Kondinin Wind and Solar Farm, Western Australia
Kondinin Energy Pty Ltd
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Commercial-in-Confidence

Noise Impact Assessment

Kondinin Wind and Solar Farm, Western Australia

Noise Impact Assessment

Kondinin Wind and Solar Farm, Western Australia

Client: Kondinin Energy Pty Ltd

ABN: 35 615 594 280

Prepared by

AECOM Australia Pty Ltd
3 Forrest Place, Perth WA 6000, GPO Box B59, Perth WA 6849, Australia
T +61 8 6208 0000 F +61 8 6208 0999 www.aecom.com
ABN 20 093 846 925

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Prepared by Rachel Foster

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1.0 Requirements

A Noise Impact Assessment is required to determine the viability of Kondinin Energy's proposed development of a Wind and Solar Farm in Kondinin, Western Australia.

AECOM Australia Pty Ltd (AECOM) was commissioned by Kondinin Energy Pty Ltd (via Lacour Energy) to prepare an Noise Impact Assessment for the proposed development of a Wind and Solar Farm in Kondinin, Western Australia (the Project).

The Project is located approximately 10 km north of the Kondinin township, in Western Australia. Lacour Energy's development application (DA) comprises the installation of 46 wind turbine generators (WTGs) and a solar farm across the site.

The Project will include access tracks, cables and overhead lines, site offices, workshops and warehouse, substations including transformers and energy storage, meteorological masts and other ancillary infrastructure.

Each WTG will be of the horizontal axis type, with a rotor consisting of three blades with a maximum blade length of up to 90 m and a maximum hub height of up to 150 m. The maximum height of the WTG to blade tip is up to 220 m. Blade length chosen and wind turbine hub height will be configured so that the tip height does not exceed 220 m.

The final number, make and model of the WTGs which comprise the wind farm are not yet finalised. Therefore, the DA is for a 46 WTG wind farm and all associated infrastructure to be located within the wind farm envelope. Some areas will be designated exclusion zones, where no WTGs or associated infrastructure will be located, and existing vegetation will be retained.

The Project must demonstrate compliance with:

- The South Australia Environment Protection Authority's *Wind farms – Environmental noise guidelines*, July 2009 (refer to in this report as the SA Guidelines) which are the guidelines recognised by the Department of Water and Environmental Regulation for the assessment of noise generated by wind farms in Western Australia; and
- The Western Australia *Environmental Protection (Noise) Regulations 1997 (EPNR)* for fixed infrastructure including the substation and transformers.

Background noise measurements for the purpose of establishing site-specific noise emission criteria were undertaken at three representative noise monitoring locations near the Project site. Noise monitoring was conducted between 25 August 2017 and 22 September 2017 to measure background noise levels for a *minimum* of two weeks, in accordance with the SA Guidelines; four weeks' data was collected.

This report presents the analysis of the noise measurements conducted with respect to wind speeds measured at the Project site based on the performance outcomes specified in the SA Guidelines. Wind speed and rainfall data was measured using a portable meteorological weather station, adjacent to the noise monitoring equipment and/or the meteorological data was obtained from the Department of Primary Industries and Regional Development for the duration of the noise monitoring periods. The meteorological data was assessed to determine the applicability of the measured noise data (i.e. to determine periods of measured noise data to be excluded due to rainfall or high wind speeds). The wind speeds measured at the Project's meteorological mast were correlated with the measured noise levels to determine the applicable noise criteria as outlined in the SA Guidelines.

A computational noise model was created to predict the noise levels from the operation of the Project at 14 noise sensitive receptors in the vicinity of the Project. Based on the results of the noise predictions, the noise emission from the Project are expected to comply with the requirements of the SA Guidelines and Western Australia's environmental noise regulations.

No assessment of the solar component of the Project is included in this report as there is no noise generated by this component.

Potential construction noise and vibration impacts related to the construction of the Project are presented in general terms, as specific details of the construction methodology and equipment are not known at this early stage of the Project.

Acoustic nomenclature is included in Appendix A.

2.0 Noise Criteria

2.1 Operational Wind Turbine Generator Noise Criteria

The SA Guidelines require that, to prevent adverse impacts from the WTG noise, the noise source level must be compared to the corresponding background noise at the relevant receiver.

The predicted equivalent noise level ($L_{Aeq,10}$), adjusted for tonality in accordance with these guidelines, should not exceed:

- 35 dB(A) at relevant receivers in localities which are primarily intended for rural living, or
- 40 dB(A) at relevant receivers in localities in other zones, or
- The background noise ($L_{A90,10}$) 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 WTG and each integer wind speed between.

The Project is located within a rural area; therefore the 35 dB(A) baseline criterion and the adjusted "background + 5" dB(A) criteria apply to all relevant noise-sensitive receivers.

Sensitive receptors on private land in the vicinity of the Project which have an agreement with Lacour in relation to the location and operation of the proposed WTGs are referred to in this report as "Participating Landowners". An agreement has been reached between Lacour and the Participating Landowners to deviate from the above environmental noise criteria, which have been developed to minimise the impact of the Project on the amenity of premises which do not have such an agreement, referred to in this report as "Non-participating Landowners".

However, any such agreement cannot contravene the *Environment Protection Act*, which requires that the development may not have an adverse effect on the amenity of the area which unreasonably interferes with the enjoyment of the area. Specifically to this, health impacts must be considered, in particular sleep disturbance. The *World Health Organization Guidelines for Community Noise* recommend a 30 dB(A) indoor limit to prevent negative effects on sleep. The *Working Group on Noise from Wind Turbines (Final Report, ETSU for DTI, 1996)* recommends the outdoor noise limit of 45 dB(A) (after any adjustment for tonality) for landowners having financial involvement in the wind farm. If the wind farm noise does not exceed 30 dB(A) indoors and 45 dB(A) outdoors at the localities belonging to the financial stakeholders, it is considered acceptable.

2.2 Low Frequency Noise

Wind farms are not a significant source of low frequency noise, due to modern WTG designs having the turbine blades upwind of the tower. As there are no performance outcomes included in the SA Guidelines for low frequency noise emissions, a low frequency noise criteria of 60 dB(C) $L_{Ceq,10}$ was used to assess the potential impacts of any low frequency noise emissions, as per the *NSW Department of Planning and Infrastructure Draft NSW Planning Guidelines: Wind Farms (2011)*.

2.3 Infrastructure Associated with the Operation of the Project

The *Environmental Protection (Noise) Regulations 1997* provide criteria for allowable noise from the substation proposed for the Project. The *Assigned Level* (the allowable noise level) when received at a premises is based on the calculation of an Influencing Factor added to a base level.

For noise-sensitive premises, the Influencing Factor is calculated based on the land use zones within circles of 100 m and 450 m radius from the receiver, and address:

- The percentage of land zoned Industrial;
- The percentage of land zoned Commercial;
- The presence of major roads within circles, and
- The number of secondary roads within the 100 m radius circle.

The Assigned Levels are also dependent of the time of day, separated into day, evening and night periods.

For the noise-sensitive receivers in the vicinity of the Project, there are no commercial or industrial premises within either 100 m or 450 m, nor are there major or secondary roads within these distances; hence there is no Influencing Factor to be applied. Therefore, the Assigned Levels result in the criteria shown in Table 1 being applicable to environmental noise emission from Project's substation.

Table 1 Environmental noise emission criteria (Assigned Level)

Type of premises receiving noise	Time of day	Environmental noise emission criteria dB(A)		
		$L_{A,10}$	$L_{A,1}$	$L_{A,max}$
Noise sensitive premises – highly sensitive area	0700 to 1900 hours Monday to Saturday	45	55	65
	0900 to 1900 hours Sunday and public holidays	40	50	65
	1900 to 2200 hours all days	40	50	55
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35	45	55

These criteria do not consider annoying characteristics such as spectral modulation, tonality, or impulsiveness which are likely to arouse adverse community response at lower levels than noise without such characteristics. Where noise from site includes such annoying characteristics additional penalties will be attracted generally in accordance with the EPNR, in accordance with the following definitions:

Modulation

A variation in the emission of noise where the difference between L_{Apeak} and $L_{Amax,slow}$ is more than 15 dB when determined for a single representative event.

Impulsiveness

A variation in the emission of noise that:

a. Is more than 3 dB $L_{A,fast}$ or is more than 3 dB $L_{A,fast}$ in any one octave band;

b. Is present for at least 10% of the representative assessment period; and

c. Is regular, cyclic and audible.

Tonality

"The presence in the noise emission of tonal characteristics where the difference between –

(a) the A-weighted sound pressure level in any one-third octave band; and

(b) the arithmetic average of the A-weighted sound pressure levels in the two adjacent one-third octave bands,

is greater than 3 dB when the sound pressure levels are determined as $L_{Aeq,T}$ levels where the time period T is greater than 10% of the representative assessment period, or greater than 8 dB at any time when the sound pressure levels are determined as $L_{A\ slow}$ levels."

If any of these characteristics is demonstrated at any receiver location, the penalties outlined in Table 2 apply:

Table 2 Adjustments to measured noise levels

Where tonality is present	Where modulation is present	Where impulsiveness is present
+5 dB	+5 dB	+10 dB

These adjustments are cumulative up to a maximum of 15 dB. A requirement for suppliers to provide equipment that achieves the relevant steady-state noise emission criteria should be included in the specification and compliance with the relevant criteria should be confirmed with post construction noise monitoring.

3.0 Background Noise Monitoring

The acoustic environment in the area was evaluated by undertaking a baseline background noise monitoring programme at three representative noise monitoring locations within the vicinity of the Project, as described in Table 3 and shown in aerial view in Figure 1. Photographs of the noise monitors installed at these sites are provided in Appendix E.

The noise monitoring locations were selected to represent areas that are expected to have the greatest noise impact from the Project, and for the following specific reasons:

- Logger 1 : Known to be surrounded by trees / vegetation; background levels at this receiver anticipated to be different to other more-exposed receivers.
- Logger 2 : Representative of receivers to the south of the Project, which are more exposed to prevailing winds.
- Logger 3 : Representative of receivers to the west and north of the Project, which are likely to be somewhat sheltered by the intervening landform from the prevailing winds.

The monitoring was conducted between 25 August 2017 and 22 September 2017 to measure background noise levels for a *minimum* two weeks (approximately 2000 data points), in accordance with the SA Guidelines. Approximately 4000 data points were collected over two periods:

- Period 1: 25-08-2017 to 08-09-2017
- Period 2: 08-09-2017 to 22-9-2017

Localised meteorological monitoring was also undertaken synchronously with the noise measurements at the Logger 2 location, with a portable weather station installed 1.5 m above ground level. These measurements were used to remove measured noise samples from assessment when the measured wind speed at ground level exceeded 5 m/s, or when rain was registered by the instrument within a 10 minute interval. The measured data from the portable weather station was not correlated with the measured noise levels; rather, the measured wind speed information from the project's meteorological mast was used for correlation with measured noise levels.

Both wind speed and noise data was collected as 10 minute averages throughout the monitoring periods. In all cases, background noise was measured with a microphone at a height of 1.5 m above ground level, and at least 5 m from any significant vertical reflecting surfaces. Similarly, the noise monitors were placed as far as practicable from significant vegetation such as trees and potential sources of domestic noise.

The background noise data collected at each site was correlated with wind speed data measured at the Project's SODAR (SOnic Detection And Ranging) device in operation on site during the measurements. The wind data measured by the SODAR device at 150 m above ground was utilised in the assessment. Where the 150m data was not collected, data extrapolated from a lower height to 150m was used.

A description of the Project's SODAR device is presented below:

- KON - SOD1 Latitude -32.43932; Longitude 118.346888.

Whilst the background noise measurements were not processed to remove samples affected by extraneous noise contributions, apart from data excluded due to adverse wind and rain conditions, the results show that the majority of the noise data is concentrated within the relevant wind speeds (cut-in at 4 m/s, rated up to 14 m/s) registered by the meteorological mast during the monitoring period. As such, a small number of high level outliers are not expected to skew the results.

The background noise monitoring was used to establish applicable noise criteria, as described in Section 2.0 of this report, and also compared against the baseline 45 dB(A) and 35 dB(A) $L_{Aeq,10}$ noise criteria at Participating and Non-Participating Landowners respectively.

Table 3 Background noise monitoring locations

Noise monitoring location (Receptor ID)	Geographic coordinates (m)	
	Easting	Northing
Logger 1 – Receiver R05 – Participating Landowner	626999.27	6410592.47
Logger 2 – Receiver R12 – Participating Landowner	626278.64	6404409.79
Logger 3 – Receiver R08 – Participating Landowner	621937.13	6408857.31

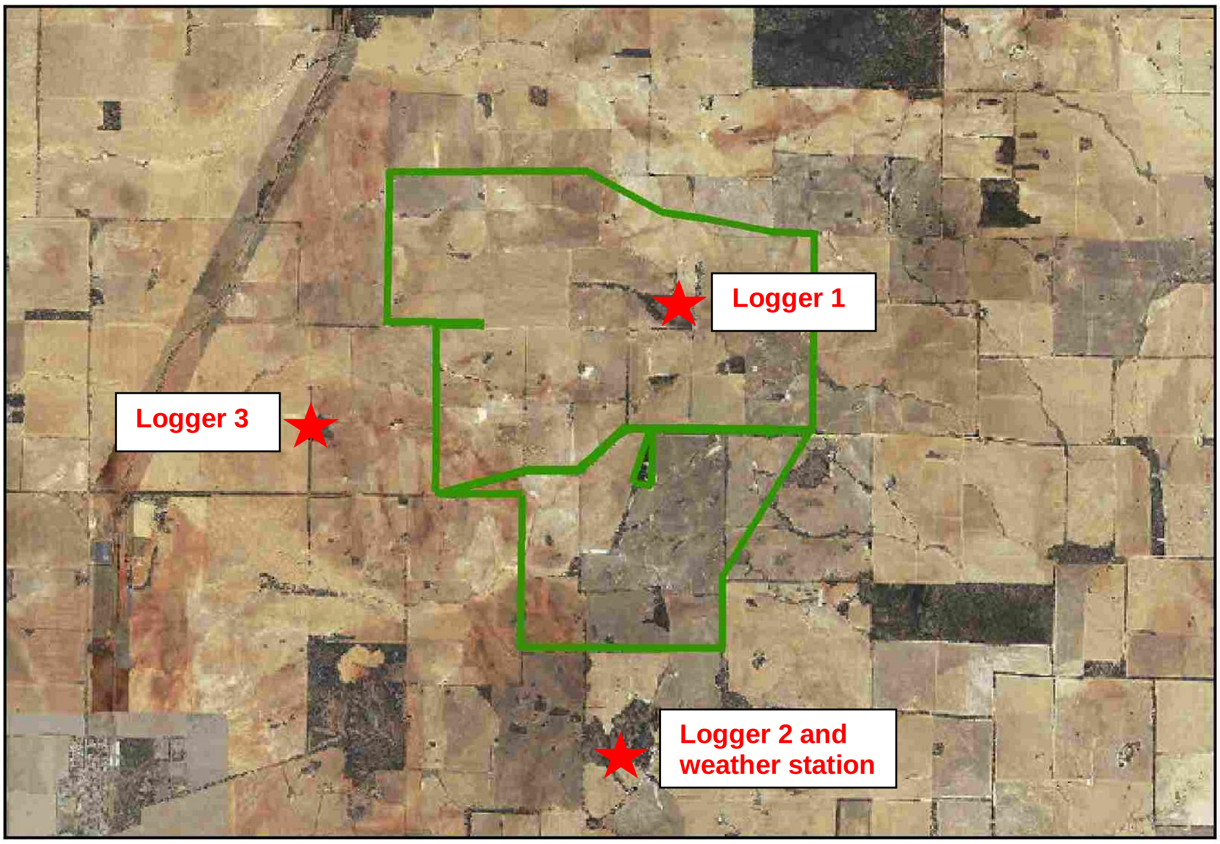

Figure 1 Background noise monitoring and weather station locations

3.1 Instrumentation

Details of the instrumentation used to record noise levels and weather parameters are provided in Appendix B. All the sound level meters used carried a current calibration certificate from a National Association of Testing Authorities (NATA) accredited laboratory and were calibrated in the field at the start and end of the measurement periods using a Class 1 acoustic calibrator. Calibration certificates for all equipment are provided in Appendix C.

The portable weather station was used to measure wind speeds and rainfall at 10 minute intervals and was synchronised with the noise monitors. The weather station was installed at 1.5 m above ground level.

4.0 Background Noise Levels and Project Noise Criteria

From the monitored noise and the measured wind speed data at 150 m hub height, regression curves were plotted and used to determine the $L_{Aeq,10}$ noise criteria for the Project at various wind speeds at the sensitive receptors. The correlation between wind speed and background noise level was calculated by least-squares regression formulae (up to third order polynomials were used as specified in the SA Guidelines). Data samples where the portable weather station recorded any rainfall or wind speeds greater than 5 m/s were discarded from the regression analysis.

The background noise levels at sensitive receptors determined using up to third order polynomials are summarised in Table 4. The regression curves and equations are presented in Appendix D.

The correlation between the measured background noise levels and hub height wind speed was generally low. This may be due to only the single SODAR device being available at the time of the measurements, which meant that the distance between the mast and the monitoring locations was large.

The noise criteria obtained from background monitoring results are presented in Table 5. These also consider the $L_{Aeq,10}$ 45 dB(A), and 35 dB(A) baseline noise criteria for Participating and Non-participating Landowners respectively (see noise criteria discussion in Section 2.0).

The noise criteria at receptors where noise monitoring was not conducted were determined from the background noise levels measured at the closest sensitive receptor where noise levels were measured.

In addition to the $L_{Aeq,10}$ noise criteria, a low frequency noise criterion of 60 dB(C) $L_{Ceq,10}$ has been applied in order to assess the potential impacts of any low frequency noise emissions.

Based on the noise criteria established with the monitored data and the conservative assessment of the wind farm layout, it is expected that the noise assessment conducted is suitable for demonstrating the Project’s ability to comply with the SA Guideline noise requirements for Development Application approval, i.e. the noise impacts have been adequately addressed.

Table 4 Background noise level, $L_{A90,10}$, obtained as per the SA Guideline

Location ID	Description	Background $L_{A90,10}$ in dB(A), measured at 1.5 m above ground level, versus wind speed (m/s) at hub height of 150 m										
		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	13 m/s	14 m/s
R05	Participating Landowner	25	25	25	26	26	26	26	26	27	27	28
R08	Participating Landowner	24	25	25	25	26	26	26	26	26	27	27
R12	Participating Landowner	25	25	26	26	26	26	26	26	26	25	25

Table 5 Noise criteria at noise sensitive receptors, $L_{Aeq,10}$

Location ID	Description	Closest measured receptor	Participating landowner?	Baseline $L_{Aeq,10}$ noise criterion dB(A)	$L_{Aeq,10}$ noise criteria in dB(A), versus wind speed (m/s) at hub height of 150 m										
					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	13 m/s	14 m/s
R01	Non-Participating Landowner	R08	N	35	35	35	35	35	35	35	35	35	35	35	35
R02	Non-Participating Landowner	R08	N	35	35	35	35	35	35	35	35	35	35	35	35
R03	Non-Participating Landowner	R08	N	35	35	35	35	35	35	35	35	35	35	35	35
R04	Non-Participating Landowner	R08	N	35	35	35	35	35	35	35	35	35	35	35	35
R05	Participating Landowner	R05	Y	45	45	45	45	45	45	45	45	45	45	45	45
R06	Non-Participating Landowner	R08	N	35	35	35	35	35	35	35	35	35	35	35	35
R07	Participating Landowner	R08	Y	45	45	45	45	45	45	45	45	45	45	45	45
R08	Participating Landowner	R08	Y	45	45	45	45	45	45	45	45	45	45	45	45
R09	Participating Landowner - Unoccupied	R12	Y	45	45	45	45	45	45	45	45	45	45	45	45
R10	Participating Landowner	R12	Y	45	45	45	45	45	45	45	45	45	45	45	45
R11	Non-Participating Landowner	R12	N	35	35	35	35	35	35	35	35	35	35	35	35
R12	Participating Landowner	R12	Y	45	45	45	45	45	45	45	45	45	45	45	45
R13	Non-Participating Landowner	R12	N	35	35	35	35	35	35	35	35	35	35	35	35
R14	Non-Participating Landowner	R12	N	35	35	35	35	35	35	35	35	35	35	35	35

5.0 Wind Farm Operational Noise Modelling

A three-dimensional computer noise model of the Project site was created in SoundPLAN Version 7.4 acoustic modelling software to predict operational noise levels for the Project. Environmental noise predictions were carried out using the algorithms from ISO 9613.2:1996 *Acoustics – Attenuation of Sound during propagation outdoors – Part 2: General method of calculation* as implemented within the SoundPLAN software package and allowed by the SA Guideline.

Results from the model are discussed in Section 6.0.

5.1 Noise Model Inputs

The following data was used to create the computer model:

- Topographical ground contours (1 metre resolution) for the wind farm site and surrounding area, received from Lacour on 8 August 2017.
- Proposed project layout containing 46 WTGs developed in December 2017. The WTGs were entered at hub height of 150 m above ground level (AGL).
- Receptor locations, received from Lacour on 5 September 2017.
- An aerial view of the Project showing the location of WTGs and sensitive receptors is provided in Appendix D.
- The following parameters were entered in the computer model, in accordance with the SA Guidelines:
  - Atmospheric conditions at 10°C temperature and 80% relative humidity.
  - 100% acoustically hard ground (G = 0.0 ground factor).
  - No barriers or intervening structures were included in the model.
  - 1.5 m receptor height.

For modelling purposes, a representative WTG has been used to demonstrate that noise compliance can be achieved. Any different turbine model, sound power level, dimension or wind farm layout built will need to comply with the noise criteria outlined in Table 5, and demonstrate this using the compliance measurement procedure outlined in Section 7.0.

The reference sound power spectra from a 2.0 MW WTG were used in the noise predictions and are presented in Figure 2. The data was corrected to correspond with integer wind speeds between 4 m/s and 14 m/s. The sound power spectra used in modelling (6.3 Hz - 16 kHz) extends beyond the minimum sound power level reporting requirement between 63 Hz to 4 kHz stated in the SA Guidelines.

No penalty for tonality was applied. The SA Wind Farm Guidelines state that:

> “Tonality is a characteristic that can increase the adverse impact of a given noise source and it can be determined by breaking the noise signature down into discrete frequency bands.
>
> If tonality is a characteristic of the WTG noise, 5 dB(A) should be added to the predicted or measured noise level from the wind farm.
>
> 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.”

It is expected that tonality would not be an audible feature at the distances separating the WTGs from the receptors; however, it will be a requirement for the manufacturer of the selected WTG model that the measured noise levels resulting from the operation of the wind farm do not exhibit tonal characteristics. It will also be required that the WTGs are properly maintained by the wind farm operator to ensure that the noise emission of the WTGs is not adversely affected by turbine wear, resulting in audible tonality. Similarly, should amplitude modulation be detected upon commissioning, the wind farm operator would be required to alter the operating parameters of some WTG to remove this effect.

Wind speed in 10m height	3	4	5	6	7	8	9	10
Wind speed in hub height	4.3	5.7	7.2	8.6	10.0	11.5	12.9	14.3
Power [kW]	153	402	808	1385	1903	1995	2000	2000
1/3 octaves	LWA	LWA	LWA	LWA	LWA	LWA	LWA	LWA
[Hz]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]
6.3	23.4	26.3	28.9	31.2	32.7	33.8	33.3	27.8
8	25.2	27.2	32.0	36.1	37.7	38.2	39.6	43.6
10	29.1	32.3	37.4	41.7	44.0	45.3	46.8	48.5
12.5	36.3	38.3	42.7	46.9	49.2	50.7	52.1	53.3
16	42.6	44.4	48.5	52.4	54.4	55.6	56.6	57.3
20	47.0	50.2	54.9	59.0	61.2	62.6	63.7	64.0
25	53.3	55.4	59.7	63.7	65.8	66.8	67.5	67.5
31.5	58.1	61.4	65.1	67.9	69.0	69.9	71.2	72.3
40	61.2	64.5	68.9	72.3	73.8	74.5	75.4	76.4
50	66.4	68.0	71.9	75.4	77.1	77.8	78.2	78.1
63	74.3	72.4	74.7	77.8	79.6	80.5	81.2	81.3
80	78.2	75.7	77.6	80.3	81.9	82.7	83.1	83.0
100	75.2	76.1	79.4	82.5	83.8	84.2	84.6	84.8
125	79.8	80.2	82.8	85.2	86.1	86.5	86.9	87.0
160	81.1	81.4	84.4	87.2	88.0	87.8	87.6	87.8
200	82.9	82.2	84.9	87.7	88.7	88.9	88.9	88.8
250	85.1	84.3	86.9	89.7	90.9	91.1	91.1	90.6
315	81.9	84.0	87.5	90.3	91.2	91.4	91.9	92.4
400	82.6	84.7	87.8	90.3	91.1	91.4	92.1	92.8
500	83.1	86.0	89.6	92.1	92.6	92.5	92.7	93.1
630	82.0	85.3	89.9	93.3	94.4	94.6	94.7	94.8
800	82.4	85.4	89.8	93.1	94.1	93.9	93.7	93.6
1000	82.1	85.7	90.5	94.1	95.1	94.9	94.5	94.1
1250	82.1	86.0	90.7	94.2	95.3	95.5	95.5	95.4
1600	81.2	85.9	90.7	93.9	94.8	94.7	94.8	94.8
2000	80.3	85.0	89.9	93.3	94.3	94.4	94.5	94.3
2500	79.8	84.2	89.1	92.6	93.7	93.7	93.7	93.8
3150	78.6	82.8	87.7	91.1	92.1	91.9	91.6	91.6
4000	77.4	80.8	85.7	89.4	90.5	90.1	89.4	89.1
5000	74.6	78.6	83.4	86.7	87.3	86.5	85.8	85.6
6300	68.7	74.1	79.5	82.9	83.6	83.0	82.5	82.3
8000	62.5	67.1	72.2	75.5	76.2	75.4	74.6	74.0
10000	55.0	59.0	63.5	66.6	67.6	67.8	68.2	68.7
12500	49.7	50.9	53.6	55.6	56.0	56.4	58.2	61.9
16000	49.7	50.9	52.8	54.3	54.7	55.3	56.7	57.7

Figure 2 WTG sound power level spectra used for the computer model

5.2 Noise Model Inputs – Substation

There are two potential substation sites – indicated as “north substation” and “south substation” in Table 6 – with power generated by the WTGs transformed in the substation to grid voltage via a 33 / 132 kV transformer.

Australian Standard AS 60076 Part 10 2009 *Power Transformers – Determination of Sound Levels* specifies applicable sound power criteria for transformers based on the transformer rating (in MVA). Whilst the MVA rating of the substation is not yet available, a conservative assumption is provided based on a 250 MVA facility, with the installation meeting the requirements of AS 60076. AS 60076 indicates that a transformer of this capacity may produce sound power levels up to 100 dB(A).

Table 6 Transformer sound power level spectra used for the computer model

Overall dB(A)	1/3 octave frequency band (Hz) noise level, in dB (linear)												
	25	**31**	**40**	**50**	**63**	**80**	**100**	**125**	**160**	**200**	**250**	**315**	**400**
100	95	97	95	96	97	96	103	92	95	106	91	98	92
	500	**630**	**800**	**1k**	**1.25k**	**1.6k**	**2k**	**2.5k**	**3.15k**	**4k**	**5k**	**6.3k**	**8k**
	98	88	85	81	81	75	77	79	79	79	76	76	71

5.3 Noise Model – Estimated Level of Accuracy

Wind farm noise is calculated according to ISO 9613-2. ISO 9613-2 predicts the equivalent continuous sound pressure level ($L_{Aeq,T}$) under meteorological conditions favourable to propagation from sources of known sound emission. These conditions are for downwind propagation, or equivalently, propagation under a moderate ground-based temperature inversion, such as commonly occurs at night, i.e. stable atmospheric conditions.

The Standard states that for receptors between 100 m and 1 km from the source and where the average height of the source and receiver is between 5 - 30 m, the estimated accuracy of the predictions is +/- 3dB. However outside of these conditions the Standard does not provide any indication of accuracy. Nevertheless ISO 9613-2 is widely used to predict noise levels from WTGs and provided appropriate assumptions are made, then realistic estimates of wind turbine noise can be determined.

A number of comparative studies have taken place which assess the reliability of wind turbine noise calculations using ISO 9613-2 when compared with actual field survey results. A recent study was carried out and reported by Hoare Lea Acoustics and concluded that:

> *’The results of the study of noise emissions from large operating windfarm sites have supported the view that engineering methods such as ISO 9613 offer a robust means of determining the upper turbine immission levels that may occur in practice under favourable, downwind propagation conditions.’*

6.0 Wind Farm Operational Noise Impacts

6.1 Wind turbine noise

Table 7 presents the results from the noise compliance assessment for the proposed WTG layout, during operation. These predicted outdoor noise levels were obtained through computational noise modelling, as outlined in Section 5.0. The noise levels presented are free field $L_{Aeq,10}$ noise levels at the receptors, and have been assessed against the stringent noise criteria of 45 dB(A) and 35 dB(A) for Participating and Non-participating landowners, respectively, and against the background-noise-based criteria described in Table 5 (which have not resulted in adjustments to the baseline criteria being applied).

The noise predictions comply with the Project $L_{Aeq,10}$ noise criteria at all receptors with the conservative baseline noise criteria and the noise contours are shown graphically in Figures 5 to 15 of Appendix G.

Table 8 also presents the low frequency noise compliance assessment for the WTG layout. The noise levels presented in the table are free-field $L_{Ceq,10}$ noise levels at the receptors, assessed against a 60 dB(C) night-time criterion. The noise predictions comply with this noise criteria at all receptors and the 60 dB(C) noise contour is shown graphically in Figure 16 of Appendix G.

As described above in Section 5.1, it is expected that tonality would not be an audible feature at the distances separating the WTGs from the receptors. Nevertheless, the predicted noise levels at the relevant receivers have been assessed against the IEC 61400−11 test for tonality, and no tonality was identified at any receiver.

It is noted that the noise contour maps given in Appendix G are indicative only; these are generated based on a grid of calculations which are interpolated to generate the contours. Single point calculations shown in Table 7 and Table 8 should be referred to for specific levels at each receptor.

The final project design may change the positions of the WTGs due to micrositing and the project may be built in stages. In addition the make, model of WTG is likely to be different and the power rating and dimensions of the wind turbine is likely to be different (larger or smaller) and therefore the sound power level spectra are likely to be different (either higher or lower). This assessment has been undertaken using a representative WTG to reflect the project application. The final project design or stage design, together with make and model of WTG used for the project or stage (including guaranteed sound power levels), will be assessed against noise criteria outlined in Table 5 and will demonstrate this using the compliance measurement procedure outlined in Section 7.0.

Table 7 Noise compliance assessment. $L_{Aeq,10}$ noise prediction of WTG noise emission assessed against the 150 m hub height wind speed noise criteria

Location ID	Description	Closest measured receptor	Participating landowner?	Baseline $L_{Aeq,10}$ noise limit dB(A)	Predicted noise levels, $L_{Aeq,10}$ versus wind speed (m/s) at hub height of 150 m											Comply
					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	13 m/s	14 m/s	
R01	Non-Participating Landowner	R08	N	35	14	12	13	15	17	19	20	20	20	20	20	YES
R02	Non-Participating Landowner	R08	N	35	23	21	23	25	27	29	29	29	30	30	30	YES
R03	Non-Participating Landowner	R08	N	35	26	25	27	29	31	33	33	33	33	34	34	YES
R04	Non-Participating Landowner	R08	N	35	18	17	18	20	23	24	25	25	25	25	25	YES
R05	Participating Landowner	R05	Y	45	32	31	33	36	38	40	40	40	40	41	41	YES
R06	Non-Participating Landowner	R08	N	35	21	20	21	23	26	27	28	28	28	28	28	YES
R07	Participating Landowner	R08	Y	45	12	11	12	14	16	18	18	19	19	19	19	YES
R08	Participating Landowner	R08	Y	45	23	22	24	27	29	30	31	31	31	31	31	YES
R09	Participating Landowner - Unoccupied	R12	Y	45	28	27	29	32	34	35	36	36	36	36	36	YES
R10	Participating Landowner	R12	Y	45	18	17	18	21	23	24	25	25	25	25	25	YES
R11	Non-Participating Landowner	R12	N	35	21	20	21	23	25	27	27	28	28	28	28	YES
R12	Participating Landowner	R12	Y	45	25	25	27	29	32	33	34	34	34	34	34	YES
R13	Non-Participating Landowner	R12	N	35	19	17	19	21	23	25	25	25	26	26	26	YES
R14	Non-Participating Landowner	R12	N	35	14	12	13	15	17	19	19	20	20	20	20	YES

Table 8 Noise compliance assessment. $L_{Ceq,10}$ noise prediction of WTG noise emission assessed against a 60 dB(C) night-time noise criterion.

Location ID	Description	Closest measured receptor	Participating landowner?	Noise criterion, dB(C)	Predicted $L_{Ceq,10}$ noise level, dB(C) versus wind speed (m/s) at hub height of 150 m											Complies ?
					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	13 m/s	14 m/s	
R01	Non-Participating Landowner	R08	N	60	34	32	34	37	39	41	42	43	43	44	44	YES
R02	Non-Participating Landowner	R08	N	60	41	40	41	44	46	48	49	50	50	51	51	YES
R03	Non-Participating Landowner	R08	N	60	44	42	44	46	48	50	51	52	53	53	53	YES
R04	Non-Participating Landowner	R08	N	60	37	35	37	39	42	44	45	46	46	47	47	YES
R05	Participating Landowner	R05	Y	60	47	46	47	50	52	54	55	56	56	56	57	YES
R06	Non-Participating Landowner	R08	N	60	40	38	40	42	45	47	48	48	49	49	50	YES
R07	Participating Landowner	R08	Y	60	32	31	33	35	38	40	41	41	42	42	43	YES
R08	Participating Landowner	R08	Y	60	40	38	40	42	45	46	47	48	49	49	49	YES
R09	Participating Landowner - Unoccupied	R12	Y	60	45	43	45	48	50	52	53	54	54	55	55	YES
R10	Participating Landowner	R12	Y	60	36	35	36	39	41	43	44	45	45	46	46	YES
R11	Non-Participating Landowner	R12	N	60	40	38	40	42	45	46	48	48	49	49	50	YES
R12	Participating Landowner	R12	Y	60	41	39	41	44	46	48	49	49	50	50	51	YES
R13	Non-Participating Landowner	R12	N	60	37	36	37	40	42	44	45	46	46	47	47	YES
R14	Non-Participating Landowner	R12	N	60	35	33	35	38	40	42	43	44	44	45	45	YES

6.2 Substation Noise

The predicted noise level at all receivers in the vicinity of the Project from the proposed southern substation is less than 20 dB(A), which is well below ambient background noise levels. The predicted noise level at all receivers in the vicinity of the Project from the proposed northern substation is less than 25 dB(A), which is at or below ambient background noise levels. The noise contours for the northern and southern substations are shown graphically in Figures 1 and 2 of Appendix G.

Taking into account the potential for tonality, as is normally the case for transformers (and has been identified in the data in Table 6), the predicted noise levels from the proposed substations are well below the 35 dB(A) environmental noise criterion.

6.3 Cumulative Impacts

No new or proposed developments have been identified within the Project's Study Area which are likely to result in combined or successive noise impacts with the Project. Cumulative noise impacts to sensitive receptors are therefore considered to be unlikely.

7.0 Wind Farm Noise Compliance Measurements

Compliance noise measurements should be undertaken at a number of the sensitive receptors adjacent to the Project site once the wind farm is operational to demonstrate that compliance with the relevant criteria has been achieved.

The SA Guideline provides a methodology for conducting compliance noise measurements on wind farms. The procedure to be followed is given in Figure 2 of the document, and is reproduced below:

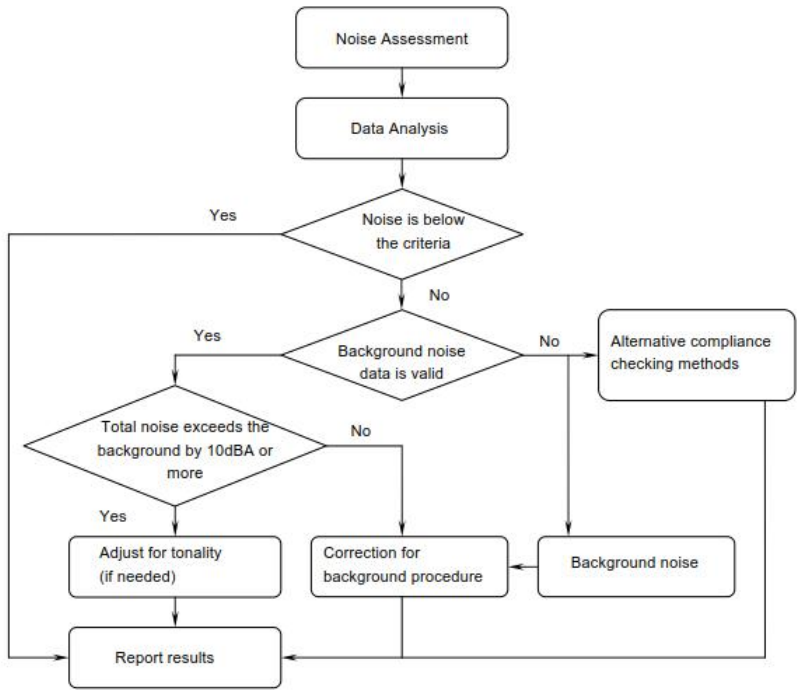

Figure 3 Compliance checking flow chart

Wind farm noise compliance measurements follow a similar procedure to background noise monitoring as described in Section 3.0. The $L_{A90,10}$ is measured with the wind farm operating at relevant receiver locations, over continuous 10-minute intervals and over at least the range of wind speeds from the cut-in speed to the speed of the rated power of the WTGs. The data must cover not less than 2,000 intervals where at least 500 pairs of data correspond to the worst case wind direction.

If data adjusted for tonality (if needed) is below the criteria it should be reported as such and no further data analysis or additional noise measurements are required.

Otherwise, a regression analysis using the same polynomial order as per the original background noise analysis should be undertaken. Ideally, the contribution from the wind farm alone should be calculated by logarithmically subtracting the background noise levels measured previously from the compliance noise measurements, and these wind-farm-only noise levels compared against the criteria.

Reference should be made to Section 4 of the SA Guidelines for details of the compliance assessment required.

Testing should be undertaken once all noise sources associated with the Project are in operating mode, i.e. all WTGs have been commissioned and are operating correctly.

8.0 Wind Farm Construction Noise and Vibration Impacts

This section addresses the potential noise and vibration impacts related to the construction of the Project.

8.1 Construction Activities

This section addresses construction noise and vibration in general terms. Specific details of the construction methodology and equipment are not known at this early stage of the Project.

It is anticipated that the construction work may include excavation, rock hammering, drilling, bulldozing, crushing and screening, concrete batching and, subject to geotechnical conditions, possible blasting.

Noise will be generated by mobile plant such as excavators, bulldozers, mobile cranes and the movement of heavy vehicles. It is expected that the following typical equipment will be used:

- Excavators
- Tracked bulldozers
- Semi-trailers
- Tractors
- Mobile cranes
- Concrete trucks.

A Construction Environmental Management Plan (CEMP) will be developed prior to construction, which will contain information to manage possible noise and vibration impacts from construction, following an objective assessment of construction noise and vibration.

8.2 Construction Phase Noise Criteria

There is no legislation in Western Australia which specifically sets construction noise limits. In Western Australia, under the EPNR, the noise from construction sites is exempt from assessment against the environmental noise criteria as described in Table 5 if the works are carried out between 7am and 7pm on any day which is not a Sunday or public holiday, and if the occupier of the site shows that:

(a) the construction work was carried out in accordance with control of environmental noise practices set out in section 4 of AS 2436 2010 *Guide to noise and vibration control on construction, maintenance and demolition sites*; and

(b) the equipment used on the premises was the quietest reasonably available; and

(c) if the occupier was required to prepare a noise management plan in respect of the construction site:

  (i) the noise management plan was prepared and given in accordance with the requirement, and approved by the CEO; and

  (ii) the construction work was carried out in accordance with the noise management plan, excluding any ancillary measure;

and

(d) if the occupier was required to prepare a noise management plan :

  (i) the noise management plan was prepared and given in accordance with the requirement, and approved by the CEO; and

  (ii) the construction work was carried out in accordance with the noise management plan, excluding any ancillary measure.

Under special circumstances, construction work may be carried out outside the permitted hours.

Thus, noise from construction activity is generally controlled through limiting the hours of operation, and through application of best practice management techniques.

The AS 2436 2010 *Guide to noise and vibration control on construction, maintenance and demolition sites* does not provide construction noise criteria or targets; rather, it presents a framework through which construction noise can best be managed and mitigated. A number of 'good practice' mitigation measures have been outlined below to reduce and manage potential noise and vibration impacts associated with the construction of the Project and to minimise the likelihood of adverse comment from nearby residents.

- Management of construction hours to avoid or minimise noise impacts to nearby residents.
- Limitation of construction hours for noisy activities to Monday to Saturday where practicable.
- Construction work out-of-hours to be assessed on a case-by-case basis and the work programme to be assessed against the potential noise impact on nearest residences.
- A Construction Environmental Management Plan (CEMP) will outline the recommended hours of work, and will include the management of noise and vibration, the Out of Hours Work (OOHW) Protocol and acoustic mitigation measures to be implemented.
- An Out of Hours Work (OOHW) Protocol will be developed for the assessment, management and approval of works outside the approved hours for construction.

  A key feature of this Protocol is considering the need and justification for any OOHW. This is the first step of the OOHW Protocol and will occur prior to any impacts being assessed. Where possible, OOHW will be avoided and scheduled to occur during the approved hours for construction. Where OOHW is needed for the safe and efficient implementation of the Project, or due to exceptional circumstances such as the need to align with favourable weather, the potential level of impact of the OOHW will be considered.

In the event that blasting is required, noise from this would be assessed against the airblast noise objectives outlined in the Australian and New Zealand Environment Council (ANZEC) Guidelines – *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration*. These guidelines provide the following criteria:

- Less than or equal to 115 dB (linear) peak for 95 per cent of total blasts over 12 months.
- Less than 120 dB (linear) peak for any blasts.

8.3 Construction Vibration Guideline – Human Response to Vibration

To assess perceptible vibration to humans, the use of vibration criteria from the Australian Standard AS 2670.2 - 1990 *Evaluation of human exposure to whole-body vibration - Part 2: Continuous and shock induced vibration in buildings (1 to 80 Hz)* should be used.

These criteria are summarised in Table 9. Both continuous and intermittent vibrations are assessed. Construction equipment and construction activities as outlined in Section 8.1 will typically operate between 7am and 7pm, Monday to Saturday. Accordingly only the daytime criterion is shown. Where out-of-hours construction is proposed, the OOHW Protocol will be followed which may include consultation with surrounding residences, if they are likely to be impacted.

Table 9 AS 2670.2 Extract - Human Comfort Vibration Limits (8Hz to 80Hz)

Space occupancy	Time of day	Peak vibration levels in mm/s over the frequency range 8 Hz to 80 Hz likely to cause "adverse comment"			
		Continuous vibration		Intermittent vibration and impulsive vibration excitation with several occurrences per day	
		Vertical	Horizontal	Vertical	Horizontal
Residential	Day	0.6 mm/s	1.6 mm/s	12.6 mm/s	36 mm/s
Workshops	Day	1.2 mm/s	3.2 mm/s	18 mm/s	51 mm/s

8.4 Construction Vibration Guideline – Structural Response to Vibration

International standards exist for vibration-induced damage to structures, and these can provide guidance on acceptable vibration limits. These documents are commonly used to assess structural response to vibration throughout Australia.

German Standard DIN 4150 *Structural vibration - Effects of vibration on structures*, British Standard BS 5228 Part 4 *Noise and vibration control on construction and open sites. Code of practice for noise and vibration control applicable to piling operations* and BS 7385 Part 2 *Evaluation and measurement for vibration in buildings. Guide to damage levels from groundborne vibration* recommend vibration criteria relating to potential structural damage to buildings. These standards are considered to be industry standard in Australia. The criteria from the standards, in Peak Particle Velocity (PPV), are summarised in Table 10 and Table 11.

Table 10 DIN 4150 vibration criteria, in PPV (mm/s)

Line	Structure type	Guideline vibration values			
		Vibration at foundation			
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	Vibration at horizontal plane of highest floor at all frequencies
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design or occupancy	5	5 to 15	15 to 20	15
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 or 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10	8

Table 11 BS 5228-4 Criteria, in PPV (mm/s)

Structure	Intermittent			Continuous		
	<10 Hz	10-50 Hz	> 50 Hz	<10 Hz	10-50 Hz	> 50 Hz
Soundly constructed residential properties	5	10	20	2.5	5	10
Industrial and commercial – light	10	20	40	5	10	20
Industrial and commercial – heavy	15	30	60	7.5	15	30

The criteria in BS 5228-4 are generally more stringent than those in DIN 4150. It is recommended that the Project adopts an objective of complying with the intermittent vibration levels specified in BS 5228-4 (i.e. Table 11), with the levels specified in DIN 4150 (i.e. Table 10) being considered upper limits.

8.5 Construction Vibration Guideline – Blasting

The blast vibration criteria identified in the ANZEC are considered conservative and were originally developed to protect communities exposed to long-term blasting operations such as mining sites. For projects such as this, with a shorter duration of blasting (if any), a higher vibration criterion may be reasonable.

Table J4.5(A) in Appendix H of AS2187.2 presents vibration limits designed to safeguard human comfort in relation to blasting which have been used by some authorities, as it defines clearer vibration limits which are dependent on the specific duration of the project. Based on the limitations of the ANZEC guideline and further guidance in AS2187.2, a human comfort vibration limit of 10 millimetres per second (peak particle velocity) for blasting operations lasing less than 12 months has been adopted for this project.

Table 12 Blasting ground vibration criteria summary

Category	Human comfort	Structural damage[1]
Sensitive structures (e.g. residential, theatres, schools etc.)	5 mm/s for 95% blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply[2]	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Occupied non-sensitive structures of reinforced concrete or steel construction (e.g. factories and commercial premises)	25 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacture's specifications or levels that can be shown to adversely affect the equipment operation.	50 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply*
Occupied non-sensitive structures that include masonry, plaster and plasterboard in their construction (e.g. factories and commercial premises)	25 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacture's specifications or levels that can be shown to adversely affect the equipment operation.	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Unoccupied non-sensitive structures of reinforced concrete or steel construction (e.g. factories and commercial premises)	N/A	50 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply[2]
Unoccupied non-sensitive structures that include masonry, plaster and plasterboard in their construction	N/A	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Services structures, such as pipelines, powerlines and cables	N/A	Limit to be determined by structural design methodology. Special consideration may be required for high pressure gas pipelines.

Note 1: The values above are less stringent than those in DIN4150 . This is because DIN4150 considers resonance in buildings from continuous vibration. Due to the short duration of blasting events the propensity for resonance within buildings is minimal, giving rise to higher criteria.

Note 2: The blast vibration criteria identified in the ANZEC are considered conservative and were originally developed to protect communities exposed to long-term blasting operations such as mining sites. For projects such as this, with a shorter duration of blasting, a higher vibration criterion may be reasonable.

The measurement of vibration should be taken at any point on ‘noise sensitive sites’ which is at least the longest dimension of the foundation of a building or structure away from such buildings or structure.

8.6 Construction Vibration Criteria Summary

The BS 5228-4 criteria for intermittent vibration in “Soundly constructed residential properties” apply to the construction area and will be used as the construction vibration guidelines for this Project.

Table 13 BS 5228-4 Criteria, in PPV (mm/s)

Structure	Intermittent		
	<10 Hz	10-50 Hz	> 50 Hz
Soundly constructed residential properties	5	10	20

A summary of the vibration criterion in relation to human comfort is given below in Table 14.

Table 14 AS 2670.2 Extract - Human Comfort Vibration Limits (8Hz to 80Hz)

Space Occupancy	Time of Day	Peak Vibration Levels in mm/s over the frequency range 8 Hz to 80Hz likely to cause “adverse comment”			
		Continuous vibration		Intermittent vibration and impulsive vibration excitation with several occurrences per day	
		Vertical	Horizontal	Vertical	Horizontal
Residential	Day	0.6 mm/s	1.6 mm/s	12.6 mm/s	36 mm/s
Workshops	Day	1.2 mm/s	3.2 mm/s	18 mm/s	51 mm/s

8.7 Proposed Mitigation Options: Construction Noise and Vibration

The potential exists for noise impacts to surrounding residents during the construction of the Project. Appropriate techniques may need to be implemented to minimise these impacts and the CEMP will outline these measures.

8.7.1 Noise Mitigation Measures

In general, noise emissions from construction plant can be reduced by fitting exhaust mufflers, using reversing alarms that emit a broadband noise (e.g. white noise) rather than a beep, maintaining plant in good working order and following industry standard construction methodologies.

To minimise the impacts of construction noise, the CEMP will outline the proposed methodology and monitoring procedures to be put in place for the duration of the works. The CEMP may incorporate some or all of the following noise mitigations:

- Community Noise Consultation
  - Regular consultation with residents to provide details of the construction plan and duration of predicted construction noise. For example, advising residents of the duration and activities they can expect.
  - Advanced notice of road works.

  - Advise local councils, particularly the Shire of Kondinin, of planned construction works to assist in complaint management.
  - Preparation of a noise complaints procedure and register.
- Site Management
  - Limit construction hours to Monday to Saturday, 7am to 7pm, where it is practicable to do so. Construction activities undertaken outside of these hours are to be minimised, and should be subject to an OOHW Protocol.
  - The contractor should keep residents informed of when noisy construction works will occur near their houses.
  - Where practicable, maintain and repair local roads during the construction of the Project to minimise the effect of heavy vehicle movements.
  - Vehicles and plant should not be left idling unnecessarily.
  - All engine exhausts should be fitted with suitable and well maintained mufflers/silencers.
  - Care should be taken not to drop materials to cause peak noise events, including materials from a height into a truck.
  - Machines which are used intermittently should be shut down in the intervening periods between works, or throttled down to a minimum.
  - The reversing of vehicles should be minimised to reduce the noise from reversing signals.
  - Vehicle warning devices such as horns should not generally be used as signalling devices.
  - Worksite induction training should be implemented, educating staff on noise sensitive issues and the need to make as little noise as possible near surrounding residences.
  - Workers should avoid shouting and whistling near surrounding residences.
  - When work is complete, the noise of packing up plant and equipment and departing from the site should be minimised.
- Equipment Management
  - Selection of low noise plant and equipment, as appropriate.
  - Equipment should be well maintained and fitted with adequately maintained mufflers/silencers which meet the equipment design specifications.
  - Silencers and enclosures should be kept intact; rotating plant should be balanced, loose bolts tightened, frictional noise reduced through lubrication and cutting noise reduced by keeping equipment sharp.
  - Only necessary power should be used to complete the task.
  - Only necessary equipment should be on site.
  - Loaders and bobcats fitted with articulated buckets should be rubber lined at the contact points to ensure that noise levels are minimised during the release of materials, where practicable, when working near noise sensitive land uses.
  - Resonance should be avoided where possible e.g. changing the speed of machines.
  - Traffic controllers should be used to prevent vehicles and equipment queuing, idling or reversing near sensitive land uses.
  - Blasting (if required) would need to be managed in accordance with blasting guidelines to minimise disturbance, and would only occur during normal working hours.
- Noise Monitoring
  - Monitoring of construction noise levels should be undertaken in response to complaints where this is considered an appropriate response.

    - Airblast monitoring would be undertaken during each blast, in accordance with blasting guidelines outlined within ANZEC.

8.7.2 Vibration Mitigation Measures

Based on typical levels of vibration from construction activities, it is expected that dwelling occupants at distances of 200 metres and greater from the works area would not be able to perceive construction vibration; much less would the buildings themselves likely experience vibration levels resulting in damage. Where adverse comment specifically arising from vibration is received after the commencement of construction, it is recommended that the following measures be considered:

- Vibration levels be measured.
- If high levels are recorded:
    - Increasing the distance between offending plant or equipment and the point of complaint.
    - Replacing offending plant or equipment with equipment which does not generate high levels of vibration.
    - Building structure surveys.

Vibration monitoring from any blasting activities would be undertaken during each blast, in accordance with blasting guidelines outlined within ANZEC.

9.0 Summary

A noise impact assessment has been conducted for the operation of the Project in general accordance with the requirements of the South Australian EPA's *Wind farms – Environmental noise guidelines – July 2009* for the WTGs and the Western Australian *Environmental Protection (Noise) Regulations 1997* (EPNR) for fixed infrastructure including the substation.

An environmental noise model of the site was created to predict noise levels at the nearest sensitive receptors to the Project. The noise predictions comply with the Project noise criteria at all receptors with the conservative baseline noise criteria. The low-frequency L_{Ceq} 60 dB(C) is predicted to be achieved at all residential receiver locations.

It will be required that the WTGs are properly maintained by the wind farm operator to ensure that the noise emission of the WTGs is not adversely affected by WTG wear, potentially resulting in audible tonality. Similarly, should amplitude modulation be detected upon commissioning, the wind farm operator would be required to alter the operating parameters of some WTGs to remove this effect.

Compliance measurements should be undertaken at a selected number of potentially most affected sensitive receptors following the commissioning of the Project in accordance with the procedure outlined in the SA Guidelines. Testing should be undertaken once all noise sources associated with the Project are in operating mode, i.e. all WTGs have been commissioned and are operating correctly.

Construction noise and vibration, including from potential blasting activities, has also been considered. Guideline noise and vibration limits for both human comfort and building damage have been provided. Mitigation measures include community consultation, management of construction hours to within 7am to 7pm Monday to Saturday, and monitoring programmes.

Appendix A

Acoustic Terminology

Appendix A Acoustic Terminology

'A' Weighted	Frequency filter applied to measured noise levels to represent the way in which humans hear sounds.
Ambient Noise	Total noise at a site comprising all sources such as industry, traffic, domestic, and natural noises.
Attended Measurement	Measurements which are attended by a person and measured with a sound level meter.
dB(A)	'A' Weighted overall sound pressure level.
dB(G)	The G-weighting for the determination of weighted sound pressure levels of sound or noise, whose spectrum lies partly or wholly within the frequency range from 1 Hz to 20 Hz, has been standardised in ISO 7196, (1995). G-weighted sound pressure levels are denoted L_{pG} and are measured or estimated in dB(G)
Frequency	The number of cycles per second, where 1 cycle per second is equal to 1Hz. The human ear responds to sounds of frequency 20 Hz to 20,000 Hz.
Impulsiveness	Noise that comprises distinct impulses in the noise (bangs, clicks, clatters, or thumps) etc.
Intermittent	Stopping and starting at irregular intervals.
L_{Aeq}	The 'A' Weighted energy-averaged noise level over the measurement period.
$L_{Aeq,10}$	The energy-averaged level of the total noise measured without adjustment for the character of the noise (e.g. tonal or impulsive), over a period of 10 minutes.
L_{max}	Maximum noise level of the measurement period.
$L_{90,10}$	Noise level exceeded for 90% of the measurement period, measured over a period of 10 minutes. This represents the background noise level, excluding nearby sources.
$L_{w(A)}$	'A' Weighted sound power level, measured in dB(A). The sound power level is a measure of the total acoustic energy produced by a source and is independent of distance and source location. The sound power level is expressed as a ratio against a reference level of 10^{-12} watts.
Least-squares regression	The method for finding a line which summarises the relationship between two parameters, e.g. wind speed and measured noise level.
Tonality	A characteristic of noise, describing a sound that contains a perceptible pitch or tone. As a general rule, a prominent tonal component may be detected in one-third octave spectra if the level of a one-third octave band exceeds the level of the adjacent bands by 5 dB or more.
Unattended Measurement	Measurements that are taken by an unattended noise logger at a given location.

Appendix B

Noise Monitoring Instrumentation Details

Appendix B Noise Monitoring Instrumentation Details

Details of the sound level instrumentation used to record noise levels at the three residential locations are presented in Table 15. Class 1 sound level meters were used to measure noise at all sites. These instruments were calibrated in the field at the start and end of the measurement periods using a Class 1 acoustic calibrator.

No field calibration drift greater than 0.5 dB was observed in all monitors, as required by the SA Guideline.

All the acoustic instrumentation employed during the noise measurements comply with the requirements of Australian Standard *AS IEC 61672.1-2004 Electroacoustics - Sound level meters – Part 1: Specifications*.

All the instrumentation used in monitoring carried a current calibration certificate from a National Association of Testing Authorities (NATA) accredited laboratory at the time of measurement.

In addition, a Vaisala WXT520 portable weather station was used to measure wind speeds and rain fall. The weather station was installed at 2.0 m above ground level. Details are presented in Table 15.

It is noted that the SA Guideline states that suitable wind shields should be installed such that the reported noise levels are not influenced by high wind speeds across the microphone – specifically where wind speeds recorded are greater than 5 m/s.

In the event that manufacturer’s data for the microphone windshield performance is not available (as is the case for the equipment utilised in this background noise monitoring survey), then measured noise levels at local wind speeds of greater than 5 m/s should be discarded.

Table 15 Noise measurement equipment details

Noise monitoring location (Receptor ID)	Calibration Information				
	Equipment make & model	Serial number	NATA calibration date at time of measurement	Measurement start	Measurement stop
Logger 1 – Receiver R05	ARL Ngara	87817B	20-10-2016	25-8-2017	8-9-2017
Logger 2 – Receiver R13	ARL Ngara	878179	20-10-2016	25-8-2017	8-9-2017
Logger 3 – Receiver R08	ARL Ngara	87817F	20-10-2016	25-8-2017	8-9-2017
Logger 1 – Receiver R05	Pulsar 105 Acoustic Calibrator	78229	20-10-2016	Used to calibrate the ARL Nagara 87817B at installation and retrieval	
Logger 2 – Receiver R13	Pulsar 105 Acoustic Calibrator	78354	20-10-2016	Used to calibrate the ARL Nagara 878179 at installation and retrieval	
Logger 3 – Receiver R08	Pulsar 105 Acoustic Calibrator	77513	20-10-2016	Used to calibrate the ARL Nagara 87817F at installation and retrieval	

Table 16 Ground-level weather monitoring equipment details

Noise monitoring location (Receptor ID)	Calibration Information				
	Equipment make & model	Serial number	NATA calibration date at time of measurement	Measurement start	Measurement stop
Receiver R13	Vaisala WXT520 Pro	M4350255	28-11-2016	25-8-2017	8-9-2017

Appendix C

Noise Monitoring Instrumentation Calibration Certificates

Appendix C Noise Monitoring Instrumentation Calibration Certificates

Acoustic Research Labs Pty Ltd
Level 7 Building 2 423 Pennant Hills Rd
Pennant Hills NSW AUSTRALIA 2120
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Sound Calibrator

IEC 60942-2004

Calibration Certificate

Calibration Number C16591

Client Details TR Pty Ltd
18 Joseph Street
BLACKBURN NORTH VIC 3130

Equipment Tested/ Model Number : Pulsar 105
Instrument Serial Number : 78229

Atmospheric Conditions
Ambient Temperature : 22.8°C
Relative Humidity : 39.9%
Barometric Pressure : 99.88kPa

Calibration Technician : Vicky Jaiswal
Calibration Date : 20/10/2016
Secondary Check: Aaron Skeates-Udy
Report Issue Date : 20/10/2016

Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
5.2.2: Generated Sound Pressure Level	*Pass*	5.3.2: Frequency Generated	*Pass*
5.2.3: Short Term Fluctuation	*Pass*	5.5: Total Distortion	*Pass*

	Nominal Level	Nominal Frequency	Measured Level	Measured Frequency
Measured Output	94.0	1000.0	94.2	1000.41

The sound calibrator has been shown to conform to the class 1 requirements for periodic testing, described in Annex B of IEC 60942:2004 for the sound pressure level(s) and frequency(ies) stated, for the environmental conditions under which the tests were performed..

Least Uncertainties of Measurement -

Specific Tests		Environmental Conditions	
Generated SPL	*±0.09dB*	*Temperature*	*±0.05°C*
Short Term Fluct.	*±0.02dB*	*Relative Humidity*	*±0.46%*
Frequency	*±0.01%*	*Barometric Pressure*	*±0.017kPa*
Distortion	*±0.5%*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

NATA
WORLD RECOGNISED ACCREDITATION

This calibration certificate is to be read in conjunction with the calibration test report.

Acoustic Research Labs Pty Ltd is NATA Accredited Laboratory Number 14172.
Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/National standards.

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Sound Level Meter

IEC 61672-3.2006

Calibration Certificate

Calibration Number C16592

Client Details TR Pty Ltd
18 Joseph Street
BLACKBURN NORTH VIC 3130

Equipment Tested/ Model Number : ARL Ngara
Instrument Serial Number : 87817B
Microphone Serial Number : 321887
Pre-amplifier Serial Number : 28378

Pre-Test Atmospheric Conditions		**Post-Test Atmospheric Conditions**	
Ambient Temperature :	21.8°C	**Ambient Temperature :**	22.4°C
Relative Humidity :	42.4%	**Relative Humidity :**	41.4%
Barometric Pressure :	99.98kPa	**Barometric Pressure :**	99.94kPa

Calibration Technician : Vicky Jaiswal
Calibration Date : 20/10/2016
Secondary Check: Aaron Skeates-Udy
Report Issue Date : 20/10/2016

Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
10: Self-generated noise	*Pass*	14: Level linearity on the reference level range	*Pass*
11: Acoustical tests of a frequency weighting	*Pass*	15: Level linearity incl. the level range control	*Pass*
12: Electrical tests of frequency weightings	*Pass*	16: Toneburst response	*Pass*
13: Frequency and time weightings at 1 kHz	*Pass*	17: Peak C sound level	*Pass*
		18: Overload Indication	*Pass*

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2006, for the environmental conditions under which the tests were performed.

However, no general statement or conclusion can be made about conformance of the sound level meter to the full requirements of IEC 61672-1:2002 because evidence was not publicly available, from an independent testing organisation responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2002 and because the periodic tests of IEC 61672-3:2006 cover only a limited subset of the specifications in IEC 61672-1:2002.

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
31.5 Hz to 8kHz	*±0.12dB*	*Temperature*	*±0.05°C*
12.5kHz	*±0.18dB*	*Relative Humidity*	*±0.46%*
16kHz	*±0.31dB*	*Barometric Pressure*	*±0.017kPa*
Electrical Tests			
31.5 Hz to 20 kHz	*±0.12dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

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Sound Calibrator

IEC 60942-2004

Calibration Certificate

Calibration Number C16596

Client Details TR Pty Ltd
18 Joseph Street
BLACKBURN NORTH VIC 3130

Equipment Tested/ Model Number : Pulsar 105
Instrument Serial Number : 78354

Atmospheric Conditions
Ambient Temperature : 22.6°C
Relative Humidity : 40.4%
Barometric Pressure : 99.88kPa

Calibration Technician : Vicky Jaiswal
Calibration Date : 20/10/2016
Secondary Check: Aaron Skeates-Udy
Report Issue Date : 20/10/2016

Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
5.2.2: Generated Sound Pressure Level	*Pass*	5.3.2: Frequency Generated	*Pass*
5.2.3: Short Term Fluctuation	*Pass*	5.5: Total Distortion	*Pass*

	Nominal Level	Nominal Frequency	Measured Level	Measured Frequency
Measured Output	94.0	1000.0	94.1	1000.37

The sound calibrator has been shown to conform to the class 1 requirements for periodic testing, described in Annex B of IEC 60942:2004 for the sound pressure level(s) and frequency(ies) stated, for the environmental conditions under which the tests were performed..

Least Uncertainties of Measurement -

Specific Tests		Environmental Conditions	
Generated SPL	*±0.09dB*	*Temperature*	*±0.05°C*
Short Term Fluct.	*±0.02dB*	*Relative Humidity*	*±0.46%*
Frequency	*±0.01%*	*Barometric Pressure*	*±0.017kPa*
Distortion	*±0.5%*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

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Sound Level Meter
IEC 61672-3.2006
Calibration Certificate

Calibration Number C16589

Client Details TR Pty Ltd
18 Joseph Street
BLACKBURN NORTH VIC 3130

Equipment Tested/ Model Number : ARL Ngara
Instrument Serial Number : 878179
Microphone Serial Number : 321886
Pre-amplifier Serial Number : 28381

Pre-Test Atmospheric Conditions		**Post-Test Atmospheric Conditions**	
Ambient Temperature :	21.6°C	**Ambient Temperature :**	21.4°C
Relative Humidity :	41.4%	**Relative Humidity :**	39.8%
Barometric Pressure :	100.25kPa	**Barometric Pressure :**	100.2kPa

Calibration Technician : Vicky Jaiswal
Calibration Date : 20/10/2016
Secondary Check: Sandra Minto
Report Issue Date : 20/10/2016

Approved Signatory : [signature] Ken Williams

Clause and Characteristic Tested	**Result**	**Clause and Characteristic Tested**	**Result**
10: Self-generated noise	*Pass*	14: Level linearity on the reference level range	*Pass*
11: Acoustical tests of a frequency weighting	*Pass*	15: Level linearity incl. the level range control	*Pass*
12: Electrical tests of frequency weightings	*Pass*	16: Toneburst response	*Pass*
13: Frequency and time weightings at 1 kHz	*Pass*	17: Peak C sound level	*Pass*
		18: Overload Indication	*Pass*

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2006, for the environmental conditions under which the tests were performed.

However, no general statement or conclusion can be made about conformance of the sound level meter to the full requirements of IEC 61672-1:2002 because evidence was not publicly available, from an independent testing organisation responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2002 and because the periodic tests of IEC 61672-3:2006 cover only a limited subset of the specifications in IEC 61672-1:2002.

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
31.5 Hz to 8kHz	*±0.12dB*	*Temperature*	*±0.05°C*
12.5kHz	*±0.18dB*	*Relative Humidity*	*±0.46%*
16kHz	*±0.31dB*	*Barometric Pressure*	*±0.017kPa*
Electrical Tests			
31.5 Hz to 20 kHz	*±0.12dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

NATA
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Sound Calibrator

IEC 60942-2004

Calibration Certificate

Calibration Number C16593

Client Details TR Pty Ltd
18 Joseph Street
BLACKBURN NORTH VIC 3130

Equipment Tested/ Model Number : Pulsar 105
Instrument Serial Number : 77513

Atmospheric Conditions
Ambient Temperature : 22.4°C
Relative Humidity : 40.9%
Barometric Pressure : 99.89kPa

Calibration Technician : Vicky jaiswal
Calibration Date : 20/10/2016
Secondary Check: Aaron Skeates-Udy
Report Issue Date : 20/10/2016

Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
5.2.2: Generated Sound Pressure Level	*Pass*	5.3.2: Frequency Generated	*Pass*
5.2.3: Short Term Fluctuation	*Pass*	5.5: Total Distortion	*Pass*

	Nominal Level	Nominal Frequency	Measured Level	Measured Frequency
Measured Output	94.0	1000.0	93.8	1000.38

The sound calibrator has been shown to conform to the class 1 requirements for periodic testing, described in Annex B of IEC 60942:2004 for the sound pressure level(s) and frequency(ies) stated, for the environmental conditions under which the tests were performed..

Least Uncertainties of Measurement -

Specific Tests		Environmental Conditions	
Generated SPL	*±0.09dB*	*Temperature*	*±0.05°C*
Short Term Fluct.	*±0.02dB*	*Relative Humidity*	*±0.46%*
Frequency	*±0.01%*	*Barometric Pressure*	*±0.017kPa*
Distortion	*±0.5%*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

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This calibration certificate is to be read in conjunction with the calibration test report.

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Sound Level Meter

IEC 61672-3.2006

Calibration Certificate

Calibration Number C16590

Client Details TR Pty Ltd
18 Joseph Street
BLACKBURN NORTH VIC 3130

Equipment Tested/ Model Number : ARL Ngara
Instrument Serial Number : 87817F
Microphone Serial Number : 321888
Pre-amplifier Serial Number : 28379

Pre-Test Atmospheric Conditions
Ambient Temperature : 22.6°C
Relative Humidity : 41.4%
Barometric Pressure : 99.93kPa

Post-Test Atmospheric Conditions
Ambient Temperature : 22.2°C
Relative Humidity : 41.9%
Barometric Pressure : 99.89kPa

Calibration Technician : Vicky Jaiswal
Calibration Date : 20/10/2016

Secondary Check: Aaron Skeates-Udy
Report Issue Date : 20/10/2016

Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
10: Self-generated noise	*Pass*	14: Level linearity on the reference level range	*Pass*
11: Acoustical tests of a frequency weighting	*Pass*	15: Level linearity incl. the level range control	*Pass*
12: Electrical tests of frequency weightings	*Pass*	16: Toneburst response	*Pass*
13: Frequency and time weightings at 1 kHz	*Pass*	17: Peak C sound level	*Pass*
		18: Overload Indication	*Pass*

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2006, for the environmental conditions under which the tests were performed.

However, no general statement or conclusion can be made about conformance of the sound level meter to the full requirements of IEC 61672-1:2002 because evidence was not publicly available, from an independent testing organisation responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2002 and because the periodic tests of IEC 61672-3:2006 cover only a limited subset of the specifications in IEC 61672-1:2002.

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
31.5 Hz to 8kHz	*±0.12dB*	*Temperature*	*±0.05°C*
12.5kHz	*±0.18dB*	*Relative Humidity*	*±0.46%*
16kHz	*±0.31dB*	*Barometric Pressure*	*±0.017kPa*
Electrical Tests			
31.5 Hz to 20 kHz	*±0.12dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

This calibration certificate is to be read in conjunction with the calibration test report.

NATA WORLD RECOGNISED ACCREDITATION

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The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/National standards.

TR techrentals

Certificate of Calibration Conformance

Certificate Number : 0
Reference : 0
Model : VAI,WXT536-KIT
Asset Number : 202917
Description : Weather Station based on the Vaisala WXT520

Date Calibrated : 28/11/2016
Technician : Daniel Markham
Serial No. : M4350255
Calibration valid for : 1095 days.

The performance of the above listed equipment has been verified for measurement accuracy to the manufacturers relevant published specification, in accordance with our Quality Assurance Procedures, using the appropriate calibrated equipment, traceable to nationally recognised standards.

Cris Ascenzo
National Service Manager

QSF 326-1/C

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Appendix D

Wind Farm Layout and Receptor Locations

Appendix D Wind Farm Layout and Receptor Locations

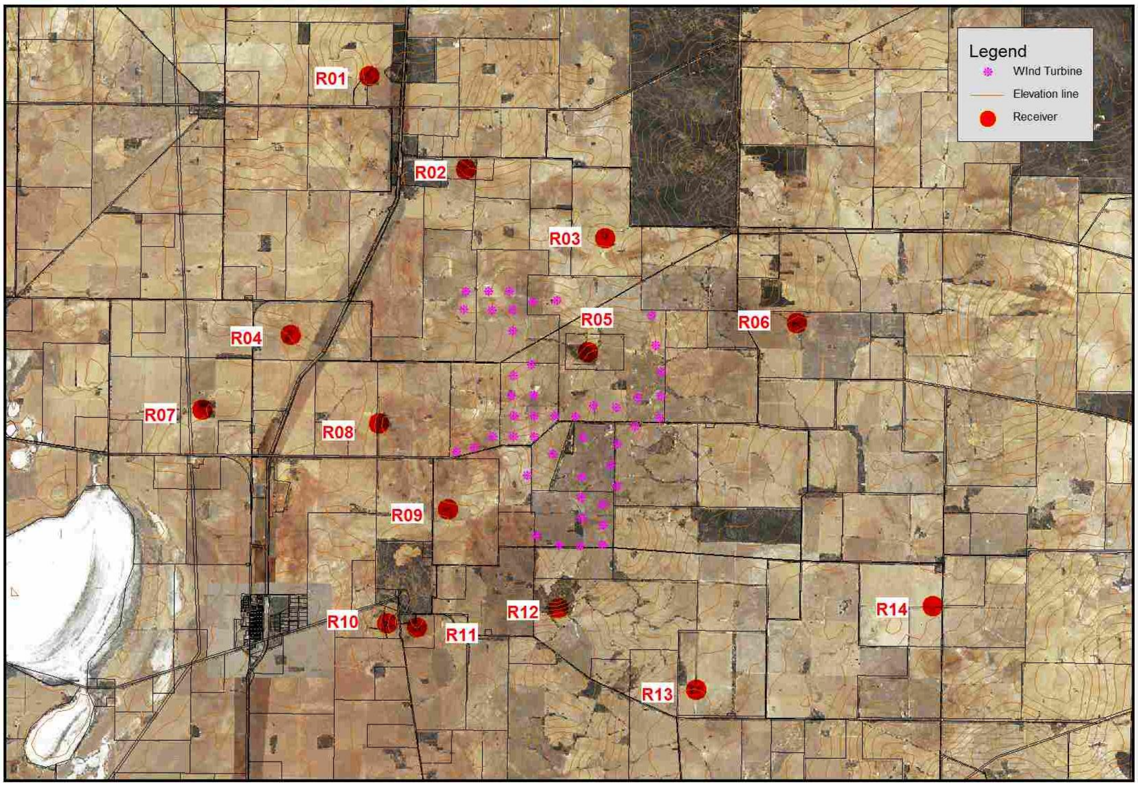


Figure 4 Receptor and WTG Layout

Receiver Locations

Receiver No:	Easting	Northing
1	621704.09	6417261.52
2	624047.97	6415017.51
3	627412.87	6413343.10
4	619802.60	6411001.74
5	626999.27	6410592.47
6	632054.83	6411287.46
7	617673.96	6409185.72
8	621937.13	6408857.31
9	623612.70	6406788.22
10	622138.04	6404037.67
11	622869.11	6403938.77
12	626278.64	6404409.79
13	629620.99	6402431.86
14	635335.13	6404460.66

Turbine Locations

Turbine No:	Latitude	Longitude
1	32°25'18.60"S	118°19'9.69"E
2	32°25'18.20"S	118°19'30.44"E
3	32°25'17.85"S	118°19'49.49"E
4	32°25'31.74"S	118°19'7.73"E
5	32°25'32.40"S	118°19'34.17"E
6	32°25'32.43"S	118°19'53.20"E
7	32°25'25.40"S	118°20'11.70"E
8	32°25'24.77"S	118°20'33.88"E
9	32°25'48.90"S	118°19'53.71"E
10	32°26'23.65"S	118°19'54.54"E
11	32°26'40.24"S	118°19'55.06"E
12	32°26'55.56"S	118°19'55.08"E
13	32°26'15.15"S	118°20'11.01"E
14	32°26'39.82"S	118°20'13.98"E
15	32°26'55.76"S	118°20'14.23"E
16	32°26'55.95"S	118°20'33.37"E
17	32°26'56.11"S	118°20'52.46"E
18	32°26'46.79"S	118°21'9.06"E
19	32°26'48.22"S	118°21'30.06"E
20	32°26'40.61"S	118°21'49.75"E
21	32°26'56.50"S	118°21'49.71"E
22	32°25'35.25"S	118°22'1.47"E
23	32°25'58.53"S	118°22'10.25"E
24	32°26'19.70"S	118°22'11.39"E
25	32°26'38.35"S	118°22'11.29"E
26	32°26'56.55"S	118°22'10.71"E
27	32°27'24.80"S	118°19'2.49"E
28	32°27'21.69"S	118°19'19.27"E
29	32°27'12.14"S	118°19'36.48"E
30	32°27'12.56"S	118°19'55.17"E
31	32°27'12.14"S	118°20'14.60"E
32	32°27'8.26"S	118°20'57.78"E
33	32°27'25.64"S	118°20'31.82"E
34	32°27'17.79"S	118°21'25.17"E
35	32°27'42.67"S	118°20'8.44"E

Turbine No:	Latitude	Longitude
36	32°27'43.05"S	118°20'59.08"E
37	32°27'33.91"S	118°21'25.49"E
38	32°27'59.65"S	118°20'59.35"E
39	32°27'50.07"S	118°21'25.52"E
40	32°28'16.04"S	118°20'59.60"E
41	32°28'6.45"S	118°21'25.59"E
42	32°28'22.70"S	118°21'25.45"E
43	32°28'36.80"S	118°20'19.03"E
44	32°28'37.43"S	118°20'38.96"E
45	32°28'37.15"S	118°20'58.84"E
46	32°28'37.70"S	118°21'25.26"E

Appendix E

Noise Monitor Photos

Appendix E Noise Monitor Photos

Logger Location 1

Logger Location 2

Logger Location 3

Appendix F

Noise Regression Curves

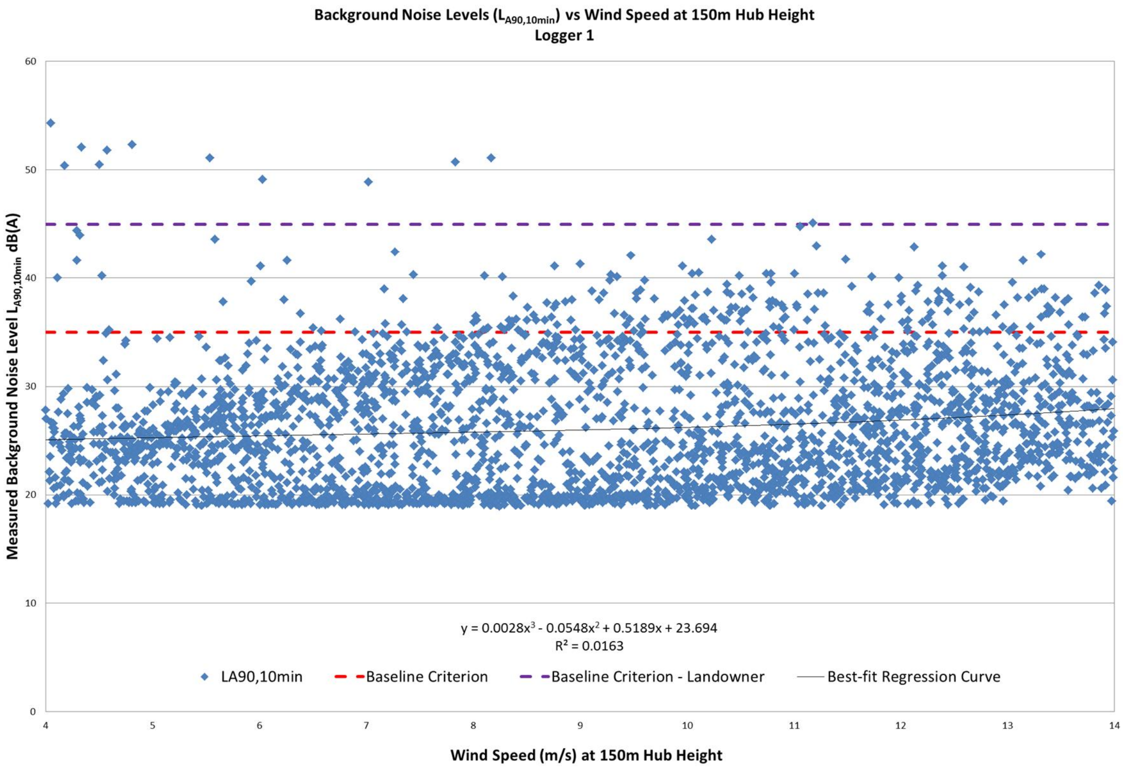
Appendix F Noise Regression Curves

For all the noise monitoring sites, an appropriate (least-squares up to third-order polynomial) regression was calculated, as per the SA Guidelines. The correlation coefficients (R) for each polynomial obtained for each monitoring location are presented in Table 17.

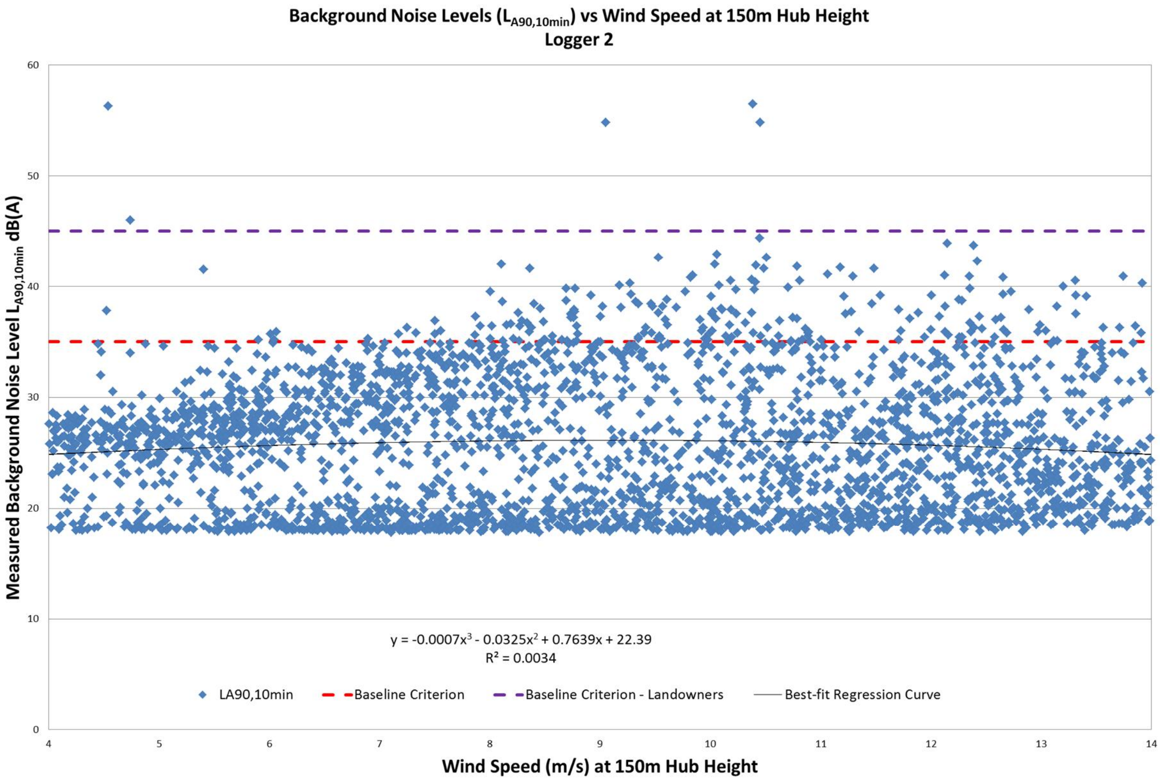
Table 17 Correlation coefficients for 3rd order polynomial regression lines

Location	Coefficient of Determination (R^2)	
	Polynomial order	R^2
Logger 1 – Receiver R05	3	0.0163
Logger 2 – Receiver R12	3	0.0034
Logger 3 – Receiver R08	3	0.0077

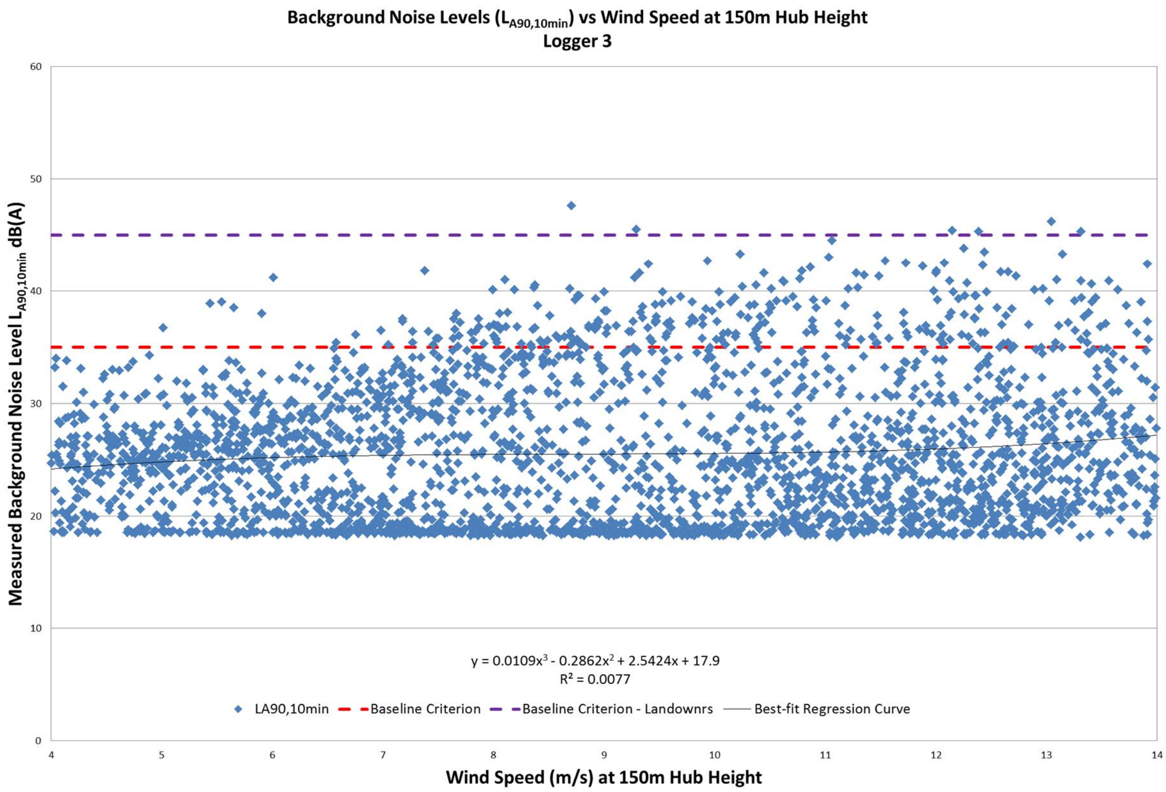
Logger Location 1 Regression Curve



Logger Location 2 Regression Curve

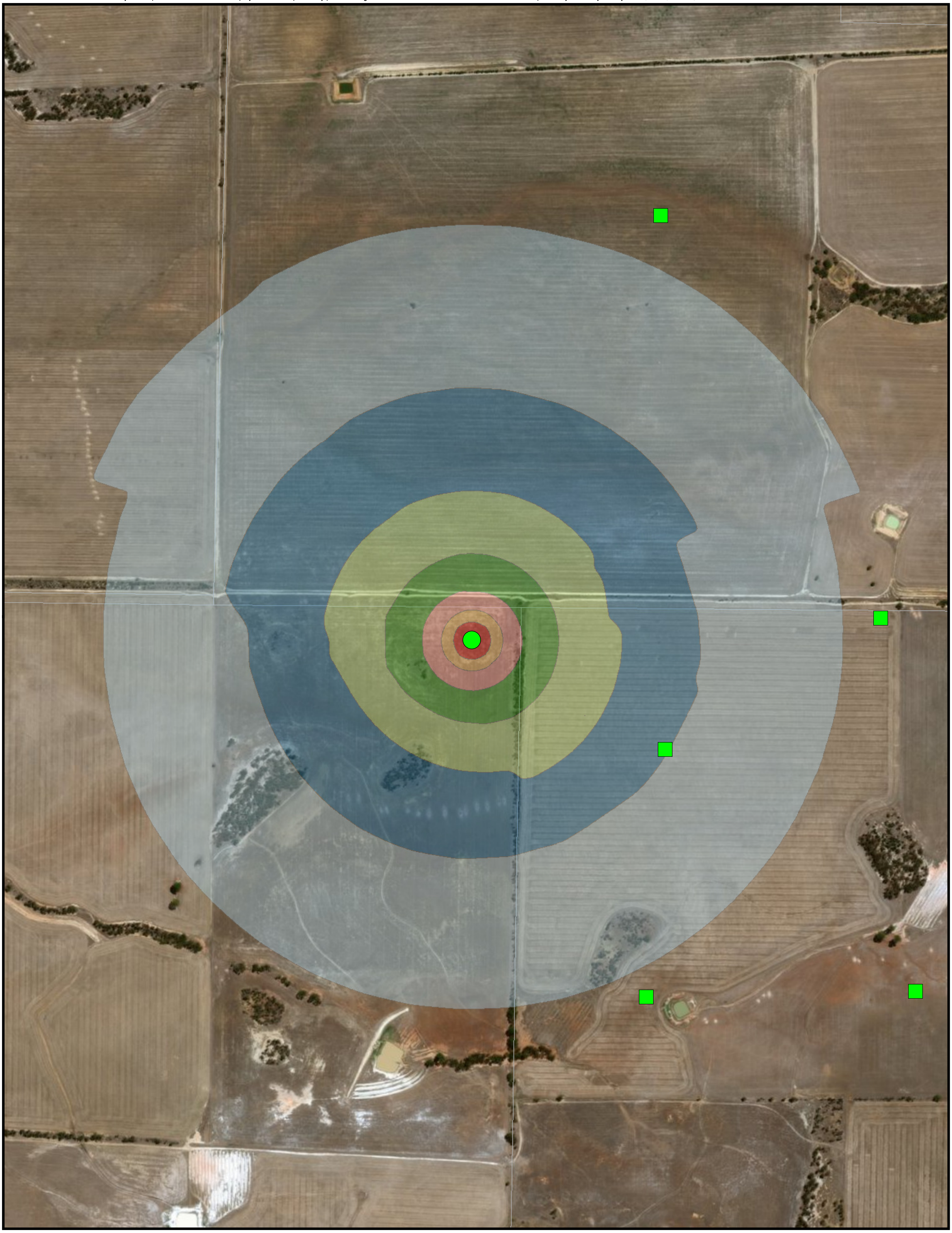


Logger Location 3 Regression Curve



Appendix G

Noise Contour Maps



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APPROVED BY	RFoster
LAST MODIFIED	18 JAN 2018

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N

DATUM GDA 1994, PROJECTION MGA ZONE 50

0 60 120 180 240

metres

1:10,000 when printed at A4

LEGEND

Substation Location

Approx Turbine Location

Cadastral Boundary

North Substation Noise Contours

LA_{eq} at 1.5m AGL

- 25
- 30
- 35
- 40
- 45
- 50
- 55

Data sources: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

North Substation LA_{eq} at 1.5m AGL Noise Contours

KONDININ ENERGY

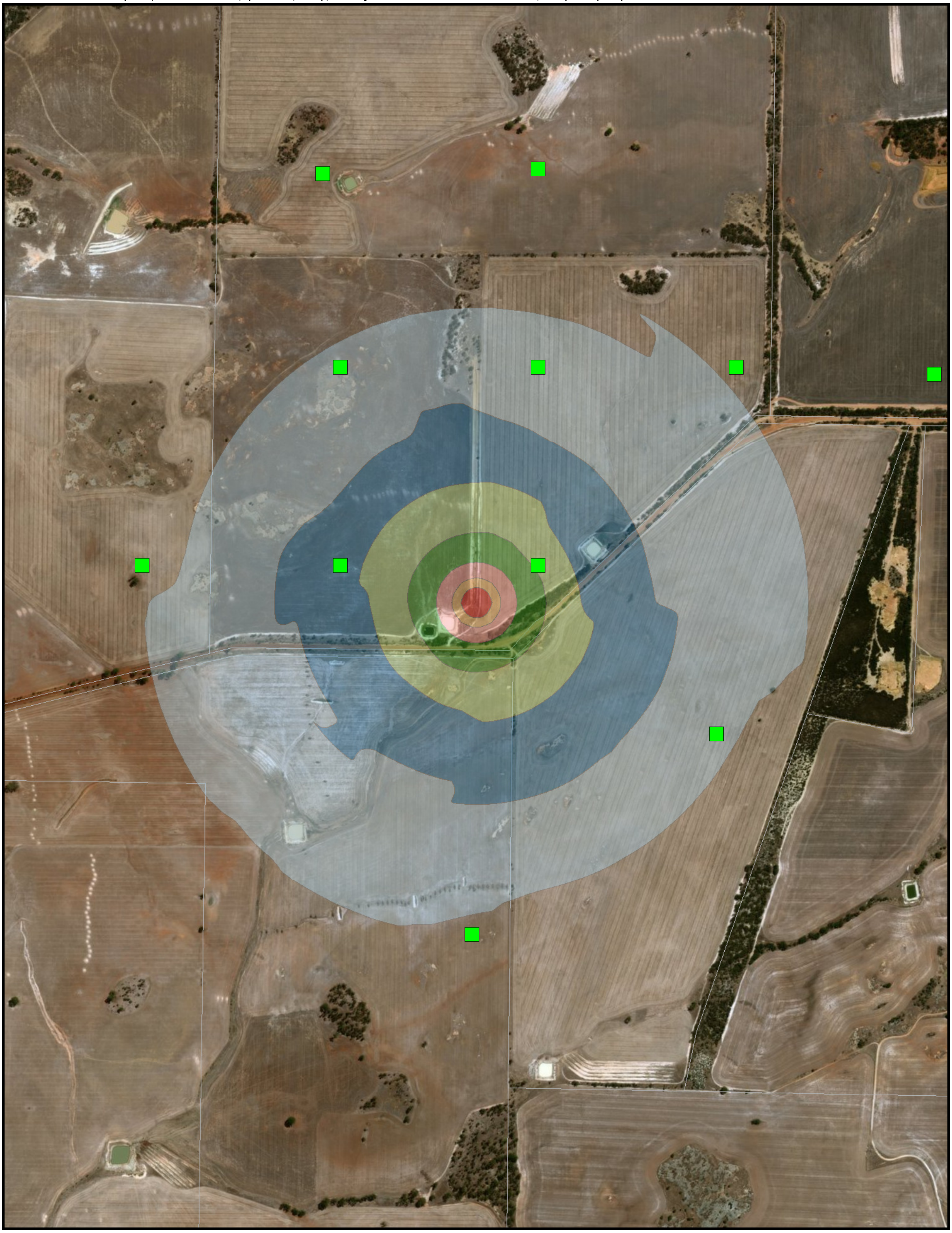
KONDININ WIND FARM NOISE ASSESSMENT

Figure

1

Map Document: \\AUPER1FP001.au.aecomnet.com\Projects\605X\60552131\4. Tech Work Area\4.99 GIS\02_MXDs\NoiseFigures\Fig1_NorthSubstation_NoiseCountours.mxd (rob.mcgregor)

A4 size



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LAST MODIFIED 18 JAN 2018

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DATUM GDA 1994, PROJECTION MGA ZONE 50

0 80 160 240 320
metres

1:12,500 when printed at A4

LEGEND

Substation Location
Approx Turbine Location
Cadastral Boundary

South Substation Noise Contours LA_{eq} at 1.5m AGL

25
30
35
40
45
50
55

Data sources: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

South Substation LA_{eq} at 1.5m AGL Noise Contours

KONDININ ENERGY

KONDININ WIND FARM NOISE ASSESSMENT

Figure

2

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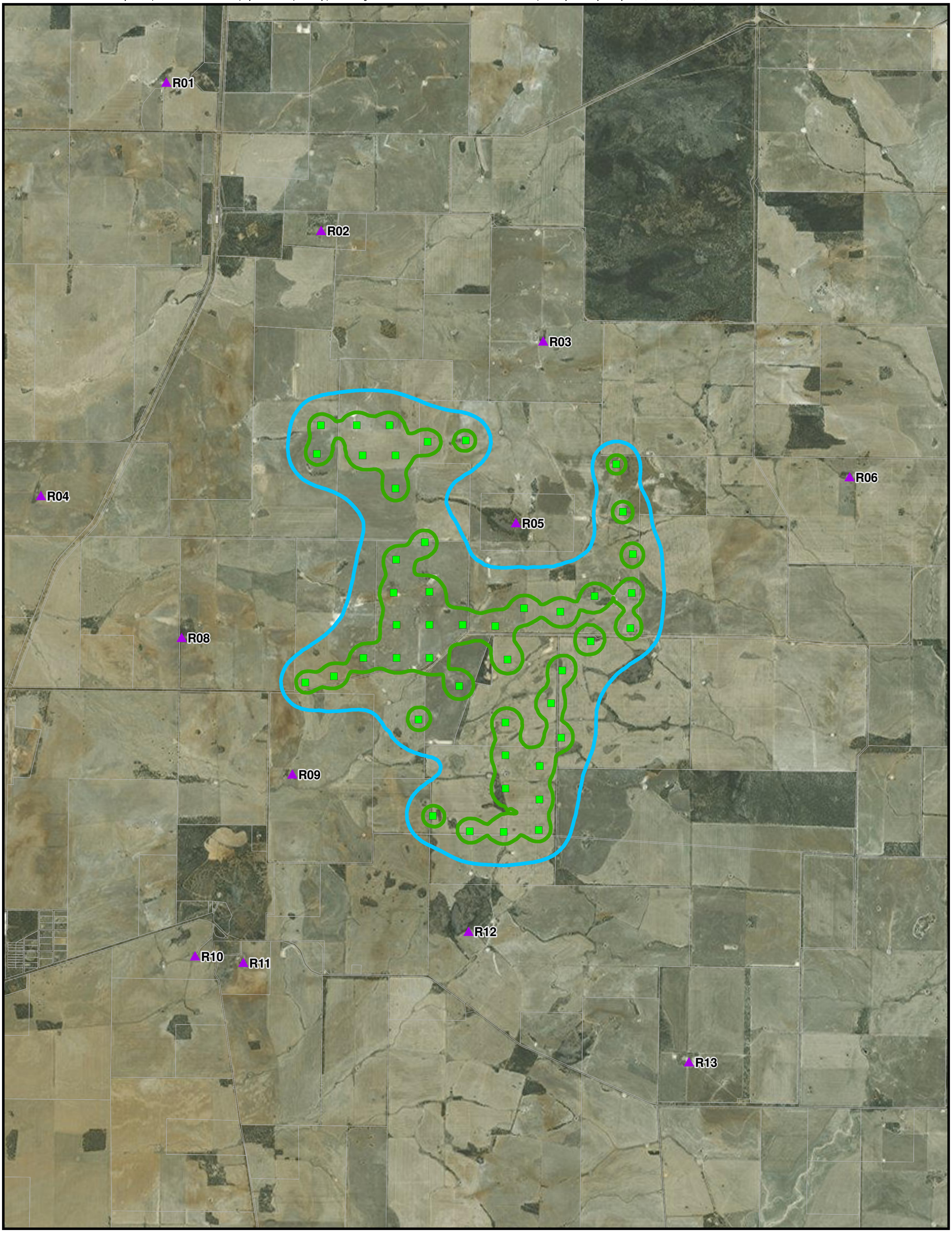

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0 480 960 1,440 1,920
metres

1:75,000 when printed at A4

LEGEND

- Approx Turbine Location
- Residential Receivers
- Cadastral Boundary

LA_{eq} at 1.5m AGL
- 35
- 40
- 45
- 50
- 55
- 60

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Turbine LA_{eq} at 1.5m AGL
Noise Contours
Wind Speed 4 m/s at Hub Height 150 m

KONDININ ENERGY

KONDININ WIND FARM NOISE ASSESSMENT

Figure

5

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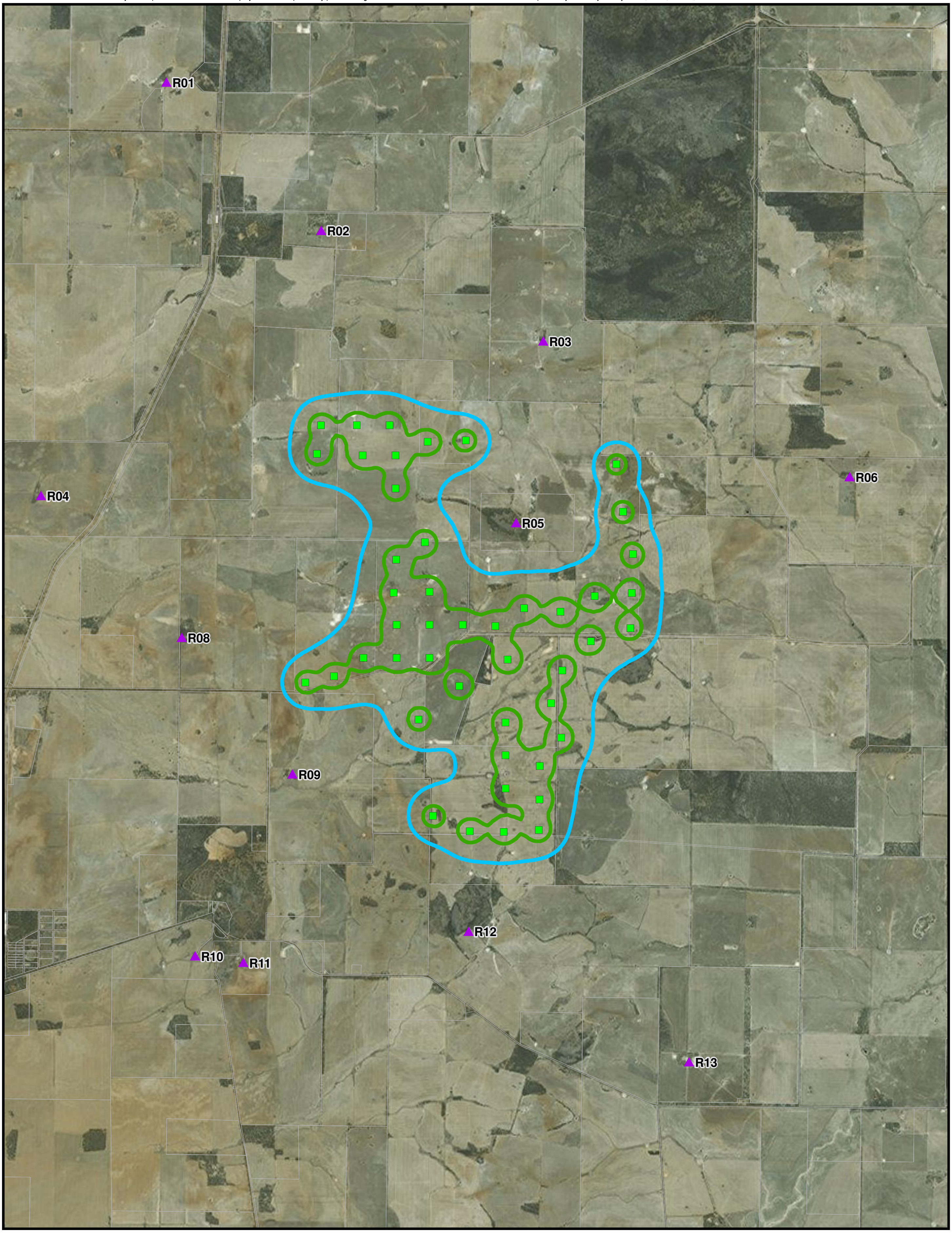

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0 480 960 1,440 1,920
metres

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LEGEND

- Approx Turbine Location
- Residential Receivers
- Cadastral Boundary

LA_{eq} at 1.5m AGL

- 35
- 40
- 45
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- 55
- 60

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Turbine LA_{eq} at 1.5m AGL Noise Contours Wind Speed 5 m/s at Hub Height 150 m

KONDININ ENERGY

KONDININ WIND FARM NOISE ASSESSMENT

Figure

6

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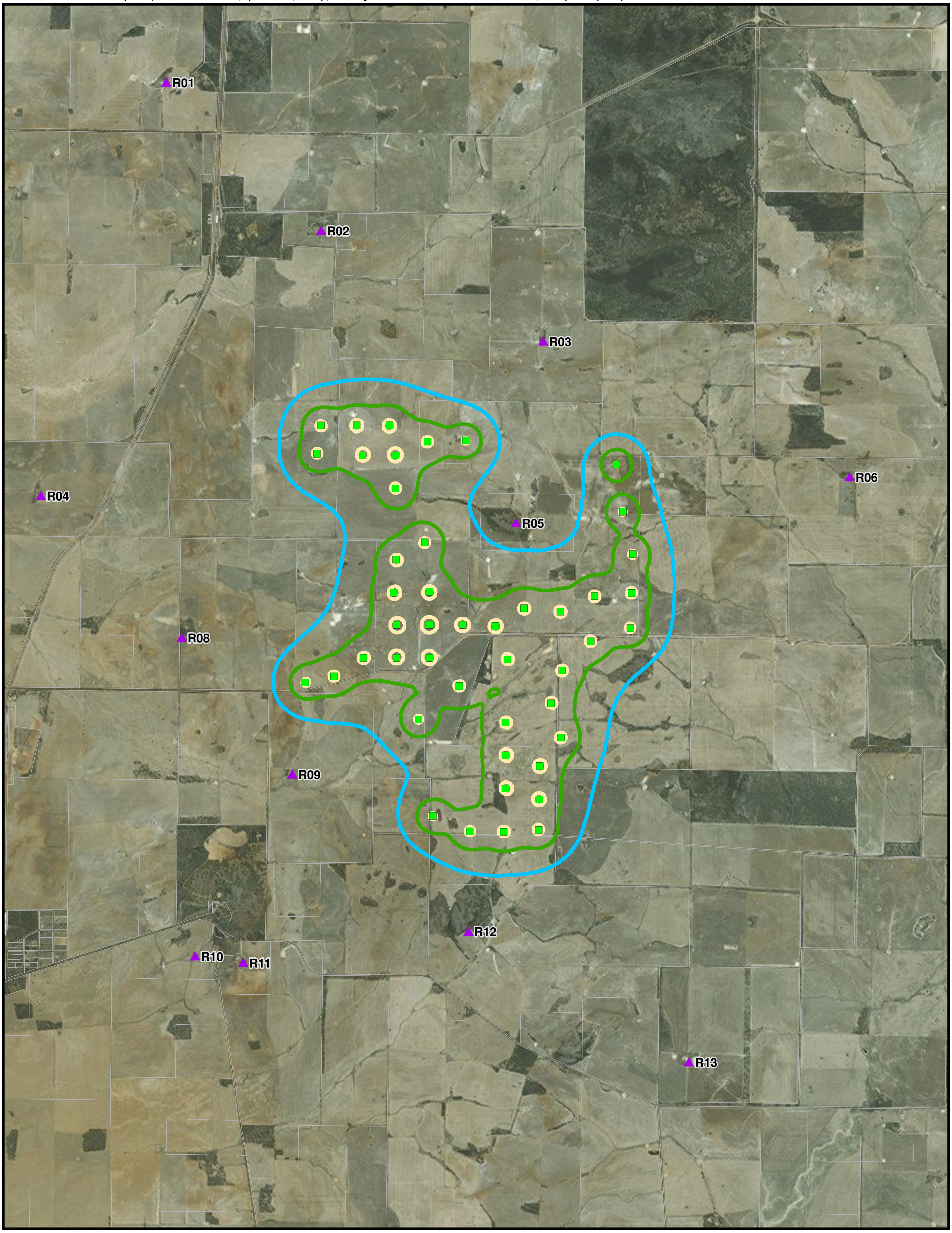

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metres

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LEGEND

- Approx Turbine Location
- Residential Receivers
- Cadastral Boundary

LA_{eq} at 1.5m AGL

- 35
- 40
- 45
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- 55
- 60

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Turbine LA_{eq} at 1.5m AGL
Noise Contours
Wind Speed 6 m/s at Hub Height 150 m

KONDININ ENERGY

KONDININ WIND FARM NOISE ASSESSMENT

Figure
7

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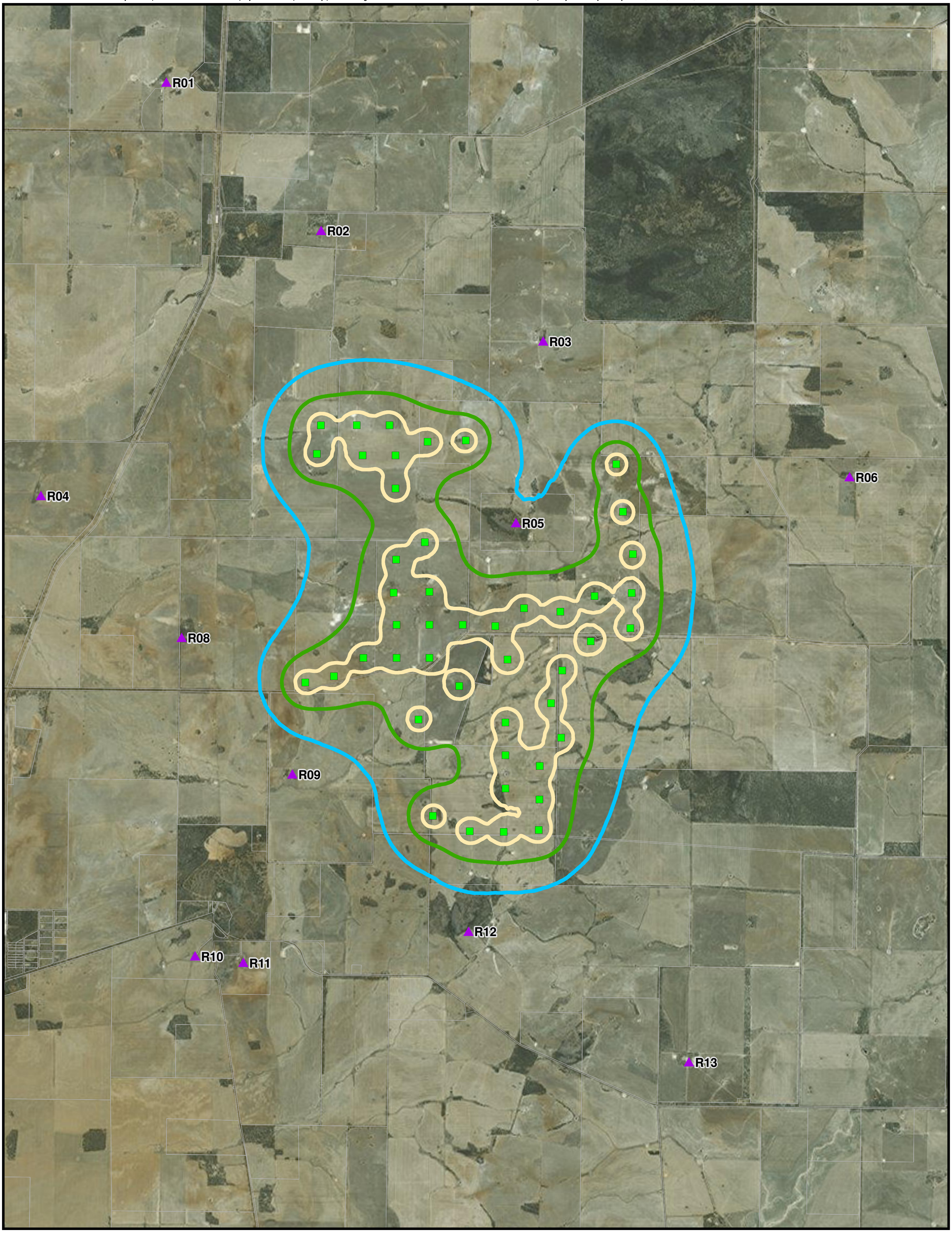

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metres

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LEGEND

- Approx Turbine Location
- Residential Receivers
- Cadastral Boundary

LA_{eq} at 1.5m AGL

- 35
- 40
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- 60

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Turbine LA_{eq} at 1.5m AGL Noise Contours Wind Speed 7 m/s at Hub Height 150 m

KONDININ ENERGY

KONDININ WIND FARM NOISE ASSESSMENT

Figure **8**

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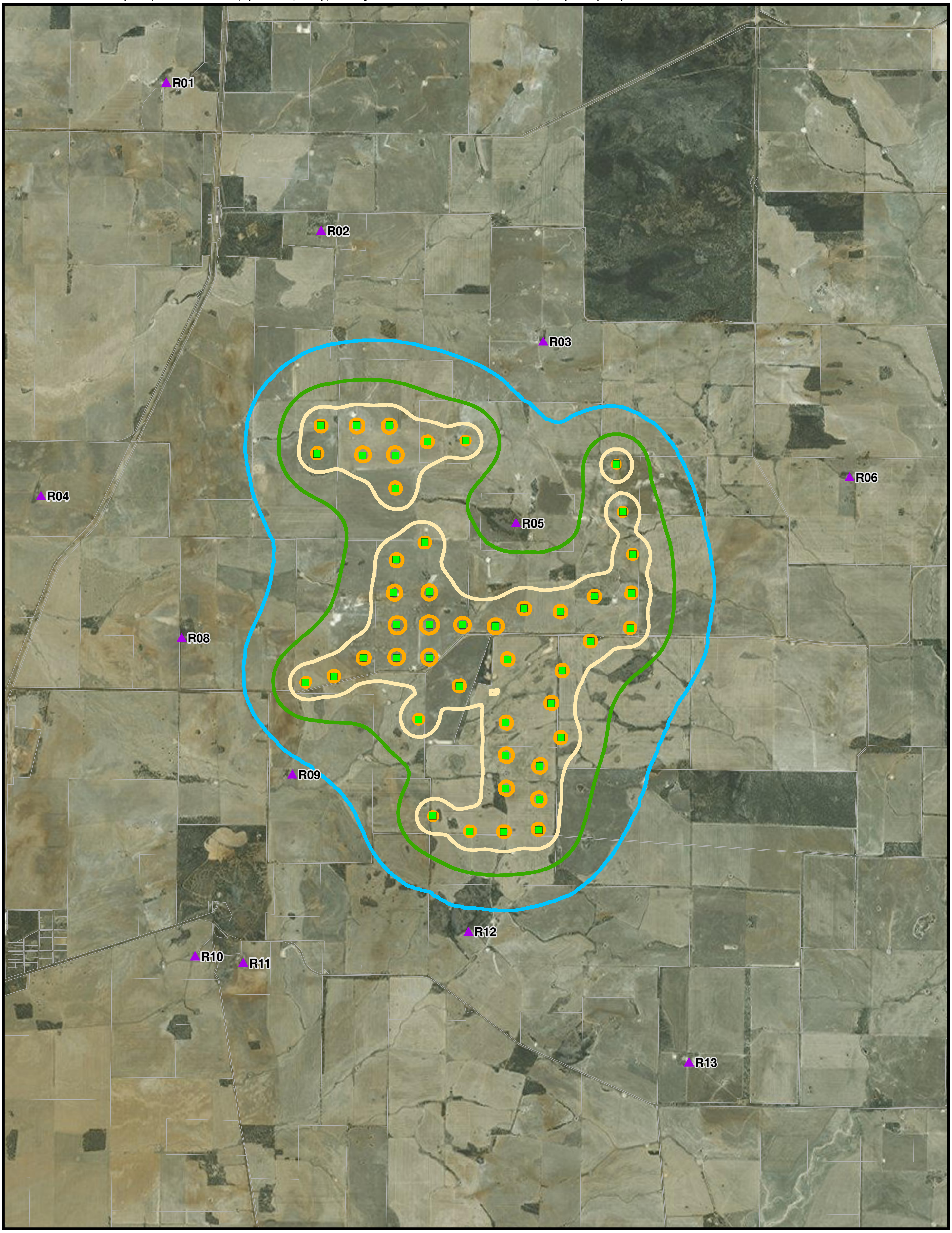

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metres

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LEGEND

- Approx Turbine Location
- Residential Receivers
- Cadastral Boundary

LA_{eq} at 1.5m AGL

- 35
- 40
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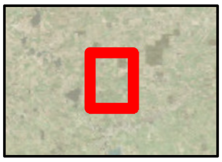

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Turbine LA_{eq} at 1.5m AGL Noise Contours Wind Speed 8 m/s at Hub Height 150 m

KONDININ ENERGY

KONDININ WIND FARM NOISE ASSESSMENT

Figure

9

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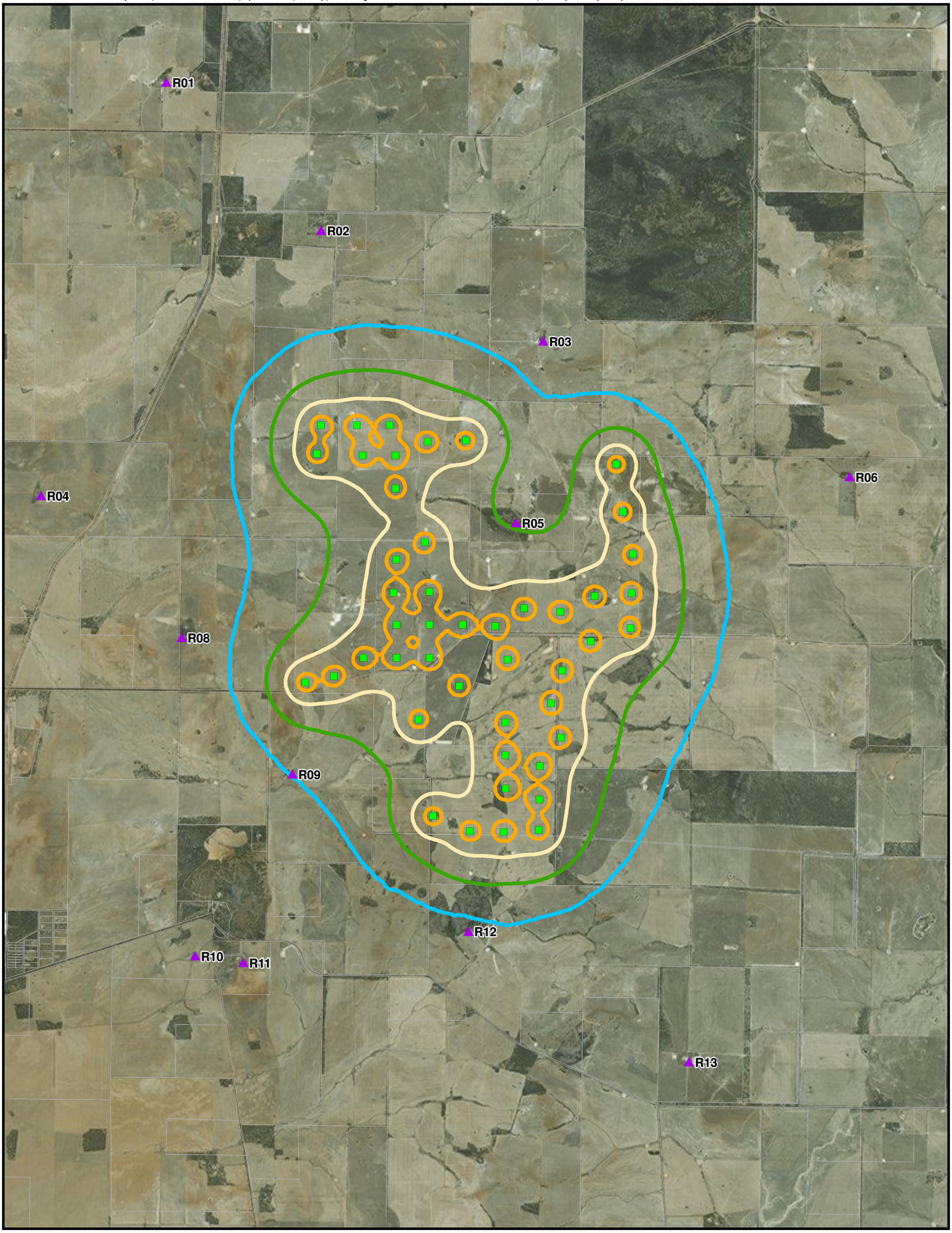

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0 480 960 1,440 1,920
metres

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LEGEND

- Approx Turbine Location
- Residential Receivers
- Cadastral Boundary

LA_{eq} at 1.5m AGL

- 35
- 40
- 45
- 50
- 55
- 60

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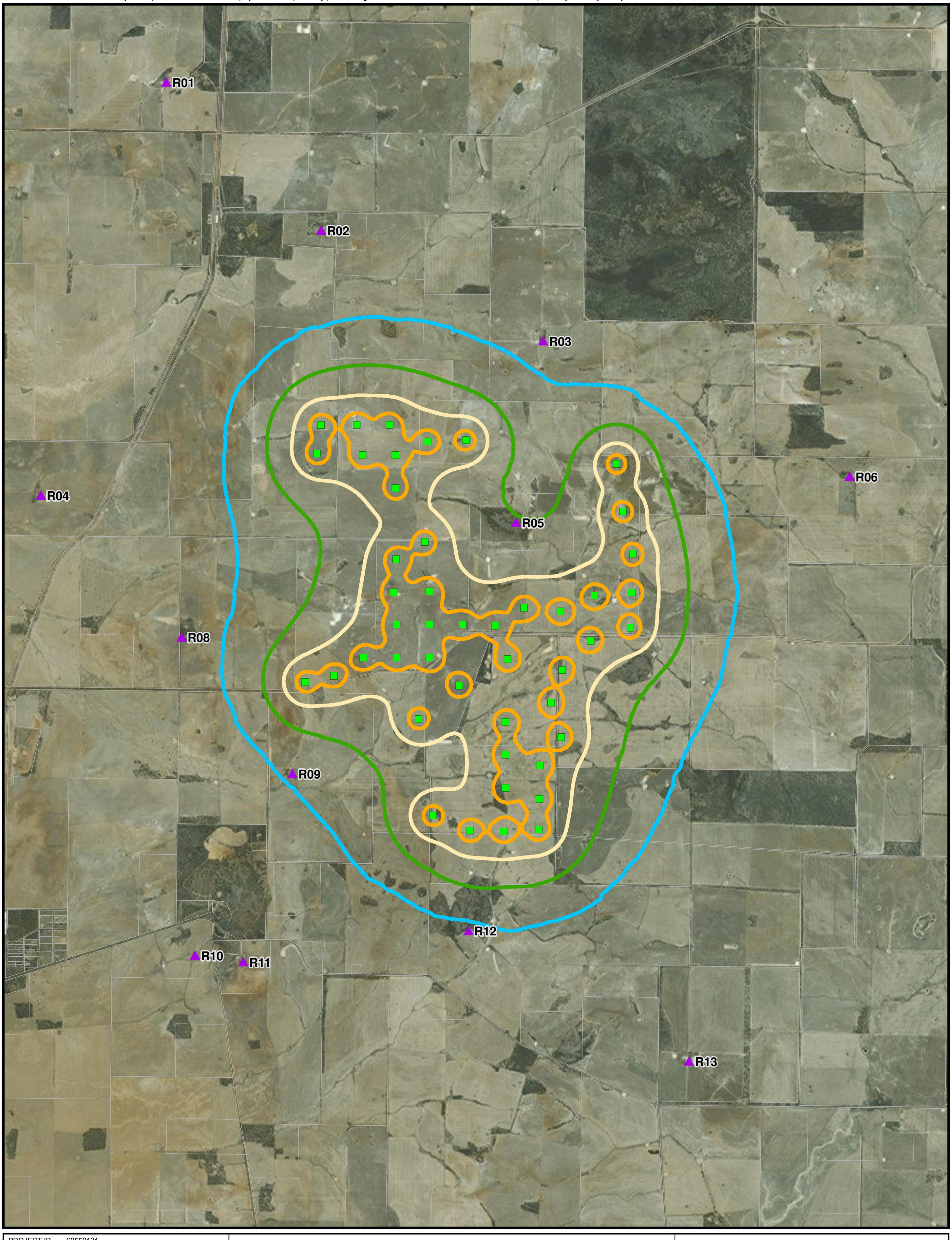
Turbine LA_{eq} at 1.5m AGL Noise Contours Wind Speed 9 m/s at Hub Height 150 m

KONDININ ENERGY

KONDININ WIND FARM NOISE ASSESSMENT

Figure
10



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metres

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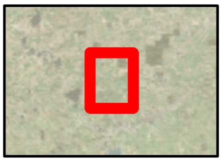
LEGEND

- Approx Turbine Location
- Residential Receivers
- Cadastral Boundary

LA_{eq} at 1.5m AGL

- 35
- 40
- 45
- 50
- 55
- 60



Data sources: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

Turbine LA_{eq} at 1.5m AGL
Noise Contours
Wind Speed 10 m/s at Hub Height 150 m

KONDININ ENERGY

KONDININ WIND FARM NOISE ASSESSMENT

Figure
11

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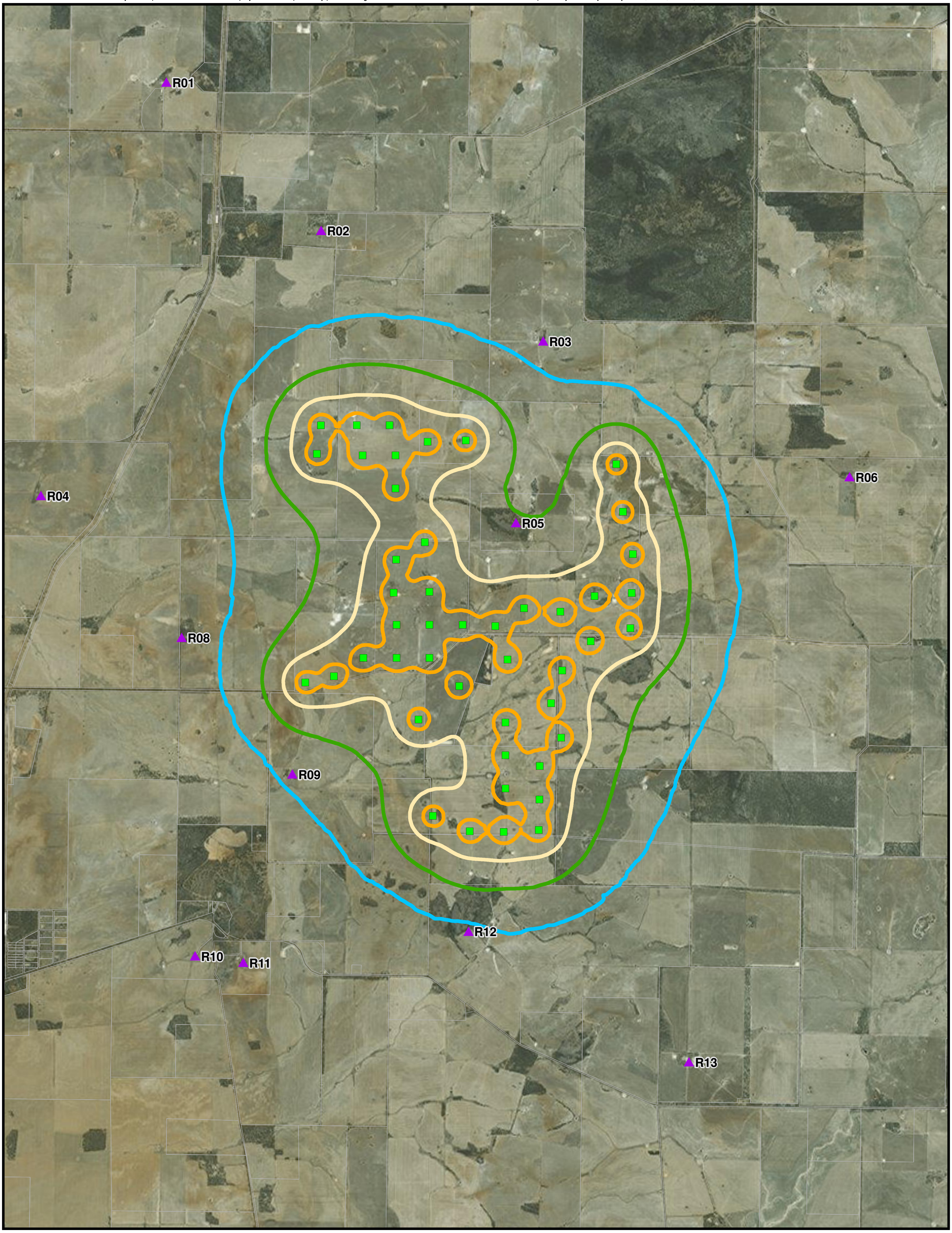

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0 480 960 1,440 1,920
metres

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LEGEND

Approx Turbine Location
Residential Receivers
Cadastral Boundary

LA_{eq} at 1.5m AGL
35
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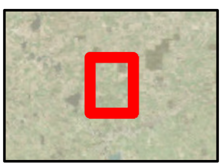

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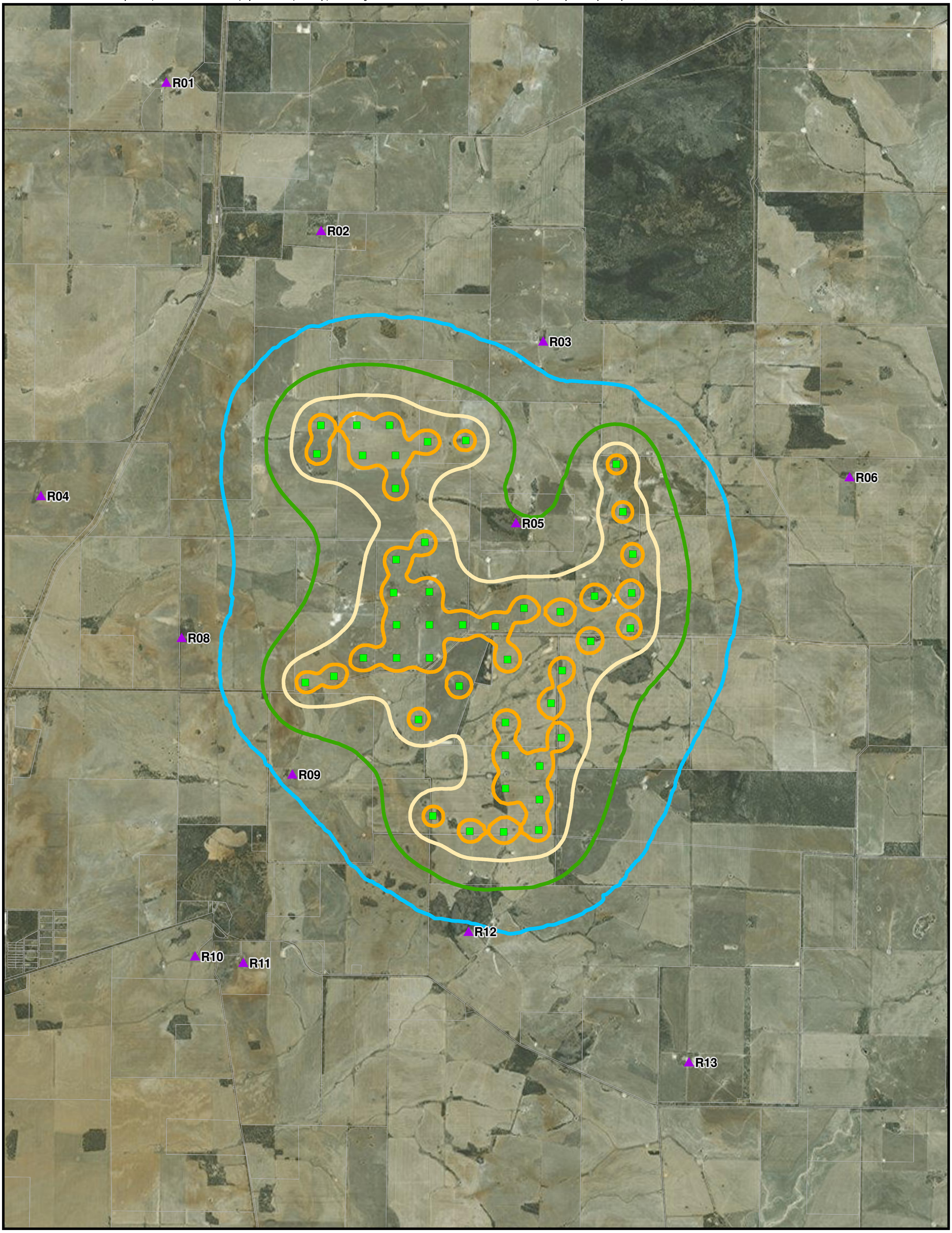
Turbine LA_{eq} at 1.5m AGL
Noise Contours
Wind Speed 11 m/s at Hub Height 150 m

KONDININ ENERGY

KONDININ WIND FARM NOISE ASSESSMENT

Figure

12



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metres

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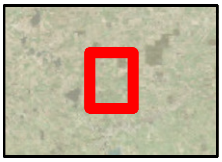
LEGEND

- Approx Turbine Location
- Residential Receivers
- Cadastral Boundary

LA_{eq} at 1.5m AGL

- 35
- 40
- 45
- 50
- 55
- 60



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Turbine LA_{eq} at 1.5m AGL Noise Contours Wind Speed 12 m/s at Hub Height 150 m

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KONDININ WIND FARM NOISE ASSESSMENT

Figure
13

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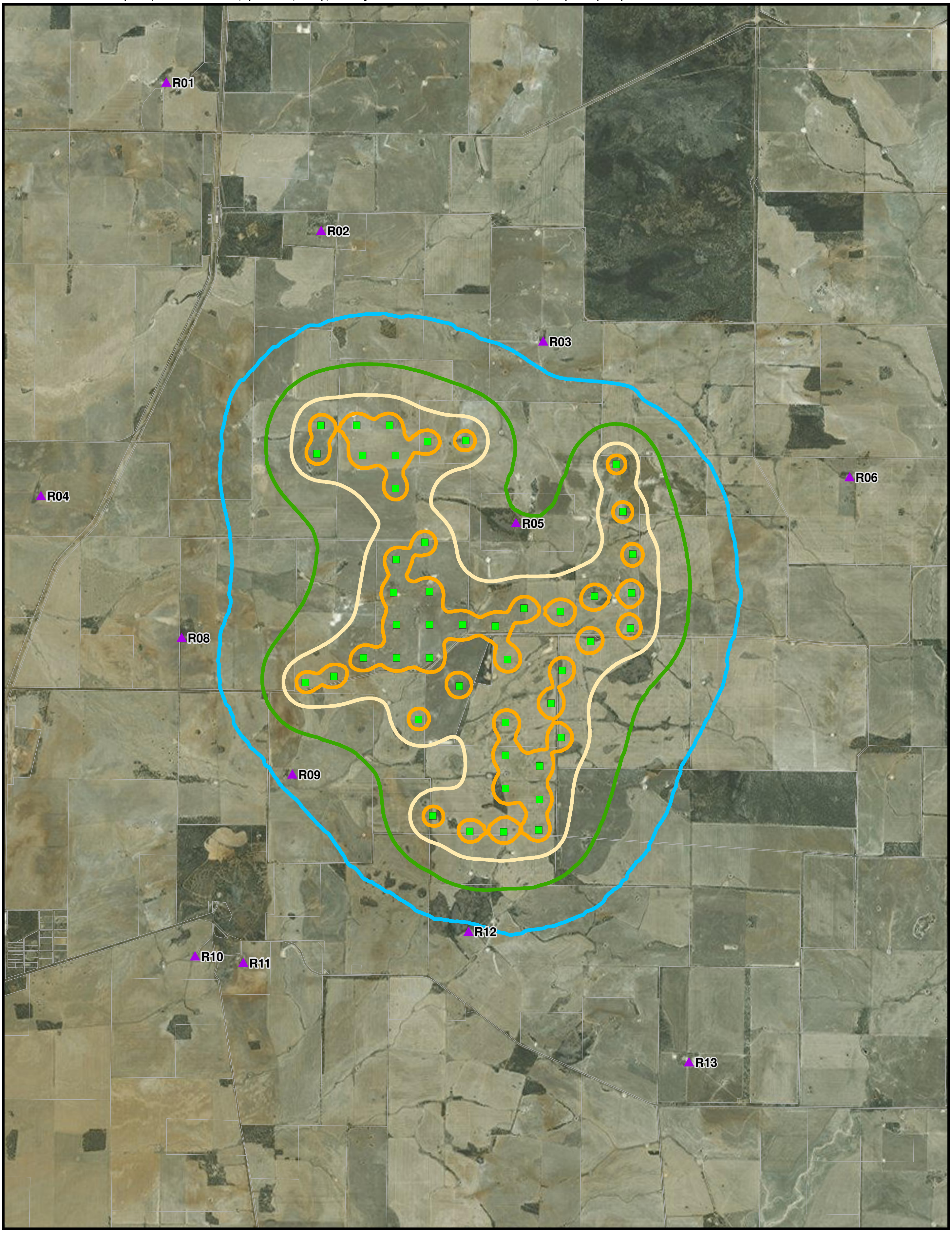

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0 480 960 1,440 1,920
metres

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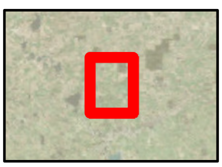
LEGEND

- Approx Turbine Location
- Residential Receivers
- Cadastral Boundary

LA_{eq} at 1.5m AGL
- 35
- 40
- 45
- 50
- 55
- 60



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Turbine LA_{eq} at 1.5m AGL Noise Contours Wind Speed 13 m/s at Hub Height 150 m

KONDININ ENERGY

KONDININ WIND FARM NOISE ASSESSMENT

Figure
14

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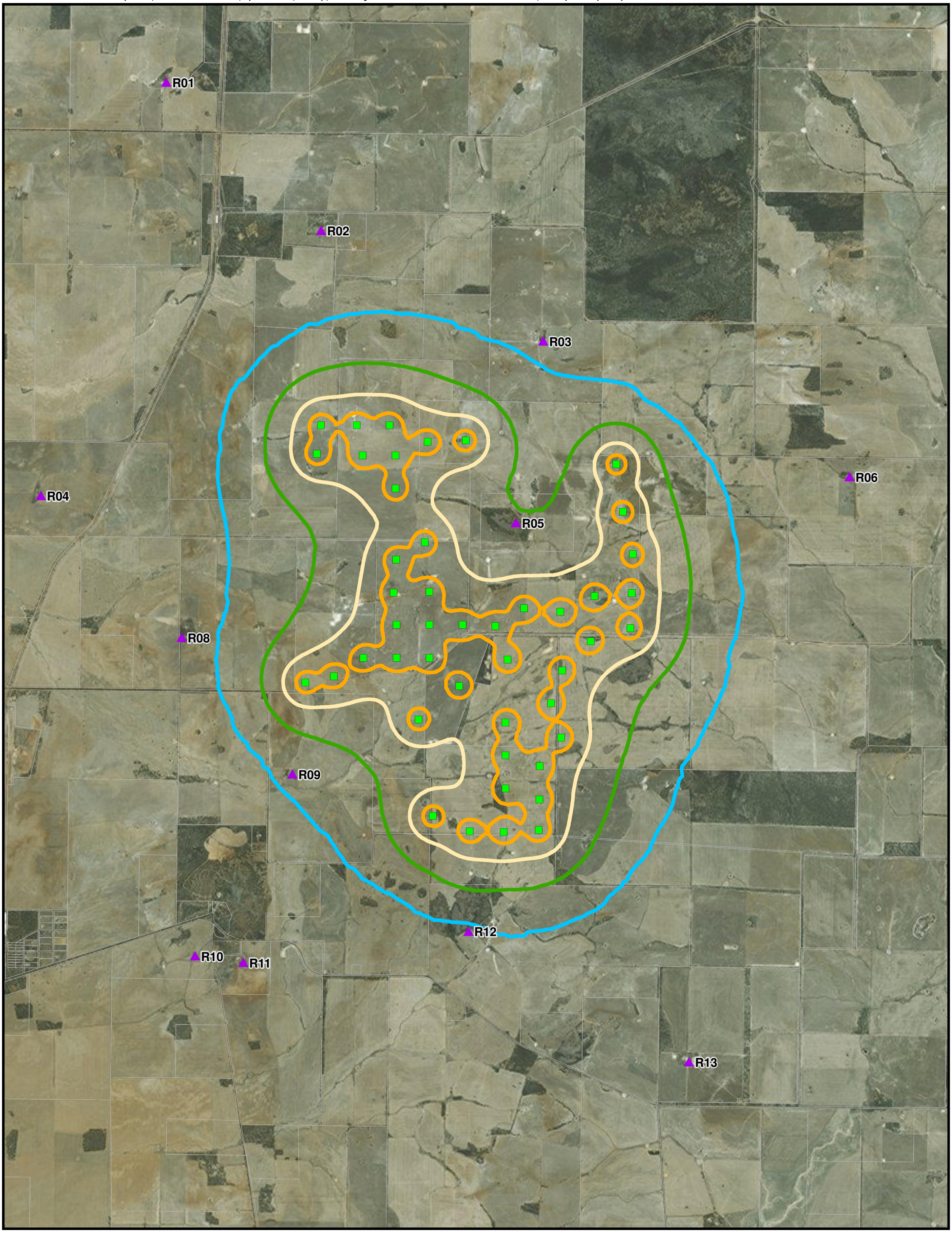

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metres

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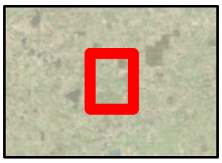
LEGEND

- Approx Turbine Location
- Residential Receivers
- Cadastral Boundary

LA_{eq} at 1.5m AGL

- 35
- 40
- 45
- 50
- 55
- 60



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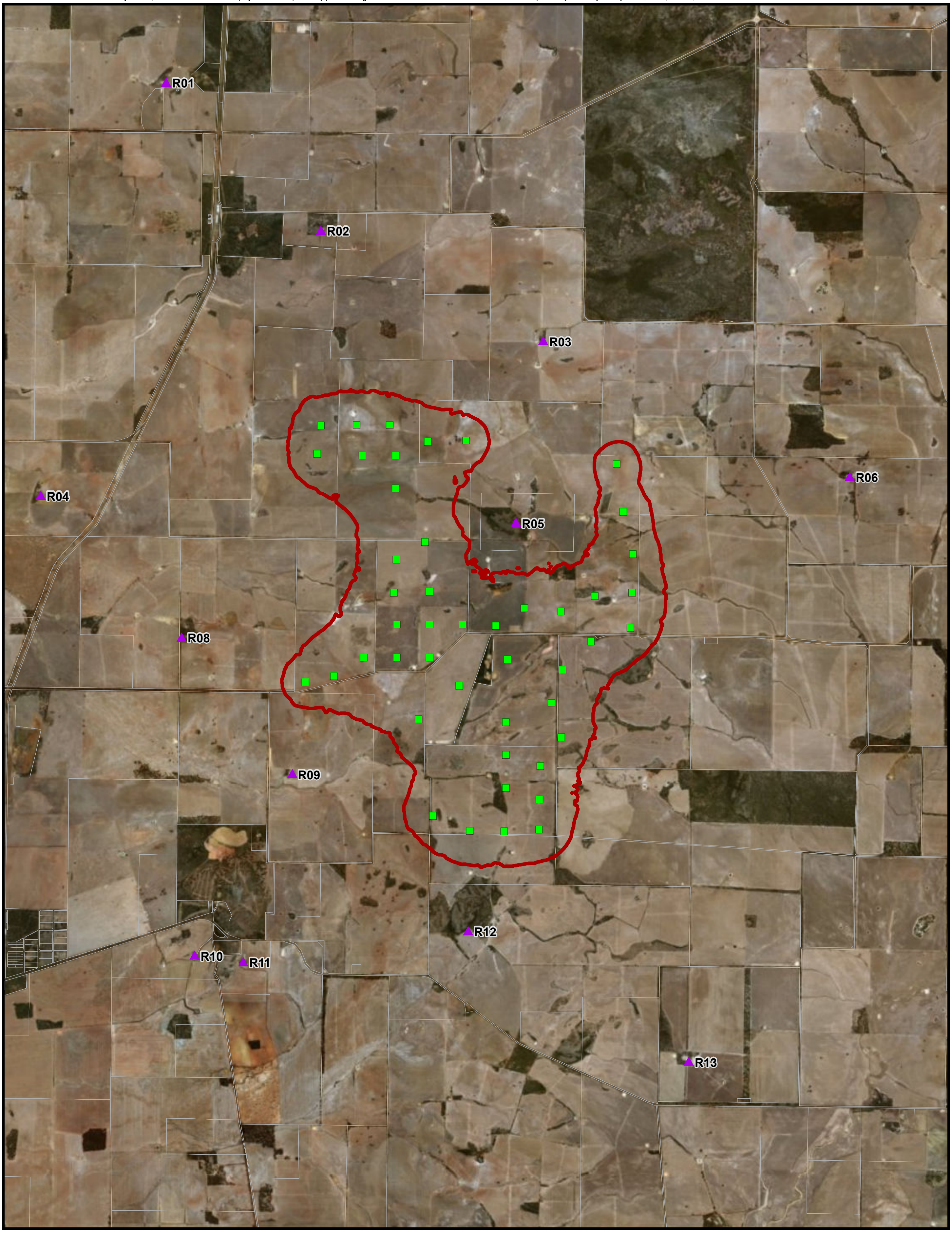
Turbine LA_{eq} at 1.5m AGL Noise Contours Wind Speed 14 m/s at Hub Height 150 m

KONDININ ENERGY

KONDININ WIND FARM NOISE ASSESSMENT

Figure

15



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LEGEND

- Approx Turbine Location
- Residential Receivers
- Cadastral Boundary

L_{ceq} at 1.5m AGL
- 60

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Turbine L_{ceq} at 1.5m AGL Noise Contours Wind Speed 14 m/s at Hub Height 150 m

KONDININ ENERGY

KONDININ WIND FARM NOISE ASSESSMENT

Figure **16**

Appendix H

Documentation Requirements – SA Wind Farm Guidelines

Section 5 *Documentation* of the SA Wind Farm Guidelines calls for specific documentation to be provided. The items included in that section are addressed here:

5.1 Predicted noise from the wind farm		
Requirement		**Response / Report Section**
a	make and model of WTGs to be used, including hub height, cut-in wind speed and speed of the rated power	Make and model yet to be determined. 2 MW WTG utilised in the assessment, hub height 150 m, 4 m/s to 14 m/s. Section 5.1
b	octave or one-third octave band sound power levels and associated wind speed of WTGs to be used	Section 5.1
c	positions of all WTGs shown in topographical map	Appendix D
d	table of WTGs and relevant receivers coordinates including distances and angle directions between the receiver and nearest WTG	Appendix D
e	description of the zone category, zone maps (if available) for all receivers in (e), as outlined in the relevant Development Plan under the Development Act 1993	Rural. Section 2.3
f	predicted noise levels for those premises in (e) for worst-case wind direction for wind speeds from cut-in speed to the speed of the WTG rated power	Section 6.0
g	the model used and the method for deriving the noise levels in (f)	Section 5.0
h	indication of accuracy of the wind farm noise prediction	Section 5.3
i	amount of noise reduction, if any, allowed for acoustic screening to estimate the levels in (h)	Nil, apart from topographical landform. Section 5.0
j	topographical map of wind farm and affected premises showing labelled noise contour lines	Appendix G
k	location of wind measuring position(s) used for noise assessment and compliance purposes	KON - SOD1 – Latitude -32.43932; Longitude 118.346888

5.2 Measurement and assessment of background noise		
Requirement		**Response / Report Section**
a	description of noise measuring equipment used, including make, model and type and including type and model of windscreen used for the microphone, data demonstrating valid calibration for all equipment at the time of measurements	Section 3.1; Appendix B; Appendix C
b	noise measurement position including height above ground, wind speed (at the noise measurement position) and distance to nearest building structure	1.5 m above local ground level. Wind speed data as shown in regression curves Appendix F
c	description and photograph of measurement	Appendix E

5.2 Measurement and assessment of background noise		
Requirement		**Response / Report Section**
	position showing nearby trees and building structures	
d	angle direction between the line connecting the noise measurement point and the nearest WTG and North (measured clockwise)	Noise measurement location = R12 Nearest WTG = T27 Distance = 1511m Angle from north = 0.86^o
e	atmospheric conditions at the wind farm including wind speed and direction, description of wind speed and direction measuring equipment used	Section 3.0
f	wind speed data at the noise measurement site	Wind speed data as shown in regression curves Appendix F
g	time and duration of monitoring	Section 3.0
h	sampling time for wind and noise measurements	10 minutes
i	total number of data pairs measured (wind farm speed and background noise level) and number of data pairs measured at the worst wind conditions between the cut-in wind speed and speed of the rated power	as shown in regression curves Appendix F
j	description of regression analysis method	least-squares regression formulae (up to third order polynomials)
k	graphical plot of data in Section 3.4 and regression curve	as shown in regression curves Appendix F
l	correlation coefficient and equation for the regression curve	as shown in regression curves Appendix F