



APPENDIX M TELECOMMUNICATIONS AND EMI ASSESSMENT



Client: ERM Australia Pty Ltd

Project: Keri Keri Wind Farm EMI Impact Assessment

Report: EMI Impact Assessment Report

Document Number: 22028-E-RPT-0001

Revision history

Table 1: Revision history

Revision	Date	Description	Prepared by	Reviewed by	Approved by
A	28/11/2022	The initial draft for client review	Shezan Arefin Eric Bendtsen	Eric Bendtsen	
B	02/03/2023	Second draft	Shezan Arefin Eric Bendtsen	Eric Bendtsen	
0	12/04/2023	First Issue	Eric Bendtsen	Timothy Cervenjak	Timothy Cervenjak
1	20/02/2024	Second Issue	Shafin Ali	Eric Bendtsen	Timothy Cervenjak
2	21/03/2024	Final Issue	Shafin Ali	Eric Bendtsen	Timothy Cervenjak

Executive Summary

Middleton Group Engineering has been engaged by Environmental Resources Management Australia (ERM) to undertake a Telecommunications and Electro-Magnetic Interference (EMI) desktop study for the Keri Keri Wind Farm (the Project) in the Riverina Murray Region.

This study assesses the potential impact of Keri Keri Wind Farm on the following telecommunication services:

- Point-to-point microwave links;
- Meteorological radar;
- Mobile voice-based communications;
- Wireless and satellite internet services;
- Broadcast and digital radio;
- Broadcast, digital and satellite television;
- Trigonometry stations; and
- GPS.

The Australian Communications and Media Authority (ACMA) database for point-to-point links within a 150 km radius of the site has been surveyed. Four links were identified passing within a 2 km buffer of the turbines, while three links pass through the project area. Detailed assessment and consultation with the owners of these three links have been undertaken based on the turbine locations provided by the Applicant (Acciona Energy Australia Global Pty Ltd) and the location of the transmitters/receiver provided by ACMA.

From a total of 8 stakeholders, 6 stakeholders have thus far responded to the consultation and have confirmed that the layout will not impact their operations.

Outstanding responses lie with link owners Optus and NSW Rural Fire Service.

While these stakeholders have not responded to the proposed layout, based on our assessment of the Project concerning telecommunication impacts, the Project is unlikely to have a material impact on existing telecommunication services.

As such, we expect that the Project has been designed, located and sited to avoid, or minimise EMI to pre-existing television, radar and radio transmission and reception. It is thus expected that this assessment is compliant with the Secretary's Environmental Assessment Requirements.

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1 Abbreviations / Definitions

Table 2: Abbreviations

Abbreviation	Explanation
ACMA	Australian Communications and Media Authority
AM	Amplitude Modulation
BSL	Broadband Service Locator
BOM	Bureau of Meteorology
C/I	Carrier-to-interference ratio
D _a	Diameter of antenna physical aperture (m)
D _{nf}	Near-field clearance distance
DTV	Digital Television
EDM	Electronic Distance Measurement
EMI	Electro-Magnetic Interference
f	frequency (GHz)
FM	Frequency Modulated
F _n	<i>n</i> th Fresnel Zone; also, F ₁ , F ₂ , etc.
G	Maximum (boresight) antenna gain (dBi)
GHz	Giga-Hertz – 1 billion Hertz
GIS	Geographic Information System
GNSS	Global Navigation Satellite System Networks
ICNIRP	International Commission on Non-Ionizing Radiation Protection
LoS	Line of Sight
MGE	Middleton Group Engineering
MHz	Mega-Hertz – 1 million Hertz
PO3	Performance Outcome 3
NSW RSF	New South Wales Rural Fire Service
RPM	Revolutions per minute
The Project	Keri Keri Wind Farm
UHF	Ultra-High Frequency
WMO	World Meteorological Organization
η	Antenna efficiency

2 Normative References

- [1] D. Bacon, "Fixed-link wind-turbine exclusion zone method," Radiocommunications Agency UK, 2002.
- [2] G. Durgin, "The Practical Behavior of Various Edge-Diffraction Formulas," *IEEE Antennas and Propagation Magazine*, vol. 51, no. 3, pp. 24-35, 2009.
- [3] Commission for Instruments and Methods of Observation, "WMO Guidance Paper on Weather Radar/Wind Turbine Siting," World Meteorological Organisation, Helsinki, 2010.
- [4] O. II, "Impact of Wind Turbines on Weather Radars," 2006.
- [5] Satheesh Gopi, R. Sathikumar, N. Madhu, "8.3 EDM Instrument Characteristics," in *Advanced Surveying: Total Station, Gis and Remote Sensing*, Pearson, 2006.
- [6] G. Australia, "GNSS Network Map," Geoscience Australia, [Online]. Available: <https://gnss.ga.gov.au/network>. [Accessed 25 05 2021].
- [7] I. Angulo, D. de la Vega, I. Cascón, J. Cañizo, Y. Wu, D. Guerra, P. Angueira, "Impact analysis of wind farms on telecommunication services," *Renewable and Sustainable Energy Reviews*, vol. 32, pp. 84-99, 2014.
- [8] B S Randhawa, R Rudd, "RF Measurement Assessment of Potential Wind Farm Interference to Fixed Links and Scanning Telemetry Devices," OFCOM, Dorset, 2009.
- [9] "Statement of the OPERA group on the cohabitation between weather radars and wind turbines," in *OPERA group*, 2006.

3 Background

The Project involves the construction, operation, maintenance and decommissioning of:

- Up to 155 Wind Turbine Generators (WTG) with a hub height of 200 metres (m) and maximum height tip height of 291.5 m (vertical tip);
- Battery energy storage system (BESS) with capacity of approximately 200 megawatt (MW) / 800 MW hours (MWh);
- Electrical reticulation, on-site substations and switchyard; and
- Other ancillary infrastructure including (but not limited to) internal access tracks, road upgrades, meteorological masts, and operation and maintenance (O&M) buildings.

Middleton Group Engineering (MGE) has been engaged by Environmental Resources Management Australia Pty Ltd (ERM) to undertake an Electro-Magnetic Interference (EMI) desktop study to inform the environmental impact statement being prepared by ERM for inclusion within an application to meet the Planning Secretary's Environmental Assessment Requirements (SEARs) for the Keri Keri Wind Farm.

4 Scope

This Telecommunications and EMI Study is a desktop study mapping the turbine locations along with telecommunication services and evaluating the impact of the wind turbines on these services.

The study has been undertaken to meet the telecommunications requirements of the SEARs. This requires the study to:

identify possible effects on telecommunications systems, assess impacts and mitigation measures including undertaking a detailed assessment to examine the potential impacts as well as analysis and agreement on the implementation of suitable options to avoid potential disruptions to radio communication services, which may include the installation and maintenance of alternative sites.

The study is confined to the analysis of publicly available information and consultation with key stakeholders.

The impact of the Keri Keri Wind Farm has been assessed with respect to the following services:

- Point-to-point microwave links;
- Meteorological radar;
- Mobile voice-based communications;
- Wireless and satellite internet services;
- Broadcast and digital radio;
- Broadcast, digital and satellite television;
- Trigonometry stations; and
- GPS.

Wind turbine Electro-Magnetic Compatibility has not been assessed in this report, however, any electrical component installed in Australia must comply with the *Radiocommunications Act (1992)* and associated notices. All installations on the wind farm will comply with the Act, including affixation of relevant compliance markers to the equipment. The original equipment manufacturers must guarantee compliance. Final wind farm layout and design will be designed to ensure compliance with the 2020 ICNIRP Health Guidelines.

5 Inputs

This assessment is based on the stakeholder infrastructure inputs specified in Table 4. The properties of the stakeholder infrastructure (locations etc.) are provided in the relevant subsections within section 6 of this report. The assessment considers the project inputs provided by the Applicant, described in Table 3.

Table 3: Study inputs – project infrastructure.

Project Detail	Value
Wind turbine coordinates	See Appendix B Note minor changes to the final layout are expected. These will be within the micro-siting allowance and have negligible impact to the findings of this report.
Wind turbine dimensions	Tip Height: 291.5 m Hub Height: 200 m Turbine Blade Diameter: 183 m

Table 4: Study inputs – stakeholder infrastructure.

Infrastructure	Source	Date Provided/Accessed
Dwelling coordinates	The Applicant (Acciona)	31-08-2022
Point-to-point microwave links, mobile voice-based communication, and internet services	ACMA Site Location Map RFNSA Website	09-09-2022 09-09-2022
AM, FM, Digital Radio Broadcasters Digital TV	List of transmitters with a licence to broadcast	09-09-2022
Meteorological Radar	http://www.bom.gov.au/australia/radar/nsw_radar_sites_table.shtml	09-09-2022
Trigonometrical Station and GPS	GNSS Network Map	16-09-2022
Survey marks	https://www.spatial.nsw.gov.au/products_and_services/spatial_data	16-09-2022
22028-E-MEM-001 Keri Keri Preliminary Impact Assessment	Middleton Group	07-04-2022

6 Analysis

6.1 Assumptions

This study has been developed on the following basis:

- The study is desktop only. No site visit or on-site ground-truthing has been conducted;
- Information, including the spatial location of items, antenna heights, emission frequencies and the like, as sourced from ACMA are correct. While MGE checked information against satellite imagery, MGE has developed the report on the basis that information supplied by/through ACMA is correct, except where a stakeholder provides updated specifications; and
- Turbines have a maximum tip height of 291.5 m and a rotor diameter of up to 183 m.

6.2 Overview

A snapshot of the site and nearby telecommunications services is shown in Figure 1 below. The Fresnel Zone of telecommunication link 1 cannot be clearly observed from the overview perspective. The link is of very high frequency, thus the Fresnel Zone of Link 1 is relatively narrow and does not appear in the image.

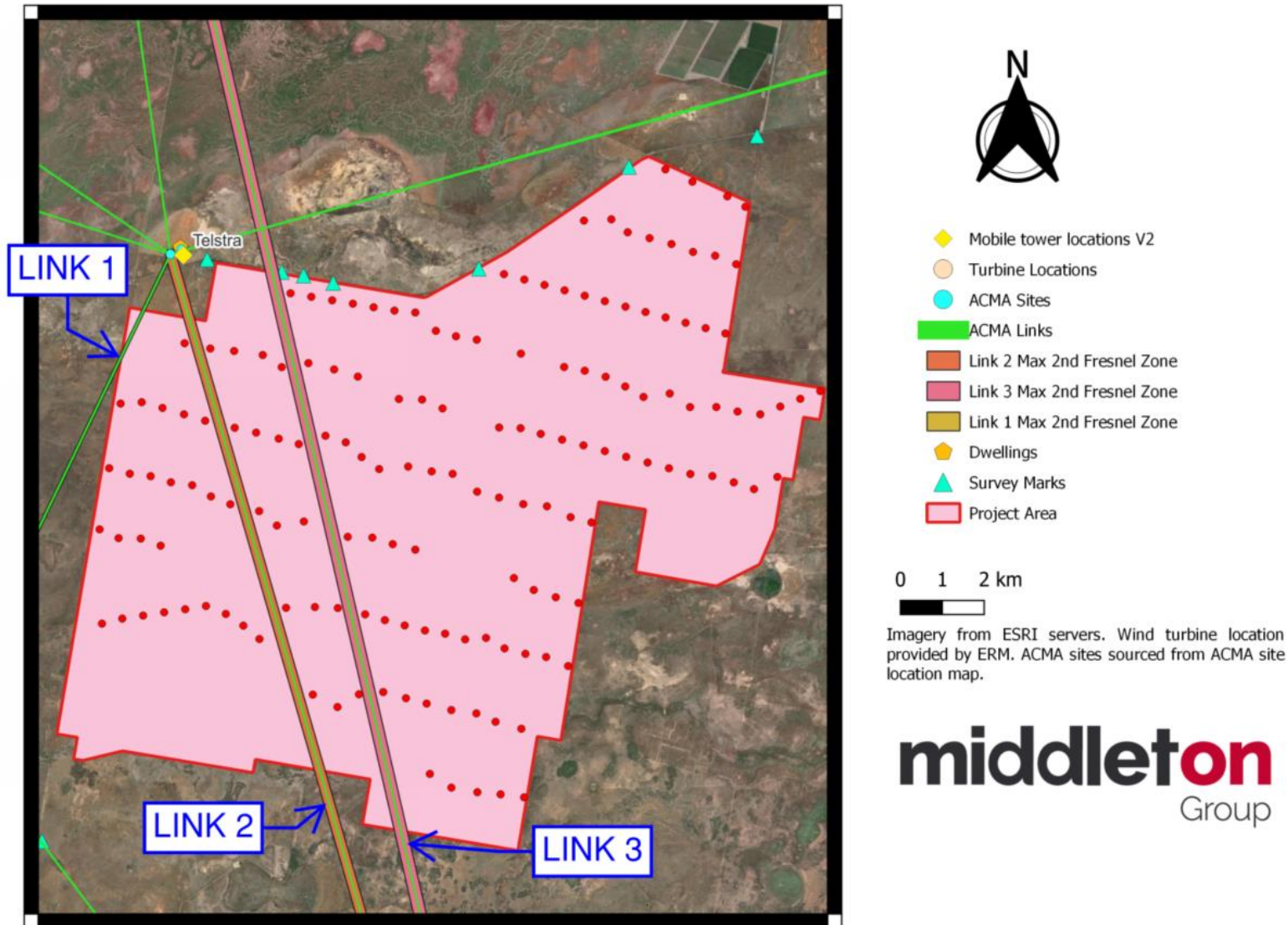


Figure 1: Wind turbine generator plan view overlaid with telecommunications services.

6.3 Point-to-Point Links

Wind turbines have the potential to impact on point-to-point communication links through three mechanisms [1]:

1. Near field effects;
2. Diffraction; and
3. Reflection or scattering effects.

Discussion of near-field and reflection/scattering effects is presented in sections 6.3.1 and section 6.3.2 respectively and diffraction effects are assessed in section 6.3.3.

Figure 2 shows that there are two communication sites registered with ACMA located just beyond the 2 km buffer of the wind turbines. As can be seen in Figure 2, there are three (3) communication links found in ACMA database which is within the 1 km boundary of the wind turbines. The links pass through the Project Area, detailed information for these links is outlined in Table 5. In depth analysis of these links is presented in following subsections.

A communication link (marked as link 4) intersects the edge of the 1 km boundary. This intersection occurs a short distance from the transmitter / receiver tower (marked as ACMA Site in Figure 2). As such, the actual Fresnel zone at this point will be small and there is negligible risk of diffraction effects occurring.

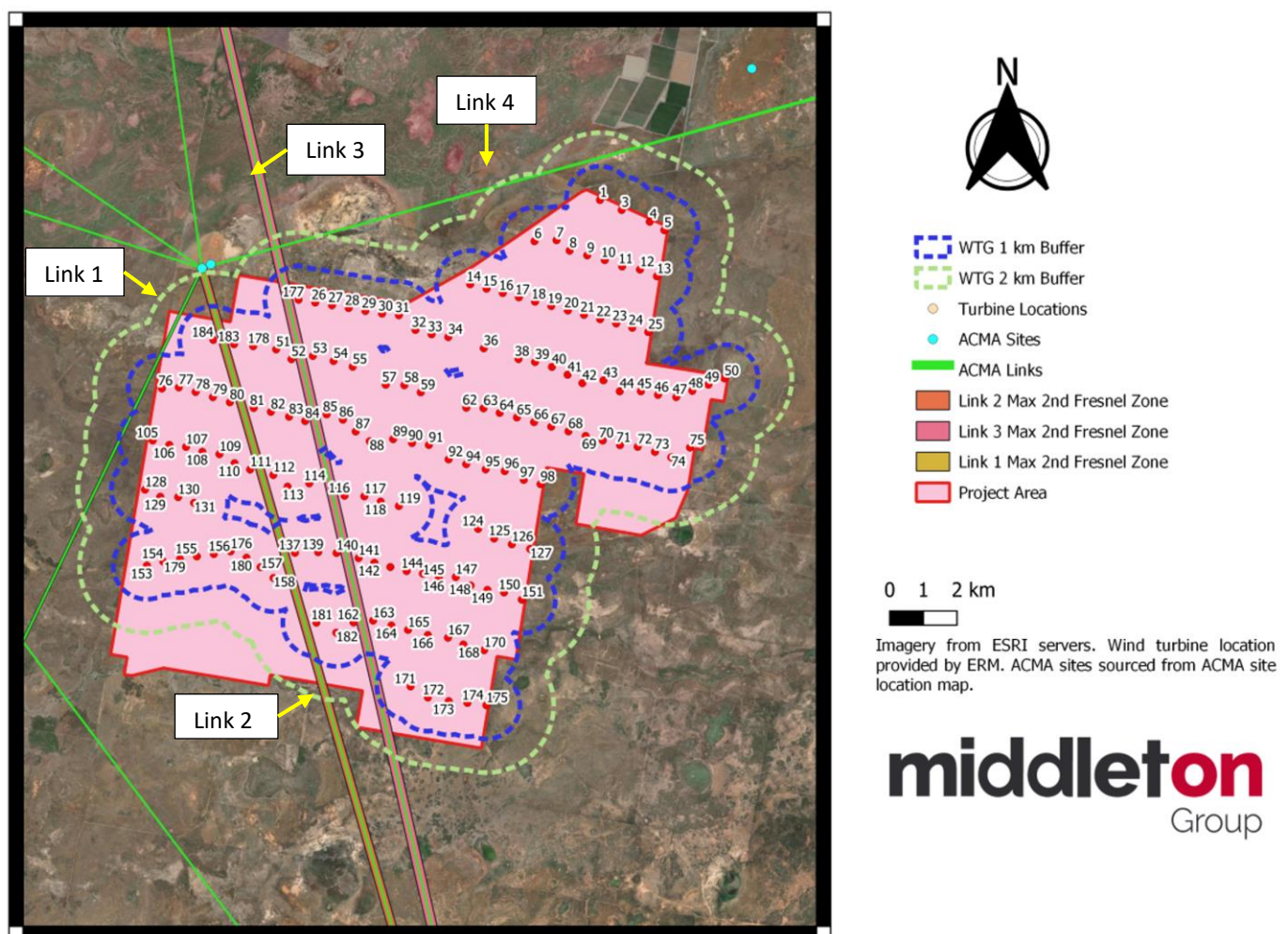


Figure 2: Wind turbines, project area and ACMA communication sites with link assignments.

Table 5: List of point-to-point links that pass across the project area.

#	BSL / Licence No	Site 1	Site 2	Length (km)	Frequency	Owner
1	10161921/1	Mallan Off Moulamein Rd ID: 9012006	Axicom 60m Guyed Mast Willowvale 35812 Sturt Hwy Yonga ID: 204310	46.8	5960	Optus Mobile Pty Limited
2	1972816/1 1972817/1	Axicom 60m Guyed Mast Willowvale 35812 Sturt Hwy Yonga ID: 204310	Murray River Council 75m Guyed Mast off Baldon Rd Moulamein ID: 201494	41.5	404.35	NSW Rural Fire Service
3	1145755/1	Sydney Water Corporation 32.5m Lattice Tower off Wendouree Ln ID: 370297	Murray River Council 75m Guyed Mast off Baldon Rd Moulamein ID: 201494	67.2	450.55	NSW Rural Service

6.3.1 Near-field effects

Near-field effects occur in the vicinity of the transmitter and receiver, typically being impacted by objects with inductive fields up to several hundred metres from the transmitter/receiver – though the precise impact is difficult to calculate.

As per Bacon [1], the near-field clearance distance, D_{nf} (m) can be calculated as follows:

For a dish or horn type of antenna:

$$D_{nf} = 10 \times \eta \times D_a^2 \times f$$

For any other type of antenna:

$$D_{nf} = 0.1 \times 10^{0.1G} / f$$

Where:

η = antenna efficiency

D_a = diameter of antenna physical aperture (m)

f = frequency (GHz)

G = maximum (boresight) antenna gain (dBi)

Link 1 antenna has near field clearance distance of approximately 193 m, while Link 2 antenna has near field clearance distance of approximately 52 m.

No ACMA communication sites were found within 1 km boundary of the wind turbines as shown in Figure 2. Therefore, no material near-field effects due to the Keri Keri wind farm are anticipated.

6.3.2 Reflection/scattering effects

Reflection and scattering relate to the interference by an object that reflects the signal from the transmitter to the receiver. This process creates a longer path between the transmitter and receiver, which can cause undesirable temporal modulation. However, where the carrier to interference ratio, that is the ratio of the strength of the intended signal to the interference signal is sufficiently high, the performance will be unaffected. This threshold varies from site to site. Generally, impacts on signal will be negligible beyond 2 km from a transmitter/receiver.

As per Figure 2, two communication sites are located more than 2 km of wind turbines. The nearest WTG, ID 184, is located more than 2.1 km from both of the communication sites.

Thus, the relative positions of the WTGs to the transmitter/receiver poses negligible risk of causing reflection/scattering effects.

The owners of the impacted links (Link 1 – Optus Mobile, Link 2 – NSW RFS) were contacted for comment.

6.3.3 Diffraction effects

Diffraction is where an object modifies a wave, by obstructing its path of travel. Fresnel zones define an envelope of influence along the length of the ray line, whereby a rotating wind turbine could adversely impact the signal.

The radius of the n -th Fresnel Zone, F_n , of a point-to-point link of length D , at a distance d_1 from the transmitter (or receiver) is given by the following equation:

$$F_n = \sqrt{\frac{n\lambda d_1(D - d_1)}{D}}$$

The wavelength of the transmittal signal, λ , is calculated as c/f , where c is the speed of light in air and f is the frequency of the transmittal signal.

Obstacles within the 1st Fresnel Zone will adversely impact the signal, whereas, beyond the 1st Fresnel Zone the impact is reduced. More specifically, for odd values of n the Fresnel Zone is a region of constructive interference; whereas for even values of n the Fresnel Zone is a region of destructive interference [2].

In calculating the paths of the links and the relative impact of obstacles, it is important to account for the curvature of the earth and the height of any antennae, as available.

Some sources recommend a clearance threshold of 60% of the 1st Fresnel Zone Radius - in particular for ground clearance and the like [1]; this advice typically relates to 400 MHz links. However, a more conservative approach for wind turbines is often preferred – that is, maintaining a clearance of the full 1st Fresnel Zone, or, as recommended by Bacon [1], clearance of the full 2nd Fresnel Zone. The latter is typically required for GHz (higher frequency) links. In particular, for sub-GHz links, the impact of a wind turbine on the link will be a function of the carrier to interference ratio, C/I. In some instances, the presence of a wind turbine penetrating the 1st Fresnel Zone will have no material impact on the link; in other instances, the presence of the wind turbine may have an impact, and mitigation strategies may be required.

The maximum radii of the 1st and 2nd Fresnel Zones of the communication links is summarised in Table 6 for the three links that may have diffraction effects.

Table 6: Information of point-to-point links

#	BSL/ Licence No	Length (km)	Minimum Frequency (MHz)	Nearest Turbine	Offset from LoS to Turbine (m)	F_1 Max (m)	F_2 Max (m)	Exclusion zone buffer (m)
1	10161921/1	46.8	5960	76	470	24.26	34.30	125.80
2	1972816/1 1972817/1	41.5	404.35	184	268	87.65	123.96	144.09
3	1145755/1	67.2	450.55	162	240.5	105.71	149.50	154.93

6.3.3.1 Link 1: Optus Mobile managed licence 10161921/1

Optus Mobile manages licence 10161921/1 which connects Site 1 (Mallan off Moulamein Rd, ID 9012006) to Site 2 (Axicom 60m Guyed Mast in Willowvale, ID 204310). The lowest frequency signal, 5960 MHz, has been applied in this analysis.

Figure 3, below, shows the wind turbine locations in the vicinity of Link 1. The closest wind turbine to this link is wind turbine 76, positioned 43 km away from Site 1 (Mallan off Moulamein Rd, ID 9012006). The rotor extent of wind turbine 76 has 344 m clearance from the edge of the second maximum Fresnel zone.

Optus were consulted for statement regarding the proximity of their licence to the proposed wind turbines. Optus comment was not available at time of issue and will be incorporated in subsequent issue of this report.

This assessment finds that, while Optus comment would provide further confirmation, the proposed turbine locations are unlikely to cause telecommunications interference with Link 1.



Figure 3: Link 1 passing wind turbine 76

6.3.3.2 Link 2: NSW Rural Fire Service managed licences 1972816/1 and 1972817/1

NSW Rural Fire Service owns two telecommunication licences which track the same path and have been summarised as Link 2. The link connects Site 1 (Axicom 60m Guyed Mast in Willowvale, ID 204310) to Site 2 (75 m Guyed Mast off Baldon Rd in Moulamein, ID201494). The lowest frequency signal, 404.35 MHz, has been applied in this analysis.

Figure 4, below, shows the closest wind turbine locations in the vicinity of Link 2. The closest wind turbine to this link is wind turbine 184, positioned 2.1 km away from Site 1 (Axicom 60m Guyed Mast in Willowvale, ID 204310). The rotor extent of wind turbine 184 has 52 m clearance from the edge of the second maximum Fresnel zone.

NSW Rural Fire Service were consulted for statement regarding the proximity of their licence to the proposed wind turbines. NSW RFS comment was not available at time of issue and will be incorporated in subsequent issue of this report.

This assessment finds that, while NSW RFS comment would provide further confirmation, the proposed turbine locations are unlikely to cause telecommunications interference with Link 2.

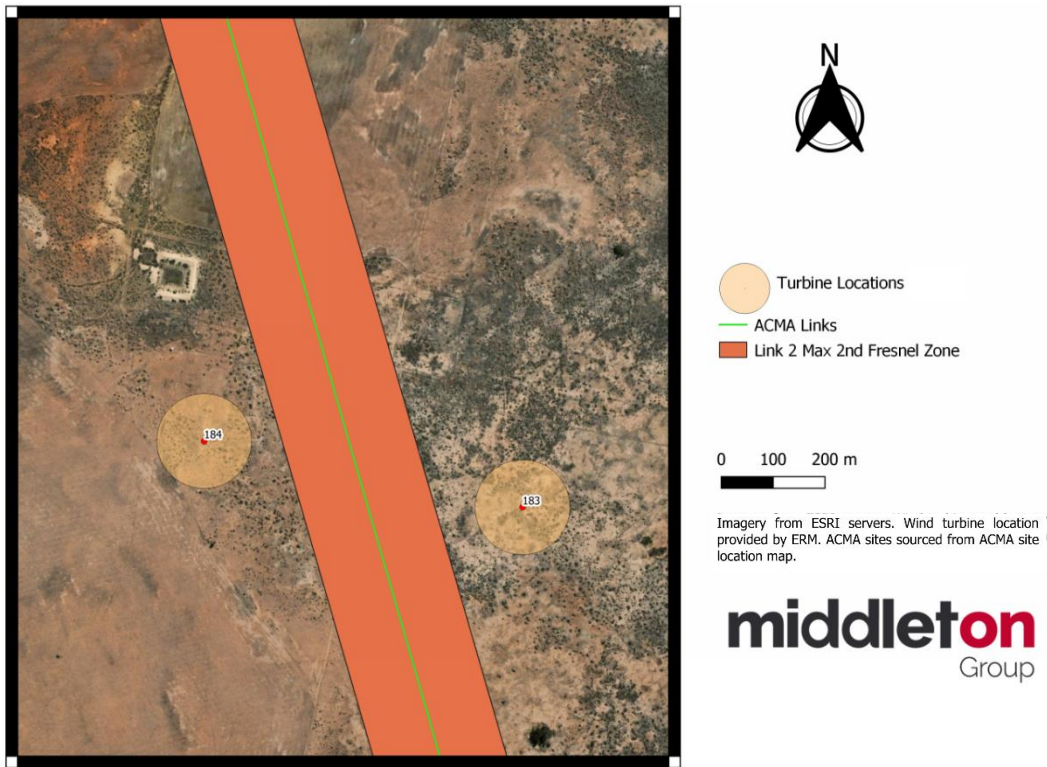


Figure 4: Link 2 passing wind turbine 183 and 184

Several other wind turbines are positioned in the vicinity of Link 2's path. These turbines are shown in Figure 5, which illustrates that the rotor extents are comfortably outside the link's maximum 2nd Fresnel zone.



Figure 5: Link 2 passing nearby wind turbines in project site.

6.3.3.3 Link 3: NSW Rural Fire Service managed licence 1145755/1

NSW Rural Fire Service manages licence 1145755/1 which connects Site 1 (Sydney Water Corporation 32.5m Lattice Tower off Wendouree Ln, ID 370297) to Site 2 (75 m Guyed Mast off Baldon Rd in Moulamein, ID201494). The lowest frequency signal, 450.55 MHz, has been applied in this analysis.

Figure 6, below, shows the wind turbine locations in the vicinity of Link 3. The closest wind turbine to this link is wind turbine 162, positioned 37 km away from Site 1 (Mallan off Moulamein Rd, ID 9012006). The rotor extent of wind turbine 162 touches the edge of the second maximum Fresnel zone.

NSW RFS were consulted for statement regarding the proximity of their licence to the proposed wind turbines. NSW RFS comment was not available at time of issue and will be incorporated in subsequent issue of this report

The proposed turbine locations are unlikely to cause telecommunications interference with Link 3. Given the close proximity, care must be taken when micro-siting of turbine 52 to ensure that the final as-built location does not impact Link 3.



Figure 6: Link 3 passing wind turbine 162, 163 and 182

Several other wind turbines are positioned in the vicinity of Link 3's path. These turbines are shown in Figure 7 and Figure 8, which illustrate that the rotor extents are comfortably outside the link's maximum 2nd Fresnel zone.



Figure 7: Link 3 passing multiple wind turbines within project area (part 1 of 2)



Figure 8: Link 3 passing multiple wind turbines within project area (part 2 of 2)

6.3.4 Summary

Based on the analysis presented and consultation with link owners/managers, the proposed wind turbines are not sited in the near-field zones of any transmitters/receivers, nor are they located in the reflection or scatter zones. Optus Mobile who manages Link 1, and NSW RFS who manage Link 2 and 3, have yet to confirm that the proposed wind turbine layout will not adversely impact their operations. Assessment has shown that no wind turbines will overlap with the maximum 2nd Fresnel Zones of any links. Therefore, the wind energy facility is expected to have a negligible impact on point to point links.

6.4 Meteorological Radar

Meteorological radars detect rain and thunderstorm events, as well as other phenomena such as flocks of birds, smoke or ash, which cause echoes to be visible. The Bureau of Meteorology's (BoM's) radars typically detect rain between 2.5 km to 3.5 km above the ground within a radius of 250 km, and in some instances, beyond. Some wind farms are visible to meteorological radars, registering as static echoes.

Details of specific radars and corresponding coverage maps are available online from <http://www.bom.gov.au/australia/radar/index.shtml>.

The World Meteorological Organisation (WMO) recommends that wind turbines are sited, at a minimum, beyond 5 km from meteorological radars, and preferably beyond 20 km [3]. The Operational Programme for the Exchange of Weather Radar Information (OPERA), the radar programme of European Meteorological Services Network (EUMETNET), of state that no wind turbine should be deployed within 5 km radius of C-band radars and 10 km radius of S-band radars. An impact study should be submitted if the wind turbines are sited within 20 km radius of C-band radars and 30 km radius of S-band radars [4].

Figure 9 demonstrates the location of the Meteorological radars in relation to the Project area. The details of the closest five weather radars are outlined in Table 7.

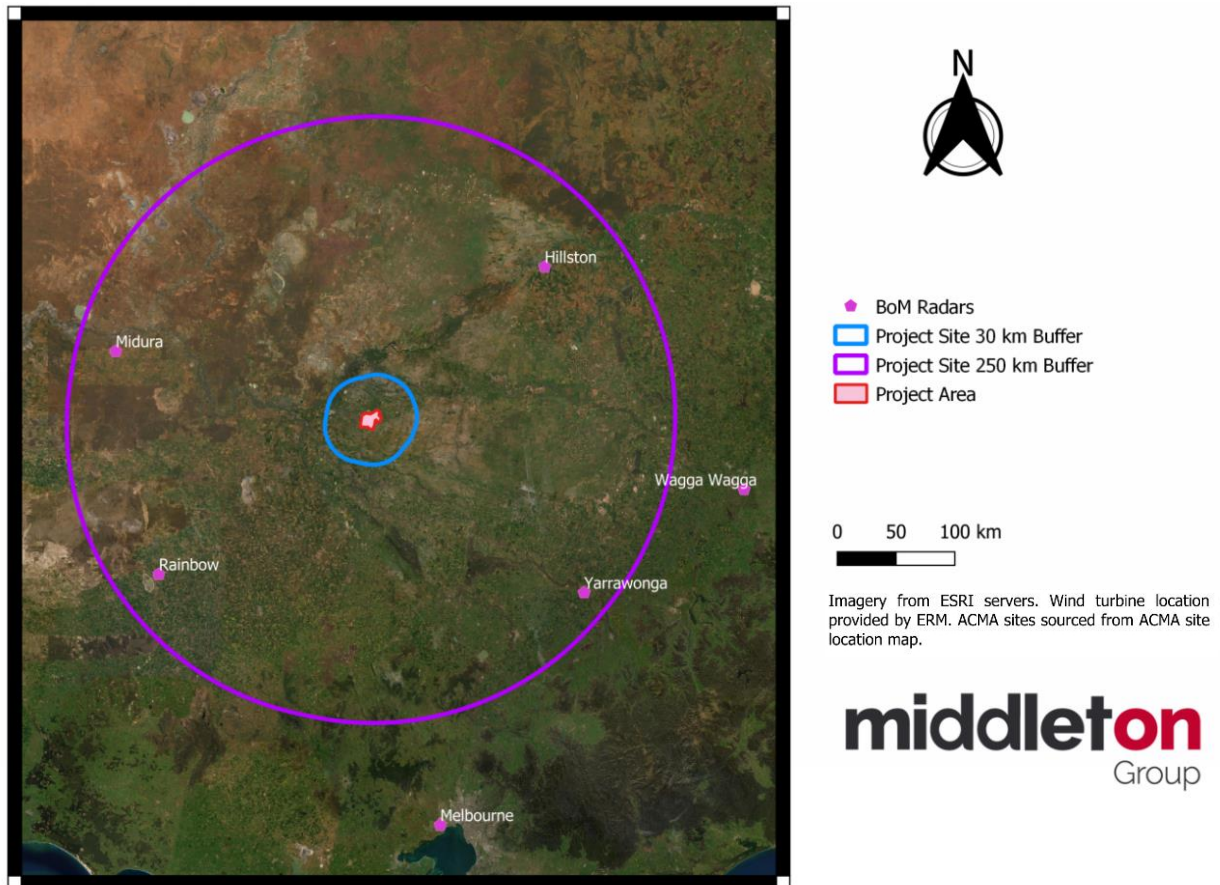


Figure 9: Meteorological radars map

Table 7: Summary table for the six closest weather radars in the Project area

Weather radar name	Coordinate	Radar type	Distance to Keri Keri Wind Farm Project Area
Midura	34.28°S, 141.59°E	Meteor 735CDP, C-band, Dual Pol	220 km
Rainbow	35.99°S, 142.01°E	Meteor 735C (C-Band, Doppler and Dual Pol)	213 km
Yarrawonga	36.03°S, 146.03°E	WSR 81C C-Band	227 km
Hillston	33.55°S, 145.52°E	Meteor 735CDP (C-Band, Doppler and Dual Pol)	185 km
Wagga Wagga	35.17°S, 147.47°E	WF 100 C Band	313 km
Melbourne	37.86°S, 144.76°E	M1500-S1, 1°S-band Doppler radar	341 km

The Keri Keri Wind Farm complies with WMO standards based on distance setbacks from the various meteorological radars in the region. Further, there is excellent coverage from the four radars within 250 km of the wind farm, giving good visibility of weather events in that region. As such, the presence

of the Wind Farm is unlikely to cause adverse performance of the radars during life threatening weather events.

Consultation with the BoM was conducted, with the complete BoM response included in Appendix A.1. BoM have requested some further assurances from the Proponent regarding operation of the wind farm, which do not strictly concern the currently proposed placement of wind turbines.

The Bureau response states:

The assessment shows manageable impact on the Bureau of Meteorology's weather radar network, in normal weather conditions. As such, the Bureau could conditionally agree to this project.

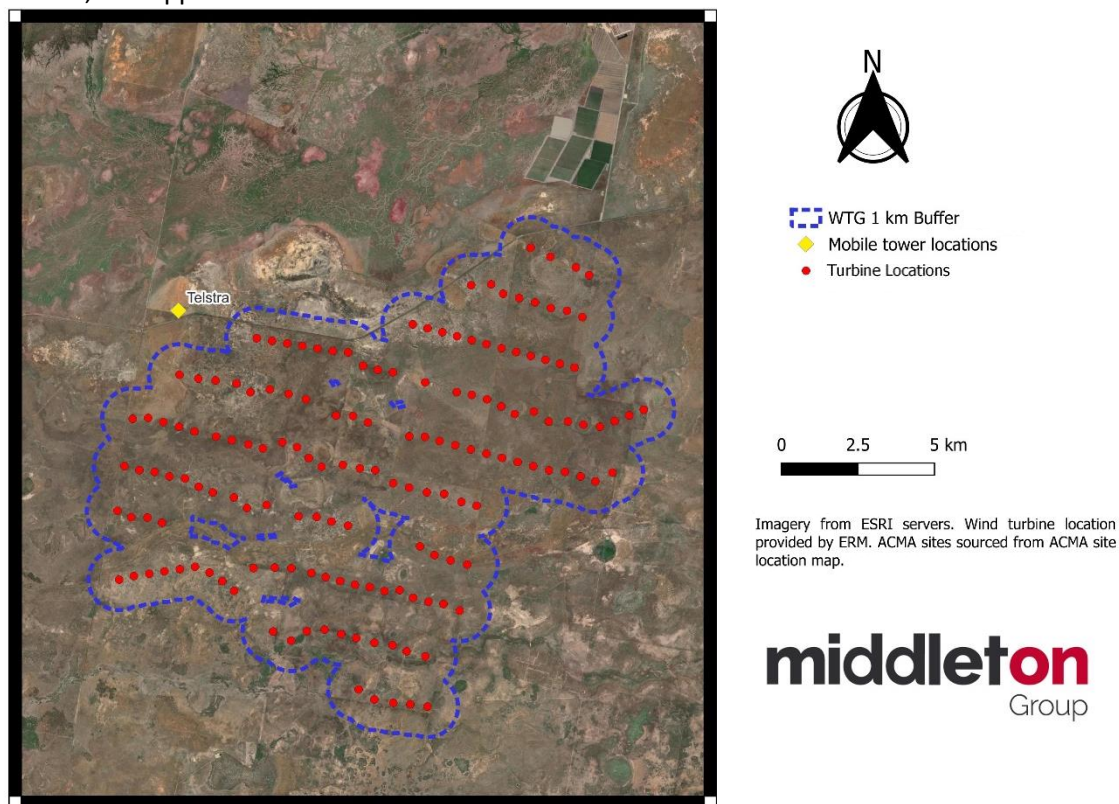
The Bureau requires a letter from the (wind) farm developer/owner to acknowledge that the operation of the proposed wind farm will include the following commitments:

1. Informing the Bureau of significant variation in turbine layout (i.e. by more than 100 m in any lateral direction, or alteration of tip height) between the initial plan and construction.
2. Providing advance notice (one week preferably) to the Bureau of any planned wind farm shutdown events for more than 12 hours, to allow the recalibration of radar systems.
3. Collaborate with the Bureau in the event of severe weather conditions to assist in endeavour of community safety.

6.5 Mobile Voice-based Communications

6.5.1 Mobile Coverage - Nearby Towers

Consultation and engagement with Telstra with respect to the impact on their mobile telemetry services has been conducted. Telstra have concluded there will be no detrimental impact to their services, see Appendix A.2 for their full letter.



6.5.2 Mobile Coverage - General

The mobile network coverage maps of Telstra and Optus within the region are shown in Figure 11 to Figure 13. It is noted that there are some mobile network services provided by Telstra and Optus in the Project area.

In the immediate vicinity of the wind turbines, some reduction in signal may occur. However, this can be mitigated by relocating the mobile phone receiver in the order of tens of metres. Beyond the project area, there will not be any significant impact on the signal.

As a result of the stakeholder consultation, Telstra have confirmed that the proposed wind farm will cause no material impact on their existing microwave links and any future upgrades. No response from Optus was received in the two weeks from the date of the letter, nor has any correspondence been received at the time of writing this report.

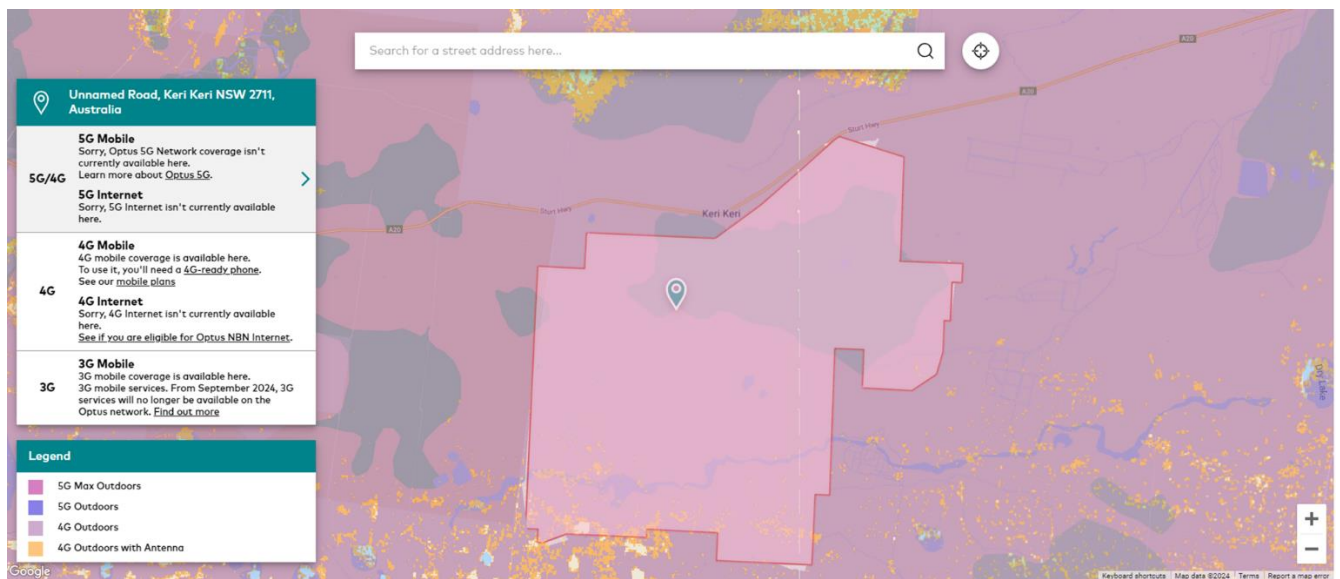


Figure 11: Optus mobile network coverage in the Project area

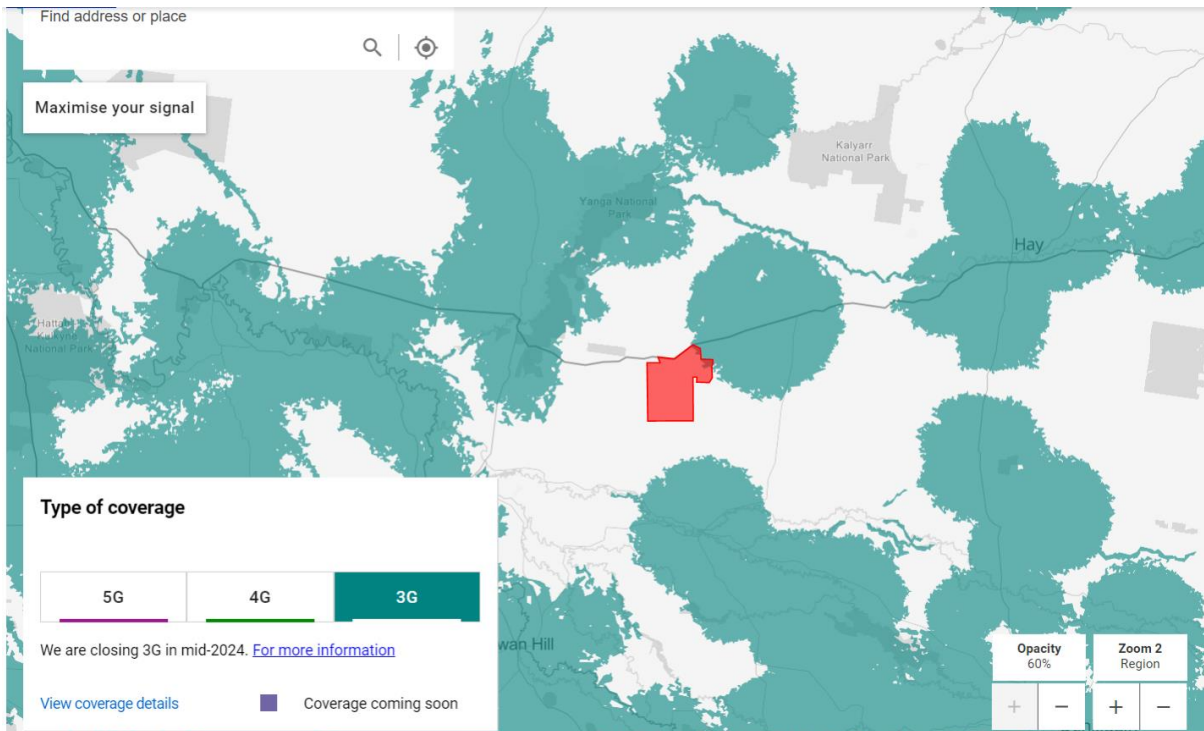


Figure 12: Telstra 3G mobile network coverage in the Project area

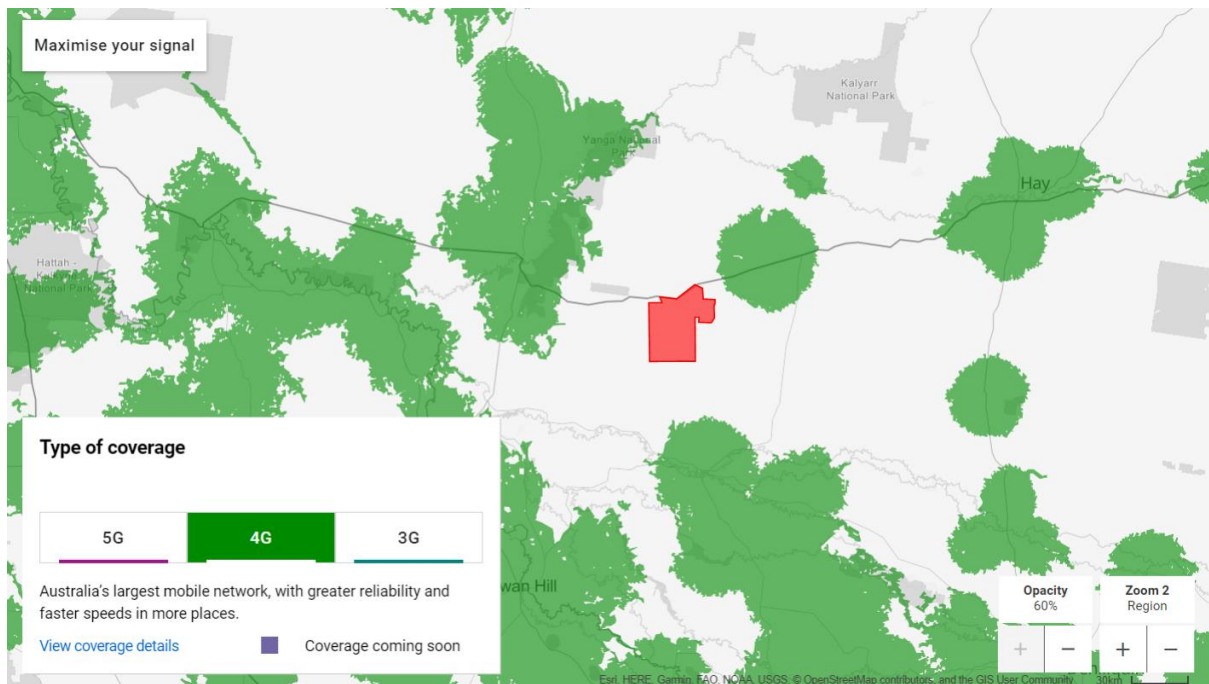


Figure 13: Telstra 4G mobile network coverage in the Project area

6.6 Wireless and Satellite Services

Satellite services will only be impacted where receivers are sited in extremely close proximity to turbines, impeding their view of the sky. These satellites typically provide pay-TV, wireless internet and satellite phone coverage, as well as TV coverage and on that 1 km there is no terrestrial service available.

Terrestrial services encompass radio and television broadcasting, mobile phone networks, and internet services delivered through land-based infrastructure like cables, antennas, and towers. They can span from local communities to entire countries, depending on the infrastructure's scale and technology.

As no dwellings are located within 2 km from a wind turbine as shown in Figure 14, therefore, it is highly unlikely that the Keri Keri Wind Farm will impact on satellite services.

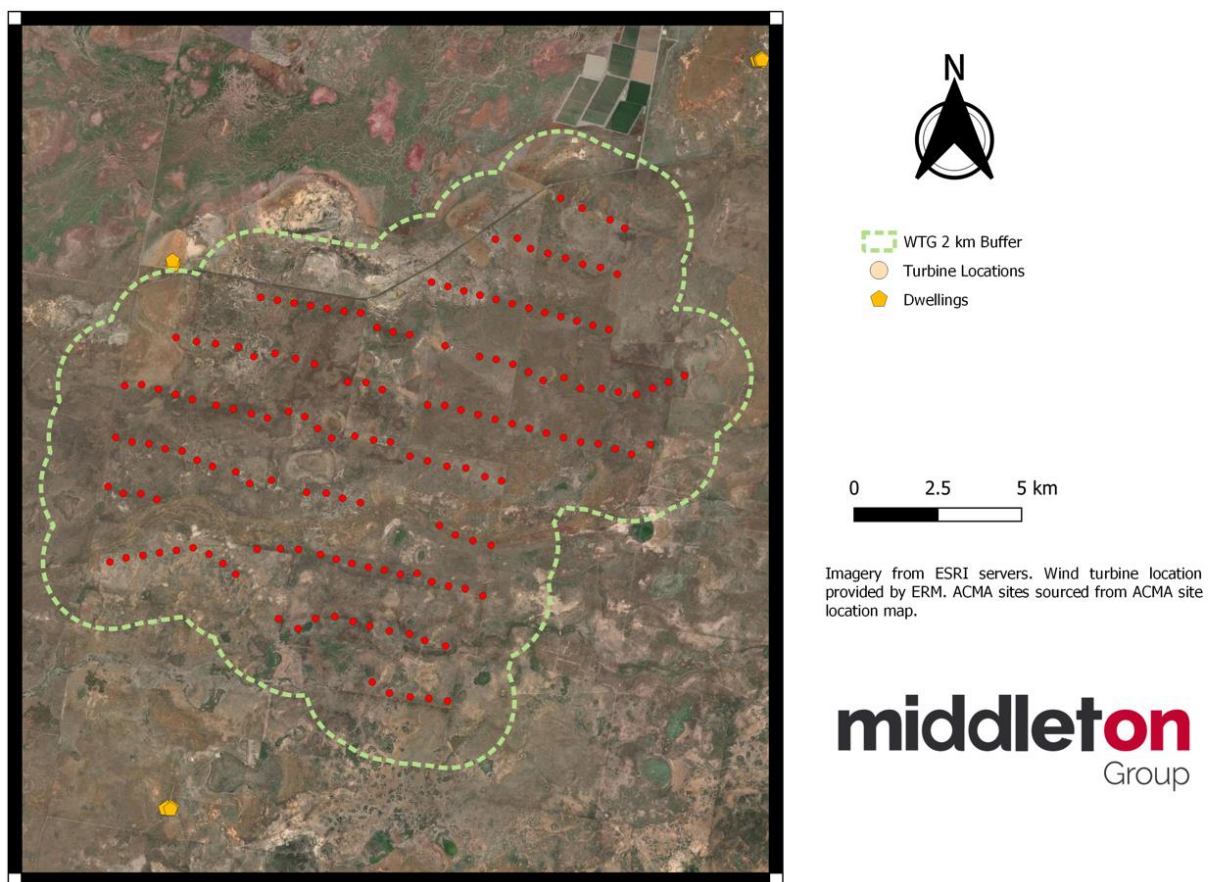


Figure 14. Dwellings around 2 km boundary of the Keri Keri wind turbines.

6.7 Trigonometrical Station and GPS

Trigonometrical stations and survey marks are observation marks used for surveying or distance measuring purposes. GPS antennas and Electronic Distance Measuring (EDM) devices may be installed at some Trigonometrical stations.

The performance of the EDM devices depends on the type of wavelength bands used. The current EDM devices operate by using three different wavelength bands: microwave systems, infrared systems and light wave systems. Microwave systems have a measurement range of up to 150 km and are not limited to line of sight or visibility. The infrared systems and light wave systems can measure a range 3 – 5 km, but accuracy may be limited by the line of sight or visibility [5]. If a line-of-sight blockage occurs, moving laterally one to two metres will typically alleviate the line-of-sight blockage. In addition, the presence of turbines will typically assist with sight navigation, providing fixed reference points.

Trigonometrical Stations (Survey Marks)

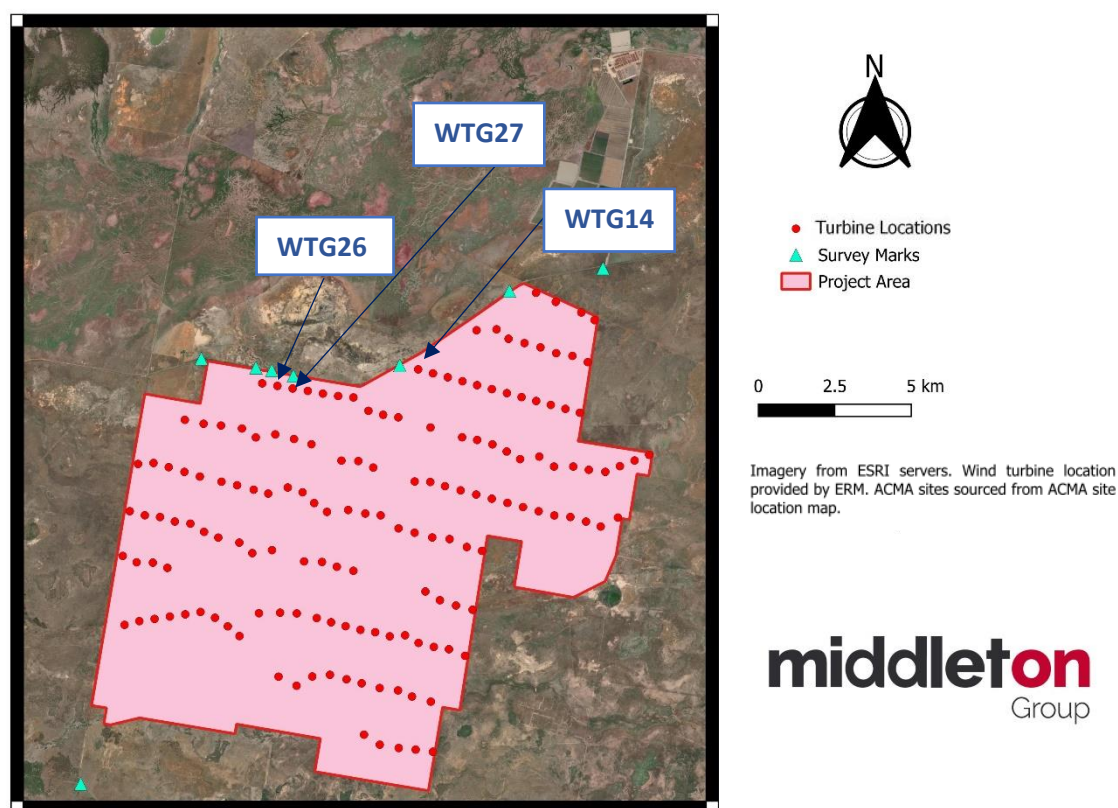


Figure 15: Survey marks near the Project area

A review on the location of all survey marks has been completed, and the findings are summarised as the below:

- There is no proposed wind turbine location that shares the same location as a survey mark.
- The closest survey marks are positioned on the Sturt Highway and border the project area.
- The closest distance between a survey mark and the wind turbine (WT26) is approximately 540 m, (WT27) is approximately 400 m, and (WT14) is approximately 600 m as shown in Figure 17.

- The site entrance point (near WTG 14) is approximately 200 m from survey mark SS4243 F. This is a satisfactory separation distance.
- The proposed infrastructure will safely avoid all survey marks. During construction, site works will need to be designed to avoid digging up or causing movement of the survey marks, or, alternatively, seek assistance from a registered surveyor to move or remove the survey marks.



Figure 16: Site entrance and nearby survey mark



Figure 17: Survey mark close up image over WTG26 and WTG27

Given the distance from the wind turbines to the survey marks, the wind farm construction can avoid these survey marks. However, if an element of the construction works is likely to impact the survey marks (e.g. site offices, temporary roads etc.), the project Proponent should consult with the NSW Government via the following website: <https://www.dnrme.NSW.gov.au/?contact=surveying>. As stated above, assistance from a registered surveyor may be required.

Trigonometrical Stations (GPS Antennae)

Global Navigation Satellite System (GNSS) networks are operated and maintained across the Australian region and the South Pacific. This includes the Australian Regional GNSS Network (ARGN), the South Pacific Regional GNSS Network (SPRGN) and the AuScope Network. GNSS networks provide the geodetic framework for the spatial data infrastructure in Australia and its territories. Data from the GNSS Network also contributes to the International GNSS Service (IGS).

Based on the GNSS network map provided by Geoscience Australia [6], the EMI impact of the project to the GNSS stations has been analysed. Figure 18 demonstrates that there are no GNSS stations within 20 km of the Keri Keri Project Area boundary. The closest GNSS station, MOUL is 27 km away from the nearest wind turbine. The next closest GNSS stations, PIAN and BLRN are 31 km and 55 km away from the nearest wind turbines respectively.

As all the GNSS stations are outside 20 km boundary of the wind turbines, it is unlikely that the Keri Keri Wind Farm will impact on the GNSS networks.

Consultation and engagement with Geoscience Australia were initiated by Middleton Group on 24 October 2022, as shown in Appendix A.3. Geoscience Australia responded on the 1st of November 2022 that the proposed wind farm development will not cause any impact to the Commonwealth owned trigonometrical stations and/or Global Navigation Satellite System (GNSS) reference stations or associated assets.



Figure 18 GNSS stations location and 20 km wind turbine buffer

6.8 Broadcast and Digital Radio and Television

Amplitude Modulation (AM) signals are long wave signals. Operating wind turbines can influence the radiating patterns, with the potential to result in reduced signal quality and strength, as well as causing interference at neighbouring frequencies. Consultation with the relevant operators should be undertaken for any AM transmitters within 2 km of a WTG. The field of influence from the receiver's perspective is in the order of tens of metres.

Frequency modulated (FM) signals tend to be more robust around obstructions such as buildings and wind farms. At the edge of their transmission range, where the signal to noise ratio is already quite low, wind turbines can have an adverse influence on the signal. Consultation with the relevant operators should be undertaken for any FM transmitters within 1 km of a WTG.

Digital signals tend to be more robust than analogue signals. A 2 km radius is generally desirable around transmitters – for both digital radio and Digital Television (DTV). Digital signals are more robust against ghosting, though wind turbine rotor pass can cause signal frequency variation.

As can be seen in Figure 19, no AM, FM, DTV or Temporary Licence transmitters are located within 30 km of a turbine. No digital radio transmitters were identified in the vicinity of the site.

If issues are encountered with television reception, this is most readily mitigated by readjusting the receptor, to capture signal from an alternative transmitter.

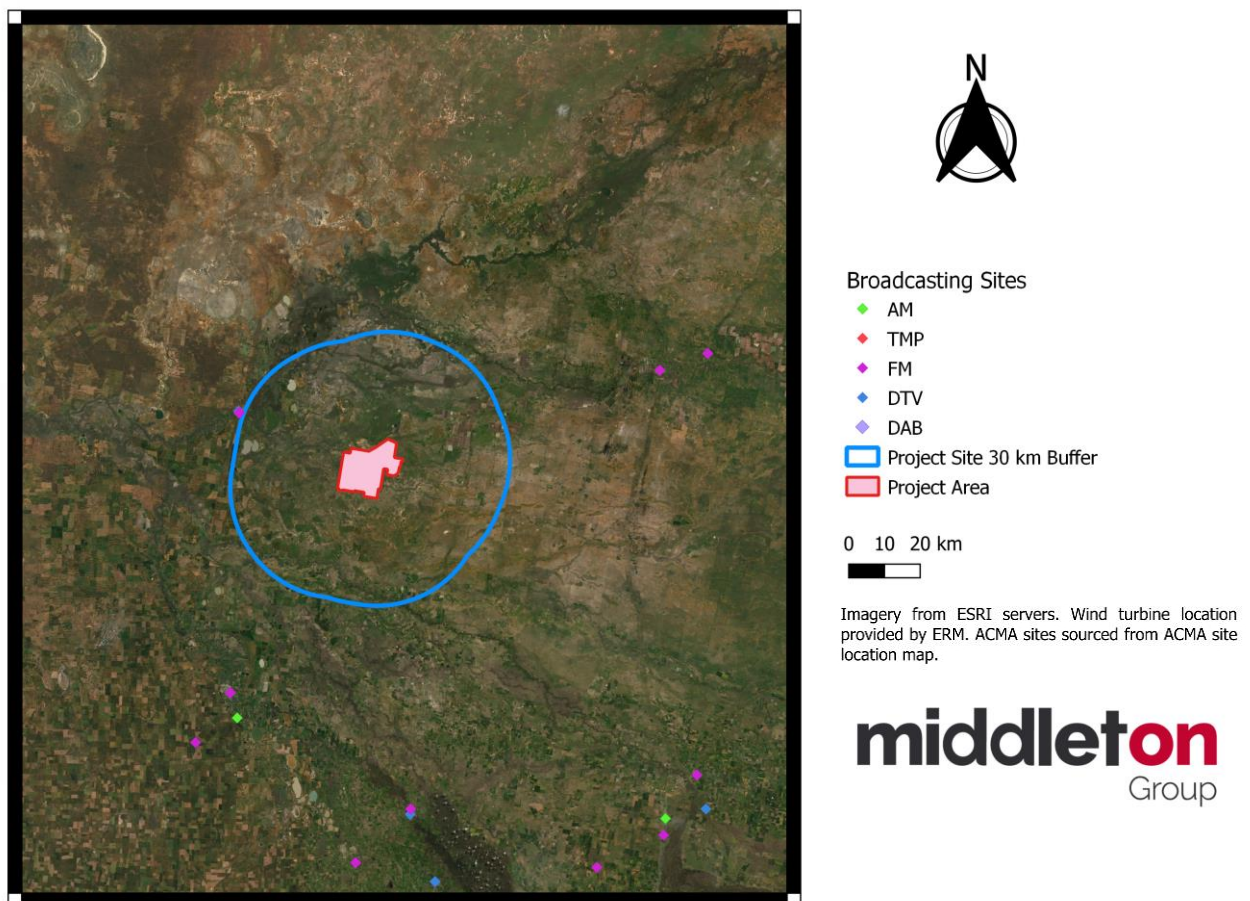


Figure 19: Location of broadcasters relative to the Project.

7 Stakeholder Engagement

Consultation and engagement with stakeholders were initiated by the Applicant. A list of key stakeholders is presented in Table 8. Responses from these stakeholders are provided in Appendix A.

A summary of the engagement is listed below:

- Telstra has confirmed that their analysis had not identified any potential obstruction concern from the proposed wind farm on their communication services.
- NSW Rural Fire Service have not yet responded to consultation email
- Optus have not yet responded to consultation emails
- The Bureau of Meteorology have stated their assessment shows manageable impact on the Bureau of Meteorology's weather radar network, in normal weather conditions. The BoM could agree to this project with some minor management conditions
- Geoscience Australia has confirmed that the proposed wind farm will cause no impact on their trigonometrical stations and GNSS reference stations or associated assets.

Table 8: List of stakeholder engagement.

Stakeholder	Email address	Impact	Responses
NSW Fire and Emergency Services	pes@rfs.nsw.gov.au	Fixed point-to-point link (License No.s: 1972816/1, 1972817/1 and 1145755/1)	No response
Optus Mobile Pty Limited	emeenquiries@optus.com.au	Fixed point-to-point link (License No: 10161921/1) Mobile service operation	No response
Bureau of Meteorology	windfarmenquiries@bom.gov.au	Meteorological radar operation	No impact in normal conditions. Ongoing negotiation re: management of wind farm in abnormal conditions
Telstra	David.Jonas@team.telstra.com	Mobile service operation	No impact.
Geoscience Australia	clientservices@ga.gov.au	Survey marks	No impact.

8 Conclusions

The potential electromagnetic interference impact of the Keri Keri Wind Farm has been assessed in this report.

Based on analysis and consultation with key stakeholders, the Project will have no material impact on:

- Wireless and satellite internet services;
- Broadcast and digital radio;
- Broadcast, digital and satellite television;
- Trigonometry stations; and
- GPS.

Based on analysis the Project is expected to have no material impact on the following, however consultation responses from stakeholders have not been received for:

- Point-to-point microwave links (Optus & NSW Rural Fire Service);
- Mobile voice-based communications (Optus).

The Bureau of Meteorology have requested some further assurances from the Proponent regarding operation of the wind farm, which do not strictly concern the currently proposed placement of wind turbines.

Appendix A Stakeholder Correspondence

Appendix A.1 Bureau of Meteorology

Hi Eric,

We have finalized our assessment through desktop analysis for the proposed Keri Keri Wind Farm.

The assessment shows manageable impact on the Bureau of Meteorology's weather radar network, in normal weather conditions. As such, the Bureau could conditionally agree to this project.

The Bureau requires a letter from the farm developer/owner to acknowledge that the operation of the proposed wind farm will include the following commitments:

4. Informing the Bureau of significant variation in turbine layout (i.e. by more than 100 m in any lateral direction, or alteration of tip height) between the initial plan and construction.
5. Providing advance notice (one week preferably) to the Bureau of any planned wind farm shutdown events for more than 12 hours, to allow the recalibration of radar systems.
6. Collaborate with the Bureau in the event of severe weather conditions to assist in endeavour of community safety.

Please let me know if you need any further information related to this assessment.

Kind Regards,

Muhammad Usman Afzal (Ph.D)

Spectrum Engineer

Observing Systems and Operations Program, Data and Digital Group

M: 0420 696 374

Level 15, 300 Elizabeth St, Surry Hills, NSW 2000

| www.bom.gov.au



From: Muhammad Afzal <>

Sent: Tuesday, 25 October 2022 9:02 AM

To: Eric Bendtsen <> windfarmenquiries
<windfarmenquiries@bom.gov.au>

Subject: RE: Keri Keri Wind Farm BoM email [SEC=OFFICIAL]

Hi Eric,

Thanks for the providing us with the data.

We'll have to run our simulations to understand the impact on the weather radars. We've received few wind farm assessment this month and currently working on them.

We will provide you with our assessment as soon as possible.

Kind Regards,

Muhammad Usman Afzal (Ph.D)

Spectrum Engineer

Observing Systems and Operations Program, Data and Digital Group

M: 0420 696 374

Level 15, 300 Elizabeth St, Surry Hills, NSW 2000

| www.bom.gov.au



From: Eric Bendtsen <_____.>
Sent: Monday, 24 October 2022 4:22 PM
To: windfarmenquiries <windfarmenquiries@bom.gov.au>
Subject: Keri Keri Wind Farm BoM email

To whom it may concern,

We are conducting early-stage consultation on the topic of Electro-Magnetic Interference (EMI) for the Keri Keri Wind Farm on behalf of Acciona (the Proponent). The wind farm is located in NSW, just north of the Murray River approximately 32 km east-south-east of Biloela, 32 km north of Moulamein.

As a result of our assessment, four (4) sites have been identified as per below:

- Mildura Meteor 735CDP, C-band, Dual Pol
- Rainbow Meteor 735C (C-Band, Doppler and Dual Pol enabled)
- Yarrawonga WSR 81C C-Band
- Hillston Meteor 735CDP (C-Band, Doppler and Dual Pol enabled)

The nearest meteorological radar, Hillston is 183 km from the project site. The next nearest radars, Rainbow and Mildura, are both approx. 210 km from the project site. All other radars are more than 250 km from the project site. Based on our analysis of the coverage area of BoM radars and the

WMO guidance document (WMO- No.1064, Annex VI Table), we do not anticipate that the wind farm will significantly impact the radar operation.

We attach both a Google Earth .kml file of the wind farm layout and a .csv file containing the wind turbine co-ordinates in GDA94 zone 56, noting that the rotor diameter of the Proponent's turbines will be up to 200 m with a maximum tip height of 300 m.

If you have any concerns relating to the development and any potential impacts on your operations, please get in contact by replying to this email or by calling us on the phone number listed below prior to 11th November 2022.

Kind regards,

Eric Bendtsen

MEng (Electrical)

Power Engineer

middleton
Group

M: +61 409 850 842

Suite 3, L10, 350 Collins Street, Melbourne, VIC 3000

www.middletongroup.com.au



Appendix A.2 Telstra

Appendix A.3 Geoscience Australia

Dear Eric,

Geoscience Australia do not foresee any impact on our GNSS assets in relation to the proposed windfarm at Keri Keri.

Kind regards,

Ryan Ruddick | Director
GNSS Infrastructure and Informatics Section | Positioning Australia
Space Division

t +61 2 6249 9426 **m** +61 429 771 069 ga.gov.au



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Geoscience Australia acknowledges the traditional owners and custodians of Country throughout Australia and acknowledges their continuing connection to land, waters and community. We pay our respects to the people, the cultures and the elders past and present.

From: Eric Bendtsen <[\[redacted\]](#)>
Sent: Monday, 24 October 2022 4:23 PM
To: Client Services <ClientServices@ga.gov.au>
Subject: Keri Keri Wind Farm - Geoscience Australia EMI Consultation

To Whom it May Concern,

We are conducting early stage consultation on the topic of Electro-Magnetic Interference (EMI) for the Keri Keri Wind Farm on behalf of Acciona (the Proponent). Our consultation particularly relates to potential impact on survey marks and GNSS stations.

The wind farm is located in NSW, just north of the Murray River approximately 32 km east-south-east of Biloela, 32 km north of Moulamein. We attach both a Google Earth .kml file of the wind farm layout and a .csv file containing the wind turbine co-ordinates in GDA94 zone 54, noting that the rotor diameter of the Proponent's turbines will be up to 183 m with a maximum tip height of 292 m.

If you have any concerns relating to the development and any potential impacts on your operations, please get in contact by replying to this email or by calling us on the phone number listed below prior to 11th November 2022

Kind regards,

Eric Bendtsen

MEng (Electrical)

Power Engineer



M: +61 409 850 842

Suite 3, L10, 350 Collins Street, Melbourne, VIC 3000

www.middletongroup.com.au



Appendix A.4 NSW Telecommunications Authority

Appendix B WTG Coordinates

Table 9: WTG Coordinates

WTG ID	Easting	Northing
1	777091	6156229
3	777736	6155933
4	778571	6155585
5	779003	6155334
6	775145	6155005
7	775799	6155035
8	776190	6154725
9	776712	6154585
10	777235	6154445
11	777750	6154255
12	778280	6154165
13	778783	6153963
14	773233	6153726
15	773719	6153596
16	774200	6153466
17	774681	6153338
18	775162	6153209
19	775644	6153080
20	776137	6152948
21	776616	6152819
22	777094	6152691
23	777573	6152563
24	778052	6152434
25	778525	6152307
26	768627	6153184
27	769125	6153101
28	769621	6153020
29	770117	6152934
30	770614	6152854
31	771113	6152808
32	771605	6152370
33	772086	6152240
34	772583	6152157
36	773638	6151825
38	774670	6151506
39	775162	6151417
40	775663	6151273

WTG ID	Easting	Northing
41	776130	6151040
42	776568	6150790
43	777195	6150872
44	777679	6150547
45	778308	6150548
46	778816	6150442
47	779358	6150374
48	779836	6150560
49	780315	6150745
50	780792	6150930
51	767466	6151792
52	767920	6151502
53	768557	6151599
54	769172	6151448
55	769740	6151276
57	770722	6150741
58	771275	6150728
59	771763	6150516
62	773118	6150059
63	773629	6150043
64	774111	6149907
65	774622	6149770
66	775132	6149633
67	775643	6149496
68	776154	6149359
69	776665	6149222
70	777176	6149085
71	777687	6148949
72	778214	6148899
73	778725	6148748
74	779208	6148587
75	779767	6148878
76	764068	6150632
77	764572	6150664
78	765070	6150528
79	765585	6150374
80	766090	6150220
81	766797	6150053
82	767309	6149937
83	767849	6149793
84	768327	6149663
85	768966	6149862

WTG ID	Easting	Northing
86	769450	6149705
87	769830	6149354
88	770249	6149066
89	770943	6149126
90	771504	6149011
91	772006	6148952
92	772591	6148526
94	773116	6148384
95	773693	6148229
96	774260	6148177
97	774825	6147916
98	775323	6147790
105	763796	6149087
106	764289	6148955
107	764786	6148896
108	765271	6148750
109	765779	6148680
110	766228	6148412
111	766692	6148225
112	767380	6148061
113	767804	6147716
114	768450	6147814
116	769498	6147446
117	770086	6147428
118	770573	6147271
119	771112	6147140
124	773470	6146462
125	773944	6146176
126	774470	6146003
127	775013	6145866
128	763567	6147626
129	764021	6147416
130	764552	6147404
131	765026	6147235
137	768023	6145750
139	768714	6145769
140	769261	6145745
141	769914	6145594
142	770385	6145455
143	770860	6145328
144	771343	6145208
145	771826	6145132

WTG ID	Easting	Northing
146	772304	6144996
147	772804	6145031
148	773246	6144780
149	773745	6144650
150	774240	6144574
151	774766	6144359
153	763624	6145372
154	764109	6145493
155	765109	6145643
156	765613	6145715
157	767003	6145324
158	767387	6145004
162	769767	6143683
163	770346	6143737
164	770890	6143591
165	771384	6143461
166	771974	6143306
167	772573	6143227
168	773031	6143027
170	773648	6142859
171	771462	6141780
172	771976	6141453
173	772597	6141343
174	773151	6141292
175	773714	6141220
176	766110	6145793
177	768130	6153268
178	766783	6151888
179	764607	6145565
180	766585	6145604
181	768663	6143676
182	769253	6143379
183	766212	6151946
184	765598	6152074