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 WHO *Environmental Noise Guidelines for the European Region* 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 risk of 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 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 L_{Aeq}-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."

It is therefore considered that the conditional WHO recommended average noise exposure level (i.e. 45dB L_{den}) if applied, as target noise criteria for an existing or proposed wind turbine development in Ireland, should be done with caution. The L_{den} criteria has been not adopted as part of this assessment; this is based upon the review set out above and the conclusion that the conditional WHO recommended average noise exposure level (i.e. 45dB L_{den}) may be a poor characterization of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes.

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

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 and Resonate Acoustics, 2013)[3] 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."

---

3 *EPA South Australia, 2013, Wind farms* https://www.epa.sa.gov.au/files/477912_infrasound.pdf

A German report[4], 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)[5]"*

> *"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:

- '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.

---

4 *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*

5 *DIN 45680:2013-09 – Draft "Measurement and Assessment of Low-frequency Noise Immissions" November 2013*

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, post-commissioning measurements. 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 and 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[6]. 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.

---

6 *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*

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[7]. 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, 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.

7 *Australian Medical Association, 2014, Wind farms and health. Available at https://ama.com.au/position-statement/wind-farms-and-health-2014*

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 proposed turbines (>750m), levels 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 Planning Permissions relating to the other wind farm developments are discussed in the following sections. As previously stated, it is a requirement that turbine noise emissions from all existing, permitted and proposed wind energy developments are included in the noise impacts assessment.

11.3.6.1 Garvagh Glebe Wind Farm

The permissible noise limits for the Garvagh Glebe development are contained in Condition No. 3 of planning permission granted by Leitrim County Council, Reference 03/257.

The permitted development provides, by way of condition of consent, that noise levels at all dwellings shall not exceed 45dB $L_{eq,5min}$.

For the assessment presented in this report we have assumed that the absolute noise limit of 43dB $L_{A90\ 10min}$ on turbine noise from the Garvagh Glebe wind farm will apply to all NSLs.

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 10 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 spread over a large area and 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."*

In addition to data filtering, which is discussed in later sections, the noise monitoring campaign was expanded so as to capture data at locations further from the acoustic influence of existing turbines. Examples of this "doubling up" on locations in different sectors surrounding the site is the Location D and Location B pairing and also Location E and Location J. The monitoring locations are representative of houses within a given "cluster" of properties in the localised area.

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 LA90 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 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.

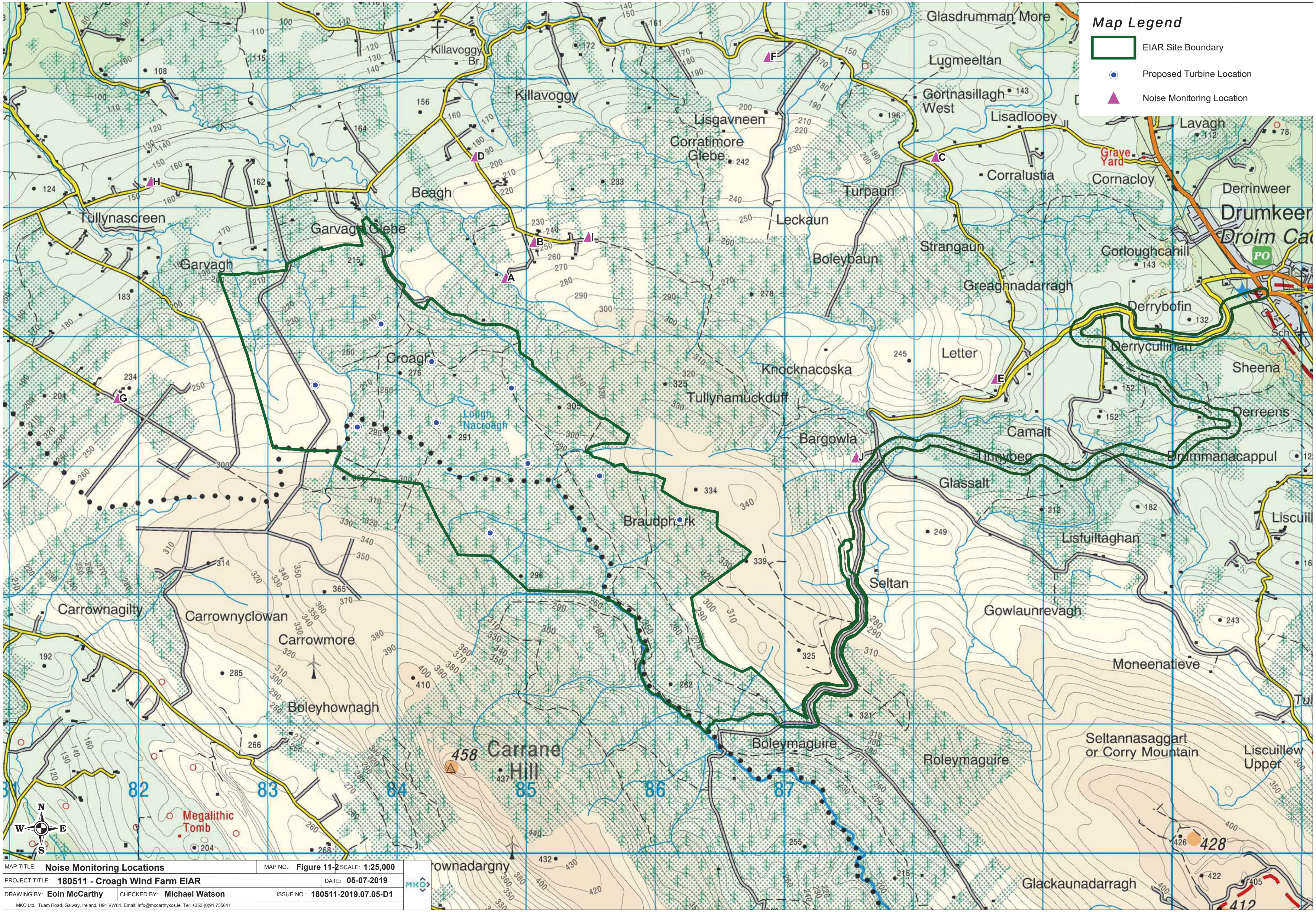
Table 11-4 Measurement Location Coordinates

Location	Coordinates – Irish Grid (ITM)	
	Easting	Northing
A (H37)	584799	824463
B (H32)	585018	824742
C (H52)	588128	825402
D (H30)	584566	825405
E (H58)	588593	823683
F (H45)	586831	826176
G (H1)	581795	823532
H (H12)	582051	825211
I (H35)	585438	824780
J (H65)	587511	823073

The background noise away from any significant sources were typically noted to be distant traffic movements, activity in and around the residences and wind generated noise from nearby foliage and other typical anthropogenic sources typically found in such rural settings.

Site visits were carried out during the morning and afternoon time; therefore, no observations were made during night-time periods. There was no perceptible source of vibration noted at any of the survey locations.

Plate 11-1to 11-10 illustrate the installed noise monitoring kits.



MAP TITLE: Noise Monitoring Locations	MAP NO.: Figure 11-2	SCALE: 1:25,000	
PROJECT TITLE: 180511 - Croagh Wind Farm EIAR		DATE: 05-07-2019	
DRAWING BY: Eoin McCarthy	CHECKED BY: Michael Watson	ISSUE NO.: 180511-2019.07.05-D1	

MKO

MKO Ltd., Tuam Road, Galway, Ireland, H91 VW84. Email: info@mccarthykos.ie Tel: +353 (0)91 735611

11.3.7.1.1 Location A

Plate 11-1 Location A (H37)

11.3.7.1.2 Location B

Plate 11-2 Location B (H32)

11.3.7.1.3 Location C

Plate 11-3 Location C (H52)

11.3.7.1.4 Location D

Plate 11-4 Location D (H30)

11.3.7.1.5 Location E

Plate 11-5 Location E (H58)

11.3.7.1.6 Location F

Plate 11-6 Location F (H45)

11.3.7.1.7 Location G

Plate 11-7 Location G (H1)

11.3.7.1.8 Location H

Plate 11-8 Location H (H12)

11.3.7.1.9 Location I

Plate 11-9 Location I (H35)

11.3.7.1.10 Location J

Plate 11-10 Location J (H65)

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 (H37)	24 January 2019	8 March 2019
B (H32)	24 January 2019	8 March 2019
C (H52)	24 January 2019	8 March 2019
D (H30)	24 January 2019	8 March 2019
E (H58)	24 January 2019	8 March 2019

Location	Start Date	End Date
F (H45)	24 January 2019	8 March 2019
G (H1)	24 January 2019	8 March 2019
H (H12)	24 January 2019	8 March 2019
I (H35)	14 February 2019	27 March 2019
J (H65)	8 March 2019	27 March 2019

The survey was completed when an adequate number of datasets had been measured as recommended in the IOA GPG to determine a suitable representation of the typical background noise.

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 half way through the survey periods. The following instrumentation was used at the various locations:

Table 11-6 Instrumentation Details

Location	Equipment	Serial Number
A (H37)	RION – NL-52	620878
B (H32)	RION – NL-52	732145
C (H52)	RION – NL-52	732075
D (H30)	RION – NL-52	1021277
E (H58)	RION – NL-52	710288
F (H45)	RION – NL-52	620867
G (H1)	RION – NL-52	976222
H (H12)	RION – NL-52	186671
I (H35)	RION – NL-52	186667
J (H65)	RION – NL-52	186671

Before and after the survey the measurement apparatus was check calibrated using a Brüel & Kjær 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 of sample periods affected 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 an anemometer 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	584,274	823,568

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. $L_{Aeq,10min}$ 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 Garvagh Glebe 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.

Additional filtering has been applied due to the contribution of existing wind farms in the area. In order to capture baseline noise levels unaffected by existing wind farms, wind direction filtering has been applied. Measurement locations where this approach has been applied include locations A, B, I and J. The filtering involved identifying the downwind direction sector for each of these locations, i.e. the wind directions where the wind was blowing from existing wind farms to a given noise sensitive receiver or dwelling and therefore having the potential for the highest noise contribution at these locations. Downwind periods were therefore excluded and upwind periods only were used to derive the background noise levels at these four locations. This approach is outlined in Section 5.2.3 of the IOA GPG.

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.

The background noise levels are derived for each location with reference to the standardised 10m height wind speed relative to the assessment hub height of 103.5m.

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 65m and 85m heights have been corrected to a height of 103.5m (the 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: $U = U_{ref} \times [(H \div H_{ref})]^m$

Where:

U	Calculated wind speed
U_{ref}	Measured HH 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 = $\log(U/U_{ref})/\log(H/H_{ref})$

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

Roughness Length Shear Profile: $U_1 = U_2 \times [(\ln(H_1 \div z))/ (\ln(H_2 \div z))]$

Where:

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

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

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 cumulative noise level associated with the operation of the permitted and proposed developments. 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 (LWA);
- 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 11-8 details the co-ordinates of the 10 no. proposed turbines that are being considered in this assessment.

Table 11-8 Proposed Croagh Turbine Co-ordinates

Turbine Ref.	Co-ordinates (ITM)	
	Easting	Northing
T01	583,322	823,639
T02	583,831	824,112
T03	583,648	823,314
T04	584,223	823,820
T05	584,259	823,347
T06	584,841	823,616
T07	584,968	823,032
T08	585,523	822,935
T09	586,144	822,595
T010	584,676	822,493

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 103.5m above ground.

Table 11-2 details the noise spectra used for noise modelling purposes for the proposed Croagh Wind Farm development. As discussed in previous sections, appropriate guidance is couched in terms of a L_{A90} criterion. The provided turbine noise is referenced in terms of the L_{Aeq} parameter, best practice guidance contained within the *Institute of Acoustics Good Practice Guide* (IoA GPG) states that "L_{A90} levels should be determined from calculated L_{Aeq} levels by subtraction of 2 dB". Therefore, in accordance with best practice guidance, a 2dB reduction has been applied to the predicted results in this assessment.

For the purposes of all predictions presented in this report to account for various uncertainties in the measurement of turbine source levels, a +2dB uncertainty factor has been added to all noise emission values in line with guidance for wind turbine noise assessment contained in the IOA GPG.

Table 11-9 Lwa Spectra Used for Prediction Model – Croagh Wind Farm

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB L_{WA}
	63	125	250	500	1000	2000	4000	8000	
4	84.3	89.7	92.6	94.3	94.1	92.4	85.2	69.8	100.2
5	88	93.4	96.3	98	97.8	96.1	88.9	73.1	103.9
6	88.6	94.3	97.7	99.6	99.6	97.4	90.2	77.3	105.3
7	89.3	95	98.6	100.4	100.1	98.1	90.9	72.9	106
≥8	89.5	95.1	98.4	100	100.1	98.4	91.3	73.2	106

Best practice specifies that a penalty should be added to the predicted noise levels, where any tonal component is present. The level of this penalty is described and is related to the level by which any tonal components exceed audibility. On review of derived noise emission levels, 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.

A list of existing, permitted and proposed windfarm developments in proximity to the subject site was provided at the early stages of the assessment process. A noise modelling exercise was carried out to address the potential for cumulative impacts associated with other windfarms in conjunction with the Croagh development. 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. Other developments that were predicted to contribute to cumulative impacts included:

- Garvagh Glebe – Operational development of 10 no. turbines with an associated HH of 70m.
- Black Banks 1 – Operational development of 4 no. turbines with an associated HH of 49m.
- Black Banks 2 – Operational development of 8 no. turbines with an associated HH of 49m.

The following noise data presented in Table 11-10 and Table 11-11 was used as inputs for the other developments identified within the study area, as identified above, see Chapter 2 of this EIAR for further details.

Table 11-10 L_{wa} Spectra Used for Prediction Model – Garvagh Glebe Wind Farm

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB L_{WA}
	63	125	250	500	1000	2000	4000	8000	
5	82.5	89.2	93.4	92.3	90.4	89.8	84.5	71.9	98.6

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB L_{WA}
	63	125	250	500	1000	2000	4000	8000	
6	84.5	91.9	96.6	97.0	95.7	94.0	89.9	79.0	102.7
7	86.1	93.9	98.1	97.9	97.0	96.5	92.5	80.2	104.3
≥8	91.8	98.3	100.9	98.6	96.0	90.7	76.9	61.1	105.2

Table 11-10 details the noise emission values used for noise modelling of the Garvagh Glebe turbines. The relevant noise emission data in AWN's database has been utilised following the identification of the turbine model installed at the Garvagh Glebe development.

Table 11-11 L_{wa} Spectra Used for Prediction Model – Black Banks 1 and 2 Wind Farms

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB L_{WA}
	63	125	250	500	1000	2000	4000	8000	
5	72.2	80.1	85.9	91.5	91.2	87.3	80.9	70.7	95.9
6	76.6	84.5	90.3	95.9	95.6	91.7	85.3	75.1	100.3
7	79.9	87.8	93.6	99.2	98.9	95.0	88.6	78.4	103.6
≥8	80.5	88.4	94.2	99.8	99.5	95.6	89.2	79.0	104.2

The above noise emission levels have been used for Black Banks 1 and 2 wind farms.

Table 11-11 details the noise emission values used for noise modelling of the Black Banks turbines which data has been taken from manufacturer's data.

Appendix 11-4 presents additional details relation to the turbine noise model inputs and the turbine location coordinates for other turbines.

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°).

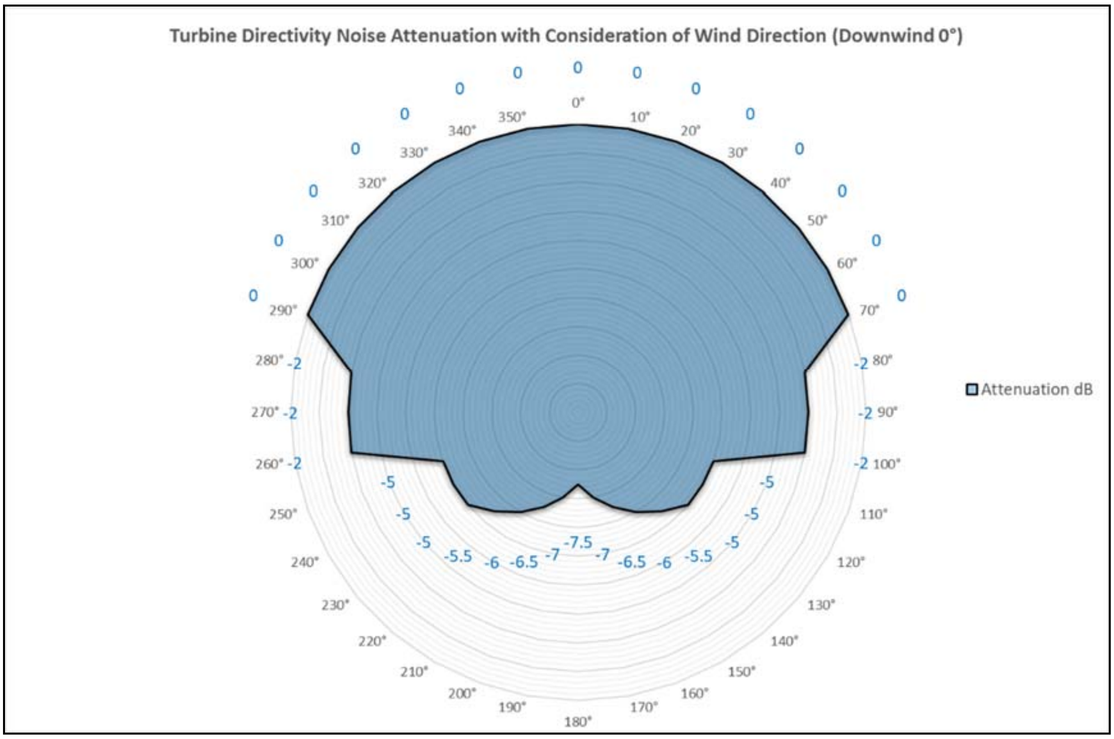


Figure 11-2 Turbine Directivity Attenuation with Consideration of Wind Direction

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 Table 11-9 to identify any locations with a potential exceedance.
- Undertake directional noise prediction calculations to refine the noise prediction results as described in Section 11.3.8.3.
- Identify any locations with potential cumulative exceedances that occur as result of the proposed development only (i.e. Croagh turbines).
- Calculate the level of attenuation required from the Croagh turbines to achieve the adopted turbine noise criteria or the attenuation required to Croagh such that the predicted contribution of the Croagh 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 in the vicinity of the noise sensitive locations (NSLs) in proximity to the proposed development. The methodology for the assessment is outlined in Section 11.3.7 and the results of the assessment are outlined in the following sections.

A variety of wind speed and weather conditions were encountered over the survey period outlined in Section11.3.7.2. Figure 11-4 illustrates the distributions of wind speed and wind direction standardised to 10 metre height over the baseline noise survey period detailed in Table 11-5.

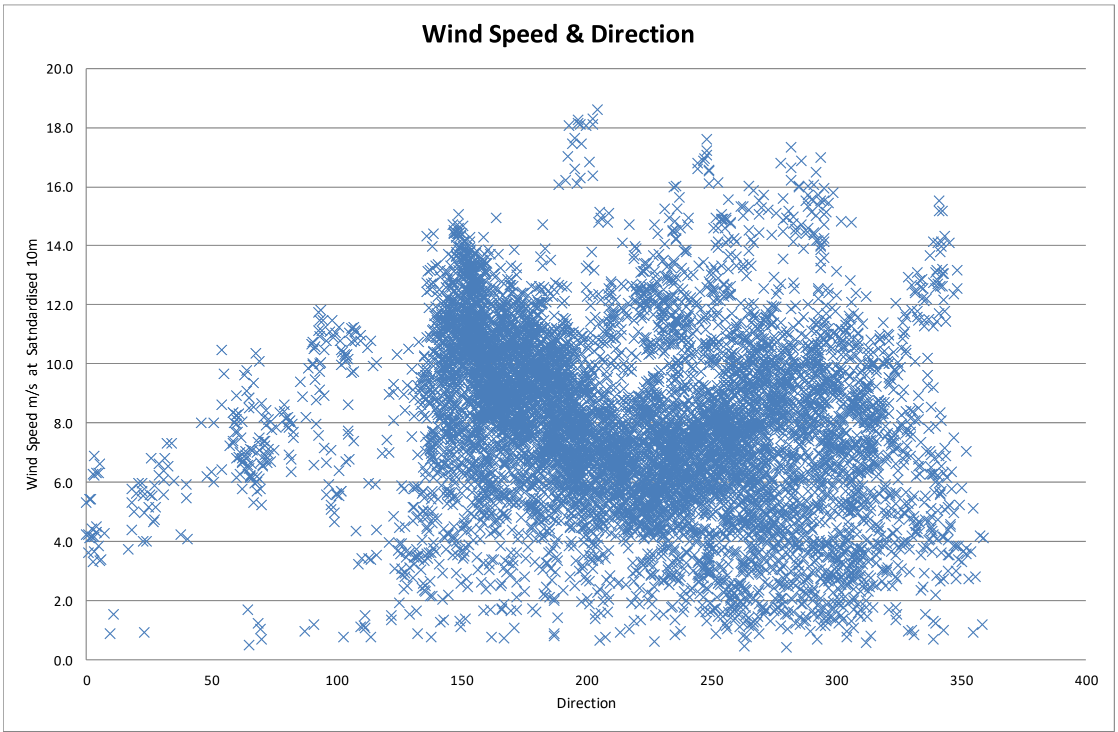


Figure 11-4 Distributions of Wind Speeds and Directions Over the Survey Period

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 set out above. For each location two graphs are presented one shows the screened noise datasets used to derive the daytime background noise levels and the other shows the night time datasets.

11.4.1.1 Location A (H37)

11.4.1.1.1 Daytime Quiet Periods

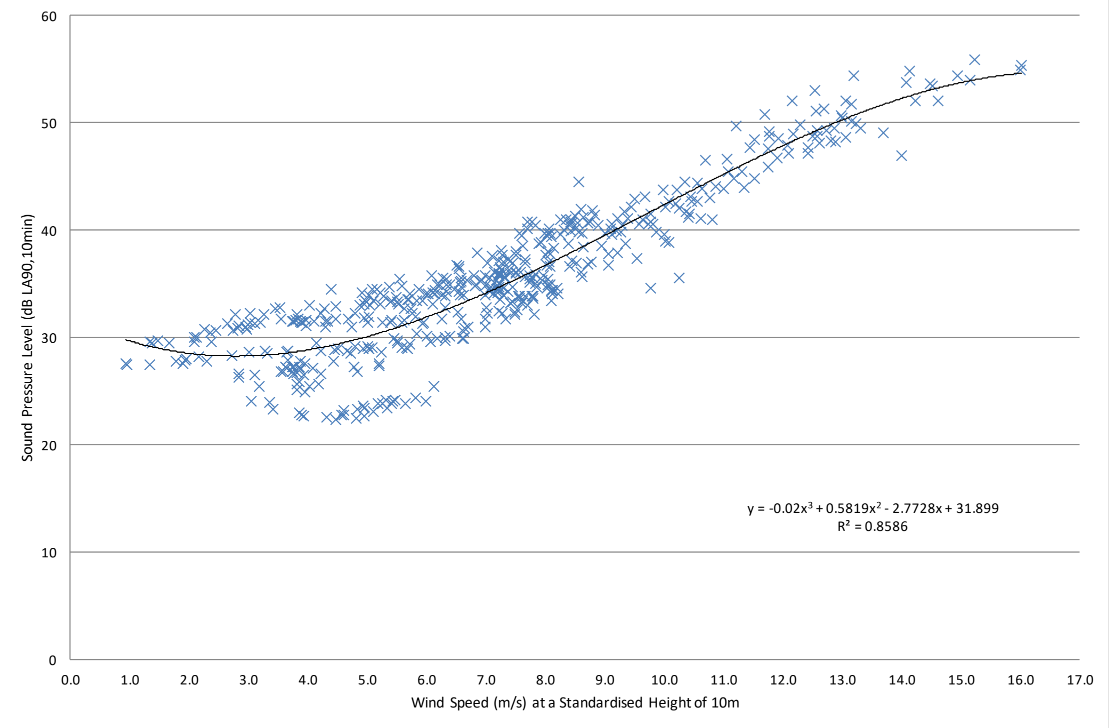


Figure 11-3 Location A (H37) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Daytime

11.4.1.1.2 Night-time Quiet Periods

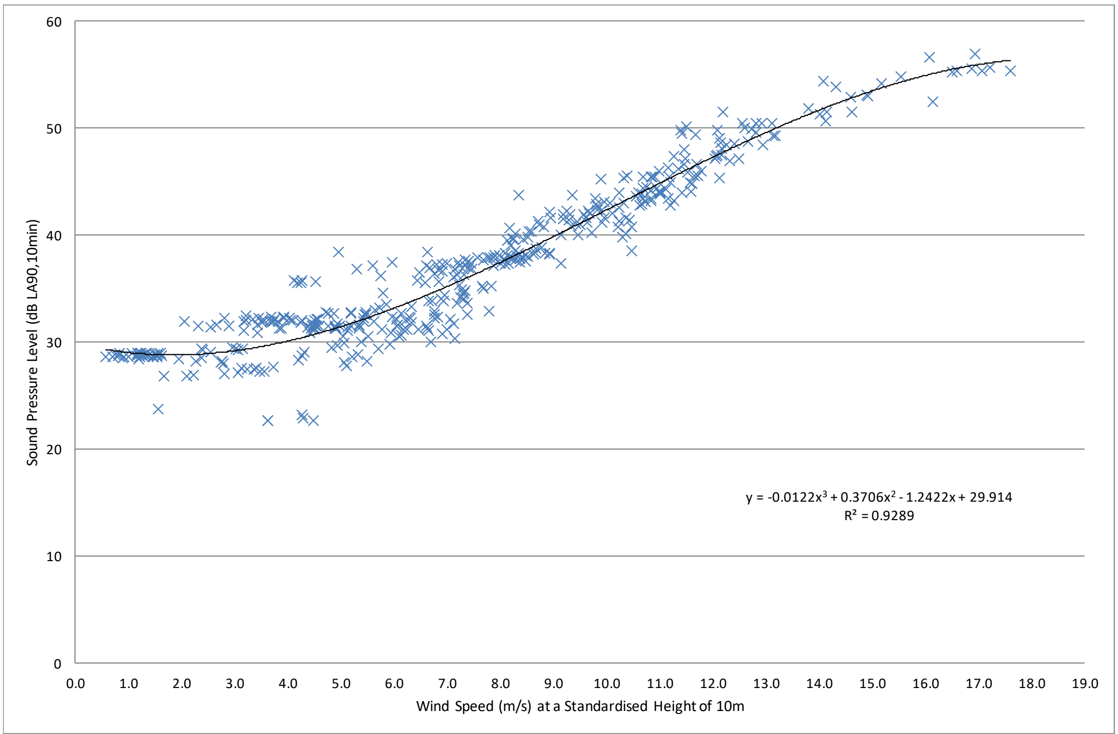


Figure 11-4 Location A (H37) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Night -time

11.4.1.2 Location B (H32)

11.4.1.2.1 Daytime Quiet Periods

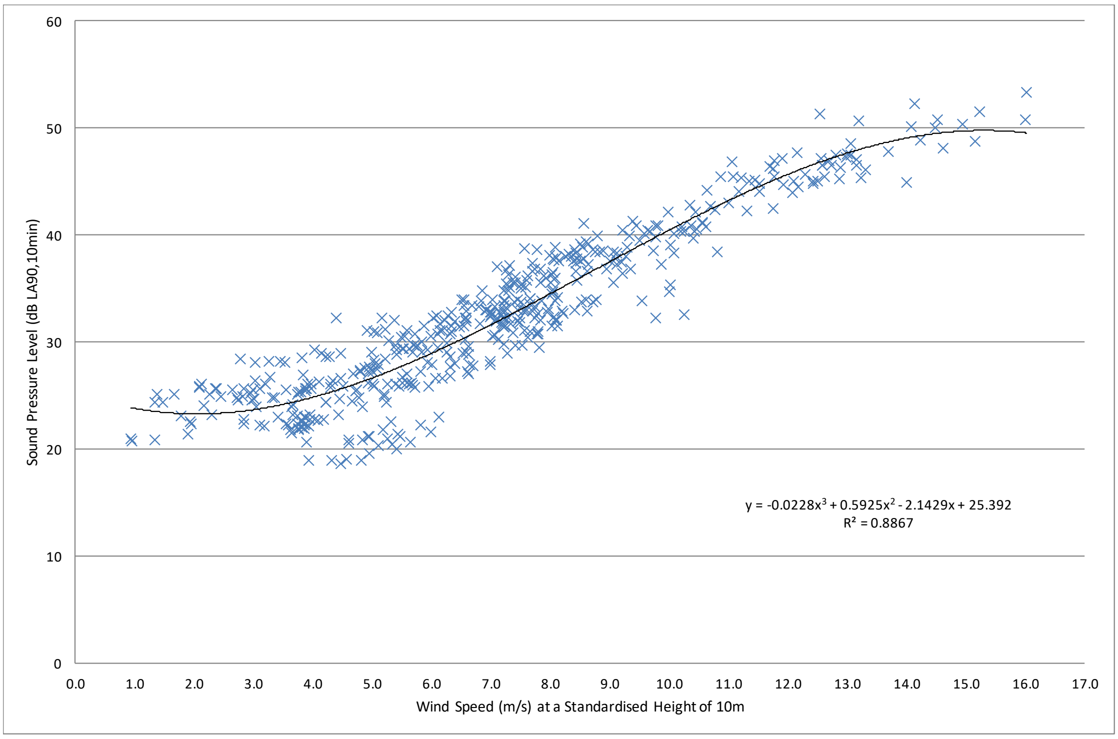


Figure 11-5 Location B (H32) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Daytime

11.4.1.2.2 Night-time Quiet Periods

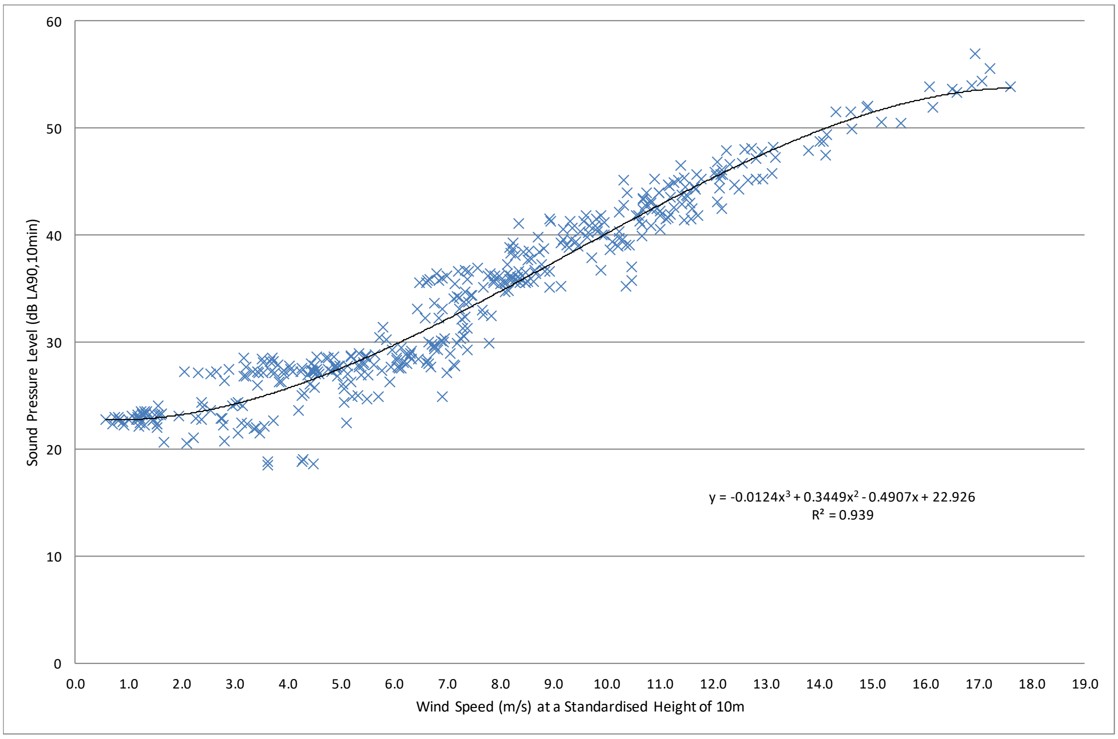


Figure 11-6 Location B (H32) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Night -time

11.4.1.3 Location C (H52)

11.4.1.3.1 Daytime Quiet Periods

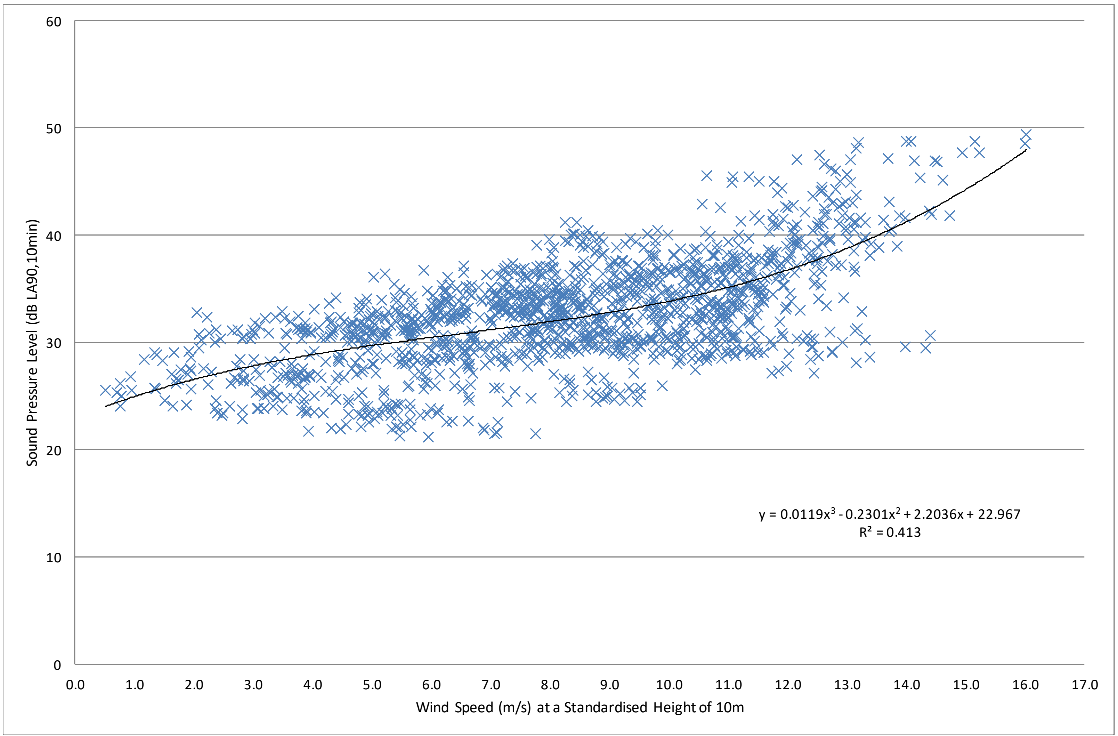


Figure 11-7 Location C (H52) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Daytime

11.4.1.3.2 Night-time Quiet Periods

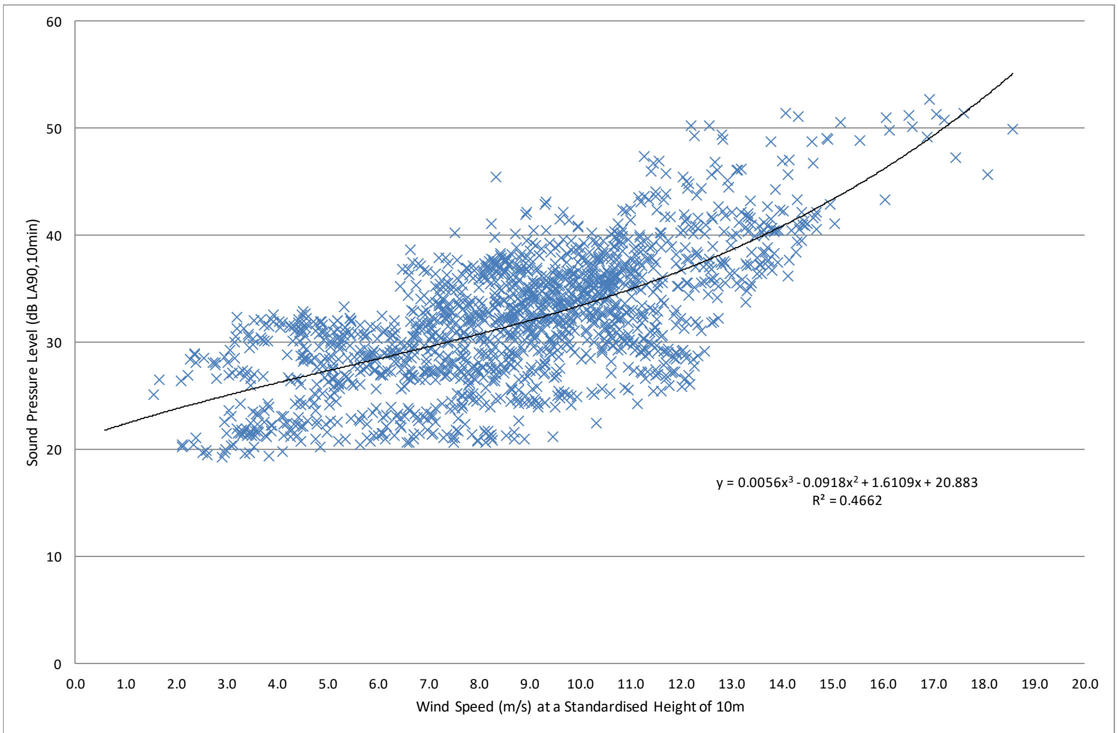


Figure 11-8 Location C (H52) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night -time

11.4.1.4 Location D (H30)

11.4.1.4.1 Daytime Quiet Periods

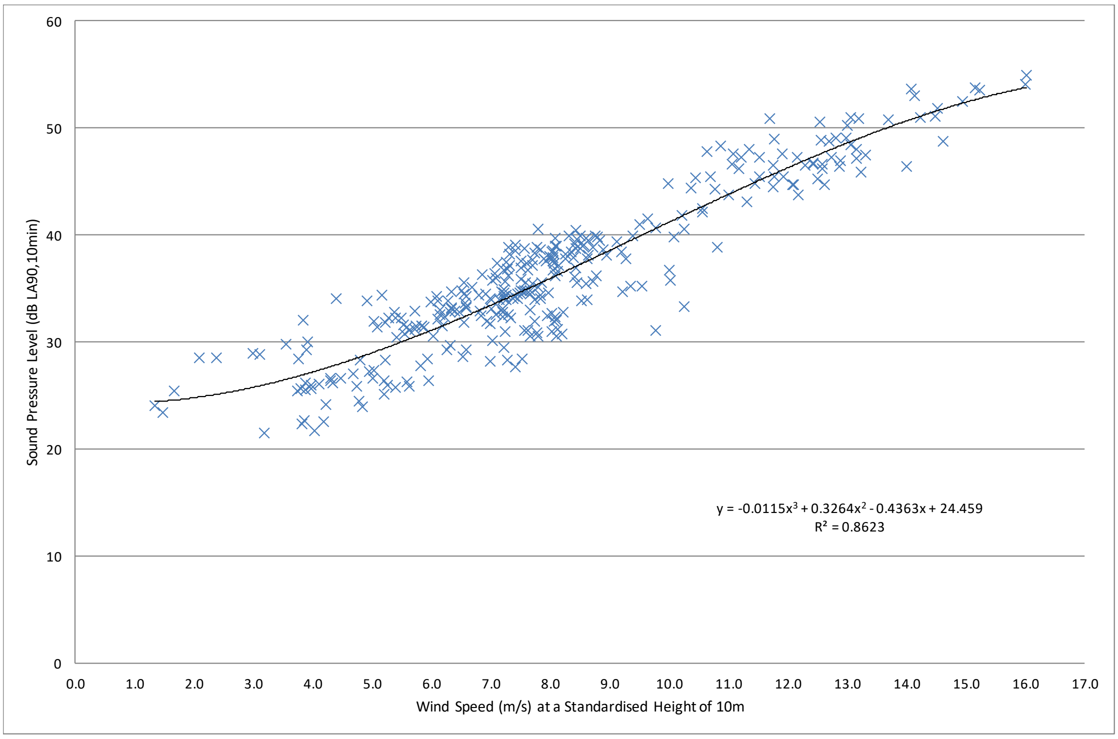


Figure 11-9 Location D (H30) Background Noise Levels $L_{A90,\ 10\ min}$ dB –Daytime

11.4.1.4.2 Night-time Quiet Periods

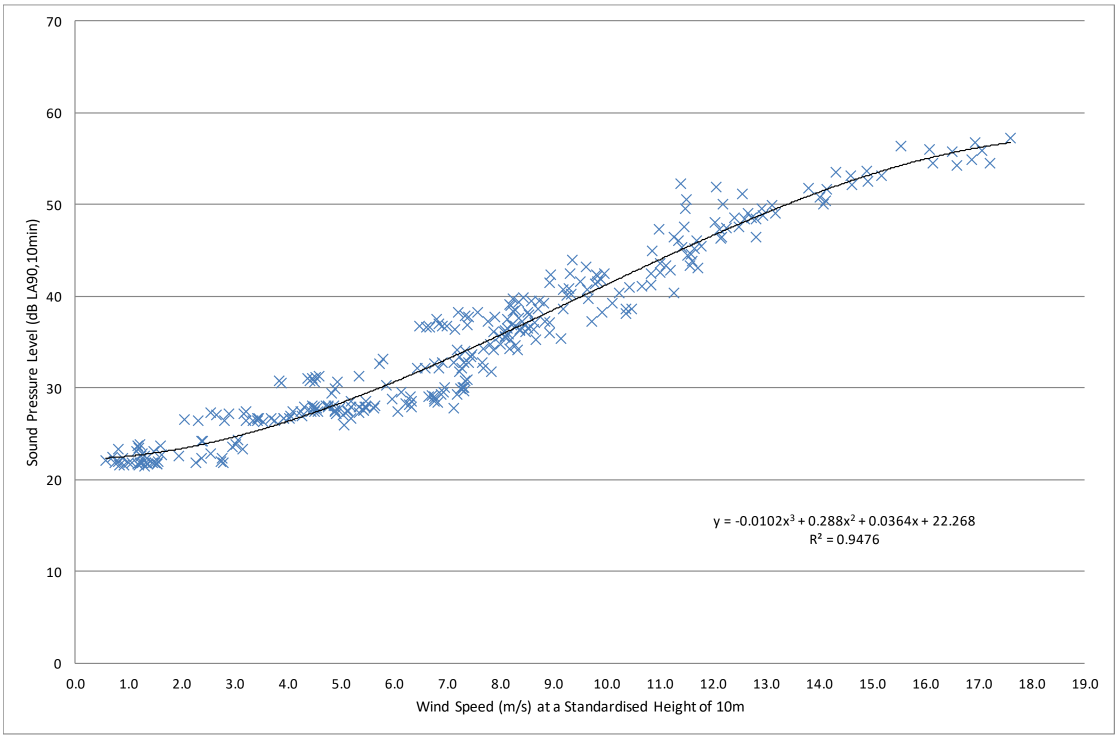


Figure 11-10 Location D (H30) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night -time

11.4.1.5 Location E (H58)

11.4.1.5.1 Daytime Quiet Periods

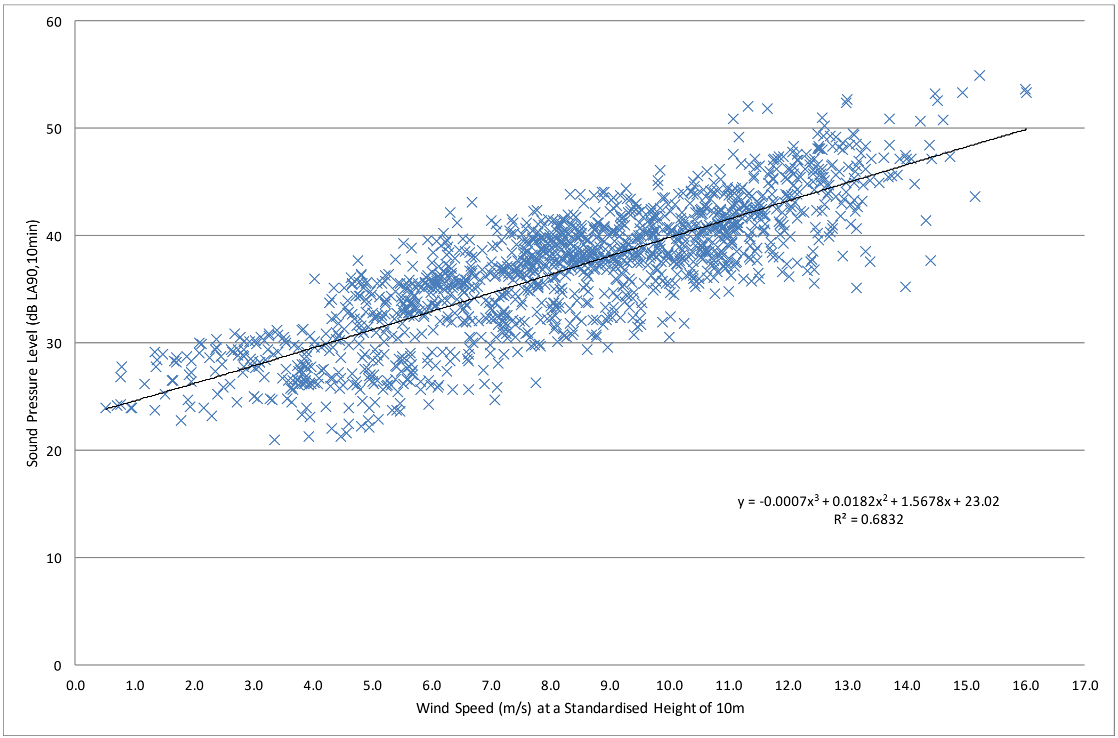


Figure 11-11 Location E (H58) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Daytime

11.4.1.5.2 Night-time Quiet Periods

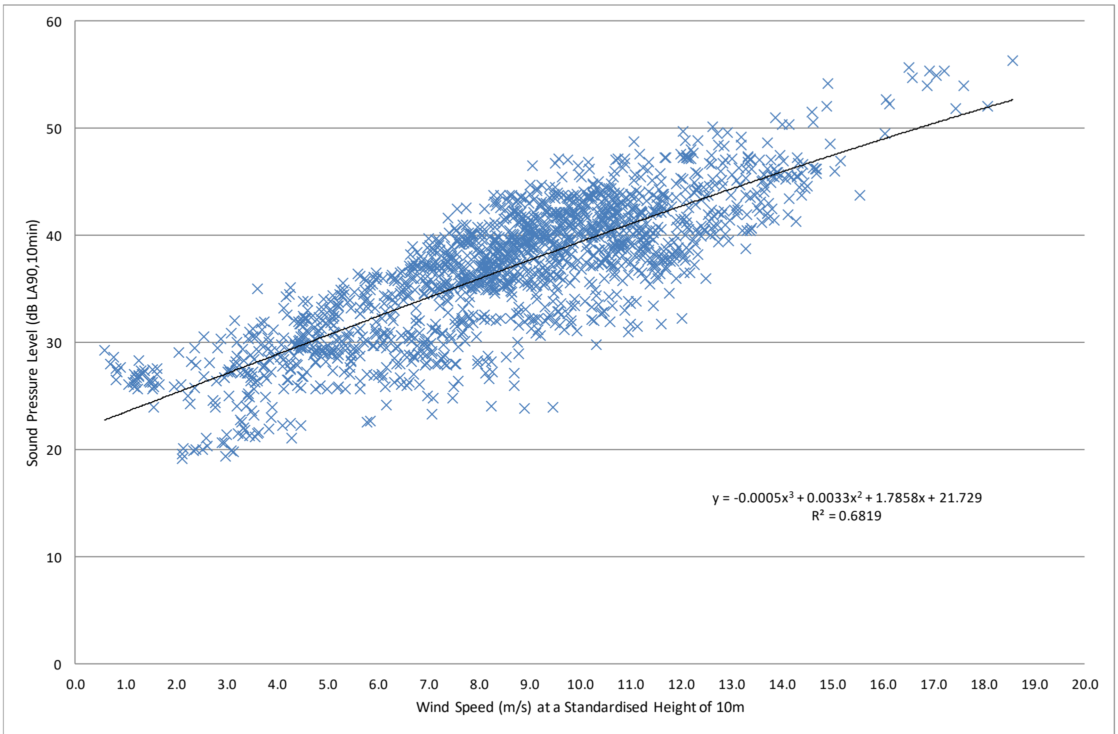


Figure 11-12 Location E (H58) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night -time

11.4.1.6 Location F (H45)

11.4.1.6.1 Daytime Quiet Periods

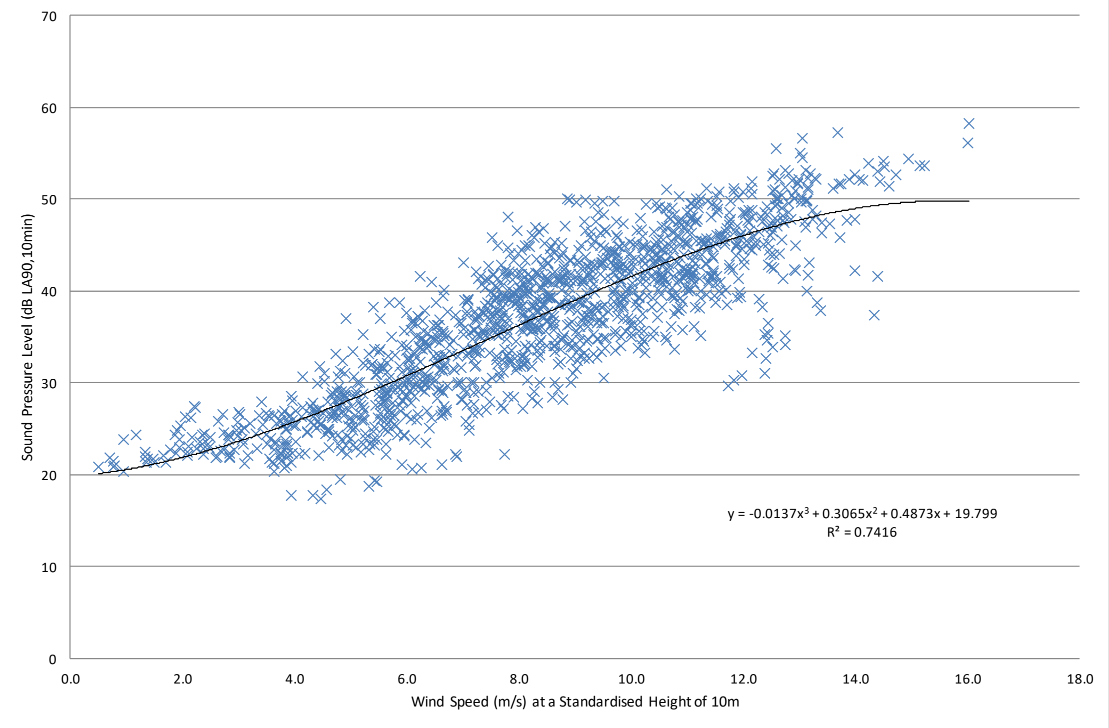


Figure 11-13 Location F (H45) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Daytime

11.4.1.6.2 Night-time Quiet Periods

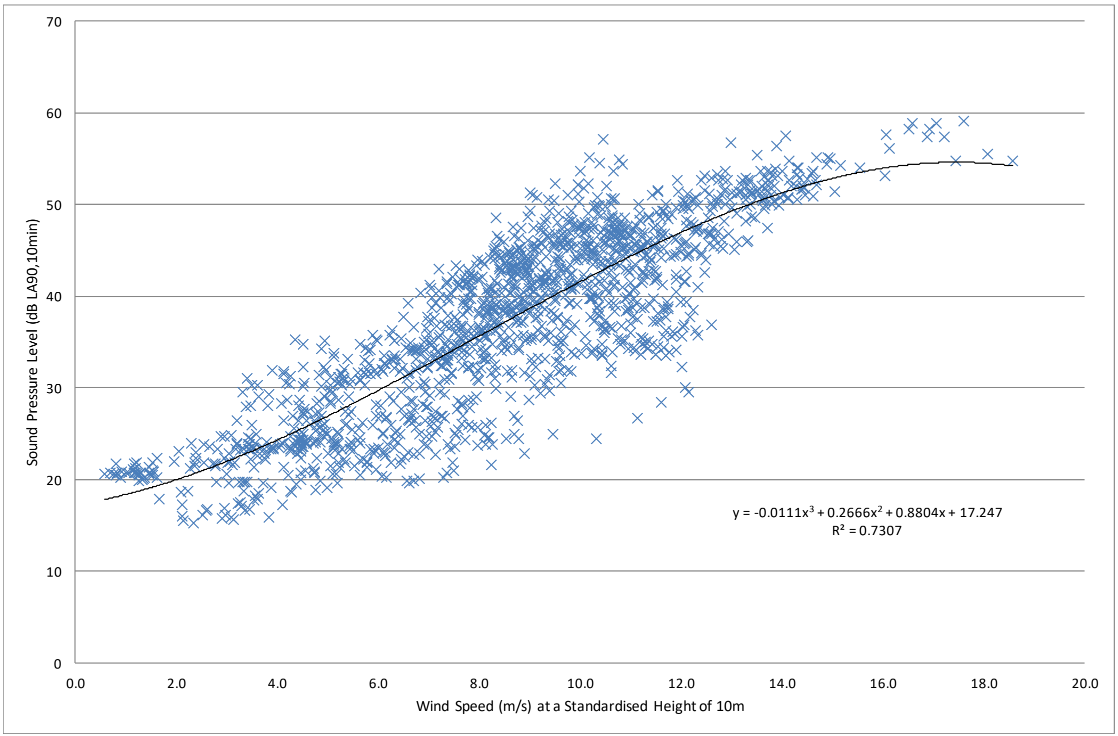


Figure 11-14 Location F (H45) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night -time

11.4.1.7 Location G (H1)

11.4.1.7.1 Daytime Quiet Periods

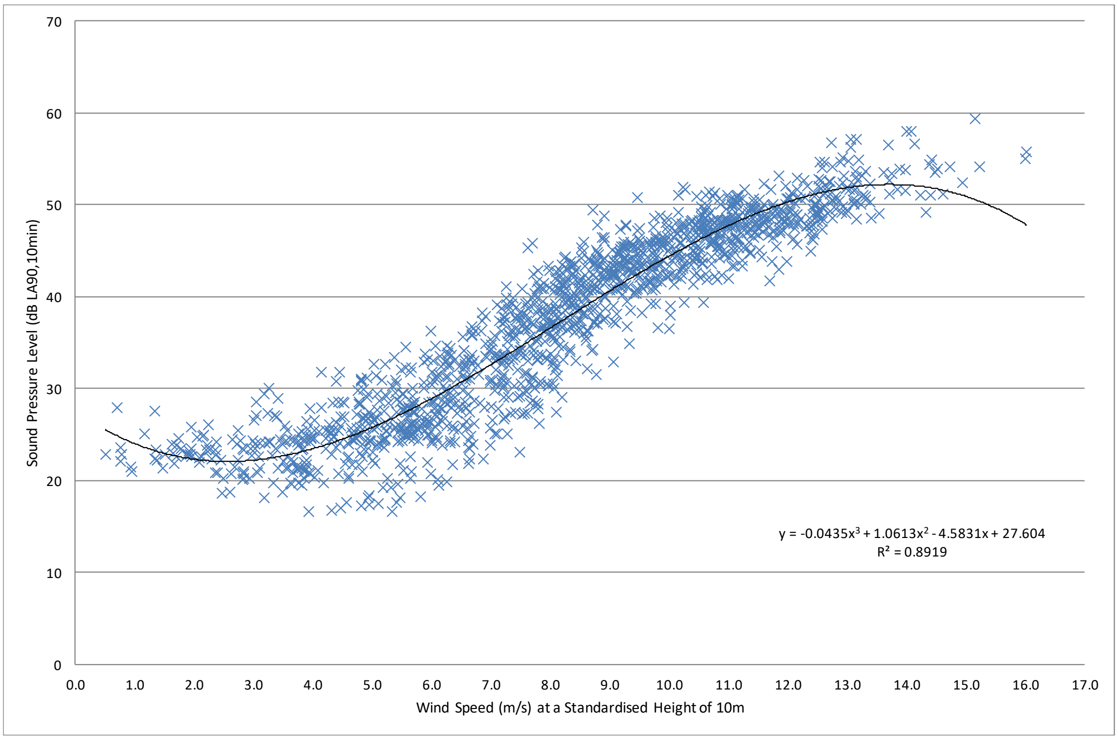


Figure 11-15 Location G (H1) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Daytime

11.4.1.7.2 Night-time Quiet Periods

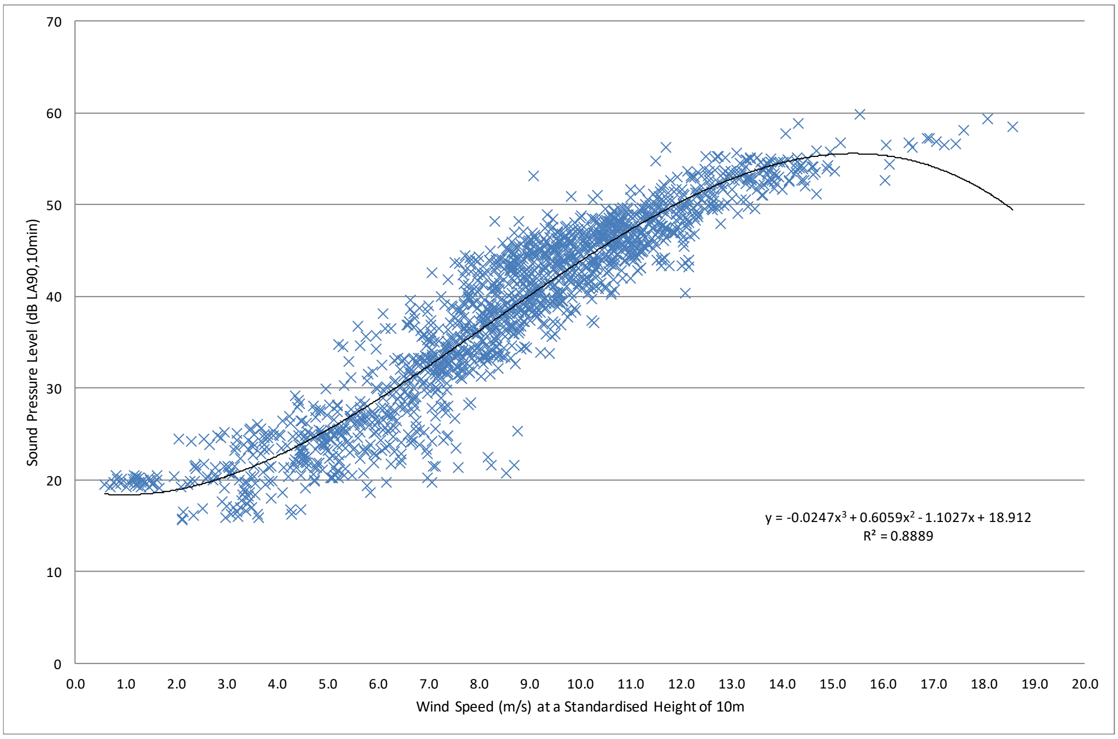


Figure 11-16 Location G (H1) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night -time

11.4.1.8 Location H (H12)

11.4.1.8.1 Daytime Quiet Periods

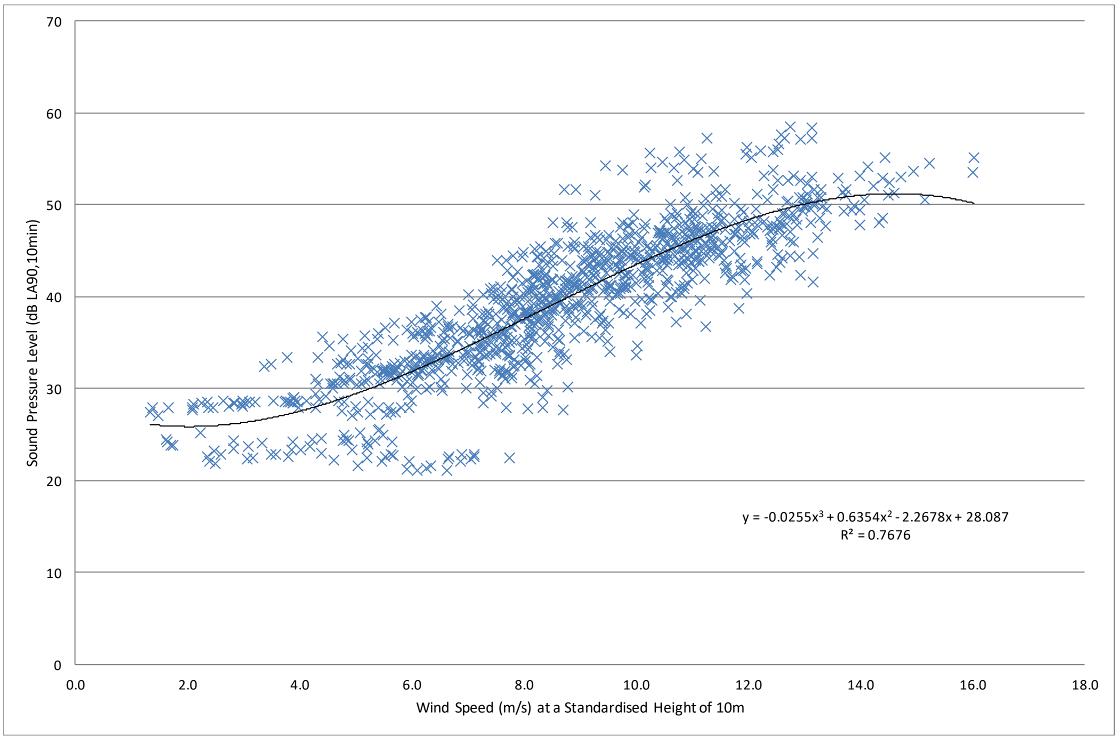


Figure 11-17 Location H (H12) Background Noise Levels $L_{A90, 10\ min}$ dB – Daytime

11.4.1.8.2 Night-time Quiet Periods

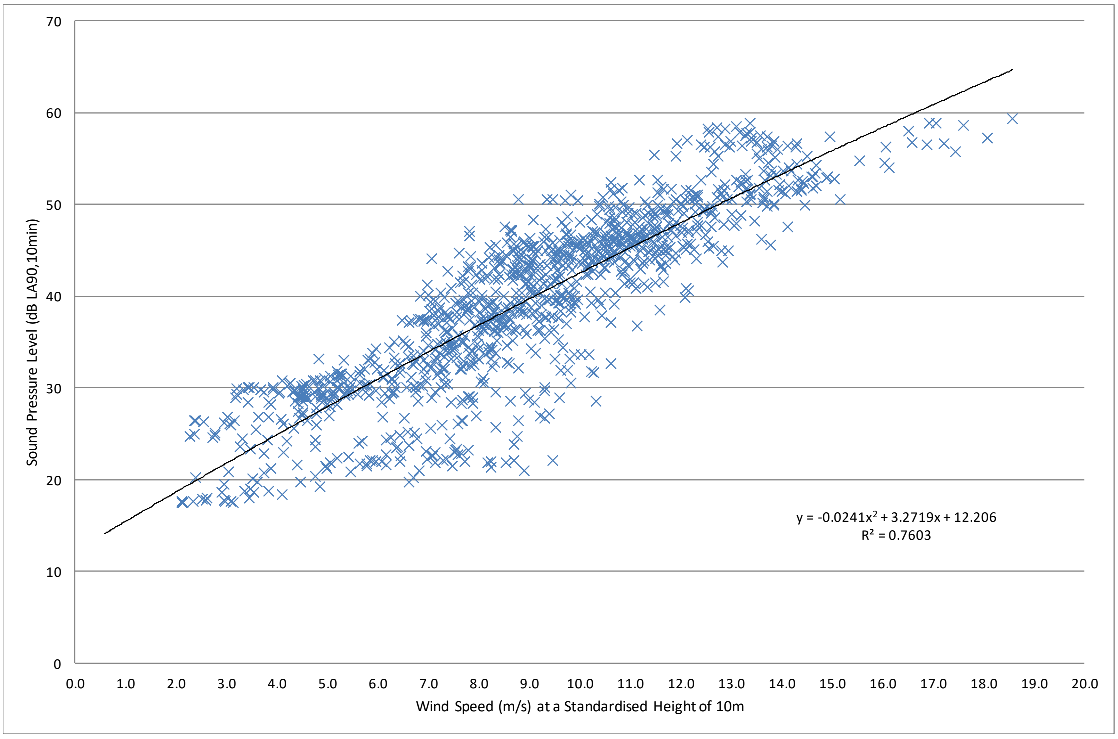


Figure 11-18 Location A (H37) Background Noise Levels $L_{A90, 10\ min}$ dB – Location A (H01) – Night -time

11.4.1.9 Location I (H35)

11.4.1.9.1 Daytime Quiet Periods

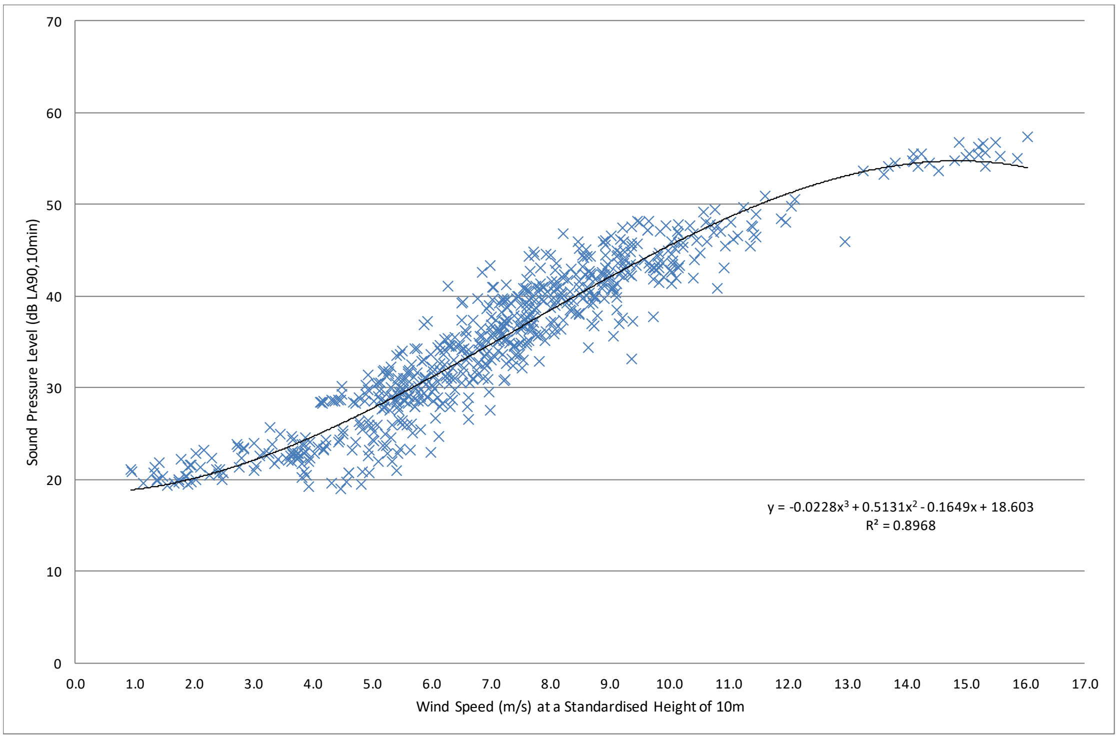


Figure 11-19 Location I (H35) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Daytime

11.4.1.9.2 Night-time Quiet Periods

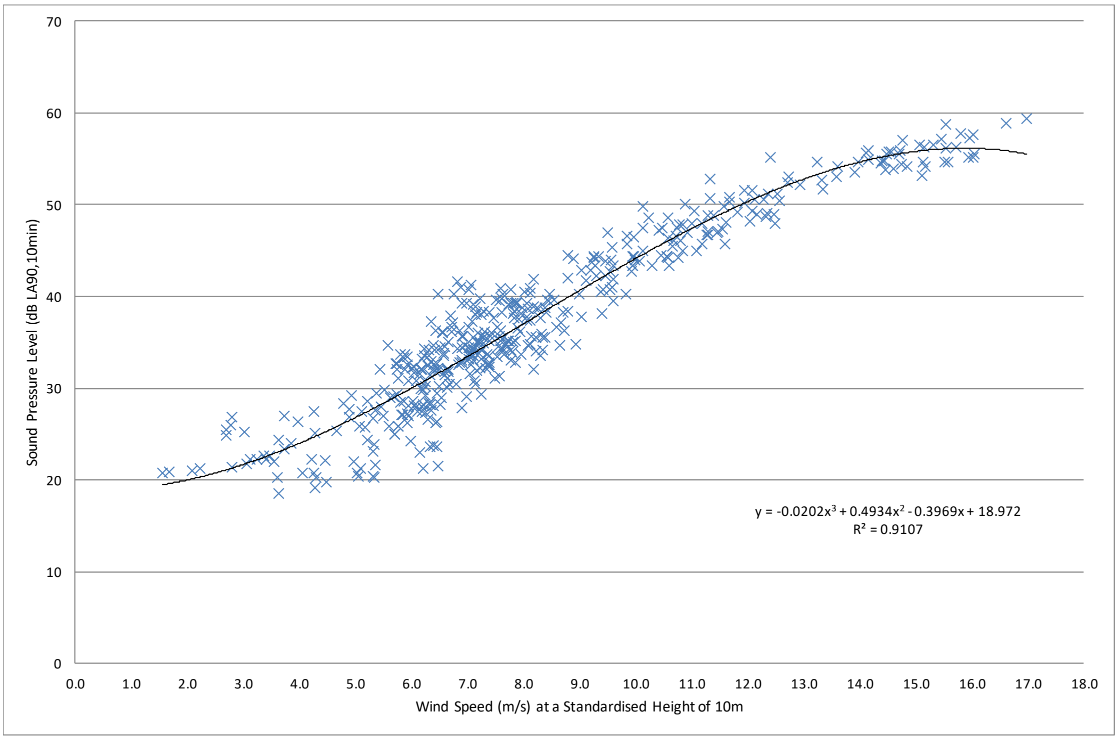


Figure 11-20 Location I (H35) Background Noise Levels $L_{A90,\ 10\ min}$ dB – Night -time

11.4.1.10 Location J (H65)

As described in Section 11.5.6 above, directional filtering was applied to the measured noise data in order to capture prevailing background noise levels without the contribution of existing windfarms. Over the two-week survey period at this location the prevailing wind conditions were from the south west and west and therefore a very low number of data points were captured in upwind conditions, therefore it was not possible to derive background noise levels.

11.4.1.11 Summary of Background Noise Levels

Table 11-12 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.

The background noise data shall be used to derive appropriate noise limits for each of the noise sensitive locations. In a situation where measurements have been conducted near another receiver, the background noise levels measured nearby have been deemed representative for establishing appropriate noise limits.

Table 11-12 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)							
		3	4	5	6	7	8	9	10
A (H37)	Day	28.3	28.8	30.1	31.9	34.1	36.7	39.5	42.4
	Night	29.0	29.8	31.2	32.9	35.0	37.3	39.8	42.4
B (H32)	Day	23.7	24.8	26.6	28.9	31.6	34.5	37.5	40.4
	Night	24.2	25.7	27.5	29.7	32.1	34.7	37.4	40.1
C (H52)	Day	27.8	28.9	29.7	30.5	31.2	32.0	32.8	33.9
	Night	25.0	26.2	27.3	28.5	29.6	30.8	32.0	33.4
D (H30)	Day	25.8	27.2	29.0	31.1	33.5	36.0	38.6	41.2
	Night	24.6	26.2	28.1	30.4	32.8	35.4	38.1	40.8
E (H58)	Day	27.9	29.5	31.2	32.9	34.6	36.4	38.1	39.8
	Night	27.1	28.9	30.7	32.5	34.2	36.0	37.7	39.4
F (H45)	Day	23.6	25.8	28.2	30.8	33.5	36.3	39.0	41.6
	Night	22.0	24.3	26.9	29.7	32.7	35.7	38.7	41.6
G (H1)	Day	22.2	23.5	25.8	28.9	32.6	36.6	40.6	44.4
	Night	20.4	22.6	25.5	28.8	32.4	36.2	40.1	43.8
H (H12)	Day	26.3	27.6	29.4	31.8	34.6	37.6	40.6	43.4
	Night	21.8	24.9	28.0	31.0	33.9	36.8	39.7	42.5
I (H35)	Day	22.1	24.7	27.7	31.1	34.8	38.5	42.1	45.5
	Night	21.7	23.9	26.7	29.9	33.3	36.9	40.5	44.1
Envelope	Day	22.1	23.5	25.8	28.9	31.2	32.0	32.8	33.9
	Night	20.4	22.6	25.5	28.5	29.6	30.8	32.0	33.4

A worst-case envelope based on the lowest average levels at the various wind speeds for both day and night time is also presented in Table 11-12. The derived background noise curves for this assessment are set out in the table below.

Table 11-13 Assignment of background noise levels to noise-sensitive locations

Representative Background Noise Levels	Noise Sensitive Location (NSL)
A	H037
B	H032
C	H052
D	H030
E	H058
F	H045
G	H001
H	H012
I	H035
Envelope	All other locations

11.4.2 Wind Turbine Noise Criteria

A lower daytime threshold of 40 dB $L_{A90,10\text{-}min}$ has been adopted 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 deemed appropriate considering of the following:

- The EPA document 'Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)' (EPA, 2016) 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.
- The nearby Garvagh Glebe wind farm has permitted noise limits are as per Condition by Leitrim County Council, Reference 03/257 with a lower threshold for turbine noise of 45 dB $L_{Aeq,5min}$.
- 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 other national guidance (EPA, 2016) in relation to acceptable noise levels in areas of low background noise and grant of planning conditions for other permitted wind turbine development in the area 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.

With respect to the methodology in relevant guidance documents outlined in Section 11.3.2.2 the noise criteria curves in Table 11-14 have been derived for the NSLs surrounding the proposed development. These limit values are determined through applying the criteria to the derived background noise levels.

Table 11-14 Noise Criteria Curves

Location	Period	Derived LA90, 10 min Levels (dB) at various Standaridsed10m Height Wind Speed (m/s)							
		3	4	5	6	7	8	9	10
A (H37)	Day	40.0	40.0	45.0	45.0	45.0	45.0	45.0	47.4
	Night	43.0	43.0	43.0	43.0	43.0	43.0	44.8	47.4
B (H32)	Day	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.4
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.1
C (H52)	Day	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
D (H30)	Day	40.0	40.0	40.0	45.0	45.0	45.0	45.0	46.2
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.1	45.8
E (H58)	Day	40.0	40.0	45.0	45.0	45.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.4
F (H45)	Day	40.0	40.0	40.0	45.0	45.0	45.0	45.0	46.6
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.7	46.6
G (H1)	Day	40.0	40.0	40.0	40.0	45.0	45.0	45.6	49.4
	Night	43.0	43.0	43.0	43.0	43.0	43.0	45.1	48.8
H (H12)	Day	40.0	40.0	40.0	45.0	45.0	45.0	45.6	48.4
	Night	43.0	43.0	43.0	43.0	43.0	43.0	44.7	47.5
I (H35)	Day	40.0	40.0	40.0	45.0	45.0	45.0	47.1	50.5
	Night	43.0	43.0	43.0	43.0	43.0	43.0	45.5	49.1
Envelope	Day	40.0	40.0	40.0	45.0	45.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

11.5 Likely Significant Effects and Associated Mitigation Measures

11.5.1 Do-Nothing Scenario

If the development is not progressed the existing noise environment in the vicinity of the site and noise sensitive receivers will remain largely unchanged as commercial forestry operations would continue and no other significant wind energy projects are currently permitted or proposed within 5km of the site of the proposed development.

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 other site works. 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.

Due to the nature of the construction activities it is difficult to calculate the actual magnitude of noise emissions to the local environment. However, it is possible 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.

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.

There are several stages and elements associated with the construction phase of the proposed development which will include the following:

- Turbines and Hardstands;
- Substation and Grid connection;
- Site entrances;
- Internal roads;
- a Meteorological Mast;
- Internal amenity pathways;
- Additional amenity links; and
- Amenity Carpark.

Detailed information is included in Chapter 4: Description of the Proposed Development.

In general, the distances between the construction activities associated with the Proposed Development and the nearest NSLs are such that there will be no significant noise and vibration impacts at NSLs. The following sections present an assessment of the main stages of the construction phase that have the potential for associated noise and vibration impacts, all other stages and element are considered not to have significant noise and vibration impacts at NSLs.

11.5.2.1 Turbines, Hardstands, Substation, Grid Connection, Met Mast, Amenity Walkways including car park and Internal Roads

As the construction programme has been established in outline form only, it is difficult to calculate the actual magnitude of noise emissions to the local environment. However, it is possible to predict typical noise levels 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. In this instance, the noise sensitive locations surround the site at distances varying with the nearest property to any proposed work area being the order of 590m (i.e. approximate distance between H037 and the nearest section of existing track to be upgraded). Turbine foundation works are anticipated at a distance of some 850m from the nearest NSL (H037). 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 with respect to equipment on-times and number of plant items operating simultaneously, construction noise levels will be lower at properties located further from the works.

11.5.2.1.1 *Noise*

Turbines and Hardstanding

Several indicative sources that would be expected on a site of this nature have been identified and predictions of the potential noise emissions calculated at the nearest noise sensitive receiver. The assessment is considered to be a worst-case, construction noise levels will be lower at properties located further from the works. The nearest sensitive location (R037) is situated approximately 850m from proposed Turbine 6.

Table 11-15 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 hours assessment period.

Table 11-15 Typical Construction Noise Emission Levels

Item (BS 5228 Ref.)	Activity/ Notes	Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$)	Predicted Noise Level at 850m (dB $L_{Aeq,T}$) Turbine Construction
HGV Movement (C.2.30)	Removing spoil and transporting fill and other materials.	79	40
Tracked Excavator (C.4.64)	Removing soil and rubble in preparation for foundation.	77	38
Piling Operations (C.12.14)	Standard pile driving.	88	49
General Construction (Various)	All general activities plus deliveries of materials and plant.	82	45
Dewatering Pumps (D.7.70)	If required.	80	41
JCB (D.8.13)	For services, drainage and landscaping.	82	43
Vibrating Rollers (D.8.29)	Road surfacing.	77	38

Item (BS 5228 Ref.)	Activity/ Notes	Plant Noise Level at 10m Distance (dB $L_{Aeq,T}$)	Predicted Noise Level at 850m (dB $L_{Aeq,T}$) Turbine Construction
Rock Crusher (C.1.14)	Associated with blasting for turbine foundations (If required)	82	43
Rock Breaking (C.9.11)	Rock Breaking for turbine foundations (If required)	93	54
Grid Connection Works	Breaking, excavation, loaders and road roller	82	42
Total Construction Noise (cumulative for all activities)			57

The predicted noise levels from turbine construction activities at the closest dwellings are in the range of 38 to 57 dB $L_{Aeq,T}$.

In all instances the total construction noise levels are predicted to be below the appropriate Category A value (i.e. 65dB $L_{Aeq,T}$), as outlined in Section 11.4.1 above, and therefore a significant effect is not predicted in relation to the nearest noise sensitive locations in terms of construction noise.

There are no items 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 Table 11-1.

Substation and Grid Connection Works

The proposed substation is located in northern sector of the site close to proposed Turbine 7. The noise impact at the nearest NSL has been assessed to identify the potential greatest impact associated with the construction of the Substation.

The nearest NSL to the substation site is R037 at approximately 620m away with grid connection works expected to take place at a closer distance of 580m to the same NSL at the closest point of the works. Based on the same construction activities as outlined in Table 11-15 it is predicted that the likely worst-case potential noise level due to construction activities associated with the substation will be in the order of 54dB $L_{Aeq,T}$ at the nearest NSL which is well below the significance threshold of 65dB $L_{Aeq,1hr.}$ outlined in Section 11.4.1.1.

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

Internal Roads

It is proposed to construct new internal roads and upgrade existing internal roads to access the proposed turbines and associated infrastructure, such as site access roads, as part of the proposed development. Review of the internal road layout has identified that the nearest NSL is H065 which is located 135m from the proposed works. All other locations are at greater distances with the majority at significantly greater distances. The full description of the proposed internal roads is outlined in Chapter 4 of the EIAR.

The predicted noise level associated with construction of internal roads is 53 dB $L_{Aeq,T}$ at the nearest NSL. At NSLs at greater distances the predicted noise level is lower again.

Therefore, it is concluded that there will be no significant noise impacts associated with the construction of internal roads and therefore no specific mitigation measures will be required.

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 receivers 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 and Internal Roads 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 NSLs should the various elements of the construction phase be undertaken simultaneously.

11.5.2.2 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
- Stage 2a – Extended Artic Deliveries
- Stage 2b – Conventional Deliveries

Table 11-16 Assumptions for Construction Traffic Noise Assessment: Northern Delive

Route	Stage	Traffic Units	%HGV
L-4232	Existing	217	44%
	1a	697	65%
	1b	345	42%
	2a – Large Deliveries	357	55%
	2b – Conventional deliveries	272	41%
R280 North	Existing	2,074	11%
	1a	2,514	24%
	1b	2,202	13%
	2a – Large Deliveies	2,214	15%
	2b – Conventional deliveries	2,129	12%
R280 South	Existing	2,074	11%
	1a	2,514	24%
	1b	2,202	13%
	2a – Large Deliveies	2,214	15%
	2b – Conventional deliveries	2,129	12%
N4 east of Carrick-on-Shannon	Existing	8,458	14%
	1a	8,898	17%
	1b	8,586	14%
	2a – Large Deliveies	8,598	15%
	2b – Conventional deliveries	8,513	14%
N16 west of Belcoo	Existing	3,097	13%
	1a	3,537	21%
	1b	3,225	14%
	2a – Large Deliveies	3,237	15%
	2b – Conventional deliveries	3,152	13%

Based on the assumptions presented above changes in noise level based on the existing flows have been estimated and is presented in Table 11-17.

Table 11-17 Estimated Changes in Traffic Noise Levels

Route	Stage	Change in Traffic Noise Level dB(A)	Estimated Number of Days
L-4232	1a	5.1	10
	1b	2.0	245
	2a	2.2	10
	2b	1.0	18
R280 North	1a	0.8	10
	1b	0.3	245
	2a	0.3	10
	2b	0.1	18
R280 South	1a	0.8	10
	1b	0.3	245
	2a	0.3	10
	2b	0.1	18
N4 east of Carrick-on-Shannon	1a	0.2	10
	1b	0.1	245
	2a	0.1	10
	2b	0.0	18
N16 west of Belcoo	1a	0.6	10
	1b	0.2	245
	2a	0.2	10
	2b	0.1	18

In the majority of routes and construction phases, the predicted increases in traffic noise levels during each of the construction stages of the proposed development are less than 3 dB. With reference to the criteria set out in Section 11.3.2.1.2 the potential impacts are minor are worst case and no additional mitigation measures are proposed.

Along the L4232 during Stage 1a, the noise level increase is 5dB. However, the predicted noise level due to construction traffic along this road results in a noise level of 63dB $L_{Aeq,1hr}$ which is within the criteria for construction noise presented in Table 11-1.

It is concluded that there will be no significant noise impacts associated with the additional traffic generated during the construction phase of the proposed development and therefore no specific mitigation measures will be required.

11.5.2.2.1 *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 Pits

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[8]
- 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 pit location indicated in Table 11-18.
- Table 11-19 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.

Table 11-18 Proposed Borrow Pit Locations

Borrow Pit ID	Co-ordinates	
	Easting	Northing
BOR 1	585,735	822,430

8 *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 and ancillary constructions, where relevant.*

Table 111-19 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

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 11-20 at the 10 no. closest NSLs.

Table 111-20 Typical Plant Noise Levels

Borrow Pit			
Loc.	Predicted Construction Noise Level $L_{Aeq,1hr}$		Diff. dB(A)
	Scenario		
	A	B	
R065	28	39	-11
R037	26	36	-10
R034	26	36	-10
R069	26	36	-11
R035	25	35	-10
R038	25	35	-10
R032	25	35	-10
R064	25	35	-10
R036	24	34	-10
R031	23	32	-10

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

- Predicted construction noise levels for both Scenario A and B at the borrow pit are well within the relevant construction noise criteria (65dB $L_{Aeq,T}$). It is assumed that construction works at the borrow pit will only occur during daytime periods only (07:00 to 19:00hrs).
- The blasting proposal results in lower levels of construction noise as the rock breaking plant is not required in this scenario. Predicted noise levels are lower at all assessed locations for Scenario A. Predicted levels of 10 to 11dB(A) lower at the various locations assessed.

- It is accepted that the individual blast events will be audible at certain locations. Blast events will be designed and controlled such that the best practice limits values outlined in the mitigation section of this chapter are not exceeded.

11.5.3 Operational Phase Potential Impacts

11.5.3.1 Turbine Noise Assessment

The cumulative noise levels for the proposed, existing and permitted sites in the study area have been calculated for all noise sensitive receivers identified within 5 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 11-14. Table 11-21 presents the details of the exercise at all 78 no. noise sensitive locations considered as part of this assessment.

Table 11-21 Review of Cumulative Predicted Turbine Noise Levels against Relevant Criteria

House ID	Description	dB $L_{A90,10min}$ at Various Standardised Wind Speeds (m/s)				
		4	5	6	7	≥8
R001	Dwelling	28.1	31.5	33	33.9	34.3
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R002	Dwelling	27.3	30.7	32.2	33.1	33.5
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R003	Dwelling	25.8	29	30.5	31.4	32.1
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R004	Dwelling	26.6	29.9	31.4	32.3	32.9
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R005	Dwelling	27.2	30.5	32	32.9	33.4
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R006	Dwelling	26.8	30	31.6	32.5	33.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–

House ID	Description	dB $L_{A90,10min}$ at Various Standarised Wind Speeds (m/s)				
		4	5	6	7	≥8
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R007	Dwelling	27.4	30.7	32.2	33.1	33.6
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R008	Dwelling	28.2	31.6	33.1	34	34.4
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R009	Dwelling	23.8	27.2	28.7	29.5	29.9
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R010	Dwelling	23.9	27.3	28.7	29.6	30.1
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R011	Dwelling	24.5	28	29.4	30.3	30.6
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R012	Dwelling	26.7	29.9	31.4	32.3	33.0
	Daytime Criterion	40.0	40.0	45.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R013	Dwelling	27.8	31.1	32.6	33.5	34.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R014	Dwelling	31.9	35.4	36.9	37.8	38.1
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–

House ID	Description	dB $L_{A90,10min}$ at Various Standarised Wind Speeds (m/s)				
		4	5	6	7	≥8
R015	Dwelling	32.4	35.8	37.4	38.3	38.5
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R016	Dwelling	28.7	31.9	33.5	34.4	34.9
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R017	Dwelling	30	33.3	34.9	35.8	36.2
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R018	Dwelling	31.4	34.9	36.4	37.3	37.4
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R019	Dwelling	30.2	33.5	35.1	36	36.5
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R020	Dwelling	31.6	35	36.5	37.5	37.8
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R021	Dwelling	32	35.4	37	37.9	38.3
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R022	Dwelling	32.2	35.5	37.1	38.1	38.5
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R023	Dwelling	32.5	35.9	37.5	38.4	38.8
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0

House ID	Description	dB $L_{A90,10min}$ at Various Standarised Wind Speeds (m/s)				
		4	5	6	7	≥8
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R024	Dwelling	31.5	35	36.5	37.4	37.6
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R025	Dwelling	28.4	31.2	33	34	34.9
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R026	Dwelling	28.5	31.2	33.1	34.1	35.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R027	Dwelling	29.4	32.1	34	35	35.9
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R028	Dwelling	30	33.3	34.9	35.8	36.2
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R029	Dwelling	29.8	32.9	34.6	35.6	36.2
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R030	Dwelling	30.5	33.3	35.2	36.2	37.1
	Daytime Criterion	40.0	40.0	45.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R031	Dwelling	32.3	35.1	37	38	38.8
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0

House ID	Description	dB $L_{A90,10min}$ at Various Standarised Wind Speeds (m/s)				
		4	5	6	7	≥8
	Night time Excess	–	–	–	–	–
R032	Dwelling	34.5	36.9	39.1	40.2	41.1
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R033	Derelict	33.8	35.8	38.2	39.3	40.6
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R034	Dwelling	35	36.9	39.5	40.6	41.9
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R035	Dwelling	33.5	35.4	37.9	39	40.3
	Daytime Criterion	40.0	40.0	45.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R036	Dwelling	35.1	38.2	39.9	40.9	41.4
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R037	Dwelling	36.9	39.7	41.7	42.7	43.3
	Daytime Criterion	40.0	45.0	45.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	0.3
R038	Dwelling	34.2	36.2	38.7	39.8	41.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R039	Dwelling	26	28.6	30.5	31.5	32.7
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R040	Dwelling	25.4	27.8	29.8	31	32.3

House ID	Description	dB $L_{A90,10min}$ at Various Standarised Wind Speeds (m/s)				
		4	5	6	7	≥8
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R041	Dwelling	25.6	27.9	30	31.1	32.5
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R042	Dwelling	24.6	26.2	28.7	30	32.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R043	Dwelling	24.3	26.1	28.5	29.8	31.6
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R044	Dwelling	24.3	26	28.5	29.8	31.7
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R045	Dwelling	25.6	27.3	29.7	31	32.9
	Daytime Criterion	40.0	40.0	45.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R046	Derelict	25.8	27.4	29.9	31.1	33.0
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R047	Dwelling	25.8	27.4	30	31.3	33.1
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–
	Night time Criterion	43.0	43.0	43.0	43.0	43.0
	Night time Excess	–	–	–	–	–
R048	Derelict	26.3	27.9	30.5	31.9	33.6
	Daytime Criterion	40.0	40.0	40.0	45.0	45.0
	Daytime Excess	–	–	–	–	–