APPENDIX 4
PRELIMINARY NOISE ASSESSMENT REPORT (MARSHALL DAY)

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VALLEY OF THE WINDS
PRELIMINARY NOISE ASSESSMENT

Report No. 001 20191254 | 7 April 2020

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Project: **Valley of the Winds**
Preliminary Noise Assessment

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EXECUTIVE SUMMARY

A preliminary assessment of operational noise for the proposed Valley of the Winds project has been carried out. The preliminary noise assessment has been prepared in accordance with the NSW Department of Planning and Environment's *Wind Energy: Noise Assessment Bulletin - For State significant wind energy development*, dated December 2016 (the NSW Noise Assessment Bulletin).

Although this project has the potential for approximately one hundred and seventy-five (175) wind turbines, the preliminary noise assessment has been carried out on the basis of the current project design comprising one hundred and sixty-four (164) multi-megawatt turbines.

Noise modelling was carried out on the basis of the Vestas V162-5.6MW candidate turbine model which has been nominated by UPC as being representative of the size and type of turbine which are being considered for the site.

The results of the modelling demonstrate that the project can be designed and operated to comply with the operational noise requirements of the NSW Noise Assessment Bulletin. Once the Secretary's Environmental Assessment Requirements (SEARs) are released for this project, further detailed assessment will be undertaken. This would include background noise monitoring, revised modelling and, if required, layout refinements to demonstrate how compliance would be achieved for the specific noise matters defined by the SEARs for the project.

Cumulative noise levels associated with operation of the consented Liverpool Range Wind Farm to the north-east of the Valley of the Winds project site has also been considered in this assessment. The results of the preliminary assessment demonstrate that cumulative noise considerations associated with the Valley of the Winds can be practically managed, in terms of receivers near to both projects.

Further noise modelling and assessment work is to be undertaken to support a subsequent development application for the Valley of the Winds project. This is expected to included background noise monitoring at key receiver locations around the site, and assessment of other noise considerations including special noise characteristics, construction and ancillary infrastructure.

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1.0 INTRODUCTION

UPC\AC Renewables Australia (UPC) is proposing to develop a wind farm known as the Valley of the Winds to the south of Coolah in New South Wales.

This report presents the results of a preliminary noise assessment prepared for submission with a Scoping Report and a Secretary's Environmental Assessment Requirements (SEARs) request.

The preliminary noise assessment has been prepared in accordance with the NSW Department of Planning and Environment's *Wind Energy: Noise Assessment Bulletin - For State significant wind energy development*, dated December 2016 (the NSW Noise Assessment Bulletin).

The preliminary noise assessment is based on:

- The minimum (base) operational noise limit determined in accordance the NSW Noise Assessment Bulletin;
- Preliminary noise modelling for the project based on the current proposed site layout and a candidate turbine model that is representative of the size and type of turbine being considered for the site; and
- A comparison of the predicted noise levels with the base noise limit.

The preliminary assessment primarily addresses potential operational noise levels associated with the project's wind turbines. Information concerning potential cumulative noise considerations relating to the approved Liverpool Range Wind Farm to the northeast of the Valley of the Winds site is also presented.

Other noise considerations relating to the project would be assessed during the development application stage of the project. This would include the noise of construction and ancillary infrastructure associated with the project, along with any other specific noise matters defined by the SEARs for the project.

Acoustic terminology used in this report is presented in Appendix A.

2.0 PROJECT DESCRIPTION

2.1 Overview

The Valley of the Winds project is proposed to be located to the south of Coolah in New South Wales.

The current project design comprises one hundred and sixty-four (164) wind turbines extending over an area spanning approximately 27 km from north to south and 19 km from west to east.

The proposed project comprises three separate clusters, connected electrically: Mount Hope, Black Stump and Leadville. The coordinates of the wind turbines are presented in tabular and graphical format in Appendix B.

A total of sixty (60) noise sensitive receivers within 3 km[1] of the project have been identified by UPC\AC renewables and considered in this preliminary noise assessment. This includes twenty-two (22) receivers where a noise agreement is proposed between the landowners and UPC, which are referred to as participating receivers herein, and another six (6) receivers where noise agreements are yet to be confirmed from ongoing discussions.

The coordinates of the receivers are tabulated in Appendix C.

A site layout plan illustrating the turbine layout and receiver locations is provided in Appendix D.

In addition to on-site ancillary infrastructure such as substations, a range of offsite grid connection options are being evaluated by UPC.

2.2 Candidate wind turbine model

The turbine model(s) to be assessed in detail as part of the development application will be determined from ongoing project design development. Further, if the project was ultimately approved, the final wind turbine model would only be selected after a tender process to procure the supply of turbines. The final selection would be made on account of a range of design requirements including achieving compliance with relevant noise limits at surrounding noise sensitive receiver locations.

Accordingly, to assess the proposed development at this stage in the project, it is necessary to consider a representative candidate turbine model for the size and type of turbines being considered. The purpose of the candidate turbine is to inform a preliminary assessment of operational noise, accounting for the base noise limit and noise emission levels that are typical of the size of turbines being considered for the development.

The candidate wind turbine selected by UPC for this preliminary assessment is the Vestas V162-5.6MW.

It is a variable speed wind turbine, with the speed of rotation and the amount of power generated by the turbines being regulated by control systems which vary the pitch of the turbine blades (the angular orientation of the blade relative to its axis). Two different types of blade design are available for the Vestas V162-5.6MW turbine:

- A standard non-serrated version; and
- A serrated version which reduces the total noise emissions of the turbine.

This assessment has been based on the serrated variant of the turbine.

[1] The 3 km distance is a nominal distance commonly referenced on account of being significantly greater than the separation distance required to achieve compliance with the lowest possible noise limit of 35 dB L_{Aeq}.

Details of the candidate wind turbine model are provided in Table 1.

Table 1: Candidate wind turbine model details

Item	Detail
Model	Vestas V162
Rated power	5.6 MW
Rotor diameter	162 m
Modelled hub height	169 m
Modelled tip height	250 m
Operating mode	Mode 0
Serrated trailing edge	Yes

If a different wind turbine model is considered due to technology updates or other constraints through the preparation of the Environmental Impact Statement (EIS), the noise assessment would need to be revised to reflect the changes.

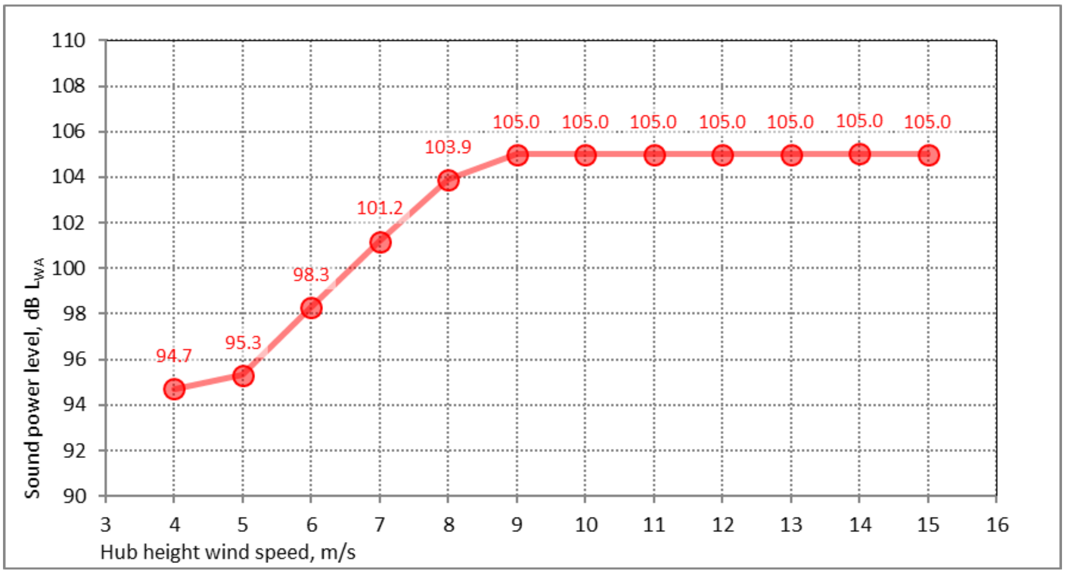
2.3 Wind turbine noise emissions

The noise emissions of wind turbines are described in terms of the sound power level for different wind speeds at the hub height. The sound *power* level is a measure of the total sound energy produced by each turbine and is distinct from the sound *pressure* level which depends on a range of factors such as the distance from the turbine.

Sound power level data for the candidate turbine model were sourced from the Vestas document No. 0079-5298_01 *V162-5.6MW Third octave noise emission* dated 23 January 2019 (the Vestas Document). The sound power data provided in the document has been adjusted by the addition of +1.0 dB at each wind speed to provide a margin for typical values of test uncertainty.

The sound power levels referenced in this assessment, including the +1.0 dB adjustment, are illustrated in Figure 1. The overall level represents the total noise emission of the turbines, including the secondary contribution of ancillary plant associated with the turbines (e.g. cooling fans and internal transformer).

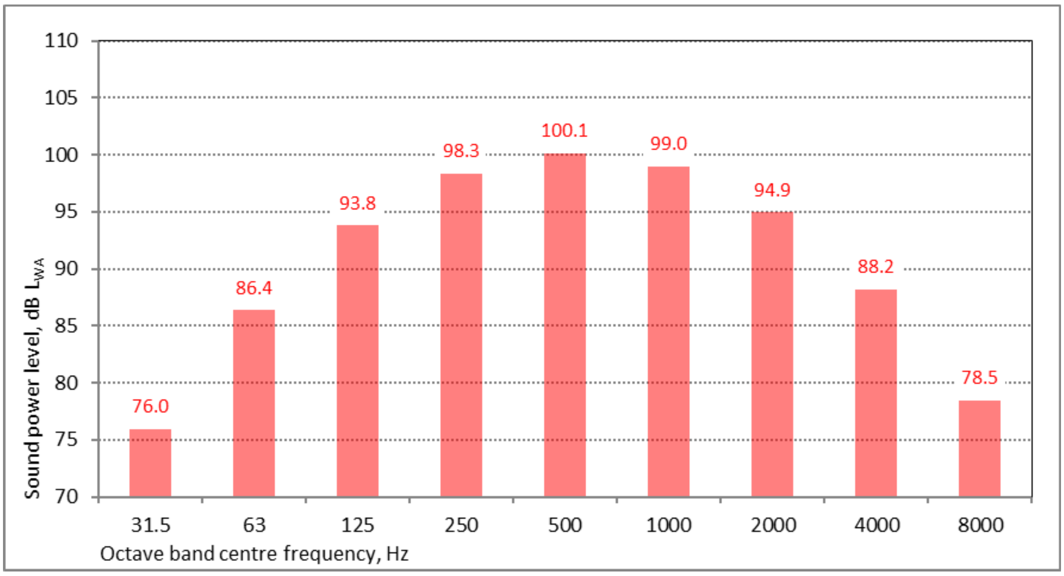
Figure 1: V162-5.6MW assessment sound power levels, dB L_{WA}



The sound power levels in Figure 1 are considered typical of the range of noise emissions associated with comparable multi-megawatt wind turbines. The data is therefore considered appropriate to reference in this preliminary assessment as a representation of the apparent sound power levels of the turbines when tested and rated in accordance with International Electrotechnical Commission publication IEC 61400-11:2012 *Wind turbines - Part 11: Acoustic noise measurement techniques* (IEC 61400-11).

The sound frequency characteristics of the turbines were also sourced from the Vestas Document. The reference spectrum used as the basis for this assessment is illustrated Figure 2 and corresponds to the highest overall sound power level illustrated in Figure 1.

Figure 2: V162-5.6MW assessment sound power level spectrum, dB L_{WA}



The manufacturer specification for the candidate turbine model does not provide information about tonality.

The occurrence of tonality in the noise of contemporary multi-megawatt turbine designs is generally limited. This is supported by evidence of operational wind farms in Australia which indicates that the occurrence of tonality at receiver locations is atypical. On this basis, adjustments for tonality have not been applied to the predicted noise levels presented in this preliminary assessment. Notwithstanding this, the subject of tonality would be addressed in subsequent assessment stages for the project. As part of this, further information will need to be obtained from the manufacturer concerning tonality.

3.0 ASSESSMENT CRITERIA

3.1 NSW Noise Assessment Bulletin

The NSW Department of Planning and Environment publication *Wind Energy: Noise Assessment Bulletin* (the NSW Noise Assessment Bulletin) dated December 2016 provides guidance on how noise impacts are to be assessed for large-scale wind energy development projects that are State significant development.

The NSW Noise Assessment Bulletin states that the South Australian EPA publication *Wind farms environmental noise guidelines* dated July 2009 (the SA EPA Guideline) is to be used as the relevant assessment standard, subject to a set of variations that apply to the assessment of NSW projects. The variations are defined for:

- noise limits
- special noise characteristics
- noise monitoring.

In relation to noise limits, the variation defined in the NSW Noise Assessment Bulletin sets the base criterion at a value of 35 dB for all projects, in lieu of the 35 to 40 dB base criterion range defined in the SA EPA Guideline. The criteria in the NSW Noise Assessment Bulletin are subsequently defined as follows:

> *The predicted equivalent noise level ($L_{Aeq,10\ minute}$)*, adjusted for tonality and low frequency noise in accordance with these guidelines, should not exceed 35 dB(A) or the background noise ($L_{A90(10\ minute)}$) by more than 5 dB(A), whichever is the greater, at all relevant receivers for wind speed from cut-in to rated power of the wind turbine generator and each integer wind speed in between.*
>
> ** Determined in accordance with SA 2009, Section 4.*

Variations are also defined in the NSW Noise Assessment Bulletin for the assessment of special noise characteristics. These procedures will be referenced in subsequent detailed assessment phases for the project.

The NSW Noise Assessment Bulletin notes the following in relation to the types of receiver locations where the noise limits apply:

> *The criteria in this Bulletin have been developed to address potential noise impacts on the amenity of residents and other relevant receivers in the vicinity of a proposed wind energy project. Wind energy proponents commonly negotiate agreements with private land owners where applicable noise limits may not be achievable at relevant receiver locations. A negotiated agreement will be considered as part of the assessment of a wind energy project, as will the requirements of SA 2009 and this Bulletin. The proponent's EIS should clearly identify the expected noise levels at all receiver locations including host properties to ensure that affected persons are appropriately informed regarding the development proposal.*

3.2 Participating receivers

The assessment criteria detailed in the previous section apply to all noise sensitive receiver locations that are not associated with the proposed project (e.g. by way of land ownership or a negotiated agreement). However, in accordance with the requirements of the NSW Noise Assessment Bulletin, predicted noise levels are also presented for participating receiver locations, comprising host properties and receivers where a noise agreement is in place.

Notwithstanding the above, a reference level of 45 dB L_{Aeq} is presented as a base criterion for participating receivers in order to provide context to the predicted noise levels for these locations. This is consistent with the SA EPA Guideline which recommends a level of 45 dB for *financial stakeholders*. Comparisons between the predicted noise levels and the 45 dB reference level are provided for informative purposes only. Noise levels at these locations will ultimately need to be managed in accordance with the commercial agreements established between the proponent and the landowners.

4.0 ASSESSMENT METHOD

Operational wind farm noise levels are predicted using:

- Noise emission data for the wind turbines;
- A 3D digital model of the site and the surrounding environment; and
- International standards used for the calculation of environmental sound propagation.

At this preliminary stage of assessment, the primary consideration is potential A-weighted noise levels associated with operation of the project. The assessment of special noise characteristics during subsequent the development application stages of the project will involve additional predictions, including C-weighted noise levels associated with operation of the project.

The method selected to predict A-weighted noise levels is International Standard ISO 9613-2: 1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2). The prediction method is consistent with the guidance provided by SA EPA Guideline and has been shown to provide a reliable method of predicting the typical upper A-weighted levels of the noise expected to occur in practice from wind farm developments.

The ISO 9613-2 method is used in conjunction with a set of input choices and procedural modifications that are specific to wind farm noise assessment, based on international research and guidance.

The noise prediction method is summarised in Table 2 with further discussion of the method and the calculation choices is provided in Appendix F.

Table 2: Downwind prediction methodology

Detail	Description
Software	Proprietary noise modelling software SoundPLAN version 8.1
Method	International Standard ISO 9613-2:1996 *Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation* (ISO 9613-2). Adjustments to the ISO 9613-2 method are applied on the basis of the guidance contained in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* (the UK Institute of Acoustics guidance). The adjustments are applied within the SoundPLAN noise modelling software and relate to the influence of terrain screening and ground effects on sound propagation. Specific details of adjustments are noted below and are discussed in Appendix F.
Source characterisation	Each wind turbine is modelled as a point source of sound. The total sound of the wind farm is then calculated on the basis of simultaneous operation of all wind turbines and summing the contribution of each. Calculations of turbine to receiver distances and average sound propagation heights are made on the basis of the point source being located at the position of the hub of the turbine. Calculations of terrain related screening are made on the basis of the point source being located at the maximum tip height of each turbine. Further discussion of terrain screening effects is provided below.
Terrain data	Elevation contours in 10 m resolution provided by UPC

Detail	Description
Terrain effects	Adjustments for the effect of terrain are determined and applied on the basis of the UK Institute of Acoustics guidance and research outlined in Appendix F. • Valley effects: +3 dB is applied to the calculated noise level of a wind turbine when a significant valley exists between the wind turbine and calculation point. A significant valley is determined to exist when the actual mean sound propagation height between the turbine and calculation point is 50 % greater than would occur if the ground was flat. • Terrain screening effects: only calculated if the terrain blocks line of sight between the maximum tip height of the turbine and the calculation point. The value of the screening effect is limited to a maximum value of 2 dB. The project is located in a hilly area characterised by significant variations in ground elevation between the turbines and surrounding receivers. These terrain characteristics were sufficient to result in the application of adjustments to the predicted noise levels. Specifically, based on comparison of predicted noise levels with and without terrain elevation data included indicates adjustments for terrain effects typically equated to ±2 dB. For reference purposes, the ground elevations at the turbine and receiver locations are tabled in Appendix B and Appendix C respectively. The topography of the site is depicted in the elevation map provided in Appendix E.
Ground conditions	Ground factor of G = 0.5 on the basis of the UK good practice guide and research outlined in Appendix F. The ground around the site corresponds to acoustically soft conditions (G = 1) according to ISO 9613-2. The adopted value of G = 0.5 assumes that 50 % of the ground cover is acoustically hard (G = 0) to account for variations in ground porosity and provide a cautious representation of ground effects.
Atmospheric conditions	Temperature 10 °C and relative humidity 80 % These represent conditions which result in relatively low levels of atmospheric sound absorption and are chosen on the basis of the UK Institute of Acoustics guidance and the SA EPA Guideline. The calculations are based on sound speed profiles[2] which increase the propagation of sound from each turbine to each receiver location, whether as a result of thermal inversions or wind directed toward each calculation point. The primary consideration for wind farm noise assessment is wind speed and direction. The noise level at each calculation point is assessed on the basis of being simultaneously downwind of every wind turbine at the site. Other wind directions in which part or the entire wind farm is upwind of the receiver will result in lower noise levels. In some cases, it is not physically possible for a receiver to be simultaneously downwind of each turbine and the approach is therefore conservative in these instances.
Receiver heights	1.5 m above ground level This is a deviation from UK Institute of Acoustics guidance. However, the modelling also does not include the 2 dB subtraction recommended by the UK Institute of Acoustics guidance. This approach has been shown to be valid for predicting noise level of wind farms expected to be measured using the L_{A90} parameter (as per the NSW Noise Assessment Bulletin).

[2] The sound speed profile defines the rate of change in the speed of sound with increasing height above ground

5.0 WIND TURBINE NOISE ASSESSMENT

5.1 Preliminary predicted noise levels

This section of the report presents the preliminary predicted A-weighted noise levels of the Valley of the Winds project at surrounding receiver locations, and an assessment of compliance with the base noise limit.

Sound levels in environmental assessment work are typically reported to the nearest integer to reflect the practical use of measurement and prediction data. However, in the case of wind farm layout design, significant layout modifications may only give rise to fractional changes in the predicted noise level. This is a result of the relatively large number of sources influencing the total predicted noise level, as well as the typical separating distances between the turbine locations and surrounding assessment positions. It is therefore necessary to consider the predicted noise levels at a finer resolution than can be perceived or measured in practice. It is for this reason that the levels presented in this section are reported to one decimal place.

The non-participating receiver locations where operational wind farm noise levels are predicted to be higher than 30 dB L_{Aeq} are listed in Table 3 and Table 4. The table also includes receiver locations where the participation status is yet to be confirmed. The predicted noise levels are for conditions when the wind farm's noise emissions have reached their highest level (corresponding to hub height wind speeds of 9 m/s and above) and the wind is directed from the wind farm to each receiver location.

The value of 30 dB is referenced here for informative purposes. The minimum noise limit applicable to the wind farm at non-participating receivers is 35 dB L_{Aeq}.

Predicted noise levels for each integer wind speed are tabulated in Appendix G for all considered receiver locations, including dwellings where the highest predicted noise level is below 30 dB L_{Aeq}.

Table 3: Highest predicted noise level at non-participating receivers with predicted levels over 30 dB L_{Aeq}

Receiver	dB L_{Aeq}	Distance to the nearest turbine, m	Below the base criterion
Non-participating receivers			
5	34.2	1,847	Yes
6	31.3	1,708	Yes
25	32.0	2,137	Yes
76	31.0	2,388	Yes
77	30.5	2,524	Yes
78	30.4	2,740	Yes
79	31.2	1,948	Yes
84	31.2	2,149	Yes
85	31.8	2,225	Yes
86	32.6	2,080	Yes
87	30.9	2,723	Yes
88	32.4	2,161	Yes
89	32.6	2,534	Yes

Receiver	dB L_{Aeq}	Distance to the nearest turbine, m	Below the base criterion
90	32.0	2,276	Yes
91	32.5	2,014	Yes
187	31.7	1,319	Yes
190	31.3	1,823	Yes
199	30.1	2,446	Yes
238	35.7	1,374	No
277	31.3	2,155	Yes
278	35.5	1,179	No
282	33.6	1,847	Yes
Receivers where participation status to be confirmed			
328	33.3	1,574	Yes
330	30.8	2,976	Yes
331	35.0	1,713	Yes
332	30.6	3,150	Yes
333	30.2	3,363	Yes
334	30.3	1,743	Yes
497	34.4	1,368	Yes

It can be seen from Table 3 that the predicted noise levels from the proposed Valley of the Winds project are below the NSW Noise Assessment Bulletin base criterion of 35 dB L_{Aeq} at the majority non-participating receiver locations. At all receivers where the participation status is yet to be confirmed, the predicted noise levels in Table 3 are below the base criterion of 35 dB L_{Aeq}.

The exceptions are two of the assessed non-participating receivers (238 and 278) where the predicted noise levels are marginally higher than the base criterion by up to 0.7 dB. The following relevant considerations are noted:

- Levels higher than 35 dB L_{Aeq} are only applicable for wind speeds of 9 m/s and above. At wind speeds below 9 m/s, the predicted noise levels would be below 35 dB at all non-participating receivers (noting that the Vestas candidate turbine's noise emissions are 1.1 dB lower at 8 m/s than at 9 m/s, compared to the highest margin above the base criterion of 0.7 dB for receiver 238); and
- Background noise levels at 9 m/s and are likely to be greater than 30 dB, in which case the applicable noise limits would be above 35 dB L_{Aeq} base criterion and enable compliance to be demonstrated. This would ultimately need to be confirmed by background noise surveys in the area.

The above findings support that the project can be designed and operated to comply with the operational noise requirements of the NSW Noise Assessment Bulletin. This will involve further detailed assessment work including background noise monitoring and, if required, iterative modelling and layout refinements to demonstrate how compliance would be achieved. This would account for ongoing design changes to the layout and the types of turbines being considered for the site.

Information relating to participating receiver locations is provided in Table 4.

Table 4: Highest predicted noise level at participating receivers with predicted levels over 30 dB L_{Aeq}

Receiver	dB L_{Aeq}	Distance to the nearest turbine, m	Below or equal to the reference level
4	32.9	2,334	Yes
250	37.9	880	Yes
251	32.8	2,353	Yes
252	32.0	2,144	Yes
253	31.3	2,312	Yes
254	32.9	1,898	Yes
256	36.6	1,373	Yes
257	38.0	1,108	Yes
258	39.4	1,051	Yes
259	34.4	1,105	Yes
276	31.4	2,985	Yes
279	31.3	2,924	Yes
280	33.0	1,757	Yes
281	35.0	1,293	Yes
297	37.1	1,097	Yes
303	39.1	1,023	Yes
304	35.5	1,411	Yes
305	39.7	588	Yes
306	43.8	371	Yes
309	34.3	1,176	Yes
310	45.0	331	Yes
329	34.3	1,554	Yes

It can be seen from Table 4 that the predicted noise levels from the proposed Valley of the Winds project are below or equal to the reference level for all participating receivers.

The location of the total predicted 30 dB, 35 dB and 40 dB L_{Aeq} noise contours is illustrated in Figure 3 to Figure 5 for the areas around each of the three wind turbine clusters.

Figure 3: Mount Hope cluster - highest predicted noise level contours (corresponding to hub-height wind speeds of 9 m/s or greater)

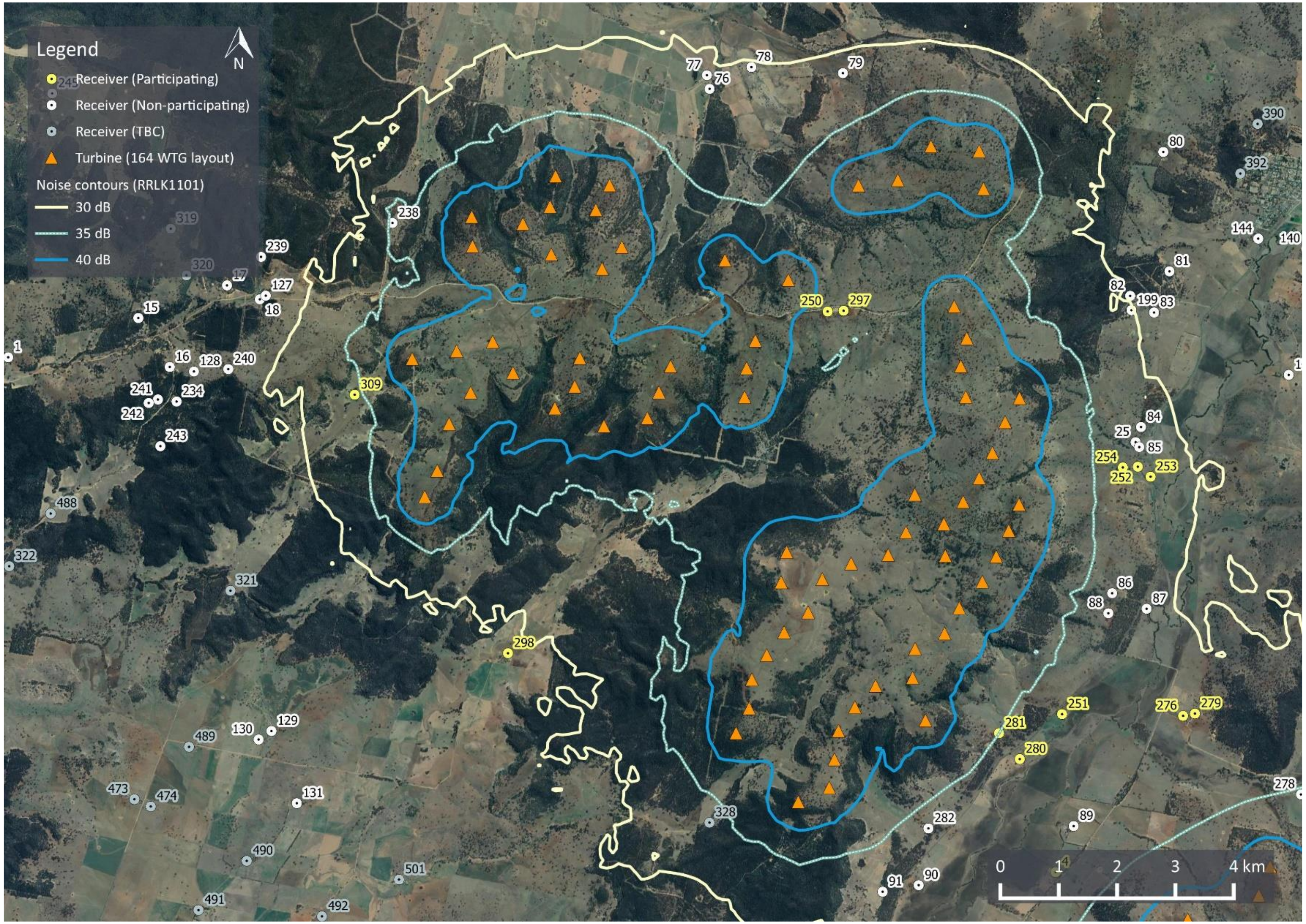


Figure 4: Black Stump cluster - highest predicted noise level contours (corresponding to hub-height wind speeds of 9 m/s or greater)

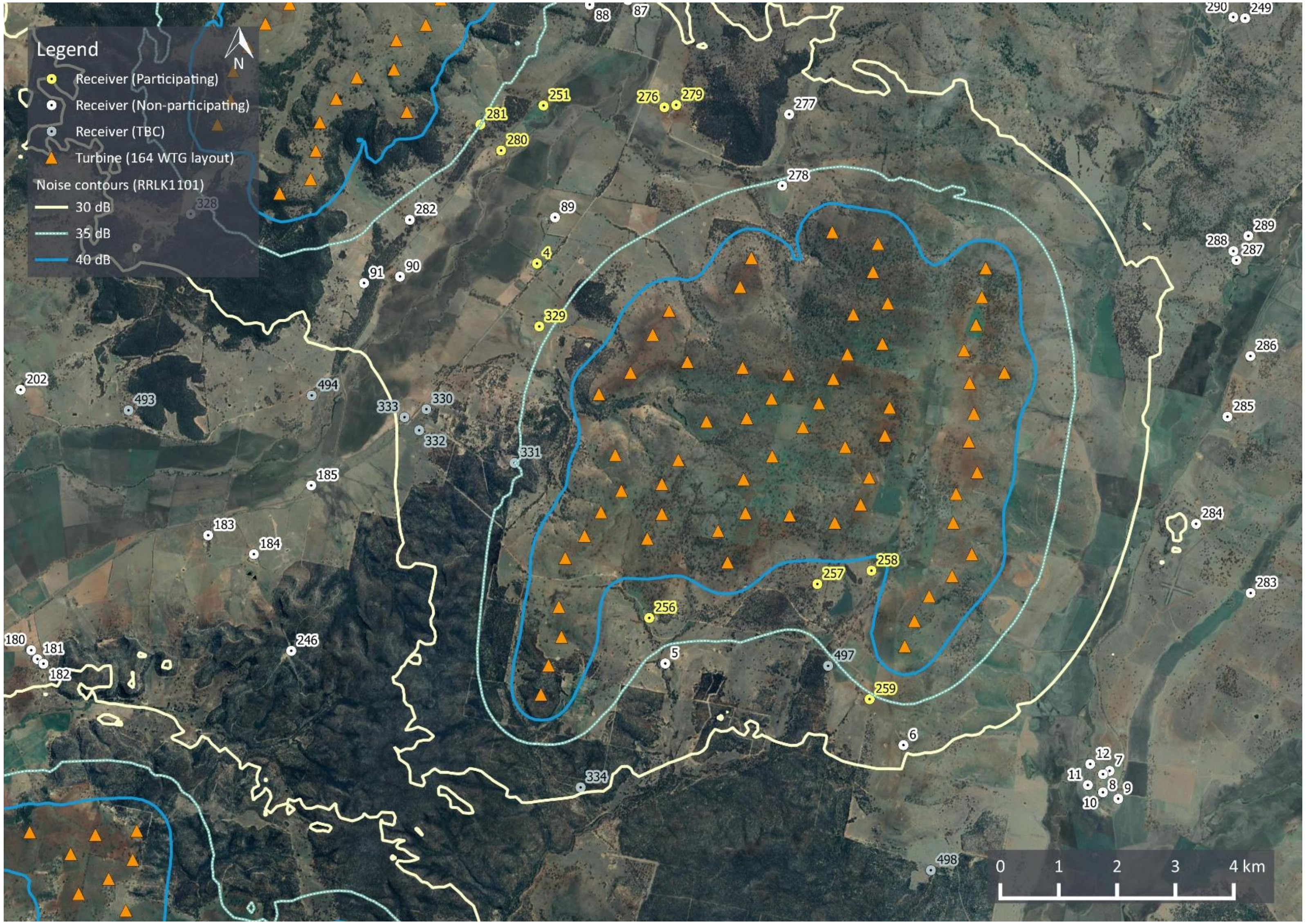
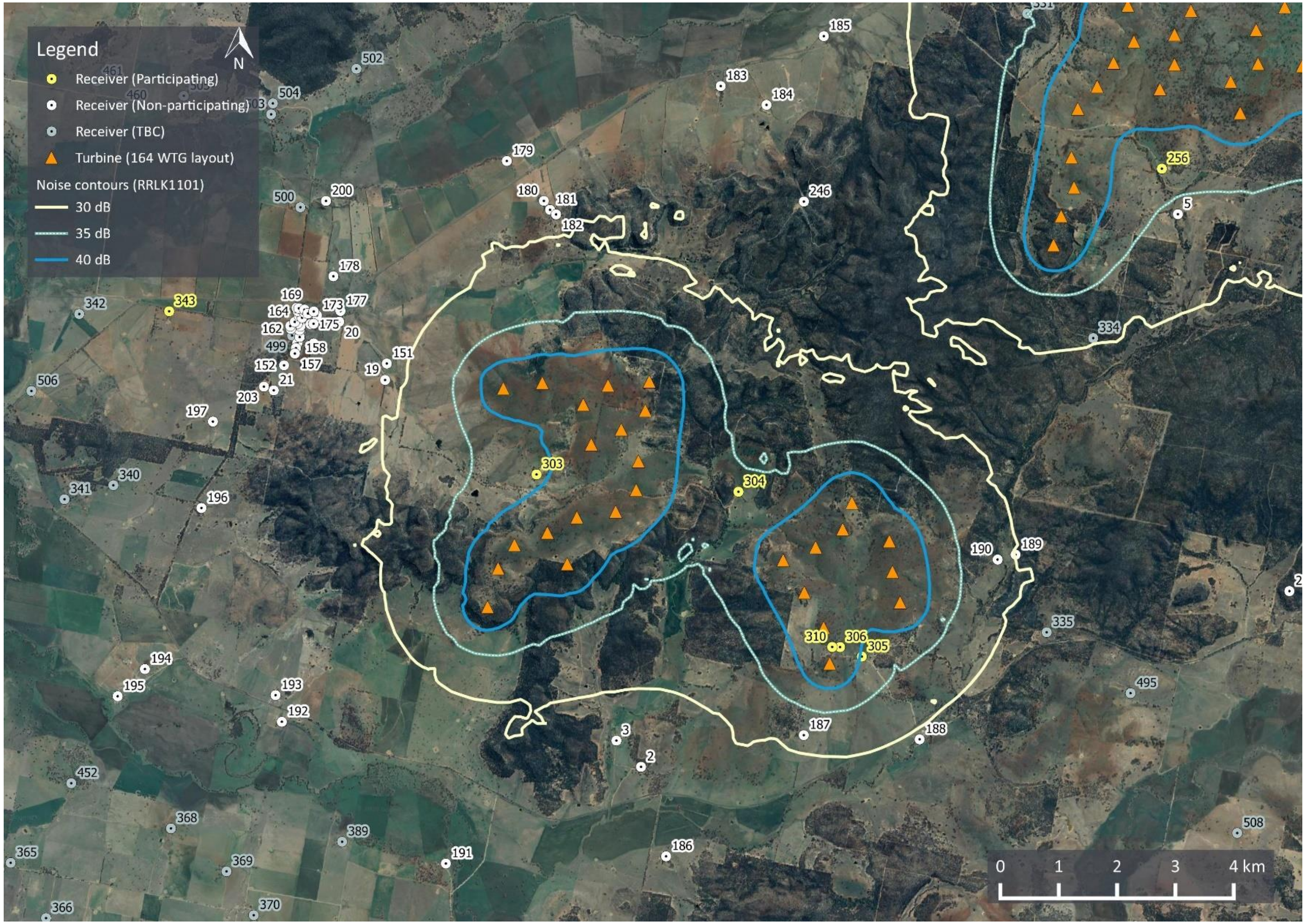


Figure 5: Leadville cluster - highest predicted noise level contours (corresponding to hub-height wind speeds of 9 m/s or greater)



5.2 Cumulative wind farm noise levels

The Liverpool Range Wind Farm, located approximately 10 km north-east of the proposed Valley of the Winds project received development consent in March 2018 for up to two hundred and sixty-seven (267) wind turbines with a tip height of up to 165 m. It is understood that Tilt Renewables are now progressing the development of the project, but the status of the development is presently unknown.

A site plan showing the location of Liverpool Range Wind Farm in relation to the proposed Valley of the Winds project is provided in Figure H1 of Appendix H.

In relation to other wind farm developments, the NSW Noise Assessment Bulletin does not make specific recommendations concerning cumulative noise. The SA EPA Guidelines do however refer to cumulative noise, noting that the criteria have been specified to allow for other potential development, and that any noise criteria which are set relative to background noise levels should not include the influence of other wind farms. While neither document explicitly states a requirement to assess the combined noise levels of multiple wind farm projects, nor do they define criteria which directly applies to cumulative noise, an assessment of cumulative noise from the project and the neighbouring Liverpool Range Wind Farm is provided herein.

Noise levels around the Liverpool Range Wind Farm have been predicted using the methodology detailed in Section 4.0 with the following additional key details:

- Turbine layout comprising 267 turbines provided by UPC
- Turbine hub height: 80 m, as detailed in Section 4.1 of the LRWF Noise Assessment Report[3]
- Candidate turbine model: Vestas V112- 3.0MW, as detailed in Table 7 of the LRWF Noise Assessment Report
- Turbine sound power levels: Detailed in Table 8 and Appendix B of the LRWF Noise Assessment Report and reproduced in Section H2 of Appendix H

Cumulative operational noise requires consideration in two ways:

- The potential for the Liverpool Range Wind Farm to influence noise levels at receivers near the Valley of the Winds project; and
- The potential for the Valley of the Winds project influence noise levels at receivers near the Liverpool Range Wind Farm;

As an indication of potential cumulative noise, predicted noise levels for the two projects are provided for the receiver locations where the predicted noise level of either wind farm is approaching the 35 dB L_{Aeq} base criterion which applies to each wind farm. Specifically, Table 5 and Table 6 presents predicted cumulative noise levels for the receivers where predicted wind farm noise levels are higher than 32 dB L_{Aeq}[4] as a result of the Valley of the Winds and the Liverpool Range Wind Farm respectively.

In addition to the receiver-specific information of Table 5 and Table 6, additional data relevant to cumulative noise is provided in the noise contour maps of Appendix H. This data is discussed further below.

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[3] Report Number 640.10487-R1 *Liverpool Range Wind Farm Noise Impact Assessment* dated 12 March 2014, prepared by SLR Consulting Australia Pty Ltd for Epuron Pty Ltd (the LRWF Noise Assessment Report) https://epuron.com.au/documents/219/Liverpool_Range_Wind_Farm_Environmental_Assessment_Appendix_B_Noise.pdf

[4] The value of 32 dB L_{Aeq} was chosen as the minimum level that must occur from either project for there to be a possibly that the influence of the neighbouring wind farm could result in the total predicted noise level being higher than 35 dB L_{Aeq} base criterion which applies to each project.

Table 5: Cumulative assessment for relevant Valley of the Winds receivers

Receiver	Predicted noise level, dB L_{Aeq}			Change in compliance outcome due to cumulative effects
	Valley of the Winds only	Liverpool Range Wind Farm only	Cumulative	
Non-participating receivers				
5	34.2	20.5	34.4	No
25	32.0	25.7	32.9	No
86	32.6	24.9	33.3	No
88	32.4	24.8	33.1	No
89	32.6	22.2	33.0	No
90	32.0	21.7	32.4	No
91	32.5	21.6	32.8	No
238	35.7	19.3	35.8	No
278	35.5	23.3	35.8	No
282	33.6	22.0	33.9	No
Receivers with status To Be Confirmed				
328	33.3	19.8	33.5	No
331	35.0	20.8	35.2	Yes
497	34.4	23.2	34.7	No

It can be seen from Table 5 that the predicted noise levels from the Liverpool Range Wind Farm are low at receivers near to the Valley of the Winds project; specifically, less than 26 dB at all of the relevant receivers near the Valley of the Winds project. As a result, the change in predicted noise level attributable to the influence of the Liverpool Range Wind Farm is small, ranging from 0.1 to 0.9 dB. For context, a 1 dB difference is generally not measurable or discernible in practice, particularly in the context of the much larger variations in ambient noise levels. In terms of the 35 dB L_{Aeq} base criterion which applies to each wind farm, the contribution of the Liverpool Range Wind Farm only results in an outcome change (i.e. whether the predicted total wind farm noise level is above or below 35 dB L_{Aeq}) at one (1) receiver location; receiver 331 (status yet to be confirmed) where the prediction marginally increases from 35.0 to 35.2 dB L_{Aeq}.

Table 6: Cumulative assessment for relevant Liverpool Range Wind Farm receivers

Receiver	Predicted noise level, dB L_{Aeq}			Change in compliance outcome due to cumulative effects
	Valley of the Winds only	Liverpool Range Wind Farm only	Cumulative	
Non-participating receivers				
26	17.5	35.7	35.8	No
93	20.7	33.0	33.2	No
94	20.6	33.9	34.1	No
95	21.6	35.5	35.7	No

Receiver	Predicted noise level, dB L_{Aeq} Valley of the Winds only	Liverpool Range Wind Farm only	Cumulative	Change in compliance outcome due to cumulative effects
96	23.0	32.3	32.8	No
100	22.4	32.0	32.5	No
101	20.9	32.9	33.2	No
102	21.1	36.9	37.0	No
103	21.1	37.4	37.5	No
106	20.2	32.4	32.7	No
107	20.0	33.4	33.6	No
108	19.5	32.8	33.0	No
109	18.0	35.2	35.3	No
113	18.2	36.1	36.2	No
114	15.6	38.9	38.9	No
115	14.8	39.8	39.8	No
116	17.6	33.7	33.8	No
117	14.5	38.7	38.7	No
118	14.2	39.3	39.3	No
119	14.9	39.4	39.4	No
133	22.3	32.7	33.1	No
134	20.0	32.2	32.5	No
135	18.8	33.2	33.4	No
136	18.0	34.0	34.1	No
137	19.3	34.5	34.6	No
198	15.4	39.0	39.0	No
204	12.7	41.4	41.4	No
205	12.8	41.7	41.7	No
206	18.0	33.7	33.8	No
207	18.1	33.8	33.9	No
208	17.3	35.5	35.6	No
209	17.6	32.8	32.9	No
211	16.1	38.0	38.0	No
212	16.0	38.1	38.1	No
213	16.0	38.6	38.6	No
262	11.6	32.2	32.2	No

Receiver	Predicted noise level, dB L_{Aeq}			Change in compliance outcome due to cumulative effects
	Valley of the Winds only	Liverpool Range Wind Farm only	Cumulative	
263	12.0	34.1	34.1	No
294	17.7	33.9	34.0	No
295	18.0	33.2	33.3	No
296	17.9	33.3	33.4	No
Receivers with status To Be Confirmed				
393	15.3	40.9	40.9	No
510	15.8	40.6	40.6	No

Note: Coordinates datum: MGA94 Zone 55

It can be seen from Table 6 that the predicted noise levels from the Valley of the Winds project are low at receivers near to the Liverpool Range Wind Farm; specifically, 23 dB or less at all of the relevant receivers near the Valley of the Winds project. As a result, the change in predicted noise level attributable to the influence of the Valley of the Winds project is small, ranging from 0 to 0.5 dB; a difference that is not expected to be measurable or discernible in practice. In terms of the 35 dB L_{Aeq} base criterion which applies to each wind farm, the contribution of the Valley of the Winds project does not result in an outcome change (i.e. whether the predicted total wind farm noise level is above or below 35 dB L_{Aeq}) at any of the relevant receiver locations.

As a further visual guide to cumulative noise considerations, Appendix H presents the predicted 25 dB L_{Aeq} contours of each project. The 25 dB value corresponds to a level that is 10 dB below the base noise criterion that applies to each project. The noise level contours relate to the separate contribution of each wind farm (i.e. rather than the total predicted noise level of each wind farm).

The predicted noise levels in Table 5 and Table 6, and the contours presented in Appendix H, are for the wind speeds which give rise to the highest noise emissions from each site respectively. It is also noted that the noise level contours are predicted on the basis of downwind propagation from each turbine; in most instances where cumulative noise is considered, a noise sensitive receiver cannot be simultaneously downwind of all wind turbines of adjoining projects. The predictions are therefore conservative[5] for the purpose of considering cumulative noise levels.

The results of the preliminary assessment demonstrate that cumulative noise considerations associated with the Valley of the Winds can be practically managed, in terms of receivers near to both projects. In particular, the predicted increases in noise levels as a result of the cumulative influence of each project are small and, in most cases, not sufficient to result in an outcome change relative to the 35 dB L_{Aeq} base criterion which applies to each project.

[5] By a margin of up to 3 dB when compared to downwind predictions from each wind farm individually. This is distinct to variation of noise levels when a receiver is upwind of each wind farm when noise levels would be significantly lower than the downwind predictions.

6.0 DETAILED ASSESSMENT PHASE

A detailed assessment of a NSW wind farm development involves addressing a number of environmental noise considerations detailed in the project specific SEARs. For example, the document titled *Standard Secretary's Environmental Assessment Requirements* dated September 2016 notes that an EIS must address:

- Operational wind turbine noise
- Ancillary infrastructure noise
- Construction noise
- Construction traffic noise
- Construction vibration.

Environmental noise considerations relating to construction and ancillary infrastructure would be addressed at the development application phase of the assessment, once the project specific SEARs have been released.

Given the findings of the preliminary noise modelling presented in Section 4.0, further detailed assessment work will involve background noise monitoring at key receiver locations to determine the applicable criteria in accordance with the NSW Noise Assessment Bulletin. The results of any background noise monitoring would be documented in the noise assessment report prepared to accompany the development application for the Valley of the Winds project.

The NSW Noise Assessment Bulletin specifies additional criteria relating to *special characteristics*, defined as tonality and low frequency. While tonality cannot be readily predicted, in relation to low frequency noise, the bulletin states that:

> *Noise assessments for proposed wind energy projects shall assess the potential for non-associated residential receiver locations to experience low frequency noise levels exceeding 60 dB(C).*

Low frequency noise characteristics are highly specific to the turbine being considered, and its assessment can involve detailed modelling using alternative procedures to those used for A-weighted noise levels. In accordance with the NSW Noise Assessment Bulletin, this modelling data is to be provided as part of an application to develop a wind farm. Accordingly, this modelling is to be undertaken and reported at the development application phase of the assessment.

7.0 SUMMARY

A preliminary assessment of operational noise for the proposed Valley of the Winds project has been carried out. The preliminary noise assessment has been prepared in accordance with the NSW Department of Planning and Environment's *Wind Energy: Noise Assessment Bulletin - For State significant wind energy development*, dated December 2016 (the NSW Noise Assessment Bulletin).

Although this project has the potential for approximately one hundred and seventy-five (175) wind turbines, the preliminary noise assessment has been carried out on the basis of the current project design comprising one hundred and sixty-four (164) multi-megawatt turbines.

Noise modelling was carried out on the basis of the Vestas V162-5.6MW candidate turbine model which has been nominated by UPC as being representative of the size and type of turbine which are being considered for the site.

The results of the modelling demonstrate that the project can be designed and operated to comply with the operational noise requirements of the NSW Noise Assessment Bulletin. Once the Secretary's Environmental Assessment Requirements (SEARs) are released for this project, further detailed assessment will be undertaken. This would include background noise monitoring, revised modelling and, if required, layout refinements to demonstrate how compliance would be achieved for the specific noise matters defined by the SEARs for the project.

Cumulative noise levels associated with operation of the consented Liverpool Range Wind Farm to the north-east of the Valley of the Winds project site has also been considered in this assessment. The assessment is based on conservative modelling which assumes simultaneous downwind noise levels from each project; a situation cannot generally occur in practice for the receiver locations between the two projects. The noise modelling for the two projects has demonstrated that the predicted increase in noise levels as a result of the cumulative influence of each project are small at the nearest receivers to each project (changes that are that small cannot be generally measured or discerned in practice). The modelling also demonstrates that in most cases, the cumulative influence of each project is not sufficient to change whether the total predicted wind farm noise level is above the 35 dB L_{Aeq} base criterion which applies to each project. Accordingly, the results of the preliminary assessment demonstrate that cumulative noise considerations associated with the Valley of the Winds can be practically managed, in terms of receivers near to both projects.

Further noise modelling and assessment work is to be undertaken to support a subsequent development application for the Valley of the Winds project. This is expected to included background noise monitoring at key receiver locations around the site, and assessment of other noise considerations including special noise characteristics, construction and ancillary infrastructure.

APPENDIX A GLOSSARY OF TERMINOLOGY

The basic quantities used within this document to describe noise adopt the conventions outlined in ISO 1996-1:2016 *Acoustics - Description measurement and assessment of environmental noise – Basic quantities and assessment procedures*.

Accordingly, all frequency weighted sound pressure levels are expressed as decibels (dB) in this report.

For example, sound pressure levels measured using an "A" frequency weighting are expressed as L_A dB. Alternative ways of expressing A-weighted decibels such as dBA or dB(A) are therefore not used within this report.

Term	Definition	Abbreviation
A-weighting	A method of adjusting sound levels to reflect the human ear's varied sensitivity to different frequencies of sound.	See discussion above this table.
C- weighting	A method of adjusting sound levels to account for non-linear frequency response of the human ear at high noise levels (typically greater than 100 decibels).	-
A-weighted 90^{th} centile	The A-weighted pressure level that is exceeded for 90 % of a defined measurement period. It is used to describe the underlying background sound level in the absence of a source of sound that is being investigated, as well as the sound level of steady, or semi steady, sound sources.	L_{A90}
A-weighted equivalent level	The A-weighted equivalent continuous pressure level.	L_{Aeq}
C-weighted equivalent level	The C-weighted equivalent continuous pressure level.	L_{Ceq}
Decibel	The unit of sound level.	dB
Hertz	The unit for describing the frequency of a sound in terms of the number of cycles per second.	Hz
Low frequency	A sound with perceptible content in the audible frequency range typically below 200 Hz	-
Octave Band	A range of frequencies. Octave bands are referred to by their logarithmic centre frequencies, these being 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz for the audible range of sound.	-
Sound power level	A measure of the total sound energy emitted by a source, expressed in decibels.	L_W
Sound pressure level	A measure of the level of sound expressed in decibels.	L_p
Special characteristics	A term used by the NSW Noise Assessment Bulletin to define sound characteristics that increase the likelihood of adverse reaction to the sound. The characteristics are tonality and low frequency.	-
Tonality	A characteristic to describe sounds which are composed of distinct and narrow groups of audible sound frequencies (e.g. whistling or humming sounds).	-

APPENDIX B TURBINE COORDINATES

The following table sets out the coordinates of the proposed turbine layout of the proposed project (data supplied by UPC on 24 January 2020).

Table 7: Turbine coordinates – MGA 94 zone 55

Turbine	Easting (m)	Northing (m)	Terrain elevation (m)	Turbine	Easting (m)	Northing (m)	Terrain elevation (m)
BS34	758,944	6,464,274	650	BS66	756,460	6,458,768	610
BS35	758,157	6,464,459	607	BS67	756,751	6,459,617	646
BS36	758,867	6,463,788	643	BS68	755,584	6,460,507	640
BS37	759,129	6,463,255	664	BS69	755,310	6,460,092	640
BS38	758,541	6,463,054	688	BS70	755,318	6,459,580	619
BS39	759,049	6,462,560	671	BS71	755,076	6,459,151	610
BS40	758,453	6,462,372	683	BS72	754,502	6,460,576	610
BS41	758,218	6,461,944	679	BS73	754,616	6,459,962	637
BS42	757,447	6,462,006	670	BS74	754,273	6,459,590	620
BS43	756,659	6,462,107	632	BS75	753,999	6,459,180	620
BS44	755,711	6,462,191	600	BS76	753,674	6,458,792	620
BS45	756,593	6,463,492	600	BS77	753,579	6,457,957	622
BS46	756,777	6,463,993	590	BS78	753,633	6,457,442	633
BS47	755,382	6,463,060	593	BS79	760,799	6,463,888	630
BS48	755,108	6,462,649	610	BS80	760,742	6,463,391	630
BS49	754,739	6,461,990	600	BS81	760,650	6,462,914	630
BS50	754,203	6,461,612	595	BS82	760,451	6,462,473	619
BS51	756,055	6,461,176	615	BS83	761,151	6,462,102	620
BS52	756,745	6,461,245	636	BS84	760,557	6,461,914	615
BS53	757,164	6,461,586	680	BS85	760,640	6,461,392	609
BS54	757,979	6,461,523	660	BS86	760,563	6,460,908	608
BS55	757,710	6,461,110	650	BS87	760,715	6,460,384	620
BS56	759,194	6,461,471	636	BS88	760,358	6,460,012	608
BS57	759,121	6,460,988	630	BS89	760,318	6,459,516	592
BS58	758,443	6,460,780	638	BS90	760,647	6,458,981	607
BS59	758,863	6,460,265	619	BS91	760,316	6,458,601	610
BS60	758,725	6,459,798	620	BS92	759,927	6,458,249	600
BS61	758,287	6,459,480	611	BS93	759,682	6,457,819	600
BS62	757,511	6,459,591	630	BS201	753,420	6,456,948	588
BS63	757,193	6,460,599	689	BS202	753,298	6,456,449	560
BS64	756,709	6,460,196	650	BS203	759,524	6,457,385	593
BS65	756,288	6,459,303	620	MH1	750,823	6,466,393	660

Turbine	Easting (m)	Northing (m)	Terrain elevation (m)
MH3	752,364	6,470,122	760
MH4	752,195	6,469,669	742
MH5	751,988	6,469,222	718
MH6	751,758	6,468,787	740
MH7	751,369	6,468,329	700
MH8	751,125	6,467,889	690
MH9	750,624	6,467,617	708
MH10	750,590	6,467,119	684
MH11	749,957	6,466,970	687
MH12	749,609	6,466,599	670
MH13	749,334	6,466,186	652
MH14	749,274	6,465,698	630
MH15	749,193	6,465,212	637
MH16	748,666	6,464,959	613
MH17	752,100	6,471,529	691
MH18	751,891	6,470,998	720
MH19	751,673	6,470,561	752
MH20	751,405	6,470,150	770
MH21	751,080	6,469,766	758
MH22	751,114	6,469,218	714
MH23	750,573	6,470,261	730
MH24	750,433	6,469,612	711
MH25	750,134	6,469,216	690
MH26	749,501	6,469,059	660
MH27	749,011	6,468,782	666
MH28	748,392	6,469,235	660
MH29	748,307	6,468,717	661
MH30	748,779	6,468,209	665
MH31	748,372	6,467,861	690
MH32	748,081	6,467,463	687
MH33	747,833	6,467,043	680
MH34	747,796	6,466,547	641
MH35	747,578	6,466,119	651
MH37	751,659	6,475,522	770
MH38	751,575	6,476,168	740
MH39	750,745	6,476,233	730
MH40	750,187	6,475,644	720
MH41	749,513	6,475,542	720
MH42	748,339	6,473,898	707
MH43	747,246	6,474,220	720
MH44	747,792	6,472,848	729
MH45	747,650	6,472,377	710
MH46	747,623	6,471,881	680
MH47	746,345	6,472,384	730
MH48	746,154	6,471,936	720
MH49	745,962	6,471,489	710
MH50	745,220	6,471,341	700
MH52	744,786	6,472,501	724
MH53	744,708	6,472,009	720
MH54	744,374	6,471,632	709
MH56	743,644	6,472,227	699
MH57	743,287	6,472,752	737
MH58	742,671	6,472,583	730
MH59	741,911	6,472,436	670
MH60	742,924	6,471,876	720
MH61	742,564	6,471,332	710
MH62	742,375	6,470,526	711
MH63	742,168	6,470,076	730
MH66	745,473	6,474,414	710
MH67	745,141	6,474,036	720
MH68	745,245	6,475,470	680
MH69	745,017	6,475,043	695
MH70	744,316	6,475,608	680
MH71	744,231	6,475,085	688
MH72	743,770	6,474,783	716
MH73	744,266	6,474,268	720
MH74	742,890	6,474,888	700
MH75	742,913	6,474,383	700

Turbine	Easting (m)	Northing (m)	Terrain elevation (m)
MH77	752,340	6,471,945	663
MH78	751,418	6,471,948	710
MH79	751,323	6,472,474	720
MH80	751,418	6,472,952	730
MH81	751,193	6,473,496	734
LV1	750,774	6,450,278	565
LV2	750,633	6,450,800	570
LV3	750,571	6,451,325	590
LV4	749,917	6,451,972	596
LV5	749,767	6,451,515	600
LV6	749,307	6,451,199	587
LV7	748,755	6,450,967	570
LV8	749,127	6,450,420	560
LV9	749,469	6,449,824	550
LV10	749,585	6,449,211	520
LV11	743,699	6,450,076	557

Turbine	Easting (m)	Northing (m)	Terrain elevation (m)
LV12	743,869	6,450,741	570
LV13	744,141	6,451,149	599
LV14	745,052	6,450,837	560
LV15	744,703	6,451,369	593
LV16	745,204	6,451,640	593
LV17	745,868	6,451,749	580
LV18	746,213	6,452,127	580
LV19	746,242	6,452,620	590
LV20	745,939	6,453,158	610
LV21	746,345	6,453,493	590
LV22	746,406	6,453,989	580
LV23	745,698	6,453,909	603
LV24	745,279	6,453,574	610
LV25	745,429	6,452,894	610
LV27	743,905	6,453,827	600
LV28	744,571	6,453,934	610

APPENDIX C RECEIVER LOCATIONS

The following table sets out the sixty (60) noise sensitive receivers located within 3 km of the proposed project and considered in the preliminary noise assessment, together with their respective distance to the nearest turbine.

Table 8: Receiver locations – MGA 94 zone 55

Receiver ID	Easting (m)	Northing (m)	Terrain elevation (m)	Distance to the nearest turbine (m)
Non-participating receivers				
5	755,422	6,457,014	520	1,847
6	759,531	6,455,686	589	1,708
18	739,280	6,473,409	639	2,811
19	741,874	6,453,935	439	2,041
25	754,344	6,471,224	489	2,137
76	746,932	6,477,152	522	2,388
77	746,882	6,477,385	514	2,524
78	747,642	6,477,536	524	2,740
79	749,213	6,477,460	569	1,948
82	754,208	6,473,729	539	2,588
83	754,622	6,473,451	509	2,739
84	754,433	6,471,485	491	2,149
85	754,408	6,471,141	485	2,225
86	753,987	6,468,628	510	2,080
87	754,583	6,468,372	462	2,723
88	753,928	6,468,284	498	2,161
89	753,397	6,464,626	454	2,534
90	750,756	6,463,567	439	2,276
91	750,140	6,463,443	462	2,014
127	739,381	6,473,473	642	2,740
151	741,898	6,454,218	434	2,051
181	744,652	6,456,901	453	2,973
182	744,757	6,456,824	460	2,900
187	749,161	6,447,974	464	1,319
188	751,149	6,447,938	449	2,024
189	752,739	6,451,131	471	2,139
190	752,433	6,451,041	465	1,823
199	754,234	6,473,485	535	2,446

Receiver ID	Easting (m)	Northing (m)	Terrain elevation (m)	Distance to the nearest turbine (m)
238	741,532	6,474,758	666	1,374
277	757,383	6,466,463	515	2,155
278	757,286	6,465,236	504	1,179
282	750,906	6,464,542	456	1,847
Participating receivers				
4	753,102	6,463,830	449	2,334
250	749,023	6,473,371	739	880
251	753,165	6,466,540	455	2,353
252	754,390	6,470,804	483	2,144
253	754,612	6,470,636	473	2,312
254	754,133	6,470,787	491	1,898
256	755,133	6,457,790	545	1,373
257	758,006	6,458,422	579	1,108
258	758,930	6,458,667	554	1,051
259	758,937	6,456,464	564	1,105
276	755,240	6,466,547	473	2,985
279	755,443	6,466,590	483	2,924
280	752,452	6,465,758	449	1,757
281	752,090	6,466,196	472	1,293
297	749,296	6,473,389	734	1,097
303	744,500	6,452,362	514	1,023
304	747,968	6,452,126	504	1,411
305	750,134	6,449,338	492	588
306	749,757	6,449,494	498	371
309	740,935	6,471,803	593	1,176
310	749,622	6,449,494	513	331
329	753,160	6,462,752	468	1,554

Receiver ID	Easting (m)	Northing (m)	Terrain elevation (m)	Distance to the nearest turbine (m)
Receivers where participation status to be confirmed				
328	747,148	6,464,576	509	1,574
330	751,248	6,461,301	446	2,976
331	752,777	6,460,407	529	1,713
334	754,006	6,454,865	509	1,743
335	753,297	6,449,810	481	2,571
497	758,215	6,457,023	569	1,368
329	753,160	6,462,752	468	1,554

APPENDIX D SITE LAYOUT PLAN

Figure 6: Proposed turbine locations and sensitive receiver locations - Overview

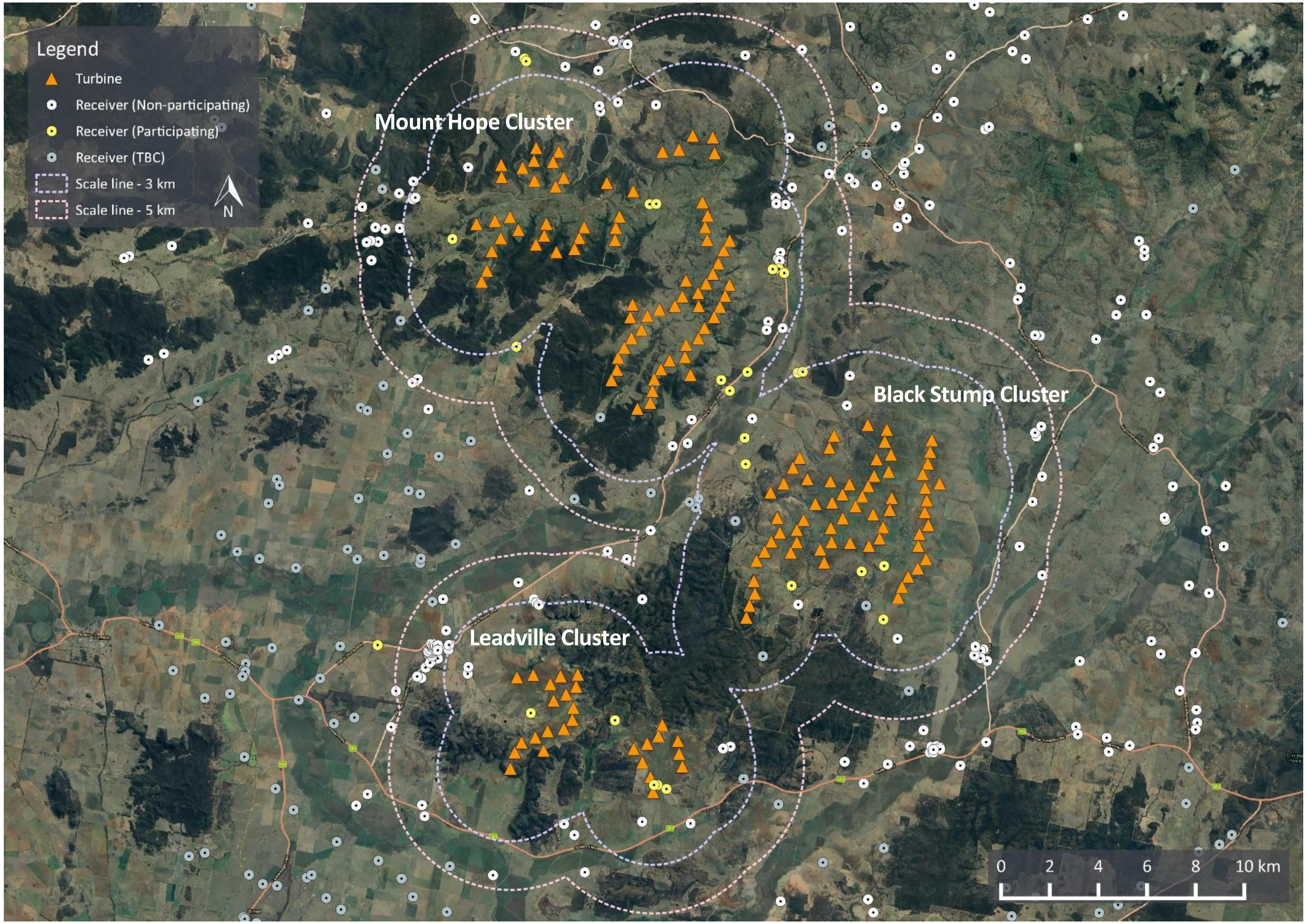


Figure 7: Proposed turbine locations and sensitive receiver locations – Mount Hope cluster

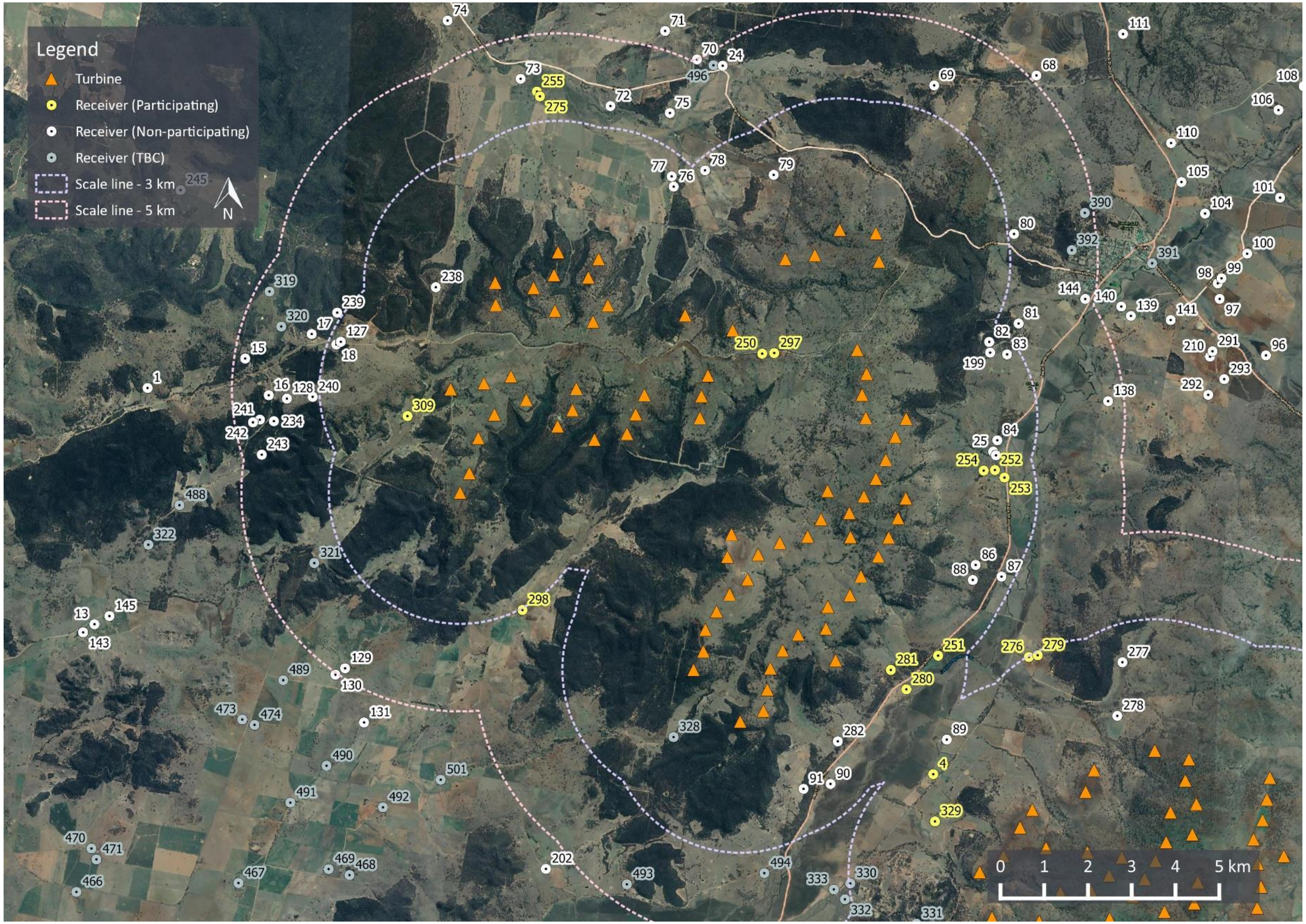


Figure 8: Proposed turbine locations and sensitive receiver locations – Black Stump cluster

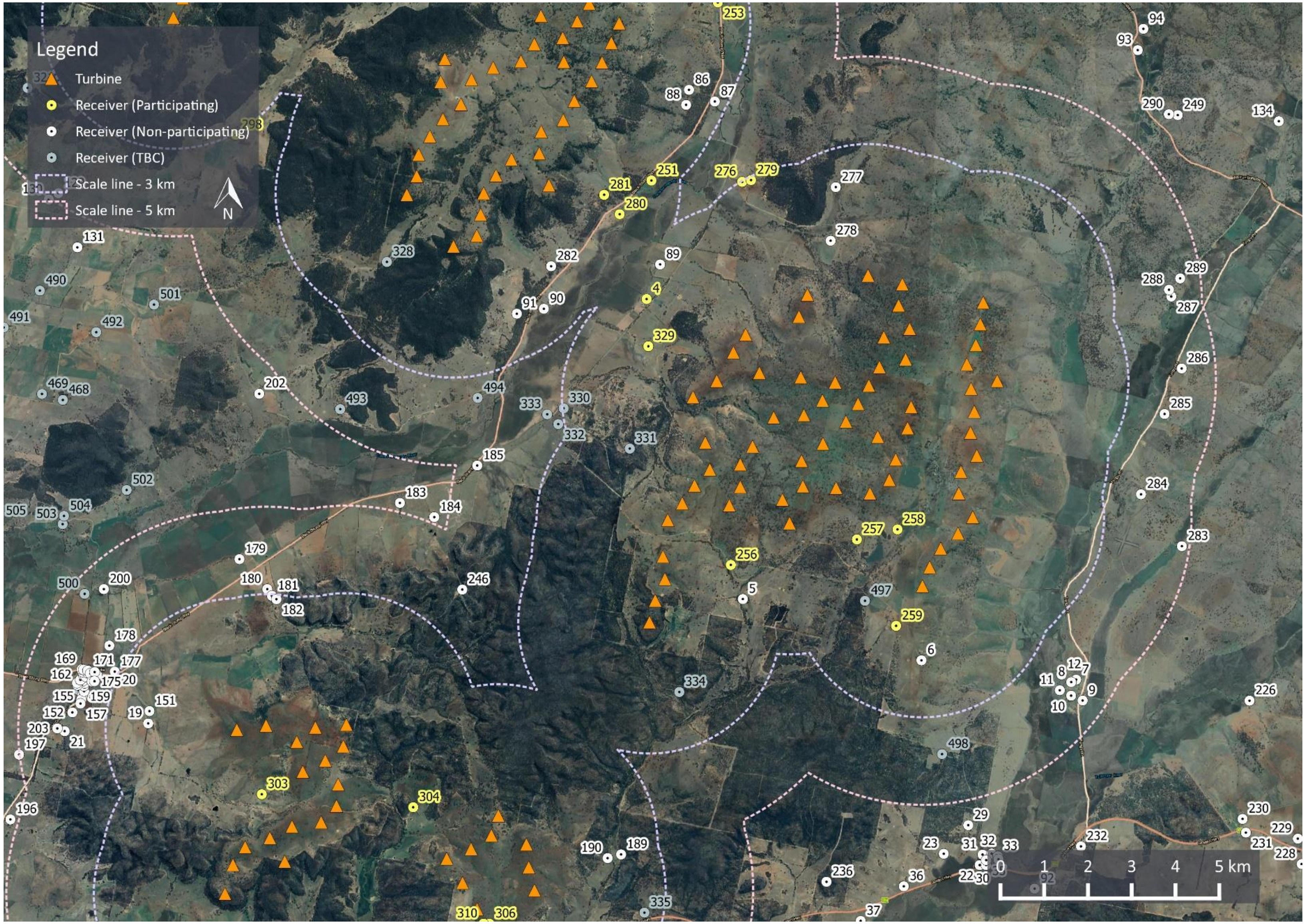
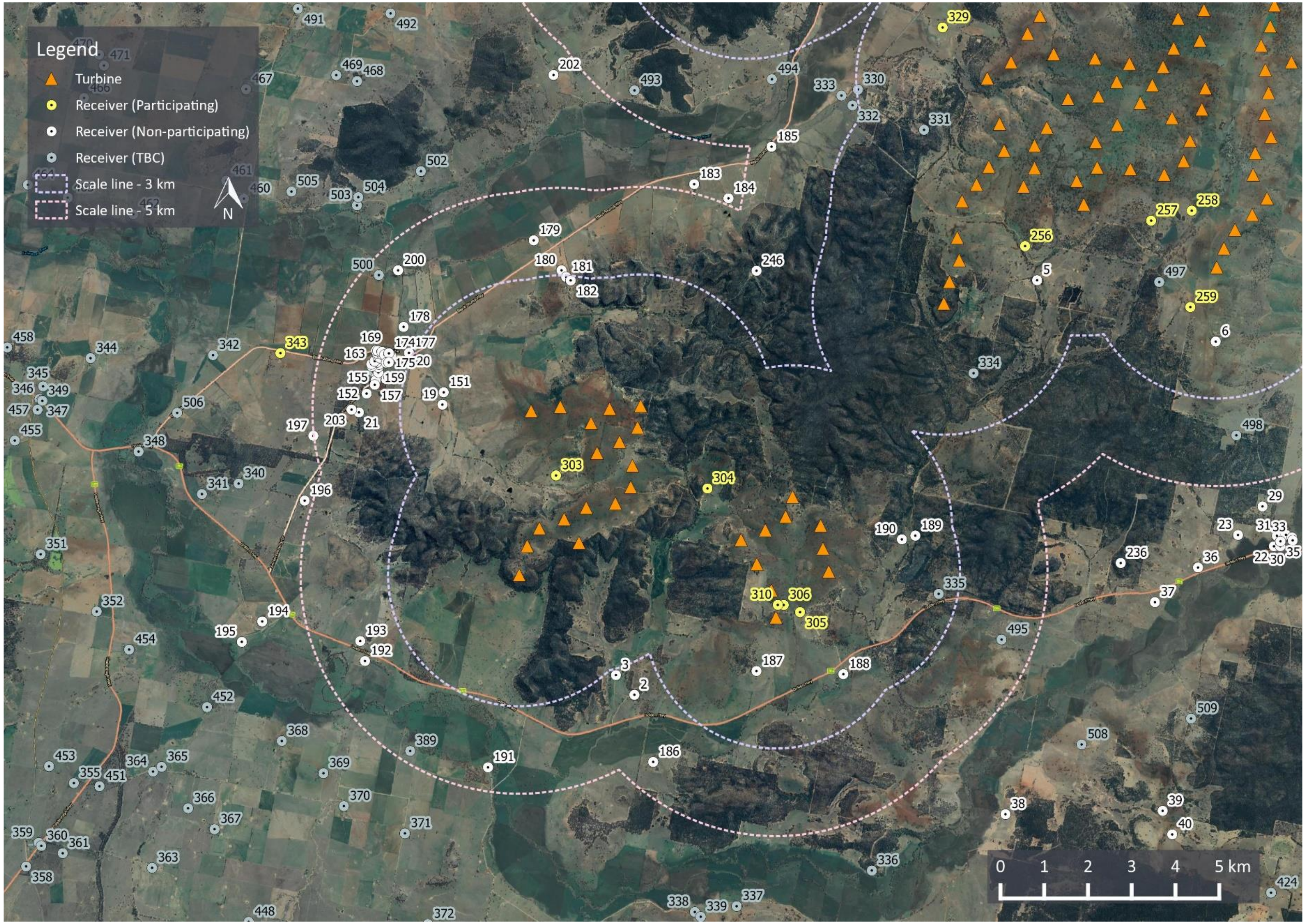
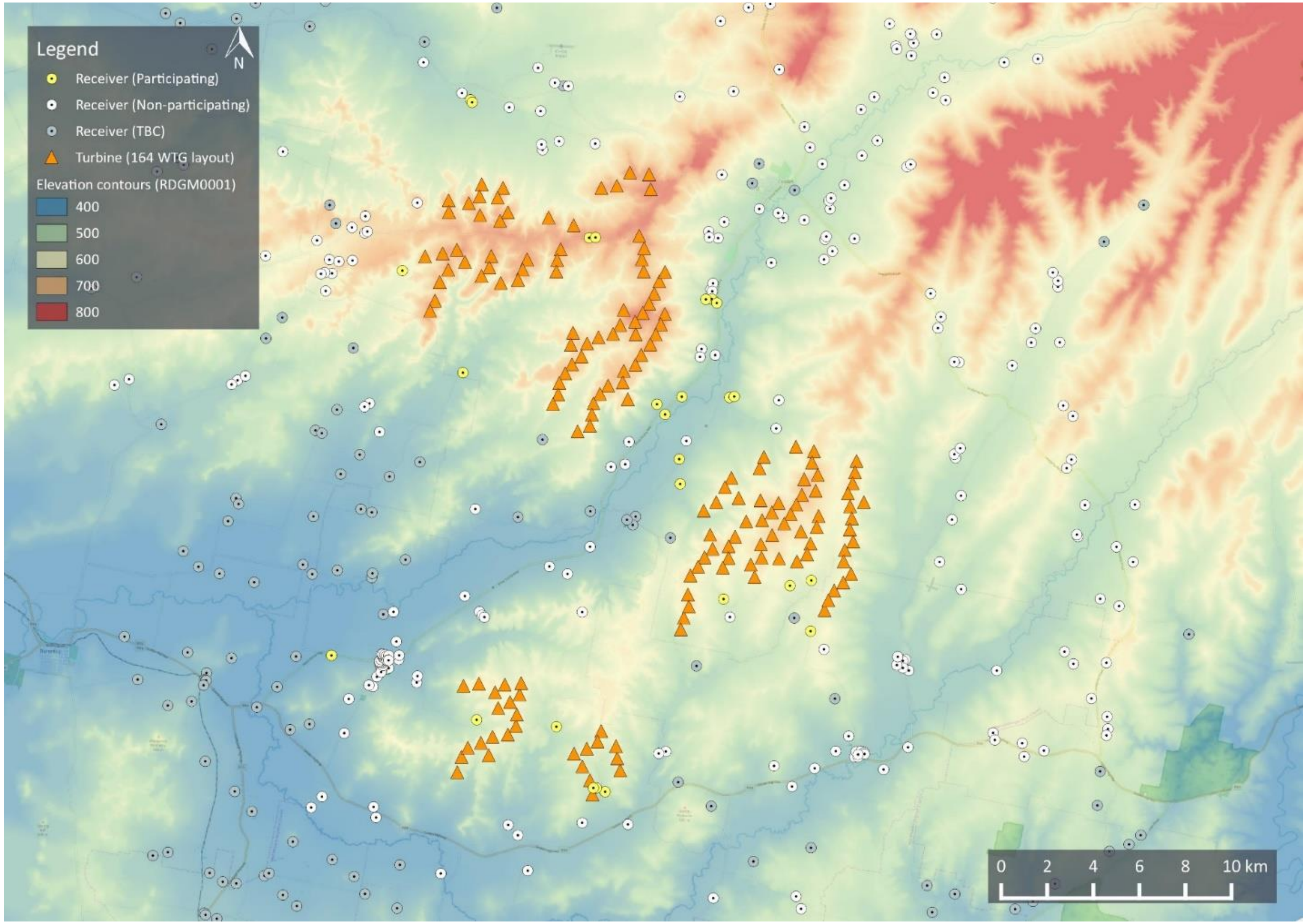


Figure 9: Proposed turbine locations and sensitive receiver locations – Leadville cluster



APPENDIX E SITE TOPOGRAPHY

Figure 10: Terrain elevation map for the Valley of the Winds project and surrounding area



APPENDIX F NOISE PREDICTION MODEL

Environmental noise levels associated with wind farms are predicted using engineering methods.

The international standard ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors - Part 2: General method of calculation* (ISO 9613-2) has been chosen as the most appropriate method to calculate the level of broadband A-weighted wind farm noise expected to occur at surrounding receptor locations. This method is considered to be the most robust and widely used international method for the prediction of wind farm noise.

The use of this standard is supported by international research publications, measurement studies conducted by Marshall Day Acoustics and direct reference to the standard in the South Australian EPA publication *Wind farms environmental noise guidelines*, NZS 6808:2010 *Acoustics – Wind farm noise* and AS 4959:2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators.*

The standard specifies an engineering method for calculating noise at a known distance from a variety of sources under meteorological conditions favourable to sound propagation. The standard defines favourable conditions as downwind propagation where the source blows from the source to the receiver within an angle of ±45 degrees from a line connecting the source to the receiver, at wind speeds between approximately 1 m/s and 5 m/s, measured at a height of 3 m to 11 m above the ground. Equivalently, the method accounts for average propagation under a well-developed moderate ground based thermal inversion. In this respect, it is noted that at the wind speeds relevant to noise emissions from wind turbines, atmospheric conditions do not favour the development of thermal inversions throughout the propagation path from the source to the receiver.

To calculate far-field noise levels according to the ISO 9613-2, the noise emissions of each turbine are firstly characterised in the form of octave band frequency levels. A series of octave band attenuation factors are then calculated for a range of effects including:

- Geometric divergence
- Air absorption
- Reflecting obstacles
- Screening
- Vegetation
- Ground reflections.

The octave band attenuation factors are then applied to the noise emission data to determine the corresponding octave band and total calculated noise level at receiver locations.

Calculating the attenuation factors for each effect requires a relevant description of the environment into which the sound propagation such as the physical dimensions of the environment, atmospheric conditions and the characteristics of the ground between the source and the receiver.

Wind farm noise propagation has been the subject of considerable research in recent years. These studies have provided support for the reliability of engineering methods such as ISO 9613-2 when a certain set of input parameters are chosen in combination. Specifically, the studies to date tend to support that the assignment of a ground absorption factor of G = 0.5 for the source, middle and receiver ground regions between a wind farm and a calculation point tends to provide a reliable representation of the upper noise levels expected in practice, when modelled in combination with other key assumptions; specifically all turbines operating at identical wind speeds, emitting sound levels equal to the test measured levels plus a margin for uncertainty (or guaranteed values), at a temperature of 10 °C and relative humidity of 70 % to 80 %, with specific adjustments for screening and ground effects as a result of the ground terrain profile.

In support of the use of ISO 9613-2 and the choice of G = 0.5 as an appropriate ground characterisation, the following references are noted:

- A factor of G = 0.5 is frequently applied in Australia for general environmental noise modelling purposes as a way of accounting for the potential mix of ground porosity which may occur in regions of dry/compacted soils or in regions where persistent damp conditions may be relevant
- In 1998, a comprehensive study (commonly cited as the Joule Report), part funded by the European Commission found that the ISO 9613-2 model provided a robust representation of upper noise levels which may occur in practice, and provided a closer agreement between predicted and measured noise levels than alternative standards such as CONCAWE and ENM. Specifically, the report indicated the ISO 9613 method generally tends to marginally over predict noise levels expected in practice
- The UK Institute of Acoustics journal dated March/April 2009 published a joint agreement between practitioners in the field of wind farm noise assessment (the UK IOA 2009 joint agreement), including consultants routinely employed on behalf of both developers and community opposition groups, and indicated the ISO 9613-2 method as the appropriate standard and specifically designated G = 0.5 as the appropriate ground characterisation. This agreement was subsequently reflected in the recommendations detailed in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* (UK Institute of Acoustics guidance). It is noted that these publications refer to predictions made at receiver heights of 4 m. Predictions in Australia are generally based on a lower prediction height of 1.5 m which tends to result in higher ground attenuation for a given ground factor, however conversely, predictions in Australia do not generally incorporate a -2 dB factor (as applied in the UK) to represent the relationship between L_{Aeq} and L_{A90} noise levels. The result is that these differences tend to balance out to a comparable approach and thus supports the use of G = 0.5 in the context of Australian prediction methodologies.

A range of measurement and prediction studies[6, 7, 8] for wind farms in which Marshall Day Acoustics' staff have been involved in have provided further support for the use of ISO 9613-2 and G = 0.5 as an appropriate representation of typical upper noise levels expected to occur in practice.

The findings of these studies demonstrate the suitability of the ISO 9613 method to predict the propagation of wind turbine noise for:

- the types of noise source heights associated with a modern wind farm, extending the scope of application of the method beyond the 30 m maximum source heights considered in the original ISO 9613-2;
- the types of environments in which wind farms are typically developed, and the range of atmospheric conditions and wind speeds typically observed around wind farm sites. Importantly, this supports the extended scope of application to wind speeds in excess of 5 m/s.

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6 Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions: The Risks of Conservatism*; Presented at the Second International Meeting on Wind Turbine Noise in Lyon, France September 2007.

7 Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions and Comparisons with Measurements*; Presented at the Third International Meeting on Wind Turbine Noise in Aalborg, Denmark June 2009.

8 Delaire, Griffin, & Walsh – *Comparison of predicted wind farm noise emission and measured post-construction noise levels at the Portland Wind Energy Project in Victoria, Australia*; Presented at the Fourth International Meeting on Wind Turbine Noise in Rome, April 2011.

In addition to the choice of ground factor referred to above, adjustments to the ISO 9613-2 standard for screening and valleys effects are applied on the basis of recommendations of the Joule Report, UK IOA 2009 joint agreement and the UK IOA Good Practice Guide. The following adjustments are applied to the calculations:

- screening effects as a result of terrain are limited to 2 dB
- screening effects are assessed on the basis of each turbine being represented by a single noise source located at the maximum tip height of the turbine rotor
- an adjustment of 3 dB is added to the predicted noise contribution of a turbine if the terrain between the turbine and receiver in question is characterised by a significant valley. A significant valley is defined as a situation where the mean sound propagation height is at least 50 % greater than it would be otherwise over flat ground.

The adjustments detailed above are implemented in the wind turbine calculation procedure of the SoundPLAN 8.1 software used to conduct the noise modelling. The software uses these definitions in conjunction with the digital terrain model of the site to evaluate the path between each turbine and receiver pairing, and then subsequently applies the adjustments to each turbine's predicted noise contribution where appropriate.

APPENDIX G TABULATED PREDICTED NOISE LEVEL DATA

Table 9: Predicted Noise Levels, dB L_{Aeq}

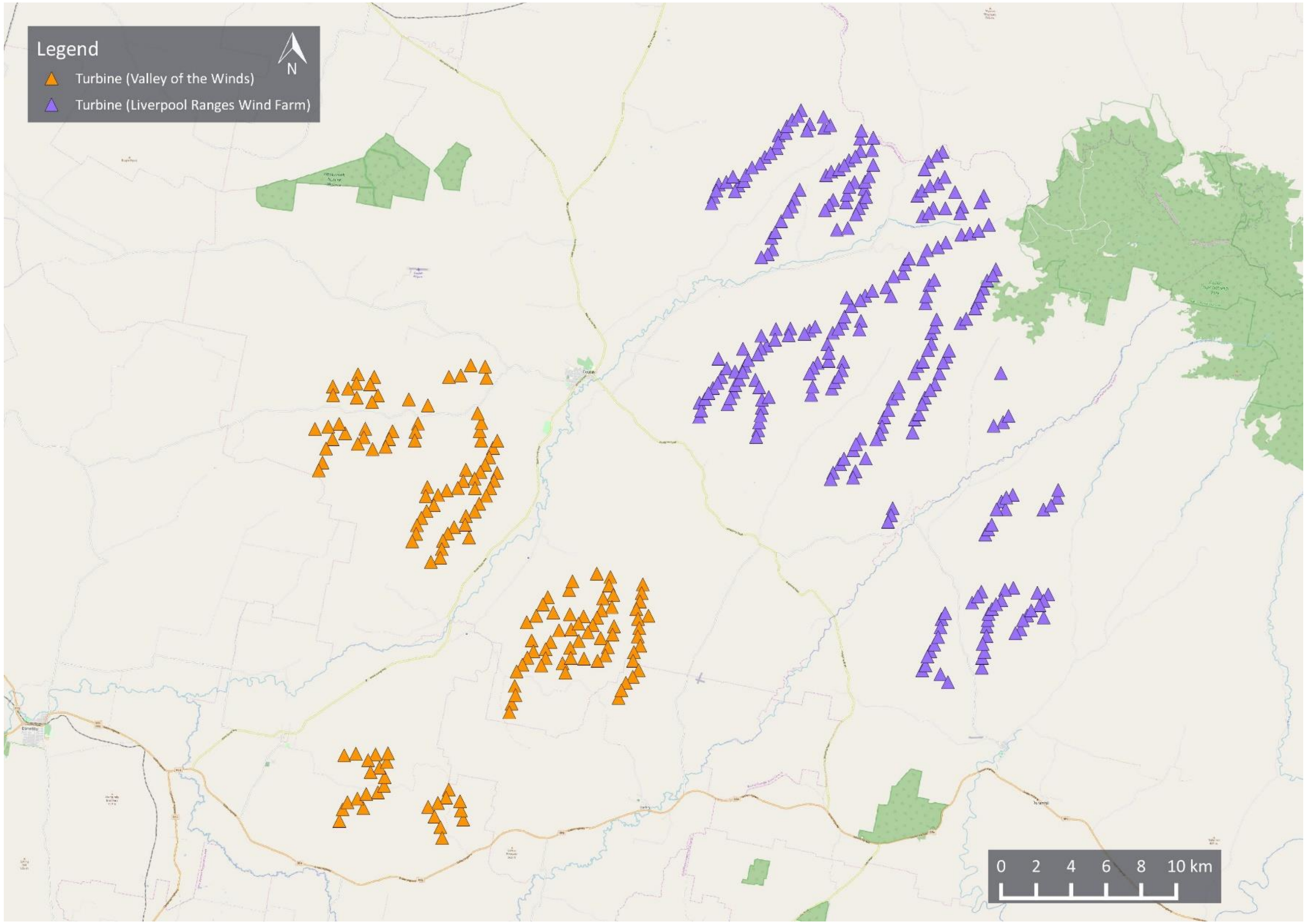
Receiver	Hub-height wind speed (m/s)						
	4	5	6	7	8	9	≥10
Non-participating receivers							
5	23.9	24.5	27.5	30.4	33.1	34.2	34.2
6	21.0	21.6	24.6	27.5	30.2	31.3	31.3
18	16.8	17.4	20.4	23.3	26.0	27.1	27.1
19	18.9	19.5	22.5	25.4	28.1	29.2	29.2
25	21.7	22.3	25.3	28.2	30.9	32.0	32.0
76	20.7	21.3	24.3	27.2	29.9	31.0	31.0
77	20.2	20.8	23.8	26.7	29.4	30.5	30.5
78	20.1	20.7	23.7	26.6	29.3	30.4	30.4
79	20.9	21.5	24.5	27.4	30.1	31.2	31.2
82	19.6	20.2	23.2	26.1	28.8	29.9	29.9
83	19.0	19.6	22.6	25.5	28.2	29.3	29.3
84	20.9	21.5	24.5	27.4	30.1	31.2	31.2
85	21.5	22.1	25.1	28.0	30.7	31.8	31.8
86	22.3	22.9	25.9	28.8	31.5	32.6	32.6
87	20.6	21.2	24.2	27.1	29.8	30.9	30.9
88	22.1	22.7	25.7	28.6	31.3	32.4	32.4
89	22.3	22.9	25.9	28.8	31.5	32.6	32.6
90	21.7	22.3	25.3	28.2	30.9	32.0	32.0
91	22.2	22.8	25.8	28.7	31.4	32.5	32.5
127	17.1	17.7	20.7	23.6	26.3	27.4	27.4
151	18.4	19.0	22.0	24.9	27.6	28.7	28.7
181	18.0	18.6	21.6	24.5	27.2	28.3	28.3
182	18.3	18.9	21.9	24.8	27.5	28.6	28.6
187	21.4	22.0	25.0	27.9	30.6	31.7	31.7
188	19.0	19.6	22.6	25.5	28.2	29.3	29.3
189	19.6	20.2	23.2	26.1	28.8	29.9	29.9
190	21.0	21.6	24.6	27.5	30.2	31.3	31.3
199	19.8	20.4	23.4	26.3	29.0	30.1	30.1
238	25.4	26.0	29.0	31.9	34.6	35.7	35.7

Receiver	Hub-height wind speed (m/s)						
	4	**5**	**6**	**7**	**8**	**9**	**≥10**
277	21.0	21.6	24.6	27.5	30.2	31.3	31.3
278	25.2	25.8	28.8	31.7	34.4	35.5	35.5
282	23.3	23.9	26.9	29.8	32.5	33.6	33.6
Participating receivers							
4	22.6	23.2	26.2	29.1	31.8	32.9	32.9
250	27.6	28.2	31.2	34.1	36.8	37.9	37.9
251	22.5	23.1	26.1	29.0	31.7	32.8	32.8
252	21.7	22.3	25.3	28.2	30.9	32.0	32.0
253	21.0	21.6	24.6	27.5	30.2	31.3	31.3
254	22.6	23.2	26.2	29.1	31.8	32.9	32.9
256	26.3	26.9	29.9	32.8	35.5	36.6	36.6
257	27.7	28.3	31.3	34.2	36.9	38.0	38.0
258	29.1	29.7	32.7	35.6	38.3	39.4	39.4
259	24.1	24.7	27.7	30.6	33.3	34.4	34.4
276	21.1	21.7	24.7	27.6	30.3	31.4	31.4
279	21.0	21.6	24.6	27.5	30.2	31.3	31.3
280	22.7	23.3	26.3	29.2	31.9	33.0	33.0
281	24.7	25.3	28.3	31.2	33.9	35.0	35.0
297	26.8	27.4	30.4	33.3	36.0	37.1	37.1
303	28.8	29.4	32.4	35.3	38.0	39.1	39.1
304	25.2	25.8	28.8	31.7	34.4	35.5	35.5
305	29.4	30.0	33.0	35.9	38.6	39.7	39.7
306	33.5	34.1	37.1	40.0	42.7	43.8	43.8
309	24.0	24.6	27.6	30.5	33.2	34.3	34.3
310	34.7	35.3	38.3	41.2	43.9	45.0	45.0
329	24.0	24.6	27.6	30.5	33.2	34.3	34.3

Receiver	Hub-height wind speed (m/s)						
	4	**5**	**6**	**7**	**8**	**9**	**≥10**
Receivers where participation status to be confirmed							
328	23.0	23.6	26.6	29.5	32.2	33.3	33.3
330	20.5	21.1	24.1	27.0	29.7	30.8	30.8
331	24.7	25.3	28.3	31.2	33.9	35.0	35.0
334	20.0	20.6	23.6	26.5	29.2	30.3	30.3
335	17.3	17.9	20.9	23.8	26.5	27.6	27.6
497	24.1	24.7	27.7	30.6	33.3	34.4	34.4

APPENDIX H CUMULATIVE ASSESSMENT

H1 Map of wind farms in the surrounding area



H2 Liverpool Range Wind Farm sound power level data

Figure 11: V112-3.0MW assessment sound power levels, dB L_{WA}

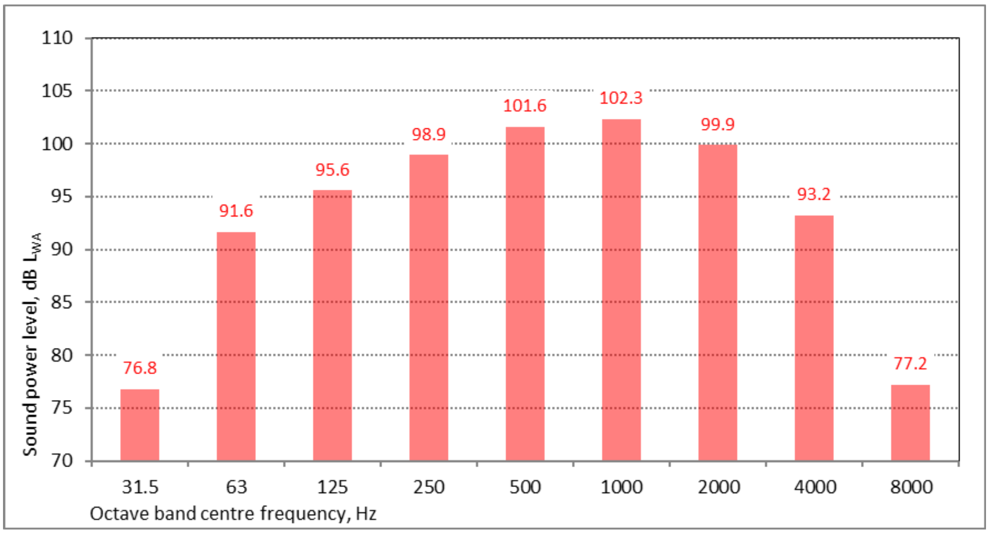
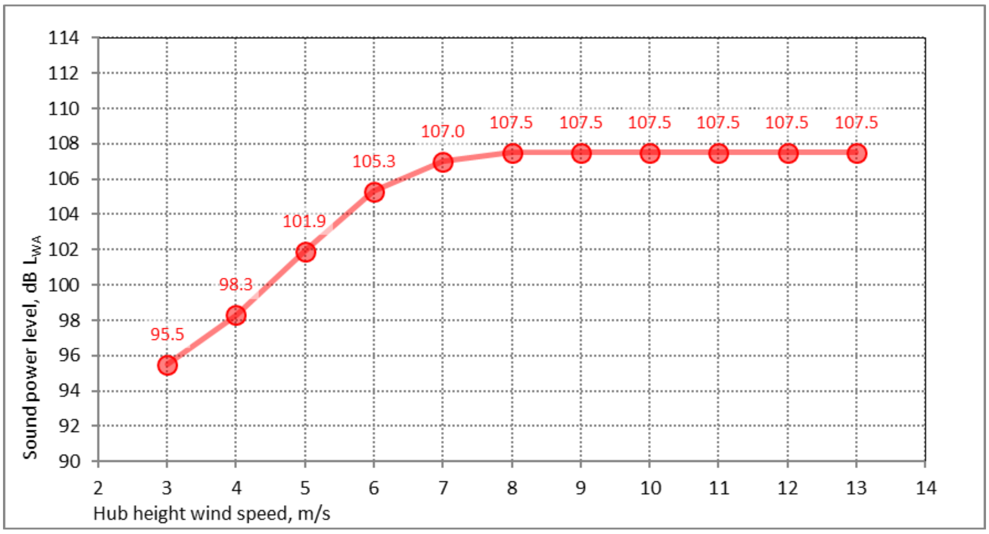


Figure 12: V112-3.0MW assessment sound power level spectrum, dB L_{WA}



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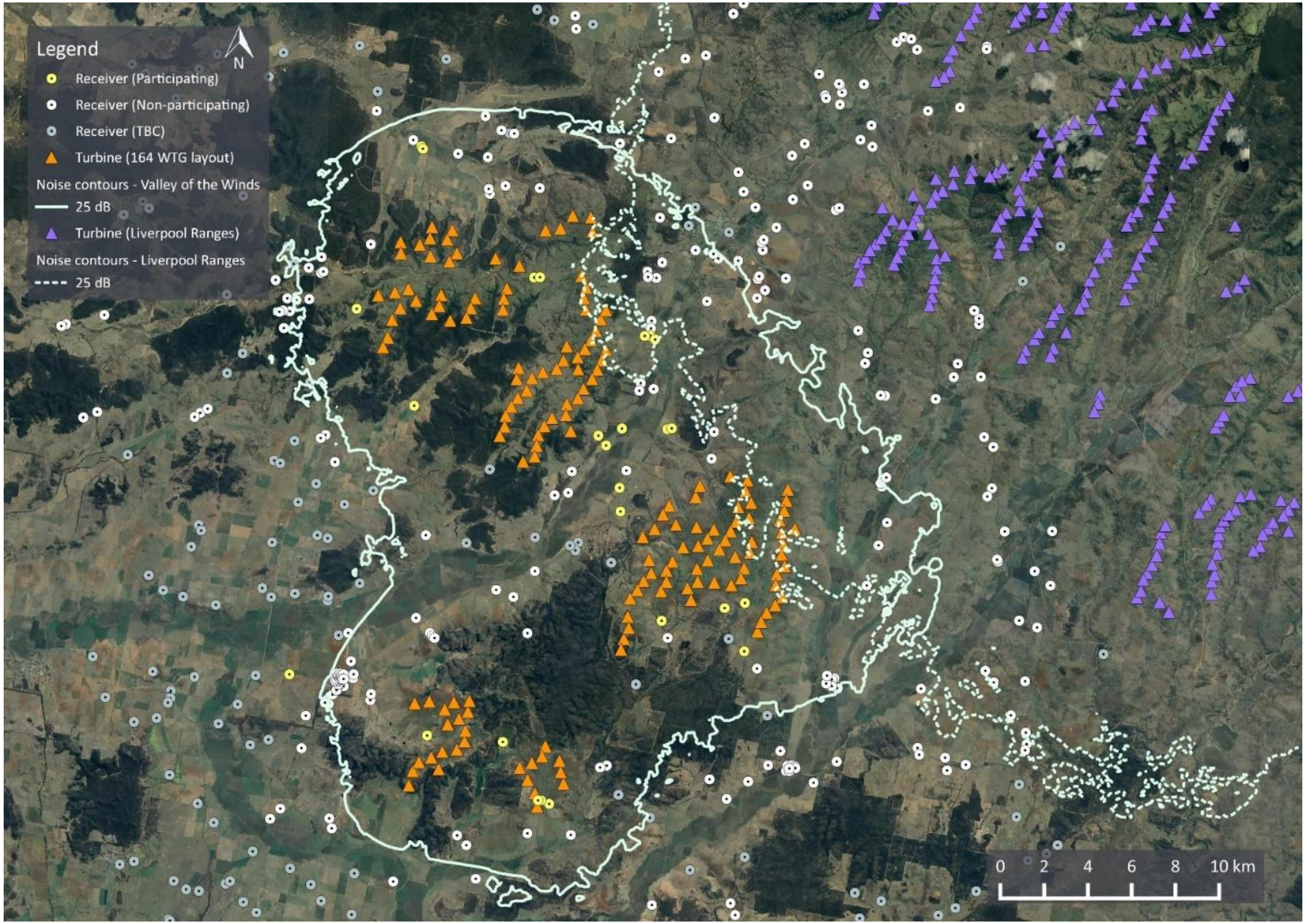
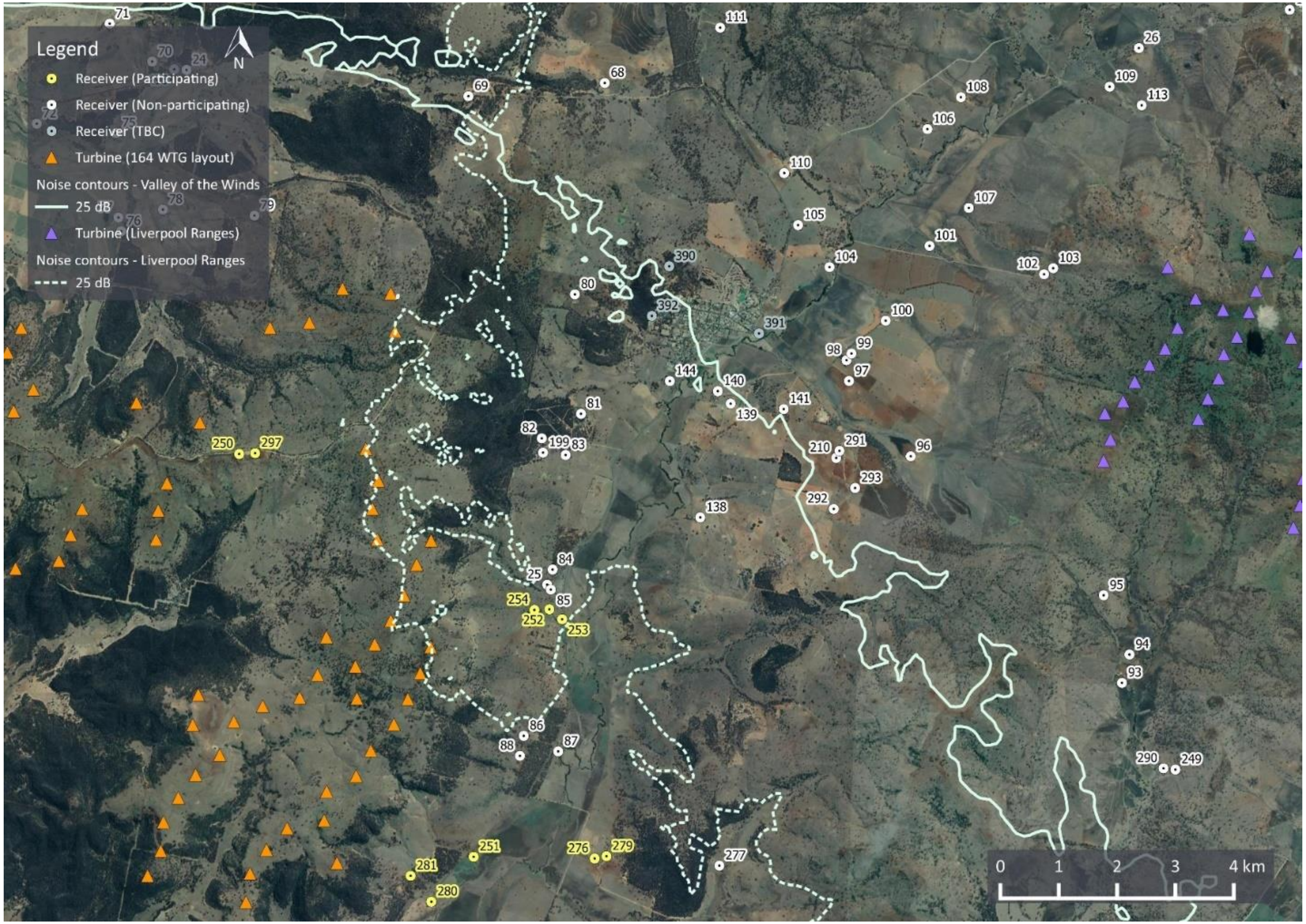
H3 Predicted 30 dB L_{Aeq} contours for the Liverpool Range Wind Farm and Valley of the Winds Overview



H4 Predicted 30 dB L_{Aeq} contours for the Liverpool Range Wind Farm and Valley of the Winds Mount Hope cluster



H5 Predicted 30 dB L_{Aeq} contours for the Liverpool Range Wind Farm and Valley of the Winds Black Stump cluster