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A specialist energy consultancy

Operational Noise Report

Craiginmoddie Wind Farm

Energiekontor Ltd

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18 March 2023

EnergieKontor

tneigroup.com

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Executive Summary

TNEI Services Ltd was commissioned by Energiekontor UK Ltd ('the Applicant') to undertake predictions of the wind turbine noise that would be emitted by the operation of the proposed Craiginmoddie Wind Farm (hereinafter referred to as 'CMWF'). The noise predictions were used to assess the potential impact of operational noise from CMWF on the nearest noise sensitive receptors.

CMWF is subject to a cojoined inquiry with two other nearby Wind Farms (Carrick Windfarm 'CWF' and Knockcronal Wind Farm 'KWF'). The Reporter has requested a Statement of Agreed Matters (SoAM) be produced. The aim of this report is to provide further information in relation to noise to inform the production of the SoAM and more generally to inform consideration of the environmental effects of CMWF. The information in this report replaces that relating to operational wind turbine noise contained within the CMWF Environmental Impact Assessment Report (EIAR) and the CMWF Additional Information Report. This report presents updated background noise levels (and resulting noise limits) which have been adjusted to account for wind shear and includes more detailed predictions for the individual wind farm schemes. This information was required to address points raised by third parties and to determine the proportion of the noise limit that is being used/ could theoretically be used by existing wind farms in the area and enabled the calculation of the available noise limit for CMWF, KWF and CWF.

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 CMWF.

The operational noise assessment has been undertaken in three stages:

1) deriving 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) predicting the likely effects (undertaking a cumulative noise assessment where required) to determine whether noise immissions at noise sensitive receptors will meet the Total ETSU-R-97 Noise Limits; and

3) deriving Site Specific Noise Limits for CMWF (taking account of the noise limit that has already been allocated to / could realistically be used by other schemes and the proportion of the noise limit that may be allocated to CWF and KWF). Predictions are then compared to the Site Specific Noise Limits.

Background noise monitoring was undertaken at a number of properties proximate to CMWF as part of the monitoring undertaken for Hadyard Hill Extension Wind Farm (which was previously proposed at the CMWF site), CWF and KWF. The background noise levels presented within the noise reports for

the schemes have been used for deriving noise limits at the closest properties. A correction was applied to the data used from Hadyard Hill Extension Wind Farm to take account of wind shear.

A total of eighteen noise sensitive receptors were chosen as Noise Assessment Locations (NALs). The NALs were chosen to represent the noise sensitive receptors located closest to CMWF and nearby cumulative schemes. 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. For consistency the NAL numbers used in this report match those in the SoAM. This report does however refer to four additional NALs (NALs 15 – 18 inclusive) which were not relevant to the SoAM (as CWF and KWF are acoustically insignificant at these locations) but have been included in this report for completeness.

The daytime Total ETSU-R-97 Noise Limit was set at 38 dB(A) or background plus 5 dB whichever is the greater. The night time Total ETSU-R-97 Noise Limit was set at 43 dB(A) or background plus 5 dB whichever is the greater. The Site Specific daytime limit for noise associated with CMWF was set such that it never exceeds 38 dB(A) or background plus 5 dB, whichever is the greater. The night time Site Specific Noise Limits was 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 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. TNEI is not aware of the occupiers of any properties being financially involved with CMWF or any nearby schemes.

Predictions of wind turbine noise for CMWF were made, based upon the sound power level data for a candidate wind turbine, the Siemens Gamesa 6.0-155, 6.6 MW with serrated blades and a hub height of 122.5 m. The 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 and is consistent with the model considered in the original noise chapter within the EIAR. Whatever the final turbine choice is, CMWF would have to meet the noise limits determined and contained within any condition applied as part of any 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 where predictions from CMWF were found to be within 10 dB of the noise predictions from all other schemes. At NALs 10-14 and 17, predicted noise from CMWF was found to be more than 10 dB below predicted from all other schemes. This indicated that CMWF was having a negligible contribution to the overall cumulative levels at those properties and therefore that a cumulative assessment was not required. Those locations were scoped out of the cumulative assessment.

The likely cumulative assessment undertaken at NALs 1-9, and 15-16 showed that CMWF can operate concurrently with the operational and proposed wind farms in the area, whilst still meeting the Total ETSU-R-97 Noise Limits. At two NALs (NALs 1 and 17) predicted noise levels from the existing Hadyard Hill Wind Farm exceed the noise limits. In practice, the existing turbines may be operated in a low noise mode (or the properties may be financially involved with the Hadyard Hill Wind Farm) to ensure compliance but there is no public information available to confirm this. Accordingly, the assessment has assumed that the turbines operate in unconstrainted mode as this represents a worst-case scenario.

Site Specific Noise Limits were derived to take account (where required) of the other wind farm developments. The approach was as follows:

- The Total ETSU-R-97 Noise Limits were established;
- Predictions were undertaken for the relevant wind farms in the area;
- Where there was an acoustically relevant contribution from operational wind farms, cautious predicted levels from those wind farms were subtracted from the Total ETSU-R-97 Noise Limits to determine the Remaining Available Noise Limit;
- Where there was not an acoustically relevant contribution from operational wind farms (e.g. it was 10 dB below the limit), Remaining Available Noise Limit was set equal to Total ETSU R 97 Noise Limit; and
- The remaining available noise Limit was then apportioned between the three proposed developments (CMWF, CWF and KWF) using the guidance in the IOA GPG.

In order to the meet the daytime noise limits at NALs 1 and 5, a number of CMWF turbines would need to operate in a noise reduced mode for a limited range of wind speeds and wind directions. At NAL7 it has been assumed that both CMWF and CWF would operate in noise reduced mode for a limited range of wind speeds and wind directions during the daytime period. Predicted noise levels (adjusted to include the reduction associated with the use of noise reduced modes) indicate that at all noise assessment locations wind turbine noise immissions were below the Site Specific Noise Limits when considering the Siemens Gamesa 6.0-155, 6.6 MW as a candidate turbine. On that basis, and as per the conclusions of the previous noise assessments undertaken for CMWF, no significant effects are predicted as a result of CMWF.

At locations where noise from Hadyard Hill Wind Farm was predicted to exceed the Total ETSU-R-97 Noise Limits, the Site Specific Noise Limit for CMWF have been set 10 dB below the Total ETSU-R-97 Noise Limit to ensure that the additional contribution from CMWF will be negligible. Accordingly, on the basis of the information available, the combined cumulative effect of all developments in the area is significant at certain receptors, the additional cumulative effect of CMWF would result in no additional significant effects.

The use of Site Specific Noise Limits ensure that any (or all) of the proposed developments could operate concurrently with other operational turbines in the area and would also ensure that each of the proposed development's individual contributions could be measured and enforced if required.

Should the Application be allowed, it would be appropriate to include a set of noise related planning conditions, which detail the noise limits applicable to CMWF. A set of draft noise conditions have been agreed among the Applicants and were forwarded to South Ayrshire Council (SAC) on 9 March 2023. As at the date of this report, the draft conditions remain subject to comment by SAC and other interested parties.

There are a number of wind turbine makes and models that may be suitable for CMWF. Should the Application be allowed 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.

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1 Introduction

1.1 Brief

1.1.1 TNEI was commissioned by Energiekontor UK Ltd ('the Applicant') to provide support in relation to noise for the co-joined Public Local Inquiry which considers the following schemes:

- WIN-370-4 Craiginmoddie Wind Farm, Dailly, South Ayrshire, KA26 ('CMWF');
- WIN-370-5 Carrick Wind Farm, approximately 6 km South of Straiton, South Ayrshire, KA19 ('CWF'); and
- WIN-370-6 Knockcronal Wind Farm, Knockcronal, Straiton, South Ayrshire, KA19 ('KWF').

1.1.2 The Reporter has requested a Statement of Agreed Matters (SoAM) be produced for the three schemes ('the Proposed Developments'). The purpose of this report is to address queries raised by third parties in relation to wind shear and to provide the required information to inform the SoAM and to enable the calculation of suitable noise limits for the Proposed Developments.

1.1.3 The following steps summarise the noise assessment process:

- Determine the most appropriate background noise dataset to be used for each Noise Assessment Location;
- Determine the Total ETSU-R-97 Noise Limits applicable to all wind farms in the area;
- Assess and undertake a cumulative noise assessment, where required, to take account of other operational or proposed schemes near to CMWF;
- Derive Site Specific Noise Limits for the Proposed Developments, suitable for inclusion in the noise related planning conditions;
- Compare predictions of the operational wind turbine noise immissions from CMWF against the Site Specific Noise Limits that will be incident at neighbouring noise sensitive receptors; and
- Assess the impact of noise from CMWF 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) (current good practice).

1.2 Background

1.2.1 CMWF is located approximately 4.2 km south east of Dailly and 5.4 km north east of Barr. The approximate OS Grid Reference for the centre of the Site is 231636, 598913 and the proposed layout is shown on Figure A1.1 in Annex 1.

1.2.2 In the absence of a confirmed turbine model, this noise assessment models a candidate turbine, the Siemens Gamesa (SG) 6.0-155 6.6 MW with serrated blades and a hub height of 122.5 m. The turbine was selected as it is representative of the turbine type which could be

installed at the Site. This turbine model was also used in the noise assessment contained within the EIAR submitted with the CMWF planning application.

1.2.3 The noise assessment has considered schemes which are operational and proposed (planning application submitted) but not those in the pre-planning stage. 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
Hadyard Hill	52	Operational	Bonus 2.3 MW, standard blade
Dersalloch	23	Operational	Siemens Gamesa SWT 3.0-101, 3 MW, standard blade
Tralorg	8	Operational	Vestas V80 2 MW, standard blade
Assel Valley	11	Operational	Vestas V90, 3 MW, standard blade
Penwhapple	1	Operational	EWT DW61, 500 kW, standard blade
Glengennet	1	Operational	Westwind 20 kW, standard blade
CWF	13*	At Appeal	Siemens Gamesa SG 6.0-155 6.6 MW, serrated blade
KWF	9	At Appeal	Vestas V150, 6 MW, serrated blade

**It is understood that the CWF Layout has been reduced to 12 turbines (removal of T10). However to provide a worst case, and for consistency with the assessments produced for CWF and KWF the 13 turbine scheme has been considered in this assessment.*

1.2.4 The operational Tralorg and Assel Valley Wind Farms were included within the preliminary cumulative noise modelling undertaken for CMWF but the predictions from both schemes were found to be >10 dB below the cumulative predictions (excluding CMWF) and as such they were scoped out from further assessment. The predictions for the two schemes are included on Figures A1.2a – r for completeness (Annex 1).

1.2.5 Figure A1.1 in Annex 1 shows the location of the above developments relative to CMWF.

1.2.6 For the purposes of assessing the above schemes in conjunction with CMWF 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 CMWF;
- 'Remaining Available Noise Limit' defined as the proportion of the Total ETSU-R-97 Noise Limit which is available once the contribution of existing operational schemes has been considered; and
- 'Site Specific Noise Limits'; defined as being the limits that are specific to a Proposed Development only, and derived through the apportionment (where required), of the 'Remaining Available Noise Limit' in accordance with current good practice.

1.2.7 Note that in this report, the term 'noise emission' relates to the sound power level 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.

1.2.8 All grid references in this report are in British National Grid and all wind speed references are measured at hub height and standardised to 10 m height in accordance with the IOA GPG.

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 CMWF, the following guidance and policy documents have been considered:

- Local Planning Policy;
- National Planning Policy;
- Web Based Renewables Advice: *'Onshore Wind Turbines'* [3];
- Planning Advice Note PAN 1/2011: *'Planning and Noise'* [4];
- 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 Local Planning Policy

2.2.1 In determining an application for planning permission the 'starting point' for decision makers is to consider whether the proposal accords with the Development Plan taken as a whole. Plans often have policies tailored specifically to control certain kinds of proposed development and such policies may carry more weight in the decision-making process.

2.2.2 When considering planning applications, decision makers should have regard to any adopted Structure Plan Policies, Local Development Plan Policies and any accompanying Supplementary Planning Guidance. In determining planning applications due regard should be had to all other material considerations, including national planning policy.

South Ayrshire Local Development Plan 2

2.2.3 The adopted Development Plan for the area comprises the South Ayrshire Local Development Plan 2 (LDP2) which was adopted in August 2022. LDP2 sets out the development strategy, key policies and proposals that provide the land use planning framework to guide future development proposals in South Ayrshire up to 2032.

2.2.4 LDP policy: renewable energy states:

'We will support proposals for generating and using renewable energy in stand-alone locations, and as part of new and existing developments, if they will not have a significant harmful effect on residential amenity, the appearance of the area and its landscape character, historic environment and cultural heritage associations.'

2.2.5 LDP Policy: wind energy states that South Ayrshire Council ("the Council") will support wind energy developments. Proposals for wind farms on sites that are not within Group 1 or Group 2 areas, as described in Scottish Planning Policy Table 1 are likely to the acceptable subject to detailed consideration against certain criteria. In relation to noise Criteria E and I state:

'e. 'they would have no other unacceptably detrimental effect upon the amenity of nearby residents, including from noise and shadow flicker.

i. Their cumulative impact in combinations with other existing and approved wind energy developments, and those for which applications for approval have already been submitted, is acceptable.'

2.2.6 LDP policy: air, noise and light pollution states:

'We will not allow development which would expose people to unacceptable levels of air, noise or light pollution.

Note: In determining planning applications for development that might generate pollution, we'll take the advice of the Council's Environmental Health Service, as local pollution regulator, as to whether the development would be likely to generate unacceptable levels of pollution. The Council may seek additional relevant impact assessments to demonstrate impacts on, or from proposed development on air, noise or light pollution.'

2.3 National Planning Policy

2.3.1 National Planning Framework 4 [(5)] ('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.'*

2.3.2 The Scottish Government's online Onshore Wind: Policy Statement 2022 [(6)] (published on 21 December 2022) 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.'*

2.4 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' which:

'provides 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. The Bulletin article was effectively 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 1990s, 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 m 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 then 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 CMWF.

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

2.8 WSP BEIS Report

2.8.1 On 10th February 2023, WSP published *'A review of noise guidance for onshore wind turbines'* [9] ('WSP BEIS report'), a report that had been 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 15 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 26 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 At time of writing there has been no official response to the report from BEIS or any of the new Government departments which are being created to replace BEIS. In the event that a decision is made to follow up on the recommendations within the WSP BEIS report, it is unclear how new guidelines would account for the UK or Scottish Governments' Net Zero targets nor is there any indication of timescales within which updated guidance would be produced.

2.8.6 In relation to the guidance that should be used to assess CMWF, 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 CMWF.

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 issue reported in relation to 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 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 115 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[315,316]*, 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 116 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 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 The Acoustics community has made 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), whilst in the WSP BEIS report a new term was introduced: non-trailing edge directivity and convective amplification-related AM 'non-TEDCAR-AM'. 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 [17] 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 former Department for Energy and Climate Change (DECC), 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 [18] 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;* [tonality means mechanical sound already covered by ETSU noise limits]*; 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 CMWF;
- 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 CMWF 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/ that could theoretically be used by other schemes in the area; and
- Calculate the likely noise immission levels due to the operation of CMWF on its own and compare it to CMWF'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 existing Total ETSU-R-97 Noise Limits (which are applicable to noise from all wind turbines in the area operating concurrently) at noise sensitive receptors;
- Stage 2 – undertake a cumulative assessment where noise predictions from CMWF are within 10 dB of the total noise predictions from the other wind farms/turbines within the area; and
- Stage 3 – establish CMWF'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 CMWF 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 CMWF. In the absence of a confirmed turbine model, this noise assessment models a candidate turbine, the SG 6.0-155, 6.6 MW with serrated blades and a hub height of 122.5 m. The turbine was selected as it is representative of the turbine type which could be installed at the Site. 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

4.2.1 Consultation was undertaken with South Ayrshire Council (SAC) to inform the EIAR. SAC agreed with the findings of the original noise assessment therefore no additional consultation was undertaken with the Council.

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

Wind Shear

4.3.1 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.

4.3.2 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.

4.3.3 The IOA GPG set outs out in Section 5.2.3 four methods which can be used to determine suitable background noise levels in areas where measured levels have the potential to be influenced by operational wind turbines. The fourth option states that assessments can be undertaken:

'utilising background noise level data as presented within the Environmental Statement/s for the original wind farm/s (the suitability of the background noise level data should be established).'

4.3.4 The IOA GPG goes on to state, in Section 5.2.4, that:

'If the developer wishes to utilise previously presented background noise level data, care should also be taken with respect to any differences in wind speed conditions between the original and proposed site. The underlying principle of ETSU-R-97 requires that the background noise levels at any given location must be correlated with the wind speeds measured on the wind farm site of interest. Where a systematic difference exists between the wind conditions on the two sites, then a correction will need to be applied, meaning that the derived background noise curves for the two sites will be different.'

4.3.5 The approach used to account for wind shear when considering background noise levels for properties proximate to CMWF is detailed in Section 5.1 below.

Noise Impact Criteria in ETSU-R-97

4.3.6 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. The fixed minimum limits adopted for this assessment are detailed in Section 6.4.

4.3.7 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 noise sensitive receptors proximate to CMWF and other nearby operational and proposed wind farm developments to determine whether the wind turbine noise immissions from CMWF were within 10 dB of the wind turbine noise immissions 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 CMWF, 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'* [19] 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 (with predicted noise levels usually slightly higher than 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.

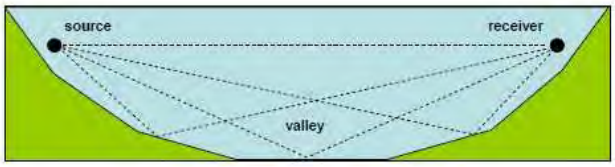
4.4.7 The model uses as its acoustic input data the octave band sound power output of the turbine and calculates, on an octave band basis, attenuation due to the factors above, as appropriate.

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 6.3 below.

4.5 Setting the Site Specific Noise Limits (Stage 3)

4.5.1 Summary Box 21 of the IOA GPG states:

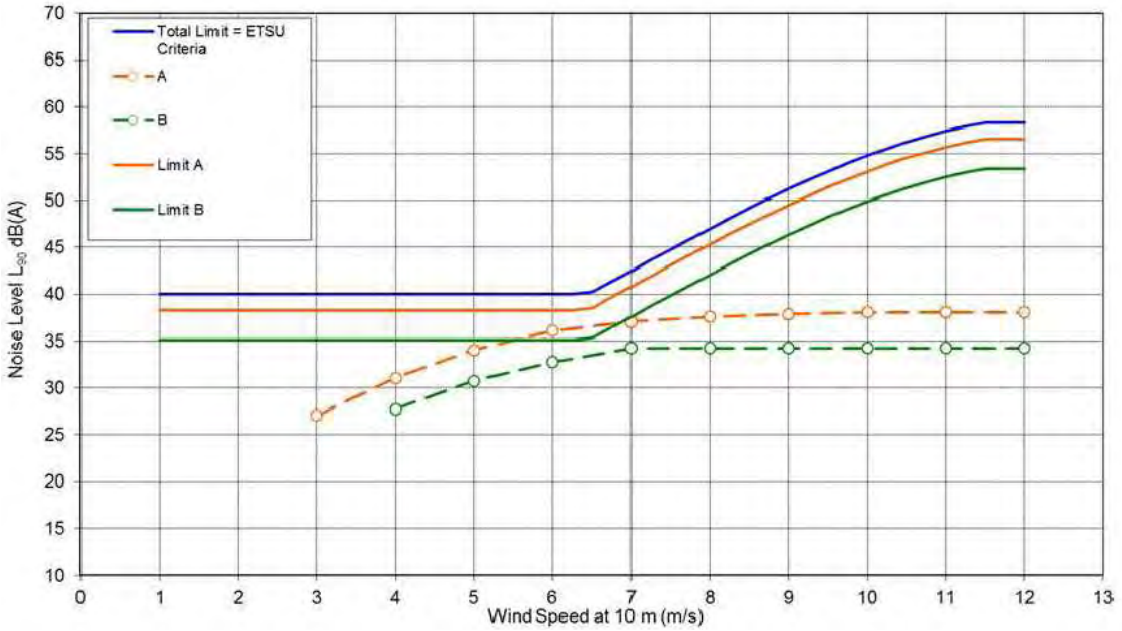
'Whenever a cumulative situation is encountered, the noise limits for an individual wind farm should be determined in such a way that no cumulative excess of the total ETSU-R-97 noise limit would occur.'

4.5.2 In order to determine Site Specific noise limits at receptors in proximity to CMWF (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 ETSU-R-97 Noise Limit (shown in blue) is shared between two proposed wind farms (A and B). The two noise limits for each scheme (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 Proposed Developments.

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 ETSU-R-97 Noise Limit. 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. 2 dB has been added to predictions for Hadyard Hill Wind Farm whilst an addition was not required for Dersalloch Wind Farm as the noise emissions of the turbines installed at that site are controlled by a noise related planning condition.

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 CMWF. Further information on the approach to apportionment is provided in Section 6.6 below.

4.6 Assessment Criteria

4.6.1 Planning Advice Note PAN 1/2011 Planning and Noise provides advice on the role of the planning system in helping to prevent and limit the adverse effects of noise. PAN 1/2011 refers to the Web based planning advice on renewable technologies for Onshore Wind Turbines which states that ETSU-R-97 should be used to assess and rate noise from wind energy developments. ETSU-R-97 does not define significance criteria, but describes a framework for the measurement of windfarm noise and gives indicative noise levels considered to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development. Achievement of ETSU-R-97 derived noise limits ensures that wind turbine noise will meet current Government guidance.

4.6.2 In terms of the EIA Regulations [20], the terminology of significance used in this report refers to compliance/non-compliance with the ETSU-R-97 derived noise limits. For situations where predicted wind turbine noise meets or is less than the noise limits defined in ETSU-R-97, then the noise effects are deemed not significant. Any breach of the ETSU-R-97 derived noise limits due to CMWF is deemed to result in a significant effect.

4.6.3 For the purposes of this assessment, residential properties are considered to be noise sensitive receptors.

5 Baseline

5.1 Background Noise Surveys

5.1.1 Background noise monitoring has been undertaken at properties proximate to CMWF, CWF and KWF as summarised below:

- 2015 – background noise monitoring was undertaken for the then proposed Hadyard Hill Extension Wind Farm which was located in a similar area to CMWF.
- 2018 - background noise monitoring was undertaken for the then proposed Linfairn Wind Farm which was located in a similar area to the proposed KWF; and
- 2020 - background noise monitoring was undertaken for proposed CWF.

5.1.2 Extracts from the relevant noise reports are included within Annex 2.

5.1.3 In accordance with Section 4.3.5 above, the baseline datasets collected as part of Hadyard Hill Extension have been adjusted to take account of wind shear such that they correlate with wind speeds measured on the CMWF site. An adjustment was previously applied to wind turbine noise predictions in the Additional Information for CMWF but this assessment includes a more conservative adjustment which has been applied to the background noise levels. Adjustment of the background noise levels was considered by TNEI to more appropriate as it ensures that wind shear is accounted for in the noise limits. The steps below outline the process that was adopted:

- A wind resource model was created by The Wind Consultancy Service (TWCS) using the specialist software specialist software packages windPRO and WAsP-CFD.
- The model considered long term[1] wind speed data, the topography of the site and the surrounding area and surface roughness[2] and this was used to determine 'speed up values' to determine the ratio of the wind speeds at the height of the 80 m mast used for Hadyard Hill Extension Wind Farm and the proposed hub height at the CMWF site. A speed up factor of 1.15 indicates that measurements of 1 ms^{-1} at the Hadyard Hill mast are expected to equate to a wind speed of 1.15 ms^{-1} at the CMWF site.
- The model was run in the time domain, with speed-up factors calculated for each time-step. From the resultant data, average speed up factors were calculated across a range of wind speeds for both the ETSU-R-97 quiet daytime and night time periods. The standard deviation of the speed up factor was also calculated for each 1 ms^{-1} wind speed bin.
- The data provided by TWCS were then used by TNEI to adjust the background noise data using the following steps:
    - The background noise levels presented for Hadyard Hill Extension Wind Farm (which were standardised to 10 m) were presented relative to winds at 80 m at the Hadyard Hill Extension mast;

[1] Approximately 20 years of data was included in the model
[2] Surface roughness is a parameter used to describe the roughness of the surface of the ground, surface roughness influences the flow of air over a region and also the levels of wind shear.

- The background noise levels were then set relative to hub height (122.5 m) at the CMWF site. This was achieved by multiplying the values by the average speed up value plus one standard deviation (to represent a cautious approach); and
- The background noise levels were then set relative to standardised wind speeds at the CMWF site to accord with good practice.

5.1.4 The adjustments applied, along with the accompanying wind shear report are included within Annex 3.

5.2 Prevailing Background Noise Level

5.2.1 Table 5.1 and Table 5.2 summarise the prevailing background noise levels measured during the noise monitoring periods. The data includes the adjustment for shear as set out in Section 5.1.

Table 5.1 Summary of Prevailing Background Noise Levels during Quiet Daytime Periods (dB(A))

NML	Prevailing Background Noise Level $L_{A90,10\ min}$											
	1	2	3	4	5	6	7	8	9	10	11	12
Knockrochar*	31.0	31.0	31.0	31.2	31.8	33.2	35.3	37.8	40.7	43.7	46.7	49.6
Dobbingstone*	31.4	31.4	31.4	32.3	33.4	34.3	35.4	36.5	37.6	38.8	40.0	41.3
Doughty Farm*	28.1	28.1	28.1	28.8	29.7	30.9	32.4	34.2	36.1	38.1	40.3	42.5
Dalwyne Cottage*	32.7	32.7	32.7	33.1	33.9	35.0	36.5	38.4	40.3	42.4	44.6	46.7
Milton Farm*	28.6	28.6	28.6	29.5	30.7	32.0	33.5	35.3	37.0	38.9	40.8	42.7
Glenginnet Road*	26.3	26.3	26.3	27.5	28.9	30.5	32.4	34.4	36.4	38.5	38.5	38.5
Doughty Farm**	23.8	23.8	24.5	25.5	26.7	28.2	29.8	31.6	33.6	35.6	37.7	39.9
White Row**	29.2	29.2	29.4	29.7	30.2	31.0	32.0	33.3	34.7	36.5	38.5	40.7
Glenalla**	26.6	26.6	27.4	28.2	29.0	29.9	31.0	32.2	33.7	35.4	37.3	39.6
Blair Farm**	23.3	23.3	24.0	25.3	27.0	29.1	31.5	34.1	36.9	39.8	42.7	45.6
Genoch Cottage**	28.4	28.4	28.8	29.4	30.2	31.1	32.2	33.4	34.8	36.2	37.8	39.5
Tairlaw Toll House**	33.0	33.7	33.9	34.2	34.7	35.3	36.2	37.2	38.3	39.6	41.0	42.5
Knockskae***	26.5	26.5	26.8	27.0	27.4	28.2	29.3	30.8	32.5	34.4	36.0	37.1

NML	Prevailing Background Noise Level $L_{A90,10\ min}$											
	1	2	3	4	5	6	7	8	9	10	11	12
Linfairn Farm***	29.6	29.6	30.0	30.9	32.0	33.4	34.7	35.9	37.1	38.2	39.3	40.6

**Dataset collected as part of the baseline survey undertaken for Hadyard Hill Extension*

***Dataset collected as part the baseline survey undertaken for CWF*

****Dataset collected as part the baseline survey undertaken for Linfairn*

NB where data were not available at 1 ms^{-1} data from 2 ms^{-2} have been adopted. This has no material impact on the Total ETSU-R-97 noise limits as they are based on the fixed minimum limits at this windspeed. The only exception is where the dataset for Tairlaw Toll House has been used, in this case a reduced background noise level of 33 dB has been assumed – this results in a Total ETSU-R-97 Noise Limit which is consistent with those presented in the CWF and KWF assessments.

Table 5.2 Summary of Prevailing Background Noise Levels during Night time Periods (dB(A))

NML	Prevailing Background Noise Level $L_{A90,10\ min}$											
	1	2	3	4	5	6	7	8	9	10	11	12
Knockrochar*	29.7	29.7	29.7	30.0	30.9	32.2	34.2	36.5	39.2	42.1	45.1	48.1
Dobbingstone*	28.0	28.0	28.0	29.6	31.1	32.7	34.3	36.0	37.7	39.6	41.4	43.2
Doughty Farm*	27.6	27.6	27.6	28.0	28.8	30.0	31.7	33.7	35.9	38.2	40.7	43.2
Dalwyne Cottage*	31.3	31.3	31.3	32.1	33.2	34.5	36.0	37.9	39.9	42.0	44.2	46.6
Milton Farm*	27.9	27.9	27.9	29.0	30.2	31.5	32.9	34.5	36.2	38.1	39.9	41.9
Glenginnet Road*	26.1	26.1	26.1	26.6	27.0	27.6	28.7	30.6	33.4	37.3	42.8	42.8
Doughty Farm**	23.4	23.4	23.5	24.1	25.3	26.8	28.8	30.9	33.3	35.6	38.0	40.3
White Row**	28.8	28.8	29.0	29.4	30.1	31.0	32.1	33.3	34.6	35.9	37.4	38.8
Glenalla**	27.4	27.4	27.5	28.0	28.9	30.1	31.5	33.1	34.8	36.5	38.2	39.8
Blair Farm**	23.1	23.1	23.3	24.2	25.8	27.8	30.2	32.8	35.6	38.3	41.0	43.3
Genoch Cottage**	25.7	25.7	26.1	26.8	28.0	29.4	31.0	32.7	34.4	36.1	37.6	38.9
Tairlaw Toll House	33.4	33.4	34.0	34.5	35.0	35.5	36.0	36.6	37.3	38.2	39.3	40.6
Knockskae***	26.5	26.5	27.4	27.6	27.8	28.3	29.4	31.0	33.1	35.4	37.2	38.1

NML	Prevailing Background Noise Level $L_{A90,10\ min}$											
	1	2	3	4	5	6	7	8	9	10	11	12
Linfairn Farm***	28.1	28.1	30.1	31.6	32.7	33.5	34.1	34.7	35.3	36.2	37.5	39.2

**Dataset collected as part of the baseline survey undertaken for Hadyard Hill Extension*

***Dataset collected as part the baseline survey undertaken for CWF*

****Dataset collected as part the baseline survey undertaken for Linfairn*

NB where data were not available at 1 ms^{-1} data from 2 ms^{-2} have been adopted. This has no material impact on the Total ETSU-R-97 noise limits as they are based on the fixed minimum limits at this windspeed.

5.2.2 The use of the background noise datasets for the various schemes were agreed with SAC. For ease of reference here on in the Hadyard Hill Extension dataset will be referred to as the CMWF datasets and the Linfairn datasets will be referred to as the KWF dataset.

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 eighteen noise sensitive receptors were chosen as representative NALs. Predictions of wind turbine noise have been made at each of the NAL as detailed in Table 6.1.

6.1.2 The NALs that have been selected include the properties that are closest to each of the Proposed Developments. This approach ensures that the report models the worst case (loudest) 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 6.3 and thus the closer to a noise source, the higher the noise level. This approach is consistent with ETSU-R-97[3]. Table 6.1 details which NML has been used to set noise limits for each NAL. The location referred to as Knockinculloch Enclosure in the CWF assessment has not been included as it is a scheduled monument and not a dwelling.

Table 6.1 Noise Assessment Locations

Noise Assessment Location (NAL)	Easting (m)	Northing (m)	Elevation (m AOD)	Background Noise Data Used (Location - scheme)
NAL1 - Delamford Cottage	229057	599154	192	Knockrochar – CMWF
NAL2 - Dobbingstone Farm	230179	600461	199	Dobbingstone - CMWF
NAL3 - Knockrochar	229733	600740	186	Knockrochar – CMWF
NAL4 - Dalquhairn Farm	232098.6	596259	146	Dalwyne Cottage - CMWF
NAL5 - Corphin Cottage	228698	596634	225	Doughty Farm – CMWF
NAL6 - Daljedburgh Farm	230804	596256	144	Dalwyne Cottage - CMWF
NAL7 - Doughty Farm	232462	597692	252	Doughty Farm - CWF

[3] Page iv of ETSU-R-97 states: "*The Noise Working Group recommends that the current practice on controlling wind farm noise by the application of noise limits at the nearest noise sensitive properties is the most appropriate approach. This approach has the advantage that the limits can directly reflect the existing environment at the nearest properties and the impact that the wind farm may have on this environment.*"

Noise Assessment Location (NAL)	Easting (m)	Northing (m)	Elevation (m AOD)	Background Noise Data Used (Location - scheme)
NAL8 - White Row	234596	595806	163	White Row - CWF
NAL9 - Glenalla	234681	600218	260	Glenalla - CWF
NAL10 - Knockskae	237279	601396	191	Knockskae – KWF
NAL11 - Linfairn Farm	238159	601207	162	Linfairn Farm - KWF
NAL12 - Genoch Cottage	239049	600791	135	Genoch Cottage - CWF
NAL13 - Tairlaw Toll House/Cottage	239762	599541	230	Tairlaw Toll House - CWF
NAL14 - Tallaminnoch Cottage	240021	598257	267	Tairlaw Toll House - CWF
NAL15 - Milton Farm	229064	596009	140	Milton Farm - CMWF
NAL16 - Alton Albany Lodge	227746	594448	128	Glenginnet Road - CMWF
NAL17 - Lanes Farm	226165	595977	212	Doughty Farm – CMWF
NAL18 - Blair Farm	232447	602454	234	Blair Farm - CWF

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 CMWF. This assessment considers the SG 6.0-155, 6.6 MW with serrated blades and a hub height of 122.5 m. The turbine models consider for other wind turbines in the area are detailed in Annex 5.

6.2.2 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 (2013). Details of the sound power level, octave data and measurement uncertainty used for the turbines considered in this assessment are included in Annex 5.

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 CMWF is 122.5 m. The hub heights considered for the other wind farm/turbine developments are summarised in Annex 4.

6.2.4 The location of the wind turbines are shown on Figure A1.1 and grid references are included in Annex 4.

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 4.

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 4. 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 CMWF.

6.3.7 The IOA GPG recommends (Section 4.4.1) that directivity attenuation factors adopted in any assessment should be clearly stated. The cumulative predictions presented in this assessment have *not* taken into account directivity to ensure consistency with the approach taken in the CWF and KWF assessments. The assessment assumes that each NAL is directly downwind of all wind turbines simultaneously (which cannot occur in practice).

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 CMWF operating in conjunction with other operational and proposed schemes, a Fixed Minimum Limit of 38 dB has been adopted to establish the daytime Total ETSU-R-97 Noise Limit. This limit was chosen with due regard to the guidance in ETSU-R-97, existing noise conditions and the feedback from the SACs noise consultant ACCON.

6.4.3 The ACCON response (Paragraph 9) dated 23 March 2021 states: *'The daytime operational noise limits for the proposed development are indicated as 38 dB L_{A90} or background plus 5dB whichever is the higher and the night-time noise limits as 43 dB L_{A90} or background plus 5dB whichever is the higher. These limits are in line with the consultation advice provided to the applicant.'*

6.4.4 The noise assessment for Hadyard Hill Extension detailed that a number of properties were Financially Involved (FI) with Hadyard Hill and/or the Proposed Extension (Delamford Cottage, Doughty Farm and Lanes Cottage). As the application was subsequently withdrawn and no specific noise conditions were set it is unclear from the information available if that FI related to Hadyard Hill alone and as such for the purposes of this assessment, it has been assumed that no occupiers are FI.

6.4.5 The Total ETSU-R-97 Noise Limits have been established for each of the NALs as detailed in Table 6.2 and Table 6.3 below, based on a fixed minimum of 38 dB(A) (daytime) or 43 dB(A) (Night time) or background plus 5 dB(A).

Table 6.2 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 - Delamford Cottage	38.0	38.0	38.0	38.0	38.0	38.2	40.3	42.8	45.7	48.7	51.7	54.6
NAL2 - Dobbingstone Farm	38.0	38.0	38.0	38.0	38.4	39.3	40.4	41.5	42.6	43.8	45.0	46.3
NAL3 - Knockrochar	38.0	38.0	38.0	38.0	38.0	38.2	40.3	42.8	45.7	48.7	51.7	54.6
NAL4 - Dalquhairn Farm	38.0	38.0	38.0	38.1	38.9	40.0	41.5	43.4	45.3	47.4	49.6	51.7
NAL5 - Corphin Cottage	38.0	38.0	38.0	38.0	38.0	38.0	38.0	39.2	41.1	43.1	45.3	47.5
NAL6 - Daljedburgh Farm	38.0	38.0	38.0	38.1	38.9	40.0	41.5	43.4	45.3	47.4	49.6	51.7
NAL7 - Doughty Farm	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.6	40.6	42.7	44.9
NAL8 - White Row	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.3	39.7	41.5	43.5	45.7

Location	Wind Speed (ms^{-1}) as standardised to 10m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL9 - Glenalla	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.7	40.4	42.3	44.6
NAL10 - Knockskae	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	39.4	41.0	42.1
NAL11 - Linfairn Farm	38.0	38.0	38.0	38.0	38.0	38.4	39.7	40.9	42.1	43.2	44.3	45.6
NAL12 - Genoch Cottage	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.4	39.8	41.2	42.8	44.5
NAL13 - Tairlaw Toll House/Cottage	38.0	38.7	38.9	39.2	39.7	40.3	41.2	42.2	43.3	44.6	46.0	47.5
NAL14 - Tallaminnoch Cottage	38.0	38.7	38.9	39.2	39.7	40.3	41.2	42.2	43.3	44.6	46.0	47.5
NAL15 - Milton Farm	38.0	38.0	38.0	38.0	38.0	38.0	38.5	40.3	42.0	43.9	45.8	47.7
NAL16 - Alton Albany Lodge	38.0	38.0	38.0	38.0	38.0	38.0	38.0	39.4	41.4	43.5	43.5	43.5
NAL17 - Lanes Farm	38.0	38.0	38.0	38.0	38.0	38.0	38.0	39.2	41.1	43.1	45.3	47.5
NAL18 - Blair Farm	38.0	38.0	38.0	38.0	38.0	38.0	38.0	39.1	41.9	44.8	47.7	50.6

Table 6.3 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 - Delamford Cottage	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.2	47.1	50.1	53.1
NAL2 - Dobbingstone Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.6	46.4	48.2
NAL3 - Knockrochar	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.2	47.1	50.1	53.1
NAL4 - Dalquhairn Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9	47.0	49.2	51.6
NAL5 - Corphin Cottage	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.2	45.7	48.2
NAL6 - Daljedburgh Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9	47.0	49.2	51.6
NAL7 - Doughty Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.3
NAL8 - White Row	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8
NAL9 - Glenalla	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.2	44.8
NAL10 - Knockskae	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.1
NAL11 - Linfairn Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.2
NAL12 - Genoch Cottage	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.9
NAL13 - Tairlaw Toll House/Cottage	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.2	44.3	45.6

Location	Wind Speed (ms^{-1}) as standardised to 10m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL14 - Tallaminnoch Cottage	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.2	44.3	45.6
NAL15 - Milton Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.1	44.9	46.9
NAL16 - Alton Albany Lodge	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	47.8	47.8
NAL17 - Lanes Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.2	45.7	48.2
NAL18 - Blair Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.3	46.0	48.3

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

6.5.1 Figures A1.2a-r (Annex 1) show predictions from CMWF operating in isolation and cumulative predicted levels with and without CMWF against the Total ETSU-R-97 Noise Limits. If the solid green line (Cumulative including CMWF) is at or below the solid red line (Total ETSU-R-97 Noise Limit) then cumulative wind farm immissions from the combined effect of all of the operational and proposed schemes meets the noise limits established in accordance with ETSU-R-97. The individual contribution of each of the individual schemes listed in Table 1.1 above are also shown on Figures A1.2a-r. Predictions for CWF and CMWF include mode management where required as discussed further in Section 6.6 below. For completeness, full mode predictions for CWF and CMWF are included as Tables A6.3 and A6.5 respectively in Annex 6. Mode management has been incorporated to ensure predicted noise levels from CWF and CMWF meet the Site Specific Noise Limits derived in Section 6.6 below. The predicted levels for CWF and CMWF including mode management are included in Tables A6.7 and A6.8 respectively (Annex 6). Details of the mode management available for the candidate turbine (the SG 6.0-155 6.6 MW) are also provided in Annex 6 and show that the available noise modes can be used to achieve the required reduction in noise level.

6.5.2 A comparison has been undertaken of the predicted wind turbine noise immission levels from CMWF with the predicted cumulative noise levels from other schemes (excluding CMWF) to determine whether predictions were within 10 dB of each other. The relevant data is shown on Figures 1.2a – 1.2r in Annex 1 (as detailed on the figures, predicted noise levels from CMWF are shown in blue whilst cumulative noise excluding CMWF is shown as the dashed green line[4]). Table 6.4 below summarises the results and whether a cumulative noise assessment was required. As is detailed in Section 4.4 above, if the predictions are greater than 10 dB apart then a cumulative noise assessment was not required.

[4] In some cases the dashed green line can be difficult to identify as it shown underneath another line (e.g. it is underneath the predictions of Hadyard Hill Wind Farm at NAL1 – where Hadyard Hill Wind Farm dominates the cumulative levels excluding CMWF, whilst it is also shown underneath the cumulative noise levels including CMWF at locations where CMWF is having a negligible contribution, for example at NAL10)

Table 6.4 Cumulative Assessment Requirement

Noise Assessment Location (NAL)	Are CMWF predicted wind turbine noise levels within 10 dB of cumulative excluding CMWF?	Is a cumulative assessment required?
NAL1 - Delamford Cottage	YES*	YES
NAL2 - Dobbingstone Farm	YES	YES
NAL3 - Knockrochar	YES	YES
NAL4 - Dalquhairn Farm	YES	YES
NAL5 - Corphin Cottage	YES	YES
NAL6 - Daljedburgh Farm	YES	YES
NAL7 - Doughty Farm	YES	YES
NAL8 - White Row	YES	YES
NAL9 - Glenalla	YES	YES
NAL10 - Knockskae	NO	NO
NAL11 - Linfairn Farm	NO	NO
NAL12 - Genoch Cottage	NO	NO
NAL13 - Tairlaw Toll House/Cottage	NO	NO
NAL14 - Tallaminnoch Cottage	NO	NO
NAL15 - Milton Farm	YES	YES
NAL16 - Alton Albany Lodge	YES	YES
NAL17 - Lanes Farm	NO	NO
NAL18 - Blair Farm	YES	YES
* During the night time period (noise levels are not within 10 dB during the day as mode management is included).		

6.5.3 As summarised in Table 6.4 above a cumulative noise assessment is required at twelve receptors.

6.5.4 A likely cumulative noise assessment was undertaken at the twelve NALs and the results are summarised in tabular form in Table 6.5 and Table 6.6. The results show that the predicted cumulative wind turbine noise immission levels meet the Total ETSU-R-97 Noise limits under all conditions except at NAL1 where an exceedance is predicted as a result of the contribution of Hadyard Hill Wind Farm. The predicted 'likely' cumulative levels are the actual levels expected at an NAL (assuming that Hadyard Hill Wind Farm operates unconstrainted) and include the addition of an appropriate level of uncertainty to the turbine data as per Section 4.2 of the IOA GPG.

Table 6.5 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 – Delamford Cottage	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.2	40.3	42.8	45.7	48.7	51.7	54.6
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	41.3	41.3	42.1	43.1	44.2	44.6	44.6	44.6
	Exceedance Level	-	-	-	-	**3.3***	**3.1***	**1.8***	**0.3***	-1.5	-4.1	-7.1	-10.0
NAL2 – Dobbingstone Farm	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.4	39.3	40.4	41.5	42.6	43.8	45.0	46.3
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	36	36.8	37.2	37.9	38.6	38.8	38.8	38.8
	Exceedance Level	-	-	-	-	-2.4	-2.5	-3.2	-3.6	-4.0	-5.0	-6.2	-7.5
NAL3 - Knockrochar	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.2	40.3	42.8	45.7	48.7	51.7	54.6
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	35.6	36.3	36.8	37.5	38.2	38.5	38.5	38.5
	Exceedance Level	-	-	-	-	-2.4	-1.9	-3.5	-5.3	-7.5	-10.2	-13.2	-16.1
NAL4 – Dalquhairn Farm	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.1	38.9	40.0	41.5	43.4	45.3	47.4	49.6	51.7
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	31.4	32.5	32.8	33.2	33.7	33.9	33.9	33.9
	Exceedance Level	-	-	-	-	-7.5	-7.5	-8.7	-10.2	-11.6	-13.5	-15.7	-17.8
NAL5 – Corphin Cottage	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	39.2	41.1	43.1	45.3	47.5
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	37.3	37.3	38.0	39.2	40.7	40.8	41.0	41.0
	Exceedance Level	-	-	-	-	-0.7	-0.7	0.0	0.0	-0.4	-2.3	-4.3	-6.5
NAL6 – Daljedburgh Farm	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.1	38.9	40.0	41.5	43.4	45.3	47.4	49.6	51.7
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	33	33.9	34.4	34.9	35.6	35.8	35.8	35.8
	Exceedance Level	-	-	-	-	-5.9	-6.1	-7.1	-8.5	-9.7	-11.6	-13.8	-15.9

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL7 – Doughty Farm	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.6	40.6	42.7	44.9
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	37.1	37.7	37.7	37.6	38.1	39.2	39.2	39.2
	Exceedance Level	-	-	-	-	-0.9	-0.3	-0.3	-0.4	-0.5	-1.4	-3.5	-5.7
NAL8 – White Row	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.3	39.7	41.5	43.5	45.7
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	28.2	29.7	30	30.4	30.8	30.9	30.9	30.9
	Exceedance Level	-	-	-	-	-9.8	-8.3	-8.0	-7.9	-8.9	-10.6	-12.6	-14.8
NAL9 – Glenalla	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.7	40.4	42.3	44.6
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	35.6	37.7	37.8	37.9	37.9	38.1	38.1	38.1
	Exceedance Level	-	-	-	-	-2.4	-0.3	-0.2	-0.1	-0.8	-2.3	-4.2	-6.5
NAL15- Milton Farm	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.5	40.3	42.0	43.9	45.8	47.7
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	34.2	34.5	35.2	36.1	37.1	37.3	37.3	37.3
	Exceedance Level	-	-	-	-	-3.8	-3.5	-3.3	-4.2	-4.9	-6.6	-8.5	-10.4
NAL16 –Alton Albany Cottage	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	39.4	41.4	43.5	43.5	43.5
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	32.6	33.1	33.4	34.5	35.6	35.9	35.9	35.9
	Exceedance Level	-	-	-	-	-5.4	-4.9	-4.6	-4.9	-5.8	-7.6	-7.6	-7.6
NAL18 – Blair Farm	Total Noise Limit: ETSU-R-97 L_{A90}	38.0	38.0	38.0	38.0	38.0	38.0	38.0	39.1	41.9	44.8	47.7	50.6
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	27.9	29.5	30	30.4	30.8	31.0	31.0	31.0
	Exceedance Level	-	-	-	-	-10.1	-8.5	-8.0	-8.7	-11.1	-13.8	-16.7	-19.6

Location	Wind Speed (ms^{-1}) as standardised to 10 m height											
	1	2	3	4	5	6	7	8	9	10	11	12
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}. * Predicted noise levels excluding CMWF exceed the noise limit. The exceedance is a result of the predicted contribution of Hadyard Hill Wind Farm. In the event that the properties are financially involved with Hadyard Hill Wind Farm, higher noise limits would be appropriate and, as a result, the Hadyard turbines may be able to operate in full operational mode. In the event that the properties are not financially involved with Hadyard Hill Wind Farm then theoretically there would be a noise exceedance at these properties if the turbines run in full operational mode. It is possible the Hadyard Hill Wind Farm operator (SSE) undertakes measures to manage the noise effects in relation to these properties through turbine mode management, but there is no publicly available information regarding this. At all wind speeds where an exceedance is predicted noise from CMWF is at least 10 dB below the predicted levels for Hadyard Hill Wind Farm, as such CMWF is having a negligible effect.											

Table 6.6 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 – Delamford Cottage	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.2	47.1	50.1	53.1
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	41.3	41.8	42.6	43.1	44.2	44.6	44.6	44.6
	Exceedance Level	-	-	-	-	-1.7	-1.2	-0.4	**0.1***	0.0	-2.5	-5.5	-8.5
NAL2 – Dobbingstone 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	44.6	46.4	48.2
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	36	36.8	37.2	37.9	38.6	38.8	38.8	38.8
	Exceedance Level	-	-	-	-	-7.0	-6.2	-5.8	-5.1	-4.4	-5.8	-7.6	-9.4
NAL3 - Knockrochar	Total Noise Limit: ETSU-R-97 L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.2	47.1	50.1	53.1
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	35.6	36.3	36.8	37.5	38.2	38.5	38.5	38.5
	Exceedance Level	-	-	-	-	-7.4	-6.7	-6.2	-5.5	-6.0	-8.6	-11.6	-14.6
NAL4 – Dalquhairn 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	44.9	47.0	49.2	51.6
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	31.4	32.5	32.8	33.2	33.7	33.9	33.9	33.9
	Exceedance Level	-	-	-	-	-11.6	-10.5	-10.2	-9.8	-11.2	-13.1	-15.3	-17.7
NAL5 – Corphin Cottage	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	43.2	45.7	48.2
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	37.4	37.7	38.7	39.7	40.7	40.8	41.0	41.0
	Exceedance Level	-	-	-	-	-5.6	-5.3	-4.3	-3.3	-2.3	-2.4	-4.7	-7.2
NAL6 – Daljedburgh 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	44.9	47.0	49.2	51.6
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	33	33.9	34.4	34.9	35.6	35.8	35.8	35.8
	Exceedance Level	-	-	-	-	-10.0	-9.1	-8.6	-8.1	-9.3	-11.2	-13.4	-15.8

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL7 – Doughty 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	43.0	43.0	45.3
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	37.1	38.5	38.9	39	39.1	39.2	39.2	39.2
	Exceedance Level	-	-	-	-	-5.9	-4.5	-4.1	-4.0	-3.9	-3.8	-3.8	-6.1
NAL8 – White Row	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	43.8
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	28.2	29.7	30	30.4	30.8	30.9	30.9	30.9
	Exceedance Level	-	-	-	-	-14.8	-13.3	-13.0	-12.6	-12.2	-12.1	-12.1	-12.9
NAL9 – Glenalla	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	43.2	44.8
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	35.6	37.7	37.8	37.9	37.9	38.1	38.1	38.1
	Exceedance Level	-	-	-	-	-7.4	-5.3	-5.2	-5.1	-5.1	-4.9	-5.1	-6.7
NAL15- Milton 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	43.1	44.9	46.9
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	34.2	34.5	35.2	36.1	37.1	37.3	37.3	37.3
	Exceedance Level	-	-	-	-	-8.8	-8.5	-7.8	-6.9	-5.9	-5.8	-7.6	-9.6
NAL16 –Alton Albany Cottage	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	47.8	47.8
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	32.6	33.1	33.4	34.5	35.6	35.9	35.9	35.9
	Exceedance Level	-	-	-	-	-10.4	-9.9	-9.6	-8.5	-7.4	-7.1	-11.9	-11.9
NAL18 – Blair 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	43.3	46.0	48.3
	Predicted Cumulative Wind Turbine Noise (including CMWF) L_{A90}	-	-	-	-	27.9	29.5	30	30.4	30.8	31	31	31
	Exceedance Level	-	-	-	-	-15.1	-13.5	-13.0	-12.6	-12.2	-12.3	-15.0	-17.3

Location	Wind Speed (ms^{-1}) as standardised to 10 m height											
	1	2	3	4	5	6	7	8	9	10	11	12
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}. * Predicted noise levels excluding CMWF exceed the noise limit. The exceedance is a result of the predicted contribution of Hadyard Hill Wind Farm. In the event that the properties are financially involved with Hadyard Hill Wind Farm, higher noise limits would be appropriate and, as a result, the Hadyard turbines may be able to operate in full operational mode. In the event that the properties are not financially involved with Hadyard Hill Wind Farm then theoretically there would be a noise exceedance at these properties if the turbines run in full operational mode. It is possible the Hadyard Hill Wind Farm operator (SSE) undertakes measures to manage the noise effects in relation to these properties through turbine mode management, but there is no publicly available information regarding this. At all wind speeds where an exceedance is predicted noise from CMWF is at least 10 dB below the predicted levels for Hadyard Hill Wind Farm, as such CMWF is having a negligible effect.											

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 Site Specific Noise Limits have been derived using the guidance in the IOA GPG. Calculation of a Site Specific Noise Limit for CMWF is only required where CMWF predictions are within 10 dB of the Total ETSU-R-97 Noise Limit. Where predictions are more than 10 dB below, CMWF will be using a negligible proportion of the Total ETSU-R-97 Noise Limit therefore a Site Specific Noise Limit is not required.

6.6.3 The approach to calculating Site Specific Noise Levels set out in this report is based on predictions undertaken by TNEI. The limits have been derived to ensure that the Total ETSU-R-97 noise limits will not be breached as a result of the combined operation of the three proposed developments (operating concurrently with the existing operational wind turbines in the area). It is acknowledged that alternative limits may be agreed within the SoAM (which is likely to consider the worst case (highest) predictions included in this assessment and the two assessments for CWF and KWF). The approach taken in this report does however adopt the same principles included in the SoAM (which is in draft at time of writing[5]), which follows the guidance in the IOA GPG. Within the draft SoAM, the approach to apportionment of the limit between CMWF and CWF at NAL7 has not been finalised, this report presents one potential option which was discussed during production of the SoAM.

6.6.4 For each of the NALs considered in Tables 6.6 and 6.7 a comparison was undertaken of the predictions from the individual existing schemes against their individual noise limits. Specifically:

- For Hadyard Hill Wind Farm, it was noted that the planning conditions attached to the consent (as reproduced below) were poorly worded meaning that the noise limits for uninvolved properties, at higher windspeeds, are unspecified:

> 7.11 At properties occupied by persons with a financial interest in the development, day and night time noise levels must not exceed an L_{A90} (10 minutes) of 45 decibels. At wind speeds above 5.5 metres per second the L_{A90} should not exceed L_{eq} (10 minutes) by more than 5 decibels.
>
> Reason: to ensure operational noise levels do not affect the amenity of those living in the vicinity of the windfarm.
>
> 7.12 At residential properties with no such financial interest, for wind speeds of up to 5.5 metres per second the L_{A90}, (10 minutes) should not exceed 38dB (day time) and 43dB (night time) when measured at the external façade of the nearest residential properties.

[5] Draft 9 dated 17-03-2023

- In the absence of clear enforceable limits, it has been assumed that noise from Hadyard Hill Wind Farm is 2 dB louder than the likely predicted noise levels. The resulting 'cautious' predictions of noise from Hadyard Hill are included in Table 6.2 in Annex 6;
- For Dersalloch Wind Farm, it is noted that maximum noise emissions were detailed in information submitted to discharge condition 15 of that wind farms planning consent (as set out in paragraphs 150 to 153). Whilst the submissions made to discharge condition 15 detailed a maximum sound power level of 109 dB(A) this assessment has been based on a sound power level of 110 dB(A) (to match the worst case assumption considered in the KWF assessment). The resulting 'cautious' predictions of noise from Dersalloch are included in Table 6.1 in Annex 6; and
- For the Glengennet Wind Turbine predicted, 'likely' noise levels are very low at all properties (predicted levels are more than 10 dB below noise from Hadyard Hill Wind Farm at all locations meaning that the scheme is having a negligible contribution) except at NAL5. At NAL5, predictions of noise from the Glengennet turbine are approximately 10 dB below the Total ETSU-R-97 Noise Limits at all windspeeds (meaning that there is significant headroom as defined by the IOA GPG). For the purposes of this assessment 2 dB has been added to the predicted levels to determine 'cautious' predictions of noise[6].

6.6.5 The apportionment options provided in the IOA GPG were then considered to determine the most appropriate option for each scheme. Table 6.7 below summarises the approach adopted at each NAL in order to derive the Remaining Available Noise Limit and Site Specific Noise Limits for the Proposed Developments.

Table 6.7 Limit Derivation Strategy

NAL	Calculation of the Remaining Available Noise Limit	Apportionment of the Remaining Available Noise Limit to determine Site Specific Noise Limits for the Proposed Developments
NAL1	Cautious predictions of cumulative noise (excluding CMWF) exceed the Total ETSU-R-97 Noise Limit (TNL) at wind speeds of up to 9 ms^{-1} (daytime) and 10 ms^{-1} (night time). At those wind speeds the Remaining Available Noise Limit (RANL) has been set 10 dB below the TNL. At higher wind speeds the RANL has been calculated by subtracting the relevant[7] cautious predicted noise level from the TNL.	Predictions from CWF and KWF are more than 10 dB below the TNL so those schemes do not require a share of the noise budget and do not require a Site Specific Noise limit (SSNL). The CMWF SSNL has been set equal to the RANL.
NAL2, 3 4, and 6	The RANL has been calculated by subtracting the relevant cautious predicted noise level from the TNL.	

[6] In practice the Site Specific Noise Limit proposed for CMWF at this location is 10 dB below the Total ETSU-R-97 Noise Limit meaning that cautious predictions are not used for the calculation of the Site Specific Noise Limits. Accordingly the contribution from the Glengennet Wind Turbine has been excluded from the SoAM.
[7] The cautious predictions are only relevant where they are within 10 dB of the TNL.

NAL	Calculation of the Remaining Available Noise Limit	Apportionment of the Remaining Available Noise Limit to determine Site Specific Noise Limits for the Proposed Developments
NAL5	Cautious predictions of cumulative noise (excluding CMWF) exceed Total ETSU-R-97 Noise Limit (TNL) at wind speeds of up to 10 ms^{-1} (daytime only). At higher wind speeds during the day and all wind speeds during the night RANL has been calculated by subtracting the relevant cautious predicted noise level from the TNL.	
NAL7	The RANL has been calculated by subtracting the relevant cautious predicted noise level from the TNL.	Predictions from KWF are more than 10 dB below the TNL so that scheme does not require a share of the noise budget and does not require a SSNL. The RANL has been apportioned between CMWF and CWF[8] using the guidance in the IOA GPG.
NAL9	Cautious predicted noise levels from all existing schemes are more than 10 dB below the TNL. As such the RANL is the TNL.	The RANL has been apportioned between CMWF, CWF and KWF using the guidance in the IOA GPG.
NB – Whilst the RANL has been calculated for all NALs (as shown on Figures A1.2a to A1.2r, this table only includes NALs where predicted noise from CMWF is within 10 dB of the TNL – at all other locations (NAL4, 8, and NALs 10-18) CMWF does not require a SSNL.		

6.6.6 Table 6.8 and Table 6.9 show the daytime and night time Site Specific Noise Limits for CMWF, noise predictions for CMWF 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 meet the Site Specific Noise Limits under all conditions and at all locations for both daytime and night time periods. To meet the noise limits at NALs 1, 5 and 7 it has been assumed that certain turbines will operate in low noise mode for a limited range of wind speeds and wind directions during the daytime period.

6.6.8 Figures A1.3a – A1.3i[9] present the SSNLs derived by TNEI for CMWF, CWF and KWF alongside the predicted noise levels for each of the three schemes. As per Tables 6.8 and 6.9 the predicted noise levels account for the use of low noise modes where required, this is referenced in the Legend included on each figure where appropriate.

[8] To meet the SSNL proposed for CWF in this report, and assuming the candidate turbine set out in Table 1.1 above, mode management would need to be applied to CWF to reduce noise to comply with the proposed SSNL. The potential for the candidate turbine to adopt mode management was discussed in the CWF application (ES Chapter 9 section 9.5.1.3). The level of mode management required would be achievable using the available low noise modes. The degree of curtailment required (if any) would depend on the final turbine model selected for use at that site and the final SSNLs agreed in the final SoAM but would only apply to a limited range of wind speeds and directions and would only be needed during the daytime.

[9] The letters included with the Figure numbers are consistent with those used on the A1.2 Figures (e.g. A1.2a is NAL1, A1.2b is NAL2 etc). In relation to the A1.3 figures not all NALs are included (as CMWF does not require SSNLs at every NAL) but the numbering convention is retained for ease of cross referencing (i.e. A1.2i corresponds with A1.3i).

Table 6.8 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 – Delamford Cottage	Site Specific Noise Limit CMWF L_{A90}	28.0	28.0	28.0	28.0	28.0	28.2	30.3	32.8	35.7	44.5	50.1	53.8
	Predicted Wind Turbine Noise CMWF L_{A90}	-	-	20.6	25.8	28*	28.2*	30.3*	32.5	32.5	32.5	32.5	32.5
	Exceedance Level	-	-	-7.4	-2.2	0.0	0.0	0.0	-0.3	-3.2	-12.0	-17.6	-21.3
NAL2 – Dobbingstone Farm	Site Specific Noise Limit CMWF L_{A90}	34.9	34.9	34.9	34.9	34.9	36.8	38.1	39.2	40.3	42.0	43.8	45.4
	Predicted Wind Turbine Noise CMWF L_{A90}	-	-	22	27.2	31.9	33.8	33.8	33.8	33.8	33.8	33.8	33.8
	Exceedance Level	-	-	-12.9	-7.7	-3.0	-3.0	-4.3	-5.4	-6.5	-8.2	-10.0	-11.6
NAL3 - Knockrochar	Site Specific Noise Limit CMWF L_{A90}	33.5	33.5	33.5	33.5	33.5	33.9	37.6	41.1	44.6	48.7	51.7	54.6
	Predicted Wind Turbine Noise CMWF L_{A90}	-	-	20.4	25.6	30.4	32.2	32.2	32.2	32.2	32.2	32.2	32.2
	Exceedance Level	-	-	-13.1	-7.9	-3.1	-1.7	-5.4	-8.9	-12.4	-16.5	-19.5	-22.4
NAL5 – Corphin Cottage	Site Specific Noise Limit CMWF L_{A90}	28.0	28.0	28.0	28.0	28.0	28.0	28.0	29.2	31.1	33.1	42.4	46.0
	Predicted Wind Turbine Noise CMWF L_{A90}	-	-	18.6	23.8	28.0*	28.0*	28.0*	29.2*	30.4	30.4	30.4	30.4
	Exceedance Level	-	-	-9.4	-4.2	0.0	0.0	0.0	0.0	-0.7	-2.7	-12.0	-15.6
NAL6 – Daljedburgh Farm	Site Specific Noise Limit CMWF L_{A90}	37.7	37.7	37.7	37.7	37.7	39.1	40.8	43.4	45.3	47.4	49.6	51.7
	Predicted Wind Turbine Noise CMWF L_{A90}	-	-	19.2	24.4	29.2	31.1	31.1	31.1	31.1	31.1	31.1	31.1
	Exceedance Level	-	-	-18.5	-13.3	-8.5	-8.0	-9.7	-12.3	-14.2	-16.3	-18.5	-20.6
NAL7 – Doughty Farm	Site Specific Noise Limit CMWF L_{A90}	37.5	37.5	37.5	37.5	37.5	36.8	36.6	36.4	36.8	39.2	42.2	44.4
	Predicted Wind Turbine Noise CMWF L_{A90}	-	-	26.1	31.3	36.1	36.8*	36.6*	36.4*	36.8*	38.0	38.0	38.0
	Exceedance Level	-	-	-11.4	-6.2	-1.4	0.0	0.0	0.0	0.0	-1.2	-4.2	-6.4

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL9 – Glenalla	Site Specific Noise Limit CMWF L_{A90}	30.8	30.8	30.8	30.8	31.0	30.8	30.7	30.6	31.3	33.0	34.9	37.2
	Predicted Wind Turbine Noise CMWF L_{A90}	-	-	18.6	23.8	28.6	30.5	30.5	30.5	30.5	30.5	30.5	30.5
	Exceedance Level	-	-	-12.2	-7.0	-2.4	-0.3	-0.2	-0.1	-0.8	-2.5	-4.4	-6.7
*Assumes mode management													

Table 6.9 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 – Delamford Cottage	Site Specific Noise Limit CMWF L_{A90}	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	34.2	37.5	47.5	51.9
	Predicted Wind Turbine Noise CMWF L_{A90}	-	-	20.6	25.8	30.6	32.5	32.5	32.5	32.5	32.5	32.5	32.5
	Exceedance Level	-	-	-12.4	-7.2	-2.4	-0.5	-0.5	-0.5	-1.7	-5.0	-15.0	-19.4
NAL2 – Dobbingstone Farm	Site Specific Noise Limit CMWF L_{A90}	42.1	42.1	42.1	42.1	42.1	42.1	41.9	41.5	40.9	43.1	45.5	48.2
	Predicted Wind Turbine Noise CMWF L_{A90}	-	-	22	27.2	31.9	33.8	33.8	33.8	33.8	33.8	33.8	33.8
	Exceedance Level	-	-	-20.1	-14.9	-10.2	-8.3	-8.1	-7.7	-7.1	-9.3	-11.7	-14.4
NAL3 - Knockrochar	Site Specific Noise Limit CMWF L_{A90}	42.0	42.0	42.0	42.0	42.0	42.0	41.8	41.3	42.6	46.3	50.1	53.1
	Predicted Wind Turbine Noise CMWF L_{A90}	-	-	20.4	25.6	30.4	32.2	32.2	32.2	32.2	32.2	32.2	32.2
	Exceedance Level	-	-	-21.6	-16.4	-11.6	-9.8	-9.6	-9.1	-10.4	-14.1	-17.9	-20.9
NAL5 – Corphin Cottage	Site Specific Noise Limit CMWF L_{A90}	40.9	40.9	40.9	40.9	40.9	40.9	40.3	39.1	36.8	36.9	43.3	47.0
	Predicted Wind Turbine Noise CMWF L_{A90}	-	-	18.6	23.8	28.6	30.4	30.4	30.4	30.4	30.4	30.4	30.4
	Exceedance Level	-	-	-22.3	-17.1	-12.3	-10.5	-9.9	-8.7	-6.4	-6.5	-12.9	-16.6

Location		Wind Speed (ms^{-1}) as standardised to 10 m height											
		1	2	3	4	5	6	7	8	9	10	11	12
NAL6 – Daljedburgh Farm	Site Specific Noise Limit CMWF L_{A90}	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9	47.0	49.2	51.6
	Predicted Wind Turbine Noise CMWF L_{A90}	-	-	19.2	24.4	29.2	31.1	31.1	31.1	31.1	31.1	31.1	31.1
	Exceedance Level	-	-	-23.8	-18.6	-13.8	-11.9	-11.9	-11.9	-13.8	-15.9	-18.1	-20.5
NAL7 – Doughty Farm	Site Specific Noise Limit CMWF L_{A90}	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	44.8
	Predicted Wind Turbine Noise CMWF L_{A90}	-	-	26.1	31.3	36.1	38.0	38.0	38.0	38.0	38.0	38.0	38.0
	Exceedance Level	-	-	-16.4	-11.2	-6.4	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-6.8
NAL9 – Glenalla	Site Specific Noise Limit CMWF L_{A90}	35.8	35.8	35.8	35.8	36.0	35.8	35.7	35.6	35.6	35.6	35.8	37.4
	Predicted Wind Turbine Noise CMWF L_{A90}	-	-	18.6	23.8	28.6	30.5	30.5	30.5	30.5	30.5	30.5	30.5
	Exceedance Level	-	-	-17.2	-12.0	-7.4	-5.3	-5.2	-5.1	-5.1	-5.1	-5.3	-6.9

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. In the event that consent is granted for CMWF it would be appropriate to set noise limits equal to the Site Specific Noise Limits contained Table 6.8 and Table 6.9 (or any alternative noise limits agreed within the SoAM).

6.7 Micrositing

6.7.1 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 CMWF 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 CMWF.

7.1.2 Three separate background noise surveys were undertaken to consider properties located proximate to CMWF, CWF and KWF. A total of eighteen noise sensitive receptors were chosen as noise assessment locations. For properties located adjacent to CMWF, background noise levels measured as part of the assessment for Hadyard Hill Extension Wind Farm were adjusted to account for wind shear using analysis of wind data undertaken by The Wind Consultancy Limited. For the assessment locations where no background noise measurements were undertaken, noise data collected at proxy locations was used to assess the noise impact at those receptors.

7.1.3 A Total ETSU-R-97 Noise Limit of 38 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 in this assessment. This is consistent with the approach adopted with the CMWF EIAR and the assessments undertaken for KWF and CWF.

7.1.4 There are a number of operational and proposed wind farms in proximity to CMWF. A cumulative assessment was undertaken where predicted levels from CMWF 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 meet the Total ETSU-R-97 Noise Limits at all locations except NAL1 and 17.

7.1.5 At NAL 1 and 17, predicted cumulative noise levels are dominated by the operational Hadyard Hill Wind Farm. It may be that the properties are financially involved with the Hadyard Hill Wind Farm, and it may be that the Hadyard Hill Wind Farm operates with some turbines in low noise mode to ensure that the limits are met at those locations. In the absence of publicly available information regarding financial involvement and the operation of those turbines this assessment has adopted a worst case assumption that the existing wind farm is utilising all of the Total ETSU-R-97 Noise Limit at those properties. Where such an exceedance already exists CMWF would operate such that it will cause a negligible increase in levels, accordingly the Proposed Development would result in no significant effects.

7.1.6 The Remaining Available Noise Limits has been calculated for each NAL by taking account of the proportion of the Total ETSU-R-97 Noise Limit that has been allocated to/ can realistically be used by existing operational developments. The approach used to determine the Remaining Available Noise Limits is based on principles outlined in the draft SoAM. Site Specific Noise Limits have also been derived by apportioning the Remaining Available Noise Limits between the three proposed developments (CMWF, CWF and KWF) based on the guidance in the IOA GPG, whilst the overarching approach is consistent with the SoAM it is noted that the limits agreed in the SoAM (which is current in draft form) may differ slightly from those presented in this report.

7.1.7 In order to the meet the daytime noise limits at NALs 1 and 5, a number of CMWF turbines would need to operate in a noise reduced mode for a limited range of wind speeds and wind directions. At NAL7 it has been assumed that both CMWF and CWF would operate in noise

reduced mode for a limited range of wind speeds and wind directions during the daytime period. Predicted noise levels (adjusted to include the reduction associated with the use of noise reduced modes) indicate that at all noise assessment locations wind turbine noise immissions were below the Site Specific Noise Limits when considering the SG 6.0-155, 6.6 MW as a candidate turbine. On that basis, and as per the conclusions of the previous noise assessments undertaken for CMWF, no significant effects are predicted as a result of CMWF.

7.1.8 The Residual Available Noise Limits and the Site Specific Noise Limits presented in this report have been calculated based on TNEIs predictions. The SoAM may present updated limits, which, if agreed, would replace those in this report.

7.1.9 There are a range of potential turbine models that could be installed on the Site should consent be granted. Should the Application be allowed, 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.

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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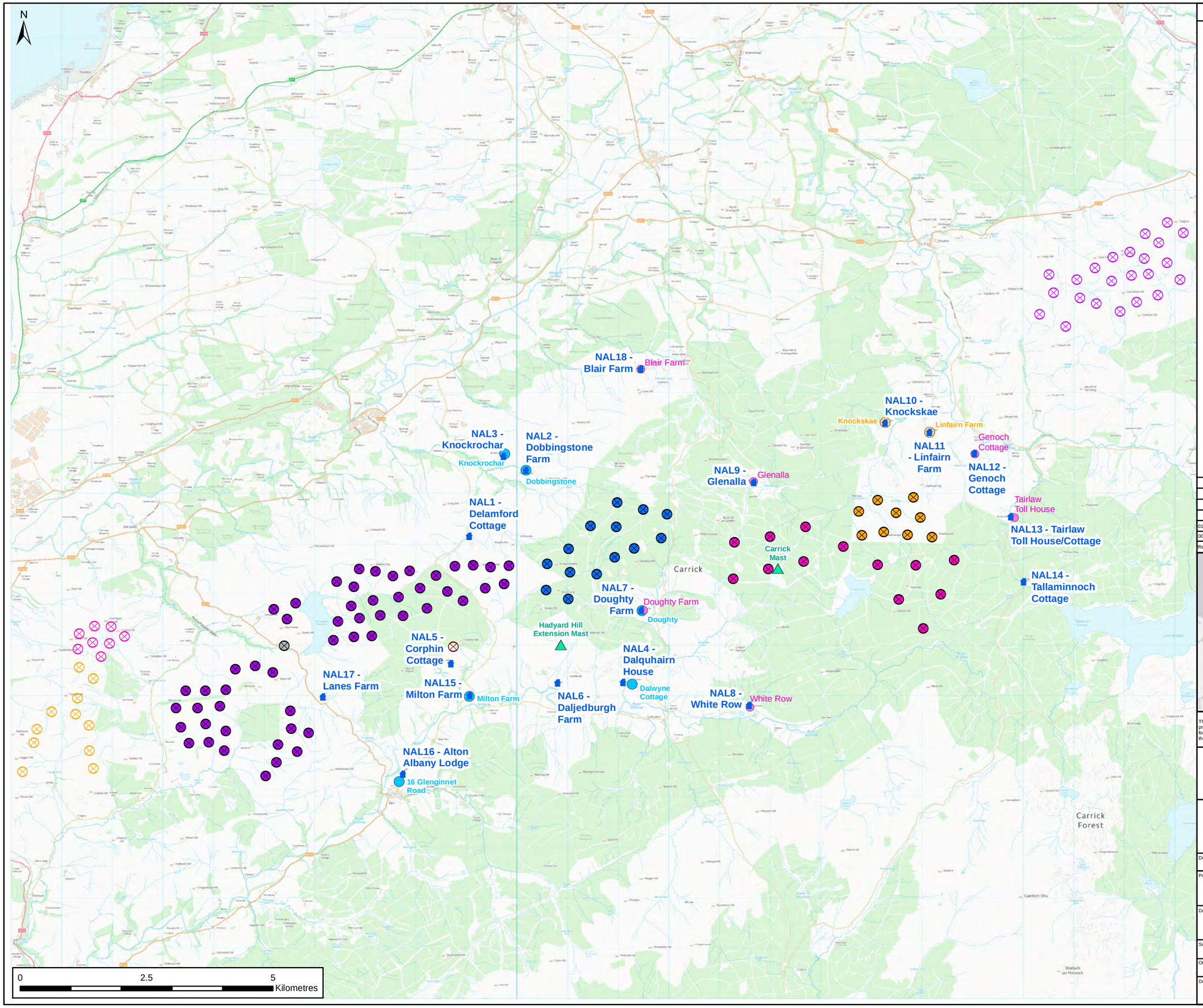
Annex 1 – Figures



LEGEND

- Noise Assessment Locations (NALs)
- Carrick Noise Monitoring Locations (NMLs)
- Craiginmoddie Noise Monitoring Locations (NMLs)
- Knockcronal Noise Monitoring Locations (NMLs)
- Met Masts

Wind Farm/Turbine Development

- Craiginmoddie
- Assel Valley
- Carrick
- Dersalloch
- Glengennet
- Hadyard Hill
- Knockronal
- Penwhapple
- Tralorg

Rev.	Date	Amendment Details	Drwn	Chkd	Appd
01	17/03/23	SECOND ISSUE	JCM	JM	JM
00	12/03/23	FIRST ISSUE	GC	JM	JM

Drawing Status: FOR PLANNING

Project Title: Craiginmoddie Wind Farm

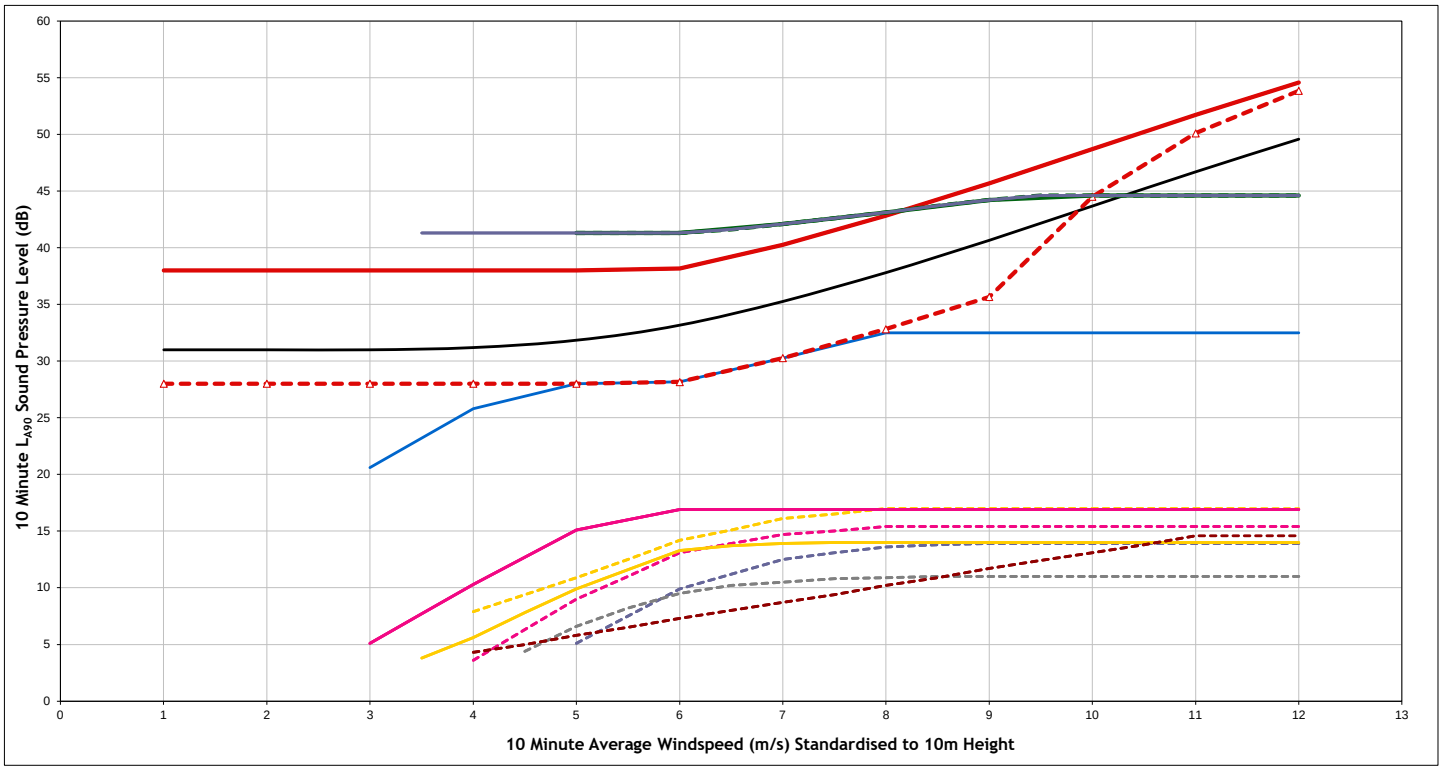
Drawing Title: Figure A1.1 - Cumulative Assessment Map

Scale	Designed	Drawn	Checked	Approved
1:70,000	JCM	JCM	JM	JM
Original Size	**Date**	**Date**	**Date**	**Date**
A3	17/03/2023	17/03/2023	17/03/2023	17/03/2023

Drawing Number: 15659-008

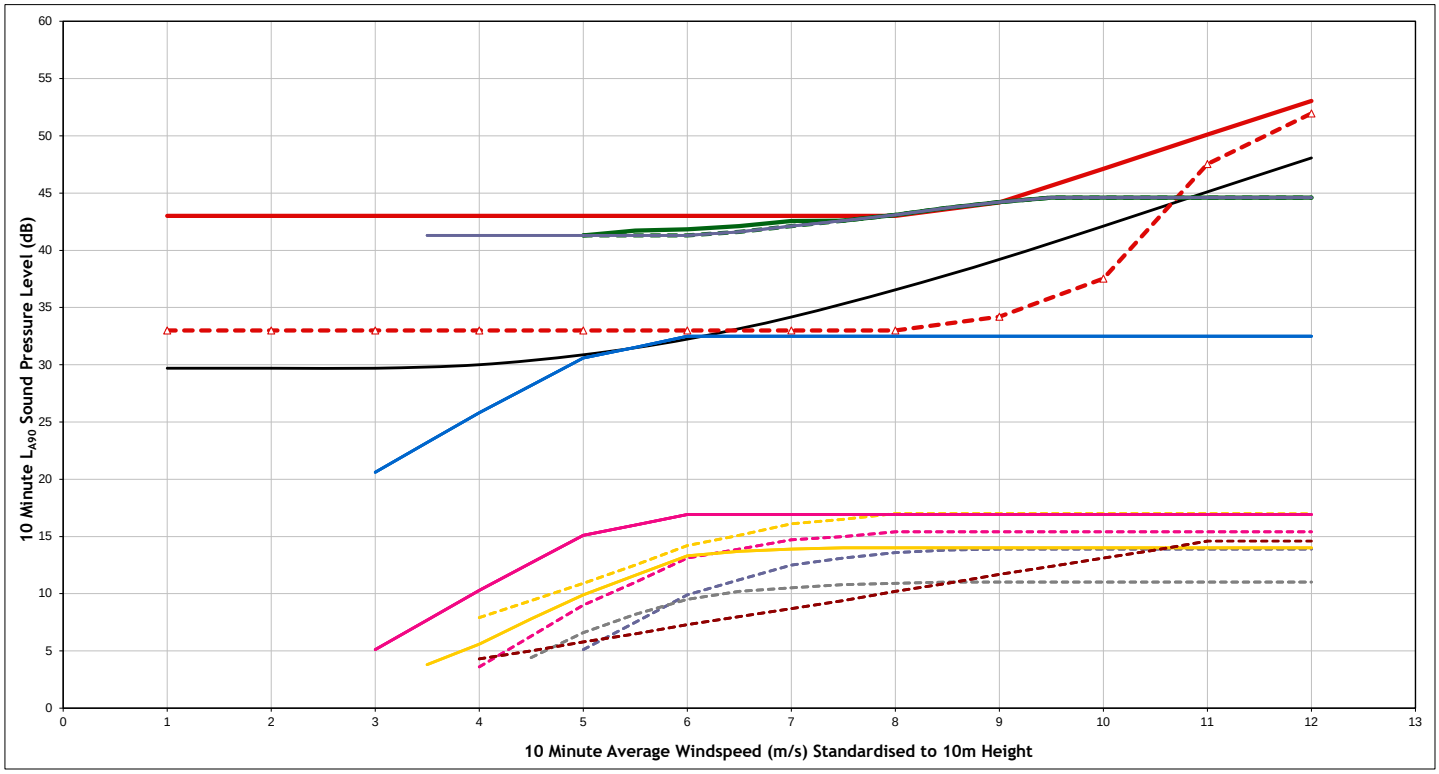
Revision: 1

Daytime - Delamford Cottage (NAL1)



NB Daytime predictions include mode management for: CMWF

Night Time - Delamford Cottage (NAL1)



Legend:

- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF NB Includes mode management (daytime only)
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Delamford Cottage (NAL1)
Figure Number	Figure A1.2a
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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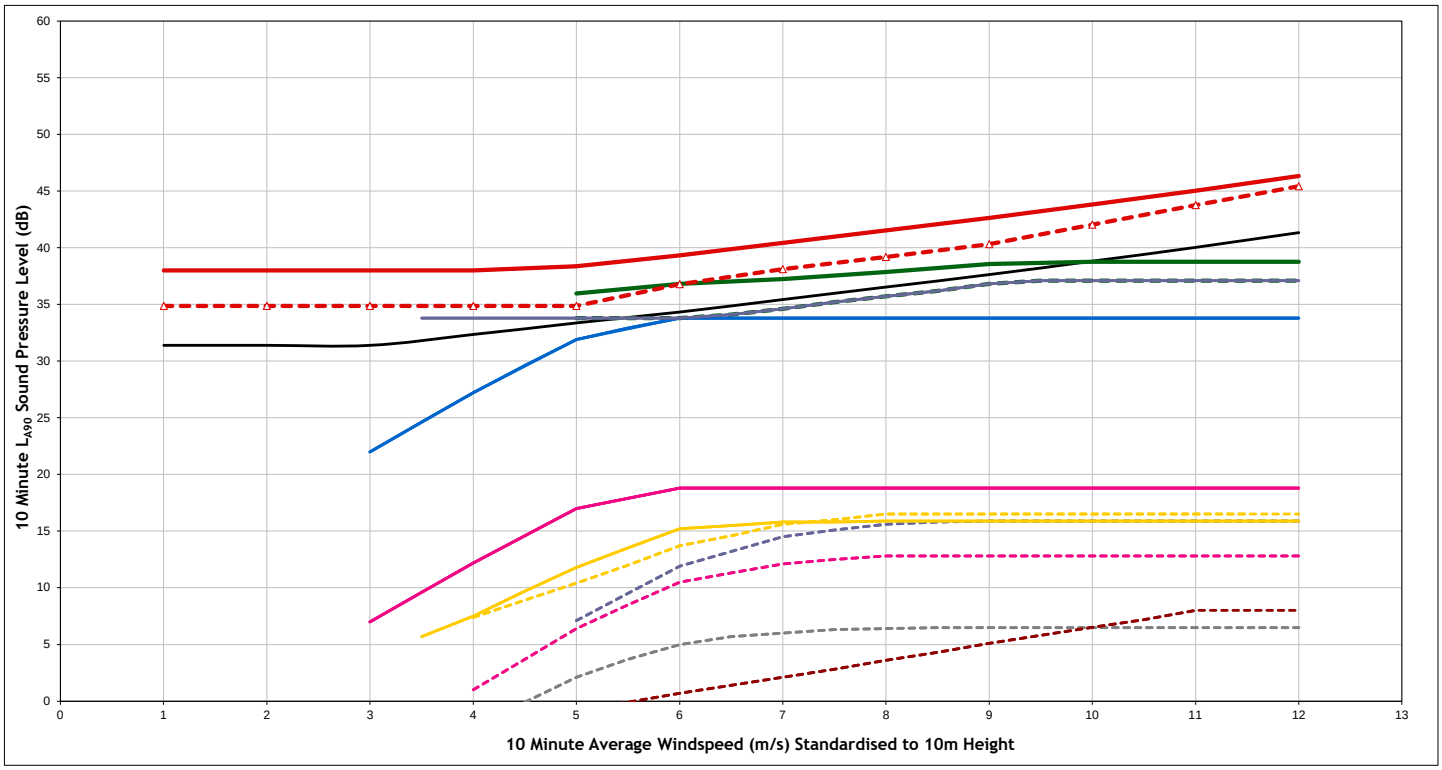
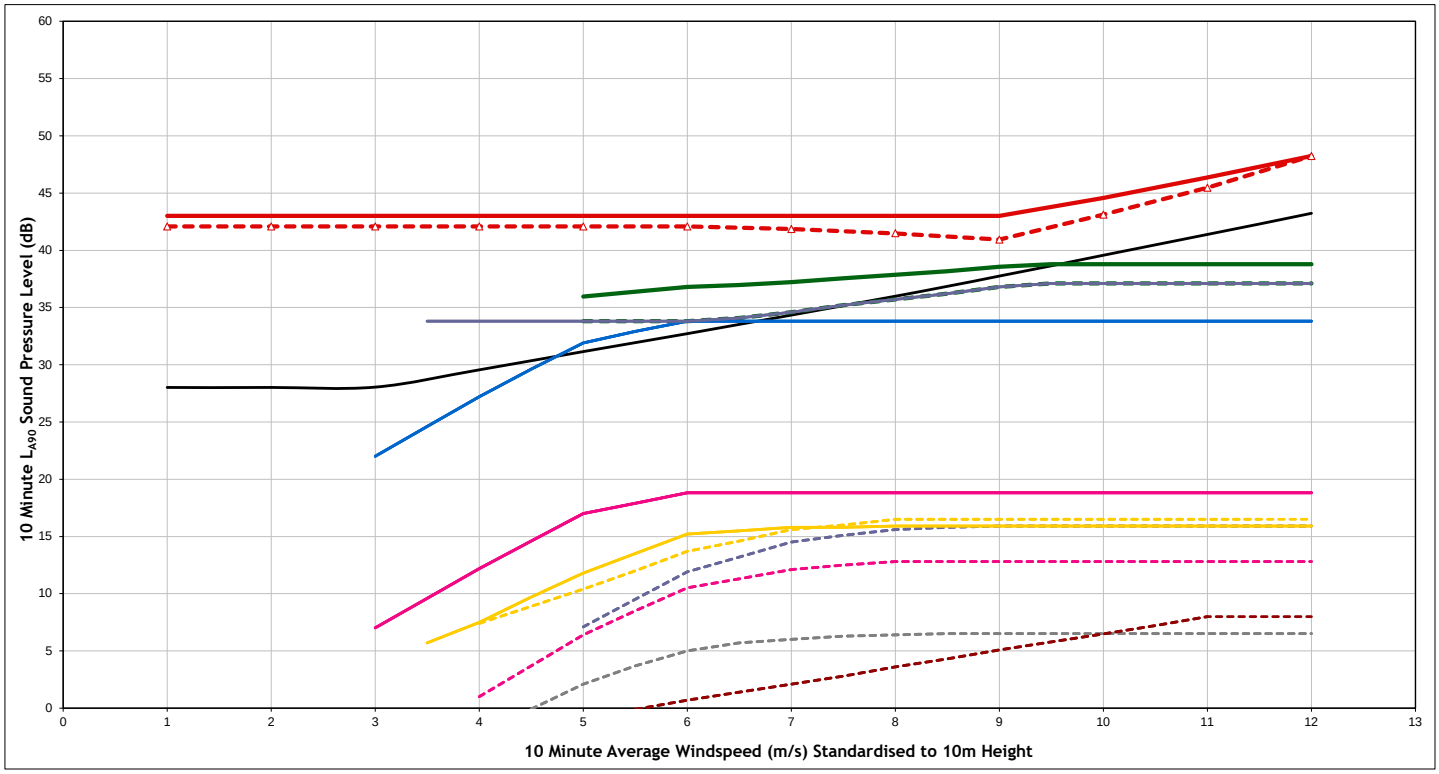
Daytime - Dobbingstone Farm (NAL2)



Night Time - Dobbingstone Farm (NAL2)



Legend:

- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Dobbingstone Farm (NAL2)
Figure Number	Figure A1.2b
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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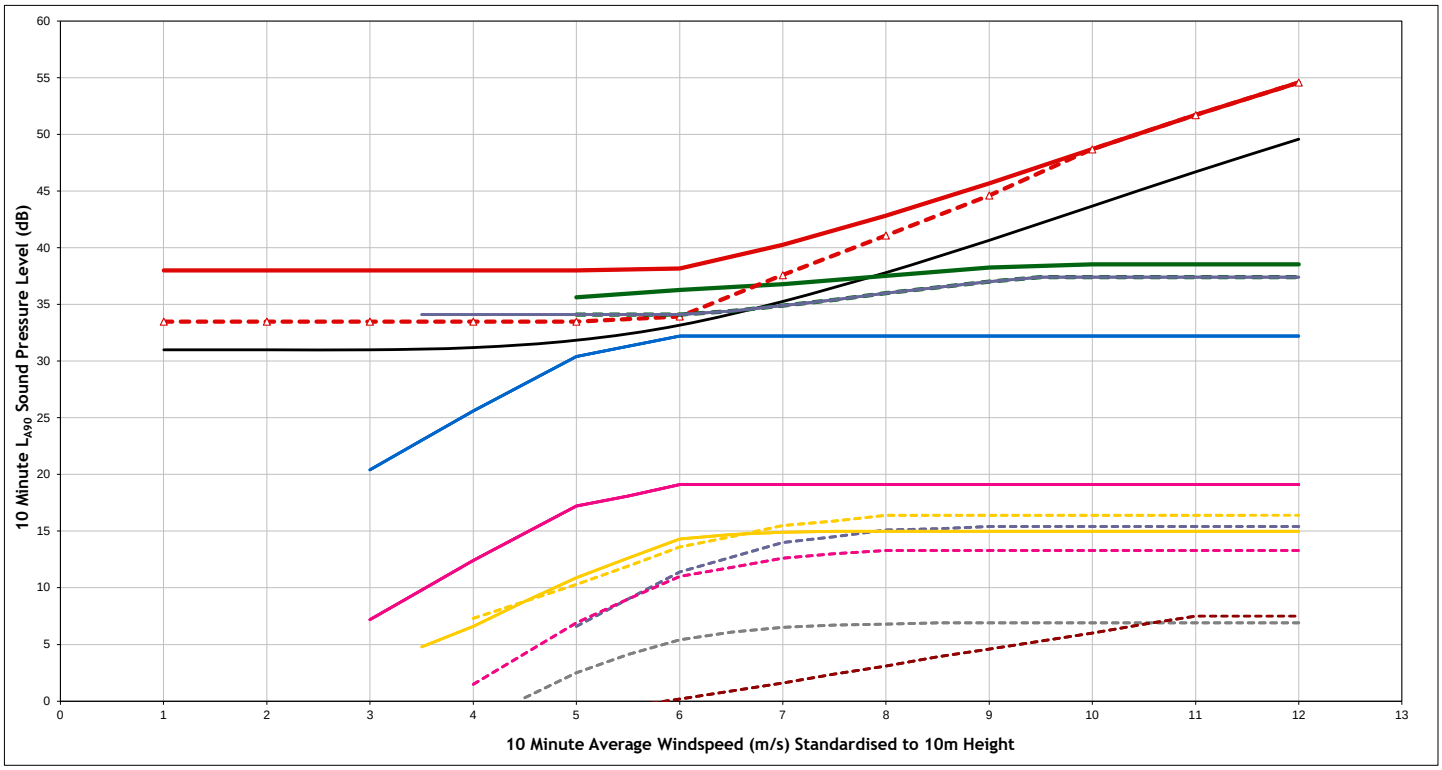
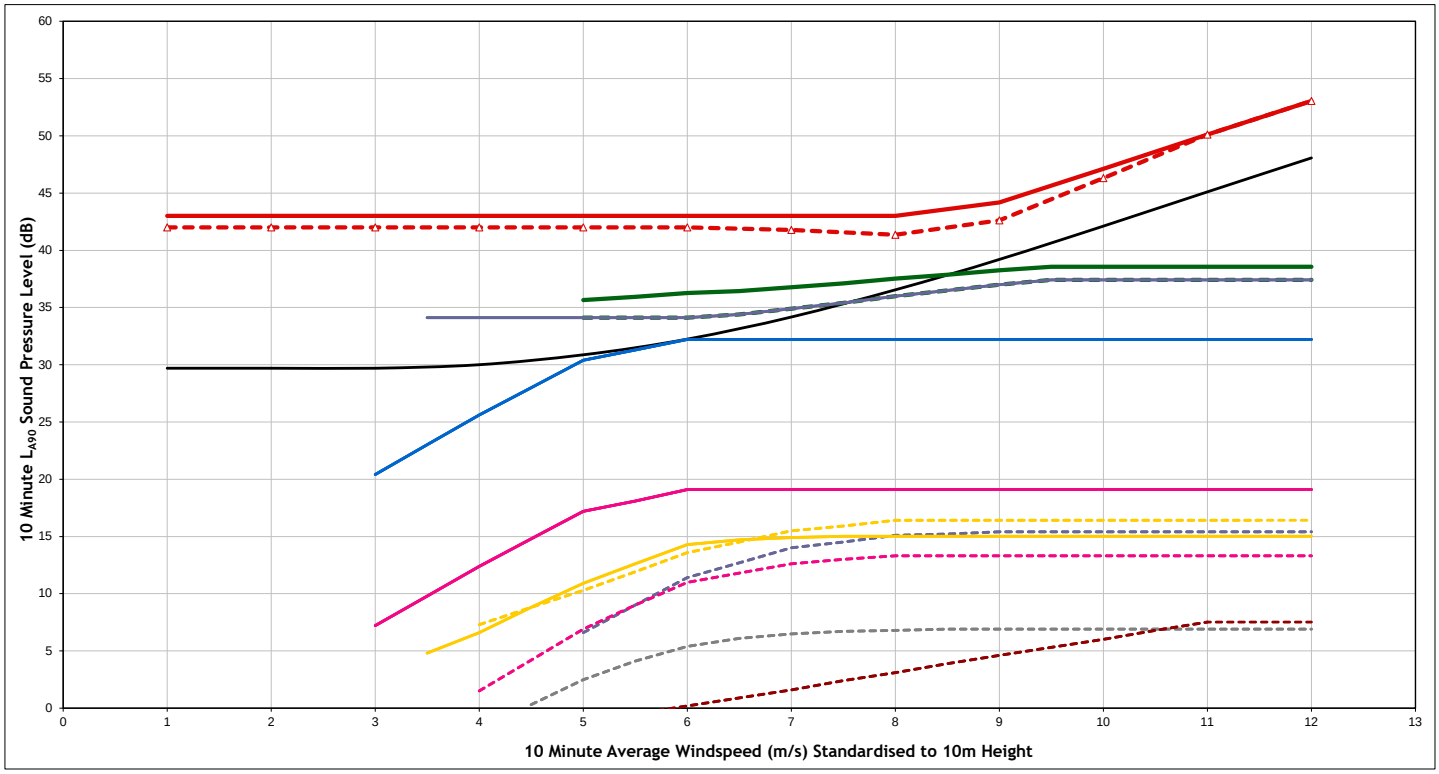
Daytime - Knockrochar (NAL3)



Night Time - Knockrochar (NAL3)



Legend:

- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Knockrochar (NAL3)
Figure Number	Figure A1.2c
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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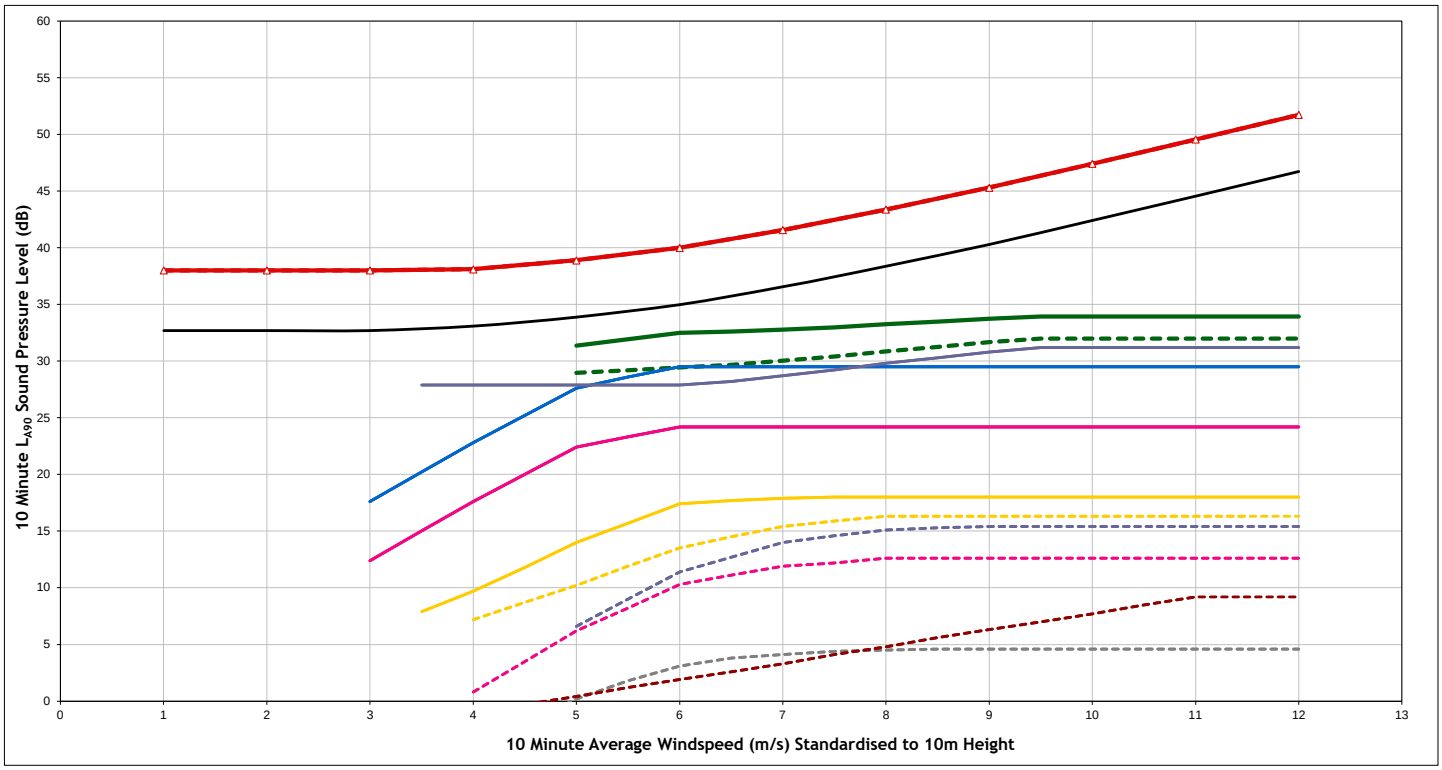
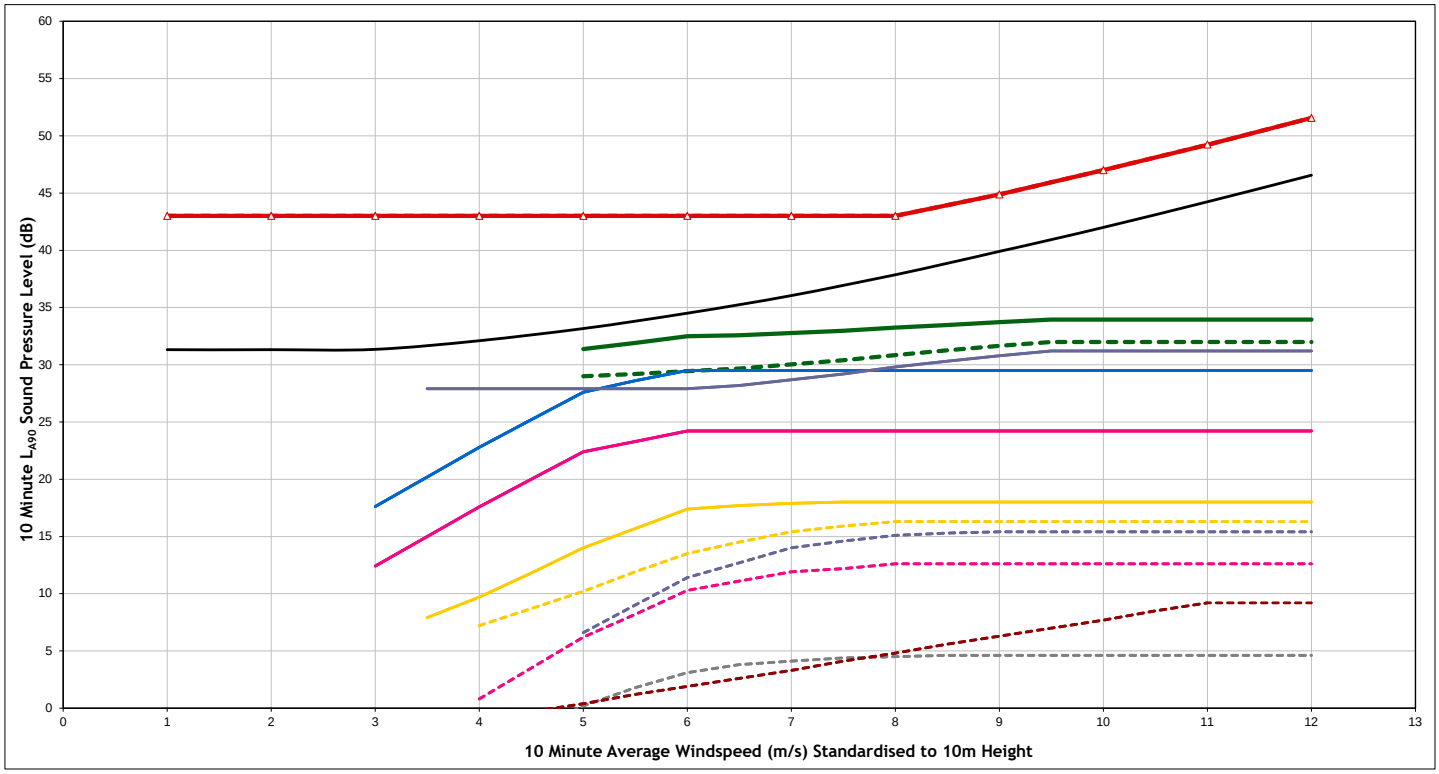
Daytime - Dalquhairn House (NAL4)



Night Time - Dalquhairn House (NAL4)

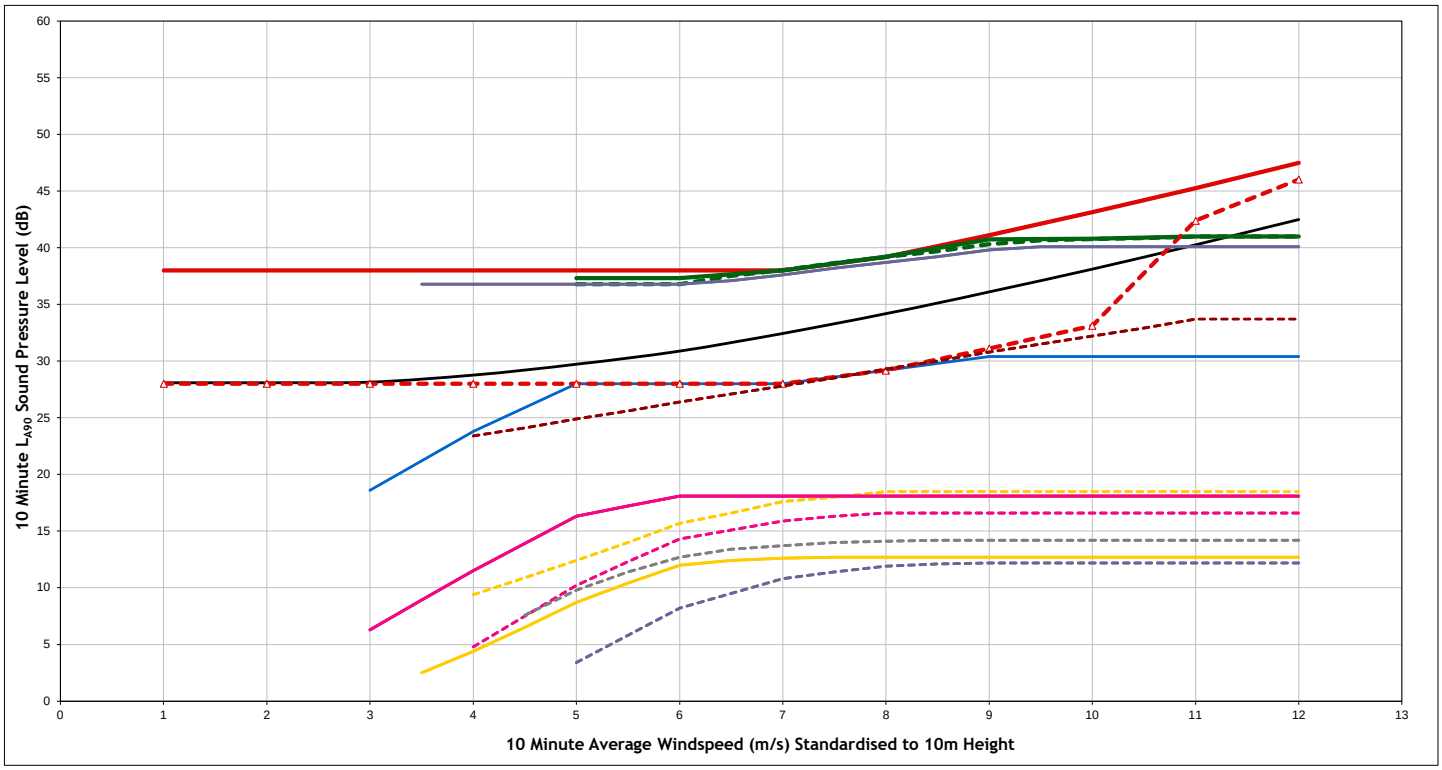


Legend:

- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

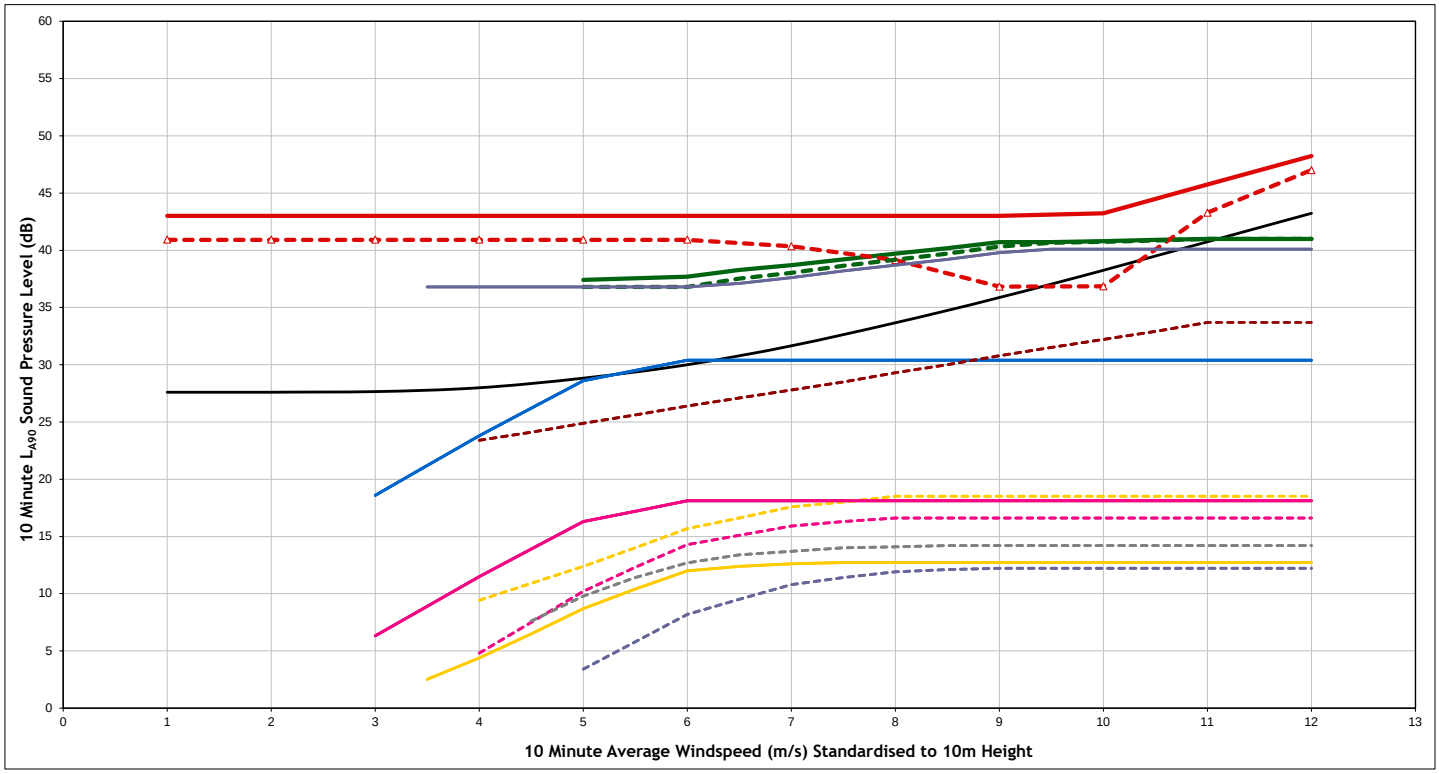
Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Dalquhairn House (NAL4)
Figure Number	Figure A1.2d
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

Daytime - Corphin Cottage (NAL5)



NB Daytime predictions include mode management for: CMWF

Night Time - Corphin Cottage (NAL5)



Legend:

- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF — NB Includes mode management (daytime only)
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Corphin Cottage (NAL5)
Figure Number	Figure A1.2e
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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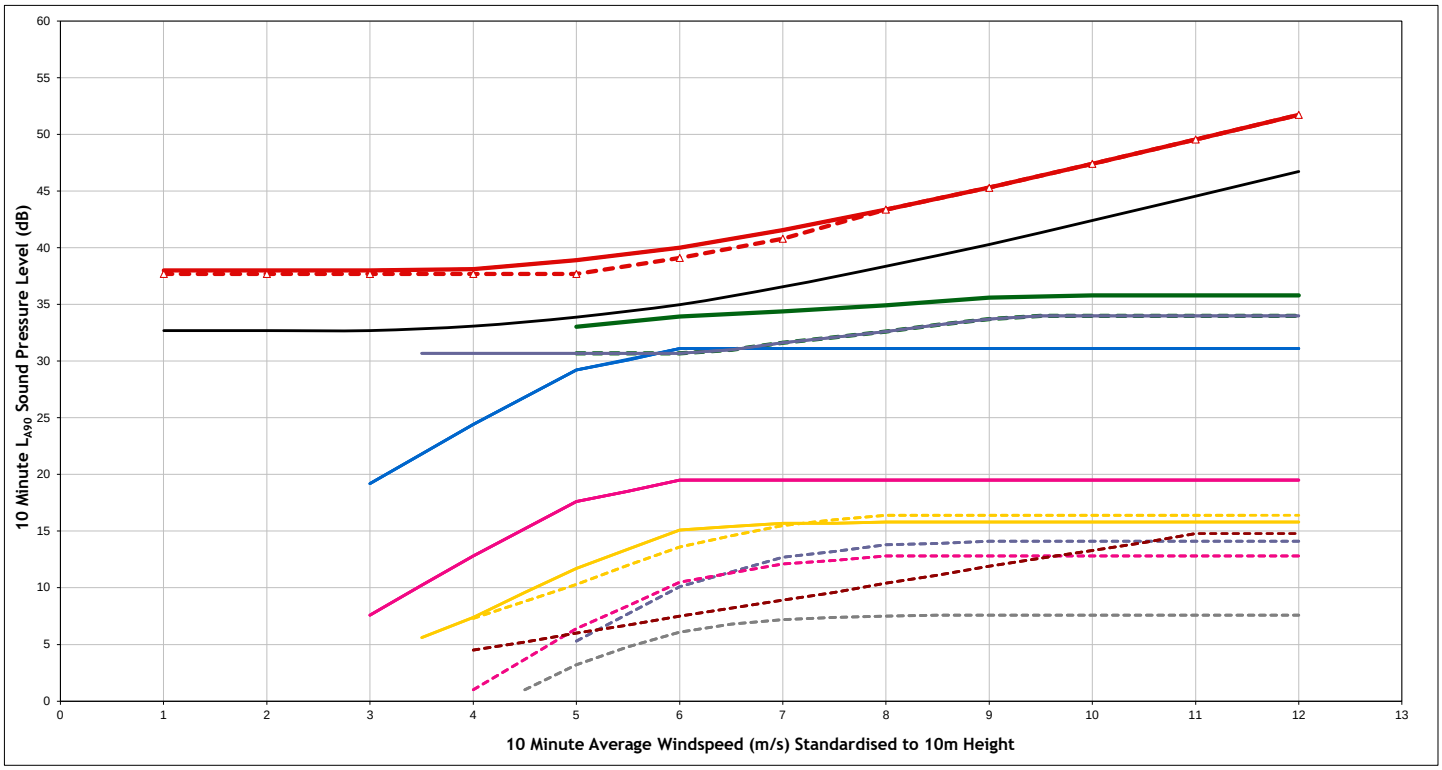
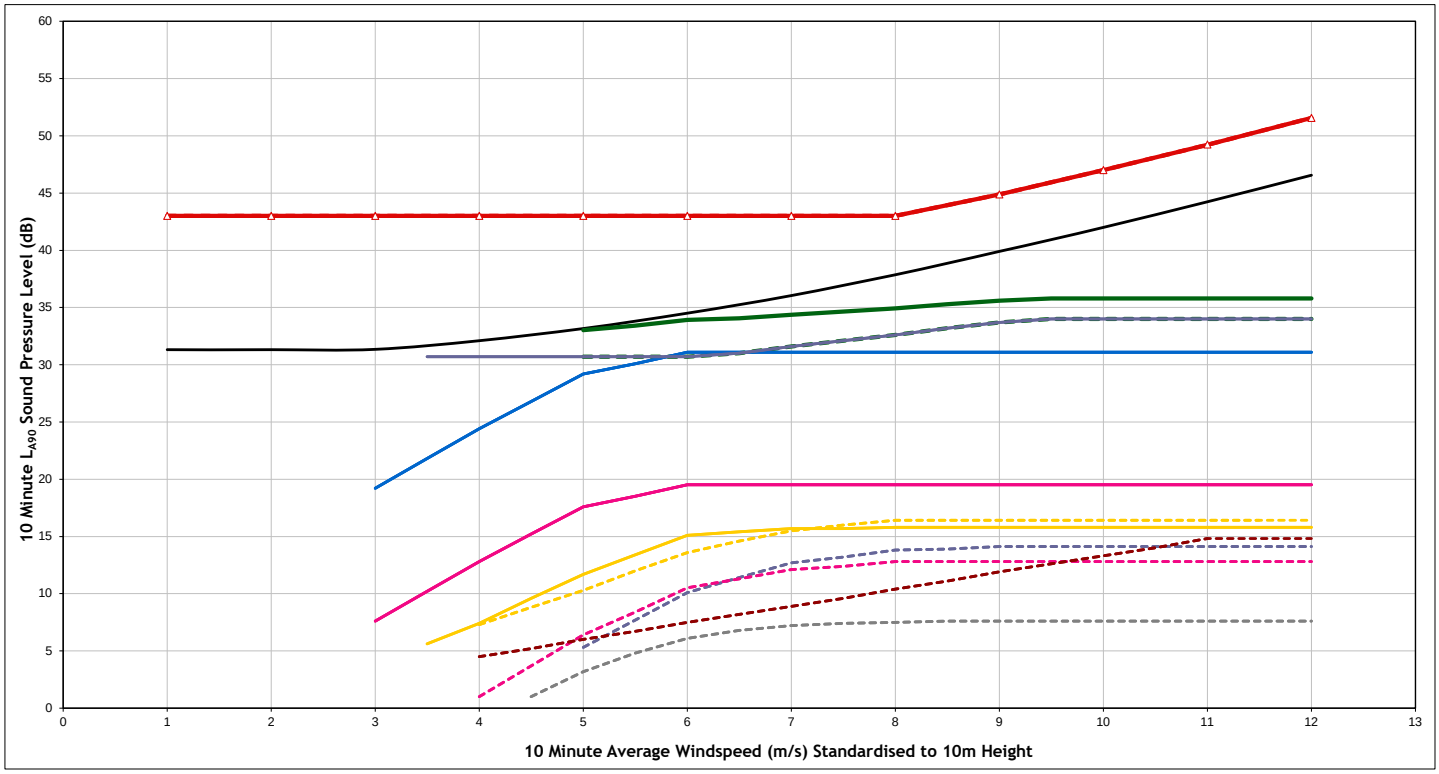
Daytime - Daljedburgh Farm (NAL6)



Night Time - Daljedburgh Farm (NAL6)



Legend:

- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Daljedburgh Farm (NAL6)
Figure Number	Figure A1.2f
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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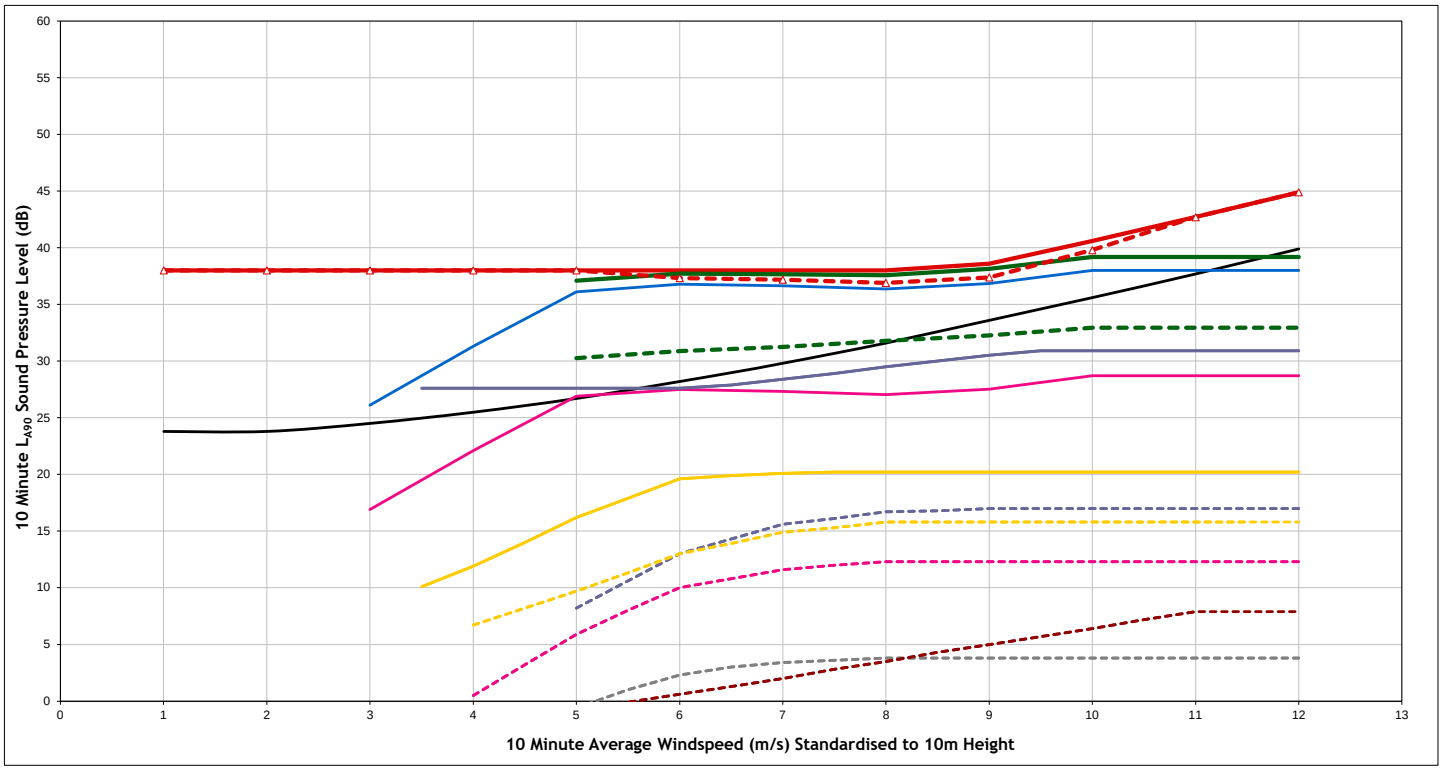
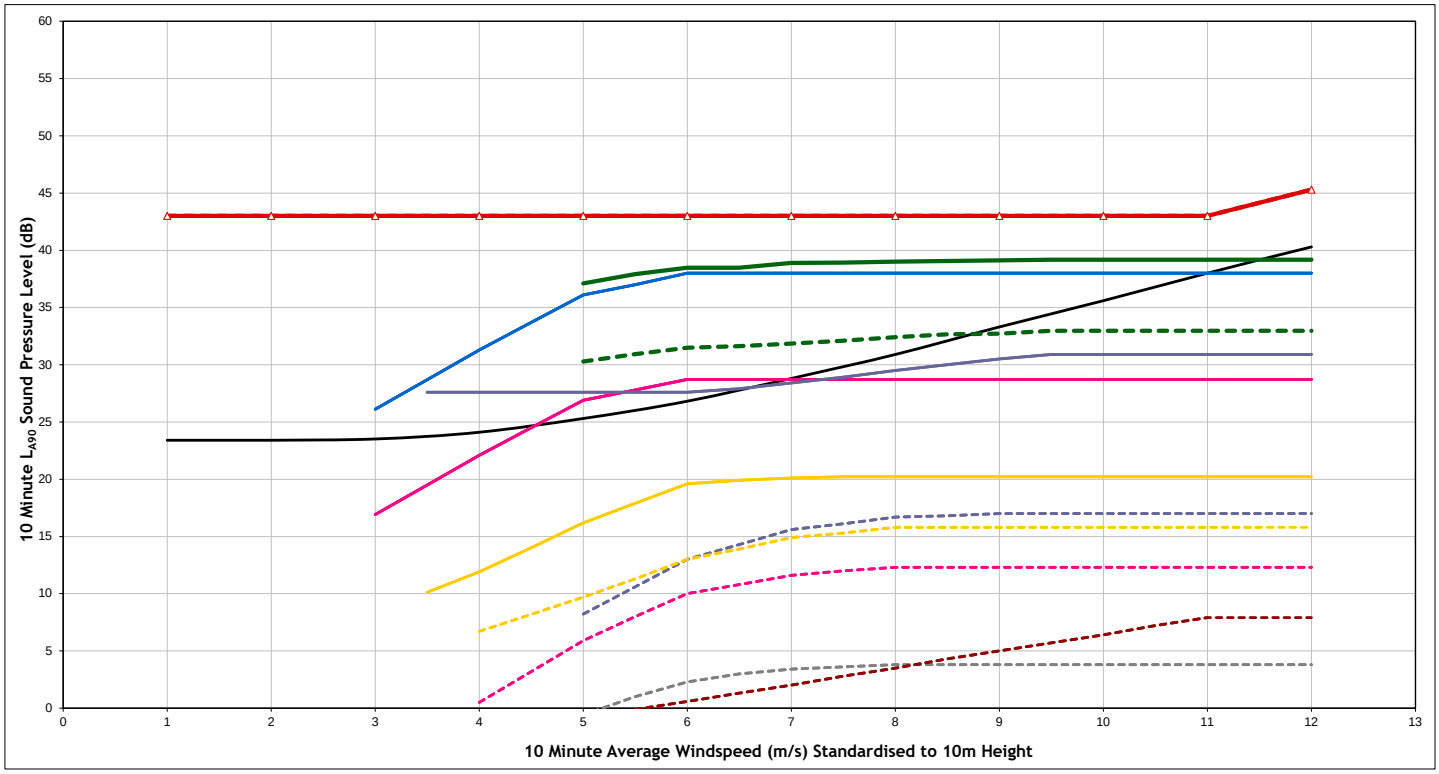
Daytime - Doughty Farm (NAL7)



NB Daytime predictions include mode management for: CWF CMWF

Night Time - Doughty Farm (NAL7)



Legend:

- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF — NB Includes mode management (daytime only)
- CWF — NB Includes mode management (daytime only)
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Doughty Farm (NAL7)
Figure Number	Figure A1.2g
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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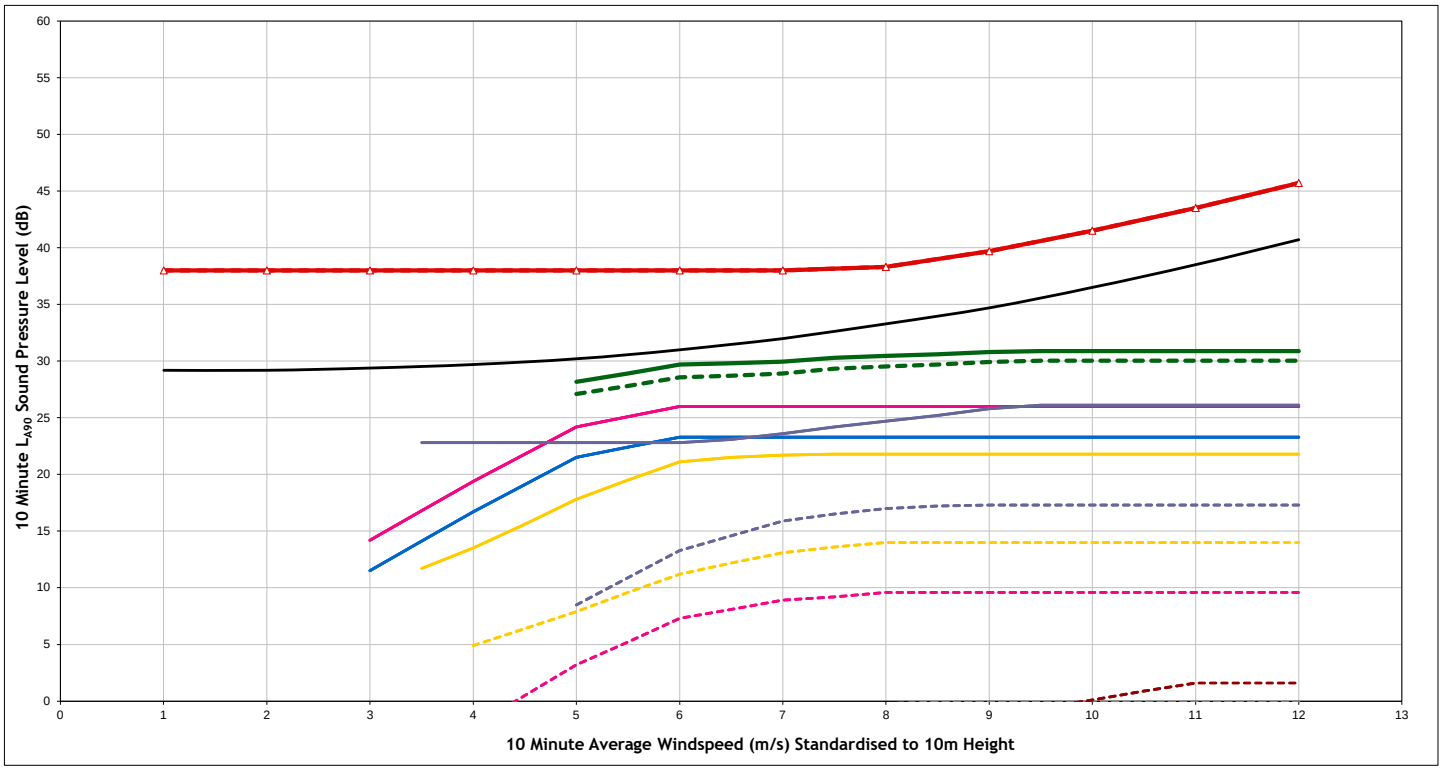
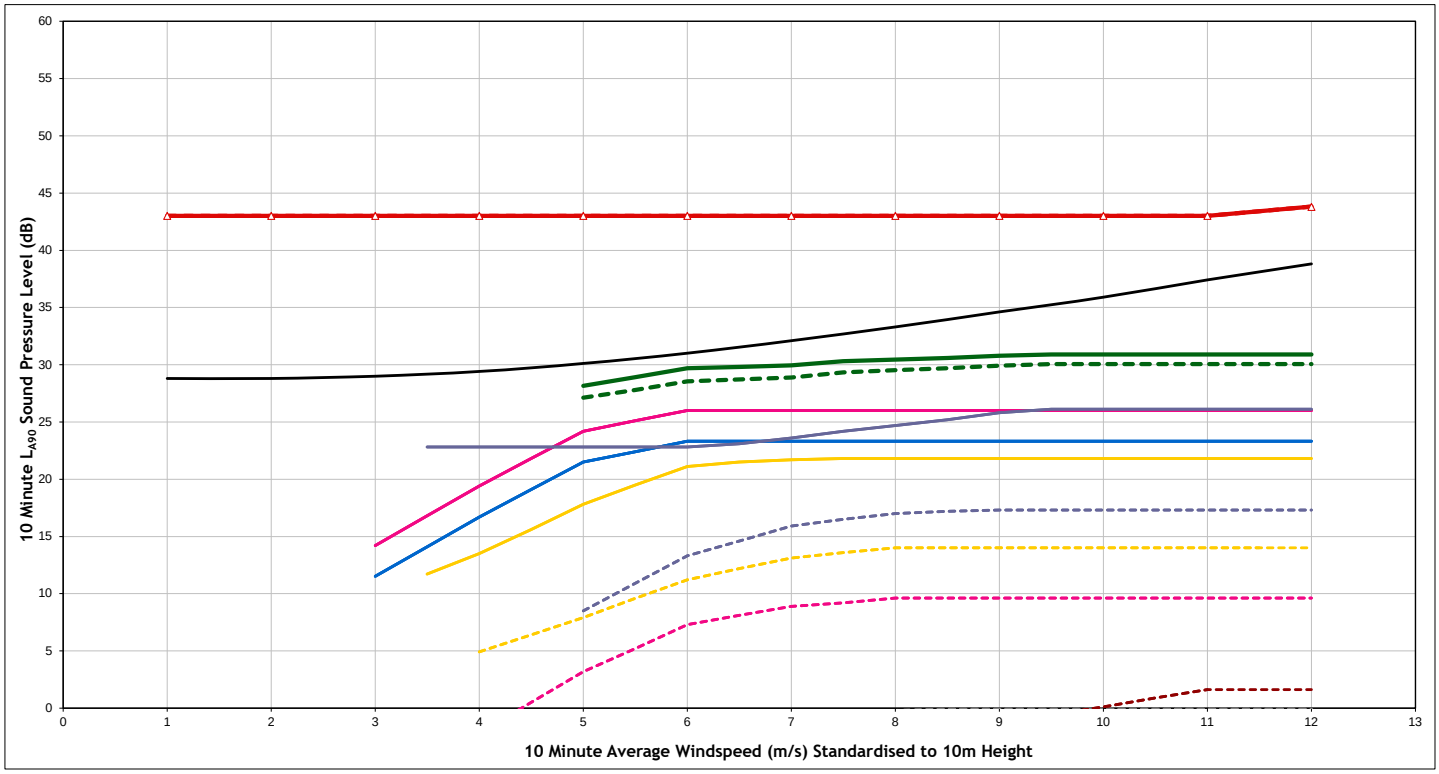
Daytime - White Row (NAL8)



Night Time - White Row (NAL8)

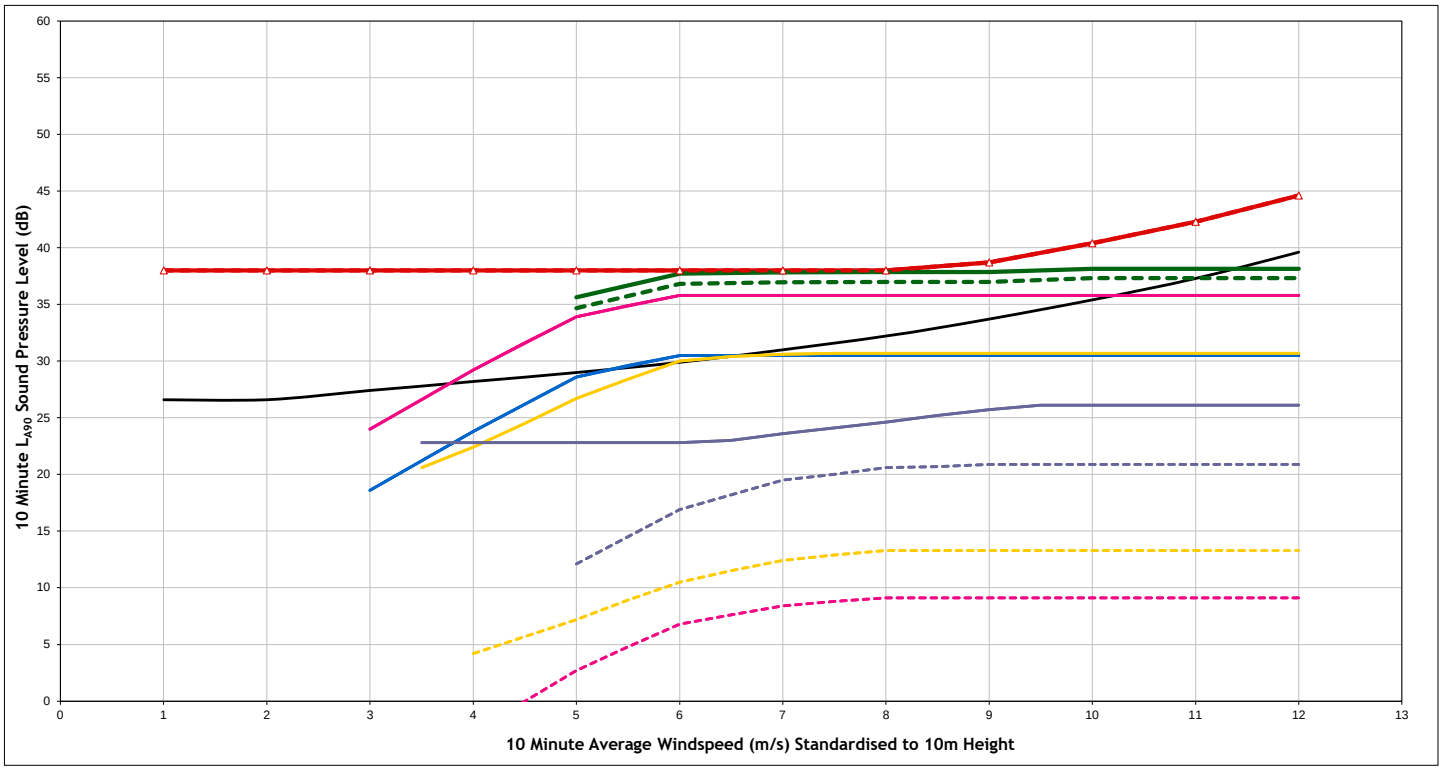


Legend:

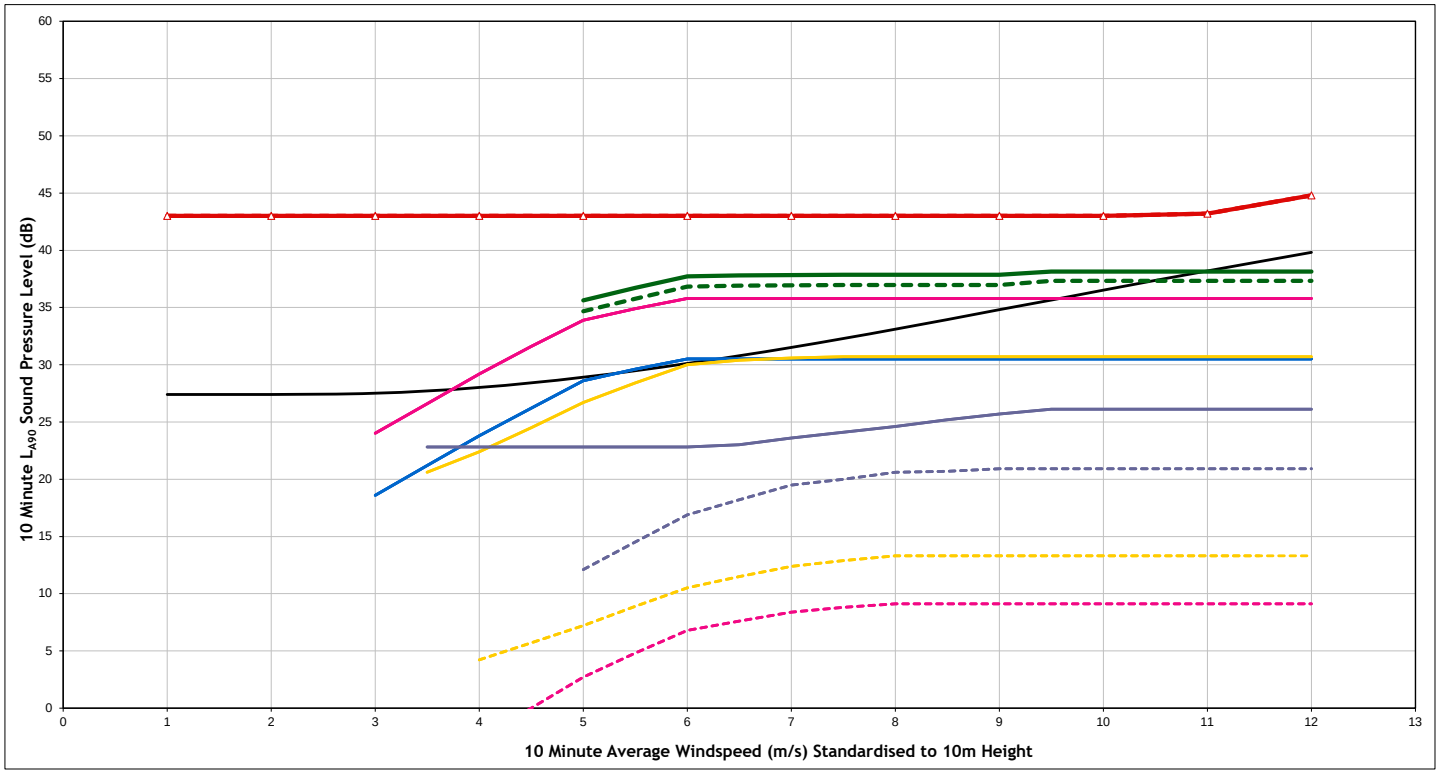
- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment White Row (NAL8)
Figure Number	Figure A1.2h
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

Daytime - Glenalla (NAL9)



Night Time - Glenalla (NAL9)



Legend:

- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Glenalla (NAL9)
Figure Number	Figure A1.2i
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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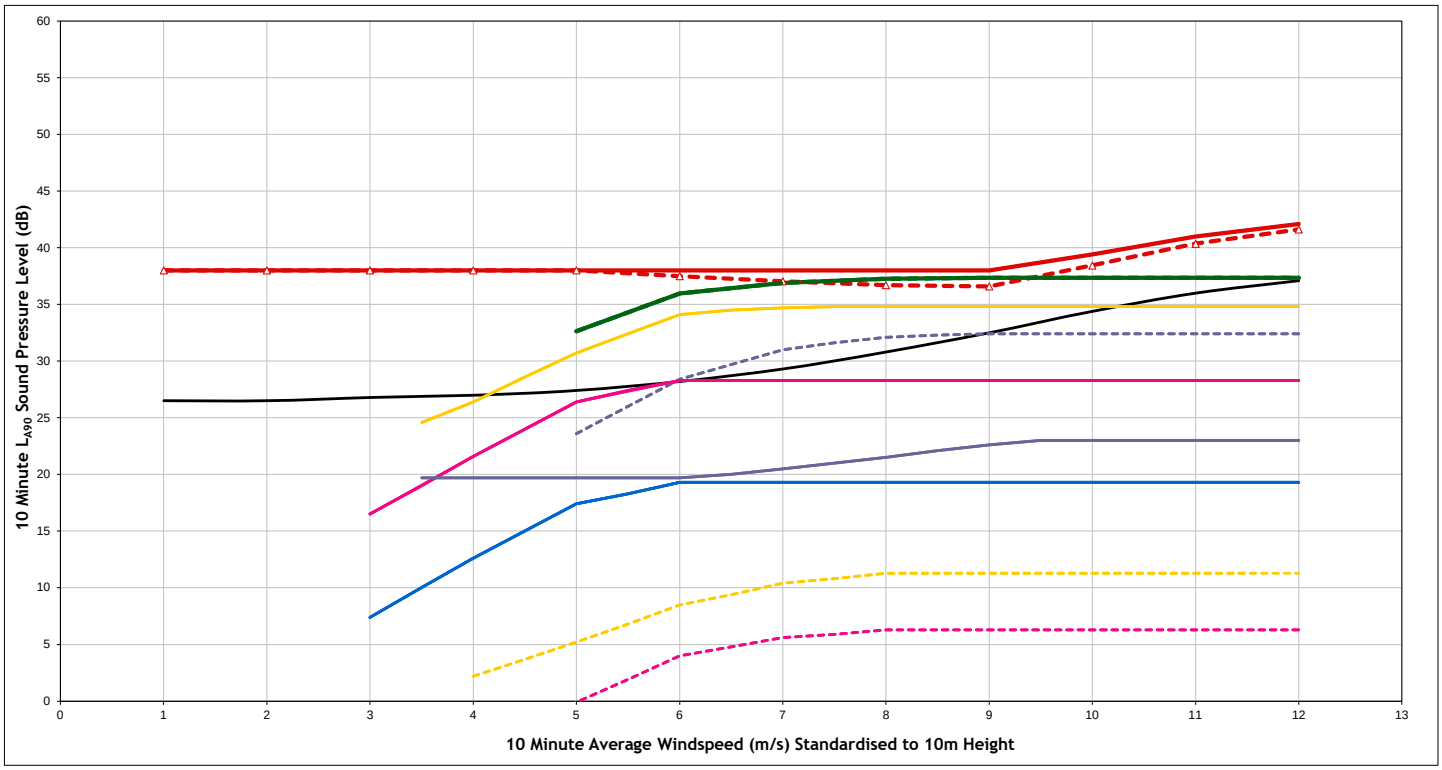
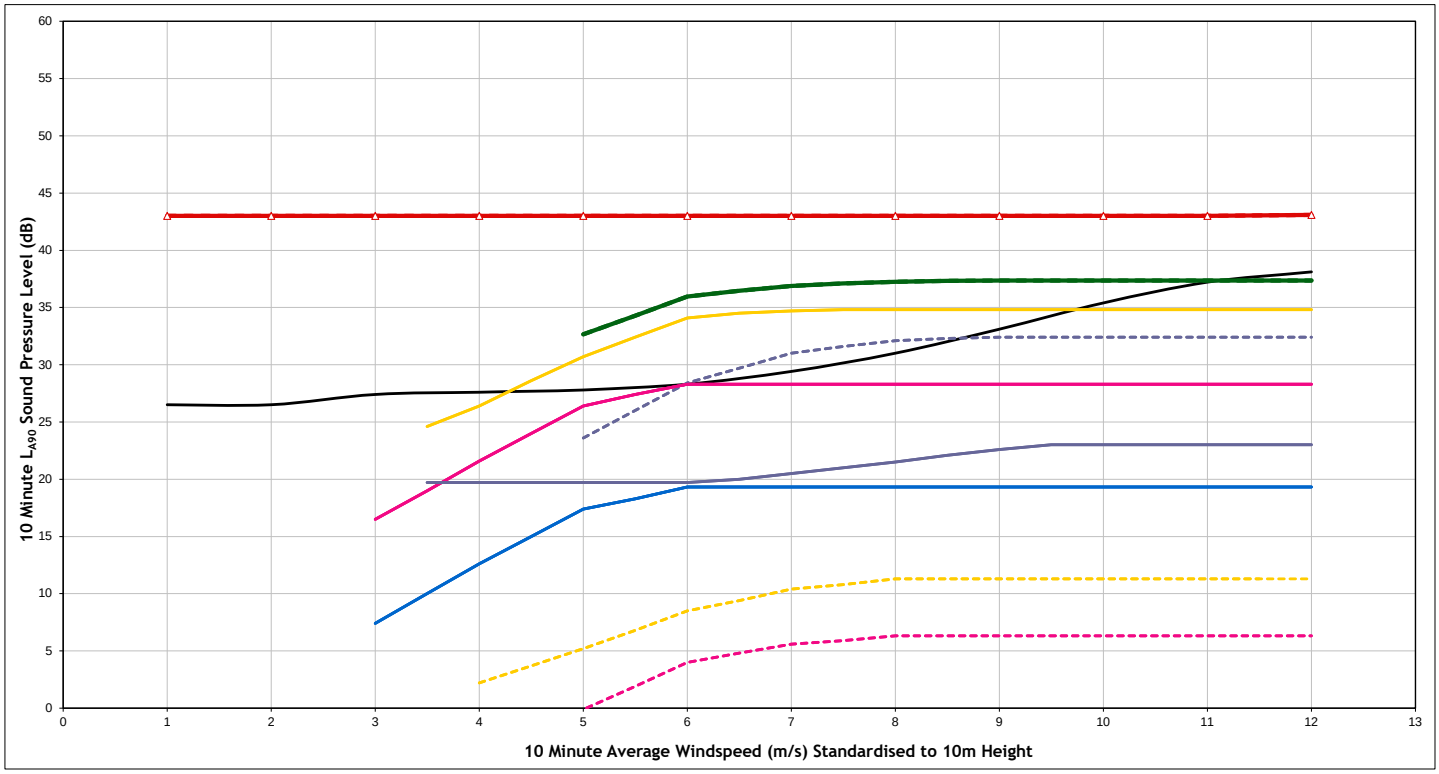
Daytime - Knockskae (NAL10)



Night Time - Knockskae (NAL10)



Legend:

- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Knockskae (NAL10)
Figure Number	Figure A1.2j
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

EnergieKontor

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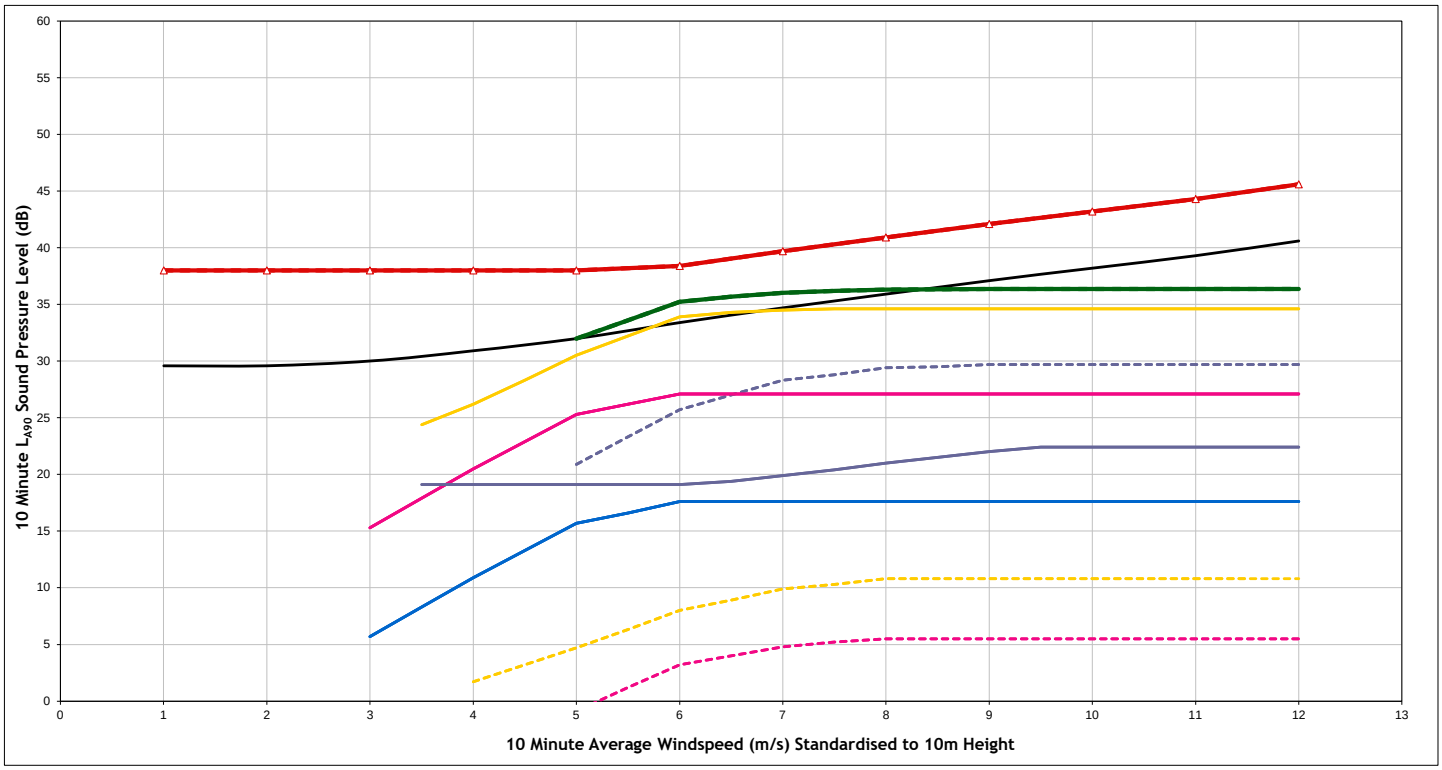
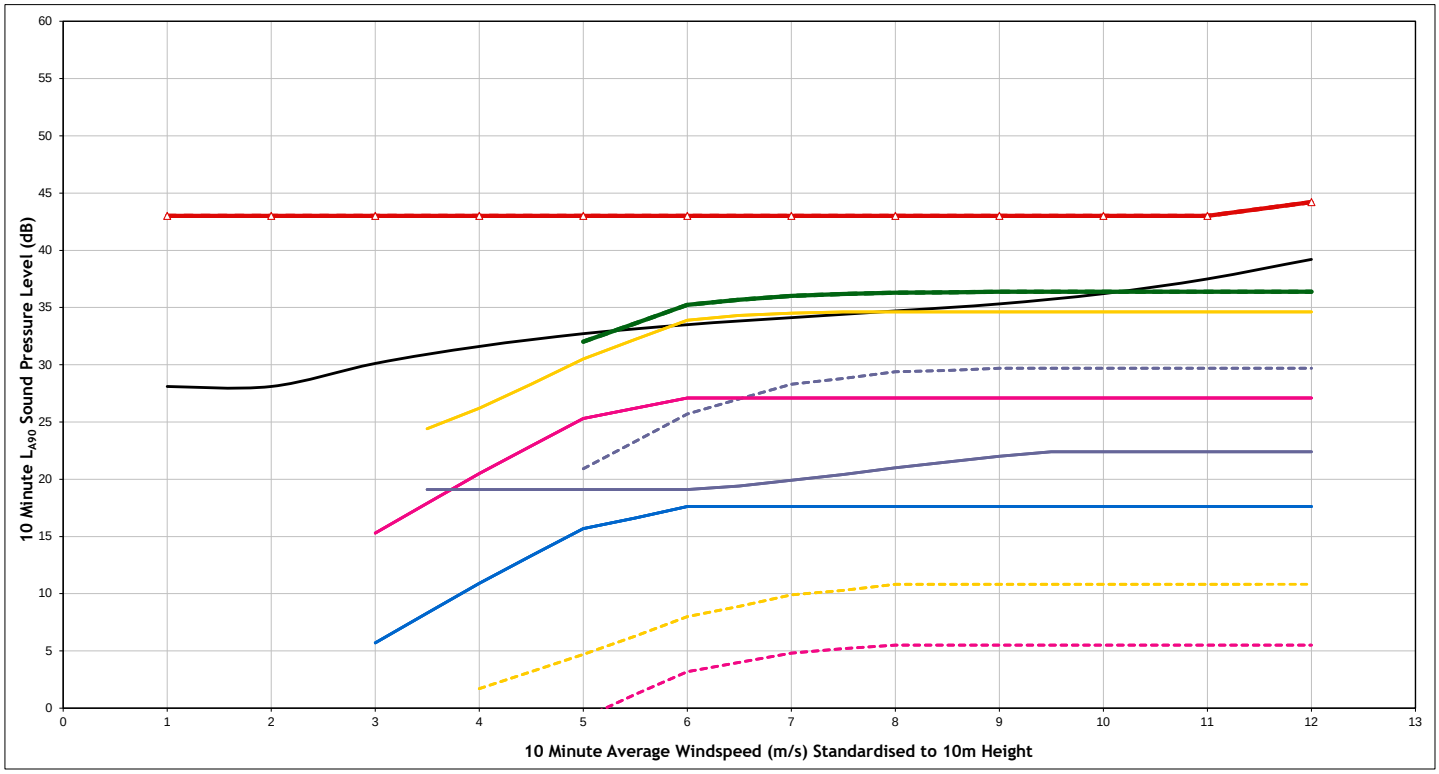
Daytime - Linfairn Farm (NAL11)



Night Time - Linfairn Farm (NAL11)

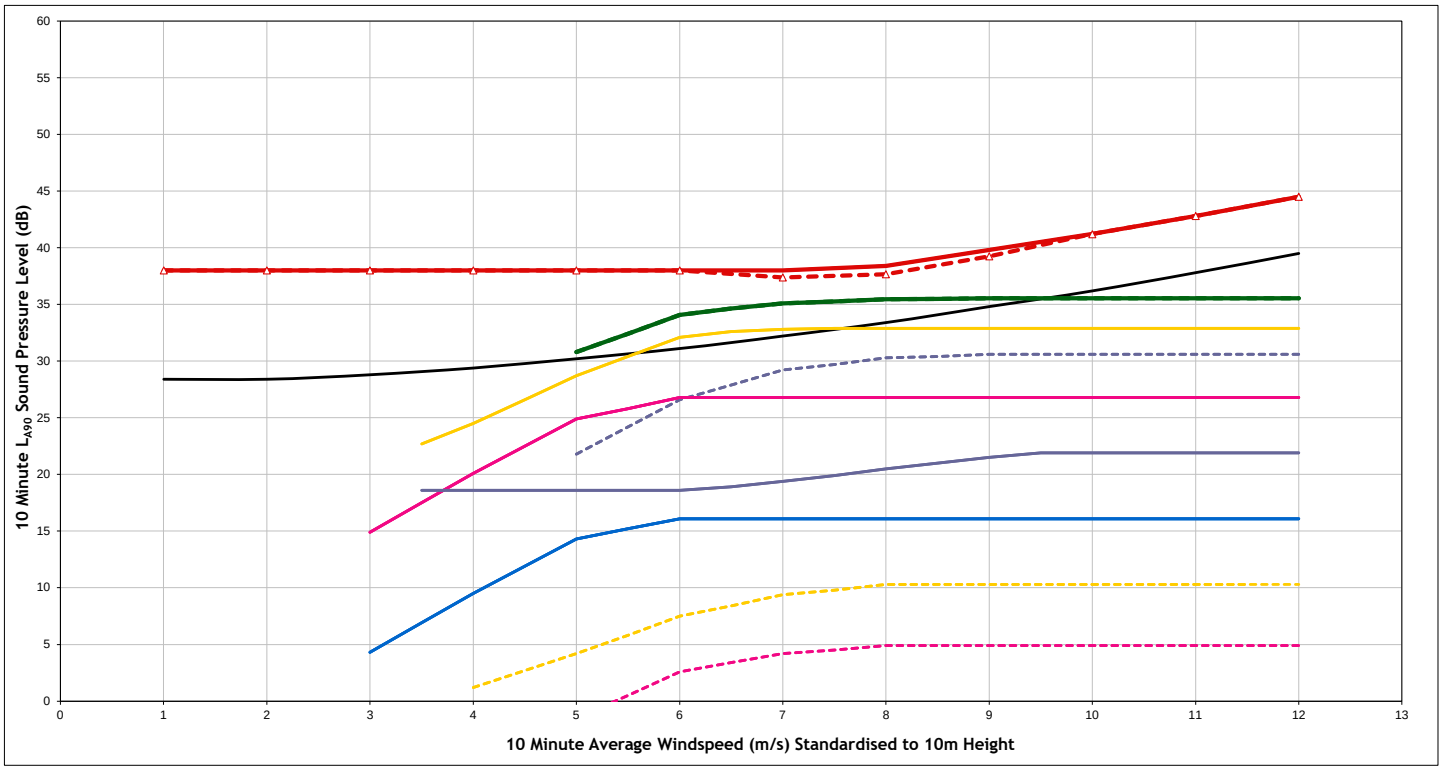


Legend:

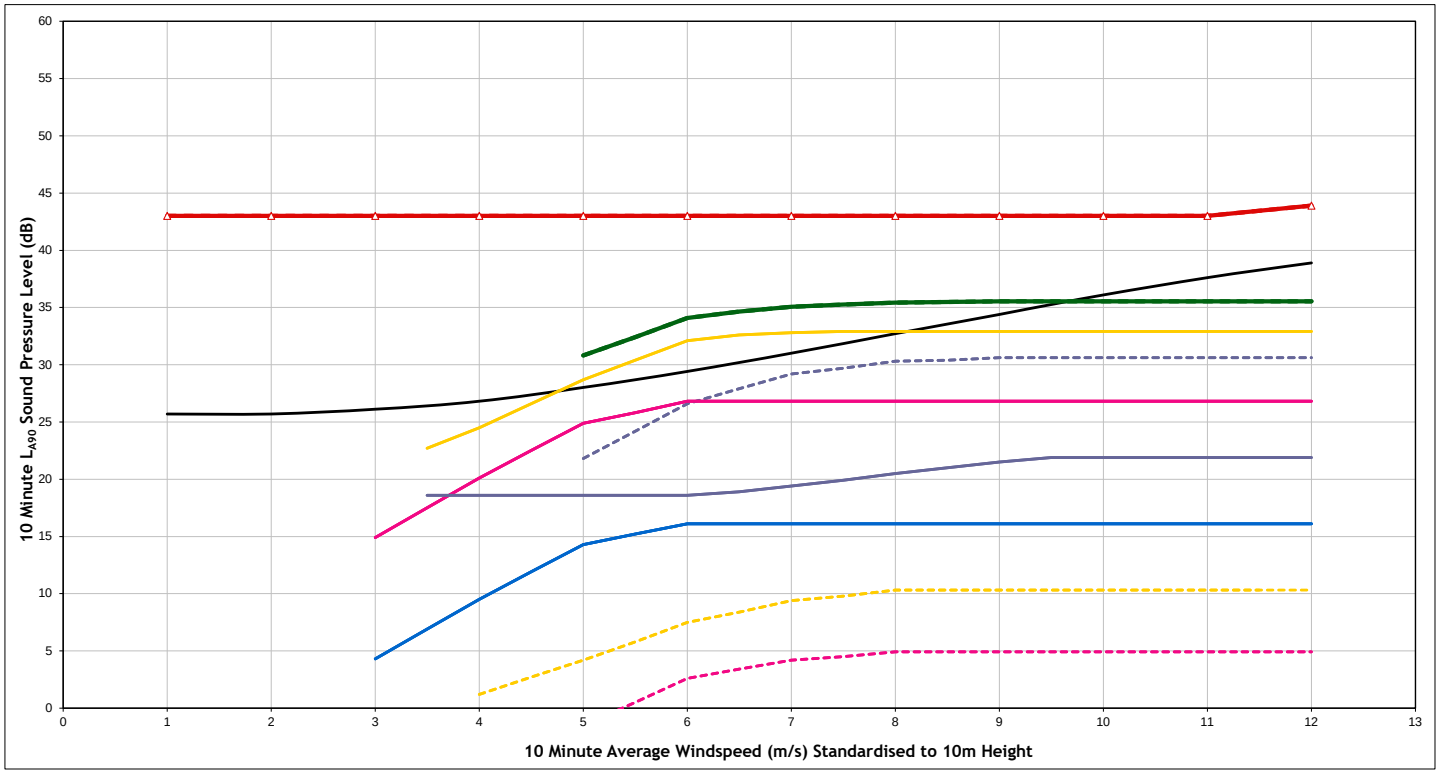
- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Linfairn Farm (NAL11)
Figure Number	Figure A1.2k
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

Daytime - Genoch Cottage (NAL12)



Night Time - Genoch Cottage (NAL12)

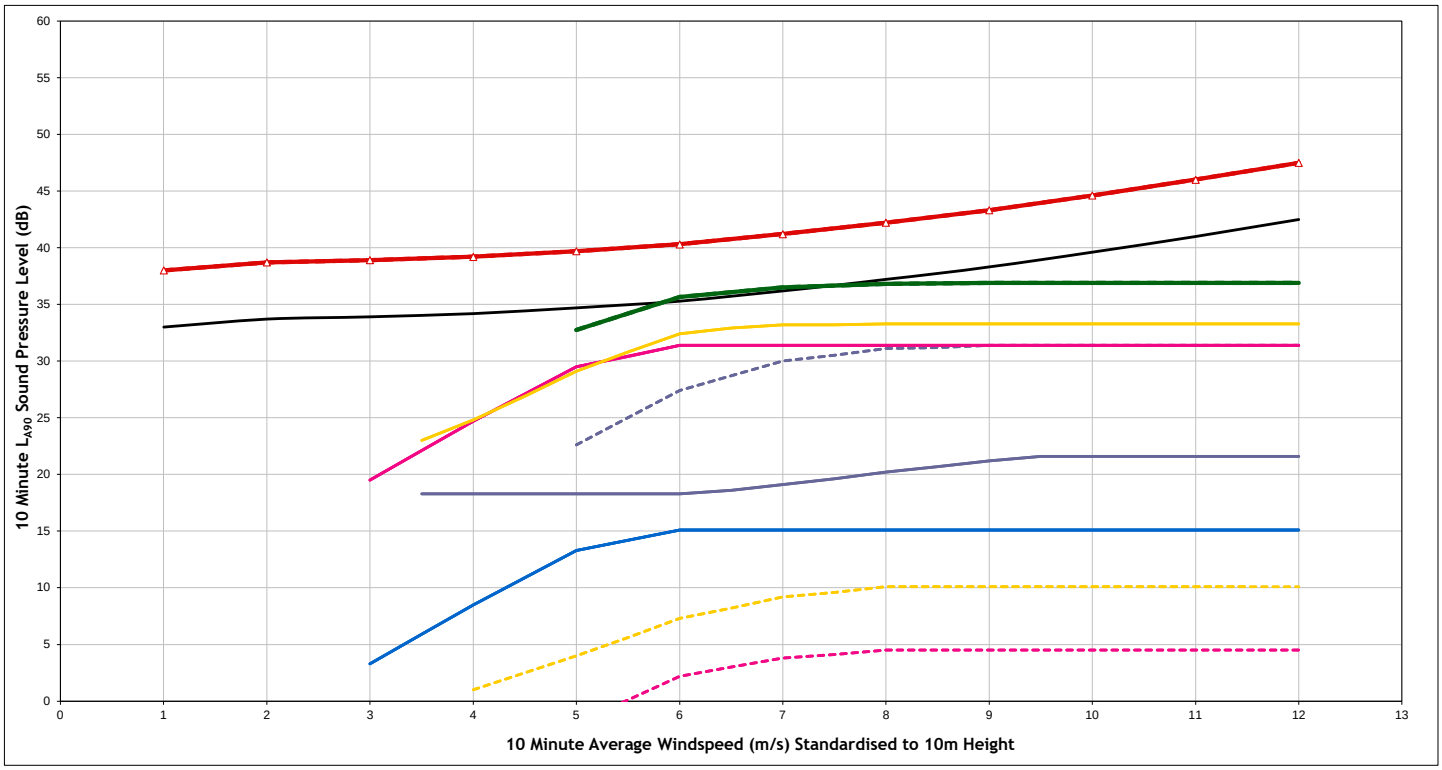


Legend:

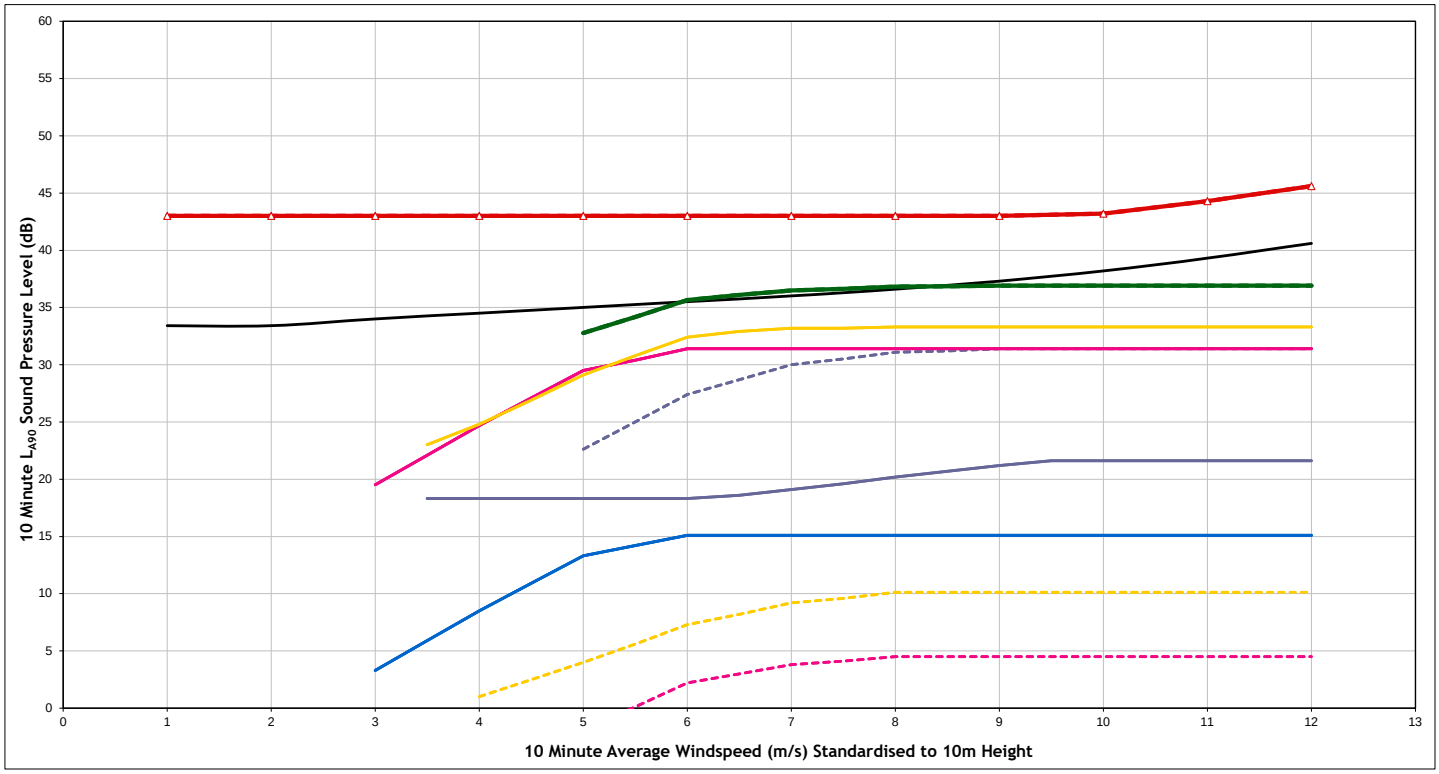
- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Genoch Cottage (NAL12)
Figure Number	Figure A1.2l
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

Daytime - Tairlaw Toll House/Cottage (NAL13)



Night Time - Tairlaw Toll House/Cottage (NAL13)



Legend:

- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Tairlaw Toll House/Cottage (NAL13)
Figure Number	Figure A1.2m
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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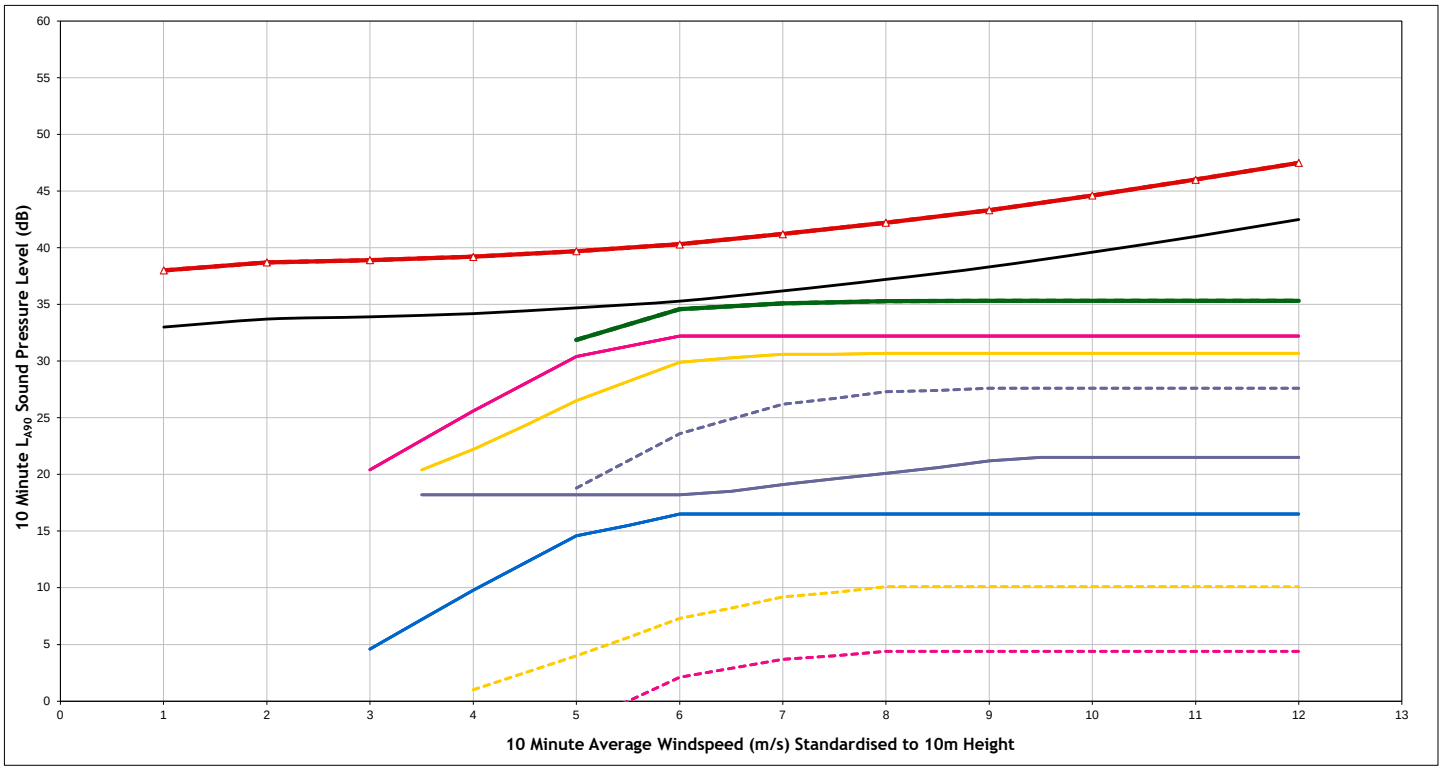
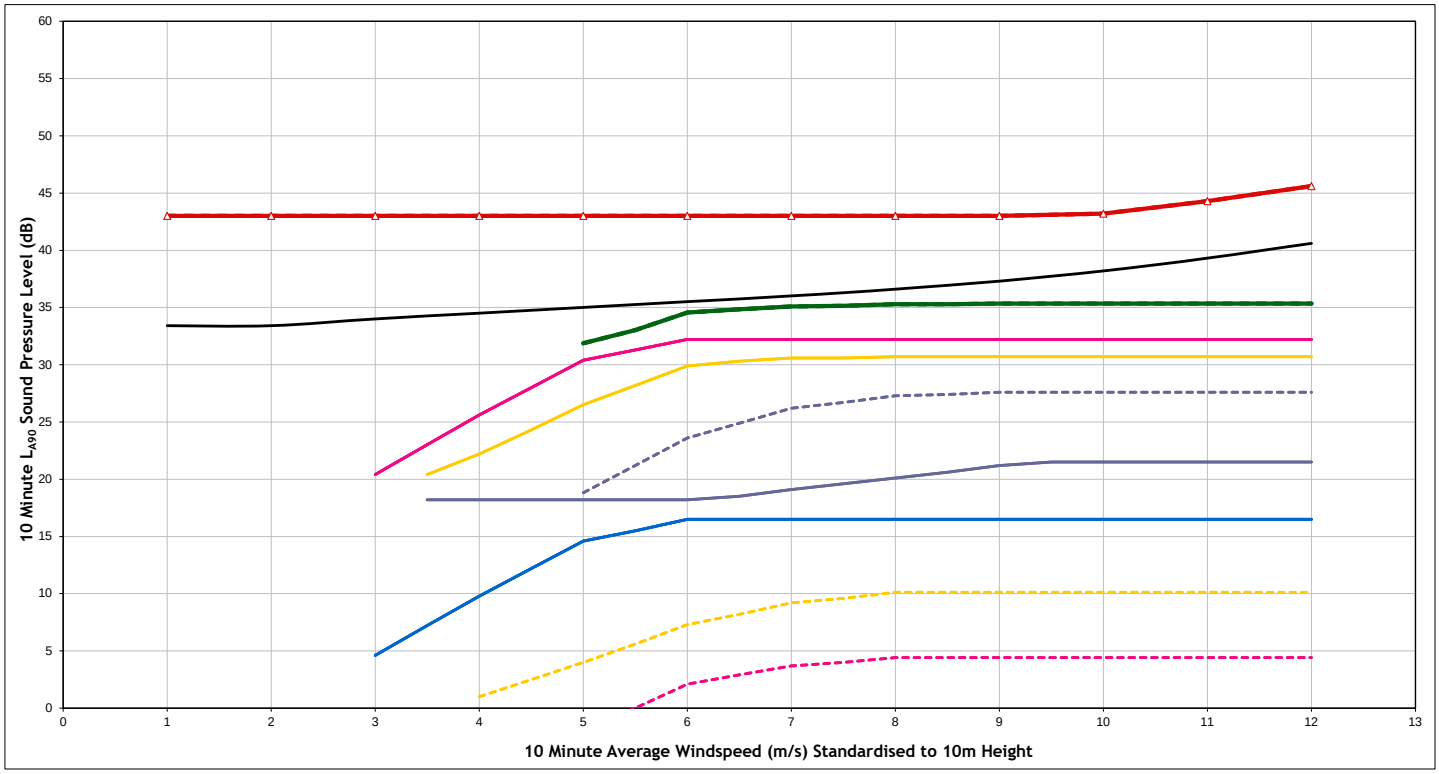
Daytime - Tallaminnoch Cottage (NAL14)



Night Time - Tallaminnoch Cottage (NAL14)

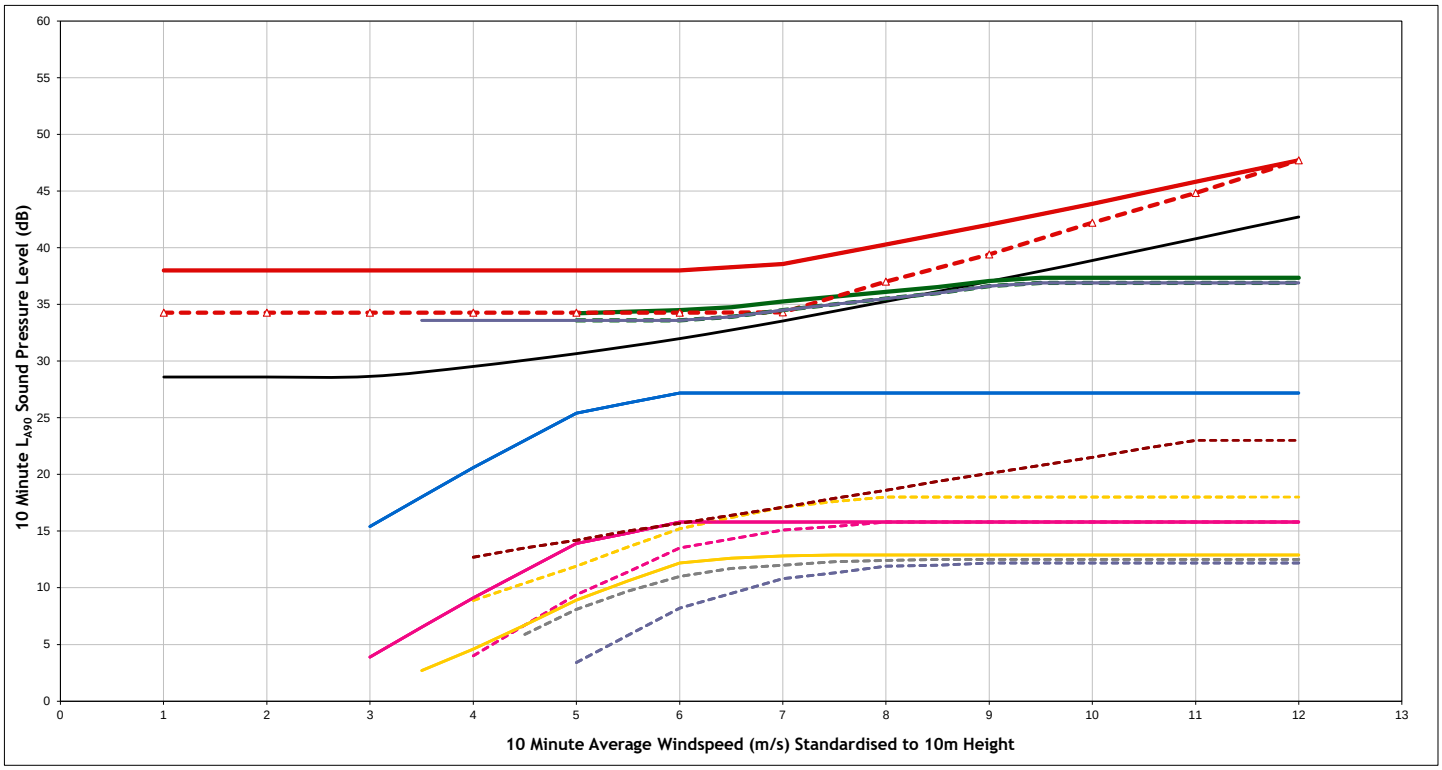


Legend:

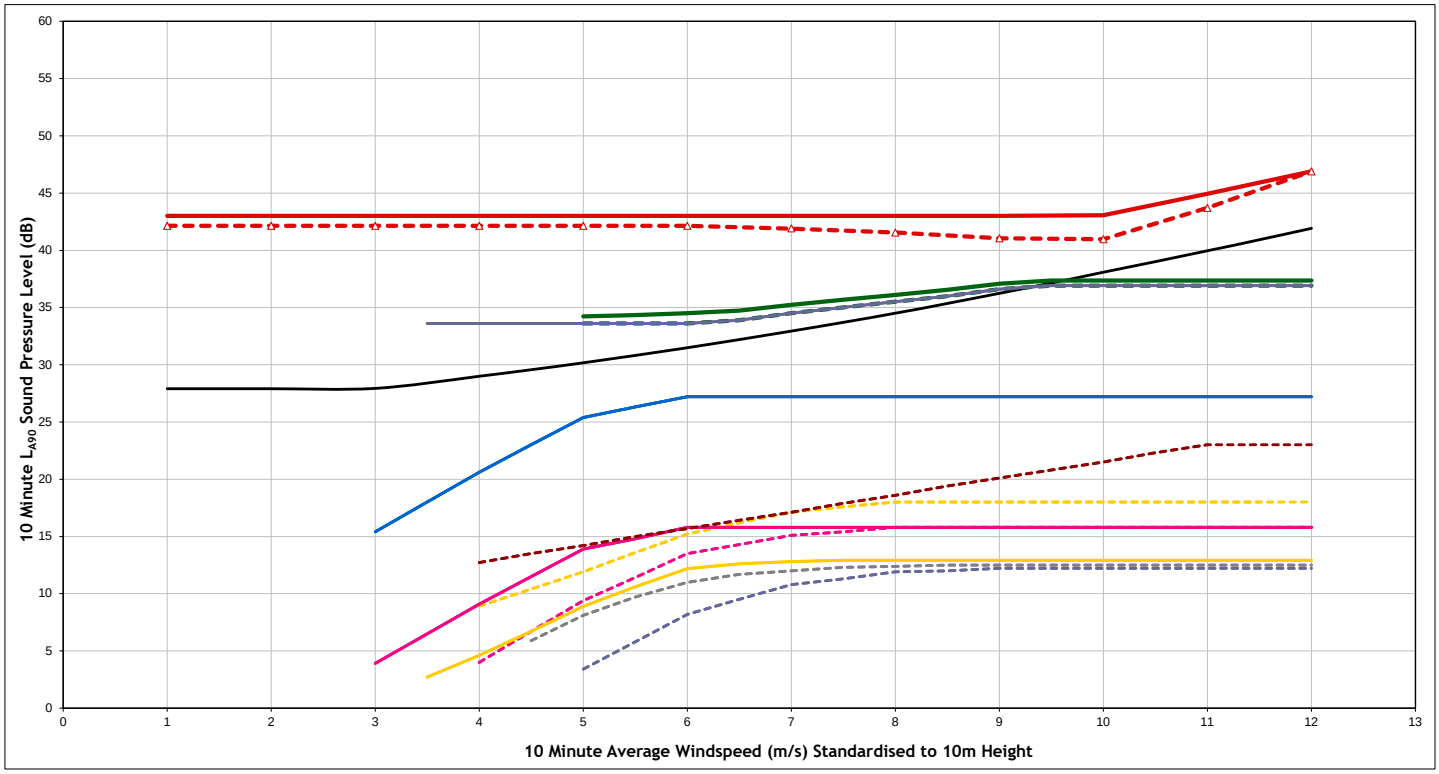
- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Tallaminnoch Cottage (NAL14)
Figure Number	Figure A1.2n
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

Daytime - Milton Farm (NAL15)



Night Time - Milton Farm (NAL15)



Legend:

- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Milton Farm (NAL15)
Figure Number	Figure A1.2o
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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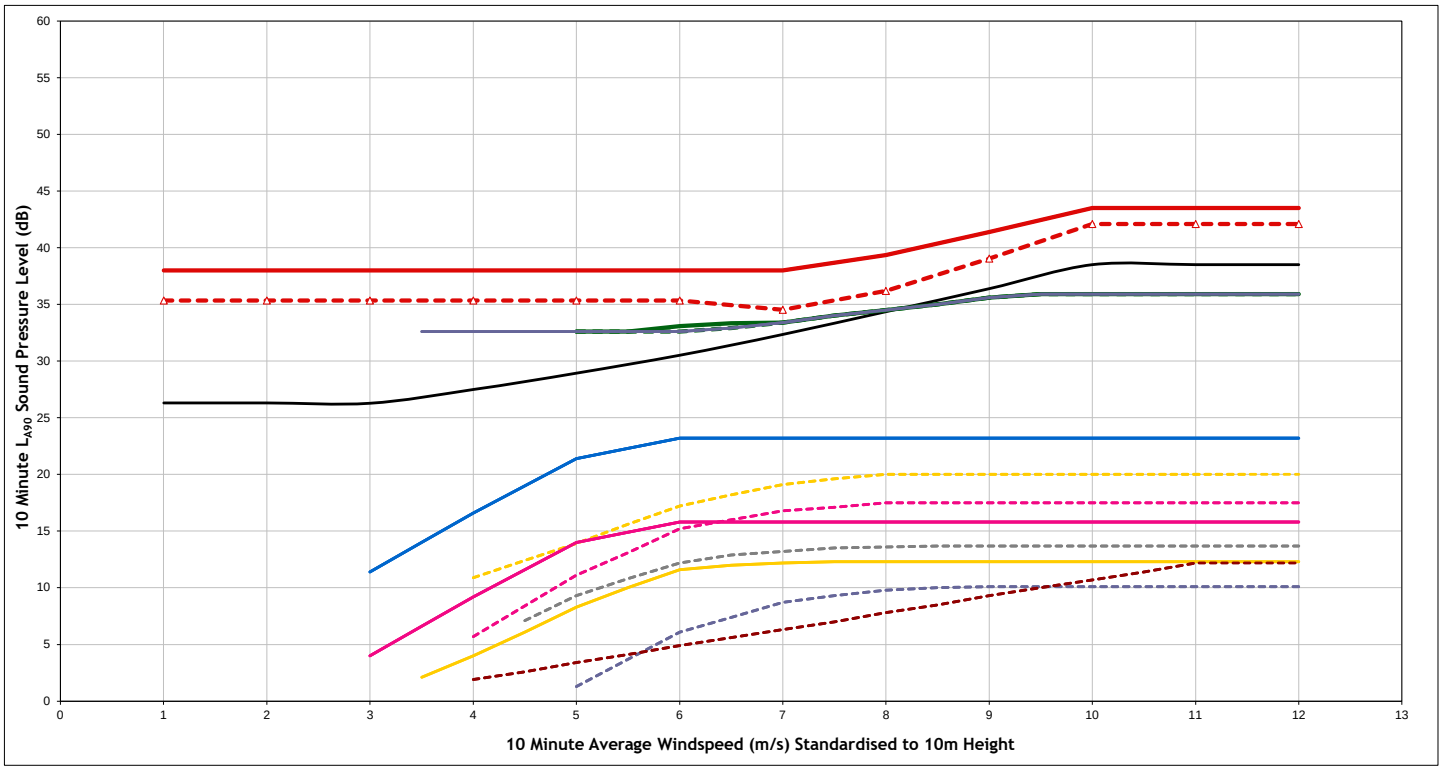
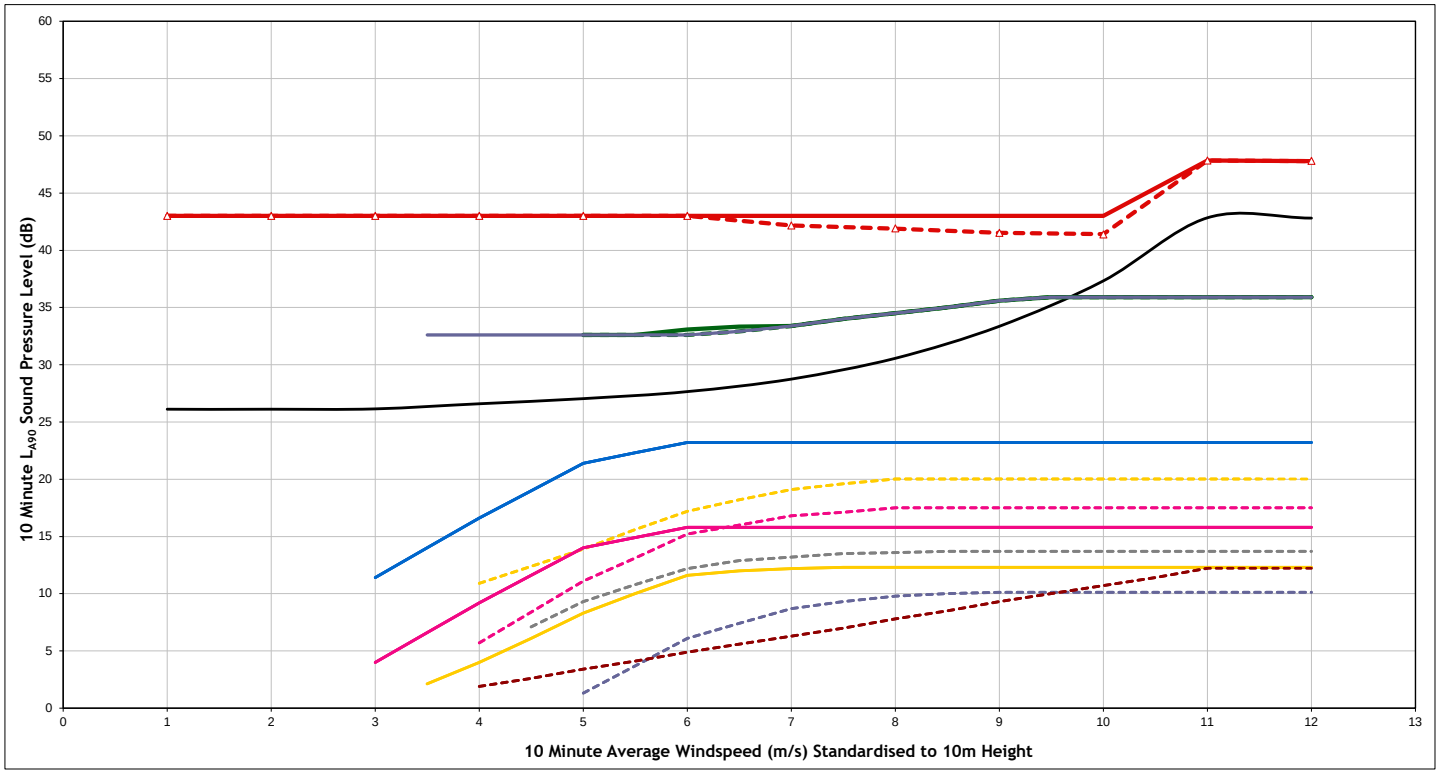
Daytime - Alton Albany Lodge (NAL16)



Night Time - Alton Albany Lodge (NAL16)

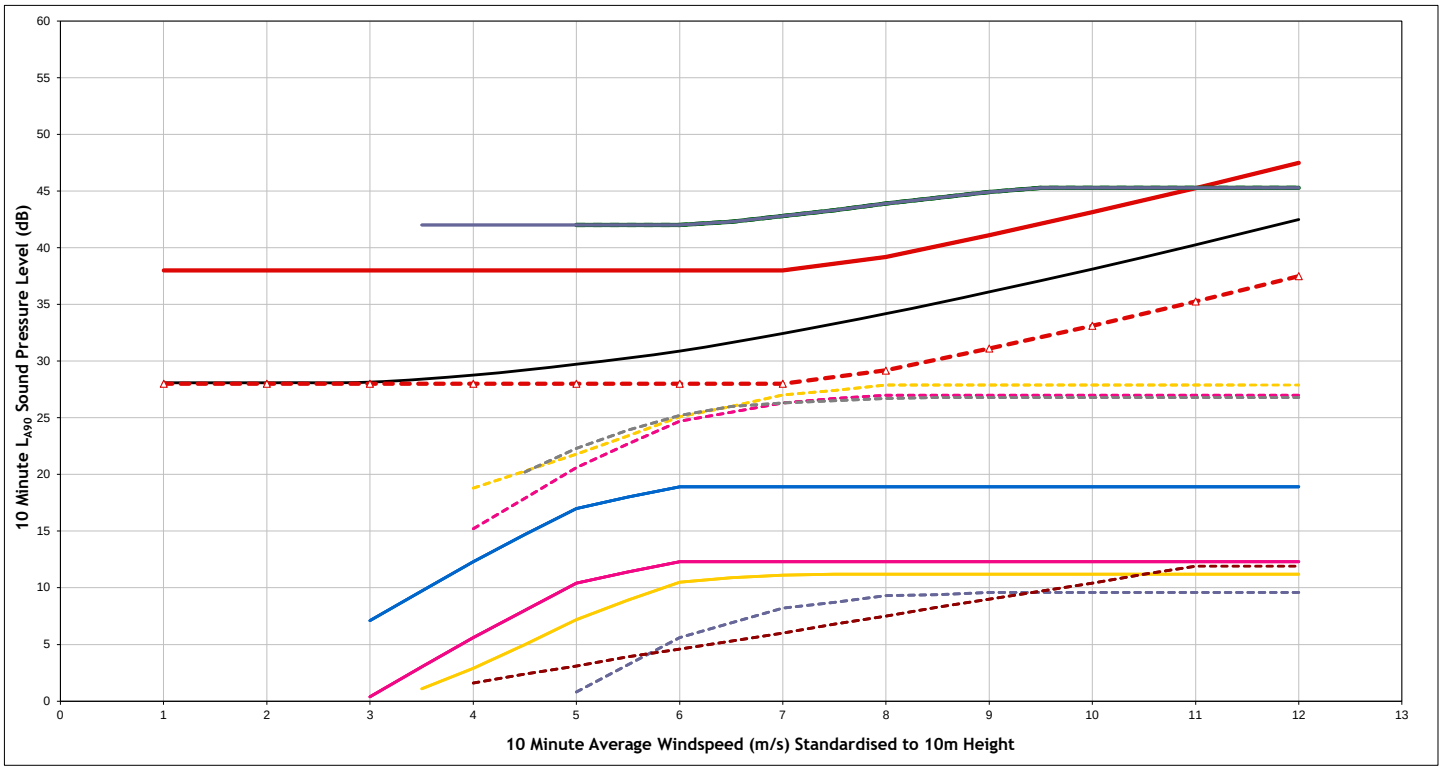


Legend:

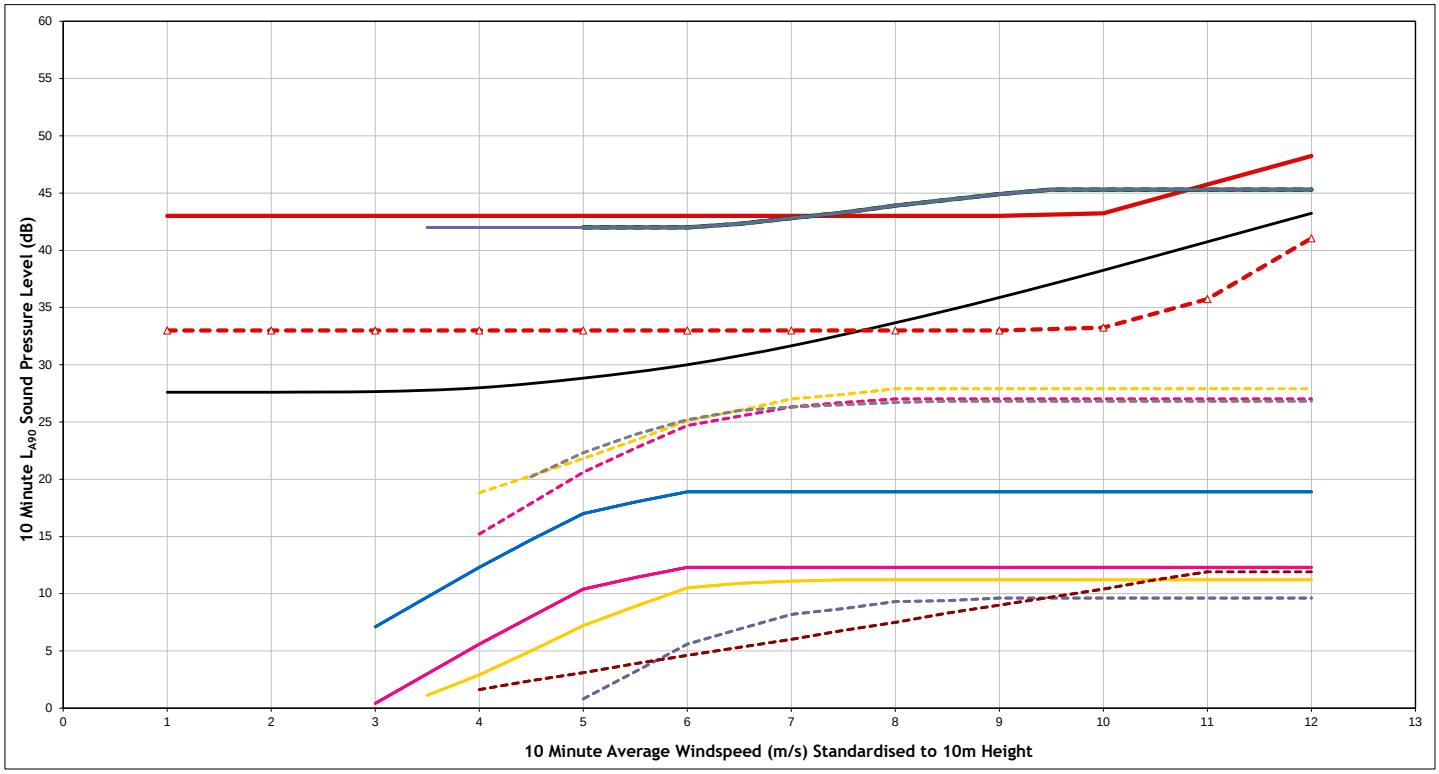
- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Alton Albany Lodge (NAL16)
Figure Number	Figure A1.2p
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

Daytime - Lanes Farm (NAL17)



Night Time - Lanes Farm (NAL17)

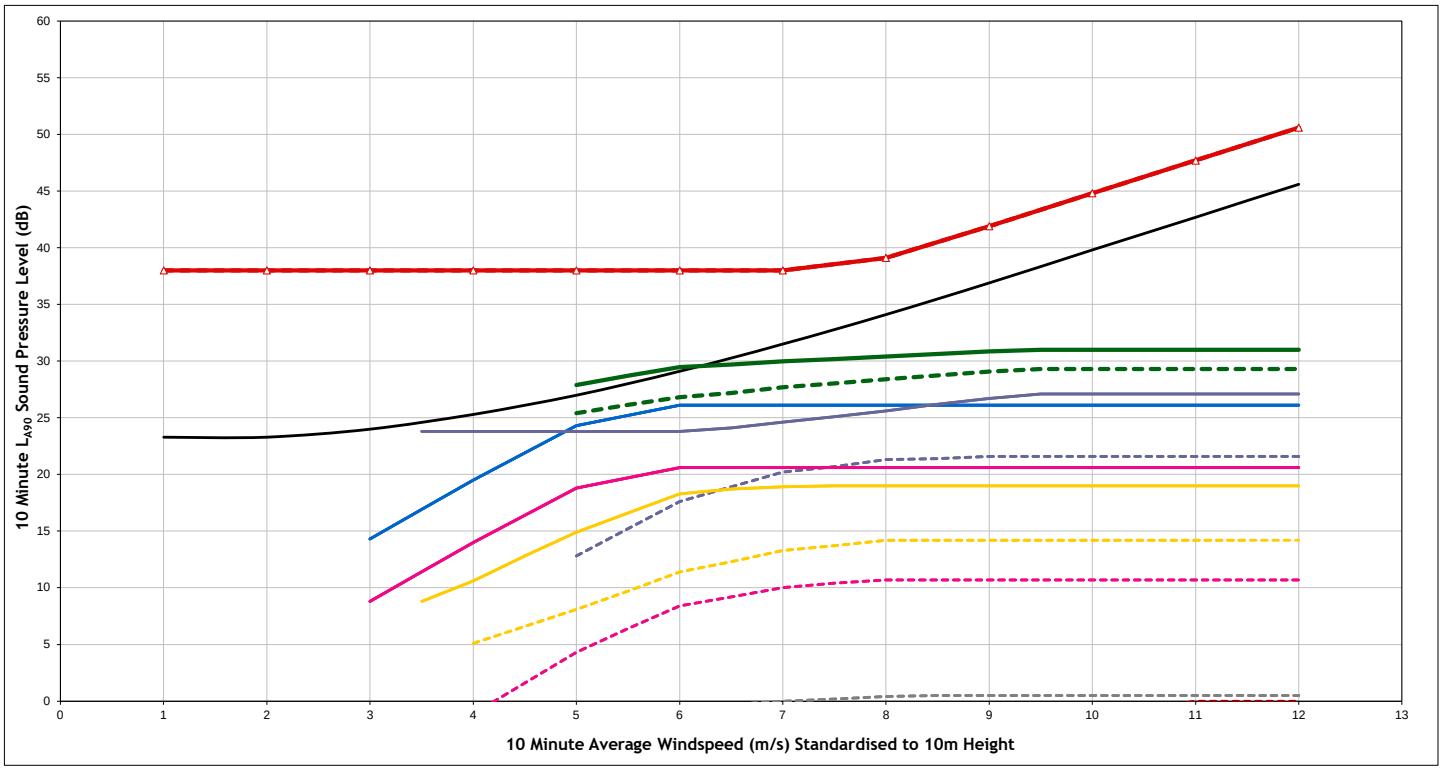


Legend:

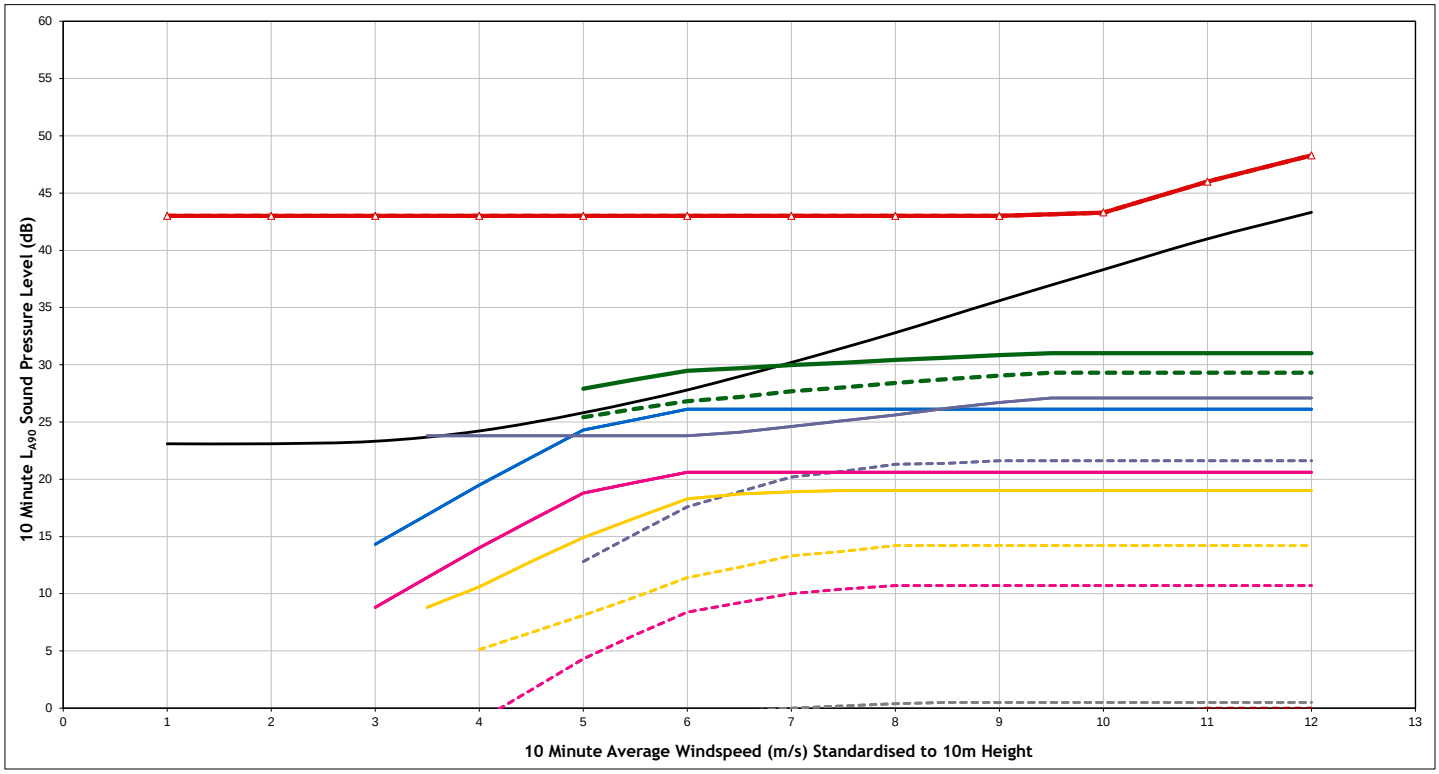
- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Lanes Farm (NAL17)
Figure Number	Figure A1.2q
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

Daytime - Blair Farm (NAL18)



Night Time - Blair Farm (NAL18)



Legend:

- Background Noise Level
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- Cumulative (including CMWF)
- Cumulative (excluding CMWF)
- CMWF
- CWF
- KWF
- Hadyard Hill
- Dersalloch
- Tralorg
- Assel Valley
- Penwhapple
- Glengennet

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Noise Assessment Blair Farm (NAL18)
Figure Number	Figure A1.2r
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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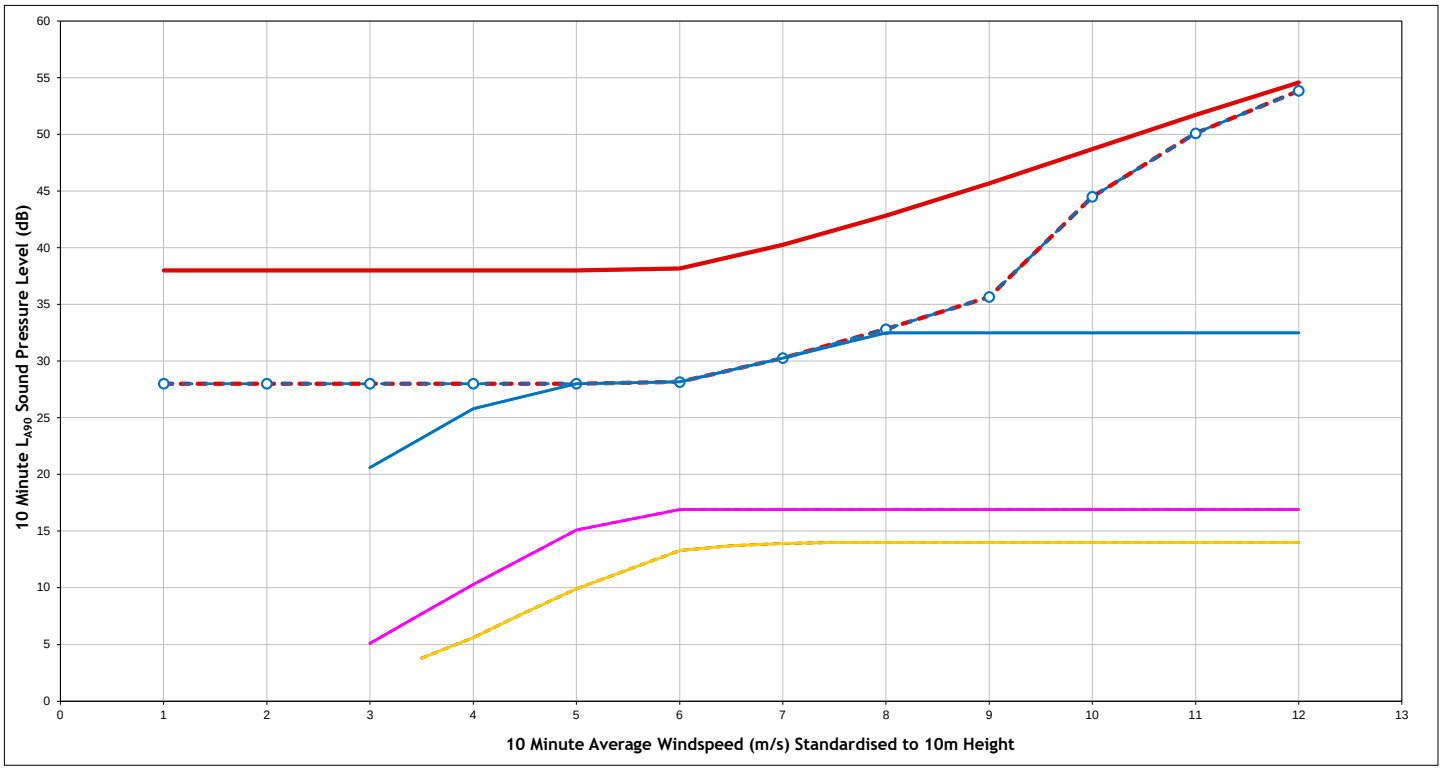
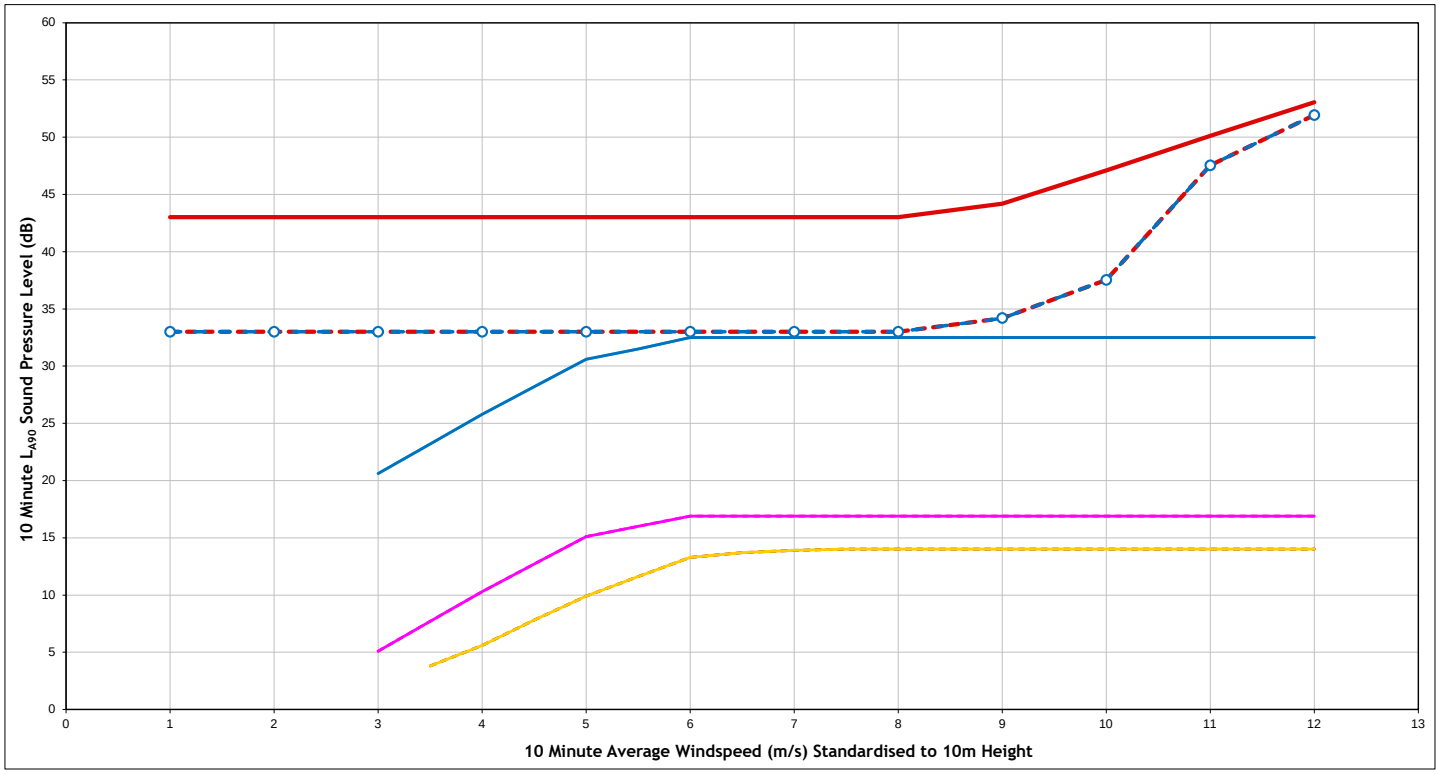
Daytime - Delamford Cottage (NAL1)



Night Time - Delamford Cottage (NAL1)



Legend:

- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- CMWF predictions — NB Includes mode management (daytime only)
- CWF predictions — NB - 10 dB below TNL, no SSNL required
- KWF predictions — NB - 10 dB below TNL, no SSNL required
- CMWF SSNL
- CMWF SSNL
- Knockronal SSNL

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Site Specific Noise Limits Delamford Cottage (NAL1)
Figure Number	Figure A1.3a
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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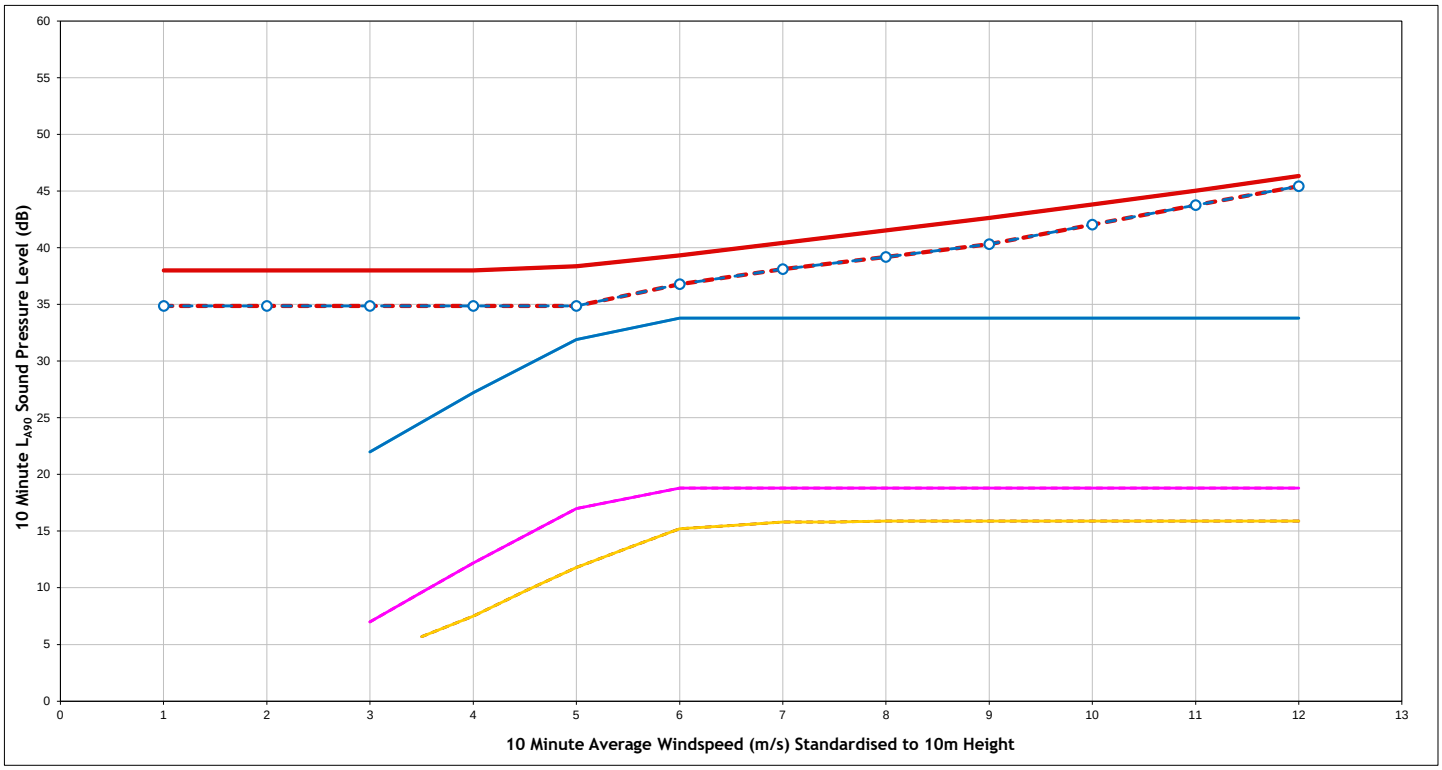
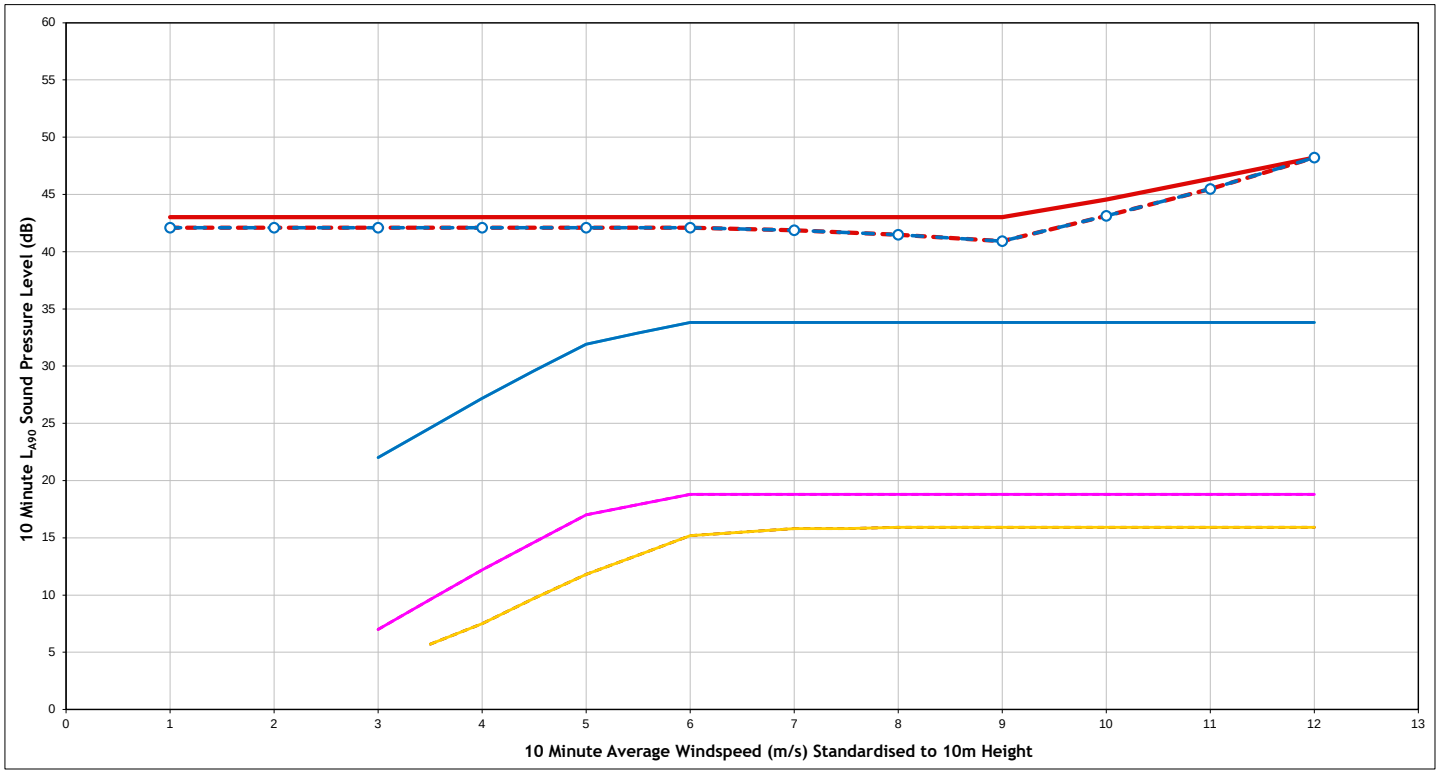
Daytime - Dobbingstone Farm (NAL2)



Night Time - Dobbingstone Farm (NAL2)

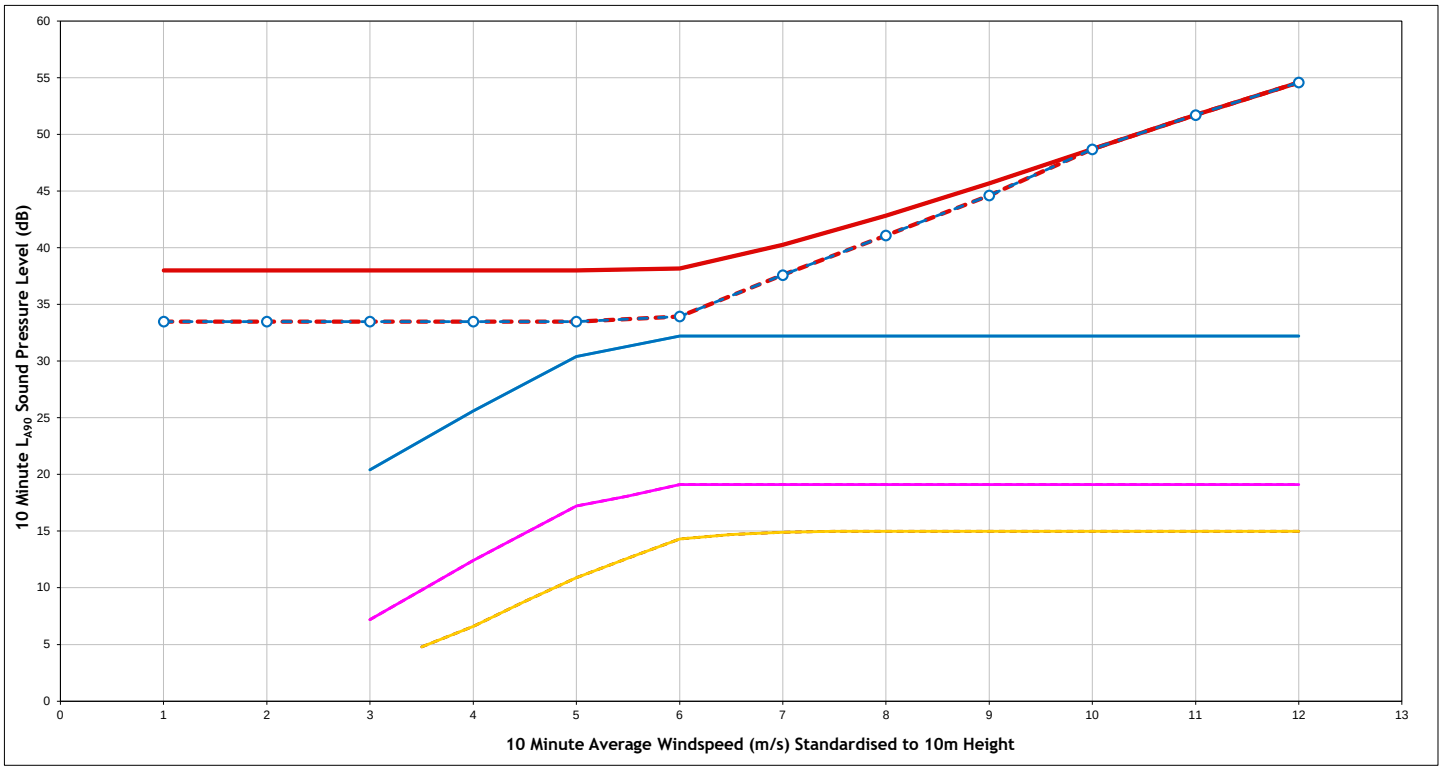


Legend:

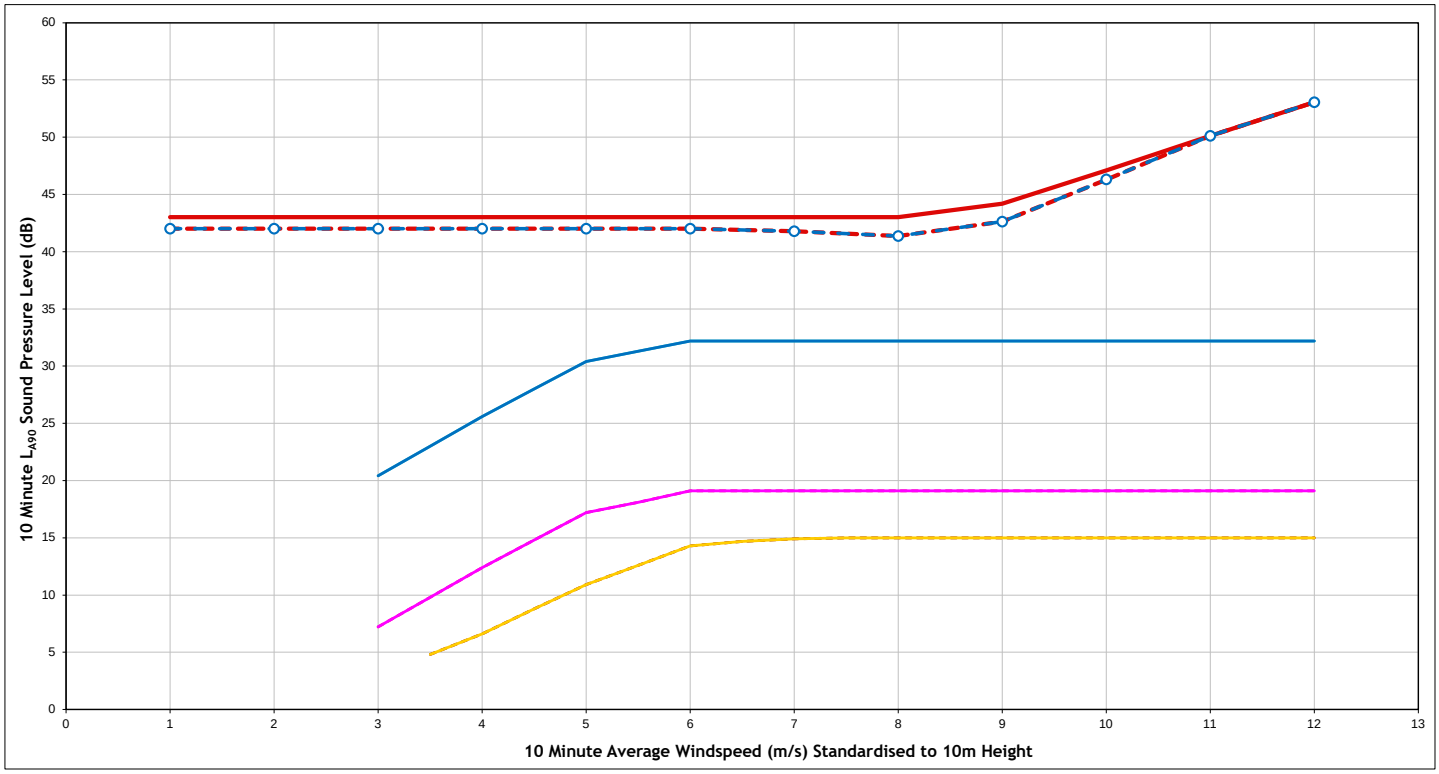
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- CMWF predictions
- CWF predictions — NB - 10 dB below TNL, no SSNL required
- KWF predictions — NB - 10 dB below TNL, no SSNL required
- CMWF SSNL
- CMWF SSNL
- Knockronal SSNL

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Site Specific Noise Limits Dobbingstone Farm (NAL2)
Figure Number	Figure A1.3b
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

Daytime - Knockrochar (NAL3)



Night Time - Knockrochar (NAL3)



Legend:

- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- CMWF predictions
- CWF predictions — NB - 10 dB below TNL, no SSNL required
- KWF predictions — NB - 10 dB below TNL, no SSNL required
- CMWF SSNL
- CMWF SSNL
- Knockronal SSNL

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Site Specific Noise Limits Knockrochar (NAL3)
Figure Number	Figure A1.3c
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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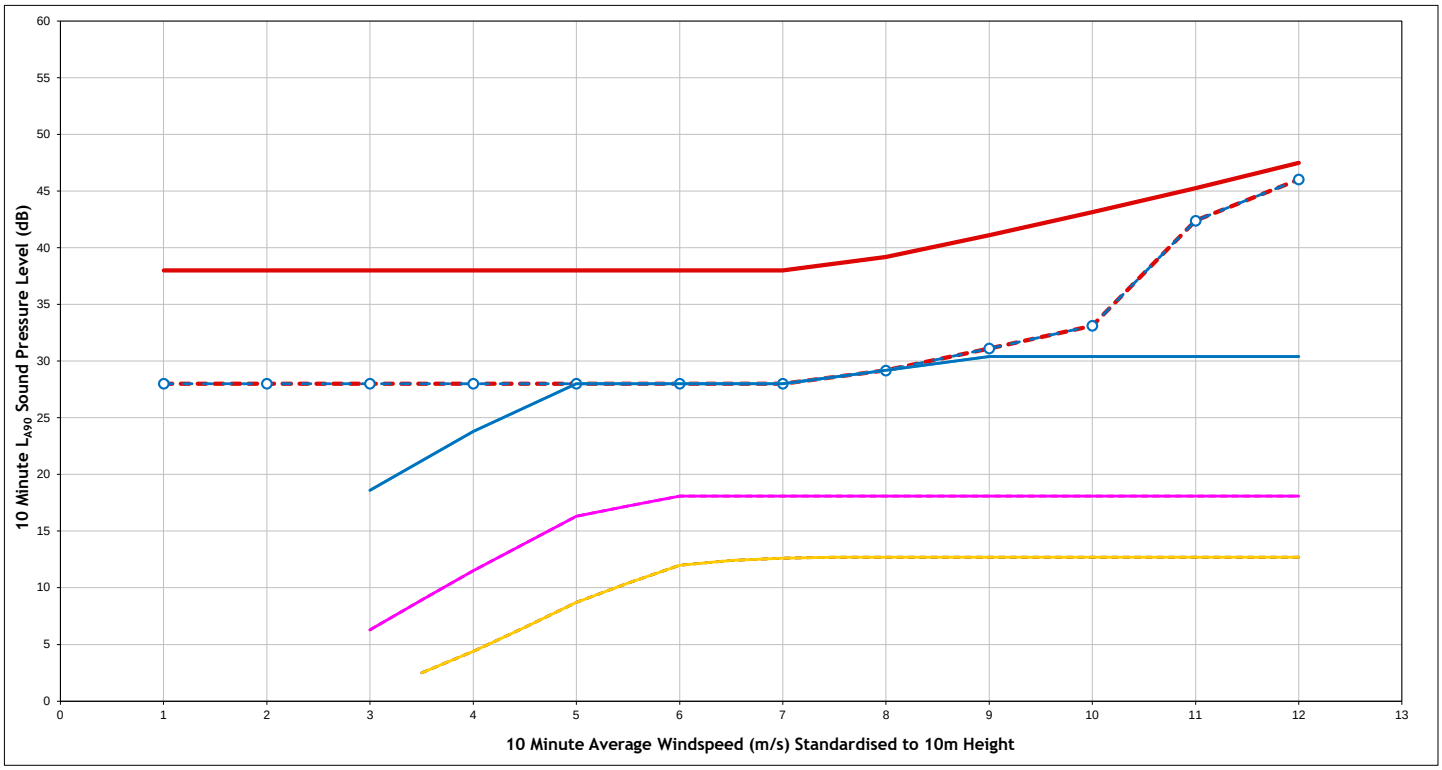
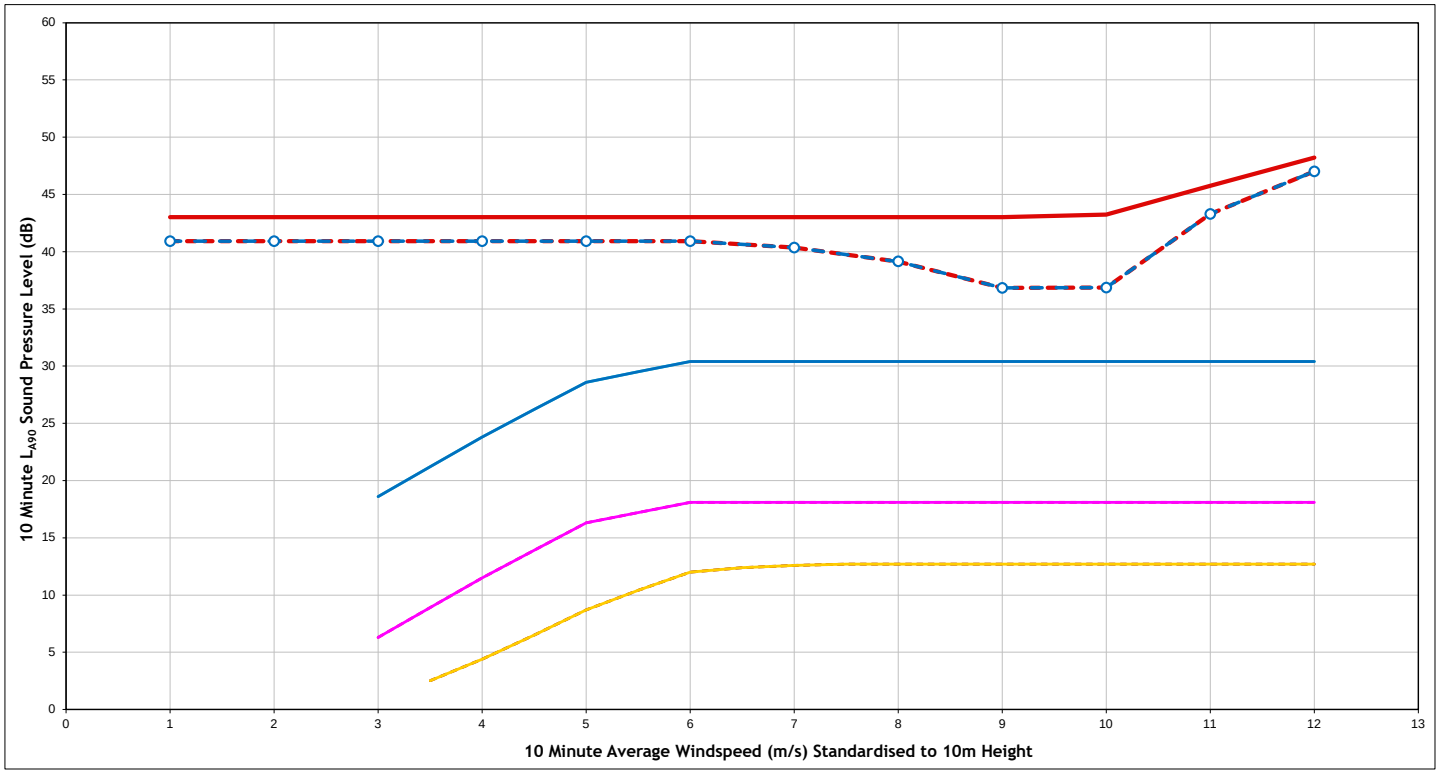
Daytime - Corphin Cottage (NAL5)



Night Time - Corphin Cottage (NAL5)



Legend:

- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- CMWF predictions — NB Includes mode management (daytime only)
- CWF predictions — NB - 10 dB below TNL, no SSNL required
- KWF predictions — NB - 10 dB below TNL, no SSNL required
- CMWF SSNL
- CMWF SSNL
- Knockronal SSNL

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Site Specific Noise Limits Corphin Cottage (NAL5)
Figure Number	Figure A1.3e
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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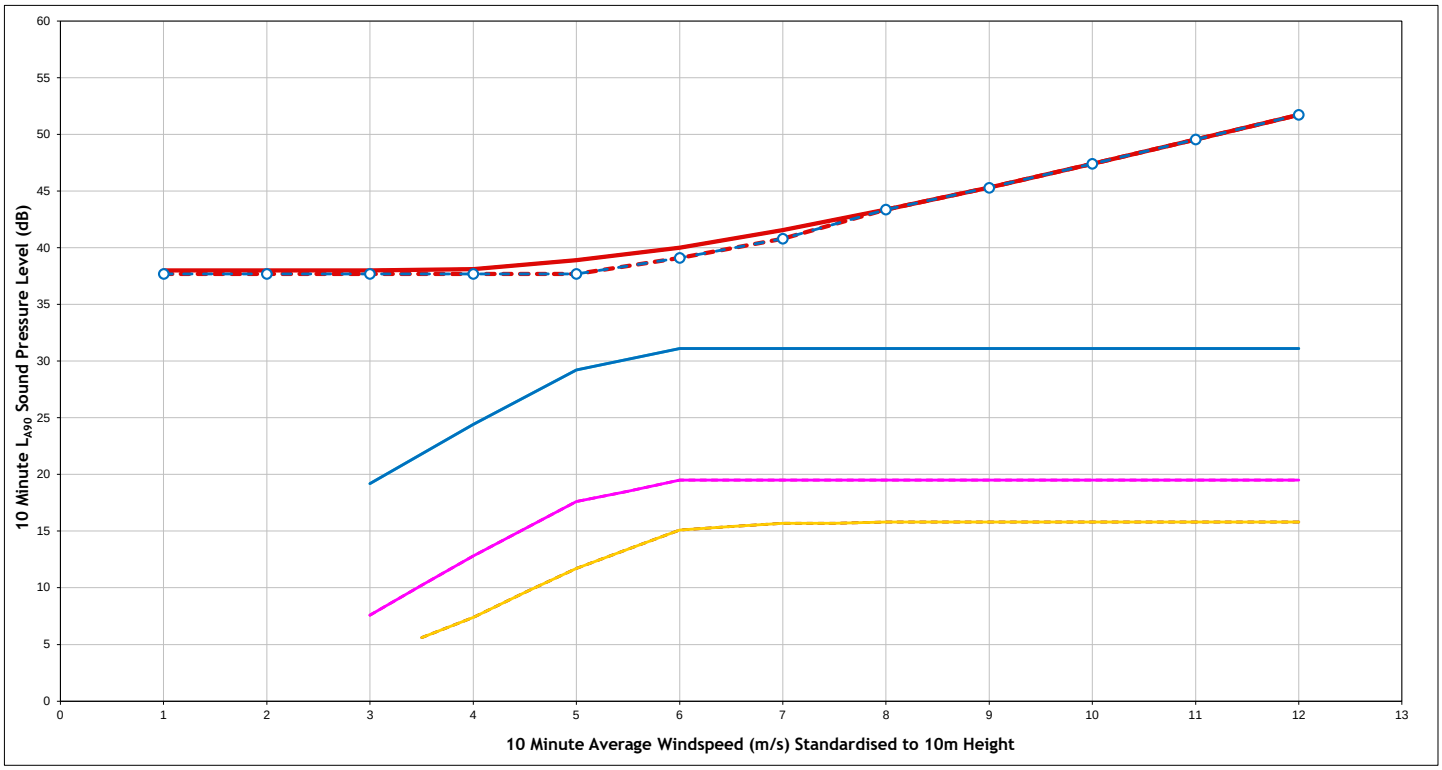
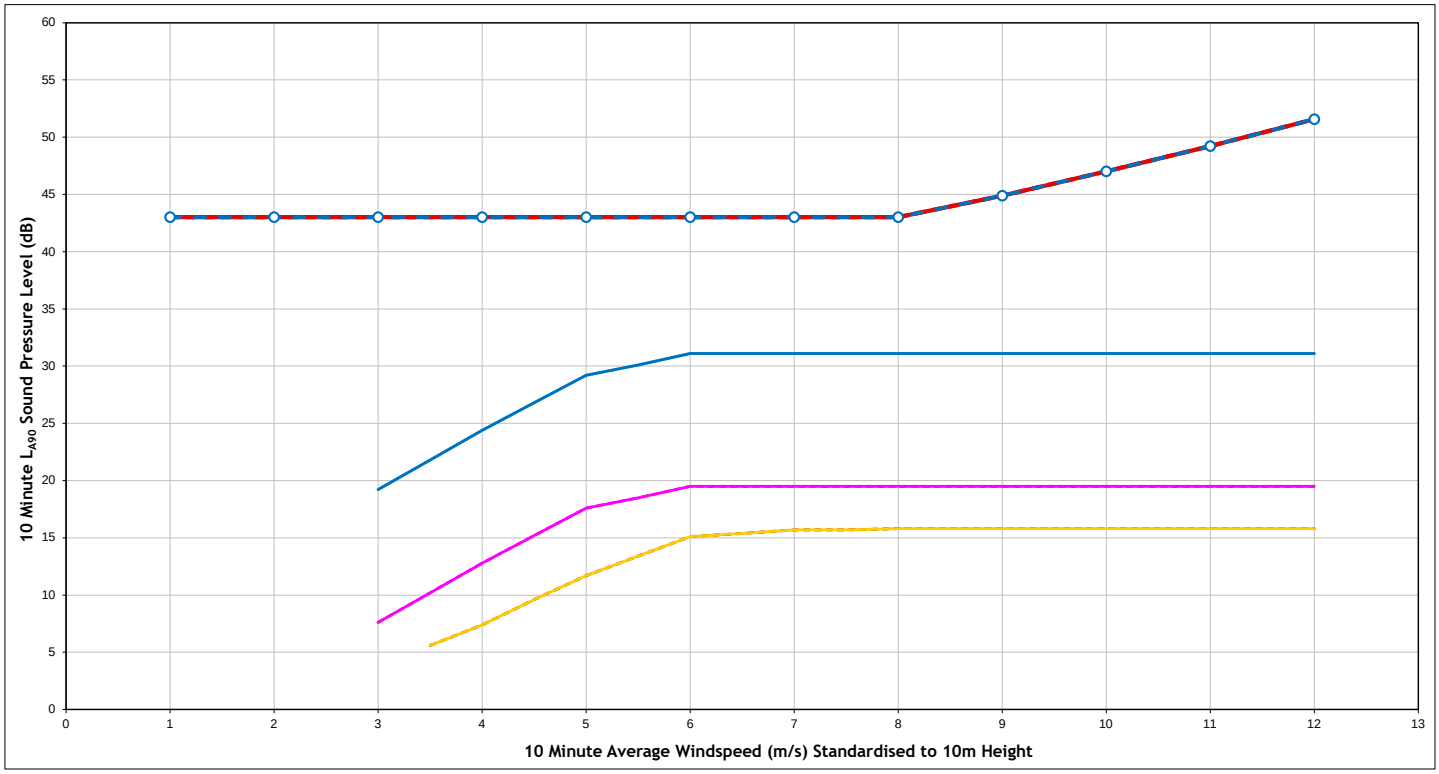
Daytime - Daljedburgh Farm (NAL6)



Night Time - Daljedburgh Farm (NAL6)

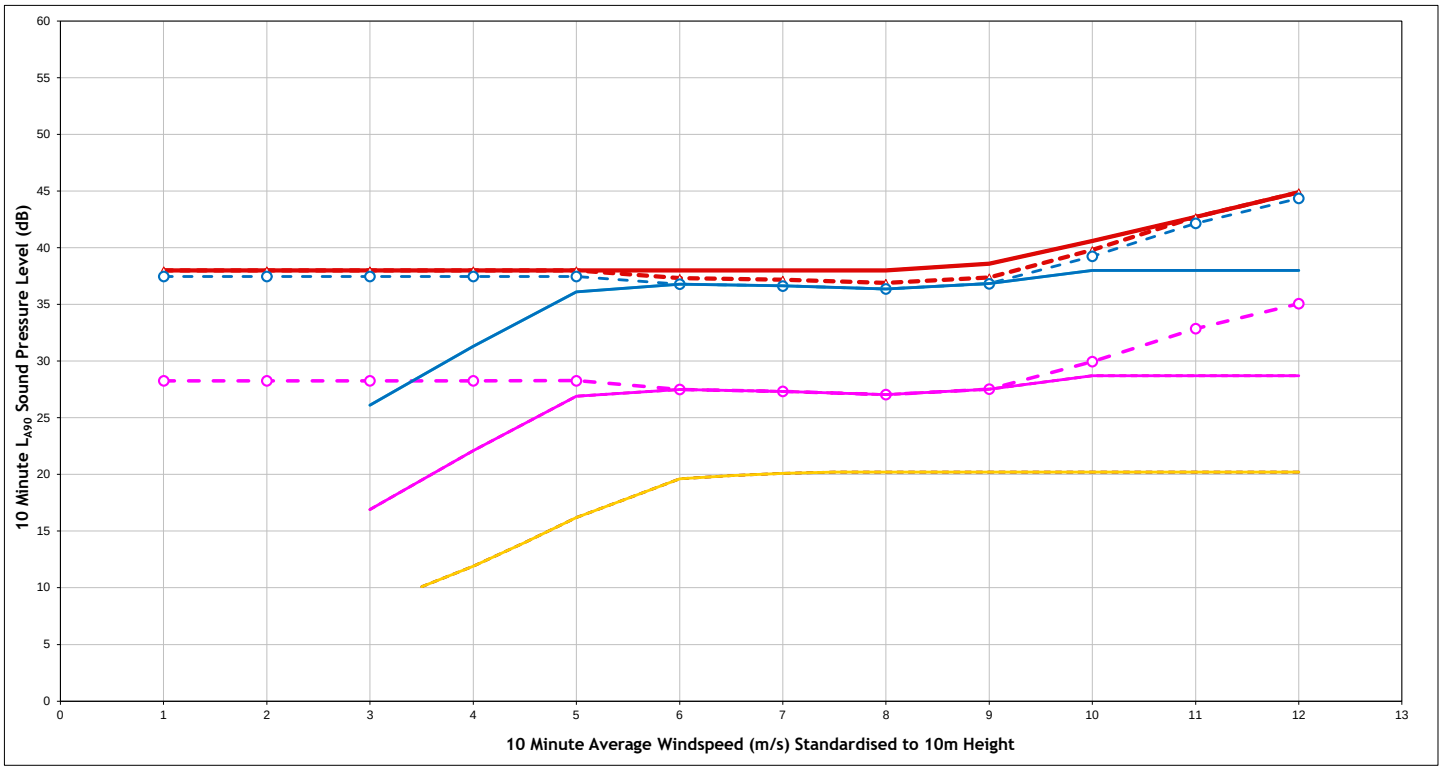


Legend:

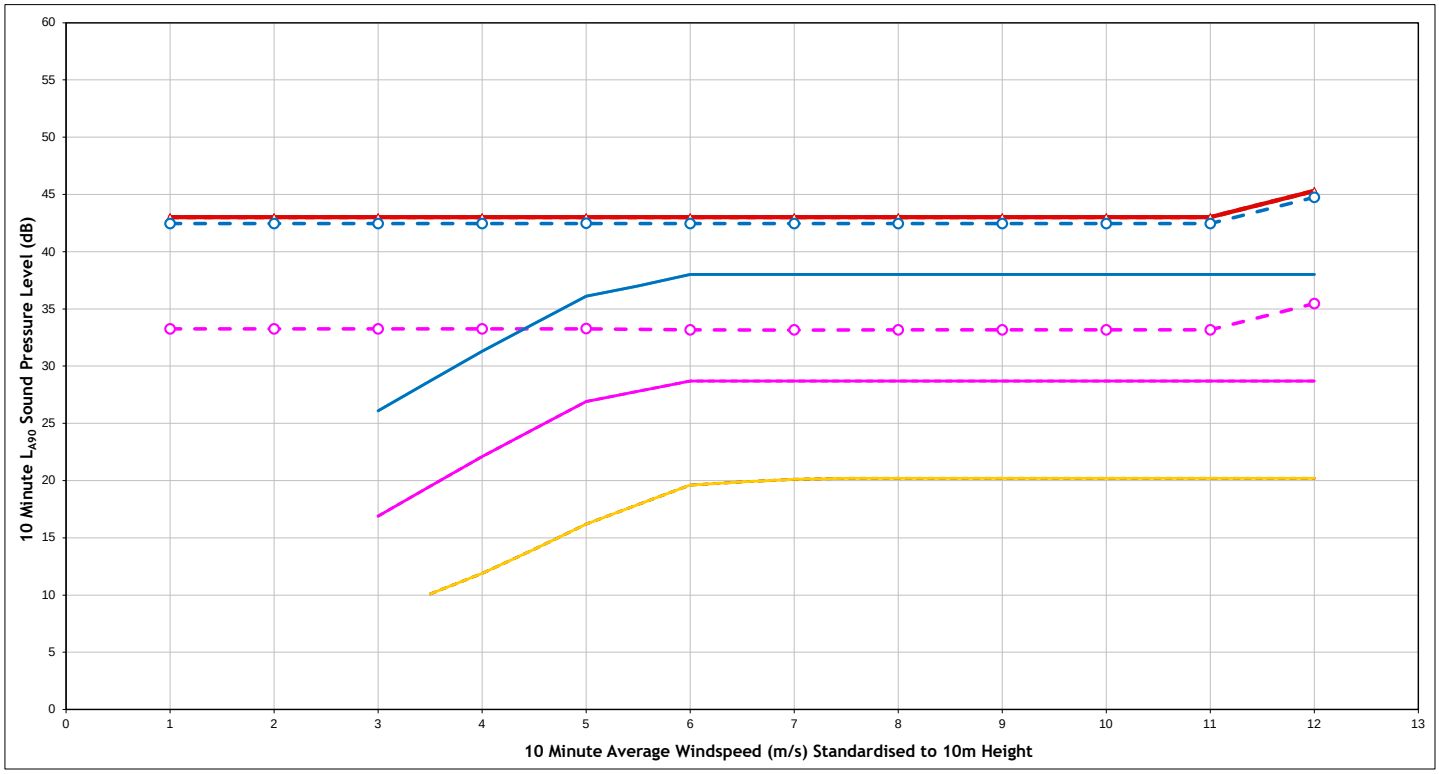
- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- CMWF predictions
- CWF predictions — NB - 10 dB below TNL, no SSNL required
- KWF predictions — NB - 10 dB below TNL, no SSNL required
- CMWF SSNL
- CMWF SSNL
- Knockronal SSNL

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Site Specific Noise Limits Daljedburgh Farm (NAL6)
Figure Number	Figure A1.3f
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

Daytime - Doughty Farm (NAL7)



Night Time - Doughty Farm (NAL7)



Legend:

- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- CMWF predictions — NB Includes mode management (daytime only)
- CWF predictions — NB Includes mode management (daytime only)
- KWF predictions — NB - 10 dB below TNL, no SSNL required
- CMWF SSNL
- CMWF SSNL
- Knockronal SSNL

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Site Specific Noise Limits Doughty Farm (NAL7)
Figure Number	Figure A1.3g
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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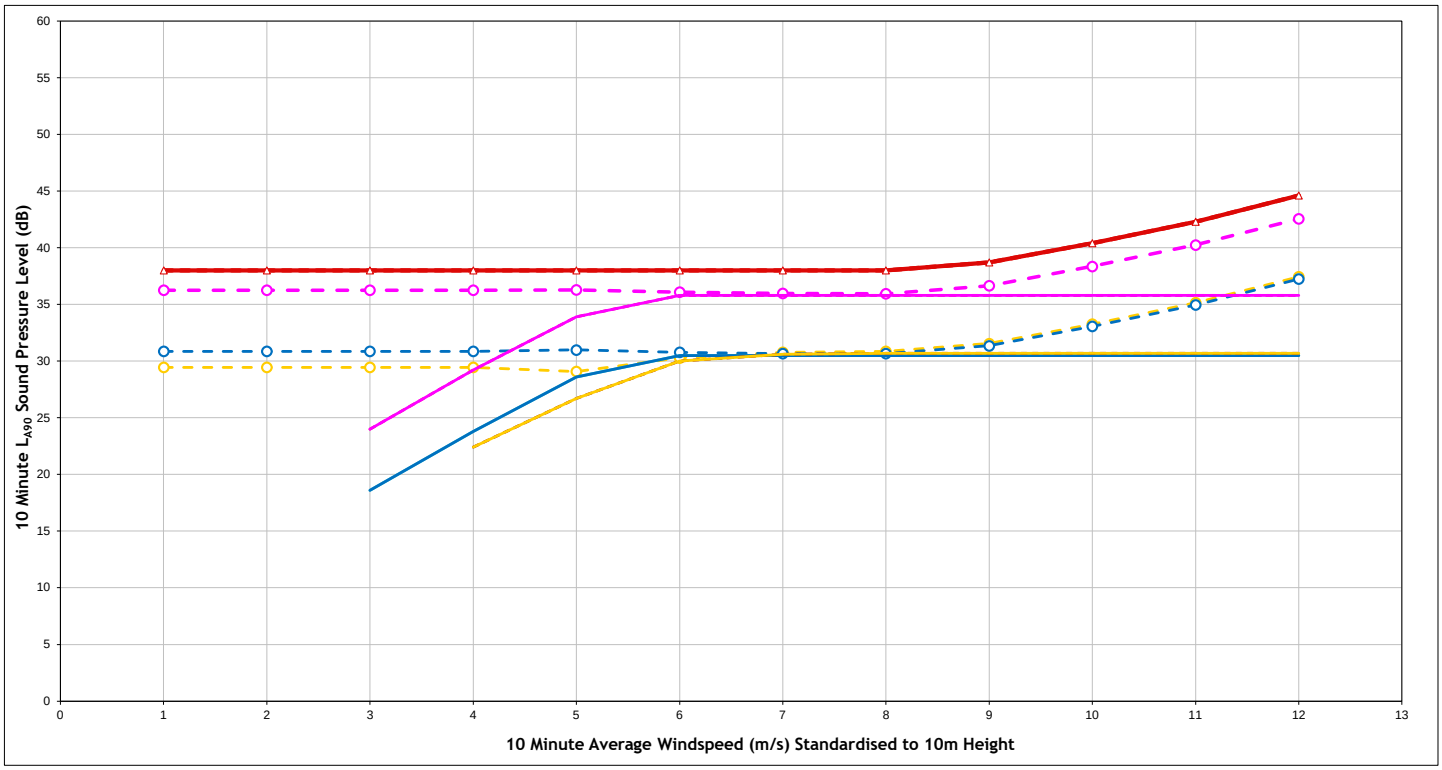
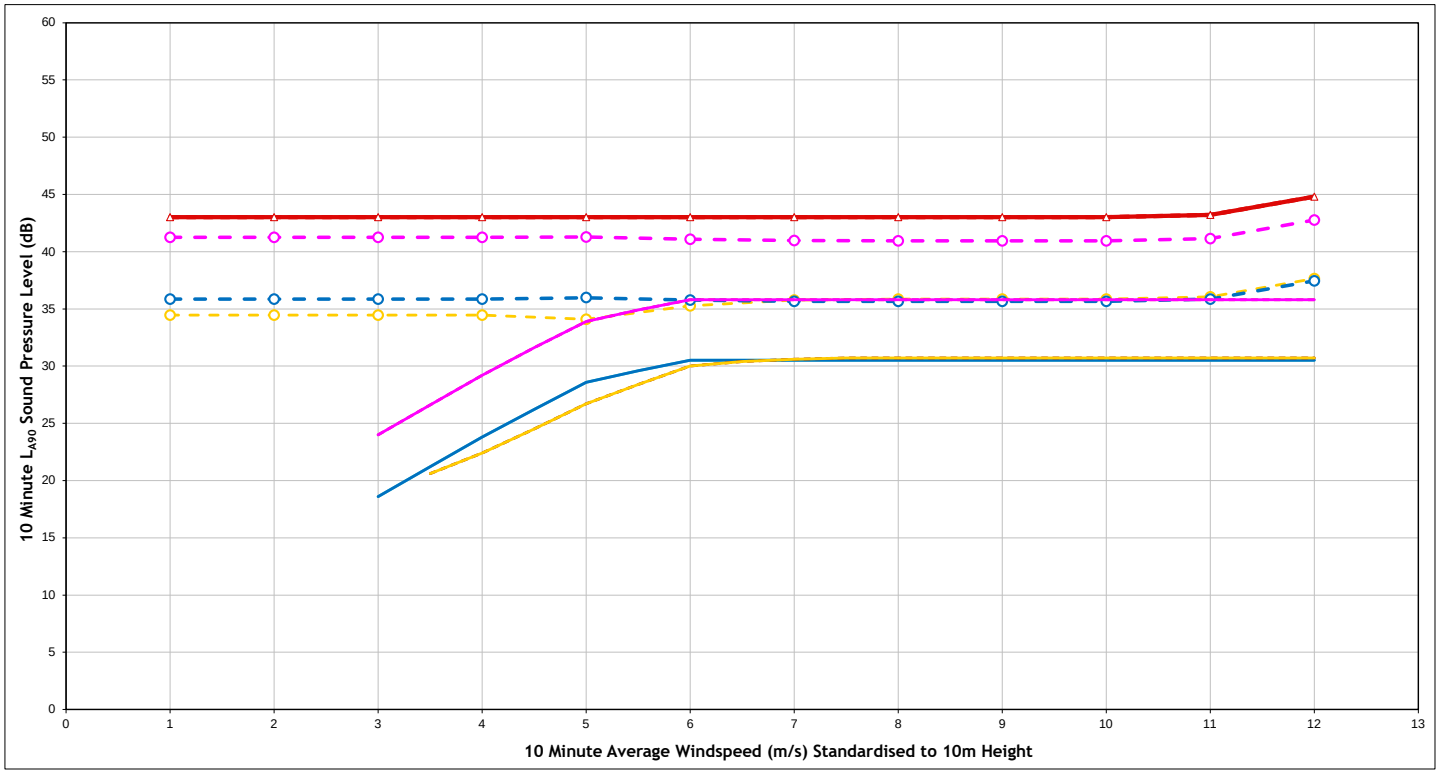
Daytime - Glenalla (NAL9)



Night Time - Glenalla (NAL9)



Legend:

- Total ETSU-R-97 Noise Limit
- Remaining Available Noise Limit
- CMWF predictions
- CWF predictions
- KWF predictions
- CMWF SSNL
- CMWF SSNL
- Knockronal SSNL

Project	Craiginmoddie Wind Farm
Client	EnergieKontor
Title	Site Specific Noise Limits Glenalla (NAL9)
Figure Number	Figure A1.3i
Scale	NTS
Drawn	AD
Checked	JM
Date	10/03/2023
Document Reference	15659 - Noise Models

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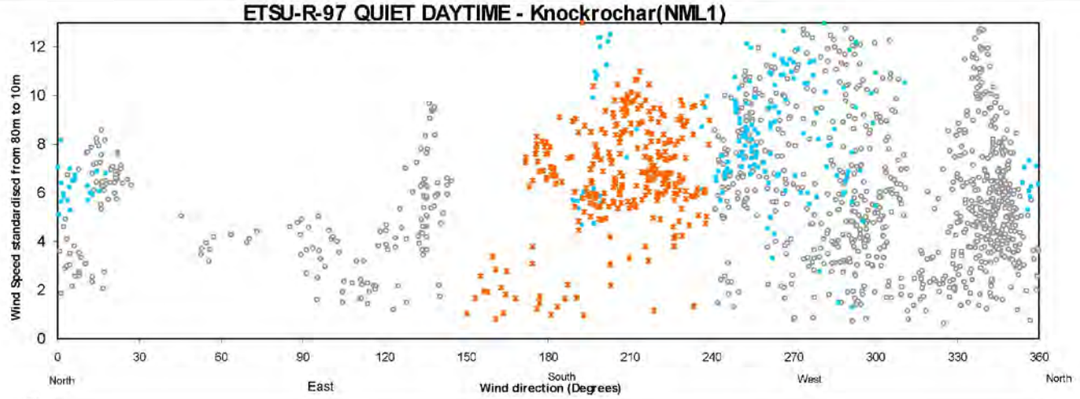
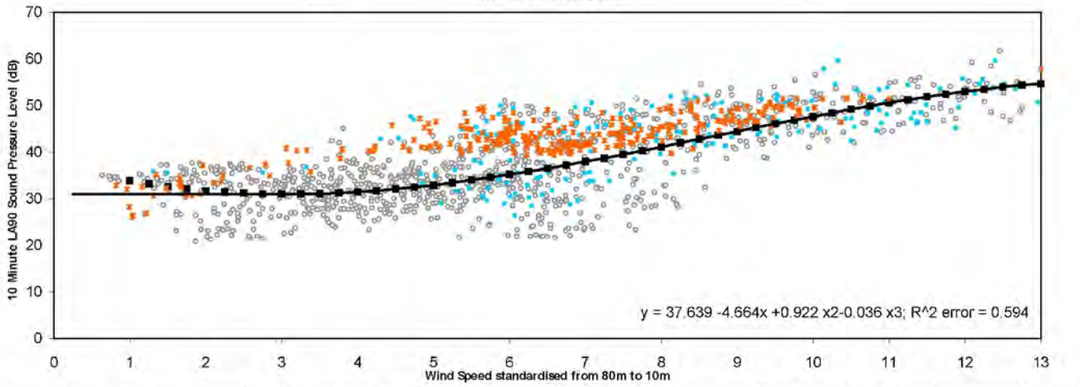
Annex 2 – Extracts from Background Noise Assessments

Wind Conditions Quiet Daytime

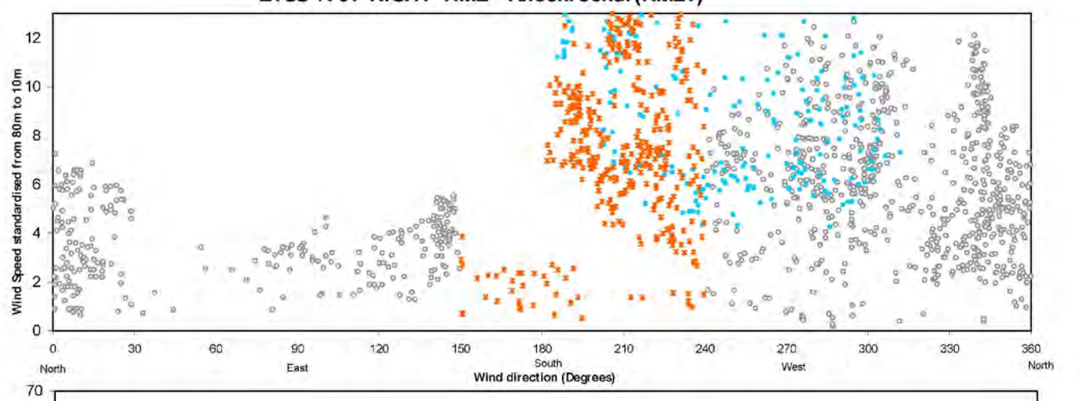


Regression Analysis Quiet Daytime

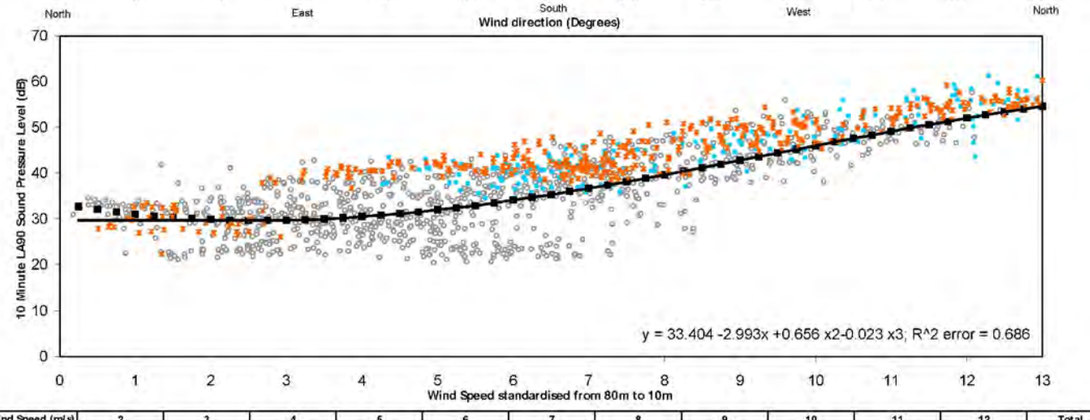


Wind Speed (m/s)	2	3	4	5	6	7	8	9	10	11	12	Total
Number of data points	87	91	136	140	143	93	76	65	45	37	27	940
Prevailing Background	31	31	31.5	32.9	35.2	38	41.1	44.4	47.6	50.6	53	

Wind Conditions Night-Time



Regression Analysis Night-Time



Wind Speed (m/s)	2	3	4	5	6	7	8	9	10	11	12	Total
Number of data points	87	137	130	135	115	114	66	56	49	35	17	942
Prevailing Background	29.7	29.7	30.5	32	34.1	36.7	39.6	42.8	46	49.1	52	

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ENVIRON

Key

- L_{A90} 10 Minute Measurement Point
- Line of best fit
- Line of best fit flat lined where appropriate (Prevailing Background)
- Excluded Data-Manual exclusion
- Excluded Data-Rain
- Excluded Data-Filtered Wind Direction

N

Scale 1:35,000 @ A3

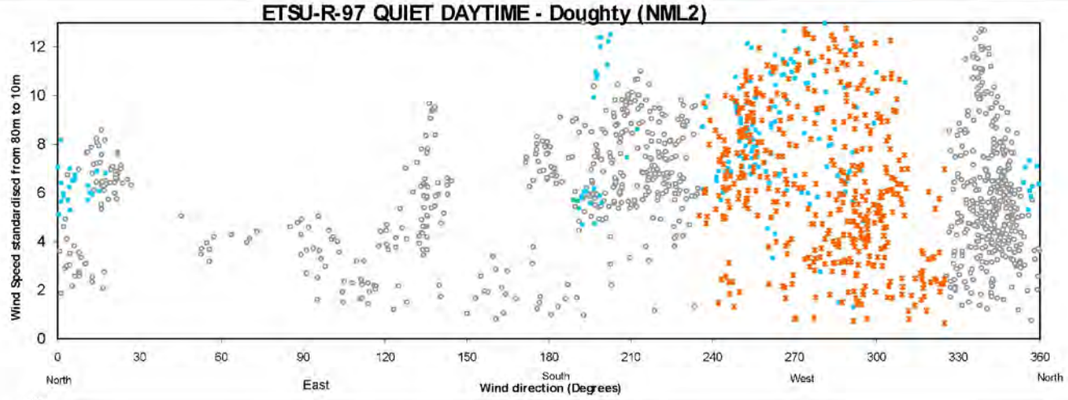
0 0.25 0.5 1 km

Figure 6.2.2a
Wind Condit ions & Regression Analysis Knockrochar (NML1)

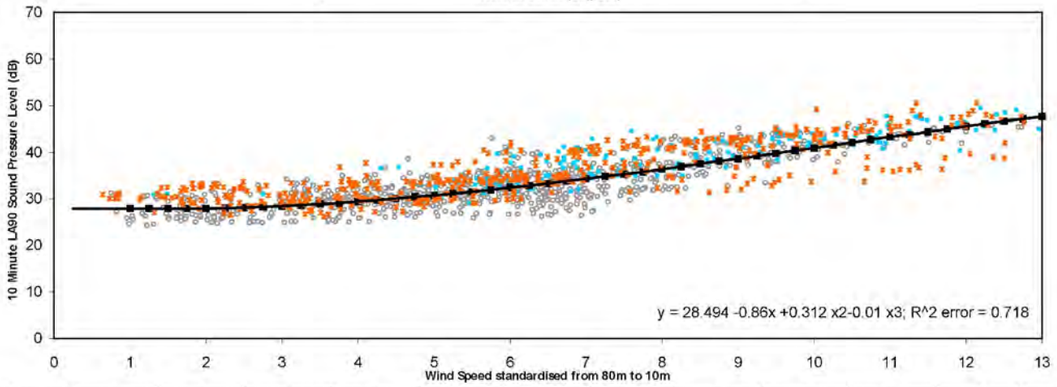
Hadyard Hill Extension Wind Farm Environmental Statement

ETSU-R-97 QUIET DAYTIME - Doughty (NML2)

Wind Conditions Quiet Daytime



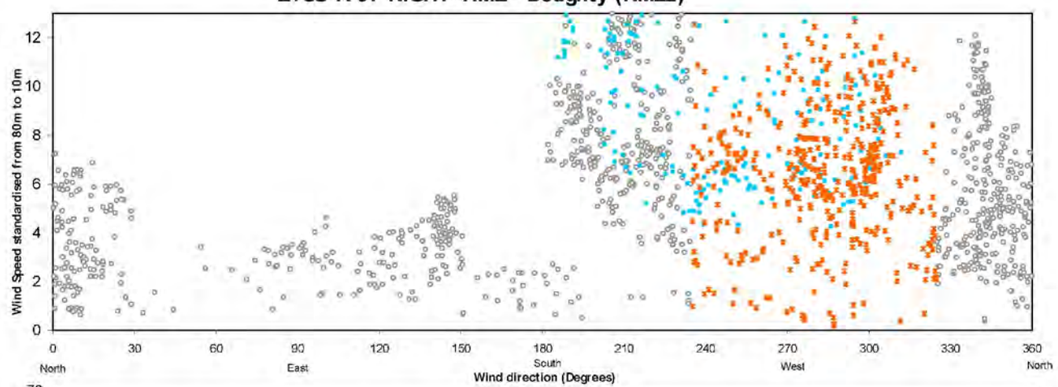
Regression Analysis Quiet Daytime



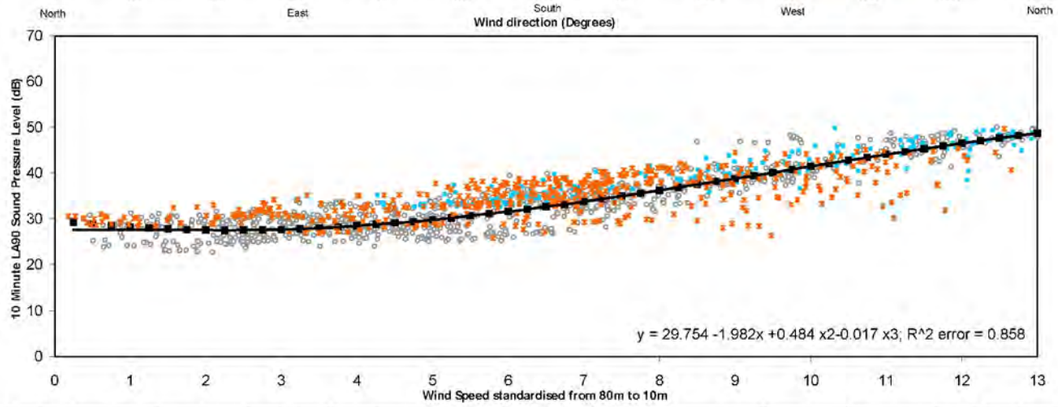
Wind Speed (m/s)	2	3	4	5	6	7	8	9	10	11	12	Total
Number of data points	57	61	103	112	147	117	83	59	36	13	9	797
Prevailing Background	27.9	28.4	29.4	30.7	32.4	34.3	36.4	38.6	40.9	43.3	45.6	

ETSU-R-97 NIGHT-TIME - Doughty (NML2)

Wind Conditions Night-Time



Regression Analysis Night-Time



Wind Speed (m/s)	2	3	4	5	6	7	8	9	10	11	12	Total
Number of data points	84	120	117	115	79	97	57	55	48	32	36	840
Prevailing Background	27.6	27.7	28.5	29.8	31.6	33.8	35.2	38.8	41.5	44.1	46.5	

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ENVIRON

Key

- L_{A90} 10 Minute Measurement Point
- Line of best fit
- Line of best fit flat lined where appropriate (Prevailing Background)
- Excluded Data-Manual exclusion
- Excluded Data-Rain
- Excluded Data-Filtered Wind Direction

N

Scale 1:35,000 @ A3

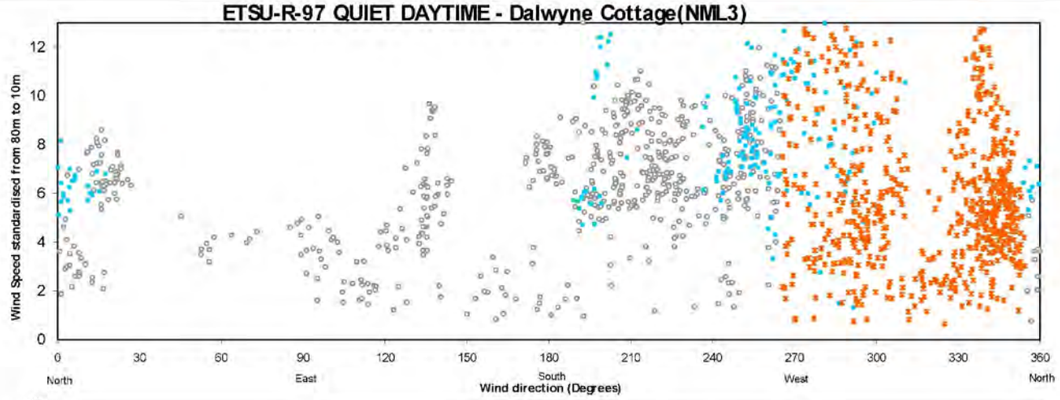
0 0.25 0.5 1 km

Figure 6.2.2b
Wind Condit ions & Regression Analysis Doughty Farm (NML2)

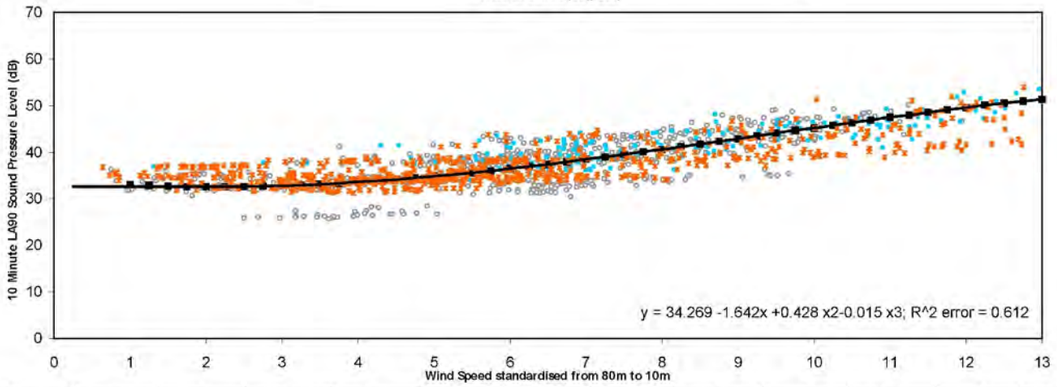
Hadyard Hill Extension Wind Farm Environmental Statement

ETSU-R-97 QUIET DAYTIME - Dalwyne Cottage(NML3)

Wind Conditions Quiet Daytime



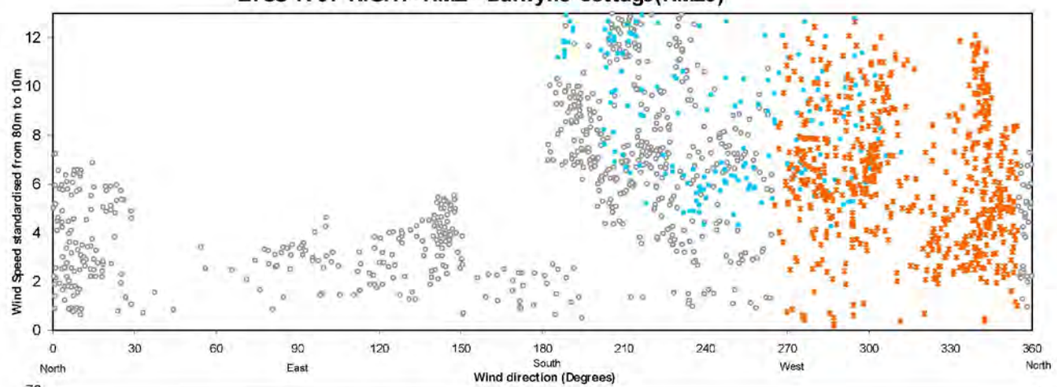
Regression Analysis Quiet Daytime



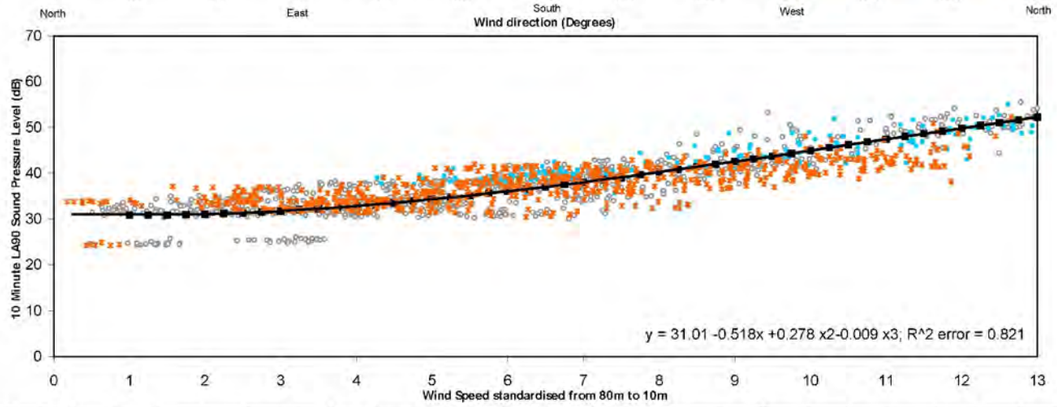
Wind Speed (m/s)	2	3	4	5	6	7	8	9	10	11	12	Total
Number of data points	41	34	50	58	111	109	78	58	38	12	1	590
Prevailing Background	32.6	32.8	33.6	34.8	36.5	38.5	40.6	42.9	45.2	47.5	49.6	

ETSU-R-97 NIGHT-TIME - Dalwyne Cottage(NML3)

Wind Conditions Night-Time



Regression Analysis Night-Time



Wind Speed (m/s)	2	3	4	5	6	7	8	9	10	11	12	Total
Number of data points	71	94	88	71	68	99	45	43	33	21	29	662
Prevailing Background	31	31.7	32.8	34.3	36	38	40.2	42.5	44.9	47.4	49.8	

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ENVIRON

Key

- L_{A90} 10 Minute Measurement Point
- Line of best fit
- Line of best fit flat lined where appropriate (Prevailing Background)
- Excluded Data-Manual exclusion
- Excluded Data-Rain
- Excluded Data-Filtered Wind Direction

N

Scale 1:35,000 @ A3

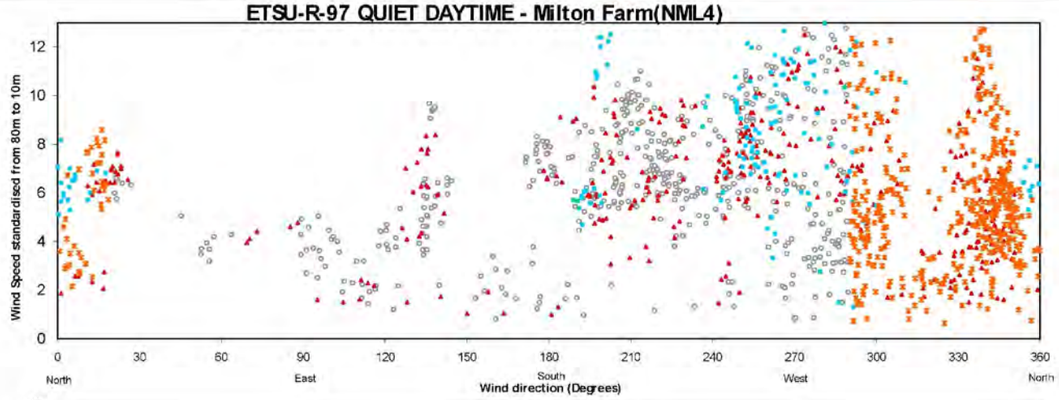
0 0.25 0.5 1 km

Figure 6.2.2c
Wind Condit ions & Regression Analysis
Dalwyne Cottage (NML3)

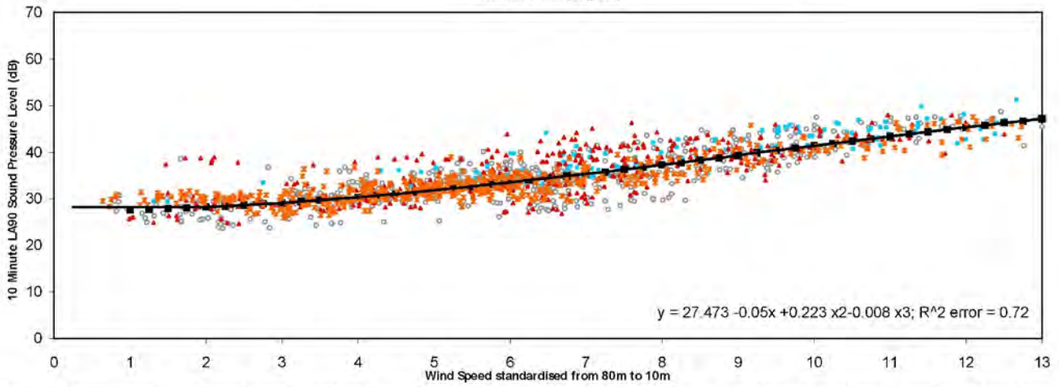
Hadyard Hill Extension Wind Farm
Environmental Statement

ETSU-R-97 QUIET DAYTIME - Milton Farm(NML4)

Wind Conditions Quiet Daytime



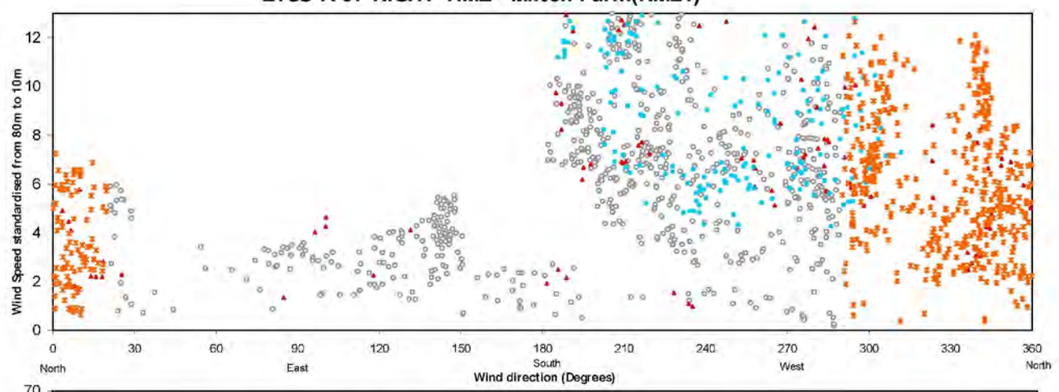
Regression Analysis Quiet Daytime



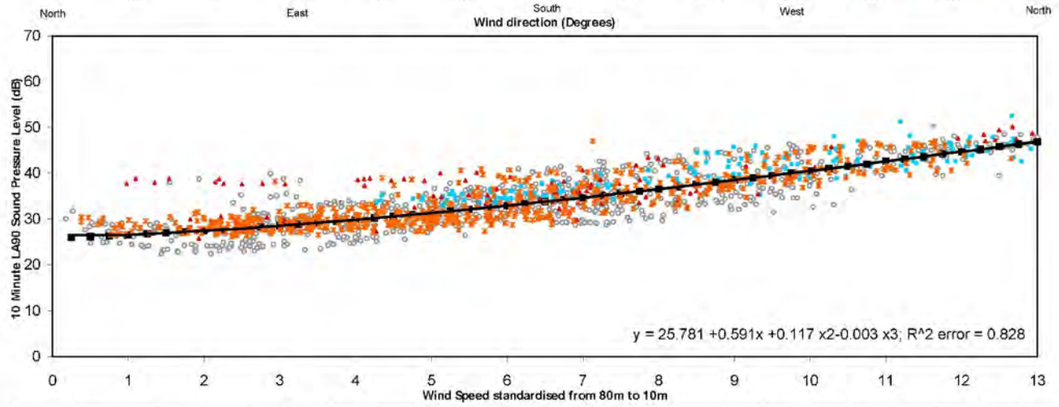
Wind Speed (m/s)	2	3	4	5	6	7	8	9	10	11	12	Total
Number of data points	31	33	48	49	84	71	51	45	37	17	8	474
Prevailing Background	28.2	29.1	30.3	31.8	33.5	35.4	37.3	39.3	41.4	43.4	45.4	

ETSU-R-97 NIGHT-TIME - Milton Farm(NML4)

Wind Conditions Night-Time



Regression Analysis Night-Time



Wind Speed (m/s)	2	3	4	5	6	7	8	9	10	11	12	Total
Number of data points	40	74	80	66	71	101	53	53	40	29	31	638
Prevailing Background	27.4	28.5	29.8	31.3	32.9	34.6	36.5	38.5	40.5	42.6	44.7	

sse

ENVIRON

Key

- L_{A90} 10 Minute Measurement Point
- Line of best fit
- Line of best fit flat lined where appropriate (Prevailing Background)
- Excluded Data-Manual exclusion
- Excluded Data-Rain
- Excluded Data-Filtered Wind Direction

N

Scale 1:35,000 @ A3

0 0.25 0.5 1 km

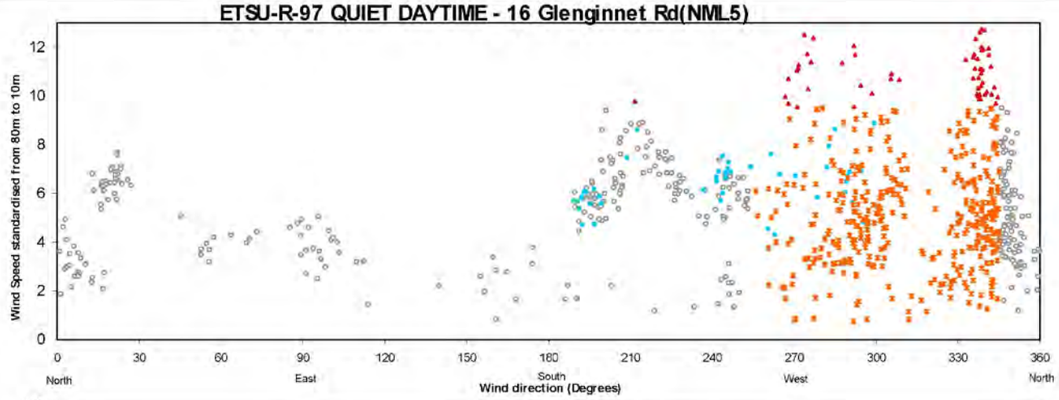
Figure 6.2.2d
Wind Condit ions & Regression Analysis Milton Farm (NML4)

Hadyard Hill Extension Wind Farm Environmental Statement

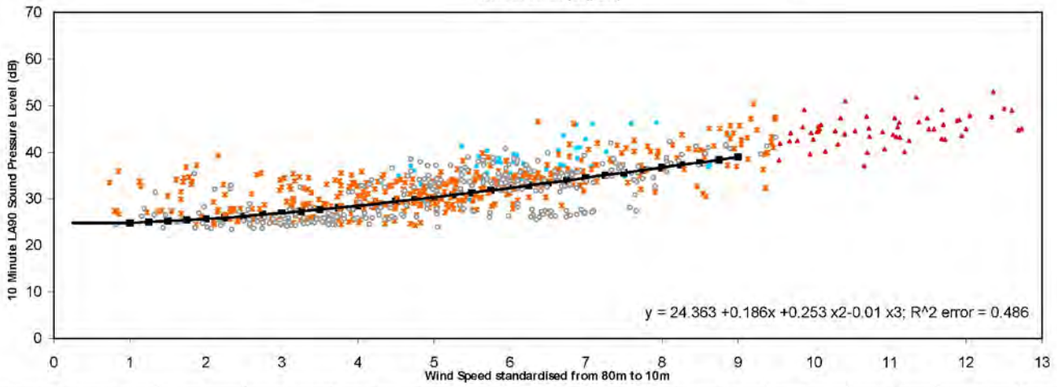
Document Path: P:\CONTRACT\UK196xx\UK1219606 SSE Renewables_Hadyard Hill WF Ext EIA\GIS\Mapfiles\ESFigs\TA6_Noise\UK1219606_Fig6.2.2d_RegressionAnalysis_NML4_A.mxd

ETSU-R-97 QUIET DAYTIME - 16 Glenginnet Rd(NML5)

Wind Conditions Quiet Daytime



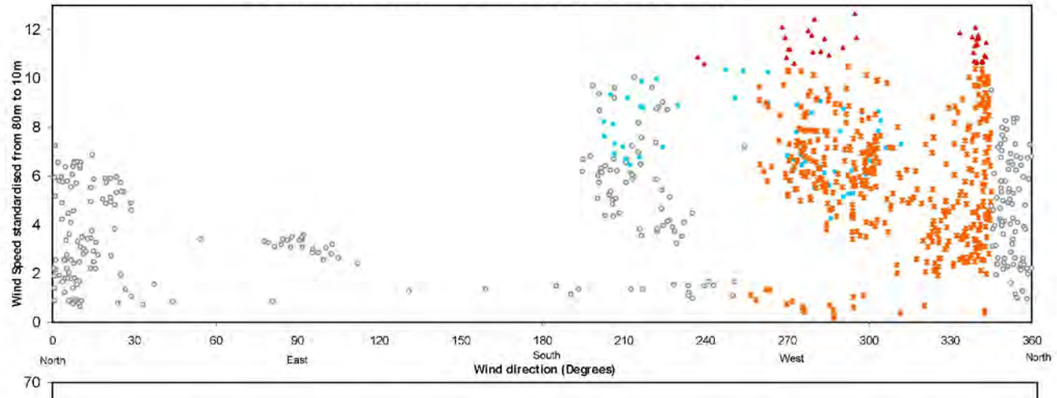
Regression Analysis Quiet Daytime



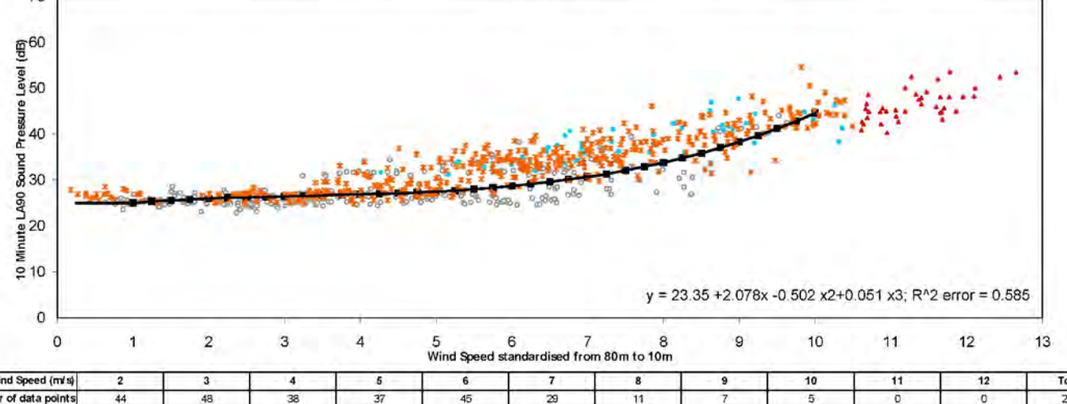
Wind Speed (m/s)	2	3	4	5	6	7	8	9	10	11	12	Total
Number of data points	20	42	48	46	72	50	21	9	0	0	0	308
Prevailing Background	25.7	26.9	28.5	30.3	32.3	34.5	36.7	39	-	-	-	

ETSU-R-97 NIGHT-TIME - 16 Glenginnet Rd(NML5)

Wind Conditions Night-Time



Regression Analysis Night-Time



Wind Speed (m/s)	2	3	4	5	6	7	8	9	10	11	12	Total
Number of data points	44	48	38	37	45	29	11	7	5	0	0	264
Prevailing Background	25.9	26.4	26.9	27.5	28.7	30.7	33.8	38.3	44.6	-	-	

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ENVIRON

Key

- L_{A90} 10 Minute Measurement Point
- Line of best fit
- Line of best fit flat lined where appropriate (Prevailing Background)
- Excluded Data-Manual exclusion
- Excluded Data-Rain
- Excluded Data-Filtered Wind Direction

Scale 1:35,000 @ A3

0 0.25 0.5 1 km

N

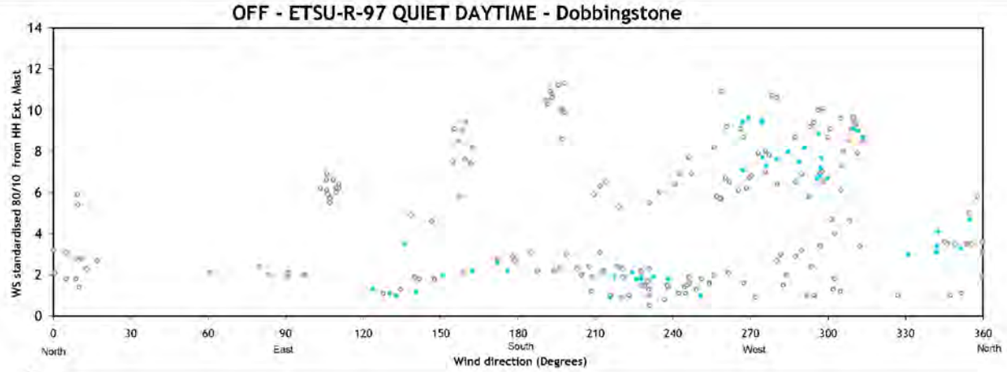
Figure 6.2.2e
Wind Condit ions & Regression Analysis
16 Glenginnet Rd (NML5)

Hadyard Hill Extension Wind Farm
Environmental Statement

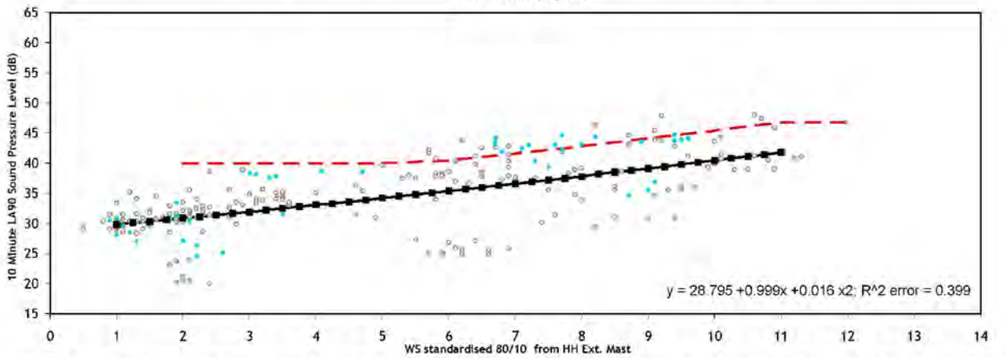
Document Path: P:\CONTRACT\UK196xx\UK1219606 SSE Renewables_Hadyard Hill WF Ext EIA\GIS\Mapfiles\ESFigs\TA6_Noise\UK1219606_Fig6.2.2e_RegressionAnalysis_NML5_A.mxd

OFF - ETSU-R-97 QUIET DAYTIME - Dobbingstone

Wind Conditions Quiet Daytime (OFF)



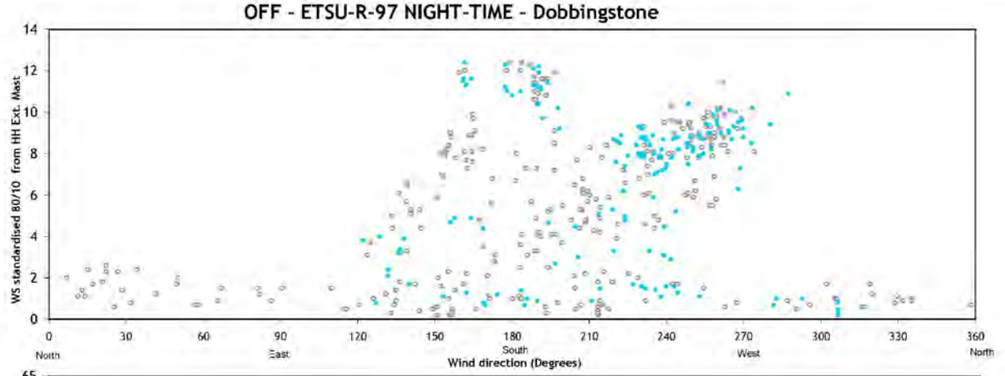
Regression Analysis Quiet Daytime (OFF)



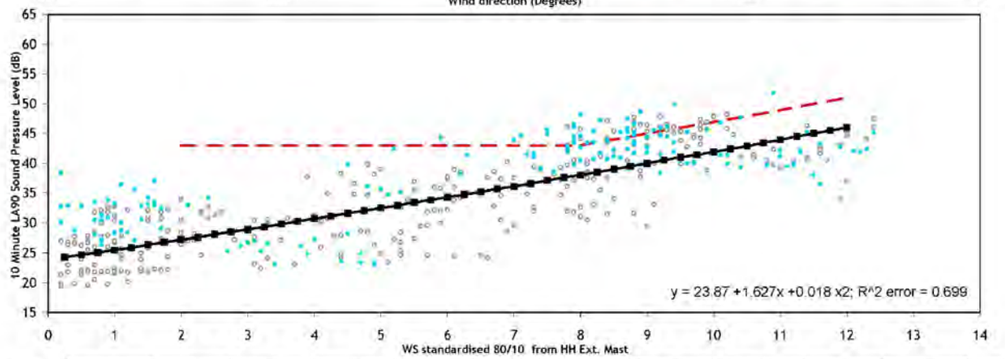
Wind Speed (m/s)	2	3	4	5	6	7	8	9	10	11	12	Total
Number of data points	48	18	7	7	25	19	10	17	11	9	0	171
Average Measured Noise Levels(OFF)	30.9	31.9	33.1	34.2	35.4	36.6	37.8	39.1	40.4	41.8		
Noise Limits	40	40	40	40	40.4	41.6	42.8	44.1	45.4	46.8	46.8	

OFF - ETSU-R-97 NIGHT-TIME - Dobbingstone

Wind Conditions Quiet Daytime (OFF)



Regression Analysis Quiet Daytime (OFF)



Wind Speed (m/s)	2	3	4	5	6	7	8	9	10	11	12	Total
Number of data points	34	11	17	19	22	19	33	29	21	10	12	227
Average Measured Noise Levels(OFF)	27.2	28.9	30.7	32.5	34.3	36.1	38	40	41.9	43.9	46	
Noise Limits	42	42	42	42	42	43	43	45	46.9	48.9	51	

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Key

- LA90 10-Minute Measurement Point (OFF)
- Line of best fit raw (OFF)
- Line of best fit adjusted if required:: Average Measured Noise Levels(OFF)
- ETSU-R-97 Noise Limits
- Excluded Data-Rain

Figure 7.3A.2
Wind Conditions&Regression Analysis (OFF) Dobbingstone

Hadyard Hill Extension Wind Farm Addendum Environmental Statement

purposes of deriving noise limits in accordance with ETSU-R-97 and that would apply during the day-time and night-time periods up to 12 m/s. Tabular values of these background noise levels at integer wind speeds are shown in Tables 3 and 3 for each of the survey locations and for day-time and night-time periods.

6.9 Dersalloch Windfarm was operating during the noise survey and may potentially have influenced measured noise levels. The resident at Knockskae informed us that they had heard wind turbine noise from Dersalloch under downwind conditions. Dersalloch is approximately 3.7 km from Knockskae. Dersalloch Windfarm was not heard during any of the site visits however downwind conditions would generally be with wind directions from approximately 30 to 80 degrees and are less common in the UK. In order to consider whether this may have influenced the survey results, additional data-filters were applied to data from Knockskae, to exclude wind directions from 30 to 80 degrees which would put Knockskae downwind of Dersalloch Windfarm. Figures D13 and D14 of Annex D show that excluded data tend to be present for lower wind speeds and this filtering did not have an acoustically significant effect on the position of the best-fit lines during both day-time and night-time periods. It is concluded that operation of Dersalloch Windfarm during the noise survey did not influence the survey results and these additional filters are not necessary.

Table 2 – Table of background noise levels at integer standardised ten metre wind speeds for each of the survey locations during quiet day-time periods.

Property	1	2	3	4	5	6	7	8	9	10	11	12
Glenalla Farm	29.0	28.7	28.6	28.9	29.6	30.7	32.1	33.7	35.6	37.5	39.2	40.7
Knockskae	25.8	26.5	26.8	27.0	27.4	28.2	29.3	30.8	32.5	34.4	36.0	37.1
Linfairn Farm	30.1	29.6	30.0	30.9	32.0	33.4	34.7	35.9	37.1	38.2	39.3	40.6
Genoch Cottage	34.5	34.3	34.4	34.7	35.2	35.8	36.5	37.2	38.1	39.2	40.6	42.5
Tairlaw Toll Cottage	40.7	39.9	39.6	39.9	40.4	41.3	42.3	43.4	44.5	45.6	46.6	47.5
Tairlaw Toll House	35.0	35.0	35.0	35.2	35.6	36.4	37.6	39.0	40.8	42.7	44.6	46.2

Table 3 – Table of background noise levels at integer standardised ten metre wind speeds for each of the survey locations during night-time periods.

Property	1	2	3	4	5	6	7	8	9	10	11	12
Glenalla Farm	26.6	28.4	29.4	29.9	30.4	30.9	31.7	32.9	34.5	36.3	38.2	40.0
Knockskae	24.3	26.5	27.4	27.6	27.8	28.3	29.4	31.0	33.1	35.4	37.2	38.1
Linfairn Farm	25.4	28.1	30.1	31.6	32.7	33.5	34.1	34.7	35.3	36.2	37.5	39.2
Genoch Cottage	32.5	33.7	34.6	35.4	36.0	36.3	36.5	36.6	36.9	37.5	38.8	40.9
Tairlaw Toll Cottage	38.5	40.5	41.3	41.3	41.2	41.0	41.2	41.9	43.0	44.6	46.4	48.2
Tairlaw Toll House	32.9	34.7	35.5	35.7	35.8	36.0	36.7	37.8	39.4	41.4	43.7	46.0

6.10 Comparing the survey results from Tairlaw Toll Cottage and Tairlaw Toll House indicates that in general water flow noise is around 5 dB(A) lower at low wind speeds to the rear of Tairlaw Toll House than at the side of Tairlaw Toll Cottage. Background noise levels at Tairlaw Toll House at lower wind speeds are similar to those obtained at Genoch Cottage, but increase as wind speeds increase at a slightly greater rate. This greater rate change with wind speed may be indicative of increased exposure of Tairlaw Toll House to the wind, being at approximately 100 metres higher elevation than Genoch Cottage. Tallaminnoch is at a similar elevation (~265 m above datum) to Tairlaw Toll House (~235 m above datum) and might therefore be expected to have similar exposure to the wind. Tallaminnoch

Appendix 9.5

Baseline Noise Conditions

SCOTTISHPOWER RENEWABLES

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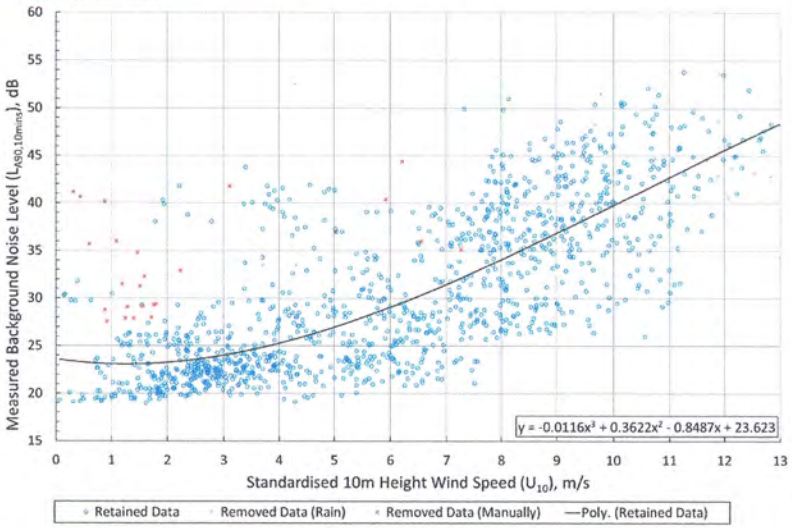
9.1 Carrick Baseline Noise Survey Results

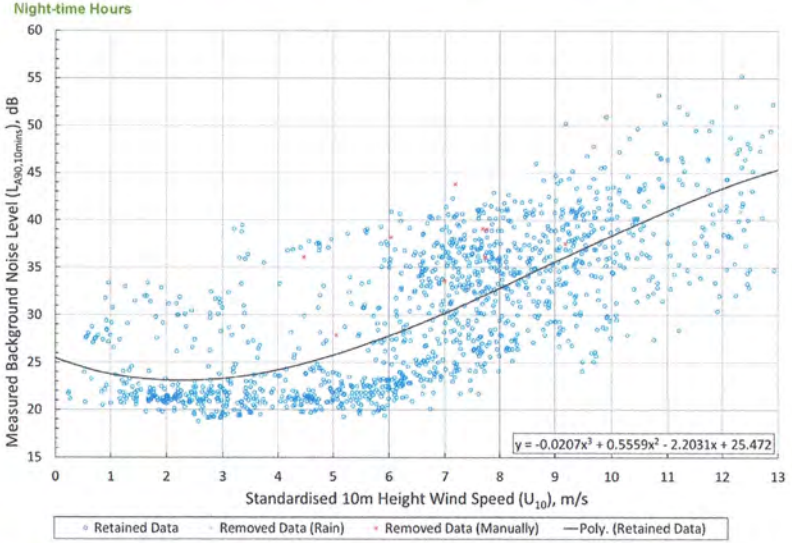
9.1.1 Measurement Location A: Blair Farm

Quiet Daytime Hours



Graph 9.5.1 Location A Blair Farm – Quiet Daytime Background Noise (dB(A)) Versus Wind Speed (m/s)

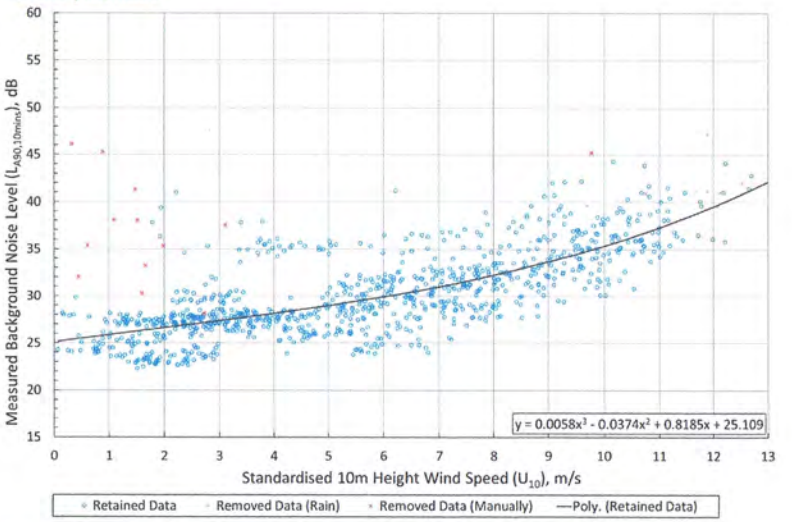
Night-time Hours



Graph 9.5.2 Location A Blair Farm – Night-time Background Noise (dB(A)) Versus Wind Speed (m/s)

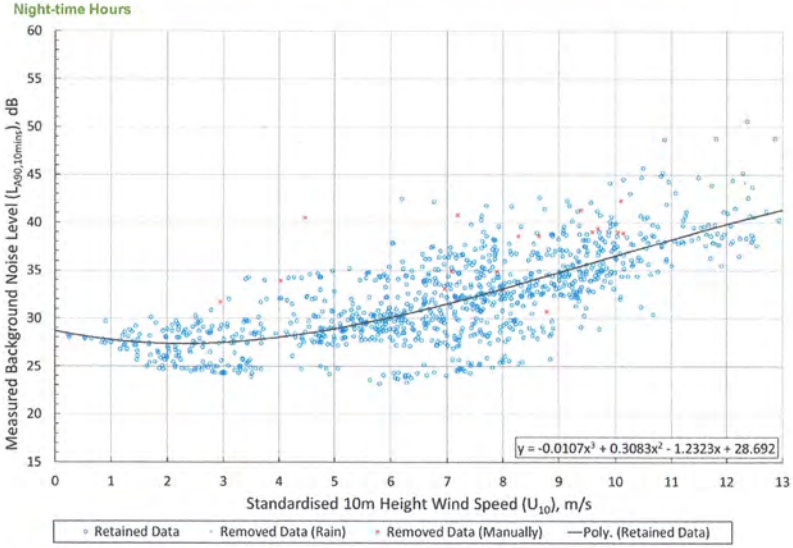
9.1.2 Measurement Location B: Glenalla

Quiet Daytime Hours



Graph 9.5.3 Location B Glenalla – Quiet Daytime Background Noise (dB(A)) Versus Wind Speed (m/s)

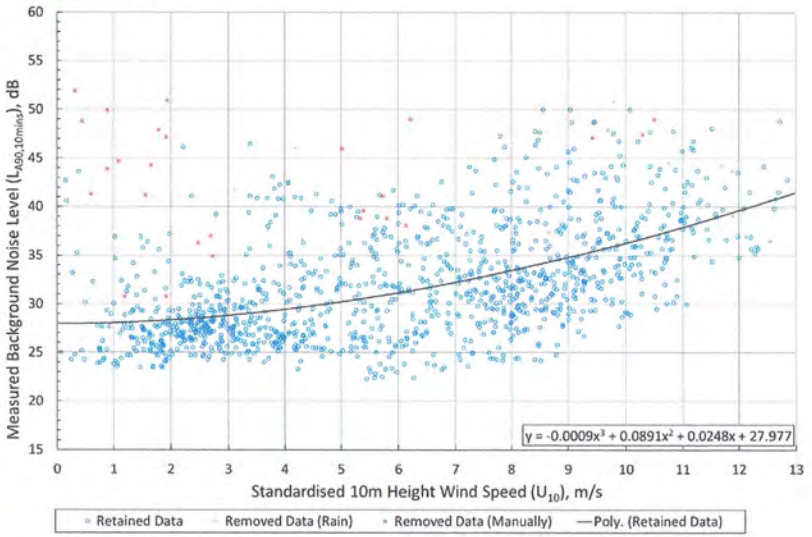
Night-time Hours



Graph 9.5.4 Location B Glenalla – Night-time Background Noise (dB(A)) Versus Wind Speed (m/s)

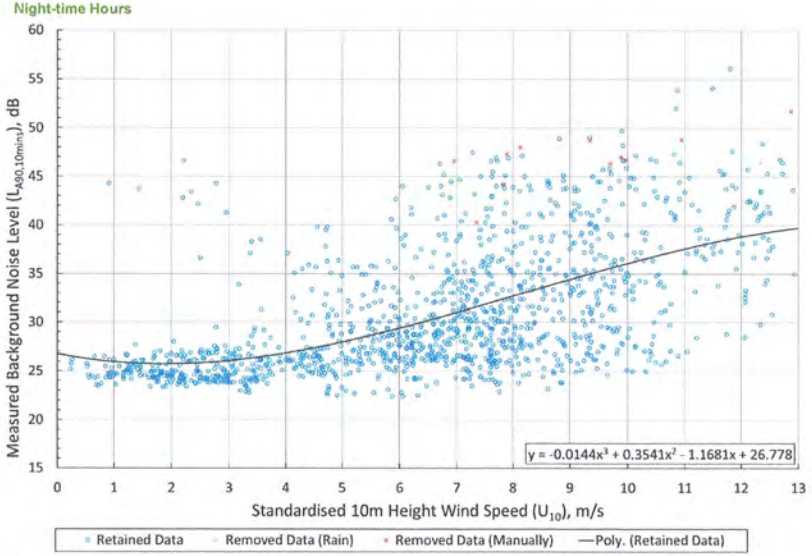
9.1.3 Measurement Location C: Genoch Cottage

Quiet Daytime Hours



Graph 9.5.5 Location C Genoch Cottage – Quiet Daytime Background Noise (dB(A)) Versus Wind Speed (m/s)

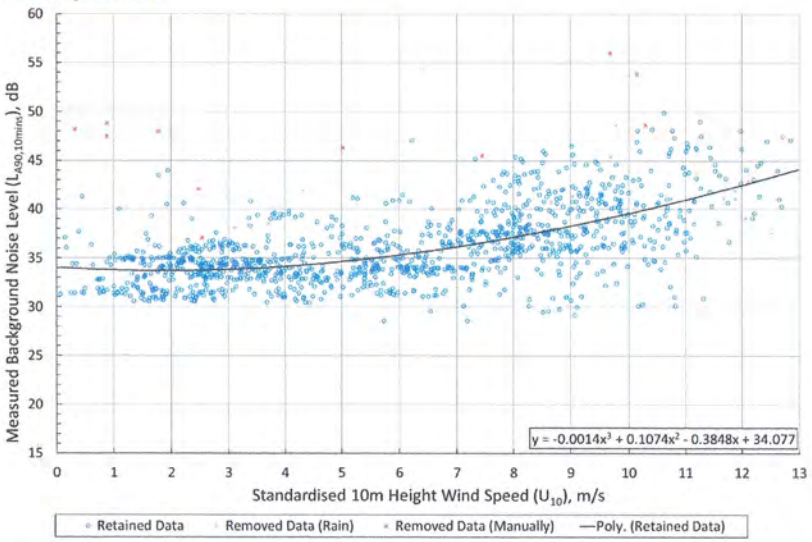
Night-time Hours



Graph 9.5.6 Location C Genoch Cottage – Night-time Background Noise (dB(A)) Versus Wind Speed (m/s)

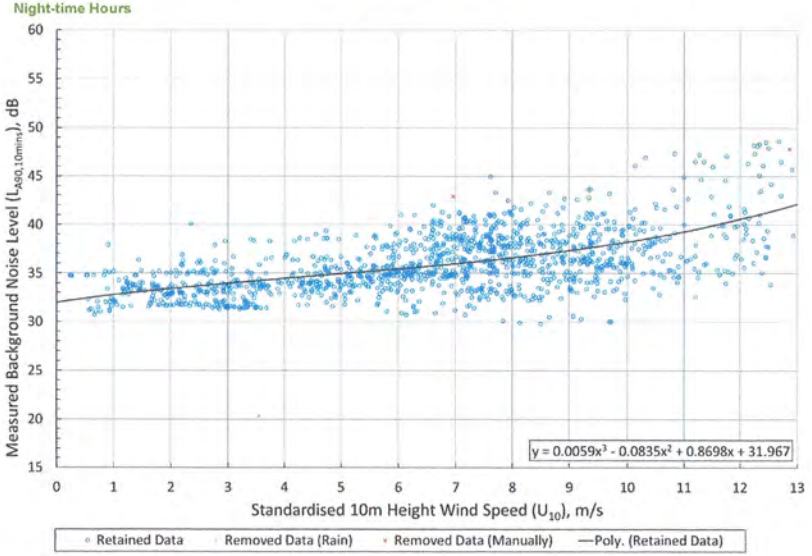
9.1.4 Measurement Location D: Tairlaw Toll

Quiet Daytime Hours



Graph 9.5.7 Location D Tairlaw Toll – Quiet Daytime Background Noise (dB(A)) Versus Wind Speed (m/s)

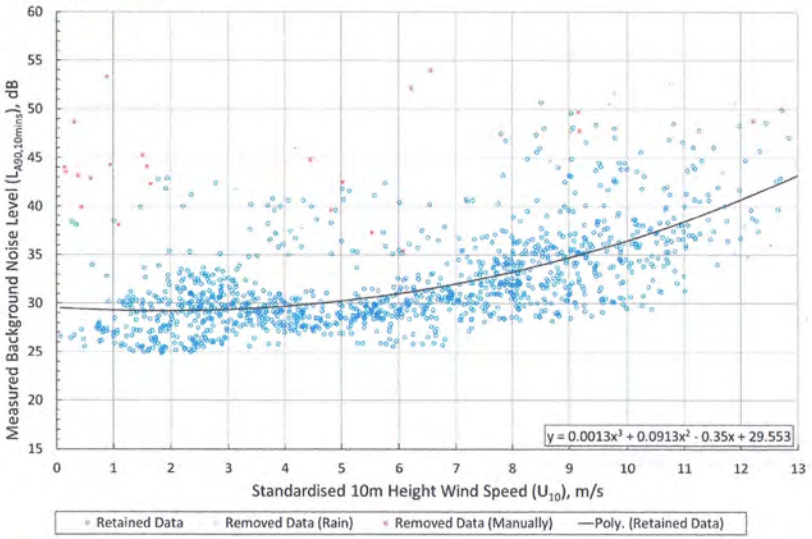
Night-time Hours



Graph 9.5.8 Location D Tairlaw Toll – Night-time Background Noise (dB(A)) Versus Wind Speed (m/s)

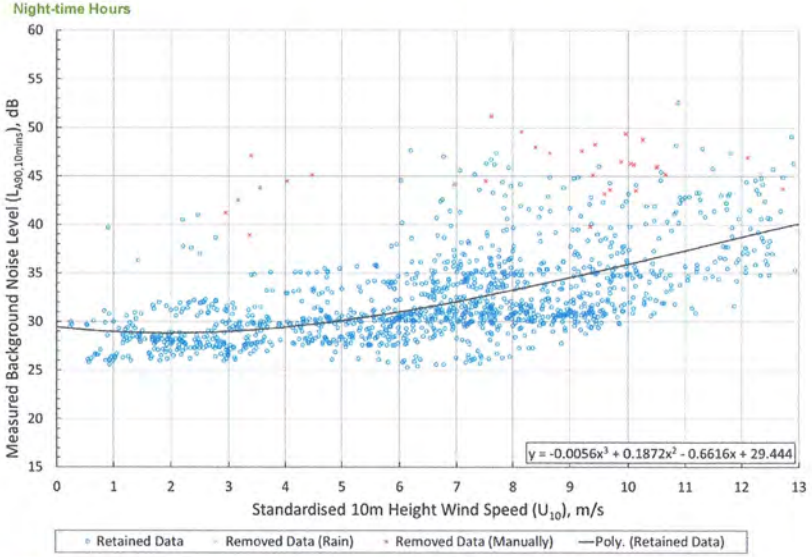
9.1.5 Measurement Location E: White Row

Quiet Daytime Hours



Graph 9.5.9 Location E White Row – Quiet Daytime Background Noise (dB(A)) Versus Wind Speed (m/s)

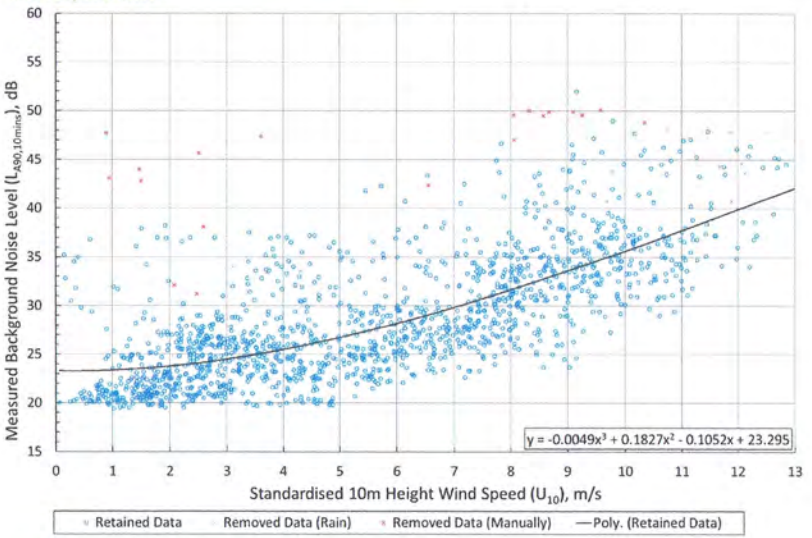
Night-time Hours



Graph 9.5.10 Location E White Row – Night-time Background Noise (dB(A)) Versus Wind Speed (m/s

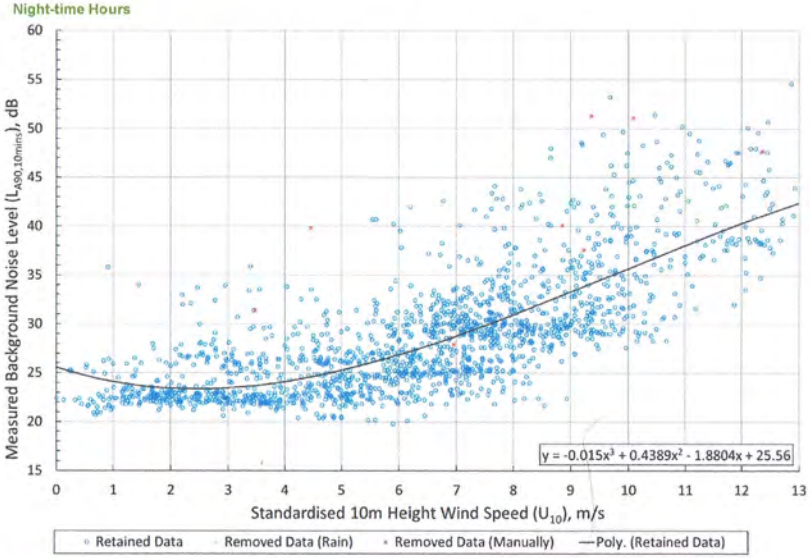
9.1.6 Measurement Location F: Doughty Farm

Quiet Daytime Hours



Graph 9.5.11 Location F Doughty Farm – Quiet Daytime Background Noise (dB(A)) Versus Wind Speed (m/s)

Night-time Hours



Graph 9.5.12 Location F Doughty Farm – Night-time Background Noise (dB(A)) Versus Wind Speed (m/s)

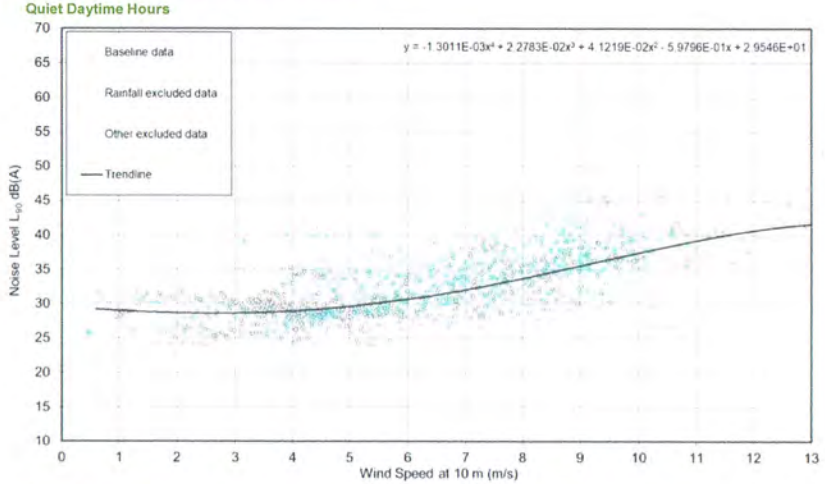
Annex Page 40

9.2 Knockcronal Baseline Noise Survey Results

1. The following baseline assessment graphs have been taken form the publicly available Knockcronal Windfarm Scoping Report.

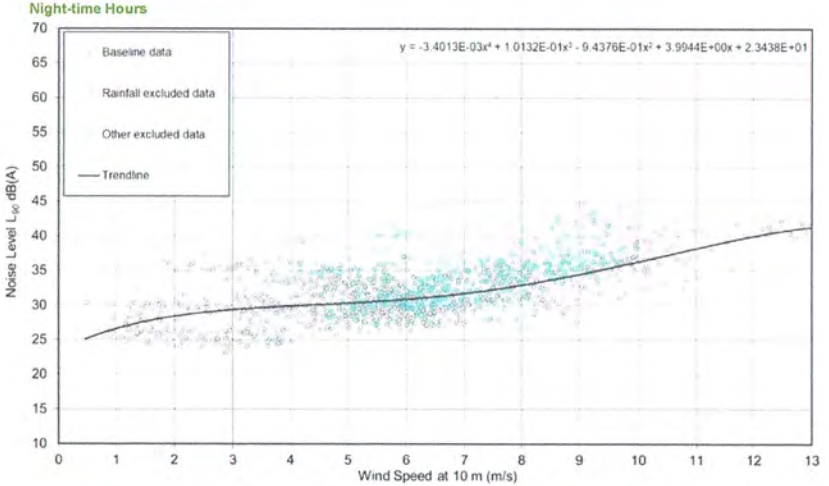
9.2.1 Measurement Location: Glenalla

Quiet Daytime Hours



Graph 9.5.13 Location: Glenalla – Quiet Daytime Background Noise (dB(A)) Versus Wind Speed (m/s)

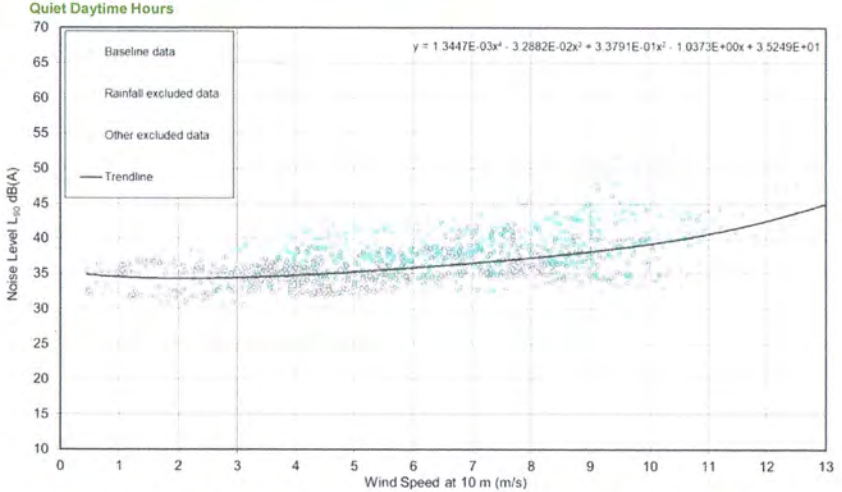
Night-time Hours



Graph 9.5.14 Location: Glenalla – Night-time Background Noise (dB(A)) Versus Wind Speed (m/s)

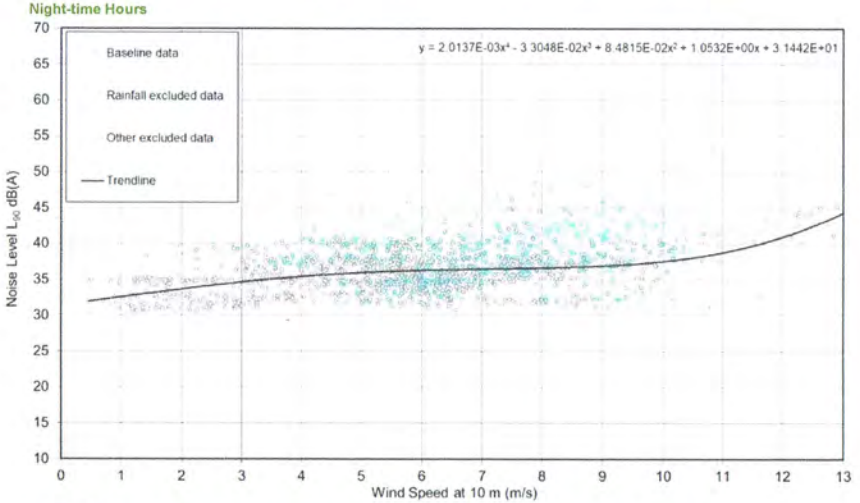
9.2.2 Measurement Location: Genoch Cottage

Quiet Daytime Hours



Graph 9.5.15 Location: Genoch Cottage – Quiet Daytime Background Noise (dB(A)) Versus Wind Speed (m/s)

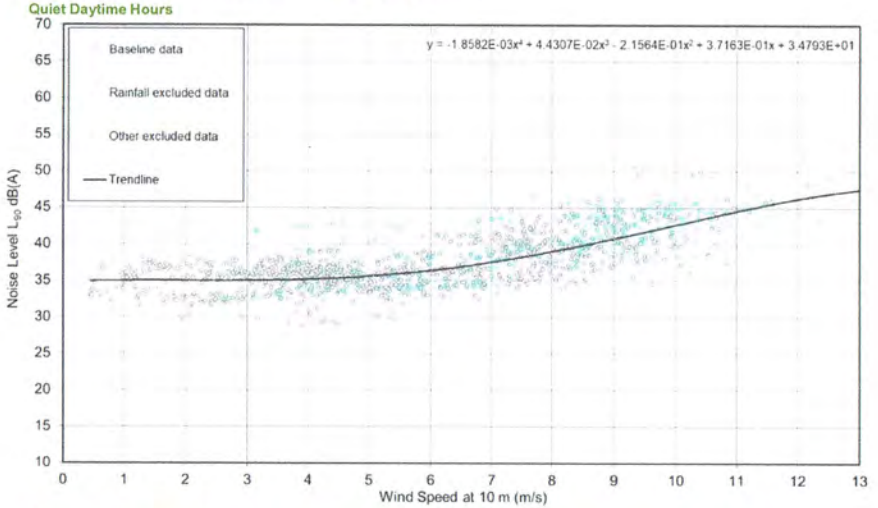
Night-time Hours



Graph 9.5.16 Location: Genoch Cottage – Night-time Background Noise (dB(A)) Versus Wind Speed (m/s)

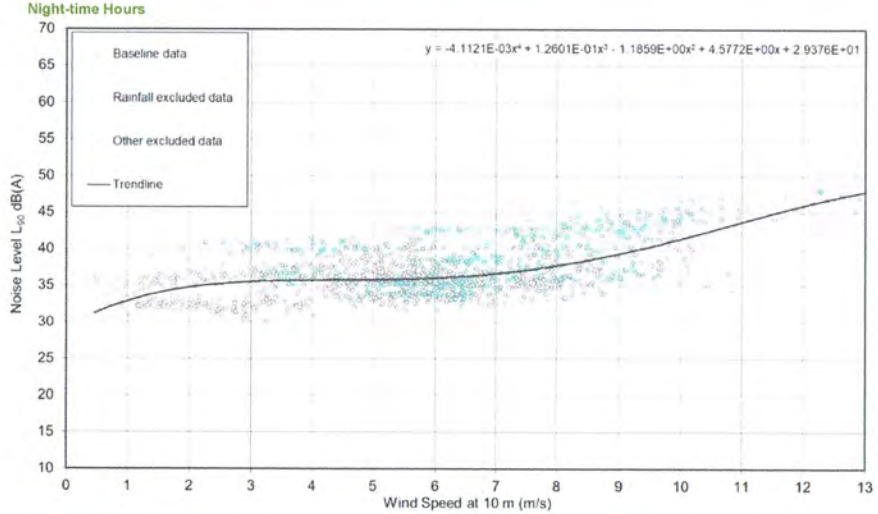
9.2.3 Measurement Location: Tairlaw Toll House

Quiet Daytime Hours



Graph 9.5.17 Location: Tairlaw Toll House – Quiet Daytime Background Noise (dB(A)) Versus Wind Speed (m/s)

Night-time Hours

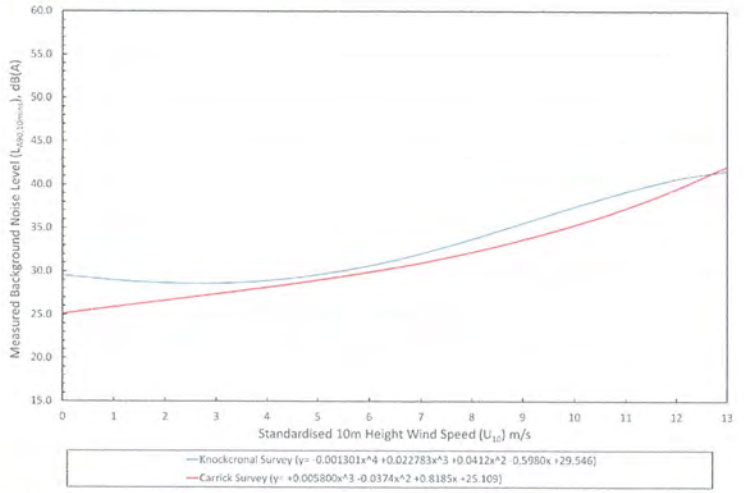


Graph 9.5.18 Location: Tairlaw Toll House – Night-time Background Noise (dB(A)) Versus Wind Speed (m/s)

9.3 Comparison of Carrick and Knockcronal Baseline Survey Results

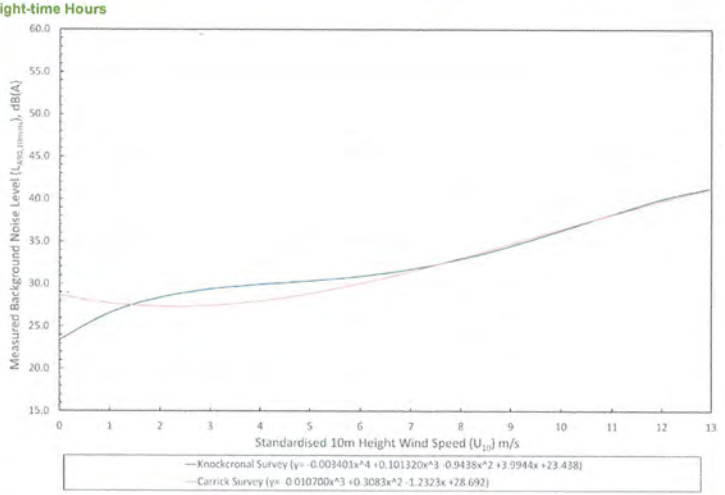
9.3.1 Measurement Location: Glenalla

Quiet Daytime Hours



Graph 9.5.19 Location: Glenalla – Quiet Daytime Background Noise Comparison (dB(A)) Versus Wind Speed (m/s)

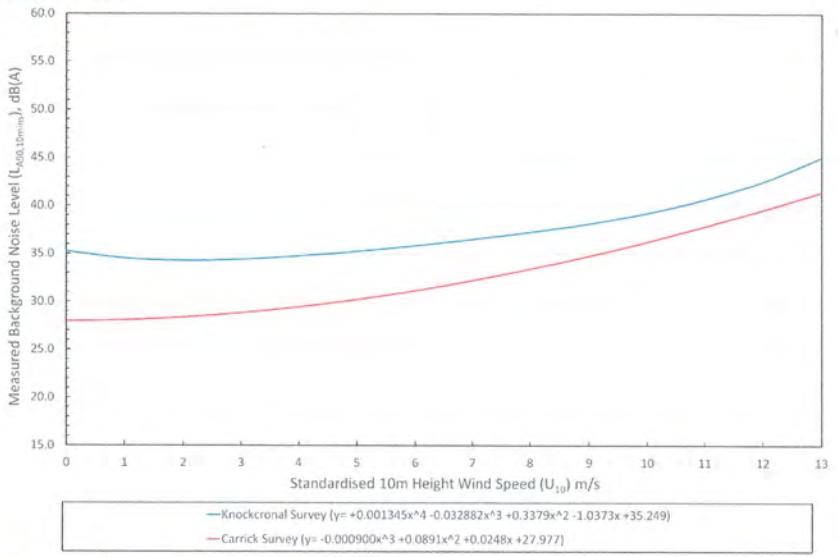
Night-time Hours



Graph 9.5.20 Location: Glenalla – Night-time Background Noise Comparison (dB(A)) Versus Wind Speed (m/s)

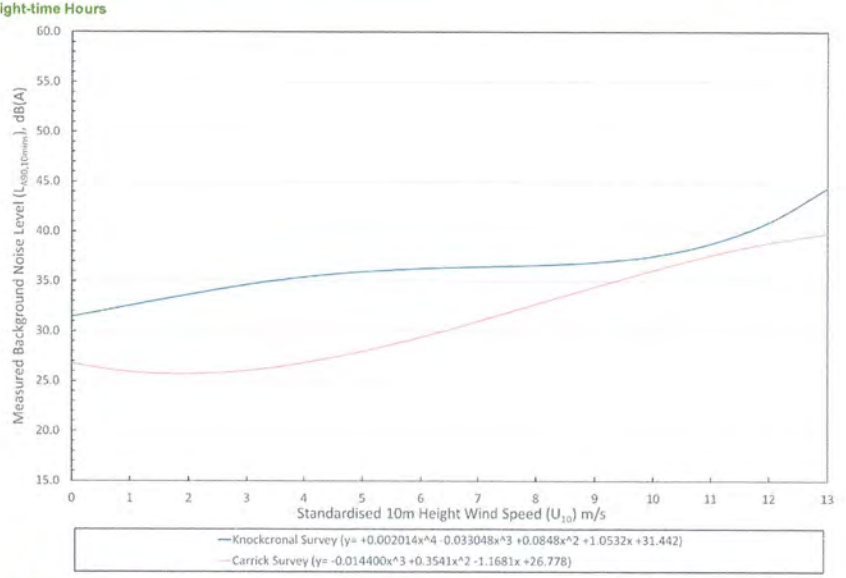
9.3.2 Measurement Location: Genoch Cottage

Quiet Daytime Hours



Graph 9.5.21 Location: Genoch Cottage – Quiet Daytime Background Noise Comparison (dB(A)) Versus Wind Speed (m/s)

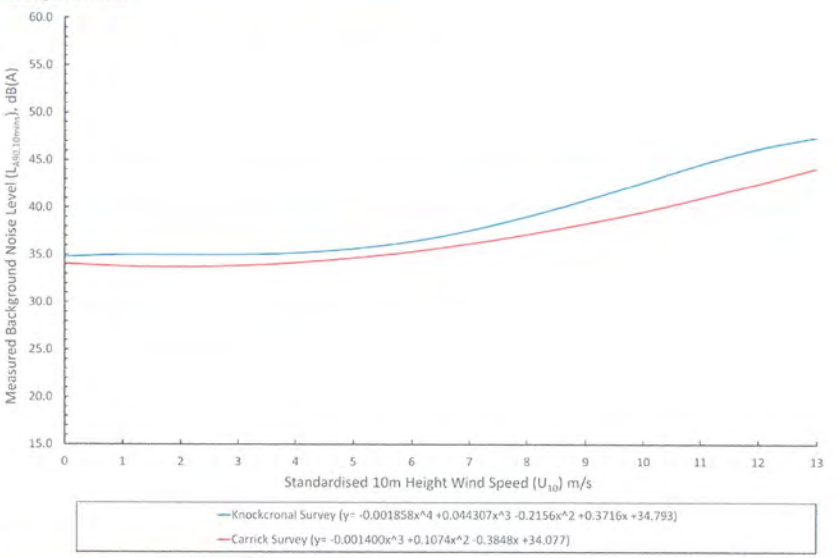
Night-time Hours



Graph 9.5.22 Location: Genoch Cottage – Night-time Background Noise Comparison (dB(A)) Versus Wind Speed (m/s)

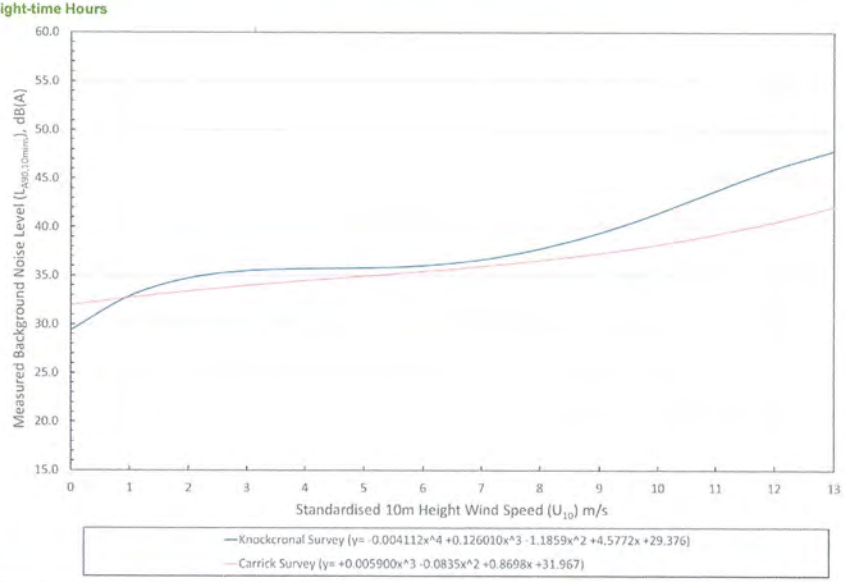
9.3.3 Measurement Location: Tairlaw Toll House

Quiet Daytime Hours



Graph 9.5.23 Location: Tairlaw Toll House – Quiet Daytime Background Noise Comparison (dB(A)) Versus Wind Speed (m/s)

Night-time Hours



Graph 9.5.24 Location: Tairlaw Toll House – Night-time Background Noise Comparison (dB(A)) Versus Wind Speed (m/s)

Carrick Windfarm Project Team

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RENEWABLES

Annex 3 – Wind Shear Adjustments and Wind Shear Report

WIND CONSULTANCY

Report 8801_R126b

Craiginmoddie

Calculation of speed-ups For noise assessment

For TNEI
March 2023

The Wind Consultancy Service
17 Ford Lane
Morton
Bourne
PE10 0RQ

Disclaimer

In receiving this report, the Client accepts that Paul Hannah trading as The Wind Consultancy Service can in no way be held responsible for the application or use of the results and findings reported herein either now or in the future. The Client is, and remains, responsible for the use of such information and any consequences thereof.

Version History

8801_R126	06/03/2023	Original issue
8801_R126a	13/03/2023	Minor corrections
8801_R126b	14/03/2023	Minor corrections

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Calculation of speed-ups for noise assessment - Craiginmoddie

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1. Introduction

1.1. TWCS background

I am Paul Hannah. I am an independent wind energy consultant trading as The Wind Consultancy Service. I specialise in the analysis and assessment of windspeed and direction data collected on potential wind energy projects. I hold the following degrees:

- Bachelor of Engineering (Hons.) in Aeronautical Engineering (Bristol, 1987)
- Master of Science in Atmospheric Sciences (UEA Norwich, 1989)
- Doctor of Philosophy in Windspeed Prediction Techniques (UEA Norwich, 1993)
- Master of Business Administration (Open University, 2004)

I first worked on wind energy projects in 1988 during the project phase of the MSc noted above. My PhD was concerned with computational and statistical methods of windspeed prediction in complex terrain.

Following completion of my PhD, I was employed by National Wind Power (now RWE Renewables UK) for ten years in their Technology Department. During that time, I installed meteorological masts, collected and analysed data from over one hundred masts located in the UK and beyond, and provided the technical elements of wind farm design for more than fifty projects, many of which have become operational.

Since leaving National Wind Power in 2003, I have provided independent technical advice to over two hundred clients covering many hundreds of wind energy projects of all sizes, trading as The Wind Consultancy Service. In addition, since 2006, I have been the UK & Ireland agent for EMD International A/S, a Danish consultancy which provides the windPRO software package to wind energy professionals around the world. Of the 2,500 user organisations worldwide, approximately eighty are located in the UK and Ireland and I provide technical support and training to users as they require.

I am a Member of the Energy Instituite and through them, a Chartered Engineer. I am also a Fellow of the Royal Meteorological Society.

1.2. Client Scope

The Wind Consultancy Service (TWCS) understands that TNEI is advising Energiekontor UK on the noise analysis required as part of a conjoined public inquiry for its Craiginmoddie site with two others. TNEI has asked TWCS to calculate the speed-ups between two locations in the area to enable an appropriate noise assessment to be made.

1.3. Details of the site

This report relates to the proposed project on land 5.1km south-east of Dailly. The site is known as Craiginmoddie. A site visit has not been made in support of this report.

2. Data supplied

2.1. On-site wind data

No on-site wind data have been supplied nor are available through other sources. The assessment will therefore be carried out using data collected or modelled at other locations near the project site.

2.2. Off-site wind data

Off-site windspeed and direction data are available from a range of sources including observed and modelled sources. These sources include data accessible via the online data services provided to active users of EMD's windPRO software[1]. Sources of data may include measured values from the METAR or SYNOP reporting systems as well as modelled data from the MERRA and EMD-WRF datasets.

[1] http://www.emd.dk/windpro

2.3. Client's requirements

Completion of a table of speed-ups between two locations tabulated against effective 10m windspeed at one of the locations, for both Quiet Daytime and Night-time periods as defined by ETSU-R-97[2]. Both mean and standard deviation of speed-ups required.

2.4.The Craiginmoddie site

Figure 1 shows the proposed layout of the Craiginmoddie site. The project is proposed to consist of up to fourteen turbines up to 200m tip height.

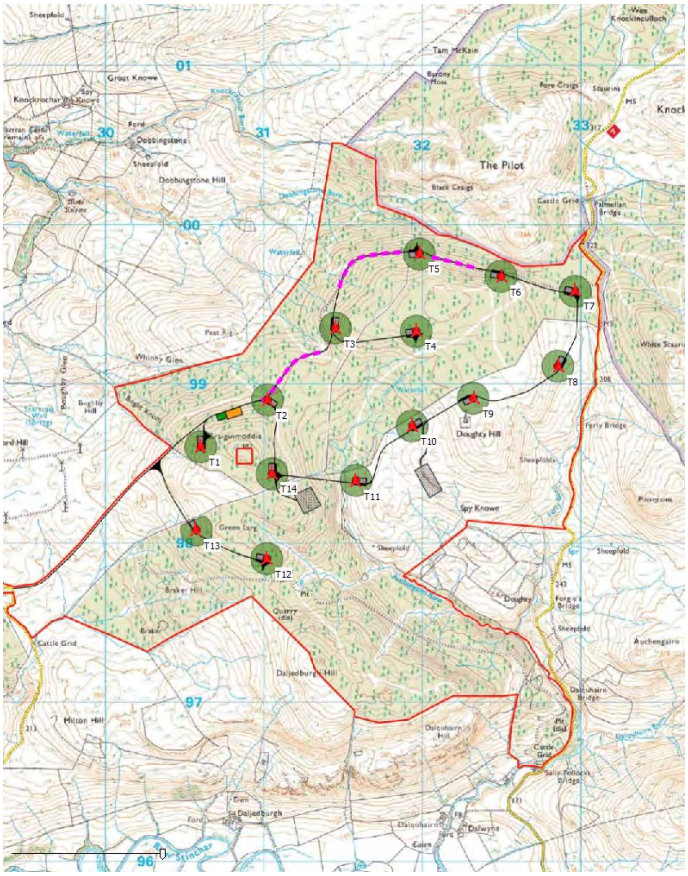


Figure 1. Proposed layout at Craiginmoddie © Crown Copyright, 2023.

2 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/49869/ETSU_Full_copy__Searchable_.pdf

2.5. The speed-up locations

The noise assessment submitted with the Craiginmoddie development referenced background noise levels previously measured for the historic Hadyard Hill Extension Wind Farm (HHExt). This application was withdrawn.

The HHExt assessment set noise limits assuming an 80m hub height. Speed-ups are therefore required between that point and a point at Craiginmoddie at the proposed hub height of 122.5m. Figure 2 shows the locations used to define the speed-ups.

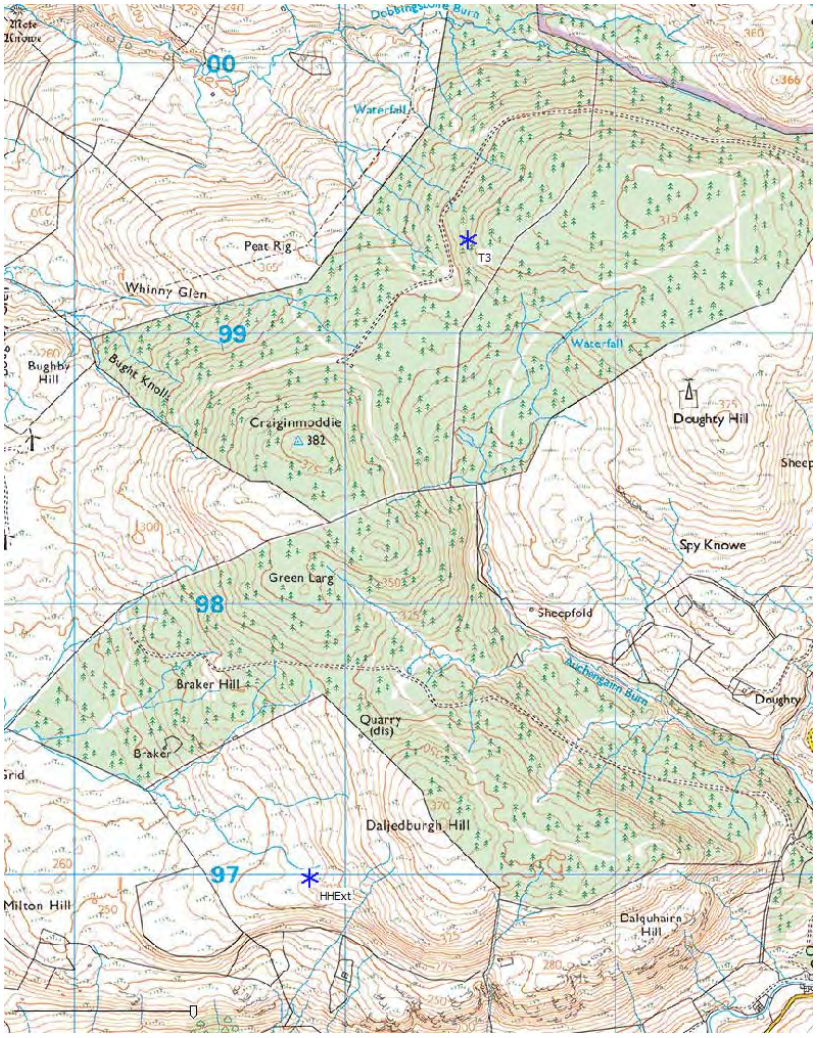


Figure 2. Speed-up locations at Craiginmoddie © Crown Copyright, 2023.

3. Available off-site data

3.1.EMD WRF data

Windspeed and direction data were obtained via the online data service provided to users of windPRO. The EMD online data service allows licenced users of the windPRO software package to access data from various sources across the World including many in the UK.

One such data source windPRO users have access to is EMD WRF data. EMD WRF data are modelled meso-scale data. The data description is as follows:

> *High resolution Meso scale data modelled by EMD (http://www.emd.dk).*
>
> *The meso scale model is run in-house at a spatial resolution of 3x3 km with hourly temporal resolution. ERA5 data from ECMWF (http://www.ecmwf.int) has been used as the global boundary data set. The data set covers most parts of Europe.*

The nearest grid-cell to Craiginmoddie was located within the site. The data were supplied as hourly statistics of windspeed, direction, temperature and pressure. The data begin in January 2003 and run through until December 2022.

3.2.Scaling of EMD-WRF data

To validate the approach, the regional wind atlas created from the EMD-WRF data was used to estimate the production at the existing nearby project at Assel Valley, 10km west of Craiginmoddie. The nearer project at Hadyard Hill was discounted due to inconsistent production data records.

Assel Valley has been operational since 2016 and therefore has a long enough timeline of production that can be used to estimate the long-term production. The value is 33.6% expressed as a capacity factor (for the period after construction and until the neighbouring Tralorg project became operational in late 2020).

By plotting monthly reported generation (expressed as a capacity factor) against monthly values of a normalised wind index (the index is created by dividing the monthly WRF windspeed by the long-term mean, such that the index has an overall average of 1.00), the slope and intercept of a best-fit line can be used to estimate the long-term capacity factor. The plot is shown in Figure 3. Using this method eliminates any bias in the monthly values used.

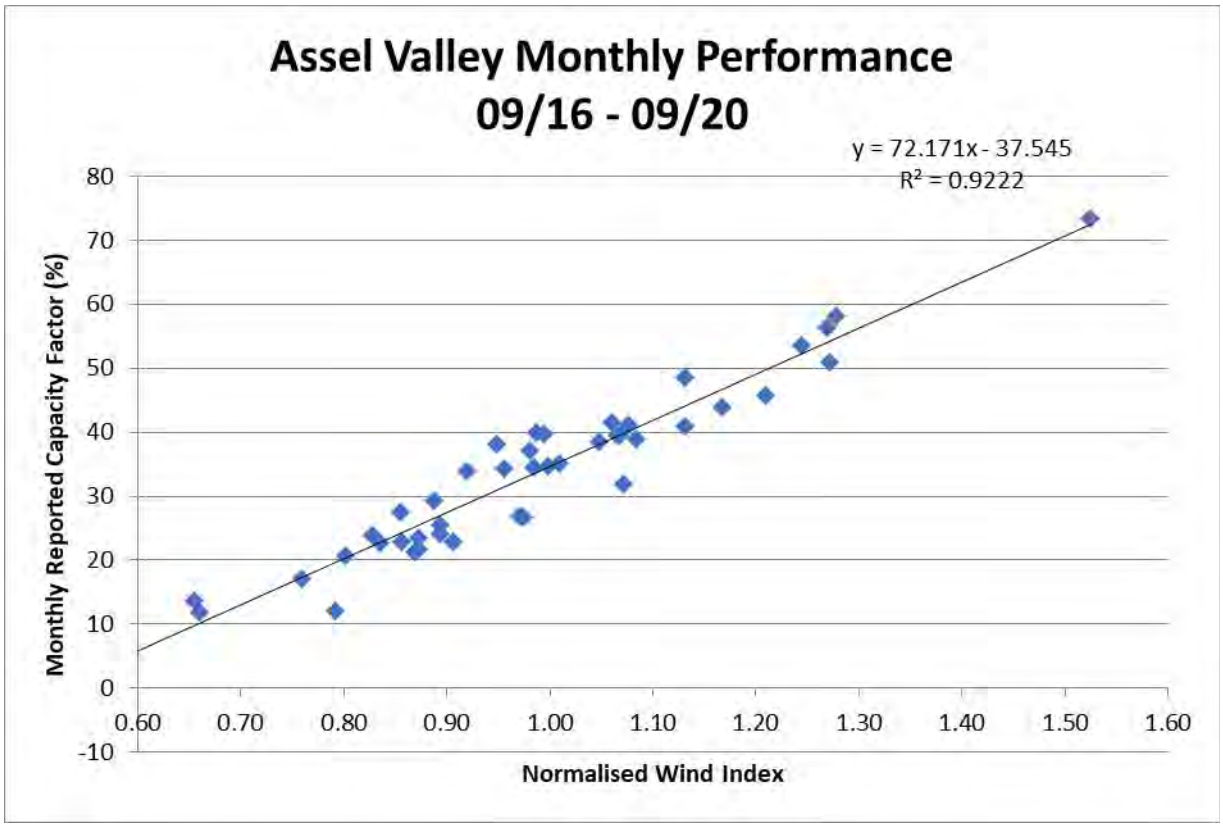


Figure 3. Monthly performance of Assel Valley.

Clearly, there is some uncertainty surrounding the published production figures as these may include periods of poor availability, under-performance due to power curve issues, grid availability and other issues. Where obvious, outliers have been removed. Nevertheless, it is a reasonable approach given the lack of useable data at the site. In total, 90% of the available data from 2016 – 2020 were used.

The results from the application of the data to the site are shown in Appendix A. A nominal 10.0% was applied to the gross energy estimate to account for cabling losses, availability, etc.

The initial predicted capacity factor was 43.3%. An adjustment was made to the original wind data to decrease the prediction to values closer to the estimate figure derived from the production data of 33.6%. The adjustment was a factor of 0.8565 to the original EMD-WRF windspeeds.

4. Speed-up estimation at Craiginmoddie

4.1. Methodology

The long-term corrected EMD-WRF data were used as initialisation data for WAsP-CFD[3]. WAsP-CFD is one of the wind energy calculation engines used by windPRO. WAsP CFD enables windPRO users to calculate the wind resources in semi-complex or complex terrains.

Contour data were derived from three sources:

- On the site itself (encompassing both the speed-up locations): OS Terrain 5 5m gridded data sourced from Ordnance Survey[4] as 5m contours
- Further afield: lidar data from the Scottish Government[5] (10m grid) as 5m contours
- To extend out to the distances required by WAsP-CFD, OS Terrain 50 10m contours[6] - the overall area covered was 50km x 50km.

Roughness data were obtained via the Corine 2018 project[7], and this was supplemented with more detailed digitisation of roughness features within proximity to the speed-up sites and other areas of interest including neighbouring windfarms - the overall area covered was 60km x 60km. The felling plan for Craiginmoddie was incorporated.

windPRO v3.6.363 was then run in the time domain, so that a time-series of predicted windspeeds was created for each speed-up location. Each location was modelled as a wind turbine of the appropriate hub height (HHExt – 80m; Craiginmoddie T3: 122.5m), however no wake model was used.

The resultant time-series were then processed to create the speed-ups and appropriate filters were used to select data for the periods as defined in ETSU-R-97:

[3] https://www.emd-international.com/windpro/cfd/wasp-cfd/
[4] https://beta.ordnancesurvey.co.uk/products/os-terrain-5
[5] https://remotesensingdata.gov.scot/
[6] https://beta.ordnancesurvey.co.uk/products/os-terrain-50
[7] https://help.emd.dk/mediawiki/index.php?title=Corine_Land_Cover

Quiet Daytime:

- All evenings from 18:00 – 23:00
- Saturday afternoons from 13:00 – 18:00
- All day Sunday from 07:00 – 18:00

Night-time:

- All days from 23:00 – 07:00

4.2.Results

The results of the speed-up calculations are shown overleaf.

The results will be used by TNEI to estimate corrections for the background noise characteristics of the site in order to complete a noise assessment.

Wind speed at HHext standardised to 10 m	1	2	3	4	5	6	7	8	9	10	11	12
Average speed up factor	1.157	1.152	1.154	1.160	1.172	1.174	1.172	1.167	1.162	1.155	1.150	1.148
Standard deviation of the speed up factor	0.255	0.136	0.109	0.087	0.071	0.056	0.048	0.043	0.041	0.040	0.038	0.037

Table 1. Predicted speed-up statistics: Quiet Daytime.

Wind speed at HHext standardised to 10 m	1	2	3	4	5	6	7	8	9	10	11	12
Average speed up factor	1.127	1.141	1.159	1.168	1.179	1.182	1.179	1.175	1.165	1.159	1.152	1.145
Standard deviation of the speed up factor	0.279	0.166	0.128	0.102	0.079	0.057	0.043	0.039	0.038	0.037	0.036	0.034

Table 2. Predicted speed-up statistics: Night-time.

5. Conclusions

Speed-ups between two locations at the site known as Craiginmoddie have been prepared on behalf of TNEI to assist with noise prediction modelling.

Off-site wind data were scaled to match the long-term production of a neighbouring wind farm

These scaled data were then used with detailed terrain and roughness data in a CFD model to produce results for the area and to estimate a time-series of windspeeds at two locations, modelled as appropriately-sized wind turbines (with no wake effects).

The speed-ups were filtered by windspeed and by ETSU-R-97 period to produce two summary tables of mean and standard deviation of speed-up, for quiet daytime and night-time.

Speed-up values were generally consistent across the windspeed range assessed, and the standard deviation decreased with increasing windspeed.

Appendix A. CFD results

Technical University of Denmark

WAsP CFD Calculation Report

JobID: 4C95B3FF-D221-4222-97CD-34DB3DC0D997
Calculation Start: Sun Mar 5 17:26:27 2023
Calculation Stop: Sun Mar 5 17:48:34 2023
Process time: 94 CPU hours (EllipSys3D)

Server Information: Cerebrum EMD International
WAsP CFD version: 1.11.2.6
Client: WindPRO 3.6.365
User: mail@windconsult.co.uk

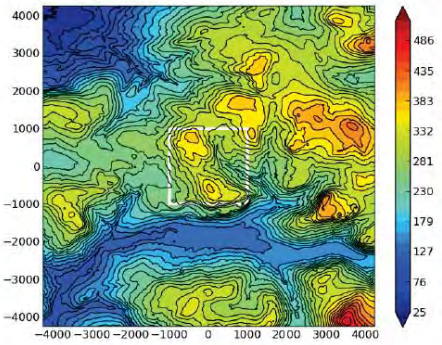
Simulations Overview

Dir	*Ok?*	*log(r)*	*Iteration*	Z_{0ref}	Z_{ref}
0.0	yes	-4.320	1734	0.0323	83.8
10.0	yes	-4.324	1695	0.1090	91.9
20.0	yes	-4.325	1706	0.0781	164.3
30.0	yes	-4.319	1631	0.0966	147.9
40.0	yes	-4.316	1603	0.1104	243.9
50.0	yes	-4.318	1610	0.1298	279.7
60.0	yes	-4.318	1620	0.0936	318.3
70.0	yes	-4.304	1683	0.0979	281.2
80.0	yes	-4.302	1750	0.0986	299.7
90.0	yes	-4.313	1765	0.0733	280.0
100.0	yes	-4.304	1767	0.1016	309.6
110.0	yes	-4.304	1763	0.1062	289.5
120.0	yes	-4.301	1760	0.0914	337.4
130.0	yes	-4.309	1616	0.1088	450.0
140.0	yes	-4.309	1612	0.1036	517.0
150.0	yes	-4.327	1669	0.1252	275.9
160.0	yes	-4.306	1720	0.1735	250.1
170.0	yes	-4.307	1768	0.1394	268.1
180.0	yes	-4.304	1714	0.1456	179.6
190.0	yes	-4.304	1641	0.1586	179.9
200.0	yes	-4.310	1628	0.1489	173.9
210.0	yes	-4.323	1635	0.1281	191.9
220.0	yes	-4.325	1632	0.0987	133.9
230.0	yes	-4.303	1601	0.0638	125.8
240.0	yes	-4.327	1629	0.0418	197.4
250.0	yes	-4.325	1817	0.0260	170.3
260.0	yes	-4.308	1859	0.0183	30.4
270.0	yes	-4.306	1669	0.0156	9.0
280.0	yes	-4.327	1671	0.0146	8.3
290.0	yes	-4.307	1700	0.0111	7.2
300.0	yes	-4.317	1740	0.0116	7.4
310.0	yes	-4.328	1734	0.0143	10.7
320.0	yes	-4.309	1674	0.0048	13.2
330.0	yes	-4.304	1662	0.0112	63.7
340.0	yes	-4.317	1686	0.0235	109.1
350.0	yes	-4.327	1719	0.0276	168.8

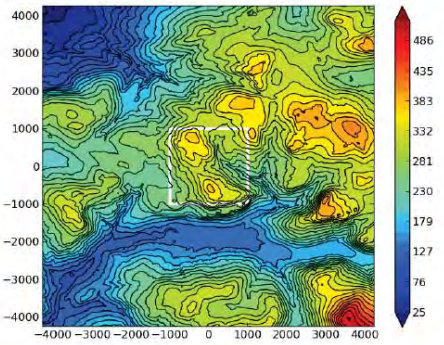
Dir the simulated direction in degrees
Ok? is convergence achieved? ($log(r) \leq -4.3$)
log(r) the end-residual (max of all variables)
Iteration iteration steps used to reach convergence
Z_{0ref} the mesoscale reference roughness in metres
Z_{ref} the farfield terrain height in metres

Simulations Setup

1. The figure shows the user specified height contours of the inner part of the domain including the 2 by 2 km WAsP CFD tile.



2. The figure shows the terrain prepared for CFD. The terrain was filtered and gently flattened in the farfield (not seen) before the computational grid was made.



3. A polar CFD domain was used; domain dimensions and mean resolution of the inner 4 by 4 km area:

Number of Grid Points	7 mill
Domain Height/Diameter	14/34 km
Mean Resolution Horizontal/Vertical	20.7/5 m

4. Convective terms were discretized using the third order QUICK scheme and the $k-\epsilon$ eddy-viscosity model of Launder and Spalding (1974) was used:

C_μ	σ_k	σ_ε	$C_{\varepsilon 1}$	$C_{\varepsilon 2}$	κ
0.052	1.0	1.3	1.38	1.92	0.4

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Department of Wind Energy

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Technical University of Denmark DTU

WAsP CFD Calculation Report

JobID: 1976EF1B-A272-470C-85DE-154D2C488A29
Calculation Start: Sun Mar 5 17:26:28 2023
Calculation Stop: Sun Mar 5 17:59:11 2023
Process time: 93 CPU hours (EllipSys3D)

Server Information: Cerebrum EMD International
WAsP CFD version: 1.11.2.6
Client: WindPRO 3.6.365
User: mail@windconsult.co.uk

Simulations Overview

Dir	*Ok?*	*log(r)*	*Iteration*	Z_{0ref}	Z_{ref}	*Dir*	*Ok?*	*log(r)*	*Iteration*	Z_{0ref}	Z_{ref}
0.0	yes	-4.313	1678	0.0309	89.9	180.0	yes	-4.323	1721	0.1512	204.5
10.0	yes	-4.321	1717	0.0853	77.7	190.0	yes	-4.316	1716	0.1440	194.0
20.0	yes	-4.307	1838	0.0654	116.0	200.0	yes	-4.341	1668	0.1617	196.8
30.0	yes	-4.336	1793	0.0906	164.5	210.0	yes	-4.318	1609	0.1134	189.9
40.0	yes	-4.326	1666	0.1087	190.9	220.0	yes	-4.305	1596	0.1031	171.9
50.0	yes	-4.315	1612	0.1298	217.7	230.0	yes	-4.320	1588	0.0801	147.6
60.0	yes	-4.302	1619	0.0968	261.7	240.0	yes	-4.325	1722	0.0471	137.6
70.0	yes	-4.303	1591	0.1173	266.3	250.0	yes	-4.316	1901	0.0277	107.9
80.0	yes	-4.302	1649	0.0985	273.8	260.0	yes	-4.316	1878	0.0157	39.8
90.0	yes	-4.307	1779	0.0765	292.5	270.0	yes	-4.317	1737	0.0145	11.2
100.0	yes	-4.306	1871	0.0574	303.9	280.0	yes	-4.305	1693	0.0138	8.2
110.0	yes	-4.326	1793	0.1651	299.2	290.0	yes	-4.329	1706	0.0121	8.1
120.0	yes	-4.308	1732	0.1129	307.6	300.0	yes	-4.316	1682	0.0116	8.9
130.0	yes	-4.308	1635	0.1237	369.1	310.0	yes	-4.306	1688	0.0109	10.3
140.0	yes	-4.309	1612	0.0763	449.0	320.0	yes	-4.301	1771	0.0043	17.7
150.0	yes	-4.304	1702	0.1013	383.1	330.0	yes	-4.305	1802	0.0131	73.8
160.0	yes	-4.308	1835	0.1538	259.6	340.0	yes	-4.309	1721	0.0239	160.4
170.0	yes	-4.318	1813	0.1461	220.2	350.0	yes	-4.308	1713	0.0276	144.8

Dir	the simulated direction in degrees
Ok?	is convergence achieved? ($log(r) \leq -4.3$)
log(r)	the end-residual (max of all variables)
Iteration	iteration steps used to reach convergence
Z_{0ref}	the mesoscale reference roughness in metres
Z_{ref}	the farfield terrain height in metres

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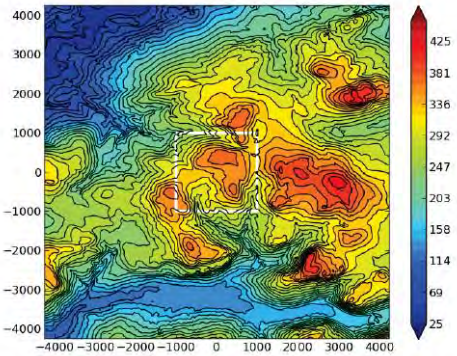
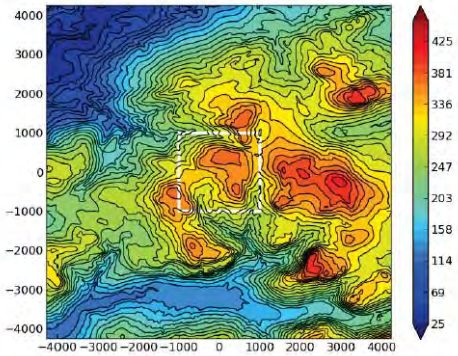


2. The figure shows the terrain prepared for CFD. The terrain was filtered and gently flattened in the farfield (not seen) before the computational grid was made.



3. A polar CFD domain was used; domain dimensions and mean resolution of the inner 4 by 4 km area:

Number of Grid Points	7 mill
Domain Height/Diameter	14/34 km
Mean Resolution Horizontal/Vertical	20.7/5 m

4. Convective terms were discretized using the third order QUICK scheme and the $k-\epsilon$ eddy-viscosity model of Launder and Spalding (1974) was used:

C_μ	σ_k	σ_ε	$C_{\varepsilon 1}$	$C_{\varepsilon 2}$	κ
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WAsP CFD Calculation Report

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Calculation Start: Sun Mar 5 17:49:31 2023
Calculation Stop: Sun Mar 5 18:21:36 2023
Process time: 94 CPU hours (EllipSys3D)

Server Information: Cerebrum EMD International
WAsP CFD version: 1.11.2.6
Client: WindPRO 3.6.365
User: mail@windconsult.co.uk

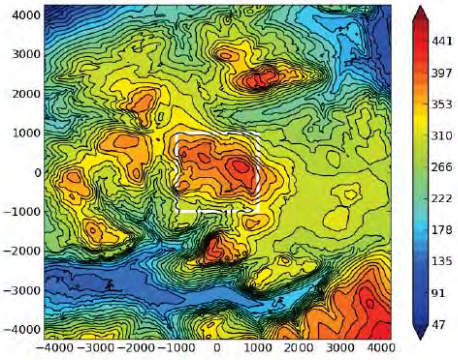
Simulations Overview

Dir	*Ok?*	*log(r)*	*Iteration*	Z_{0ref}	Z_{ref}	*Dir*	*Ok?*	*log(r)*	*Iteration*	Z_{0ref}	Z_{ref}
0.0	yes	-4.315	1569	0.0946	60.5	180.0	yes	-4.306	1632	0.1208	264.3
10.0	yes	-4.323	1682	0.0794	103.1	190.0	yes	-4.311	1709	0.1495	197.3
20.0	yes	-4.314	1830	0.0805	167.3	200.0	yes	-4.306	1704	0.1436	197.0
30.0	yes	-4.318	1729	0.1151	182.3	210.0	yes	-4.338	1670	0.1406	219.9
40.0	yes	-4.317	1607	0.1123	253.9	220.0	yes	-4.321	1632	0.1277	196.8
50.0	yes	-4.304	1593	0.0796	196.7	230.0	yes	-4.302	1594	0.1006	196.7
60.0	yes	-4.317	1616	0.0646	162.8	240.0	yes	-4.318	1596	0.0529	128.2
70.0	yes	-4.323	1682	0.0925	184.1	250.0	yes	-4.320	1671	0.0329	144.0
80.0	yes	-4.330	1752	0.0934	267.3	260.0	yes	-4.304	1808	0.0198	189.2
90.0	yes	-4.320	1766	0.0806	224.6	270.0	yes	-4.302	1815	0.0201	25.3
100.0	yes	-4.312	1785	0.0494	312.9	280.0	yes	-4.303	1809	0.0185	31.3
110.0	yes	-4.324	1755	0.1388	245.0	290.0	yes	-4.308	1626	0.0188	29.5
120.0	yes	-4.315	1649	0.1521	287.5	300.0	yes	-4.324	1579	0.0211	70.7
130.0	yes	-4.321	1635	0.1363	407.3	310.0	yes	-4.323	1577	0.0140	114.5
140.0	yes	-4.304	1626	0.1101	434.0	320.0	yes	-4.302	1608	0.0078	144.5
150.0	yes	-4.325	1633	0.0738	501.6	330.0	yes	-4.328	1588	0.0226	129.0
160.0	yes	-4.311	1663	0.1176	348.6	340.0	yes	-4.305	1594	0.0344	151.6
170.0	yes	-4.326	1631	0.1838	221.1	350.0	yes	-4.304	1612	0.0326	73.9

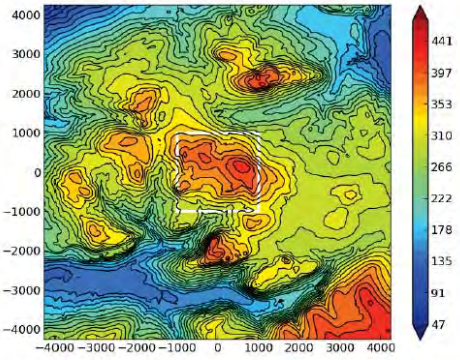
Dir	the simulated direction in degrees
Ok?	is convergence achieved? ($log(r) \leq -4.3$)
log(r)	the end-residual (max of all variables)
Iteration	iteration steps used to reach convergence
Z_{0ref}	the mesoscale reference roughness in metres
Z_{ref}	the farfield terrain height in metres

Simulations Setup

1. The figure shows the user specified height contours of the inner part of the domain including the 2 by 2 km WAsP CFD tile.



2. The figure shows the terrain prepared for CFD. The terrain was filtered and gently flattened in the farfield (not seen) before the computational grid was made.



3. A polar CFD domain was used; domain dimensions and mean resolution of the inner 4 by 4 km area:

Number of Grid Points	7 mill
Domain Height/Diameter	14/34 km
Mean Resolution Horizontal/Vertical	20.7/5 m

4. Convective terms were discretized using the third order QUICK scheme and the $k-\epsilon$ eddy-viscosity model of Launder and Spalding (1974) was used:

C_μ	σ_k	σ_ε	$C_{\varepsilon 1}$	$C_{\varepsilon 2}$	κ
0.052	1.0	1.3	1.38	1.92	0.4

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Appendix B. windPRO results

Project:
TNEI_Craiginmoddie
For Energiekontor UK: noise-related speed-up calculation

Description:
In receiving this report, the client accepts that Paul Hannah trading as The Wind Consultancy Service can in no way be held responsible for the application or use of the results and findings reported herein either now or in the future. The client is, and remains, responsible for the use of such information and any consequences thereof.
The results presented in this report, whilst following standard industry practice, cannot be claimed to be "bankable" as no bank engineers' approval has been sought by Paul Hannah trading as The Wind Consultancy Service.

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Paul Hannah / mail@windconsult.co.uk
Calculated:
06/03/2023 15:16/3.6.365

PARK - Main Result

Calculation: Speed-up using scaled EMD-WRF

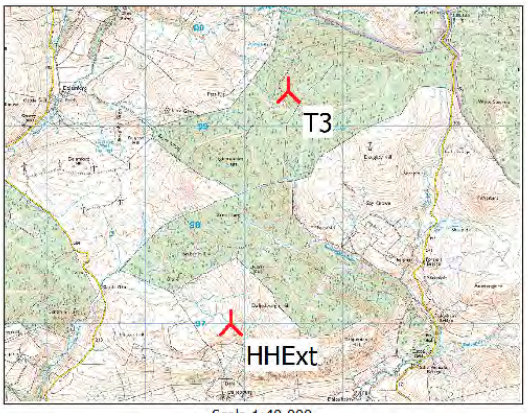
Setup
AEP scaled to a full year based on number of samples
Scaling factor from 20.0 years to 1 year: 0.050

Calculation performed in UTM (north)-WGS84 Zone: 30
At the site centre the difference between grid north and true north is: -1.4°

Wake
Wake Model: No model
Reference WTG: Siemens Gamesa SG 6.0-155 6600 155.0 !O! hub: 122.5 m (TOT: 200.0 m) (16)

Scaler/wind data

Name	EMD Default Meso Scaler
Terrain scaling	Meso-scale Data Downscaling
Micro terrain flow model	WAsP CFD result files - Ellipsys - 1.11.2.6
Used period	01/01/2003 - 31/12/2022 23:00:00
Meteo object(s)	EMD-WRF Europe+ (ERA5)_N55.252937_W004.656982 (10)
Displacement height: Sector-wise from calculator	Default 15m forest based on roughness data
RIX correction used	
WAsP version	WAsP 11 Version 11.06.0028



Scale 1:40,000

Calculated Annual Energy for each of 2 new WTGs with total 9.1 MW rated power

	Hub height [m]	Wind speed free [m/s]
HHExt	80.0	7.20
T3	122.5	8.36

Annual Energy result includes shown losses. Additional losses and uncertainty must be considered for an investment decision.

WTG siting

		British TM-OSGB36/Airy (GB/IE) Easting	Northing	Z [m]
HHExt	New	230,868	596,987	286.9
T3	New	231,453	599,350	342.6

Project:
TNEI_Craiginmoddie
For Energiekontor UK: noise-related speed-up calculation

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Paul Hannah / mail@windconsult.co.uk
Calculated:
06/03/2023 15:16/3.6.365

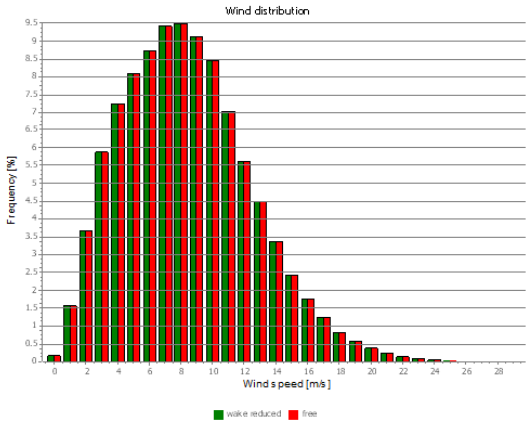
PARK - Wind Data Analysis

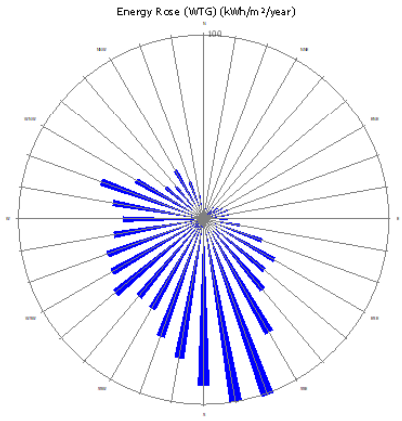
Calculation: Speed-up using scaled EMD-WRF **Wind data:** T3

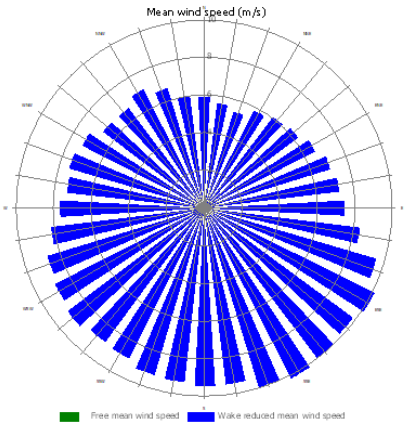
Hub height: 122.5

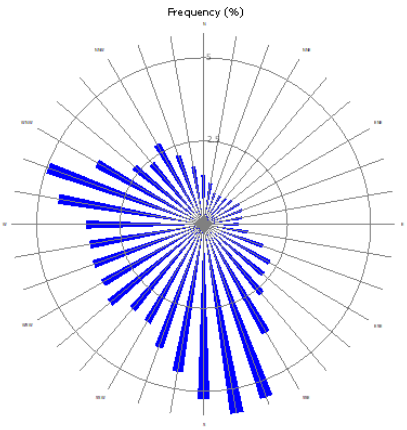
Site coordinates
British TM-OSGB36/Airy (GB/IE)
East: 231.453 North: 599,350
T3

Masts used
Take nearest









Project:
TNEI_Craiginmoddie
For Energiekontor UK: noise-related speed-up calculation

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Paul Hannah / mail@windconsult.co.uk

Calculated:
06/03/2023 15:16/3.6.365

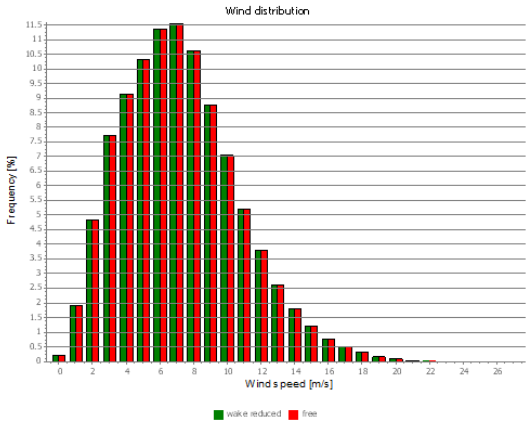
PARK - Wind Data Analysis

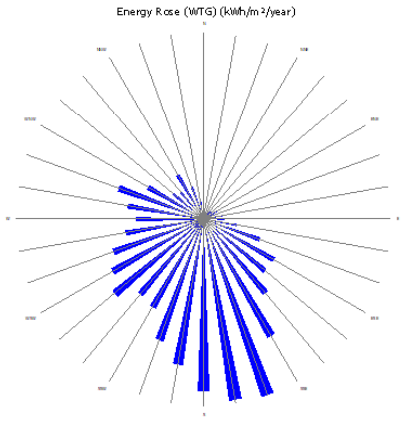
Calculation: Speed-up using scaled EMD-WRF **Wind data:** HHExt

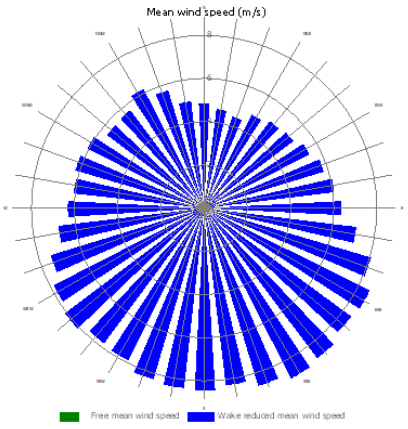
Hub height: 80.0

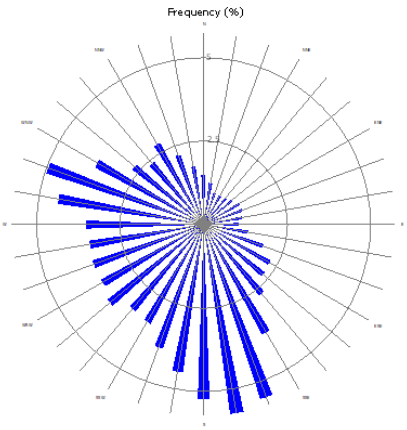
Site coordinates
British TM-OSGB36/Airy (GB/IE)
East: 230,868 North: 596,987
HHExt

Masts used
Take nearest









Project:
TNEI_Craiginmoddie
For Energiekontor UK: noise-related speed-up calculation

Description:
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Paul Hannah / mail@windconsult.co.uk
Calculated:
06/03/2023 15:16/3.6.365

PARK - Scaling info

Calculation: Speed-up using scaled EMD-WRF

Scaler settings

Name	EMD Default Meso Scaler
Terrain scaling	Meso-scale Data Downscaling
RIX correction	Omni-directional RIX correction
Displacement height	from calculator
Sector-wise from calculator	Default 15m forest based on roughness data
Micro terrain flow model	WAsP CFD result files - Ellipsys - 1.11.2.6
Overall factor	0.8565
Overall offset	0.0000
By sector	No
By month	No
By hour	No
By wind speed	No

CFD results and info

	British TM-OSGB36/Airy (GB/IE)			Software versions			Calculated	
	Easting	Northing	Result file	Ellipsys	Client	Server	Date	Time
A	231,300	597,800	Area 1.cfdres	1.11.2.6	WindPRO 3.6.365	Cerebrum EMD International	05/03/2023	17:48:35
B	232,000	599,100	Area 2.cfdres	1.11.2.6	WindPRO 3.6.365	Cerebrum EMD International	05/03/2023	17:59:13
C	234,400	598,700	Area 3.cfdres	1.11.2.6	WindPRO 3.6.365	Cerebrum EMD International	05/03/2023	18:21:37

CFD files used

	Result file	Result file
A	Area 1.cfdres	D:\PHPC\Documents\Tools\Data\Sites\8800_TNEI\TNEI_Craiginmoddie\OnlineCFDResults\Craiginmoddie\Area 1.cfdres
B	Area 2.cfdres	D:\PHPC\Documents\Tools\Data\Sites\8800_TNEI\TNEI_Craiginmoddie\OnlineCFDResults\Craiginmoddie\Area 2.cfdres
C	Area 3.cfdres	D:\PHPC\Documents\Tools\Data\Sites\8800_TNEI\TNEI_Craiginmoddie\OnlineCFDResults\Craiginmoddie\Area 3.cfdres

Project:
TNEI_Craiginmoddie
For Energiekontor UK: noise-related speed-up calculation

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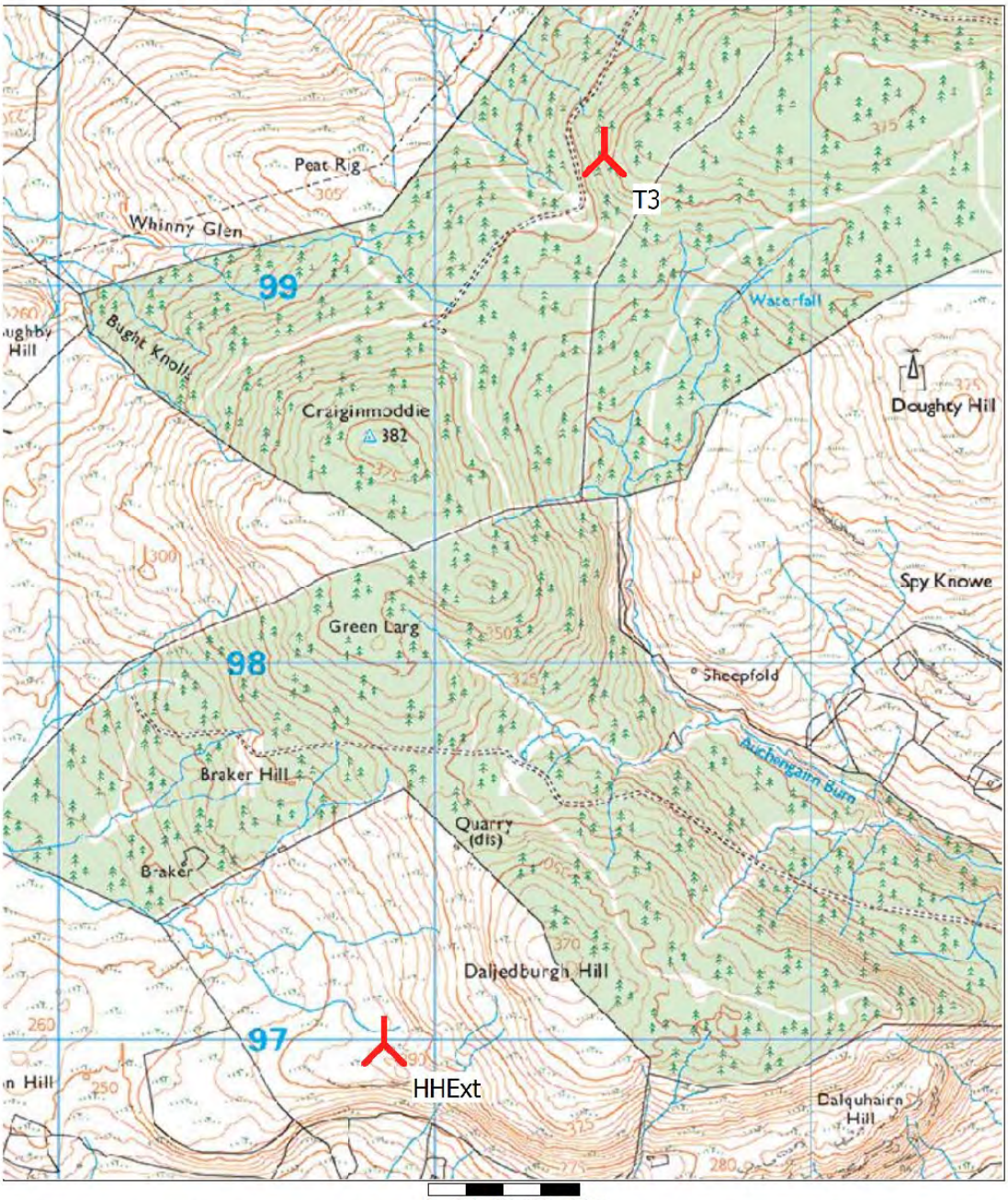
Calculated:
06/03/2023 15:16/3.6.365

PARK - Map

Calculation: Speed-up using scaled EMD-WRF



Map: Neighbours , Print scale 1:10,000, Map center British TM-OSGB36/Airy (GB/IE) East: 231,161 North: 598,169

New WTG

Wind shear adjustments for Craiginmoddie Wind Farm
06/03/2023

Introduction
This spreadsheet uses speed up factors as calculated by The Wind Consultancy Limited to adjust background noise levels as measured for the Hadyard Hill Wind Farm Extension (HHext) Project (application withdrawn)

Input Data

HHext Wind Farm Hub Height	80	m
Craiginmoddie Wind Farm (CMWF) Hub Height	122.5	m
Reference Height	10	m
Standard Roughness Length	0.05	m
NML Reference	a	
NML Name	Knockrochar	

Formulas used in this sheet

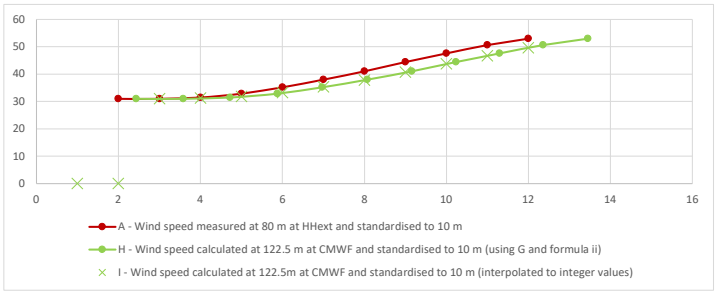
i	vhh=v10(ln(Hhh/z0)/ln(Href/z0))
ii	v10=vhh/(ln(Hhh/z0)/ln(Href/z0))

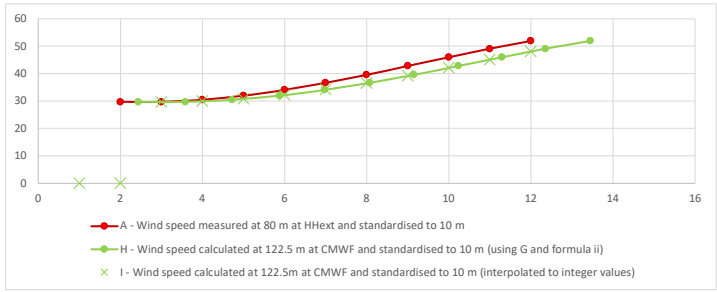
Day-time

A - Wind speed measured at 80 m at HHext and standardised to 10 m	1	2	3	4	5	6	7	8	9	10	11	12
B - Measured background noise level (from HHext assessment)		31	31	31.5	32.9	35.2	38	41.1	44.4	47.6	50.6	53
C - Wind speed calculated at 80 m at HHExt mast (using A and formula i)	1.392	2.785	4.177	5.570	6.962	8.355	9.747	11.140	12.532	13.925	15.317	16.710
D - Average speed up factor (between 80 m at HHext and 122.5 at CMWF)	1.157	1.152	1.154	1.160	1.172	1.174	1.172	1.167	1.162	1.155	1.150	1.148
E - One standard deviation (s.d.) of the speed up factor	0.255	0.136	0.109	0.087	0.071	0.056	0.048	0.043	0.041	0.040	0.038	0.037
F - Speed up factor used for modeling (average plus one s.d.)	1.41	1.29	1.26	1.25	1.24	1.23	1.22	1.21	1.20	1.20	1.19	1.19
G - Wind speed calculated at 122.5 m at CMWF (C * F)	1.966	3.588	5.278	6.950	8.655	10.271	11.889	13.482	15.074	16.641	18.201	19.807
H - Wind speed calculated at 122.5 m at CMWF and standardised to 10 m (using G and formula ii)	1.335	2.436	3.584	4.719	5.876	6.974	8.072	9.153	10.234	11.298	12.357	13.448

Night-time

A - Wind speed measured at 80 m at HHext and standardised to 10 m	1	2	3	4	5	6	7	8	9	10	11	12
B - Measured background noise level (from HHext assessment)		29.7	29.7	30.5	32	34.1	36.7	39.6	42.8	46	49.1	52
C - Wind speed calculated at 80 m at HHExt mast (using A and formula i)	1.392	2.785	4.177	5.570	6.962	8.355	9.747	11.140	12.532	13.925	15.317	16.710
D - Average speed up factor (between 80 m at HHext and 122.5 at CMWF)	1.127	1.141	1.159	1.168	1.179	1.182	1.179	1.175	1.165	1.159	1.152	1.145
E - One standard deviation (s.d.) of the speed up factor	0.279	0.166	0.128	0.102	0.079	0.057	0.043	0.039	0.038	0.037	0.036	0.034
F - Speed up factor used for modeling (average plus one s.d.)	1.41207	1.2885	1.2635	1.24778	1.24305	1.2294	1.21971	1.21024	1.20279	1.19503	1.18824	1.18537
G - Wind speed calculated at 122.5 m at CMWF (C * F)	1.966	3.588	5.278	6.950	8.655	10.271	11.889	13.482	15.074	16.641	18.201	19.807
H - Wind speed calculated at 122.5 m at CMWF and standardised to 10 m (using G and formula ii)	1.335	2.436	3.584	4.719	5.876	6.974	8.072	9.153	10.234	11.298	12.357	13.448





Interpolation of data

I - Wind speed calculated at 122.5m at CMWF and standardised to 10 m (interpolated to integer values)	1	2	3	4	5	6	7	8	9	10	11	12
J - Background noise level to be used for CMWF	-	-	31.0	31.2	31.8	33.2	35.3	37.8	40.7	43.7	46.7	49.6

I - Wind speed calculated at 122.5m at CMWF and standardised to 10 m (interpolated to integer values)	1	2	3	4	5	6	7	8	9	10	11	12
J - Background noise level to be used for CMWF	-	-	29.7	30.0	30.9	32.2	34.2	36.5	39.2	42.1	45.1	48.1

Wind shear adjustments for Craiginmoddie Wind Farm
06/03/2023

Introduction
This spreadsheet uses speed up factors as calculated by The Wind Consultancy Limited to adjust background noise levels as measured for the Hadyard Hill Wind Farm Extension (HHext) Project (application withdrawn)

Input Data

HHext Wind Farm Hub Height	80	m
Craiginmoddie Wind Farm (CMWF) Hub Height	122.5	m
Reference Height	10	m
Standard Roughness Length	0.05	m
NML Reference	b	
NML Name	Doughty Farm	

Formulas used in this sheet

i	vhh=v10(ln(Hhh/z0)/ln(Href/z0))
ii	v10=vhh/(ln(Hhh/z0)/ln(Href/z0))

Day-time

	1	2	3	4	5	6	7	8	9	10	11	12
A - Wind speed measured at 80 m at HHext and standardised to 10 m		27.9	28.4	29.4	30.7	32.4	34.3	36.4	38.6	40.9	43.3	45.6
B - Measured background noise level (from HHext assessment)	1.392	2.785	4.177	5.570	6.962	8.355	9.747	11.140	12.532	13.925	15.317	16.710
C - Wind speed calculated at 80 m at HHExt mast (using A and formula i)	1.157	1.152	1.154	1.160	1.172	1.174	1.172	1.167	1.162	1.155	1.150	1.148
D - Average speed up factor (between 80 m at HHext and 122.5 at CMWF)	0.255	0.136	0.109	0.087	0.071	0.056	0.048	0.043	0.041	0.040	0.038	0.037
E - One standard deviation (s.d.) of the speed up factor	1.41	1.29	1.26	1.25	1.24	1.23	1.22	1.21	1.20	1.20	1.19	1.19
F - Speed up factor used for modeling (average plus one s.d.)	1.966	3.588	5.278	6.950	8.655	10.271	11.889	13.482	15.074	16.641	18.201	19.807
G - Wind speed calculated at 122.5 m at CMWF (C * F)	1.335	2.436	3.584	4.719	5.876	6.974	8.072	9.153	10.234	11.298	12.357	13.448
H - Wind speed calculated at 122.5 m at CMWF and standardised to 10 m (using G and formula ii)												

Night-time

	1	2	3	4	5	6	7	8	9	10	11	12
A - Wind speed measured at 80 m at HHext and standardised to 10 m		27.6	27.7	28.5	29.8	31.6	33.8	36.2	38.8	41.5	44.1	46.5
B - Measured background noise level (from HHext assessment)	1.392	2.785	4.177	5.570	6.962	8.355	9.747	11.140	12.532	13.925	15.317	16.710
C - Wind speed calculated at 80 m at HHExt mast (using A and formula i)	1.127	1.141	1.159	1.168	1.179	1.182	1.179	1.175	1.165	1.159	1.152	1.145
D - Average speed up factor (between 80 m at HHext and 122.5 at CMWF)	0.279	0.166	0.128	0.102	0.079	0.057	0.043	0.039	0.038	0.037	0.036	0.034
E - One standard deviation (s.d.) of the speed up factor	1.41207	1.2885	1.2635	1.24778	1.24305	1.2294	1.21971	1.21024	1.20279	1.19503	1.18824	1.18537
F - Speed up factor used for modeling (average plus one s.d.)	1.966	3.588	5.278	6.950	8.655	10.271	11.889	13.482	15.074	16.641	18.201	19.807
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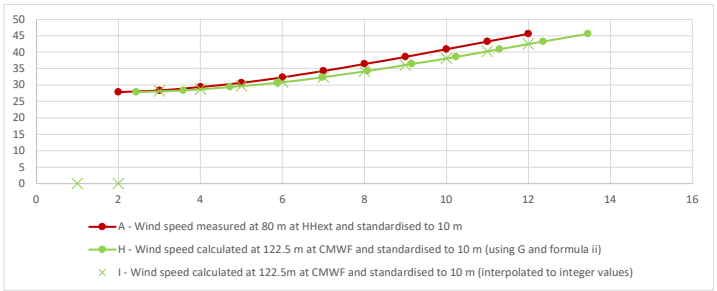
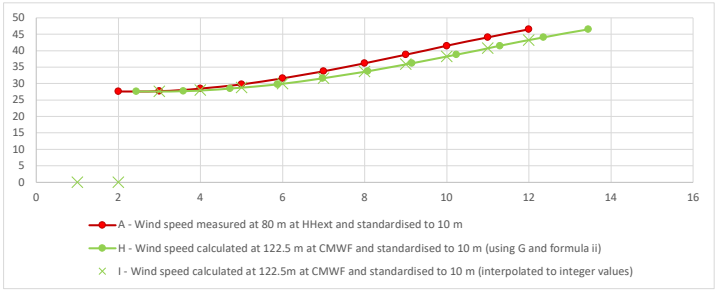
H - Wind speed calculated at 122.5 m at CMWF and standardised to 10 m (using G and formula ii)												





Interpolation of data

	1	2	3	4	5	6	7	8	9	10	11	12
I - Wind speed calculated at 122.5m at CMWF and standardised to 10 m (interpolated to integer values)												
J - Background noise level to be used for CMWF	-	-	28.1	28.8	29.7	30.9	32.4	34.2	36.1	38.1	40.3	42.5

	1	2	3	4	5	6	7	8	9	10	11	12
I - Wind speed calculated at 122.5m at CMWF and standardised to 10 m (interpolated to integer values)												
J - Background noise level to be used for CMWF	-	-	27.6	28.0	28.8	30.0	31.7	33.7	35.9	38.2	40.7	43.2

Wind shear adjustments for Craiginmoddie Wind Farm
06/03/2023

Introduction
This spreadsheet uses speed up factors as calculated by The Wind Consultancy Limited to adjust background noise levels as measured for the Hadyard Hill Wind Farm Extension (HHext) Project (application withdrawn)

Input Data

HHext Wind Farm Hub Height	80	m
Craiginmoddie Wind Farm (CMWF) Hub Height	122.5	m
Reference Height	10	m
Standard Roughness Length	0.05	m
NML Reference	c	
NML Name	Dalwyne Cottage	

Formulas used in this sheet

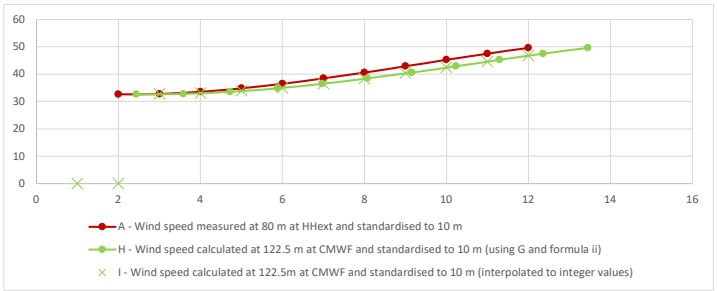
i	vhh=v10(ln(Hhh/z0)/ln(Href/z0))
ii	v10=vhh/(ln(Hhh/z0)/ln(Href/z0))

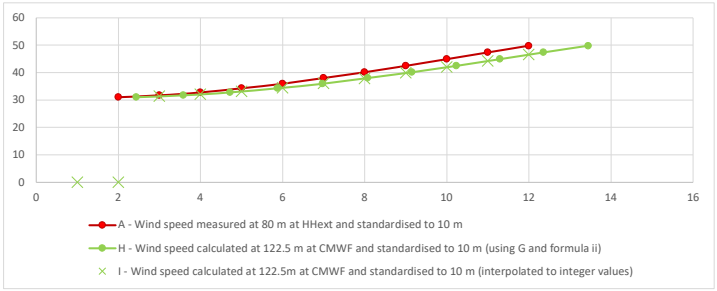
Day-time

A - Wind speed measured at 80 m at HHext and standardised to 10 m	1	2	3	4	5	6	7	8	9	10	11	12
B - Measured background noise level (from HHext assessment)		32.6	32.8	33.6	34.8	36.5	38.5	40.6	42.9	45.2	47.5	49.6
C - Wind speed calculated at 80 m at HHExt mast (using A and formula i)	1.392	2.785	4.177	5.570	6.962	8.355	9.747	11.140	12.532	13.925	15.317	16.710
D - Average speed up factor (between 80 m at HHext and 122.5 at CMWF)	1.157	1.152	1.154	1.160	1.172	1.174	1.172	1.167	1.162	1.155	1.150	1.148
E - One standard deviation (s.d.) of the speed up factor	0.255	0.136	0.109	0.087	0.071	0.056	0.048	0.043	0.041	0.040	0.038	0.037
F - Speed up factor used for modeling (average plus one s.d.)	1.41	1.29	1.26	1.25	1.24	1.23	1.22	1.21	1.20	1.20	1.19	1.19
G - Wind speed calculated at 122.5 m at CMWF (C * F)	1.966	3.588	5.278	6.950	8.655	10.271	11.889	13.482	15.074	16.641	18.201	19.807
H - Wind speed calculated at 122.5 m at CMWF and standardised to 10 m (using G and formula ii)	1.335	2.436	3.584	4.719	5.876	6.974	8.072	9.153	10.234	11.298	12.357	13.448

Night-time

A - Wind speed measured at 80 m at HHext and standardised to 10 m	1	2	3	4	5	6	7	8	9	10	11	12
B - Measured background noise level (from HHext assessment)		31	31.7	32.8	34.3	36	38	40.2	42.5	44.9	47.4	49.8
C - Wind speed calculated at 80 m at HHExt mast (using A and formula i)	1.392	2.785	4.177	5.570	6.962	8.355	9.747	11.140	12.532	13.925	15.317	16.710
D - Average speed up factor (between 80 m at HHext and 122.5 at CMWF)	1.127	1.141	1.159	1.168	1.179	1.182	1.179	1.175	1.165	1.159	1.152	1.145
E - One standard deviation (s.d.) of the speed up factor	0.279	0.166	0.128	0.102	0.079	0.057	0.043	0.039	0.038	0.037	0.036	0.034
F - Speed up factor used for modeling (average plus one s.d.)	1.41207	1.2885	1.2635	1.24778	1.24305	1.2294	1.21971	1.21024	1.20279	1.19503	1.18824	1.18537
G - Wind speed calculated at 122.5 m at CMWF (C * F)	1.966	3.588	5.278	6.950	8.655	10.271	11.889	13.482	15.074	16.641	18.201	19.807
H - Wind speed calculated at 122.5 m at CMWF and standardised to 10 m (using G and formula ii)	1.335	2.436	3.584	4.719	5.876	6.974	8.072	9.153	10.234	11.298	12.357	13.448





Interpolation of data

I - Wind speed calculated at 122.5m at CMWF and standardised to 10 m (interpolated to integer values)	1	2	3	4	5	6	7	8	9	10	11	12
J - Background noise level to be used for CMWF	-	-	32.7	33.1	33.9	35.0	36.5	38.4	40.3	42.4	44.6	46.7

I - Wind speed calculated at 122.5m at CMWF and standardised to 10 m (interpolated to integer values)	1	2	3	4	5	6	7	8	9	10	11	12
J - Background noise level to be used for CMWF	-	-	31.3	32.1	33.2	34.5	36.0	37.9	39.9	42.0	44.2	46.6

Wind shear adjustments for Craiginmoddie Wind Farm
06/03/2023

Introduction
This spreadsheet uses speed up factors as calculated by The Wind Consultancy Limited to adjust background noise levels as measured for the Hadyard Hill Wind Farm Extension (HHext) Project (application withdrawn)

Input Data

HHext Wind Farm Hub Height	80	m
Craiginmoddie Wind Farm (CMWF) Hub Height	122.5	m
Reference Height	10	m
Standard Roughness Length	0.05	m
NML Reference	d	
NML Name	Milton Farm	

Formulas used in this sheet

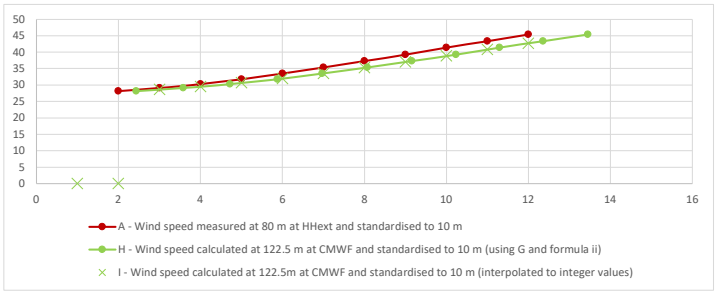
i	vhh=v10(ln(Hhh/z0)/ln(Href/z0))
ii	v10=vhh/(ln(Hhh/z0)/ln(Href/z0))

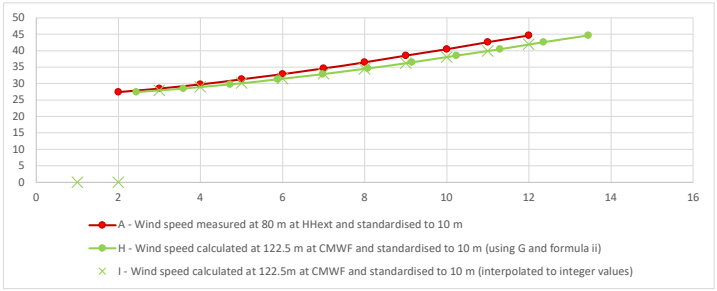
Day-time

	1	2	3	4	5	6	7	8	9	10	11	12
A - Wind speed measured at 80 m at HHext and standardised to 10 m		28.2	29.1	30.3	31.8	33.5	35.4	37.3	39.3	41.4	43.4	45.4
B - Measured background noise level (from HHext assessment)	1.392	2.785	4.177	5.570	6.962	8.355	9.747	11.140	12.532	13.925	15.317	16.710
C - Wind speed calculated at 80 m at HHExt mast (using A and formula i)	1.157	1.152	1.154	1.160	1.172	1.174	1.172	1.167	1.162	1.155	1.150	1.148
D - Average speed up factor (between 80 m at HHext and 122.5 at CMWF)	0.255	0.136	0.109	0.087	0.071	0.056	0.048	0.043	0.041	0.040	0.038	0.037
E - One standard deviation (s.d.) of the speed up factor	1.41	1.29	1.26	1.25	1.24	1.23	1.22	1.21	1.20	1.20	1.19	1.19
F - Speed up factor used for modeling (average plus one s.d.)	1.966	3.588	5.278	6.950	8.655	10.271	11.889	13.482	15.074	16.641	18.201	19.807
G - Wind speed calculated at 122.5 m at CMWF (C * F)	1.335	2.436	3.584	4.719	5.876	6.974	8.072	9.153	10.234	11.298	12.357	13.448
H - Wind speed calculated at 122.5 m at CMWF and standardised to 10 m (using G and formula ii)												

Night-time

	1	2	3	4	5	6	7	8	9	10	11	12
A - Wind speed measured at 80 m at HHext and standardised to 10 m		27.4	28.5	29.8	31.3	32.9	34.6	36.5	38.5	40.5	42.6	44.7
B - Measured background noise level (from HHext assessment)	1.392	2.785	4.177	5.570	6.962	8.355	9.747	11.140	12.532	13.925	15.317	16.710
C - Wind speed calculated at 80 m at HHExt mast (using A and formula i)	1.127	1.141	1.159	1.168	1.179	1.182	1.179	1.175	1.165	1.159	1.152	1.145
D - Average speed up factor (between 80 m at HHext and 122.5 at CMWF)	0.279	0.166	0.128	0.102	0.079	0.057	0.043	0.039	0.038	0.037	0.036	0.034
E - One standard deviation (s.d.) of the speed up factor	1.41207	1.2885	1.2635	1.24778	1.24305	1.2294	1.21971	1.21024	1.20279	1.19503	1.18824	1.18537
F - Speed up factor used for modeling (average plus one s.d.)	1.966	3.588	5.278	6.950	8.655	10.271	11.889	13.482	15.074	16.641	18.201	19.807
G - Wind speed calculated at 122.5 m at CMWF (C * F)	1.335	2.436	3.584	4.719	5.876	6.974	8.072	9.153	10.234	11.298	12.357	13.448
H - Wind speed calculated at 122.5 m at CMWF and standardised to 10 m (using G and formula ii)												





Interpolation of data

	1	2	3	4	5	6	7	8	9	10	11	12
I - Wind speed calculated at 122.5m at CMWF and standardised to 10 m (interpolated to integer values)												
J - Background noise level to be used for CMWF	-	-	28.6	29.5	30.7	32.0	33.5	35.3	37.0	38.9	40.8	42.7

	1	2	3	4	5	6	7	8	9	10	11	12
I - Wind speed calculated at 122.5m at CMWF and standardised to 10 m (interpolated to integer values)												
J - Background noise level to be used for CMWF	-	-	27.9	29.0	30.2	31.5	32.9	34.5	36.2	38.1	39.9	41.9

Wind shear adjustments for Craiginmoddie Wind Farm
06/03/2023

Introduction
This spreadsheet uses speed up factors as calculated by The Wind Consultancy Limited to adjust background noise levels as measured for the Hadyard Hill Wind Farm Extension (HHext) Project (application withdrawn)

Input Data

HHext Wind Farm Hub Height	80	m
Craiginmoddie Wind Farm (CMWF) Hub Height	122.5	m
Reference Height	10	m
Standard Roughness Length	0.05	m
NML Reference	e	
NML Name	Glenginnet Road	

Formulas used in this sheet

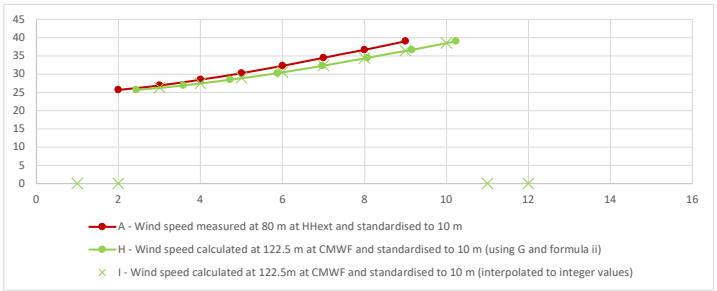
i	vhh=v10(ln(Hhh/z0)/ln(Href/z0))
ii	v10=vhh/(ln(Hhh/z0)/ln(Href/z0))

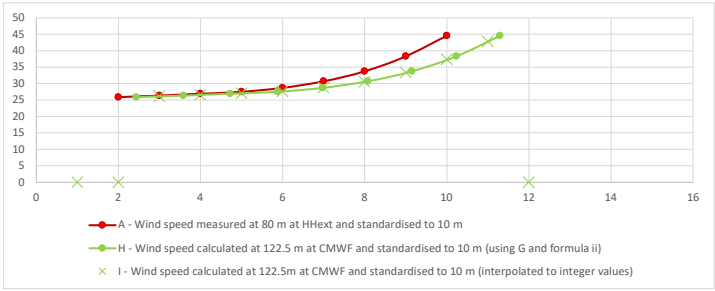
Day-time

	1	2	3	4	5	6	7	8	9	10	11	12
A - Wind speed measured at 80 m at HHext and standardised to 10 m												
B - Measured background noise level (from HHext assessment)		25.7	26.9	28.5	30.3	32.3	34.5	36.7	39			
C - Wind speed calculated at 80 m at HHExt mast (using A and formula i)	1.392	2.785	4.177	5.570	6.962	8.355	9.747	11.140	12.532	13.925	15.317	16.710
D - Average speed up factor (between 80 m at HHext and 122.5 at CMWF)	1.157	1.152	1.154	1.160	1.172	1.174	1.172	1.167	1.162	1.155	1.150	1.148
E - One standard deviation (s.d.) of the speed up factor	0.255	0.136	0.109	0.087	0.071	0.056	0.048	0.043	0.041	0.040	0.038	0.037
F - Speed up factor used for modeling (average plus one s.d.)	1.41	1.29	1.26	1.25	1.24	1.23	1.22	1.21	1.20	1.20	1.19	1.19
G - Wind speed calculated at 122.5 m at CMWF (C * F)	1.966	3.588	5.278	6.950	8.655	10.271	11.889	13.482	15.074	16.641	18.201	19.807
H - Wind speed calculated at 122.5 m at CMWF and standardised to 10 m (using G and formula ii)	1.335	2.436	3.584	4.719	5.876	6.974	8.072	9.153	10.234	11.298	12.357	13.448

Night-time

	1	2	3	4	5	6	7	8	9	10	11	12
A - Wind speed measured at 80 m at HHext and standardised to 10 m												
B - Measured background noise level (from HHext assessment)		25.9	26.4	26.9	27.5	28.7	30.7	33.8	38.3	44.6		
C - Wind speed calculated at 80 m at HHExt mast (using A and formula i)	1.392	2.785	4.177	5.570	6.962	8.355	9.747	11.140	12.532	13.925	15.317	16.710
D - Average speed up factor (between 80 m at HHext and 122.5 at CMWF)	1.127	1.141	1.159	1.168	1.179	1.182	1.179	1.175	1.165	1.159	1.152	1.145
E - One standard deviation (s.d.) of the speed up factor	0.279	0.166	0.128	0.102	0.079	0.057	0.043	0.039	0.038	0.037	0.036	0.034
F - Speed up factor used for modeling (average plus one s.d.)	1.41207	1.2885	1.2635	1.24778	1.24305	1.2294	1.21971	1.21024	1.20279	1.19503	1.18824	1.18537
G - Wind speed calculated at 122.5 m at CMWF (C * F)	1.966	3.588	5.278	6.950	8.655	10.271	11.889	13.482	15.074	16.641	18.201	19.807
H - Wind speed calculated at 122.5 m at CMWF and standardised to 10 m (using G and formula ii)	1.335	2.436	3.584	4.719	5.876	6.974	8.072	9.153	10.234	11.298	12.357	13.448





Interpolation of data

	1	2	3	4	5	6	7	8	9	10	11	12
I - Wind speed calculated at 122.5m at CMWF and standardised to 10 m (interpolated to integer values)												
J - Background noise level to be used for CMWF	-	-	26.3	27.5	28.9	30.5	32.4	34.4	36.4	38.5	-	-

	1	2	3	4	5	6	7	8	9	10	11	12
I - Wind speed calculated at 122.5m at CMWF and standardised to 10 m (interpolated to integer values)												
J - Background noise level to be used for CMWF	-	-	26.1	26.6	27.0	27.6	28.7	30.6	33.4	37.3	42.8	-

Wind shear adjustments for Craiginmoddie Wind Farm
06/03/2023

Introduction
This spreadsheet uses speed up factors as calculated by The Wind Consultancy Limited to adjust background noise levels as measured for the Hadyard Hill Wind Farm Extension (HHext) Project (application withdrawn)

Input Data

HHext Wind Farm Hub Height	80	m
Craiginmoddie Wind Farm (CMWF) Hub Height	122.5	m
Reference Height	10	m
Standard Roughness Length	0.05	m
NML Reference	f	
NML Name	Dobbingstone	

Formulas used in this sheet

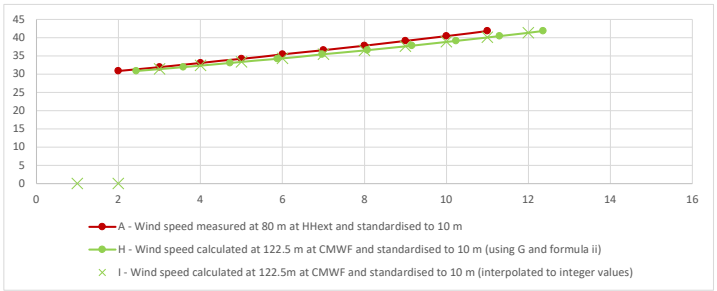
i	vhh=v10(ln(Hhh/z0)/ln(Href/z0))
ii	v10=vhh/(ln(Hhh/z0)/ln(Href/z0))

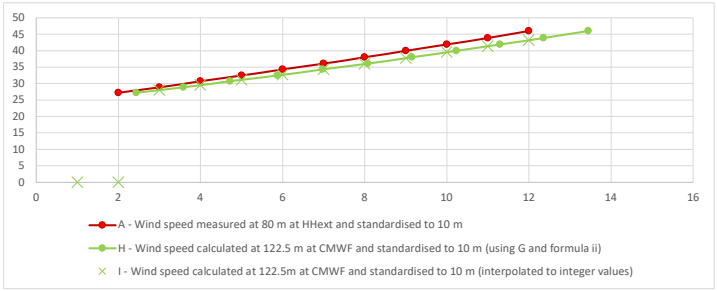
Day-time

	1	2	3	4	5	6	7	8	9	10	11	12
A - Wind speed measured at 80 m at HHext and standardised to 10 m												
B - Measured background noise level (from HHext assessment)		30.9	31.9	33.1	34.2	35.4	36.6	37.8	39.1	40.4	41.8	
C - Wind speed calculated at 80 m at HHExt mast (using A and formula i)	1.392	2.785	4.177	5.570	6.962	8.355	9.747	11.140	12.532	13.925	15.317	16.710
D - Average speed up factor (between 80 m at HHext and 122.5 at CMWF)	1.157	1.152	1.154	1.160	1.172	1.174	1.172	1.167	1.162	1.155	1.150	1.148
E - One standard deviation (s.d.) of the speed up factor	0.255	0.136	0.109	0.087	0.071	0.056	0.048	0.043	0.041	0.040	0.038	0.037
F - Speed up factor used for modeling (average plus one s.d.)	1.41	1.29	1.26	1.25	1.24	1.23	1.22	1.21	1.20	1.20	1.19	1.19
G - Wind speed calculated at 122.5 m at CMWF (C * F)	1.966	3.588	5.278	6.950	8.655	10.271	11.889	13.482	15.074	16.641	18.201	19.807
H - Wind speed calculated at 122.5 m at CMWF and standardised to 10 m (using G and formula ii)	1.335	2.436	3.584	4.719	5.876	6.974	8.072	9.153	10.234	11.298	12.357	13.448

Night-time

	1	2	3	4	5	6	7	8	9	10	11	12
A - Wind speed measured at 80 m at HHext and standardised to 10 m												
B - Measured background noise level (from HHext assessment)		27.2	28.9	30.7	32.5	34.3	36.1	38	40	41.9	43.9	46
C - Wind speed calculated at 80 m at HHExt mast (using A and formula i)	1.392	2.785	4.177	5.570	6.962	8.355	9.747	11.140	12.532	13.925	15.317	16.710
D - Average speed up factor (between 80 m at HHext and 122.5 at CMWF)	1.127	1.141	1.159	1.168	1.179	1.182	1.179	1.175	1.165	1.159	1.152	1.145
E - One standard deviation (s.d.) of the speed up factor	0.279	0.166	0.128	0.102	0.079	0.057	0.043	0.039	0.038	0.037	0.036	0.034
F - Speed up factor used for modeling (average plus one s.d.)	1.41207	1.2885	1.2635	1.24778	1.24305	1.2294	1.21971	1.21024	1.20279	1.19503	1.18824	1.18537
G - Wind speed calculated at 122.5 m at CMWF (C * F)	1.966	3.588	5.278	6.950	8.655	10.271	11.889	13.482	15.074	16.641	18.201	19.807
H - Wind speed calculated at 122.5 m at CMWF and standardised to 10 m (using G and formula ii)	1.335	2.436	3.584	4.719	5.876	6.974	8.072	9.153	10.234	11.298	12.357	13.448





Interpolation of data

	1	2	3	4	5	6	7	8	9	10	11	12
I - Wind speed calculated at 122.5m at CMWF and standardised to 10 m (interpolated to integer values)												
J - Background noise level to be used for CMWF	-	-	31.4	32.3	33.4	34.3	35.4	36.5	37.6	38.8	40.0	41.3

	1	2	3	4	5	6	7	8	9	10	11	12
I - Wind speed calculated at 122.5m at CMWF and standardised to 10 m (interpolated to integer values)												
J - Background noise level to be used for CMWF	-	-	28.0	29.6	31.1	32.7	34.3	36.0	37.7	39.6	41.4	43.2

Annex 4 – Topographical Corrections and Turbine Coordinates

Table 1: Topographical (concave ground/ barrier) Noise Prediction Adjustment Table

Notes/Comments

Requirement to include a concave ground profile correction of +3dB has been calculated in accordance with section 4.3.9 of the IOA GPG (July 2011)

A barrier correction of -2dB is included where the landform completely obscures a turbine at the noise assessment location

Where analysis indicates that both are required the barrier correction take precedence and a correction of -2dB is applied

Wind Farm	Hub	T ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hadyard Hill	58.5	1	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	-2	-2	3	0
Hadyard Hill	58.5	2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	-2	-2	3	0
Hadyard Hill	58.5	3	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	-2	-2	3	0
Hadyard Hill	58.5	4	-2	-2	-2	0	-2	-2	-2	0	0	0	0	0	0	0	-2	-2	0	0
Hadyard Hill	58.5	5	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	-2	-2	3	0
Hadyard Hill	58.5	6	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	-2	-2	3	0
Hadyard Hill	58.5	7	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	-2	-2	3	0
Hadyard Hill	58.5	8	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	-2	-2	0	0
Hadyard Hill	58.5	9	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	-2	-2	3	0
Hadyard Hill	58.5	10	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	-2	-2	3	0
Hadyard Hill	58.5	11	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	-2	-2	3	0
Hadyard Hill	58.5	12	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	-2	-2	3	0
Hadyard Hill	58.5	13	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	-2	-2	0	-2
Hadyard Hill	58.5	14	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	-2	0	0	-2
Hadyard Hill	58.5	15	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	-2	0	0	-2
Hadyard Hill	58.5	16	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	-2	-2	0	0
Hadyard Hill	58.5	17	-2	-2	-2	3	-2	3	-2	-2	0	0	0	0	0	0	-2	-2	0	0
Hadyard Hill	58.5	18	-2	-2	-2	3	-2	3	-2	-2	0	0	0	0	0	0	3	-2	3	0
Hadyard Hill	58.5	19	-2	-2	-2	3	-2	3	-2	-2	0	0	0	0	0	0	-2	-2	3	0
Hadyard Hill	58.5	20	-2	-2	-2	3	-2	3	-2	-2	0	0	0	0	0	0	-2	-2	3	-2
Hadyard Hill	58.5	21	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	-2	-2	0	-2
Hadyard Hill	58.5	22	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	0	-2
Hadyard Hill	58.5	23	-2	-2	-2	3	-2	-2	-2	-2	0	0	0	0	0	0	-2	-2	3	-2
Hadyard Hill	58.5	24	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	0	-2
Hadyard Hill	58.5	25	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	0	-2
Hadyard Hill	58.5	26	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	0	0	-2
Hadyard Hill	58.5	27	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	58.5	28	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	0	-2
Hadyard Hill	58.5	29	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	58.5	30	-2	0	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	0	-2
Hadyard Hill	58.5	31	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	58.5	32	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	58.5	33	-2	0	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	0	0	-2
Hadyard Hill	58.5	34	-2	0	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	58.5	35	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	58.5	36	-2	0	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	58.5	37	0	3	0	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	68.5	38	-2	0	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	68.5	39	0	3	3	-2	0	0	-2	-2	-2	0	0	0	0	0	-2	0	0	-2
Hadyard Hill	68.5	40	-2	0	0	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	68.5	41	0	0	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	68.5	42	-2	0	3	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	68.5	43	0	3	0	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	68.5	44	-2	0	3	-2	0	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2
Hadyard Hill	68.5	45	0	0	3	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	68.5	46	0	3	3	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	-2	-2	-2	-2
Hadyard Hill	58.5	47	0	3	3	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	-2	-2	-2	-2
Hadyard Hill	58.5	48	-2	0	3	-2	0	-2	-2	-2	-2	-2	-2	0	0	0	-2	0	-2	-2
Hadyard Hill	58.5	49	0	3	3	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	-2	-2	-2	-2
Hadyard Hill	58.5	50	-2	0	3	-2	0	-2	-2	-2	-2	-2	-2	-2	0	0	-2	3	-2	-2
Hadyard Hill	58.5	51	0	3	3	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	-2	0	-2	-2
Hadyard Hill	58.5	52	0	0	3	-2	0	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	0	-2	-2

Dersalloch	64.5	105	0	0	0	0	0	0	0	0	-2	3	-2	-2	-2	3	0	0	0	3
Dersalloch	64.5	106	0	0	0	0	0	0	0	0	-2	3	-2	-2	-2	3	0	0	0	3
Dersalloch	64.5	107	0	0	0	0	0	0	-2	-2	-2	3	-2	-2	-2	3	0	0	0	-2
Dersalloch	64.5	108	0	0	0	0	0	0	0	-2	-2	3	-2	-2	3	3	0	0	0	-2
Dersalloch	64.5	109	0	0	0	0	0	0	0	0	-2	3	-2	-2	3	3	0	0	0	3
Dersalloch	64.5	110	0	0	0	0	0	0	0	0	-2	3	-2	-2	-2	3	0	0	0	3
Dersalloch	64.5	111	0	0	0	0	0	0	0	0	-2	3	-2	-2	3	-2	0	0	0	-2
Dersalloch	64.5	112	0	0	0	0	0	0	0	0	-2	3	-2	-2	3	-2	0	0	0	3
Dersalloch	64.5	113	0	0	0	0	0	0	0	0	-2	3	-2	-2	3	-2	0	0	0	3
Dersalloch	64.5	114	0	0	0	0	0	0	0	0	-2	3	-2	-2	3	-2	0	0	0	3
Dersalloch	64.5	115	0	0	0	0	0	0	0	0	-2	3	-2	-2	3	-2	0	0	0	3
Dersalloch	64.5	116	0	0	0	0	0	0	0	0	-2	3	-2	-2	3	-2	0	0	0	3
Dersalloch	64.5	117	0	0	0	0	0	0	0	0	-2	-2	-2	-2	-2	-2	0	0	0	0
Dersalloch	64.5	118	0	0	0	0	0	0	0	0	-2	0	-2	-2	-2	-2	0	0	0	0
Dersalloch	64.5	119	0	0	0	0	0	0	0	0	-2	-2	-2	-2	3	-2	0	0	0	0
Dersalloch	64.5	120	0	0	0	0	0	0	0	0	-2	0	-2	-2	-2	-2	0	0	0	0
Dersalloch	64.5	121	0	0	0	0	0	0	0	0	-2	-2	-2	-2	-2	-2	0	0	0	0
Dersalloch	64.5	122	0	0	0	0	0	0	0	0	-2	3	-2	-2	-2	-2	0	0	0	0
Dersalloch	64.5	123	0	0	0	0	0	0	0	0	-2	-2	-2	-2	-2	-2	0	0	0	0
Dersalloch	64.5	124	0	0	0	0	0	0	0	0	-2	3	-2	-2	3	-2	0	0	0	-2
Dersalloch	64.5	125	0	0	0	0	0	0	0	0	-2	3	-2	-2	-2	-2	0	0	0	-2
Dersalloch	64.5	126	0	0	0	0	0	0	0	0	-2	-2	-2	-2	-2	-2	0	0	0	0
Dersalloch	64.5	127	0	0	0	0	0	0	0	0	-2	3	-2	-2	3	-2	0	0	0	0
Tralorg	60	128	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	0	-2	-2	3	0
Tralorg	60	129	-2	-2	-2	0	-2	-2	0	0	0	0	0	0	0	0	-2	-2	-2	0
Tralorg	60	130	-2	-2	-2	0	-2	-2	0	0	0	0	0	0	0	0	-2	-2	3	0
Tralorg	60	131	-2	-2	-2	0	-2	-2	0	0	0	0	0	0	0	0	-2	-2	3	0
Tralorg	60	132	-2	-2	-2	0	-2	-2	0	0	0	0	0	0	0	0	-2	-2	3	0
Tralorg	60	133	-2	-2	-2	0	-2	-2	0	0	0	0	0	0	0	0	-2	-2	3	0
Tralorg	60	134	-2	-2	-2	0	-2	-2	0	0	0	0	0	0	0	0	-2	-2	3	0
Tralorg	60	135	-2	-2	-2	0	-2	-2	0	0	0	0	0	0	0	0	-2	-2	3	0
Assel Valley	80	136	-2	-2	-2	0	-2	-2	0	0	0	0	0	0	0	0	-2	-2	3	0
Assel Valley	80	137	-2	-2	-2	0	-2	-2	0	0	0	0	0	0	0	0	-2	-2	3	0
Assel Valley	80	138	-2	-2	-2	0	-2	-2	0	0	0	0	0	0	0	0	-2	-2	3	0
Assel Valley	80	139	-2	0	-2	0	-2	-2	0	0	0	0	0	0	0	0	-2	-2	3	0
Assel Valley	80	140	-2	0	-2	0	-2	-2	0	0	0	0	0	0	0	0	-2	-2	3	0
Assel Valley	80	141	-2	0	0	0	-2	0	0	0	0	0	0	0	0	0	-2	-2	0	0
Assel Valley	80	142	-2	0	0	0	-2	0	0	0	0	0	0	0	0	0	-2	-2	3	0
Assel Valley	80	143	-2	0	0	0	-2	0	0	0	0	0	0	0	0	0	-2	-2	3	0
Assel Valley	80	144	-2	0	0	0	-2	-2	0	0	0	0	0	0	0	0	-2	-2	3	0
Assel Valley	80	145	-2	0	0	0	-2	-2	0	0	0	0	0	0	0	0	-2	-2	0	0
Assel Valley	80	146	-2	0	0	0	-2	0	0	0	0	0	0	0	0	0	-2	-2	3	0
Carrick	122.5	147	-2	-2	0	0	0	-2	0	-2	0	-2	0	-2	-2	0	-2	3	-2	-2
Carrick	122.5	148	-2	-2	0	0	0	-2	0	-2	0	-2	0	-2	-2	3	-2	0	-2	-2
Carrick	122.5	149	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	0	-2	-2	0	-2	-2	0	-2
Carrick	122.5	150	-2	-2	0	0	3	-2	0	-2	0	-2	-2	-2	-2	0	-2	3	-2	-2
Carrick	122.5	151	-2	-2	0	0	3	-2	0	-2	0	-2	0	-2	-2	0	-2	3	-2	-2
Carrick	122.5	152	-2	-2	0	0	-2	-2	0	-2	0	0	-2	-2	0	0	-2	0	-2	-2
Carrick	122.5	153	-2	-2	-2	0	-2	-2	-2	-2	0	0	-2	-2	0	0	-2	-2	0	-2
Carrick	122.5	154	-2	-2	-2	0	-2	-2	-2	-2	0	0	-2	-2	0	0	-2	0	0	-2
Carrick	122.5	155	-2	-2	-2	-2	-2	-2	-2	-2	0	0	-2	-2	0	0	-2	0	0	-2
Carrick	122.5	156	-2	-2	-2	-2	0	-2	-2	-2	0	0	-2	-2	0	0	-2	0	0	-2
Carrick	122.5	157	-2	-2	-2	-2	-2	-2	0	-2	0	0	-2	-2	0	0	-2	0	0	-2
Carrick	122.5	158	-2	-2	-2	-2	-2	-2	0	-2	0	0	-2	-2	0	0	-2	0	0	-2
Carrick	122.5	159	-2	-2	-2	-2	-2	-2	-2	-2	0	0	-2	-2	0	0	-2	0	0	-2
Knockronal	125	160	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	-2	-2	0	-2	0	0	-2
Knockronal	125	161	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	-2	-2	0	-2	0	0	-2
Knockronal	125	162	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	-2	0	0	-2	0	0	-2
Knockronal	105	163	-2	-2	-2	-2	-2	-2	-2	-2	3	0	0	0	0	0	-2	0	0	-2
Knockronal	105	164	-2	-2	-2	-2	-2	-2	-2	-2	0	0	-2	-2	0	0	-2	0	0	-2
Knockronal	105	165	-2	-2	-2	-2	-2	-2	-2	-2	0	0	-2	-2	0	0	-2	0	0	-2
Knockronal	125	166	-2	-2	-2	-2	-2	-2	-2	-2	0	0	-2	-2	0	0	-2	0	0	-2

Knockronal	125	167	-2	-2	-2	-2	-2	-2	-2	-2	0	0	-2	-2	0	0	-2	0	0	-2
Knockronal	125	168	-2	-2	-2	-2	-2	-2	-2	-2	0	0	-2	-2	0	0	-2	0	0	-2
Penwhapple	40	169	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0	0	-2	-2	0	-2
Craiginmoddie	122.5	171	0	0	3	-2	3	-2	0	-2	-2	-2	-2	-2	-2	0	0	3	-2	-2
Craiginmoddie	122.5	172	0	0	0	-2	0	-2	0	-2	-2	-2	-2	-2	-2	-2	0	0	-2	-2
Craiginmoddie	122.5	173	0	0	3	-2	0	-2	0	-2	0	-2	-2	-2	-2	0	-2	0	-2	-2
Craiginmoddie	122.5	174	0	0	0	-2	0	-2	0	-2	0	-2	-2	-2	-2	0	-2	0	-2	-2
Craiginmoddie	122.5	175	0	0	0	-2	0	-2	0	-2	0	-2	-2	-2	-2	0	-2	0	-2	-2
Craiginmoddie	122.5	176	0	0	0	-2	0	-2	0	-2	0	-2	-2	-2	-2	0	-2	0	-2	-2
Craiginmoddie	122.5	177	-2	0	0	-2	0	-2	0	-2	0	-2	-2	-2	-2	0	-2	0	-2	-2
Craiginmoddie	122.5	178	-2	-2	0	-2	0	-2	0	-2	0	-2	-2	-2	-2	0	-2	0	-2	-2
Craiginmoddie	122.5	179	-2	0	0	-2	0	-2	0	-2	0	-2	-2	-2	-2	0	-2	0	-2	-2
Craiginmoddie	122.5	180	-2	0	0	-2	0	-2	0	-2	-2	-2	-2	-2	-2	0	-2	0	-2	-2
Craiginmoddie	122.5	181	-2	0	0	-2	0	-2	0	-2	-2	-2	-2	-2	-2	-2	0	0	-2	-2
Craiginmoddie	122.5	182	0	0	0	-2	3	0	0	-2	-2	-2	-2	-2	-2	0	0	3	-2	-2
Craiginmoddie	122.5	183	0	0	0	-2	3	0	0	-2	-2	-2	-2	-2	-2	0	0	3	-2	-2
Craiginmoddie	122.5	184	0	0	0	-2	3	-2	0	-2	-2	-2	-2	-2	-2	0	0	3	-2	-2

Table 2: Wind Turbine Coordinates

Wind Farm	Easting	Northing	Height
Hadyard Hill	223513	595060	209
Hadyard Hill	223358	595374	209
Hadyard Hill	223261	595751	200
Hadyard Hill	224214	594913	186
Hadyard Hill	223908	595074	198
Hadyard Hill	223845	595430	220
Hadyard Hill	223690	595749	219
Hadyard Hill	223449	596094	208
Hadyard Hill	224246	595298	203
Hadyard Hill	224128	595790	215
Hadyard Hill	223840	596094	220
Hadyard Hill	224243	596107	230
Hadyard Hill	224433	596520	217
Hadyard Hill	224824	596587	223
Hadyard Hill	225177	596460	223
Hadyard Hill	225035	594404	221
Hadyard Hill	225246	594672	216
Hadyard Hill	225656	594887	260
Hadyard Hill	225277	595027	222
Hadyard Hill	225883	595257	225
Hadyard Hill	225520	595693	193
Hadyard Hill	225455	597511	233
Hadyard Hill	225536	595343	214
Hadyard Hill	225194	597710	214
Hadyard Hill	225626	597827	224
Hadyard Hill	226372	597101	223
Hadyard Hill	226778	598150	233
Hadyard Hill	226463	597463	222
Hadyard Hill	227156	597879	224
Hadyard Hill	226890	597529	256
Hadyard Hill	226720	597771	225
Hadyard Hill	226438	598255	240
Hadyard Hill	226778	597157	267
Hadyard Hill	226883	598505	270
Hadyard Hill	227204	598457	254
Hadyard Hill	227548	598361	252
Hadyard Hill	227877	598460	269
Hadyard Hill	227297	597583	252
Hadyard Hill	227130	597183	301
Hadyard Hill	227745	597571	244
Hadyard Hill	227657	597946	230
Hadyard Hill	228220	597729	250
Hadyard Hill	228086	598123	250
Hadyard Hill	228932	597867	267
Hadyard Hill	228627	598059	260

Hadyard Hill	228399	598370	248
Hadyard Hill	228773	598557	253
Hadyard Hill	229372	598125	260
Hadyard Hill	229135	598580	274
Hadyard Hill	229745	598201	270
Hadyard Hill	229478	598541	275
Hadyard Hill	229843	598568	270
Dersalloch	240518	604322	300
Dersalloch	240606	603965	294
Dersalloch	240334	603535	291
Dersalloch	240848	603298	291
Dersalloch	241130	603870	306
Dersalloch	241068	604225	306
Dersalloch	241456	603746	318
Dersalloch	241758	604194	327
Dersalloch	241424	604463	320
Dersalloch	241782	604671	330
Dersalloch	242145	604308	320
Dersalloch	242120	604775	324
Dersalloch	242401	604639	305
Dersalloch	242485	604335	304
Dersalloch	242669	603918	286
Dersalloch	242852	604557	315
Dersalloch	242685	604953	324
Dersalloch	242858	605357	338
Dersalloch	243174	605150	326
Dersalloch	242248	603779	332
Dersalloch	241921	603597	312
Dersalloch	243105	604221	294
Dersalloch	242421	605129	324
Tralorg	222243	597166	245
Tralorg	221976	597358	252
Tralorg	221946	597034	234
Tralorg	221776	596767	251
Tralorg	221611	597044	267
Tralorg	221646	597368	272
Tralorg	221346	597222	290
Tralorg	221325	596922	263
Assel Valley	221343	596556	270
Assel Valley	221623	596334	270
Assel Valley	221311	595947	270
Assel Valley	221274	595625	262
Assel Valley	221544	595408	241
Assel Valley	220803	595683	212
Assel Valley	220512	595339	235
Assel Valley	220449	595064	233
Assel Valley	221549	594910	213

Assel Valley	221623	594556	200
Assel Valley	220223	594492	230
Carrick	234298	599032	390
Carrick	235006	599144	382
Carrick	235701	599334	301
Carrick	234272	598308	387
Carrick	234967	598502	398
Carrick	235666	598647	362
Carrick	236449	598947	298
Carrick	237132	598584	296
Carrick	237885	598581	300
Carrick	238642	598676	285
Carrick	237546	597897	313
Carrick	238380	598000	300
Carrick	238032	597331	290
Knockronal	236759	599643	260
Knockronal	237131	599863	260
Knockronal	237491	599614	280
Knockronal	237838	599922	298
Knockronal	237972	599514	293
Knockronal	238202	599132	305
Knockronal	237720	599172	289
Knockronal	237249	599234	296
Knockronal	236820	599164	285
Penwhapple	225402	596985	206
Glengennet	228744	596963	260
Craiginmoddie	230600	598605	353
Craiginmoddie	231021	598899	328
Craiginmoddie	231450	599350	342
Craiginmoddie	231960	599330	367
Craiginmoddie	231980	599815	330
Craiginmoddie	232495	599675	345
Craiginmoddie	232964	599581	330
Craiginmoddie	232854	599111	328
Craiginmoddie	232319	598909	358
Craiginmoddie	231935	598735	318
Craiginmoddie	231580	598394	293
Craiginmoddie	231017	597903	340
Craiginmoddie	230574	598083	331
Craiginmoddie	231050	598435	363

Annex 5 – Wind Turbine Noise Data

Table A5.1: Sound Power Level Data

Wind Farm	Turbine	Hub height	Uncertainty Included	Reference Wind Speed (ms^{-1}) Standardised to 10m Height									
				3	4	5	6	7	8	9	10	11	12
Hadyard Hill[1]	Bonus 2.3 MW	80	1	104.2	104.2	104.2	104.2	105.3	106.4	107.5	107.5	107.5	107.5
Dersalloch[2]	Siemens 3.0-101, 3 MW	89.5	2	-	97.4	102.2	107.3	109.2	110	110	110	110	110
Assel Valley	Vestas V90, 3 MW	80	2	-	99.9	102.9	106.2	108.1	109	109	109	109	109
Tralorg	Vestas V80, 2 MW	60	2	-	95.2	100.6	104.7	106.3	107	107	107	107	107
Penwhapple	EWT DW61, 500 kW	50	2	-	95.3	99.8	102.5	103.2	103.5	103.5	103.5	103.5	103.5
Glengennet	Westwind, 20 kW	15	2	-	87.1	88.6	90.1	91.5	93	94.5	95.9	97.4	-
Craiginmoddie[3]	SG 6.0-155, 6.6 MW	122.5	2	95.2	100.4	105.2	107	107	107	107	107	107	107
Carrick	SG 6.0-155, 6.6 MW	122.5	2	95.2	100.4	105.2	107	107	107	107	107	107	107
Knockronal[4]	Vestas V150, 6 MW	125	2	95	98.6	103	106.3	106.8	106.9	106.9	106.9	106.9	106.9

Table A5.2: Octave Band Data

Scheme	Turbine Modelled	Octave Band (Hz)								
		63	125	250	500	1000	2000	4000	8000	Overall
Hadyard Hill	Bonus 2.3 MW	92.0	98.7	99.7	99.5	98.3	98.3	93.6	82.4	106.4
Dersalloch	Siemens 3.0-101, 3 MW	74.8	86.7	93.4	96.7	93.4	85.5	74.6	71.3	100.0
Assel Valley	Vestas V90, 3 MW	93.9	96.0	99.3	101.6	103.8	102.5	98.7	88.7	109.0
Tralorg	Vestas V80, 2 MW	84.6	93.9	99.2	99.9	97.3	95.9	91.5	77.2	107.0
Penwhapple	EWT DW61, 500 kW	82.8	90.1	96.6	98.0	95.7	91.8	85.1	74.3	102.5
Glengennet	Westwind, 20 kW	67.2	70.8	89.1	82.6	87.5	85.0	78.8	71.1	93.0
Craiginmoddie	SG 6.0-155, 6.6 MW	84.8	92.2	96.8	99.1	98.9	99.2	92.6	77.6	105.2
Carrick	SG 6.0-155, 6.6 MW	84.8	92.2	96.8	99.1	98.9	99.2	92.6	77.6	105.2
Knockronal	Vestas V150, 6 MW	81.1	88.7	93.4	95.1	94.0	89.9	82.9	72.9	100.0

Data Source

1.Hadyard Hill Extension ES, Annex 6.

2. Knockronal EIAR, Table C3 and C4

3. Craiginmoddie EIAR, Tables 10.11 and 10.12

4. Knockronal EIAR, Table C1 and C2

Annex 6 – Predictions

Table A6.1 Dersalloch Wind Farm Cautious Predictions, L_{A90}

Location	Wind Speed (ms^{-1}) as standardised to 10 m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – Delamford Cottage	-	-	-	-	5.1	9.9	12.5	13.6	13.9	13.9	13.9	13.9
NAL2 – Dobbingstone Farm	-	-	-	-	7.1	11.9	14.5	15.6	15.9	15.9	15.9	15.9
NAL3 - Knockrochar	-	-	-	-	6.6	11.4	14	15.1	15.4	15.4	15.4	15.4
NAL4 – Dalquhairn Farm	-	-	-	-	6.6	11.4	14	15.1	15.4	15.4	15.4	15.4
NAL5 – Corphin Cottage	-	-	-	-	3.4	8.2	10.8	11.9	12.2	12.2	12.2	12.2
NAL6 – Daljedburgh Farm	-	-	-	-	5.3	10.1	12.7	13.8	14.1	14.1	14.1	14.1
NAL7 – Doughty Farm	-	-	-	-	8.2	13	15.6	16.7	17	17	17	17
NAL8 – White Row	-	-	-	-	8.5	13.3	15.9	17	17.3	17.3	17.3	17.3
NAL9 – Glenalla	-	-	-	-	12.1	16.9	19.5	20.6	20.9	20.9	20.9	20.9
NAL15- Milton Farm	-	-	-	-	4.4	8.8	11	11.9	12.1	12.1	12.1	12.1
NAL16 –Alton Albany Cottage	-	-	-	-	1.3	6.1	8.7	9.8	10.1	10.1	10.1	10.1
NAL18 – Blair Farm	-	-	-	-	12.8	17.6	20.2	21.3	21.6	21.6	21.6	21.6
**0 dB was added as per Section 6.6.4 of the report as the predictions are already based on a sound power level that is 1 dB higher than agreed as part of the discharge of conditions*												

Table A6.2 Hadyard Hill Wind Farm Cautious Predictions, L_{A90}

Location	Wind Speed (ms^{-1}) as standardised to 10 m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – Delamford Cottage	-	-	-	43.3	43.3	43.3	44.1	45.1	46.2	46.6	46.6	46.6
NAL2 – Dobbingstone Farm	-	-	-	35.8	35.8	35.8	36.6	37.7	38.8	39.1	39.1	39.1
NAL3 - Knockrochar	-	-	-	36.1	36.1	36.1	36.9	38	39	39.4	39.4	39.4
NAL4 – Dalquhairn Farm	-	-	-	29.9	29.9	29.9	30.7	31.8	32.8	33.2	33.2	33.2
NAL5 – Corphin Cottage	-	-	-	38.8	38.8	38.8	39.6	40.7	41.8	42.1	42.1	42.1
NAL6 – Daljedburgh Farm	-	-	-	32.7	32.7	32.7	33.6	34.6	35.7	36	36	36
NAL7 – Doughty Farm	-	-	-	29.6	29.6	29.6	30.4	31.5	32.5	32.9	32.9	32.9
NAL8 – White Row	-	-	-	24.8	24.8	24.8	25.6	26.7	27.8	28.1	28.1	28.1
NAL9 – Glenalla	-	-	-	24.8	24.8	24.8	25.6	26.6	27.7	28.1	28.1	28.1
NAL15- Milton Farm	-	-	-	35.6	35.6	35.6	36.5	37.5	38.6	38.9	38.9	38.9
NAL16 –Alton Albany Cottage	-	-	-	34.6	34.6	34.6	35.4	36.5	37.6	37.9	37.9	37.9
NAL18 – Blair Farm	-	-	-	25.8	25.8	25.8	26.6	27.6	28.7	29.1	29.1	29.1
**+2 dB was added as Section 6.6.4 of the report*												

Table A6.3 Carrick Wind Farm Predictions – Full Mode Operation, L_{A90}

Location	Wind Speed (ms^{-1}) as standardised to 10 m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – Delamford Cottage	-	-	5.1	10.3	15.1	16.9	16.9	16.9	16.9	16.9	16.9	16.9
NAL2 – Dobbingstone Farm	-	-	7	12.2	17	18.8	18.8	18.8	18.8	18.8	18.8	18.8
NAL3 - Knockrochar	-	-	7.2	12.4	17.2	19.1	19.1	19.1	19.1	19.1	19.1	19.1
NAL4 – Dalquhairn Farm	-	-	12.4	17.6	22.4	24.2	24.2	24.2	24.2	24.2	24.2	24.2
NAL5 – Corphin Cottage	-	-	6.3	11.5	16.3	18.1	18.1	18.1	18.1	18.1	18.1	18.1
NAL6 – Daljedburgh Farm	-	-	7.6	12.8	17.6	19.5	19.5	19.5	19.5	19.5	19.5	19.5
NAL7 – Doughty Farm	-	-	16.9	22.1	26.9	28.7	28.7	28.7	28.7	28.7	28.7	28.7
NAL8 – White Row	-	-	14.2	19.4	24.2	26	26	26	26	26	26	26
NAL9 – Glenalla	-	-	24	29.2	33.9	35.8	35.8	35.8	35.8	35.8	35.8	35.8
NAL15- Milton Farm	-	-	3.9	9.1	13.9	15.8	15.8	15.8	15.8	15.8	15.8	15.8
NAL16 –Alton Albany Cottage	-	-	4	9.2	14	15.8	15.8	15.8	15.8	15.8	15.8	15.8
NAL18 – Blair Farm	-	-	8.8	14	18.8	20.6	20.6	20.6	20.6	20.6	20.6	20.6

Table A6.4 Knockronal Wind Farm Predictions – Full Mode Operation, L_{A90}

Location	Wind Speed (ms^{-1}) as standardised to 10 m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – Delamford Cottage	-	-	-	5.6	9.9	13.3	13.9	14	14	14	14	14
NAL2 – Dobbingstone Farm	-	-	-	7.5	11.8	15.2	15.8	15.9	15.9	15.9	15.9	15.9
NAL3 - Knockrochar	-	-	-	6.6	10.9	14.3	14.9	15	15	15	15	15
NAL4 – Dalquhairn Farm	-	-	-	9.7	14	17.4	17.9	18	18	18	18	18
NAL5 – Corphin Cottage	-	-	-	4.4	8.7	12	12.6	12.7	12.7	12.7	12.7	12.7
NAL6 – Daljedburgh Farm	-	-	-	7.4	11.7	15.1	15.7	15.8	15.8	15.8	15.8	15.8
NAL7 – Doughty Farm	-	-	-	11.9	16.2	19.6	20.1	20.2	20.2	20.2	20.2	20.2
NAL8 – White Row	-	-	-	13.5	17.8	21.1	21.7	21.8	21.8	21.8	21.8	21.8
NAL9 – Glenalla	-	-	-	22.4	26.7	30	30.6	30.7	30.7	30.7	30.7	30.7
NAL15- Milton Farm	-	-	-	4.6	8.9	12.2	12.8	12.9	12.9	12.9	12.9	12.9
NAL16 –Alton Albany Cottage	-	-	-	4	8.3	11.6	12.2	12.3	12.3	12.3	12.3	12.3
NAL18 – Blair Farm	-	-	-	10.6	14.9	18.3	18.9	19	19	19	19	19

Table A6.5 Craiginmoddie Wind Farm Predictions – Full Mode Operation, L_{A90}

Location	Wind Speed (ms^{-1}) as standardised to 10 m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – Delamford Cottage	-	-	20.6	25.8	30.6	32.5	32.5	32.5	32.5	32.5	32.5	32.5
NAL2 – Dobbingstone Farm	-	-	22	27.2	31.9	33.8	33.8	33.8	33.8	33.8	33.8	33.8
NAL3 - Knockrochar	-	-	20.4	25.6	30.4	32.2	32.2	32.2	32.2	32.2	32.2	32.2
NAL4 – Dalquhairn Farm	-	-	17.6	22.8	27.6	29.5	29.5	29.5	29.5	29.5	29.5	29.5
NAL5 – Corphin Cottage	-	-	18.6	23.8	28.6	30.4	30.4	30.4	30.4	30.4	30.4	30.4
NAL6 – Daljedburgh Farm	-	-	19.2	24.4	29.2	31.1	31.1	31.1	31.1	31.1	31.1	31.1
NAL7 – Doughty Farm	-	-	26.1	31.3	36.1	38	38	38	38	38	38	38
NAL8 – White Row	-	-	11.5	16.7	21.5	23.3	23.3	23.3	23.3	23.3	23.3	23.3
NAL9 – Glenalla	-	-	18.6	23.8	28.6	30.5	30.5	30.5	30.5	30.5	30.5	30.5
NAL15- Milton Farm	-	-	15.4	20.6	25.4	27.2	27.2	27.2	27.2	27.2	27.2	27.2
NAL16 –Alton Albany Cottage	-	-	11.4	16.6	21.4	23.2	23.2	23.2	23.2	23.2	23.2	23.2
NAL18 – Blair Farm	-	-	14.3	19.5	24.3	26.1	26.1	26.1	26.1	26.1	26.1	26.1

A6.1 Comparison of the predicted noise level data presented in Table A6.3 and Table A6.5 (Full Mode Operation) with the SSNLs presented on Figures A1.3a-r (In Annex 1) and Tables 6.8 and 6.9 indicate that for the majority of locations these would be compliant with the SSNLs. However, some noise mode management would need to be applied to CMWF during daytime periods only to ensure noise meets the SSNLs at NALs 1 and 5. Noise mode management would also be required to ensure that the noise from CWF and CMWF meets the SSNLs at NAL7. The maximum required reduction in predicted noise levels is 4.3 dB at 6 ms^{-1} to be applied to CMWF in the case of NAL1.

A6.2 The full mode operation predictions represent a worst case of downwind propagation, lower noise levels would arise for non-downwind directions due to directional attenuation factors (as advised in the IOA GPG). Noise levels can also be reduced through the implementation of noise mode management, applying noise constrained modes of turbine operation where required. An example is presented in Section 9.7.3 of the CWF EIAR.

A6.3 Further consideration has been given to the predicted full mode operation predictions presented in this report (shown in Tables A6.3 and A6.5 and the reductions required to meet the SSNL. Table A6.6 details the noise management modes which are available for the SG 6.0-155 6.6 MW turbine and summarises the reductions which can be achieved for each wind speed. It can be seen in Table A6.6 that at a wind speed of 6 ms^{-1} use of noise management modes can provide in excess of the 4.3 dB reduction which is required. The required levels of reduction can be achieved for every relevant wind speed using the noise control modes which are available. The use of noise constrained modes of turbine operation would only need be applied for the wind speeds and wind directions in which they are required in order to meet the SSNLs.

Table A6.6 Mode Management Options for the SG 6.0-155 (Sound Power Level L_{Aeq})

	Wind Speed (ms^{-1}) as standardised to 10 m height											
	1	2	3	4	5	6	7	8	9	10	11	12
Unrestricted AM0	-	-	95.2	100.4	105.2	107.0	107.0	107.0	107.0	107.0	107.0	107.0
Noise Reduced Mode N1	-	-	95.2	100.4	104.8	106.0	106.0	106.0	106.0	106.0	106.0	106.0
Noise Reduced Mode N2	-	-	95.2	100.4	104.6	105.5	105.5	105.5	105.5	105.5	105.5	105.5
Noise Reduced Mode N3	-	-	95.2	100.4	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0
Noise Reduced Mode N4	-	-	95.2	100.4	103.0	103.0	103.0	103.0	103.0	103.0	103.0	103.0
Noise Reduced Mode N5	-	-	95.2	100.4	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0
Noise Reduced Mode N6	-	-	95.2	100.4	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0
Noise Reduced Mode N7	-	-	95.2	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Noise Reduced Mode N8	-	-	95.2	98.8	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0
Maximum Noise Levels Reduction between unrestricted mode AM0 and Noise Reduced Mode N8	-	-	0.0	-1.6	-6.2	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0
**includes additional +2 dB uncertainty in accordance with the IOA GPG*												

A6.4 On the basis of the above, mitigated noise levels for CMWF and CWF have been set at either the unconstrained level (for wind speed where SSNL is achieved without mitigation) as presented in Tables A6.3 and A6.5, or at the SSNL for wind speeds where mitigation is required. Mitigated noise levels for CWF and CMWF are presented in Tables A6.7 and A6.8 below.

Table A6.7 Carrick Wind Farm Predictions – Mode Managed Operation, L_{A90}

Location	Wind Speed (ms^{-1}) as standardised to 10 m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL7 – Doughty Farm	-	-	16.9	22.1	26.9	27.5	27.3	27.1	27.5	28.7	28.7	28.7

Table A6.8 Craiginmoddie Wind Farm Predictions – Mode Managed Operation, L_{A90}

Location	Wind Speed (ms^{-1}) as standardised to 10 m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL1 – Delamford Cottage	-	-	20.6	25.8	28.0	28.2	30.3	32.5	32.5	32.5	32.5	32.5
NAL5 – Corphin Cottage	-	-	18.6	23.8	28.0	28.0	28.0	29.2	30.4	30.4	30.4	30.4
NAL7 – Doughty Farm	-	-	26.1	31.3	36.1	36.8	36.6	36.4	36.8	38.0	38.0	38.0