



BALDON WIND FARM

EMI and EMF Assessment

Baldon Wind Farm Pty Ltd, care of Goldwind Australia Pty Ltd

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EXECUTIVE SUMMARY

DNV has been commissioned by Baldon Wind Farm Pty Ltd, care of Goldwind Australia Pty Ltd ("Goldwind" or "the Customer"), to independently assess potential electromagnetic interference (EMI) impacts associated with the development and operation of the proposed Baldon Wind Farm ("the Project") in southern New South Wales (NSW). The results of the EMI assessment are described in this document.

Background and methodology

DNV has assessed the potential EMI impacts for the Project in accordance with the Secretary's Environmental Assessment Requirements (SEARs) for the Baldon Wind Farm [1], NSW Wind Energy Guideline [2], and Draft National Wind Farm Development Guidelines [3]. The methodology used in this study has been informed by these guidelines and various standard industry practices.

DNV has also evaluated the potential health impacts of EMF associated with the Project as required by the SEARs [1], based on internationally recognised guidelines.

A Project layout consisting of 180 wind turbines with a rotor diameter of 245 m and tip height of 300 m has been considered. These dimensions represent the maximum overall tip height within the maximum rotor and tower hub height dimensions.

There are 23 identified dwellings within 5 km of the Project, eight of which are associated dwellings and are understood to be uninhabited.

Outcomes of the assessment

Potential EMI impacts

The results of the EMI assessment are summarised in the table at the end of this section.

To date, DNV has not identified any potential for the Project to cause significant EMI-related impacts. However, consultation with the operators of some radiocommunication services is required to determine the likely impacts on those services. This consultation has commenced, and no justifiable concerns have been raised to date. In most cases, if interference is experienced, it is expected that mitigation options will be available.

Turbines at the Project may interfere with point-to-area style services such as mobile phone signals and terrestrial television broadcasting, particularly in areas with poor or marginal signal coverage. Dwellings within approximately 5-10 km of the Project that are currently receiving weak signals from the Murray Valley television broadcast transmitter may experience interference to this service. However, given that all dwellings that are both in the coverage area for this transmitter and in the interference zone established by DNV are uninhabited, the overall potential for impact is considered low. Feedback received from BAI Communications, who operate the Murray Valley transmitter, also suggests that impacts to DTV broadcasting are unlikely. If interference to any of these services is experienced, a range of options are available to rectify difficulties.

Interference to signals from a geostationary satellite that transmits programs intended for international audiences is also possible at one nearby dwelling (R22), but the Customer has advised that this dwelling no longer exists as it has been demolished. Therefore, satellite signals to dwellings in the vicinity of the Project are not expected to be intercepted by turbines.

Impacts to fixed point-to-point links crossing the proposed Project site are not expected, as there are no turbines located within the interference zones established by DNV. DNV has consulted with the operators of those links to confirm the potential for interference. Although concerns have been raised by Vodafone, these are not supported by the assessment presented here and Vodafone has not yet provided justification or specified an appropriate clearance zone to avoid impacts to their point-to-point links. No other concerns have been raised to date.

Since it is not possible to determine the potential EMI impacts on point-to-multipoint links, emergency services, and meteorological radar without obtaining further information from the relevant operators, DNV has consulted with organisations operating services that may be affected by the Project. The Bureau of Meteorology has advised that impacts to their radars are expected to be manageable, and the responses received to date from the operators of point-to-multipoint links and emergency services indicate that the Project is unlikely to have any impacts on these services.

Potential EMI impacts on other services considered in this assessment, including Starlink satellite internet, trigonometrical stations, radio broadcasting, and CB radio, are not expected or are considered to be minor.

DNV notes that the Project is located in an area of high wind farm development activity, with several other proposed, approved, and operating wind farms located nearby. The potential cumulative impacts of the Project in conjunction with the nearby wind farms have not been considered in detail in this assessment. However, for services where impact from the Project itself is considered either unlikely or non-existent, it is generally expected that there will be no cumulative impacts.

Potential EMF health impacts

The risks to human health from EMF associated with the Project are considered low. Simulation of the EMF produced by the proposed medium-voltage underground cabling network and high-voltage overhead line has shown that the EMF at the range of heights above ground level that humans are most likely to occupy (from 0 m above ground level to 2 m above ground level) will be within the exposure limits recommended for the protection of the general public. EMF from other equipment at the Project is also expected to be compliant with the relevant guidelines. The EMF levels produced by the Project are therefore expected to be within the recommended exposure limits at all publicly accessible locations in and around the Project, and indistinguishable from background levels at nearby dwellings.

Summary of EMI assessment results for the proposed Project

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Radio-communication towers	No towers within 2 km of proposed turbine locations	Consultation not considered necessary	None	None required
Fixed point-to-point links	14 links crossing Project boundary, operated by: Ambulance Service of NSW Essential Energy New South Wales Government Telecommunications Authority (NSW Telco Authority) NSW Rural Fire Service Optus Mobile Pty Limited (Optus) Vodafone Australia Pty Limited (Vodafone) No turbines in diffraction zones for all links	Vodafone: potential for interference raised, but no justification provided to date Essential Energy, Optus: no concerns raised Other operators: no response received	Unlikely to cause interference	If required – upgrade existing equipment, reroute affected links, install additional towers, replace affected links with alternative technologies
Fixed point-to-multipoint links	76 assignments within 75 km of Project boundary One base station within 20 km of Project boundary, operated by: Murray Irrigation Ltd	Water NSW: no concerns raised Other operators: no response received	Potential for interference if link paths cross the Project near turbines	If required – reroute affected links, install additional towers, replace affected links with alternative technologies
Other licence types	Point-to-area style communications: see findings for emergency services, mobile phones, radio broadcasting, and television broadcasting	-	-	-
Emergency services	Point-to-point links: Nine links crossing boundary operated by Ambulance Service of NSW, New South Wales Government Telecommunications Authority and NSW Rural Fire Service Point-to-area style communications: unlikely to be affected	NSW Police Force, St John Ambulance, NSW SES, VRA Rescue, NSW Telco Authority: no concerns raised Other operators: no response received	Point-to-point links: unlikely to cause interference Point-to-area style communications: unlikely to cause interference	Point-to-point links: as for point-to-point links Point-to-area style communications: if required – increase signal strength from affected tower or alternative towers, install signal repeater, install additional tower



**Summary of EMI assessment results for the proposed Project
(continued)**

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Meteorological radar	Nearest radar: 174 km from Project	Impacts are expected to be manageable	Potential for manageable interference	Notify the Bureau of Meteorology prior to any planned shutdown of the Project to allow calibration of systems, collaborate with the Bureau of Meteorology in the event of severe weather conditions
Trigonometrical stations	Trigonometrical stations: unlikely to be affected One trigonometrical station ('Jeraly') is located within the site boundary	No concerns raised	Unlikely to cause interference	None required
Citizen's band radio	Unlikely to be affected	Consultation not considered necessary	Unlikely to cause interference	None required
Mobile phones	Unlikely to be affected in areas with good coverage, may experience interference in areas with marginal coverage Telstra: Some 3G and 4G coverage to the north and south of the site, inside and outside the site boundary Optus: Both 3G and 4G coverage available inside the site boundary. An additional antenna may be needed for areas to the north, east and west outside the site boundary Vodafone: 4G available across the north of the site, 3G available through the centre, no coverage across the south	Optus, Vodafone: no concerns raised Telstra: no response received	Unlikely to be affected in areas with good coverage, may experience interference in areas with marginal coverage	If required – increase signal strength from affected tower or alternative towers, install additional tower
Wireless internet	Wireless broadband service providers: Field Solutions Group Pty Ltd, Telstra, Optus, Vodafone, NBN Co Field Solutions Group: nearest tower located 56 km southwest of site NBN: available as a satellite service only	Optus, Vodafone, Field Solutions Group, NBN: no concerns raised Telstra: no response received	Telstra, Optus, Vodafone: as for mobile phones Field Solution Group: unlikely to cause interference NBN: none	Telstra, Optus, Vodafone: as for mobile phones Field Solutions Group: if required – to be determined in collaboration with operator NBN: none required

**Summary of EMI assessment results for the proposed Project
(continued)**

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Satellite television and internet	<p>Geostationary satellites: signals from satellites providing services intended for Australian audiences unlikely to be affected; signals from one satellite providing services intended for international audiences intercepted at one dwelling, although this dwelling has been demolished</p> <p>Low Earth orbit (LEO) satellites: Unlikely to be affected</p>	Consultation not considered necessary	<p>Geostationary satellites: none</p> <p>LEO satellites: none</p>	<p>Geostationary satellites: none required</p> <p>LEO satellites: none required</p>
Radio broadcasting	<p>AM and FM signals: may experience interference in close proximity to turbines</p> <p>Digital radio signals: Project is outside the intended coverage area</p>	Consultation not considered necessary	<p>AM and FM signals: low likelihood of interference</p> <p>Digital radio signals: none</p>	<p>AM and FM signals: if required – install higher-quality antenna or amplifier at affected location</p> <p>Digital radio signals: none required</p>
Television broadcasting	<p>May experience interference in areas with poor or marginal reception</p> <p>Murray Valley transmitter: <i>'variable' coverage in the south of the site</i></p> <p>Seven dwellings in potential interference zone, but all dwellings which have coverage and are in the interference zone are uninhabited</p>	<p>Interference not expected – no buildings identified in potential interference areas</p> <p>Rectification of any interference is expected to form part of the Project</p>	Low likelihood of interference	If required – re-align antenna at affected dwelling to existing tower, re-direct antenna to alternative tower, install more directional or higher gain antenna, change location of antenna, install cable or satellite television, install relay transmitter



1 INTRODUCTION

Baldon Wind Farm Pty Ltd, care of Goldwind Australia Pty Ltd (“Goldwind” or “the Customer”), has commissioned DNV to independently assess the potential electromagnetic interference (EMI) related impacts associated with the proposed Baldon Wind Farm (“the Project”) in New South Wales (NSW). The results of this work are reported here. This document has been prepared in accordance with the Service Order Contract contained in DNV proposal L2C-235702-AUMEL-P-01 Issue B, dated 10 August 2022, and is subject to the terms and conditions in that agreement.

In accordance with the Secretary’s Environmental Assessment Requirements (SEARs) for the Baldon Wind Farm [1], the NSW Wind Energy Guideline for State significant wind energy development (NSW Wind Energy Guideline) prepared by the NSW Department of Planning and Infrastructure in December 2016 [2], and the National Wind Farm Development Guidelines – Draft (Draft National Guidelines) prepared by the Environment Protection and Heritage Council (EPHC) in July 2010 [3], this assessment investigates the potential EMI impact of the Project on:

- fixed point-to-point links
- fixed point-to-multipoint links
- radiocommunication assets belonging to emergency services
- meteorological radars
- trigonometrical stations
- Citizen’s band (CB) radio and mobile phones
- wireless internet
- satellite television and internet
- broadcast radio and television.

“Radiocommunications” is used as a broad term in this report to encompass all services that rely on microwave or radio frequency electromagnetic waves to transfer information, including those listed above.

This assessment also includes an evaluation of the potential health hazards and risks associated with electromagnetic fields (EMF) produced by the Project, as required by the SEARs.



2 DESCRIPTION OF THE SITE AND PROJECT

2.1 The site

The project site is located in New South Wales, approximately 139 km northwest of Echuca and 43 km east of Balranald. The surrounding area is mostly flat farmland, although Abercrombie Creek runs through the centre of the site.

2.2 The Project

2.2.1 Proposed wind farm layout

The Project is proposed to consist of 180 wind turbines [4]. A map of the site with the proposed turbine layout is shown in Figure 9, and the coordinates of the proposed turbine locations are presented in Table 8.

2.2.2 Dwelling locations

The locations of dwellings in the vicinity of the Project have been provided by the Customer [5].

For the purposes of this assessment, DNV has evaluated the potential for EMI-related impacts at identified dwellings within 5 km of the Project boundary. The locations of identified dwellings more than 5 km from the Project boundary have also been shown, where available, but impacts at these dwellings have not been considered in detail, as dwellings at these distances are not expected to experience interference due to the Project. There are 23 dwellings located within 5 km of the Project boundary, eight of which are associated dwellings. The Customer has advised DNV that all houses within the Project boundary are associated with the Project and uninhabited as they are dilapidated, and all dwellings outside the Project boundary are non-associated. The coordinates of these dwellings are presented in Table 9, and the dwellings and Project boundary considered in this assessment are shown in Figure 9.

DNV has not carried out a detailed and comprehensive survey of building locations in the area and is relying on information provided by the Customer. For the purposes of this assessment, DNV has assumed that all listed dwellings are inhabited.

3 REGULATORY REQUIREMENTS

3.1 EMI Impacts

The SEARs for the Baldon Wind Farm [1] outline the following requirements for the assessment of interference to telecommunication services:

"Telecommunications – identify possible effects on telecommunication 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."

In addition, the NSW Wind Energy Guideline [2] currently states:

"...the consent authority will give consideration to the risk of electromagnetic interference with telecommunication services in the area, and the adequacy of the measures proposed to ensure the level of service is maintained."

Although both the SEARs and the NSW Wind Energy Guideline describe the requirements for assessing EMI related impacts, they do not provide detailed methodologies for these assessments.

The EPHC, in conjunction with Local Governments and the Planning Ministers' Council released a draft version of the National Wind Farm Development Guidelines in July 2010 (Draft National Guidelines) [3]. The Draft National Guidelines cover a range of issues across the different stages of wind farm development.

In relation to EMI, the Draft National Guidelines provide advice and methodologies to identify likely affected parties, assess EMI impacts, consult with affected parties and develop mitigation steps to address the likely EMI impacts.

DNV considers that the recommendations of the Draft National Guidelines meet, if not exceed, the requirements of the SEARs and the NSW Wind Energy Guideline, and therefore the Draft National Guidelines have been used to inform the methodology adopted for this assessment.

3.2 EMF health impacts

The SEARs for the Barneys Reef Wind Farm [1] also outline the following requirement for the assessment of health impacts arising from EMF:

"Health – consider and document any health issues having regard to the latest advice of the National Health and Medical Research Council [NHMRC], and identify potential hazards and risks associated with electric and magnetic fields (EMF) and demonstrate the application of the principles of prudent avoidance."

Current advice from the NHMRC states that *"there is no direct evidence from which to draw any conclusions on an association between electromagnetic radiation produced by wind farms and health effects"* [6]. However, research commissioned by the NHMRC acknowledges that there are possible mechanisms by which EMF produced by the flow of electrical current in wind turbines and associated electrical cabling and infrastructure could impact on human health [7].

The Australian Energy Networks Association (ENA) has published an EMF Management Handbook, which recommends that electricity generation, transmission, and distribution systems be designed



and operated in compliance with recognised international EMF exposure guidelines [8]. The ENA Handbook also provides advice and guidance on using a prudent avoidance approach to minimise the possible risks of adverse health effects associated with EMF from generation, transmission, and distribution of electricity. In this context, the ENA defines prudent avoidance as the precautionary act of *"implementing low cost or very low cost measures that reduce exposure while not unduly compromising other issues."*

In relation to EMF exposure guidelines, both the ENA and the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) refer to the exposure limits set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [9] while the NHMRC refers to limits proposed by the World Health Organisation (WHO). For EMF produced by electric currents at a frequency of 50 Hz, the ICNIRP guidelines recommend that general public exposure be limited to an electric field strength of 5 kV/m, a magnetic field strength of 16 mA/m, and a magnetic flux density of 200 μ T. Conversely, the WHO guidelines recommend a limit of 100 μ T for general public exposure. While alternative limits also exist, as discussed in [7] and [8], the ICNIRP guidelines are internationally recognised and *"consistent with ARPANSA's understanding of the scientific basis for the protection of the general public"* from exposure to EMF.

For the purposes of this assessment, DNV has compared the predicted EMF levels for the Project to the general public exposure limits recommended by the ICNIRP [9] and the WHO [6].

4 EMI CAUSED BY THE PHYSICAL PRESENCE OF WIND TURBINES

4.1 Assessment approach

If not properly designed, wind farms have the potential to interfere with radiocommunication services. Two services that are most likely to be affected are television broadcast signals and fixed point-to-point signals. Terrestrial broadcast signals are commonly used to transmit domestic television, while point-to-point links are used for line-of-sight connections for data, voice, and video. The interference mechanisms are different for each of these and, hence, there are different ways to avoid interference.

The Customer has asked DNV to complete this assessment based upon a layout provided for the Project consisting of 180 wind turbines, as outlined in Table 8.

For the purpose of the EMI assessment, a hypothetical turbine with a rotor diameter of 245 m and an upper tip height of 300 m has been considered. These dimensions represent the maximum tip height and rotor diameter under consideration for the Project. The results generated based on this turbine configuration will be conservative for all turbine configurations with dimensions that remain inside the turbine envelope by satisfying all of the following criteria:

- a rotor diameter of 245 m or less
- an upper tip height of 300 m or less.

The Draft National Guidelines recommend that a radial distance of 50 km to 60 km from the centre of a wind farm would normally capture all of the potentially affected services in the area. However, the methodology for assessing the potential radiocommunications interference used in this assessment is to locate all of the radiocommunication towers within approximately 75 km of the proposed Project, and then assess the radiocommunication licences attached to these towers. This reduces the likelihood that radiocommunication links crossing the Project are inadvertently excluded from the assessment.

To conduct the EMI assessment, information regarding radiocommunications licences in the vicinity of the Project was obtained from a copy of the Australian Communications and Media Authority (ACMA) Register of Radiocommunications Licences (RRL) database dated 15 January 2024 [10].

Other services with the potential to experience interference from the Project have also been identified, and the potential for interference to those services assessed. These services include meteorological radars, trigonometrical stations, CB radio and mobile phones, wireless internet, broadcast radio, satellite television and internet, and broadcast television.

The Draft National Guidelines recommend that consultation with the relevant operator be undertaken if a turbine is located within 2 km of a radiocommunication site, within the second Fresnel zone of a point-to-point link, or within 250 nautical miles of an aeronautical or meteorological radar site. DNV has consulted with organisations operating services that may be impacted by the development and operation of the Project, to disseminate basic information on the Project and request responses from the organisations regarding whether they foresee any potential EMI-related impacts on their operations and services. The organisations that have been contacted, the dates of consultation, and all responses received to date are summarised in Table 18.

The radiocommunication licences and services with potential to experience EMI-related impacts from the proposed Project are considered in the following sections. Each section contains a brief overview of the relevant technology, followed by an assessment of the identified licences and

services in the area around the Project and the expected potential for interference. Details of any potential mitigation options are also included where appropriate.

4.2 Radiocommunication towers

Wind turbines located close to radiocommunication sites have the potential to cause interference through near-field effects or reflection or scattering of the signals. According to the Draft National Guidelines [3], the near-field zone for a transmission tower can vary from several metres to approximately 720 m depending on the service type. The Draft National Guidelines therefore recommend that any radiocommunication site within 1 km of a proposed turbine location be considered as having the potential to be impacted by near-field effects. The potential for a turbine to cause reflection or scattering of signals also depends on a number of factors, including the service type, the required signal-to-noise ratio for the service, and the distances between the user, transmission tower, and turbine. Since there is no single criterion for potential impact on radiocommunication services due to near-field effects and reflection or scattering, the Draft National Guidelines recommend consulting with the service operator if any turbine is to be located within 2 km of a radiocommunication site.

4.2.1 Locations of radiocommunication towers and potential for interference

From the ACMA RRL database, there are 213 radiocommunication towers within a nominal 75 km of the Project boundary. The locations of these radiocommunication towers relative to the Project are shown in Figure 10.

The nearest tower is located approximately 7 km northeast of the nearest proposed turbine location. Therefore, it is not expected that the Project will cause interference to the radiocommunications associated with that tower through near-field effects or reflection or scattering of the signals.

4.2.2 Mitigation options

Given that impacts to services operated from nearby radiocommunication towers through near-field effects or reflection or scattering of the signals are not expected, it is not expected that mitigation of such impacts will be required.

4.3 Fixed licences of point-to-point type

Point-to-point links are often used for line-of-sight connections for data, voice, and video. Such links often exist on mobile phone and television broadcast towers. The frequency of common microwave signals varies from approximately 1 GHz to 30 GHz.

Wind turbines can potentially cause interference to point-to-point microwave links and, in some cases, point-to-point ultra high frequency (UHF) links through three mechanisms: diffraction of the signal, reflection or scattering of the signal, and near-field effects. It is generally possible to design around these issues as the link paths and potential interference zones for these signals can be determined.

4.3.1 Locations of point-to-point links and potential for interference

DNV has analysed the registered licences for each radiocommunication tower according to the ACMA RRL database to determine the transmission paths of the licenced links. For this analysis, DNV has used a wider and more conservative frequency range of 0 GHz to 50 GHz.

Each individual link was given a unique identifier or “Assignment ID” so that it could be readily distinguished. This Assignment ID was taken as either the Device Registration ID (for spectrum licences associated with the use of certain frequency band within a particular geographic area) or the EFL ID (for apparatus licences associated with the use of a particular device).

The links paths associated with the analysed towers are shown in Figure 11. It can be seen that not all of the identified transmission towers have a fixed licence of point-to-point type transmission vector. Some towers have no active licences associated with them, and some towers are used solely for point-to-area style transmissions, such as some emergency services towers.

There are fourteen point-to-point links recorded in the ACMA RRL database that pass over the proposed Project boundary, operated by Ambulance Service of NSW, Essential Energy, New South Wales Government Telecommunications Authority (NSW Telco Authority), NSW Rural Fire Service, Optus Mobile Pty Limited (Optus), Vodafone Australia Pty Limited (Vodafone). The details of the links are provided in Table 10, and the link paths are shown in greater detail in Figure 12.

The potential interference mechanisms and interference zones established by DNV for these links are described in Sections 4.3.1.1, 4.3.1.2, and 4.3.1.3.

4.3.1.1 Interference caused by diffraction

The potential for interference to a fixed point-to-point link through diffraction or obstruction of the signal can usually be avoided by keeping clear of an exclusion zone of circular cross-section around the link path from the transmitter to the receiver [3, 11, 12], typically defined in terms of the Fresnel zones for the link. The n th Fresnel zone is comprised of all points for which, if the signal travelled in a straight line from the transmitter to the point and then to the receiver, the additional length compared to the straight transmitter-receiver path equals $\frac{n - \lambda}{2}$, where λ = wavelength.

The radius of the n th Fresnel zone varies along the length of the signal, and is given by:

$$R_{Fn} = \sqrt{\frac{n\lambda d_1 d_2}{D}}$$

where d_1 is the distance from the transmitter

d_2 is the distance from the receiver

D is the distance from the transmitter to receiver, such that $d_1 + d_2 = D$

To avoid interference to point-to-point links caused by signal diffraction, wind turbines, including the blades, should be kept outside of an exclusion zone based on the second Fresnel zone as recommended in [11]. For each of the links crossing the proposed Project boundary, DNV has established a diffraction exclusion zone based on the second Fresnel zone for that link.

It is common practice to have multiple Assignment IDs for the same physical link to cover practicalities such as licensing for sending or receiving signals. Accordingly, the second Fresnel zone for each link has been calculated based on the Assignment ID with the lowest frequency.

The potential diffraction exclusion zones in the horizontal plane are shown in Figure 12. Each exclusion zone includes the rotor radius for turbines with a 245 m rotor diameter, and an additional buffer of 25 m to account for potential inaccuracies in the tower locations given in the ACMA RRL database.

DNV has also assessed the potential for the turbine blades to intersect with the diffraction exclusion zone for each point-to-point link in the vertical plane. This was achieved by examining the elevation and antenna heights at the end of each link, as well as the approximate elevation of areas within the Project boundary over which the link crosses.

The results of this analysis are summarised in Table 1.

As shown in Figure 12, there are no turbines located within the diffraction exclusion zone for the point-to-point links passing over proposed Project site. Therefore, it is not expected that the Project will cause interference to the point-to-point links through diffraction of the signals.

Table 1 Details of turbines located within the interference zones established by DNV for point-to-point links crossing the proposed Project boundary

Operator	Link no.	Turbines within potential diffraction zone	
		Horizontal plane	Vertical plane
Ambulance Service of NSW	1	None	None
Essential Energy	2	None	None
New South Wales Government Telecommunications Authority	3, 4, 5, 6, 7	None	None
NSW Rural Fire Service	8, 9, 10	None	None
Optus Mobile Pty Limited	11, 12	None	None
Vodafone Australia Pty Limited	13, 14	None	None

4.3.1.2 Interference caused by reflection or scattering

Interference due to reflection or scattering of a fixed point-to-point link can occur when the signal produced by the transmitting antenna is reflected, scattered, or re-radiated by an intervening object into the corresponding receiver antenna. If the reflected or scattered signal is sufficiently strong that the ratio of the direct signal to the indirect signal is lower than the required carrier-to-interference (C/I) ratio, or protection ratio, for the link, the link performance can be degraded. The extent to which an object such as a wind turbine will reflect or scatter electromagnetic waves is characterised by its radar cross section (RCS) [11].

Reference [11] describes a methodology for calculating the C/I ratio that might be expected at a receiver in the presence of a reflected or scattered signal from a wind turbine at a specified location. By evaluating the C/I ratio for incremental changes in the distances between the transmitter, receiver, and wind turbine, and comparing this to the required C/I ratio, a potential interference zone can be defined.

DNV considers that the transmission towers for all of the point-to-point link crossing the Project boundary are sufficiently far from the proposed turbine locations to avoid reflection or scattering effects. Therefore, it is not expected that the Project will cause interference to the point-to-point links through reflection or scattering of the signals.

4.3.1.3 Interference caused by near-field effects

The potential for interference to fixed point-to-point links caused by near-field effects can generally be avoided by keeping clear of the near-field zone for the transmitting or receiving antenna. Within the near-field zone, local inductive and capacitive effects are significant and it is difficult to predict the potential impacts of other objects on the transmitted or received signal. Although the near-field distance typically varies with direction relative to the link path, for most practical purposes the near-field zone can be approximated as a sphere centred on the transmitting or receiving antenna.

Reference [11] presents an equation for estimating the radius of the near-field zone for a point-to-point link from the properties of the transmitting or receiving antenna.

DNV considers that the transmission towers for all of the point-to-point link crossing the Project boundary are sufficiently far from the proposed turbine locations to avoid near-field effects. Therefore, it is not expected that the Project will cause interference to the point-to-point links through near-field effects.

4.3.2 Stakeholder consultation

DNV has contacted the operators of the point-to-point links crossing the proposed Project boundary to determine the likelihood that the proposed Project will cause interference to their operations and services through diffraction, reflection or scattering, or near-field effects.

Essential Energy, NSW Telco Authority, and Optus have indicated that they do not expect the Project to interfere with their point-to-point links. The response received from Vodafone raised concerns about the potential for turbines 1, 2, 3, 4, 5, and 6 to interfere with their point-to-point links crossing the Project boundary (links 13 and 14 in Table 1). However, these concerns are not supported by the analysis presented in Section 4.3.1, which suggests that the proposed turbine locations are well clear of the diffraction exclusion zones based on the second Fresnel zones for the Vodafone links and therefore unlikely to have any impact. Additionally, the response received from Vodafone did not provide any justification for their concerns or recommendations for appropriate clearance zones to avoid the potential for interference with their links. DNV has attempted to seek clarification from Vodafone regarding their concerns and the necessary clearances, but no further response has been received to date.

No response has been received from Ambulance Service of NSW or NSW Rural Fire Service to date.

4.3.3 Mitigation options

In the event that interference to point-to-point links is experienced after the Project is operational, mitigation options would need to be confirmed through consultation with the relevant operators but may include upgrading the equipment for the affected links, re-routing links via an existing or new tower, or replacing links with alternative communication technologies such as underground fibre optic cabling.

4.4 Fixed licences of point-to-multipoint type

Fixed licences of the point-to-multipoint type are a variation of the point-to-point type. The difference between them is administrative. A point-to-point licence permits communication between two static sites, where the locations of the sites are detailed in the ACMA RRL database. A point-to-multipoint licence allows communication between one or more static sites and multiple points or between the points, and is usually licensed for a defined operational area.

Administratively, the ACMA RRL database details the location of the static station for a fixed licence of the point-to-multipoint type but does not include the remote stations that communicate with the static station. Hence, the paths of the transmission vectors are not readily identifiable.

4.4.1 Locations of point-to-multipoint licences and potential for interference

From the ACMA RRL database, DNV has identified 76 point-to-multipoint Assignment IDs within approximately 75 km of the proposed Project boundary. These licences are shown in Figure 13. The details of the licence holders as given in the ACMA RRL database are provided in Table 11.

There is one point-to-multipoint base station within 20 km of the Project boundary, operated by Murray Irrigation Ltd. There are also several point-to-multipoint base stations located more than 20 km from the Project.

Wind turbines can cause interference to point-to-multipoint links through the same mechanisms as described for point-to-point links in Section 4.3.1. As such, there may be potential for interference to point-to-multipoint links if those links cross the Project near the turbines. However, as it is not possible to know the link paths in a point-to-multipoint network without obtaining further information about the locations of each station in the network, consultation with the relevant operators is needed to determine the potential for interference.

4.4.2 Stakeholder consultation

DNV has contacted the operators of potentially affected base stations identified within approximately 60 km of the Project, to determine the likelihood that the proposed Project will cause interference to their operations and services. Water NSW has indicated that they do not expect the Project to interfere with their point-to-multipoint links, but no other responses have been received to date.

4.4.3 Mitigation options

In the event that interference to point-to-multipoint links is experienced after the Project is operational, mitigation options would need to be confirmed through consultation with the relevant operators but may include re-routing the affected links via an existing or new tower, installing additional towers, or replacing the links with alternative communications technologies such as underground fibre optic cabling.

4.5 Other licence types

Besides fixed point-to-point and point-to-multipoint licences, other licence types recorded in the ACMA RRL database include spectrum licences that permit a range of radiocommunications in a specific geographic area and frequency band, private mobile radio and public telecommunications service (PTS) licences, television and radio broadcasting licences, amateur apparatus licences, and aeronautical licences for ground to aircraft communications.

4.5.1 Locations of other licences and potential for interference

DNV has identified a number of other licences in the ACMA RRL database within 75 km of the proposed Project boundary. The locations of these licences and number of associated Assignment IDs for each licence type are shown in Figure 14 and Table 12.

Most of the licences identified can be broadly described as base to mobile station or point-to-area style communications, including commercial and private mobile telephony and radio and television

broadcasting. These licence types are generally not affected by the presence of wind turbines any more than other effects such as terrain, vegetation, and other forms of signal obstruction.

The potential for interference to emergency services signals and commercial mobile telephony signals is discussed further in Sections 4.6 and 4.11 respectively, while the potential for interference to radio and television broadcasting services is considered in Sections 4.14 and 4.15.

A number of radiodetermination licences which may be used for aircraft navigation have been identified. DNV expects that potential impacts to these services will be considered as part of an aviation impact study.

4.5.2 Mitigation options

Mitigation options for the other licence types in the vicinity of the Project are addressed in the following sections:

- emergency services mobile radio and paging systems, Section 4.6.3
- meteorological radar, Section 4.8.3
- commercial mobile phone services, Section 4.11.3
- wireless broadband internet services, Section 4.12.1.3
- radio broadcasting services, Sections 4.14.1.2, 4.14.2.2, and 4.14.3.2
- television broadcasting services, Section 4.15.3.

If mitigation of potential impacts to aircraft navigation services is required, DNV expects that this will be considered as part of an aviation impact study.

4.6 Emergency services

Licence types operated by emergency services such as state ambulance, police, fire, and rescue services typically comprise fixed point-to-point link and mobile radio communications.

4.6.1 Locations of emergency services licences and potential for interference

DNV has reviewed the ACMA RRL database to identify emergency services with licences for radiocommunication assets operating in the vicinity of the Project. The groups identified are listed in Table 13 along with their contact details. The nearest licence is associated with a tower located approximately 3 km from the Project boundary.

The potential for the turbines at the Project to interfere with emergency services point-to-point links crossing the proposed Project site is discussed in Section 4.3.

All other licences operated by emergency services in the vicinity of the Project are mobile telephony licences used for mobile radio and paging systems. As discussed in Section 4.5, mobile telephony systems are generally not affected by the presence of wind turbines any more than other forms of signal obstruction. Reference [13] provides general guidance regarding the potential for interference with mobile radio systems, and suggests that a clearance of 500 m from the tower is sufficient to avoid significant impacts to these systems. Other references recommend that turbines be kept outside of clearance zones ranging from a distance of 200 m to 1200 m from the tower for point-to-area style services [14].

Given the distance of the emergency services mobile telephony licences from the Project, DNV considers it unlikely that the Project will cause interference to mobile radio and paging systems operated by emergency services.

4.6.2 Stakeholder consultation

DNV has contacted the operators of potentially affected licences identified within approximately 60 km of the Project, to seek feedback on any potential impact that the Project could have on their operations and services. Responses have been received from several operators, as summarised in Table 18, and no concerns have been raised to date.

4.6.3 Mitigation options

Potential mitigation options for impacts to emergency services point-to-point links crossing the Project boundary are discussed in Section 4.3.3.

As noted above, interference with mobile telephony services is considered unlikely. If interference to mobile radio or paging system signals is experienced over a broad area as a result of the Project, mitigation options may include increasing the signal strength from the affected tower or alternative towers, or installing a signal repeater or additional tower on the opposite side of the Project.

4.7 Aircraft navigation systems and radar

DNV expects that a separate aviation impact study will be undertaken to assess the impact of the Project on nearby aviation navigation systems and radar.

4.8 Meteorological radar

The Bureau of Meteorology (“the Bureau”) operates a network of weather radars across Australia consisting of high-resolution Doppler radars and standard weather watch or weather surveillance radars. Operation of the Bureau’s part-time wind finding radar installations ceased in August 2019 [15].

Standard weather watch radars emit pulsed microwave radiation and use reflections or “echoes” of that radiation from water particles in the atmosphere to detect rain and storm activity. Doppler radar installations operate in the same way but are also able to measure the speed of the moving water particles, and therefore can provide information about wind speed and direction [16, 17].

While the uninhibited operation of meteorological radars may not be as critical as aviation radar, there are implications for public safety if severe weather is not predicted or if its approach is masked due to EMI. Because radar installations monitor the current weather situation over a wide area, the information they provide can be used to indicate the possibility and approach of severe storms, tropical cyclones, and flooding events. Wind profile measurements are also used to ensure the safe and economical operation of aircraft and provide an important source of data for the Bureau’s general weather forecasting system.

The optimal coverage area for a weather radar generally extends approximately 200 km from the radar installation at a height of around 3000 m [18, 19], and approximately 100 km at a height of 1000 m [19]. Therefore, wind farms can theoretically impact on weather radar operations when located within several hundred kilometres of an installation. However, due to the curvature of the earth and intervening terrain, the range at or near ground level is generally less.

The World Meteorological Organisation (WMO) currently states that wind turbines should not be located within 5 km of a meteorological radar site, due to the high potential for complete or partial blockage of the radar signal and subsequent loss of weather data [20, 21]. For wind farms located between 5 km and 20 km of a radar, the WMO recommends consultation and analysis to assess the

likelihood of turbines causing reflection or scattering of the radar signals or interfering with Doppler velocity measurements. At distances of between 20 km and 45 km, the presence of a wind farm may produce radar echoes or signal clutter that can cause loss of data or be mistaken for rain. Significant impacts are generally not expected for wind farms located more than 45 km from a meteorological radar, since in most cases the turbine will be below the radar scan line of sight. However, the WMO notes that these guidelines are only applicable to typical radar installations in flat terrain and may need to be modified for higher-powered radars or specific situations.

Recent advice received from the Bureau also suggests that there may be potential for interference to meteorological radar operations from wind farms over much greater distances than indicated by the WMO guidelines, depending on the relative elevations of the radar and the wind farm and the intervening terrain.

According to the Draft National Guidelines, operators of weather radars within 250 nautical miles (463 km) of the proposed Project should be consulted [3].

4.8.1 Locations of meteorological radars and potential for interference

DNV has identified that the Bureau operates 16 weather radars within 250 nautical miles of the proposed Project, with the closest radar located approximately 174 km northeast of the Project at Hillston. The locations of these radars are shown in Figure 15 and the details of each radar are given in Table 14.

Although the distance between the Project and the nearest Bureau radar is considerably greater than the distances at which the WMO suggests impact may occur, consultation with the Bureau is needed to determine the potential for interference.

4.8.2 Stakeholder consultation

DNV has contacted the Bureau regarding the Project, as recommended by the Draft National Guidelines, to seek feedback on whether interference to their operations and services is likely.

The response received from the Bureau indicates that the potential impact of the Project on their meteorological radars will be manageable. However, the Bureau has requested that the Customer (or the final owner or operator of the Project) agrees to:

- inform the Bureau of any changes to the Project design, including changes to the turbine locations or height
- give the Bureau at least two weeks' notice of any planned shutdown of the Project, to allow the Bureau to calibrate their systems while the turbines are not operating and hence account for the presence of the Project in their signal processing and interpretation
- collaborate with the Bureau in the event of severe weather conditions in the interests of community safety.

Based on previous discussions with the Bureau, DNV understands that any agreement to fulfil these requests would be regarded by the Bureau as a non-binding agreement for ongoing engagement and cooperation between the Bureau and the Customer (or the final owner or operator of the Project).

4.8.3 Mitigation options

Given that the Bureau expects the impact of the Project on their radars to be manageable, compliance with the requests made by the Bureau and outlined in Section 4.8.3 may help to

mitigate any interference with meteorological radar operations once the Project is operational. Alternative mitigation options would need to be confirmed through consultation with the Bureau.

4.9 Trigonometrical stations

A trigonometrical station, also known as a trig point or a trig beacon, is an observation mark used for surveying or distance measuring purposes.

Some trig points may host surveying equipment such as Global Positioning System (GPS) antennas and electronic distance measuring (EDM) devices. EDM devices measure the distance from the trig point to the target object by means of a beam of known velocity which is reflected back to the unit from the target object. Most EDM devices require the target object to be highly reflective and, accordingly, a reflective prism is placed on the target object being surveyed.

The effective range of EDM devices depends on the wavelength bands used. Light wave and infrared systems have an effective range of 3 km to 5 km, and could be intercepted or obstructed by the presence of turbines. However, the potential for impact is considered low as it is likely to be possible to relocate the target to obtain an unobstructed view of the trig point. Microwave systems can measure distances up to 150 km, but such systems are not limited by the line of sight or affected by visibility [22].

Global navigation satellite system (GNSS) technology is also commonly used for surveying and distance measurements, as it enables users to accurately determine their geographic location using positioning and timing information received from satellite signals. Geoscience Australia currently operates several GNSS networks across Australia, including the Australian Regional GNSS Network (ARGN) and the AuScope GNSS network [23]. The ARGN is comprised of 20 permanent GNSS Continuously Operating Reference Stations (CORS) which provide the geodetic framework for the spatial data infrastructure in Australia and its territories. Eight stations from the ARGN form the Australian Fiducial Network (AFN) [24], through which the Geocentric Datum of Australia (GDA) is defined. The ARGN also provides information for the measurement of geological processes and contributes data to the International GNSS Service. Additional geospatial information aimed at enhancing the accuracy and resolution of the National Geospatial Reference System is provided by the AuScope GNSS network of around 100 CORS strategically distributed across the country, and several private and state-based GNSS CORS networks. GNSS stations are typically equipped with EDM devices and GPS receivers, and transmit data to Geoscience Australia or the relevant state authority via phone lines, internet, or satellite communications.

4.9.1 Locations of trigonometrical stations and potential for interference

According to Geoscience Australia [25], there are seven trig points within 20 km of the Project boundary. One trig point, 'Jeraly', is located inside the Project boundary approximately 3.3 km northwest of turbine 2. The details of these trig points are provided in Table 15 and their locations are illustrated in Figure 16.

DNV has reviewed the primary geodetic network of Australia [26] and observed that the Project is located within the third-order triangulation region. First-order triangulation depends on trigonometrical stations of known positions, baselines and heights, with the highest degree of accuracy. Points determined from first-order triangulation are then used for the second-order triangulation network and so forth, with the degree of accuracy decreasing for subsequent networks.

The closest GNSS station is located approximately 13 km south of the Project, at Moulamein [27]. Due to the significant distance between the Project and the GNSS station, it is considered unlikely that the Project will cause interference to the GNSS network.

4.9.2 Stakeholder consultation

Although it is unlikely that the trig points in close proximity to the Project host EDM devices or other equipment that may be subject to EMI, DNV has contacted Geoscience Australia and NSW Spatial Services to inform them of the Project, and seek feedback regarding whether interference to their systems is possible. Responses have been received from both Geoscience Australia and NSW Spatial Services, and no concerns have been raised.

4.9.3 Mitigation options

It is not expected that the Customer will be required to actively mitigate potential impacts to trigonometrical stations.

4.10 Citizen's band radio

Citizen's band radio, also known as CB radio, is a class-licensed two-way, short distance communication service that can be used by any person in Australia for private or work purposes. It is commonly used in rural areas for emergency communications, road safety information, communication between recreational travellers, and general conversation. The class licence implies that all users of the CB radio operate within the same frequency range on a shared basis and no individual licence is required.

The CB radio service can be used for voice communication activities, telemetry, and telecommand applications. The radio service operates on two frequency bands, namely the high frequency (HF) band between 26.965 MHz and 27.405 MHz and the ultra-high frequency (UHF) band between 476.425 MHz and 477.400 MHz.

The HF CB radio service was legalised in Australia in the 1970s as a temporary move to switch to UHF CB over the following five years, and transmits signals in either AM (amplitude modulation) or SSB (single side band) transmission mode. The actual range over which the signal is transmitted depends on the antenna used, the terrain, and the interference levels. Over the last decade, the use of the HF CB radio service has declined and has been replaced by UHF CB radio service.

The UHF CB radio service is unique in Australia and uses the FM (frequency modulation) transmission mode. It provides clear communication over 5–20 km and is less susceptible to power line noise. However, the UHF CB radio service requires a clear line-of-sight for a strong signal and is easily hindered by hilly terrain and forested areas. Even in the absence of physical obstructions, UHF CB radio signals generally cannot travel beyond the effective radio horizon, which depends on elevation, antenna height, weather, and atmospheric conditions. If located on a hilltop, CB radio signals can be transmitted over at least 50 km. However, under normal conditions on flat ground, signal range is typically limited to around 5 km. CB repeater stations are often set up on hilltops by community groups and commercial organisations to transmit signals from one channel to another.

No individual or organisation owns or has the right to use a channel exclusively. However, out of the 40 channels available, some of them will be allocated to emergency, telemetry, or repeater inputs.

4.10.1 Locations of CB radio devices and potential for interference

Since users of CB radio services do not require a licence, there is no record of users of the service and their locations and the channels are shared among the users and the repeater stations without a right of protection from interference. Given the limitations of UHF radio signals, CB radio services are typically only intended for local or short-range communications. CB radio signals passing through the Project are likely to be intercepted by existing obstructions such as terrain and vegetation, and there is little evidence in the literature to suggest that wind turbines pose a particular risk of interference to these systems. Therefore, the impact of the Project on CB radio services is expected to be minimal.

4.10.2 Mitigation options

It is not expected that the Customer will be required to actively mitigate impacts to CB radio signals.

4.11 Mobile phones

Mobile phone networks typically operate at frequencies of either between 700 and 900 MHz, or between 1800 MHz and 2600 MHz, however some new services may operate at up to 3500 MHz. At such frequencies, signals may be affected by physical obstructions such as buildings and wind turbines. However, mobile phone networks are designed to operate in such conditions and in most cases, if there is sufficient mobile network coverage and signal strength, the presence of wind turbines is unlikely to cause any interference.

In rural areas, the mobile network coverage may be more susceptible to physical obstructions due to the large distance between the phone towers and the mobile phone user. In that case, it is theoretically possible that wind turbines could cause some interference to the signal. However, there is little evidence in the literature of wind turbines interfering with mobile phone signals, and DNV notes that previous advice received from mobile phone network operators in Australia has generally indicated that they do not expect wind farm developments to interfere with their services provided that appropriate clearances from the mobile phone towers are maintained.

4.11.1 Availability of mobile phone services and potential for interference

DNV has reviewed the locations of mobile phone towers in the vicinity of the proposed Project. The locations of these towers are shown in Figure 17. The nearest mobile phone tower is located approximately 3 km east of the Project boundary.

Mobile phone network coverage maps have been obtained for Optus, Telstra, and Vodafone.

Figure 18 and Figure 19 show the Optus Mobile network coverage for the Project area [28]. Optus 3G and 4G coverage is similar within the site boundary and surrounding area. There is good coverage within the site, some patchy coverage in the south and southwest. Outside the site, there is some patchy coverage in the east, west and north where an additional antenna might be needed to receive Optus 3G and 4G signals. In the north there are areas where there is no Optus 3G and 4G coverage available.

Figure 20 and Figure 21 show the Telstra network coverage for the Project area [29]. Telstra 3G and 4G coverage is similar within the site boundary and the surrounding area, with good coverage in the north and in the south around Moulamein, inside and outside the site and no coverage elsewhere.

Figure 22 shows the Vodafone network coverage for the Project area [30]. There is Vodafone 4G coverage in the north, spanning from the far west to east, inside and outside the site boundary. There is Vodafone 3G coverage in the centre of the site, spanning from the far west to east, inside and outside the site boundary. There is no coverage in the south of the site, spanning from the far west to east, inside and outside the site boundary.

In general, for areas with good coverage, interference to mobile phone signals is unlikely. However, for areas where the reception is likely to be marginal, such as those where an external antenna is required, the possibility for interference exists if a wind turbine intercepts the signal between a mobile phone and the tower. Given there are areas of marginal coverage near the site for all mobile phone service providers, there is potential for the Project to interfere with all mobile phone networks.

4.11.2 Stakeholder consultation

DNV has contacted Optus, Telstra, and Vodafone to inform them of the proposed Project and to seek feedback on any potential impact that the Project could have on their services. The responses received from Optus and Vodafone have indicated that they do not expect the Project to have any material impact on their mobile phone services. No response has been received from Telstra to date.

4.11.3 Mitigation options

As noted above, interference with mobile phone signals may occur in areas of marginal coverage. If interference is experienced over a broad area as a result of the Project, mitigation options may include increasing the signal strength from the affected tower or alternative towers, or installing an additional tower on the opposite side of the Project.

4.12 Wireless internet

Wireless internet services in Australia include wireless broadband provided by mobile phone network operators and other internet service providers, and fixed wireless or satellite internet services through the National Broadband Network (NBN).

4.12.1 Wireless broadband services

Wireless broadband services allow the user to connect to the internet without the need for a phone line or cable connection. The wireless signals may operate by line of sight between a base station and the user's antenna as part of a point-to-multipoint network, or may use point-to-area style transmissions such as mobile phone networks.

4.12.1.1 Availability of wireless broadband services and potential for interference

Field Solutions Group Pty Ltd hold public telecommunication service licences in the vicinity of the Project, with base stations located 56 km and 60 km southeast of the Project. As the locations of Field Solutions Group customers are not known, it is not possible to determine whether there is the potential for interference to this service. However, due to the large distances between the base stations and the Project, there is a low likelihood that these stations will be servicing customers in the vicinity of the proposed Project.

Additionally, residents in the vicinity of the Project may use wireless broadband services provided by Optus, Telstra and Vodafone. These wireless broadband services use the same networks as mobile phone services, and therefore the comments made in Section 4.11.1 are applicable here.



Specifically, there exists a potential for interference in areas with marginal reception if a wind turbine intercepts the signal between a receiver and the tower.

4.12.1.2 Stakeholder consultation

DNV has contacted Field Solutions Group to seek feedback regarding the potential for interference to their services. The response received from Field Solutions Group has indicated that they do not expect the Project to have any material impact on their services.

DNV also has contacted Telstra, Optus, and Vodafone, as discussed in Section 4.11.2, to seek feedback on any potential impact that the Project could have on their services. The responses received from Optus and Vodafone have indicated that they do not expect the Project to have any material impact on services provided through their mobile phone networks. No response has been received from Telstra to date.

4.12.1.3 Mitigation options

If interference to the wireless broadband services provided by mobile phone networks occurs, the mitigation options given in Section 4.11.3 may be applicable. Specifically, if interference is experienced, mitigation options may include increasing the signal strength from the affected tower or alternative towers, or installing a signal repeater or additional tower on the opposite side of the Project.

Field Solutions Group have suggested in the unlikely event that interference to their services is experienced they will coordinate with the Customer to implement practical mitigation measures.

4.12.2 National Broadband Network

The NBN is a national wholesale broadband access network, which consists of fixed line, fixed wireless, and satellite internet services.

NBN fixed line services use wired connections to provide internet signals directly to the user. This technology is typically only available in urban areas and is not expected to be affected by wind farm developments.

NBN fixed wireless services are available in many rural and regional areas. The signals operate by line of sight between an NBN tower and the user's antenna, with a maximum range of 14 km [31]. Consequently, the signals may be affected by physical obstructions such as terrain, vegetation, and wind turbines [32].

For rural and remote users in areas that are not able to receive fixed line or fixed wireless services, NBN satellite internet signals are available from the NBN Sky Muster I and II satellites.

4.12.2.1 Availability of NBN services and potential for interference

The NBN website [33] indicates that the network is currently available as a satellite internet service using the NBN SkyMuster I and II satellites in the areas surrounding the Project. Fixed wireless internet services are available in areas around Lake Boga and Manangatang to the south and southwest, although the coverage areas for this service do not cross the Project site.

The potential for interference to satellite internet signals from the NBN Sky Muster I and II satellites is considered in Section 4.13.

4.12.2.2 Stakeholder consultation

DNV has contacted NBN Co to seek feedback on whether there is potential for the Project to cause interference to their services, and to allow them to take the presence of the Project into account in

their coverage planning maps. NBN Co has confirmed that the Project is outside their fixed wireless internet coverage areas and is therefore not expected to impact on their services.

4.12.2.3 Mitigation options

Given that impacts to NBN internet services are not expected, it is not expected that mitigation will be required for such impacts.

4.13 Satellite television and internet

In some rural or remote areas, television and internet access can only be provided through satellite signals. There are two types of satellite that are typically used to provide commercial telecommunication services: geostationary satellites and low Earth orbit (LEO) satellites.

4.13.1 Geostationary satellite communication services

Geostationary satellites orbit the earth directly above the equator, at a height of 35,786 km above the Earth's surface [34]. At this altitude, the satellites travel at the same rate as the Earth's rotational speed and therefore appear to remain stationary at the same point in the sky relative to an observer at a fixed location. Additionally, due to their high altitude, each satellite can view (and therefore provide coverage to) a large portion of the Earth's surface. Geostationary orbits are typically used for weather monitoring satellites that continually observe a specific area of the Earth and for satellites that provide telecommunication services, since the satellite dish or antenna used on Earth to receive and transmit signals can be permanently pointed to the correct location in the sky. Both satellite television and satellite internet services are currently available in Australia via geostationary satellites.

Satellite television signals are delivered via a geostationary communication satellite to a satellite dish connected to a set-top box. Satellite television signals are typically transmitted to the user's antenna in one of two frequency bands: the C-band between 4 GHz and 8 GHz, or the Ku-band between 12 GHz and 18 GHz. Signals in the C-band are susceptible to interference due to radio relay links, radar systems, and other devices operating at a similar frequency. Signals in the Ku-band are most likely to be affected by rain which acts as an excellent absorber of microwave signals at this frequency. The main geostationary satellites that transmit Australian free-to-air or subscription television channels are the Optus C1, D1, and D3 satellites and the Intelsat 19 satellite [35, 36].

In the case of internet services provided by geostationary satellites, the user's computer is connected to a satellite modem which is in turn linked to a satellite dish or antenna mounted on the building roof. When the user accesses the internet, a request is sent to the operation centre of the satellite internet provider via the satellite antenna. Data is then sent back to the user's computer via the same path as shown in the figure below. Satellite internet signals are typically transmitted in the Ku-band, as for satellite television, or the Ka-band, with frequencies ranging from 26.5 GHz to 40 GHz. Like signals in the Ku-band, signals in the Ka-band are susceptible to deterioration caused by moisture in the air, but newer satellites contain technologies that help to minimise the loss of signal quality associated with rain and other weather conditions. The main geostationary satellites for providing satellite internet in Australia are the IPSTAR (THAICOM-4) and Optus D2 satellites, and the NBN Sky Muster I and II satellites.



Two-way connection to the internet via satellite [37]

4.13.1.1 Locations of geostationary satellite vectors and potential for interference

Due to marginal coverage of some communication services, some residents in the vicinity of the Project may use satellite television and internet.

A number of satellites transmit television and internet signals that can be received in Australia. Although only a small number of satellites are likely to be providing services specifically intended for Australian audiences, DNV has considered the line of sight to dwellings in the vicinity of the Project from all theoretically viewable satellites.

The results of this analysis are shown in Table 16 and summarised in Table 2. Based on these results, turbines at the Project may intercept signals from one satellite at one nearby dwelling (R22), but the Customer has advised that this dwelling has been demolished and is no longer existent. Therefore, the analysis has shown that satellite signals to habitable dwellings in the vicinity of the Project are not expected to be intercepted by turbines.

Table 2 Number of satellites with potential for signals to nearby dwellings to be intercepted by the proposed Project

Satellite service	Number of potentially affected satellites	Number of potentially affected dwellings
Services intended for Australian audiences	None	None
Services intended for international audiences	One	One (Dwelling R22, has been demolished)

4.13.1.2 Mitigation options

Given that impacts to geostationary satellite television and internet services are not expected, it is not expected that mitigation of such impacts will be required.

4.13.2 Low Earth orbit satellite communication services

Satellites in LEO occupy heights between 160 km and 1000 km above the Earth's surface [34]. At these altitudes, the satellites travel significantly faster than the Earth's rotational speed and typically complete a full orbit in approximately 90 minutes. Unlike geostationary satellites, LEO satellites do not have to follow a particular path around the Earth and their orbits are usually tilted

with respect to the equator. However, due to their low altitude, each satellite can only observe or communicate with a small portion of the Earth's surface at a time and this, together with their fast movement across the sky, can limit the usefulness of LEO satellites in some situations.

For telecommunication applications, satellites in LEO offer lower latency and better performance than geostationary satellites, due to the reduced distance for the signal to travel. However, using a single LEO satellite to provide telecommunication services is often impractical due to the relatively small coverage area and significant effort required to track the satellite from the ground. To compensate for this, LEO satellites used for telecommunications usually operate as part of a large network or "constellation" of multiple satellites that work together to provide continuous coverage to large areas simultaneously. As satellites within the constellation move through the field of view of a satellite dish on Earth, the dish detects and connects to the satellite with the strongest signal and then automatically switches over to another satellite as the first moves out of view. Nevertheless, these services may be sensitive to physical obstructions such as terrain, vegetation, buildings, and other structures such as wind turbines, which can unexpectedly interrupt the signal from the connected satellite and cause the service to temporarily drop out until a new satellite can be found.

4.13.2.1 Availability of low Earth orbit services and potential for interference

Starlink is the only LEO satellite internet service currently available to customers in Australia. The current Starlink LEO constellation consists of several thousand satellites orbiting the Earth at a height of approximately 550 km [38], although this may increase to tens of thousands of satellites in the future. Starlink offers two classes of satellite dish to users of their services: a standard dish that is considered suitable for most residential applications, and a high performance dish that has a wider field of view (enabling it to connect to more satellites, even in the presence of obstructions), a higher gain antenna, and improved performance under extreme environmental conditions [39, 40].

In the southern hemisphere, Starlink satellite dishes currently require a relatively clear view of the sky within a field of view of 100° tilted towards the south, with a minimum elevation angle of 25° above the southern horizon [41]. Although some obstructions can be tolerated, the impact of these obstacles will depend on their apparent size, their distance and direction relative to the satellite dish, and the proportion of the sky already obstructed. Obstacles below an elevation angle of 25° in the south, 40° in the east and west, and 40° in the north (allowing for locations where no tilt of the satellite dish is required) will not pose any obstruction to the field of view. However, as more satellites are launched and join the Starlink constellation, it is expected that the required angle of tilt towards the south will reduce until dishes can be pointed directly upwards, with elevation angles above the horizon of 40° in all directions [42], and the service will become less sensitive to obstructions due to the increased number of visible satellites at each location.

DNV has considered the potential for turbines at the Project to obstruct Starlink signals received at nearby dwellings, based on the relative locations of the dwelling and the nearby turbines, the elevations of the dwellings and turbines, and a turbine tip height of 300 m.

At all dwellings in the vicinity of the Project, the turbines are expected to be below an elevation angle of 25° above the horizon in all directions. Therefore, based on this analysis, it is not expected that turbines at the Project will obstruct Starlink signals for any nearby dwellings.

4.13.2.2 Mitigation options

Given that impacts to Starlink satellite internet services are not expected, it is not expected that mitigation of such impacts will be required.

4.14 Radio broadcasting

Radio stations typically broadcast using one of two forms of transmission: either amplitude modulation (AM) or frequency modulation (FM). In Australia, AM radio operates in the medium wave (MW) band at frequencies between 520 kHz and 1610 kHz, while FM radio operates in the very high frequency (VHF) band between 87.5 MHz and 108 MHz.

4.14.1 AM radio

AM radio signals are diffracted by the ground as they propagate, such that they follow the curvature of the earth, and are also reflected or refracted by the ionosphere at night. This means that AM radio waves are able to travel significant distances under the right conditions. Due to their long wavelength, they can readily propagate around physical obstructions on the surface of the earth (such as wind turbines), however they do not propagate easily through some dense building materials such as brick, concrete, and aluminium.

The distance over which AM radio signals can travel means that the signal may be weak and susceptible to interference by the time it reaches a receiver. Some of the possible sources of interference to AM radio waves include changes in atmospheric conditions, signals from distant AM broadcasters operating on a similar frequency, electrical power lines, and electrical equipment including electric motors.

However, as noted above, the presence of physical obstructions such as turbines is unlikely to cause significant interference to AM radio signals. Due to the long wavelength of the signal, interference is only likely in the immediate vicinity of a turbine [43].

4.14.1.1 Locations of AM transmitters and potential for interference

The locations of AM broadcast transmitters in the vicinity of the Project were determined from the ACMA Broadcast Transmitter Database [44], and are shown in Figure 23.

The closest AM transmitter is located approximately 62 km from the proposed Project boundary.

It is unlikely that any permanent AM radio receivers will be located sufficiently close to the Project to be affected by interference to the radio signals from the turbines.

4.14.1.2 Mitigation options

In the event that localised interference to AM radio signals is experienced, this can potentially be rectified by installing a high-quality antenna or amplifier at the affected residence.

4.14.2 FM radio

FM radio signals are better suited to short range broadcasting. Unlike lower frequency signals (such as AM signals), they are not reflected or refracted off the ionosphere. Instead, the waves are slightly refracted by the atmosphere and curve back towards the earth, meaning they can propagate slightly beyond the visual horizon. However, FM radio signals may be blocked by significant terrain features. FM radio stations therefore tend to have only local coverage, which means that signals are less susceptible to interference from distant FM broadcasters. FM signals are also less susceptible to interference from changes in atmospheric conditions and electrical equipment than AM signals.

FM radio signals are susceptible to interference from buildings and other structures, although they are less vulnerable than higher frequency signals. Interference to FM signals can occur by two mechanisms: reflection or scattering of the radio waves, or physical obstruction and attenuation of the broadcast signal.

Reflection or scattering of radio waves by physical structures such as wind turbines can reduce the signal strength at a receiver or can cause multi-path errors through reception of a reflected signal in addition to the primary signal from the transmitter. This can result in hissing, fluttering, or distortion being heard by the listener [45]. However, this type of interference is typically only experienced in the immediate vicinity (within several tens of metres) of a wind turbine, where the signal-to-noise ratio is low [43, 46].

Wind turbines located close to an FM transmitter may also present a physical obstruction to the radio signal. If the line-of-sight between the transmitter and a radio receiver is blocked by a turbine, this can cause a noticeable decrease in signal quality or may lower the signal strength below the threshold of the receiver's sensitivity [45]. In these situations, the attenuation of the signal may be as great as 2.5 dB in the direction of the obstructing wind turbine. However, this type of interference is generally only a problem near the edges of the FM signal coverage area, where the broadcast signal is already weak. For commercial FM broadcast signals, physical obstruction of the signal may occur if the turbines are located within approximately 4 km of the transmitter [47].

4.14.2.1 Locations of FM transmitters and potential for interference

The locations of FM broadcast transmitters in the vicinity of the Project were determined from the ACMA Broadcast Transmitter Database [44], and are shown in Figure 23.

The closest FM broadcast transmitter is located approximately 43 km from the proposed Project boundary. Therefore, it is considered unlikely that the Project will cause interference to the FM radio signals from this transmitter.

It is unlikely that any permanent FM radio receivers will be located sufficiently close to the Project to be affected by reflection or scattering of the radio signals from the turbines.

4.14.2.2 Mitigation options

In the event that localised interference to FM radio signals is experienced, this can potentially be rectified by installing a high-quality antenna or amplifier at the affected residence.

4.14.3 Digital radio

Digital radio services were introduced in metropolitan licence areas in Australia in July 2009. The digital radio services offered use an updated version of the digital audio broadcasting (DAB) digital radio standard, DAB+, to broadcast digital radio to Adelaide, Brisbane, Perth, Melbourne, and Sydney [48]. Digital radio broadcasts in Australia operate in the VHF band at frequencies between 174 MHz and 230 MHz, and therefore tend to have only local coverage within the visual horizon.

The UK telecommunications regulator Ofcom [45] states that *"In contrast [to FM signals], the signal format used for DAB digital radio is designed to offer high levels of robustness in difficult conditions and it is not materially affected by reflections. FM and DAB reception can be affected where a structure blocks signals and both may cease to function if signals are reduced below a certain threshold"*. DNV has therefore concluded that DAB signals are not affected by reflection or scattering from physical structures in the same way as FM signals, and so digital radio broadcasts are generally not susceptible to interference from wind farm developments. However, interference

may be experienced if the line-of-sight between a DAB transmitter and a radio receiver is blocked by a wind turbine.

4.14.3.1 Availability of digital radio services and potential for interference

According to the digital radio coverage search function available on the Digital Radio Plus website [49], the Project is outside the intended service area for digital radio broadcasts. Since it is therefore unlikely that residents in the vicinity of the Project are currently receiving digital radio signals, it is not expected that the Project will cause interference to these services.

4.14.3.2 Mitigation options

Given that impacts to digital radio services are not expected, it is not expected that mitigation of such impacts will be required.

4.15 Terrestrial television broadcasting

Terrestrial television is broadcast in Australia by a number of networks, both public and commercial. As of December 2013, all television broadcasts in Australia are now digital broadcasts [50]. Digital television (DTV) signals are typically more robust in the presence of interference than analogue television signals, and are generally unaffected by interference from wind turbines. DNV has experience in situations where dwellings were able to receive adequate DTV reception in an area of adequate signal strength where the DTV signal was passing through a wind farm.

The susceptibility of DTV signals to interference from wind turbines is discussed further in Section A.1 of Appendix A.

4.15.1 Availability of DTV broadcasting and potential for interference

The locations of DTV broadcast transmitters in the vicinity of the Project were determined from the ACMA Broadcast Transmitter Database [50], and are shown in Figure 23. The closest DTV transmitter to the Project is the Balranald primary transmitter, which is approximately 45 km west of the site boundary. According to the Australian Government mySwitch website [51], the main DTV transmitter used by residents in the vicinity of the Project is the Murray Valley transmitter at Goschen.

The coverage map for this broadcast transmitter is reproduced in Figure 24. There is variable coverage in the south of the site which gets stronger moving towards Goschen in the southwest.

4.15.1.1 Interference caused by large scale effects

For broadcast signals, large scale interference can generally be avoided by placing the wind turbines at some distance from the transmitter. Broadcast transmitters may be either relay or primary transmitters. Relay transmitters are more commonly found in rural areas. Primary transmitters are higher power and are more commonly located near large urban areas. A clearance of at least 1 km is recommended for relay transmitters, while a clearance of at least 6 km is recommended for primary transmitters [12].

Given that the closest DTV transmitter to the Project is located approximately 45 km away, it is considered unlikely that the Project will cause large scale interference to signals from this transmitter.

4.15.1.2 Interference caused by reflection or scattering

Although DTV signals are generally unlikely to be susceptible to interference from wind turbines in areas of adequate coverage, interference could be encountered in areas where coverage is

marginal and antennas at dwellings may receive a reflected signal from a turbine that is of sufficient power to interfere with the signal received directly from the transmitter. Based on the coverage maps for the area around the Project, it is possible that some areas could be deemed to have marginal reception and interference could be encountered.

Due to the lack of an accurate theoretical scattering model, DNV has not performed detailed scatter calculations to predict DTV interference. Instead, dwellings that have increased potential to receive back-scattered or forward-scattered signals from a turbine at the Project (assuming an antenna with a sufficiently narrow beam width and sufficiently high front-to-back ratio is being used) have been highlighted using the 'keyhole' approach described in Section A.3 of Appendix A, with a forward-scatter distance of 5 km and a back-scatter distance of 500 m.

The results of the analysis can be seen in Table 17 and Figure 24. The dwellings most likely to be susceptible to interference include those within the possible interference zone, as summarised in Table 3.

Note that if the signal received at a dwelling from the transmitter is sufficiently weak, or an antenna with insufficient directional discrimination is installed (i.e., a low gain or omni-directional antenna), interference may still occur at dwellings outside of the identified interference zones. Circumstances under which interference may occur outside the interference zones typically established using the 'keyhole' approach are discussed further in Section A.2 of Appendix A. In particular, although DNV has considered the potential for interference to DTV signals at dwellings within 5 km of the proposed turbine locations, previous advice received from BAI Communications, who are responsible for broadcasting of national public television services in Australia, has indicated that interference to DTV broadcasting may be experienced at distances of up to 10 km from turbines. For comparison, Figure 24 also shows the area within 10 km of the proposed turbine locations. DNV has contacted BAI Communications, as discussed in Section 4.15.2, to confirm the potential for interference to DTV signals received at dwellings outside the 'keyhole' interference zones.

There are seven dwellings within the Murray Valley DTV interference zone. Five of these dwellings are in areas with no existing signal coverage, and so there is no potential for interference to signals from the Murray Valley transmitter at these five dwellings. The other two dwellings, which are associated dwellings and in the south of the site, are in areas of variable coverage and therefore have potential to experience interference if they are currently receiving signals from the Murray Valley transmitter. DNV has been advised by the customer that these dwellings are uninhabited and therefore will not be affected by interference to DTV signals. However, as discussed above, there may be potential for interference to be experienced at dwellings outside the interference zone established by DNV.

Table 3 Number of dwellings located within potential interference zones for digital television broadcast transmitters in the vicinity of the Project

DTV broadcast transmitter	Number of dwellings in potential interference zone	Signal coverage in potential interference zone
Murray Valley (Goschen)	7 dwellings (6 associated dwellings)	Variable coverage in the south, no coverage in the north. Two associated dwellings in the south with potential to experience interference, although these dwellings are uninhabited.

The method used here to assess the potential interference to television signals from the Project represents a simplified approach which is expected to capture locations where interference is most likely to occur. This simplified analysis is deemed appropriate in most cases as the implications of potential television interference are typically low. If reception difficulties are encountered, there are a number of mitigation options available as discussed in further detail in Section 4.15.3.

4.15.2 Stakeholder consultation

DNV has contacted BAI Communications, who are responsible for broadcasting of national public television services in Australia, to inform them of the proposed Project and seek feedback on any potential impact that the Project could have on DTV signals in the surrounding area.

BAI Communications has conducted an assessment of the potential for turbines at the Project to interfere with DTV signals from the Murray Valley (Goschen), Hay, and Balranald transmitters [52]. The method used by BAI Communications involved modelling the reflection or scattering of DTV signals from the wind turbines, and identifying locations within 10 km of the Project where the resulting C/I ratio for a directional antenna oriented towards the transmitter of interest would be less than required for adequate signal reception.

From the results of their modelling, BAI Communications have advised that they do not expect the Project to cause interference to DTV signals from any of the transmitters considered. The modelling suggested there could be some areas at risk of experiencing degraded reception for signals from the Murray Valley DTV transmitter but, based on population density data, BAI Communications concluded that no residents are at risk of experiencing interference. Additionally, BAI Communications noted that, based on satellite and aerial imagery, there are no buildings located within the predicted interference zones for the Murray Valley transmitter. However, in the event that interference to DTV signals is experienced by residents, BAI Communications have advised that they expect any necessary mitigation to be undertaken as part of the Project.

The results of the modelling conducted by BAI Communications for the Murray Valley DTV transmitter are compared to the DTV coverage map and interference zones established by DNV in Figure 25. Figure 25 shows that the areas predicted by BAI Communications to be at risk of experiencing interference to signals from the Murray Valley transmitter are located within the Project boundary, close to the proposed turbine locations. Based on the locations of nearby dwellings provided by the Customer, there are no dwellings located within the areas modelled by BAI Communications as being at risk of experiencing interference to signals from the Murray Valley DTV transmitter.

4.15.3 Mitigation options

In the event that DTV interference is experienced at nearby dwellings as a result of the Project, potential mitigation options may include:

1. Realigning the user's television antenna more directly towards their existing transmitter.
2. Tuning the user's antenna into alternative sources of the same television signal or a substitute signal.
3. Installing a more directional or higher gain antenna at the affected dwelling.
4. Relocating the antenna to a less affected position.
5. Installing cable or satellite television at the affected dwelling.
6. Installing a television relay transmitter.

In the event of significant interference in the backscatter region, realigning the antenna or installing a more directional antenna should ensure a stronger signal from the transmitter since the backscattered signal will originate from a different direction. However, the effectiveness of this mitigation may be reduced if there is no clear line of sight from the antenna to the transmitter. In these cases, it may be more effective to move the antenna to a location where there is a clearer line of sight to the transmitter or to tune the antenna into an alternative or substitute signal (if one is available).

In the case of forward scatter, the antenna will be pointed towards both the original and scattered signal and hence a more aligned or directional antenna may not alleviate a forward scatter issue. Alternative mitigation measures to resolve issues caused by forward scatter could include tuning the antenna into an alternative signal (if one is available) or installing cable or satellite television at the affected dwelling. However, as noted in [53], DVB-T reception quality may not be substantially affected in the forward scatter region.

The ITU [54] identified that the receiver height can also affect interference. In areas that are relatively flat and free of vegetation, reflections can enhance or decrease the received signal strength relative to the free path signal strength. The ITU found that the received signal strength may not increase monotonically with receiver height. In other words, lowering the receiver height can improve reception in some cases.

In the event that terrestrial DTV reception cannot be improved, satellite television represents another potential amelioration option. Satellite based television comprises of both free to air and subscription-based broadcasts. Residents in areas which are unable to receive DTV through their normal television antenna due to local interference, terrain, or distance from the transmitter in their area may be eligible to access the Australian Government funded Viewer Access Satellite Television (VAST) service [55].

5 HEALTH IMPACTS OF EMF ASSOCIATED WITH THE PROJECT

An EMF is a physical field produced by a moving electric charge that consists of both an electric field component and a magnetic field component. The effect of each field component at any given location depends on the magnitude of the voltage or current, the distance from the EMF source, any shielding around the source, and the frequency of the source.

The strength of an electric field is proportional to the voltage of the EMF source, while the strength of a magnetic field is proportional to the current. The strengths of both electric and magnetic fields decrease with increasing distance from the source. Electric fields are shielded by opaque objects such as building materials, vegetation, and human skin, whereas magnetic fields can pass through most materials without attenuation.

EMF associated with the generation, distribution, and use of electricity is classified as extremely low frequency (ELF) EMF. In Australia, ELF EMF is often called power frequency EMF and corresponds to a frequency of 50 Hz. Since the amount of energy transported by EMF is proportional to its frequency, ELF EMF contains very little energy. In comparison, radio frequency EMF ranges from approximately 100 kHz to 300 GHz and contains enough energy to heat tissues. Although high-level exposure to ELF EMF has the potential to cause biological effects in humans, there is currently no conclusive evidence linking ELF EMF to any long-term adverse health effects [6].

In wind farms, ELF EMF is produced by transmission lines, electrical transformers, underground network cabling, any overhead cabling, and electrical cabling and equipment within the turbines themselves. At ground level, the EMF generated by transmission lines, underground cabling, overhead cabling, and wind turbines is generally comparable to background EMF levels experienced in a modern home. Other electrical components are typical of similar equipment used in other installations and do not pose a unique risk of EMF. Although there are no Australian standards or regulations governing EMF from electrical equipment, it is expected that this equipment would be designed, installed, and operated in accordance with standard industry practices, which apply the ICNIRP guidelines for EMF exposure based on the concept of prudent avoidance as discussed in Section 3.2 [8, 56, 57].

5.1 Electric and magnetic field strength modelling

DNV has conducted an assessment to characterize the EMF in terms of the electric and magnetic field strengths in the vicinity of the Project, to address the SEARs requirement to identify potential hazards and risks to human health associated with EMF. The proposed electrical infrastructure for the Project is shown in Figure 9.

For the purposes of this assessment, only the EMF produced by the medium-voltage (33 kV) underground cabling and new high-voltage (330 kV) overhead line within the Project boundaries has been modelled. The design details for the substation have not yet been finalised, and so it is not possible to characterize the likely EMF for this component of the Project at this stage of development. However, it is expected that the production of EMF will be considered in the detailed design process, and that the substation will be designed in accordance with standard industry practices to ensure appropriate electrical grounding and EMF levels, consistent with the ICNIRP guidelines and concept of prudent avoidance. Additionally, it is expected that the substation will be fenced off from public access, and that the clearances from the electrical equipment to the outer fencing will be sufficient to ensure that the EMF levels at the boundary are within the



recommended exposure limits. Therefore, the potential risks associated with EMF produced by the proposed substation are expected to be low or negligible at publicly accessible locations in and around the Project and are not considered further in this assessment.

Simulations were performed in the vicinity of the 33 kV underground electrical cables from the wind turbines to the substation and the new section of 330 kV overhead line within the Project boundaries. For the underground cables, only the magnetic field strength was considered. Simulations of the electric field strength for the underground cables were not conducted as, due to the cables being buried and the resulting attenuation effects, the electric field strength at ground level for such cables is expected to be negligible. Moreover, research into the potential health impacts of EMF suggests that if there is a risk of adverse health effects "it is more likely to be associated with the magnetic field than the electric field" [8]. For the overhead line, both the electric field strength and magnetic field strength were considered. The results were then compared to EMF limits for public exposure recommended by the relevant guidelines [9].

The assessment was performed by modelling the underground cable in COMSOL Multiphysics 5.6 [58] and the high voltage overhead line in the SESEnviroPlus module of CDEGS version 18.0.18486 [59]. The magnetic field strength due to the cables and overhead lines depends on the current flowing through the cable and the distance from the cable or line to the point where the field is measured, while the electric field strength due to the overhead line depends on the voltage across the line and the distance to the point where the field is measured. The assumptions used in the modelling are summarised in Table 4.

Table 4 Assumptions made in the simulation of magnetic field strengths for the Project

Assumption		Comment	
For medium-voltage underground cables			
Cable rating	Voltage	33 kV	Based on information provided by the Customer
	Cross-section	3x1c 1200 mm ² or 3c 800 mm ²	3x1c 1200 mm ² cable near substations and 3c 800 mm ² cable otherwise, based on information provided by the Customer
Cable layout	Burial depth	1000 mm	Based on information provided by the Customer
	Formation	Trefoil	Assumed for the purposes of the assessment
Maximum current	1000 A		Worst-case condition, assumed for the purposes of the assessment
One cable per phase			Worst-case condition, assumed for the purposes of the assessment and discussed further in Section 5.2
Screens single-point bonded at one end only			Worst-case condition, assumed for the purposes of the assessment
Cables in a balanced phase loading condition			Normal operating condition for a cable in trefoil formation, assumed for the purposes of the assessment and discussed further in Section 5.2
For high-voltage overhead line			
Line rating	330 kV		Based on information provided by the Customer
Maximum current	1000 A		Worst-case condition, assumed for the purposes of the assessment
Line heights	At towers	24/32/39 m	Assumed for the purposes of the assessment based on a tower design proposed by TransGrid for another development [60] and information provided by the Customer
	Maximum sag	8 m	
Three-phase double circuit line arrangement with reverse phasing			Expected configuration, assumed for the purposes of the assessment and discussed further in Section 5.3

Table 5 shows the electric and magnetic field exposure limits recommended by the ICNIRP [9] and WHO [7] and considered in this assessment.

Table 5 Recommended electric and magnetic field exposure limits

Exposure	ICNIRP 2010 reference level [9]		WHO recommendation [7]
	General public	Occupational ¹	General public
Electric field	5 kV/m	10 kV/m	Not specified
Magnetic field	200 μT ²	1000 μT	100 μT

- Occupational exposure refers to adults exposed to EMF at their workplaces, generally under known conditions, and as a result of performing their regular or assigned job activities. Occupational exposure has not been considered in this assessment.
- Epidemiological studies have found that everyday chronic low-intensity (above 0.3-0.4 μT) power frequency magnetic field exposure is associated with an increased risk of childhood leukaemia. However, a causal relationship between magnetic fields and childhood leukaemia has not been established nor have any other long-term effects been established.

5.2 EMF due to underground cabling

The underground cabling was modelled as a single cable per phase under balanced phase loading conditions, with a maximum current of 1,000 A taken for the magnetic field calculations.

These modelling parameters represent the worst-case conditions and are expected to correspond to the largest magnetic field strengths for the underground cabling. One cable per phase was assumed as it represents the worst-case condition compared to two cables per phase, where the interaction between the magnetic fields produced by each phase typically results in a cancellation effect. Consequently, the overall magnetic field strength of a single cable per phase configuration is higher than that of a two cable per phase configuration [8]. The assumption of balanced phases corresponds to the normal operating condition for a cable in trefoil formation. Although unbalanced phases may occur under fault conditions, it is expected that any such fault would be detected and cleared by the nearby switchgear soon after occurrence and is unlikely to persist for any reasonable length of time. Therefore, the magnetic field strengths calculated here are expected to be conservative for all underground cabling configurations proposed for the Project.

Figure 1 and Figure 2 show the modelled magnetic field strength at ground level relative to the location of the cable for 3c 800 mm² cable and 3x1c 1200 mm² cable. As may be expected, the maximum magnetic field strength at ground level due to the underground cabling is observed immediately above the cables. At this location, the magnetic field strength due to the underground cabling is approximately 14 µT for the 3c 800 mm² cable and 15.5 µT for the 3x1c 1200 mm² cable which are well below the exposure limits specified in Table 5. Since the magnetic field strength decreases as the distance from the cable increases, the magnetic field strength due to the underground cabling at ground level at all other locations will be less than the value calculated just above the cables at ground level and therefore also below the relevant exposure limits.

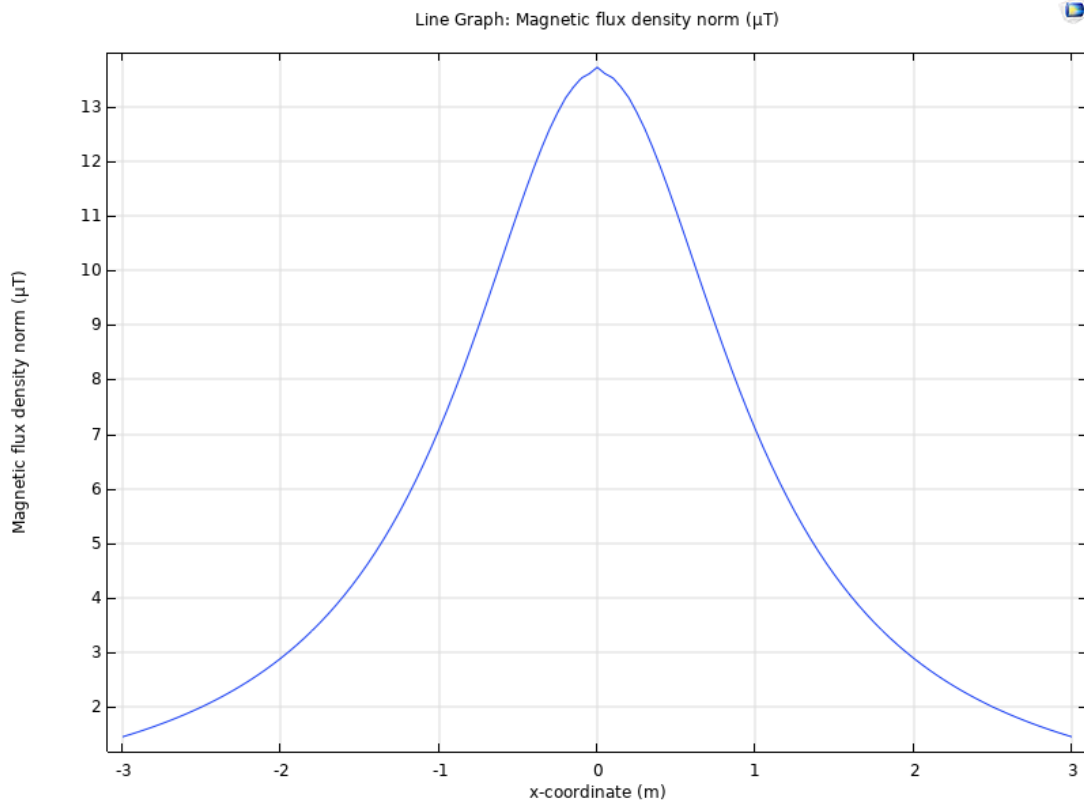


Figure 1 Magnetic field (μT) strength at ground level due to the underground cable under worst-case conditions, where $x = 0.0$ is the location immediately above the 3c 800 mm² cable

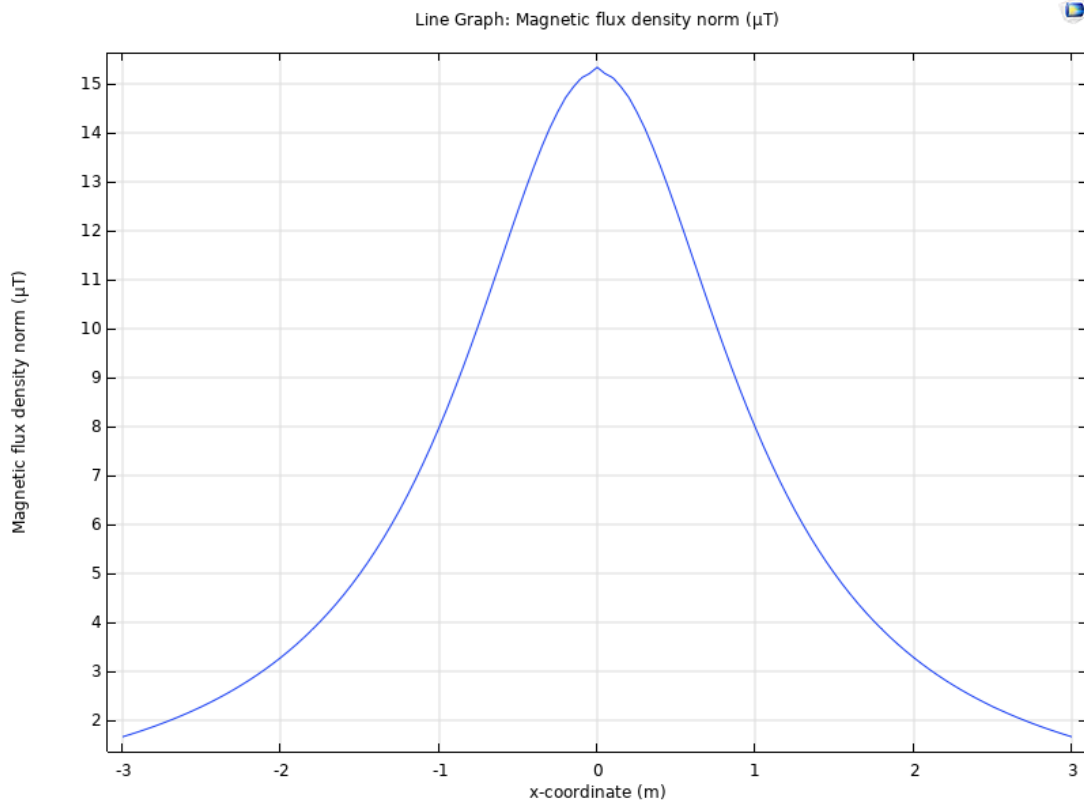


Figure 2 Magnetic field (μT) strength at ground level due to the underground cable under worst-case conditions, where $x = 0.0$ is the location immediately above the $3 \times 1 \text{c } 1200 \text{ mm}^2$ cable

5.3 EMF due to high-voltage overhead lines

The new section of high-voltage overhead line within the Project boundaries was modelled as a 330 kV three-phase double circuit line, with the line arrangement and phase configuration shown in Figure 3. A voltage of 330 kV was taken for the electric field calculations and a current of 1,000 A was taken for the magnetic field calculations.

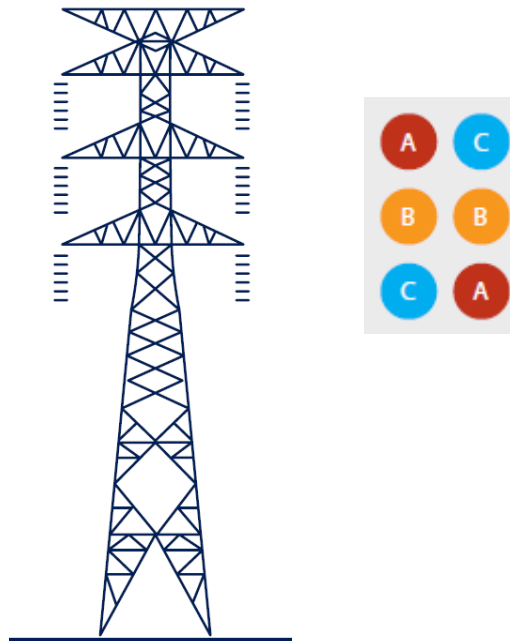


Figure 3 High-voltage overhead line arrangement [60] and phase configuration [8]

The phase configuration shown in Figure 3 (described as reverse or transposed phasing) represents the overhead line arrangement with the highest cancellation effect for the magnetic field strength, as is expected to be used in practice. Therefore, the magnetic field strengths calculated here may not be conservative for some high voltage overhead line configurations. However, any increases in the magnetic field strength caused by deviations from the phase configuration shown in Figure 3 are expected to be in the order of 10 μ T at the point immediately below the line, and the effect of the deviation will decrease as the distance from the line increases [8].

The electric field strengths at ground level below an overhead line may vary depending on the circuit configuration and the line and phase arrangement [61, 62]. However, given that the potential health impacts of electric fields are of less concern than magnetic fields, and it is expected that the high-voltage line will be designed and installed in such a way that the electric fields are minimised, the assumed circuit configuration and line and phase arrangement is considered appropriate for the high-level assessment of electric field strengths presented here.

Figure 4 shows the geometry of the high voltage overhead line in the SESEnviroPlus module of CDEGS version 18.0.18486, viewed along the length of the line at the point of maximum sag.

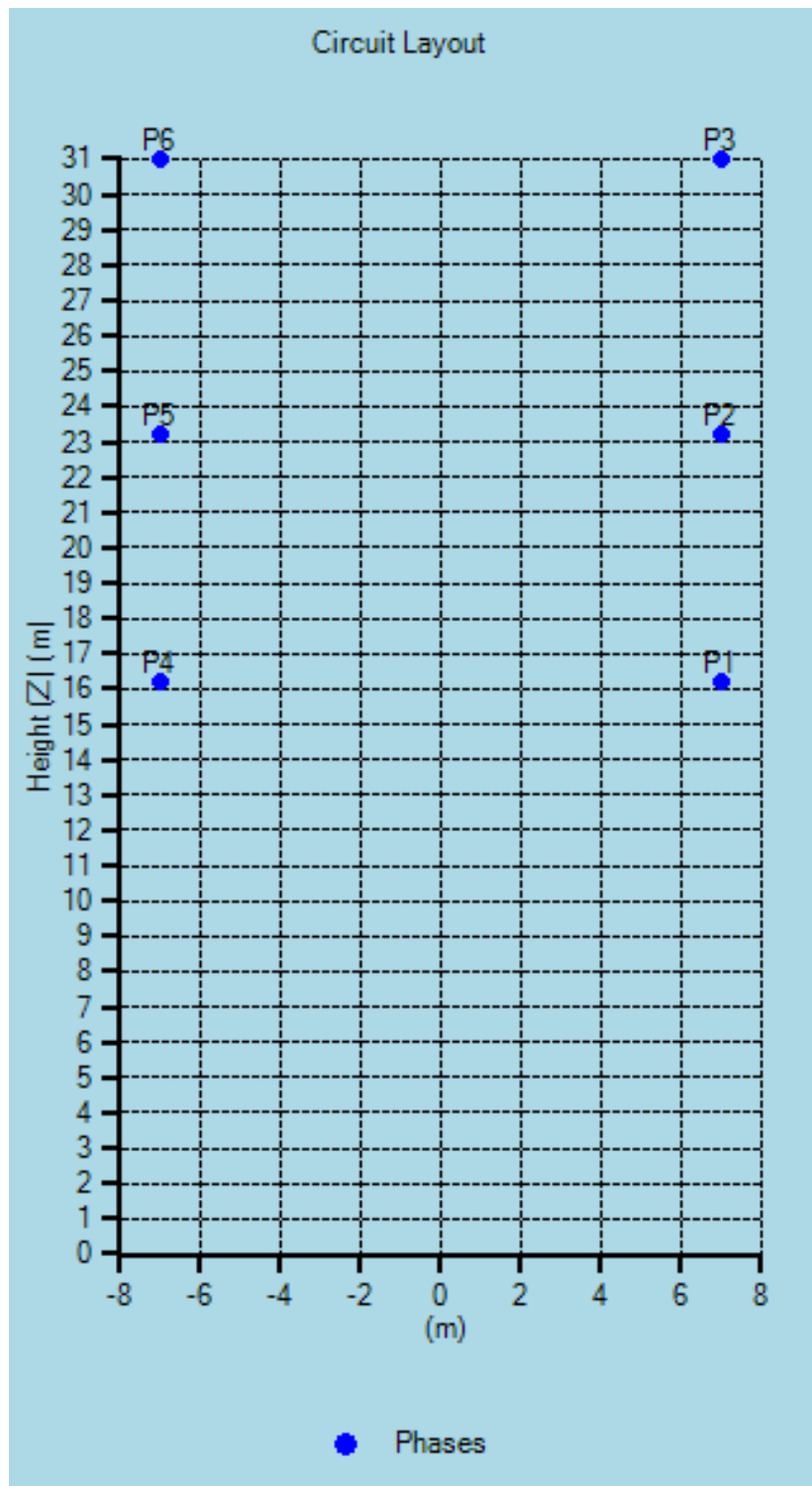


Figure 4 High voltage overhead line geometry (viewed along the length of the line at the point of maximum sag)

The electric and magnetic fields due to the high-voltage overhead line were modelled at heights of 1.5 m and 2 m above ground level (AGL), to encompass the range of typical adult heights in Australia. Figure 5 and Figure 6 show the modelled electric field strength at heights of 1.5 m and 2 m AGL, respectively, in the plane perpendicular to the overhead line at the point of maximum sag. Similarly, Figure 7 and Figure 8 show the modelled magnetic field strength at heights of 1.5 m and 2 m AGL, respectively, in the plane perpendicular to the overhead line at the point of maximum sag.

As may be expected, the maximum electric and magnetic field strengths due to the high-voltage overhead line are observed immediately below the line at a point half-way along its length. At this location, the line is at the minimum height of 16 m AGL based on the assumed lower line height of approximately 24 m at the towers with a maximum sag of 8 m, and the field strengths are:

- 1.3 kV/m at 1.5 m AGL and 1.35 kV/m at 2 m AGL for the electric field
- 6.5 μ T at 1.5 m AGL and 7.0 μ T at 2 m AGL for the magnetic field.

which are well below the exposure limits specified in Table 5. Since the electric and magnetic field strengths decrease as the distance from the line increases, the field strengths due to the overhead line at heights of 1.5 m AGL and 2 m AGL at all other locations will be less than the maximum values given above and therefore also below the relevant exposure limits. Furthermore, since the magnetic field strengths for the assumed line arrangement and phase configuration are at least 90 μ T less than the recommended exposure limits, any changes in the phasing that cause an increase in the magnetic field strength are not expected to result in field strengths that will exceed the limits for general public exposure.

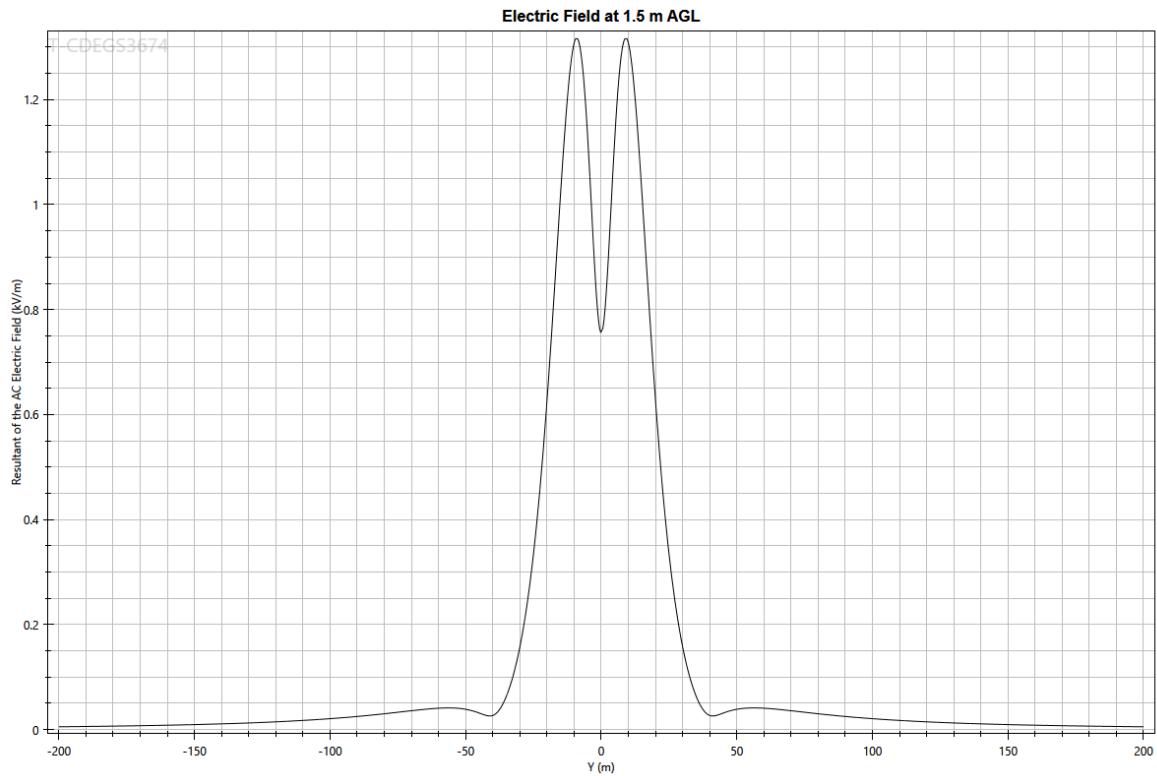


Figure 5 Electric field (kV/m) strength at 1.5 m AGL due to the high voltage overhead line, where $x = 0$ is the location immediately below the line at the point of maximum sag

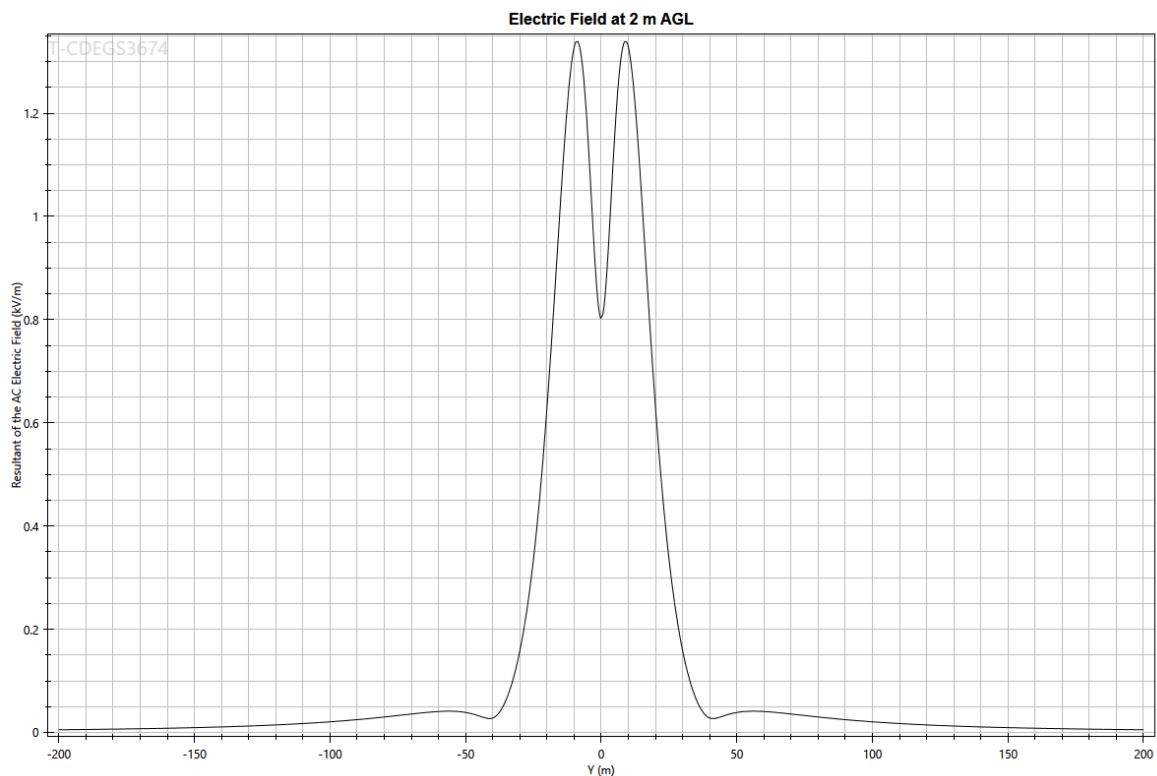


Figure 6 Electric field (kV/m) strength at 2 m AGL due to the high voltage overhead line, where $x = 0$ is the location immediately below the line at the point of maximum sag

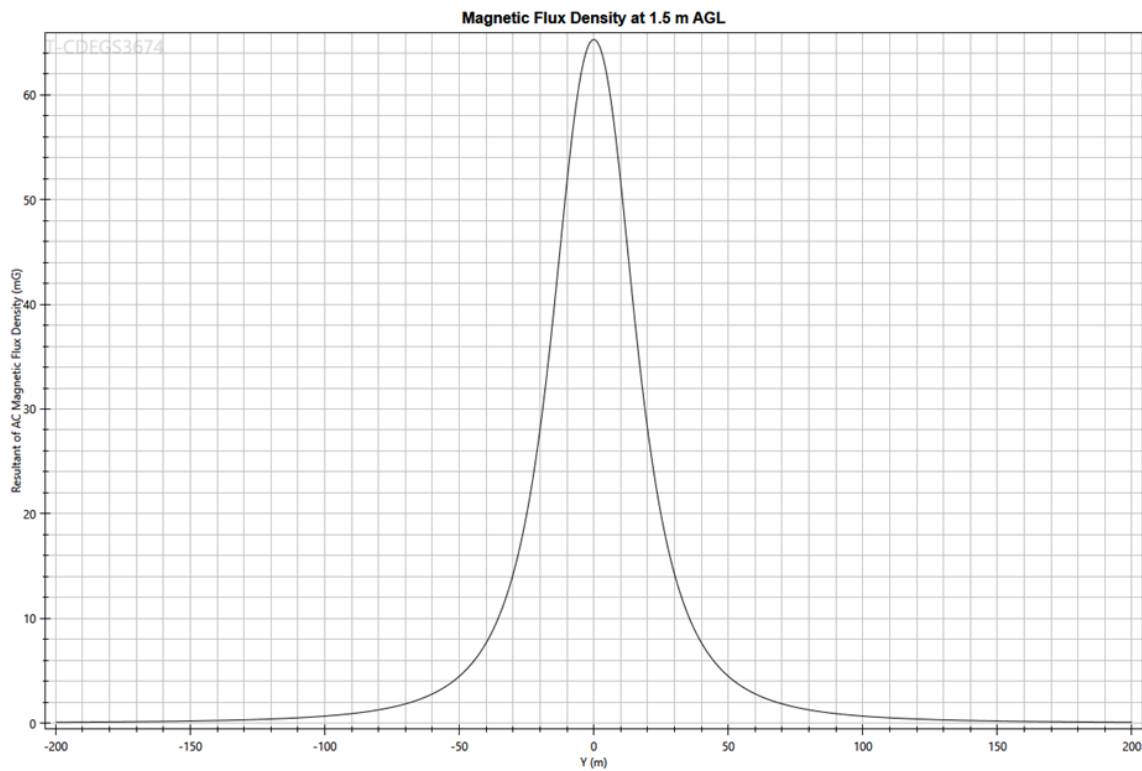


Figure 7 Magnetic field (μT) strength at 1.5 m AGL due to the high voltage overhead line, where $x = 0$ is the location immediately below the line at the point of maximum sag

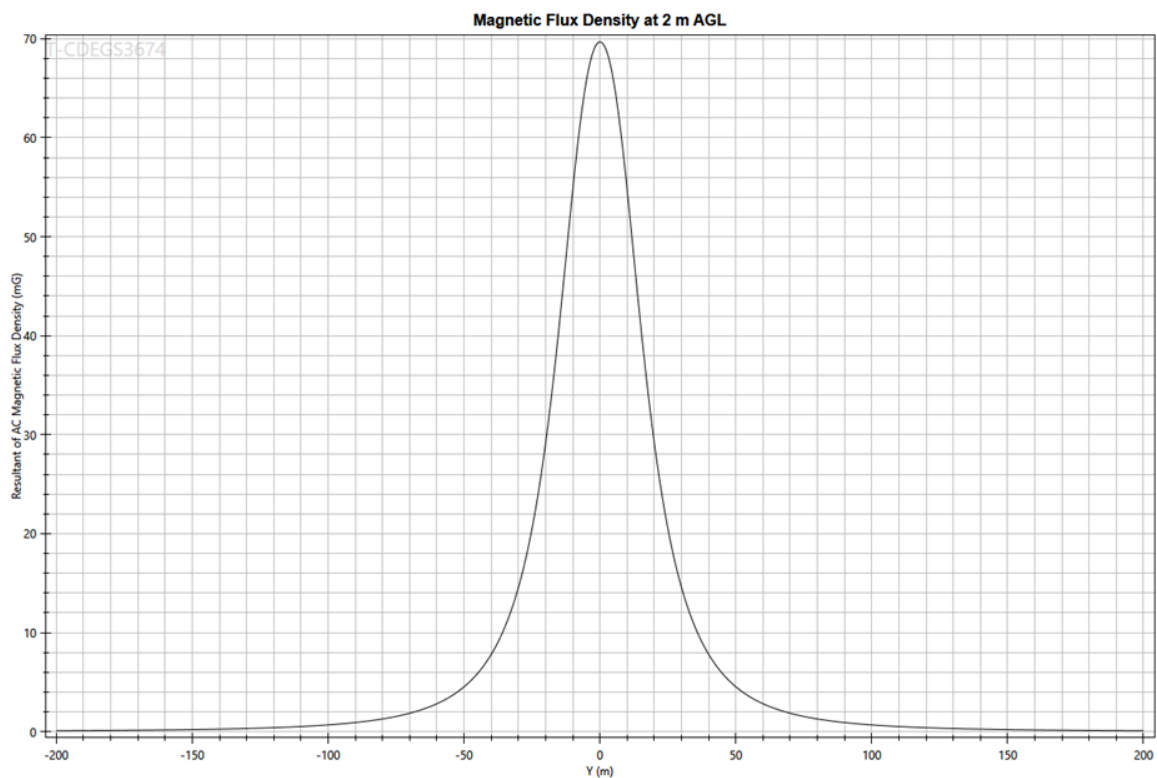


Figure 8 Magnetic field (μT) strength at 2 m AGL due to the high voltage overhead line, where $x = 0$ is the location immediately below the line at the point of maximum sag

5.4 Summary of modelled EMF and expected health impacts

The maximum electric and magnetic field strengths modelled for the medium-voltage underground cabling and high-voltage overhead line proposed for the Project are summarised and compared to the limits recommended by the ICNIRP and WHO for general public exposure in Table 6. These maximum values are observed immediately below the overhead line at a point half-way along its length, and at ground level immediately above the underground cable. Since electric and magnetic field strengths decrease as the distance from the source increases, the field strengths at all other locations are expected to be less than the maximum values given in Table 6. For the parameters and assumptions considered in this assessment, the modelled EMF at the range of heights above ground level that humans are most likely to occupy is well within the recommended exposure limits and so the risks to human health from EMF associated with the Project are considered low.

Table 6 Summary of electric and magnetic field strengths evaluated for the Project

Source and measurement location	Maximum electric field [kV/m]	Maximum magnetic field [μT]
Underground cable, measured at ground level	Not evaluated ¹	15.5
High-voltage overhead line, measured at 1.5 m AGL	1.3	6.5
High-voltage overhead line, measured at 2 m AGL	1.35	7.0
ICNIRP 2010 reference level for general public exposure [9]	5	200
WHO recommendation for general public exposure [6]	Not specified	100

1. Due to attenuation effects, the electric field strength at ground level for underground cables is expected to be negligible and has not been considered in this assessment.

The closest dwellings to the proposed underground cabling network (dwelling R21 and its associated shed) are located approximately 460 m away from the cabling. Both these dwellings are associated dwellings, and DNV understands that they are uninhabited. The closest dwelling to the proposed high-voltage overhead line (dwelling R23) is located approximately 2.1 km from the overhead line and approximately 1.2 km from the underground cabling and is also an associated dwelling that is uninhabited. All other dwellings are located more than 470 m from the underground cabling and 2.2 km from the overhead line. Since the electric and magnetic field strengths decrease with increasing distance from the source, the EMF produced by the proposed cabling and overhead line within the Project boundaries will be significantly below the relevant exposure limits at the nearby dwellings and is expected to be indistinguishable from background levels.

As discussed above, the electric and magnetic field strengths due to the medium-voltage cabling and high-voltage overhead line at all locations in and around the Project at the range of heights that humans are most likely to occupy are expected to be well within the limits recommended by the ICNIRP, even with the conservative assumptions considered in this assessment. However, DNV notes that there is a potential for cumulative EMF impacts at ground level at the points where the underground cabling network passes below the proposed 330 kV high-voltage overhead line, as shown in Figure 9. The risk of cumulative impacts can be mitigated in the detailed design of the electrical infrastructure for the Project by designing the cabling and overhead lines such that the cumulative EMF strengths are within acceptable levels.



As discussed in Section 5.1, it is expected that other electrical equipment associated with the Project, including the substation, will be designed and installed in accordance with the relevant guidelines for EMF exposure. Although substations have the potential to produce large magnetic fields, all identified dwellings are located more than 2.1 km from the proposed substation location. At this distance, attenuation of the magnetic fields will be sufficient to ensure that the field strengths are below the relevant exposure limits. It is also expected that the substation will be fenced off with sufficient clearances from the electrical equipment to the fencing to ensure that EMF levels at the boundary are within the recommended limits. The EMF levels produced by the Project are therefore expected to be within the recommended exposure limits at all publicly accessible locations in and around the wind farm site.

Based on this assessment, the risks to human health from EMF associated with the Project are considered low and there is no need to carry out further prudent avoidance.

6 CONCLUSIONS

6.1 Potential EMI impacts

Broadcast towers and transmission paths around the Project were investigated to determine if EMI would be experienced as a result of the development and operation of the Project. The Project will involve the installation of 180 wind turbine generators. DNV has considered a turbine geometry that will be conservative for turbine configurations with dimensions satisfying all of the following criteria: a rotor diameter of 245 m or less and an upper tip height of 300 m or less.

The results of this assessment are summarised in Table 7.

To date, DNV has not identified any potential for the Project to cause significant EMI-related impacts. However, consultation with the operators of some radiocommunication services is required to determine the likely impacts on those services. This consultation has commenced, and no justifiable concerns have been raised to date. In most cases, if interference is experienced, it is expected that mitigation options will be available.

Turbines at the Project may interfere with point-to-area style services such as mobile phone signals and terrestrial television broadcasting, particularly in areas with poor or marginal signal coverage. Dwellings within approximately 5-10 km of the Project that are currently receiving weak signals from the Murray Valley television broadcast transmitter may experience interference to this service. However, given that all dwellings that are both in the coverage area for this transmitter and in the interference zone established by DNV are uninhabited, the overall potential for impact is considered low. Feedback received from BAI Communications, who operate the Murray Valley transmitter, also suggests that impacts to DTV broadcasting are unlikely. If interference to any of these services is experienced, a range of options are available to rectify difficulties.

Interference to signals from a geostationary satellite that transmits programs intended for international audiences is also possible at one nearby dwelling (R22), but the Customer has advised that this dwelling no longer exists as it has been demolished. Therefore, satellite signals to dwellings in the vicinity of the Project are not expected to be intercepted by turbines.

Impacts to fixed point-to-point links crossing the proposed Project site are not expected, as there are no turbines located within the interference zones established by DNV. DNV has consulted with the operators of those links to confirm the potential for interference. Although concerns have been raised by Vodafone, these are not supported by the assessment presented here and Vodafone has not yet provided justification or specified an appropriate clearance zone to avoid impacts to their point-to-point links. No other concerns have been raised to date.

Since it is not possible to determine the potential EMI impacts on point-to-multipoint links, emergency services, and meteorological radar without obtaining further information from the relevant operators, DNV has consulted with organisations operating services that may be affected by the Project. The Bureau of Meteorology has advised that impacts to their radars are expected to be manageable, and the responses received to date from the operators of point-to-multipoint links and emergency services indicate that the Project is unlikely to have any impacts on these services.

Potential EMI impacts on other services considered in this assessment, including Starlink satellite internet, trigonometrical stations, radio broadcasting, and CB radio, are not expected or are considered to be minor.



DNV notes that the Project is located in an area of high wind farm development activity, with several other proposed, approved, and operating wind farms located nearby. The potential cumulative impacts of the Project in conjunction with the nearby wind farms have not been considered in detail in this assessment. However, for services where impact from the Project itself is considered either unlikely or non-existent, it is generally expected that there will be no cumulative impacts.

6.2 Potential EMF impacts

The risks to human health from EMF associated with the Project are considered low. Simulation of the EMF produced by the proposed medium-voltage underground cabling network and high-voltage overhead line has shown that the EMF at the range of heights above ground level that humans are most likely to occupy (from 0 m above ground level to 2 m above ground level) will be within the exposure limits recommended for the protection of the general public. EMF from other equipment at the Project is also expected to be compliant with the relevant guidelines. The EMF levels produced by the Project are therefore expected to be within the recommended exposure limits at all publicly accessible locations in and around the Project, and indistinguishable from background levels at nearby dwellings.

Table 7 Summary of EMI assessment results for the proposed Project

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Radio-communication towers	No towers within 2 km of proposed turbine locations	Consultation not considered necessary	None	None required
Fixed point-to-point links	14 links crossing Project boundary, operated by: Ambulance Service of NSW Essential Energy NSW Telco Authority NSW Rural Fire Service Optus Vodafone No turbines in diffraction zones for all links	Vodafone: potential for interference raised, but no justification provided to date Essential Energy, Optus: no concerns raised Other operators: no response received	Unlikely to cause interference	If required – upgrade existing equipment, reroute affected links, install additional towers, replace affected links with alternative technologies
Fixed point-to-multipoint links	76 assignments within 75 km of Project boundary One base station within 20 km of Project boundary, operated by: Murray Irrigation Ltd	Water NSW: no concerns raised Other operators: no response received	Potential for interference if link paths cross the Project near turbines.	If required – reroute affected links, install additional towers, replace affected links with alternative technologies
Other licence types	Point-to-area style communications: see findings for emergency services, mobile phones, radio broadcasting, and television broadcasting Aeronautical and radiodetermination: to be considered as part of an aviation impact assessment	-	-	-
Emergency services	Point-to-point links: Nine links crossing boundary operated by Ambulance service of NSW, New South Wales Government Telecommunications Authority and NSW Rural Fire Service Point-to-area style communications: unlikely to be affected	NSW Police Force, St John Ambulance, NSW SES, VRA Rescue, NSW Telco Authority: no concerns raised Other operators: no response received	Point-to-point links: unlikely to cause interference Point-to-area style communications: unlikely to cause interference	Point-to-point links: as for point-to-point links Point-to-area style communications: if required – increase signal strength from affected tower or alternative towers, install signal repeater, install additional tower

**Table 7 Summary of EMI assessment results for the proposed Project
(continued)**

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Meteorological radar	Nearest radar: 174 km from Project	Impacts are expected to be manageable	Potential for manageable interference	Notify the Bureau of Meteorology prior to any planned shutdown of the Project to allow calibration of systems, collaborate with the Bureau of Meteorology in the event of severe weather conditions
Trigonometric stations	Seven stations within 20 km of Project boundary One trigonometrical station ('Jeraly') is located within the site boundary Electronic equipment: unlikely to be affected Sight lines to other stations: may be blocked by turbines	No concerns raised	Unlikely to cause interference	None required
Citizen's band radio	Unlikely to be affected	Consultation not considered necessary	Unlikely to cause interference	None required
Mobile phones	Unlikely to be affected in areas with good coverage, may experience interference in areas with marginal coverage Telstra: Some 3G and 4G coverage to the north and south of the site, inside and outside of the Project boundary Optus: Both 3G and 4G coverage available inside the site boundary. An additional antenna may be needed for areas to the north, east and west outside the site boundary Vodafone: 4G available across the north of the site, 3G available through the centre, no coverage across the south	Optus, Vodafone: no concerns raised Telstra: no response received	Unlikely to be affected in areas with good coverage, may experience interference in areas with marginal coverage	If required – increase signal strength from affected tower or alternative towers, install additional tower

**Table 7 Summary of EMI assessment results for the proposed Project
(continued)**

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Wireless internet	<p>Wireless broadband service providers: Field Solutions Group Pty Ltd, Telstra, Optus, Vodafone, NBN Co</p> <p>Field Solutions Group: nearest tower located 56 km southwest of site</p> <p>NBN: available as a satellite service only</p>	<p>Optus, Vodafone, Field Solutions Group, NBN: no concerns raised</p> <p>Telstra: no response received</p>	<p>Telstra, Optus, Vodafone: as for mobile phones</p> <p>Field Solution Group: unlikely to cause interference</p> <p>NBN: none</p>	<p>Telstra, Optus, Vodafone: as for mobile phones</p> <p>Field Solutions Group: if required – to be determined in collaboration with operator</p> <p>NBN: none required</p>
Satellite television and internet	<p>Geostationary satellites: signals from satellites providing services intended for Australian audiences unlikely to be affected; signals from one satellite providing services intended for international audiences intercepted at one dwelling.</p> <p>Although this dwelling has been demolished.</p> <p>Low Earth orbit (LEO) satellites: Unlikely to be affected</p>	<p>Consultation not considered necessary</p>	<p>Geostationary satellites: none</p> <p>LEO satellites: none</p>	<p>Geostationary satellites: none required</p> <p>LEO satellites: none required</p>
Radio broadcasting	<p>AM and FM signals: may experience interference in close proximity to turbines</p> <p>Digital radio signals: Project is outside the intended coverage area</p>	<p>Consultation not considered necessary</p>	<p>AM and FM signals: low likelihood of interference</p> <p>Digital radio signals: none</p>	<p>AM and FM signals: if required – install higher-quality antenna or amplifier at affected location</p> <p>Digital radio signals: none required</p>
Television broadcasting	<p>May experience interference in areas with poor or marginal reception</p> <p>Murray Valley transmitter: <i>'variable' coverage in the south of the site</i></p> <p>Seven dwellings in potential interference zone, but all dwellings which have coverage and are in the interference zone are uninhabited</p>	<p>Interference not expected – no buildings identified in potential interference areas</p> <p>Rectification of any interference is expected to form part of the Project</p>	<p>Low likelihood of interference</p>	<p>If required – re-align antenna at affected dwelling to existing tower, re-direct antenna to alternative tower, install more directional or higher gain antenna, change location of antenna, install cable or satellite television, install relay transmitter</p>

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APPENDIX A – TELEVISION INTERFERENCE CAUSED BY REFLECTION OR SCATTERING OF SIGNALS

A.1 Susceptibility of DTV signals to reflection or scattering

The United Kingdom telecommunications regulator Ofcom [45] states the following with regard to interference to DTV reception:

"Digital television signals are much better at coping with signal reflections, and digital television pictures do not suffer from ghosting. However a digital receiver that has to deal with reflections needs a somewhat higher signal level than one that has to deal with the direct path only. This can mean that viewers in areas where digital signals are fairly weak can experience interruptions to their reception should new reflections appear... reflections may still affect digital television reception in some areas, although the extent of the problem should be far less than for analogue television."

DNV has drawn two conclusions from this report:

- Firstly, that DTV is very robust and does not suffer from ghosting. In most cases DTV signals are not susceptible to interference from wind farm developments.
- Secondly, that areas of weak DTV signal can experience interruptions to their reception should new reflections appear, such as those from nearby wind turbines.

For television broadcast signals, which are omni-directional or point-to-area signals, interference from wind turbines is dependent on many factors including:

- the proximity of turbines to the television broadcast transmitter
- the proximity of turbines to receivers (dwellings)
- the location of turbines in relation to dwellings and television broadcast transmitters
- the rotor blade material, rotor speed, and rotor blade direction (always into the wind)
- the properties of the receiving antenna (e.g., type, directionality, and height)
- the location of the television receiver in relation to terrain and other obstacles
- the frequency and power of the television broadcast signal.

A.2 Forward and back scatter of DTV signals

Wind turbines can cause interference to DTV signals by introducing reflections that may be received by the antenna at a dwelling, in addition to the signal received directly from the transmitter, which causes multipath errors. A wind turbine has the potential to scatter electromagnetic waves carrying DTV signals both forward and back.

Forward scatter can occur when the transmitter, one or more turbines, and receiver are almost aligned as shown in Figure A.1. The forward scatter region in this case is characterised by a shadow zone of reduced signal strength behind the turbine, where direct and scattered signals can be received, with the blade rotation introducing a rapid variation in the scattered signal [53]. Both of these effects can potentially degrade the DTV signal quality.

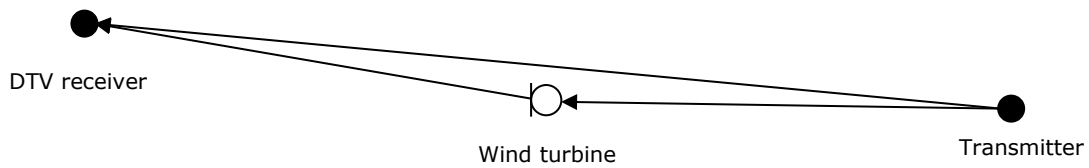


Figure A.1 Forward scatter signal path for DTV signals

Back scatter from wind turbines occurs when DTV signals are reflected from turbine towers and blades onto a receiver as shown in Figure A.2. The reflected signals are attenuated, time-delayed and phase-shifted (due to a longer path from transmitter to receiver) compared to the original signal. The reflected signals are also time-varying due to the rotation of the blades and vary with wind direction. The resultant signal at the receiver includes the original signal (transmitter to receiver) and a series of time-varying multipath signals (transmitter-turbine-receiver).

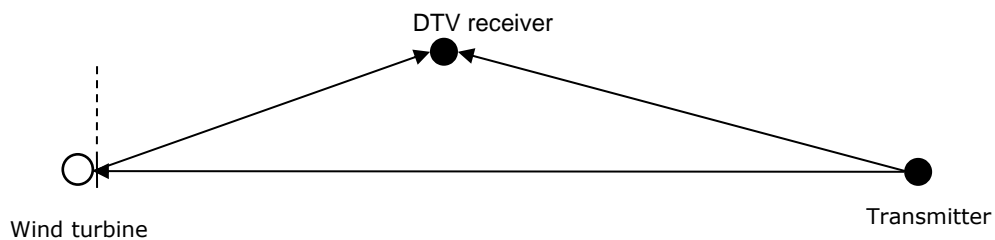


Figure A.2 Back scatter signal path for DTV signals

Interference to DTV signals from wind turbines can potentially occur in both the forward and backward scatter region. The effect of a turbine on a DTV signal can be different depending on the scattering region where the receiver is located [53].

According to Ofcom [45], the forward scatter region does not typically extend further than 5 km for the worst combination of factors [12, 63]. Interference may extend beyond 5 km if the dwellings are screened from the broadcast transmitter, but do have line-of-sight to the turbines [45]. The shape of this region, assuming a relatively high gain, directional antenna, can be represented by a circular segment with an azimuthal range of approximately $\pm 15^\circ$ to $\pm 20^\circ$, corresponding to the beam width of the antenna. If a lower gain or omni-directional antenna is being used, this region is likely to be larger.

Back scattered signals arrive at the dwelling delayed relative to the source signal from the broadcast transmitter. The back scatter region generally does not extend further than 500 m [12, 45], assuming a high gain, directional antenna that has a relatively high front-to-back ratio (meaning the signal received by the front of the antenna is much higher than that received from the back). If an antenna with a lower front-to-back ratio, or an omni-directional antenna is used, this region is likely to be larger.

The combination of the forward and back scatter regions, as shown in Figure A.3, resembles a keyhole.

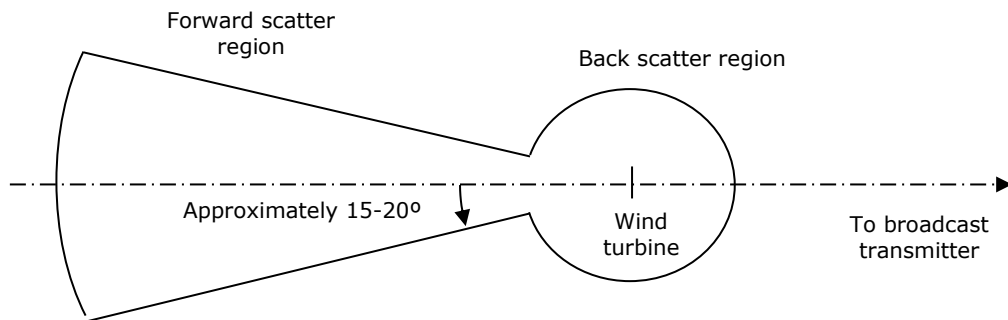


Figure A.3 Potential television interference zones around a wind turbine

Television interference mechanisms rely on many factors (as previously mentioned) and are complex to calculate. Previous experience has shown that even after great effort has been put into performing such calculations, they tend to have limited accuracy, and would require field validation after the wind farm is operational.

In Australia, DTV signals are transmitted using the DVB-T (Digital Video Broadcasting – Terrestrial) standard. The International Telecommunication Union (ITU) Recommendation BT.1893 [64] states the following in regards to the forward scatter region for DVB-T signals:

"In most of the situations where the impact of a wind farm to DVB-T reception quality was analyzed, the threshold C/N [carrier-to-noise] ratios obtained were similar to those expected in environments with the absence of wind farms. More precisely, in the forward scattering region of the wind turbines, where the transmit antenna, one or more turbines and the receive antenna are lined-up ($\pm 60^\circ$ behind the wind turbine), the DVB-T reception quality may not be affected though further work of analysis is needed in order to confirm this point, especially in the vicinity of 0° ."

In other words, wind turbines are not generally expected to affect DVB-T DTV signals in the forward scatter region. However, the ITU [54] also highlight that in the case where there is significant blockage of the direct signal, but clear line-of-sight to one or more turbines, interference to the reception of the DTV signal is possible. Results of studies reported by the ITU also suggest that interference may be more likely in areas where the existing DTV signal is already weak or degraded [54].

With regards to back scattering, the ITU states:

"In the case of the backscattering region, in those situations where the scattered signals from wind turbines are significant in amplitude and variability, the threshold C/N ratio necessary for quasi error free (QEF) condition is higher."

In other words, the C/N ratio needs to be higher in the presence of significant back scatter to achieve the same QEF condition as is the case without the presence of turbines, which effectively means that interference is more likely to occur as coverage quality decreases.

A.3 Theoretical models for wind turbine scattering estimation

Various theoretical scatter models to predict scatter of terrestrial television signals have been proposed, some dating back to the late 1970s. A review of these models, as well as a comparison against empirical data has been reported in [65]. This comparison with empirical data found:

"...none of the analyzed methods seems to be accurate enough to provide realistic estimations of the signal scattered by the wind turbines. In conclusion, a more complete scattering model is needed in order to provide more practical estimations of the scattered signals and evaluate their potential impact on the broadcasting services."

Notably, the scattering model proposed by the ITU to specifically address DTV signals [64], was found to be the most inaccurate, and does not provide signal estimations in the forward scattering zone of the blades. Additionally, DNV notes that it only applies to a single wind turbine rather than a wind farm as a whole.

As an alternative to signal scattering models, it is common practice to identify those dwellings or areas that are most likely to experience potential television interference based on likely forward and back scatter regions. As introduced above and shown in Figure A.3, this is often referred to as the 'keyhole' approach and is an established technique for predicting where terrestrial television interference is most likely, based on a number of assumptions regarding receiving antenna characteristics. The approach involves combining multiple keyhole shaped areas that are placed over each turbine location [45]. The combination of these areas forms a region where there is an increased likelihood of interference to television signals occurring.



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Table 8 Proposed turbine layout for the Project [4]

Turbine ID	Easting ¹ [m]	Northing ¹ [m]	Base elevation ² [m]	Turbine ID	Easting ¹ [m]	Northing ¹ [m]	Base elevation ² [m]
1	231146	6156906	74	91	235438	6139477	72
2	232389	6157340	75	92	236433	6139357	73
3	233575	6157609	74	93	226140	6137791	69
4	234857	6158197	74	94	225962	6136203	68
5	236118	6158631	73	95	227172	6136726	68
6	237316	6159014	72	96	228619	6136932	70
7	230721	6155181	71	97	229772	6137319	73
8	232078	6155593	73	98	230970	6137879	72
9	233284	6155904	74	99	232219	6138512	71
10	234639	6156543	75	100	233073	6138062	72
11	235867	6156958	74	101	234269	6138194	71
12	237127	6157402	73	102	235282	6137966	70
13	238376	6157836	71	103	237008	6138542	71
14	231255	6153799	69	104	224672	6134949	68
15	232390	6153914	72	105	226056	6134775	68
16	233730	6154721	72	106	227299	6135440	71
17	234976	6155150	69	107	228307	6135346	72
18	236302	6155596	72	108	229475	6135782	69
19	237628	6156043	73	109	230649	6136290	72
20	231636	6152114	69	110	231862	6136919	73
21	232927	6152947	73	111	233711	6136552	72
22	234368	6153377	73	112	234622	6136288	72
23	235610	6153821	73	113	235869	6137139	73
24	236834	6154247	73	114	236852	6136995	73
25	238052	6154552	75	115	223523	6132733	69
26	232173	6151151	69	116	224745	6133492	68
27	233441	6151639	73	117	225800	6133262	72
28	235344	6152189	74	118	227079	6133914	70
29	236568	6152490	74	119	228593	6134087	73
30	237828	6152969	73	120	229849	6134519	70
31	231601	6149386	72	121	231089	6135259	72
32	233209	6149827	71	122	232153	6135146	73
33	234492	6150421	74	123	233331	6134962	71
34	236000	6150699	73	124	234191	6134655	73
35	236985	6150424	71	125	235409	6135524	73
36	238056	6150351	75	126	236400	6135342	73
37	232078	6148342	73	127	237123	6134802	74
38	233366	6148603	75	128	237998	6134472	75
39	234803	6149189	73	129	238981	6134396	74
40	226651	6144308	69	130	239801	6133853	75
41	228004	6145166	71	131	224249	6131708	69
42	229627	6145760	70	132	226141	6131977	70
43	230824	6146269	69	133	227406	6132553	68
44	232194	6146901	71	134	228437	6132397	70
45	233783	6147459	72	135	229672	6132816	71
46	235030	6147844	71	136	230978	6133649	72
47	236850	6148833	74	137	231647	6132861	72

**Table 8 Proposed turbine layout for the Project [4]
(continued)**

Turbine ID	Easting ¹ [m]	Northing ¹ [m]	Base elevation ² [m]	Turbine ID	Easting ¹ [m]	Northing ¹ [m]	Base elevation ² [m]
48	237924	6148745	71	138	232486	6132338	73
49	227194	6143369	70	139	233753	6132830	75
50	228614	6143275	70	140	235007	6133881	72
51	230053	6144599	70	141	235668	6133067	74
52	231538	6145120	69	142	236916	6132930	73
53	232812	6145686	72	143	237959	6132774	75
54	234057	6146051	71	144	238744	6132157	73
55	235323	6146398	71	145	239843	6132163	73
56	236839	6147017	74	146	226481	6130765	72
57	237827	6146763	73	147	227529	6130623	70
58	230439	6143490	70	148	228803	6131036	72
59	231596	6143596	72	149	230103	6131719	72
60	232876	6144129	73	150	234377	6131943	71
61	235491	6144818	73	151	235548	6131465	74
62	236582	6144744	70	152	236533	6131190	73
63	226151	6141663	68	153	237349	6130626	73
64	227343	6141968	70	154	238395	6130442	73
65	225414	6139896	71	155	239275	6129998	73
66	226559	6140257	70	156	230349	6130437	72
67	228029	6141194	71	157	231524	6130605	72
68	229330	6141893	71	158	229034	6129316	72
69	230412	6141827	70	159	230406	6128962	72
70	231663	6142124	69	160	231835	6129346	72
71	233257	6142944	70	161	233038	6129594	72
72	234262	6142653	70	162	234287	6130049	73
73	235566	6143018	69	163	235079	6129452	72
74	236952	6142631	72	164	236039	6129195	73
75	227127	6139450	69	165	236974	6128650	71
76	228316	6139998	72	166	238033	6128598	72
77	229221	6139733	71	167	238650	6127720	73
78	230372	6140136	71	168	227715	6127978	70
79	232251	6141215	70	169	228521	6127272	73
80	233234	6140925	68	170	229664	6127248	70
81	234568	6141238	70	171	230841	6127620	72
82	236563	6141087	73	172	232015	6127860	73
83	225620	6138683	72	173	233250	6128243	73
84	227320	6138232	71	174	232303	6126481	71
85	228298	6138140	70	175	234017	6127608	70
86	229459	6138556	69	176	235048	6127471	73
87	230598	6138935	70	177	235845	6126878	71
88	231661	6139548	69	178	236966	6126932	75
89	233484	6139668	70	179	237583	6126048	73
90	234539	6139740	71	180	238848	6126390	72

1. Coordinate system: MGA zone 55, GDA94 datum. Coordinates were provided by the Customer in a different coordinate system and/or datum and have been converted using mapping software, which may result in small discrepancies depending on the software and transformation approach used.
2. Base elevations have been determined by DNV based on publicly available SRTM1 data.

Table 9 Dwellings within 5 km of the proposed Project boundary [5]

Dwelling ID ¹	Easting ² [m]	Northing ² [m]	Status	Distance to site boundary [m]
Hells Gate (R04a)	229127	6164225	Non-associated	1307
Hells Gate (R04b)	229049	6164154	Non-associated	1377
Hells Gate (R05a)	229277	6163872	Non-associated	1122
Hells Gate (R05b)	229303	6163755	Non-associated	1085
Hells Gate (R05c)	229391	6163642	Non-associated	986
<u>R06a</u>	<u>233241</u>	<u>6160889</u>	<u>Associated</u>	<u>Within site boundary</u>
<u>R06b</u>	<u>233253</u>	<u>6160843</u>	<u>Associated</u>	<u>Within site boundary</u>
<u>R06c</u>	<u>233225</u>	<u>6160801</u>	<u>Associated</u>	<u>Within site boundary</u>
R07	242929	6163092	Non-associated	3308
R12	223092	6150358	Non-associated	3881
R13	243073	6155527	Non-associated	4341
<u>R14</u>	<u>236374</u>	<u>6147851</u>	<u>Associated</u>	<u>Within site boundary</u>
R15a	240671	6144464	Non-associated	2462
R20a	219041	6139007	Non-associated	4348
R20b	219057	6138993	Non-associated	4327
<u>R21</u>	<u>223630</u>	<u>6133581</u>	<u>Associated</u>	<u>Within site boundary</u>
<u>R22</u>	<u>233092</u>	<u>6131248</u>	<u>Associated</u>	<u>Within site boundary</u>
<u>R23</u>	<u>233544</u>	<u>6131027</u>	<u>Associated</u>	<u>Within site boundary</u>
R24	222515	6126829	Non-associated	1582
Rest Stop	240037	6160520	Non-associated	738
R28	222383	6124201	Non-associated	3062
<u>Shed³</u>	<u>223613</u>	<u>6133424</u>	<u>Associated</u>	<u>Within site boundary</u>
R15b	240975	6144695	Non-associated	2739

1. Associated dwellings are indicated by underlined italic text. The Customer has advised that all dwellings within the Project boundary are associated and are uninhabited and derelict or demolished, while all dwellings outside the Project boundary are non-associated.
2. Coordinate system: MGA zone 55, GDA94 datum. Coordinates were provided by the Customer in a different coordinate system and/or datum and have been converted using mapping software, which may result in small discrepancies depending on the software and transformation approach used.
3. The Customer has advised that this property is a shearing shed, which is affiliated with associated dwelling R21 [66].

Table 10 Details of point-to-point links crossing the proposed Project

Link no.	Licence number	Assignment ID	Frequency [Hz]	Licence owner
1	1416195/1	802669	154712500	Ambulance Service of NSW Service Manager Telecommunications Matt Wheat Locked Bag 105 ROZELLE NSW 2039
		802670	154712500	
		802671	150112500	
		802672	150112500	
2	40839/1	683172	154987500	ESSENTIAL ENERGY Attn: Telecommunications Operations PO Box 5730 PORT MACQUARIE BC NSW 2444
		683173	154987500	
		683174	150387500	
		683175	150387500	
3	10377406/1	3330210	413475000	NEW SOUTH WALES GOVERNMENT TELECOMMUNICATIONS AUTHORITY Telco Authority (RMS) Level 18, McKell Building 2-24 Rawson Place SYDNEY NSW 2000
		3330211	413475000	
		3330212	404025000	
		3330213	404025000	
4	11243376/1	7965886	7662500000	NEW SOUTH WALES GOVERNMENT TELECOMMUNICATIONS AUTHORITY Telco Authority (NSW Ambulance) Level 14, McKell Building 2-24 Rawson Place SYDNEY NSW 2000
		7965887	7662500000	
		7965888	7501500000	
		7965889	7501500000	
5	11270984/2	9865078	7610000000	NEW SOUTH WALES GOVERNMENT TELECOMMUNICATIONS AUTHORITY Telco Authority (PSN) Locked Bag 2 HAYMARKET NSW 1240
		9865079	7610000000	
		9865080	7449000000	
		9865081	7449000000	
6	1956967/2	2089980	460675000	NEW SOUTH WALES GOVERNMENT TELECOMMUNICATIONS AUTHORITY Telco Authority (FRNSW) Level 18, McKell Building 2-24 Rawson Place SYDNEY NSW 2000
		2089981	451175000	
		2089982	451175000	
		2089983	460675000	
7	1956968/2	2089984	460675000	NEW SOUTH WALES GOVERNMENT TELECOMMUNICATIONS AUTHORITY Telco Authority (FRNSW) Level 18, McKell Building 2-24 Rawson Place SYDNEY NSW 2000
		2089985	451175000	
		2089986	451175000	
		2089987	460675000	
8	1145755/1	746487	460050000	NEW SOUTH WALES GOVERNMENT TELECOMMUNICATIONS AUTHORITY Telco Authority (FRNSW) Level 18, McKell Building 2-24 Rawson Place SYDNEY NSW 2000
		746488	460050000	
		746489	450550000	
		746490	450550000	
9	1972816/1	974662	413800000	NSW RURAL FIRE SERVICE Locked Mail Bag 17 GRANVILLE NSW 2142
		974663	413800000	
		974664	404350000	
		974665	404350000	
10	1972817/1	974666	413800000	NSW RURAL FIRE SERVICE Locked Mail Bag 17 GRANVILLE NSW 2142
		974667	413800000	
		974668	404350000	
		974669	404350000	

**Table 10 Details of point-to-point links crossing the proposed Project
(continued)**

Link no.	Licence number	Assignment ID	Frequency [Hz]	Licence owner	
11	10161918/1	2317437	8177620000	Optus Mobile Pty Limited LTE TXN 1 Lyonpark Road MACQUARIE PARK NSW 2113	
		2317438	8177620000		
		2317439	7866300000		
		2317440	7866300000		
12	11933927/1	10020870	8236920000		
		10020871	8236920000		
		10020872	7925600000		
		10020873	7925600000		
13	1956595/1	942940	8088670000		Vodafone Australia Pty Limited PO BOX 1113 Att: Ahmed Dawood NORTH SYDNEY NSW 2060
		942941	8088670000		
		942942	7777350000		
		942943	7777350000		
14	1956596/1	942944	8059020000		
		942945	8059020000		
		942946	7747700000		
		942947	7747700000		

Table 11 Details of point-to-multipoint licences within 75 km of the proposed Project

Assignment ID	Site ID	Licence no.	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]	Licence owner
2839141	10006564	10280623/1	-34.8451	143.3161	58	Augusta Operating Pty Limited as Trustee for Augusta Operating Trust PO Box 52 Tooleybuc NSW 2736
2839144	10006564	10280623/1	-34.8451	143.3161	58	
2839145	10006564	10280624/1	-34.8451	143.3161	58	
2839148	10006564	10280624/1	-34.8451	143.3161	58	
2839149	10006564	10280625/1	-34.8451	143.3161	58	
2839152	10006564	10280625/1	-34.8451	143.3161	58	
2253485	405176	10156903/1	-34.6355	143.5623	44	Balranald Shire Council 70 Market Street BALRANALD NSW 2715
2253488	405176	10156903/1	-34.6355	143.5623	44	
793720	305647	1326914/1	-35.6103	144.1331	69	Barham & District Services Memorial Club PO BOX 199 BARHAM NSW 2732
793723	305647	1326914/1	-35.6103	144.1331	69	
9313954	10030067	11699032/1	-34.9137	143.3439	55	Best Allandale Pty Ltd as the Trustee for THE BEST FAMILY TRUST Best Ag 597 Wakool Junction Road GOODNIGHT NSW 2736
9313957	10030067	11699032/1	-34.9137	143.3439	55	
9948347	10009057	11915266/1	-34.7342	143.1669	74	Boundary Bend limited Boundary Bend limited PO Box 92 LARA VIC 3212
9948350	10009057	11915266/1	-34.7342	143.1669	74	
2839193	10006565	10280685/1	-34.7275	143.5082	45	Cadell Operating Pty Limited as trustee for Cadell Operating Trust THE TRUSTEE FOR CADELL OPERATING TRUST PO Box 52 Tooleybuc NSW 2736
2839196	10006565	10280685/1	-34.7275	143.5082	45	
2839197	10006565	10280686/1	-34.7275	143.5082	45	
2839200	10006565	10280686/1	-34.7275	143.5082	45	
2839201	10006565	10280687/1	-34.7275	143.5082	45	
2839204	10006565	10280687/1	-34.7275	143.5082	45	
4080194	10006565	10509039/1	-34.7275	143.5082	45	
4080197	10006565	10509039/1	-34.7275	143.5082	45	
4080198	10006565	10509040/1	-34.7275	143.5082	45	
4080201	10006565	10509040/1	-34.7275	143.5082	45	
995661	9022487	1983383/1	-35.1039	143.3194	61	
995664	9022487	1983383/1	-35.1039	143.3194	61	

Table 11 Details of point-to-multipoint licences within 75 km of the proposed Project (continued)

Assignment ID	Site ID	Licence no.	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]	Licence owner
792289	305159	1325436/1	-35.2276	143.4677	55	Goulburn-Murray Rural Water Corporation Operations PO Box 165 TATURA VIC 3616
792292	305159	1325436/1	-35.2276	143.4677	55	
753967	306031	1183186/1	-35.3396	143.5299	58	
753970	306031	1183186/1	-35.3396	143.5299	58	
5164387	10016654	10670588/1	-35.5538	143.7620	68	
5164390	10016654	10670588/1	-35.5538	143.7620	68	
777668	205367	1229677/1	-34.5130	144.8395	64	Hay Shire Council PO Box 141 HAY NSW 2711
777671	205367	1229677/1	-34.5130	144.8395	64	
904841	51636	1931957/1	-35.3456	143.5592	57	Lower Murray Urban & Rural Water Corporation Lower Murray Water PO Box 1438 MILDURA VIC 3502
904844	51636	1931957/1	-35.3456	143.5592	57	
4144250	51636	10518079/1	-35.3456	143.5592	57	
4144253	51636	10518079/1	-35.3456	143.5592	57	
1294117	133842	1142561/1	-35.3500	143.6100	54	
1294120	133842	1142561/1	-35.3500	143.6100	54	Murray Downs Golf and Country Club Ltd PO Box 496 SWAN HILL VIC 3585
996783	201494	1983876/1	-35.0755	144.0354	11	Murray Irrigation Ltd PO Box 528 DENILIQUIN NSW 2710
996786	201494	1983876/1	-35.0755	144.0354	11	
735342	101235	1106669/1	-35.2256	143.9190	29	
735345	101235	1106669/1	-35.2256	143.9190	29	
737050	102129	1109287/1	-35.3075	144.1241	36	
737053	102129	1109287/1	-35.3075	144.1241	36	
2231836	102129	10145574/1	-35.3075	144.1241	36	
2231839	102129	10145574/1	-35.3075	144.1241	36	
912986	9013095	1937816/1	-35.4680	144.3968	58	
912989	9013095	1937816/1	-35.4680	144.3968	58	
735354	101222	1106671/1	-35.5234	144.4592	66	
735357	101222	1106671/1	-35.5234	144.4592	66	
10116885	10033240	11948842/1	-34.8756	143.3374	56	
10116886	10033240	11948842/1	-34.8756	143.3374	56	
8139036	10025915	11274094/1	-35.1068	143.2949	64	SELECT HARVESTS FOOD PRODUCTS PTY LTD Select Harvests Limited 4444b Hattah-Robinvale Road WEMEN VIC 3549
8139037	10025915	11274094/1	-35.1068	143.2949	64	

Table 11 Details of point-to-multipoint licences within 75 km of the proposed Project (continued)

Assignment ID	Site ID	Licence no.	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]	Licence owner
768486	36826	1210200/1	-34.4684	144.2990	23	
768489	36826	1210200/1	-34.4684	144.2990	23	
771445	36829	1217197/1	-34.7918	144.6277	44	
771446	36829	1217197/1	-34.7918	144.6277	44	
768510	37530	1210222/1	-34.3928	143.6298	47	
768513	37530	1210222/1	-34.3928	143.6298	47	
771461	37161	1217200/1	-34.2127	144.5758	61	
771462	37161	1217200/1	-34.2127	144.5758	61	
771473	36827	1217202/1	-34.0211	144.1663	68	
771474	36827	1217202/1	-34.0211	144.1663	68	
773195	37529	1220782/1	-34.0315	143.6868	74	
773196	37529	1220782/1	-34.0315	143.6868	74	
2807368	370296	1227142/2	-34.4615	144.3689	27	
2807369	370296	1227142/2	-34.4615	144.3689	27	
2807376	100850	1227145/2	-34.5569	143.5876	44	
2807377	100850	1227145/2	-34.5569	143.5876	44	
707723	39097	95271/1	-35.6307	144.1191	72	
707726	39097	95271/1	-35.6307	144.1191	72	
707727	39097	95271/1	-35.6307	144.1191	72	
707732	39097	95271/1	-35.6307	144.1191	72	

TELSTRA LIMITED
Telstra - Radio
Transport
Engineering
Locked Bag 3501
BRISBANE QLD
4001

WATER NSW
Attn: P Dudley PO
Box 398
Parramatta NSW
2124

Wakool Shire
Council
PO Box 40
MOULAMEIN NSW
2733

Table 12 Details of other licences identified within 75 km of the proposed Project

Licence category	Licence type	Number of assignment IDs
1800 MHz Band	Spectrum	88
2 GHz Band	Spectrum	113
2.3 GHz Band	Spectrum	260
2.5 GHz Band	Spectrum	123
3.4 GHz Band	Spectrum	450
700 MHz Band	Spectrum	252
800 MHz Band	Spectrum	176
AWL - FSS Only	Spectrum	50
AWL - Standard	Spectrum	4
Amateur Repeater	Amateur	2
Ambulatory System	Land Mobile	10
CBRS Repeater	Land Mobile	4
Commercial Radio	Broadcasting	2
Commercial Television	Broadcasting	6
Land Mobile System - > 30MHz	Land Mobile	542
Land Mobile System 0-30MHz	Land Mobile	44
Narrowband Area Service station(s)	Broadcasting	3
Narrowcasting Service (Fixed Tax)	Broadcasting	3
Narrowcasting Service (LPON)	Broadcasting	6
National Broadcasting	Broadcasting	9
PMTS Class B	PTS	142
PMTS Class B (935-960 MHz)	PTS 900 MHz	43
Paging System - Exterior	Land Mobile	19
Paging System - Interior	Land Mobile	1
Radiodetermination	Radiodetermination	3
Retransmission	Broadcasting	5

Table 13 Emergency services with radiocommunication assets in the vicinity of the proposed Project

Emergency service	Contact details	Distance from closest site to Project boundary [km]
Ambulance Service of NSW	Ambulance Service of NSW Service Manager Telecommunications Matt Wheat Locked Bag 105 ROZELLE NSW 2039	6
Ambulance Victoria	Ambulance Victoria Attn: Tim McCallum 303 Gillies Street North WENDOUREE VIC 3355	57
Australian Citizens Radio Emergency Monitors Inc.	Australian Citizens Radio Emergency Monitors Inc. ACREM 17 GIBBON CLOSE THORNTON NSW 2322	43
Country Fire Authority	Country Fire Authority PO Box 701 MOUNT WAVERLEY VIC 3149	56
RMR Regional Mobile Radio	DEPARTMENT OF JUSTICE AND COMMUNITY SAFETY RMR Regional Mobile Radio C/- Level 2 Bld M5 30 Henderson Rd CLAYTON VIC 3168	56
Visionstream Australia	DEPARTMENT OF JUSTICE AND COMMUNITY SAFETY Visionstream Australia 167-169 Cremorne Street CREMORNE VIC 3121	60
NEW SOUTH WALES GOVERNMENT TELECOMMUNICATIONS AUTHORITY	NEW SOUTH WALES GOVERNMENT TELECOMMUNICATIONS AUTHORITY Telco Authority Level 18, McKell Building 2-24 Rawson Place SYDNEY NSW 2000	3
NSW Police Force	NSW Police Force Radio Engineering Services Level 4 151-241 Goulburn St Sydney Police Centre, SURRY HILLS NSW 2010	11
NSW RURAL FIRE SERVICE	NSW RURAL FIRE SERVICE Locked Mail Bag 17 GRANVILLE NSW 2142	6
ST. JOHN AMBULANCE AUSTRALIA INCORPORATED	ST. JOHN AMBULANCE AUSTRALIA INCORPORATED Technical Services 601-609 Blackburn Road NOTTING HILL VIC 3168	66
State Emergency Service (NSW)	State Emergency Service (NSW) New South Wales State Emergency Service PO Box 6126 WOLLONGONG NSW 2500	64

Table 13 Emergency services with radiocommunication assets in the vicinity of the proposed Project (continued)

Emergency service	Contact details	Distance from closest site to Project boundary [km]
VRA RESCUE NSW LIMITED	VRA RESCUE NSW LIMITED VRA ICT Committee PO Box 6151 DURAL DC NSW 2158	44
Victoria State Emergency Service	Victoria State Emergency Service Victoria State Emergency Service Authority 168 Sturt St SOUTHBANK VIC 3006	56

Table 14 Bureau of Meteorology radar sites in the vicinity of the proposed Project

Site ID	Site name	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]
10021356	Hillston Radar off Griffith Road 8 km S of HILLSTON	-33.5520	145.5286	174
141677	Meteorological Office Mildura Airport MILDURA	-34.2353	142.0873	186
502339	Bureau of Meteorology site MILDURA AIRPORT	-34.2352	142.0861	187
304566	Met Bureau Site YARRAWONGA AIRPORT	-36.0297	146.0227	206
10012512	Wimmera Radar Pullut West Road PULLUT	-35.9977	142.0134	212
10019217	Mildura Radar off Sturt Highway CULLULLERAIN	-34.2871	141.6077	226
201025	Meteorological Office WAGGA WAGGA	-35.1582	147.4563	302
302559	Met Rd MELBOURNE AIRPORT	-37.6656	144.8320	304
49723	Met Bureau Glenlitta Ave BROADMEADOWS	-37.6902	144.9435	309
49837	Met Bureau BMTC Annex Glenlitta Ave BROADMEADOWS	-37.6905	144.9470	309
134173	Met Bureau S1 Doppler Radar Training Facility Glenlitta Avenue BROADMEADWS	-37.6911	144.9480	309
49834	Met Bureau Radar Site RAAF Base LAVERTON	-37.8552	144.7552	323
23944	Meteorology Radar Site Airport MOUNT GAMBIER	-37.7478	140.7746	423
136780	Wind Profiler Radar Site RAAF Base EAST SALE	-38.1156	147.1329	438
201743	IPS Radio Site MOUNT STROMLO	-35.3159	149.0011	443
136953	Weather Radar site Bairnsdale Aerodrome Aerodrome Road BAIRNSDALE	-37.8875	147.5755	445

Table 15 Trigonometrical stations in the vicinity of the proposed Project

Station name	Datum	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]
Jeraly	AGD66, AGD84, GDA94	-34.6634	144.0717	Within Project boundary
Merwin	AGD66, AGD84, GDA94	-34.8683	143.7812	16
Moulamein	GDA94	-35.0875	144.0366	13
NM C 126	AGD66, GDA94	-34.4996	144.0397	14
NM C 41	AGD66, GDA94	-35.0313	144.0003	7
PM70494	GDA94	-34.6336	144.2867	12
Willow Vale	AGD66, AGD84, GDA94	-34.7254	143.8952	12

Table 16 Satellite vectors with potential to be intercepted by the proposed Project

Intercepted satellite	Services provided [67]	Affected dwellings ¹
Eutelsat 70B (E70B, W5A, Eutelsat W5A)	Programs intended for international audiences	<u>R22</u>

1. Associated dwellings are indicated by underlined italic text.

Table 17 Dwellings with increased potential to experience EMI to DTV from the Murray Valley television broadcast transmitter

Dwelling ID ¹	Easting ² [m]	Northing ² [m]
<u>R06a</u>	<u>233241</u>	<u>6160889</u>
<u>R06b</u>	<u>233253</u>	<u>6160843</u>
<u>R06c</u>	<u>233225</u>	<u>6160801</u>
<u>R14</u>	<u>236374</u>	<u>6147851</u>
<u>R22</u>	<u>233092</u>	<u>6131248</u>
<u>R23</u>	<u>233544</u>	<u>6131027</u>

1. Associated dwellings are indicated by underlined italic text.
2. Coordinate system: MGA zone 55, GDA94 datum. Coordinates were provided by the Customer in a different coordinate system and/or datum and have been converted using mapping software, which may result in small discrepancies depending on the software and transformation approach used.

Table 18 Summary of service operators contacted by DNV and responses received to date

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
1	Fixed point-to-point: one link crossing the Project site No turbines in diffraction exclusion zone established by DNV	Ambulance Service of NSW (NSW Ambulance) 10373599-AUMEL-L-01	Consultation email sent on 1 March 2024 Follow-up email sent on 11 April 2024 No response received to date
2	Fixed point-to-point: one link crossing the Project site No turbines in diffraction exclusion zone established by DNV	Essential Energy 10373599-AUMEL-L-02	<u>Response received by email on 18 March 2024:</u> <i>"[We] have no issues with this proposal."</i>
3	Fixed point-to-point: five links crossing the Project site No turbines in diffraction exclusion zones established by DNV. Emergency services point-to-area: 3 km from Project boundary	New South Wales Government Telecommunications Authority (NSW Telco Authority) 10373599-AUMEL-L-03	<u>Response received by email on 30 April 2024:</u> <i>"There are no impacts from the current proposed turbines to our microwave links. Our assessment criteria is clearance of the 2nd Fresnel Zone of the microwave link. Is there a chance that more turbines would be added north of the boundary or any further updates to the turbine location? If so, then we would have to reevaluate."</i>
4	Fixed point-to-point: three links crossing the Project site No turbines in diffraction exclusion zones established by DNV Emergency services point-to-area: 11 km from Project boundary	NSW Rural Fire Service 10373599-AUMEL-L-04	Consultation email sent on 1 March 2024 Follow-up email sent on 11 April 2024 No response received to date
5	Fixed point-to-point: two links crossing the Project site No turbines in diffraction exclusion zones established by DNV PMTS/spectrum (mobile phone): 3 km from Project boundary	Optus Mobile Pty Limited (Optus) 10373599-AUMEL-L-05	<u>Response received by email on 18 March 2024:</u> <i>"Optus existing sites near the proposed location are primarily for highway coverage, the nearest one is over 6km away, and as such no significant concern arises for an adverse impact on mobile coverage as of now. There are no planned sites in this vicinity."</i> <u>Response received by email on 22 March 2024:</u> <i>"No issue with proposed wind farm as no Optus microwave links crossing the Turbine locations."</i>

**Table 18 Summary of service operators contacted by DNV and responses received to date
(continued)**

Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
6 Fixed point-to-point: two links crossing the Project site No turbines in diffraction exclusion zones established by DNV PMTS/spectrum (mobile phone): 3 km from Project boundary	Vodafone Australia Pty Limited (Vodafone) 10373599-AUMEL-L-06	<p><u>Response received by email on 18 March 2024:</u> "The proposed windfarm turbine locations do not present any significant impact to Vodafone/TPG mobile phone coverage."</p> <p><u>Response received by email on 30 April 2024:</u> "We have 2 Region3 sites 1700 and 1699 connected via Mw link, turbines 1 to 6 will cause issues for this Mw link." [Screenshot included showing turbine locations and point-to-point link path, but no details regarding interference mechanisms or required clearances provided]</p>
7 Fixed point-to-multipoint: 23 km from Project boundary PMTS/spectrum (mobile phone): 3 km from Project boundary	Telstra Limited (Telstra) 10489911-AUMEL-L-07	Consultation email sent on 4 March 2024 No response received to date
8 Fixed point-to-multipoint: 27 km from Project boundary	Water NSW 10373599-AUMEL-L-08	<p><u>Response received by email on 21 March 2024:</u> "Water NSW do not have any objections to the proposal."</p>
9 Fixed point-to-multipoint: 11 km from Project boundary	Murray Irrigation Ltd (Murray Irrigation) 10373599-AUMEL-L-09	Consultation email sent on 4 March 2024 Follow-up email sent on 11 April 2024 No response received to date
10 Emergency services point-to-area: 43 km from Project boundary	Australian Citizen radio Emergency Monitors Inc. 10373599-AUMEL-L-10	Consultation letter sent on 4 March 2024 No response received to date
11 Emergency services point-to-area: 11 km from Project boundary	NSW Police Force 10373599-AUMEL-L-11	<p><u>Response received by email on 22 March 2024:</u> "NSWPF's radio link services are not crossing the proposed wind turbine area and the... wind turbines... in [the] proposed Baldon Wind Farm are located at least over 12 km from the telecommunications assets of existing radio link services. Furthermore, with reference to the proposed wind farm boundary, there is no NSWPF land mobile radio site location located either near or within the boundary of the proposed wind farm... There should be sufficient clearance based on the boundary and location of the wind turbines as identified in kml files."</p>

**Table 18 Summary of service operators contacted by DNV and responses received to date
(continued)**

Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
12 Emergency services point-to-area: 66 km from Project boundary	St. John Ambulance Australia Incorporated (St. John Ambulance) 10373599-AUMEL-L-12	<p><u>Response received by email on 14 March 2024 (from Victorian entity):</u> <i>"The Baldon Windfarm will not cause any problems to the St John Ambulance equipment at Swan Hill as all the radio links are from the Victorian direction."</i></p> <p><u>Response received by email on 2 May 2024 (from NSW entity):</u> <i>"Happy to advise that we have no issues/concerns with this proposal."</i></p>
13 Emergency services point-to-area: 64 km from Project boundary	State Emergency Service NSW (NSW SES) 10373599-AUMEL-L-13	<p><u>Response Received by email on 16 April 2023:</u> <i>"We have investigated the proposal and do not expect any disruption to NSW SES radio infrastructure. NSW SES consent to the Baldon wind farm proposal."</i></p>
14 Emergency services point-to-area: 44 km from Project boundary	VRA Rescue NSW Limited (VRA Rescue NSW) 10373599-AUMEL-L-14	<p><u>Response Received by email on 6 March 2024:</u> <i>"Potential interference shouldn't be an issue."</i></p>
15 Meteorological radar: 175 km from Project boundary	Bureau of Meteorology 10373599-AUMEL-L-15	<p><u>Response received by email on 25 March 2024:</u> <i>"The Bureau of Meteorology's assessment of the proposed Baldon wind farm in NSW is now complete, which indicates manageable impact to our neighbouring assets, under normal propagation conditions. The Bureau requests that the owner/operator of the Baldon wind farm...:</i></p> <ul style="list-style-type: none"> <i>• informs the Bureau of any changes in the wind farm, including varying the layout of the wind farm, changing the location of a turbine by more than 100 meters, or altering turbine height,</i> <i>• informs the Bureau at least 2 weeks before any planned shut-down of the wind farm (for maintenance or any other reason) so that the Bureau may calibrate its weather radar system,</i> <i>• collaborates with the Bureau in the event of severe weather conditions to assist in matters of community safety."</i>
16 Trigonometrical station: inside site boundary GNSS station: 13 km from Project boundary	Geoscience Australia 10373599-AUMEL-L-16	<p><u>Response received by email on 05 March 2024:</u> <i>"Geoscience Australia do not foresee any interference to our GNSS infrastructure as a result of the proposed Baldon Wind Farm in NSW."</i></p>
17 Trigonometrical station: inside site boundary	NSW Spatial Services 10373599-AUMEL-L-17	<p><u>Response received by email on 05 March 2024:</u> <i>"Office of the Surveyor-General raises no objection to the proposed development."</i></p>



**Table 18 Summary of service operators contacted by DNV and responses received to date
(continued)**

Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
GNSS station: 13 km from Project boundary		

**Table 18 Summary of service operators contacted by DNV and responses received to date
(continued)**

Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
18 Spectrum (wireless internet): 64 km from Project boundary	NBN Co 10373599-AUMEL-L-18	<p><u>Response received by email on 11 March 2024:</u></p> <p><i>"I have reviewed the data provided based on the proposed wind farm location; The wind farm boundaries are outside existing nbn wireless coverage boundaries and none of the proposed wind tower locations pose any risk of introducing a physical obstruction to the RF Path Profiles or boresight paths of existing nbn microwave links. It is also noted no current nbn connected customer premises are within the wind farm boundary so there are no intrusions into their RF path toward their connected nbn eNB.</i></p> <p><i>Of potential greater concern is any impact from wind farm operated RF transmission equipment impacting nbn licensed spectrum.</i></p> <p><i>Therefore, please provide information on any planned RF transmission equipment planned to be installed so a potential interference impact can be assessed. This information should include as a minimum, the operating transmission frequencies and transmit power, channel bandwidths, antenna types and their radiation patterns as well as their exact location with antenna height, boresight azimuth and tilt [either mechanical or electrical tilt].</i></p> <p><i>A standard nbn response for wind farm applications regarding potential interference impact on the nbn Fixed Wireless network is as follows;</i></p> <p><i>Potential Impacts of the Proposed Baldon Wind Farm on NBN Co Spectrum Communication Assets.</i></p> <p><i>Referring to the email dated 4th March 2024 regarding the application for the Baldon Wind Farm.</i></p> <p><i>We confirm that NBN Co Spectrum Pty Ltd (nbn Spectrum) has a number of spectrum licenses within 75 km of the proposed Baldon Wind Farm.</i></p> <p><i>nbn has strict obligations to provide internet services to the community, and this area has been determined as a FW service area where the footprint of this service is now in place.</i></p> <p><i>nbn will be forced to consider its position as part of the planning should there an interference issue.</i></p> <p><i>If the Application is amended before it is lodged, we request that we are sent any amended Application so we can determine whether we have any objections to the amended Application.</i></p> <p><i>We note that, as you would be aware, under section 197 of the Radiocommunications Act 1992 (Cth) it is an offence to knowingly or recklessly do</i></p>

**Table 18 Summary of service operators contacted by DNV and responses received to date
(continued)**

Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
19 DTV broadcasting: 44 km from Project boundary	BAI Communications 10373599-AUMEL-L-19-A	<p><i>anything likely to interfere substantially with radiocommunications or otherwise substantially disrupt or disturb radiocommunications."</i></p> <p><u>Response received by email on 17 June 2024:</u></p> <p><i>"BAI Communications has done a study on the proposed wind farm located in Baldon, New South Wales. The impact on three digital television broadcast facilities were studied. The results show that one of the broadcast facilities is predicted to be impacted (Goschen DTV services) by the proposed wind turbines, but none of the viewers are predicted to be impacted. However, if there is any impact, remediation that is required to rectify DTV degradation to viewers is expected to form part of the wind farm project.</i></p> <p><i>...The broadcast sites that have been identified to provide coverage around the area of the wind farm are... Murray Valley (Goschen), Hay, Balranald.</i></p> <p><i>BAI has conducted field test on existing wind farms in the past for the impact on FM services. The field test measurements concluded that FM radio had some minor reflections observed by these would not be expected to cause any noticeable effect on reception. Thus, this report will not consider further impacts on FM broadcast.</i></p> <p><i>...there is no impact predicted from the wind farm to the digital TV reception from Hay.</i></p> <p><i>...there is no impact predicted from the wind farm to the digital TV reception from Balranald.</i></p> <p><i>...Population analysis was done on the potentially impacted area [for digital TV reception from Goschen] (ABS Census 2021 Data) and showed no... people are predicted to be in the low risk or high-risk areas of having degraded digital television reception. Upon closer inspection in Google Earth of the predicted interference [area], no buildings were observed.</i></p> <p><i>BAI have modelled the proposed Baldon wind turbines to assess how they will affect DTV services broadcast from Goschen, Hay and Balranald sites...</i></p> <p><i>Interference analysis shows that Hay and Balranald DTV services are not predicted to be impacted by the presence of wind [turbines] in the current configuration. Furthermore, interference analysis predicts that Goschen DTV services are affected by the proposed wind farm, but none of the viewers are predicted to be impacted.</i></p> <p><i>Whilst there are no persons predicted to be impacted by the wind farm, any degradation of DTV services caused by the wind farm development would be expected to be rectified as part of the project."</i></p>



**Table 18 Summary of service operators contacted by DNV and responses received to date
(continued)**

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
20	PMTS Class B (mobile phone): 56 km from Project boundary	Field Solutions Group 10373599-AUMEL-L-20-A	<u>Response received by email on 13 March 2024:</u> <i>"Our analysis suggests there is likely to be little to no impact to our services. Should we detect service disruptions and have reasonable evidence to suggest it relates to the wind-farm activity, we will coordinate with the wind-farm on practical mitigations."</i>

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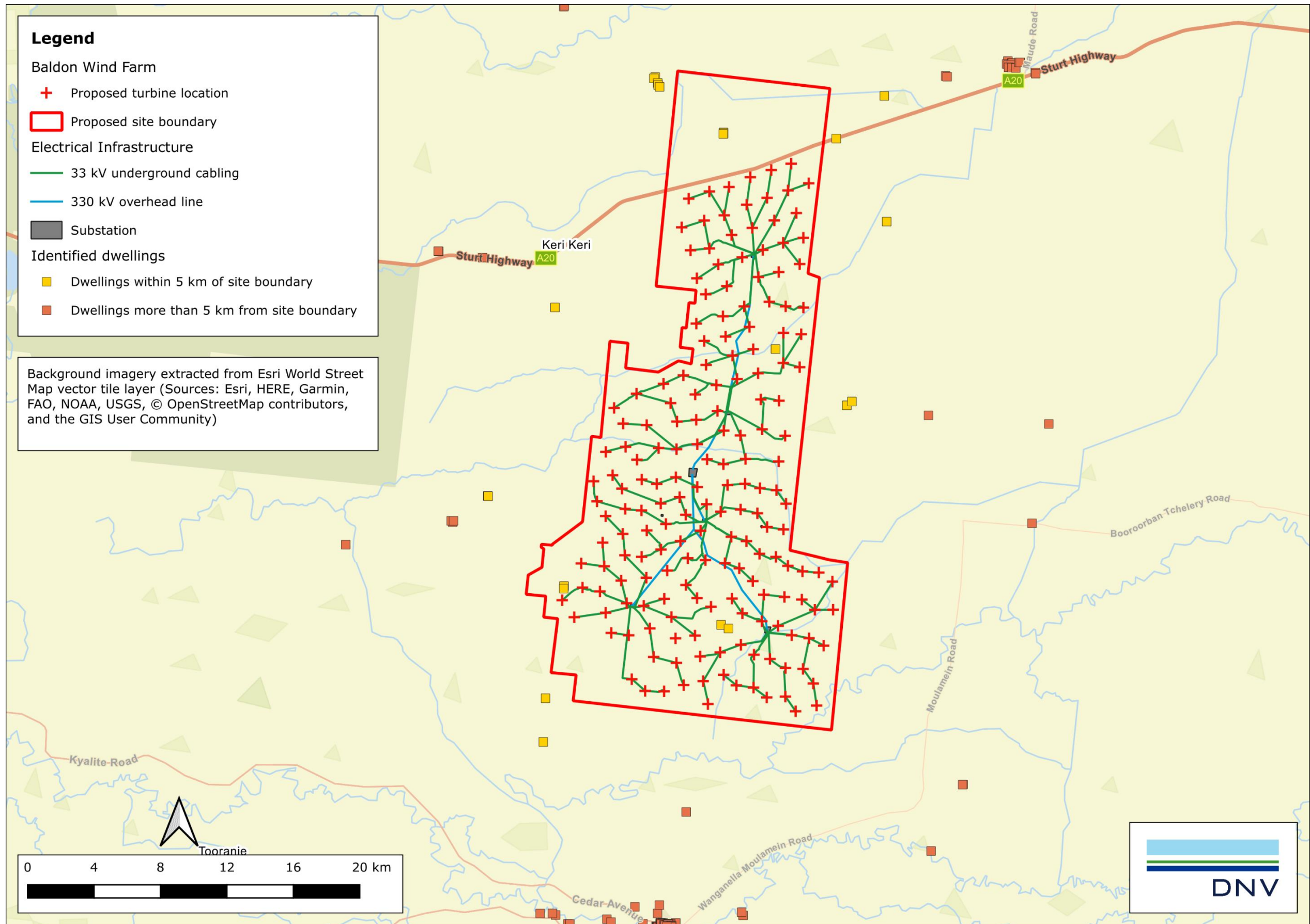


Figure 9 Map of the proposed Project, showing proposed boundary, turbine locations, electrical infrastructure, and locations of nearby dwellings

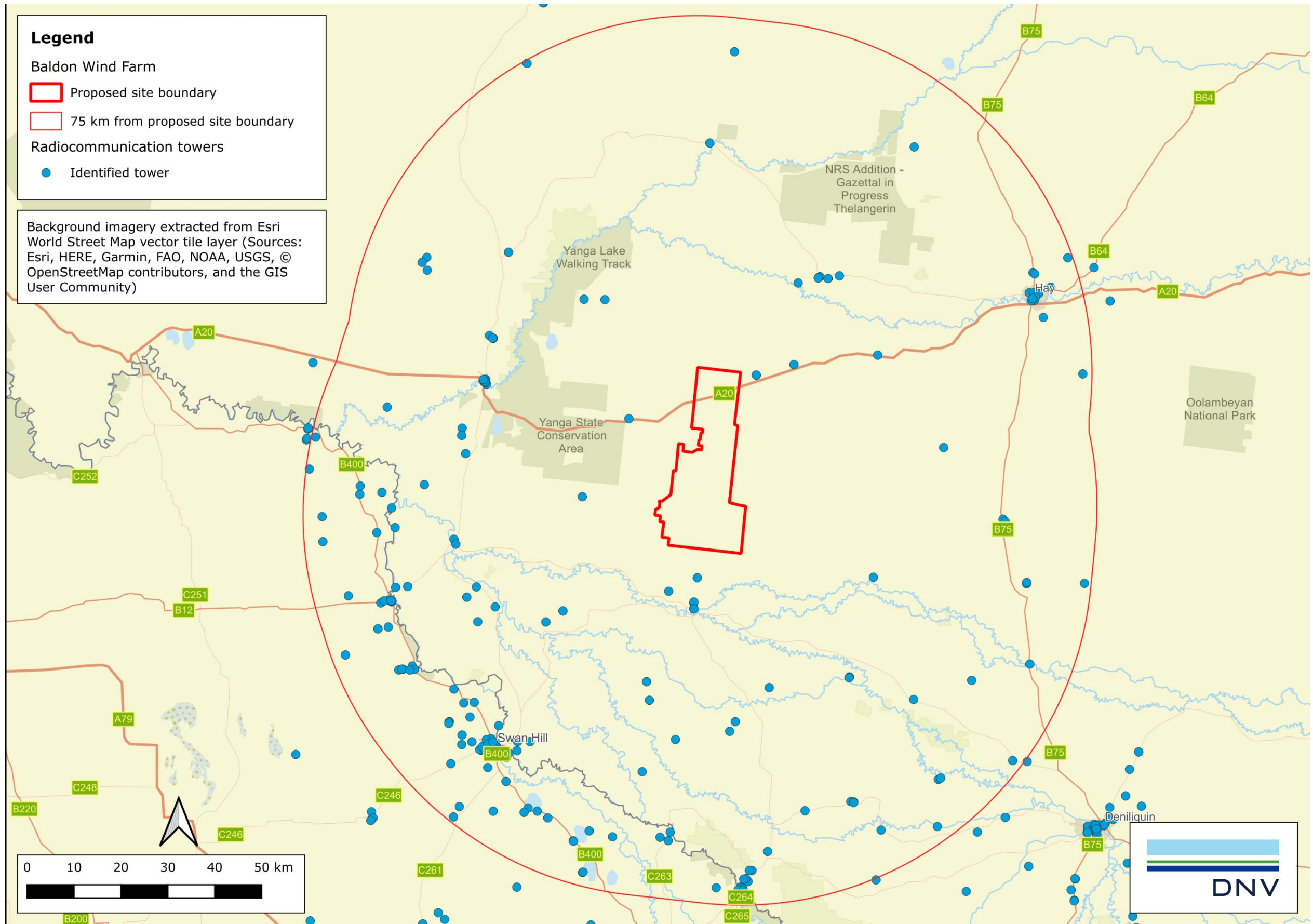


Figure 10 Location of the proposed Project and identified nearby radiocommunication sites

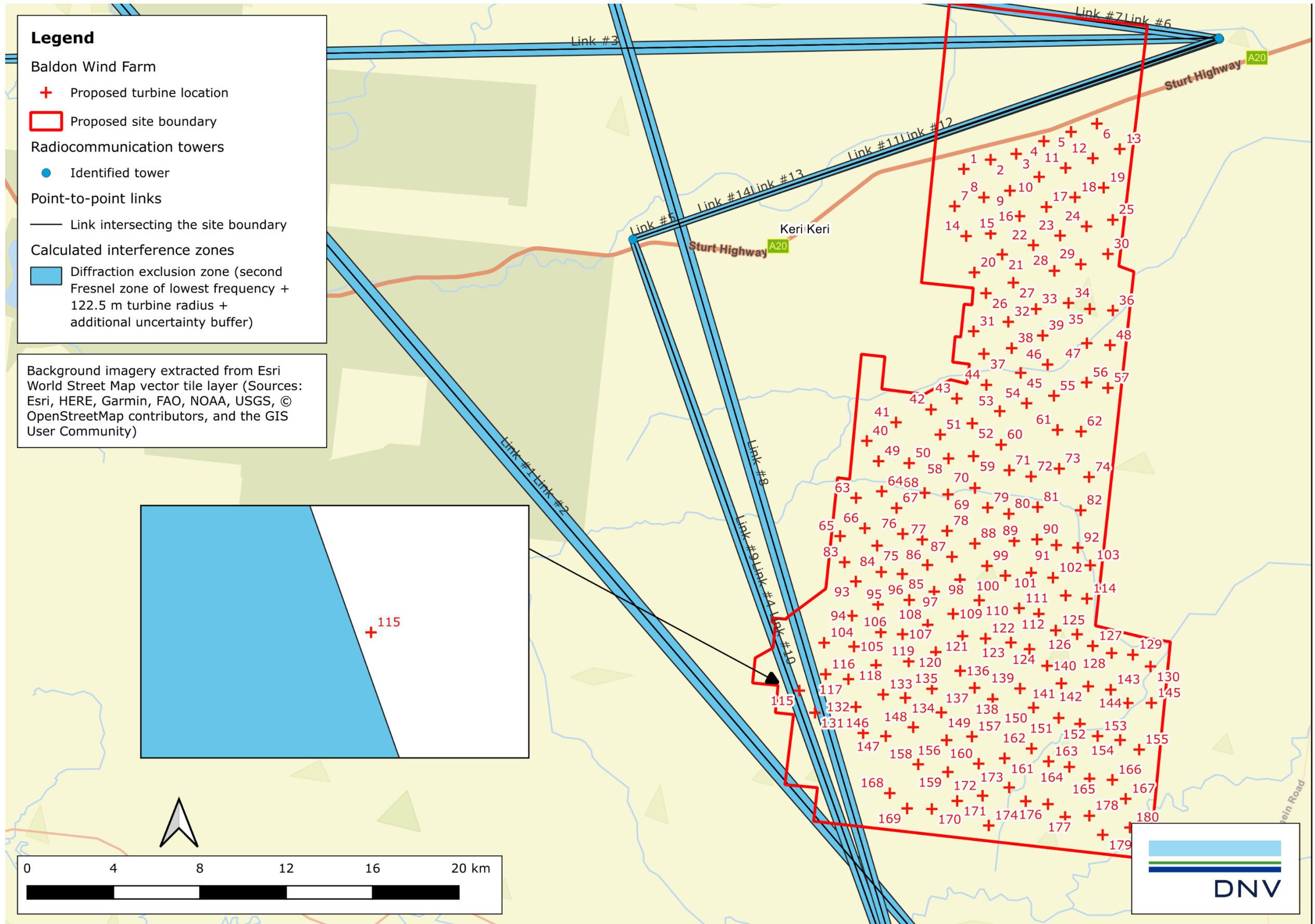


Figure 12 Identified point-to-point radiocommunication vectors crossing the proposed Project and calculated interference zones

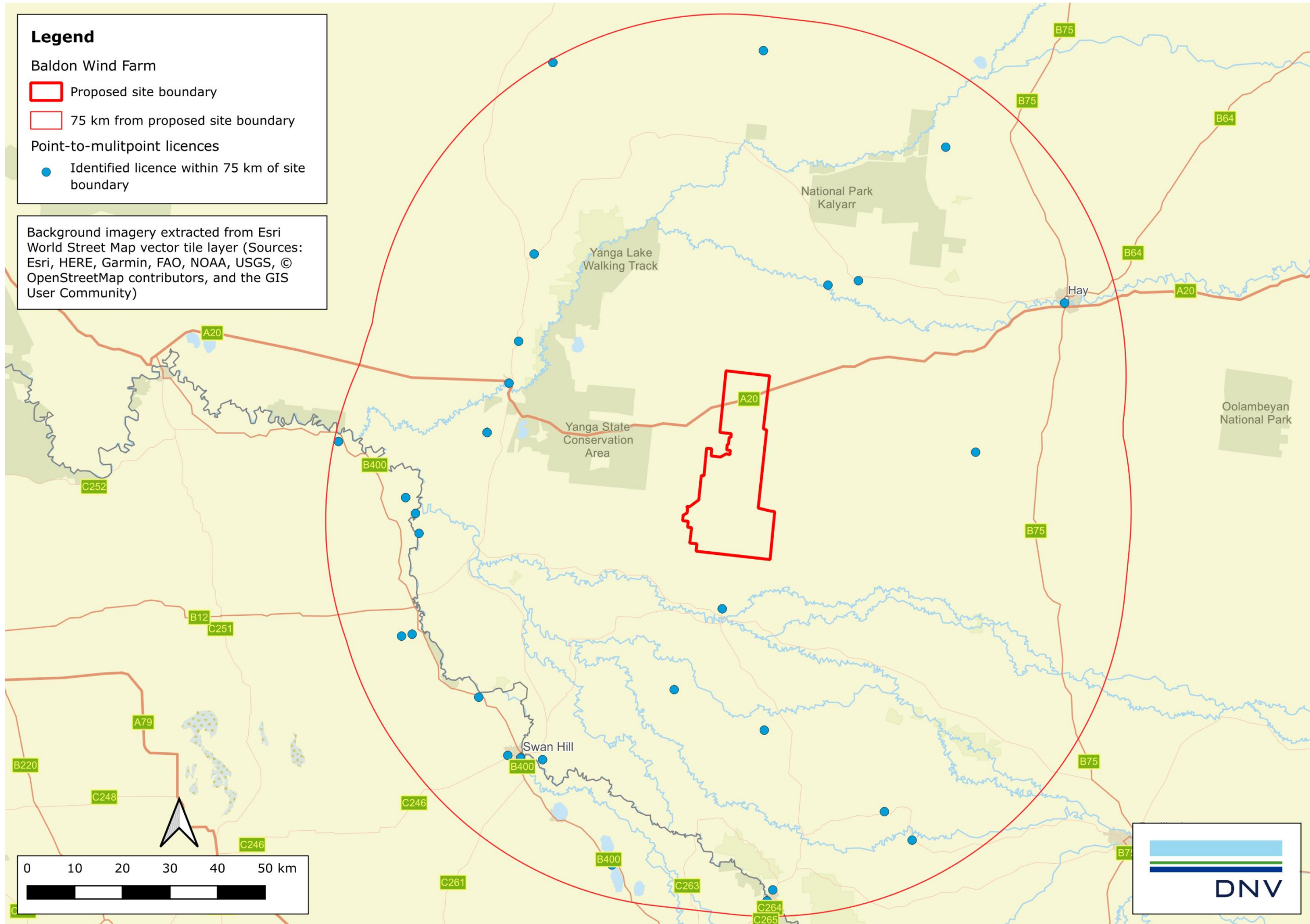


Figure 13 Location of point-to-multipoint licences in the vicinity of the proposed Project

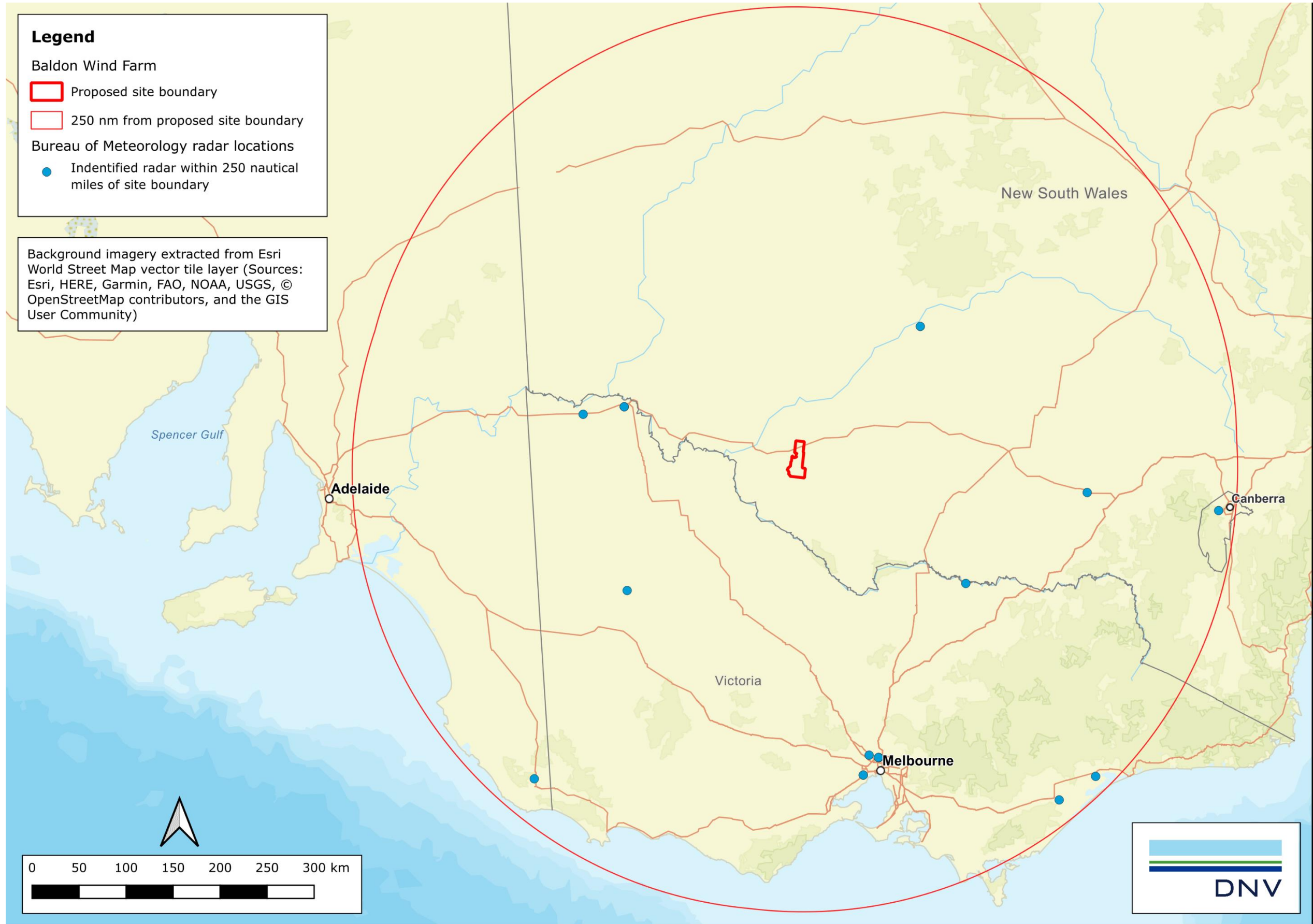


Figure 15 Location of meteorological radar sites within 250 nautical miles of the proposed Project

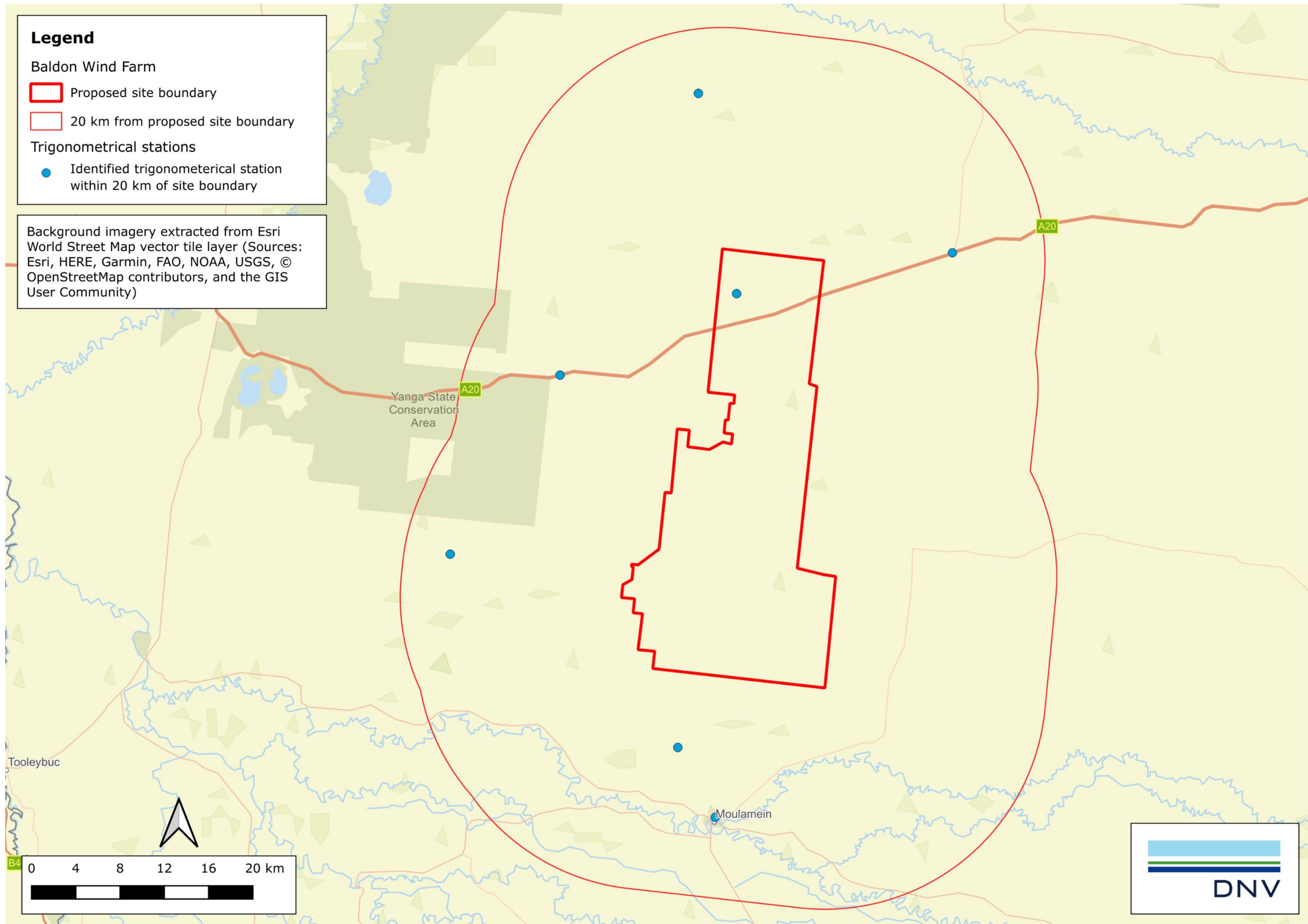


Figure 16 Location of trigonometrical stations within 20 km of the proposed Project

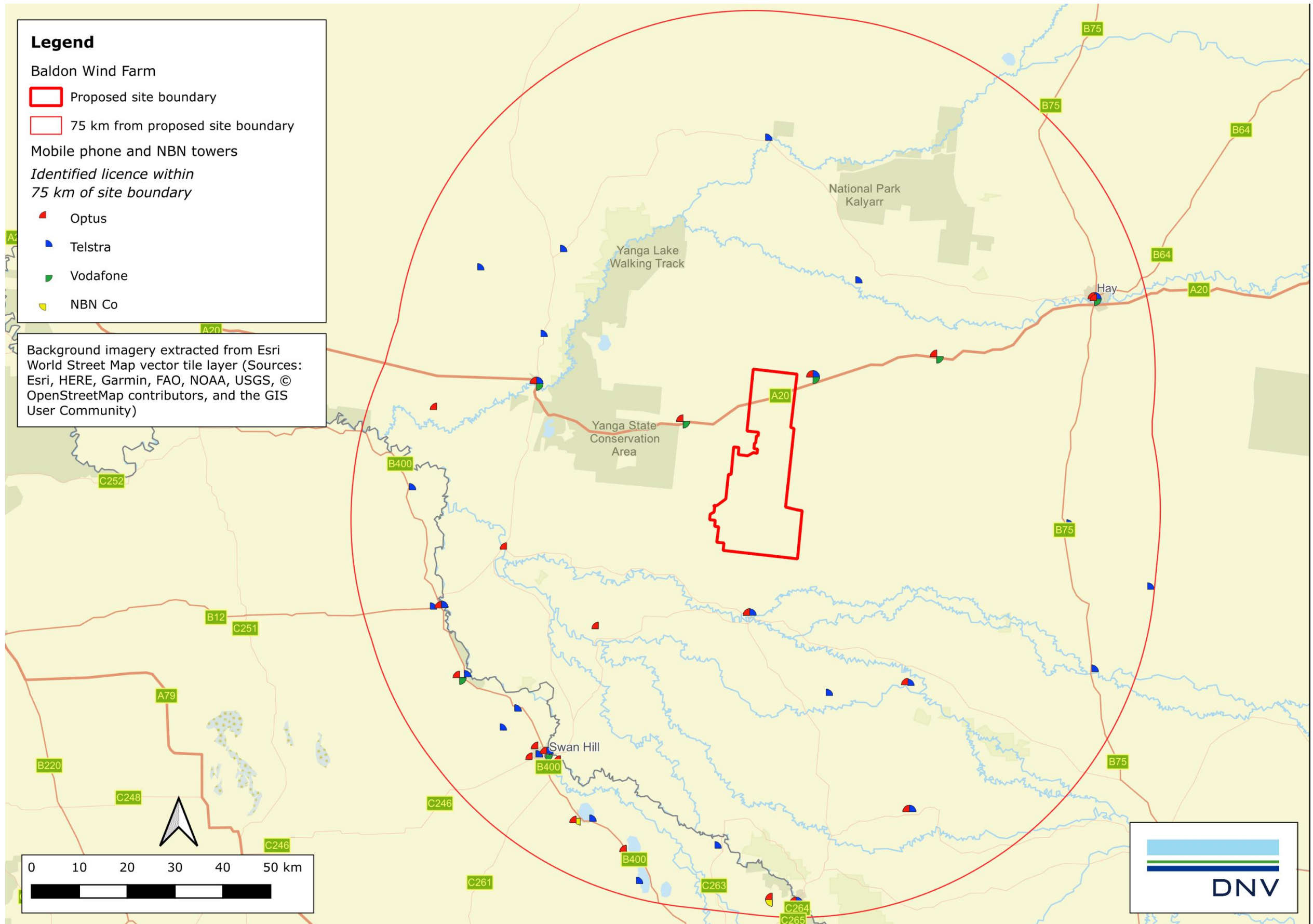


Figure 17 Location of mobile phone and NBN towers within 75 km of the proposed Project

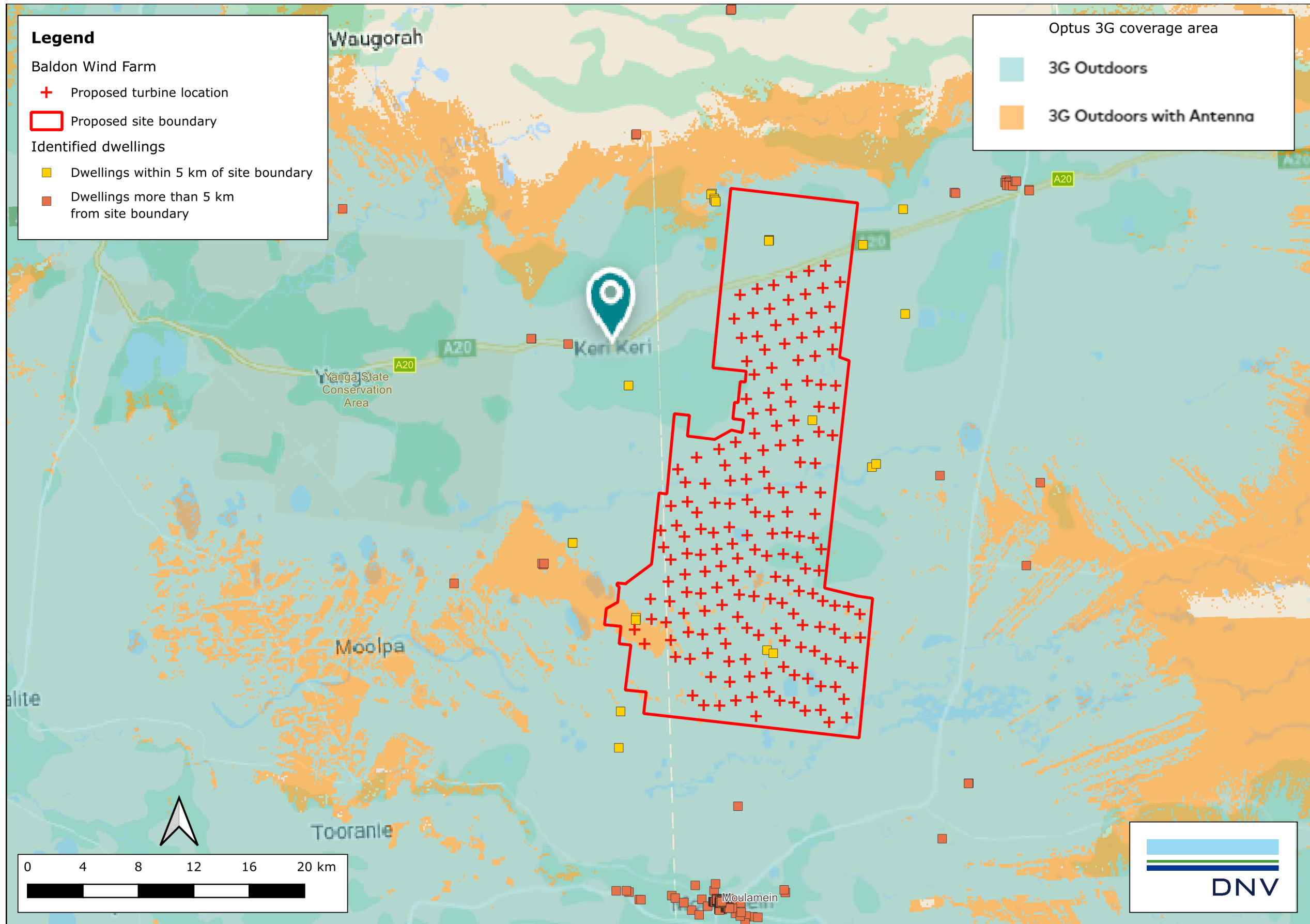


Figure 18 Optus Mobile 3G network coverage for the proposed Project

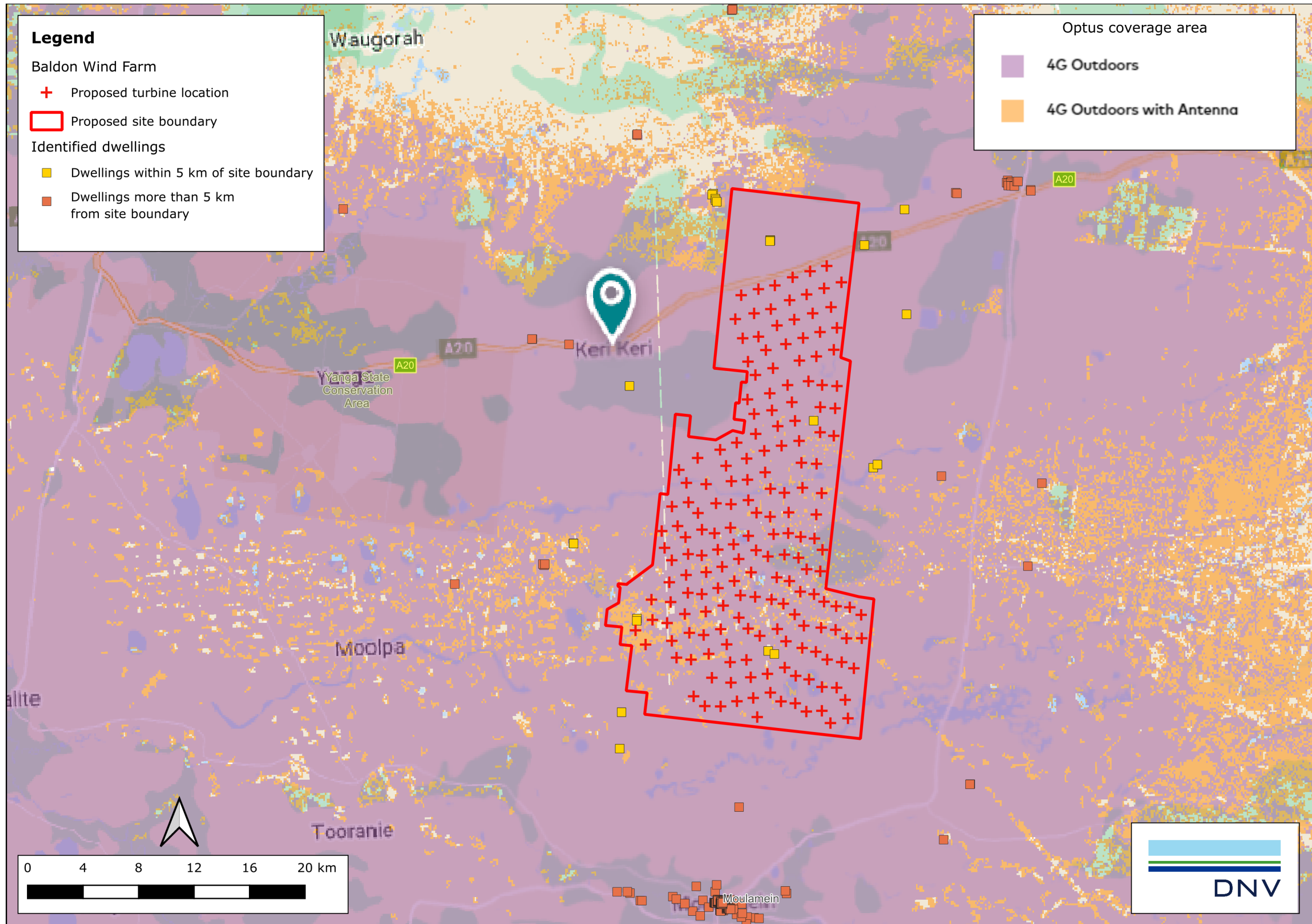


Figure 19 Optus Mobile 4G network coverage for the proposed Project

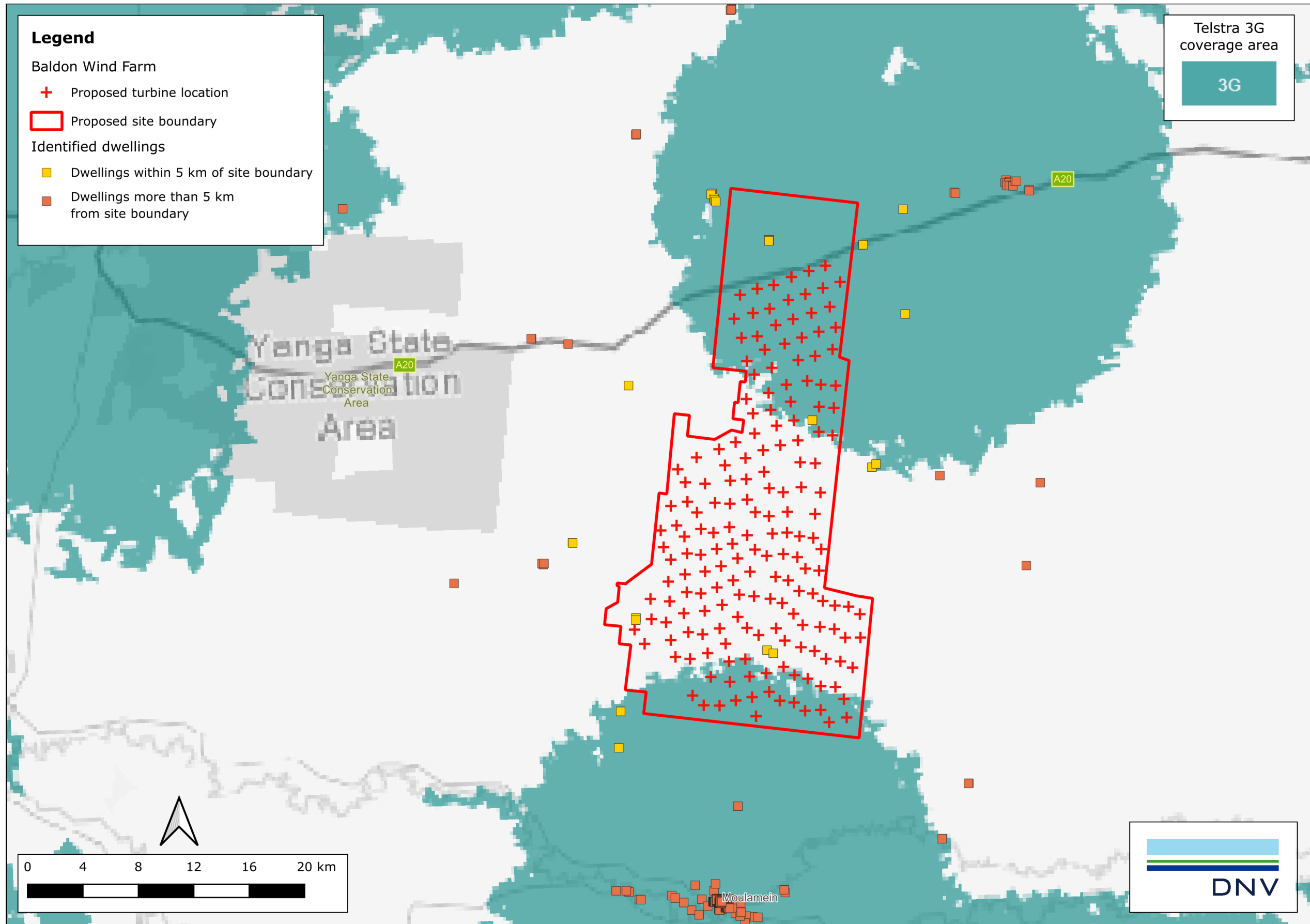


Figure 20 Telstra 3G network coverage for the proposed Project

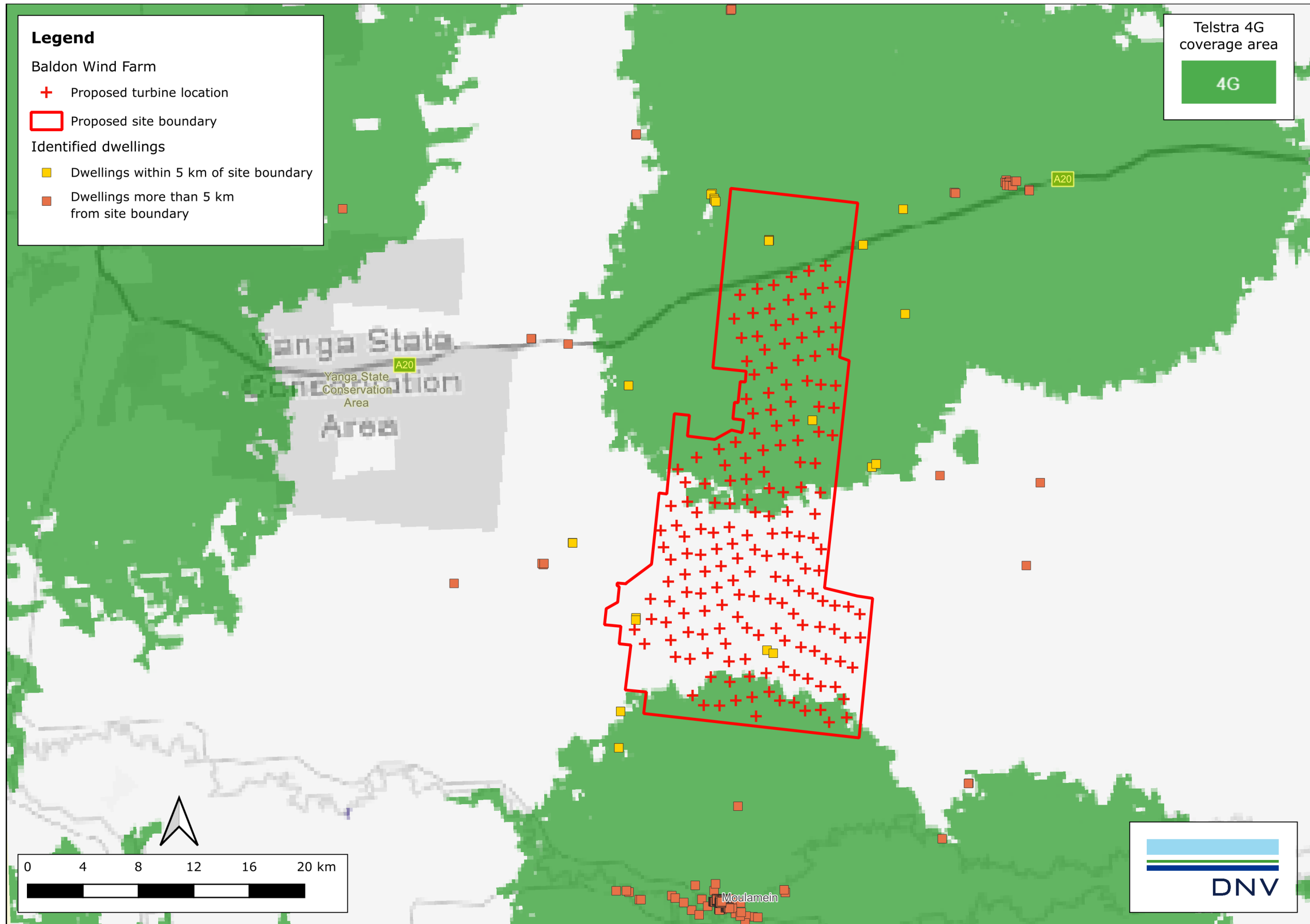


Figure 21 Telstra 4G network coverage for the proposed Project

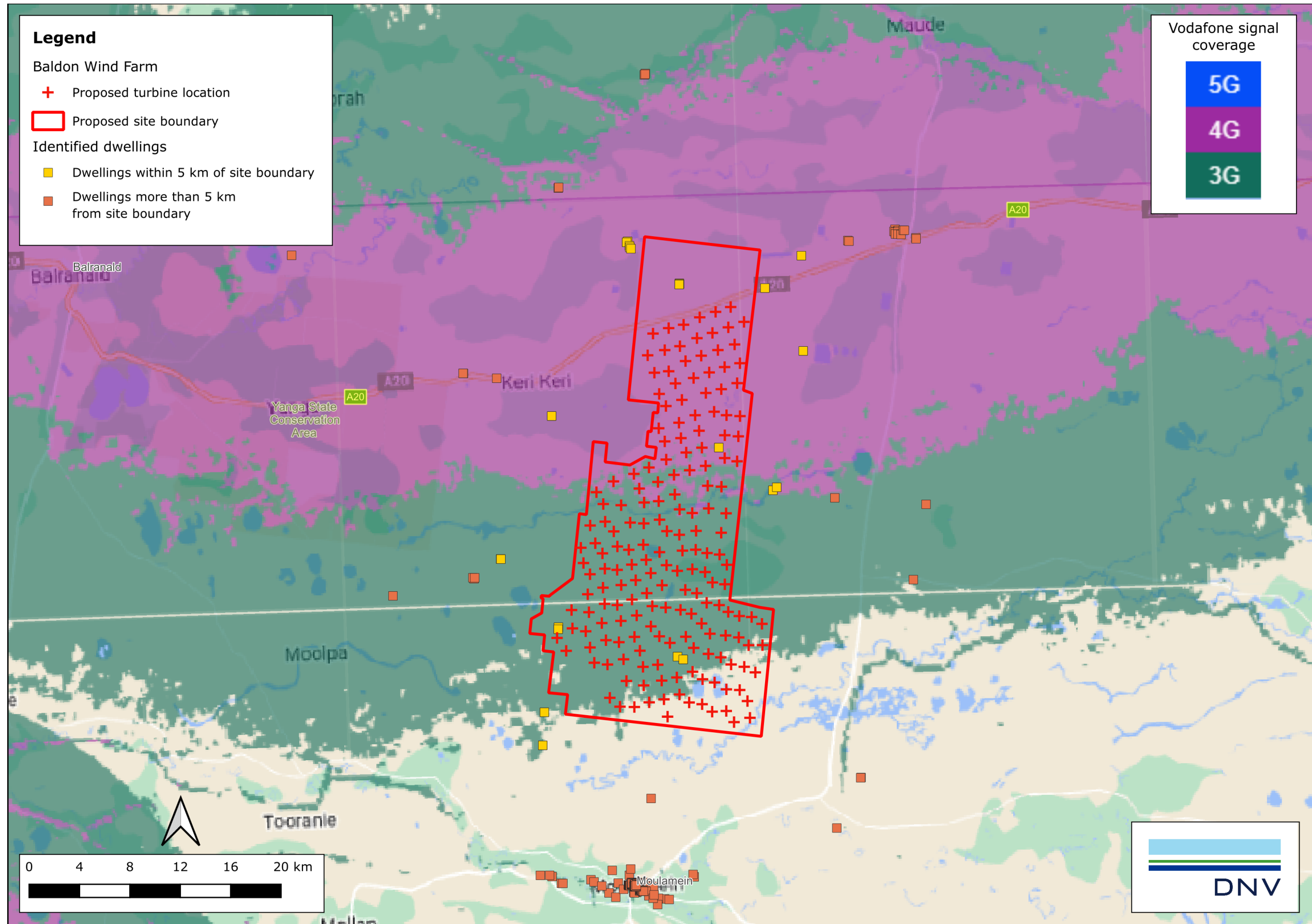


Figure 22 Vodafone network coverage (Apple iPhone 14 handset) for the proposed Project

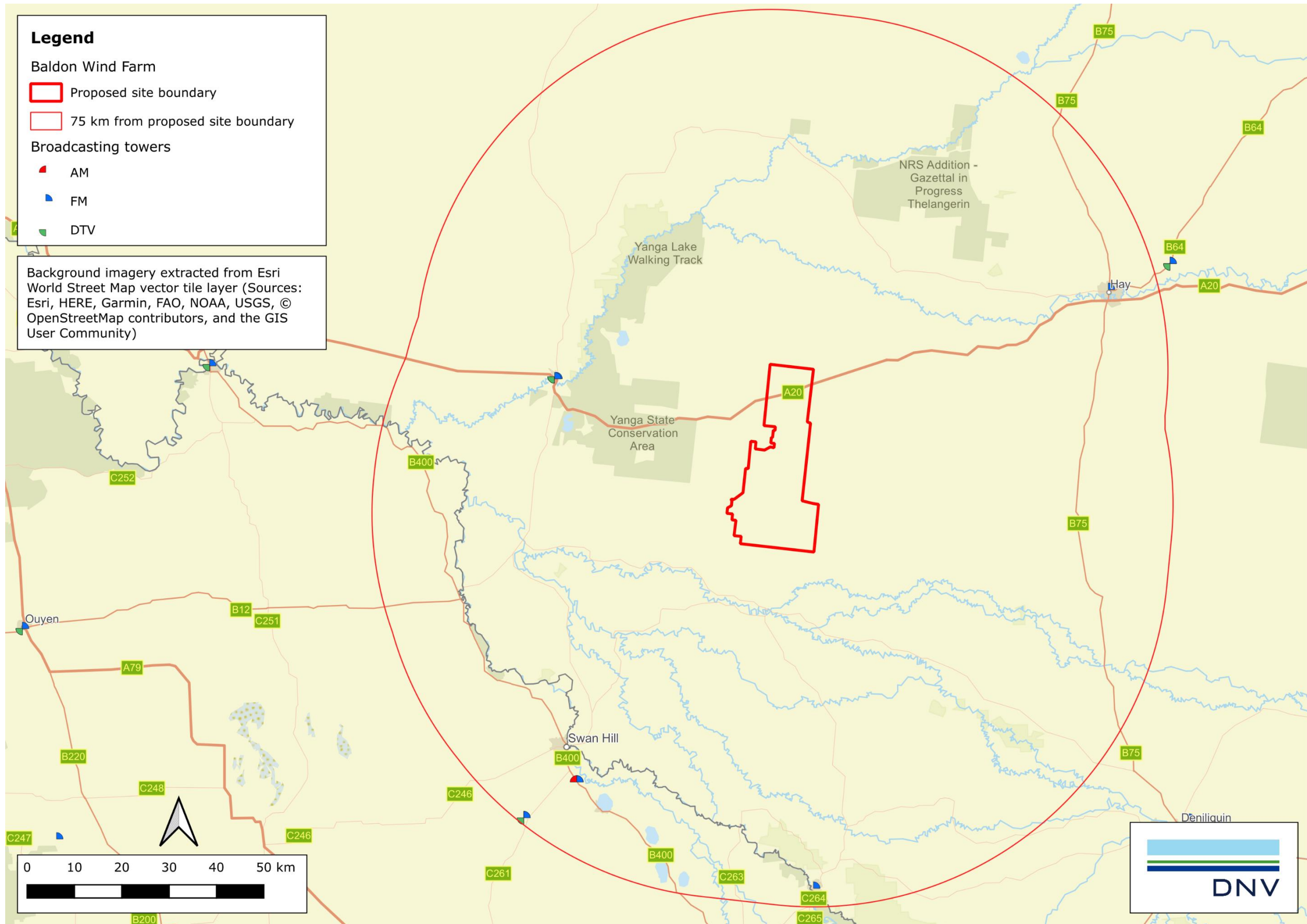


Figure 23 Location of broadcast transmitters in the vicinity of the proposed Project

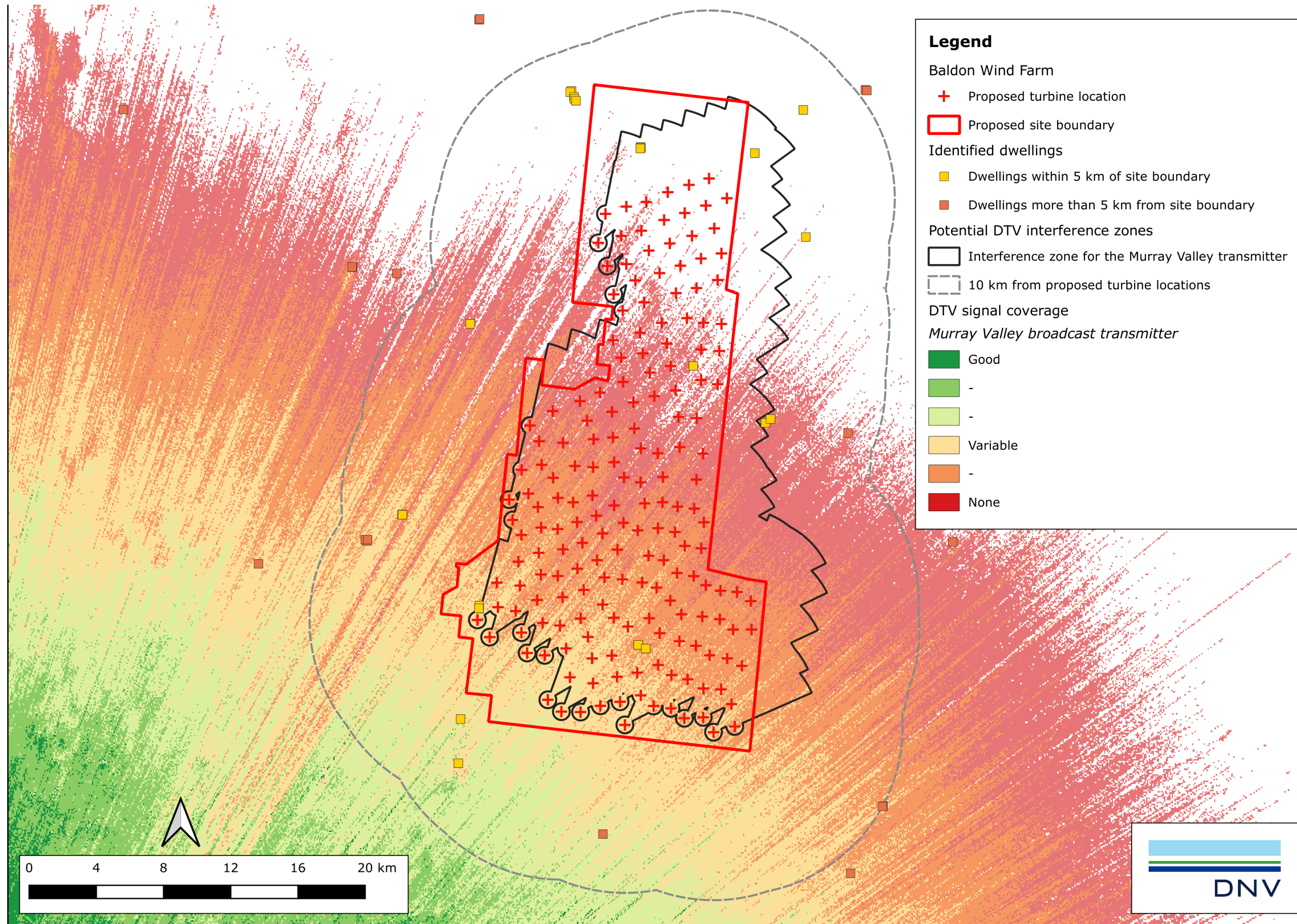


Figure 24 Potential television EMI zones for the Murray Valley broadcast transmitter from the proposed Project

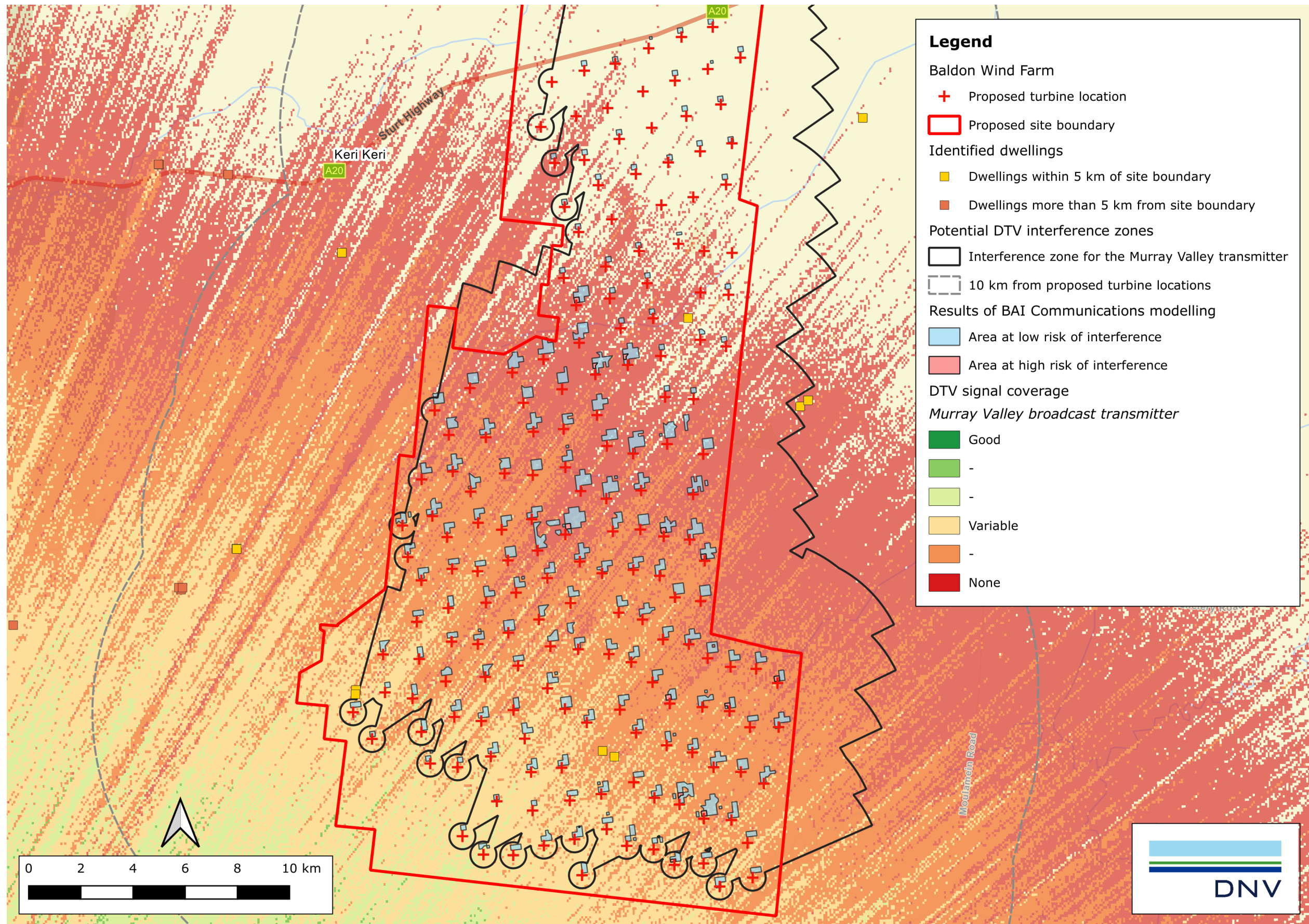


Figure 25 Results of BAI Communications modelling of potential television EMI zones for the Murray Valley broadcast transmitter from the proposed Project



About DNV

DNV is the independent expert in risk management and assurance, operating in more than 100 countries. Through its broad experience and deep expertise DNV advances safety and sustainable performance, sets industry benchmarks, and inspires and invents solutions.

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