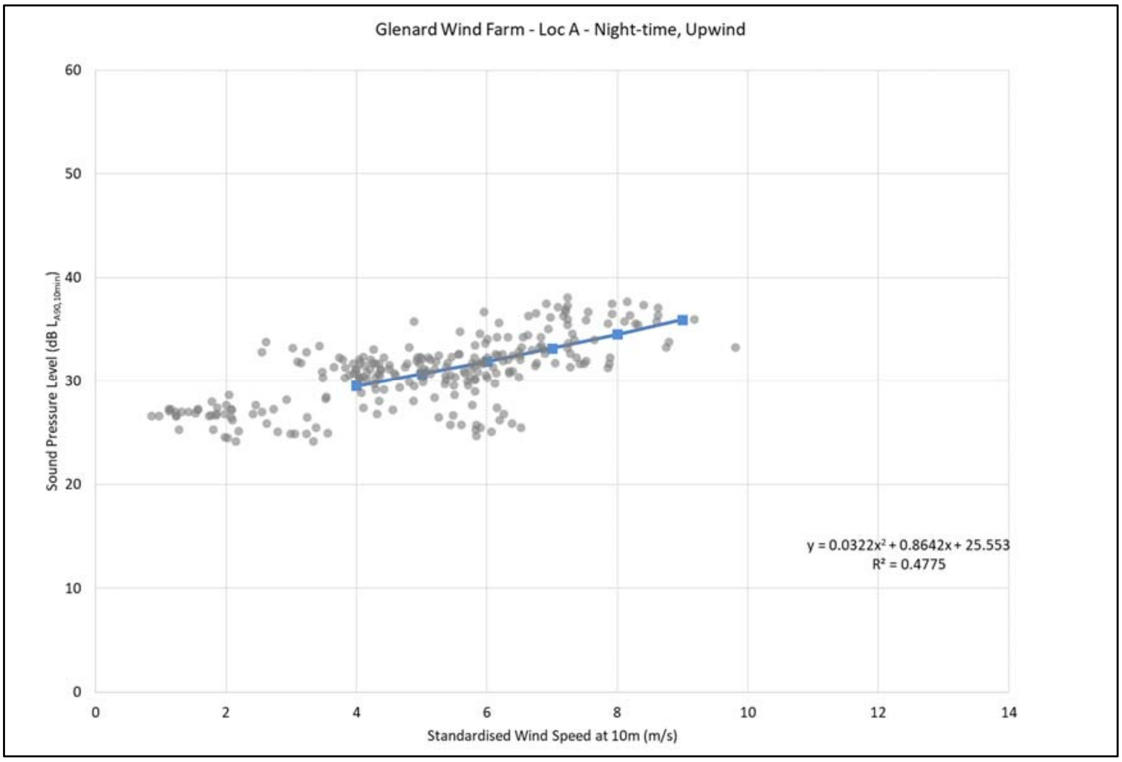

Figure 11-5 Location A (H046) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Night-time

11.4.1.2 Location B (H056)

11.4.1.2.1 *Daytime Quiet Periods*

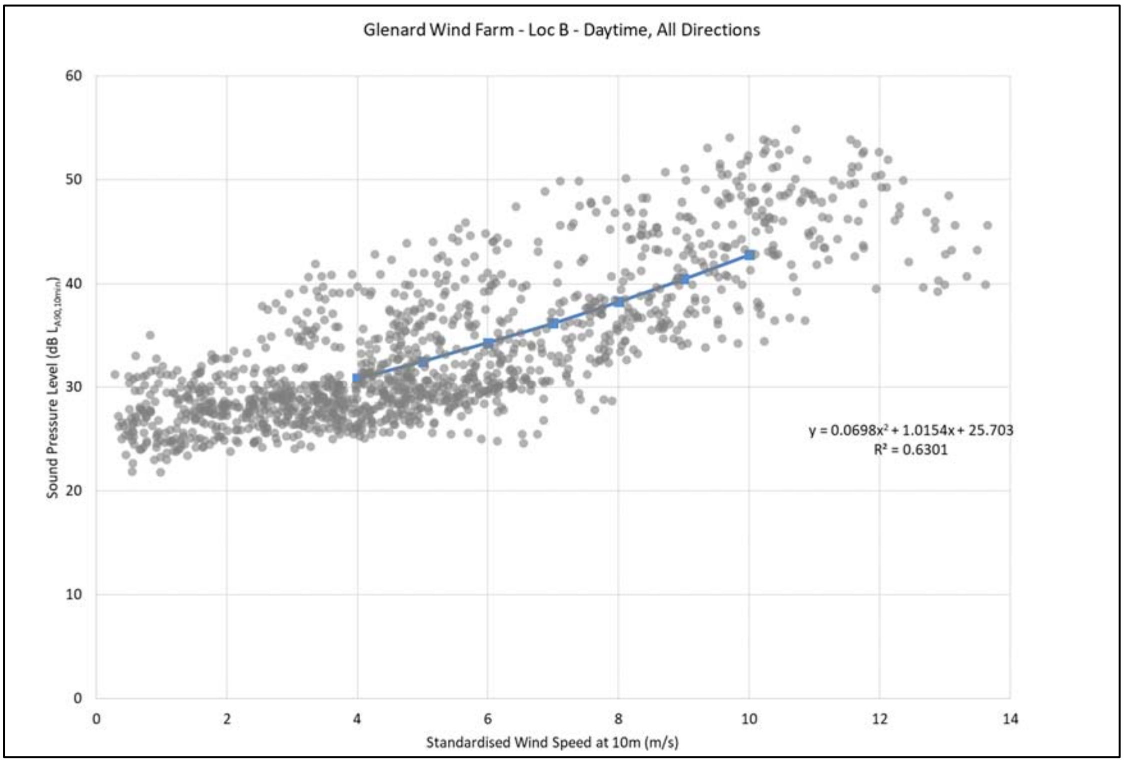

Figure 11-6 Location B (H056) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Daytime

11.4.1.2.2 *Night-time Periods*

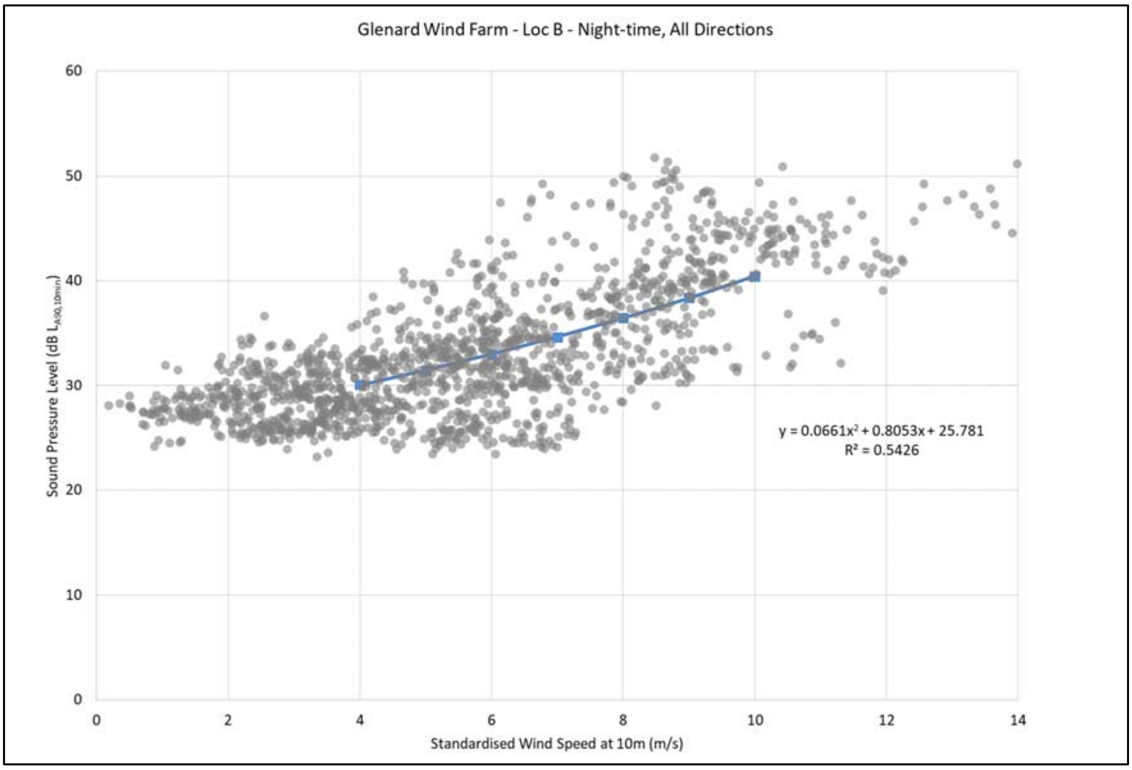

Figure 11-7 Location B (H056) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Night-time

11.4.1.3 Location C (H062)

11.4.1.3.1 Daytime Quiet Periods

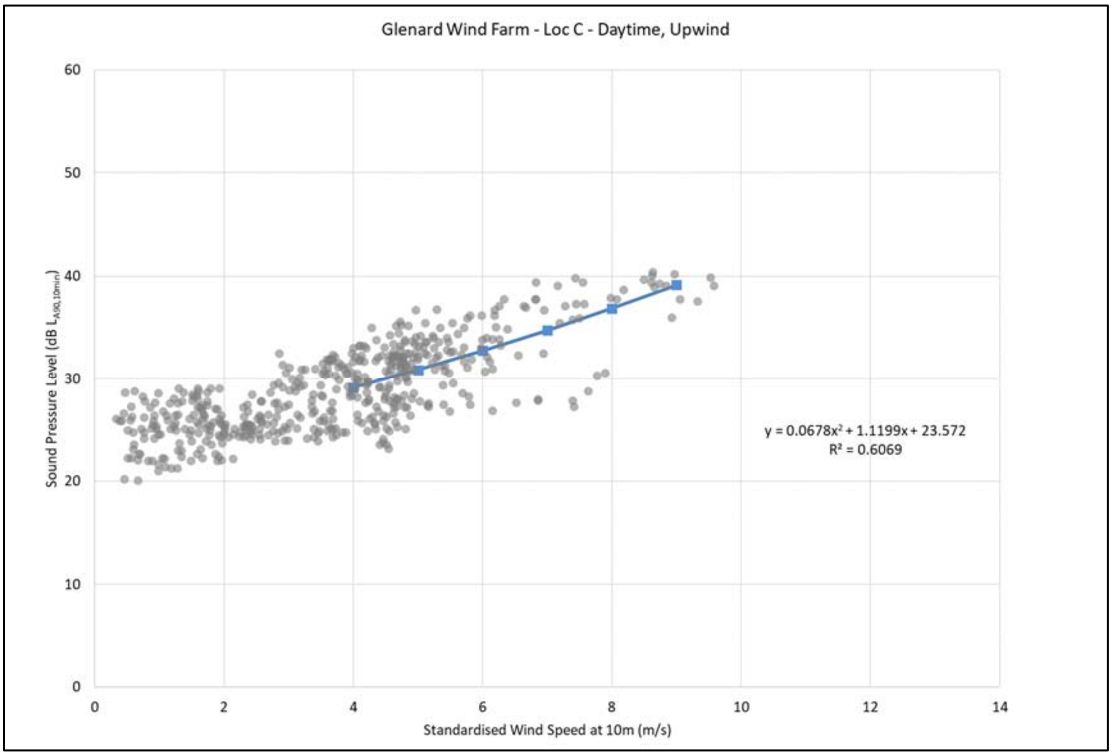

Figure 11-8 Location C (H062) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Daytime

11.4.1.3.2 Night-time Quiet Periods

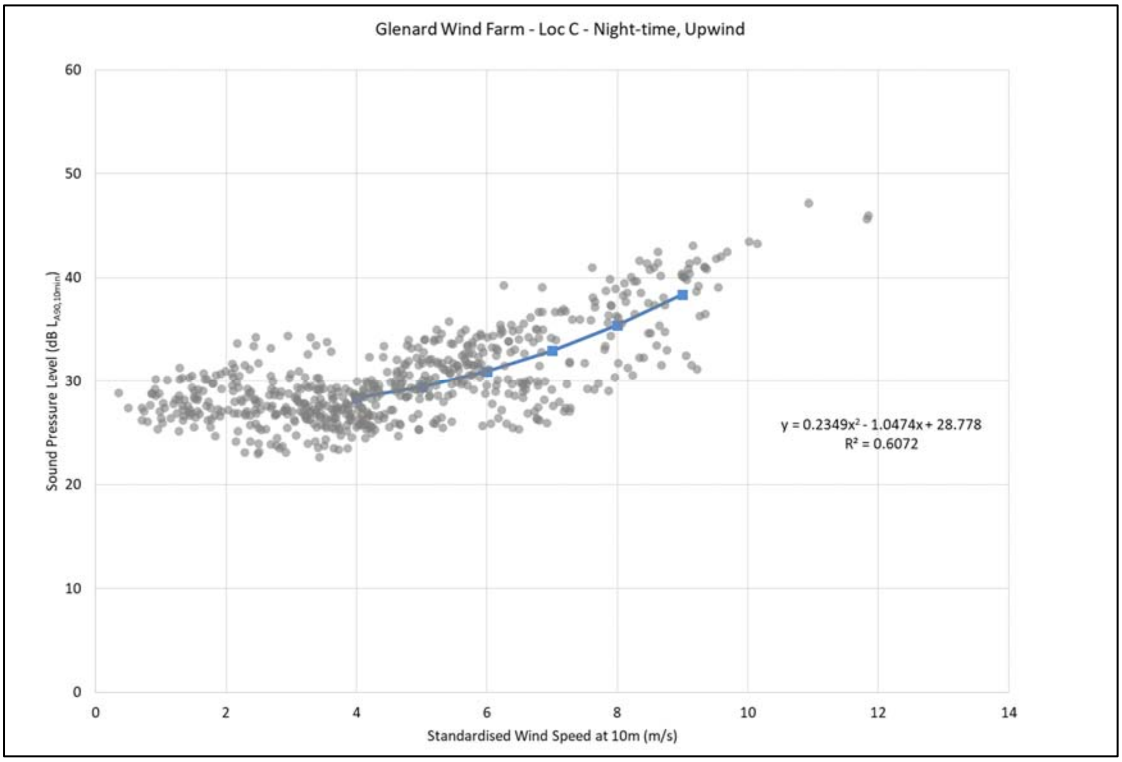

Figure 11-9 Location C (H062) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Night-time

11.4.1.4 Location D (H064)

11.4.1.4.1 Daytime Quiet Periods

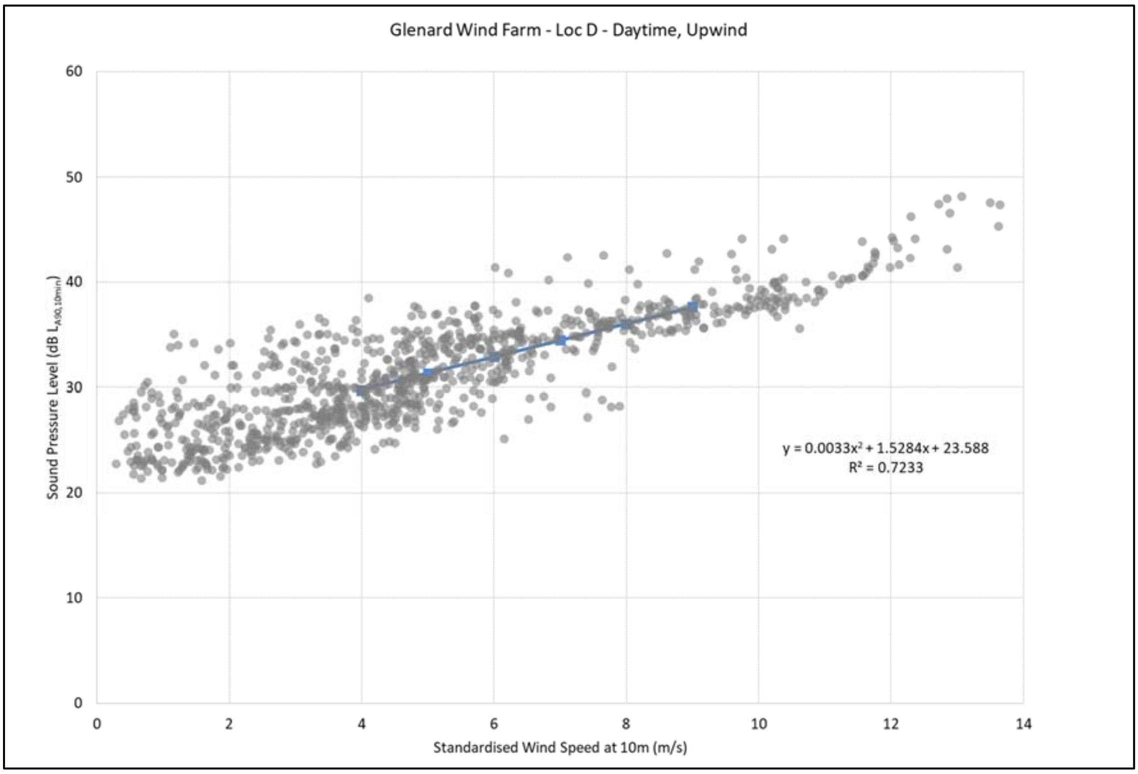

Figure 11-10 Location D (H064) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Daytime

11.4.1.4.2 Night-time Periods

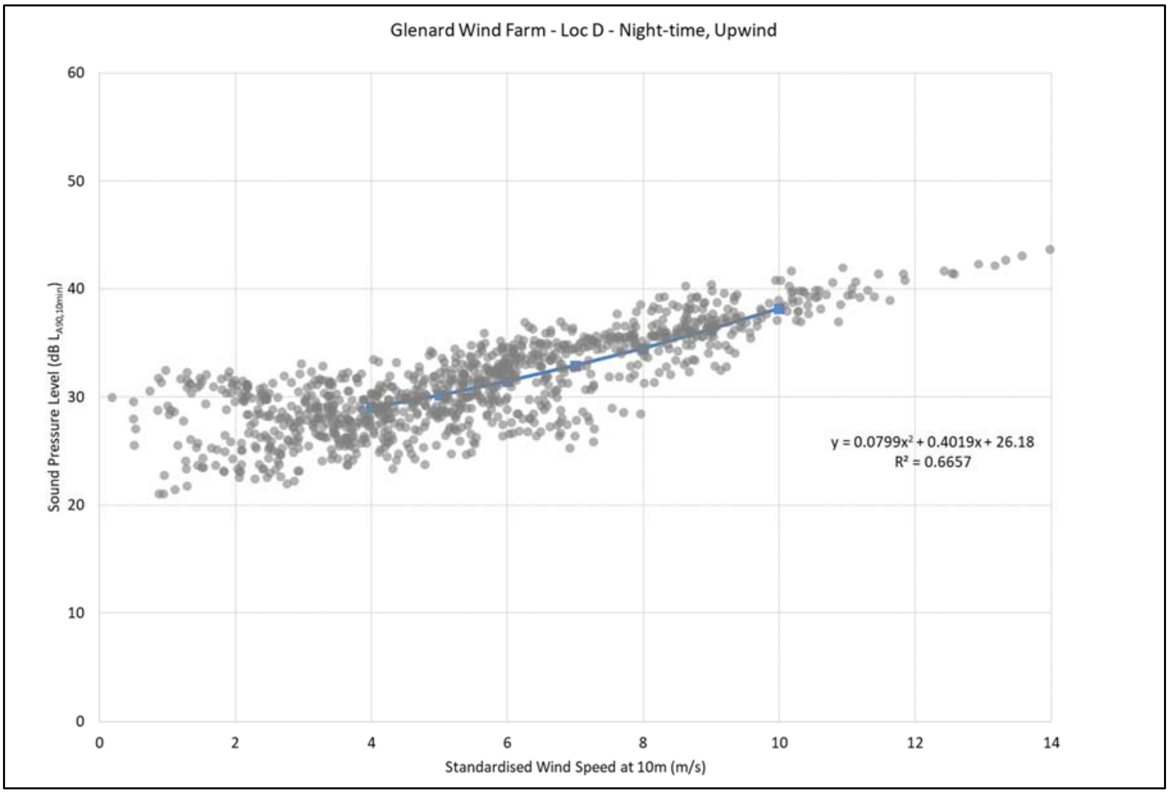

Figure 11-11 Location D (H064) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night-time

11.4.1.5 Location E (H073)

11.4.1.5.1 Daytime Quiet Periods

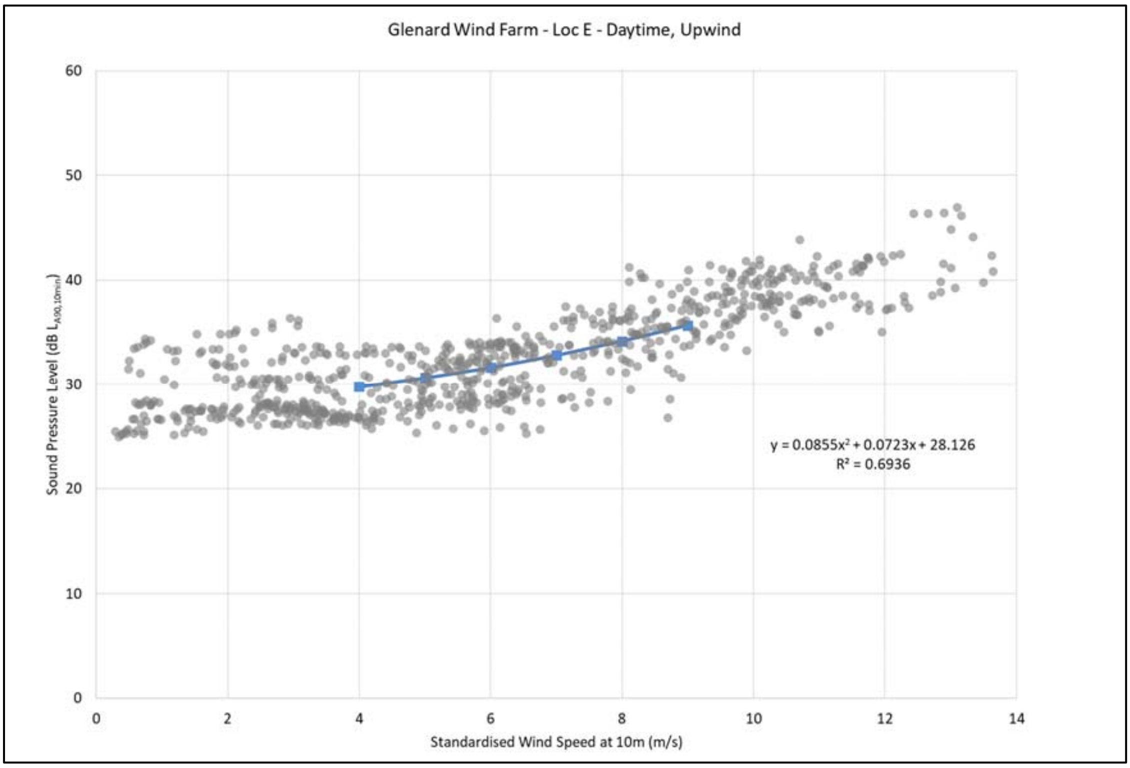

Figure 11-12 Location E (H073) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Daytime

11.4.1.5.2 Night-time Periods

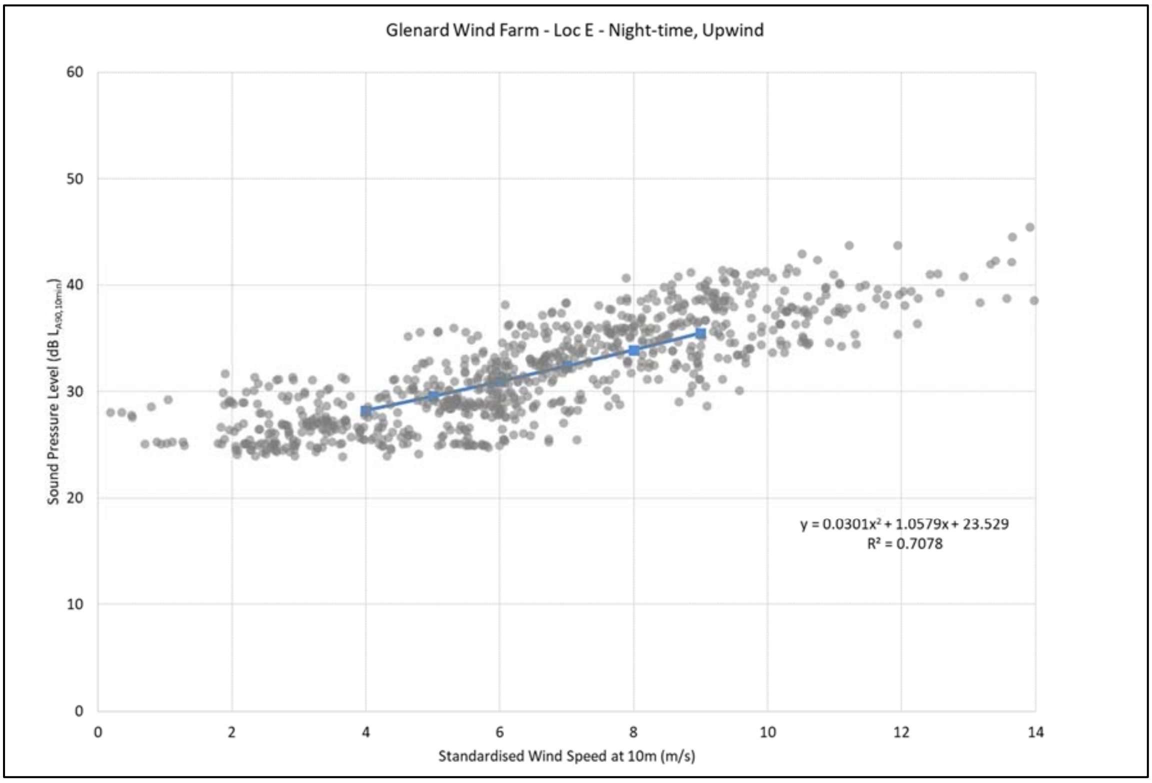

Figure 11-13 Location E (H073) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night-time

11.4.1.6 Location F (H078)

11.4.1.6.1 Daytime Quiet Periods

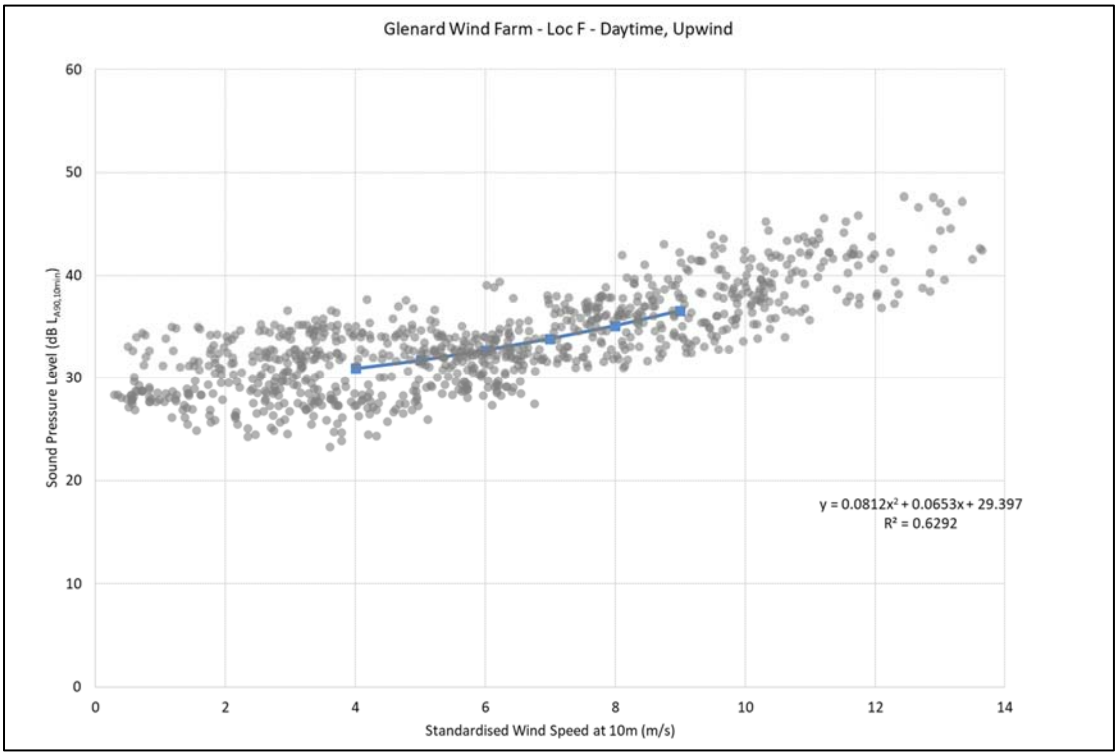

Figure 11-14 Location F (H078) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Daytime

11.4.1.6.2 Night-time Periods

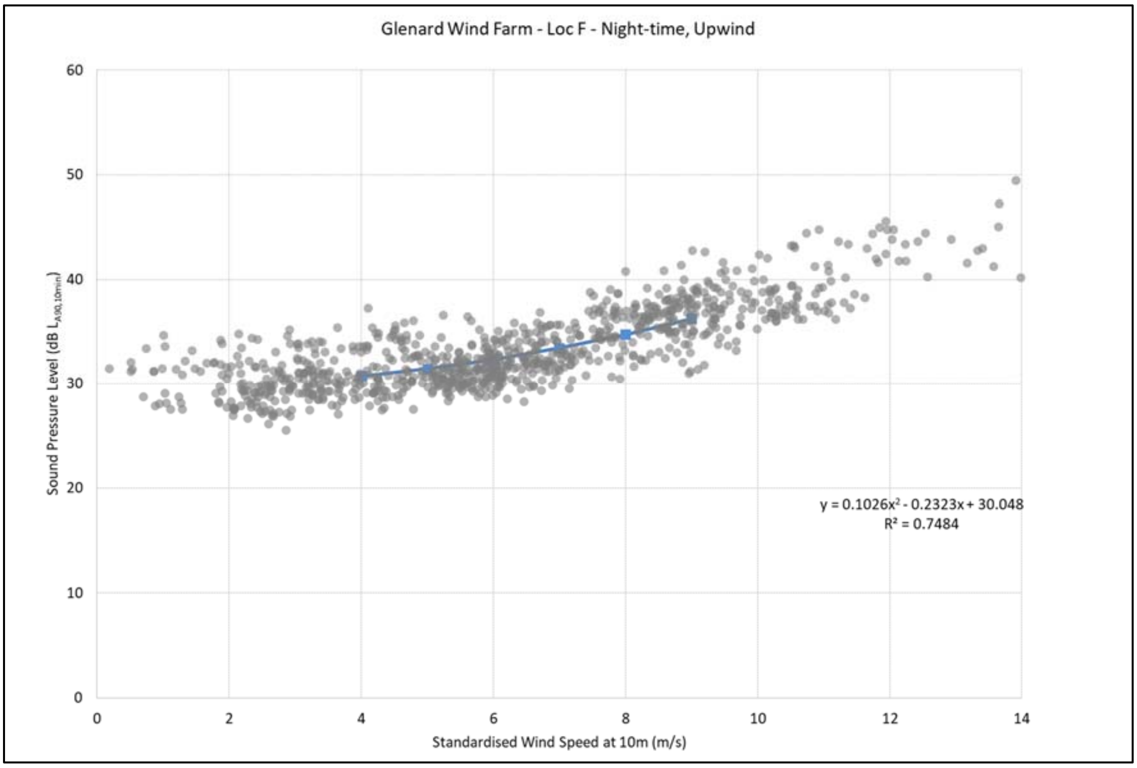

Figure 11-15 Location F (H078) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night-time

11.4.1.7 Location G (H061)

11.4.1.7.1 Daytime Quiet Periods

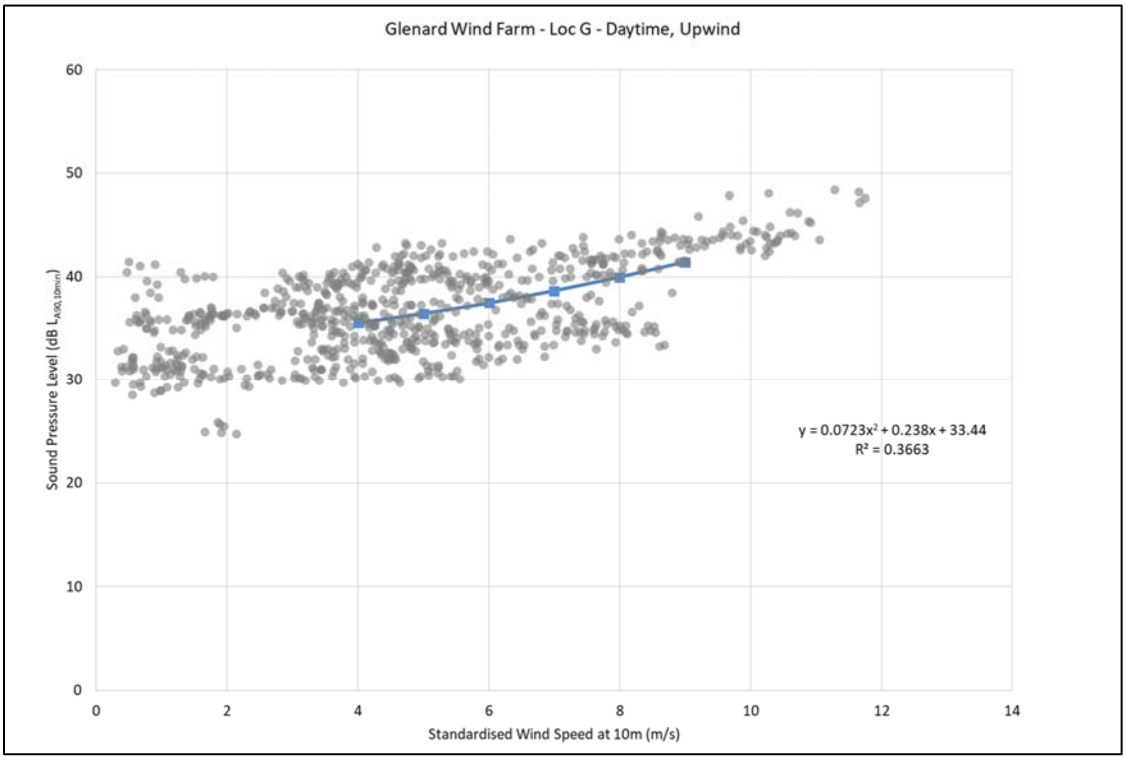

Figure 11-16 Location G (H061) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Daytime

11.4.1.7.2 Night-time Periods

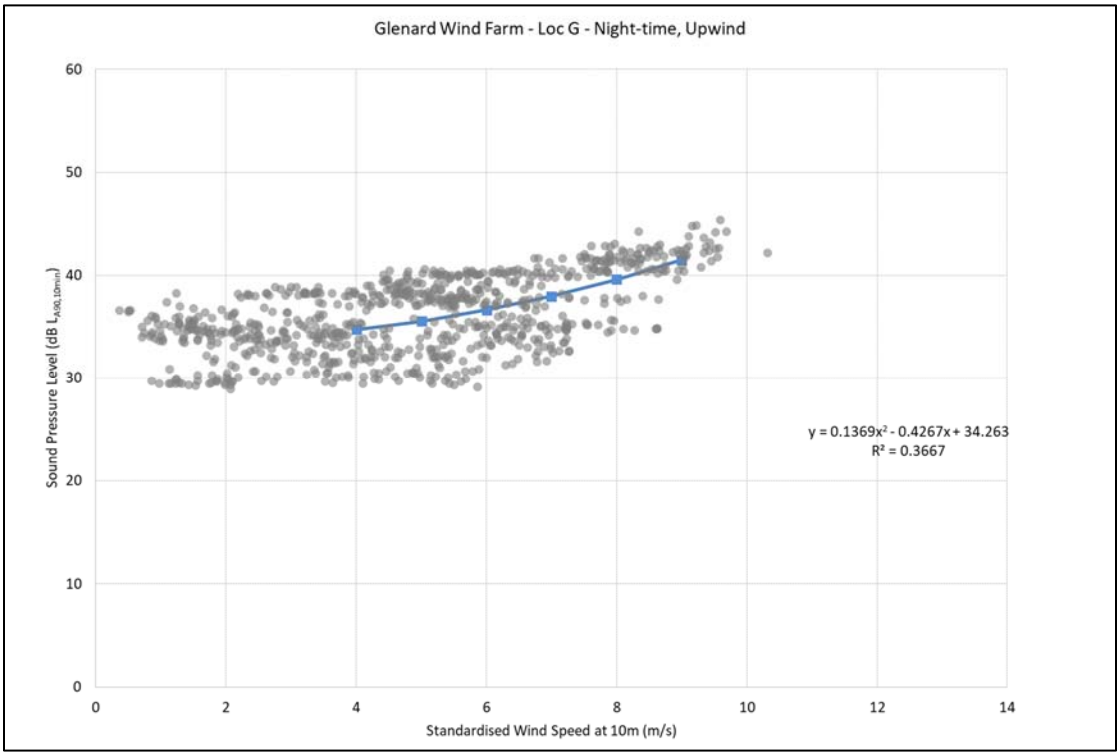

Figure 11-17 Location G (H061) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night-time

11.4.1.8 Location H (H063)

11.4.1.8.1 Daytime Quiet Periods

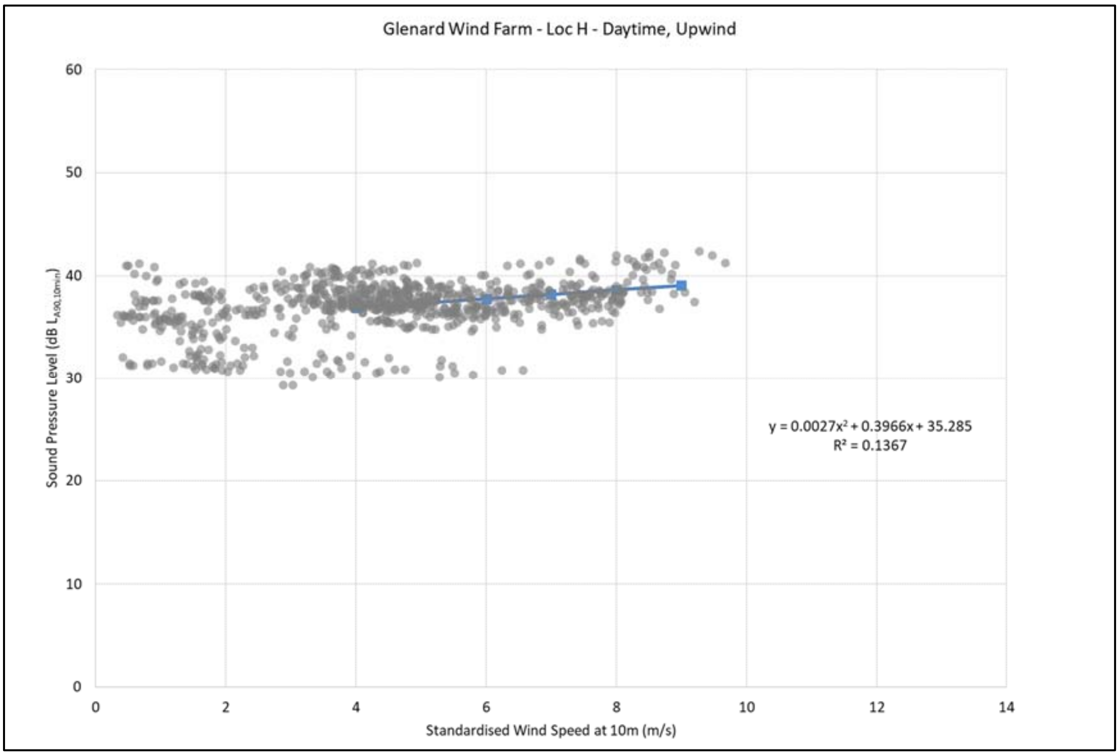

Figure 11-18 Location H (H063) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Daytime

11.4.1.8.2 Night-time Periods

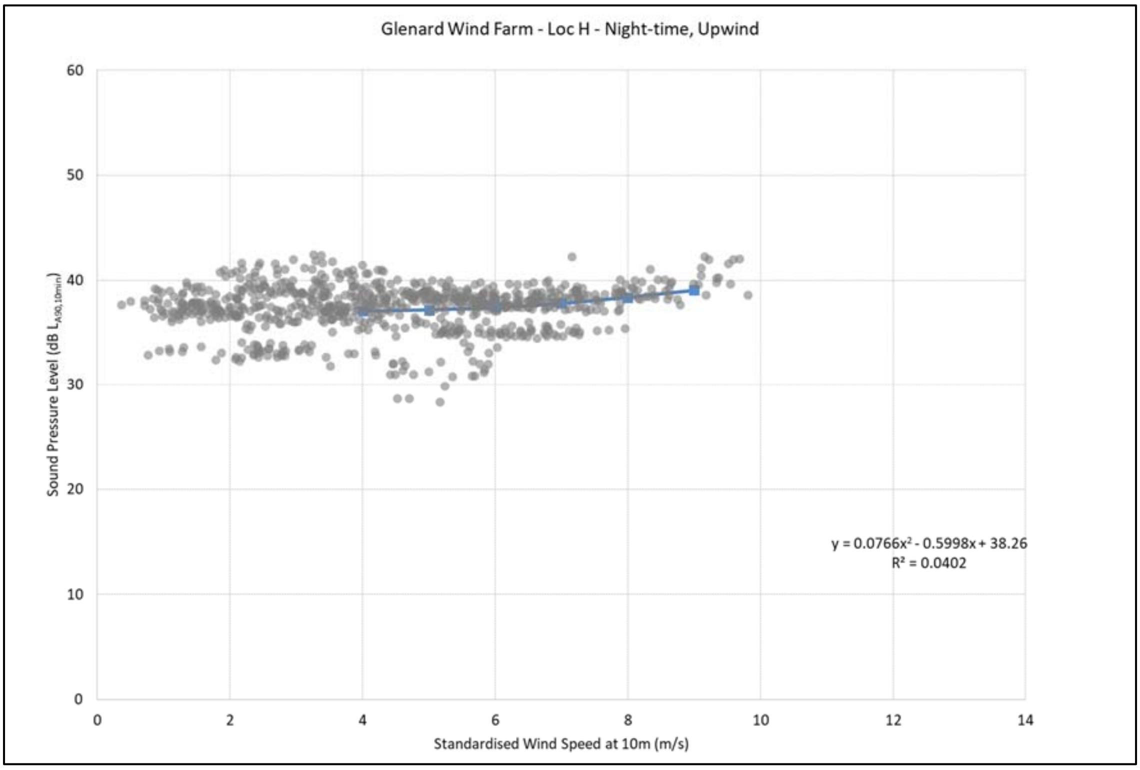

Figure 11-19 Location H (H063) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night-time

11.4.1.9 Summary

Table 11-10 presents the various derived $L_{A90,10min}$ noise levels for each of the monitoring locations for daytime quiet periods and night-time periods. These levels have been derived using regression analysis carried out on the data sets in line with guidance contained the IoA *GPG* and its SGN No. 2 *Data Collection.*

Table 11-10 Derived Noise Levels of $L_{A90,10min}$ for Various Wind Speeds

Location	Period	Derived $L_{A90, 10 min}$ Levels (dB) at various Standaridsed10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
A	Day	30.0	31.3	33.1	35.2	37.8	40.7
	Night	29.5	30.7	31.9	33.2	34.5	35.9
B	Day	30.9	32.5	34.3	36.2	38.3	40.5
	Night	30.1	31.5	33.0	34.7	36.5	38.4
C	Day	29.1	30.9	32.7	34.7	36.9	39.1
	Night	28.3	29.4	30.9	33.0	35.4	38.4
D	Day	29.8	31.3	32.9	34.5	36.0	37.6
	Night	29.8	31.3	32.9	34.5	36.0	37.6
E	Day	29.8	30.6	31.6	32.8	34.2	35.7
	Night	28.2	29.6	31.0	32.4	33.9	35.5
F	Day	31.0	31.8	32.7	33.8	35.1	36.6
	Night	30.8	31.5	32.3	33.5	34.8	36.3
G	Day	35.5	36.4	37.5	38.6	40.0	41.4
	Night	34.7	35.6	36.6	38.0	39.6	41.5
H	Day	36.9	37.3	37.8	38.2	38.6	39.1
	Night	37.1	37.2	37.4	37.8	38.4	39.1
Minimum	Day	29.1	30.6	31.4	32.1	32.9	33.8
	Night	28.2	28.8	29.5	30.2	31.0	32.0

The background noise data is used to derive appropriate noise limits for each of the noise sensitive locations where measurements took place. At all remaining locations, the worst-case envelope based on the lowest average levels across the various locations at each wind speed is used, considered separately for daytime and night-time.

11.4.2 Wind Turbine Noise Criteria

With respect to the relevant guidance documents outlined in Section 11.3.2.2.1 the following noise criteria curves have been identified for the Proposed Development. The criteria curves have been derived following a detailed review of the background noise data conducted at the nearest noise sensitive locations.

It is proposed to adopt a lower daytime threshold of 40 dB $L_{A90,10\text{-}min}$ for low noise environments where the background noise is less than 30 dB(A). This follows a review of the prevailing background noise levels and is considered appropriate in light of the following:

- The EPA document 'Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)' proposes a daytime noise criterion of 45 dB(A) in 'areas of low background noise'. The proposed lower threshold here is 5 dB more stringent than this level.
- It is reiterated that the 2006 Wind Energy Development Guidelines states that "*An appropriate balance must be achieved between power generation and noise impact.*" Based on a review of other national guidance in relation to acceptable noise levels in areas of low background noise it is considered that the criteria adopted as part of this assessment are robust.

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

- 40 dB $L_{A90,10min}$ for quiet daytime environments of less than 30 dB $L_{A90,10min}$;
- 45 dB $L_{A90,10min}$ for daytime environments greater than 30 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher), and;
- 43 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher) for night time periods.

Table 11-13 outlines the derived noise criteria curves based on the information contained within Table 11-12.

Table 11-11 Noise Criteria Curves

Location	Period	Derived $L_{A90,10min}$ Levels (dB) at various Standaridsed10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
A	Day	35-40	45	45	45	45	45.7
	Night	43	43	43	43	43	43
B	Day	45	45	45	45	45	45.5
	Night	43	43	43	43	43	43.4
C	Day	35-40	45	45	45	45	45
	Night	43	43	43	43	43	43.4
D	Day	35-40	45	45	45	45	45
	Night	43	43	43	43	43	43

Location	Period	Derived $L_{A90, 10 min}$ Levels (dB) at various Standaridsed10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
E	Day	35-40	45	45	45	45	45
	Night	43	43	43	43	43	43
F	Day	45	45	45	45	45	45
	Night	43	43	43	43	43	43
G	Day	45	45	45	45	45	46.4
	Night	43	43	43	43	44.6	46.5
H	Day	45	45	45	45	45	45
	Night	43	43	43	43	43.4	44.1
Minimum	Day	35-40	45	45	45	45	45
	Night	43	43	43	43	43	43

11.5 Likely Significant Effects and Associated Mitigation Measures

11.5.1 Do-Nothing Scenario

If the Proposed Development were not to proceed, no changes would be made to the current land-use practice of forestry and the site would continue to be managed under the existing commercial forestry arrangements.

The existing noise environment will remain largely unchanged notwithstanding other proposed and permitted wind turbine developments in the area. In areas where traffic noise is a significant source in the environment, increases in traffic volumes on the local road network would be expected to result in slight increases in overall ambient and background noise in the area over time.

11.5.2 Construction Phase Potential Impacts

A variety of items of plant will be in use for the purposes of site preparation, construction of turbines, roads, substation, and grid connection options. There will be vehicular movements to and from the site that will make use of existing roads. Due to the nature of these activities, there is potential for generation of significant levels of noise. These are discussed in the following Sections.

The predicted noise levels referred to in this section are indicative only and are intended to demonstrate that it will be possible for the contractor to comply with current best practice guidance. It should also be noted that the predicted "worst case" levels are expected to occur for only short periods of time at a very limited number of properties. Construction noise levels will be lower than these levels for most of the time at most properties in the vicinity of the Proposed Development.

11.5.2.1 Turbines, Hardstands, Met Mast, Substation, Grid Connection, Internal Roads and Road Widening

11.5.2.1.1 *Noise*

Due to the nature of construction activities it is difficult to calculate the actual magnitude of emissions to the local environment in the absence of a detailed construction programme. The standard best practice approach is to predict typical noise levels at the nearest sensitive receptor using guidance set out in BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise. Construction noise predictions have been carried out using guidance set out in British Standard BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise.

The methodology adopted for the assessment of construction noise is to analyse the various elements of the construction phase in isolation. For each element, the typical construction noise sources are assessed along with typical sound pressure levels and spectra from BS 5228 at various distances from these works.

The noise levels referred to in this section are indicative only and are intended to demonstrate that it will be possible for the contractor to comply with current best practice guidance. The predicted "worst case" levels are expected to occur for only short periods of time at a very limited number of properties. Construction noise levels will be lower than these levels for most of the time at most properties in the vicinity of the proposed development.

Construction activities will be carried out during normal daytime working hours (i.e. weekdays 0700 – 1900hrs and Saturdays 0700 – 1400hrs). 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 Authority.

Turbines Hardstands and Meteorological Mast

Works for the turbines and the met mast are anticipated at a significant distance from the closest noise sensitive receptors, with the met mast being approximately 420m from the nearest noise sensitive location (H077), H077 is located approximately 710 m from the hardstand of turbine T11.

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

Table 11-14 outlines the noise levels associated with typical construction noise sources assessed in this instance along with typical sound pressure levels and spectra from BS 5228 – 1: 2009. Calculations have assumed an on-time of 66% for each item of plant i.e. 8 hours over a 12-hour assessment period.

Table 11-12 Typical Construction Noise Levels – Turbines and Hardstanding, Substation, Grid Connection and Met Mast

Item (BS 5228 Ref.)	Activity/Notes	Plant Noise level at 10m Distance (dB $L_{Aeq,T}$)[8]	Predicted Noise Level (dB $L_{Aeq,T}$) at distance (m)	
			420	710
HGV Movement (C.2.30)	Removing soil and transporting fill and other materials.	79	40	35
Tracked Excavator (C.4.64)	Removing soil and rubble in preparation for foundation.	77	38	30
Excavator Mounted Rock Breaker (C9.12)	Excavation in rocky areas	85	46	41
Piling Operations (C.12.14)	Standard pile driving.	88	50	45
General Construction (Various)	All general activities plus deliveries of materials and plant.	84	45	40
Concrete Mixer Truck and Concrete Pump (C.4.27)	Turbine Foundations	75	36	31
Dumper Truck (C.4.4)	Backfilling Turbine Foundations	76	37	32
Mobile Telescopic Crane (C.4.39)	Turbine Erection	77	38	33
Dewatering Pumps (D.7.70)	If required.	80	41	36
JCB (D.8.13)	For services, drainage and landscaping.	82	43	38

8 All plant noise levels are derived from BS5228: Part 1

Item (BS 5228 Ref.)	Activity/Notes	Plant Noise level at 10m Distance (dB $L_{Aeq,T}$)[8]	Predicted Noise Level (dB $L_{Aeq,T}$) at distance (m)	
			420	710
Vibrating Rollers (D.8.29)	Road surfacing.	77	38	33
Total		–	53	48

It is concluded that there will be no significant noise impact associated with the construction of the turbines, hardstanding and met mast therefore no specific mitigation measures are required.

Substation and Grid Connection

The substation is to be located at coordinates E643020 N930756. The nearest NSL to the proposed substation site is H077 at approximately 350m to the southeast. As a worst-case example assuming the same construction activities as outlined in Section 11.6.2.1, it is predicted that the likely worst-case potential noise levels from construction activities associated with the substation will be in the order of 55 dB $L_{Aeq,T}$ at Location H077. This level of noise is within the construction noise criterion outlined in Table 11-6.

A connection between the proposed substation and the national electricity grid will be necessary to export the electricity generated by the Proposed Development. The full description of the proposed grid connection arrangements for the Proposed Development is outlined in Chapter 4 of the EIAR.

The grid connection work will take place alongside the construction of the internal cabling. The proposed works are located approximately 220m from H163. The nearest noise-sensitive receptor.

Using a similar approach to the calculation of construction noise for the turbine hardstandings and met mast, noise levels at various distances from the grid connection works are shown in Table 11-13 The values are well below the construction noise criteria in Table 11-6.

Table 11-13 Typical Construction Noise Levels –grid connection construction

Item (BS 5228 Ref.)	Plant Noise level at 10m Distance (dB $L_{Aeq,T}$)[9]	Highest Predicted Plant Noise Level (dB LAeq,T)		
		100	200	300
Mini Excavator with Hydraulic Breaker (C5.2)	83	58	51	47
Wheeled loader (C2.28)	76	51	44	40
Tracked excavator (C2.18)	75	50	43	39
Dozer (C2.13)	78	53	46	42
Dump truck (C2.30)	79	54	47	43
Road Roller (C2.37)	79	54	47	43
HGV Movements (20 per hour)	53	28	21	17
Total Construction Noise		62	55	51

9 All plant noise levels are derived from BS5228: Part 1

It is concluded that there will be no significant noise impact associated with the construction of the substation and grid connection, therefore no specific mitigation measures were required.

Construction of Internal Roads

It is proposed to upgrade existing internal roads and also to construct new internal roads as part of the development. Review of the road layout has identified that the nearest NSL to any point along the proposed roads is the site entrance at approximately 325m to H052. All other locations are at greater distances with the majority at significantly greater distances. The full description of the new roads is outlined in Chapter 4 of the EIAR.

Table 11-16 outlines the typical construction noise levels associated with the proposed works for this element of the construction. Calculations have assumed an on-time of 66% for each item of plant.

Table 11-14 Typical Construction Noise Emission Levels – Internal Roads

Item (BS 5228 Ref.)	Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$) [10]	Highest Predicted Noise Level at Stated Distance from Edge of Works (dB L_{Aeq},T)
		325m
HGV Movement (C.2.30)	79	37
Tracked Excavator (C.4.64)	77	35
Dumper Truck (C.4.4)	76	34
Excavator Mounted Rock Breaker (C9.12)	85	43
Vibrating Rollers (D.8.29)	77	35
Total Construction Noise (cumulative for all activities)		46

At the nearest noise sensitive location, the predicted noise levels from construction activities are of the order of 49 dB $L_{Aeq,T}$, below the significance threshold of 65dB $L_{Aeq,1hr}$.

Road Widening Works

As detailed in Chapter 4, Section 4.4, the preferred turbine delivery route option is assessed and details a proposed widening works along the L1731.

The proposed works along the L1731 will require removal of fencing and temporary placement of hardcore, so the area can be used during the delivery of large turbine components. Once the turbines have been delivered, this area will be returned to its original state.

The nearest NSL to this junction is the H049 which is lies approximately 50m from the works. Typical construction plant items and their associated noise levels at various distances are presented in Table 11-15.

[10] *All plant noise levels are derived from BS 5228: Part 1*

Table 11-15 Typical Construction Noise Levels for the Junction Accommodation

Item (BS 5228 Ref.)	Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$) [11]	Highest Predicted Noise Level at Stated Distance from Edge of Works (dB $L_{Aeq,T}$)		
		50	100	150
HGV Movement (C.2.30)	79	58	50	46
Tracked Excavator (C.4.64)	74	53	45	41
Vibrating Rollers (D.8.29)	77	56	48	44
Total Construction Noise		61	53	49

At the H049, the predicted noise levels from construction activities are of the order of 61 dB $L_{Aeq,T}$, below the significance threshold of 65dB $L_{Aeq,1hr}$.

11.5.2.1.2 *Vibration*

As would be expected, vibration associated with construction activities is typically greater in magnitude in close proximity to the plant or equipment generating the vibration. AWN previously has measured vibration generated by breaking activities on an unrelated site. At distances of 50-60m measured vibration levels were in the range 0.13 – 0.25 mm.s-1 Peak Particle Velocity.

With reference to the vibration criteria presented in Table 11.2, these levels are an order of magnitude lower than the lowest recommended vibration level. Therefore, when considering the Proposed Development, the distance between areas of works and the nearest NSL is hundreds of meters. Considering the low levels of vibration close to construction sources and the dissipation of vibration over distance, there will be no vibration impact on sensitive locations in the area surrounding the development.

11.5.2.1.3 *Description of Effects*

With respect to the EPA criteria for description of effects, the potential worst-case associated effects at the nearest noise sensitive locations associated with the construction of Turbines, Hardstands, Substation, Grid Connection, Internal Roads, and Road Widening of the proposed development are described below.

Quality	*Significance*	*Duration*
Negative	Slight	Short-term

It is not expected that there will be any significant cumulative impacts at NSL's should the various elements of the construction phase be undertaken simultaneously.

[11] *All plant noise levels are derived from BS 5228: Part 1*

11.5.2.2 Construction Traffic

11.5.2.2.1 Changes in Traffic Noise Level due to Construction Traffic

This section has been prepared in order to review potential noise impacts associated with construction traffic on the local road network. The information presented in Chapter 14 has been used to inform the assessment here. The following situations are commented upon here:

- Stage 1a – Site Preparation – Concrete Pouring
- Stage 1b – Site Preparation & Ground Works, including substation
- Stage 2a – Turbine Construction Stage – Extended Artic Deliveries
- Stage 2b – Turbine Construction Stage – Other Conventional Deliveries

The proposed turbine delivery route options are detailed in Chapter 4, Section 4.4.

Table 11-16 Assumptions for Construction Traffic Noise Assessment

Route	Stage	Construction Light Vehicles	Construction HGV
R238 (south of Quigley's Point)	Stage 1a - Concrete pouring for foundations	80	150
	Stage 1b - Site Preparation and Groundworks	80	29
	Stage 2 - Extended Artics	40	10
	Stage 2 - Other Deliveries	40	6
R240 (west of Quigley's Point)	Stage 1a - Concrete pouring for foundations	80	150
	Stage 1b - Site Preparation and Groundworks	80	29
	Stage 2 - Extended Artics	40	10
	Stage 2 - Other Deliveries	40	6
L1731	Stage 1a - Concrete pouring for foundations	80	150
	Stage 1b - Site Preparation and Groundworks	80	29
	Stage 2 - Extended Artics	40	10

Route	Stage	Construction Light Vehicles	Construction HGV
	Stage 2 - Other Deliveries	40	6
L-7131-1 Crockaheeny Road to site	Stage 1a - Concrete pouring for foundations	80	150
	Stage 1b - Site Preparation and Groundworks	80	29
	Stage 2 - Extended Artics	40	10
	Stage 2 - Other Deliveries	40	6
R238 (north of Quigley's Point)	Stage 1a - Concrete pouring for foundations	80	150
	Stage 1b - Site Preparation and Groundworks	80	29
	Stage 2 - Extended Artics	40	10
	Stage 2 - Other Deliveries	40	6
L1731 (Buncrana)	Stage 1a - Concrete pouring for foundations	80	150
	Stage 1b - Site Preparation and Groundworks	80	29
	Stage 2 - Extended Artics	40	10
	Stage 2 - Other Deliveries	40	6

Based on the assumptions presented above changes in noise level with respect to existing flows have been estimated and is presented in Table 11-21.

Table 11-17 Estimated Changes in Traffic Noise Levels

Route	Stage	Change in Traffic Noise Level dB(A)	Estimated Total Traffic Noise Level at 5m from road edge	Estimated Number of Days
R238 (south of Quigley's Point)	Stage 1a - Concrete pouring for foundations	0.8	68	16
	Stage 1b - Site Preparation and Groundworks	0.2	68	367
	Stage 2 - Extended Artics	0.1	66	29
	Stage 2 - Other Deliveries	0.1	68	16
R240 (west of Quigley's Point)	Stage 1a - Concrete pouring for foundations	1.4	66	16
	Stage 1b - Site Preparation and Groundworks	0.4	65	367
	Stage 2 - Extended Artics	0.2	64	29
	Stage 2 - Other Deliveries	0.1	65	16
L1731	Stage 1a - Concrete pouring for foundations	>10dB, See text	61	16
	Stage 1b - Site Preparation and Groundworks	5.6	55	367
	Stage 2 - Extended Artics	3.1	52	29
	Stage 2 - Other Deliveries	2.2	52	16
L-7131-1 Crockaheeny Road to site	Stage 1a - Concrete pouring for foundations	>10dB, See text	61	16
	Stage 1b - Site Preparation and Groundworks	>10dB, See text	54	367

Route	Stage	Change in Traffic Noise Level dB(A)	Estimated Total Traffic Noise Level at 5m from road edge	Estimated Number of Days
	Stage 2 - Extended Artics	>10dB, See text	50	29
	Stage 2 - Other Deliveries	7.7	49	16
R238 (north of Quigley's Point)	Stage 1a - Concrete pouring for foundations	1.6	66	16
	Stage 1b - Site Preparation and Groundworks	0.4	65	367
	Stage 2 - Extended Artics	0.2	64	29
	Stage 2 - Other Deliveries	0.1	64	16
L1731 (Buncrana)	Stage 1a - Concrete pouring for foundations	>10dB, See text	61	16
	Stage 1b - Site Preparation and Groundworks	4.4	56	367
	Stage 2 - Extended Artics	2.8	53	29
	Stage 2 - Other Deliveries	1.6	53	16

The increase in noise levels due to additional construction traffic on each of the routes is predicted to be less than 3 dB or less for the majority of routes and construction stages. With respect to the assessment criteria outlined in Section 11.3.2.1.2 the magnitude of this impact is minor and the significance of the effect is slight to moderate.

In cases where the increase in noise levels is greater, it is important to note that the predicted total noise levels at 5m from the road edge remain within the criterion of 65 dB L_{Aeq} for construction noise presented in Section 11.3.2.1.1. Similarly, taking this into account the significance of the effect is slight to moderate.

11.5.2.2.2 Turbine Delivery Route through Northern Ireland

Use of the delivery route through Northern Ireland is only required for the turbine components (Stage 2 – Extended Arctics).

The criteria for construction traffic noise assessment are based on *Design Manual for Roads and Bridges LA 111 Sustainability & Environmental Appraisal. Noise and Vibration Rev 2 (2020*) snd BS 5228: 2008+A1:2014 *Code of practice for noise and vibration control on construction and open sites* – Part 1: Noise, and are therefore also applicable in Northern Ireland.

With reference to the assessment above, the effect of construction traffic noise in Northern Ireland is slight.

11.5.2.2.3 Description of Effects

With respect to the EPA criteria for description of effects, the potential worst-case effects at the nearest noise sensitive associated with the additional traffic generated during the construction phase of the proposed development are described below.

Quality	*Significance*	*Duration*
Negative	Slight	Short-term

11.5.2.3 Borrow Pit

A borrow pit is proposed at coordinates E644210 N931656. The nearest NSL is H077 at a distance of approximately 1.250 km at its closest point. To inform this aspect of the proposal a comparative noise assessment has been prepared and is outlined in the following paragraphs. Two situations have been considered as follows:

- Scenario A Blasting operation[12]
- Scenario B Rock breaking operation

In terms of these activities please note the following:

- A mobile crusher will operate on site for both options.
- In Scenario B that two rock breakers will be in use on site during daytime periods for an estimated three-month period.
- For the purposes of this assessment we have assumed the plant is working in the vicinity of the potential borrow pits location indicated in Table 11-17.
- Table 11-18 outlines the assumed noise levels for the plant items as extracted from BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise.*
- If the blasting option is undertaken it is estimated that some 8 to 12 blasts will be required over a 4-week period. It is expected that no more than 1 blast would occur in a single working day.

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

Table 11-18 Typical Plant Noise Levels

Item	BS 5228 Ref:	dB L_w Levels per Octave Band (Hz)								dB(A)
		63	125	250	500	1k	2k	4k	8k	
Crusher	Table C1.14	121	114	107	109	103	99	94	87	110
Rock Breaker	Table C9.11	119	117	113	117	115	115	112	108	121
Dozer	Table C8.9	78	90	97	95	99	94	89	82	103
Dewatering	Table D7.70	90	95	102	102	104	100	97	83	109
Generator	Table C6.39	81	86	93	89	83	80	74	67	96

A construction noise model has been prepared to consider the expected noise emissions from the proposed construction works for the two scenarios outlined above. A percentage on-time of 66% has been assumed for the noise calculations. The predicted levels are detailed in Table 11-19, at the 10 no. closest NSL' to the borrow pit.

Table 11-19 Typical Plant Noise Levels Borrow Pit

Borrow Pit 1			
Loc.	Predicted Construction Noise Level $L_{Aeq,1hr}$ Scenario		Diff. dB(A)
	A (Blasting)	B (Rock breaking)	
H052	35	28	-7
H057	35	28	-7
H062	36	29	-7
H064	33	25	-8
H049	35	28	-7
H073	18	13	-5
H074	18	13	-5
H075	18	13	-5
H077	25	22	-3
H063	38	31	-7

Review of the data contained in Table 11-19 confirms the following:

- Predicted construction noise levels for both Scenario A and B at all borrow pits are well within the best practice construction noise criteria outlined in Table 11-6.
- It is assumed that construction works at the borrow pits will only occur during daytime periods only (07:00 to 19:00hrs).
- The blasting proposal results in lower levels of construction noise since the use of the rock breaking plant is not required in this instance. Predicted noise levels are lower at all assessed locations for Scenario A.
- It is accepted that the individual blast events will be audible at some locations. Blast events will be designed and controlled such that the best practice noise and vibration limit values outlined in the mitigation section of this chapter are not exceeded.

11.5.2.3.1 Description of Effects

With respect to the EPA criteria for description of effects, the potential worst-case associated effects at the nearest noise sensitive locations associated with the construction of Turbines, Hardstands, Substation, Grid Connection, Internal Roads, and Road Widening of the proposed development are described below.

Quality	*Significance*	*Duration*
Negative	Slight	Short-term

11.5.3 Operational Phase Potential Impacts

11.5.3.1 Turbine Noise Assessment

The noise levels for the Proposed Development site have been calculated for all noise sensitive receivers identified within 3 km of the proposed turbines.

A worst-case assessment has been completed assuming all noise locations are downwind of all turbines at the same time. The predicted levels have been compared against the adopted noise criteria curves as detailed in Table 11-20 presents the details of the exercise at the houses for which potential exceedances of the noise criteria are predicted, which are: H071, H072, H073, H074, H075, H77 and H080.

Table 11-20 Review of Cumulative Predicted Turbine Noise Levels against Relevant Criteria

House ID	Description	Predicted Noise Level dB LA90 at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	≥9
H071	Dwelling	34.1	35.1	39.7	42.2	43.4	44.1
	Daytime Limits	40	45	45	45	45	45
	Potential Daytime Exceedance	–	–	–	–	–	–
	Night-time Limits	43	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	0.4	1.1
H072	Dwelling	33.4	34.7	39.4	42	43.2	44.1
	Daytime Limits	40	45	45	45	45	45
	Potential Daytime Exceedance	–	–	–	–	–	–
	Night-time Limits	43	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	0.2	1.1
H073	Dwelling	32.6	34.5	39.4	41.9	43.3	44.4
	Daytime Limits	40	45	45	45	45	45
	Potential Daytime Exceedance	–	–	–	–	–	–
	Night-time Limits	43	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	0.3	1.4
H074	Dwelling	33.0	35.0	39.8	42.3	43.8	45

	Daytime Limits	40	45	45	45	45	45
	Potential Daytime Exceedance	–	–	–	–	–	–
	Night-time Limits	43	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	0.8	2.0
H075	Dwelling	31.6	33.6	38.4	40.9	42.3	43.4
	Daytime Limits	40	45	45	45	45	45
	Potential Daytime Exceedance	–	–	–	–	–	–
	Night-time Limits	43	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	–	0.4
H077	Dwelling	33.5	38.4	41.8	42.5	42.8	43.1
	Daytime Limits	40	45	45	45	45	45
	Potential Daytime Exceedance	–	–	–	–	–	–
	Night-time Limits	43	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	–	0.1
H080	Dwelling	32.8	36.3	40.7	42.4	43.6	44.6
	Daytime Limits	40	45	45	45	45	45
	Potential Daytime Exceedance	–	–	–	–	–	–
	Night-time Limits	43	43	43	43	43	43
	Potential Night time Exceedance	–	–	–	–	0.6	1.6

Contours of omni-directional noise levels for standard mode operation rated power wind speed (i.e. highest noise emission) has been presented in Appendix 11-8.

The cumulative predicted noise levels at various wind speeds have been compared against the noise criteria curves outlined in Table 11-11. The predicted omni-directional noise levels for all turbines operating in standard mode has identified some exceedances at noise sensitive locations at certain windspeeds.

11.5.3.1.1 *Locations H071, H072, H073, H074 and H075*

It is noted that H071, H072, H073, H074 and H075 are located south of the Aught wind farm, as shown in Figure 11-20.

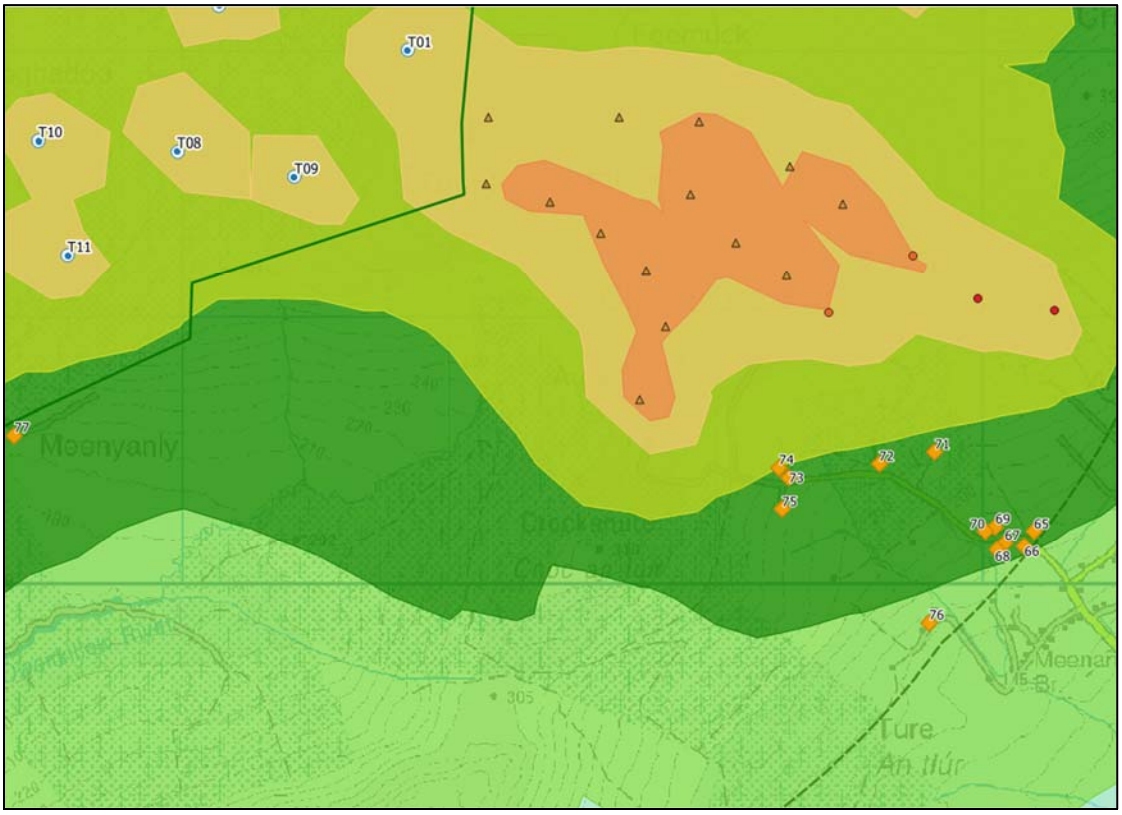

Figure 11-20 Detail of Noise Model showing H074 and nearby locations (excerpt from Appendix 11-8)

Taking H074 as an example, the total predicted wind turbine noise level is 45 dB L_{A90}, which is within the daytime criterion of 45 dB L_{A90} but 2dB in excess of the night-time criterion of 43 dB L_{A90}. Looking at the relative contribution for the different wind farms to the total predicted wind turbine noise level is shown in for the wind speed of 9 m/s.

Table 11-21 Breakdown of noise level contributions at H080

Wind Farm / Turbine	Predicted noise Level, dB L_{A90}
Aught	43.3
Glackmore	38.1
Three Trees 1	31.9
Three Trees 1	29.9
Glenard	25.9
Crockahenny	24.6
Total	45.0

Thus the contribution from the proposed development to the noise level at H074 is not significant, being more that 10 dB below the existing noise level from other wind farms. Taking this in to account, mitigation of noise levels from the proposed development is not required in respect of locations H071, H072, H073, H074 and H075.

11.5.3.1.2 Locations H077 and H080

The next stage in the assessment is to consider the smaller exceedances remaining for night-time periods at locations H077 and H080. The location of these NSLs and the nearest turbines to them is shown in Figure 11-21:

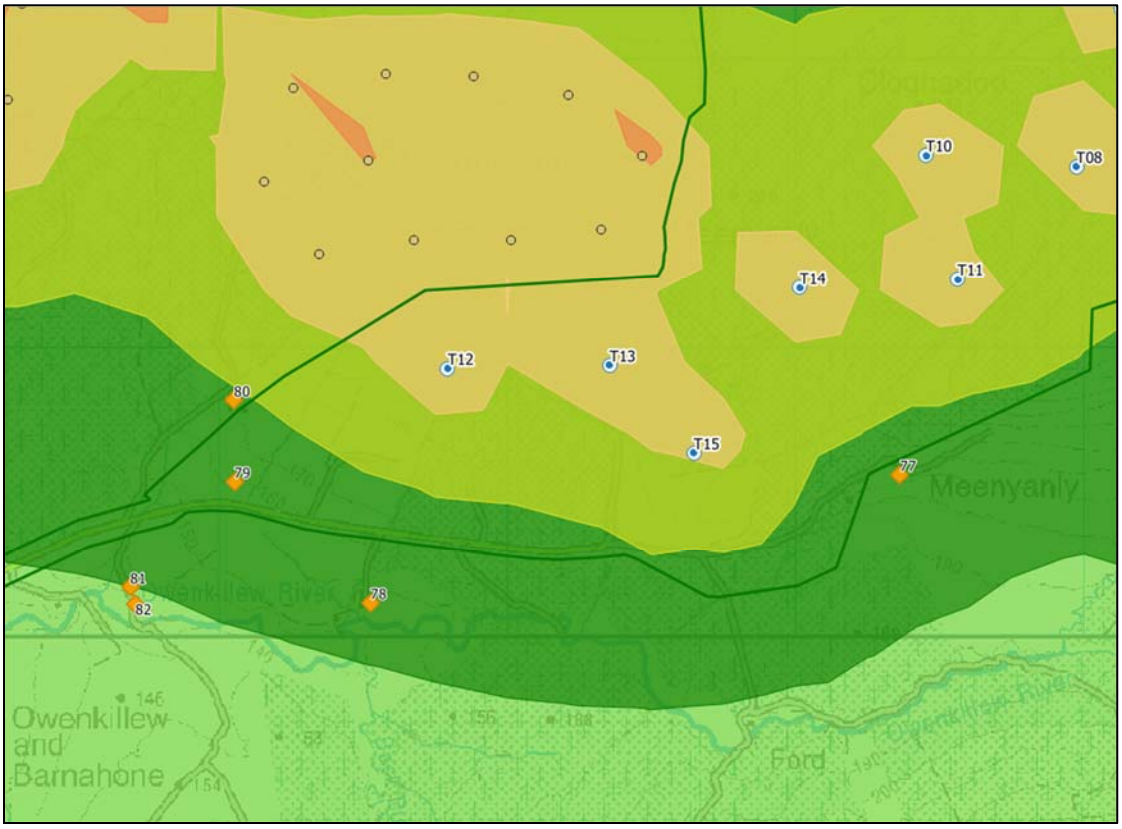

Figure 11-21 Locations of H077 and H080

As presented in Section 11.3.8.3 above, the effect of the directionality of noise emissions from wind turbine means that noise levels in certain wind directions, noise levels are less than the values presented in Table 11-20, as a given noise-sensitive location is not downwind of all turbines at the same time.

Directional noise predictions models have been developed to identify the number and magnitude of exceedances to the noise criteria at the various noise sensitive locations with the proposed turbines operating in standard mode. The full tabulated results of this assessment are shown in Appendix 11-9.

Cumulative predicted turbine noise levels at H077 and H080 once directional effects are taken into account are presented Table 11-22 and Table 11-23. At H077, all directional noise levels are within the daytime and night-time criteria. At H080, while all directional noise levels are within daytime criteria, there remain a small number of exceedances of the night-time criteria, details of which are shown in Table 11-24.

Table 11-22 Summary of Predicted Directional Noise Levels at H077 compared to Night-time Noise Limits

Dwelling H077	Excesses of Criterion dB $L_{A90,10min}$ at Various Standarised Wind Speeds (m/s)					
Wind Direction	4	5	6	7	8	9
North	33.1	38.0	41.4	42.1	42.4	42.7
North-east	32.2	37.1	40.5	41.2	41.5	41.8
East	30.8	35.7	39.1	39.8	40.1	40.4
South-east	29.1	34.0	37.4	38.1	38.4	38.7
South	28.9	33.8	37.2	37.9	38.2	38.5
South-west	30.9	35.8	39.2	39.9	40.2	40.5
West	32.1	37.0	40.4	41.1	41.4	41.7
North-West	33.1	38.0	41.4	42.1	42.4	42.7
Daytime Limits	40	45	45	45	45	45
Night-time Limits	43	43	43	43	43	43
Exceedances	–	–	–	–	–	–

Table 11-23 Summary of Predicted Directional Noise Levels at H080 compared to Night-time Noise Limits

Dwelling H080	Excesses of Criterion dB $L_{A90,10min}$ at Various Standarised Wind Speeds (m/s)					
Wind Direction	4	5	6	7	8	9
North	32.5	36	40.3	42.1	43.3	44.3
North-east	32.5	36	40.3	42.1	43.3	44.3
East	31.9	35.4	39.7	41.5	42.7	43.7
South-east	30.3	33.8	38.1	39.9	41.1	42.1
South	28	31.5	35.8	37.6	38.8	39.8
South-west	27.8	31.3	35.6	37.4	38.6	39.6
West	29.5	33	37.3	39.1	40.3	41.3
North-West	31.4	34.9	39.2	41	42.2	43.2
Daytime Limits	40	45	45	45	45	45

Dwelling H080	Excesses of Criterion dB $L_{A90,10min}$ at Various Standarised Wind Speeds (m/s)					
Wind Direction	4	5	6	7	8	9
Night-time Limits	43	43	43	43	43	43
Exceedances (Night-time Only)	–	–	–	–	See Table 11-24	

Table 11-24 Summary of Predicted Potential Exceedances – H080

Dwelling H080		Excesses of Criterion dB $L_{A90,10min}$ at Various Standarised Wind Speeds (m/s)					
Wind Direction	Period	4	5	6	7	8	9
Northwest	Daytime	–	–	–	–	–	–
	Night-time	–	–	–	–	–	0.2
North	Daytime	–	–	–	–	–	–
	Night-time	–	–	–	–	0.3	1.3
Northeast	Daytime	–	–	–	–	–	–
	Night-time	–	–	–	–	0.3	1.3
East	Daytime	–	–	–	–	–	–
	Night-time	–	–	–	–	–	0.7

At H080, there remain some exceedances in direction sectors northwest to east, though none in the southeast, south southwest and west sectors. Looking in detail at the highest exceedance in Table 11-24, that at 9 m/s in the northeast sector, the relative contribution all wind turbines in the noise model is as shown in

Table 11-25:

Table 11-25 Breakdown of noise level contributions at H080, Northeast Wind Direction at 9 m/s

Wind Farm / Turbine	Predicted noise Level, dB L_{A90}
Glenard	38.8
All other wind turbines combined	43.4
Total	44.3
Criterion (Night-time)	43
Excess	1.3

Wind turbines can be programmed to run in reduced modes of operation (or low noise modes) in order to achieve noise criteria during certain periods (i.e. day or night) and in specific wind conditions (i.e. wind speed and direction). The turbine technology that has been assumed for this assessment offers various low noise modes of operation which typically will have an associated energy output reduction. *Operating the turbines in reduced modes is generally referred to as curtailment and in the context of this EIAR is a proven effective mitigation to ensure noise limits are complied with. Given the relative contribution to the total noise levels as shown in*

Table 11-25 it is appropriate to curtail the proposed development such that the contribution from Glenard Wind Farm is 10 dB below the noise level of all other wind turbines combined, i.e. to 43.4 dB – 10 dB = 33.4 dB.

A detailed curtailment strategy matrix will be finalised as part of the detailed design for the selected turbine technology to achieve the noise criteria at each of the noise sensitive locations. To demonstrate the principle of curtailment, a typical curtailment strategy matrix has been developed and is presented in
Table 11-26 for north-easterly winds to address the exceedance listed in this wind direction sector. The required noise emission reductions to the relevant turbines are summarised in

Table 11-26.

Table 11-26 Indicative Turbine Curtailment Matrix for Northwest Wind Direction

Wind Direction Sector	Period	Turbine Curtailment (dB) at Standardised Wind Speeds (m/s)					
		4	5	6	7	8	9
Northeast	Day	–	–			–	–
	Night	–	–	–	–	T12: -6dB T13: -3dB T14: -3dB	T12: -6dB T13: -3dB T14: -3dB

With this curtailment in place during periods of northerly winds, the relative contribution from each set of wind turbines at Location H080 is shown in

Table 11-27.

Table 11-27 Breakdown of noise level contributions at H080, Northwest Wind Direction at 9 m/s

Wind Farm / Turbine	Predicted noise Level, dB L_{A90}
Glenard	33.4
All other wind turbines combined	43.4
Total	43.8
Criterion (Night-time)	43
Excess	0.8

There is a 0.8 dB exceedance remaining, but this is not due to the operation of the proposed Glenard wind farm development, therefore no further mitigation is required.

There is no remaining exceedance at for H080, at 9 m/s winds in the northerly direction.

The above analysis is based on a wind turbine sound power level which is worst-case, i.e. based on the envelope of sound power level values from a number of candidate wind turbines. The sound power level values derived in this way can be higher than those for any specific wind turbine. Moreover, if permitted and constructed, a commissioning noise survey with the Glenard wind turbines operating normally (i.e. without curtailment) would be carried out and any exceedances of the planning conditions which can be attributed to Glenard wind farm would be mitigated by implementing a suitable curtailment. Further discussion on mitigation is presented in Section 11.5.5.1.

11.5.3.1.3 *Summary*

For the purposes of this assessment, a specific turbine model, as detailed in Section 11.3 was selected. The actual turbine to be installed on the site will be the subject of a competitive tender process and could include other turbines models (including models not currently available). Regardless of the make or model of the turbine eventually selected for installation on site, the noise it shall give rise to should be of no greater significance than that used for the purposes of this assessment, to ensure the required noise limits are achieved at all noise sensitive locations. The turbines will be capable of achieving the limits set by the relevant guidance or planning permission conditions.

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

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

11.5.3.1.4 *Description of Effects*

With respect to the EPA criteria for description of effects, the potential worst-case associated effects at the nearest noise sensitive locations associated with the construction of Turbines, Hardstands, Substation, Grid Connection, Internal Roads, and Road Widening of the proposed development are described below.

Quality	*Significance*	*Duration*
Negative	Moderate	Short-term

11.5.3.2 Site Roads

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

11.5.3.2.1 *Description of Effects*

With respect to the EPA criteria for description of effects, the potential worst-case associated effects at the nearest noise sensitive locations associated with the construction of Turbines, Hardstands, Substation, Grid Connection, Internal Roads, and Road Widening of the proposed development are described below.

Quality	*Significance*	*Duration*
Negative	Moderate	Short-term

11.5.3.3 Substation

As previously stated, the proposed substation is located at a distance of 335 m from H165, at the coordinates shown in Table 11-32 below.

Table 11-28 Proposed Substation Location

Irish Transverse Mercator (ITM)	
Easting	Northing
643020	930756

The substation will be operational 24/7 and the noise impact at the nearest NSL has been assessed to identify the potential greatest impact associated with the operation of the Substation at the nearest NSL.

The following extract from the EirGrid Evidence Based Environmental Studies Study 8: Noise – Literature review and evidence-based field study on the noise effects of high voltage transmission development (May 2016) states the following in relation to noise impacts associated with 110kVA substation installations:

> *"The survey on the 110kV substation at Dunfirth indicated that measured noise levels (L_{Aeq}) were less than 40dB(A) at 5m from each of the boundaries of the substation. This is below the WHO night-time free-field threshold limit of 42dB for preventing effects on sleep and well below the WHO daytime threshold limits for serious and moderate annoyance in outdoor living areas (i.e. 55dB and 50dB respectively). Spectral analysis of the data recorded at this site demonstrated that there were no distinct tonal elements to the recorded noise level. To avoid any noise impacts from 110kV substations at sensitive receptors, it is recommended that a minimum distance of 5m is maintained between 110kV substations and the land boundary of any noise sensitive property."*

The substation installation will have comparable noise emissions to the 110kV unit discussed above (albeit likely to be less as it is a 38kV substation) and considering the distance between the substation and the nearest noise sensitive location (i.e. 1km from location H14) the noise from the operation of the proposed substation is not significant and any noise emissions from the substation will be inaudible at the nearest NSL.

It is therefore concluded that noise emissions from the operation of the substation will be negligible, the noise from the substation will be inaudible at the nearest NSL and will have no impact on the operation noise emissions from the Proposed Development.

11.5.4 Construction Phase Mitigation Measures

Regarding construction activities, reference will be made to BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*, which offers detailed guidance on the control of noise & vibration from demolition and construction activities. It is proposed that various practices be adopted during construction, including:

- managing the hours according to the CEMP [Appendix 4-3] during which site activities likely to create high levels of noise or vibration are permitted;
- establishing channels of communication between the contractor/developer, Local Authority and residents;
- appointing a site representative responsible for matters relating to noise and vibration;
- monitoring typical levels of noise and vibration during critical periods and at sensitive locations;
- keeping site access roads even to mitigate the potential for vibration from lorries.

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

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

11.5.4.1 Construction Phase Mitigation Measures – Noise

While it was concluded in Section 11.5.2 that there will be no significant noise impacts associated with the construction of the proposed development and that no specific mitigation measures were required, the following best practice mitigation measures from BS5528-1 standard will be implemented for the duration of the construction phase:

- limiting the hours during which site activities likely to create high levels of noise or vibration are permitted;
- establishing channels of communication between the contractor/developer, Local Authority and residents;
- appointing a site representative responsible for matters relating to noise and vibration;
- monitoring typical levels of noise and vibration during critical periods and at sensitive locations;
- keeping site access roads even to mitigate the potential for vibration from lorries.

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

- selection of plant with low inherent potential for generation of noise and/ or vibration;
- placing of noise generating / vibratory plant as far away from sensitive properties as possible within the site constraints, and;
- regular maintenance and servicing of plant items.

The contract documents will clearly specify that the Contractor undertaking the construction of the works will be obliged to take specific noise abatement measures and comply with the recommendations of British Standard BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise.* The following list of measures will be implemented on site, 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 close to NSL's outside of general construction hours will be surrounded by an acoustic enclosure or portable screen.
- During the course of the construction programme, supervision of the works will include ensuring compliance with the limits detailed in Section 11.3.2 using methods outlined in British Standard BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*.
- The hours of construction activity will be limited to avoid unsociable hours where possible. Construction operations shall generally be restricted to between 7:00hrs and 19:00hrs Monday to Saturday. However, to ensure that optimal use is made of good weather periods or at critical periods within the programme (i.e. concrete pours, rotor/tower deliveries) it will be necessary on occasion to work outside of these hours.

Where rock breaking is employed, the following are examples of measures that will be considered, 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.

- Air overpressure from a blast is difficult to control because of its variability, however, much can be done to reduce the effect. A reduction in the amount of primer cord used, together with the adequate burial of any that is above the ground, can give dramatic reduction to air overpressure intensities especially in the audible frequency range. Most complaints are likely to be received from an area downwind of the blast site, and therefore, if air blast complaints are a continual problem, it would be advisable to postpone blasting during unfavourable weather conditions if possible. As air blast intensity is a function of total charge weight, then a reduction in the total amount of explosives used can also reduce the air overpressure value.
- Further guidance will be obtained from the recommendations contained within BS 5228: Part 1 and the European Communities (Construction Plant and Equipment) (Permissible Noise Levels) Regulations 1988 in relation to blasting operations.

The methods used to minimise effects may consist of some or all the following:

- Restriction of hours within which blasting can be conducted.
- A publicity campaign undertaken before any work and blasting starts (e.g. 48 hours written notification).
- The firing of blasts at similar times to reduce the 'startle' effect.
- On-going circulars informing people of the progress of the works.
- The implementation of an onsite documented complaints procedure.
- The use of independent monitoring by external bodies for verification of results.

- Trial blasts in less sensitive areas to assist in blast designs and identify potential zones of influence.

11.5.4.2 Construction Phase Mitigation Measures – Vibration

While it was concluded in above that there will be no significant vibration impacts associated with the construction of the Proposed Development and that no specific mitigation measures were required, it is recommended that vibration from construction activities will be limited to the values set out in Section 11.4.1.3.

It should be noted that these limits are not absolute but provide guidance as to magnitudes of vibration that are very unlikely to cause cosmetic damage. Magnitudes of vibration slightly greater than those in the table are normally unlikely to cause cosmetic damage, but construction work creating such magnitudes should proceed with caution. Where there is existing damage these limits may need to be reduced by up to 50%.

Considering the distances between locations where works with the potential to generate significant vibration will take place and the nearest NSL's, no significant impact will be experienced. Therefore, no mitigation measures are proposed.

With respect to blasting, the following mitigation measures shall be employed to control the impact during blasts:

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

11.5.5 Operational Phase Mitigation Measures

An assessment of the operation noise levels has been undertaken in accordance with best practice guidelines and procedures as outlined in Section 11.3.2.2 of this Chapter. The findings of the assessment confirmed that the predicted operational noise levels will be within the relevant best practice noise criteria curves for wind farms at all locations and therefore no mitigation measures are required.

If alternative turbine technologies are considered for the site an updated noise assessment will be prepared to confirm that the noise emissions associated with the selected turbines will comply with the noise criteria curves as per best practice guidance outlined in Section 11.3.2.2 and/or the relevant operational criteria associated with the grant of planning for the Proposed Development. If necessary suitable curtailment strategies will be designed and implemented for alternative technologies to ensure compliance with the relevant noise criteria curves, should detailed assessment conclude that this is necessary.

In the unlikely event that an issue with low frequency noise is associated with the Proposed Development, it is recommended that an appropriate detailed investigation be undertaken. Due consideration should be given to guidance on conducting such an investigation which is outlined in Appendix VI of the EPA document entitled *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities* (NG4) (EPA, 2016). This guidance is based on the threshold values outlined in the Salford University document *Procedure for the assessment of low frequency noise complaints, Revision 1, December 2011.*

In the unlikely event that a complaint is received which indicates potential amplitude modulation (AM) associated with turbine operation, the operator shall employ an independent acoustic consultant to assess the level of AM in accordance with the methods outlined in the Institute of Acoustics (IoA) Noise working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) namely, *A Method for Rating Amplitude Modulation in Wind Turbine Noise* (August 2016) or subsequent revisions.

The measurement method outlined in the IoA AMWG document, known as the '*Reference Method*', will provide a robust and reliable indicator of AM and yield important information on the frequency and duration of occurrence, which can be used to evaluate different operational conditions including mitigation.

11.5.5.1 Monitoring

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

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

11.5.6 Decommissioning Phase

In relation to the decommissioning phase, similar overall noise levels as those calculated for the construction phase would be expected, as similar tools and equipment will be used. The noise and vibration impacts associated with any decommissioning of the site are considered to be comparable to those outlined in relation to the construction of the Proposed Development (as per Section 11.6.2). There is no item of plant that would be expected to give rise to noise levels that would be considered out of the ordinary or in exceedance of the levels outlined in Section 11.5.7.

Considering that in all aspects of the construction and decommissioning the predicted noise levels are expected to be below the appropriate Category A value (i.e. 65dB $L_{Aeq,T}$) at current noise sensitive locations for the decommissioning phase.

11.5.6.1 Decommissioning Phase Mitigation

The mitigation measures that will be considered in relation to any decommissioning of the site are the same as those proposed for the construction phase of the development, i.e. as per Section 11.5.2.

11.6 Description of Residual Effects

11.6.1 Do-Nothing Scenario

If the Proposed Development were not to proceed, no changes would be made to the current land-use practice of forestry and the site would continue to be managed under the existing commercial forestry arrangements.

The existing noise environment will remain largely unchanged considering the existing and permitted wind turbine developments in the area. In areas where traffic noise is a significant source in the noise environment, increases in traffic volumes on the local road network would be expected to result in slight increases in overall ambient and background noise in the area over time.

11.6.2 Construction Phase

During the construction phase of the project there will be some effect on nearby noise sensitive properties due to noise emissions from site traffic and other construction activities. However, given the distances between the main construction works and nearby noise sensitive properties and the fact that the construction phase of the development is temporary in nature, it is expected that the various noise sources will not be excessively intrusive. Furthermore, the application of binding noise limits and hours of operation, along with implementation of appropriate noise and vibration control measures, will ensure that noise and vibration effect is kept within the guidance limits.

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

11.6.2.1 Turbines, Hardstands, Met Mast, Substation, Grid Connection, Internal Roads and Road Widening

The predicted construction noise and vibration effects associated with on-site construction activities including are short-term and slight and are summarised as follows:

Quality	Significance	Duration
Negative	Slight	Short-term

11.6.2.2 Construction Traffic

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

Quality	Significance	Duration
Negative	Slight to Moderate	Short-term

11.6.2.3 Borrow Pit Activity

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

Quality	Significance	Duration
Negative	Slight	Short-term

11.6.3 Operational Phase

11.6.3.1 Noise

11.6.3.1.1 *Wind Turbine Noise*

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

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

The predicted residual operational turbine noise effects are summarised as follows at the closest noise sensitive locations to the site i.e. H062, H063 H064 and H077:

Quality	Significance	Duration
Negative	Moderate	Long-term

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

At other locations, there is a degree of wind turbine noise due to the existing and permitted wind farms, therefore the addition of Glenard Wind Farm would not increase the amount of wind turbine noise to the same degree as at the closest locations mentioned above; the residual effect at other locations as follows:

Quality	Significance	Duration
Negative	Slight	Long-term

Note that this comparison of existing turbine noise and predicted turbine noise is for the purposes of describing the effects as required by the EPA guidance documents only. The selection of wind turbine noise criteria is based on the guidance presented in Section 11.3.2.2.2 and Section 11.3.2.2.3.

11.6.3.1.2 Site Roads

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

Quality	Significance	Duration
Neutral	Imperceptible	Long-term

11.6.3.1.3 Substation Noise

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

Quality	Significance	Duration
Negative	Not significant	Long-term

11.6.3.2 Vibration

There are no expected sources of vibration associated with the operational phase of the Proposed Development. In relation to of vibration the associated effect is summarised as follows:

Quality	Significance	Duration
Negative	Imperceptible	Long-term

11.6.4 Decommissioning Phase

During the decommissioning phase of the Proposed Development, there will be some effect on nearby noise sensitive properties due to noise emissions from site traffic and other on-site activities. Similar overall noise levels as those calculated for the construction phase would be expected, as similar tools and equipment will be used. The noise and vibration impacts associated with any decommissioning of the site are considered to be comparable to those outlined in relation to the construction of the Proposed Development.

With respect to the EPA criteria for description of effects, the anticipated associated effects at the nearest noise sensitive locations associated with the decommissioning phase are described below.

Quality	Significance	Duration
Negative	Slight	Short-term

11.6.5 Cumulative Effects of other wind farms

The above operational noise assessment has considered the potential cumulative impacts of the Proposed Development in combination with other wind energy developments in the area as required by best practice guidance discussed in Section 11.3.2.2.1 and as detailed in Section 11.3.

As noted in Section 11.7.3, the predicted noise levels associated with the Proposed Development, which takes into account other wind energy developments in the area, will be within best practice noise criteria curves recommended in Irish guidance '*Wind Energy Development Guidelines for Planning Authorities'*

It is therefore considered that a significant effect is not associated with the Proposed Development in combination with other wind farm developments.

11.7 Transboundary Effects

With regards to noise sensitive locations in Northern Ireland, the ETSU-R-97 Guidelines are pertinent as the "Wind Energy Development Guidelines" published by the Department of the Environment, Heritage and Local Government (2006) are not applicable in this jurisdiction.

It is noted that there is no noise-sensitive location within Northern Ireland in the study area, or within the 35dB cumulative contour.

Use of the delivery route through Northern Ireland is only required for the turbine components (Stage 2 – Extended Artics).

The criteria for construction traffic noise assessment are based on *Design Manual for Roads and Bridges LA 111 Sustainability & Environmental Appraisal. Noise and Vibration Rev 2 (2020*) snd BS 5228: 2008+A1:2014 *Code of practice for noise and vibration control on construction and open sites* – Part 1: Noise, and are therefore also applicable in Northern Ireland.

With reference to the assessment in Section 11.5.2.2 above, the effect of construction traffic noise in Northern Ireland is slight.