Technical Appendix 10.2: Operational Noise Report

A specialist energy consultancy

Technical Appendix 10.2

Operational Noise Report

M74 West Renewable Energy Park

M74 West Limited

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Executive Summary

TNEI Services Ltd was commissioned by Ramboll on behalf of M74 West Limited ('the Applicant') to undertake predictions of the wind turbine noise that would be emitted by the operation of the proposed M74 West Renewable Energy Park (hereinafter referred to as 'the Proposed Development'). The noise predictions were used to assess the potential impact of operational noise from the Proposed Development on the nearest noise sensitive receptors.

The Scottish Government's web based renewables advice on 'Onshore Wind Turbines' states: *'The Report, "The Assessment and Rating of Noise from Wind Farms" (Final Report, Sept 1996, DTI), (ETSU-R-97), describes a framework for the measurement of wind farm noise, which should be followed by applicants and consultees, and used by planning authorities to assess and rate noise from wind energy developments, until such time as an update is available. This gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable burdens on wind farm developers, and suggests appropriate noise conditions.'* The advice document then goes on to state: *'The Institute of Acoustics (IOA) has since published Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise [IOA GPG]. The document provides significant support on technical issues to all users of the ETSU-R-97 method for rating and assessing wind turbine noise, and should be used by all IOA members and those undertaking assessments to ETSU-R-97. The Scottish Government accepts that the guide represents current industry good practice.'* The guidance contained within ETSU-R-97 and current good practice has been used to assess the potential operational noise impact of the Proposed Development.

The operational noise assessment has been undertaken in three stages:

1) derive the Total ETSU-R-97 Noise Limits (which are applicable to noise from all wind turbines in the area operating concurrently) at noise sensitive receptors;
2) predict the likely effects (undertaking a cumulative noise assessment where required) to determine whether noise immission at the noise sensitive receptors will meet the Total ETSU-R-97 Noise Limits; and
3) derive Site Specific Noise Limits for the Proposed Development (taking account of the noise limit that has already been allocated to / could realistically be used by other schemes) and undertake predictions against those limits.

Background noise monitoring was undertaken at five noise sensitive receptors. The monitoring locations were considered to be representative of the noise sensitive receptors located closest to the Proposed Development.

A total of nine noise sensitive receptors were chosen as Noise Assessment Locations (NALs). The NALs were chosen to represent the noise sensitive receptors located closest to the Proposed Development and an additional receptor was included to consider cumulative noise impacts. For the assessment locations where no background noise measurements were undertaken, noise data collected at proxy locations deemed representative of the expected background noise environment was used to assess the wind turbine noise impact at those receptors.

Wind speed data was measured using a SODAR unit. The wind data measured at 100 m and 120 m height was used to calculate hub height wind speeds (at 122.5 m). These hub height wind speeds were then standardised to a height of 10 m in accordance with current good practice. Analysis of the measured data was undertaken in accordance with ETSU-R-97 and current good practice to determine the pre-existing background noise environment and to establish the daytime and night-time noise limits at each of the NALs.

Based on the guidance in ETSU-R-97 and to reflect the presence of existing wind turbines in the area, the daytime Total ETSU-R-97 Noise Limit was set at 40 dB(A) or background plus 5 dB whichever is the greater. The night-time Total ETSU-R-97 Noise Limit has been set at 43 dB(A) or background plus 5 dB whichever is the greater. The Site Specific daytime limit for noise associated with the Proposed Development has been set such that it never exceeds 35 dB(A) or background plus 5 dB, whichever is the greater. This represents the lower end of the daytime limits that can be applied under ETSU-R-97. The night-time Site Specific Noise Limits have been set at 43 dB(A) or background plus 5 dB whichever is the greater.

The exception to the setting of both the daytime and night-time fixed minimum noise limits occurs where a property occupier has a financial involvement in the wind farm development where the fixed minimum limit can be increased to 45 dB(A) or a higher permissible limit above background during the daytime and night-time periods. Five residential properties are financially involved with the Proposed Development, two being situated at Blackburn and three at Netherton Farm. For the purposes of this assessment, only the closest property at Blackburn and Netherton Farm to the Proposed Development has been considered.

Predictions of wind turbine noise for the Proposed Development were made, based upon the sound power level data for the Siemens Gamesa SG 6.6-155 with Serrated Blades and a hub height of 122.5 m. This wind turbine model has been chosen as it is considered to be representative of the type of turbine that could be installed at the site. Whatever the final turbine choice is, the Proposed Development would have to meet the noise limits determined and contained within any condition applied as part of consent.

Modelling was undertaken using the ISO 9613: 1996 *'Acoustics – Attenuation of sound during propagation outdoors Part 2: General method of calculation'* noise prediction model which accords with current good practice and is considered to provide a realistic impact assessment. For the other schemes, predictions have been undertaken using sound power level data for the installed turbines or a suitable candidate. The model of turbine was either identified through an online search, or through the use of the Council's Planning Application Portal.

A cumulative assessment was undertaken at the NALs closest to the Proposed Development in each direction. The likely cumulative assessment, required at nine NALs, shows that the Proposed Development can operate concurrently with other operational, consented and proposed (in planning) wind farms and wind turbine developments in the area at all NALs whilst still meeting the Total ETSU-R-97 Noise Limit. At NAL9, mitigation for the Proposed Development would be required for certain wind speeds and directions as summarised below.

Site Specific Noise Limits have also been derived that take account (where required) of the other wind farm/turbine developments. Where wind turbine immission from the other wind turbines at a given receptor were found to be at least 10 dB below the Total ETSU-R-97 Noise Limit, it is considered that they will be using a negligible proportion of the limit, as such it was considered appropriate to allocate the entire noise limit to the Proposed Development. For the receptors where turbine predictions were found to be within 10 dB of the Total ETSU-R-97 Noise Limit, apportionment of the Total ETSU-R-97 Noise Limits was undertaken in accordance with current good practice.

Predicted noise levels indicate that wind turbine noise immission were below the Site Specific Noise Limits at all NALs (except NAL9). At NAL9, an exceedance ranging from 0.8 dB to 4.7 dB was predicted between 5 ms^{-1} and 10 ms^{-1} during the daytime and an exceedance ranging from 1.7 dB up to 5.3 dB was predicted between 5 ms^{-1} and 12 ms^{-1} during the night-time. Predicted noise levels have therefore been reduced to ensure that the Site Specific Noise Limits are met, this would be achieved by the combination of turbine shut down or the adoption of low noise modes, but this would only be required for a limited range of wind speeds and wind directions. It should be noted that it is unclear whether

NAL9 is in use but it has been included in the assessment at this stage for completeness. The use of Site Specific Noise Limits would ensure that the Proposed Development could operate concurrently with other wind farms/ turbines in the area and would also ensure that the Proposed Development's individual contribution could be measured and enforced if required.

Should consent be granted for the Proposed Development it would be appropriate to include a set of noise related planning conditions, which detail the noise limits applicable to the Proposed Development. A suggested planning condition has been included in Annex 8.

There are a number of wind turbine makes and models that may be suitable for the Proposed Development. Should the Proposed Development receive consent the final choice of turbine would be subject to a competitive tendering process. As such, predictions of wind turbine noise are for information only. The final choice of turbine would, however, have to meet the noise limits determined and contained within any condition imposed.

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ANNEXES

1 Introduction

1.1 Brief

1.1.1 TNEI Services Ltd was commissioned by Ramboll on behalf of M74 West Limited ('the Applicant') to undertake an operational noise assessment for the proposed M74 West Renewable Energy Park (hereinafter referred to as 'the Proposed Development'). The following steps summarise the noise assessment process:

- Measure existing background noise levels, assess and present the noise data with reference to existing Government Guidance and the recommendations of the Department of Trade and Industry Noise Working Group on Noise from Wind Turbines which are contained within ETSU-R-97 *'The Assessment and Rating of Noise from Wind Farms'*[1] and *'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise'*[2] (IOA GPG) which represents current good practice;
- Determine the Total ETSU-R-97 Noise Limits applicable to all wind farms/ turbines in the area;
- Assess and undertake a cumulative noise assessment, where required, to take account of other proposed, consented or operational schemes near to the Proposed Development;
- Derive Site Specific Noise Limits for the Proposed Development, suitable for inclusion in the noise related planning condition should Scottish Ministers be minded to grant consent for the Proposed Development;
- Undertake predictions of the operational wind turbine noise immission from the Proposed Development that will be incident at neighbouring noise sensitive receptors;
- Compare predictions of the operational wind turbine noise immission from the Proposed Development against the Site Specific Noise Limits that will be incident at neighbouring noise sensitive receptors; and
- Assess the impact of noise from the Proposed Development with reference to existing Government Guidance and the recommendations of the Department of Trade and Industry Noise Working Group on Noise from Wind Turbines, which are contained within ETSU-R-97 and the IOA GPG (current good practice).

1.2 Background

1.2.1 The site is located immediately northwest of Abington in South Lanarkshire, Scotland. The approximate OS Grid Reference for the centre of the site is 289227, 626397 and the proposed layout is shown on Figure A1.1 (Annex 1). The area surrounding the site is rural in nature, comprising of open moorland, improved and semi-improved grassland and is intersected by the M74 motorway, the B7078 and B740 local roads.

1.2.2 In the absence of a confirmed turbine model, this noise assessment models a candidate turbine provided by the Applicant, the Siemens Gamesa SG 6.6-155 with serrated blades and a hub height of 122.5 m. This turbine has been selected as it is representative of the turbine type which could be installed at the site.

1.2.3 The noise assessment has considered schemes which are operational, consented and proposed (planning application submitted). The schemes considered in the assessment are summarised in Table 1.1.

Table 1.1 Cumulative Wind Farm/ Turbine Development

Wind Farm/ Wind Turbine	Number of Turbines	Status	Make and Model of Turbine considered in Modelling
Clyde	152	Operational	Siemens SWT-2.3-93 2.3 MW - 80 m hub height
Clyde Extension	54	Operational	Siemens SWT-3.2-101 3.2 MW – mix of 75 m and 90 m hub heights
Andershaw	11	Operational	Vestas V112 3.3 MW - 81.5 m hub height
Middle Muir	15	Operational	Senivon 3.4M-114 3.4MW - 100 m hub height
Douglas West	13	Operational	Vestas V136 4.2 MW - 81.9 m hub height
Hagshaw Hill Extension	20	Operational	Siemens 1.3-62 1.3MW - 49 m hub height
Galawhistle	22	Operational	Vestas V90 3MW – mix of 65.2 m and 76.2 m hub heights
Dalquhandy	15	Under Construction	Vestas V112 3.3 MW – mix of 75 m and 93.9 m hub heights
Broken Cross	10	Under Construction	Vestas V136 4.0/4.2 MW - 82 m hub height
Priestgill	7	Consented	Vestas V150 6.0 MW – mix of 105 m and 125 m hub heights
Douglas West Extension	13	Consented	Siemens Gamesa SG 6.0-155 6.6MW - 135 m hub height
Hagshaw Repowering	14	Consented	Siemens Gamesa SG-3.4-132 3.4MW - 135 m hub height
Little Gala	6	In Planning	Nordex N133 4.8MW – 83.4 m hub height
Bodinglee	37	In Planning	GE 5.3-158 5.3MW – mix of 151 m and 171 m hub heights

1.2.4 Figure A1.2 in Annex 1 shows the location of the above developments relative to the Proposed Development.

1.2.5 The Site Specific Noise Limits presented in this report for the Proposed Development have taken account of the noise limits that have already been allocated to, or could potentially be used by, the other schemes in the area.

1.2.6 For the purposes of assessing the above schemes in conjunction with the Proposed Development the following terms have been referred to throughout the assessment:

- 'Total ETSU-R-97 Noise Limits'; defined as being the limit that should not be exceeded from the cumulative operation of all wind farm developments, including the Proposed Development; and
- 'Site Specific Noise Limits'; defined as being the limit that is specific to the Proposed Development only, and derived through the apportionment (where required), of the 'Total ETSU-R-97 Noise Limits' in accordance with current good practice.

1.2.7 Note that in this report, the term 'noise emission' relates to the sound power level actually radiated from each wind turbine, whereas the term 'noise immission' relates to the sound pressure level (the received noise) at any receptor location due to the operation of the wind turbines. All references to dB are dB(A) unless otherwise stated. A full glossary of terms is provided in Section 8.

2 Noise Planning Policy and Guidance

2.1 Overview of Noise Planning Policy and Guidance

2.1.1 In assessing the potential noise impacts of the Proposed Development, the following guidance and policy documents have been considered:

- National Planning Policy [3];
- Local Policy;
- Web Based Renewables Advice: *'Onshore Wind Turbines'* [4];
- Planning Advice Note PAN 1/2011: *'Planning and Noise'* [5];
- ETSU-R-97 *'The Assessment and Rating of Noise from Wind Farms'*; and
- Institute of Acoustics *'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise'* (IOA GPG) May 2013.

2.2 National Planning Policy

2.2.1 As the Proposed Development has capacity to generate over 50 MW, the Proposed Development requires consent from the Scottish Ministers under Section 36 of the Electricity Act 1989. In such cases the Planning Authority is a statutory consultee in the development management process and procedures.

2.2.2 In determining an application for Section 36 consent, the Scottish Ministers must first have regard to the extent to which the Applicant has met its duties in terms of Schedule 9 of the Electricity Act 1989. The Applicant must assess and, if required, mitigate the effects of the Proposed Development on environmental matters.

2.2.3 Furthermore, decision makers must also consider National Energy and Planning Policy, and, in the context of a Section 36 application, the statutory Development Plan. As of February 2023, National Planning Framework 4 ('NPF4') now forms part of the statutory Development Plan alongside the relevant Local Development Plan and any related Supplementary Guidance. Such plans will often contain policies tailored specifically to control certain kinds of development and such policies should carry more weight and be more dominant in the minds of decision makers.

2.2.4 National Planning Framework 4 ('NPF4') was adopted on 13 February 2023 and supersedes National Planning Framework 3 and Scottish Planning Policy. Policy 11 – Energy states that renewable energy projects must be able to demonstrate how any noise impacts on communities have been addressed through the project's design and any associated mitigation. Policy 23 – Health and Safety outline how '*development proposals that are likely to raise unacceptable noise issues will not be supported*' and states that *'a Noise Impact Assessment may be required where the nature of the proposal or its location suggests that significant effects are likely.'*

2.2.5 The Scottish Government's online Onshore Wind: Policy Statement 2022 (published on 21 December 2022) [6] states (in Section 3.7) that: *'The Assessment and Rating of Noise from Wind Farms' (Final Report, Sept 1996, DTI), (ETSU-R-97) provides the framework for the*

measurement of wind turbine noise, and all applicants are required to follow the framework and use it to assess and rate noise from wind energy developments.'

2.3 Local Policy

South Lanarkshire Local Development Plan

2.3.1 The adopted Local Development Plan for the area comprises the South Lanarkshire Local Development Plan 2 (LDP2) which was adopted on 9th April 2021. The Local Plan sets out the vision, objectives and strategy which will be used to guide future development proposals in South Lanarkshire.

2.3.2 The Plan contains a number of overarching polices, the aim of which is to deliver high standards of development including Policy 5: Development Management and Placemaking and Policy RE1: Renewable Energy. Policy 5 states that; '*development shall not have an unacceptable significant adverse impact on the amenity of any nearby residential properties in terms of overshadowing, overlooking or other loss of residential amenity as a result of light, noise, odours, dust or particulates or other emissions'*. Policy RE1 then specifically considers renewable energy developments and refers to an Assessment Checklist (included as Appendix 1 of LDP Volume 2) for Renewable Energy Proposals which in turn references the Supporting Planning Guidance (SPG) on Renewable Energy.

2.3.3 The SPG directs developers to consider the Scottish Government Planning Advice Note 1/2011 Planning and Noise, the Scottish Governments online guidance for Onshore Wind Farms as well as the Institute of Acoustics (IOA) Best Practice Guide (A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise, May 2013). These documents are discussed further below and have been used to inform the scope of the assessment.

2.4 Planning Advice Note PAN 1/2011: Planning and Noise

2.4.1 PAN 1/2011 provides advice on the role of the planning system in helping to prevent and limit the adverse effects of noise. Paragraph 29 contains some specific information on noise from wind farms and 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.'

2.5 Web Based Planning Advice – Onshore Wind Turbines

2.5.1 The 'Onshore Wind Turbines' web-based document also describes the types of noise (mechanical and aerodynamic) that wind turbines generate. Mechanical noise is generated by the gearbox and generator and other parts of the drive train, which can be radiated as

noise through the nacelle, gear box, tower and supporting structures, together with the aerodynamic noise generated by the action of the blades rotating through the air. The document states '*there has been significant reduction in the mechanical noise generated by wind turbines through improved turbine* design' and goes on to note:

'The Report, "The Assessment and Rating of Noise from Wind Farms" (Final Report, Sept 1996, DTI), (ETSU-R-97), describes a framework for the measurement of wind farm noise, which should be followed by applicants and consultees, and used by planning authorities to assess and rate noise from wind energy developments, until such time as an update is available. This gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable burdens on wind farm developers, and suggests appropriate noise conditions.'

2.5.2 The web-based document then refers to the IOA GPG as a source, which provides:

'significant support on technical issues to all users of the ETSU-R-97 method for rating and assessing wind turbine noise, and should be used by all IOA members and those undertaking assessments to ETSU-R-97. The Scottish Government accepts that the guide represents current industry good practice.'

2.5.3 The document also refers to the role of PAN1/2011 'Planning and Noise' to:

'provide advice on the role of the planning system in helping to prevent and limit the adverse effects of noise. The associated Technical Advice Note provides guidance which may assist in the technical evaluation of noise assessment.'

2.5.4 Examination of the Technical Advice Note [7] confirms that it provides advice on wind farms by referring to ETSU-R-97 and relevant parameters for modelling identified in the Institute of Acoustics Bulletin March 2009, on page 37. This has been superseded by the introduction of the IOA GPG in May 2013.

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

2.6.1 As wind farms started to be developed in the UK in the early 1990's, it became apparent that existing noise standards did not fully address the issues associated with the unique characteristics of wind farm developments and there was a need for an agreed methodology for defining acceptable noise limits for wind farm developments. This methodology was developed for the former Department of Trade and Industry (DTI) by the Working Group on Noise from Wind Turbines (WGNWT).

2.6.2 The WGNWT comprised a number of interested parties including, amongst others, Environmental Health Officers, wind farm operators, independent acoustic consultants and legal experts who:

'…between them have a breadth and depth of experience in assessing and controlling the environmental impact of noise from wind farms.'

2.6.3 In this way it represented the views of all the stakeholders that are involved in the assessment of noise impacts of wind farm developments. The recommendations of the WGNWT are presented in the DTI Report – ETSU-R-97 *'The Assessment and Rating of Noise from Wind Farms (1996).'*

2.6.4 The basic aim of the WGNWT in arriving at the recommendations was the intention to provide:

'Indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding to the costs and administrative burdens on wind farm developers or local authorities.'

2.6.5 ETSU-R-97 makes it clear from the outset that any noise restrictions placed on a wind farm must balance the environmental impact of the wind farm against the national and global benefits that would arise through the development of renewable energy sources:

'The planning system must therefore seek to control the environmental impacts from a wind farm whilst at the same time recognising the national and global benefits that would arise through the development of renewable energy sources and not be so severe that wind farm development is unduly stifled.'

2.6.6 Where noise at the nearest noise sensitive receptors is limited to an $L_{A90,10min}$ of 35 dB(A) up to wind speeds of 10 ms^{-1} at a height of 10 m, then it does not need to be considered in the noise assessment, as protection of the amenity of these properties can be controlled through a simplified noise limit. In this regard ETSU-R-97 states that:

'For single turbines or wind farms with very large separation distances between the turbines and the nearest properties, a simplified noise condition may be suitable. If the noise is limited to an $L_{A90,10min}$ of 35 dB(A) up to wind speeds of 10 m/s at 10 m height, then this condition alone would offer sufficient protection of amenity, and background noise surveys would be unnecessary.'

2.6.7 The ETSU-R-97 assessment procedure specifies that where wind turbine noise is expected to be above the simplified limit of 35 dB L_{A90} noise limits should be set relative to existing background noise levels at the nearest receptors. These limits should reflect the variation in both turbine source noise and background noise with wind speed. Absolute lower limits, different for daytime and night-time, are applied where low levels of background noise are measured. The wind speed range that should be considered ranges between the cut-in wind speed for the turbines (usually about 2 to 3 ms^{-1}) and up to 12 ms^{-1}, where all wind speeds are referenced to a 10 metre measurement height.

2.6.8 Separate noise limits apply for daytime and for night-time. Daytime limits are chosen to protect a property's external amenity, and night-time limits are chosen to prevent sleep disturbance indoors, with windows open.

2.6.9 The daytime noise limit is derived from background noise data measured during so-called 'quiet periods of the day', which comprise weekday evenings (18:00 to 23:00), Saturday afternoons and evenings (13:00 to 23:00) and all day and evening on Sundays (07:00 to 23:00). Multiple samples of 10 minute background noise levels using the $L_{A90,10min}$ measurement index are logged continuously over a range of wind speed conditions. These measured noise levels are then plotted against concurrent wind speed data and a 'best fit' curve is fitted to the data to establish the background noise level as a function of wind speed. The ETSU–R-97 daytime noise limit, sometimes referred to as a 'criterion curve', is then set at a level 5 dB(A) above the best fit curve over the desired wind speed range; subject to an appropriate daytime fixed minimum limit:

'For wind speeds where the best fit curve to the background noise data lies below a level of 30 - 35 dB(A) the criterion curve is set at a fixed level in the range 35 - 40 dB(A). The precise choice of criterion curve level within the range 35 - 40 dB(A) depends on a number of factors: the number of noise affected properties, the likely duration, the level of exposure and the potential impact on the power output of the wind farm. The quiet daytime limits have been set in ETSU-R-97 on the basis of protecting the amenity of residents whilst outside their dwellings in garden areas.'

2.6.10 The night time noise limit is derived from background noise data measured during the night time periods (23:00 to 07:00), with no differentiation being made between weekdays and weekends. The 10 minute L_{A90} noise levels measured over the night time periods are plotted against concurrent wind speed data and a 'best fit' correlation is established. The night time noise limit is also based on a level 5 dB(A) above the best fit curve over the 0 - 12 ms^{-1} wind speed range, with a fixed minimum limit of 43 dB L_{A90}.

2.6.11 The exception to the setting of both the daytime and night time fixed minimum limits occurs where a property occupier has a financial involvement in the wind farm development. Paragraph 24 of ETSU-R-97 states:

'The Noise Working Group recommends that both day and night time lower fixed limits can be increased to 45 dB(A) and that consideration should be given to increasing the permissible margin above background where the occupier of the property has some financial involvement in the wind farm.'

2.6.12 ETSU-R-97 provides a robust basis for determining the noise limits for wind turbine(s) and since its introduction has become the accepted standard for such developments across the UK.

2.7 Current Good Practice

A Good Practice Guide on the Application of ETSU-R-97

2.7.1 In May 2013, the Institute of Acoustics issued *'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise'* (IOA GPG). The document provides guidance on background data collection, data analysis and limit derivation, noise predictions, cumulative issues, reporting requirements and other matters such as noise related planning conditions.

2.7.2 The Authors of the IOA GPG sets out the scope of the document in Section 1.2:

'This guide presents current good practice in the application of the ETSU-R-97 assessment methodology for all wind turbine developments above 50 kW, reflecting the original principles within ETSU-R-97, and the results of research carried out and experience gained since ETSU-R-97 was published. The noise limits in ETSU-R-97 have not been examined as these are a matter for Government.'

2.7.3 The guidance document was endorsed, on behalf of Scottish Government by the Cabinet Secretary for Finance, Employment and Sustainable Growth, Mr John Swinney MSP [8] The recommendations included in the IOA GPG have been considered and applied throughout this noise assessment for the Proposed Development.

2.7.4 The IOA GPG refers to six Supplementary Guidance Notes and where applicable these have also been considered in this report.

2.7.5 The guidance contained within ETSU-R-97 and the IOA GPG has therefore been used to assess and rate the operational noise emissions from the Proposed Development.

2.8 WSP BEIS Report

2.8.1 In February 2023, WSP published *'A review of noise guidance for onshore wind turbines'* [9]('WSP BEIS report'). The report, which was subsequently re-issued as version 4 in May 2023, was commissioned by (the former) UK Government Department for Business, Energy & Industrial Strategy (BEIS). The primary aim of the review was to make a recommendation on whether, in view of government policies on noise and Net Zero, and available evidence, the existing guidance requires updating.

2.8.2 The WSP BEIS report concluded that:

'the guidance would benefit from further review and updating of the aspects identified. This could be supported by currently available evidence, which is summarised in this report. However, the study has also highlighted gaps in the state of knowledge, which should be addressed by further research, to support any updates to the guidance.'

2.8.3 A series of recommendations are made regarding further research whilst some additional suggestions are included regarding the development of new or updated guidance. The following recommendation is included on page 26 of the WSP BEIS report:

'the separation of the 'policy position' (addressing the balance between controlling noise impact and enabling renewable energy development), 'technical guidance' (application of the assessment approach), and 'technical justification' (the supporting evidence) into discrete, linked documents'

2.8.4 The WSP BEIS report notes at the outset that *'Any views expressed within it do not necessarily represent the views of the UK government or the governments of any of the devolved administrations'.* The report does state on page 25 that:

'Consideration should be given to including a clear position statement in guidance confirming the intended policy balance between protection from noise impact, and enabling of renewable energy development (to achieve Net Zero), linked with the wider policies that underpin the government approach to noise management.'

2.8.5 The UK Government Department for Energy Security and Net Zero (DESNZ) has recently issued a tender seeking support to update ETSU-R-97. At the present time there are no set timescales for such an update to be published or adopted.

2.8.6 In relation to the guidance that should be used to assess the Proposed Development, the Scottish Government Guidance is clear; the Onshore Wind Policy Statement 2022 states:

'3.7.1. 'The Assessment and Rating of Noise from Wind Farms' (Final Report, Sept 1996, DTI), (ETSU-R-97) provides the framework for the measurement of wind turbine noise, and all applicants are required to follow the framework and use it to assess and rate noise from wind energy developments.'

'3.7.4. Until such time as new guidance is produced, ETSU-R-97 should continue to be followed by applicants and used to assess and rate noise from wind energy developments.'

2.8.7 The guidance contained within ETSU-R-97 and the IOA GPG has therefore been used to assess and rate the operational noise emissions from the Proposed Development.

3 Potential Impacts

3.1 Operational Noise Sources

3.1.1 Wind turbines may emit two types of noise. Firstly, aerodynamic noise is a more natural sounding 'broad band' noise, albeit with a characteristic modulation, or 'swish', which is produced by the movement of the rotating blades through the air. Secondly, mechanical noise may emanate from components within the nacelle of a wind turbine. Potential sources of mechanical noise include gearboxes or generators.

3.1.2 Aerodynamic noise is usually perceived when the wind speeds are fairly low although at very low wind speeds the blades do not rotate, or rotate very slowly, and so negligible aerodynamic noise is generated. In higher winds aerodynamic noise may be masked by the normal sound of wind blowing through the trees and around buildings. The level of this natural 'masking' noise relative to the level of wind turbine noise is one of the several factors that determine the subjective audibility of the wind turbines [(10)].

3.2 Infrasound, Low Frequency Noise and Vibration

3.2.1 The term infrasound can be defined as the frequency range below 20 Hz, while low frequency noise (LFN) is typically in the frequency range 20 – 200 Hz [(11)]. An average young healthy adult has an audible range from 20 Hz to 20,000 Hz, although the sensitivity of the ear varies with frequency and is most sensitive to sounds with frequencies between 500 Hz and 4,000 Hz. Wind turbines do produce low frequency sounds [(12)], but our threshold of hearing at such low frequencies is relatively high and they therefore go unnoticed. Infrasound from wind turbines is often at levels below that of the noise generated by wind around buildings and other obstacles.

3.2.2 In 2004, the former DTI commissioned The Hayes McKenzie Partnership to report on claims that infrasound or LFN emitted by wind turbine generators (WTGs) were causing health effects. Of the 126 wind farms operating in the UK, five had reported LFN problems, therefore, such complaints are an exception, rather than a general problem that exists for all wind farms. Hayes McKenzie investigated the effects of infrasound and LFN at three wind farms for which complaints had been received and the results were reported in May 2006 [(13)]. The report concluded that:

- *'infrasound associated with modern wind turbines is not a source which will result in noise levels which may be injurious to the health of a wind farm neighbour;*
- *low frequency noise was measurable on a few occasions but below the existing permitted Night Time Noise Criterion. Wind turbine noise may result in internal noise levels within a dwelling that is just above the threshold of audibility, however at all sites it was always lower than that of local road traffic noise;*
- *that the common cause of complaint was not associated with LFN, but the occasional audible modulation of aerodynamic noise especially at night. Data collected showed that the internal noise levels were insufficient to wake up residents at these three sites. However once awoken, this noise can result in difficulties in returning to sleep.'*

3.2.3 The Applied and Environmental Geophysics Research Group at Keele University was commissioned by the Ministry of Defence (MOD), the DTI and the British Wind Energy Association (BWEA) to undertake microseismic and infrasound monitoring of LFN and vibrations from wind farms for the purposes of siting wind farms in the vicinity of Eskdalemuir in Scotland. Whilst the testing showed that vibration can be detected several kilometres away from wind turbines, the levels of vibration from wind turbines were so small that only the most sophisticated instrumentation can reveal their presence and they are almost impossible to detect. Nevertheless, the Renewable Energy Foundation alleged potential adverse health effects and when that story was picked up in the popular press, notably the Scotsman, the report's authors expressed concern over the way in which their work had been misinterpreted and issued a rebuttal statement [(14)] in August 2005:

'Vibrations at this level and in this frequency range will be available from all kinds of sources such as traffic and background noise – they are not confined to wind turbines. To put the level of vibration into context, they are ground vibrations with amplitudes of about one millionth of a millimetre. There is no possibility of humans sensing the vibration and absolutely no risk to human health.'

3.2.4 In response to concerns that wind turbines emit infrasound and cause associated health problems, Dr Geoff Leventhall, Consultant in Noise Vibration and Acoustics and author of the Defra Report on Low Frequency Noise and its Effects, said in the article in the Scotsman ('Wind farm noise rules 'dated'- James Reynolds, 5 August 2005'):

'I can state quite categorically that there is no significant infrasound from current designs of wind turbines.'

3.2.5 An article [(15)] published in the IOA Bulletin (March/April 2009) concluded that there is no robust evidence that either low frequency noise (including 'infrasound') or ground-borne vibration from wind farms, has an adverse effect on wind farm neighbours.

3.2.6 Work [(16)] by Dr Leventhall looked at infrasound levels within the ear compared to external sources and concluded:

'The conclusion is that the continuous inner ear infrasound levels due to internal sources, which are in the same frequency range as wind turbine rotational frequencies, are higher than the levels produced in the inner ear by wind turbines, making it unlikely that the wind turbine noise will affect the vestibular systems, contrary to suggestions made following the measurements at Shirley. The masking effect is similar to that in the abdomen (Leventhall 2009). The body, and vestibular systems, appear to be built to avoid disturbance from the high levels of infrasound which are produced internally from the heartbeat and other processes. In fact, the hearing mechanisms and the balance mechanisms, although in close proximity, have developed to minimise interaction (Carey and Amin 2006).'

3.2.7 More recently during a planning Appeal (PPA-310-2028, Clydeport Hunterston Terminal Facility, approximately 2.5 km south-west of Fairlie, 9 Jan 2018), the health impacts related to LFN associated with wind turbines were considered at length by the appointed Reporter (Mr M Croft). The Reporter considered evidence from Health Protection Scotland and the National Health Service. In addition, he also considered LFN surveys undertaken by the Appellant and the Local Authority, both of which demonstrated compliance with planning conditions and did not identify any problems attributable to the turbine operations; some

periods with highest levels of low frequency noise were in fact recorded when the turbines were not operating.

3.2.8 The Reporter concluded that:

- The literature reviews by bodies with very significant responsibilities for the health of local people found insufficient evidence to confirm a causal relationship between wind turbine noise and the type of health complaints cited by some local residents;
- The NHS's assessment is that concerns about health impact are not supported by good quality research; and
- Although given the opportunity, the Community Council failed to provide evidence that can properly be set against the general tenor of the scientific evidence.

3.2.9 The WSP BEIS Report notes on page 113 that:

'Several studies have investigated the claimed links between adverse health symptoms and infrasound emissions from wind turbines. Although some experimental studies have linked infrasonic signals with activation of physiological sensory processing, these have tended to be based on signals that are not representative of wind turbine infrasound. There remains no compelling evidence of adverse health effects associated with wind turbine infrasound exposure at sound frequencies and' levels expected to be present at noise-sensitive receptor locations in the vicinity of wind farms'

3.2.10 The WSP BEIS Report goes on to note on page 114 that:

'Overall, the findings from the existing evidence base indicate that infrasound from wind turbines at typical exposure levels has no direct adverse effects on physical or mental health, and reported symptoms of ill-health are more likely to be psychogenic in origin.'

3.2.11 It is noted that research into infrasound is ongoing but the WSP BEIS report concluded that:

'It is expected that further evidence from ongoing studies into wind turbine infrasound effects will emerge soon, in particular from the NHMRC studies in Australia. However, based on the existing scientific evidence, it does appear probable that the above findings will not be contradicted by newer evidence.'

3.2.12 Since the publication of the WSP BEIS report, the study that was granted funding by NHMRC (the National Health and Medical Research Council of Australia) was published in the Environmental Health Perspectives (EHP) journal which is published by the United States National Institute of Environmental Health. The study [(17)] aimed to test the effect of exposure to 72 hours of infrasound (designed to simulate a wind turbine infrasound signature) exposure on human physiology, particularly sleep. The study concluded that:

'Our findings did not support the idea that infrasound causes WTS[1]. High level, but inaudible, infrasound did not appear to perturb any physiological or psychological measure tested in these study participants.'

[1] WTS stands for Wind Turbine Syndrome which is a term for adverse human health effected related to the proximity of wind turbines.

3.2.13 It is therefore not considered necessary to carry out specific assessments of LFN and it has not been considered further in the noise assessment.

3.3 Amplitude Modulation of Aerodynamic Noise (AM)

3.3.1 In the context of wind turbine noise amplitude modulation describes a variation in noise level over time; for example, observers may describe a 'whoosh whoosh' sound, which can be heard close to a wind turbine as the blades sweep past. Amplitude Modulation of aerodynamic noise is an inherent characteristic of wind turbine noise and was noted in ETSU-R-97, on page 68:

'The modulation or rhythmic swish emitted by wind turbines has been considered by some to have a characteristic that is irregular enough to attract attention. The level and depth of modulation of the blade noise is, to a degree, turbine-dependent and is dependent upon the position of the observer. Some wind turbines emit a greater level of modulation of the blade noise than others. Therefore, although some wind turbines might be considered to have a character that may attract one's attention, others have noise characteristics which are considerably less intrusive and unlikely to attract one's attention and be subject to any penalty.

This modulation of blade noise may result in a variation of the overall A-weighted noise level by as much as 3dBA (peak to trough) when measured close to a wind turbine. As distance from the wind turbine [or] wind farm increases, this depth of modulation would be expected to decrease as atmospheric absorption attenuates the high frequency energy radiated by the blade.'

3.3.2 In recent times the Acoustics community has sought to make a distinction between the AM discussed within ETSU-R-97, which is expected at most wind farms and as such may be considered as 'Normal Amplitude Modulation' (NAM), compared to the unusual AM that has sometimes been heard at some wind farms, hereinafter referred to as 'Other Amplitude Modulation' (OAM). The term OAM is used to describe an unusual feature of aerodynamic noise from wind turbines, where a greater than normal degree of regular fluctuation in sound level occurs at blade passing frequency, typically once per second. In some appeal decisions it may also be referred to as 'Excess Amplitude Modulation' (EAM). It should be noted that the noise assessment and rating procedure detailed in ETSU-R-97 fully takes into account the presence of the intrinsic level of NAM when setting acceptable noise limits for wind farms.

3.3.3 On 16 December 2013, RenewableUK (RUK) released six technical papers [18] on AM, which reflected the outcomes of research commissioned over the previous three years, together with a template planning condition. Whilst this research undoubtedly improved understanding of Other Amplitude Modulation (OAM) and its effects, it should be noted that at the time of writing it has not been endorsed by any relevant body such as the Institute of Acoustics (IOA).

3.3.4 On 22 January 2014, the IOA released a statement regarding the RUK research and the proposed planning condition to deal with the issue of amplitude modulation from a wind turbine and stated:

'This research is a significant step forward in understanding what causes amplitude modulation from a wind turbine, and how people react to it. The proposed planning

condition, though, needs a period of testing and validation before it can be considered to be good practice. The IOA understands that RenewableUK will shortly be making the analysis tool publicly available on their website so that all interested parties can test the proposed condition, and the IOA will review the results later in the year. Until that time, the IOA cautions the use of the proposed planning condition.'

3.3.5 Research regarding amplitude modulation continued. In April 2015, the IOA issued a discussion document entitled *'Methods for Rating Amplitude Modulation in Wind Turbine Noise'*. The document presented three methods that can be used to quantify the level of AM at a given measurement location. After extensive consultation a preferred method of measuring OAM, which provides a framework for practitioners to measure and rate AM, was recommended by the IOA.

3.3.6 On 3 August 2015, the Department for Energy and Climate Change (DECC), now the Department for Business, Energy and Industrial Strategy (BEIS), commissioned independent consultants WSP Parsons Brinkerhoff to carry out a literature review on OAM (which they refer to simply as AM). The stated aims were as follows:

- *To review the available evidence on Amplitude Modulation (AM) in relation to wind turbines, including but not limited to the research commissioned and published by RenewableUK in December 2013;*
- *To work closely with the Institute of Acoustics' AM working group, who are expected to recommend a preferred metric and methodology for quantifying and assessing the level of AM in a sample of wind turbine noise data;*
- *To review the robustness of relevant dose response relationships, including the one developed by the University of Salford as part of the RenewableUK study, on which the correction (or penalty) for amplitude modulation proposed as part of its template planning condition is based;*
- *To consider how, in a policy context, the level(s) of AM in a sample of noise data should be interpreted, in particular determining at what point it causes a significant adverse impact;*
- *To recommend how excessive AM might be controlled through the use of an appropriate planning condition; and*
- *To consider the engineering/cost trade-offs of possible mitigation measures.*

3.3.7 Their report, which was released in October 2016, concluded that there is sufficient robust evidence that excessive AM leads to increased annoyance from wind turbine noise and recommended that excessive AM is controlled through a suitably worded planning condition, which will control it during periods of complaint. Those periods should be identified by measurement using the metric proposed by the work undertaken by the IOA, and enforcement action would rely upon professional judgement by Local Authority Environmental Health Officers based on the duration and frequency of occurrence.

3.3.8 It is not clear within the body of the report which evidence the authors relied upon to arrive at their conclusions, although the Executive Summary states (page 4);

"It is noted that none of the Category 1 or 2 papers have been designed to answer the main aim of the current review in its entirety. The Category 1 studies have limited representativeness due to sample constraints and the artificiality of laboratory

environments, whereas the Category 2 studies generally do not directly address the issue of AM WTN exposure-response. A meta - analysis of the identified studies was not possible due to the incompatibility of the various methodologies employed. Notwithstanding the limitations in the evidence, it was agreed with DECC that the factors to be included in a planning condition should be recommended based on the available evidence, and supplemented with professional experience".

3.3.9 The report [19] states that any planning condition must accord with existing planning guidance, and should be subject to legal advice on a case by case basis. Existing guidance would include compliance with the six tests of a planning condition embodied in Circular 4/98. The report's authors did not dictate a particular condition to be used but did suggest that any condition should include the following elements (p5):

- *"The AM condition should cover periods of complaints (due to unacceptable AM);*
- *The IoA-recommended metric should be used to quantify AM (being the most robust available objective metric);*
- *Analysis should be made using individual 10-minute periods, applying the appropriate decibel 'penalty' to each period, with subsequent analysis;*
- *The AM decibel penalty should be additional to any decibel penalty for tonality; and*
- *An additional decibel penalty is proposed during the night time period to account for the current difference between the night and day limits on many sites to ensure the control method works during the most sensitive period of the day."*

3.3.10 AM was considered in the WSP BEIS report. The report notes that the IOA Method provides a suitable approach to measure and quantify AM (whilst noting that work is ongoing to refine the approach) but also highlights that further work is required to develop a robust mechanism for controlling AM that could be incorporated into a planning condition. In relation to the potential adoption of a penalty scheme to control AM the WSP BEIS report notes on page 208 that:

'In practice, the details of applying such a penalty scheme are complicated by the complexities of wind turbine sound measurements. These often involve a considerable amount of data filtering and data aggregation to address the practical difficulties of measuring a highly variable source, which is often also at a level that is relatively low compared with other, fluctuating residual sounds present in the acoustic environment. Such details will need to be carefully considered in further study, and the example planning condition proposed by a group of IOA members in 2017 [505] should be considered as a starting point.'

3.3.11 Until such a 'further study' is completed, and additional guidance is published, the approach set out in the IOA GPG remains valid, the document states (paragraph 7.2.10):

'7.2.1 The evidence in relation to "Excess" or "Other" Amplitude Modulation (AM) is still developing. At the time of writing, current practice is not to assign a planning condition to deal with AM.'

4 Methodology

4.1 Assessing Operational Noise Impact

4.1.1 To undertake an assessment of the operational noise impact in accordance with the requirements of ETSU-R-97 and the IOA GPG, the following steps are required:

- Specify the location of the wind turbines for the Proposed Development;
- Measure the background noise levels as a function of on-site wind speed at a selection of representative Noise Monitoring Locations (NML);
- Identify the locations of all nearby noise sensitive receptors and select a sample of relevant Noise Assessment Locations (NAL). For each NAL, identify the most representative measured background noise data;
- Establish for each NAL the Total ETSU-R-97 Noise Limits on analysis of the measured background noise levels;
- Specify the likely noise emission characteristics of the wind turbines for the Proposed Development and all nearby cumulative wind turbines;
- Calculate the likely noise immission levels due to the cumulative operation of all relevant wind turbines and compare it to the Total ETSU-R-97 Noise Limits;
- Determine the Site Specific Noise Limits which take account of the noise limit already allocated to/ could theoretically be used by other schemes in the area; and
- Calculate the likely noise immission levels due to the operation of the Proposed Development on its own and compare it to the Proposed Development's Site Specific Noise Limits.

4.1.2 In order to consider the steps outlined above the assessment has been split into three separate stages:

- Stage 1 – determine the Total ETSU-R-97 Noise Limits (which are applicable to noise from all wind turbines in the area operating concurrently) at the NALs;
- Stage 2 – undertake a cumulative assessment where noise predictions from the Proposed Development are within 10 dB of the total noise predictions from the other wind farms/turbines within the area; and
- Stage 3 – establish the Proposed Development's Site Specific Noise Limits (at levels below the Total ETSU-R-97 Noise Limits, where limit apportionment is required) and compare the noise predictions from the Proposed Development on its own against the proposed Site Specific Noise Limits.

4.1.3 There are a range of turbine makes and models that may be appropriate for the Proposed Development. In the absence of a confirmed turbine model, this noise assessment models a candidate turbine, the Siemens Gamesa SG6.6-155 with a hub height of 122.5 m. The final selection of turbine will follow a competitive tendering process and thus the final model of turbine may differ from those on which this assessment has been based. However, the final choice of turbine will be required to comply with the noise limits which have been established for the site.

4.2 Consultation

Scoping Opinion (dated April 2024)

4.2.1 The scoping opinion issued by the Scottish Government's Energy Consents Unit stated that the noise assessment should be carried out in accordance with the relevant legislation and standards detailed in Section 3.9 of the scoping report and that the report should be formatted as per Table 6.1 of the IOA GPG.

4.2.2 South Lanarkshire Council (SLC) did not respond to the Scoping Report so it is assumed that they had no comment to make in relation to the proposed noise assessment. Additional consultation was undertaken directly with SLCs Environmental Health Officer (EHO) as summarised in the sections below.

Consultation with South Lanarkshire Council's EHO (January 2024)

4.2.3 Prior to the commencement of the noise impact assessment for the Proposed Development, direct consultation was undertaken with the Environmental Health Department at SLC in order to agree the approach to the noise assessment and the noise monitoring locations. In addition, a representative from the Environmental Health Department was also invited to attend the installation of the noise monitoring equipment, however at the time of the installation no response had been received from SLC. Further consultation was undertaken post installation in order to provide an update on the final installed noise monitoring locations.

4.2.4 In response to the post installation consultation, an Environmental Health Officer (EHO) from SLC commented on the installed monitoring locations at NML4 and 5. At NML4 the monitoring equipment was located within a disused play area next to the property and the EHO mentioned the potential for unusual outliers in the measured data should the play equipment be used. At NML5 the EHO exercised caution should the plastic polytunnel in the garden be loose as data measured at higher wind speeds may be unusually high due to noise from the polycarbonate material. Further information on the noise monitoring locations are included within Section 5 below, together with more detailed information on NMLs 4 and 5 within Section 5.2.4 and 5.2.5.

4.2.5 A copy of the original consultation letter and subsequent email correspondence is included in Annex 2.

4.3 Setting the Total ETSU-R-97 Noise Limits (Stage 1)

Identifying Existing Noise Limits

4.3.1 Noise limits have already been set at some properties located closest to the Proposed Development due to other wind farm schemes in area.

4.3.2 The noise and meteorological data collected as part of the noise assessment work undertaken for the Proposed Development has been used to derive a set of Total ETSU-R-97 Noise Limits at some of the nearest noise sensitive receptors.

Background Noise Levels and Wind Shear

4.3.3 Wind shear can be defined as *'the change in the relationship between wind speed at different heights'.* Due to wind shear, wind speeds recorded on one meteorological mast at different heights are usually different, generally the higher the anemometer the higher the wind speed recorded. For example, if a wind speed of 4 ms^{-1} is recorded at 80 m height, 3.5 ms^{-1} may be recorded at 40 m and 2.5 ms^{-1} may be recorded at 10 m.

4.3.4 Hub height wind speed is the key wind speed for a wind farm noise assessment, as it is the wind speed at hub height which will determine the noise emitted by the wind turbines and informs the turbine control system. Ideally, both wind turbine noise predictions and background noise level measurements should refer to hub height wind speed (or a representation thereof), ensuring that there is no discrepancy between the wind speed at which the noise is emitted and the wind speed at which the corresponding background noise is measured.

4.3.5 The IOA GPG states that one of three methods (A, B or C) to account for wind shear may be adopted. For this assessment the 'Method A' of Section 2.6.3 of the IOA GPG was used to fully take account of wind shear. The details are described in the Section 5 'Baseline'.

Noise Impact Criteria in ETSU-R-97

4.3.6 Analysis of the measured data has been undertaken in accordance with ETSU-R-97 and current good practice to determine the pre-existing background noise environment and to establish, for each NAL, the daytime and night-time Total ETSU-R-97 Noise Limits, which would apply for the cumulative operation of all wind turbines in the area. The Total ETSU-R-97 Noise Limits for the daytime has been set at 40 dB(A) or background plus 5 dB whichever is the greater, and the Total ETSU-R-97 Noise Limits at night-time has been set at 43 dB(A) or background plus 5 dB whichever is the greater. This 'Total' limit relates to noise from all wind farm developments in the area. The limit was chosen with due regard to the guidance in ETSU-R-97 and following a review of the existing noise limits at receptors set by nearby wind farms.

4.3.7 As detailed in Section 2.6.9 above, ETSU-R-97 suggests that the daytime fixed minimum limit should be set somewhere in the range between 35 and 40 dB. The precise choice of criterion level within the range 35 - 40 dB(A) depends on a number of factors, including the number of dwellings in the neighbourhood of the wind farm, the effect of noise limits on the number of kWh generated and the duration and level of exposure to any noise. Site Specific Noise Limits have been derived such that they are always at or below the limit established using the lower fixed minimum limit.

4.3.8 The acceptable limits for wind turbine operational noise are clearly defined for all time periods by the application of the ETSU-R-97 methodology. Consequently, the test applied to operational noise is whether or not the predicted wind turbine noise immission levels at nearby noise sensitive properties lie below the ETSU-R-97 noise limits. Depending on the levels of background noise, the satisfaction of the ETSU-R-97 derived limits can lead to a situation whereby, at some locations under some wind conditions and for a certain proportion of the time, the wind turbine noise would be audible.

4.4 Assessment of likely effects and the requirement for a cumulative assessment (Stage 2)

4.4.1 The IOA GPG (2013) includes a detailed section on cumulative noise and provides guidance on where a cumulative assessment is required. Section 5.1.4 and 5.1.5 of the GPG state:

'During scoping of a new wind farm development consideration should be given to cumulative noise impacts from any other wind farms in the locality. If the proposed wind farm produces noise levels within 10 dB of any existing wind farm/s at the same receptor location, then a cumulative noise impact assessment is necessary.

Equally, in such cases where noise from the proposed wind farm is predicted to be 10 dB greater than that from the existing wind farm (but compliant with ETSU-R-97 in its own right), then a cumulative noise impact assessment would not be necessary.'

4.4.2 An assessment was undertaken at each of the NALs located proximate to the Proposed Development and other nearby operational, consented and proposed (planning application submitted) wind farm developments to determine whether the wind turbine noise immission from the Proposed Development were within 10 dB of the wind turbine noise immission from the other schemes. Where predictions were found to be within 10 dB of each other, then a cumulative noise assessment was undertaken to determine the likely impacts of the Proposed Development, however, if wind turbine immissions were greater than 10 dB apart then a cumulative noise assessment was not required.

Noise Prediction / Propagation Model

4.4.3 The ISO 9613-2: 1996 *'Acoustics – Attenuation of sound during propagation outdoors Part 2: General method of calculation'* [20] model algorithm provides a robust prediction method for calculating the noise immission levels at the nearest receptors. A European Commission (EC) research project into wind farm noise propagation over large distances, published as 'Development of a Wind Farm Noise Prediction Model,' JOULE project JOR3-CT95-0051 in 1998, identified a simplified version of ISO 9613-2 as the most suitable at that time, but the full method has been used for this assessment.

4.4.4 The use of ISO 9613-2 is discussed in the IOA GPG which states, in Section 4.1.4:

'ISO 9613-2 standard in particular, which is widely used in the UK, can be applied to obtain realistic predictions of noise from on-shore wind turbines during worst case propagation conditions (i.e. sound speed gradients due to downwind conditions or temperature inversions), but only provided that the appropriate choice of input parameters and correction factors are made.'

4.4.5 There is currently no standard approach to specifying error bands on noise predictions. Table 5 of ISO 9613-2 suggests, at best, an estimated of accuracy of ± 3 dB(A). The work undertaken as part of the EC research study concluded that the ISO 9613-2 algorithm reliably predicted noise levels that would generally occur under downwind propagation conditions. The error bands referenced in the ISO standard itself relate to the general application of the standard. Additional, wind farm specific studies, have also been undertaken to validate the use of the standard to predict wind farm noise and these are referenced in Section 4 of the IOA GPG which goes on to conclude that: *'The outcome of this research has demonstrated that the*

ISO 9613-2 standard in particular, which is widely used in the UK, can be applied to obtain realistic predictions of noise from on-shore wind turbines during worst case propagation conditions (i.e. sound speed gradients due to downwind conditions or temperature inversions), but only provided that the appropriate choice of input parameters and correction factors are made.' TNEIs experience of undertaking compliance monitoring for operational wind farms indicates that the predictions undertaken using the guidance in the IOA GPG show a good correlation with measured levels.

4.4.6 The ISO 9613-2 model can take account of the following factors that influence sound propagation outdoors:

- Geometric divergence;
- Atmospheric absorption;
- Reflecting obstacles;
- Screening;
- Vegetation; and
- Ground attenuation.

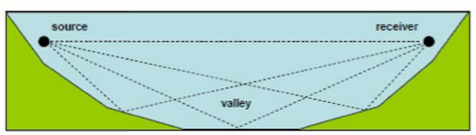
4.4.7 The model uses as its acoustic input data the octave band sound power output of the turbine and calculates, on an octave band basis, attenuation due to the factors above, as appropriate.

4.4.8 The IOA GPG quotes a comparative study undertaken in Australia that indicated ISO 9613-2 can, in some conditions, under-predict ground attenuation effects and the potential for additional reflection paths 'across a valley', whilst slightly over-predicting on flat terrain. It should be noted, however, that the wind farm layouts studied were untypical for the UK, with rows of turbines spreading over 10 km on an elevated ridge. It also should be noted that no correction for background contribution was undertaken and the monitoring locations were located as far as 1.7 km from the nearest turbine, where turbine noise may be at similar levels to background noise and therefore difficult to differentiate. For the study's modelling work topographic height data was included as an input, which is consistent with ISO 9613-2 methodology generally, but not with the requirements of the IOA GPG.

4.4.9 The model used in this assessment does not model barrier attenuation using the method in ISO 9613-2, but instead uses the guidance in the IOA GPG to consider whether any topographical corrections are required as set out below in Sections 4.4.10 to 4.4.13. Any differences in ground height (AOD) between the receptors and the turbines are considered when calculating the propagation distance between each source and receiver.

4.4.10 The IOA GPG states that a *'further correction of +3 dB should be added to the calculated overall A-weighted level for propagation 'across a valley', i.e. a concave ground profile or where the ground falls away significantly between a turbine and the receiver location.'* The potential reflection paths are illustrated in Schematic 4.1 below.

Schematic 4.1: Multiple reflection paths for sound propagation across concave ground



Source: IOA GPG, page 21, Figure 5

4.4.11 A formula from the JOULE Project JOR3-CT95-0051 dated 1998 is suggested for determining whether a correction is required.

$$h_m \geq 1.5 \times (abs\ (h_s - h_r) / 2)$$

where h_m is the mean height above the ground of the direct line of sight from the receiver to the source (as defined in ISO 9613-2, Figure 3), and h_s and h_r are the heights above local ground level of the source and receiver respectively).

4.4.12 The calculation of h_m requires consideration of the digital terrain model and needs to be performed for each path between every turbine and every receiver. Interpretation of the results of the calculation above and the subsequent inclusion of a concave ground profile correction requires careful consideration with any topographical variation considered in the context of a site.

4.4.13 The IOA GPG also discusses the potential for topographical screening effects of the terrain surrounding a wind farm and the nearby noise sensitive receptors. Although barrier screening effects in ISO 9613-2 can make corrections of up to 15 dB, the IOA GPG states that where there is no line of sight between the highest point on the rotor and the receiver location a reduction of no more than 2 dB may be applied.

4.4.14 The modelling parameters used in this assessment are detailed in Section 0 below.

4.5 Setting the Site Specific Noise Limits (Stage 3)

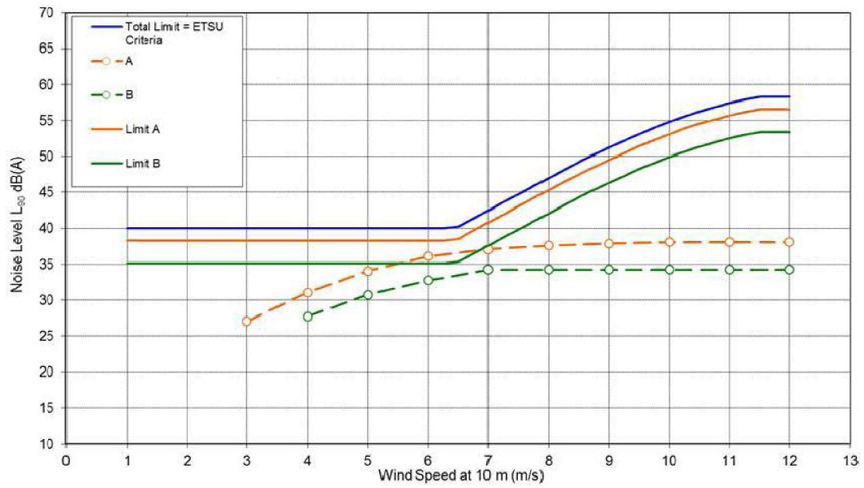
4.5.1 Summary Box 21 of the IOA GPG states:

'Whenever a cumulative situation is encountered, the noise limits for an individual wind farm should be determined in such a way that no cumulative excess of the total ETSU-R-97 noise limit would occur.'

4.5.2 In order to determine Site Specific Noise Limits at receptors in proximity to the Proposed Development (where required) limit apportionment has been undertaken. The limit apportionment has considered the noise limit already allocated to other wind farms in the area.

4.5.3 This approach is demonstrated in Graph 4.1 below. In this example the total limit (shown in blue) is shared between wind farm A and wind farm B. The two noise limits for a given receptor (the solid orange and green lines) when added together equate to the Total ETSU-R-97 Noise Limit, and the predicted levels for each wind farm (the dashed lines) meet the specific limits established for the individual wind farms.

Graph 4.1: Limit Apportionment Example



4.5.4 The limit derivation can also be undertaken with consideration to the amount of headroom between another schemes(s) predictions and the Total Noise Limit. With regard to this Section 5.4.11 of the IOA GPG states:

'In cases where there is significant headroom (e.g. 5 to 10 dB) between the predicted noise levels from the existing wind farm and the Total Noise Limits, where there would be no realistic prospect of the existing wind farm producing noise levels up to the Total Noise Limits, agreement could be sought with the LPA as to a suitable predicted noise level (including an appropriate margin to cover factors such as potential increases in noise) from the existing wind farm to be used to inform the available headroom for the cumulative assessment without the need for negotiation or cumulative conditioning. This may be the case particularly at low wind speeds.'

4.5.5 With this in mind, where appropriate, an additional 2 dB buffer has been added to the other schemes' turbine noise predictions. This is considered to be a suitable buffer in accordance with Section 5.4.11 of the IOA GPG and would represent a 60 % increase in emitted noise levels from the other schemes.

4.5.6 Where predicted wind turbine noise levels from the individual wind farm/ turbine schemes are found to be >10 dB below the Total ETSU-R-97 Noise Limits then it has been deemed appropriate to allocate the entire noise limit to the Proposed Development. Further information on the approach to apportionment is provided in Section 6.6 below.

5 Baseline

5.1 Identification of Potential Noise Receptors

5.1.1 At the start of the noise assessment, preliminary desktop noise modelling was undertaken using the Resoft 'WindFarm' [21] software in order to locate noise sensitive receptors which may be affected and to identify suitable locations at which to monitor background noise levels. An initial wind turbine layout was input into the 'WindFarm' software and using noise data for a candidate turbine representative of the type that could be installed on the site a noise contour plot was produced. The noise contour plot was included in the consultation letter sent to the Environmental Health Department at South Lanarkshire Council. A copy of that letter is included in Annex 2.

5.1.2 The noise contour plot predicted wind turbine noise levels at the noise sensitive receptors surrounding the Proposed Development with predicted turbine noise (measured in $dB_{(A),\ L90}$) decreasing with distance from the Proposed Development. All properties or clusters of properties within the 35 dB(A) contour were identified and assessed to determine which properties would provide representative background noise data for others in the area. For completeness, the nearest receptors to the east and southeast were also assessed despite being located outside of the 35 dB contour line.

5.1.3 In accordance with ETSU-R-97, the noise contour plot was based on a noise level at a wind speed of 10 ms^{-1} (as standardised to 10 m height) as the manufacturer determined that this is the wind speed with the highest predicted noise level between 0 and 10 ms^{-1} for the candidate turbine.

5.1.4 The IOA GPG notes *that 'noise-sensitive receptors*, [are] *principally houses (existing or for which planning consent is being sought / has been given) and any building used for long-term residential purposes (such as a nursing home)'*. Following a review of noise sensitive receptors surrounding the Proposed Development, the closest receptors were found to be residential properties.

5.1.5 The properties identified for noise monitoring were selected following a detailed review of the area using aerial photography to identify receptors which would be representative of other nearby properties. Where possible, locations were selected which were subject to minimal influence from other noise sources such as local watercourses, operational wind turbines and vegetation.

5.2 Background Noise Survey

5.2.1 Background noise monitoring was undertaken for the purposes of setting the Total ETSU-R-97 Noise Limits. Data was recorded over the period 18 January - 26 March 2024 at five noise sensitive receptors.

5.2.2 Details of the exact monitoring periods, the rationale behind the exact kit location and the dominant noise sources observed at each of the Noise Monitoring Location (NML) are detailed in the Field Data Sheets (FDS) and installation report included in Annex 3.

5.2.3 The NML is the position that the sound level meter was sited at each property, as shown on Figure A1.1 (Annex 1) and summarised in Table 5.1 below.

Table 5.1 Noise Monitoring Locations

NML/ Receptor Name	Easting	Northing
NML1 – Over Balgray	288047	624648
NML2 – Duneaton Bridge House	291629	624561
NML3 – Netherton Farm	290936	625425
NML4 – Maidencots Farm	292798	626245
NML5 – Crawfordjohn Mill Farm	289688	624128

5.2.4 The Environmental Health Department at SLC commented on the potential for measured data collected at NML4 and 5 being influenced by nearby noise sources. NML4 was situated in a disused play area and the EHO advised that noise from play equipment being used may influence measured data. At NML5 the EHO advised that wind induced noise from the plastic on the polytunnel may influence measured data if the polycarbonate material is loose.

5.2.5 Comments made by the EHO were considered. Upon installation of equipment at NML4, it was apparent that the play area was not in use and had not been used for a considerable amount of time. This location was attended by TNEI staff four times throughout the monitoring period and at no point were there signs that the equipment had been in use. Furthermore, no atypical datapoints were discovered upon analysis of the noise data, further indicating that the equipment had not been used.

5.2.6 The polytunnel at NML5 was not audible during any of the site visits. As a precautionary measure, once the first four week monitoring period was completed the noise kit was moved further away from the polytunnel (~15 m to the east). No atypical datapoints were discovered during the analysis of the noise data and therefore there is no indication that data was influenced by noise from the polytunnel.

5.3 Noise Monitoring Equipment

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

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

5.3.2 The noise monitoring equipment used for the background noise survey meets with the requirements of the IOA GPG. Details of the noise monitoring equipment used, the calibration drift recorded and photographs at each NML are detailed in the FDS included in Annex 3. The IOA GPG states that for calibration drift greater than 1 dB the measurements should be discarded. The maximum calibration drift recorded during the noise survey was 0.1 dB as detailed in the FDS (included in Annex 3).

5.3.3 Copies of the calibration/conformance certificates for the sound level meters and sound level calibrator used for the noise survey are included in Annex 4. All sound level meters conform to Class 1/ Type 1.

5.3.4 The microphones were all mounted between 1.2 m and 1.5 m above local ground level, situated between 3.5 m and 20 m from the dwelling and were located *'in an area frequently used for rest and relaxation'* (Section 2.5.1 of IOA GPG), where appropriate, away from obvious local sources of noise such as boiler flues, fans and running water. The sound level meters were situated as far away from hard reflective surfaces such as fences and walls as practicable.

5.3.5 All measurement systems were set to log the L_{A90} and L_{Aeq} noise levels over the required ten minute intervals continuously over the deployment period.

5.4 Meteorological Data

5.4.1 ETSU-R-97 states on Page 84 that:

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

5.4.2 The preferred methodologies for measuring or calculating wind shear are detailed in Section 4.3.3.

5.4.3 For the Proposed Development, concurrent wind speed/direction were recorded using a SODAR unit which was located within the site (grid reference 289574, 627065). The meteorological data was collected, processed, and provided by the Applicant. The installation report and calibration information for the SODAR can be provided upon request.

5.4.4 Tipping bucket rain gauges were installed at NML2 and NML3 for the duration of the noise survey to record periods of rainfall, time synchronised to the sound measurements. Rain data were collected by TNEI. As per the recommendations in Section 3.1.9 of the IOA GPG, the rain data were analysed by TNEI and the 10 minute periods which contain the registered rainfall events and the preceding 10 minute period have been excluded. All excluded rainfall periods are shown on Figures A1.3a-A1.3e (Annex 1) as blue squares.

5.4.5 Wind speed and direction data were collected over the same timescale and averaged over the same ten-minute periods as the noise data to provide the analysis of the measured background noise as a function of wind speed and direction.

5.4.6 In accordance with the IOA GPG, methodology A, has been adopted for this assessment which involved using data collected at 100 m and 120 m on the SODAR which were used to calculate hub height (122.5 m) wind speeds which, in turn, were standardised to a height of 10 m above ground.

Influence of Existing Turbines on Background Measurements

5.4.7 ETSU-R-97 states that background noise levels should be determined such that they are not influenced by existing turbine noise. The IOA GPG details that, in situations where measurement locations are potentially influenced by existing turbine noise, the following approaches can be adopted:

1. The existing wind turbines can be switched off (assuming the applicant has control of those turbines and noting that there would be associated cost implications);
2. The contribution of the wind turbines can be accounted for by filtering the measured data by direction (only including background data when a receptor is upwind of the wind turbines) or by subtracting predicted turbine noise from the measured levels;
3. Limits can be set using 'proxy' datasets measured at location(s) outside of the influence of the wind turbines; or
4. Limits can be set using data collected as part of previous background noise assessments undertaken before the wind turbines were operational, providing the equipment and both noise and meteorological data obtained are appropriate.

5.4.8 Choosing NMLs in this area was complex because there was the potential for the measured levels to be influenced by road traffic noise and wind turbine noise from the operational Middle Muir Wind Farm, which is located to the south west of the Proposed Development. The NMLs were carefully selected such that they were located away from operational wind farms wherever possible. NML1 (Over Balgray) was located closest to the operational scheme and upon installation and removal of the equipment the wind turbines at Middle Muir were not audible.

5.4.9 It is possible that measured data from NML1 could have been influenced by turbine noise from Middle Muir therefore measured data from NML1 was analysed in accordance with Section 5.2.3 of the IOA GPG (approach 2 as detailed in Section 5.4.7 above) to remove the potential turbine noise from measured data. Middle Muir was accounted for through adopting both the filtering and subtractive approaches described in approach 2 (see Annex 1, Figure A1.4a-f).

5.4.10 The data was directionally filtered to remove data when the NML was downwind of the Middle Muir wind turbines. A number of filter angles were considered and an excluded angle of 90 degrees was selected as removing more data would have resulted in higher background noise levels (as the remaining data would be increasingly influenced by road traffic noise); this is illustrated in Annex 1, Figures A14a-f which presents an analysis using alternative filter angles.

5.4.11 To ensure that the influence of Middle Muir Wind Farm was appropriately considered the remaining data (covering an arc of 270 degrees) was adjusted by subtracting the predicted wind turbine noise levels (for each ten-minute period) from the noise level measured at the NML (this method is also referenced in Section 5.2.3 of the IOA GPG). Where predicted noise levels we equal to or above the measured noise levels it is not possible to undertake the correction and in this case it has been assumed that the background noise levels are 10 dB below the measured value. Adoption of this approach has resulted in a band of data between 10 and 15 dB, in practice this is considered to be a cautious approach which should result in the calculation of a cautious prevailing background noise level. The results of this analysis are visible on Figure A1.4f, where the data has been removed when the wind was blowing from 240 to 330 degrees. For the remaining data the original measured data is shown in blue and the corrected background noise data is shown in grey; the corrected background noise levels effectively shift down as viewed on the graph.

5.5 Directional Filtering of Background Noise

5.5.1 In Section 3.1.22 of the IOA GPG the need to directionally filter background noise data is discussed. Where a receiver is located upwind of a dominant local noise source whilst also being systematically downwind of the turbines then it may be necessary to filter background noise data particularly when this corresponds to the prevailing wind direction.

5.5.2 For this site the M74 motorway was the dominant noise source. The Proposed Development and M74 motorway are upwind of most receivers concurrently, so in accordance with Section 3.1.22 of the IOA GPG directional filtering was not deemed necessary.

5.5.3 NML3 – Netherton Farm is located downwind of turbines 20, 21 and 22 to the west whilst upwind of the M74 to the east. Filtering from the east was tested, however since the M74 curves around Netherton Farm both to the north/northwest and to the south, the receptor is subject to road noise from all of these directions and filtering from the east made no difference to the measured background noise levels. As such, measured data at NML3 was not directionally filtered as road noise can be considered typical of the soundscape at that property.

5.5.4 Directional filtering of background noise was undertaken at NML1 to filter out potential noise from Middle Muir Wind Farm as discussed in 5.4.9 above.

5.6 Analysis of Measured Data

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

5.6.2 Meteorological data was screened upon receipt by TNEI and where rainfall occurred, the noise and wind speed data has been excluded from the assessment as detailed in Section 5.4 above.

5.6.3 Time series graphs are provided in Annex 5, which show the variation in measured wind speed/direction and noise level over the monitoring period. These graphs also show where data was excluded, either due to rainfall, birdsong or manual exclusions due to atypical data.

5.7 Prevailing Background Noise Level

5.7.1 Table 5.1 and Table 5.2 summarise the prevailing background noise levels measured during the noise monitoring period, after filtering of the individual datasets as discussed above.

Table 5.2 Summary of Prevailing Background Noise Levels during Quiet Daytime Periods ($L_{A90,10\ min}$ dB(A))

NML	Wind Speed (ms^{-1}) as standardised to 10m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NML1 – Over Balgray	26.4	26.8	27.6	29.0	31.0	33.5	36.5	40.0	44.1	48.7	53.9	59.6
NML2 – Duneaton Bridge House	32.7	33.2	34.0	35.0	36.3	37.7	39.4	41.2	43.2	45.3	47.6	50.0

NML	Wind Speed (ms^{-1}) as standardised to 10m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NML3 – Netherton Farm	40.3 *	40.3 *	40.3	40.5	41.2	42.4	44.0	46.2	48.7	51.7	55.0	58.7
NML4 – Maidencots Farm	46.7	46.9	47.1	47.3	47.6	47.9	48.3	48.8	49.4	50.2	51.2	52.4
NML5 – Crawfordjohn Mill Farm	29.7 *	29.7	29.8	30.5	31.6	33.0	34.7	36.4	38.1	39.7	41.0	42.0

* Flatlined where derived minimum occurs at lower wind speeds and derived maximum occurs at higher wind speeds, see Sections 5.7.4 and 5.7.6 .

Table 5.3 Summary of Prevailing Background Noise Levels during Night-time Periods ($L_{A90,10\ min}$ dB(A))

NML	Wind Speed (ms-1) as standardised to 10m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NML1 – Over Balgray	21.8	22.8	24.3	26.2	28.5	31.2	34.4	38.0	42.0	46.4	51.3	56.6
NML2 – Duneaton Bridge House	29.8	30.1	30.9	32.1	33.6	35.5	37.6	40.0	42.4	44.9	47.4	49.9
NML3 – Netherton Farm	37.2 *	37.2 *	37.2	37.8	38.9	40.3	42.3	44.6	47.3	50.3	53.8	57.5
NML4 – Maidencots Farm	43.1 *	43.1 *	43.1	43.2	43.4	43.9	44.6	45.7	47.2	49.1	51.5	54.4
NML5 – Crawfordjohn Mill Farm	29.2 *	29.2 *	29.2	29.7	30.7	32.0	33.6	35.3	36.9	38.4	39.7	40.5

* Flatlined where derived minimum occurs at lower wind speeds and derived maximum occurs at higher wind speeds, see Sections 5.7.4 and 5.7.6

5.7.2 A series of graphs are presented for each of the NMLs to illustrate the data collected, these are included as Figures A1.3a-e (Annex 1). There is a set of graphs for each of the NMLs, which show the range of wind speeds and directions recorded during the survey by the SODAR and the 10-minute average wind speeds plotted against the recorded $L_{A90,\ 10min}$ noise levels at the NML along with a calculated 'best fit' polynomial regression line for the quiet daytime and night-time periods. Each Figure also includes a table with the number of recorded data points per integer wind speed bin and the prevailing measured background noise levels.

5.7.3 The prevailing measured background noise levels have been calculated using a best fit polynomial regression line of no more than a fourth order through the measured $L_{A90,\ 10min}$ noise data, as required by ETSU-R-97 and the IOA GPG.

5.7.4 In line with the recommendations included in Section 3.1.21 of the IOA GPG, where relevant, the polynomial background curve for the low-speed conditions has been flatlined at the lower wind speeds where the derived minimum occurs. This is presented on the figures; the final regression analysis curve is shown as a continuous black line and the original polynomial line of best fit through the data is shown as a dashed black line.

5.7.5 Section 2.9.5 of the IOA GPG recommends that no fewer than 200 valid data points should be recorded in each of the quiet daytime and night-time periods, with no fewer than 5 valid data points in any 1 ms^{-1} wind speed bin. Where the background noise data has been filtered by wind direction the IOA GPG (Section 2.9.6) recommends that 100 data points and 3 per wind speed bin may be appropriate. Where the minimum number of data points in a wind speed bin was not achieved, data in that bin has been manually excluded from the assessment.

5.7.6 ETSU-R-97 states (Page 101) that data may not be extrapolated beyond the measured range of wind speeds. It is however reasonable to assume that background noise levels will not decrease at higher wind speeds. As such, in the interest of protecting residential amenity, the noise levels for higher wind speeds where data has not been collected have been set equal to those derived for lower wind speeds as set out below (as per Section 3.1.20 of the IOA GPG).

5.7.7 A summary of the analysis applied to the individual datasets as recommended by the IOA GPG is included in Table 5.4 below.

Table 5.4 Analysis of Measured Datasets

NML	Quiet Daytime	Night Time
NML1 – Over Balgray	Not flatlined at any wind speed due to sufficient datapoints in each wind speed bin.	Not flatlined at any wind speed due to sufficient datapoints in each wind speed bin.
NML2 – Duneaton Bridge House	Not flatlined at any wind speed due to sufficient datapoints in each wind speed bin.	Not flatlined at any wind speed due to sufficient datapoints in each wind speed bin.
NML3 – Netherton Farm	Flatlined below 3 ms^{-1} (minimum level recorded).	Flatlined below 3 ms^{-1} (minimum level recorded).
NML4 – Maidencots Farm	Not flatlined at any wind speed due to sufficient datapoints in each wind speed bin.	Flatlined below 3 ms^{-1} (minimum level recorded).
NML5 – Crawfordjohn Mill Farm	Flatlined below 2 ms^{-1} (minimum level recorded).	Flatlined below 3 ms^{-1} (minimum level recorded).

5.7.8 The number of data points measured in each wind speed bin for each receptor, once exclusions were applied, are summarised in Figures A1.3a - A1.3e (Annex 1). The Figures also show the final prevailing background noise levels which have been determined following the analysis detailed above.

6 Noise Assessment Results

6.1 Noise Assessment Locations

6.1.1 Noise Assessment Locations (NAL) refer to the position on the curtilage denoted by the blue house symbol on Figure A1.1 (Annex 1). A total of nine noise sensitive receptors were chosen as representative NALs. The NALs chosen were the closest receptors to the Proposed Development and other wind farm developments. Predictions of wind turbine noise have been made at each of the NAL as detailed in Table 6.1.

6.1.2 This approach ensures that the report models the worst case (highest) noise immission level expected at each group of noise sensitive receptors, as, generally speaking, sound levels decrease due to the attenuating factors described in Section 6.2.2 and thus the closer to a noise source, the higher the noise level. Table 6.1 details which NML has been used to determine noise limits for each NAL.

Table 6.1 Noise Assessment Locations

Noise Assessment Location (NAL)	Easting	Northing	Elevation (m AOD)	Approximate Distance to Nearest M74 West Turbine* (m)	Background Noise Data Used
NAL1 - Greenfield	288097	624999	288	1,180 (T19)	NML1
NAL2 - Blackburn	289013	625359	262	535 (T20)	NML1
NAL3 - Netherton Farm	290783	625537	295	835 (T22)	NML3
NAL4 – Maidencots Cottage	292636	626346	272	1,430 (T16)	NML4
NAL5 - Duneaton Bridge House	291590	624581	241	1,620 (T22)	NML2
NAL6 - Crawfordjohn Mill Farm	289660	624172	250	1,060 (T22)	NML5
NAL7 – Redshaw**	286042	628519	306	2,260 (T10)	Data collected for the proposed Bodinglee Wind Farm
NAL8 - Over Balgray	288054	624662	290	1,500 (T19)	NML1
NAL9 – Red Moss Hotel**	287458	627018	275	305 (T17)	Data collected for the proposed Bodinglee Wind Farm

** Please note the distances to nearest turbines quoted above may differ from those reported elsewhere. Distances for the noise assessment are taken from the nearest turbine to the closest edge of the amenity area (usually the garden).*
*** Taken from Annex E, Figure E7 & E8 of the Bodinglee Wind Farm Environmental Noise Assessment, dated 9th June 2023.*

6.1.3 Red Moss Hotel (to the west of the Proposed Development) has been uninhabited for some time and the land on which it is situated has been the subject of an EIA screening request

for a large BESS facility. The developer of the BESS facility, Green Switch Capital, has indicated that they anticipate a planning application being submitted by the end of 2024. Due to the current status of the hotel and the uncertainty regarding its future use, for completeness, it has been considered as a NAL.

6.1.4 The receptor Thirstone Cottage (located adjacent to Thirstone Quarry) and the Strand are financially Involved with the Proposed Development. It is intended that both properties will be repurposed (as a site office and site spares office) as part of the Proposed Development and will not continue in residential use, therefore they have not been considered as NSRs.

6.2 Noise Emission Characteristics of the Wind Turbines

6.2.1 There are a range of wind turbine models which may be suitable for installation at the Proposed Development. This assessment considers the Siemens Gamesa SG 6.6-155 with serrated blades and a hub height of 122.5 m.

6.2.2 The turbines considered in the cumulative assessment are summarised in Annex 6. Details of the sound power level, octave data and measurement uncertainty used for the turbines considered in this assessment are included in Annex 7. The data for the candidate turbine used in this assessment and for modelling some of the other nearby schemes has not been included due to data confidentiality. The detailed noise data would be available upon request subject to the signing of the appropriate Non-Disclosure Agreement. Due to the differences in the way in which levels are provided by the different manufacturers, TNEI has accounted for uncertainty using the guidance contained within Section 4.2 of the IOA GPG.

6.2.3 Manufacturer data is usually supplied based on a specific hub height whilst values are presented as standardised to 10 m height. The noise model used in this assessment alters turbine noise data to account for different hub heights, where applicable. The hub height modelled for the Proposed Development is 122.5 m. The hub heights considered for the other wind farm/turbine developments are summarised in Annex 6.

6.2.4 The location of the wind turbines are shown on Figure A1.2 and grid references are included in Annex 6.

6.3 Noise Propagation Parameters

6.3.1 As detailed in Section 4.4 above, the full version of the ISO 9613-2 model has been used to calculate the noise immission levels at the nearest receptors.

6.3.2 For the purposes of the present assessment, all noise level predictions have been undertaken using a receiver height of 4.0 m above local ground level, mixed ground (G=0.5) and air absorption co-efficients based on a temperature of 10 °C and 70 % relative humidity to provide a realistic impact assessment. The modelling parameters reflect current good practice as detailed within the IOA GPG.

6.3.3 The wind turbine noise immission levels are based on the $L_{A90,10\ minute}$ noise indicator in accordance with the recommendations in ETSU-R-97, which were obtained by subtracting 2dB(A) from the turbine sound power level data (L_{Aeq} indicator).

6.3.4 A topographical assessment has been undertaken between each noise sensitive receptor and wind turbine location to determine whether any concave ground profiles exist between the source and receiver (noise sensitive receptor). Analysis undertaken using a combination of CadnaA [(22)] and an Excel model found that if the formula in the IOA GPG is applied directly a +3 dB correction is required for some turbines at a number of receptors as summarised in Annex 6.

6.3.5 In addition, an assessment has been undertaken to determine whether any topographical screening effects of the terrain occur where there is no direct line of sight between the highest point on the turbine rotor and the receiver location. Upon analysis of each noise sensitive receptor it was found that a barrier correction of -2 dB could be applied for some turbines at a number of receptors as detailed in Annex 6. In reality, there is significant screening at some of the locations so more attenuation may occur in practice, the use of a 2 dB value is therefore considered to be conservative as it results in the highest predicted levels. All corrections have been applied, where necessary, in all of the Tables and Graphs in this report.

6.3.6 The need to include a concave ground/screening correction may change depending on the final location of the turbines (following micrositing) and the final turbine hub height. Nevertheless, turbine noise levels will have to meet the noise limits detailed in planning conditions regardless of any difference in noise propagation caused by topography. Should consent be granted, the need to apply a concave slope correction will need to be considered by the Applicant prior to the final selection of a turbine model for the Proposed Development.

6.3.7 The cumulative assessment has taken into account directivity effects in line with good practice. The directivity of wind turbines has been recognised for some time. Building on earlier work by NASA, in 1988 Wyle Laboratories studied sound propagation using an omnidirectional loudspeaker source elevated 80 ft above ground, in upwind, downwind and cross wind situations, and in both flat and hilly terrain, then compared those measurements to measured data from actual wind turbines. Their study quantified directivity factors for a limited frequency range but was unable to conclusively demonstrate the anticipated directivity effects on real wind turbines. It also highlighted, but was unable to explain, measured differences observed between flat and hilly terrain.

6.3.8 Hubbard (1990) (IOA GPG Section 4.4.3) described a number of factors believed to influence propagation and directivity, notably refraction caused by vertical wind and temperature gradients. In the downwind direction the wind gradient causes the sound rays to bend toward the ground, whereas in the upwind direction the rays curve upward away from the ground. Upwind of the turbine this results in a region of increased attenuation termed the ‘shadow zone’. The excess attenuation is frequency dependent, with lowest frequencies least attenuated. Relating this to the earlier NASA studies, Hubbard noted that the distance from the source to the edge of the shadow zone is related to the wind speed gradient and the elevation of the source, which for a typical turbine source was calculated to be approximately 5 times the source height.

6.3.9 This observation was adopted in the IOA GPG, which states (Section 4.4.2) ‘Such reductions (due to “shadow zone” refraction effects) will in practice only progressively come into play at distances of between 5 and 10 turbine tip heights’, while Section 4.4.3 provides graphical examples of increasing broadband directivity with increasing tip height scaling in both flat and hilly terrain, without qualifying either of those designations.

6.3.10 The IOA GPG recommends (Section 4.4.1) that directivity attenuation factors adopted in any assessment should be clearly stated. The TNEI noise model can consider the effect of directivity, and in line with current good practice the attenuation values used are detailed in Table 6.2. These are based upon the examples given in the IOA GPG (Section 4.4.2), using interpolation where required, to adopt a single attenuation value for receptors located more than 5 tip heights from a receiver.

Table 6.2 Wind Directivity Attenuation Factors used in Modelling

Direction (º)	0	15	30	45	60	75	90	105	120	135	150	165
Attenuation dB(A))	-10	-9.9	-9.3	-8.3	-6.7	-4.6	-2	0	0	0	0	0
Direction (º)	180	195	210	225	240	255	270	285	300	315	330	345
Attenuation (dB(A))	0	0	0	0	0	0	-2	-4.6	-6.7	-8.3	-9.3	-9.9

6.4 Total ETSU-R-97 Noise Limits (Stage 1)

6.4.1 The ETSU-R-97 noise limits are derived by establishing the 'best fit' correlation between background noise level and wind speed. These limits, sometimes referred to as the 'criterion curve', are based on a level 5 dB(A) above this best fit correlation curve, over a wind speed range from 0 to 12 ms^{-1}. Where the derived criterion curve for the daytime period lies below a fixed level in the range 35 – 40 dB(A) then ETSU-R-97 provides that the criterion curve may be set at an absolute level somewhere within that range.

6.4.2 When considering the cumulative impacts of the Proposed Development operating in conjunction with other operational, consented and proposed schemes a Fixed Minimum Limit of 40 dB has been adopted to establish the daytime Total ETSU-R-97 Noise Limit. This limit was chosen following a review of the noise limits allocated or proposed for nearby wind farms and with due regard to the guidance in ETSU-R-97.

6.4.3 Whilst a cumulative daytime Total ETSU-R-97 Noise Limit of 40 dB (or background noise plus 5 dB) is proposed, the Proposed Developments Site Specific Noise Limit has been set such that it never exceeds 35 dB (or background noise plus 5 dB whichever is the greater); this represents the lower end of the daytime limit that can be applied under in ETSU-R-97.

6.4.4 The Total ETSU-R-97 Noise Limits have been established for each of the NALs as detailed in Table 6.3 and Table 6.4 below, based on a fixed minimum of 40dB(A) (daytime) or 43 dB(A) (Night time) or background plus 5 dB(A). An exception occurs where the properties are financially involved with the proposed development where the daytime and night-time fixed minimum limit is increased to 45 dB(A), the Applicant has confirmed that the occupiers of NALs 2 and 3 (this includes all dwellings at both Blackburn and Netherton Farm) are financially involved with the Proposed Development.

Table 6.3 Total ETSU-R-97 Noise Limits Daytime

Location	Wind Speed (ms^{-1}) as standardised to 10m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – Greenfield	40.0	40.0	40.0	40.0	40.0	40.0	41.5	45.0	49.1	53.7	58.9	64.6
NAL2 - Blackburn*	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	49.1	53.7	58.9	64.6
NAL3 - Netherton Farm*	45.3	45.3	45.3	45.5	46.2	47.4	49.0	51.2	53.7	56.7	60.0	63.7
NAL4 – Maidencots Cottage	51.7	51.9	52.1	52.3	52.6	52.9	53.3	53.8	54.4	55.2	56.2	57.4
NAL5 - Duneaton Bridge House	40.0	40.0	40.0	40.0	41.3	42.7	44.4	46.2	48.2	50.3	52.6	55.0
NAL6 - Crawfordjohn Mill Farm	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.4	43.1	44.7	46.0	47.0
NAL7 - Redshaw**	43.1	43.1	43.1	43.1	43.1	43.2	43.5	44.0	44.8	45.8	47.1	48.6
NAL8 - Over Balgray	40.0	40.0	40.0	40.0	40.0	40.0	41.5	45.0	49.1	53.7	58.9	64.6
NAL9 - Red Moss Hotel**	43.1	43.1	43.1	43.1	43.1	43.2	43.5	44.0	44.8	45.8	47.1	48.6

**Occupiers are FI with the Proposed Development*
*** Taken from Table 4 of the Bodinglee Wind Farm Environmental Noise Assessment, dated 9th June 2023.*

Table 6.4 Total ETSU-R-97 Noise Limits Night-time

Location	Wind Speed (ms^{-1}) as standardised to 10m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – Greenfield	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	47.0	51.4	56.3	61.6
NAL2 – Blackburn*	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.0	51.4	56.3	61.6
NAL3 – Netherton Farm*	45.0	45.0	45.0	45.0	45.0	45.3	47.3	49.6	52.3	55.3	58.8	62.5
NAL4 – Maidencots Cottage	48.1	48.1	48.1	48.2	48.4	48.9	49.6	50.7	52.2	54.1	56.5	59.4
NAL5 - Duneaton Bridge House	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.0	47.4	49.9	52.4	54.9
NAL6 - Crawfordjohn Mill Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.4	44.7	45.5
NAL7 - Redshaw**	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
NAL8 - Over Balgray	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	47.0	51.4	56.3	61.6
NAL9 - Red Moss Hotel**	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

**Occupiers are FI with the Proposed Development*
*** Taken from Table 5 of the Bodinglee Wind Farm Environmental Noise Assessment, dated 9th June 2023.*

6.5 Predicting the requirement for a cumulative assessment and the likely effects (Stage 2)

6.5.1 A comparison has been undertaken of the predicted wind turbine noise immission levels from the Proposed Development alongside all other schemes at each of the identified noise sensitive receptors in order to demonstrate whether predictions are within 10 dB of each other. All turbines have been assumed to be operating in full unconstrained mode. Table 6.5 below summarises the results and whether a cumulative noise assessment is required. As is

detailed in Section 4.4 above, if the predictions are greater than 10 dB apart then a cumulative noise assessment is not required. Where predictions are found to be within 10 dB of each other a cumulative assessment is required.

Table 6.5 Cumulative Assessment Requirement

Noise Assessment Location (NAL)	Are predicted wind turbine noise levels within 10 dB?	Is a cumulative assessment required?
NAL1 - Greenfield	YES	YES
NAL2 - Blackburn	YES	YES
NAL3 - Netherton Farm	NO	NO
NAL4 - Maidencots Cottage	YES	YES
NAL5 - Duneaton Bridge House	YES	YES
NAL6 - Crawfordjohn Mill Farm	YES	YES
NAL7 - Redshaw	YES	YES
NAL8 - Over Balgray	YES	YES
NAL9 - Red Moss Hotel	YES	YES

6.5.2 As summarised in Table 6.5 above predicted turbine noise was within 10 dB of existing turbine noise at all NALs except NAL3, however, for completeness a cumulative noise assessment was undertaken for all NALs. A detailed list of all of the wind farms/ wind turbine developments considered in the noise predictions are included in Table A6.1 of Annex 6. In addition, a summary of the noise prediction comparisons are included as Table A6.3 of Annex 6.

6.5.3 The results of the cumulative assessment are summarised in tabular form in Table 6.6 and Table 6.7. The results show that the predicted cumulative wind turbine noise immission levels meet the Total ETSU-R-97 Noise limits under all conditions at all NALs. The predicted 'likely' cumulative levels are the actual levels expected at an NAL and include the addition of an appropriate level of uncertainty to the turbine data as per Section 4.2 of the IOA GPG. The uncertainty level added is generally +2 dB but this can vary depending on the turbine manufacturer data available for each turbine.

6.5.4 Figures A1.5a-i (Annex 1) show predictions from the Proposed Development and 'cumulative (including Proposed Development)' against the 'Total ETSU-R-97 Noise Limits'. The individual contribution of the cumulative schemes are also shown.

Table 6.6 ETSU-R-97 Compliance Table – Likely Cumulative Noise - Daytime

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL1 - Greenfield	Total Noise Limit: ETSU-R-97 L_{A90}	40.0	40.0	40.0	40.0	40.0	40.0	41.5	45.0	49.1	53.7	58.9	64.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	36.3	38.5	38.7	38.7	38.7	38.7	38.7	38.7
	Exceedance Level	-	-	-	-	-3.7	-1.5	-2.8	-6.3	-10.4	-15.0	-20.2	-25.9
NAL2 - Blackburn	Total Noise Limit: ETSU-R-97 L_{A90}	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	49.1	53.7	58.9	64.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	40.8	42.7	42.8	42.8	42.8	42.8	42.8	42.8
	Exceedance Level	-	-	-	-	-4.2	-2.3	-2.2	-2.2	-6.3	-10.9	-16.1	-21.8
NAL3 - Netherton Farm	Total Noise Limit: ETSU-R-97 L_{A90}	45.3	45.3	45.3	45.5	46.2	47.4	49.0	51.2	53.7	56.7	60.0	63.7
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	40.5	42.4	42.4	42.4	42.4	42.4	42.4	42.4
	Exceedance Level	-	-	-	-	-5.7	-5.0	-6.6	-8.8	-11.3	-14.3	-17.6	-21.3
NAL4 – Maidencots Cottage	Total Noise Limit: ETSU-R-97 L_{A90}	51.7	51.9	52.1	52.3	52.6	52.9	53.3	53.8	54.4	55.2	56.2	57.4
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	32.5	34.7	35.0	35.0	35.0	35.0	35.0	35.0
	Exceedance Level	-	-	-	-	-20.1	-18.2	-18.3	-18.8	-19.4	-20.2	-21.2	-22.4
NAL5 - Duneaton Bridge House	Total Noise Limit: ETSU-R-97 L_{A90}	40.0	40.0	40.0	40.0	41.3	42.7	44.4	46.2	48.2	50.3	52.6	55.0
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	32.9	35.0	35.1	35.2	35.2	35.2	35.2	35.2
	Exceedance Level	-	-	-	-	-8.4	-7.7	-9.3	-11.0	-13.0	-15.1	-17.4	-19.8
NAL6 - Crawfordjohn Mill Farm	Total Noise Limit: ETSU-R-97 L_{A90}	40.0	40.0	40.0	40.0	40.0	40.0	40.0	41.4	43.1	44.7	46.0	47.0
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	34.8	36.8	36.9	36.9	36.9	36.9	36.9	36.9
	Exceedance Level	-	-	-	-	-5.2	-3.2	-3.1	-4.5	-6.2	-7.8	-9.1	-10.1

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL7 - Redshaw	Total Noise Limit: ETSU-R-97 L_{A90}	43.1	43.1	43.1	43.1	43.1	43.2	43.5	44.0	44.8	45.8	47.1	48.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	35.7	38.7	38.9	38.9	39.0	39.0	39.0	39.0
	Exceedance Level	-	-	-	-	-7.4	-4.5	-4.6	-5.1	-5.8	-6.8	-8.1	-9.6
NAL8 - Over Balgray	Total Noise Limit: ETSU-R-97 L_{A90}	40.0	40.0	40.0	40.0	40.0	40.0	41.5	45.0	49.1	53.7	58.9	64.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	35.4	37.7	37.9	38.0	38.0	38.0	38.0	38.0
	Exceedance Level	-	-	-	-	-4.6	-2.3	-3.6	-7.0	-11.1	-15.7	-20.9	-26.6
NAL9 - Red Moss Hotel	Total Noise Limit: ETSU-R-97 L_{A90}	43.1	43.1	43.1	43.1	43.1	43.2	43.5	44.0	44.8	45.8	47.1	48.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	42.0*	40.7*	41.0*	41.9*	43.1*	44.5*	45.3	45.3
	Exceedance Level	-	-	-	-	-1.1	-2.5	-2.5	-2.1	-1.7	-1.3	-1.8	-3.3

Note: For the cumulative noise predictions the noise model considers the range of noise data available for each turbine type modelled. For some turbines noise data was not available for wind speeds less than 5 ms^{-1} therefore no cumulative predictions are included for wind speeds less than 5 ms^{-1}.
**Mitigation applied to M74 West (see Section 6.6.7 below for further information)*

Table 6.7 ETSU-R-97 Compliance Table – Likely Cumulative Noise – Night-time

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL1 - Greenfield	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	47.0	51.4	56.3	61.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	36.3	38.5	38.7	38.7	38.7	38.7	38.7	38.7
	Exceedance Level	-	-	-	-	-6.7	-4.5	-4.3	-4.3	-8.3	-12.7	-17.6	-22.9
NAL2 - Blackburn	Total Noise Limit: ETSU-R-97 L_{A90}	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.0	51.4	56.3	61.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	40.8	42.7	42.8	42.8	42.8	42.8	42.8	42.8
	Exceedance Level	-	-	-	-	-4.2	-2.3	-2.2	-2.2	-4.2	-8.6	-13.5	-18.8
NAL3 - Netherton Farm	Total Noise Limit: ETSU-R-97 L_{A90}	45.0	45.0	45.0	45.0	45.0	45.3	47.3	49.6	52.3	55.3	58.8	62.5
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	40.5	42.4	42.4	42.4	42.4	42.4	42.4	42.4
	Exceedance Level	-	-	-	-	-4.5	-2.9	-4.9	-7.2	-9.9	-12.9	-16.4	-20.1
NAL4 – Maidencots Cottage	Total Noise Limit: ETSU-R-97 L_{A90}	48.1	48.1	48.1	48.2	48.4	48.9	49.6	50.7	52.2	54.1	56.5	59.4
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	32.5	34.7	35.0	35.0	35.0	35.0	35.0	35.0
	Exceedance Level	-	-	-	-	-15.9	-14.2	-14.6	-15.7	-17.2	-19.1	-21.5	-24.4
NAL5 - Duneaton Bridge House	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.0	47.4	49.9	52.4	54.9
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	32.9	35.0	35.1	35.2	35.2	35.2	35.2	35.2
	Exceedance Level	-	-	-	-	-10.1	-8.0	-7.9	-9.8	-12.2	-14.7	-17.2	-19.7
NAL6 - Crawfordjohn Mill Farm	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.4	44.7	45.5
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	34.8	36.8	36.9	36.9	36.9	36.9	36.9	36.9
	Exceedance Level	-	-	-	-	-8.2	-6.2	-6.1	-6.1	-6.1	-6.5	-7.8	-8.6

Location		Wind Speed (ms⁻¹) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL7 - Redshaw	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	35.7	38.7	38.9	38.9	39.0	39.0	39.0	39.0
	Exceedance Level	-	-	-	-	-7.3	-4.3	-4.1	-4.1	-4.0	-4.0	-4.0	-4.0
NAL8 - Over Balgray	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	47.0	51.4	56.3	61.6
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	35.4	37.7	37.9	38.0	38.0	38.0	38.0	38.0
	Exceedance Level	-	-	-	-	-7.6	-5.3	-5.1	-5.0	-9.0	-13.4	-18.3	-23.6
NAL9 - Red Moss Hotel	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Predicted Cumulative Wind Turbine Noise L_{A90}	-	-	-	-	41.9*	40.4*	40.1*	40.1*	40.1*	40.1*	40.1*	40.1*
	Exceedance Level	-	-	-	-	-1.1	-2.6	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9

Note: For the cumulative noise predictions the noise model considers the range of noise data available for each turbine type modelled. For some turbines noise data was not available for wind speeds less than 5 ms⁻¹ therefore no cumulative predictions are included for wind speeds less than 5 ms⁻¹.
**Mitigation applied to M74 West (see Section 6.6.7 below for further information)*

6.6 Derivation of Site Specific Noise Limits (Stage 3)

6.6.1 In order to protect residential amenity, the IOA GPG (2013) recommendations are that cumulatively, all schemes operate within the Total ETSU-R-97 Noise Limits. This can be found in summary box SB21 of the IOA GPG (2013) which states:

'Whenever a cumulative situation is encountered, the noise limits for an individual wind farm should be determined in such a way that no cumulative excess of the total ETSU-R-97 noise limit would occur.'

6.6.2 As detailed in Section 4.3.6 above, the daytime Site Specific Noise Limits (SSNLs) have been derived based on the lower Fixed Minimum Noise Limits as detailed within ETSU-R-97. This assumes that all consented/ in planning turbines are built and that the operational turbines continue to operate for the lifetime of their consent.

6.6.3 The apportionment options provided in the IOA GPG were considered to determine the most appropriate option for each NAL. Site Specific Noise Limits have been derived for each of the noise sensitive receptors considered within Table 6.1 above. Table 6.8 below summarises the approach adopted at each NAL in order to derive the Site Specific Noise Limits for the Proposed Development.

Table 6.8 Limit Derivation Strategy

NAL	Limit Derivation Strategy
NALs 1 and 8 - 9	The likely predictions level from other schemes were found to be within 10 dB of the Total Noise Limits. As such, the limit has been apportioned based on a cautious prediction of cumulative turbine noise. The noise predictions for the other proposed, consented and operational schemes show that there is, in theory, significant headroom between the likely predicted levels and the Total ETSU-R-97 Noise Limit (>5 dB). In accordance with Section 4.5 above, a 2 dB buffer was therefore added to the turbine noise predictions for each of the other developments; this is considered to be a suitable buffer in accordance with Section 5.4.11 of the IOA GPG and would represent a 60% increase in emitted noise levels from the other schemes. The resulting 'cautious' predictions of cumulative wind turbine noise have then been logarithmically subtracted from the Total ETSU-R-97 Noise Limit to determine the 'residual noise limit'. The Site Specific Noise Limits are then determined as follows: • The night time limit is set to the residual noise limit. • The daytime noise limit is determined by taking the lowest of either: ○ The residual noise limit; or ○ Background noise plus 5 dB or the daytime fixed minimum limit of 35 dB (whichever is greater).

NAL	Limit Derivation Strategy
NALs 2 and 3	The occupiers of these properties are financially involved with the Proposed Development and therefore are subject to a higher fixed minimum limit of 45 dB or background +5 dB whichever is higher. The likely predictions level from other schemes were found to be more than 10 dB below the Total ETSU-R-97 Noise Limits and as such the entire noise limits has been allocated to the Proposed Development.
NALs 4 - 6	The likely predictions level from other schemes were found to be more than 10 dB below the Total ETSU-R-97 Noise Limits and as such the entire noise limits has been allocated to the Proposed Development.
NAL 7	The likely predictions level from other schemes were found to be within 5 dB of the Total ETSU-R-97 Noise Limits at certain wind speeds during both day and night-time periods. As such, the Site Specific Noise Limit at these wind speeds was derived to be 10 dB below the Total ETSU-R-97 Noise Limit. At wind speeds where the predicted cumulative noise (excluding the Proposed Development) was >5 dB below the Total ETSU-R-97 Noise Limit, significant headroom was available. In accordance with Section 4.5 above, a 2 dB buffer was therefore added to the turbine noise predictions for each of the other developments; this is considered to be a suitable buffer in accordance with Section 5.4.11 of the IOA GPG and would represent a 60% increase in emitted noise levels from the other schemes. The resulting 'cautious' predictions of cumulative wind turbine noise have then been logarithmically subtracted from the Total ETSU-R-97 Noise Limit to determine the 'residual noise limit'. The Site Specific Noise Limits were derived as follows: • When significant headroom is not available, the Site Specific Noise Limit were derived to be 10 dB below the Total ETSU-R-97 Noise Limit. • When significant headroom is available, the Site Specific Noise Limits were then determined by taking the lowest of either: ○ The residual noise limit; or ○ Background noise plus 5 dB or the daytime FML of 35 dB (whichever is greater).

6.6.4 Please note the buffers detailed above are in addition to the appropriate level of uncertainty already added to the turbine data as per Section 4.2 of the IOA GPG.

6.6.5 As summarised in Table 6.8 above, it is proposed that the full ETSU-R-97 noise limits be allocated to the Proposed Development at five of the NALs (NAL2-6), as the other schemes do not need a portion of the limit. For the remaining NALs, apportionment was required in order to allow the Proposed Development and the other wind farm developments to co-exist within the Total ETSU-R-97 Noise Limits.

6.6.6 Table 6.9 and Table 6.10 show the daytime and night-time Site Specific Noise Limits, noise predictions for the Proposed Development and the exceedance level. A negative exceedance demonstrates compliance with the Site Specific Noise Limits.

6.6.7 The Tables show that the predicted wind turbine noise immission levels assuming all turbines operate in full unconstrained mode meet the limits at all receptors except at NAL9, where an exceedance ranging from 0.8 dB to 4.7 dB was predicted between 5 ms^{-1} and 10 ms^{-1} during the daytime and an exceedance ranging from 1.7 dB up to 5.3 dB was predicted

between 5 ms^{-1} and 12 ms^{-1} during the night-time. Predicted noise levels have therefore been reduced to ensure that the limits are met, this would be achieved by the combination of turbine shut down or the adoption of low noise modes, but this would only be required for a limited range of wind speeds and wind directions. The Tables show that, subject to the adoption of mitigation to ensure compliance, the predicted wind turbine noise immission levels meet the Site Specific Noise Limits under all conditions and at all locations for both daytime and night-time periods.

6.6.8 A series of graphs to show the predicted wind turbine noise from the Proposed Development compared to the Site Specific Noise Limits are included as Figures A1.6a-i (Annex 1). There is a set of graphs for each of the NAL, which show the Total ETSU-R-97 Noise Limit (solid red line), the prevailing background noise level (black line), the Site Specific Noise Limit (dashed red line with triangles) and the predicted wind turbine noise from the Proposed Development (solid blue line). It should be noted that at a number of locations the Total ETSU-R-97 Noise Limits are equal to the Site Specific Noise Limits so it can sometimes be difficult to distinguish between the two.

Table 6.9 Site Specific Noise Limits Compliance Table – Daytime

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL1 - Greenfield	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	36.0	37.2	39.5	44.2	49.1	53.7	58.9	64.6
	Predicted Wind Turbine Noise L_{A90}	-	-	24.8	30.0	34.7	36.6	36.6	36.6	36.6	36.6	36.6	36.6
	Exceedance Level	-	-	-10.2	-5.0	-1.3	-0.6	-2.9	-7.6	-12.5	-17.1	-22.3	-28.0
NAL2 - Blackburn	Site Specific Noise Limit L_{A90}	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	49.1	53.7	58.9	64.6
	Predicted Wind Turbine Noise L_{A90}	-	-	30.7	35.9	40.7	42.5	42.5	42.5	42.5	42.5	42.5	42.5
	Exceedance Level	-	-	-14.3	-9.1	-4.3	-2.5	-2.5	-2.5	-6.6	-11.2	-16.4	-22.1
NAL3 - Netherton Farm	Site Specific Noise Limit L_{A90}	45.3	45.3	45.3	45.5	46.2	47.4	49.0	51.2	53.7	56.7	60.0	63.7
	Predicted Wind Turbine Noise L_{A90}	-	-	30.3	35.5	40.3	42.1	42.1	42.1	42.1	42.1	42.1	42.1
	Exceedance Level	-	-	-15.0	-10.0	-5.9	-5.3	-6.9	-9.1	-11.6	-14.6	-17.9	-21.6
NAL4 – Maidencots Cottage	Site Specific Noise Limit L_{A90}	51.7	51.9	52.1	52.3	52.6	52.9	53.3	53.8	54.4	55.2	56.2	57.4
	Predicted Wind Turbine Noise L_{A90}	-	-	21.8	27.0	31.8	33.6	33.6	33.6	33.6	33.6	33.6	33.6
	Exceedance Level	-	-	-30.3	-25.3	-20.8	-19.3	-19.7	-20.2	-20.8	-21.6	-22.6	-23.8
NAL5 - Duneaton Bridge House	Site Specific Noise Limit L_{A90}	37.7	38.2	39.0	40.0	41.3	42.7	44.4	46.2	48.2	50.3	52.6	55.0
	Predicted Wind Turbine Noise L_{A90}	-	-	22.2	27.4	32.2	34.0	34.0	34.0	34.0	34.0	34.0	34.0
	Exceedance Level	-	-	-16.8	-12.6	-9.1	-8.7	-10.4	-12.2	-14.2	-16.3	-18.6	-21.0
NAL6 - Crawfordjohn Mill Farm	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.5	36.6	38.0	39.7	41.4	43.1	44.7	46.0	47.0
	Predicted Wind Turbine Noise L_{A90}	-	-	24.1	29.3	34.0	35.9	35.9	35.9	35.9	35.9	35.9	35.9
	Exceedance Level	-	-	-10.9	-6.2	-2.6	-2.1	-3.8	-5.5	-7.2	-8.8	-10.1	-11.1

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL7 - Redshaw	Site Specific Noise Limit L_{A90}	43.1	43.1	43.1	43.1	41.7	33.2	33.5	41.2	42.6	44.1	45.9	47.7
	Predicted Wind Turbine Noise L_{A90}	-	-	18.0	23.2	27.9	29.8	29.8	29.8	29.8	29.8	29.8	29.8
	Exceedance Level	-	-	-25.1	-19.9	-13.8	-3.4	-3.7	-11.4	-12.8	-14.3	-16.1	-17.9
NAL8 - Over Balgray	Site Specific Noise Limit L_{A90}	35.0	35.0	35.0	35.0	36.0	37.0	39.4	44.1	49.1	53.7	58.9	64.6
	Predicted Wind Turbine Noise L_{A90}	-	-	22.9	28.1	32.9	34.7	34.7	34.7	34.7	34.7	34.7	34.7
	Exceedance Level	-	-	-12.1	-6.9	-3.1	-2.3	-4.7	-9.4	-14.4	-19.0	-24.2	-29.9
NAL9 - Red Moss Hotel	Site Specific Noise Limit L_{A90}	43.1	43.1	43.1	43.1	41.9	40.6	40.9	41.8	43.0	44.5	46.1	48.6
	Predicted Wind Turbine Noise L_{A90}	-	-	33.5	38.7	41.9*	40.6*	40.9*	41.8*	43.0*	44.5*	45.3	45.3
	Exceedance Level	-	-	-9.6	-4.4	0.0	0.0	0.0	0.0	0.0	0.0	-0.8	-3.3

*Predicted noise levels inclusive of indicative mitigation.

Table 6.10 Site Specific Noise Limits Compliance Table – Night-time

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL1 - Greenfield	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	43.0	41.8	41.7	41.7	47.0	51.4	56.3	61.6
	Predicted Wind Turbine Noise L_{A90}	-	-	24.8	30.0	34.7	36.6	36.6	36.6	36.6	36.6	36.6	36.6
	Exceedance Level	-	-	-18.2	-13.0	-8.3	-5.2	-5.1	-5.1	-10.4	-14.8	-19.7	-25.0
NAL2 - Blackburn	Site Specific Noise Limit L_{A90}	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.0	51.4	56.3	61.6
	Predicted Wind Turbine Noise L_{A90}	-	-	30.7	35.9	40.7	42.5	42.5	42.5	42.5	42.5	42.5	42.5
	Exceedance Level	-	-	-14.3	-9.1	-4.3	-2.5	-2.5	-2.5	-4.5	-8.9	-13.8	-19.1
NAL3 - Netherton Farm	Site Specific Noise Limit L_{A90}	45.0	45.0	45.0	45.0	45.0	45.3	47.3	49.6	52.3	55.3	58.8	62.5
	Predicted Wind Turbine Noise L_{A90}	-	-	30.3	35.5	40.3	42.1	42.1	42.1	42.1	42.1	42.1	42.1
	Exceedance Level	-	-	-14.7	-9.5	-4.7	-3.2	-5.2	-7.5	-10.2	-13.2	-16.7	-20.4
NAL4 – Maidencots Cottage	Site Specific Noise Limit L_{A90}	48.1	48.1	48.1	48.2	48.4	48.9	49.6	50.7	52.2	54.1	56.5	59.4
	Predicted Wind Turbine Noise L_{A90}	-	-	21.8	27.0	31.8	33.6	33.6	33.6	33.6	33.6	33.6	33.6
	Exceedance Level	-	-	-26.3	-21.2	-16.6	-15.3	-16.0	-17.1	-18.6	-20.5	-22.9	-25.8
NAL5 - Duneaton Bridge House	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.0	47.4	49.9	52.4	54.9
	Predicted Wind Turbine Noise L_{A90}	-	-	22.2	27.4	32.2	34.0	34.0	34.0	34.0	34.0	34.0	34.0
	Exceedance Level	-	-	-20.8	-15.6	-10.8	-9.0	-9.0	-11.0	-13.4	-15.9	-18.4	-20.9
NAL6 - Crawfordjohn Mill Farm	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.4	44.7	45.5
	Predicted Wind Turbine Noise L_{A90}	-	-	24.1	29.3	34.0	35.9	35.9	35.9	35.9	35.9	35.9	35.9
	Exceedance Level	-	-	-18.9	-13.7	-9.0	-7.1	-7.1	-7.1	-7.1	-7.5	-8.8	-9.6

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL7 - Redshaw	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	41.6	33.0	33.0	33.0	33.0	33.0	33.0	33.0
	Predicted Wind Turbine Noise L_{A90}	-	-	18.0	23.2	27.9	29.8	29.8	29.8	29.8	29.8	29.8	29.8
	Exceedance Level	-	-	-25.0	-19.8	-13.7	-3.2	-3.2	-3.2	-3.2	-3.2	-3.2	-3.2
NAL8 - Over Balgray	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	43.0	41.7	41.6	41.6	47.0	51.4	56.3	61.6
	Predicted Wind Turbine Noise L_{A90}	-	-	22.9	28.1	32.9	34.7	34.7	34.7	34.7	34.7	34.7	34.7
	Exceedance Level	-	-	-20.1	-14.9	-10.1	-7.0	-6.9	-6.9	-12.3	-16.7	-21.6	-26.9
NAL9 - Red Moss Hotel	Site Specific Noise Limit L_{A90}	43.0	43.0	43.0	43.0	41.8	40.3	40.0	40.0	40.0	40.0	40.0	40.0
	Predicted Wind Turbine Noise L_{A90}	-	-	33.5	38.7	41.8*	40.3*	40.0*	40.0*	40.0*	40.0*	40.0*	40.0*
	Exceedance Level	-	-	-9.5	-4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Predicted noise levels inclusive of indicative mitigation.

6.6.9 The assessment shows that the predicted wind turbine noise immission levels meet the Site Specific Noise Limits under all conditions and at all locations for both daytime and night-time periods.

6.6.10 In the event that consent is granted for the Proposed Development it would be appropriate to set noise limits equal to the Site Specific Noise Limits contained Table 6.9 and Table 6.10.

6.7 Choice of Daytime Fixed Minimum Noise Limit (35 – 40 dB)

6.7.1 Having due regard to the guidance in ETSU-R-97 and considering the cumulative impacts of the Proposed Development operating in conjunction with other proposed, consented or operational schemes a fixed minimum limit of 40 dB has been adopted. This aligns with the approach adopted for the noise assessments for the operational Middle Muir and proposed Bodinglee wind farms. For Site Specific Noise Limits, the lowest Fixed Minimum Limit of 35 dB is proposed for Daytime periods.

6.7.2 If consent is granted for the Proposed Development it would be appropriate to set noise limits equal to the Site Specific Noise Limits contained within Table 6.9 and Table 6.10 which have been determined based on the use of a 40 dB daytime fixed minimum limit to set Total ETSU-R-97 Noise Limits and a 35 dB day time fixed minimum limit to set Site Specific Noise Limits. In the event that an alternative daytime fixed minimum limit is deemed appropriate new Site Specific Noise Limits would need to be calculated in accordance with the methodology presented in this report.

6.8 Micrositing

6.8.1 A 100 m micrositing distance is proposed. It should be noted that the need to include a concave ground profile correction and/or barrier correction may change depending on the final location of the turbines (following micrositing) and the final turbine hub height. Nevertheless, turbine noise levels will have to meet the noise limits established in this report regardless of any increases and decreases in noise propagation caused by topography. Should consent be granted, the need to apply a concave ground profile/ barrier correction will need to be considered by the Applicant prior to the final selection of a turbine model for the site.

7 Summary and Conclusions

7.1.1 This report has assessed the potential impact of operational noise from the Proposed Development on the residents of nearby receptors. The guidance contained within ETSU-R-97 and current good practice (IOA GPG) has been used to assess the potential noise impact of the Proposed Development.

7.1.2 Background noise monitoring was undertaken by TNEI at five noise sensitive receptors neighbouring the Proposed Development. A total of nine noise sensitive receptors were chosen as Noise Assessment Locations. The assessment locations were chosen to represent the noise sensitive receptors located closest to the Proposed Development and other nearby wind farms. For the assessment locations where no background noise measurements were undertaken, noise data collected at proxy locations and as part of the noise assessments for other nearby schemes considered representative of the expected background noise environment was used to assess the noise impact at those receptors.

7.1.3 Wind speed data was collected using a SODAR unit located within the wind farm site. The data collected at 100 m and 120 m height which were used to calculate hub height wind speeds (122.5 m) which were then standardised to 10 m height, in accordance with current good practice.

7.1.4 Analysis of the measured data was undertaken in accordance with ETSU-R-97 and current good practice to determine the pre-existing background noise environment and to establish the daytime and night-time noise limits for each of the assessment locations. A Total ETSU-R-97 Noise Limit of 40 dB(A) daytime or background plus 5dB (whichever is the greater) and 43 dB(A) night-time or background plus 5dB (whichever is the greater) was used for this assessment.

7.1.5 There are a number of operational, consented and proposed (in planning) wind turbine developments in proximity to the Proposed Development. A cumulative assessment was undertaken where predicted levels from the Proposed Development were found to be within 10 dB of the predicted cumulative levels from other schemes in the area. The results show that the predicted cumulative wind farm noise immission levels would meet the Total ETSU-R-97 Noise Limits at all NALs during both the daytime and night-time periods subject to some mitigation being applied to the Proposed Development at NAL9 for certain wind speeds and directions as discussed below.

7.1.6 Site Specific Noise Limits have also been derived based on a daytime fixed minimum limit of 35 dB or background plus 5 dB and a night-time limit of 43 dB or background plus 5 dB. The limit derivation took account (where required) of the other consented and proposed (in planning) wind farms in the area. Where the noise immission from other wind farms at a given receptor were found to be at least 10 dB below the Total ETSU-R-97 Noise Limit; then the other wind farms would be using a negligible proportion of the limit. As such it is considered appropriate to allocate the entire noise limit to the Proposed Development. For receptors where turbine predictions were found to be within 10 dB of the Total ETSU-R-97 Noise Limits, apportionment of the Total ETSU-R-97 Noise Limits was undertaken in accordance with good practice.

7.1.7 An assessment was undertaken to determine whether the Proposed Development could operate within the Site Specific Noise Limits and it was found that at all receptors (excluding

NAL9) wind turbine noise immission were below the Site Specific Noise Limits when considering the Siemens Gamesa SG 6.6-155 with Serrated blades as a candidate turbine.

7.1.8 At NAL9, an exceedance ranging from 0.8 dB to 4.7 dB was predicted between 5 ms^{-1} and 10 ms^{-1} during the daytime and an exceedance ranging from 1.7 dB up to 5.3 dB was predicted between 5 ms^{-1} and 12 ms^{-1} during the night-time. Predicted noise levels have therefore been reduced to ensure that the Site Specific Noise Limits are met, this would be achieved by the combination of turbine shut down or the adoption of low noise modes, but this would only be required for a limited range of wind speeds and wind directions.

7.1.9 There are a range of potential turbine models that could be installed on the site should consent be granted. When undertaking the modelling presented in this report TNEI has sought to adopt appropriate assumptions in terms of turbine models and dimensions, specifically:

- Topographical corrections have been considered in accordance with Section 5.3 of this report. Topographical blocking points have considered the highest candidate tip height (200 m), this is worst case as the model applies additional attenuation where the landform blocks line of sight between a turbine and a receptor. Consideration of concave ground profiles has considered the lowest hub height being considered (122.5 m) as this results in the greatest likelihood of concave ground corrections being calculated (which would increase the predicted levels).
- Sound power level data has been used for the Siemens Gamesa SG 6.6-155 with a hub height of 122.5 m and serrated trailing edge blades. This model is considered to be representative of the type of turbine that could be installed on the site.

7.1.10 There are a number of wind turbine makes and models that may be suitable for the Proposed Development. Should the proposal receive consent, the final choice of turbine would be subject to a competitive tendering process. The final choice of turbine would, however, have to meet the noise limits determined and contained within any condition imposed. A suggested noise related planning condition, drafted in accordance with current good practice, has been included in Annex 9.

8 Glossary of Terms

AOD: Above Ordnance Datum is the height above sea level.

Amplitude Modulation: a variation in noise level over time; for example observers may describe a 'whoosh whoosh' sound, which can be heard close to a wind turbine as the blades sweep past.

Attenuation: the reduction in level of a sound between the source and a receiver due to any combination of effects including: distance, atmospheric absorption, acoustic screening, the presence of a building façade, etc.

Background Noise: the noise level rarely fallen below in any given location over any given time period, often classed according to daytime, evening or night time periods. The L_{A90} indices (see below) is often used to represent the background noise level.

Bin: subset or group into which data can be sorted; in the case of wind speeds, bins are often centred on integer wind speeds with a width of 1 m/s. For example the 4 m/s bin would include all data with wind speeds of 3.5 to 4.5 m/s.

Dawn Chorus: noise due to birds which can occur at sunrise.

Broadband Noise: noise with components over a wide range of frequencies.

Decibel (dB): the ratio between the quietest audible sound and the loudest tolerable sound is a million to one in terms of the change in sound pressure. A logarithmic scale is used in noise level measurements because of this wide range. The scale used is the decibel (dB) scale which extends from 0 to 140 decibels (dB) corresponding to the intensity of the sound level.

dB(A): the ear has the ability to recognise a particular sound depending on its pitch or frequency. Microphones cannot differentiate noise in the same way as the ear, and to counter this weakness the noise measuring instrument applies a correction to correspond more closely to the frequency response of the human ear. The correction factor is called 'A Weighting' and the resulting measurements are written as dB(A). The dB(A) is internationally accepted and has been found to correspond well with people's subjective reaction to noise. Some typical subjective changes in noise levels are:

- a change of 3 dB(A) is just perceptible;
- a change of 5 dB(A) is clearly perceptible;
- a change of 10 dB(A) is twice (or half) as loud.

Directivity: the property of a sound source that causes more sound to be radiated in one direction than another.

Frequency: the pitch of a sound in Hz or kHz. See Hertz.

Ground Effects: the modification of sound at a receiver location due to the interaction of the sound wave with the ground along its propagation path from source to receiver. Described using the term 'G', and ranges between 0 (hard), 0.5 (mixed) and 1 (soft).

Hertz (Hz): sound frequency refers to how quickly the air vibrates, or how close the sound waves are to each other (in cycles per second, or Hertz (Hz)).

L_w: is the sound power level. It is a measure of the total noise energy radiated by a source of noise, and is used to calculate noise levels at a distant location. The L_{WA} is the A-weighted sound power level.

L_{eq}: is the equivalent continuous sound level, and is the sound level of a steady sound with the same energy as a fluctuating sound over the same period. It is possible to consider this level as the ambient noise encompassing all noise at a given time. The $LA_{eq,T}$ is the A-weighted equivalent continuous sound level over a given time period (T).

L_{90}: index represents the noise level exceeded for 90 percent of the measurement period and is used to indicate quieter times during the measurement period. It is often used to measure the background noise level. The $L_{A90,10min}$ is the A-weighted background noise level over a ten minute measurement sample.

Noise emission: the noise energy emitted by a source (e.g. a wind turbine).

Noise immission: the sound pressure level detected at a given location (e.g. the nearest dwelling).

Night Time Hours: ETSU-R-97 defines the night time hours as 23.00 to 07.00 every day.

Quiet Daytime Hours: ETSU-R-97 defines the amenity hours as 18.00 to 23.00 Monday to Friday, 13.00 to 23.00 on Saturdays and 07.00 to 23.00 on Sundays.

Sound Level Meter: an instrument for measuring sound pressure level.

Sound Power Level: the total sound power radiated by a source, in decibels.

Sound Pressure Level: a measure of the sound pressure at a point, in decibels**.**

Standardised Wind Speed: a wind speed measured at a height different than 10 m (generally measured at the turbine hub height) which is expressed to a reference height of 10 m using a roughness length of 0.05 for standardisation purpose (in accordance with the IEC 61400-11 standard).

Tonal Noise: noise which covers a very restricted range of frequencies (e.g. a range of ≤20 Hz). This noise can be more annoying than broadband noise.

Wind Shear: the increase of wind speed with height above the ground.

9 References

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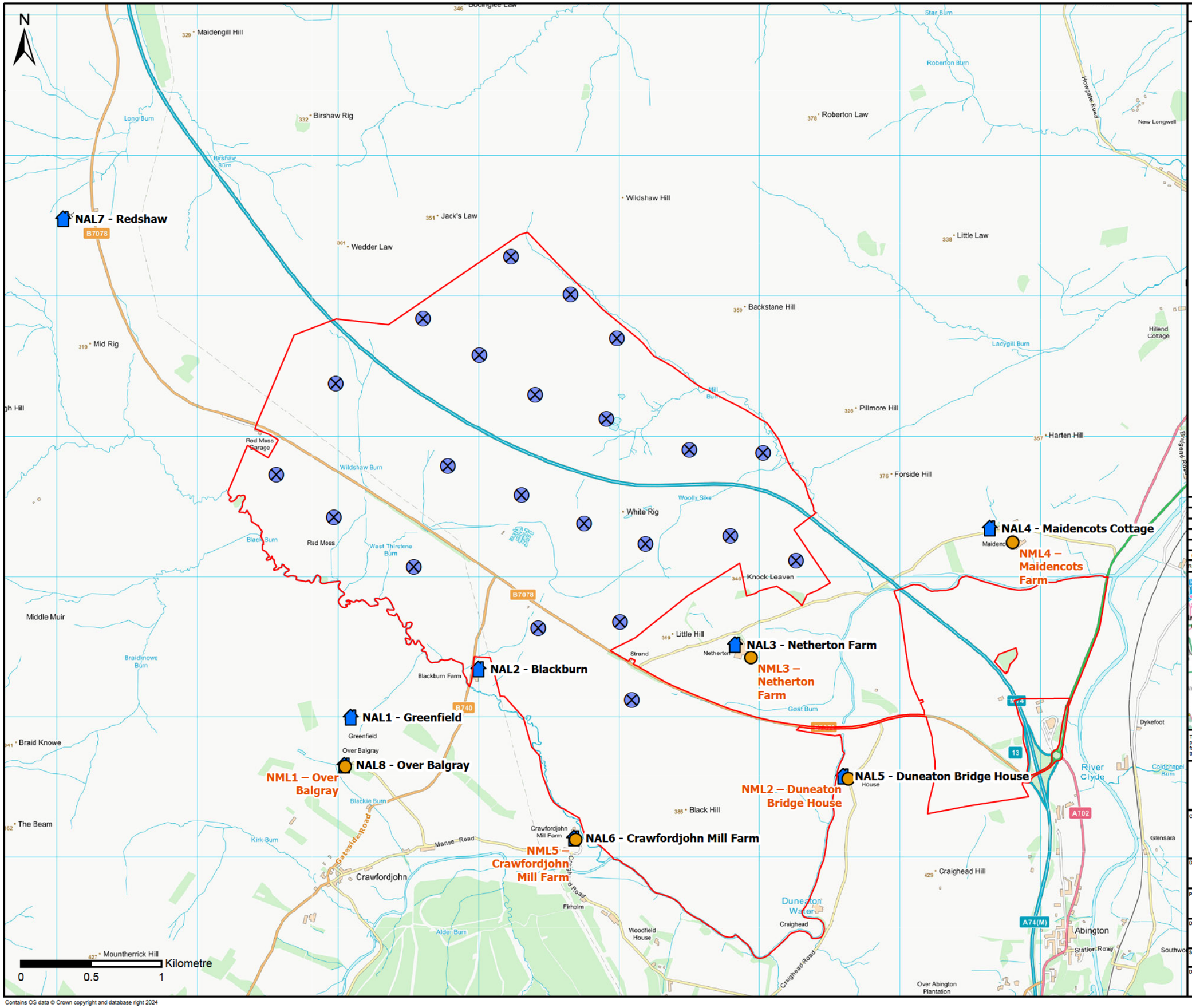
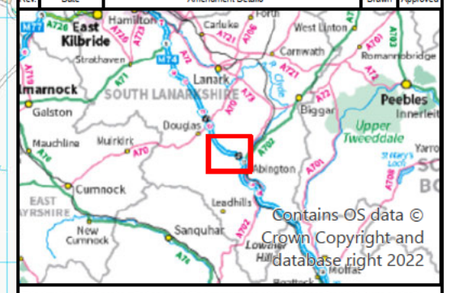
Annex 1 – Figures



LEGEND

- Proposed Development Site Boundary
- M74 West Turbines
- Noise Monitoring Locations (NMLs)
- Noise Assessment Locations (NALs)

Rev.	Date	Amendment Details	Drawn	Approved
0	17/07/2024	FIRST ISSUE	JOM	GC



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Client: Renewco POWER

Drawing Status: FOR PLANNING

Project Title: M74 WEST RENEWABLE ENERGY PARK

Drawing Title: FIGURE A1.1 - NOISE MONITORING AND ASSESSMENT LOCATIONS

Scale:	Original Size:	Spatial Reference:
1:25,000	A3	British National Grid

Drawing Number: 15990-009