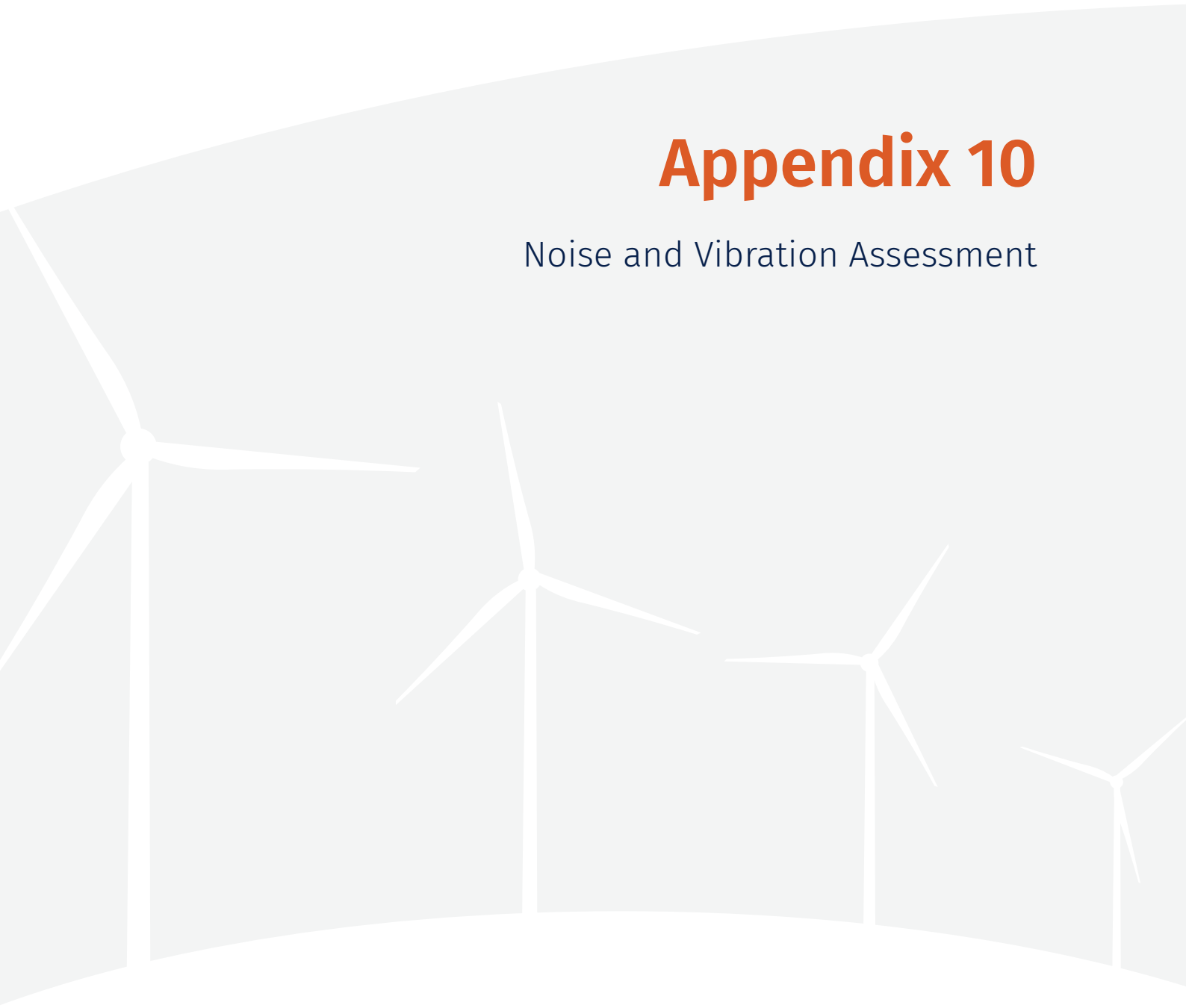
Appendix 10

Noise and Vibration Assessment



Thunderbolt Energy Hub – Stage 1

Noise and Vibration Assessment

February 2022

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CONTENTS

GLOSSARY

A-weighting	Frequency adjustment applied to measured noise levels to replicate the frequency response of the human ear.
AGL	Above Ground Level.
Ambient noise level	The noise level of all existing noise sources in the environment (in the absence of the wind farm).
Associated dwelling	Any dwelling where the landowner has reached a financial or in kind agreement in relation to the wind farm (except where the agreement excludes noise impacts).
Background noise level	The ambient noise level which excludes intermittent noise sources.
C-weighting	Frequency adjustment applied to measured noise levels to indicate low frequency content.
CONCAWE	The oil companies' international study group for conservation of clean air and water - Europe, *The propagation of noise from petrochemical complexes to neighbouring communities* (May 1981).
dB(A)	A-weighted noise in decibels.
dB(C)	C-weighted noise in decibels.
DEC 2006	New South Wales Department of Environment and Conservation *Assessing Vibration: a technical guideline* (2006).
Construction Noise Guideline	New South Wales Department of Environment and Climate Change *Interim Construction Noise Guideline* (2009).
NSW Road Noise Policy	Department of Environment, Climate Change and Water *NSW Road Noise Policy* (2011).
EPA	Environment Protection Authority.
Equivalent noise level	Energy averaged noise level over a period of time.
Intermittent noise sources	Noise caused by infrequently occurring events such as from aircraft, dogs barking, mobile farm machinery and the occasional vehicle movements.
$L_{A90, \text{time period}}$	A-weighted noise level exceeded for 90% of defined time period. Represents the background noise level for the defined time period.
$L_{Aeq, \text{time period}}$	A-weighted equivalent noise level over a defined time period.
RBL	The Rating Background Level is an overall, single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period
SA 2009	South Australian Environment Protection Authority *Wind Farms Environmental Noise Guidelines* (2009).
SEARs	Secretary's Environmental Assessment Requirements.
Sound power level	A measure of the sound energy emitted from a source of noise.
NPfI	New South Wales Environment Protection Authority *Noise Policy for Industry* (2017).
The Project	Thunderbolt Energy Hub – Stage 1
The Bulletin	New South Wales Planning and Environment *Wind Energy: Noise Assessment Bulletin* (2016).
Non-Associated dwelling	Not an Associated dwelling.
Weather category 6	The CONCAWE weather conditions which is most conducive for the propagation of noise, resulting in highest predicted noise levels.
WHO Guidelines	*World Health Organisation Guidelines for Community Noise.*
Worst-case	Operational and weather conditions which result in the highest noise level at a dwelling
WTG	Wind turbine generator.

1 INTRODUCTION

A noise and vibration assessment has been made of the construction and operation of the proposed Thunderbolt Energy Hub – Stage 1 (the **Project**). The Project Area is located approximately 47 km north-east of Tamworth and adjacent to the New England Highway.

The Project will include 32 wind turbine generators (WTGs) with a maximum tip height of approximately 260m and a capacity of approximately 192 megawatts (MW). The Project also includes the construction and operation of associated infrastructure including operation and maintenance buildings, roads, civil works and electrical infrastructure (including one new substation and switching station) required to connect to the existing electricity transmission network.

The NSW Department of Planning, Industry and Environment has provided *Secretary's Environmental Assessment Requirements* (SEARs) for the assessment of noise and vibration from the Project. The noise and vibration related sections of the SEARs are provided in Appendix A of this report and seek the following assessment framework:

- Wind turbine noise in accordance with the *NSW Wind Energy: Noise Assessment Bulletin* (EPA/DPE, 2016);
- Noise generated by ancillary infrastructure in accordance with the *NSW Noise Policy for Industry* (EPA, 2017);
- Construction noise under the *Interim Construction Noise Guideline* (DECC, 2009);
- Traffic noise under the *NSW Road Noise Policy* (DECCW, 2011); and,
- Vibration under the *Assessing Vibration: A Technical Guideline* (DECC, 2006);

This noise and vibration assessment addresses the SEARs.

A response to a peer review conducted on this assessment is provided in Appendix F.

2 PROJECT LAYOUT

An indication of layout of the wind turbines is shown below, with the full project layout, including ancillary equipment, shown in Appendix B.

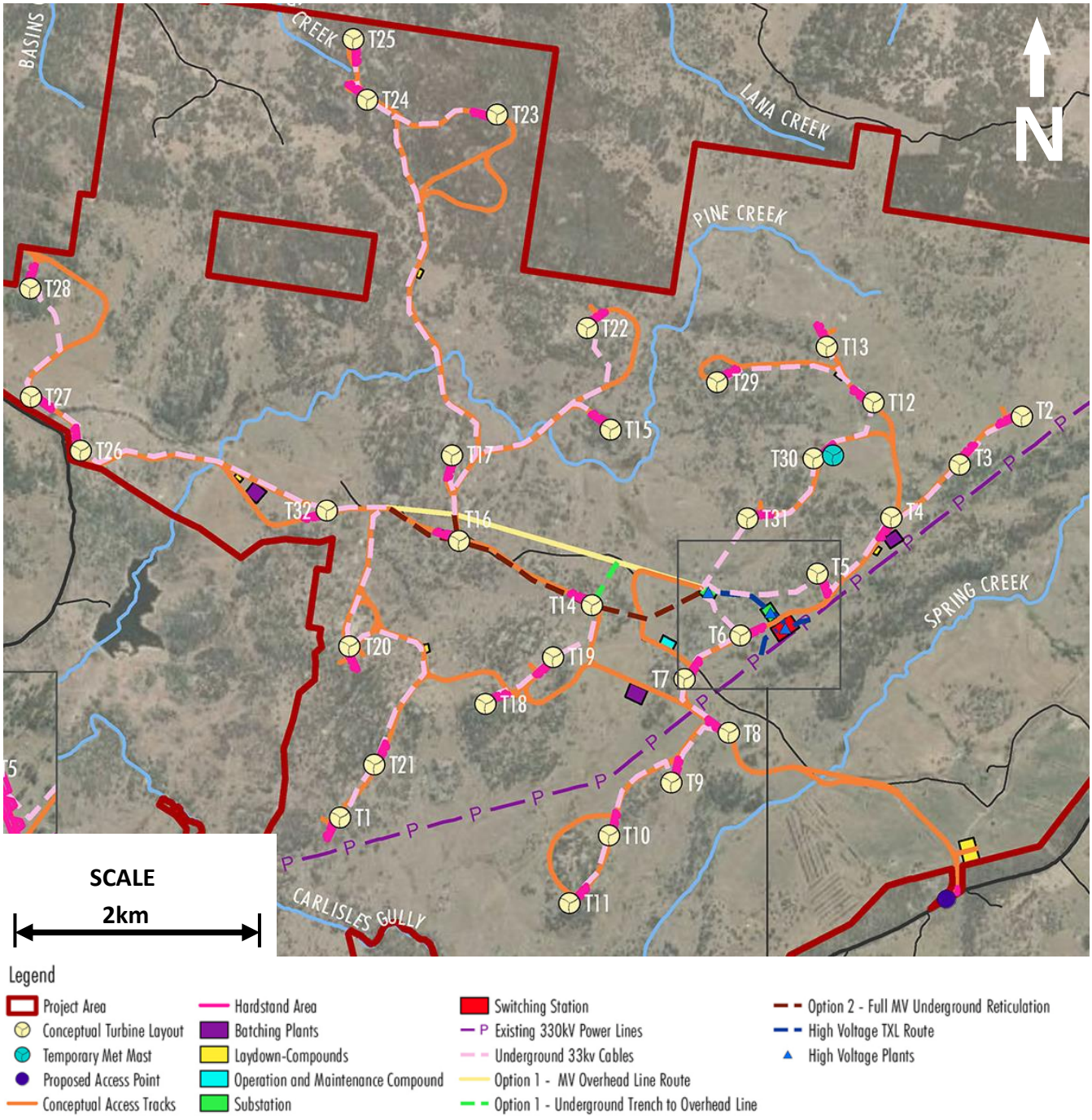


Figure 1: Layout of wind turbines

2.1 Wind Turbine Generators

The coordinates of the 32 WTG layout are provided in Table 1 and the locations of the ancillary infrastructure and batching are provided in Table 2.

Table 1: Coordinates of WTGs

WTG ID	WTG Coordinates (UTM WGS84 56J)	
	Easting	Northing
T1	335661	6594107
T2	341225	6597378
T3	340719	6596988
T4	340162	6596552
T5	339556	6596100
T6	338931	6595599
T7	338473	6595240
T8	338834	6594805
T9	338365	6594397
T10	337854	6593964
T11	337532	6593412
T12	340014	6597494
T13	339635	6597942
T14	337718	6595842
T15	337867	6597269
T16	336629	6596361
T17	336574	6597065
T18	336850	6595039
T19	337401	6595420
T20	335739	6595504
T21	335940	6594542
T22	337676	6598098
T23	336942	6599833
T24	335883	6599958
T25	335768	6600449
T26	333549	6597099
T27	333137	6597539
T28	333131	6598418
T29	338740	6597656
T30	339527	6597038
T31	338989	6596546
T32	335555	6596610

Table 2: Coordinates of Key Noise Generating Ancillary Infrastructure

Ancillary Infrastructure	Approximate Coordinates (UTM WGS84 56J)	
	Easting	Northing
Substation Option 1	338669	6595945
Substation Option 2	339179	6595779
Batching Plant	334980	6596750
Batching Plant	338090	6595060
Batching Plant	340180	6596380

2.2 Dwellings in the Vicinity of the Wind Farm

The non-associated dwellings located within 5km of the WTGs are listed in Table 3 and the associated dwellings are listed in Table 4. Tables 3 and 4 also provide the distance to the closest turbine and the representative background noise monitoring location (refer to the background noise monitoring section of this assessment for further detail).

Table 3: Non-Associated Dwelling Locations within 5km of the WTGs

Dwelling ID	Coordinates (UTM WGS84 56J)		Distance to Closest Turbine (m)	Closest Turbine	Representative Monitoring Location
	Easting	Northing			
3	345978	6596744	4795	T2	6
5	344710	6595921	3777	T2	6
6	344299	6595615	3543	T2	6
10	340629	6592135	3201	T9	29
12	339274	6590819	3124	T11	29
18	339149	6600709	2374	T23	219
19	339010	6590368	3384	T11	29
20	342417	6592461	4282	T8	29
26	341941	6593172	3510	T8	29
27	341318	6593565	2776	T8	29
28	341090	6593361	2679	T8	29
29	339724	6592770	2121	T9	29
41	342111	6594228	3033	T4	6
55	332742	6600385	2005	T28	270
219	341469	6599624	2259	T2	219
220	341858	6600032	2728	T2	219
221	338474	6602191	2812	T23	219
222	342872	6599122	2399	T2	219
223	343614	6600525	3951	T2	219
224	343624	6600743	4133	T2	219
225	343664	6601724	4984	T2	219
226	335911	6602846	2401	T25	270
227	332822	6603678	4371	T25	270
229	330378	6602290	4751	T28	270
260	333842	6591136	3483	T1	29
308	339242	6599999	2094	T13	219
309	339123	6600480	2275	T23	219

Table 4: Host and Associated Dwelling Locations

Dwelling ID	Coordinates (UTM WGS84 56J)		Distance to Closest Turbine	Closest Turbine	Representative Monitoring Location
	Easting	Northing			
4[2]	343635	6596914	2454	T2	6
17[2]	334195	6599732	1691	T28	270
230	330667	6590549	6132	T1	29
231	329376	6589088	8043	T1	29
270	334904	6598857	1473	T24	270
275	332282	6594903	2535	T26	270
277	332736	6595809	1525	T26	270
278[1]	333672	6591649	3162	T1	29
279	332359	6594847	2547	T26	270
282	329220	6588789	8352	T1	29
286	330187	6601650	4372	T28	270
298[2]	343989	6596780	2828	T2	6
299[2]	344220	6596330	3173	T2	6
300[1, 2]	340929	6594484	2119	T8	29
302[1, 2]	338378	6595428	211	T7	29
305	330163	6601956	4618	T28	270
306	332872	6594144	2789	T1	270
307	331563	6593389	4160	T1	270
310[1]	333797	6595810	1313	T26	270

Note 1: It is understood that the residence is unoccupied.
Note 2: Host Landholder residence

The locations of the dwellings in relation to the turbines, and the monitoring locations, are shown on noise prediction contours provided in Appendix E.

3 SEARS

The noise related SEARs for the Project refer to the following assessment framework:

- assess wind turbine noise in accordance with the *NSW Wind Energy: Noise Assessment Bulletin (EPA/DPE, 2016);*
- assess noise generated by ancillary infrastructure in accordance with the *NSW Noise Policy for Industry (EPA, 2017);*
- assess construction noise under the *Interim Construction Noise Guideline (DECC, 2009);*
- assess traffic noise under the *NSW Road Noise Policy (DECCW, 2011); and*
- assess vibration under the *Assessing Vibration: A Technical Guideline (DEC, 2006);*

Each of the above assessment elements is described in further detail below as relevant.

3.1 Wind Turbine Generators

The SEARs reference the New South Wales Planning and Environment *Wind Energy: Noise Assessment Bulletin* (**the Bulletin**) for the assessment of operational noise from the WTGs.

The Bulletin adopts the South Australian Environment Protection Authority *Wind Farms – Environmental Noise Guidelines* (**SA 2009**) as the basis of the regulatory noise standard and assessment methodology in NSW.

The SA Noise Guidelines were developed with the "*core objective……to balance the advantage of developing wind energy projects ... with protecting the amenity of the surrounding community from adverse noise impacts"*.

The Bulletin states that:

> [The] *NSW Government recognises that rural land use zones in NSW are often more densely settled than those of South Australia and that there is a relatively high density of rural residential living in parts of regional NSW with reliable wind resources.*
>
> *Therefore only the lower base noise criteria in [the SA Noise Guidelines] will be applied in NSW. This Criteria is defined as:*
>
> > *"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."*

Non-Associated Dwellings

Based on the Bulletin, noise from the wind farm at non-associated dwellings should not exceed an outdoor noise level of 35 dB(A) or the background noise ($L_{A90,\ 10\ minute}$) by more than 5 dB(A), whichever is the greater.

Associated Dwellings

Where a landowner has formed a commercial agreement with the developer, the Bulletin enables less onerous noise criteria to be used. The noise criteria at associated dwellings will be the subject of an agreement between Neoen and the landholder.

3.1.1 Special Noise Characteristics

The Bulletin prescribes a 5 dB(A) penalty adjustment (added to the measured or predicted noise level) for the presence of repeated and excessive tonality and/or low frequency which occurs for more than 10 percent of an assessment period. Excessive tonality and low frequency are determined as follows:

Tonality

The Bulletin references the methodology described in *ISO 1996.2: 2007 Acoustics - Description, measurement and assessment of environmental noise – Determination of environmental noise levels (Annex D – Objective method for assessing the audibility of tones in noise – Simplified method)*. Excessive tonality is present at a particular one-third octave band if the band level exceeds the adjacent bands on both sides by at least:

- 5 dB, if the centre frequency of the band is in the range 500 Hz to 10,000 Hz;
- 8 dB, if the centre frequency of the band is in the range 160 Hz to 400 Hz; and/or
- 15 dB, if the centre frequency of the band is in the range 25 Hz to 125 Hz.

The penalty for tonality only applies if the tone from the wind farm is audible at the receiver location and is determined to be excessive using the above one-third octave band assessment method. The absence of a tone at a location in the vicinity of a WTG (where noise from the WTG is dominant in comparison to the ambient environment) will be sufficient to demonstrate that the wind farm noise at the relevant receiver location is non-tonal.

In addition, the Bulletin notes that noise assessments for wind energy projects shall also report the results of tonality assessments under IEC61400-11 for the particular turbine being considered. IEC61400-11 describes a method to measure tonality in close proximity to the WTG. Where tonality is found using this method, it indicates there is potential for there to be tonality at a residence and that further consideration should be

given using ISO 1996.2. If there is no tonality detected in close proximity to the turbine, there will not be tonality at residences.

Low Frequency Noise

The A-weighted noise level includes a frequency adjustment to represent the response of human hearing and is therefore used to provide an objective assessment of the level of noise from the operation of the WTGs. The C-weighted noise level includes a frequency adjustment, which emphasises the low frequency content.

To determine if excessive low frequency noise is present, the Bulletin requires that the C-weighted noise level be assessed at non-associated residential receiver locations. Excessive low frequency noise is not present if the low frequency noise level at non-associated dwellings does not exceed 60 dB(C).

3.2 Ancillary Noise Generating Infrastructure

The SEARs reference the New South Wales Environment Protection Authority's *Noise Policy for Industry* (**the NPfI**) for the assessment of noise from ancillary infrastructure such as substations and switching stations. It is understood that the transformers at the substation will generate noise, but other infrastructure such as the switching gear at the switching station will not generate appreciable levels of noise.

The NPfI establishes noise trigger levels based on the existing background noise environment (intrusiveness) and the amenity for particular land uses (amenity). The noise trigger levels are the lower values provided by the two methods, which in a rural environment will generally be the intrusiveness noise levels.

In accordance with the NPfI, the Rating Background Level (**RBL**) is used to determine the *intrusiveness noise levels* for each of the day, evening and night periods. The RBL is determined from the lower tenth percentile of the measured background noise level ($L_{A90,\ 15\ minute}$) in the environment, effectively representing the quietest periods of the noise monitoring. The NPfI also provides minimum RBL levels for quiet environments.

Further detail is provided regarding the existing background noise environment and resulting criteria in the Ancillary Infrastructure Section of this report.

3.3 Construction

The SEARs reference the New South Wales Department of Environment & Climate Change *Interim Construction Noise Guideline* (**Construction Noise Guideline**) for the assessment of construction noise.

The construction of a wind farm comprises activities such as road construction, civil works, excavation, foundation construction, electrical infrastructure works and turbine erection. These construction activities require processes such as heavy vehicle movements, crushing and screening, concrete batching, use of mobile plant and equipment (such as loaders, excavators, generators, cranes) and potentially blasting of rock.

The Construction Noise Guideline provides an emphasis on implementing "feasible" and "reasonable" noise reduction measures and does not establish mandatory objective criteria. However, the Construction Noise Guideline does establish different "management levels" based on the existing RBL.

For the assessment of blasting impacts, the Construction Noise Guideline makes reference to the Australian and New Zealand Environment Conservation Council's (ANZECC) guidelines titled *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* (**the ANZECC Guidelines**).

The ANZECC Guidelines provide objective limits for the assessment of ground vibration and overpressure as a result of blasting activities.

3.4 Traffic

The SEARs reference the New South Wales Department of Environment, Climate Change and Water *NSW Road Noise Policy* (**NSW Road Noise Policy**) for the assessment of traffic noise.

Whilst there is no specific category for a wind farm and its construction activities, the most appropriate classification for traffic associated with the wind farm within the NSW Road Noise Policy is considered to be provided by "*Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments".*

The traffic associated with the wind farm will predominantly occur during construction. However, it should be noted that the NSW Road Noise Policy criterion/classification applies to an ongoing operation, as distinct to a temporary process and as such provides a conservative criterion for comparison with the predicted noise levels during construction. When taking this factor into account, the criterion can therefore be exceeded

without unreasonable impacts to non-associated landowners, provided suitable noise reduction measures and work practices are implemented.

3.5 Vibration

The SEARs reference the New South Wales Department of Environment and Conservation's *Assessing Vibration: a technical guideline* (**DEC 2006**) for the assessment of vibration.

DEC 2006 provides an emphasis on construction activity implementing feasible and practicable vibration reduction measures and establishes goal vibration levels for continuous, intermittent and impulsive vibration based on human response.

For construction activity occurring during the daytime, the DEC 2006 can be interpreted to provide goal vibration levels criteria at the dwellings based on the British Standard *BS 6472-1992 "Evaluation of human exposure to vibration in buildings (1-80Hz)".*

Vibration associated with blasting during construction of the wind farm is governed by the requirements of the ANZECC Guidelines, as noted above in the construction section.

4 WIND TURBINE OPERATION

4.1 Background Noise Monitoring

Background noise monitoring has been conducted at four dwellings in the vicinity of the Project Area between 6 May 2021 and 1 August 2021. The monitoring was conducted in accordance with SA 2009. The Monitoring locations are show in Appendix E.

The four monitoring locations, as summarised in Table 5, were selected based on preliminary noise predictions of the initial wind farm layout. Preference was given to dwellings (without agreements) with the highest predicted noise levels in each direction of the wind farm, subject to permission being granted by the landowner to place equipment.

Table 5: Monitoring locations and periods.

Dwelling ID	Coordinates (UTM WGS84 56J)		Monitoring Period	Model and Type	Serial Number	Calibration Due
	Easting	Northing				
6	344299	6595615	18/06/21-01/08/21	Rion NL-21, Type 2	01298931	8/10/2021
29	339724	6592770	18/06/21-01/08/21	Rion NL-21, Type 2	00709523	9/10/2021
219	341469	6599624	18/06/21-01/08/21	Rion NL-21, Type 2	00354109	28/5/2022
270	334904	6598857	06/05/21-15/06/21	Rion NL-21, Type 2	01298933	5/7/2021

The background noise was measured with *Rion NL-21, Type 2* sound level meters, with a noise floor of less than 20 dB(A), calibrated at the beginning and end of the measurement period with a *Rion NC74* calibrator with negligible drift observed. All microphones were positioned approximately 1500mm above ground level and fitted with windshields with a diameter of greater than 150mm. Each noise logger was placed in accordance with SA 2009 to provide an indication of the noise at the residence on the wind farm side of the dwellings.

The locations were chosen to best represent the background noise at the facade of dwellings. This was achieved by placing loggers away from mechanical noise sources, such as air conditioning units, as generally these do not operate continuously and only influence a small portion of the dwelling facade. Careful consideration was given to the influence of any tall trees in the vicinity of the dwelling. Tall trees are the most significant source of background noise during high wind speeds and therefore their influence needs to be properly included in the background noise monitoring. In order to accurately quantify the contribution of the trees, loggers were placed at an approximate equivalent distance from the facade of the dwelling as any significant trees. For example, if a tall tree was 30m from the facade of a dwelling, the logger was placed approximately 30m from the tree.

The background noise level was measured in 10-minute intervals at each of the monitoring locations. Photographs of the noise monitoring equipment are provided in Appendix C.

During the background noise monitoring regime, wind speed was measured on the wind farm site. The wind speed was measured in 10-minute intervals at 49.9m, 70m, and 79.1m. Neoen has "sheared" the data to a reference height of 170m, being equivalent to the proposed WTG hub height, using the following process:

- Data was checked and invalid data points removed, including wind speed readings when sheltered by the mast;
- The wind shear was calculated for each timestep based on the different wind speeds at each height;
- The wind speed was extrapolated to 170m using the measured shear rate for each timestep. This method assumes that the shear profile is consistent (the shear between the mast measurement heights is the same as the shear above the mast)

Table 6 provides the meteorological mast coordinates.

Table 6: Meteorological mast coordinates.

Coordinates UTM WGS84 56J	Easting	Northing
	385152	6580287

Local weather loggers were also deployed, which measured rainfall and wind speed at approximately 1.5m above ground level. The rainfall and wind speed data were collected to determine the periods when weather directly on the microphone may have influenced the measured background noise levels in the vicinity. Local weather loggers were installed at locations with Dwelling ID 6 and 29.

The noise data corresponding to any periods of measured rainfall and/or measured wind speed exceeding 5 m/s at the microphone height for more than 90% of the measurement period were discarded. These periods correspond to times when rain on the wind shield or the excessive wind on the microphone may have artificially increased the monitored noise level.

SA 2009 states "data should be collected at wind speeds between the cut-in speed and the speed of rated power". Data corresponding to periods with an average wind speed below the cut-in wind speed (i.e. 3m/s) and above the rated power wind speed (approximately 12m/s) were therefore also discarded. The approach is consistent with that used to determine compliance of a wind farm and therefore is the best comparison of the

noise levels before and after a wind farm is constructed. Table 7 summarises the number of data points at each monitoring location before and after the removal of data points.

Table 7: Data points.

Dwelling ID	Number of Data Points	
	Before Removal	After Removal
6	6357	4299
29	6329	4303
219	6330	4295
270	5754	4222

Following data removal, the background noise data were correlated with the WTG hub height wind speed data measured at the metrological mast. A least squares regression analysis of the data was undertaken to determine the line of best fit for the correlations in accordance with SA 2009. The data and the regression curves are shown in Appendix D. Based on the regression analysis, the background noise levels (L_{A90}) at a range of wind speeds within the operating range of the WTGs are provided in Table 8. The measured background noise levels are a combination of sources in the environment, such as insects, birds and wind in vegetation (particularly tall trees). Higher noise levels at higher wind speeds indicates that wind in vegetation is a dominant noise source. Noise levels above 30 dB(A) at lower wind speeds indicate that there is a significant contribution from sources such as insects and birds. The levels measured are typical of a rural environment which is influenced by these environmental noise sources.

Table 8: Background noise levels (dB(A))

Dwelling ID	Background Noise Levels for Integer Hub Height Wind Speed (dB(A))									
	3m/s	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	11m/s	12m/s
6	32	31	31	31	32	33	34	35	35	35
29	33	32	32	32	33	33	34	34	35	34
219	23	24	24	25	26	28	29	30	32	33
270	21	22	22	23	23	24	24	25	26	28

The correlation coefficient of each regression curve in Appendix D indicates the relationship between the background noise at the dwelling and the wind speed at the wind farm site. A low correlation coefficient indicates a limited relationship, as will naturally occur in many circumstances including locations that are shielded from the wind across the wind farm site, rather than indicating any deficiency in the data analysis.

It is noted that high noise levels have been measured across the entire wind speed range at some locations. This indicates that background noise levels in the vicinity of the dwellings are not entirely controlled by the wind speed.

4.2 Criteria

Non-Associated Dwellings

The operational noise criteria for non-associated dwellings have been determined from the results at each relevant noise monitoring location as provided in Table 9. The closest non-associated dwelling to the monitoring location has been assigned the relevant criteria from Table 8 (refer to Tables 3 and 4 for further details):

Table 9: Project Noise Criteria – WTG Noise

Dwelling ID	Noise Criteria for Integer Hub Height Wind Speed (dB(A))									
	3m/s	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	11m/s	12m/s
6	37	36	36	36	37	38	39	40	40	40
29	38	37	37	37	38	38	39	39	40	39
219	35	35	35	35	35	35	35	35	37	38
270	35	35	35	35	35	35	35	35	35	35

4.3 Assessment

Noise Sources

The assessment of WTG noise has been made based on the following:

- A representative contemporary WTG selection comprising a *Vestas 6.0MW V162* with serrated blade edges and a WTG hub height of 170m*;* and,
- Sound Power Levels as provided in Table 10 for the "Normal" operating mode

The Bulletin requires that the WTG noise level be adjusted where excessive levels of tonality and/or low frequency noise is identified to a maximum adjustment of 5 dB(A).

A tonality assessment under IEC61400-11 is not available for the *Vestas 6.0MW V162.* However, analysis of the available 1/3 octave band Sound Power Level data indicates that the turbines do not have tonal characteristics in accordance with the method of Annex D of *ISO 1996.2: 2007.* Therefore, this assessment does not apply an adjustment for tonality.

The application of a penalty for the noise character of low frequency is discussed further in the following sections.

Table 10: Vestas V162 6MW Sound Power Levels: Normal Operating Mode

One-third Octave Band Centre Frequency	Sound Power Levels for Integer Hub Height Wind Speed (dB(A))									
	3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
6.3 Hz	20.4	22.0	21.6	22.9	26.1	29.2	31.5	32.0	32.5	32.5
8 Hz	26.9	28.5	28.2	29.6	32.8	35.8	38.1	38.6	39.0	38.9
10 Hz	32.7	34.2	34.1	35.5	38.6	41.7	43.9	44.4	44.8	44.6
12.5 Hz	38.2	39.7	39.6	41.1	44.2	47.2	49.5	49.9	50.2	50.0
16 Hz	43.9	45.3	45.3	46.9	50.0	52.9	55.2	55.6	55.8	55.6
20 Hz	48.8	50.1	50.2	51.8	54.9	57.8	60.0	60.4	60.6	60.4
25 Hz	53.3	54.6	54.7	56.4	59.4	62.4	64.6	64.9	65.1	64.8
31.5 Hz	57.6	58.9	59.1	60.8	63.8	66.7	68.9	69.2	69.4	69.1
40 Hz	61.8	63.0	63.3	65.0	68.0	70.9	73.1	73.3	73.4	73.2
50 Hz	65.4	66.5	66.8	68.5	71.6	74.4	76.6	76.9	76.9	76.7
63 Hz	68.8	69.8	70.1	71.9	74.9	77.8	79.9	80.2	80.2	80.0
80 Hz	71.9	72.9	73.2	75.0	78.0	80.9	83.0	83.2	83.2	83.0
100 Hz	74.5	75.4	75.8	77.6	80.6	83.4	85.6	85.8	85.8	85.5
125 Hz	76.8	77.6	78.0	79.9	82.9	85.7	87.8	88.0	88.0	87.8
160 Hz	79.0	79.7	80.1	82.0	85.0	87.8	89.9	90.1	90.1	89.9
200 Hz	80.7	81.3	81.7	83.6	86.6	89.4	91.5	91.7	91.6	91.4
250 Hz	82.0	82.6	82.9	84.8	87.8	90.6	92.7	92.9	92.8	92.7
315 Hz	83.1	83.6	83.9	85.8	88.8	91.6	93.7	93.9	93.8	93.7
400 Hz	83.8	84.2	84.5	86.4	89.4	92.2	94.3	94.5	94.4	94.3
500 Hz	84.2	84.5	84.8	86.7	89.7	92.5	94.6	94.7	94.7	94.7
630 Hz	84.3	84.5	84.7	86.6	89.6	92.4	94.5	94.7	94.7	94.7
800 Hz	84.0	84.1	84.3	86.2	89.2	92.0	94.1	94.3	94.3	94.3
1 kHz	83.5	83.4	83.5	85.4	88.4	91.2	93.3	93.5	93.6	93.7
1.25 kHz	82.6	82.4	82.5	84.4	87.4	90.2	92.3	92.5	92.6	92.7
1.6 kHz	81.2	81.0	80.9	82.8	85.8	88.6	90.8	91.0	91.1	91.3
2 kHz	79.7	79.3	79.2	81.1	84.1	86.9	89.0	89.3	89.4	89.7
2.5 kHz	77.9	77.4	77.1	79.0	82.0	84.9	87.0	87.2	87.4	87.8
3.15 kHz	75.7	75.0	74.7	76.5	79.6	82.4	84.6	84.8	85.0	85.5
4 kHz	73.0	72.2	71.8	73.6	76.6	79.5	81.7	82.0	82.2	82.7
5 kHz	70.2	69.3	68.7	70.5	73.6	76.5	78.7	79.0	79.3	79.9
6.3 kHz	67.0	65.9	65.2	67.0	70.1	73.0	75.2	75.5	75.9	76.6
8 kHz	63.3	62.1	61.3	63.0	66.1	69.1	71.3	71.6	72.1	72.8
10 kHz	59.6	58.2	57.2	58.9	62.1	65.0	67.3	67.6	68.2	69.0
Total	**93.9**	**94.1**	**94.3**	**96.2**	**99.2**	**102.0**	**104.1**	**104.3**	**104.3**	**104.3**

Noise Propagation Model

The predictions of environmental noise from the Project have been based on the CONCAWE noise propagation model and SoundPLAN noise modelling software. The CONCAWE noise propagation model is accepted by SA 2009 and is considered to accurately predict the noise from WTG operation. The sound propagation model considers the following influences:

- sound power levels of each individual noise source;
- the locations of noise sources;
- separation distances between noise sources and dwellings;
- local topography;
- influence of the ground;
- air absorption; and,
- meteorological conditions.

The CONCAWE model divides meteorological conditions into six separate "weather categories", depending on wind speed, wind direction, time of day and level of cloud cover. Weather Category 1 provides the weather conditions associated with the "lowest" propagation of noise, whilst Weather Category 6 provides "worst-case" (i.e. highest noise level) conditions. Weather Category 4 provides "neutral" weather conditions for noise propagation (that is, conditions which do not account for the effects of temperature inversion or wind on propagation).

The assessment has been based on the following input conditions that result in conservative noise predictions:

- weather category 6 (representing a temperature inversion and wind conditions that assist with the propagation of noise);
- atmospheric conditions at 10°C and 80% relative humidity (representing conditions that result in low levels of sound absorption from the atmosphere);
- wind direction from all noise sources to the particular dwelling under consideration, even in circumstances where sources are located in opposite directions from the dwelling (representing the absolute worst-case noise propagation from the wind). This will overestimate the predicted noise level where dwellings have WTGs located around them in more than a singular direction;
- acoustically soft ground (representing the pastoral nature of the land); and,
- maximum barrier attenuation from topography of 2 dB(A) (representing a conservative assessment of any shielding provided by topography).

Noise Predictions

The noise level from operation of WTGs has been predicted for all integer wind speeds from cut in to rated power. The following table is restricted to dwellings where the predicted noise level is greater than 30 dB(A).

Table 11: Wind Farm Noise Predictions at Dwellings.

Dwelling ID	Predicted Noise Level at Hub Height integer wind speeds (dB(A))																			
	3 m/s		4 m/s		5 m/s		6 m/s		7 m/s		8 m/s		9 m/s		10 m/s		11 m/s		12 m/s	
	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction
Associated Dwellings																				
17		24		25		25		27		30		33		35		35		35		35
270		26		26		26		28		31		34		36		36		36		36
277		23		23		24		26		29		31		34		34		34		34
300 - Vacant		24		25		25		27		30		33		35		35		35		35
302 - Vacant		38		39		39		41		44		47		49		49		49		49
310 - Vacant		25		26		26		28		31		34		36		36		36		36
Non-Associated Dwellings																				
18	35	20	35	20	35	21	35	23	35	26	35	28	35	30	35	31	37	31	38	31
27	38	20	37	20	37	21	37	23	38	26	38	28	39	31	39	31	40	31	39	31
28	38	20	37	21	37	21	37	23	38	26	38	29	39	31	39	31	40	31	39	31
29	38	23	37	23	37	23	37	25	38	28	38	31	39	33	39	33	40	33	39	33
55	35	19	35	20	35	20	35	22	35	25	35	28	35	30	35	30	35	30	35	30
219	35	21	35	21	35	22	35	23	35	26	35	29	35	31	35	32	37	32	38	31
308	35	23	35	23	35	23	35	25	35	28	35	31	35	33	35	33	37	33	38	33
309	35	21	35	22	35	22	35	24	35	27	35	30	35	32	35	32	37	32	38	32

The highest predicted low frequency noise level at non-associated dwellings is less than 50 dB(C) (at residence 29), which is less than the 60 dB(C) criterion. Therefore, a penalty for excessive low frequency noise is not applicable and no adjustment has been made to the predictions provided above.

Based on the predictions above, without any noise mitigation measures, the noise from the 32 WTGs will achieve the baseline operational noise criterion of 35 dB(A) at all non-associated dwellings in the vicinity of the wind farm.

The noise assessment has been made based on a representative WTG and the selection may change during the detailed design of the Project. A pre-construction noise assessment will therefore be undertaken to demonstrate how the final turbine selection will achieve the relevant criteria. The pre-construction assessment will include the final micro-sited layout, guaranteed sound power levels, consideration of tonality and low frequency noise and final agreements with landowners.

Predictions will be compared against the criteria to demonstrate that compliance will be achieved at all locations for the final WTG selection and layout. In addition, operational noise monitoring will be carried out following commissioning of the Project to verify compliance with the noise criteria.

The predicted noise level contours for the hub height wind speed of 10m/s are provided in Appendix E. The wind speed corresponds to the lowest wind speed at which the maximum noise is emitted and therefore represents the smallest difference between the predictions and criteria. Appendix E also shows:

- the locations of *non-associated* and *associated residences*;
- the noise monitoring locations; and,
- the WTG locations.

5 ANCILLARY INFRASTRUCTURE - SUBSTATIONS

5.1 Criteria

The Policy establishes noise trigger levels based on the existing background noise environment (intrusiveness noise levels) and the amenity for particular land uses (amenity noise levels). The noise trigger levels are the lower values provided by the two methods.

The amenity level for a noise source which operates during the night in a rural area is 40 dB(A).

The intrusiveness noise level is determined from the background noise environment. Based on the measured background noise levels, the effective RBLs were calculated to be less than 30 dB(A) at some of the monitoring locations, resulting in an intrusiveness level ($L_{Aeq,\ 15\ minute}$) of 35 dB(A) during the night at those locations.

Based on the above, the Policy noise trigger level ($L_{Aeq,\ 15\ minute}$) has conservatively been assumed to be 35 dB(A) for ancillary infrastructure at all locations.

If noise assessed under the NPfI is found to have a character that has the potential to be annoying, such as tonality, modulation or dominant low-frequency content, a modifying correction factor is to be applied to the predicted noise levels at the dwelling before comparison with the project *noise trigger levels*.

5.2 Assessment

Noise Sources

The Project will comprise of a substation in one of the two locations detailed in Section 2.

The proposed substation will include a transformer and therefore the noise from the transformer has been assessed against the objective noise criteria. No assessment has been made of the noise from the other infrastructure, as it is understood that it will not generate any appreciable levels of noise.

The predictions have been made based on a high-voltage transformer with an overall capacity of 270MVA. The total sound power level for the prediction has been derived from the Australian/New Zealand Standard AS/NZS60076.10:2009, *Power transformers - Determination of sound levels (IEC 60076-10, Ed. 1(2001) MOD)* and octave band data for a transformer. The sound power level is summarised in Table 12.

Table 12: 270MVA substation transformer sound power levels.

Octave Band Centre Frequency (Hz)	Sound Power Level (dB(A) re 1 ρW)
63 Hz	79
125 Hz	87
250 Hz	95
500 Hz	97
1,000 Hz	89
2,000 Hz	87
4,000 Hz	79
Overall	**100**

Noise Predictions

A noise level of less than 15 dB(A) is predicted for the closest non-associated dwellings (residences 27, 28 and 29) to each of the Substation options under worst case weather conditions, therefore easily achieving the criteria.

Transformers will often have audible tonality in close proximity, although the potential for it to be a dominant characteristic is diminished at the separation distances to the dwellings. Given the low predicted noise levels, it is unlikely that a penalty would apply to the noise level, however if a 5 dB(A) adjustment were to be conservatively applied, the 35 dB(A) criterion would still easily be achieved.

It is noted that the noise from the substation is significantly less than that of the wind turbines. Therefore, there would be no increase in the wind turbine noise level by cumulatively adding the ancillary infrastructure.

The assessment of noise from the substation will be updated should the size of the transformer(s) or sound power level change from that assumed in this report prior to construction.

Any updates to the predictions should ensure that the highest equivalent noise level, at a non-associated dwelling, from operation of the substation transformer will comply with the relevant criteria under conditions most conducive to noise propagation (such as temperature inversions).

6 CONSTRUCTION NOISE

6.1 Criteria

The Construction Noise Guideline provides an emphasis on implementing "feasible" and "reasonable" noise reduction measures and does not set mandatory objective criteria. The Construction Noise Guideline establishes "management levels" based on the existing RBL. As noted in Section 5.1 the minimum RBL is 30 dB(A) for the evening and night and 35 dB(A) for the day.

Normal Construction

For normal construction activity, the framework to address construction activity is provided in Table 13:

Table 13: Construction Noise Guideline Requirements.

Time of Day	**Management level** $L_{Aeq\ (15\ min)}$	**How to apply**
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected **RBL + 10 dB = 45dB(A)**	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected **75 dB(A)**	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near dwellings 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected **RBL + 5 dB = 35dB(A)**	A strong justification would typically be required for works outside the recommended standard hours if such works could be expected to be above the Management Level. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

Blasting

The Standard hours for blasting are Monday to Friday from 9am to 5 pm, and Saturday from 9am to 1pm. No blasting on Sundays or public holidays.

Overpressure and vibration from blasting are to be assessed against the levels in the Australian and New Zealand Environment Conservation Council's (ANZECC) guidelines titled *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* (**the ANZECC Guidelines**).

Air-blast Overpressure

To minimise the annoyance and discomfort from air-blast overpressure to persons at sensitive receptors, the ANZECC Guidelines state:

- the recommended maximum level for air-blast overpressure is 115 dB (Lin, Peak);
- the level of 115 dB may be exceeded on up to 5% of the total number of blasts over a period of 12 months. However, the level should not exceed 120 dB (Lin, Peak) at any time.

6.2 Assessment

General Construction Activities

The equipment and activities on site will vary throughout the construction of the Project, depending on various stages of construction, required processes and specific equipment used. The predicted noise from construction activity is presented as a typical worst case (highest noise level) scenario for the various stages of construction.

The predictions are based on weather conditions that are the most conducive for the propagation of noise, being CONCAWE Category 6 conditions. These conditions represent the worst case scenario when receivers are downwind of noise sources and there is light to no cloud in the morning or evening. Other weather conditions would result in lower noise levels than those predicted for these conditions.

All non-associated dwellings are separated by 2000m or more from the closest proposed WTG location (with residence 55 closest to the WTG locations), and 2700m or more from the closest proposed temporary concrete batching plants (with 29 closest to the batching plant location).

Predictions during Standard Hours

Table 14 and Table 15 provide summaries of predicted noise levels for each phase of construction. For each

phase, the following information is provided:

- The assumed major plant and equipment operating concurrently and cumulatively;
- The separation distance required to achieve the "noise affected" management level of 45 dB(A);
- Predicted noise levels and the separation distances for the closest residence.

Table 14: Predicted WTG construction noise levels

Phase	Main Plant and Equipment	Separation to Achieve 45 dB(A)	Residence	Approximate Distance to Activity	Predicted Noise Level (dB(A))
Site Set-Up and Civil Works	Generator Transport truck Excavator Low loader	1100m	55	2000m	37
Hard Stand Construction	Mobile crushing and screening plant Dozer Roller Low loader Tipper truck Excavator Scraper Transport truck	1800m	55	2000m	43
Excavation and foundation construction	Excavator Front end loader Mobile crushing and screening plant Truck-mounted concrete pump Concrete mixer truck Mobile crane Transport truck Tipper truck	1700m	55	2000m	42
Electrical Installation	Rock trencher Concrete mixer truck Low loader Tipper truck Mobile crane	1800m	55	2000m	43
Turbine Delivery and Erection	Extendable trailer truck Low loader Mobile crane Support crane Grinder Rattle Gun	1100m	55	2000m	37

Table 14 shows that the noise from construction at the WTG sites will achieve the "noise affected" management level at all locations.

Table 15: Predicted road and track construction noise levels

Phase	Main Plant and Equipment	Separation to Achieve 45 dB(A)	Residence	Approximate Distance to Activity	Predicted Noise Level (dB(A))
Road upgrades, and Track Construction	Mobile crushing and screening plant Dozer Roller Tipper truck Excavator Scraper Transport truck	1800m	28	400m	58
			27	600m	54
			29	1100m	52
			41	1300m	49
			26	1300m	49
			10	1300m	49

Table 15 shows that the noise from road and track construction will achieve the "noise affected" management level at all locations, with the exception of some activities at six non associated residences, when activity is occurring within 1800m of these residences.

Predictions Outside of Standard Hours

In addition to construction activities during standard hours, some activities may need to be undertaken outside of these "standard hours". These activities may include the operation of a batching plant, concrete pouring and turbine erection at WTG sites early in the morning (prior to 7am). The predicted noise level for these activities is provided in Table 16. The required separation distance in order to achieve the *noise affected level* of 35 dB(A) for activity outside of standard hours is also provided.

Table 16: Predicted construction noise levels

Phase	Main Plant and Equipment	Separation to Achieve 35 dB(A)	Residence	Approximate Distance to Activity	Predicted Noise Level (dB(A))
Batching	Front end loader Truck	2400m	29	2700m	33
Concrete Pour	Generator Truck Concrete pump	1900m	55	2000m	34
Turbine Erection	Crain Lights Pressure Washer Impact Drivers Bolt Tensioner	1500	55	2000m	25

Summary

In accordance with the Construction Noise Guideline, if the noise is "particularly annoying" to nearby residents, a modifying correction factor is to be applied to the measured level. The noise associated with construction activity can exhibit annoying characteristics on occasion and therefore a 5 dB(A) correction (increase to the predicted level) has been applied to the above noise predictions.

It is noted that separation distances greater than the distances presented in the above tables will result in lower noise levels. Based on the predicted noise levels, it is expected that construction:

- during standard hours will potentially be at noise levels of greater than 45 dB(A) for some activities at six non-associated residences (being locations with Dwelling ID 10, 26, 27, 28, 29 and 41) when activity is occurring in the vicinity of these residences. However, the predicted noise levels are significantly less than 75 dB(A) (the point where there may be strong community reaction to noise).
- outside of standard hours will satisfy the 35 dB(A) criterion for the activities shown. Any other construction proposed outside of standard hours should be assessed once scheduling is known.

Blasting

The relationships between the air-blast overpressure and ground vibration from blasting are dependent on a number of variables specific to that site. While the magnitude of the air-blast overpressure and ground vibration decrease with increasing distance from the blast, and increase with increasing charge weight per delay; other variables such as geometries, rock type and formation and the local geology also have an influence on the result of blasting. It is therefore common practice for the blasting specialist to design each blast to achieve the project criterion.

At this stage the detailed information regarding site conditions and the location and frequency of blasting work are not yet known. To provide an indication of the likely levels of ground vibration and blast overpressure from blasting, predictions have been made based on the procedures described in Appendix J of Australian Standard AS 2187.2-2006 *Explosives – Storage and Use, Part 2: Use of Explosives* (**the Australian Standard**) using 'average' site conditions as noted by the Standard and a typical input for charge weight per delay.

The final blasting methodology will be designed by the blasting specialist, or similar, during the detailed design and construction phase to ensure the project criterion are achieved, and will consider the following factors:

- the type of rock and stratigraphy/faulting;
- the distance between the blast site and the sensitive receptors;
- the type, size and number of charges used;
- the depth and manner in which the charge is installed, and;
- meteorological conditions.

Based on the 'average' site conditions noted in the Standard, the minimum separation distances required to achieve the air-blast overpressure and vibration levels recommended by the Standard have been predicted.

For a charge mass per delay of 80kg, a minimum separation in the order of 500 metres is estimated to be required for a confined blasthole charge to achieve an air-blast overpressure no greater than 115 dB (Lin, peak).

The Project air-blast overpressure criterion of 115 dB (Lin, peak) is therefore expected to be readily achievable at all non-associated residences for blasting at all WTG sites as all WTG sites are more than 500 metres from any residence. The nearest non-associated residence to any turbine is residence 55, which is approximately 2000m from T28.

6.3 Recommendations

General Construction Activities

For construction with noise levels greater than 45 dB(A) during standard hours and greater than 35 dB(A) outside of standard hours, the Construction Noise Guidelines require the developer to apply all feasible and reasonable work practices, and to inform the residents of the proposed construction work.

"Feasible and reasonable" noise control strategies to minimise noise during construction may include engineering measures such as the construction of temporary acoustic barriers, the use of proprietary enclosures around machines, the use of silencers, the substitution of alternative construction processes and the fitting of broadband reversing signals. It may also include administrative measures such as inspections, scheduling and providing training to establish a noise minimisation culture for the works.

The following mitigation measures should be incorporated when finalising the construction methodology, Construction Environmental Management Plan (**CEMP**) and out of hours construction noise assessment for the

Project to ensure that all feasible and reasonable measures are incorporated. This assessment of feasible and reasonable measures will need to be considered once the final construction methods, timing, locations and equipment have been determined. With the implementation of the of the final noise control strategies, any impacts can be managed in accordance with the requirements of the Construction Noise Guideline.

The mitigation measures which may be included in the final management plan are as follows:

Scheduling

Construction works, including heavy vehicle movements into and out of the site, will generally be restricted to the hours between 7am and 6pm Monday to Friday, and between 8am and 1pm on Saturdays. Works carried out outside of the hours will be limited to:

- works that do not cause noise emissions above 35 dB(A) at any nearby non associated dwellings; or,
- the delivery of materials as requested by Police or other authorities for safety reasons; or,
- emergency work to avoid the loss of lives, property, and/or to prevent environmental harm; or
- works where a proponent demonstrates and justifies a need to operate outside the recommended standard hours.

If any other works are required outside of the specified hours, they will only be carried out with the prior consent of the relevant authority.

Location of Fixed Noise Sources

Locate fixed noise sources such as crushing and screening plant, concrete batching plant, generators and compressors at the maximum practicable distance to the nearest dwellings, and where possible, use existing topography (or raw or processed materials) to block line of sight between the fixed noise source and the dwelling.

Provide Acoustic Screens around Fixed Noise Sources

Provide acoustic screens or mounding for *fixed* crushing and screening plant and concrete batching plant should these noise sources be located within 2400m of a non-associated dwelling and do not have direct line of sight blocked by site topography to that dwelling, in accordance with the following requirements:

- Locate the acoustic screens or mounding as close as practicable to the noise source;
- Construct from mounding using excavated soil from the site or a material with a minimum surface density of 10 kg/m^2, such as 1.2mm thick sheet steel or 9mm thick compressed fibre cement sheeting, or use proprietary barriers such as the *FlexShield* "Sonic Quilt";
- Construct to a minimum height that blocks direct line of sight between the noise source and any dwellings within 2400m;
- Construct such that air gaps or openings at joints between sections of the acoustic screens are minimised.

Enclose Generators and Compressors

Provide proprietary acoustic enclosures for site compressors and generators if they are located within 2400m of a non-associated dwelling.

Alternative Processes

Investigate and implement alternative processes where feasible and reasonable, such as hydraulic or chemical splitters as an alternative to impact rock breaking, or the use of broadband reversing alarms in lieu of the high-pitched alarms. A broadband reversing alarm emits a sound which addresses the annoyance from the high-pitched alarms. The fitting of a broadband alarm should be subject to an appropriate risk assessment, with the construction team being responsible for ensuring the alarms are installed and operated in accordance with all relevant occupational, health and safety legislative requirements.

Site Management

- Select and locate centralised site activities and material stores as far from dwellings as practicable;
- Care should be taken not to excessively drop materials such as rock, to cause peak noise events, including materials from a height into a truck. Site personnel should be directed as part of a training regime to consider such practices;
- Plant known to emit noise strongly in one direction, such as the exhaust outlet of generator set, shall be orientated so that the noise is directed away from noise sensitive areas if practicable;
- Machines that are used intermittently shall be shut down in the intervening periods between works or throttled down to a minimum;
- Implement worksite induction training, educating staff.

Equipment and Vehicle Management

- Ensure equipment has Original Equipment Manufacturer (OEM) mufflers (or better) installed;
- Ensure equipment is well maintained and fitted with adequately maintained silencers which meet the OEM design specifications. This inspection should be part of a monitoring regime;
- Use only necessary power to complete the task;
- Inspect, as part of a monitoring regime, plant and equipment to determine if it is noisier than other similar machines, and replace or rectify as required.

Community Consultation

Implement the following noise related elements into the overall community consultation process. The aim of the consultation is to ensure adequate community awareness and notice of expected construction noise.

The minimum elements should include:

- Community Information newsletters, providing details of the construction plan and duration of the construction phases;
- A website providing copies of the newsletter, updated construction program details, and contact details of relevant project team members;
- A feedback mechanism for the community to submit questions to the construction team, and for the construction team to respond;
- Regular updates on the construction activities to local authorities to assist in complaint management if necessary;
- Contact details of the project manager and/or site "Environmental Representative".

In addition, prior to any construction activity outside of standard work hours occurring within 2000m of a non-associated dwelling, or significant construction traffic periods or impacts on local road conditions:

- Contact the local community potentially affected by the proposed works and inform them of the proposed work, the location of the work, the day(s) and date(s) of the work and the hours involved;
- This contact should be made a reasonable time before the proposed commencement of the work; and,
- Contact details of the project manager and / or site "Environmental Representative" should be provided.

The above measures should be incorporated and implemented through the construction phase. The mitigation measures should be determined by the construction team once the final design is complete and construction activities and schedule have been confirmed.

Blasting

The separation distances between any potential blasting activity and the non-associated dwellings are of the order of magnitude for which ground vibration and airblast levels have been adequately controlled at other sites.

Given the range of factors associated with both the generation and control of blasting, it is recommended that in the event of blasting occurring that:

- a blasting methodology be designed by the blasting specialist, or similar, during the detailed design phase to ensure the project criterion are achieved; and,
- a monitoring regime is implemented to ensure compliance with relevant blasting criteria.

7 TRAFFIC

The traffic associated with the Project will predominantly occur during construction and will include semi-trailers, low loaders, trucks, mobile cranes, water tankers, four-wheel-drive vehicles and passenger vehicles. There will be a small number of traffic movements associated with the operation of the Project, however, these will be substantially smaller than the construction phase.

7.1 Criteria

The NSW Road Noise Policy provides the following criteria for noise at residential land uses:

Table 17: Road noise criteria

Road Category	Type of project/land use	Assessment criteria – dB(A)	
		Day 7am – 10pm	Night 10pm – 7am
Freeway/ arterial/ sub-arterial roads	*Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments*	$L_{Aeq, (15\ hour)}$ 60 (external)	$L_{Aeq, (9\ hour)}$ 55 (external)

The above noise levels are to be achieved outside, at a distance of 1m from the facade of a dwelling and at a height of 1.5m.

It should be noted that the NSW Road Noise Policy applies to a permanent change to the environment as it is established for the assessment of changes to the permanent road network. Therefore, its application to transient and fixed term construction activity represents a conservative approach. Indeed, higher construction traffic noise levels than NSW Road Noise Policy could be accommodated without adverse impacts, subject to traffic movements being governed under an adequate Construction Management Plan (whereby routes, content and times are clearly articulated to the local community).

7.2 Assessment

During the peak of construction, the highest number of vehicles associated with the wind farm development have been estimated by Neoen to comprise 56 light vehicles and 12 heavy vehicles entering/exiting the site within one hour during the morning or evening.

Dwelling setback distances in the vicinity of the wind farm are understood to be more than 40m from highways.

A traffic noise model has been used to predict that for a 40m setback distance, with the peak volume of traffic noted above and the assumption that traffic will disperse evenly in different directions from the site, a noise level of 50 dB(A) will be achieved at the closest residences during the day period. For a small number of deliveries to the site during the night period, average noise levels from these traffic movements will be much less.

The predictions described above demonstrate that the vehicle movements would achieve the 60 dB(A) and 55 dB(A) criteria.

Notwithstanding the above, in accordance with the general principles of dealing with temporary construction noise impacts, the following mitigation measures should be employed to reduce construction traffic noise:

- Communicate with the affected community in accordance with the provisions above;
- Avoid excessive acceleration of trucks and the use of truck engine brakes in close proximity to dwellings, particularly through towns and around site entry and exit points to site. Such behaviour should be reinforced through worksite induction training.
- Incorporate information regarding the route to all drivers prior to accessing the site and the need to minimise impacts through driver operation at locations where residences are closest to the road and are most likely to be impacted;
- Schedule construction traffic deliveries such that it is as evenly dispersed as practicable; and,
- Restrict construction to the day-time operating hours for the construction site, subject to the justifications for activity outside of this time as detailed in the CEMP.

8 CONSTRUCTION GROUND VIBRATION

8.1 Criteria

Normal Construction

DECC 2006 references the British Standard *BS 6472-1992 "Evaluation of human exposure to vibration in buildings (1-80Hz)"* as the technical basis for vibration criteria. From this, it can be interpreted that the vibration criteria detail in Table 18 applies for construction activity when measured at the residences during the daytime.

Table 18: Vibration Criteria

Continuous Vibration Vertical (rms)		Impulsive Vibration Vertical (rms)		Vibration Dose Value for Intermittent Vibration	
Preferred	Maximum	Preferred	Maximum	Preferred	Maximum
0.01 m/s^2	0.02 m/s^2	0.3 m/s^2	0.6 m/s^2	0.2 $m/s^{1.75}$	0.4 $m/s^{1.75}$

Continuous vibration is uninterrupted for an extended period of time. Intermittent vibration is an interrupted form of continuous vibration, and impulsive vibration is a sudden event or events.

Blasting

To minimise the annoyance and discomfort from ground vibration to persons at sensitive receptors, the ANZECC Guidelines state:

- the recommended maximum level for ground vibration is 5mm/s (peak particle velocity (**PPV**));
- the ppv level of 5mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 10mm/s at any time.

The above 5mm/s PPV criterion is consistent with that recommended by DIN 4150-3 *Structural vibration - Effects of vibration on structures (1999)* for *dwellings and buildings of similar design and/or occupancy* to prevent damage that reduces the serviceability of the building. Compliance with the above criterion will therefore also be sufficient to reduce the likelihood that structural damage occurs to structures in the vicinity of the Project.

8.2 Assessment

General Construction Activity

It is expected that the main sources of construction vibration will be the rock trenching equipment and roller operation during the road and hard stand construction. The level of vibration at a distance will be subject to the input of the equipment and the local ground conditions. Typically, the distances required to achieve the

construction vibration criteria provided in DECC 2006 are in the order of 20m. At a distance of 100m, vibration from these activities is unlikely to be detectable.

Based on the separation distances between the construction activities and the nearest dwellings, being well in excess of 100m, vibration levels are expected to easily achieve the criteria and no vibration effects are predicted during construction.

If construction activities producing high levels of vibration occur within 100m of a dwelling, it is recommended that a monitoring regime is implemented to ensure compliance with DECC 2006.

Blasting

To achieve a ground vibration peak particle velocity (PPV) no greater than 5mm/s, a minimum separation distance in the order of 300 metres is required based on a charge mass of 80kg (consistent with the blasting noise assessment) carried out on a free face under average field conditions.

Based on the 2000m separation distance between any non-associated residence and the nearest turbine, the Project ground vibration criterion of 5mm/s is therefore also expected to be readily achievable at all non-associated residences for blasting at all WTG sites.

As noted in the construction noise assessment section, given the range of factors associated with both the generation and control of blasting, it is recommended that in the event of blasting occurring that a blasting methodology be designed and a monitoring regime is implemented.

9 CONCLUSION

A noise and vibration assessment has been undertaken for the construction and operation of the Thunderbolt Energy Hub – Stage 1.

The Project will generally involve up to 32 wind turbine generators and ancillary infrastructure, including electricity substation, access tracks and temporary batching facilities during construction.

The noise and vibration assessment addresses the "Secretary's Environmental Assessment Requirements" (SEARs) issued for the Project (SSD-10807896) dated 16 December 2020. The SEARs provide the relevant noise and vibration guidelines for determining the proposed wind farm assessment criteria.

Noise predictions have been made of the wind turbine operation, the substation, traffic on local roads and construction activities including batching. Vibration predictions have also been made for construction activities.

Based on the predictions, the relevant operation and construction noise and vibration criteria can be achieved under conditions most conducive to noise propagation at all dwellings where activity is managed in accordance with the recommendations within this report.

When considering the above, the Thunderbolt Energy Hub – Stage 1 can satisfy the noise and vibration related aspects of the SEARs.

APPENDIX A: Environmental Noise and Vibration Assessment Requirements

Secretary's Environmental Assessment Requirements (SEARs)

Planning Secretary's Environmental Assessment Requirements

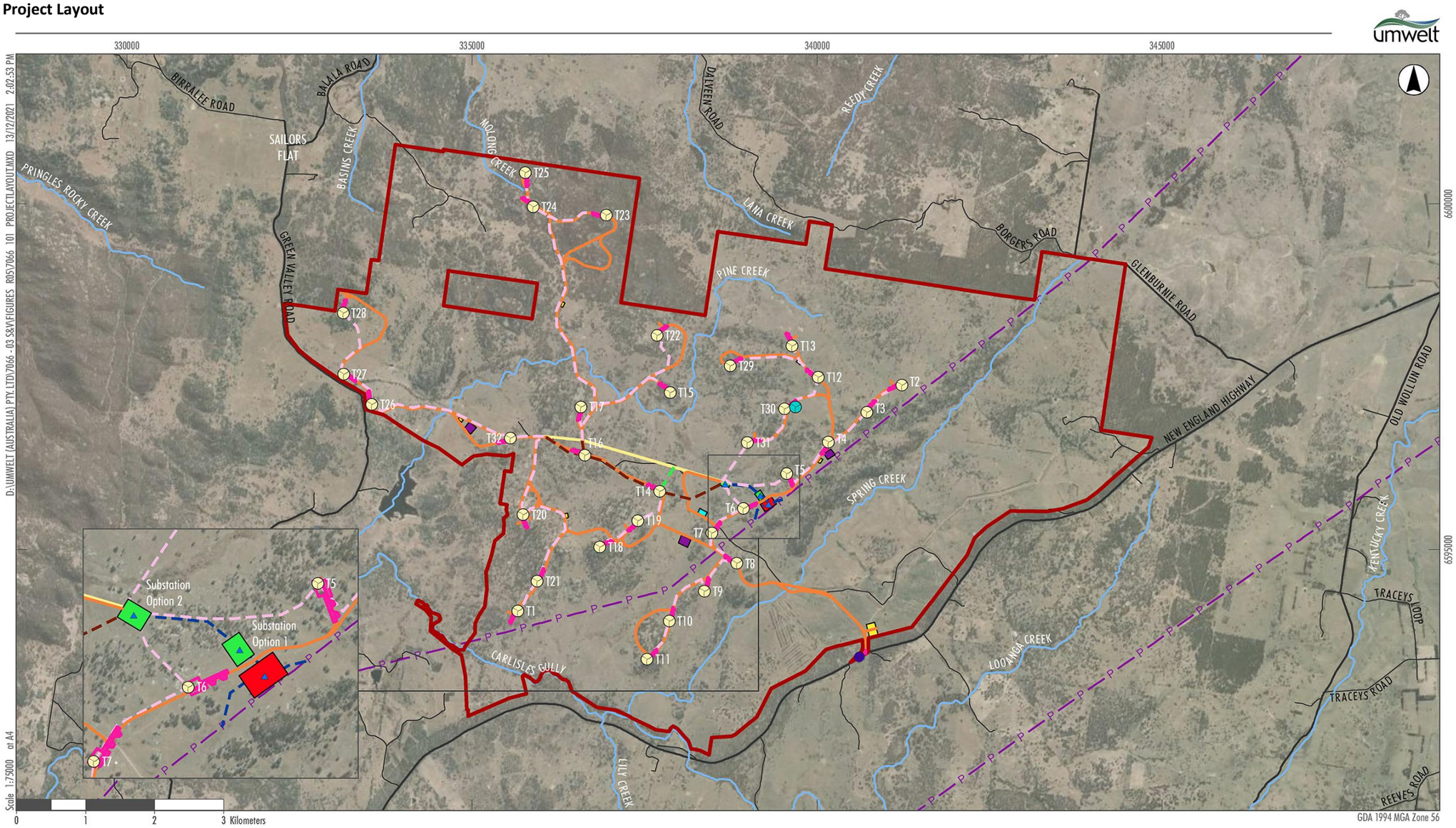
Section 4.12(8) of the *Environmental Planning and Assessment Act 1979* Schedule 2 of the Environmental Planning and Assessment Regulation 2000

Application Number	SSD-10807896
Project Name	Thunderbolt Energy Hub Wind Farm, which includes: • the construction, operation and decommissioning of a wind farm with an estimated capacity of 380 megawatts (MW), a maximum of 70 turbines and a maximum height of 250 metres (to blade tip); and • ancillary infrastructure including access tracks, road upgrades, underground and overhead electricity cabling, substations, transmission lines and grid connection to the TransGrid transmission network.
Location	Approximately 40 km north east of Tamworth in Tamworth Regional, Uralla Shire and Walcha Shire local government areas
Applicant	Neoen Australia Pty Ltd
Date of Issue	16/12/2020

...

Key issues	The EIS must address the following specific issues for the wind farm and associated infrastructure: **Landscape and Visual** – the EIS must include a detailed assessment of the visual impacts of all components of the project (including turbines, transmission lines, substations, and any other ancillary infrastructure and (if required) night lighting) in accordance with the *NSW Wind Energy: Visual Assessment Bulletin* (DPE, 2016), including detailed consideration of potential visual impacts on local residences. **Noise and Vibration** – the EIS must: • assess wind turbine noise in accordance with the *NSW Wind Energy: Noise Assessment Bulletin* (EPA/DPE, 2016); • assess noise generated by ancillary infrastructure in accordance with the *NSW Noise Policy for Industry* (EPA, 2017); • assess construction noise under the *Interim Construction Noise Guideline* (DECC, 2009); and • assess traffic noise under the *NSW Road Noise Policy* (DECCW, 2011); and • assess vibration under the *Assessing Vibration: A Technical Guideline* (DECC, 2006).

APPENDIX B: Project Layout



APPENDIX C: Photographs of Logging Equipment at Dwellings

Noise Logger at Dwelling 6

Noise Logger at Dwelling 6

Noise Logger at Dwelling 6

Noise Logger at Dwelling 6

Weather Logger at Dwelling 6

Weather Logger at Dwelling 29

Noise Logger at Dwelling 29

Noise Logger at Dwelling 29

Noise Logger at Dwelling 29

Noise Logger at Dwelling 29

Noise Logger at Dwelling 219

Noise Logger at Dwelling 219

Noise Logger at Dwelling 219

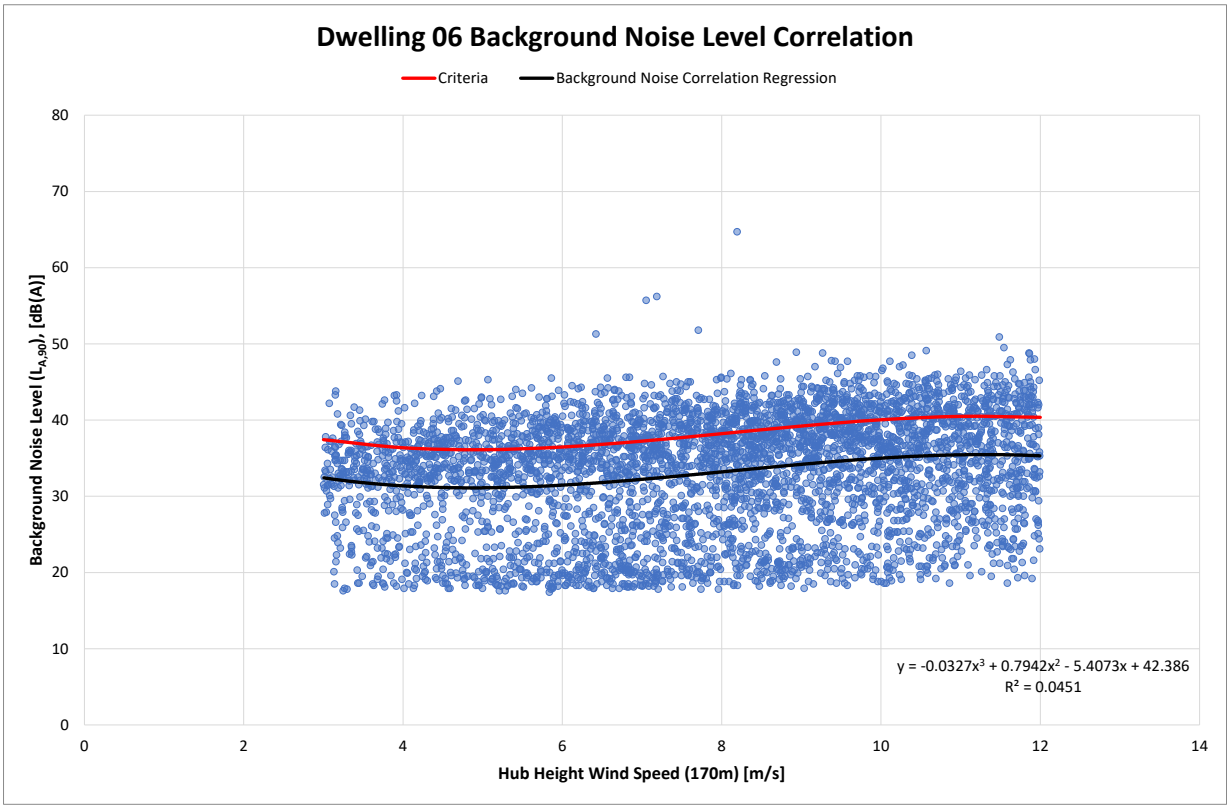
Noise Logger at Dwelling 219

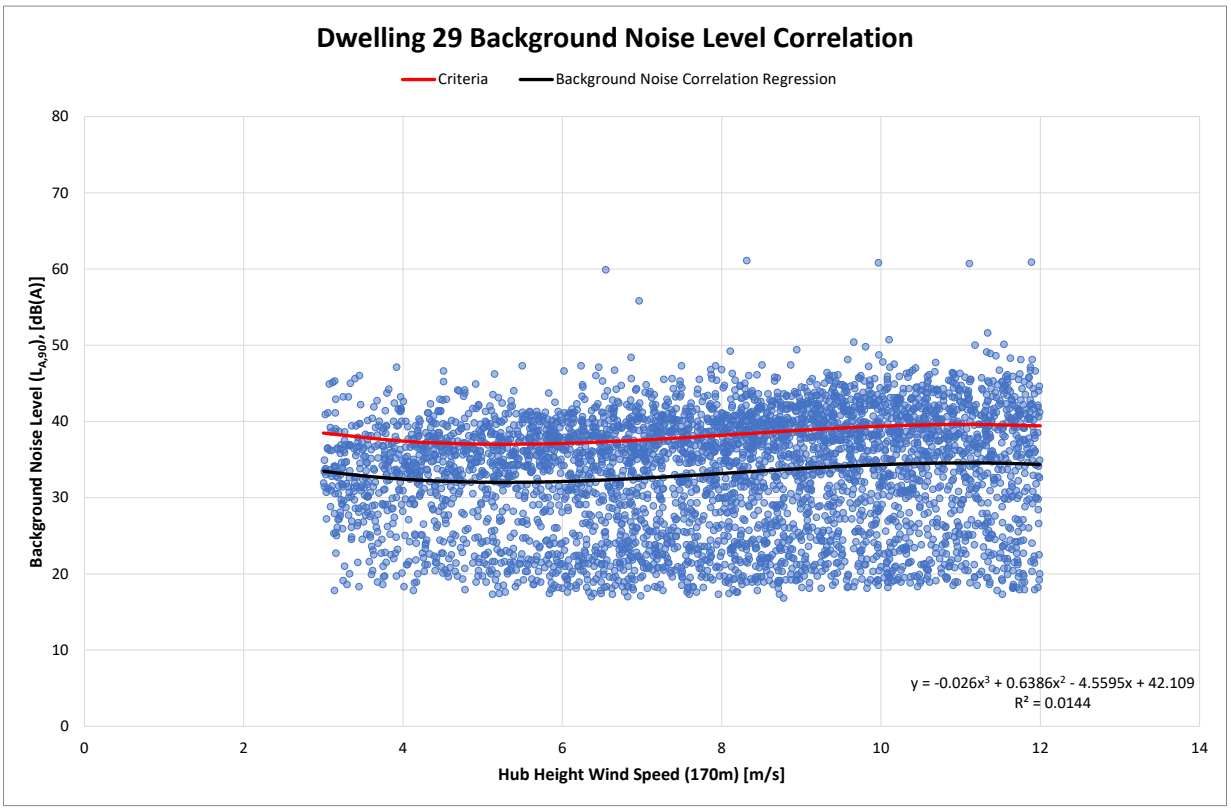
Noise Logger at Dwelling 270

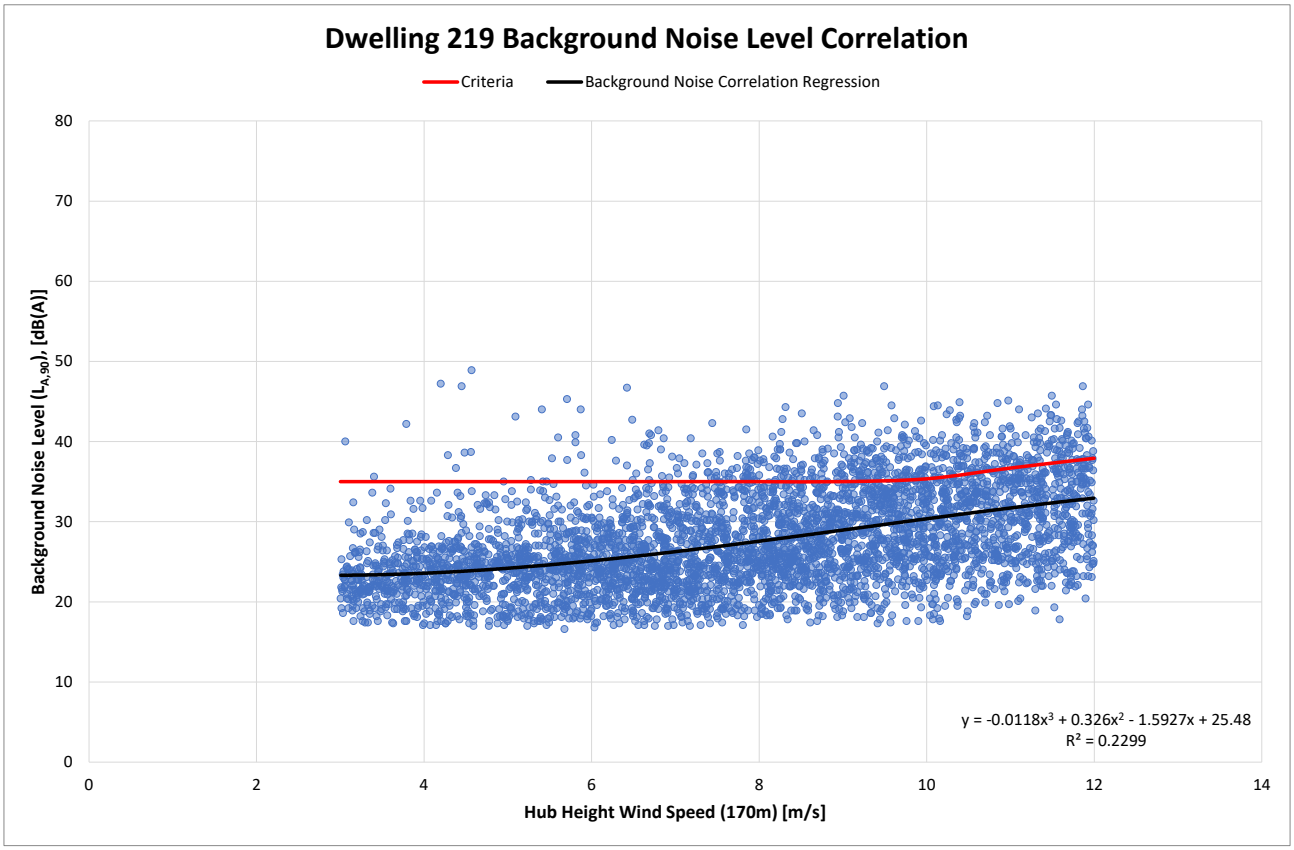
Noise Logger at Dwelling 270

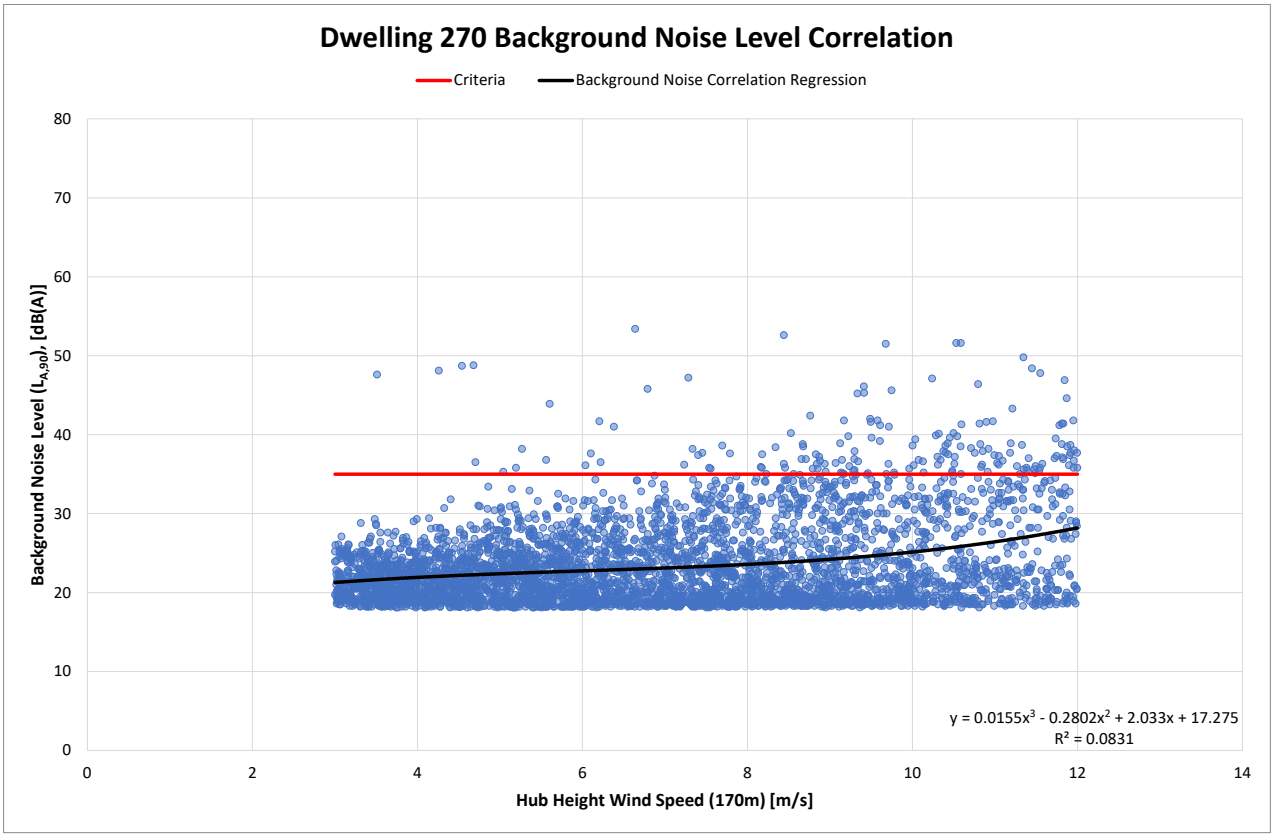
Noise Logger at Dwelling 270

APPENDIX D: Background Noise and Wind Speed Correlation Charts

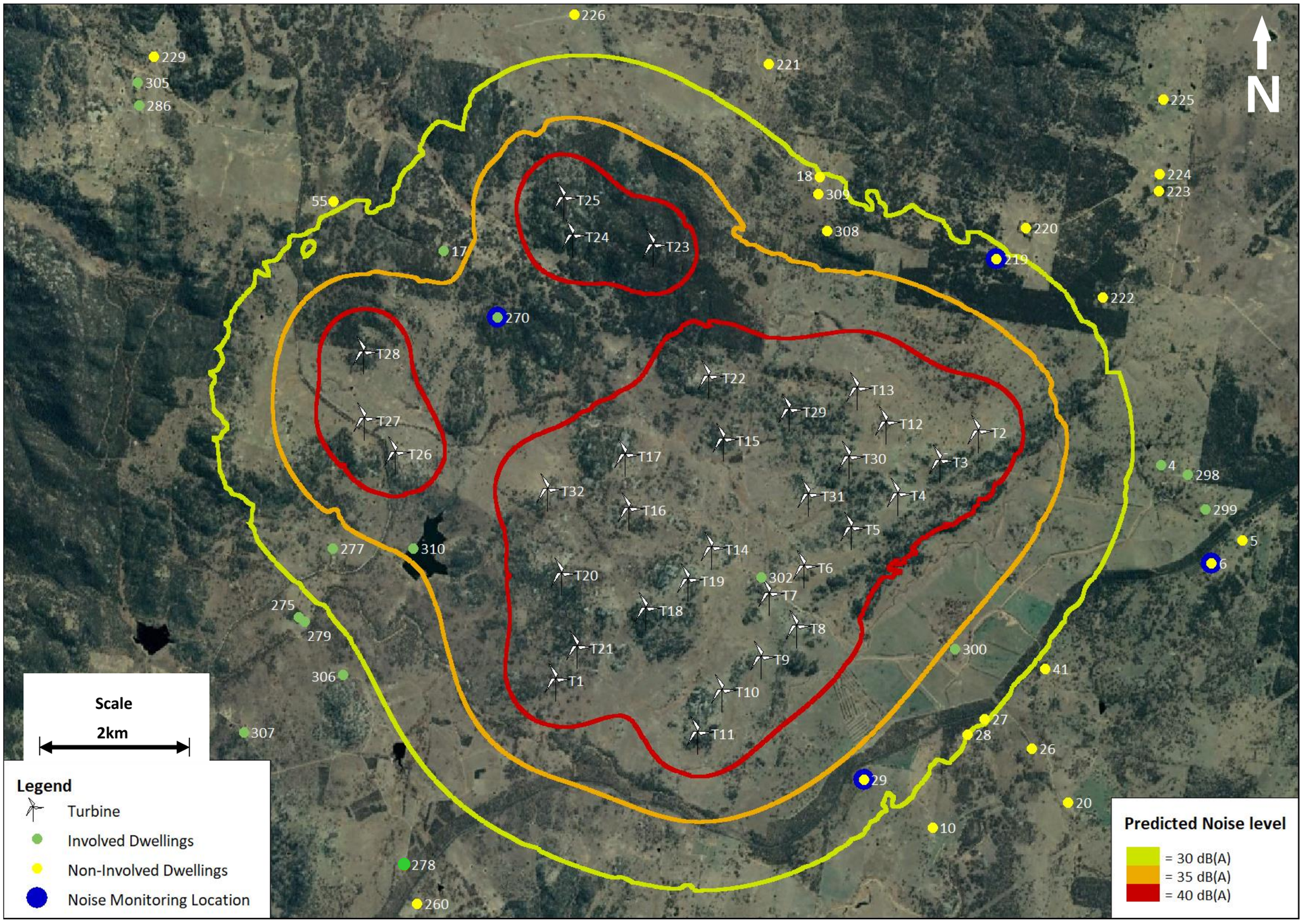





Dwelling 219 Background Noise Level Correlation
Criteria
Background Noise Correlation Regression
Background Noise Level ($L_{A,90}$), [dB(A)]
Hub Height Wind Speed (170m) [m/s]
y = -0.0118x³ + 0.326x² - 1.5927x + 25.48
R² = 0.2299


Dwelling 270 Background Noise Level Correlation
Criteria
Background Noise Correlation Regression
Background Noise Level ($L_{A,90}$), [dB(A)]
Hub Height Wind Speed (170m) [m/s]
y = 0.0155x³ - 0.2802x² + 2.033x + 17.275
R² = 0.0831

APPENDIX E: Noise Prediction Contours (Wind Speed of 10m/s at Hub Height)



APPENDIX F: Response to SLR Consulting Peer Review

SLR Comment	Response
2 Project Layout – this section really requires a visual map, that shows and labels, WTG layout, ancillary equipment, meteorological mast, sensitive receptors (involved & uninvolved) and monitoring locations.	WTG layout map added in *Section 2, page 6* Project layout including ancillary equipment and meteorological mast shown in *Appendix B, page 41* Dwelling layout showing sensitive receptors (involved & uninvolved) and monitoring locations shown in *Appendix E, page 53*
2 Project Layout - *Table 3 Dwellings in the Vicinity of the Wind Farm* – this table would be more useful to list the distance to the closest WTG	Table 3 updated to show distance to closest WTG. *Section 2, page 8.*
3.1.1 Special Noise Characteristics - Tonality – The method for determining tonality described in the Sonus Report is limited to the ISO 1996.2: 2007 Simplified Method (e.g. 1/3 octave band). NSW adopts SA 2009, which The Bulletin states: *SA 2009 requires that development applications for wind energy projects report the following: "To help determine whether there is tonality, the method and results of testing (such as in accordance with IEC 61400−11) carried out on the proposed WTG model to determine the presence of tonality should also be specified in the development application"* As well as the following notes: *Note 1: Narrow band analysis using the reference method in ISO1996-2:2007, Annex C may be required by the consent / regulatory authority where it appears that a tone is not being adequately identified, for example where it appears that the tonal energy is at or close to the third octave band limits of contiguous bands.* *Note 2: Noise assessments for wind energy projects shall, however, also report the results of tonality assessments under IEC61400-11 for the particular turbine being considered.* For planning approval noise impact assessments, it is customary to evaluate the potential for tonality by examining WTG noise test reports which have been completed in accordance with under IEC61400-11, as per Note 2. If tonality is at all present, then appropriate SAC penalty should be included in the predictions.	Section 3.1.1 – Tonality: updated to include discussion of IEC61400-11. *Pages 11-12*. A tonality assessment in accordance with IEC61400-11 is not available for the indicative turbine. In these circumstances, an assessment in accordance with Annex D of ISO 1996.2: 2007 has been made. An updated assessment will be made prior to construction, when the final turbine model has been selected.

SLR Comment	Response
4.1 Background Noise Monitoring – For full transparency and traceability a technical report should list all equipment details, SLM model, serial numbers and a confirmation of NATA calibration status.	Table 5 updated to include SLM model and type, serial numbers and calibration due date. *Section 4.1, page 15.*
4.1 Background Noise Monitoring – The Sonus Report states logger placement was *'at an equivalent distance from the facade of the dwelling as any significant trees*'. This is perhaps just requiring re-phrasing. SA EPA 2009 requires that *'The microphone should be positioned 1.2–1.5 metres above the ground and at least 5 metres from any reflecting surface (other than the ground). In general, any area within 30 metres of a house and in the direction of the wind farm would be a valid measuring position. Care should be taken to ensure that the area is not screened from the wind farm by house, shelter or other elements. Background noise levels can be significantly affected by local conditions, such as the presence of trees nearby.* *Photographs from multiple directions are to be taken showing the noise measurement position and associated surroundings, such as buildings, trees and topography'*.	Section 4.1 was re-phrased, including an explanation of the care taken in placing loggers, relative to the location of tall trees. *Page 15.*
4.1 Background Noise Monitoring – The Sonus Report provides photographs of the noise monitoring equipment in Appendix B. Appendix B only shows typically 1 photograph of noise equipment in-situ at each location. SA EPA requires Photographs from multiple directions are to be taken showing the noise measurement position and associated surroundings, such as buildings, trees and topography. It is customary to include photographs of the equipment in-situ from all 4 compass directions	Additional available photos added for each logging location in *Appendix C, pages 42-50.*
4.1 Background Noise Monitoring – Meteorological mast - it would be useful to include the location of the Met mast on the overall layout map. Furthermore, it would be useful to understand the met mast wind heights, also a brief explanation of the 'shearing up' process. Is it based on a constant average shear, or determined by 10-minute bin determined shear?	Wind data were provided to Sonus by Neoen. Neoen performed the 'shearing up' process to determine wind speeds referenced to hub height.

SLR Comment	Response
4.3 Assessment – Noise Sources – Tonality - The Sonus Report provides '*The assumption has been confirmed for the representative wind turbine model by reviewing the 1/3 octave band data'*. The more appropriate method to evaluate tonality is nearfield tests in accordance with IEC61400-11 narrow band tonal audibility test.	Section 4.3 updated to state that a tonality assessment under IEC61400-11 is not available for the *Vestas 6.0MW V162* WTG. *Page 18*
4.3 Assessment – Propagation Model – The Sonus Report provides *'predictions of environmental noise from the Project have been based on the CONCAWE noise propagation model and SoundPLAN noise modelling software'.* Current best practice is described in Institute of Acoustics (IOA) - *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise.* It advocates for use of the ISO 9613-2 standard, with special input parameters detailed in Section 4.3 of the Guideline. The Sonus Report lists *'widely accepted input conditions',* many of which are not aligned with the IOA special input parameters detailed in Section 4.3 of the Guideline. e.g. relative humidity, soft ground, receptor height. My recommendation is for the modelling to be in accordance with the best practice IOA Guideline, alternatively a significantly more robust justification of the selection of CONCAWE is warranted and the author should provide evidence of how and why the input conditions are *'widely accepted'.*	It is not agreed that the ISO9613 methodology represents "current best practice". CONCAWE is listed as an acceptable methodology in the SA Guidelines (used in NSW) as well as the QLD Code. Sonus considers that both ISO9613 and CONCAWE are acceptable methods, provided that appropriate inputs are used. It is not relevant to compare the required inputs for ISO9613 with the inputs used for CONCAWE. This is because CONCAWE is able to accurately predict the noise from wind farms without modifying inputs. Conversely, artificial inputs (such as a 4m receiver height) are required in ISO9613 to enable accurate predictions for wind farms. The inputs used by Sonus are those recommended in the QLD Code. At typical setback distances, they result in very similar predicted noise levels to those predicted in ISO9613 with IOA inputs.
5.1 Criteria - The Sonus Report states *'The amenity level for a noise source which operates over a 24-hour period in a rural area is 40 dB(A)'*. This would be better re-phrased as *'…..*noise source which operates during the night period'.	Section 5.1 updated to include proposed change. *Page 23*
6.2 Assessment – Table 16 header – '*Predicted construction noise levels for the non-associated locations > 40 dB(A)'.* The Night-time Noise Management Level is RBL+5dBA = 35 dBA	Table 16 header updated. *Page 28.*
7 Traffic - Criteria - If deliveries are anticipated to occur out of standard hours, e.g. delivery of blades/tower/nacelle etc. due to traffic safety considerations then I would suggest an Lmax sleep disturbance assessment is appropriate.	Where deliveries are required out of hours for safety reasons or as required by Police, it is not considered appropriate to assess the noise against Lmax criteria.

SLR Comment	Response
Appendix B - Photographs of Logging Equipment at Dwellings – as there generally are only a single photograph of the noise monitoring equipment in-situ it is difficult to ascertain if the selection of monitoring sites are in accordance with the requirements of SA EPA 2009. Noise Logger at Dwelling 6 - Noise logger appears that it may possibly less than 5m from reflective surface. Noise Logger at Dwelling 29 - Noise logger appears that it may be greater than 30m from the dwelling. It also appears to be closely surrounded by orchard trees. From the photograph it is not possible to judge if the equipment location is indicative of dwelling.	Photographs of Logging Equipment at Dwellings moved to *Appendix C, pages 42-50.* Additional photos added for each dwelling. Photos added for Dwelling 6 show that noise logger is at a distance greater than 5m from any reflective surface. Logger at Dwelling 29 was placed between the wind farm and the orchard as shown in the following figure and was placed at an equivalent distance from the significant tree highlighted as the facade of the dwelling. Although the logger was close to the orchard, there were no leaves on the trees and therefore these trees had no impact on the assessment.
Appendix D - Noise Prediction Contours - Whilst 35 dBA represents the minimum criteria, it would be useful to see more than one contour, especially given that not all presented receptors are detailed in the results table.	Noise Prediction Contours moved to *Appendix E, page 53.* Updated to show additional predicted noise level contour bands at 30 dB(A) and 40 dB(A).