8 Noise

Contents

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8 Noise and Vibration

8.1 Executive Summary

8.1.1 An assessment of noise and vibration effects arising from the construction, operation and decommissioning of the Proposed Development has been undertaken. This has involved deriving suitable noise limits in accordance with current policy and guidance and with reference to baseline noise data obtained from surveys at nearby noise-sensitive receptors. Noise levels expected to be generated by the Proposed Development have been modelled based on a candidate turbine of the scale and capacity likely to be constructed, and predicted noise levels at noise-sensitive receptors have been compared with the derived limits. Cumulative effects have also been assessed by considering noise from other operational, consented or proposed (in planning) wind energy developments in the vicinity.

8.1.2 Construction and decommissioning noise and vibration has been considered and assessed; potentially significant noise and vibration effects have been identified during the construction phase, associated with construction of the access track. Mitigation has been specified such that appropriate measures to control construction noise and vibration will be implemented, in line with good practice.

8.1.3 Significant noise effects have been identified during the operational phase when the Proposed Development is operating at the closest noise-sensitive receptors to the west and south-west, whereby predicted noise levels exceed the derived noise limits by up to 1.7 dB during the daytime period. A commitment has been made to address these exceedances through appropriate turbine selection, or an operational noise management plan, such that the residual significance of daytime operation noise effects has been reduced to “not significant”.

8.1.4 During the night-time period predicted noise levels meet the derived noise limits at all noise-sensitive receptors. Operational noise effects have therefore found to be not significant during the night-time period.

8.1.5 Few potentially cumulative developments have been identified in the study area, and the assessment addresses cumulative noise by derivation of appropriate noise limits for the Proposed Development, which take the consented noise limits of cumulative developments into account and no significant effects were identified.

8.2 Introduction

8.2.1 This chapter provides an assessment of the potential effects of the Proposed Development on receptors sensitive to noise during the construction, operational and decommissioning phases.

Scope of Assessment

8.2.2 The scope of this assessment has comprised the following:

- Consultation with North Ayrshire Council (NAC) and Inverclyde Council (IC) Environmental Health Departments, both at Scoping stage and during the assessment;
- Characterisation of baseline noise environment;
- Evaluation of noise and vibration effects associated with construction of the Proposed Development;
- Evaluation of noise effects associated with operation of the Proposed Development;
- Evaluation of potential cumulative noise effects;
- Specification of appropriate mitigation, where necessary; and
- Evaluation of residual effects.

8.2.3 Potential vibration effects associated with the operational phase are considered to be negligible and have been scoped out. Noise and vibration effects associated with decommissioning are considered to be similar to, but lesser than, those associated with construction. This assessment assumes that similar mitigation will be put in place during the decommissioning phase as that included in the construction phase, and further consideration of decommissioning effects has therefore been scoped out.

8.2.4 NAC has requested that potential effects associated with low frequency noise/infrasound generated by wind turbines are considered as part of this assessment. This requirement has been addressed by a review of existing guidance and published scientific papers on low frequency (LF) noise associated with onshore wind turbines. A brief summary of the current evidence surrounding low-frequency noise effects associated with wind turbines has been provided in Appendix 8.6.

About the author

8.2.5 This assessment has been undertaken by Simon Waddell BSc (Hons). Simon is an acoustician with 10 years' experience in environmental noise, he is a corporate member of the Institute of Acoustics (IoA) and has completed the IoA postgraduate diploma in Acoustics and Noise Control. Simon has worked on numerous wind farm noise assessments, including planning applications (EIAs) and compliance noise assessments.

Acoustics terminology and concepts

8.2.6 The following terms and concepts are used within this document:

- Noise – defined as 'unwanted sound'.
- Decibel, dB – the unit of measurement of sound, which operates on a logarithmic scale. Given the logarithmic nature of the scale, where two noise levels which differ by 10 dB or more are summed together, the resultant level is equal to the greater of the two levels, i.e. the lower level has a negligible contribution to the total. A +3 dB increase represents a doubling of sound energy, however, in 'normal' (i.e. not laboratory) conditions, a +3 dB increase is the smallest change commonly perceptible to most people, and a +10 dB increase may be perceived as a 'doubling' in loudness.
- A-weighting – an electronic filter applied by sound level meters to approximate the response of the human ear's frequency response to measured noise levels. Environmental noise guidance used in the UK, including that dealing with wind farm noise, typically uses the A-weighting filter.
- Ambient noise level, $dBL_{Aeq,10min}$ – the equivalent continuous sound pressure level is the constant noise level that would result in the same total sound/noise energy being produced over a given period (period is 10 minutes in wind farm noise assessments) as that measured from a variable source/sources. Measured in A-weighted dB and commonly referred to as the "ambient level".
- Background noise level, $dBL_{A90,10min}$ – the A-weighted noise level, measured in dB, that is exceeded 90 percent of the time over a given period (period is 10 minutes in wind farm noise assessments), and therefore excludes the contribution of short-duration, loud events.
- Peak Particle Velocity, PPV – movement of the ground described with reference to particles measured in millimetres per second (mm/s).

8.3 Legislation, Policy and Guidelines

Legislation

8.3.1 Noise related legislation tends to be either EU-derived and focussed on specific items of noise-emitting plant, or relates more to general nuisance, such as that addressed by the provisions of the Environmental Protection Act 1990.

8.3.2 In lieu of any specific legislation, assessing the effect of such a development during the construction, operational and decommissioning phases must draw on information from a variety of sources. This assessment therefore makes reference to a number of British Standards, official planning advice notes and national guidance.

National Planning Policy and Guidance

Planning Advice Note PAN1/2011: Planning and Noise

8.3.3 Published in March 2011, this document provides advice on the role of the planning system in helping to prevent and limit adverse effects of noise (Scottish Government, 2011a). Information and advice on noise assessment methods are provided in the accompanying *Technical Advice Note (TAN): Assessment of Noise*. Included within the PAN document and the accompanying TAN are details of the legislation, technical standards and codes of practice for specific noise issues.

8.3.4 With regard to noise from wind turbines, paragraph 29 of PAN 1/2011 states the following:

"There are two sources of noise from wind turbines – the mechanical noise from the turbines and the aerodynamic noise from the blades. Mechanical noise is related to engineering design. Aerodynamic noise varies with rotor design and wind speed, and is generally greatest at low speeds. Good acoustical design and siting of turbines is essential to minimise the potential to generate noise. Web based planning advice on renewable technologies for onshore wind turbines provides advice on 'The Assessment and Rating of Noise from Wind Farms' (ETSU-R-97) published by the former Department of Trade and Industry (DTI) and the findings of the Salford University report into Aerodynamic Modulation of Wind Turbine Noise."

8.3.5 With regard to appropriate assessment methods, the 'web-based planning advice' referred to in PAN 1/2011 is contained in an online document entitled 'Onshore wind turbines', published by the Scottish Government (updated December 2013). The document is summarised in the corresponding section, and also refers to the use of ETSU-R-97 assessment guidance (discussed in paragraphs 8.3.12 to 8.3.24).

8.3.6 The accompanying TAN to PAN 1/2011 also refers to ETSU-R-97, including a summary of the associated assessment approach (Scottish Government, 2011b). The TAN points out that the ETSU-R-97 report presents a consensus view of a group of experts, who between them have a breadth and depth of experience in assessing and controlling the environmental impact of noise from wind farms.

8.3.7 With regards to the assessment and control of noise and vibration from construction sites, the use of BS 5228: 2009 (Parts 1 and 2) is discussed. These parts of BS 5228 have been superseded by BS 5228 1:2009+A1:2014: *Code of practice for noise and vibration control on construction and open sites. These* standards are summarised in paragraphs 8.3.46 to 8.3.56.

8.3.8 Of relevance to the assessment of development-generated road traffic noise, it is stated that a change of 3 dB(A) is the minimum perceptible increment under normal conditions, and that a change of 10 dB(A) corresponds roughly to a halving or doubling of the perceived loudness of a sound.

8.3.9 Neither PAN 1/2011 nor the associated TAN provide specific guidance on the assessment of noise from fixed plant, but the TAN includes an example assessment scenario for *'New noisy development (incl. commercial and recreation) affecting a noise sensitive building'*, which is based on BS4142:1997: *Method for rating industrial noise affecting mixed residential and industrial areas.*

This British Standard has been superseded by BS4142:2014: Methods for rating and assessing industrial and commercial sound.

8.3.10 In summary, national planning policy on assessment of operational noise impacts from wind farms stipulates the use of the ETSU-R-97 assessment method and application of the Institute of Acoustics (IoA) Good Practice Guide (GPG), whilst construction noise and vibration should be assessed with reference to BS 5228. These guidance documents, and others relevant to the assessment of possible noise and vibration impacts generated by the Proposed Development, are summarised below.

Local Planning Policy

8.3.11 Local planning policy is discussed in Chapter 16 of this EIAR.

Guidance

ETSU-R-97: The Assessment and Rating of Noise from Windfarms (ETSU)

8.3.12 As referenced for use in PAN/2011 and the online planning advice for "Onshore wind turbines", this document was written by a Noise Working Group including developers, noise consultants and environmental health officers, set up in 1995 by the Department of Trade and Industry through ETSU (the Energy Technology Support Unit).

8.3.13 ETSU presents a consensus view of the working group and was prepared to present a common approach to the assessment of noise from wind turbines. The document states that noise from wind turbines or wind farms should be assessed against site specific noise limits.

8.3.14 Noise limits are derived based on a series of acceptable lower limits and based on an allowable exceedance above the prevailing background noise level, including consideration to a variety of different prevailing wind speed conditions. The noise limits should be derived for external areas used for relaxation, or areas where a quiet noise environment is highly desirable. Separate limits are required for night-time and daytime periods. Night-time limits are derived drawing upon measured night-time background noise levels, whilst daytime limits are derived drawing upon the background noise levels arising during 'quiet daytime' periods.

8.3.15 Night-time is defined as the period between 23:00 and 07:00 hours, whilst quiet daytime periods are defined as 18:00 to 23:00 hours on all days, as well as 13:00 to 18:00 hours on Saturdays and Sundays, and 07:00 to 13:00 hours on Sundays.

8.3.16 For daytime, the suggested limits are 5 dB above the prevailing background noise level determined during quiet daytime periods, or 35 to 40 dB(A), whichever is the higher. The absolute criterion between the 35 to 40 dB(A) range is selected taking account of the site environs (e.g. number of local receptors), the energy generation capacity (e.g. number of kWh that can be generated) of a proposed development, and the associated duration and level of exposure.

8.3.17 During night-time, the suggested limits are 5 dB above the prevailing night-time background noise level or 43 dB(A), whichever is the higher. The absolute criterion for the night-time is higher than that for the daytime, as the derivation of this limit is based on preventing sleep disturbance within a building whereas for the daytime, limits are based on occupation of external spaces used for relaxation.

8.3.18 It is required that the prevailing background noise levels be determined in terms of the $L_{A90,10min}$ noise index for both quiet daytime and night-time periods, for wind conditions ranging from 2 ms^{-1} to 12 ms^{-1}.

8.3.19 The noise limits are calculated by undertaking a regression analysis of the $L_{A90,10min}$ noise levels and the prevailing average wind speed for the same 10-minute period, when measured or determined at 10m above ground at the location of the proposed turbines. The allowable limit is then defined at +5 dB above the average noise level at each wind speed (as defined by the regression analysis), or the absolute noise level lower limit, whichever is the higher (assuming no financial involvement within the scheme).

8.3.20 Where a property has a financial involvement in the scheme, the document allows a relaxation of the derived noise limits, stating that *'It is widely accepted that the level of disturbance or annoyance caused by a noise source is not only dependent upon the level and character of noise but also the receiver's attitude towards the noise source in general. If the residents at the noise-sensitive properties were financially involved in the project, then higher noise limits will be appropriate'. The guidance goes on to state that it is 'recommended that both the day and night-time lower fixed limits can be increased to 45 dB(A) and the consideration should be given to increasing the permissible margin above background where the occupier of the property has some financial involvement in the windfarm'.* The amount by which the permissible margin above background can be relaxed is not specified, but the allowable relaxation to 45 dB(A) of the lower limits is an increase of (at least) 5 dB during the daytime and 2 dB during the night-time, so similar levels of relaxation might also be applied to background related element of the noise level limits.

8.3.21 The ETSU guidance states that the derived limits should be applied to noise from the proposed wind farm or turbines in terms of the $L_{A90,T}$ index, and that the $L_{A90,T}$ of the wind farm noise is typically 1.5 to 2.5 dB less than the $L_{Aeq,T}$ measured over the same period.

8.3.22 The derived noise limits are applicable to both the aerodynamic (e.g. 'blade swish') and mechanical (e.g. generator related) components of wind farm noise.

8.3.23 Where noise from the wind farm is tonal, a correction of between 2 and 5 dB is to be applied to the wind farm noise. Guidance is provided on how to determine the level of correction required, but typically, for proposed developments, the need for any applicable correction is confirmed by the turbine manufacturers.

8.3.24 It is stated within this document that *'The Noise Working Group is of the opinion that 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. It is clearly unreasonable to suggest that, because a windfarm was constructed in the vicinity in the past which resulted in increased noise levels at some properties, that residents of those properties are now able to tolerate still higher noise levels. The existing windfarm should not be considered as part of the prevailing background noise'.* Accordingly, where an existing wind farm contributes to the prevailing background noise levels, it is necessary to either include for the contribution of this wind farm when comparing against the allowable noise limit or correct for this contribution when deriving a limit applicable to a proposed development acting alone.

Good Practice Guide to the Application of ETSU-R-97

8.3.25 The Institute of Acoustics' Good Practice Guide (IoA GPG) presents the report of a 'noise working group' (NWG) assembled in response to a request from the former Department of Energy & Climate Change (DECC). The guide is intended to represent current good practice in applying the ETSU method to assessing the noise impact of wind turbine developments with a power rating of over 50kW.

8.3.26 In addition to detailed consideration of various issues and factors concerned with current 'state of the art' knowledge of UK wind turbine noise assessment, a series of 'summary boxes' (SBs) highlighting key guidance points are included.

8.3.27 The SBs provide clarification and updated guidance on a range of matters relating to ETSU noise assessments, including consultation with relevant stakeholders, background noise survey methodology, noise survey data analysis, derivation of noise limits, noise prediction model input data, algorithms and parameters, cumulative impact assessment procedures, assessment reporting, planning conditions and amplitude modulation. A set of supplementary guidance notes (SGNs) also form part of the publication and include further specific detail for different technical areas.

8.3.28 The detail of the IoA GPG has been considered in the preparation of this assessment. Some of the key considerations relevant to this assessment are summarised as follows:

- Background noise surveys should be carried out for sufficient duration to obtain a suitably-sized dataset; as a guideline, it is suggested that no fewer than 200 data points be obtained within each of the night-time and amenity hour periods for a given survey location, with no fewer than

five data points within each contiguous wind speed integer interval. Where the data have been filtered by wind direction the guideline values are reduced.

- Background noise survey data should be analysed and anomalous periods of noise removed from the dataset; anomalous noise might include rain-affected periods and increased noise from water courses following rainfall, seasonal effects such as early-morning birdsong ('dawn chorus'), atypical traffic movements and other unusual noise sources affecting measured levels.
- Due to the potential for non-standard site-specific wind shear (i.e. differences in wind speed at different heights above the ground – a 'standard' profile increases logarithmically with height) background noise levels should be correlated with 10m height wind speeds derived using a method that 'standardises' the wind speeds using the assumed shear profile. Since wind turbine sound power levels are determined using the same shear profile, this procedure ensures a link between the predicted sound levels at a given hub height wind speed and the background noise levels at receptors near the ground under the same wind speed conditions (obtained using the 'standardised' 10 m height wind speed).
- Derivation of the prevailing background noise levels should be carried out using polynomial regression analysis, of order one to four, depending on the nature of the noise environment. The regression curve used should reach minimum and maximum values at the lowest and highest wind speeds for which the dataset is valid, respectively.
- Calculations of predicted wind turbine noise may be carried out using ISO 9613-2: Acoustics – Attenuation of Sound during Propagation Outdoors (International Organization for Standardization, 1996); preferred receptor heights, meteorological and ground absorption input parameters for this calculation procedure are given.
- Turbine sound power level source data should include appropriate uncertainty corrections. Guidance is given for determining when such uncertainty corrections have been inherently included in turbine source emission data.
- A correction for topographic screening of a maximum -2 dB may be applied where there is no line of sight between the turbine (tip) and the receptor (4 m above ground level).
- A correction for constructive reflection within valleys of +3 dB should apply where concave topography is determined to lie between the turbine and the receptor point.

8.3.29 In addition to the above, the IoA GPG confirms that the ETSU-R-97 noise level limits should be applied cumulatively, and provides guidance on appropriate assessment methods for a variety of different cumulative scenarios. These scenarios include *'concurrent applications', 'existing wind farm consented with less than total ETSU-R-97 limits', 'existing wind farm/s consented to the total ETSU-R-97 limits currently operating', and 'permitted wind farms consented to total ETSU-R-97 limits but not yet constructed'.*

8.3.30 In the section entitled 'Existing windfarm/s, consented to the total ETSU limits, currently operating' it is stated that *"In the first instance, the consented noise limits should be used within the cumulative noise impact calculations unless otherwise agreed with the local authority. Provided the sum of the noise limits derived for the proposed site when added to those already consented for the operational sites does not exceed the limits that would otherwise be within the requirements of ETSU-R-97 for the cumulative impact, then the noise limits derived for the proposed site can be applied directly".*

8.3.31 In practical terms this can be achieved by ensuring that the noise limit for the Proposed Development is set 10 dB or more below that permitted to be generated by the existing development.

8.3.32 It is subsequently discussed that this may not always be necessary, e.g. where there is a 'controlling' property', whereby compliance with the noise limit at that controlling property would result in noise levels never realising the noise level limit 'in full' at another property (e.g. because the second

property is further removed from the existing development), thereby leaving a proportion of the limits available for use at the second property by the subsequently proposed development. Another reason that is discussed is where there is no realistic prospect of the existing wind farm producing noise levels up to the consented limit, again thereby leaving a proportion of the limit available for the subsequently proposed development.

8.3.33 In the section entitled 'concurrent applications' it is stated that where there are no pre-existing wind farms, this scenario permits the apportionment of the ETSU limits between the concurrent developments, i.e. each of the developments could be subject to noise limits below the full ETSU guidance, such that even if the individual limits applied to each development were utilised 'in full', the combined effect would be that the ETSU guidance would not be exceeded cumulatively.

BS4142:2014+A1:2019 – Methods for rating and assessing industrial and commercial sound

8.3.34 BS4142 is applicable for use in the assessment of control building / substation and transformer noise. It sets out a method for rating and assessing sound of an industrial and/or commercial nature, including *"sound from fixed installations which comprise mechanical and electrical plant and equipment".*

8.3.35 The assessment procedure contained within BS4142 requires that initially the 'rating level' ($L_{Ar,Tr}$) that is (or would be) generated by the source under assessment is determined, externally, at the assessment location. Where this source does not include any acoustic features, such as tonality, impulsivity or intermittency etc., then the rating level ($L_{Ar,Tr}$) equals the specific sound level (Ls), which is the sound pressure level produced by the source using the $L_{Aeq,T}$ noise index. Where the source under assessment does include acoustic characteristics, then a series of corrections are added to the specific sound level to determine the rating level. The degree of correction applied to determine the rating level depends upon the results of either subjective or objective appraisals.

8.3.36 The background sound level at the assessment location, measured using the $L_{A90,T}$ index, is then subtracted from the rating level. The result provides an indication of the magnitude of impact, where the greater the difference, the greater the magnitude of impact.

8.3.37 The following advice for determining level of impact is presented:

- A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.
- A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context.
- The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact.
- Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.

8.3.38 It can be seen from the above that the degree of impact is also dependent upon the context in which the sound arises. Factors that are considered with respect to context include: the absolute level of sound, and the character and level of the residual sound (that in absence of the source under assessment) compared to the character and level of the specific sound.

8.3.39 With regard to the absolute level, it is stated, amongst other points, that *"where background sound levels and rating levels are low, absolute levels might be as, or more relevant than the margin by which the rating level exceeds the background. This is especially true at night".*

8.3.40 The 1997 version of BS4142 stated that rating levels below 35 dB and background noise levels below 30 dB(A) were considered to be *"very low"*.

BS5228:2009+A1:2014 – Code of practice for noise and vibration control on construction and open sites – Part 1 (noise) and Part 2 (vibration)

Noise

8.3.41 Part 1 of the standard sets out techniques to predict the likely noise effects from construction works, based on detailed information on the type and number of plant items being used, their location and the length of time they are in operation.

8.3.42 The noise prediction methods can be used to establish likely noise levels in terms of the $L_{Aeq,T}$ over the core working day. This standard also documents a database of information, including previously measured sound pressure level data for a variety of different construction plant undertaking various common activities.

8.3.43 Three example methods are presented for determining the significance of construction noise impacts. In summary, these methods adopt either a series of fixed noise level limits, are concerned with ambient noise level changes as a result of the construction operations or a combination of the two.

8.3.44 With respect to absolute fixed noise limits, those detailed within Advisory Leaflet 72: 1976*: Noise control on building sites* are presented. These limits are presented according to the nature of the surrounding environment, for a 12-hour working day. The presented limits are:

- 70 dB(A) in rural, suburban and urban areas away from main road traffic and industrial noise; and
- 75 dB(A) in urban areas near main roads and heavy industrial areas.

8.3.45 The above noise level limits are applicable at the façade of the receptor in question (not free-field).

8.3.46 The standard goes on to provide methods for determining the significance of construction noise levels by considering the change in the ambient noise level that would arise as a result of the construction operations. An example assessment method is presented; the 'ABC method' as summarised within Table 8.1.

Table 8.1 - Example threshold of potential significant effect at dwellings (construction noise) – ABC method

Assessment Category and Threshold Value Period	Threshold Value, in Decibels (dB) ($L_{Aeq,T}$)		
	Category (A)	Category (B)	Category (C)
Night-time (23:00 – 07:00)	45	50	55
Evenings and weekends (D)	55	60	65
Daytime (07:00 – 19:00) and Saturdays (07:00 – 13:00)	65	70	75
Notes			
NOTE 1: A potential significant effect is indicated if the $L_{Aeq,T}$ noise level arising from the site exceeds the threshold level for the category appropriate to the ambient noise level. *NOTE 2: If the ambient noise level exceeds the Category C threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a potential significant effect is indicated if the total $L_{Aeq,T}$ noise level for the period increases by more than 3 dB due to site noise.* *NOTE 3: Applied to residential receptors only*			

Notes
A) Category A: threshold values to use when ambient levels (when rounded to the nearest 5 dB) are less than these values. *B) Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as Category A values.* *C) Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than Category A values.* *D) 19.00-23.00 weekdays, 13.00-23.00 Saturdays and 07.00-23.00 Sundays*

Vibration

8.3.47 Part 2 of the standard provides basic recommendations for the control of vibration effects associated with construction and open sites. The legislative background to vibration control is described and guidance is provided concerning methods of measuring vibration and assessing its significance.

8.3.48 Guidance criteria are provided for the evaluation of the significance of vibration effects. The criteria are provided in terms of Peak Particle Velocities (PPV) in millimetres per second (mm/s), and are concerned with both human and structural responses to vibration. Those applicable to human perception and disturbance are presented in Table 8.2.

Table 8.2 – Guidance criteria for the assessment of significance of vibration for human perception and disturbance

Vibration level PPV, mm/s	*Effect*
0.14	*Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies people are less sensitive to vibration.*
0.3	*Vibration might be just perceptible in residential environments*
1.0	*It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been provided to residents.*
10.0	*Vibration is likely to be intolerable for any more than a very brief exposure to this level*

8.3.49 The standard further provides criteria applicable to the vibration response limits of buildings in terms of the component PPV; these are provided in Table 8.3.

Table 8.3 – Guidance criteria for the assessment of significance of vibration for human perception and disturbance

Type of building	*Peak component particle velocity in frequency range of predominant pulse*	
	4 Hz – 15 Hz	*15 Hz and above*
Reinforced or framed structures *Industrial and heavy commercial buildings*	*50 mm/s at 4 Hz and above*	*50 mm/s at 4Hz and above*

Type of building	*Peak component particle velocity in frequency range of predominant pulse*	
	4 Hz – 15 Hz	*15 Hz and above*
Unreinforced or light-framed structures Residential or light commercial buildings	*15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz*	*20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above*
Note 1 – Values referred to are at the base of the building *Note 2 – At frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) is not to be exceeded*		

8.3.50 It should be noted that the values provided in Table 8.3 are applicable to cosmetic damage only. It is stated within BS5228-2 that minor structural damage is possible at vibration magnitudes which are greater than those given in Table 8.3.

Design Manual for Roads and Bridges (DMRB)

8.3.51 DMRB Section LA111 Noise and Vibration sets out the requirements for assessing and reporting the effects of highways noise and vibration from construction, operation and maintenance projects. The document is 'live' and is frequently updated[1].

8.3.52 The DMRB guidance regarding construction noise and vibration reflects that provided in BS5228, with significance determined similarly. Additional information is drawn from a study undertaken by the Transport Research Laboratory (TRL) "*TRL Report 429*"[2]. With regard to vibration the DMRB notes that a study area of 100 m from the closest construction activity with the potential to generate vibration is normally sufficient to encompass vibration sensitive receptors, and for construction vibration the baseline should be assumed to be zero. For construction noise, DMRB advises that a study area of 300 m is normally sufficient.

8.3.53 For operational road traffic noise, DMRB advises that the Lowest Observable Adverse Effect Level (LOAEL) is 55 $dBL_{A10,18hr}$ (façade) during the daytime period (06:00 - 24:00), and 40 $dBL_{night,outside}$ (free-field) during the night-time period (00:00 – 06:00).

Infrasound

8.3.54 Refer to Appendix 8.6 for further information on infrasound and low frequency noise.

8.4 Consultation

8.4.1 Details of consultation undertaken with relevant regulatory bodies, together with action undertaken by the Applicant in response to consultation feedback are provided in Table 8.4. Copies of relevant consultation correspondence are included in Appendix 8.1.

[1] *At the time of reporting, the latest revision was dated November 2019*

[2] *TRL report 429. Groundborne vibration caused by mechanised construction works. TRL, 2000.*

Table 8.4 – Consultation undertaken

Consultation by Applicant	Consultation response / Applicant Action
Email 22/08/2019 North Ayrshire Council (NAC) email setting out preferred methodology and baseline survey monitoring locations (22nd August 2019)	*Email 06/09/2019* NAC Environmental Health had no objections to the monitoring locations after further email conversations and phone calls regarding micro-siting. It was requested that consultation with IC was also undertaken. *Applicant action* Noise survey undertaken at appropriate locations. Consultation was undertaken with Inverclyde Council (IC).
Emails & phone conversations 11 - 12/09/2019 Consultation on baseline survey approach with IC	ITPE agreed with IC that no additional monitoring was required, given that existing monitoring locations suitably representative of properties within their administrative area.
Emails 16/09/2019 Details of installed monitoring locations and description of noise environment provided to NAC and IC for comment	No comment provided in response
Email 23/10/2019 Email to NAC and IC seeking to agree use of measured baseline noise levels and the Noise Sensitive Receptor (NSR) locations that could be used as proxies. Also seeking to agree the fixed minimum (daytime) noise limit to be applied (35 dBL_{A90} or 40 dBL_{A90}).	*Phone call 28/10/2019 with NAC EHO Paul Brennan* NAC Environmental Health accepted the proposed proxy locations for the NSRs and specified 35 dBL_{A90} as the fixed minimum daytime limit for the Proposed Development. *Applicant action* NSRs confirmed and used in evaluation against 35 dBL_{A90} fixed minimum daytime limit as specified by NAC.
Email 18/12/2019 NAC Senior Development Management Officer noted that that Council has received concerns regarding the impact of infrasound and amplitude modulation (AM) from wind turbines, advising that these concerns should be addressed.	No comment provided in response *Applicant action* Refer to Appendix 8.6

8.4.2 It is noted that, while NAC has specifically requested that AM and LF noise should be addressed, this assessment has been undertaken in accordance with current guidance and legislation. No prediction or assessment has been undertaken with regard to AM or LF noise, as there are no agreed methods

by which this may be undertaken, nor guidance of how AM may be predicted. Details of the current scientific consensus on infrasound and LF noise are provided in Appendix 8.6.

8.5 Assessment Methodology and Significance Criteria

Study Area and Noise Sensitive Receptors (NSRs)

8.5.1 The study area for this assessment has been informed by maps and aerial images of the Proposed Development site and its surroundings, as well as site visits undertaken during the baseline noise survey. A sample of the closest and therefore potentially worst-affected NSRs to the Proposed Development have been identified and adopted for the evaluation of noise impacts. These have been selected to represent a geographic spread across the local area, including those located between the Proposed Development and the cumulative developments considered. NSRs identified are either single dwellings or representative of a group or cluster of dwellings.

8.5.2 Determination of the study area for a wind farm typically requires that the 35 dBL_{A90} noise contour is predicted; NSRs which lie beyond the contour are assumed to meet the most stringent ETSU noise limit, and are therefore scoped out and discounted from further consideration. NSRs which are identified within the 35 dBL_{A90} noise contour are scoped in, and noise impacts are assessed further. Where cumulative developments are identified, a more detailed evaluation may be required.

8.5.3 No significant potentially-cumulative wind farm developments have been identified within approximately 10 km of the Proposed Development, however, a development of two 100 kW turbines has been identified to the north, within IC region[3]. The cumulative turbines are shown in Figure 8.1 and the method by which cumulative effects have been addressed is discussed further in para. 8.5.31 - 8.5.36.

8.5.4 The 35 dBL_{A90} operational noise contour for the Proposed Development in isolation (i.e. without cumulative developments) at the wind speed at which the proposed turbines generate their maximum sound power level, is shown in Figure 8.1. This predicted contour does not include any corrections for concave topography or for the visibility of the turbines from receptor locations, and is intended only as a screening tool for the purposes of identifying an appropriate study area.

8.5.5 Figure 8.1 shows all of the identified properties within and slightly beyond the 35 dB noise contour. The representative NSRs considered in the assessment are listed in Table 8.5. NSRs marked with an asterisk lie within the predicted 35 dBL_{A90} contour.

Table 8.5 – Identified representative NSRs in the study area

NSR name	NSR ID	Grid reference (OS GB)	
		Easting	Northing
East Grassyards	NSR1*	222358	664796
Tourgill	NSR2	222675	664252
Dykes	NSR3*	220592	665036
Property on Barr Farm Road (1)	NSR4*	220330	665292
Property on Barr Farm Road (2)	NSR5*	219989	665380
Property on Barr Farm Road (3)	NSR6	220157	665283
Barr Farm (FI)	NSR7*	220558	665601

[3] *Planning reference no. 15/0109/IC*

NSR name	NSR ID	Grid reference (OS GB)	
		Easting	Northing
Barr Farm Caravan Park	NSR8*	220260	665648
Skelmorlie Mains (FI)	NSR9	219842	666317
Skelmorlie Mains Caravan Park	NSR10	220260	665647
Properties on Caskie Drive	NSR11	219887	667266
Properties on Golf Course Road	NSR12	219820	667702
Kelly Bank Cottage	NSR13	220734	668398
Outerwards	NSR14	223467	666166

Note – FI denotes financial involvement with the Proposed Development

8.5.6 The identified NSRs are predominantly to the north, south and west of the Proposed Development. The areas to the east of the Proposed Development are sparsely developed. Not all of the representative NSRs considered lie within the predicted 35 dBL_{A90} noise contour, however, receptors beyond the contour have been considered, such that the potential for concave ground corrections and cumulative effects can be considered in the assessment.

Baseline Noise Survey

8.1.1 Baseline noise monitoring was agreed with NAC's EHO and undertaken in accordance with the requirements of ETSU-R-97, with simultaneous wind speed and rainfall measurements. The baseline survey was completed within the period 13th September to 5th October 2019. The Noise Monitoring Positions (NMPs) at which baseline measurements were completed are provided in Table 8.6 and shown on Figure 8.1.

Table 8.6 – Baseline noise measurement positions

Monitoring position	Noise environment considered representative of NSRs	Grid reference (OS GB)	
		Easting	Northing
NMP1 – Fardens	N/A	221154	666486
NMP2 – Golf Course Road	NSR10, NSR11, NSR12	219820	667702
NMP3 – Barr Farm	NSR3, NSR4, NSR5, NSR6, NSR7, NSR8, NSR9, NSR13	220558	665601
NMP4 – Outerwards	NSR1, NSR2, NSR14	223467	666166

8.5.7 Monitoring was undertaken at NMP1 Fardens, since the property was occupied at the time of the baseline survey. The Applicant has confirmed, however, that this property will be taken out of residential use prior to construction of the Proposed Development. The property has therefore not been assessed as a potential NSR in this assessment, however, the measured levels are reported here to provide further information on the baseline noise environment, and in particular to enable comparison with measured levels at NMP4, which lies within a similar noise environment.

8.5.8 The Sound Level Meters (SLMs) used were compliant with Class 1 specification, as described in BS EN 6172-1:2003 after each measurement and no significant drift in calibration was noted. The SLMs and the calibrator used were within their accredited laboratory calibration period of two years and one year, respectively. Calibration certificates are provided in Appendix 8.2.

8.5.9 The SLMs were installed at the monitoring positions each with a microphone at a height of approximately 1.5 m above ground in a free-field location, i.e. at least 3.5 m from any vertical sound reflective surfaces. The microphones were fitted with double-skin outdoor wind shields with a minimum 200 mm diameter.

8.5.10 The monitoring locations are described as follows:

- **NMP1 Fardens –** SLM installed within garden of dwelling, on the western side of the house. The SLM was sited more than 3.5 m from the western façade of the house, and as distant from trees and bushes as could be achieved. A rain gauge was installed adjacent to the SLM.
- **NMP2 Golf Course Road** – SLM installed within front garden to the east of the dwelling. The SLM was sited more than 3.5 metres from the eastern façade of the house, and as far away as possible from the back garden where there were occasionally power tools in operation.
- **NMP3 Barr Farm** – SLM installed within front garden of dwelling. The SLM was sited more than 3.5m from the southern façade of the house. An air-source heat pump was noted on the northern elevation of the dwelling, the NMP was therefore positioned such that the wall of the dwelling screened noise from the heat pump.
- **NMP4 Outerwards –** SLM installed on land to the east of the property, which appeared to be uninhabited during the survey. The SLM was sited more than 3.5m away from any reflecting facades and as distant from trees and bushes as could be achieved.

8.5.11 Full details of the monitoring locations and photographs of the equipment in-situ are provided in Appendix 8.3.

Construction Phase

Construction Traffic

8.5.12 The baseline traffic flow on the site access route, Craigmarloch Road, is 50 vehicles per day (refer to Chapter 11). This is considered to be a very low traffic flow, which is below the level at which noise due to road traffic can be accurately predicted.

8.5.13 Projected construction traffic flows will not exceed 34 vehicle movements per day, including both light vehicles and heavy goods vehicles (HGVs). While this represents a substantial increase over the baseline flow in percentage terms, the resultant absolute flow is still 'very low' and noise levels due to road traffic will therefore not change significantly. Noise levels due to baseline road traffic flows plus projected construction traffic flows will be substantially below 55 $dBL_{A10,18hr}$ (façade) and therefore are below the Lowest Observable Adverse Effect Level (LOAEL) as described in DMRB. Noise effects due to construction traffic have therefore been scoped out of further assessment.

On-site Construction Activities; Method of Prediction

8.5.14 A breakdown of the construction schedule and plant for the Proposed Development will be produced prior to construction, however, at present no detail on the numbers of plant is available. Drawing on our experience of previous wind farm development, the following assumptions have been made in the prediction of construction noise:

<u>Working hours</u>

- 08.00 – 18.00 Monday – Fridays;
- 08.00 – 12.30 Saturdays; and
- No working Sundays and bank holidays.

Construction plant:

Access tracks and turbine hardstandings

- 4 x road wagons (BS 5228 Table C11, Item 4) – line source along access track, 4 movements per hour;
- 2 x 35T excavator (BS 5228 Table C6, Item 7) – point sources, placed adjacent to nearest NSRs;
- 2 x 6T dump trucks (BS 5228 Table C4, Item 3) – line source along access track, 2 movements per hour;
- 1 x 12T bulldozer (BS 5228 Table C2, Item 13) – line source along access track, 1 movement per hour; and
- 1 x 12T roller (BS 5228 Table C2, Item 38) – line source along access track, 1 movement per hour

Turbine bases

- 2 x 35T excavators (BS 5228 Table C6, Item 7) – point source, placed at turbine bases closest to NSRs;
- 2 x concrete pumps (BS 5228 Table C3 Item 26) – point source, placed at turbine bases closest to NSRs; and
- 2 x cement trucks (BS 5228 Table C4, Item 27) – point sources, placed at turbine bases closest to NSRs

Turbine installation

- 1 x 400T crane (BS 5228 Table C4, Item 38) – point source, placed at turbine bases closest to NSRs; and
- 1 x road wagon (BS 5228 Table C11, Item 4) – point source, placed at turbine bases closest to NSRs

Other assumptions

- all plant has been assumed to operate continuously (100 % utilisation) throughout the working hours;
- all plant has been placed at the closest approach of construction works to the closest NSRs, noise levels at more distant NSRs will be lower, and demonstration of compliance with derived noise limits at more distant NSRs;
- noise levels have been predicted in accordance with the BS5228 prediction method;
- the effect of local topography has been included within predictions; and
- each item of construction plant has been assumed to have an effective height of 2 m above local ground level

Derivation of Construction Phase Noise Limits

8.5.15 The predicted site preparation / construction noise levels have been assessed based on noise level criteria determined based on guidance contained within BS5228. As detailed within Section 8.3, BS5228 provides three example methods for determining the significance of potential construction noise impacts. This assessment adopts the 'ABC method', in which the most stringent assessment criterion (Category A), applies during the weekday daytime period (including Saturday mornings) where the prevailing ambient noise levels are below 65 $dBL_{Aeq,T}$. Where Category A applies, the allowable noise levels arising from construction is 65 dB(A).

8.5.16 Criteria have been derived with reference to measured baseline noise levels, and are provided in para. 8.5.15.

Vibration – evaluation

8.5.17 There is no method provided in BS5228 for prediction of vibration from construction activities other than percussive piling. No piling is proposed as part of the construction phase, therefore no vibration predictions have been undertaken. This assessment relies instead on a semi-qualitative approach to screen out NSRs at which vibration effects are highly unlikely.

8.5.18 The assumed activities associated with the construction of Proposed Development infrastructure have been reviewed and, based on our experience of construction vibration measurement, the following approach to defining a study area and screening criteria have been used to identify potential vibration impacts:

- As noted in DMRB, a study area of 100 m from the closest construction activity is normally sufficient to encompass vibration sensitive receptors;
- All construction activities which occur at a distance greater than 100 m from NSRs can be assumed to result in vibration levels lower than 0.3 mm/s PPV (the Lowest Observable Adverse Effect Level, as defined in DMRB), and excluded from further consideration;
- In the absence of predicted vibration levels, and with reference to the TRL report, worst-case construction vibration is assumed to arise from use of twin-drum vibrating rollers; these are the most significant potential sources of vibration identified in the assumed list of construction plant;
- TRL Report 429 (Figure 18) indicates that at a distance of >50 m from an operational vibrating roller, the vibration level will be below 0.3 mm/s PPV, and at a distance of <10 m the vibration level will exceed 1.0 mm/s PPV;
- Construction activities occurring at a distance of <10 m from NSRs have been assumed to result in vibration levels >1.0 mm/s PPV;
- Construction activities occurring at a distance of >10 m from NSRs have been assumed to result in vibration levels <1.0 mm/s PPV; and
- Construction activities occurring at a distance of >50 m from NSRs have been assumed to result in vibration levels <0.3 mm/s PPV.

8.5.19 These assumptions are considered to be robust, and represent worst-case levels which would only occur for short durations. Actual vibration levels are likely to be lower.

8.5.20 A borrow pit is proposed for the extraction of material for project infrastructure. The location of the proposed borrow pit is approximately 1 km from the nearest NSRs and substantially beyond the distance at which potential vibration effects may occur. Vibration associated with borrow pit extraction has been scoped out of further evaluation.

Operational Phase Noise

General Method of Prediction

8.5.21 A detailed noise model has been prepared for the study area, including the identified representative NSRs. Predictions were undertaken using CadnaA® software. The model was set to use the ISO 9613 prediction method, which includes prescribed methods for accounting for the effects of geometric divergence, ground absorption, and atmospheric absorption, in accordance with the requirements of ETSU and the IOA GPG.

8.5.22 Whilst the IOA GPG presents methods for the determination of additional corrections to account for propagation directivity, which could be used for example to account for the effects of wind direction where a receptor is located between two developments, such corrections have not been

included within this assessment. The predicted operational noise levels can therefore be considered worst-case in this regard.

8.5.23 The noise model was configured to ensure noise level predictions in compliance with the IOA GPG, including the following:

- ground absorption: G=0.5;
- receptor height: 4 m;
- A correction from $L_{Aeq,T}$ to $L_{A90,T}$ of -2 dB was applied;
- Temperature: 10°C; and
- Humidity: 70%.

8.5.24 The requirement to apply valley corrections and topographic screening (line of sight) corrections was determined with reference to the IoA GPG. Valley corrections have been determined on a turbine-by-turbine basis for all identified NSRs using proprietary software within Geographic Information System (GIS) software. Where topographic screening has been determined to be applicable, no valley correction has been applied, since it is assumed that if the turbine is not visible at the NSRs, then any concavity determined to lie between the turbine and the NSR will not result in constructive acoustic reflections. The applicability of valley and topographic screening corrections at NSRs within the study area is detailed for each turbine in Appendix 8.4.

Proposed Development

Candidate Turbine

8.5.25 This assessment has been undertaken for the Vestas V117, which has a 4.2 MW rated power output and a hub height of 91.4 metres, as a representative candidate turbine model for the Proposed Development. The actual turbine model built may be different from the candidate turbine, however should this be the case further assessment will be undertaken to confirm that the chosen turbine model meets the consented noise limits for the development. The source noise terms of the candidate turbine model have been provided by Vestas, both as 1/3 octave band data, and as broad-band levels, quoted as sound power levels over a range of operational hub-height wind speeds.

8.5.26 The broad-band sound power levels have been standardised to 10 m height wind speeds and an uncertainty correction of +2 dB has been applied to the declared sound power levels, in accordance with the requirements of the IOA GPG. The resultant source noise terms for the candidate turbine model are provided in Table 8.7.

Table 8.7 – Source noise terms of Proposed Development candidate turbines

Wind speed, m/s	Sound power level standardised to 10m height wind speed, dB(A)
	Vestas V117 4.2MW (91.5m hub height)
4	98.0
5	102.2
6	106.0
7	107.9
8	108.0

Wind speed, m/s	Sound power level standardised to 10m height wind speed, dB(A)
	Vestas V117 4.2MW (91.5m hub height)
9	108.0
10	108.0
11	108.0
12	108.0

8.5.27 The candidate turbine model reaches its maximum sound power level at a 10 m wind speed of 8 m/s.

8.5.28 The octave band spectra have been applied to the broad-band levels within the noise model. Octave-band data for 8 m/s wind speed, at which the turbine has reached its maximum sound power level, are provided in Table 8.8.

Table 8.8 – Octave band data for candidate turbines, 8 m/s wind speed

	Octave band centre frequency, Hz								
	31.5	63	125	250	500	1000	2000	4000	8000
Sound power level, dBA	72.8	85.5	93.4	97.0	98.2	100.6	96.4	91.9	76.3

Fixed (Non-turbine) Plant Noise

8.5.29 Drawing upon the results of the completed baseline noise survey, and the guidance contained within BS 4142:2014, a series of applicable fixed plant noise level limits have been determined for non-turbine plant, such as electrical transformers. This assessment considers that planning conditions may be set to limit noise from fixed (non-turbine) plant to ensure a commensurate level of protection against noise for local receptors. Noise from such plant will be controlled by specification of appropriate attenuation as required, or selection of quiet plant.

8.5.30 The impact magnitude and effect significance of noise from fixed plant has been determined following the criteria described in Table 8.13 and Table 8.14 on the assumption that the installed plant will be appropriately specified or attenuated.

Cumulative Noise

Identification of cumulative developments, derivation of cumulative noise limits

8.5.31 A review was undertaken of existing and proposed wind energy developments in the vicinity of the site, using information available on the NAC and IC planning portals, and in consultation with the Environmental Health departments of both councils. This review has been completed to identify those developments which have the potential to give rise to a cumulative noise impact when operating simultaneously with the Proposed Development. The results of this desk-based review have been used to inform the assessment of operational turbine noise.

8.5.32 Where two predicted noise levels differing by 10 dB or more are summed, the total level is the same as the larger of the two levels; i.e. the lower level contributes a negligible amount to the total. This principle has been used to determine the cumulative study area for this assessment, and to identify which turbines contribute cumulatively to the Proposed Development.

8.5.33 This principle can be used to determine cumulative noise limits; when an existing cumulative development is consented to the full ETSU noise limit at a given NSR, the noise limit for a new

development can be set at a level 10 dB below the full ETSU limit, such that it will not contribute to total noise levels. Alternatively, the assessment can determine the amount of 'headroom' available to a proposed development between the contribution of other existing/consented developments and an agreed cumulative noise limit.

8.5.34 A review of potential cumulative developments has identified a single development at Kelly Bank Cottage, in the northern extent of the study area. The planning application indicates that the development comprises two Northern Power 100 kW turbines with a hub height of 23 m. The application further notes that the nearest noise-sensitive property (other than Kelly Bank Cottage, presumed owner of the Kelly Bank turbine[4]s) is approximately 500 m from the turbines, and that the simplified ETSU limit of 35 $dBL_{A90,10min}$ is met at a distance of 425 m from the turbines at a wind speed of 8 m/s. The application further proposes a higher night-time noise limit of 38 $dBL_{A90,10min}$.

8.5.35 This assessment assumes that the Kelly Bank turbines operate at their consented noise limits (daytime and night-time) at the closest non-FI property across the range of wind speeds. The closest non-FI property to the Kelly Bank turbines is identified as a caravan park approximately 350 m to the west of Kelly Bank Cottage.

8.5.36 Modelling predictions have been used to determine the potential contribution of the Kelly Bank turbines to noise levels at NSRs at which cumulative effects may occur with the Proposed Development, assuming their compliance with their own consented noise limits. At NSRs where the assumed noise level due to the Kelly Bank turbines is within 10 dB of the noise limit derived for the Proposed Development, the assumed contribution of the Kelly Bank turbines has been logarithmically subtracted from the noise limit derived from measured 2019 background noise levels. This approach maintains headroom for the operation of cumulative turbines, such that the Proposed Development does not result in the exceedance of applicable cumulative noise limits, as per the requirements of ETSU (refer to para. 8.3.30). The application of noise limits at identified NSRs is provided in Table 8.15.

Impact Magnitude and Effect Significance Criteria

8.5.37 The impact magnitude and effect significance have been determined following the criteria described in the assessment of potential effect significance section below.

Receptor Sensitivity

8.5.38 The guidance contained within Technical Advice Note (TAN) to PAN 1/2011 has been drawn upon in the generation of an appropriate set of significance criteria. The receptor sensitivity criteria for both the construction, operational and decommissioning phases of the Proposed Development are considered to be the same, these are presented in Table 8.9.

Table 8.9 - Receptor sensitivity criteria

Receptor Sensitivity	Description	Examples
High	Receptors where people or operations are particularly susceptible to noise and/or vibration.	Residential, quiet outdoor recreational areas, schools and hospitals.
Medium	Receptors moderately sensitive to noise and/or vibration, where it may cause some distraction or disturbance.	Offices and restaurants.

[4] *Property noted is assumed to be a caravan park to the north-west of Kelly Bank Cottage*

Receptor Sensitivity	Description	Examples
Low	Receptors where distraction or disturbance from noise and/or vibration is minimal.	Buildings not occupied, factories and working environments with existing levels of noise.

8.5.39 All residential NSRs within the study area have been assumed to be of "high" sensitivity to noise and vibration.

Impact magnitude - Construction Noise

8.5.40 The construction noise impact magnitudes have been determined with reference to threshold levels derived in accordance with the ABC method provided in BS5228. The impact magnitudes are provided in **Table 8.10**.

Table 8.10 – Impact magnitude scale for construction noise

Difference (d) between predicted construction noise level and threshold level (dB)	Impact magnitude
d ≥+5	High
0 ≤ d < +5	Medium
-10 ≤ d < 0	Low
<-10	Negligible

Impact magnitude – Construction Vibration

8.5.41 The impact magnitude for construction vibration has been derived from BS5228, and is provided in Table 8.11.

Table 8.11 – Impact magnitude scale – construction vibration

Vibration level, mm/s PPV	Impact magnitude
>1.0	High
>0.3, ≤1. 0	Medium
≥0.14, ≤0.3	Low
<0.14	Negligible

Impact magnitude - Operational Wind Turbine Noise

8.5.42 The impact magnitude for operational noise from the wind turbines for the Proposed Development scale has been derived based on evaluation of compliance with noise limits derived in accordance with the ETSU-R-97 guidance; the criteria are summarised in Table 8.12.

Table 8.12 - Impact magnitude scale – wind turbine noise

Difference (d) between turbine noise level and applicable limit (dB)	Impact magnitude
d ≥+5	High
0 ≤ d < +5	Medium
-10 ≤ d < 0	Low
<-10	Negligible

8.5.43 Where values of 'd', the difference between the noise limit and the predicted noise level, are below than zero (i.e. the wind farm complies with the derived noise limits), then impacts will be low or negligible. Exceedance of the noise limit (value of 'd' is greater than zero), results in an impact of medium or high.

Impact Magnitude - Fixed (Non-turbine) Plant Noise

8.5.44 For noise from any fixed (non-turbine) plant such as any transformers, control buildings or substations, it is appropriate to determine significance criteria based on the guidance contained within BS4142, i.e. by consideration of the difference between the rating level from the plant noise and the prevailing background sound levels, but also with respect to context and the resulting sound levels in absolute terms.

8.5.45 The impact magnitudes associated with noise generated from fixed plant are presented in Table 8.13.

Table 8.13 - Impact magnitude for fixed (Non-turbine) plant noise

Difference between Rating Level ($L_{Ar,Tr}$) and Background Sound Level (L_{A90})	BS4142 Guidance – description of impact	Adopted Impact Magnitude
≥+10	Indication of significant adverse impact	High
+5	Indication of adverse impact	Medium
0	Indication of low Impact	Low
-10	-	Negligible
Where the rating level ($L_{Ar.Tr}$) is below 35dB the impact magnitude is classified as 'Negligible' regardless of the relationship to the background noise level. *+ indicates rating level above background noise level* *- indicates rating level below background noise level*		

Effect Significance

8.5.46 The effect significance has been determined by consideration of both the receptor sensitivity and the impact magnitude according to the matrix detailed in Table 8.14.

Table 8.14 - Significance of effect matrix

Impact Magnitude	Receptor Sensitivity		
	High	**Medium**	**Low**
High	Major	Moderate	Minor
Medium	Moderate	Minor	Neutral
Low	Minor	Neutral	Neutral
Negligible	Neutral	Neutral	Neutral

8.5.47 Adverse effects of "moderate" or "major" significance are considered "significant" and require mitigation.

Requirements for Mitigation

8.5.48 Consideration has been given to available mitigation measures to reduce adverse effects and enhance beneficial effects. Where mitigation measures are detailed, these are committed to by the Applicant and have been determined through prediction. Following commissioning of the Proposed Development, it is anticipated that the predicted noise levels due to the Proposed Development, and hence the requirements for implementation of mitigation, will be confirmed by compliance monitoring.

8.5.49 Where required, modern turbines allow the control/reduction in the noise levels generated by operation in various reduced noise operational modes. Whilst the use of such modes has an associated reduction in power generation, and so should be avoided where possible, they can be operated where necessary to ensure compliance with applicable noise level limits. A turbine management scheme can be operated which monitors the prevailing meteorological conditions (e.g. wind speed and direction) and controls the applicable operational mode (e.g. standard setting or a reduced noise operational mode) accordingly.

Assessment of Residual Effect Significance

8.5.50 Residual effects have been assessed following the methods described above, and take into account any committed mitigation measures.

Limitations to Assessment

8.5.51 This assessment has been undertaken in accordance with the information available at the time, making appropriately conservative assumptions. Potential sources of uncertainty, and the measures taken within this assessment to mitigate these, are identified below:

- levels of vibration associated with assumed construction methods;
- variation in background noise levels – minimised by extended duration of baseline survey;
- source noise terms of turbines – uncertainty correction applied, in accordance with IoA GPG; and
- method of prediction – method provided in IoA GPG followed.

8.5.52 The assessment of operational impacts associated with the wind turbines has been undertaken adopting source noise levels for the candidate turbine models. Following completion of the tendering process, it is possible that the precise turbine make and model will change from that adopted within the assessment. The candidate turbine assessed has been identified (by the Applicant) as having the highest operational noise emissions of the potential turbine options under

consideration, therefore noise effects associated with other turbine models will be lesser than those assessed.

8.6 Baseline Conditions

Description of Baseline Noise Environment

8.6.1 Time-history charts of the measured ambient (L_{Aeq}) and background (L_{A90}) noise levels for each monitoring location are provided in Appendix 8.5. Periods of rainfall-affected data, which have been screened out of subsequent analysis in accordance with the GPG, are also shown.

8.6.2 Charts showing the measured background noise levels correlated with wind speed, and divided into Quiet Daytime and Night-time periods, in accordance with ETSU, are provided in Appendix 8.5 for both NMPs. The charts show the wind-dependent background noise level, the "background +5 dB" criterion and the derived noise limits.

NMP1 – Fardens

8.6.3 The dominant noise source was wind-induced rustling of vegetation, therefore efforts were made to locate the SLM as far away as possible from any vegetation in the garden of the property. Birdsong was also audible and fairly continuous.

8.6.4 A time-history graph of measured L_{Aeq} (ambient) and L_{A90} (background) levels and rainfall events is provided as Chart 8.1 in Appendix 8.5. With reference to Chart 8.1, the following observations are noted with regard to measured baseline noise levels:

- the ambient and background levels show a close correlation throughout the majority of the measurement period; this is indicative of a fairly constant noise source such as wind-induced noise, rather than intermittent anthropogenic activities;
- there is a clear diurnal variation on some days, with declining noise levels during the evening, the lowest noise level in the middle of the night and increasing noise levels towards the morning;
- the diurnal variation does not occur every day; elevated noise levels occur during the night-time period on some days, attributed to high wind speeds;
- during periods of heavy rainfall the ambient and background levels exhibit lower consistency, attributed to rain-induced noise on the microphone wind shield (rain-affected data has been screened out of further consideration in the assessment).

8.6.5 The measured daytime and night-time background noise levels for NMP1, correlated to wind speed, and with rain-affected data removed, are provided in Appendix 8.5. Chart 8.2 shows the daytime period and Chart 8.3 the night-time period.

8.6.6 The following observations are noted with regard to the correlation of noise and wind speed data, and the derivation of noise limits:

- there are a substantial number of datapoints across the full range of operational wind speeds, both during the daytime and night-time period, comfortably fulfilling the GPG minimum data requirements;
- with reference to Chart 8.2, there is a strong correlation between wind speed and measured background noise level with no outliers and no banding of datapoints;
- during the daytime period the measured background level +5 dB exceeds the fixed minimum daytime noise limit (35 dB) at wind speeds above 5 m/s, this is attributed to the exposed setting of the NMP (and its surrounding NSRs); and
- with reference to Chart 8.3, there is a strong correlation between wind speed and measured background noise level. There are numerous datapoints in the range 20 – 25 dB across the range

of wind speeds. Where low noise levels occur at high wind speeds it is assumed that this occurred when the wind direction was such that topography and the buildings at Fardens screened the monitoring position from the wind.

NMP2 – Golf Course Road

8.6.7 The dominant noise source was wind induced rustling of vegetation. Trees and bushes were present in the area surrounding the monitoring position, however, care was taken with micro-siting such that the SLM was positioned as far from vegetation as possible. Noise from road traffic elsewhere in the village was a lesser contributor to total noise levels and conversations between residents, birdsong and sporadic vehicles passes on Golf Course Road were minimal contributors to total noise levels.

8.6.8 A commercial/industrial shed is located at the end of golf Course Road, which appeared to be the base for a small contracting company. Occasional clatters and bangs from loading/unloading of contractors' vans were noted during set-up of the monitoring equipment; this was in the late afternoon when vans were noted returning to the building. It is anticipated that noise from the infrequent vehicle movements on Golf Course Road and noise from the contracting business will have a negligible effect on derived noise limits for this location, given the exclusion of weekday daytime data in accordance with the requirements of the ETSU method.

8.6.9 Chart 8.4 in Appendix 8.5 provides a time-history of measured ambient and background levels and rainfall events. With reference to Chart 8.4, the following observations are noted with regard to measured baseline noise levels:

- The ambient and background levels show a generally close correlation throughout the majority of the measurement period, however, the difference between the two indices is greater than at NMP1, considered to be indicative of the greater contribution of anthropogenic noise such as road traffic on the wider road network, commensurate with proximity to the village.
- On most days there is a clear diurnal variation, however, as with NMP1, there are times when this is disrupted, assumed to be a result of higher noise levels on windy days.

8.6.10 The measured daytime and night-time background noise levels for NMP2, correlated to wind speed, and with rain-affected data removed, are provided in Appendix 8.5, Chart 8.5 shows the daytime period and Chart 8.6 the night-time period. The following observations are noted with regard to the correlation of noise and wind speed data, and the derivation of noise limits:

- There are a substantial number of datapoints across the full range of operational wind speeds, both during the daytime and night-time period.
- With reference to Chart 8.5, there is a correlation between wind speed and measured background noise level, with some outliers at lower wind speeds and no banding of datapoints. Compared with NMP1, there is a wide range of noise levels for each wind speed, again, attributed to the greater contribution of anthropogenic noise sources. The outliers have been attributed to anthropogenic noise such as vehicles passing the SLM.
- During the daytime period the measured background level +5 dB exceeds the fixed minimum daytime noise limit (35 dB) at wind speeds above 6 m/s.

NMP3 – Barr Farm

8.6.11 The dominant noise source was wind-induced rustling from vegetation in the surrounding area, though there was none in close proximity to the SLM. Lesser contributors to ambient noise levels included fairly constant birdsong and continuous distant traffic noise.

8.6.12 A time-history graph of measured L_{Aeq} (ambient) and L_{A90} (background) levels and rainfall events is provided as Chart 8.7 in Appendix 8.5. With reference to Chart 8.7, the following observations are noted with regard to measured baseline noise levels:

- The ambient and background levels show a fairly close correlation throughout the majority of the measurement period; this is indicative of a fairly constant noise source such as wind-induced noise, rather than intermittent anthropogenic activities.
- There were periods where the ambient level was substantially higher than the background level; this is attributed to activity from farm machinery and rainfall events; and
- There is a clear diurnal variation on most days, with declining noise levels during the evening, the lowest noise level in the middle of the night and increasing noise levels towards the morning.

8.6.13 The measured daytime and night-time background noise levels for NMP3, correlated to wind speed, and with rain-affected data removed, are provided in Appendix 8.5, Chart 8.8 shows the daytime period and Chart 8.9 the night-time period. The following observations are noted with regard to the correlation of noise and wind speed data, and the derivation of noise limits:

- There are a substantial number of datapoints across the full range of operational wind speeds, both during the daytime and night-time period;
- With reference to Chart 8.8, there is a strong correlation between wind speed and measured background noise level with no outliers and no banding of datapoints; and
- During the daytime period the measured background level +5 dB exceeds the fixed minimum daytime noise limit (35 dB) at wind speeds of 6 m/s and above.

NMP4 – Outerwards

8.6.14 The dominant noise source was wind-induced rustling of vegetation; clusters of trees were noted to be present in the surrounding area, though the SLM was sited at least 50 m from the closest trees. Other noise audible during the survey included the occasional bleating of sheep and barely-audible running water in the burn.

8.6.15 A time-history graph of measured L_{Aeq} (ambient) and L_{A90} (background) levels and rainfall events is provided as Chart 8.10 in Appendix 8.5. With reference to Chart 8.10, the following observations are noted with regard to measured baseline noise levels:

- The ambient and background levels show a very close correlation throughout the majority of the measurement period; this is indicative of a fairly constant noise source such as wind-induced noise, rather than intermittent anthropogenic activities; and
- There is no clear diurnal variation throughout the measurement, attributed to the remoteness of the NMP from anthropogenic noise sources. The primary influence on noise levels was the weather, with spikes in ambient and background levels attributed to high wind speeds and rainfall events.

8.6.16 The measured daytime and night-time background noise levels for NMP4, correlated to wind speed, and with rain-affected data removed, are provided in Appendix 8.5, Chart 8.11 shows the daytime period and Chart 8.12 the night-time period. The following observations are noted with regard to the correlation of noise and wind speed data, and the derivation of noise limits:

- There are a substantial number of datapoints across the full range of operational wind speeds, both during the daytime and night-time period;. With reference to Chart 8.11, there is a strong correlation between wind speed and measured background noise level with no outliers and no banding of datapoints.

- With reference to Chart 8.12, night-time noise levels show a generally good correlation between measured noise levels and wind speed, however, analysis of the data revealed a small number of discrete periods of elevated noise levels at low wind speeds. These events had a duration of several hours on a single night (21st September), and did not correspond to periods of rainfall or particular wind directions. The events are considered to be unexplained, given the remoteness of the unoccupied property from anthropogenic noise sources. The outlier data has been excluded from the regression analysis, and excluded data is shown in yellow in Chart 8.12.
- During the daytime period the measured background level +5 dB exceeds the fixed minimum daytime noise limit (35 dB) at wind speeds above 5 m/s.

Summary of Measured Baseline Noise Levels

8.6.17 The measured noise levels at Outerwards show a similar pattern to those at Fardens, where the background and ambient levels are similar throughout the measurement and the background level rarely drops below approximately 20 dB. The close correlation between the ambient and background levels is attributed to the dominance of wind-induced noise, which typically varies gradually, and the limited influence of anthropogenic noise sources, which typically vary over short timescales, at these more remote locations.

8.6.18 At Barr Farm and Golf Course Road the measured noise levels show less consistency between ambient and background levels, attributed to the greater influence of noise from anthropogenic sources. The measured ambient and background levels at these locations do, however, reach lower minimum values, attributed to the more sheltered nature of these locations.

8.6.19 In general the monitoring locations can be divided into two groups; NMP1 and NMP4 in exposed locations, where wind noise was dominant, and NMP2 and NMP3 in more sheltered locations, where anthropogenic sources were occasionally dominant.

Adopted noise limits

Construction and decommissioning noise limits

8.6.20 With reference noise levels presented in Appendix 8.5, specifically in Chart 8.1 and Chart 8.4, the baseline ambient level is below 65 dB throughout the survey. The construction phase noise limit for weekday daytimes and Saturdays, in accordance with the ABC method provided in BS 5228, is therefore Category A; 65 $dBL_{Aeq,T}$.

Operational noise limits – fixed non-turbine plant

8.6.21 Operational noise limits for fixed non-turbine plant, such as transformers and substations, have been derived in accordance with BS4142 with reference to measured background noise levels at NMP1, the closest NMP to the proposed substation. It is assumed that such plant will operate at a constant level, therefore noise limits will be determined by the night-time background level, when noise from road traffic and other anthropogenic sources is at a minimum. At wind speeds lower than 5 m/s and in the absence of rainfall (as required by BS4142), as shown in Chart 8.1 and Chart 8.4 the lowest measured background level during the night-time period at NMP1 was 20 $dBL_{A90,T}$.

Operational noise limits – wind turbine noise

8.6.22 Operational noise limits have been derived for the Proposed Development across the range of operational wind speeds for the candidate turbine. The operational noise limits have been derived from measured background noise levels, in accordance with the method provided in ETSU. The allocation of representative NMPs to determine background levels at NSRs was agreed with the EHOs of NAC and IC.

8.6.23 Given the relatively simple cumulative situation, with a single small-scale cumulative development identified at Kelly Bank, the noise limits at the majority of NSRs are the ETSU limit of 'background +5 dB or 35 dB, whichever is the higher'. At NSRs at which the potential for cumulative

noise effects have been identified, the noise limit applicable to the Proposed Development have been derived using the following process:

- Determine the maximum potential contribution of cumulative wind turbines to noise levels at the NSR;
- Subtract (logarithmically) cumulative noise contribution from the derived ETSU noise limit to determine the available noise limit applicable to the Proposed Development;
- Where no headroom exists (e.g. 'background +5 dB' is below 35 dB and the assumed cumulative contribution is 35 dB), the applicable noise limit has been set to 10 dB below the assumed cumulative contribution;

8.6.24 The process detailed above has been applied at NSR 13 Kelly Bank Cottage only. As noted in para. 8.5.34, for the Kelly Bank turbines to meet the noise limits of their planning condition (35 $dBL_{A90,10min}$ daytime and 38 $dBL_{A90,10min}$) at the closest non-FI receptor, the noise level due to the Kelly Bank turbines may not exceed the non-FI noise limits at NSR13 Kelly Bank Cottage.

8.6.25 The NSRs at which the derived noise limits have been used to allocate noise limits are provided in Table 8.15.

Table 8.15 – Derived noise limits

Wind speed, m/s	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
NMP1 – Fardens										
Not applicable at any NSRs – property will be unoccupied upon construction of Proposed Development										
NMP2 – Golf Course Road										
Daytime	35.0	35.0	35.0	35.0	35.5	36.1	36.7	37.5	38.4	39.3
Night-time	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Applicable at NSR10, NSR11, NSR12										
NMP3 – Barr Farm										
Daytime	35.0	35.0	35.0	35.2	36.0	36.8	37.6	38.5	39.4	40.4
Night-time	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Applicable at NSR3, NSR4, NSR5, NSR6, NSR8										

Wind speed, m/s	3	4	5	6	7	8	9	10	11	12
Limit accounting for available cumulative headroom, derived from NMP3 data										
Daytime	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.9	37.4	38.9
Night-time	41.3	41.3	41.3	41.3	41.3	41.3	41.3	41.3	41.3	41.3
Applicable at NSR13 Kelly Bank Cottage										
Financially-Involved noise limit, derived from NMP3 data										
Daytime	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Night-time	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Applicable at NSR7 Barr Farm and NSR9 Skelmorlie Mains										
NMP4 – Outerwards										
Daytime	35.0	35.0	35.0	36.5	38.3	40.2	42.1	43.9	45.7	47.3
Night-time	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Applicable at NSR1 East Grassyards, NSR2 Tourgill and NSR14 Outerwards										

8.6.26 Barr Farm and Skelmorlie Mains will be financially involved in the Proposed Development, therefore the higher Financially Involved (FI) noise limit applies at these NSRs.

8.7 Receptors Brought Forward for Assessment

8.7.1 The NSRs considered in this assessment are provided in Table 8.5 and shown in Figure 8.1.

8.8 Standard Mitigation

Construction phase

8.8.1 A Construction Environmental Management Plant (CEMP) will be prepared prior to the commencement of construction works. The CEMP will detail all measures which will be adopted to minimise noise and vibration impacts at NSRs, implementing good practice procedures provided in BS5228, as selection of which are provided below:

- Construction activities will take placed during the daytime period only, as defined in BS5228;
- avoid unnecessary revving of engines and switching off plant when not required (i.e. no idling);
- haul routes to be kept well maintained, with no steep gradients;
- minimising the drop height of materials during delivery to, and movement around, site;
- starting up plant and vehicles sequentially, rather than all together;

- specification of plant with white-noise or directional reversing alarms, rather than beeper type alarms;
- where possible, selection of quiet / noise reduced plant;
- vehicles accessing the site will have regard to the normal operating hours of the site and the location of nearby NSRs;
- use and siting of equipment will be considered such that noise and vibration is minimised. For example, any generators or powered cabins within the construction compound will be sited such that noise from the generator exhaust is directed away from the closest NSRs, and cabins and other infrastructure are used to screen noise from such plant wherever possible; and
- where vibration-generating activities will be undertaken in close proximity to dwellings, such as use of vibrating rollers for ground compaction during access track construction, vibration levels will be monitored. Should vibration levels exceed appropriate thresholds, further mitigation will be put in place.

8.8.2 The CEMP will set out a complaints procedure and appoint an on-site contact, such that noise and vibration complaints are logged and acted upon promptly. In the event of construction noise or vibration complaints being received, the contractor may commence noise and vibration monitoring, to determine when appropriate limits are being exceeded, such that activities can be modified to reduce levels.

Operational phase

Fixed (non-turbine) plant noise

8.8.3 Noise from non-turbine operational plant will comprise noise from substations only. The sound power level and final location of the substation(s) are yet to be finalised, however, noise from the final type and location of the substation will be attenuated by acoustic enclosure (if required), such that it meets the derived non-turbine noise limits (refer to para. 8.6.21). A sound power level of 95 dB(A), would enable the noise limit to be met. The installed substation will meet this criterion.

8.9 Potential Effects

Construction

On-site construction noise

8.9.1 The highest predicted noise levels at closest NSRs to the Proposed Development site, due to the three stages of construction considered are provided and evaluated against the adopted noise limits in Table 8.16. Where predicted noise levels exceed the noise limit, this is shown in red text.

Table 8.16 – Evaluation of worst-case construction phase noise levels at closest NSRs

Scenario (NSR)	Predicted level, $dBL_{Aeq,T}$	Exceedance of noise limit, dB
Construction of access tracks		
NSR7 Barr Farm	67.5	2.5
NSR8 Barr Farm Caravan Park	67.0	2.0
NSR9 Skelmorlie Mains	44.0	-21.0
NSR10 Skelmorlie Mains Caravan Park	31.5	-33.5

Scenario (NSR)	Predicted level, $dBL_{Aeq,T}$	Exceedance of noise limit, dB
Construction of turbine bases		
NSR7 Barr Farm	38.9	-26.1
NSR8 Barr Farm Caravan Park	36.7	-28.3
NSR9 Skelmorlie Mains	35.2	-29.8
NSR10 Skelmorlie Mains Caravan Park	23.3	-41.7
Installation of turbines		
NSR7 Barr Farm	41.3	-23.7
NSR8 Barr Farm Caravan Park	39.2	-25.8
NSR9 Skelmorlie Mains	37.5	-27.5
NSR10 Skelmorlie Mains Caravan Park	23.8	-41.2

8.9.2 At NSR7 and NSR8, predicted worst-case noise levels during to construction of the access track exceed the threshold criterion by a margin of up to 2.5 dB. With reference to Table 8.10 the impact magnitude at these NSR7 and NSR8 for this stage of works is **medium.** With reference to Table 8.14 the significance of effect is **moderate**, and is therefore **significant**.

8.9.3 At NSR7 and NSR8 for all other stages of works, and at all other NSRs during all stages of works, the magnitude of impact is **negligible** and the significance of effect is **neutral**.

8.9.4 The highest construction noise levels are predicted at NSR7 Barr Farm. This property is financially involved with the Proposed Development (house of the site landowner), and may therefore be considered to have a lower sensitivity to construction noise.

8.9.5 The activity having the greatest noise impact at NSRs will be construction of the access track. This stage of the construction programme will be of limited duration, and significant noise effects will therefore be transient in nature, further reducing the significance of the effect.

Construction vibration

8.9.6 The property NSR7 Barr Farm and the properties represented by NSR8 Barr Farm Caravan Park lie within approximately 20 m of the route of the proposed access track. Vibration levels due to construction of the track are therefore assumed to be within the range 0.3 – 1.0 mm/s PPV. With reference to para. 8.5.18 and Table 8.14, resulting in a **medium** impact magnitude, and a resultant **moderate** significance of effect.

Operation

Fixed (non-turbine) plant noise

8.9.7 The Proposed Development will include a substation which will generate noise, which will potentially be tonal in nature. No details are currently available on the source noise levels of the substation, and it is therefore considered appropriate that suitable noise control limits will be set to which any such ancillary plant items will be required to conform. The noise limits apply to the rating level, which includes any corrections for acoustic characteristics, such as tonality and intermittency, in accordance with the BS4142 method.

8.9.8 This assessment adopts the rating level noise limit of 20 dB at any identified NSR, equivalent to the baseline background noise levels at NMP1. Provided that the noise limit is met by all non-turbine plant, including the substation, with reference to Table 8.13 the impact magnitude will be low. At high sensitivity NSRs, the resultant effect significance will be minor and therefore **not significant**.

Wind turbine noise – noise from the Proposed Development Only

8.9.9 Predicted noise levels due to operation of the Proposed Development in isolation are provided in Table 8.17 across the range 4 m/s – 12 m/s. The predicted levels include corrections for concave topography and topographic screening, as determined in Appendix 8.4.

Table 8.17 – Predicted turbine noise levels due to Proposed Development including corrections

NSR ID	Wind Speed, m/s								
	4	5	6	7	8	9	10	11	12
	Predicted noise level, dBL_{A90}								
NSR1	27.1	31.3	35.1	37.0	37.1	37.1	37.1	37.1	37.1
NSR2	22.0	26.2	30.1	32.0	32.0	32.1	32.1	32.1	32.1
NSR3	27.5	31.7	35.6	37.5	37.5	37.6	37.6	37.6	37.6
NSR4	26.9	31.1	34.9	36.8	36.9	36.9	36.9	36.9	36.9
NSR5	25.6	29.8	33.6	35.5	35.6	35.6	35.6	35.6	35.6
NSR6	24.6	28.8	32.7	34.6	34.7	34.7	34.7	34.7	34.7
NSR7	30.7	34.9	38.7	40.6	40.7	40.7	40.7	40.7	40.7
NSR8	27.7	31.9	35.8	37.7	37.7	37.8	37.8	37.8	37.8
NSR9	25.9	30.1	33.9	35.8	35.9	35.9	35.9	35.9	35.9
NSR10	24.2	28.4	32.2	34.1	34.2	34.2	34.2	34.2	34.2
NSR11	22.2	26.4	30.2	32.1	32.2	32.2	32.2	32.2	32.2
NSR12	19.1	23.3	27.1	29.0	29.1	29.2	29.2	29.2	29.2
NSR13	20.2	24.4	28.2	30.1	30.2	30.2	30.2	30.2	30.2
NSR14	23.4	27.6	31.4	33.3	33.4	33.4	33.4	33.4	33.4

8.9.10 The predicted noise levels at NSRs due to the Proposed Development operating in isolation are evaluated against the applicable noise limits in Table 8.18. The predicted levels are evaluated against the noise limits graphically in Appendix 8.5 in Chart 8.13 – Chart 8.18.

Table 8.18 – Evaluation of compliance; predicted turbine noise level minus derived noise limits – Proposed Development only

NSR ID	Wind Speed, m/s								
	4	5	6	7	8	9	10	11	12
	Exceedance of noise limit, dBL_{A90}								
Daytime period									
NSR1	-7.9	-3.7	-1.4	-1.3	-3.1	-5.0	-6.9	-8.6	-10.2
NSR2	-13.0	-8.8	-6.4	-6.3	-8.2	-10.0	-11.9	-13.6	-15.2
NSR3	-7.5	-3.3	0.5	1.5	0.8	0.0	-0.9	-1.8	-2.7
NSR4	-8.1	-3.9	-0.3	0.8	0.1	-0.7	-1.6	-2.5	-3.5
NSR5	-9.4	-5.2	-1.5	-0.4	-1.2	-2.0	-2.8	-3.7	-4.7

NSR ID	Wind Speed, m/s								
	4	5	6	7	8	9	10	11	12
	Exceedance of noise limit, dBL_{A90}								
NSR6	-10.4	-6.2	-2.5	-1.4	-2.1	-2.9	-3.8	-4.7	-5.7
NSR7	-14.3	-10.1	-6.3	-4.4	-4.3	-4.3	-4.3	-4.3	-4.3
NSR8	-7.3	-3.1	0.6	1.7	1.0	0.2	-0.7	-1.6	-2.6
NSR9	-19.1	-14.9	-11.1	-9.2	-9.1	-9.1	-9.1	-9.1	-9.1
NSR10	-10.8	-6.6	-2.8	-1.3	-1.9	-2.5	-3.3	-4.1	-5.1
NSR11	-12.8	-8.6	-4.8	-3.4	-3.9	-4.6	-5.3	-6.2	-7.1
NSR12	-15.9	-11.7	-7.9	-6.4	-6.9	-7.6	-8.3	-9.2	-10.1
NSR13	-14.8	-10.6	-6.8	-4.9	-4.8	-4.8	-5.6	-7.2	-8.6
NSR14	-11.6	-7.4	-3.6	-3.2	-4.9	-6.8	-8.7	-10.5	-12.3
Night-time									
NSR1	-15.9	-11.7	-7.9	-6.0	-5.9	-5.9	-5.9	-5.9	-5.9
NSR2	-21.0	-16.8	-12.9	-11.0	-11.0	-10.9	-10.9	-10.9	-10.9
NSR3	-15.5	-11.3	-7.4	-5.5	-5.5	-5.4	-5.4	-5.4	-5.4
NSR4	-16.1	-11.9	-8.1	-6.2	-6.1	-6.1	-6.1	-6.1	-6.1
NSR5	-17.4	-13.2	-9.4	-7.5	-7.4	-7.4	-7.4	-7.4	-7.4
NSR6	-18.4	-14.2	-10.3	-8.4	-8.3	-8.3	-8.3	-8.3	-8.3
NSR7	-14.3	-10.1	-6.3	-4.4	-4.3	-4.3	-4.3	-4.3	-4.3
NSR8	-15.3	-11.1	-7.2	-5.3	-5.3	-5.2	-5.2	-5.2	-5.2
NSR9	-19.1	-14.9	-11.1	-9.2	-9.1	-9.1	-9.1	-9.1	-9.1
NSR10	-18.8	-14.6	-10.8	-8.9	-8.8	-8.8	-8.8	-8.8	-8.8
NSR11	-20.8	-16.6	-12.8	-10.9	-10.8	-10.8	-10.8	-10.8	-10.8
NSR12	-23.9	-19.7	-15.9	-14.0	-13.9	-13.8	-13.8	-13.8	-13.8
NSR13	-21.1	-16.9	-13.1	-11.2	-11.1	-11.1	-11.1	-11.1	-11.1
NSR14	-19.6	-15.4	-11.6	-9.7	-9.6	-9.6	-9.6	-9.6	-9.6

Where the predicted noise levels exceed the derived noise limits the resultant difference is shown in red text.

8.9.11 The findings of the evaluation are summarised as follows:

- Predicted operational noise levels meet the derived daytime period noise limits across the full range of wind speeds at NSR1, NSR2, NSR5, NSR6, NSR7, NSR9, NSR10, NSR11, NSR12, NSR13 and NSR14.

- Predicted operational noise levels exceed the derived daytime period noise limits at one or more wind speed at NSR3, NSR4 and NSR8. The magnitude of the predicted exceedances ranges from 0.1 dB (NSR4, 8 m/s), up to 1.7 dB (NSR8, 7 m/s).
- At all representative NSRs, predicted noise levels meet the derived noise limits at all wind speeds during the night-time period.

8.9.12 The Applicant has confirmed that, where exceedances are identified, mitigation will be put in place such that operational noise limits are met, wherever this situation arises.

Summary of significance

8.9.13 With reference to Table 8.12 and Table 8.14, the magnitude of impact and significance of effect have been derived for operational wind turbine noise, and are reported in Table 8.19.

Table 8.19 – Magnitude of impact, significance of effect

NSR name	NSR ID	Daytime period		Night-time period	
		Magnitude of impact	Significance of effect	Magnitude of impact	Significance of effect
East Grassyards	NSR1	Low	Minor	Low	Minor
Tourgill	NSR2	Low	Minor	Negligible	Neutral
Dykes	NSR3	Medium	Moderate	Low	Minor
Barr Farm Road (1)	NSR4	Medium	Moderate	Low	Minor
Barr Farm Road (2)	NSR5	Low	Minor	Low	Minor
Barr Farm Road (3)	NSR6	Low	Minor	Low	Minor
Barr Farm	NSR7	Low	Minor	Low	Minor
Barr Farm Caravan Park	NSR8	Medium	Moderate	Low	Minor
Skelmorlie Mains	NSR9	Low	Minor	Low	Minor
Skelmorlie Mains Caravan Park	NSR10	Low	Minor	Low	Minor
Properties on Caskie Drive	NSR11	Low	Minor	Negligible	Neutral
Properties on Golf Course Road	NSR12	Low	Minor	Negligible	Neutral
Kelly Bank Cottage	NSR13	Low	Minor	Negligible	Neutral
Outerwards	NSR14	Low	Minor	Low	Minor

8.9.14 At NSR1, NSR2, NSR5, NSR6, NSR7, NSR9, NSR10, NSR11, NSR12, NSR13 and NSR14 operational wind turbine noise effects during the daytime period have been determined to be **not significant**.

8.9.15 At NSR3, NSR4 and NSR8 operational wind turbine noise effects during the daytime period have been determined to be **significant**. As noted in 8.9.12, where exceedances of the noise limit are identified, mitigation will be put in place such that these do not occur.

8.9.16 At all NSRs operational wind turbine noise effects during the night-time period have been determined to be **not significant.**

8.10 Additional Mitigation and Enhancement

Construction noise and vibration

8.10.1 No additional mitigation beyond that provided in Section 8.8 is proposed at this stage, however, it is anticipated that specific additional mitigation measures will be identified in the proposed CEMP.

Operational wind turbine noise

8.10.2 A significant effect has been identified at five of the fourteen identified representative NSRs. Of these NSRs, Barr Farm Caravan Park represents multiple dwellings. At these NSRs the predicted noise level exceeds the derived noise limit by a margin of up to 1.7 dB and therefore mitigation is required to enable the noise limit to be met.

8.10.3 There are a variety of methods by which compliance with the noise limit could be achieved, including the use of low-noise mode operation of one or more of the closest turbines to NSR1 under particular wind conditions. It is likely that operation of the closest turbines to NSRs at which exceedances have been identified in "noise reduced mode" at 6 m/s to 9 m/s wind speeds would enable the noise limits to be met while having a limited impact on the generating capacity of the Proposed Development. When these NSRs are up-wind of the Proposed Development it is anticipated that the exceedances would be reduced.

8.10.4 This assessment has been undertaken using the Vestas V117 candidate turbine. Should a different turbine model be chosen then a supplementary noise assessment will be undertaken to confirm compliance with the derived noise limits. A warranty covering the noise emissions of the selected turbine will be obtained from the turbine supplier/manufacturer.

8.10.5 Following first operation of the Proposed Development a noise assessment will be commissioned by the Applicant to determine compliance with the consented noise limits. Should any exceedances of noise limits attributable to the Proposed Development be identified the Applicant will put in place an operational noise management plant, such that noise limits are met.

8.11 Residual Effects

Construction noise and vibration

8.11.1 No requirement for specific additional mitigation (beyond good practice measures) has been determined for the construction phase, therefore no additional mitigation is proposed, and residual effects remain unchanged, and are therefore **significant** at NSR7 Barr Farm (a financially involved property) and NSR8 Barr Farm Caravan Park, and **not significant** at all other NSRs.

8.11.2 The Applicant has committed to completion of a CEMP (see Section 8.8), such that construction noise and vibration effects are minimised according to best practice. Following implementation of the mitigation measures outlined in the CEMP, noise and vibration effects associated with construction will be **not significant** at all NSRs.

Operation

Fixed non-turbine plant

8.11.3 No additional mitigation is required for fixed non-turbine plant, therefore residual effects remain unchanged, and are therefore **not significant** at all NSRs.

Noise from wind turbines

8.11.4 Following selection and procurement of the final turbine model, and implementation of an appropriate turbine noise management plan, where required, it is anticipated that operational wind turbine noise levels will meet the derived noise limits at all NSRs across the full range of wind speeds, both during the daytime and the night-time periods. With reference to Table 8.12 the resultant impact magnitude at NSR1, NSR3, NSR4, NSR5 and NSR8 will be **low**, therefore with reference to Table 8.14 the effect significance will be **minor**, and noise effects will therefore be **not significant**.

8.11.5 At all other NSRs, operational noise levels due to the Proposed Development will remain the same, or decrease as a result of mitigation enacted to enable noise limits to be met at NSRs at which predicted exceedances have been identified. The resultant noise impact magnitude at other NSRs will therefore either be unchanged, or will be reduced. The significance of effect at other NSRs will therefore remain **not significant**.

8.12 Cumulative Assessment

8.12.1 No cumulative effects are anticipated during the construction phase, and cumulative noise effects are therefore considered to be **not significant**.

8.12.2 Cumulative operational effects are accounted for in the derived noise limits, and have therefore been determined to be **not significant**.

8.13 Summary

8.13.1 This chapter has considered potential noise effects associated with construction and operation of the Proposed Development.

8.13.2 The assessment of noise and vibration comprised consultation with NAC and IC, characterisation of the baseline noise environment, prediction of noise levels associated with construction activities, operational wind turbines and operation of other non-turbine fixed plant, and evaluation of predicted levels against derived criteria. Vibration effects from construction have been evaluated semi-qualitatively.

8.13.3 A review has been undertaken of current guidance and scientific consensus on potential LF noise associated with onshore wind turbines in Appendix 8.6. The review determined that infrasound and low frequency noise associated with modern wind turbines are below the level at which adverse health effects occur, and therefore no further evaluation is required. There is currently no method for prediction of potential AM. A standard method for the measurement and evaluation of AM is provided in current guidance. It is therefore possible to condition AM, such that should it be identified upon commissioning then the wind farm operator must put in place mitigation such that AM is reduced to acceptable levels. The Applicant is willing to accept such a condition as part of the planning consent for the Proposed Development.

8.13.4 Baseline noise levels in the study area were found to be split between exposed, high elevation monitoring locations (NMP1 and NMP4) were typically dominated by wind noise, with measured noise levels showing a strong correlation with wind speed. Measured noise levels at more sheltered monitoring locations (NMP2 and NMP3) showed evidence of other noise sources, including anthropogenic sources such as road traffic, and noise from wind-induced movement of vegetation.

8.13.5 Noise and vibration levels associated with construction activities will meet threshold noise levels set out in the relevant guidance at the majority of identified NSRs, during weekday daytimes and Saturday mornings. Predicted noise and vibration levels at the closest NSRs to construction works, NSR7 and NSR8, exceed the threshold levels. Mitigation has therefore been specified to reduce noise and vibration effects at NSR7 and NSR8. Following implementation of mitigation measures, noise and vibration effects at all NSRs will be not significant.

8.13.6 Noise limits have been derived for non-turbine fixed plant associated with operation of the Proposed Development. Items of fixed plant will be specified such that they meet the derived noise limits at all representative NSRs. Noise effects from fixed plant are therefore not significant.

8.13.7 At NSR2, NSR6, NSR7, NSR9, NSR10, NSR11, NSR12, NSR13 and NSR14 predicted operational wind turbine noise levels during the daytime period meet the daytime noise limits, and noise effects have therefore been determined to be not significant.

8.13.8 At NSR3, NSR4 and NSR8 predicted operational wind turbine noise levels during the daytime period exceed the daytime noise limits, and noise effects have therefore been determined to be significant. The Applicant has committed to implementing appropriate mitigation such that noise limits are met during operation. Following the implementation of mitigation, operational noise effects during the daytime are not significant.

8.13.9 At all NSRs, operational wind turbine noise effects during the night-time period have been determined to be not significant.

Table 8.20 – Summary of Effects

Description of Effect	Significance of Potential Effect		Mitigation Measure	Significance of Residual Effect	
	Significance	Beneficial/ Adverse		Significance	Beneficial/ Adverse
Construction					
Noise and vibration from construction activities	Negligible - Moderate	Adverse	Completion and implementation of CEMP	Minor	Adverse
Operation					
Noise effects from operation of wind turbines	Moderate	Adverse	Turbine selection, implementation of noise control mitigation, as required	Minor	Adverse
Decommissioning					
Noise and vibration from construction activities	Negligible - Moderate	Adverse	Completion and implementation of CEMP	Minor	Adverse

Table 8.21 – Summary of Cumulative Effects

Receptor	Effect	Cumulative Developments	Significance of Cumulative Effect	
			Significance	Beneficial/ Adverse
Residential properties	Cumulative noise from wind turbines	Kellybank wind turbines (x2)	Minor	Adverse

8.14 References

AECOM. (2011). Wind Farm Noise Statutory Nuisance Complaint Methodology. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69222/pb-13584-windfarm-noise-statutory-nuisance.pdf

BSi. (1997). BS4142:1997 Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas.

BSi. (2009/2014). BS 5228-1:2009+A1:2014: Code of Practice for Noise and Vibration Control on Construction and Open Sites, Noise.

BSi. (2009/2014). BS 5228-2:2009+A1:2014: Code of Practice for Noise and Vibration Control on Construction and Open Sites, Vibration.

BSi. (2013). Electroacoustics, Sound Level Meters Specifications.

BSi. (2014). BS4142:2014 Methods for Rating and Assessing Industrial and Commercial Sound.

BSi. (2014b). Guidance on Sound Insulation and Noise Reduction for Buildings.

Hayes McKenzie. (2011). Analysis of How Noise Impacts are Considered in the Determination of Wind Farm Planning Applications. Retrieved from https://www.gov.uk/government/publications/analysis-of-how-noise-impacts-are-considered-in-the-determination-of-wind-farm-planning-applications

Highways Agency. (1989). Design Manual for Roads and Bridges. January 2020 updated version retrieved from: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3.htm

IOA. (2013). A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise.
Retrieved from: https://www.ioa.org.uk/sites/default/files/IOA%20Good%20Practice%20Guide%20on%20Wind%20Turbine%20Noise%20-%20May%202013.pdf

ISO. (1996). Acoustics. Attenuation of Sound During Propagation Outdoors - Part 2.

Scottish Government. (2008). PAN 45 Renewable Energy, Annex 2 - Spatial Frameworks and Supplementary Planning Guidance for Wind Farms. Retrieved from https://www2.gov.scot/Publications/2006/10/03093936/0

Scottish Government. (2011a). PAN1/2011: Planning for Noise. Retrieved from https://www.gov.scot/publications/planning-advice-note-1-2011-planning-noise/

Scottish Government. (2011b). Technical Advice Note 1/2011. Retrieved from https://www.gov.scot/publications/technical-advice-note-assessment-noise

Scottish Government. (2014). Onshore Wind Turbines: Planning Advice. Retrieved from https://www.gov.scot/publications/onshore-wind-turbines-planning-advice

Scottish Government. (2014). Scottish Planning Policy. Retrieved from https://www.gov.scot/publications/scottish-planning-policy

The Working Group on Noise from Wind Turbines. (1996). The Assessment and Rating of Noise from Wind Farms. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/49869/ETSU_Full_copy__Searchable_.pdf

Transport Research Laboratory. (2000). Groundborne Vibration Caused by Mechanised Construction Works.

UK Government. (1990). Environmental Protection Act. Retrieved from https://www.legislation.gov.uk/ukpga/1990/43/contents

University of Salford Manchester. (2007). Research into Aerodynamic Modulation of Wind Turbine Noise: Final Report. Retrieved from http://usir.salford.ac.uk/1554/

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