9 Noise

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9 Noise

9.1 Executive Summary

9.1.1 This chapter considers potential noise effects associated with the construction and operation of the Proposed Development. No potential vibration effects have been identified and consideration of vibration has therefore been scoped out. Potential noise effects to ecological receptors arising from marine construction and piling operations are outside the scope of this chapter and are considered separately in Chapter 16 (Underwater Noise Assessment).

9.1.2 The assessment of noise comprised consultation with Orkney Islands Council (OIC) Environmental Health Department, characterisation of the baseline noise environment, prediction of noise levels associated with construction activities, construction traffic, operation of wind turbines and operation of other non-turbine fixed plant, and evaluation of predicted levels against derived criteria, taking into account potential cumulative effects.

9.1.3 Initial predictions to determine the extent of the 35 dB noise contour used to define the study area identified Noise Sensitive Receptors (NSRs) on the western side of Eday. NSRs on Westray were beyond the 35 dB contour and were scoped out of the assessment.

9.1.4 Noise effects from construction, including on-site activities and construction traffic, were found to be not significant. Noise effects from fixed non-turbine plant have been evaluated and determined to be not significant. Likely significant effects associated with operational wind turbine noise were identified at a small number of NSRs at 6 m/s and 7 m/s wind speeds associated with predicted noise levels marginally above derived noise limits.

9.1.5 The Applicant has committed to noise levels associated with operation of the Proposed Development meeting the development-specific noise limits to be agreed through the consenting process at all NSRs. Where necessary, and subject to final turbine selection, a noise management plan will be produced, identifying the curtailment to be enacted at wind speeds and directions at which predicted operational noise levels exceed the consented noise limits. The requirement to implement the noise management plan will be subject to the findings of compliance monitoring. Residual noise effects due to operation are therefore not significant.

9.2 Introduction

9.2.1 This chapter considers the potential noise effects of the Proposed Development on receptors sensitive to noise during the construction phase and the operational phase.

Scope of assessment

9.2.2 The scope of this assessment has comprised the following:

- scoping consultation with OIC Environmental Health Department;
- evaluation of noise effects associated with construction of the Proposed Development;
- evaluation of noise effects associated with operation of the Proposed Development in isolation;
- evaluation of noise effects associated with the operation of the Proposed Development cumulatively with other wind turbines in the study area;
- specification of appropriate mitigation, where necessary; and
- evaluation of residual effects.

9.2.3 Given the separation distances involved between sources and NSRs, vibration associated with construction and operation of the Proposed Development at the closest sensitive receptors will be negligible, therefore vibration has been scoped out of further assessment.

9.2.4 There will be negligible road traffic movements within the study area associated with the Proposed Development, therefore road traffic noise has been scoped out of this assessment.

9.3 Legislation, Policy and Guidelines

9.3.1 Details of relevant legislation, policy and guidelines that have been taken into consideration during the assessment are provided below.

Legislation

9.3.2 For a development of this nature, there is no specific all-encompassing legislation relating to the standards associated with noise emission/effects. Noise legislation, where it does exist, tends to be either EU-derived and focussed on specific items of noise-emitting plant or on more general nuisance, such as that addressed by the provisions of the Environmental Protection Act 1990 and Control of Pollution Act 1974 (UK Government, 1974).)

Environmental Protection Act 1990

9.3.3 Section 79 of the Act defines statutory nuisance with regard to noise and determines that local planning authorities have a duty to detect such nuisances in their area.

9.3.4 The Act also defines the concept of "Best Practicable Means" (BPM):

- 'practicable' means reasonably practicable having regard among other things to local conditions and circumstances, to the current state of technical knowledge and to the financial implications;
- the means to be employed include the design, installation, maintenance and manner and periods of operation of plant and machinery, and the design, construction and maintenance of buildings and structures;
- the test is to apply only so far as compatible with any duty imposed by law; and
- the test is to apply only so far as compatible with safety and safe working conditions, and with the exigencies of any emergency or unforeseeable circumstances.

9.3.5 Section 80 of the Act provides local planning authorities with powers to serve an abatement notice requiring the abatement of a nuisance or requiring works to be executed to prevent their occurrence.

Control of Pollution Act 1974

9.3.6 Section 60 of the Act provides powers to Local Authority Officers to serve an abatement notice in respect of noise nuisance from construction works.

9.3.7 Section 61 provides a method by which a contractor can apply for 'prior consent' for construction activities before commencement of works. The 'prior consent' is agreed between the Local Authority and the contractor and may contain a range of agreed working conditions, noise limits and control measures designed to minimise or prevent the occurrence of noise nuisance from construction activities. Application for a 'prior consent' is a commonly used control measure in respect of potential noise impacts from major construction works.

9.3.8 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. Therefore, this assessment makes reference to a number of British Standards, official planning policy and advice notes and national guidance.

Planning Policy

Scottish Planning Policy

9.3.9 The latest Scottish Planning Policy (Scottish Government, 2014a) details policies relating to renewable energy. The SPP recognises the need to facilitate the transition to a low carbon economy

and supports the development of a diverse range of electricity generation from renewable energy sources, noting:

"*Development plans should seek to ensure an area's full potential for electricity and heat from renewable sources is achieved, in line with national climate change targets, giving due regard to relevant environmental, community and cumulative impact considerations.*"

9.3.10 The SPP provides guidance on where wind farms will and will not be acceptable, according to a spatial framework as follows:

- Group 1 – Areas where wind farms will not be acceptable, comprising National Parks and National Scenic Areas;
- Group 2 – Areas of significant protection where wind farms may be appropriate in some circumstances, with consideration required to demonstrate that any significant effects on the qualities of these areas can be substantially overcome by siting, design or other mitigation; and
- Group 3 – Areas with potential for wind farm development, where wind farms are likely to be acceptable, subject to detailed consideration against identified policy criteria, which may include noise.

Regional and Local Planning Policy

9.3.11 Local planning policy is discussed in Chapter 5 of this EIA Report.

Planning Advice Note 1/2011 Planning and Noise

9.3.12 Published in March 2011 and last updated in 2014, the Planning Advice Note (PAN) provides advice on the role of the planning system in helping to prevent and limit adverse effects of noise (Scottish Government, 2014b). 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.

9.3.13 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."

9.3.14 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 2014). The document is summarised in the corresponding section below, and also refers to the use of ETSU-R-97 assessment guidance (discussed in paragraphs 9.3.21 to 9.3.34 below).

9.3.15 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.

9.3.16 With regards to the assessment and control of noise from construction sites the use of BS 5228: 2009 (Parts 1 and 2) is discussed. BS 5228 has been superseded by BS 5228 1:2009+A1:2014: *Code of practice for noise and vibration control on construction and open sites. Noise*. The standard is summarised in paragraphs 9.3.58 to 9.3.64.

9.3.17 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 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.

9.3.18 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+A1:2019 Methods for rating and assessing industrial and commercial sound. The standard is summarised in paragraphs 9.3.48 to 9.3.54.

9.3.19 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' Good Practice Guide (IoA 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.

Guidance

9.3.20 Cognisance has been taken of the following guidance and best practice guidelines.

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

9.3.21 As referenced for use in PAN 1/2011 and the online planning advice for renewable technologies: 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).

9.3.22 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.

9.3.23 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.

9.3.24 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.

9.3.25 For daytime, the suggested limits are 5 dB above the prevailing background noise level determined during quiet daytime periods, or 35 dB(A) to 40 dB(A), whichever is the higher. The absolute criterion between the 35 dB(A) to 40 dB(A) range is selected taking account of three factors:

- The number of dwellings in the neighbourhood of the wind farm;
- The effect of noise limits on the kilowatt hours (kWh) generated; and
- The duration and level of exposure (to noise).

9.3.26 No specific criteria are provided in ETSU for the evaluation of the above factors, however, and the Applicant is required to justify the application of the lower noise limit based on these factors.

9.3.27 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.

9.3.28 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}.

9.3.29 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 10 m 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).

9.3.30 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 the background related element of the noise level limits.

9.3.31 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 dB to 2.5 dB less than the $L_{Aeq,T}$ measured over the same period.

9.3.32 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.

9.3.33 Where noise from the wind farm is tonal, a correction of between 2 dB 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.

9.3.34 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 the proposed development acting alone.

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

9.3.35 The 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-R-97 method to assessing the noise impact of wind turbine developments with a power rating of over 50 kW.

9.3.36 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.

9.3.37 The SBs provide clarification and updated guidance on a range of matters relating to ETSU R-97 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.

9.3.38 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 10 m 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.
- 'Excess amplitude modulation' (i.e. where the wind turbine noise has higher variability with momentary time than the 2 dB(A) – 3 dB(A) considered within ETSU-R-97) is still the subject of research; current practice (at the time of publishing of the IoA GPG) in relation to determining applications for wind turbine developments is to not impose a planning condition specific to this phenomenon.

9.3.39 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*'.

9.3.40 This guidance in relation to cumulative effects is relevant to the assessment of noise from the Proposed Development because it is proposed in the vicinity of a number of other operational wind turbines.

9.3.41 In the section titled '*existing windfarm/s, consented to the total ETSU-R-97 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*".

9.3.42 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. In most cases this approach will result in a highly restrictive noise limit.

9.3.43 It is, however, then 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. Additionally, this can apply 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.

9.3.44 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-R-97 limits between the concurrent developments, i.e. each of the developments could be subject to noise limits below the full ETSU-R-97 guidance, such that even if the individual limits applied to each development were utilised 'in full', the combined effect would be that the ETSU-R-97 guidance would not be exceeded cumulatively.

9.3.45 A method is provided for determining the effect of directivity, such that reductions attributable to individual turbines at specific receptors may be determined for when the receptor is under cross-wind or up-wind orientation with respect to the turbine.

9.3.46 A set of supplementary guidance notes (SGNs) also form part of the IoA GPG and include further specific detail for different technical areas. SGN6 addresses prediction of noise via propagation over water and provides the following equation to calculate noise levels at receptors when water accounts for more than 700 m of the distance between source and receptor:

$$L = Ls - 20.Log(r) - 11 + 3 - \Delta La + 10.Log(\frac{r}{700})$$

9.3.47 Where:

- L = L_{A90} sound pressure (noise) level at receptor location
- Ls = sound power level of turbine
- ΔLa = integrated frequency-dependent absorption coefficient, which is a function of r
- r = distance from turbine hub to the receptor location

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

9.3.48 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*".

9.3.49 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 (L_s), 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.

9.3.50 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.

9.3.51 The following guidance is presented regarding the difference between the rating and background levels:

- 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.

9.3.52 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.

9.3.53 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".*

9.3.54 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*".

Design Manual for Roads and Bridges (DMRB)

9.3.55 DMRB (Highways England, 2020) provides standards and advice regarding the assessment, design and operation of roads in the UK. DMRB provides screening criteria, by which percentage changes in traffic flow can be related to a predicted change in road traffic noise and vibration. The guidance also provides significance criteria, by which the percentage of people adversely affected by traffic noise can be related to the total noise or vibration level due to road traffic, or the increase over an existing level.

9.3.56 Previous iterations of DMRB provided screening criteria whereby a change in noise level of 1 $dBL_{A10,18hr}$ is equivalent to a 25% increase or 20% decrease in traffic flow, and a change in noise level of 3 $dBL_{A10,18hr}$ is equivalent to a 100% increase or 50% decrease in traffic flow.

9.3.57 The threshold criteria used for traffic noise assessment during the daytime is a permanent change in magnitude of 1 dB $L_{A10,18hr}$ in the short term (i.e. on opening) or a 3 dB $L_{A10,18hr}$ change in the long term (typically 15 years after project opening). For night time noise impacts, the threshold criterion

of a 3 dB $L_{night,outside}$ noise change in the long term should also apply but only where an $L_{night,outside}$ greater than 55 dB is predicted in any scenario.

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

9.3.58 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.

9.3.59 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.

9.3.60 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.

9.3.61 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.

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

9.3.63 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. Two example assessment methods are presented, these are the 'ABC method' as summarised within Table 9.1 and the '5 dB(A) change' method as described in paragraph 9.3.64.

Table 9.1 – 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
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*			
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*			

9.3.64 With respect to the '5 dB(A) change' method, the guidance states:

"Noise levels generated by construction activities are deemed to be significant if the total noise (pre-construction ambient plus construction noise) exceeds the pre-construction ambient noise by 5 dB or more, subject to lower cut-off values of 65 dB, 55 dB and 45 dB L_{Aeq}, from construction noise alone, for the daytime, evening and night-time periods, respectively; and a duration of one month or more, unless works of a shorter duration are likely to result in significant impact."

9.4 Consultation

9.4.1 Table 9.2 provides details of consultations undertaken with relevant regulatory bodies, together with action undertaken by the Applicant in response to consultation feedback. Copies of relevant consultation correspondence are included in Appendix 9.1.

Table 9.2 – Consultation undertaken

Consultation sent	Consultation response	Applicant action
8th August 2018 Orkney Islands Council Scoping Opinion (refer to Appendix 4.2)	Proposed location on an uninhabited island means noise and vibration impacts are unlikely to cause significant concern to human receptors. Environmental Health required the use of ETSU-R-97 (including Institute of Acoustics GPG/SGN) based methodology and general approach. OIC Environmental Health note that the propagation of noise between turbines and noise sensitive receptors will predominately be over water, as such the developer should have due regard to 'IoA SGN 6: Noise propagation over water for on-shore Wind Turbines'.	Accepted comments and agreed approach
28th February 2020 Email to Environmental Health Department at OIC. Proposed baseline survey locations on Eday and Westray and set out proposed approach to assessment	**2nd March 2020** Noted that baseline measurements on Westray may not be required if predicted levels below 35 dB at receptor locations Accepted proposed monitoring locations and specified that two rain gauges would be required, given the geographical separation of monitoring positions on Eday and Westray Noted other potential noise sources on Eday which should be considered when reporting baseline conditions.	Accepted comments and agreed approach
22nd January 2021 Email to Environmental Health Department at OIC. Provided details of approach to apportionment of cumulative noise limits, including calculation detail for comment	**31st March 2021** Agreed approach to derivation of noise limits is acceptable/appropriate – caveated that detailed checking of the arithmetic not yet completed.	Accepted comments and agreed approach

Consultation sent	Consultation response	Applicant action
7th August 2020 Email to Environmental Health Department at OIC. Proposed revised baseline survey locations following response from residents to requests to site monitoring equipment on Eday, scoped out monitoring on Westray and set out proposed approach to treatment of baseline data	**7th August 2020** Accepted monitoring locations and outline approach	Accepted comments and agreed approach

9.5 Assessment Methodology and Significance Criteria

Consultation

9.5.1 Details of consultation with OIC are provided in Section 9.4.

Study Area

9.5.2 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 considered cumulative developments. NSRs at which noise limits have been set for cumulative developments have been identified for the evaluation of potential cumulative effects. NSRs identified are either single dwellings or representative of a group or cluster of dwellings.

9.5.3 Determination of the study area for a wind farm typically requires that the 35 dBL_{A90} noise contour is predicted, and 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.

9.5.4 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 9.1. The contour relies on predictions in accordance with ISO9613 over an acoustically reflective surface (representative of water), rather than the propagation over water method provided in SGN6 the IoA GPG and has therefore been used as a screening tool only.

9.5.5 The 35 dB contour in Figure 9.1 demonstrates that predicted noise levels are below 35 dB at all NSRs. The NSRs considered in this assessment lie outside the 35 dBL_{A90} noise contour but are included to account for potential cumulative effects and the more conservative prediction method provided in the IoA GPG SGN6. The representative NSRs considered in the assessment are listed in Table 9.3.

Table 9.3 – Identified representative NSRs

NSR name	NSR ID	Grid reference (OSGB)	
		X	Y
Crowber	NSR1	355216	1037385
Lesshamar	NSR2	355146	1037057
North Guith	NSR3	354993	1036574
Mid Guith	NSR4	355265	1036568
Benstonhall	NSR5	355369	1036359
Bredakirk	NSR6	355497	1036256
Shoehall	NSR7	355623	1036225
Newark	NSR8	355815	1036031
Fers Ness	NSR9	353042	1033772
High Hill	NSR10	354005	1033336

9.5.6 The island of Westray lies to the north-west of Faray and the Proposed Development. All potential NSRs on Westray are outside the preliminary 35 dB contour, and a supplementary calculation undertaken in accordance with the IoA GPG SGN6 confirmed that predicted worst-case noise levels at the closest NSR on Westray to the Proposed Development will not exceed 32.6 dBL_{A90}. As such, the Proposed Development will meet the simplified ETSU 35 dB noise limit at all NSRs on Westray.

9.5.7 As noted in Table 9.2, this was confirmed with OIC's EHO, and they confirmed that no baseline monitoring was therefore required on Westray, and that noise limits applicable to the Proposed Development at Westray NSRs would be the 'flat' simplified ETSU 35 dB noise limit. Further evaluation of potential noise effects at Westray NSRs has therefore been scoped out of this assessment.

Baseline Noise Survey

9.5.8 A baseline survey was undertaken at two locations to characterise baseline noise levels at representative NSRs within the study area. The noise monitoring positions (NMPs) used are provided in Table 9.4 and shown on Figure 9.2.

Table 9.4 – Baseline noise monitoring positions

NMP name	NSR ID	Grid reference (OSGB)	
		X	Y
Shoehall	NMP1	355650	1036251
Fers Ness	NMP2	353070	1033775

9.5.9 The baseline survey was completed over the period 18th August to 29th September 2020.

9.5.10 The sound level meters (SLMs) used were compliant with Class 1 specification, as described in BS EN 61672-1:2003. The calibration of the SLMs was checked in the field before and 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 for the SLMs and calibrator are provided in Appendix 9.2.

9.5.11 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.

9.5.12 There is an existing small turbine at Fers Ness, and the monitoring location at Shoehall is within 350 m of two small turbines; one at Bredakirk and one at Newark. When micro-siting the noise monitoring positions, consideration was given to making use of screening by buildings, such that noise from existing turbines at the NMPs was minimised. The treatment of baseline data to account for the noise contribution of existing turbines is discussed in para. 9.5.17 - 9.5.38. The locations of the existing turbines are shown in Figure 9.2.

9.5.13 The monitoring locations are described as follows:

- NMP1 Shoehall – SLM installed within the curtilage of a steading, in a paddock to the north of the property. The SLM was sited more than 3.5 m from any façades, and the house and its associated outbuildings were used to provide screening to noise from the closest existing turbine, sited at Bredakirk. There was line of sight from the NMP to the more distant turbine at Newark. A rain gauge was installed adjacent to the SLM. Weather conditions during installation were dry, foggy, with moderate wind speeds. The NMP was down-wind of the Bredakirk turbine during the installation, and the turbine was audible at nearby locations, but as a result of the screening provided by the steading it was inaudible at the NMP.
- NMP2 Fers Ness – SLM installed within a paddock immediately to the south of the farmhouse, positioned such that the SLM is at least 3.5 m away from any facades and protected from livestock. Weather conditions during installation were dry, foggy, with moderate wind speeds. The SLM was sited such that the steading and associated barns provided screening to noise from the single turbine to the north of the farm. The turbine was not audible at the monitoring position during the site visit.

9.5.14 Full details of the monitoring locations and photographs of the equipment in-situ are provided in Appendix 9.3.

9.5.15 With reference to Figure 9.2, NMP1 has been used to represent baseline noise levels at NSR1 – NSR8, and NMP2 has been used to represent baseline noise levels at NSR9 and NSR10.

9.5.16 Wind speed data was gathered using a Lidar device, sited on Faray close to the centre of the island (refer to Figure 9.2). Wind speeds were measured at multiple heights above the local ground level of 25 m, including at the candidate turbine hub height of 80 m.

Derivation of Representative Background Noise Levels

9.5.17 There are numerous small turbines on Eday, and exclusion of noise from these turbines from the measured baseline noise levels was necessary to derive a representative background noise level for the setting of appropriate noise limits. The baseline data has therefore been corrected by screening, and screened levels have been compared with predicted noise levels for the existing small turbines. The processes followed to derive a background level which excludes noise from existing turbines is described below.

9.5.18 Measured wind-speed data required to be 'cleaned' before further evaluation of baseline data was undertaken. The LIDAR device recorded erroneous data during poor visibility weather conditions, and also suffered occasional power outages during the measurement campaign. Following data cleaning the total number of datapoints met the minimum requirements of the IoA GPG.

9.5.19 Turbines with the potential to influence noise levels in the vicinity of the monitoring locations were identified using OIC's planning portal and, where possible, confirmed visually during the commissioning and decommissioning visits. Details of the turbines, including their sound power levels and coordinates were also obtained from the planning portal.

9.5.20 Wind turbines are directional noise sources and the IoA GPG provides a method whereby the reduction attributable to the sound pressure level at a given location can be determined for situations where a receptor is in cross-wind to up-wind orientation to turbines. The scale of reduction is dependent on the proximity of the turbine to the receptor location, determined using a ratio of the tip height of the turbine to separation distance between the turbine and receptor. Both NMP1 and NMP2 were located such that the separation distance to tip height ratio was 12 or greater, at which the applicable reduction to turbine noise in up-wind conditions is approximately 9 dB[1].

9.5.21 To minimise the effect of noise from existing turbines, baseline data was screened to exclude wind directions when the NMPs were down-wind of the turbines. The identified turbines and the wind directions excluded are shown in Figure 9.3. With reference to Figure 9.3, NMP1 is potentially affected by noise from turbines at Bredakirk to the south-west and Newark to the south-east. Baseline data from NMP1 was split between down-wind conditions, collected under wind directions 35° - 340° and up-wind conditions, collected under wind directions 340° – 35°.

9.5.22 NMP2 is potentially affected by noise from a single turbine at Fers Ness to the north of the NMP. Baseline data from NMP2 was split between down-wind conditions, collected under wind directions 270° - 90° and up-wind conditions, collected under wind directions 90° – 270°.

9.5.23 The background noise level under up-wind conditions and down-wind conditions were then compared to determine the potential contribution of wind turbines. Charts showing the comparison are provided in Appendix 9.4. The charts show background noise relative to the measured 10 m height wind speed[2], therefore are not directly comparable to the ETSU derived noise limits which use hub height wind speeds corrected to 10m.

NMP1

9.5.24 With reference to Figure 9.2, when NMP1 was down-wind of the existing turbines it was also down-wind of the sea, but also received screening of noise and wind by the buildings of Shoehall. Conversely, when NMP1 was up-wind of the turbines it received no screening from the buildings and was therefore exposed to the wind. When the NMP would be expected to receive the most noise from the sea, it also received maximum screening by the buildings.

9.5.25 With reference to Chart 9.1 in Appendix 9.4, the daytime background noise level at NMP1 showed a difference of up to 3 dB between up-wind and down-wind conditions. Chart 9.2 shows the night-time period, for which there are more datapoints at lower wind speeds than during the daytime. In Chart 9.2 a difference of up to 5 dB between up-wind and down-wind conditions is evident at wind speeds of 5 – 7 m/s. The difference is primarily attributed to wave noise.

9.5.26 NSRs for which baseline data collected at NMP1 is a proxy will only ever be down-wind of the Proposed Development and the sea simultaneously, therefore exclusion of conditions when the NMP was down-wind of the sea is a highly robust measure to defining representative background noise levels.

NMP2

9.5.27 With reference to Figure 9.2, NMP2 lies on a peninsula and was therefore down-wind of the sea under most wind directions. NMP2 was screened from noise and wind by the buildings of Fers Ness under northerly wind directions, when the NMP was down-wind of the turbine. When the NMP would be expected to receive the most noise from the turbine, it also received maximum screening by the buildings.

9.5.28 With reference to Chart 9.3 in Appendix 9.4, the daytime background noise level at NMP2 showed little difference between up-wind and down-wind conditions. During the night-time period

[1] IoA GPG Figure 6 a) – assumed relationship of change of noise levels with wind direction, flat landscapes.

[2] Measured 10 m height wind speed given that that existing turbines have hub heights of 15 m – 17.8.

(Chart 9.4 in Appendix 9.4), where there are more datapoints at lower wind speeds, a difference of up to 5 dB is evident at wind speeds of 4 - 8 m/s.

Findings of Screening Process

9.5.29 Both NMPs were positioned such that buildings would provide maximum screening to turbine noise under down-wind conditions. Comparison between background noise levels showed a difference of up to 5 dB between up-wind and down-wind conditions, with the greatest difference at wind speeds of approximately 4 m/s – 8 m/s.

Verification by Prediction

9.5.30 The potential contribution of the small turbines to measured background noise levels was determined using the following process:

- Using details for existing turbines obtained from the OIC planning portal, a noise model was constructed within CadnaA noise prediction software.
- Noise levels arising due to the small turbines during down-wind (i.e. worst case) conditions were predicted at the NMPs. The effect of screening by the closest buildings was included within the noise model, based on the surveyor's observations of the audibility of turbines at the monitoring locations.
- The predicted level due to the turbines was then logarithmically subtracted from the derived background noise level under down-wind conditions (i.e. when the contribution from the turbines was at a maximum) to derive a 'corrected background level', with the contribution of the turbines removed.
- The potential contribution of the small turbines to background noise levels was then determined by subtraction of the corrected background noise level from the derived un-corrected level.

9.5.31 The results of the process are provided in Appendix 9.5. At NMP2 the potential contribution of the small turbines to the background level was determined to be less than 0.5 dB across the range of wind speeds (up to 10 m/s), both during the daytime and the night-time. This is considered to be within the range of prediction and measurement error, and no further correction has been made to background noise levels.

9.5.32 At NMP1 the potential contribution of the small turbines to the background level was determined to be less than 0.5 dB across the range of wind speeds (up to 10 m/s) during the night-time period. Accordingly, no further correction has been made to background noise levels.

9.5.33 At NMP1 during the daytime period, the potential contribution of small turbines to the background level ranged from 0.6 dB at 8 m/s and 9 m/s, up to a maximum of 4.5 dB at 12 m/s. In the mid wind speeds of 6 – 10 m/s the difference was ≤1 dB and is considered to be within the range of prediction and measurement error, and no further correction has been made to background noise levels.

9.5.34 At low wind speeds of 4 and 5 m/s the potential contribution of small turbines to measured levels was 1.4 dB and 1.3 dB, respectively. The measured background level at these wind speeds was substantially below the daytime Fixed Minimum Limit of 35 dB, and any correction would result in no change to the overall noise limit.

9.5.35 No correction has been made at wind speeds of 11 m/s and above, as the larger differences at these wind speeds are attributed to the smaller number of datapoints captured at higher wind speeds and the nature of the sound power data for the small turbines, which is quoted as a single value at 8 m/s, and a rate of change per 1 m/s wind speed above and below this value.

9.5.36 Given the remote, rural nature of the study area and the low prevalence of non-turbine anthropogenic noise, this assessment considers that the contribution of the existing turbines to background noise levels may be most accurately determined by reference to the night-time period,

where there were more datapoints captured and trends are therefore more clearly evident. At both NMP1 and NMP2, the contribution has therefore been determined to be negligible.

9.5.37 On the basis of the above, no corrections have been applied to standardised 10 m wind speed data collected under up-wind conditions in the derivation of the representative background noise level.

Corrections applied to baseline data

9.5.38 The directional filters described above have been applied to baseline data derived from hub height wind speeds to 10 m to determine the representative background noise level. The results of this analysis are provided in Section 9.6.

Construction Phase Noise

On-site Construction Activities; Method of Prediction

9.5.39 A detailed breakdown of the construction schedule and plant for the Proposed Development is not yet available. Drawing on experience of previous wind farm development, and preliminary information available, the following assumptions have been made in the prediction of construction noise:

Working hours

9.5.40 The proposed hours of operation for the construction phase are 07:00 – 20:00, 7 days a week.

Construction plant:

Site origination

- 4 x 7.5T excavators (BS 5228 Table C2, Item 8)
- 4 x tractors and trailers (BS 5228 Table C4, Item 75)

Slipway works

- 1 x barge-mounted piling rig for sheet pile (BS 5228 Table C3, Item 2)
- 1 x 35T excavator (BS 5228 Table C3, Item 23)
- 1 x concrete pump (BS 5228 Table C4, Item 26)
- 1 x cement truck (BS 5228 Table C4, Item 21)

Access tracks and turbine hardstandings

- 1 x 32T excavator (BS 5228 Table C2, Item 15)
- 3 x 7T dump trucks (BS 5228 Table C4, Item 3)
- 1 x 18T roller (BS 5228 Table C2, Item 38)

Turbine bases and borrow pits

- 1 x concrete batching plant (BS 5228 Table C4, Item 22)
- 1 x hydraulic breaker (BS 5228 Table C1, Item 9)
- 1 x 32T excavator (BS 5228 Table C2, Item 15)
- 1 x 7.5T excavator (BS 5228 Table C2, Item 8)
- 1 x concrete pump (BS 5228 Table C3, Item 26)
- 1 x cement truck (BS 5228 Table C4, Item 20

Turbine installation

- 1 x 400T crane (BS 5228 Table C4, Item 38)
- 1 x road wagon (BS 5228 Table C11, Item 4)

Other assumptions

- all plant has been assumed to operate continuously (100 % utilisation) throughout the working hours;
- all plant has been placed at the closest distance of approach of each construction activity to the closest NSR, within the area of proposed construction activity;
- noise levels have been predicted in accordance with the BS 5228 prediction method;
- Ground absorption of G=0, representative of an acoustically reflective surface has been assumed for all areas of water, G=1 for all areas of land; and
- construction plant has been assumed to have an effective height of 2 m above local ground level.

9.5.41 The closest NSR to the assumed worst-case construction activities is NSR3 North Guith. Noise levels, and therefore the magnitude of impacts associated with construction activities, will be lesser at NSRs further from the Proposed Development, therefore noise impacts associated with the construction phase have been evaluated using predicted levels at NSR3.

Derivation of Construction Phase Noise Limits

9.5.42 The predicted site preparation / construction noise levels have been assessed based on noise level criteria determined following a worst-case interpretation of the guidance contained within BS5228. As detailed within Section 9.3, BS5228 details three example methods for determining the significance of potential construction noise impacts. With regard to the presented absolute noise level criteria (example method 1), following a worst-case approach, the lowest absolute noise level criterion for the daytime period (07:00 to 19:00) is 70 dB(A) façade, (equivalent to 67 dB(A) free field), which is stated to apply in rural areas.

9.5.43 Following the ABC assessment method, and noting the low levels of ambient noise, the most stringent assessment criterion (Category A) applies during the daytime, evening and night-time periods (refer to Table 9.1).

9.5.44 Criteria have been derived drawing on the above and are provided in Table 9.8 within the Impact Magnitude section.

Operational Phase Noise

General Method of Prediction

9.5.45 Given that the island of Faray is uninhabited, and the surface between turbines and NSRs is predominantly water, all predictions have been undertaken using the prediction method provided in the IoA GPG SGN6 (refer to para. 9.3.46 - 9.3.47).

9.5.46 SGN6 of the IoA GPG does not specify how the sound power level of the turbine should be treated with regard to derivation to 10 m or uncertainty, therefore this assessment assumes that both of these aspects should be undertaken, in accordance with the wider application of the IoA GPG method.

9.5.47 With reference to 9.3.47 the ΔLa corrections were obtained from ISO9613 for an air temperature of 10^{o}C and relative humidity of 70%.

9.5.48 Given the generally flat-lying topography of Faray and the extent of water between the turbines and NSRs, no corrections for concave topography or topographic screening apply.

Proposed Development

9.5.49 The Proposed Development comprises six turbines. This noise assessment is based on the Vestas V136 candidate turbine, which has a hub height of 80 m and a serrated trailing edge of the turbine blades to reduce noise. The source noise terms of the Vestas V136 have been provided by Vestas as 1/3 octave band data, quoted as sound power levels over a range of operational hub-height wind speeds. This may not be the final turbine chosen for the Proposed Development, but the Applicant will ensure any change in turbine meets the noise levels detailed within this assessment.

9.5.50 The 1/3 octave band data has been accumulated into octave-band data and standardised to 10 m height wind speeds, and an appropriate uncertainty correction of 2 dB has been applied to the sound power levels in accordance with the requirements of the IoA GPG. The resultant source noise terms for the Vestas V136 are provided in Table 9.5.

Table 9.5 – Sound power levels of the Vestas V136

Wind speed, m/s	Sound power level standardised to 10 m height wind speed, dB(A)
3	93.4
4	96.7
5	101.5
6	105.3
7	105.9
8	105.9
9	105.9
10	105.9
11	105.9
12	105.9

9.5.51 The Vestas V136 operates at its maximum sound power level at wind speeds of 7 m/s and above.

9.5.52 Octave-band data for the turbine at height of 10 m for a wind speed of 9 m/s is provided for reference in Table 9.6.

Table 9.6 – Octave band sound power levels at 9 m/s wind speed

Octave band centre frequency, Hz	31.5	63	125	250	500	1000	2000	4000	8000
Sound power level, dB(A)	76.2	86.8	94.5	99.2	101.0	99.9	95.8	88.9	78.8

9.5.53 The proposed turbine layout is shown in Figure 9.1.

Cumulative Noise

Identification of Cumulative Developments

9.5.54 A review was undertaken of existing and proposed wind energy developments in the vicinity of the site, using information available on the OIC planning portal and in consultation with Environmental Health. 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. The identified cumulative developments are as follows:

- Newark Wind Turbine
  - Planning reference 11/727/TPP
  - Evance R9000
  - Height 15 m
  - Operational
  - Noise limits – simplified ETSU: 35 $dBL_{A90,10min}$ at the nearest noise sensitive property
- Bredakirk Wind Turbine
  - Planning reference 13/430/TPP
  - Evance R9000
  - Height 17.8 m
  - Operational
  - Noise limits – simplified ETSU: 35 $dBL_{A90,10min}$ at the nearest noise sensitive property
- Fers Ness Wind Turbine
  - Planning reference 11/487/TPP
  - Evance R9000
  - Height 15 m
  - Operational
  - Noise limits – simplified ETSU: 35 $dBL_{A90,10min}$ at the nearest noise sensitive property
- Heritage Centre Wind Turbine
  - Planning reference 07/583/PPF
  - 6 kW
  - Height 15 m
  - Operational
  - Noise limits – simplified ETSU: 35 $dBL_{A90,10min}$ at the nearest noise sensitive property
- New Brimbanks Wind Turbine
  - Planning reference 13/422/TPP
  - Evance R9000
  - Height 17.8 m
  - Operational
  - Noise limits – simplified ETSU: 35 $dBL_{A90,10min}$ at the nearest noise sensitive property
- South House Wind Turbines
  - Planning reference 11/694/TPP

- Evance R9000
- Height 18 m
- Operational
- Noise limits – simplified ETSU: 35 $dBL_{A90,10min}$ at the nearest noise sensitive property

- North Panhouse
  - Planning reference 11/234/TPP
  - Evance R9000
  - Height 18 m
  - Operational
  - Noise limits – simplified ETSU: 35 $dBL_{A90,10min}$ at the nearest noise sensitive property

9.5.55 Cumulative turbines considered in this assessment are shown in Figure 9.2.

9.5.56 Where it is not explicitly stated in the planning conditions that the financially involved (FI) noise limit of 45 $dBL_{A90,10min}$ applies at the associated property, this assessment assumes that the FI limit applies.

Review of Cumulative Noise Limits

9.5.57 Consented noise limits for the identified cumulative developments are in accordance with the 'simplified ETSU' approach, whereby noise levels due to small individual turbines or clusters of small turbines are conditioned to a simplified noise limit of a 'flat' 35 $dBL_{A90,10min}$ across the range of wind speeds at all properties not FI with the turbines.

Derivation of Noise Limits at NSRs where Potential Cumulative Effects Identified

9.5.58 The evaluation of operational wind turbine noise is a multi-stage process, which is necessarily highly technical in nature. The process is particularly complex where cumulative noise from existing or proposed/consented turbines requires consideration. The stages are summarised as follows:

- **Identify potentially cumulative developments** – refer to para. 9.5.54 and Figure 9.2;
- **Identify NSRs at which cumulative effects may occur** – Review worst-case predicted noise levels from existing turbines at all NSRs, and screen out NSRs at which significant cumulative effects will not occur (i.e. predicted noise levels from existing turbines are not within 10 dB of consented noise limits and/or are not within 10 dB of predicted noise levels from Proposed Development) from further consideration of cumulative effects;
- **Derive Overall Noise Limits (ONLs) from measured background noise levels for the daytime and night-time period** – refer to para. 9.5.17 - 9.5.23. Note that the noise limits are derived using background noise levels which exclude the contribution of noise from existing wind turbines at the baseline noise monitoring locations to determine 'true' baseline.
- **Apportion the ONL to determine the applicable site-specific Residual Noise Limit (RNL) at each NSR, accounting for the Consented Noise Limits (CNLs) of existing and consented cumulative developments and their predicted contribution to cumulative noise levels –** RNLs have been derived from ONLs using the following process:
  - Where the predicted level from cumulative turbines is ≥10 dB below the simplified ETSU 35 dBL_{A90} CNL, the RNL is the same as the ONL;
  - Where the predicted level from cumulative turbines is <10 dB below the simplified ETSU 35 dBL_{A90} CNL, the RNL is equal to the ONL minus the CNL;

- Where the CNL and the ONL are very similar (i.e. <2 dB different), the available RNL as determined using the process described above is highly restrictive, and results in noise limits substantially below the 35 dB simplified ETSU limit. The following additional stage has been taken in such instances:
- Where significant headroom (≥5 dB) is available between the predicted noise level of cumulative turbine and its CNL, the RNL has been determined by subtracting a 'cautious prediction' (predicted noise level of cumulative turbines +2 dB[3]) from the ONL;
- At NSRs which are assumed to be FI with one or more of the existing cumulative turbines, but not with the Proposed Development (FI NSRs), noise limits have been set using the same process, where the cautious prediction excludes the contribution of the NSR's own turbine(s).
- At these FI NSRs the RNL of the FI ONL (FI RNL) has also been derived; and
- The applicable RNL at FI NSRs is the lower of the RNL and the FI RNL, such that neither the FI nor the non-FI ONLs are exceeded at these properties.

9.5.59 The approach to deriving the RNLs described above has been complicated by the presence of existing small turbines with 'flat' 35 dB noise limits. Initial predictions for these turbines based on the available information showed that these turbines were producing noise levels at or above 35 dB at the owning NSRs, such that there would be limited headroom for the Proposed Development to operate.

9.5.60 The applicable overall noise limit at NSRs which operate their own turbines could be assumed to be the FI noise limit of 45 dB, however, the Proposed Development cannot rely on FI noise limits at NSRs with which it is not FI, as the operation of the wind farm would then rely on matters outside of the operator's control. For example; should RNLs be set for the Proposed Development be set on the basis of a FI ONL, these would cease to be appropriate if the small turbines were to be decommissioned and the RNL would have to be revised.

9.5.61 At NSRs which have their own turbine, the RNL derivation process followed in this assessment determines the headroom available within the non-FI ONL to the Proposed Development, accounting for other cumulative turbines but excluding noise from the turbines with which the NSR is FI.

9.5.62 This allows an appropriate noise limit to be set for the Proposed Development, which does not rely on FI limits at properties affected by noise from their own turbines, and means that should their own turbines be decommissioned then noise limits at these NSRs would not need to be revised.

9.5.63 The final stage of the process considers the cumulative noise level including the contribution of the turbines owned by the FI NSRs. RNLs have been calculated such that the assumed background-derived FI ONL is not exceeded, for the protection of residential amenity. Where this FI RNL is lower than the non-FI RNL, the lower of the two RNLs has been selected.

Assessment of Potential Effect Significance

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

Receptor Sensitivity

9.5.65 The guidance contained within Technical Advice Note to PAN 1/2011 has been drawn upon in the generation of an appropriate set of significance criteria. The receptor sensitivity criteria for the construction, operational and decommissioning phases of the Proposed Development are

[3] *Where the cautious prediction exceeds the simplified ETSU 35 dB noise limit at non-FI NSRs, the noise level due to existing turbines has been assumed to meet the 35 dB CNL*

considered to be the same. These are presented within Table 9.7 and are applicable to both noise and vibration effects.

Table 9.7 – Noise and vibration 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.
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.

Impact Magnitude - Construction Noise

9.5.66 The construction noise impact magnitude has been determined according to the threshold levels provided in Table 9.8.

Table 9.8 – Evaluation criteria for noise from construction activities (predicted façade level), weekday daytimes (08:00 – 18:00) and Saturdays 08:00 – 12:30

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

Impact Magnitude - Operational Wind Turbine Noise

9.5.67 For noise from the proposed wind turbines once operational, the impact magnitude scale has been derived based on the guidance contained with ETSU-R-97. It is considered that where cumulative wind turbine noise meets the applicable noise limits (and is up to 10 dB below the limits), an impact magnitude of low would arise. Where cumulative wind turbine noise falls ≥10 dB below the applicable limits, the impact magnitude is considered to be negligible. Where cumulative wind turbine noise exceeds the applicable limits by up to 5 dB, an impact magnitude of medium is considered to arise. Where the there is an exceedance of a limit by >5 dB, an impact magnitude of high is considered to arise. These criteria are summarised in Table 9.9.

Table 9.9 – Impact magnitude scale – wind turbine noise

Difference (d) between predicted turbine noise level and applicable limit, dB	Impact magnitude
d ≥+5	High
0 ≤ d < +5	Medium

Difference (d) between predicted turbine noise level and applicable limit, dB	Impact magnitude
-10 ≤ d < 0	Low
d <-10	Negligible

Impact Magnitude - Fixed (Non-turbine) Plant Noise

9.5.68 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.

9.5.69 The impact magnitudes associated with noise generated from fixed plant are presented in Table 9.10.

Table 9.10 – Impact magnitude for fixed (non-turbine) plant noise

Difference between Rating Level ($L_{Ar,Tr}$) and Background Sound Level (L_{A90})	BS4142 Guidance	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

9.5.70 The effect significance has been determined by consideration to both the receptor sensitivity and the impact magnitude according to the matrix detailed in Table 9.11.

Table 9.11 – Effect significance matrix

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

9.5.71 This assessment considers all identified NSRs to be of 'high' sensitivity in accordance with Table 9.7, given that they are residential dwellings. This assessment considers that effects with a significance

of 'moderate' and 'major' are significant and effects with a significance of 'neutral' and 'minor' are not significant.

Requirements for Mitigation

9.5.72 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 professional judgement and the implementation of best practice.

Assessment of Residual Effect Significance

9.5.73 Residual effects have been assessed following the methods described above but taking into account the committed mitigation measures.

Limitations to Assessment

9.5.74 Detailed information on techniques and equipment for the construction phase of the Proposed Development is not currently available. Consequently, appropriate and robust assumptions have been made regarding the nature of likely construction activities and plant, and noise predictions made accordingly. It is therefore anticipated that predicted noise levels represent the "worst case" potential construction noise levels.

9.5.75 The assessment of operational impacts associated with the wind turbines has been undertaken adopting source noise levels for the Vestas V136. Following completion of the tendering process, it is possible that the precise turbine make / model adopted and / or the operational mode will change from that adopted within the assessment. It should be noted, however, that the final turbine model chosen will be selected to ensure compliance with the derived noise level limits.

9.6 Baseline Conditions

Wind Conditions

9.6.1 Wind speed data was checked for quality on receipt and it was identified that when the Lidar device was displaying an error (e.g. temporary shut-down arising from battery outage), then a wind speed of 999 or 0 m/s was displayed. All wind speeds <1 m/s and other erroneous data (e.g. 999) were therefore excluded from further analysis.

9.6.2 A wind rose of measured wind speeds and directions derived to 10 m above ground level over the period of the baseline survey is provided in Chart 9.5 in Appendix 9.4. The wind rose shows that the most commonly occurring wind speeds were in the range 5 m/s – 10 m/s and the most prominent wind directions were south-south-easterly and south-westerly.

Description of Baseline Noise Environment

9.6.3 Time-history charts of the measured ambient[4] (L_{Aeq}) and background[5] (L_{A90}) noise levels for each monitoring location are provided in Appendix 9.4. Periods of rainfall-affected data, which have been screened out of subsequent analysis, are shown in dark blue.

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[4] Ambient level – the equivalent continuous sound pressure level of the totally encompassing sound in a given situation at a given time, usually from multiple sources, at the assessment location over a given time interval, T.

[5] Background level - the A-weighted sound pressure level that is exceeded for 90 percent of a given time interval, T. The background level is unaffected by short-duration, noisy events, and is therefore representative of the lowest-occurring noise levels in a given noise environment. This noise index is used in the evaluation of the baseline noise environment and predicted noise levels from wind turbines in wind farm noise assessments.

9.6.4 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 9.4 for both NMPs. The proposed hub height of 80 m was used to derive the 10 m wind speed for correlation with background noise levels. The charts show the wind-dependent background noise level, the 'background +5 dB' criterion and the derived noise limits. Rainfall-affected data has been screened out, in accordance with the IoA GPG (i.e. with the periods preceding and after the recorded rainfall also excluded).

NMP1 – Shoehall

9.6.5 The dominant noise source observed during the installation was the wind, with lesser contributions from wind-induced rustling of vegetation, bird calls and distant waves. The small wind turbine at Newark, which was up-wind of the NMP during installation, was barely audible.

9.6.6 A time-history graph of measured ambient and background levels and rainfall events is provided as Chart 9.6 in Appendix 9.4. The following observations are noted regarding 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;
- the variation in ambient and background levels closely tracks the variation in wind speed;
- there is no clear diurnal variation and the primary control on noise levels is attributed to weather and sea conditions, rather than time of day;
- straight lines in the chart during the period 18th – 21st September are representative of gaps in the data, caused by errors with the LIDAR device; and
- there were relatively few rainfall events.

9.6.7 This was the closer of the two NMPs to Eday (London) Airport, however, no evidence of noise from aircraft was evident in the data.

9.6.8 The measured quiet daytime and night-time background noise levels for NMP1 correlated to wind speed are provided in Appendix 9.4. Chart 9.7 shows the quiet daytime period and Chart 9.8 the night-time period. The datasets have been split between 'up-wind' and 'down-wind' conditions, using the process described in para. 9.5.21 and only the up-wind data is shown. Given the very limited rainfall during the survey, excluded rainfall-affected data is not shown on the chart.

9.6.9 The following observations are noted regarding the correlation of noise and wind speed data, and the derivation of noise limits:

- There are a substantial number of datapoints across the range of operational wind speeds up to the wind speed at which the turbine reaches its maximum sound power level (7 m/s at 10 m), both during the daytime and night-time period. The data fulfils the minimum requirements of the IoA GPG;
- The datapoints in Chart 9.7 (daytime) generally lie close to the trendline. There is no banding of the data, and no outliers;
- Overall Noise Limits (ONLs) for NSRs which are not FI with the Proposed Development have been derived based on the 35 dB ETSU fixed minimum daytime limit up to the maximum wind speed for which data is available (10 m/s);
- The datapoints in Chart 9.8 (night-time) show slightly greater variability, however, this is attributed to the greater number of datapoints. There is no banding of the data, and no obvious outliers; and
- ONLs for NSRs which are not FI with the Proposed Development have been derived based on the 43 dB ETSU fixed minimum night-time limit up to the maximum wind speed for which data is available (10 m/s).

NMP2 – Fers Ness

9.6.10 The dominant noise source observed during the installation of the NMP was cattle in the adjacent field, with lesser contributions from bird calls including farm geese and wild birds and distant farm machinery operating. The small wind turbine at Fers Ness was inaudible at the monitoring position during commissioning under up-wind conditions. This was the closer of the two NMPs to the Enercon E44 and the hydrogen production facility mentioned by the EHO, however, the NMP was determined to be substantially beyond the distance at which either of these would be audible.

9.6.11 A time-history graph of measured ambient and background levels and rainfall events is provided as Chart 9.9 in Appendix 9.4. The following observations are noted regarding 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 or animal activities;
- the variation in ambient and background levels closely tracks the variation in wind speed;
- there is no clear diurnal variation and the primary control on noise levels is attributed to weather and sea conditions, rather than time of day;
- straight lines in the chart during the period 18th – 21st September are representative of gaps in the data, caused by errors with the LIDAR device; and
- there were relatively few rainfall events.

9.6.12 The measured daytime and night-time background noise levels for NMP2 correlated to wind speed are provided in Appendix 9.4. Chart 9.10 shows the daytime period and Chart 9.11 the night-time period. The data has been split between 'up-wind' and 'down-wind' conditions, using the process described in para. 9.5.21 and only the up-wind data is shown. Given the very limited rainfall during the survey, excluded rainfall-affected data is not shown on the chart.

9.6.13 The following observations are noted regarding the correlation of noise and wind speed data, and the derivation of noise limits:

- There are a substantial number of datapoints across the range of operational wind speeds up to the wind speed at which the turbine reaches its maximum sound power level (7 m/s at 10 m), both during the daytime and night-time period. The data fulfils the minimum requirements of the IoA GPG;
- Datapoints in Chart 9.11 approximately 10 dB above the trendline at wind speeds of approximately 4.5 m/s to 8 m/s are attributed to noise from the sea and are not considered to be significant outliers. There is no banding of the data which may indicate the influence of non-representative noise sources;
- ONLs for NSRs which are not FI with the Proposed Development have been derived based on the 35 dB ETSU fixed minimum daytime limit up to the maximum wind speed for which data is available (10 m/s);
- The datapoints in Chart 9.11 (night-time) show slightly greater variability, however, this is attributed to the greater number of datapoints. There is no banding of the data, and no obvious outliers; and
- ONLs for NSRs which are not FI with the Proposed Development have been derived based on the 43 dB ETSU fixed minimum night-time limit up to the maximum wind speed for which data is available (10 m/s).

Adopted Noise Limits

Construction and decommissioning noise limits

9.6.14 With reference to Appendix 9.4 the daytime baseline ambient levels shown in Chart 9.7 and Chart 9.10, were below 65 dB throughout the survey. During the night-time period, as shown in Chart 9.8 and Chart 9.11 night-time ambient levels were below 45 dB at low wind speeds. The construction phase noise limits in accordance with the ABC method provided in BS5228 therefore fall within Category A, and are as follows:

- **Weekday daytimes, Saturday mornings** – 65 $dBL_{Aeq,T}$;
- **Evenings and weekends** – 55 $dBL_{Aeq,T}$; and
- **Night-time** – 45 $dBL_{Aeq,T}$

Operational noise limits – fixed non-turbine plant

9.6.15 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, which is representative of the closest NSRs to proposed items of plant. 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 Appendix 9.4 Chart 9.8, the measured background level during the night-time period at NMP2 was approximately 25 $dBL_{A90,T}$. In accordance with BS4142, a rating level of up to 5 dB above the representative background level is indicative of a 'low' impact, therefore the adopted noise limit for the rating level of fixed non-turbine plant at the closest receptor is 30 dB.

Operational noise limits – wind turbine noise

9.6.16 Noise limits for the Proposed Development have been derived using measured background noise levels. The noise levels have been used to determine an Overall Noise Limit (ONL), shown as a red line in Chart 9.7, Chart 9.8, Chart 9.10 and Chart 9.11. In the absence of noise from cumulative turbines, the ONL would apply directly to the Proposed Development.

9.6.17 Where potential cumulative effects have been identified, the process described in 9.5.58 has been used to determine a NSR-specific RNL which applies to the Proposed Development only.

9.6.18 The ONLs derived from baseline data collected at NMP1 and NMP2 are provided in Table 9.12 for the range of operational wind speeds. ETSU allows that the daytime Fixed Minimum Limit (FML) may be set within the range 35 dB – 40 dB. In consultation, OIC Environmental Health requested that the daytime FML for the Proposed Development should be 35 dB, at the lower end of the ETSU range.

9.6.19 The noise limits derived from measurements at NMPs have been allocated to NSRs on the basis of observations of the noise environment while setting up the SLMs, the proximity of NSRs to the NMPs and the predicted contribution of existing turbines.

Table 9.12 – Derived ONLs, $dBL_{A90,10min}$

Wind speed, m/s	Derived noise limit, $dBL_{A90,10min}$								
	4	5	6	7	8	9	10	11	12
NMP1 – Shoehall – ONL derived from 'background +5 dB' measured when NMP under up-wind conditions relative to existing turbines									
Daytime period	35.0	35.0	35.7	37.9	40.3	43.0	46.4	46.4	46.4
Daytime period – FI	45.0	45.0	45.0	45.0	45.0	45.0	46.4	46.4	46.4
Night-time period	43.0	43.0	43.0	43.0	43.0	45.3	45.9	45.9	45.9
Night-time period FI	45.0	45.0	45.0	45.0	45.0	45.3	45.9	45.9	45.9
Overall limit applicable at: NSR1, NSR2, NSR3, NSR4, NSR5, NSR6, NSR7 and NSR8									
NMP2 – Fers Ness – ONL derived from 'background +5 dB' measured when NMP under up-wind conditions relative to existing turbine									
Daytime period	38.3	40.3	42.5	44.7	46.7	48.2	49.0	49.0	49.0
Daytime period – FI	45.0	45.0	45.0	45.0	46.7	48.2	49.0	49.0	49.0
Night-time period	43.0	43.0	43.0	44.5	46.6	47.5	47.8	47.8	47.8
Night-time period FI	45.0	45.0	45.0	45.0	46.6	47.5	47.8	47.8	47.8
Overall limit applicable at: NSR9, NSR10									

9.6.20 None of the identified NSRs will be Financially Involved (FI) with the project, however, several NSRs are considered to be FI with their own turbines.

9.6.21 The ONLs have been used to derive RNLs for each NSR, accounting for consented noise limits according to the process described in 9.5.58. The process of deriving the RNLs is shown in Appendix 9.6, and the adopted RNLs are shown in Table 9.13.

Table 9.13 – Derived RNLs, $dBL_{A90,10min}$

Wind speed, m/s	Derived noise limit, $dBL_{A90,10min}$								
	4	5	6	7	8	9	10	11	12
Daytime period (07:00 – 23:00)									
NSR1	35.0	35.0	35.7	37.9	38.7	42.3	46.1	46.1	45.9
NSR2	35.0	35.0	35.7	37.9	40.3	43.0	46.1	46.3	46.3
NSR3	35.0	35.0	35.7	37.9	40.3	43.0	46.1	46.3	46.3
NSR4	35.0	35.0	35.7	37.9	38.7	42.3	46.1	46.2	46.1
NSR5	35.0	35.0	34.7	36.9	38.7	42.3	46.1	45.5	44.7
NSR6*	35.0	35.0	35.7	37.9	40.3	43.9	45.1	44.0	41.3
NSR7	35.0	35.0	34.9	37.1	38.7	42.3	46.1	45.6	44.4
NSR8*	35.0	35.0	35.7	37.9	44.0	43.2	44.2	41.9	45.7
NSR9*	38.3	40.3	42.5	44.7	46.4	47.9	48.6	48.3	47.8
NSR10	38.3	40.3	42.5	44.7	46.7	48.2	49.0	49.0	49.0
Night-time period (23:00 – 07:00)									
NSR1	43.0	43.0	43.0	43.0	43.0	45.3	45.9	45.9	45.9
NSR2	43.0	43.0	43.0	43.0	43.0	45.3	45.9	45.9	45.9
NSR3	43.0	43.0	43.0	43.0	43.0	45.3	45.9	45.9	45.9
NSR4	43.0	43.0	43.0	43.0	43.0	45.3	45.9	45.9	45.9
NSR5	43.0	43.0	43.0	43.0	43.0	44.9	45.5	44.8	44.0
NSR6*	43.0	43.0	43.0	43.0	43.0	44.3	44.4	43.1	39.4
NSR7	43.0	43.0	43.0	43.0	43.0	45.3	45.5	45.9	45.9
NSR8*	43.0	43.0	43.0	44.4	44.0	43.6	43.3	40.3	47.8
NSR9*	43.0	43.0	43.0	44.5	46.3	47.2	47.2	46.8	46.1
NSR10	43.0	43.0	43.0	44.5	46.6	47.5	47.8	47.8	47.8

Note – at NSRs marked * the adopted RNL is the lower of the non-FI RNL and the FI RNL. Refer to Appendix 9.6 for derivation of RNLs at all NSRs, including NSRs which are FI with their own turbines.

9.7 Receptors Brought Forward for Assessment

9.7.1 All of the NSRs listed in Table 9.3 have been brought forward for assessment.

9.8 Standard Mitigation

Construction phase

9.8.1 The following good practice measures will be implemented during construction to limit unnecessary noise:

- avoid unnecessary revving of engines and switching off plant when not required (i.e. no idling);
- haul routes to be kept well maintained;
- 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; and
- use and siting of equipment will be considered such that noise 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.

The measures outlined above, plus additional measures put in place relating to specific construction challenges associated with access to the island will be formalised in a Construction Environmental Management Plan (CEMP).

Operational phase

Fixed (non-turbine) plant noise

9.8.2 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 (see para. 9.6.15). A total sound power level of 93 dB(A), equivalent to a sound pressure level of 75 dB(A) at 10 m, would enable the noise limit to be met. The installed plant will meet these criteria.

9.9 Likely Effects

Construction

9.9.1 The predicted noise levels at NSR3, the closest property to construction activities for the Proposed Development site, are provided and evaluated against the adopted noise limits in Table 9.14 for each of the stages of construction considered. Negative numbers indicate predicted levels meet the adopted criteria.

Table 9.14 – Evaluation of worst-case construction phase noise levels at closest NSR (NSR3)

Scenario	Predicted level, $dBL_{Aeq,T}$	Comparison of predicted level with noise limits (predicted level minus limit), $dBL_{Aeq,T}$	
		Weekday daytime, Saturday mornings	Evenings and weekends
Site origination	40	-25	-15
Slipway works	43	-22	-12
Construction of access tracks and turbine hardstandings	37	-28	-18
Excavation of borrow pits and construction of turbine bases	46	-19	-9
Installation of turbines	39	-26	-16

9.9.2 At NSR3, predicted worst-case noise levels due to construction activities during the daytime and evening periods meet the derived noise limits by a margin of 9 dB or more. No night-time working is proposed.

9.9.3 With reference to Table 9.8 the impact magnitude ranges from **negligible** to **low**, therefore with reference to Table 9.11 the effect significance ranges from **neutral** to **minor**. Noise impacts associated with the construction phase are therefore **not significant**.

Operation

Fixed (non-turbine) plant noise

9.9.4 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.

9.9.5 This assessment adopts the rating level noise limit of 30 dB at any identified NSR, equivalent to the baseline background noise levels at NMP1 at wind speeds of 5 m/s and below (refer to Appendix 9.4 Chart 9.7 and Chart 9.8). Provided that the noise limit is met by all non-turbine plant, including the substation, with reference to Table 9.10 the impact magnitude will be **low**. At high sensitivity NSRs, the resultant effect significance will be **minor** and therefore **not significant**.

Wind turbine noise

9.9.6 Predicted noise levels due to operation of the Proposed Development with all turbines operating in power-optimised mode (i.e. not in noise-reduced modes), are provided in Table 9.15 across the range 4 m/s – 12 m/s. Predictions have been calculated in accordance with SGN6 of the IoA GPG.

Table 9.15 – Predicted wind turbine noise levels due to Proposed Development

NSR ID	Wind Speed, m/s								
	4	5	6	7	8	9	10	11	12
	Predicted noise level, dBL_{A90}								
NSR1	27.2	32.1	35.8	36.4	36.4	36.4	36.4	36.4	36.4
NSR2	28.5	33.3	37.1	37.7	37.7	37.7	37.7	37.7	37.7
NSR3	29.0	33.9	37.6	38.2	38.2	38.2	38.2	38.2	38.2
NSR4	28.2	33.1	36.8	37.4	37.4	37.4	37.4	37.4	37.4
NSR5	27.8	32.7	36.4	37.0	37.0	37.0	37.0	37.0	37.0
NSR6	27.4	32.2	36.0	36.6	36.6	36.6	36.6	36.6	36.6
NSR7	27.0	31.8	35.6	36.2	36.2	36.2	36.2	36.2	36.2
NSR8	26.3	31.1	34.9	35.5	35.5	35.5	35.5	35.5	35.5
NSR9	26.5	31.4	35.1	35.7	35.7	35.7	35.7	35.7	35.7
NSR10	24.9	29.7	33.5	34.1	34.1	34.1	34.1	34.1	34.1

9.9.7 The predicted operational noise levels are evaluated against the derived daytime and night-time RNLs (i.e. accounting for the contribution of cumulative turbines) in Table 9.16. Negative numbers indicate predicted compliance with the RNL. Where predicted noise levels are above the noise limits, the result is shown in **bold** text.

Table 9.16 – Comparison of predicted wind turbine noise levels due to Proposed Development with RNLs

NSR ID	Wind Speed, m/s								
	4	5	6	7	8	9	10	11	12
	RNL minus predicted noise level, dBL_{A90}								
Daytime period									
NSR1	-7.8	-2.9	**0.1**	-1.5	-2.3	-5.9	-9.6	-9.7	-9.5
NSR2	-6.5	-1.7	**1.3**	-0.2	-2.6	-5.4	-8.4	-8.7	-8.6
NSR3	-6.0	-1.1	**1.9**	**0.3**	-2.1	-4.8	-7.9	-8.1	-8.1
NSR4	-6.8	-1.9	**1.1**	-0.5	-1.3	-4.9	-8.7	-8.8	-8.7
NSR5	-7.2	-2.3	**1.7**	**0.1**	-1.7	-5.3	-9.0	-8.4	-7.7
NSR6	-7.6	-2.8	**0.3**	-1.3	-3.7	-7.3	-8.5	-7.4	-4.7
NSR7	-8.0	-3.2	**0.6**	-0.9	-2.6	-6.1	-9.9	-9.5	-8.3
NSR8	-8.7	-3.9	-0.8	-2.4	-8.5	-7.7	-8.7	-6.4	-10.2
NSR9	-11.8	-8.9	-7.4	-9.0	-10.7	-12.2	-12.9	-12.6	-12.1
NSR10	-13.4	-10.6	-9.1	-10.6	-12.6	-14.1	-14.9	-14.9	-14.9

NSR ID	Wind Speed, m/s								
	4	5	6	7	8	9	10	11	12
	RNL minus predicted noise level, dBL_{A90}								
Night-time period									
NSR1	-15.8	-10.9	-7.2	-6.6	-6.6	-8.9	-9.5	-9.5	-9.0
NSR2	-14.5	-9.7	-5.9	-5.3	-5.3	-7.6	-8.2	-8.2	-8.2
NSR3	-14.0	-9.1	-5.4	-4.8	-4.8	-7.1	-7.7	-7.7	-7.7
NSR4	-14.8	-9.9	-6.2	-5.6	-5.6	-7.9	-8.5	-8.5	-8.5
NSR5	-15.2	-10.3	-6.6	-6.0	-6.0	-7.8	-8.5	-7.8	-7.0
NSR6	-15.6	-10.8	-7.0	-6.4	-6.4	-7.7	-7.8	-6.5	-2.8
NSR7	-16.0	-11.2	-7.4	-6.8	-6.8	-9.1	-9.4	-9.7	-9.7
NSR8	-16.7	-11.9	-8.1	-8.9	-8.5	-8.1	-7.8	-4.8	-12.3
NSR9	-16.5	-11.6	-7.9	-8.8	-10.6	-11.5	-11.5	-11.1	-10.4
NSR10	-18.1	-13.3	-9.5	-10.4	-12.5	-13.5	-13.7	-13.7	-13.7

9.9.8 The comparison provided in Table 9.16 demonstrates that operational noise from the Proposed Development will meet the derived RNLs at all NSRs across the full range of wind speeds during the night-time period.

9.9.9 During the daytime period the Proposed Development can operate within the RNLs at all NSRs at all wind speeds, with the exceptions of NSR1, NSR2, NSR3, NSR4, NSR5, NSR6 and NSR7 at 6 m/s, where predicted noise levels are up to 1.9 dB above the derived RNLs, and with further exceptions at NSR3 and NSR5 at 7 m/s where predicted levels are up to 0.3 dB above the RNL.

9.9.10 The impact magnitude and effect significance associated with operational wind turbine noise have been derived with reference to Table 9.9 and Table 9.11 and are summarised as follows:

- The impact magnitude at all NSRs during the night-time period ranges from **negligible** to **low**, dependent on wind speed. The resultant effect significance ranges from **neutral** to **minor**. Operational wind turbine noise effects during the night-time period are therefore **not significant**.
- The impact magnitude at NSR8, NSR9 and NSR10 during the daytime period ranges from **negligible** to **low**, dependent on wind speed. The resultant effect significance ranges from **neutral** to **minor**. Operational wind turbine noise effects during the daytime period at these receptors are therefore **not significant**.
- The impact magnitude at NSR1, NSR2, NSR4, NSR6 and NSR7 during the daytime period ranges from **low** at wind speeds 4 – 5 m/s and 7 – 12 m/s, to **medium** at 6 m/s. The resultant effect significance ranges from **minor** to **moderate** and is therefore **significant**.
- The impact magnitude at NSR3 and NSR5 during the daytime period ranges from **low** at wind speeds 4 – 5 m/s and 8 – 12 m/s, to **medium** at 6 m/s and 7 m/s. The resultant effect significance ranges from **minor** to **moderate** and is therefore **significant**.

Decommissioning

9.9.11 The Applicant is seeking in-perpetuity consent for the Proposed Development. In the event of decommissioning, or replacement of turbines, it is anticipated that noise levels would be similar to noise levels during construction, however, given the lower intensity of works, noise levels would be lower. Considering predicted noise levels for construction provided in Table 9.14, and with reference to Table 9.8 the impact magnitude ranges from **negligible** to **low**, therefore with reference to Table 9.11 the effect significance ranges from **neutral** to **minor**. Noise impacts associated with the decommissioning phase are therefore **not significant**. Decommissioning would be undertaken in line with best practice processes and methods at that time and will be managed through an agreed Decommissioning Environmental Management Plan.

9.10 Additional Mitigation and Enhancement

9.10.1 Beyond the commitment to produce and implement a CEMP, no significant noise effects have been identified associated with the construction or decommissioning phases and no additional mitigation is proposed.

9.10.2 Similarly, no significant noise effects have been identified associated with non-turbine plant during the operational phase, and no additional mitigation is proposed.

9.10.3 Predicted operational wind turbine noise levels exceed the derived noise limits at NSR1, NSR2, NSR3, NSR4, NSR5, NSR6 and NSR7 at 6 m/s wind speed and at NSR3 and NSR5 at 7 m/s during the daytime period. No mitigation is required during the night-time period.

9.10.4 Given the relatively small margin by which predicted noise levels exceed the daytime noise limits and the degree of conservatism in the prediction method, it is possible that measurable exceedances would not occur in practice. The Applicant commits to meeting the noise limits, however, and subject to the sound power level of the installed turbine model, mitigation will be put in place such that the noise limits are met.

9.10.5 The predicted levels consider the 'worst-case' scenario, when NSRs lie down-wind of the Proposed Development, which will occur under westerly wind conditions. Under cross-wind conditions and up-wind conditions the effect of directivity will result in lower noise levels from the Proposed Development, and compliance with the RNL at all NSRs. Any noise management plan would therefore only be required under a specific sector of wind directions and would likely have a limited impact on the generating capacity of the Proposed Development.

9.10.6 As required, a noise management plan will be enacted under specific wind speeds and directions, when operational wind turbine noise exceeds the noise limits. Potential options to control wind turbine noise will comprise curtailment of the closest turbines to the affected NSRs, either by operation in low-noise modes, or switching individual turbines off. Given the relatively small margin of predicted exceedance of the noise limits and limited range of wind speeds under which mitigation may be required, the loss of energy yield associated with any such mitigation would be limited.

9.11 Residual Effects

Construction

9.11.1 Residual effects will remain unchanged and are **not significant**.

Operation

9.11.2 Residual effects associated with non-turbine plant will remain unchanged and are **not significant**.

9.11.3 Following implementation of mitigation, if mitigation is determined to be required based on the specific characteristics of the installed model of turbine, residual effects associated with operational wind turbine noise during the daytime period will range from **negligible** to **low**, with resultant effect significance of **neutral** to **minor,** and are therefore **not significant**.

9.11.4 Residual effects associated with operational wind turbine noise during the night-time period will remain unchanged and are **not significant**.

Decommissioning

9.11.5 Residual effects will remain unchanged and are **not significant**.

9.12 Cumulative Assessment

9.12.1 The predicted worst-case cumulative noise levels including the Proposed Development and existing cumulative turbines within the study area are provided in Table 9.17. Actual noise levels will be lower, given the effects of directivity.

Table 9.17 – Predicted worst-case cumulative wind turbine noise levels

NSR ID	Wind Speed, m/s								
	4	5	6	7	8	9	10	11	12
	Predicted noise level, dBL_{A90}								
NSR1	27.7	32.3	36.0	36.7	36.8	37.0	37.4	37.9	38.5
NSR2	28.6	33.4	37.1	37.7	37.8	37.8	37.9	38.0	38.2
NSR3	29.1	33.9	37.6	38.3	38.3	38.3	38.4	38.5	38.7
NSR4	28.4	33.2	36.9	37.5	37.6	37.7	37.9	38.2	38.6
NSR5	29.0	33.3	36.9	37.7	38.0	38.5	39.2	40.2	41.4
NSR6	29.8	33.7	37.0	38.0	38.6	39.5	40.7	42.1	43.7
NSR7	28.1	32.5	36.0	36.8	37.1	37.6	38.3	39.3	40.5
NSR8	30.1	33.6	36.7	37.9	38.9	40.1	41.6	43.3	45.1
NSR9	28.5	32.5	35.9	36.8	37.4	38.2	39.2	40.5	42.0
NSR10	24.9	29.7	33.5	34.1	34.1	34.1	34.2	34.2	34.3

9.12.2 The predicted cumulative operational noise levels are evaluated against the 35 dB daytime ONL and 43 dB night-time ONL in Table 9.18. Negative numbers indicate predicted compliance with the ONL. Where predicted noise levels are above the noise limits, the result is shown in **bold** text.

Table 9.18 – Comparison of predicted cumulative wind turbine noise levels with ONLs

NSR ID	Wind Speed, m/s								
	4	5	6	7	8	9	10	11	12
	ONL minus predicted noise level, dBL_{A90}								
Daytime period									
NSR1	-7.3	-2.7	**0.3**	-1.2	-3.5	-6.0	-9.0	-8.5	-7.9
NSR2	-6.4	-1.6	**1.4**	-0.2	-2.5	-5.2	-8.5	-8.4	-8.2
NSR3	-5.9	-1.1	**1.9**	**0.4**	-2.0	-4.7	-8.0	-7.9	-7.7
NSR4	-6.6	-1.8	**1.2**	-0.4	-2.7	-5.3	-8.5	-8.2	-7.8
NSR5	-6.0	-1.7	**1.2**	-0.2	-2.3	-4.5	-7.2	-6.2	-5.0

NSR ID	Wind Speed, m/s								
	4	5	6	7	8	9	10	11	12
	ONL minus predicted noise level, dBL_{A90}								
NSR6	-5.2	-1.3	**1.3**	**0.1**	-1.6	-3.5	-5.7	-4.3	-2.7
NSR7	-6.9	-2.5	**0.3**	-1.1	-3.1	-5.4	-8.1	-7.1	-5.9
NSR8	-4.9	-1.4	**1.0**	0.0	-1.4	-2.9	-4.8	-3.1	-1.3
NSR9	-9.8	-7.8	-6.6	-7.9	-9.3	-10.0	-9.7	-8.5	-6.9
NSR10	-13.4	-10.6	-9.0	-10.6	-12.6	-14.1	-14.8	-14.8	-14.7
Night-time period									
NSR1	-15.3	-10.7	-7.0	-6.3	-6.2	-8.3	-8.5	-8.1	-7.4
NSR2	-14.4	-9.6	-5.9	-5.3	-5.2	-7.5	-8.0	-7.9	-7.7
NSR3	-13.9	-9.1	-5.4	-4.7	-4.7	-7.0	-7.5	-7.4	-7.2
NSR4	-14.6	-9.8	-6.1	-5.5	-5.4	-7.6	-8.0	-7.8	-7.3
NSR5	-14.0	-9.7	-6.1	-5.3	-5.0	-6.8	-6.7	-5.7	-4.5
NSR6	-13.2	-9.3	-6.0	-5.0	-4.4	-5.7	-5.2	-3.8	-2.2
NSR7	-14.9	-10.5	-7.0	-6.2	-5.9	-7.7	-7.6	-6.6	-5.4
NSR8	-12.9	-9.4	-6.3	-5.1	-4.1	-5.2	-4.3	-2.6	-0.8
NSR9	-14.5	-10.5	-7.1	-7.7	-9.2	-9.4	-8.5	-7.3	-5.7
NSR10	-18.1	-13.3	-9.5	-10.4	-12.5	-13.4	-13.6	-13.6	-13.5

9.12.3 The comparison provided in Table 9.18 demonstrates that cumulative worst-case noise levels will meet the derived noise limits at all NSRs across the full range of wind speeds during the night-time period.

9.12.4 During the daytime period, predicted noise levels meet the noise limits at all NSRs at all wind speeds, except for NSR1, NSR2, NSR3, NSR4, NSR5, NSR6, NSR7 and NSR8 at 6 m/s and at NSR3 and NSR6 at 7 m/s. At 6 m/s the predicted worst-case cumulative noise level is up to 1.9 dB above the ONL and at 7 m/s the predicted level is up to 0.4 dB above the ONL.

9.12.5 The impact magnitude and effect significance associated with cumulative operational wind turbine noise have been derived with reference to Table 9.9 and Table 9.11 and are summarised as follows:

- The impact magnitude at all NSRs during the night-time period ranges from **negligible** to **low**, dependent on wind speed. The resultant effect significance ranges from **neutral** to **minor**. Operational wind turbine noise effects during the night-time period are therefore **not significant**.
- The impact magnitude at NSR9 and NSR10 during the daytime period ranges from **negligible** to **low**, dependent on wind speed. The resultant effect significance ranges from **neutral** to **minor**. Operational wind turbine noise effects during the daytime period at these receptors are therefore **not significant**.

- The impact magnitude at NSR1, NSR2, NSR4, NSR6, NSR7 and NSR8 during the daytime period ranges from **low** at wind speeds 4 – 5 m/s and 7 – 12 m/s, to **medium** at 6 m/s. The resultant effect significance ranges from **minor** to **moderate** and is therefore **significant**.
- The impact magnitude at NSR3 and NSR6 during the daytime period ranges from **low** at wind speeds 4 – 5 m/s and 8 – 12 m/s, to **medium** at 6 m/s and 7 m/s. The resultant effect significance ranges from **minor** to **moderate** and is therefore **significant**.

9.12.6 Comparing the results presented in Table 9.18 with those in Table 9.16 it is clear that a similar pattern is present; where predicted noise levels are above the noise limits this occurs at broadly the same set of NSRs, at the same wind speeds and by a similar margin. It is therefore apparent that the Proposed Development is the dominant contributor to predicted exceedances of the noise limits. Mitigation put in place to prevent the exceedance of the RNLs by the Proposed Development will therefore be effective in preventing cumulative exceedance of the ONLs where this can be attributed to the Proposed Development.

9.12.7 Following implementation of appropriate mitigation, the Proposed Development will meet the derived noise limits, therefore the resultant impact magnitude at all wind speeds will be negligible to low, with a resultant effect significance of neutral to minor. Cumulative noise effects are therefore **not significant**.

9.13 Summary

9.13.1 This chapter has considered potential noise effects associated with construction, operation and decommissioning of the Proposed Development. No potential vibration effects have been identified and consideration of vibration has therefore been scoped out.

9.13.2 The assessment of noise comprised consultation with OIC Environmental Health, characterisation of the baseline noise environment, prediction of noise levels associated with construction activities, construction traffic, operational wind turbines and operation of other non-turbine fixed plant, and evaluation of predicted levels against derived criteria.

9.13.3 Baseline noise levels in the study area are typically dominated by the wind and the sea. Existing small wind turbines are the greatest anthropogenic contributor to overall noise levels, however, the effect of these has been screened out of baseline noise levels by directional filtering.

9.13.4 Predicted noise levels associated with construction activities meet threshold noise levels set out in the relevant guidance at all identified representative NSRs, during weekday daytimes, evenings and weekends. Noise effects from construction activities are therefore not significant.

9.13.5 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.

9.13.6 The Applicant has committed to meeting the derived noise limits for the Proposed Development. Predicted wind turbine noise levels associated with operation of the Proposed Development can meet derived noise limits during the daytime period at all identified representative NSRs, with minimal requirement for mitigation. Noise effects from wind turbine operation are therefore not significant.

Table 9.19 – Summary of Effects

Description of Effect	Significance of Potential Effect		Mitigation Measure	Significance of Residual Effect	
	Significance	Beneficial/ Adverse		Significance	Beneficial/ Adverse
Construction					
Noise from construction activities	Minor and not significant	Adverse	Implementation of appropriate noise controls regarding hours of work, timing of site deliveries, and use of best practice to minimise unnecessary noise.	Minor and not significant	Adverse
Operation					
Noise from non-turbine fixed plant	Minor and not significant	Adverse	Selection of plant which complies with specified maximum sound power level such that the derived noise limits are met.	Minor and not significant	Adverse
Noise from wind turbines	Neutral to moderate and not significant to significant	Adverse	A noise management plan may be required such that Residual Noise Limits are met at all NSRs at all wind speeds under down-wind conditions, however, predicted exceedances of noise limits are minor (≤1.9 dB).	Neutral to minor and not significant	Adverse
Decommissioning					
Noise from construction activities	Minor and not significant	Adverse	Implementation of appropriate noise controls regarding hours of work, timing of site deliveries, and use of best practice to minimise unnecessary noise.	Minor and not significant	Adverse

Table 9.20 – Summary of Cumulative Effects

Receptor	Effect	Cumulative Developments	Significance of Cumulative Effect	
			Significance	Beneficial/ Adverse
All NSRs	Cumulative wind turbine noise	Multiple small turbine developments on Eday.	Minor and not significant	Adverse

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