Vale of Leven Wind Farm Limited

Vale of Leven Wind Farm

Environmental Impact Assessment

Chapter 11 – Noise and Vibration

Technical Appendix 11.1 – Environmental Noise Assessment: Supplementary Information

663510 – 3 (00)

OCTOBER 2023

CONTENTS

FIGURES

ADDITIONAL STATUTORY AND PLANNING CONTEXT

Infrasound and Low Frequency Noise

11.1.1 Infrasound is sound below 20 Hz and low frequency noise is generally below 200 Hz. In relation to Infrasound, the following extract from the EPA document Guidance Note for Noise Assessment of Wind Turbine Operations at EPA Licensed Sites NG3 discusses:

“There is similarly no significant infrasound from wind turbines. Infrasound is high level sound at frequencies below 20 Hz. This was a prominent feature of passive yaw “downwind” turbines where the blades were positioned downwind of the tower which resulted in a characteristic “thump” as each blade passed through the wake caused by the turbine tower. With modern active yaw turbines (i.e. the blades are upwind of the tower and the turbine is turned to face into the wind by a wind direction sensor on the nacelle activating a yaw motor) this is no longer a significant feature.”

11.1.2 In 2010, the UK Health Protection Agency published a report titled ‘Health Effects of Exposure to Ultrasound and Infrasound, Report of the independent Advisory Group on Non-ionising Radiation’. The exposures considered in the report related to medical applications and general environmental exposure. The report notes:

“Infrasound is widespread in modern society, being generated by cars, trains and aircraft, and by industrial machinery, pumps, compressors and low speed fans. Under these circumstances, infrasound is usually accompanied by the generation of audible, low frequency noise. Natural sources of infrasound include thunderstorms and fluctuations in atmospheric pressure, wind and waves, and volcanoes; running and swimming also generate changes in air pressure at infrasonic frequencies.

For infrasound, aural pain and damage can occur at exposures above about 140 dB, the threshold depending on the frequency. The best-established responses occur following acute exposures at intensities great enough to be heard and may possibly lead to a decrease in wakefulness. The available evidence is inadequate to draw firm conclusions about potential health effects associated with exposure at the levels normally experienced in the environment, especially the effects of long-term exposures. The available data do not suggest that exposure to infrasound below the hearing threshold levels is capable of causing adverse effects.”

11.1.3 The Institute of Acoustics Bulletin in March 2009 included a statement of agreement between acoustic consultants regularly employed on behalf of wind farm developers, and conversely acoustic consultants regularly employed on behalf of community groups campaigning against wind farm developments. The intent of the article was to promote consistent assessment practices, and to assist in restricting wind farm noise disputes to legitimate matters of concern. On the subject of infrasound, the article notes:

“Infrasound is the term generally used to describe sound at frequencies below 20 Hz. At separation distances from wind turbines which are typical of residential locations the levels of infrasound from wind turbines are well below the human perception level. Infrasound from wind turbines is often at levels below that of the noise generated by wind around buildings and other obstacles.

Sounds at frequencies from about 20 Hz to 200 Hz are conventionally referred to as low-frequency sounds. A report for the DTI in 2006 by Hayes McKenzie concluded that neither infrasound nor low frequency noise was a significant factor at the separation distances at which people lived. This *was confirmed by a peer review by a number of consultants working in this field. We concur with this view."*

11.1.4 The article concludes that:

"From examination of reports of the studies referred to above, and other reports widely available on internet sites, we conclude that there is no robust evidence that low frequency noise (including 'infrasound') or ground -borne vibration from wind farms, generally has adverse effects on wind farm neighbours."

11.1.5 A report released in January 2013 by the South Australian Environment Protection Authority namely, Infrasound levels near windfarms and in other environments (EPA, 2013) found that the level of infrasound from wind turbines is insignificant and no different to any other source of noise, and that the worst contributors to household infrasound are air-conditioners, traffic and noise generated by people.

11.1.6 The study included several houses in rural and urban areas, both adjacent to and away from a wind farm, and measured the levels of infrasound with the wind farms operating and switched off.

11.1.7 There were no noticeable differences in the levels of infrasound under all these different conditions. In fact, the lowest levels of infrasound were recorded at one of the houses closest to a wind farm, whereas the highest levels were found in an urban office building.

11.1.8 The EPA's study concluded that the level of infrasound at houses near wind turbines was no greater than in other urban and rural environments, and stated that:

"The contribution of wind turbines to the measured infrasound levels is insignificant in comparison with the background level of infrasound in the environment."

11.1.9 In the unlikely event that an issue with low frequency noise is associated with the operation of the Proposed Development, it is recommended that an appropriate detailed investigation be undertaken. Due consideration should be given to guidance on conducting such an investigation which is outlined in Appendix VI of the EPA Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4) (EPA, 2016). This guidance is based on the threshold values outlined in the Salford University document Procedure for the assessment of low frequency noise complaints, Revision 1, December 2011.

Amplitude Modulation

11.1.10 Amplitude Modulation (AM) is defined in the institute of Acoustics Noise Working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) document 'A Method for Rating Amplitude Modulation in Wind Turbine Noise' as:

"Periodic fluctuations in the level of audible noise from a wind turbine (or wind turbines), the frequency of the fluctuations being related to the blade passing frequency (BPF) of the turbine rotor(s)."

11.1.11 It is now generally accepted that there are two mechanisms which can cause amplitude modulation:

- 'Normal' AM (NAM), and:
- 'Other' AM (OAM)

11.1.12 NAM can generally be described as an observer at ground level close to a wind turbine experiencing 'blade swish' because of the directional characteristics of the noise radiated from the trailing edge of the blades as it rotates towards and then away from the observer. This effect is reduced for an observer on or close to the turbine axis, and would not generally be expected to be significant at typical separation distances, at least on relatively level sites. The RenewableUK AM project has coined the term NAM for this inherent characteristic of wind turbine noise, which has long been recognised and discussed in ETSU-R-97.

11.1.13 OAM is observed at large distances from a wind turbine (or turbines). The sound is generally heard as a periodic 'thumping' or 'whoomphing' at relatively low frequencies. On sites where it has been reported, occurrences appear to be occasional, although they can persist for several hours under some conditions, dependent on atmospheric factors, including wind speed and direction. It was proposed in the RenewableUK 2013 study that the fundamental cause of this type of AM is transient stall conditions occurring as the blades rotate, giving rise to the periodic thumping at the blade passing frequency. Transient stall represents a fundamentally different mechanism from blade swish and can be heard at relatively large distances, primarily downwind of the rotor blade. The RenewableUK AM project report adopted the term OAM for this characteristic. The terms 'enhanced' or 'excess' AM (EAM) have been used by others, although such definitions do not distinguish between the source mechanisms and presuppose a 'normal' level of AM, presumably relating back to blade swish as described in ETSU-R-97.

11.1.14 In both cases of NAM and OAM, the result is a regular fluctuation in amplitude at the Blade Passing Frequency (BPF) of the wind turbine blades (the rate at which the blades of the turbine pass a fixed point). For a three-bladed turbine rotating at 20 rpm, this equates to a modulation frequency of 1 Hz.

11.1.15 The frequency of occurrence of AM was researched by Salford University commissioned by the Department of Environment Food and Rural Affairs (DEFRA), the Department of Business, Enterprise and Regulatory Reform (BERR) and the Department of Communities and Local Government (CLG) investigated the issue of AM associated with wind turbine noise. The results were reviewed and published in the report 'Research into Aerodynamic Modulation of Wind Turbine Noise'. The broad conclusions of this report was that aerodynamic modulation was only considered to be an issue at 4, and a possible issue at a further 8, of 133 sites in the UK that were operational at the time of the study and considered within the review. At the four sites where AM was confirmed as an issue, it was considered that conditions associated with AM might occur between about 7-15% of the time. It also emerged that for three out of the four sites the complaints have subsided, in one case due to the introduction of a turbine control system. The research has shown that AM is a rare and unlikely occurrence at operational wind farms.

11.1.16 It should be noted that AM is associated with wind turbine operation and it is not possible to predict an occurrence of AM at the planning stage. It should also be noted that it is a rare event associated with a limited number of wind farms. While it can occur, it is considered to be an exception rather than the rule.

11.1.17 The RenewableUK Research Document states the following in relation to matter:

"Even on those limited sites where it has been reported, its frequency of occurrence appears to be at best infrequent and intermittent."

"It has also been the experience of the project team that, even at those wind farm sites where AM has been reported or identified to be an issue, its occurrence may be relatively infrequent. Thus, the capture of time periods when subjectively significant AM occurs may involve elapsed periods of several weeks or even months."

"There is nothing at the planning stage that can presently be used to indicate a positive likelihood of OAM occurring at any given proposed wind farm site, based either on the site's general characteristics or on the known characteristics of the wind turbines to be installed."

11.1.18 Research and Guidance in the area is ongoing with recent publications being issued by the Institute of Acoustics Noise working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) namely, 'A Method for Rating Amplitude Modulation in Wind Turbine Noise'. The document proposes an objective method for measuring and rating AM. The AMWG does not propose what level of AM is likely to result in adverse community response.

11.1.19 In summary, research has shown that OAM is not something that is possible to foresee at the planning stage, it is infrequent (does not occur on every site), and when it does occur, it does so under very specific wind conditions. But its presence can be measured and rated, typically in the event of a complaint post construction. It is therefore standard practice for OAM to investigated only in the event of complaint and where the investigation verifies its presence, mitigation measures put in place to address the identified turbine OAM noise characteristics.

Tonality

11.1.20 Tonality may be defined as a concentration of acoustic energy into a very narrow frequency range, sometimes describes as a whine or hum. Where tones are found to be present a correction is added to the measured or predicted noise level before comparison with the recommended targets/criteria. The audibility of any tones is assessed by comparing the narrow band level of such tones with the masking level contained in a band of frequencies around the tone called the critical band. The criteria recommendations suggest a tone correction which depends on the amount by which the tone exceeds the audibility threshold and should be included as part of the consent conditions. The turbines to be used for this site would be chosen to ensure that the noise emitted will comply with the relevant noise targets including any relevant tonality corrections.

Wind Shear

11.1.21 Wind shear, also known as wind gradient, is the difference in wind speed and/or direction over a short distance in the atmosphere. In relation to wind farms and turbines, vertical wind sheer is the change in wind speed with relation to height. ETSU-R-97 suggests that a standardised height of 10 m is appropriate for referencing background noise levels against wind speeds. It should be noted that this is not representative of wind at hub height, which is what affects the noise generated by the turbines.

11.1.22 ETSU-R-97 and the GPG suggest that the preferred method of accounting for wind shear is by referencing background noise measurements to hub height wind speeds. The hub height wind speeds are then corrected to the standardised 10 m height.

Audibility

11.1.23 Potential audibility of noise generated from the operation of wind farms depends largely the amount that the predicted noise level of the turbine exceeds the background noise level and if there are any acoustical features, such as tonality or amplitude modulation, that make it more prominent. Where predicted noise levels are equal to or near the background noise level, it is suggested that the turbine noise will be slightly audible, with audibility increasing as the as the predicted level increases.

Sleep Disturbance

11.1.24 The potential for sleep disturbance from wind turbines depends on the average and maximum noise levels of sleeping areas during the night. ETSU-R-97 aims to protect against sleep disturbance by limiting the amount of turbine noise outside of dwellings, assuming that the windows are open for ventilation as a worst case scenario. The internal noise levels in such circumstances can be calculated by assuming a 10-15 dB reduction in noise from outside to inside.

11.1.25 The World Health Organization (WHO) recommends that average night-time noise levels in sleeping areas should not exceed 30 dB L_{Aeq}. This figure relates to overall noise levels in sleeping areas, but the potential for sleep disturbance specifically from turbine noise can be evaluated for each dwelling by subtracting 10-15 dB from the predicted turbine noise level and comparing with this criterion. After also adding 2 dB to convert the predicted turbine noise level to an L_{Aeq} value, this will give an estimate of the noise level that would be experienced indoors with the windows open.

11.1.26 The WHO also recommends that the population is not exposed to average external night-time noise levels, over a whole year, of more than 40 dB L_{Aeq}. This average yearly noise level will depend on the variation in wind speed, wind direction, and noise from other sources over each year period.

11.1.27 The latest guidance from the WHO conditionally recommends that turbine noise should not exceed an L_{den} of 45 dB. L_{den} is the average noise level over one year, where noise during evening and night-time periods is penalized with a 5 and 10 dB correction respectively. Although compliance can be shown through predictions, it would be almost impossible to establish compliance with this target through measurements at residential locations.

11.1.28 It is also important to note that potential difficulty in getting to sleep, either at the start of the night or once awoken by other sources, may be more related to the audibility of the noise indoors under specific circumstances than by average noise level. For example, a sudden loud noise may be more disruptive to sleep than a constant lower-level noise.

BASELINE NOISE SURVEY PHOTOS

Figure 1 Highdykes Farm baseline noise measurement location, looking southeast

Figure 2 Highdykes Farm baseline noise measurement location, looking northeast

Figure 3 Gallangad Lodge baseline noise measurement location, looking southwest

Figure 4 Gallangad Lodge baseline noise measurement location, looking northwest

BACKGROUND NOISE SCATTER GRAPHS

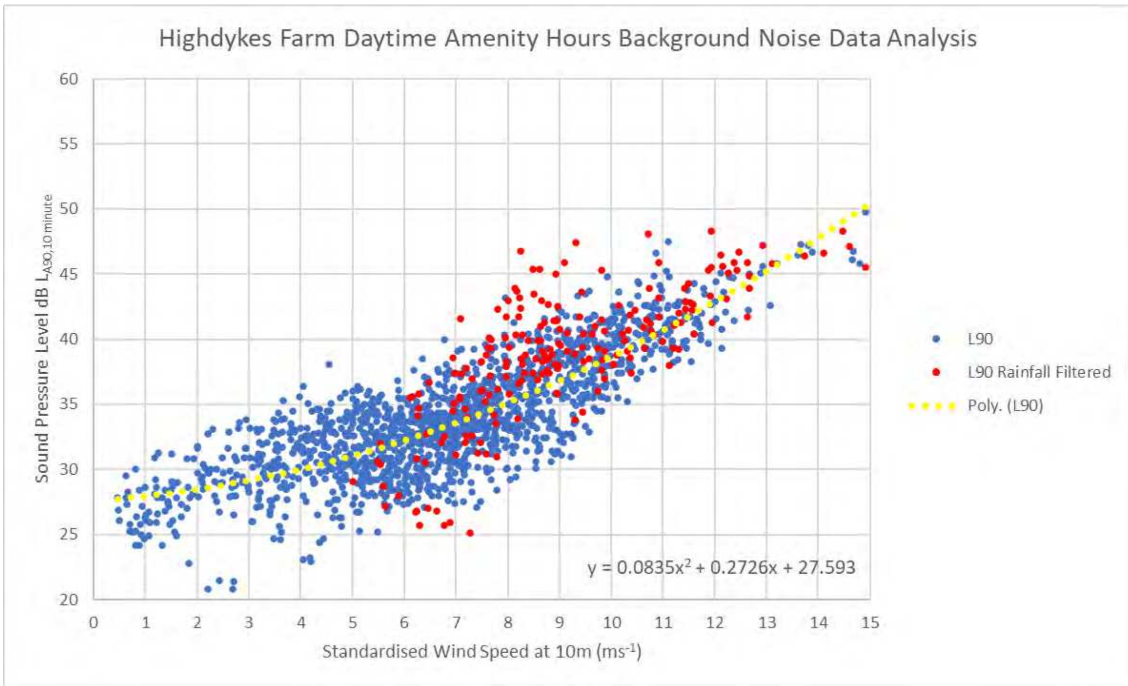


Figure 5 Highdykes Farm Daytime Regression Analysis

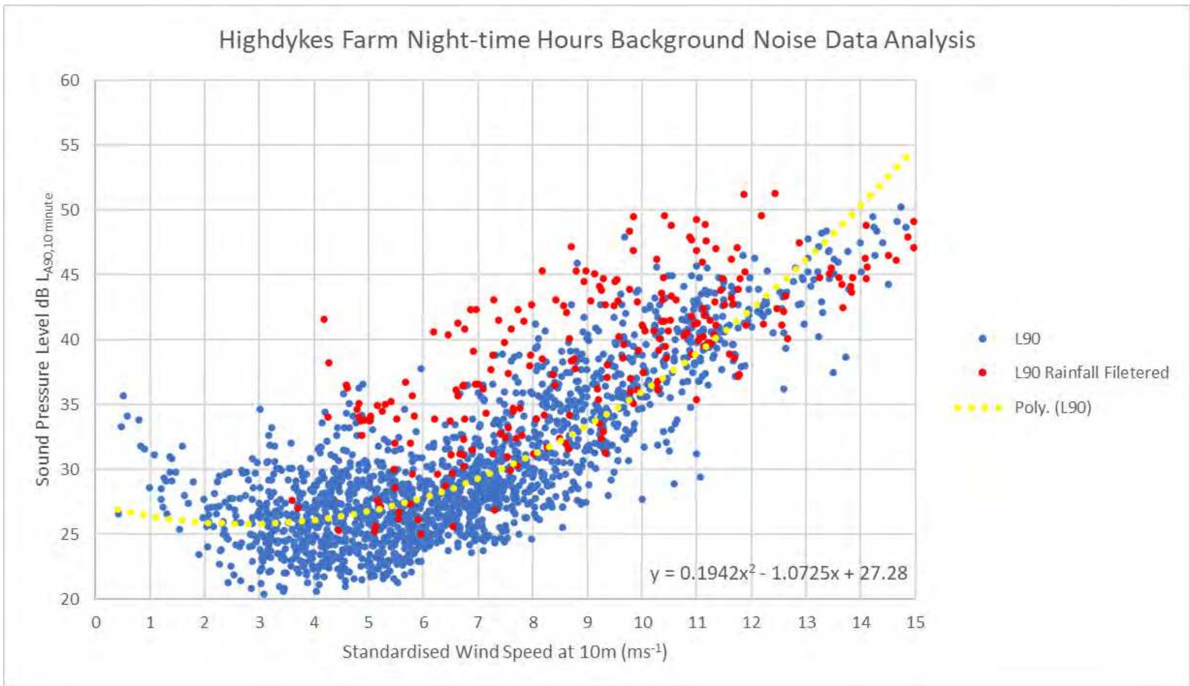


Figure 6 Highdykes Farm Night-time Regression Analysis

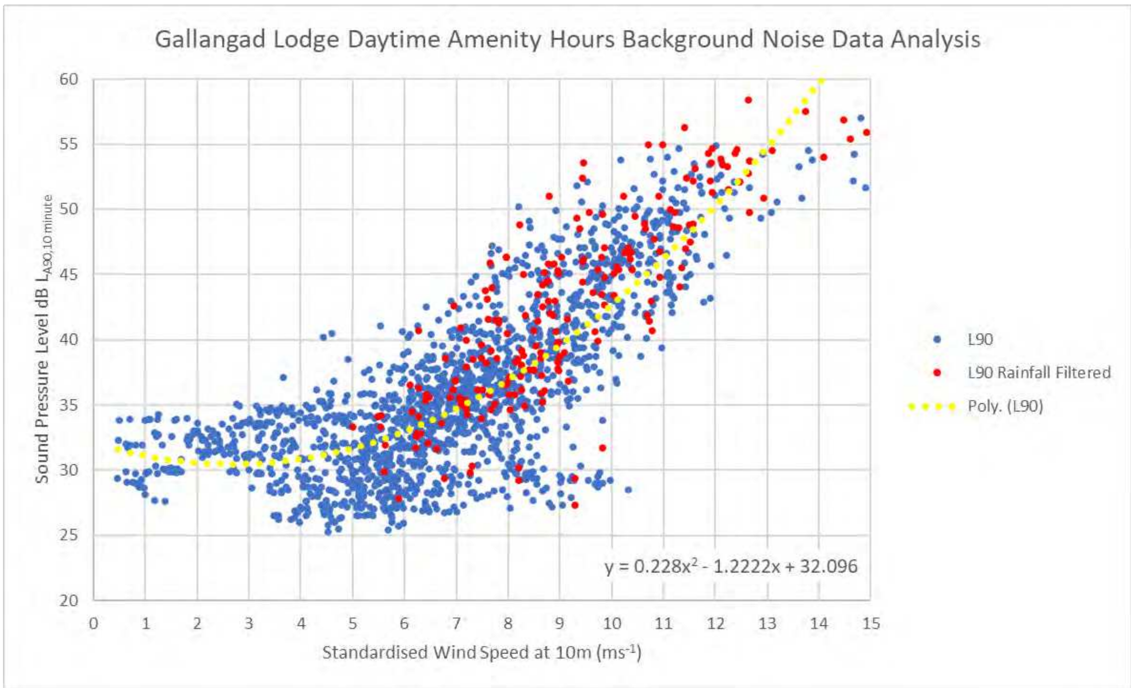


Figure 7 Gallangad Lodge Daytime Regression Analysis

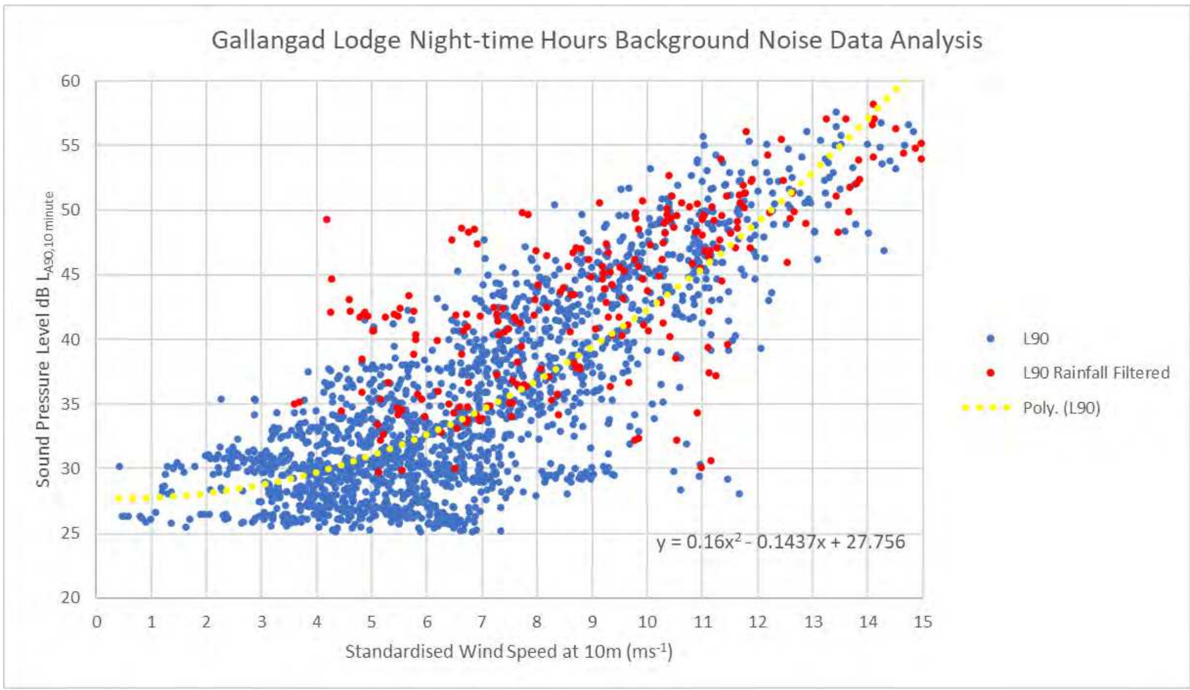


Figure 8 Gallangad Lodge Night-time Regression Analysis

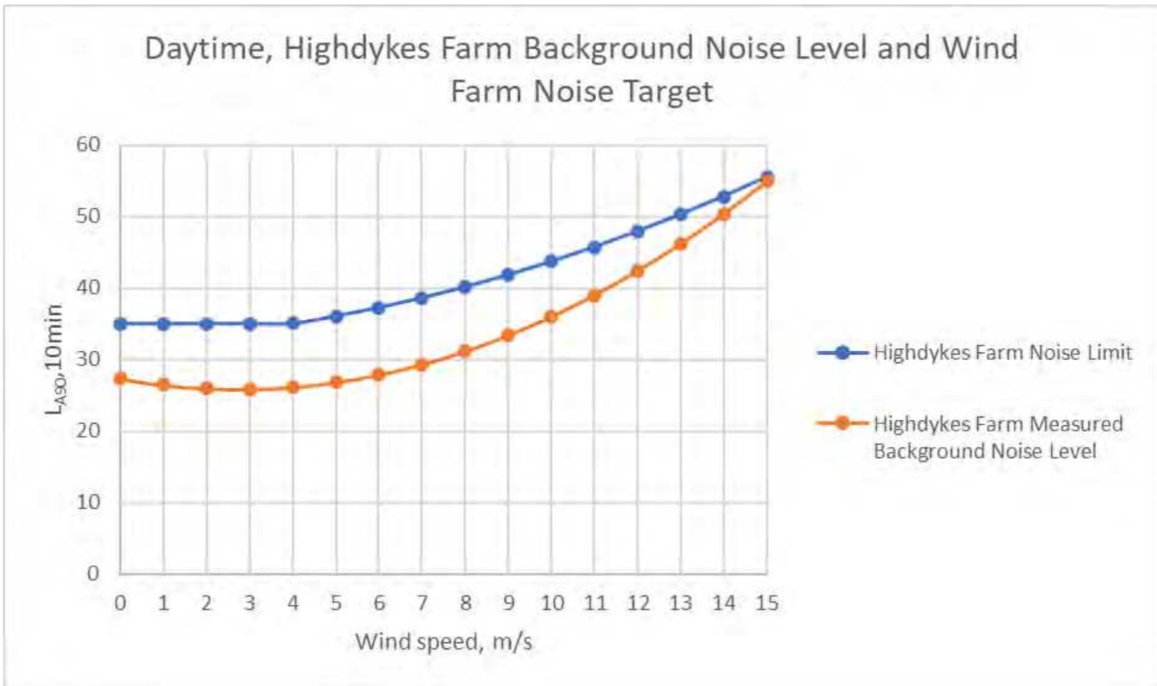


Figure 9 Daytime Criteria derivation at Highdykes Farm

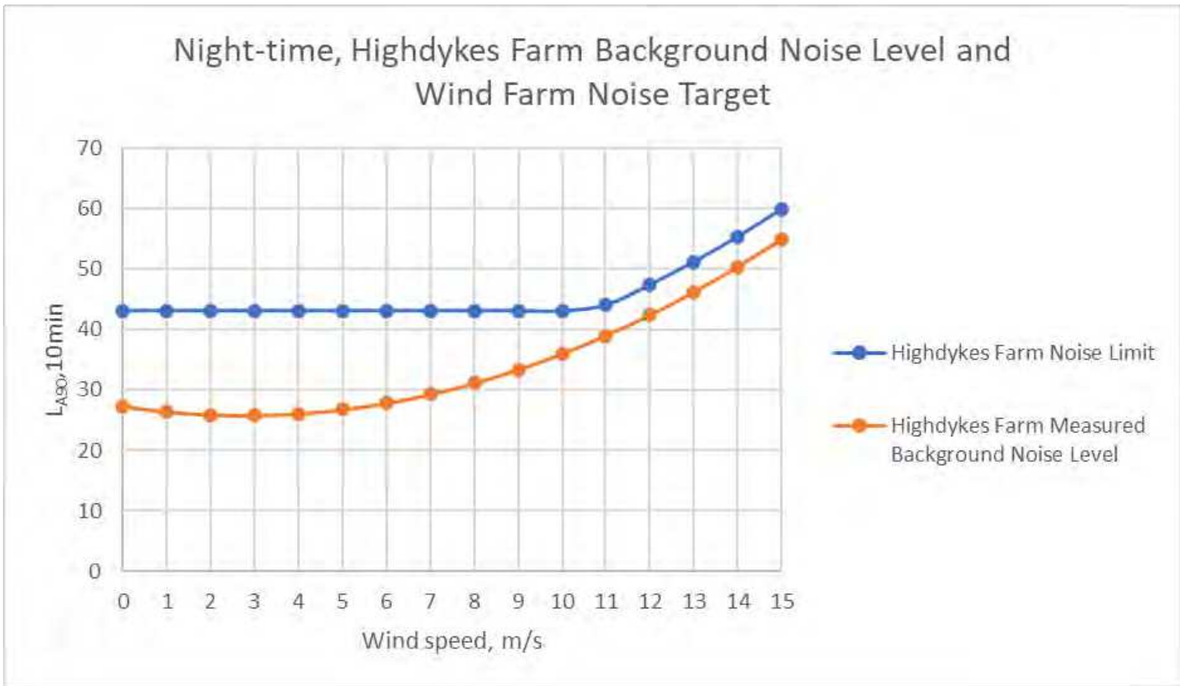


Figure 10 Night-time Criteria derivation at Highdykes Farm

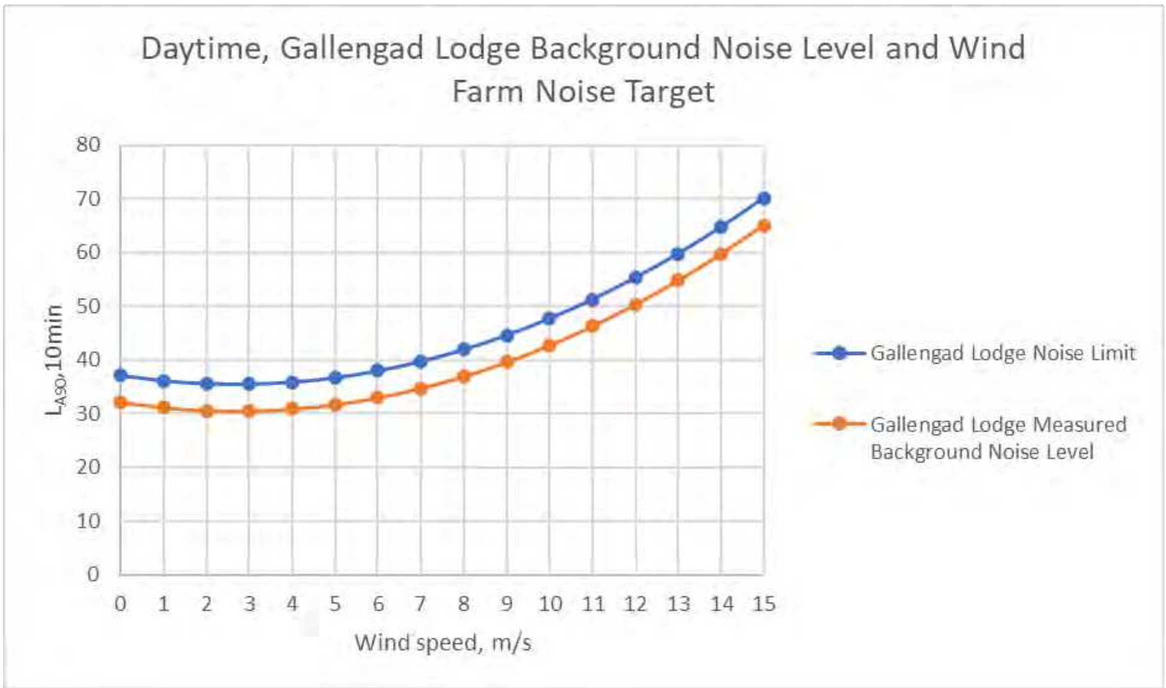


Figure 11 Daytime Criteria derivation at Gallengad Lodge

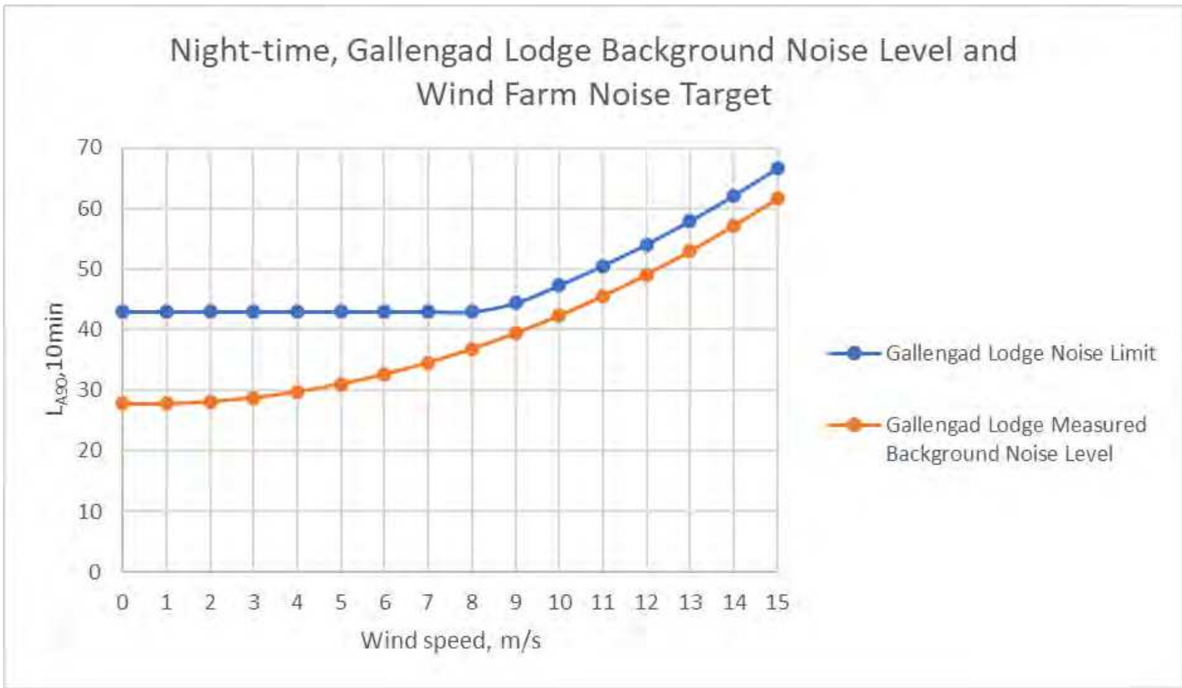


Figure 12 Night-time Criteria derivation at Highdykes Farm

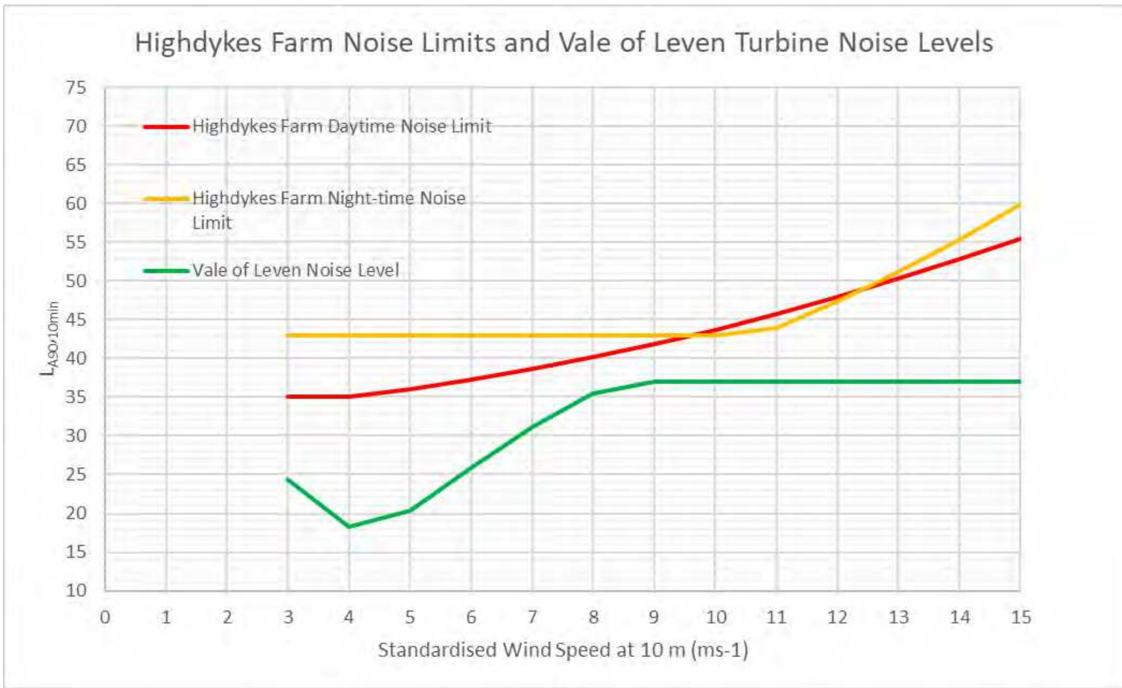


Figure 13 Vale of Leven Operation Turbine Noise Levels at Highdykes Farm

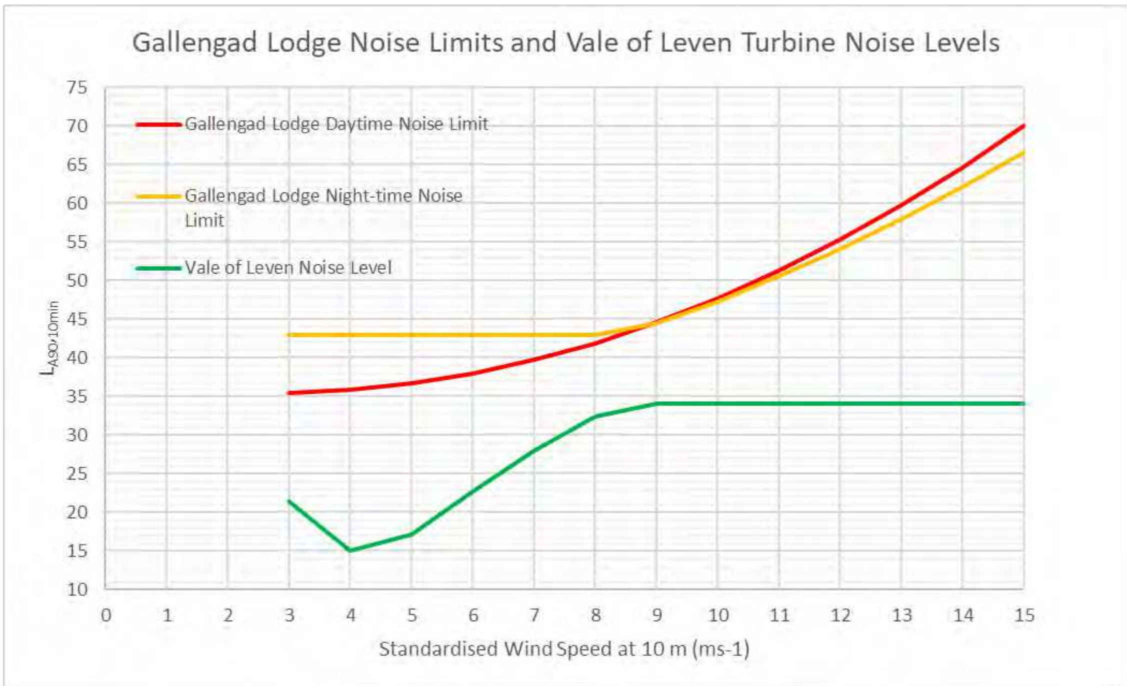
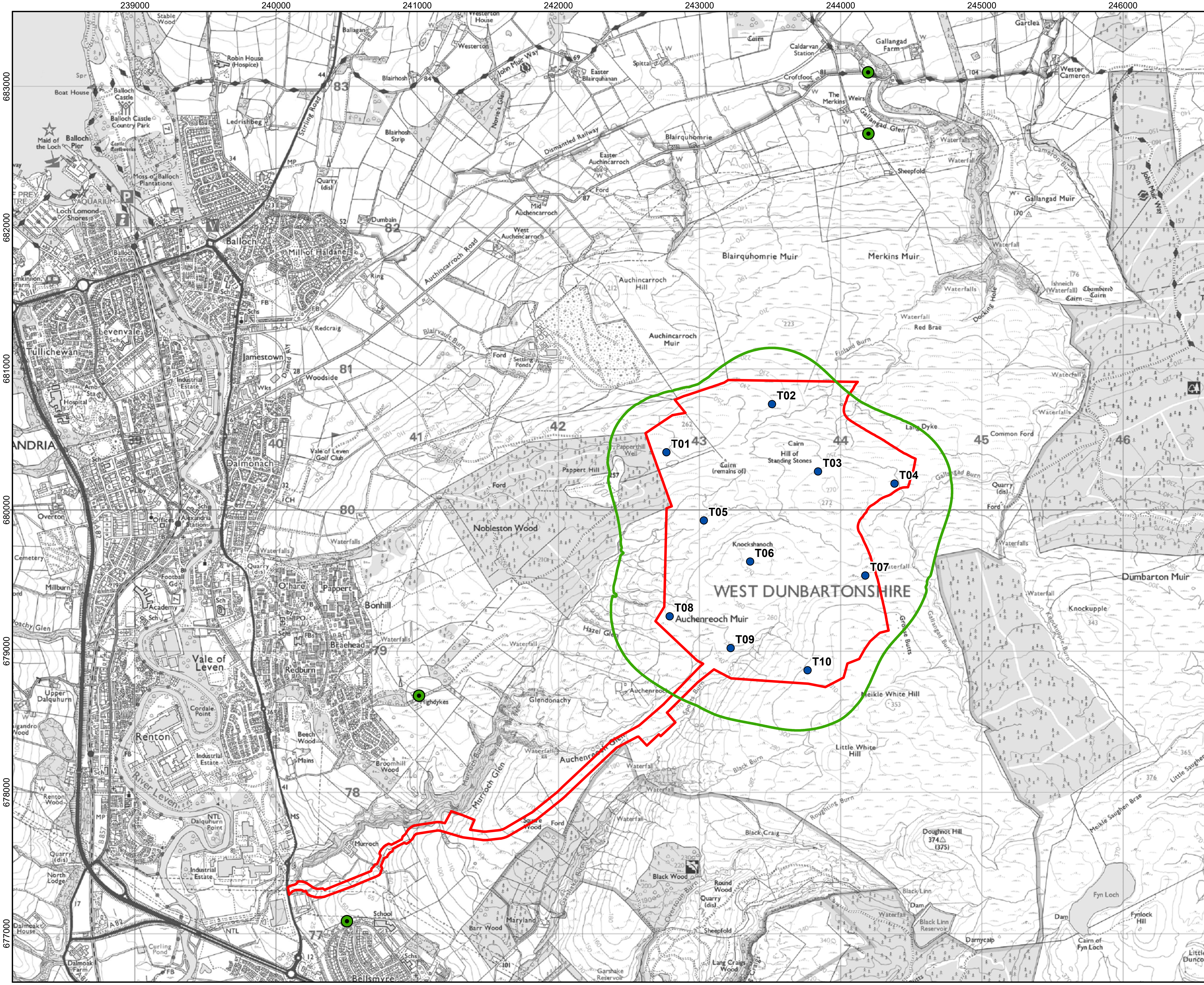


Figure 14 Vale of Leven Operation Turbine Noise Levels at Gallengad Lodge

NOISE MODEL CONTOURS

Figure 15: 3 ms Wind Speed Noise Contours



Legend:

- Application Boundary
- Proposed Turbine Locations
- Noise Sensitive Receptor

Predicted Noise Level (dB LA90)

- 35

Coordinate System: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
Units: Meter

Rev	Date	Description	Drn	Chk	App
00	17/08/2023	Wind Speed Contours	DL	RB	RB

Vale of Leven Wind Farm

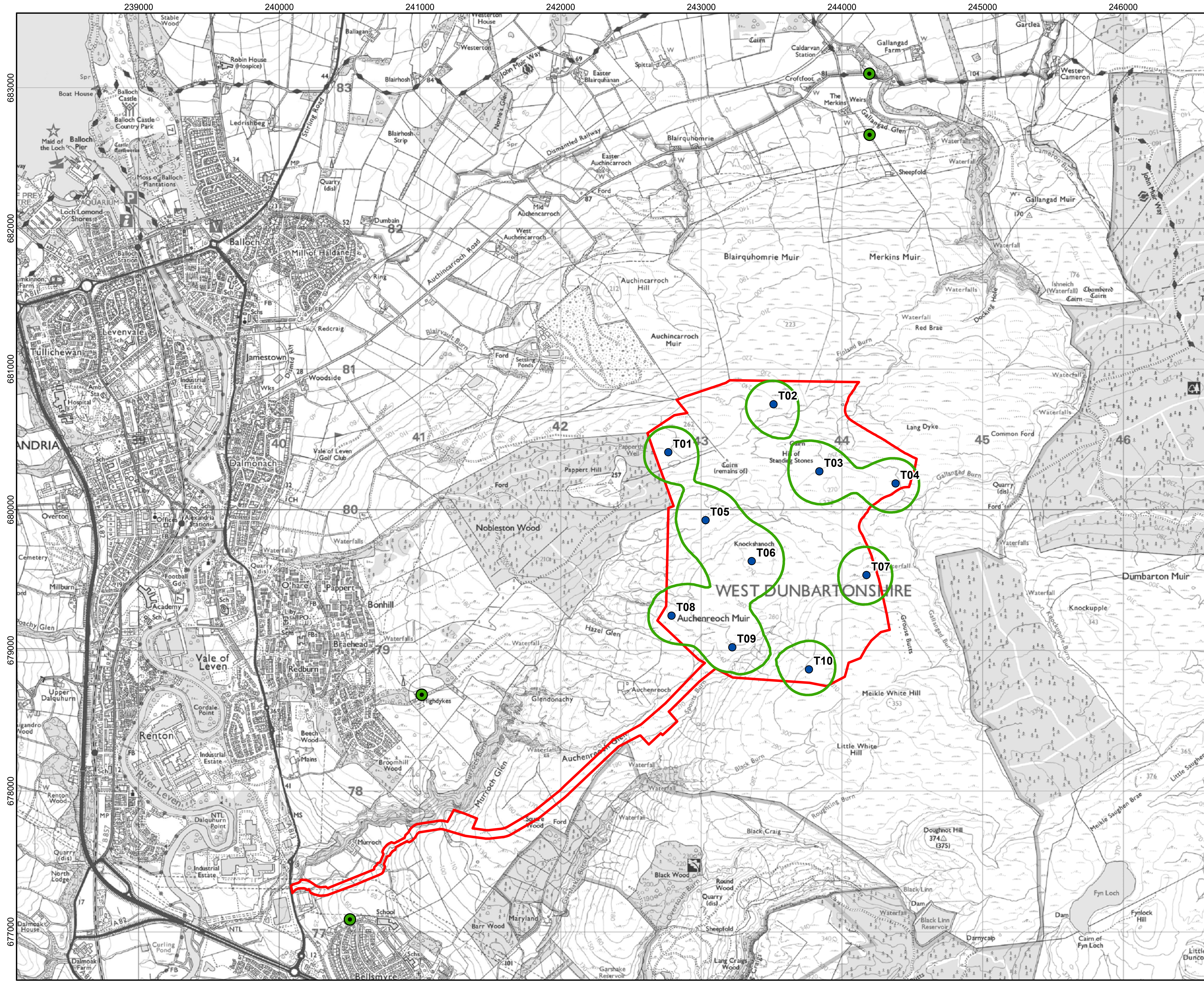
TITLE: Figure 15:
Wind Speed Contours 3ms

ID:P663510 - Noise_Appendix_Wind Speed Noise Contours 3ms

0 0.5 1
Kilometres
Scale: 1:25,000 @ A3

REV 00

Figure 16: 4 ms Wind Speed Noise Contours



Legend:
- Application Boundary
- Proposed Turbine Locations
- Noise Sensitive Receptor

Predicted Noise Level (dB LA90)
- 35

Coordinate System: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
Units: Meter

Rev	Date	Description	Drn	Chk	App
00	17/08/2023	Wind Speed Contours	DL	RB	RB

Vale of Leven Wind Farm

RSK

Coriolis Energy

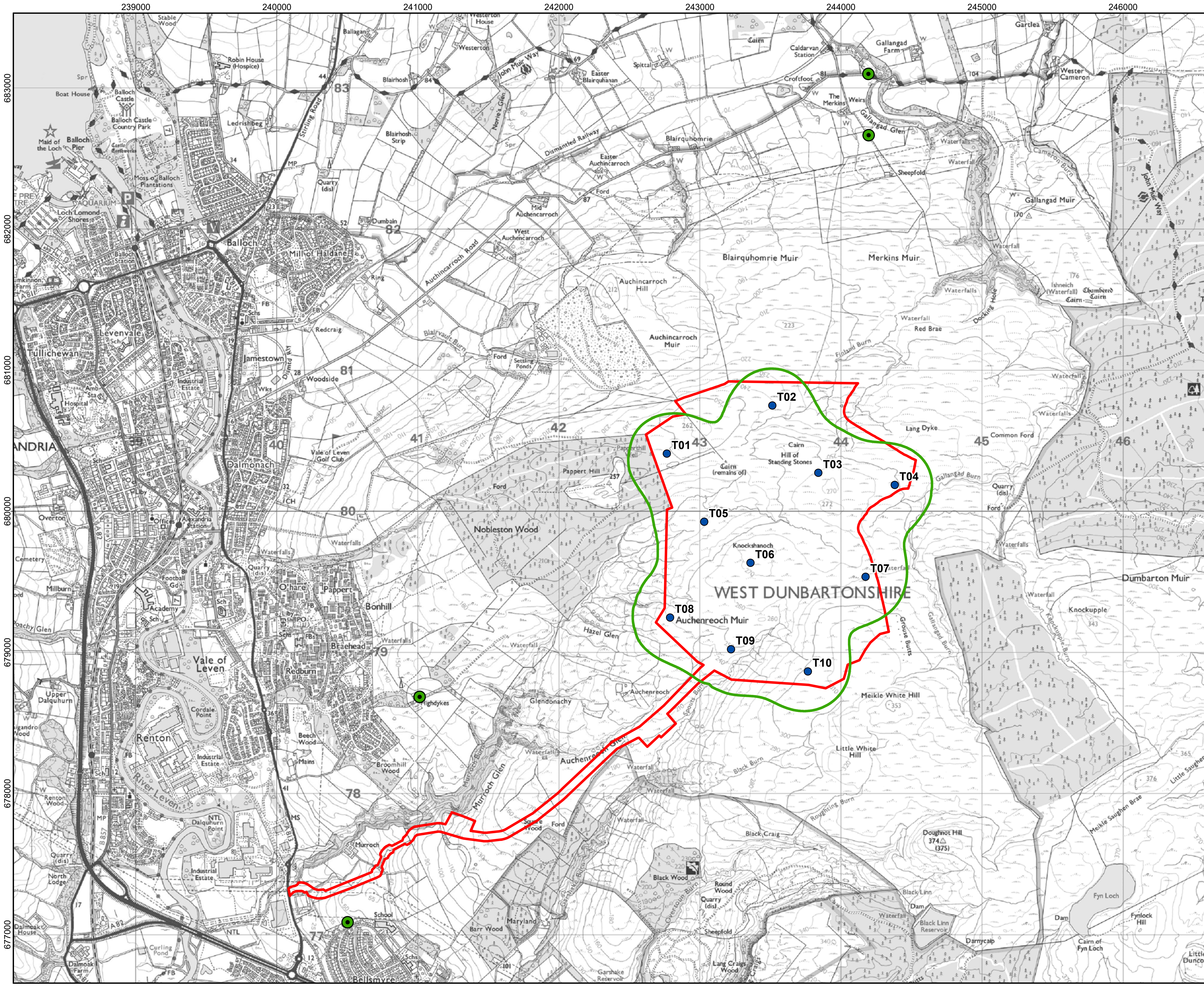
TITLE: Figure 16:
Wind Speed Contours 4ms

ID:P663510 - Noise_Appendix_Wind Speed Noise Contours 4ms

0 0.5 1
Kilometres
Scale: 1:25,000 @ A3

REV 00

Figure 17: 5 ms Wind Speed Noise Contours



Legend:

- Application Boundary
- Proposed Turbine Locations
- Noise Sensitive Receptor

Predicted Noise Level (dB LA90)

- 35

Coordinate System: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
Units: Meter

Rev	Date	Description	Drn	Chk	App
00	17/08/2023	Wind Speed Contours	DL	RB	RB

Vale of Leven Wind Farm

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Coriolis Energy

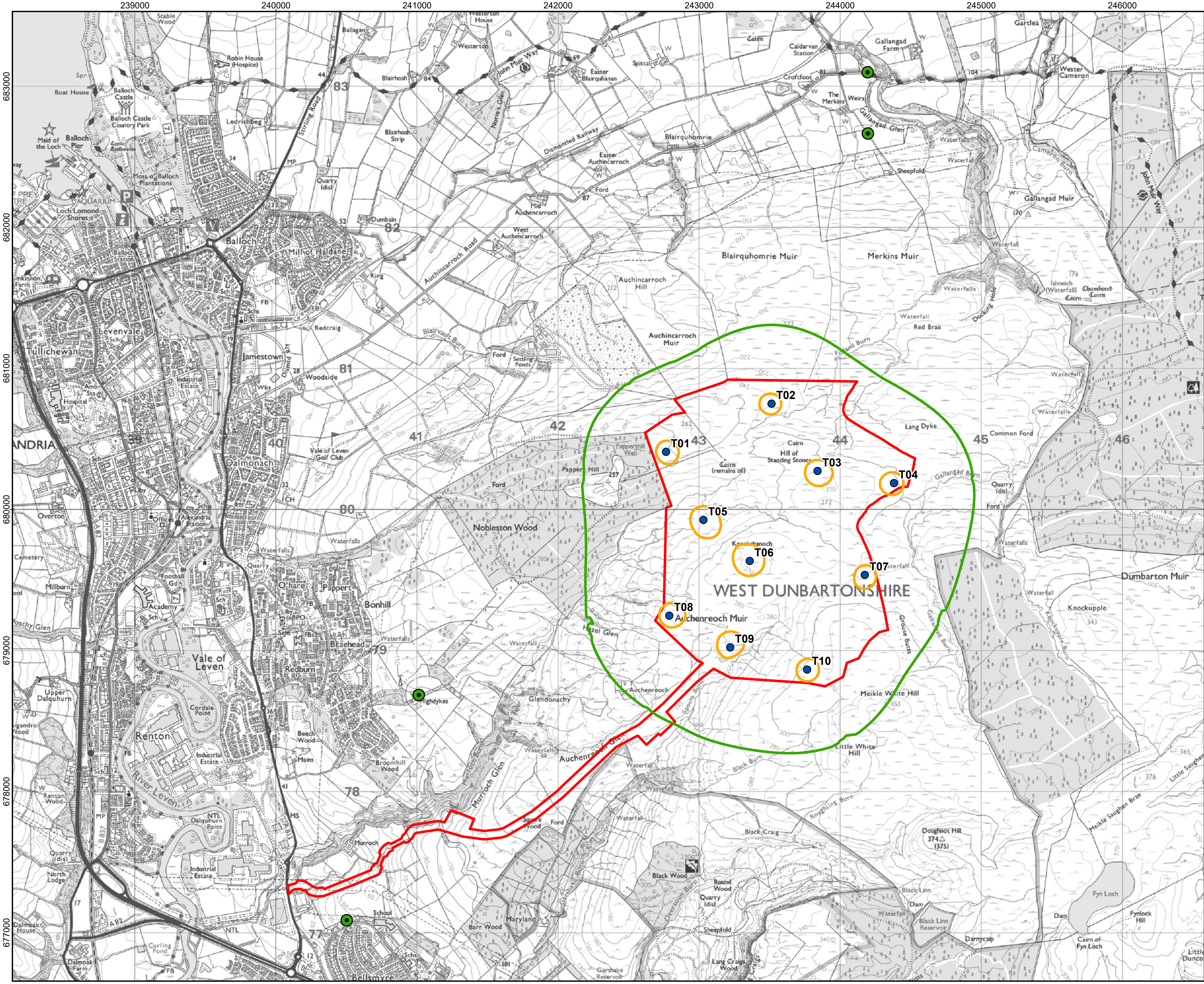
TITLE: Figure 17:
Wind Speed Contours 5ms

ID:P663510 - Noise_Appendix_Wind Speed Noise Contours 5ms

0 0.5 1
Kilometres
Scale: 1:25,000 @ A3

REV 00

Figure 18: 6 ms Wind Speed Noise Contours



Legend:

- Application Boundary
- Proposed Turbine Locations
- Noise Sensitive Receptor

Predicted Noise Level (dB LA90)

- 35
- 45

Coordinate System: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
Units: Meter

Rev	Date	Description	Drn	Chk	App
00	17/08/2023	Wind Speed Contours	DL	RB	RB

Vale of Leven Wind Farm

RSK

Coriolis Energy

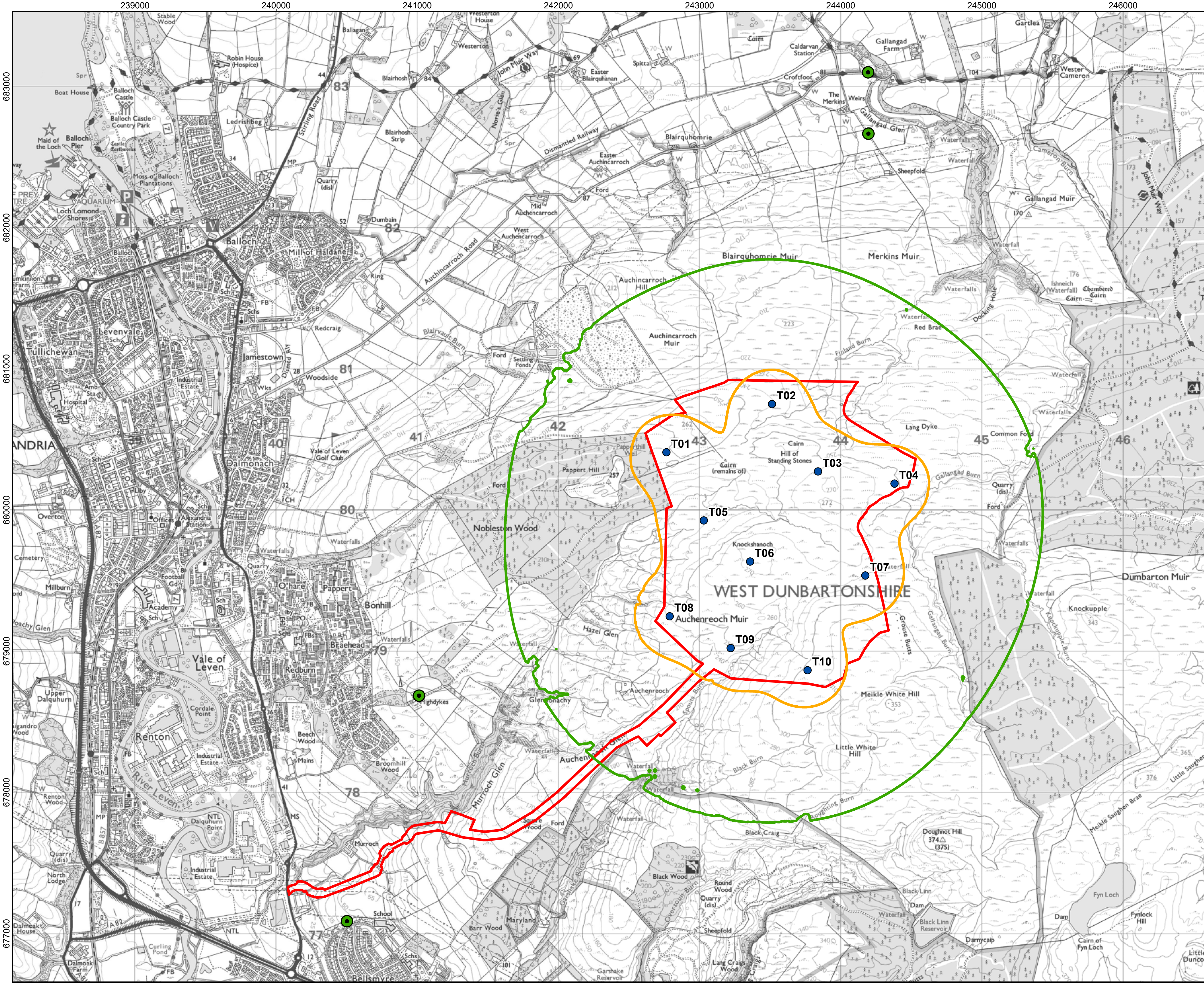
TITLE: Figure 18:
Wind Speed Contours 6ms

ID:P663510 - Noise_Appendix_Wind Speed Noise Contours 6ms

0 0.5 1
Kilometres
Scale: 1:25,000 @ A3

REV 00

Figure 19: 7 ms Wind Speed Noise Contours



Legend:

- Application Boundary
- Proposed Turbine Locations
- Noise Sensitive Receptor

Predicted Noise Level (dB LA90)

- 35
- 45

Coordinate System: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
Units: Meter

Rev	Date	Description	Drn	Chk	App
00	17/08/2023	Wind Speed Contours	DL	RB	RB

Vale of Leven Wind Farm

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TITLE: Figure 19:
Wind Speed Contours 7ms

ID:P663510 - Noise_Appendix_Wind Speed Noise Contours 7ms

0 0.5 1
Kilometres
Scale: 1:25,000 @ A3

N E S W

REV 00

Figure 20: 8 ms Wind Speed Noise Contours

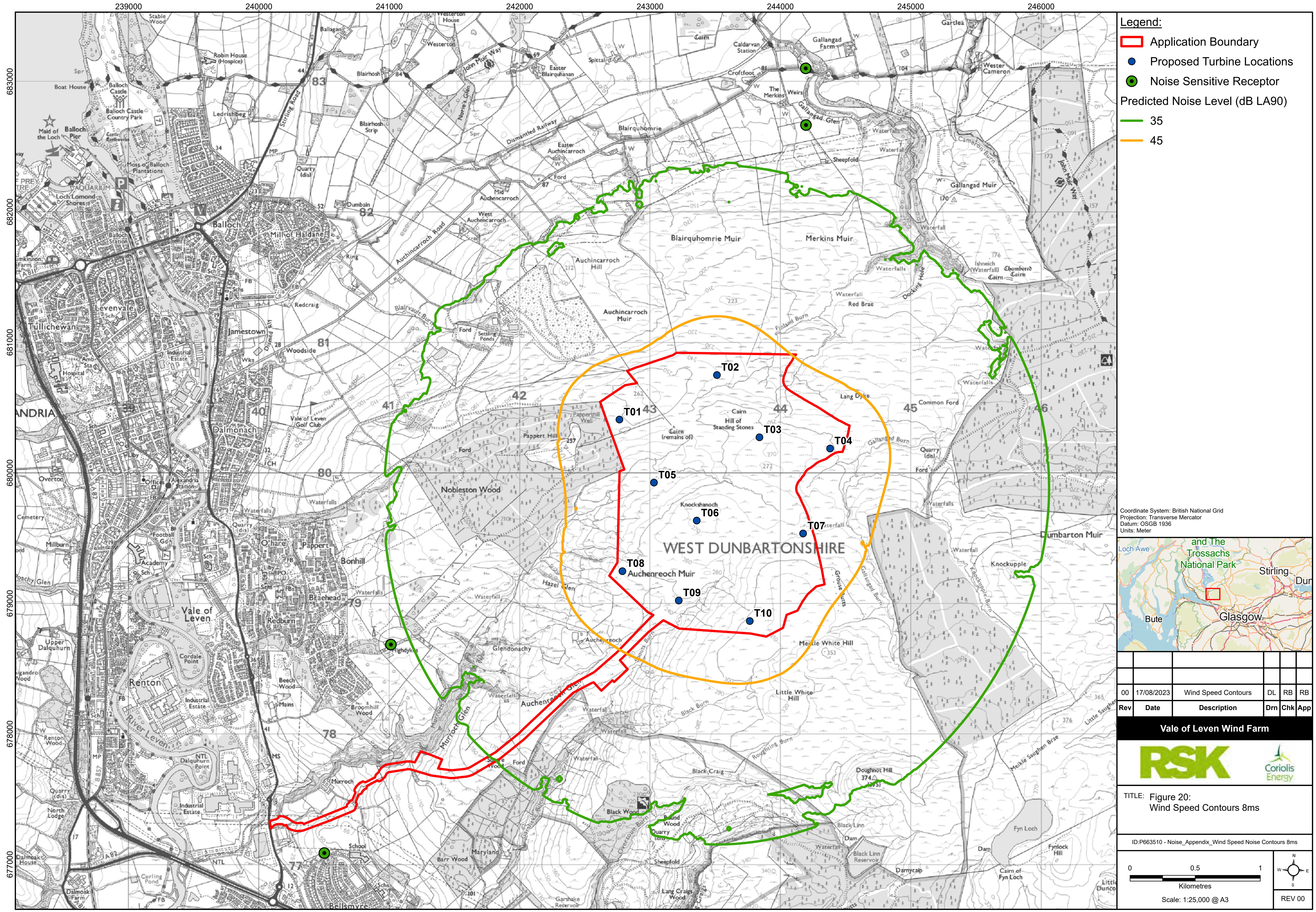
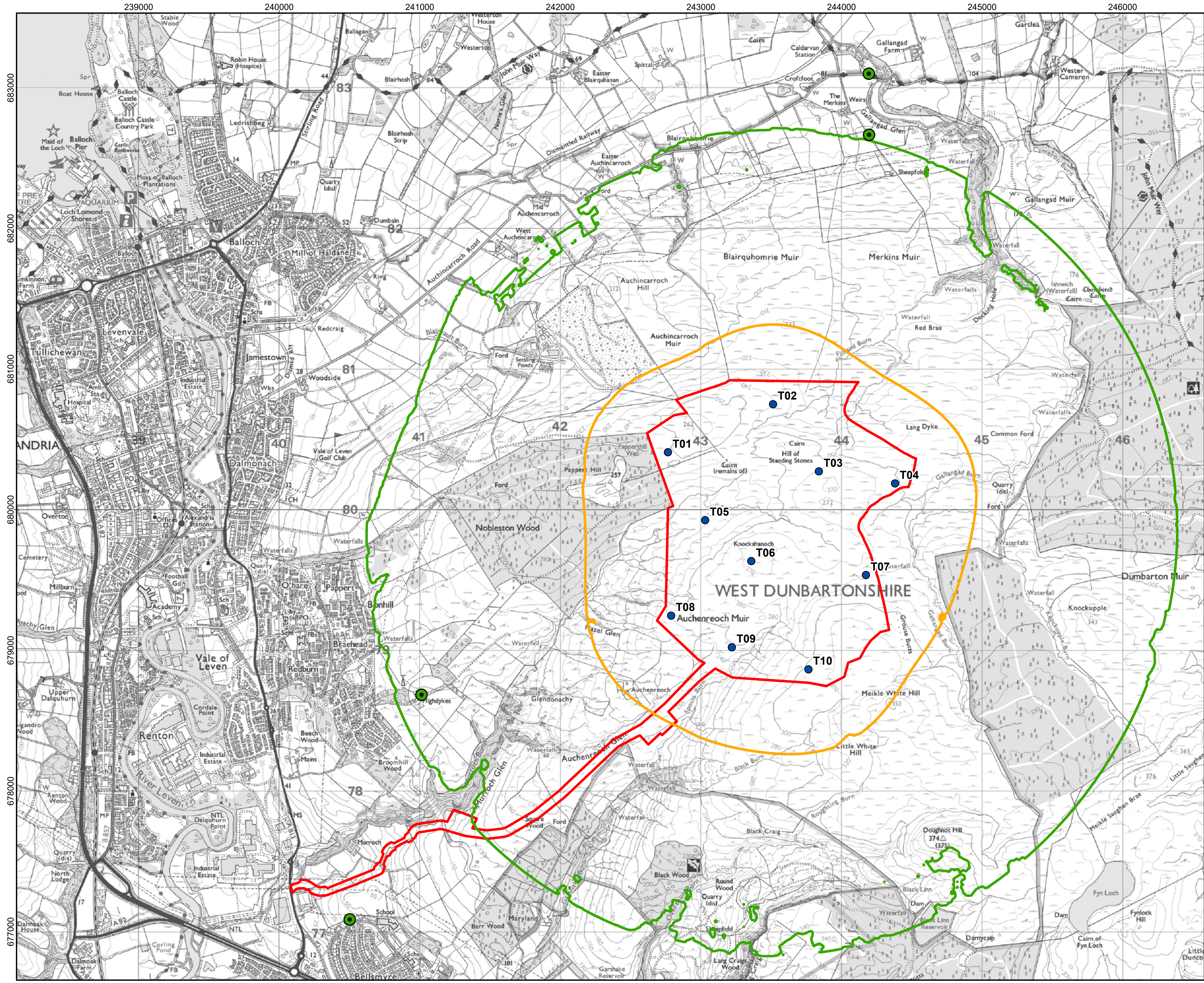

Legend:
Application Boundary
Proposed Turbine Locations
Noise Sensitive Receptor
Predicted Noise Level (dB LA90)
35
45
T01
T02
T03
T04
T05
T06
T07
T08
T09
T10
WEST DUNBARTONSHIRE
Coordinate System: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
Units: Meter
Loch Awe
and The Trossachs National Park
Stirling
Bute
Glasgow
00 | 17/08/2023 | Wind Speed Contours | DL | RB | RB
Rev | Date | Description | Drn | Chk | App
Vale of Leven Wind Farm
RSK
Coriolis Energy
TITLE: Figure 20: Wind Speed Contours 8ms
ID:P663510 - Noise_Appendix_Wind Speed Noise Contours 8ms
0 0.5 1
Kilometres
Scale: 1:25,000 @ A3
REV 00

Figure 21: 9+ ms Wind Speed Noise Contours



Legend:

- Application Boundary
- Proposed Turbine Locations
- Noise Sensitive Receptor

Predicted Noise Level (dB LA90)

- 35
- 45

Coordinate System: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
Units: Meter

Rev	Date	Description	Drn	Chk	App
00	17/08/2023	Wind Speed Contours	DL	RB	RB

Vale of Leven Wind Farm

RSK

Coriolis Energy

TITLE: Figure 21:
Wind Speed Contours 9ms plus

ID:P663510 - Noise_Appendix_Wind Speed Noise Contours 9plusms

0 0.5 1
Kilometres

Scale: 1:25,000 @ A3

REV 00