BEENUP WIND FARM

EMI Assessment

Urbis Ltd

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EXECUTIVE SUMMARY

DNV has been commissioned by Urbis Ltd (Urbis or "the Customer") to independently assess potential electromagnetic interference (EMI) impacts associated with the development and operation of the proposed Beenup Wind Farm ("the Project") in Western Australia. 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 Draft National Wind Farm Development Guidelines [1]. The methodology used in this study has been informed by these guidelines and various standard industry practices.

A Project layout consisting of 20 wind turbines with a rotor diameter of 172 m, upper tip height of 250 m, and lower tip height of 78 m has been considered. These dimensions represent the maximum and minimum overall tip heights and maximum rotor diameter under consideration for the Project. DNV understands that the current turbine layout is preliminary and subject to change, and that the final layout will incorporate findings from the EMI assessment to mitigate identified risks.

There are 33 identified dwellings within 5 km of the Project, 13 of which are involved dwellings.

Outcomes of the assessment

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

There are two radiocommunication towers located within the Project boundary, with licences operated by Western Australia Police, Telstra, Optus and TPG at Site ID 28122, and licences operated by Western Power at Site ID 10002490. Types of licences operated at these towers include point-to-point links, point-to-multipoint links and point-to-area style services as discussed below.

There are 10 point-to-point links crossing the Project boundary operated by Western Power, Telstra, Optus and WA Police. Of the 10 links, links by Optus and WA Police are not expected to experience interference by turbines. Based on interference zones calculated by DNV, turbines are situated within exclusion/interference zones for the links operated by Western Power and Telstra. For the links operated by Telstra, three turbines are within the diffraction exclusion zones calculated for two links. Telstra has been approached for consultation on potential interference to these links, but no response has been received at the time of writing. For the links operated by Western Power, one turbine is within the diffraction exclusion zone for one link, and three turbines are within the potential reflection/scattering zone for three links. Western Power has responded with no concerns for interference to these links by turbines at the Project.

Water Corporation and Western Power have been contacted to seek feedback regarding potential for interference to their point-to-multipoint services in the vicinity of the Project. Responses have been received from both operators with no concerns raised.

Turbines at the Project may interfere with point-to-area style services such as mobile phone signals, radio broadcasting, and terrestrial television broadcasting, particularly in areas with poor or marginal signal coverage. Dwellings within approximately 5-10 km of the Project are within interference zones calculated for the Augusta and Bunbury television broadcast transmitters. Dwellings that are currently receiving weak signals from these transmitters may experience

interference to their services. However, most dwellings within the interference zones for both television broadcast transmitters may not be currently receiving signals from these transmitters. Telstra, Optus and Vodafone/TPG mobile phone signal coverage by is generally available throughout most of the Project area, and is unlikely to experience interference. If interference to these services is experienced, a range of options are available to rectify difficulties.

Interference to signals from geostationary satellites that transmit programs intended for international audiences is also possible at one dwelling, but it is considered unlikely that residents will be receiving signals from these satellites. For the same dwelling, interference is also possible to signals from the NBN Sky Muster satellite. DNV recommends that the proponent of the Project engages with the owner of this dwelling prior to construction of the Project to determine whether it is currently inhabited or expected to be inhabited during the lifetime of the Project and whether the residents are currently receiving or intending to receive signals from the NBN Sky Muster satellites, and to establish an understanding of how any impact to those services may be mitigated.

Since it is not possible to determine the potential EMI impacts on point-to-multipoint links 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. To date, no concerns have been raised. Further consultation will be undertaken to enable the proponent of the Project to ensure that the Project remains compliant with all relevant standards and community expectations.

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

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	2 towers within 2 km of proposed turbine locations, operated by: **Site ID 10002490** Electricity Networks Corporation (Western Power) **Site ID 28122** Optus Mobile Pty Limited (Optus) Telstra Limited (Telstra) Western Australia Police (WA Police) TPG Internet Pty Ltd (TPG)	**Western Power, Optus and WA Police:** No concerns raised **Telstra:** No response received **TPG:** DNV intends to consult	**Point-to-point links:** *See Fixed point-to-point links* **Land mobile services operated by Western Power:** Low likelihood of interference **All other services:** Unlikely to cause interference	**Point-to-point links:** *See Fixed point-to-point links* **Land mobile services operated by Western Power:** If required - increasing the signal strength from the affected tower or alternative towers, or installing additional towers in the vicinity of the Project **All other services:** None required
Fixed point-to-point links	10 links crossing Project boundary, operated by: Western Power (3 links) Optus (1 link) Telstra (4 links) WA Police (2 links) **Western Power links:** 1 turbine in diffraction zones, 3 turbines in potential reflection/scattering zones, no turbines in potential near-field zones **Optus links:** no turbines in calculated interference zones **Telstra links:** 3 turbines in diffraction zones, 3 turbines in potential reflection/scattering zones, no turbines in potential near-field zones **WA Police links:** no turbines in calculated interference zones	**Western Power, Optus and WA Police:** No concerns raised **Telstra:** No response received	**Western Power:** Low likelihood of interference through reflection/scattering **Telstra links:** High likelihood of interference through diffraction **Optus and WA Police links:** Unlikely to cause interference	**Western Power:** If required – reroute affected links, install additional towers, replace affected links with alternative technologies **Telstra links:** Relocate turbines to be outside of interference zones, reroute affected links, install additional towers, replace affected links with alternative technologies **Optus and WA Police:** none required
Fixed point-to-multipoint links	52 assignments within 75 km of Project boundary 2 base stations within 20 km of Project boundary, operated by: Western Power Water Corporation	**Western Power and Water Corporation:** No concerns raised	Unlikely to cause interference	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
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:** 2 WA Police links crossing boundary (see above) **Point-to-area style communications:** unlikely to be affected	**WA Police:** No concerns raised **Other operators:** DNV intends to consult	**Point-to-point links:** None **Point-to-area style communications:** Unlikely to cause interference	**Point-to-point links:** none required **Point-to-area style communications:** if required – increase signal strength from affected tower or alternative towers, install signal repeater, install additional tower
Meteorological radar	Nearest radar: 204 km from Project	**Bureau of Meteorology:** 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 **Survey marks:** unlikely to be affected	**Geoscience Australia:** No concerns raised	None	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	**NBN and Optus:** no concerns raised **Telstra:** No response received **Vodafone/TPG:** DNV intends to consult	Unlikely to cause interference	If required – increase signal strength from affected tower or alternative towers, 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
Wireless internet	**Wireless broadband service providers:** Mobile JV Pty Ltd, mobile phone networks, NBN Co **NBN:** available as a fixed wireless and satellite service	**NBN and Optus:** no concerns raised **Telstra:** No response received **Vodafone/TPG, Mobile JV Pty Ltd:** DNV intends to consult	**Wireless broadband services**: see findings for mobile phones **NBN fixed wireless service:** Low likelihood of interference	**Wireless broadband services:** as for mobile phones **NBN fixed wireless service:** none required
Satellite television and internet	**Geostationary satellites:** signals from NBN Sky Muster satellite intercepted at one dwelling; signals from 7 satellites providing services intended for international audiences intercepted at one dwelling **Low Earth orbit (LEO) satellites:** unlikely to be affected	Consultation with operators not considered necessary	**Geostationary satellites:** *Services intended for international audiences* – low likelihood of interference *NBN Sky Muster* – potential for interference at one dwelling **LEO satellites:** unlikely to cause interference	**Geostationary satellites:** if required – redirect satellite dish to alternative satellite, install larger or higher-quality satellite dish, change location or height of satellite dish **LEO satellites:** none required
Radio broadcasting	**AM and FM signals:** may experience interference in close proximity to turbines **Digital radio signals:** Project is outside the intended coverage area	Consultation not considered necessary	**AM and FM signals:** low likelihood of interference **Digital radio signals:** None	**FM and AM signals:** if required – install higher-quality antenna at affected location and/or move antenna to a new location **Digital radio signals:** 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
Television broadcasting	May experience interference in areas with poor or marginal reception **Augusta transmitter:** *'variable' coverage throughout most of the site, with no coverage to the east of the boundary.* 8 dwellings in potential interference zone **Bunbury transmitter:** *'variable' to no coverage throughout most areas in and around the site, with pockets of poor coverage.* 17 dwellings in potential interference zone	Consultation yet to commence	Unlikely to cause 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

Urbis Ltd (Urbis or "the Customer") has commissioned DNV to independently assess the potential electromagnetic interference (EMI) related impacts associated with the proposed Beenup Wind Farm ("the Project") in Western Australia. The results of this work are reported here. This document has been prepared in accordance with DNV proposal Urbis Sub Consultancy Agreement "Beenup Wind Farm Project: Provision of services by DNV Australia Pty Ltd", dated 11 October 2024, and is subject to the terms and conditions in that agreement.

In accordance with the National Wind Farm Development Guidelines – Draft (Draft National Guidelines) prepared by the Environment Protection and Heritage Council (EPHC) in July 2010 [1], 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.

2 DESCRIPTION OF THE SITE AND PROJECT

2.1 The site

The Project is located approximately 58 km south of Busselton and 12 km northeast of Augusta.

The terrain at the site is relatively simple with elevation ranging from approximately 10 m to 40 m above sea level. The site is comprised of mainly agricultural land with sparse pockets of shrubs throughout.

2.2 The Project

2.2.1 Proposed wind farm layout

The Project is proposed to consist of 20 wind turbines [2]. A map of the site with the proposed turbine layout is shown in Figure 1, and the coordinates of the proposed turbine locations are presented in Table 7. DNV understands that the current turbine layout is preliminary and subject to change, and that the final layout will incorporate findings from the EMI assessment to mitigate identified risks.

2.2.2 Dwelling locations

The locations of dwellings in the vicinity of the Project have been provided by the Customer [3]. There are 33 dwellings located within 5 km of the Project boundary, 13 of which are involved dwellings. The coordinates of these dwellings are presented in Table 8, and the dwellings and Project boundary considered in this assessment are shown in Figure 1.

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.

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

The development of wind farms in Western Australia is governed by the Western Australian Planning Commission's Position Statement on renewable energy facilities ("the WA Position Statement"), published in March 2020 [4]. However, the WA Position Statement does not address the potential for wind farms to cause EMI-related impacts on nearby radiocommunication services.

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) [1]. 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.

Since the WA Position Statement does not provide any guidance on the assessment of EMI-related impacts, DNV considers that the recommendations of the Draft National Guidelines are relevant to the assessment of EMI impacts for wind farms in Western Australia. Therefore the Draft National Guidelines have been used to inform the methodology adopted for this assessment.

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 20 wind turbines, as outlined in Table 7.

For the purpose of the EMI assessment, a hypothetical turbine with a rotor diameter of 172 m, an upper tip height of 250 m, and a lower tip height of 78 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 172 m or less
- an upper tip height of 250 m or less
- a lower tip height of 78.

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 6 May 2025 [5].

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, or is intending to consult 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 and all responses received to date are summarised in

Table 17. Further consultation will be undertaken to enable the proponent of the Project to ensure the Project remains compliant with all relevant standards and community expectations.

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 feedback obtained from the service operators and 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 [1], 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 289 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 2.

There are 2 radiocommunication towers located within 2 km of the proposed turbine locations. These towers and the consultation zones recommended by the Draft National Guidelines [1] are shown in Figure 3 based on information obtained from the ACMA RRL database, provided by the tower operators, and extracted from aerial or satellite imagery. Each consultation zone includes the rotor radius for turbines with a 172 m rotor diameter, and an additional buffer to account for potential inaccuracies in the tower locations. The size of the uncertainty buffer in each case is based on the deviations between the tower locations given in the ACMA RRL database and the apparent locations determined from aerial or satellite imagery.

Details of the licences associated with these radiocommunication towers are given in Table 1**.** These licences and services include point-to-point links, point-to-multipoint links, and point-to-area style communications, comprising land mobile licences used for private mobile telephony (mobile radio and paging systems) and spectrum licences used for commercial public mobile phone networks.

Table 1 Details of radiocommunication towers located within 2 km of turbines at the proposed Project

Site ID	Operator	Licence/service types	Distance to nearest turbine [m]
28122	Western Australia Police (WA Police)	Point-to-point links	1726
	Telstra Limited (Telstra)	Point-to-point links Point-to-area (spectrum)	
	Optus Mobile Pty Limited (Optus)	Point-to-point links Point-to-area (spectrum)	
	TPG Internet Pty Ltd (TPG)	Point-to-area (spectrum)	
10002490	Electricity Networks Corporation (Western Power)	Point-to-point links Fixed point-to-multipoint Point-to-area (land mobile)	598

The potential for the Project to interfere with point-to-point links through reflection or scattering of signals or near-field effects is discussed further in Section 4.3. For the point-to-point links associated with the radiocommunication towers shown in Table 1, DNV has established potential reflection/scattering and near-field interference zones as described in Sections 4.3.1.2 and 4.3.1.3. Based on these interference zones, it is not expected that the Project will cause interference to the point-to-point links through near-field effects. However, there may be potential for the Project to cause interference to the point-to-point links operated by Western Power and Telstra through reflection or scattering of the signals.

The potential for the Project to interfere with point-to-multipoint links is discussed further in Section 4.4. Unlike point-to-point licences, the ACMA RRL database details only the static or base station for a point-to-multipoint licence. Therefore, the paths of the transmission vectors, and the potential for interference, are not readily identifiable unless advised by the operators through consultation. Site ID 10002490 is currently being operated as a base station for a point-to-multipoint licence by Western Power, and the potential for the Project to cause interference to the associated links has been evaluated through consultation as described in Section 4.2.2.

Point-to-area style radiocommunications such as mobile radio and paging systems are typically designed to operate in a range of environments and 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. However, interference caused by reflection or scattering of signals or near-field effects can be a problem if the turbines are located close to the transmission tower. Reference [6] 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 due to reflection or scattering of signals. 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 these types of services [7]. Previous advice received from mobile phone network operators in Australia has suggested that clearances of between 500 m and 1000 m from their towers may be required to avoid the potential for impacts to mobile phone signals.

Given the proximity of the proposed wind turbine locations to the towers shown in Table 1, there is a potential for the Project to interfere with the associated point-to-area style communications

operated by Western Power through reflection or scattering of the signals. However, feedback from Western Power indicates that they do not expect impact to their services, as outlined in Section 4.2.2. Since the turbines are located outside the clearance zones previously recommended by mobile phone network operators, interference with the mobile phone services operated by Telstra, Optus, and TPG from the tower at Site ID 28122 is considered unlikely. Near-field zones for these types of systems are typically only a few metres in radius, and so it is considered unlikely that the Project will cause interference to the services associated with these towers through near-field effects.

4.2.2 Stakeholder consultation

DNV has contacted the WA Police, Telstra, Optus, and Western Power to determine the likelihood that the proposed Project will cause interference to their services associated with the towers shown in Table 1 through near-field effects or reflection or scattering of signals. Responses have been received from WA Police, Optus, and Western Power and no concerns have been raised, as summarised in Table 17. No response has been received from Telstra to date.

DNV is also intending to contact TPG to seek their feedback on the potential for interference to their services associated with the tower at Site ID 28122.

4.2.3 Mitigation options

Potential mitigation options for impacts to the point-to-point links operated by WA Police, Telstra, Optus, and Western Power are discussed in Section 4.3.3. It is not expected that mitigation will be required for point-to-multipoint links.

In the event that interference to land mobile communications operated by Western Power at site ID 10002490 is experienced after the Project is operational, mitigation options would need to be confirmed through consultation with Western Power but may include increasing the signal strength from the affected tower or alternative towers, or installing additional towers in the vicinity of the Project.

Potential mitigation options for impacts to mobile phone services operated by Telstra, Optus and TPG are discussed in Section 4.11.3.

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 4. 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 10 point-to-point links recorded in the ACMA RRL database that pass over the proposed Project boundary, operated by Western Power, Optus, Telstra and WA Police. The details of the links are provided in Table 9, and the link paths are shown in greater detail in Figure 5 based on information obtained from the ACMA RRL database and extracted from aerial or satellite imagery.

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, and summarised in Section 4.3.1.4. Feedback obtained from the operators of the links is summarised in Section 4.3.2.

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 [1, 8, 9], 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 either the second Fresnel zone as recommended in [8], or potentially 60% of the first Fresnel zone for links below 1,000 MHz with a clear line of sight as suggested in [6] (although DNV understands that this zone is under review by the authors of that document). 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 5. Each exclusion zone includes the rotor radius for turbines with a 172 m rotor diameter, and an additional buffer to account for potential inaccuracies in the tower locations. The size of the uncertainty buffer

in each case is based on the deviations between the tower locations given in the ACMA RRL database and the apparent locations determined from aerial or satellite imagery.

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 2.

For links operated by Telstra, two turbines (T10 and T13) are located within the exclusion zone for Link #8, and one turbine (T8) for Link #7. For links operated by Western Power, one turbine (T4) is located within the exclusion zone for Link #3.

There are no turbines located within the diffraction exclusion zones for the point-to-point links operated by Optus and WA Police, so it is not expected that the Project will cause interference to those links through diffraction of the signals.

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) [8].

Reference [8] 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.

For each of the identified links with a transmission tower near the proposed turbine locations, DNV has established a reflection/scattering interference zone based on the antenna gains and length of the link, the worst-case RCS for the turbine calculated according to the equation proposed in [10], and an assumed minimum C/I ratio of 20 dB [10]. The radiation patterns for the antennas were approximated using the reference radiation patterns given in the International Telecommunication Union (ITU) Recommendation F.699-8 [11].

The potential reflection/scattering interference zones are shown in Figure 5. Each interference zone includes the rotor radius for turbines with a 172 m rotor diameter, and an additional buffer to account for potential inaccuracies in the tower locations. The size of the uncertainty buffer in each case is based on the deviations between the tower locations given in the ACMA RRL database and the apparent locations determined from aerial or satellite imagery.

For comparison, Figure 5 also shows the 2 km radius consultation zones for reflection or scattering effects as recommended by the Draft National Guidelines, centred on the transmission towers for the point-to-point links crossing the Project boundary.

The results of this analysis are summarised in Table 2.

For links operated by Telstra, three turbines (T4, T5 and T6) are located within the potential reflection/scattering interference zone for Link #6. For links operated by Western Power, one turbine (T2) is located within the potential reflection/scattering interference zone for both Links #1 and #2, and two turbines (T4 and T5) for that of Link #3.

There are no turbines located within the potential reflection/scattering interference zones for the point-to-point links operated by Optus and WA Police, so it is not expected that the Project will cause interference to those links through reflection or scattering effects.

The method used to establish the reflection/scattering interference zones shown in Figure 5 assumes that the direct path for the point-to-point link has a clear line of sight with respect to the first Fresnel zone, and that the paths for the reflected or scattered signal from the transmitter to the turbine and from the turbine to the receiver also have a clear line of sight with respect to terrain [8]. For low frequency links, the direct path between the transmitter and the receiver is often obstructed by terrain. In this situation, a signal that has been reflected or scattered from a wind turbine with a clear line of sight to the transmitter or receiver may be considerably stronger than the direct signal and therefore have greater potential to cause interference [6]. As indicated in Table 2, one of three point-to-point links operated by Western Power crossing the Project boundary does not have a clear line of sight between the transmitter and receiver. For these links, the necessary clearance zones to minimise the potential for interference caused by reflection or scattering may be larger than those shown in Figure 5.

Nevertheless, DNV notes that the reflection/scattering interference zones shown in Figure 5 are approximations only and may be overly conservative [1]. This is especially true for high frequency links where increased antenna directionality (or gain) and narrower scatter regions can make the signal less susceptible to interference caused by reflection or scattering [6]. The turbine RCS and C/I ratios used to establish the interference zones were based on recommendations developed on behalf of the United Kingdom telecommunications regulator Ofcom [10], and may not be appropriate for point-to-point links operating in Australia. Uncertainties are also associated with the assumptions used to derive the Ofcom recommendations, and the use of ITU reference radiation patterns rather than the actual radiation patterns for the transmitting and receiving antennas. To account for these uncertainties, DNV has contacted the operators of the point-to-point links crossing the proposed Project boundary, as described in Section 4.3.2, to seek their feedback on the potential for the Project to cause interference to those 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 [8] 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.

For each of the identified links with a transmission tower located near the proposed turbine locations, DNV has established a near-field interference zone based on the operating frequency and antenna gain for that link.

The potential near-field interference zones are shown in Figure 5. Each interference zone includes the rotor radius for turbines with a 172 m rotor diameter, and an additional buffer to account for potential inaccuracies in the tower locations. The size of the uncertainty buffer in each case is based on the deviations between the tower locations and the apparent locations determined from aerial or satellite imagery.

The results of this analysis are summarised in Table 2.

There are no turbines located within the near-field interference zones for any of the point-to-point links passing over the proposed Project boundary. Therefore, it is not expected that the Project will cause interference to the point-to-point links through near-field effects.

4.3.1.4 Summary of point-to-point interference effects

Table 2 summarises the turbines located within the calculated diffraction, reflection/scattering, and near-field interference zones for each of the point-to-point links crossing the Project boundary.

Table 2 Details of turbines located within the interference zones established by DNV for point-to-point links crossing the proposed Project boundary

Link no.	Operator	Turbines within potential interference zone			
		Diffraction		Reflection/ scattering	Near-field
		Horizontal plane	Vertical plane		
1	Western Power	-	-	1 (T2)[1]	-
2	Western Power	-	-	1 (T2)	-
3	Western Power	1 (T4)	1 (T4)	2 (T4, T5)	-
4	Optus	-	-	-	-
5	Telstra	-	-	-	-
6	Telstra	-	-	3 (T4, T5, T6)	-
7	Telstra	1 (T8)	1 (T8)	-	-
8	Telstra	2 (T10, T13)	2 (T10, T13)	-	-
9	WA Police	-	-	-	-
10	WA Police	-	-	-	-

1. Direct link path does not have a clear line-of-sight with respect to the first Fresnel zone. The necessary clearance zone to minimise potential for interference caused by reflection or scattering may be larger than shown in Figure 5 for this link.

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. Responses have been received from Western Power, Optus and WA Police, as summarised in Table 17, and no concerns have been raised.

Western Power has conducted an assessment to calculate the exclusion zone for interference caused by diffraction based on the second Fresnel zone. The result of their assessment indicates that there is a discrepancy between the path of the link with licence number 11749221/1 used in

their assessment and the assessment presented here. Further consultation is ongoing with Western Power to confirm the exact locations of the endpoint towers.

No response has been received from Telstra to date.

4.3.3 Mitigation options

To avoid the potential for interference to the Telstra point-to-point links crossing the Project boundary, DNV recommends that turbines T8, T10, and T13 be moved outside of the diffraction exclusion zones established by DNV and shown in Figure 5. Alternative mitigation options would need to be confirmed through consultation with Telstra.

In the event that interference to the Western Power point-to-point links are experienced after the Project is operational, mitigation options would need to be confirmed through consultation with the relevant operator 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.

It is not expected that mitigation would be required for the point-to-point links operated by Optus and WA Police.

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 52 point-to-multipoint Assignment IDs within approximately 75 km of the proposed Project boundary. These licences are shown in Figure 6. The details of the licence holders as given in the ACMA RRL database are provided in Table 10.

There are two point-to-multipoint base stations within 20 km of the Project boundary, operated by Western Power and Water Corporation. 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 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. A response has been received from Western Power as summarised

in Table 17, and no concerns have been raised. Water Corporation has advised that none of their links are within 300 m of the Project boundary.

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 7 and Table 11.

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 aeronautical licences, and 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.

4.6 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 12 along with their contact details. The nearest licence is associated with a tower located within the Project boundary, 1.7 km from the nearest turbine.

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 [6] 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 [7].

Given the distance of 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 WA Police to seek feedback regarding the potential for interference to their operations and services. A response has been received and no concerns have been raised.

DNV is also intending to contact other operators of potentially affected emergency services licences within approximately 60 km of the Project to seek feedback on any potential impact that the Project could have on their operations and services.

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 localised interference to mobile radio or paging system signals is experienced, this can often be mitigated by the user moving a short distance to a new or higher location to receive a clearer signal or by using an external antenna to improve the signal reception. Other 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 [12].

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 [13, 14].

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 [15, 16], and approximately 100 km at a height of 1000 m [16]. 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 [17, 18]. 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 [1].

4.8.1 Locations of meteorological radars and potential for interference

DNV has identified that the Bureau operates 7 weather radars within 250 nautical miles of the proposed Project, with the closest radar located approximately 204 km north of the Project at Hopeland. The locations of these radars are shown in Figure 8 and the details of each radar are given in Table 13.

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, and that the Bureau has no objections to the Project provided that the following conditions are met:

- the Bureau is informed of any changes to the Project design, including changes to the turbine locations or height
- the owner or operator of the Project gives 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

- the owner or operator of the Project collaborates with the Bureau in the event of severe weather conditions in the interests of community safety.

4.8.3 Mitigation options

Considering that the Bureau expects the impact of the Project on their radars to be manageable/significant, compliance with the conditions specified by the Bureau and outlined in Section 4.8.2 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.

According to the WMO, there are currently no automated signal processing techniques available that can be used to effectively filter radar data to remove interference caused by wind farms [18], However, if analysis indicates there is a potential for the wind farm to cause reflection or scattering of radar signals, the WMO suggests it may be possible to reduce the potential impact through the relocation of individual turbines prior to construction. In situations where the expected interference is limited to signal clutter, the radar operator may also be able to mask these effects in the data or train the users to take the locations of the wind farms into account.

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 [19].

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 [20]. 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) [21], 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 [22], there are 33 trig points within 20 km of the Project boundary. The details of these trig points are provided in Table 14 and their locations are illustrated in Figure 9.

There are also 21 permanent survey marks within 2 km of the Project boundary [23] as shown in Figure 10. The closest survey mark is located 387 m southwest of turbine T16.

DNV has reviewed the primary geodetic network of Australia [24] 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 16 km northeast of the Project, at Kerridale [25]. 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 to inform them of the Project, and seek feedback regarding whether interference to their systems is possible. A response has been received from Geoscience Australia as summarised in Table 17 and no concerns have been raised.

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

If interference to CB radio signals is experienced, simple steps such as moving a short distance to a new or higher location until the signal strength improves may help to mitigate the impact. CB radio users can also increase their signal range and improve reception by switching their equipment to a higher power setting, using a longer antenna, or increasing the antenna mounting height.

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 11. The nearest mobile phone tower is located within the Project boundary.

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

Figure 12 shows the Optus Mobile network coverage for the Project area [26]. Optus 4G coverage is available within the Project boundary. Beyond the Project boundary, coverage is generally available to the west from north to south, whereas it is sparse to the east especially further north-east towards the South Blackwood State Forest.

Figure 13 shows the Telstra network coverage for the Project area [27]. Telstra 4G coverage is available within the Project boundary, and also in the immediate surroundings. Coverage becomes limited to none in areas to the south-east beyond the Project boundary.

Figure 14 shows the Vodafone/TPG network coverage for the Project area [28]. Vodafone 4G coverage is generally available within the Project boundary. Coverage becomes mostly unavailable from east of the boundary to outwards further east.

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.

4.11.2 Stakeholder consultation

DNV has contacted Optus and Telstra to inform them of the proposed Project and to seek feedback on any potential impact that the Project could have on their services. A response has been received from Optus as summarised in Table 16, and no concerns have been raised to date.

DNV is also intending to contact Vodafone/TPG to seek feedback regarding the potential for interference to their services.

4.11.3 Mitigation options

As noted above, interference with mobile phone signals is considered unlikely. If localised interference is experienced by mobile phone users, this can often be rectified by the user moving a short distance to a new or higher location until the signal improves, or using an external antenna to improve the signal reception. For interference over a larger area, or in cases where it would not be possible or practical for the user to change their location, 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

Mobile JV Pty Ltd holds point-to-area spectrum licences in the vicinity of the Project. As the locations of Mobile JV Pty Ltd customers are not known, it is not possible to determine whether

there is the potential for interference to this service, however it is possible that stations at these distances may 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/TPG. 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 is a low theoretical 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 Telstra and Optus, as discussed in Section 4.11, to seek feedback on any potential impact that the Project could have on their services. A response has been received from Optus with no concerns raised. No response has been received from Telstra to date.

DNV is also intending to contact Vodafone/TPG and Mobile JV Pty Ltd to seek feedback regarding the potential for interference to their services.

4.12.1.3 Mitigation options

As noted above, interference with wireless broadband services is considered unlikely. 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, localised interference can often be rectified by the user moving a short distance or using an external antenna to improve signal reception. For interference over a larger area, or in cases where it would not be possible or practical for the user to change their location, 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.

4.12.2 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 [29]. Consequently, the signals may be affected by physical obstructions such as terrain, vegetation, and wind turbines [30].

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 [31] indicates that the network is currently available as a fixed wireless and satellite internet service in the area surrounding the Project. It is therefore likely that some residents are currently accessing the internet via the NBN and that the network will also be available to other residents in the vicinity of the Project in the near future. The locations of NBN fixed wireless internet towers within 75 km of the Project boundaries are shown in Figure 11, and a map of NBN service coverage in the vicinity of the Project is shown in Figure 15.

The NBN fixed wireless towers servicing the Project area are located at Molloy Island and Augusta. Based on the relative positions of these towers and the nearby dwellings, and the fixed wireless coverage areas shown in Figure 15, it is considered unlikely that turbines at the Project will intercept the line of sight between these towers and nearby dwellings.

DNV understands that NBN Co is planning to extend the fixed wireless coverage range for some towers from 14 km to 29 km [30]. In addition to the NBN fixed wireless internet towers at Molloy Island and Augusta, there are other NBN fixed wireless internet towers located within 29 km of the proposed turbine locations at Witchcliffe and Rosa Brook. If the coverage from these towers is extended and additional residents in the vicinity of the Project begin receiving fixed wireless internet signals prior to the construction of the Project, there may be potential for interference to the NBN fixed wireless service at other dwellings. Conversely, in the event that interference to NBN fixed wireless internet signals from the towers at Molloy Island and Augusta is experienced, extension of the coverage from the other nearby towers may allow affected dwellings to receive signals from an alternative tower. However, the assessment presented here is based on the current network availability, as shown in Figure 15.

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. A response has been received from NBN Co, as summarised in Table 17, and no concerns have been raised.

4.12.2.3 Mitigation options

As noted above, interference with NBN fixed wireless internet services is considered unlikely. If interference to NBN fixed wireless signals is experienced at nearby dwellings as a result of the Project, several mitigation options may be available to improve the signal reception. NBN Co has previously advised that in most instances where the signal line of sight from a given tower is obstructed an alternative tower can be used to service the affected dwelling. If an alternative tower is not available, interference can usually be rectified by moving the outdoor antenna at the affected dwelling a short distance from the building, to a location where the signal is not impacted by the turbines, and connecting that antenna to the dwelling via a cable (described by NBN Co as a "non-standard install process" [29]). It may also be possible to avoid impact by micro-siting the turbines in some cases, or by installing a new NBN tower to service the affected dwellings. Although the NBN Sky Muster satellite internet service is a potential alternative to the fixed wireless internet service, NBN Co have previously advised that the Sky Muster service cannot be considered as a mitigation option for dwellings affected by interference from wind turbines.

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.

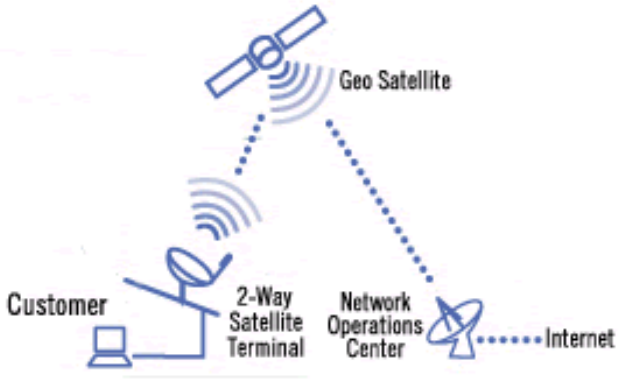
4.13.1 Geostationary satellite communication services

Geostationary satellites orbit the earth directly above the equator, at a height of 35,786 km above the Earth's surface [32]. 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 [33, 34].

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 [35]

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 15 and summarised in Table 3. Based on these results, turbines at the Project may intercept signals from eight satellites at one nearby dwelling, dwelling 26, which is an involved dwelling.

Dwelling 26 has potential to experience interference to satellite internet signals from the NBN Sky Muster II satellite. The dwelling is located approximately 344 m from the nearest proposed turbine location, and DNV has not been advised whether this dwelling will be inhabited while the Project is operational. If the dwelling is not inhabited, or if the residents are not intending to use the NBN satellite internet service, there will be no potential for the Project to impact on that service.

DNV understands that all other potentially affected satellites provide television signals intended for international audiences, and considers it unlikely that residents in the vicinity of the Project will currently be receiving signals from these satellites. Many of these satellites have a low angle of elevation above the horizon at the Project site location, and so degradation caused by atmospheric effects or interference from terrain or other obstacles may already prevent the signals from being received at the affected dwellings. For some of these satellites, the programs transmitted on the beam footprints that cover Australia may also be available through other satellite services which have a higher angle of elevation above the horizon and are not expected to be intercepted by turbines at the Project. If residents are not currently receiving signals from these satellites, either by choice or because those signals are not available due to existing degradation or interference, there will be no potential for the Project to impact on those services.

Table 3 Number of satellites with potential for signals to nearby dwellings to be intercepted by the proposed Project

Satellite service	Number of potentially affected satellites	Potentially affected dwellings
Services intended for Australian audiences	1	Dwelling 26 (involved dwelling)
Services intended for international audiences	7	Dwelling 26 (involved dwelling)

4.13.1.2 Stakeholder consultation

As discussed in Section 4.13.1.1, one involved dwelling has the potential to experience interference to NBN satellite internet services. DNV recommends that the proponent of the Project engages with the owners of this dwelling prior to construction of the Project to determine whether it is currently inhabited or expected to be inhabited during the lifetime of the Project and whether the residents are currently receiving or intending to receive signals from the NBN Sky Muster satellites, and to establish an understanding of how any impact to those services may be mitigated.

If desired by the proponent, similar engagement could also be undertaken with the owners of this dwelling to determine if any are currently receiving signals from the potentially affected satellites providing services intended for international audiences, although this is considered unlikely.

4.13.1.3 Mitigation options

If nearby residents that are currently using television services provided via geostationary satellites experience interference to those services caused by the Project, several mitigation options may be available. If an alternative source of the same programming is available, the satellite dishes at affected dwellings can simply be re-directed to receive signals from the other satellite. In some cases, residents may also be able to access the affected programs directly over the internet. If an alternative source of programming is not available, it may be possible to rectify interference by installing a larger or higher-quality satellite dish, or by changing the height or location of the dish to obtain a stronger signal.

If nearby residents that are currently using internet services provided via geostationary satellites experience interference to those services caused by the Project, it may also be possible to rectify interference by installing a larger or higher-quality satellite dish, or by changing the height or location of the dish to receive a stronger signal.

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 [32]. At these altitudes, the satellites travel significantly faster than the Earth's rotational speed and typically compete 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, LOE 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 [36], 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 [37, 38].

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 [39]. 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 [40], 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 dwellings and the nearby turbines, the elevations of the dwellings and turbines, and a turbine tip height of 250 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.

4.14 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 [41].

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 [42], and are shown in Figure 16.

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 [43]. 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 [41, 44].

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 [43]. 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 [45].

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 [42], and are shown in Figure 16.

The closest FM broadcast transmitter is located approximately 12 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 [46]. 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 [43] 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 [47], 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.

4.15 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 [48]. 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 [48], and are shown in Figure 16. The main DTV transmitter used by residents in the vicinity of the Project is the Augusta transmitter. However, according to the Australian Government mySwitch website [49], it is also possible that residents in the vicinity of the Project are able to receive DTV signals from the Bunbury transmitter.

The DTV broadcast transmitters likely to be servicing the area around the Project are summarised in Table 4 below. Coverage maps for these broadcast transmitters are reproduced in Figure 17 to Figure 18.

Table 4 DTV broadcast transmitters servicing the Project area

DTV broadcast transmitter	Signal coverage in the vicinity of the Project	Figure containing coverage map
Augusta	Marginal to poor coverage throughout most of the site, with no coverage to the east of the boundary. Signal coverage gradually increases at areas closer to Augusta.	Figure 17
Bunbury	No coverage throughout most areas in and around the site, with pockets of poor coverage.	Figure 18

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 [9].

The closest DTV transmitter to the Project is the Augusta primary transmitter, which is approximately 13 km away. Therefore, 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 16 and Figure 17 to Figure 18. The dwellings most likely to be susceptible to interference include those within the possible interference zones, as summarised in Table 5.

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 17 and Figure 18 also shows the area within 10 km of the proposed turbine locations. DNV is intending to contact 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.

Table 5 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
Augusta	8 (5 involved dwellings)	Marginal to poor coverage throughout most of the site, with no coverage to the east of the boundary. Signal coverage gradually increases at areas closer to Augusta. Dwellings within the potential interference zones may be currently receiving weak to no signals from the Augusta transmitter.
Bunbury	17 (9 involved dwellings)	No coverage throughout most areas in and around the site, with pockets of poor coverage. It is unlikely that dwellings within the potential interference zones are currently receiving signals from the Bunbury transmitter.

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 is intending to contact 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.

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 [50], DVB-T reception quality may not be substantially affected in the forward scatter region.

The ITU [51] 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 [52].

5 CONCLUSIONS

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 20 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 172 m or less, an upper tip height of 250 m or less, and a lower tip height of 78 m or more. DNV understands that the current turbine layout is preliminary and subject to change. The final layout will incorporate findings from the EMI assessment to mitigate identified risks. Further consultation will be undertaken to ensure the wind farm remains compliant with all relevant standards and community expectations.

The results of this assessment, including feedback obtained from relevant stakeholders, are summarised in Table 6 Summary of EMI assessment results for the proposed ProjectTable 6.

There are two radiocommunication towers located within the Project boundary, with licences operated by Western Australia Police, Telstra, Optus and TPG at Site ID 28122, and licences operated by Western Power at Site ID 10002490. Types of licences operated at these towers include point-to-point links, point-to-multipoint links and point-to-area style services as discussed below.

There are 10 point-to-point links crossing the Project boundary operated by Western Power, Telstra, Optus and WA Police. Of the 10 links, links by Optus and WA Police are not expected to experience interference by turbines. Based on interference zones calculated by DNV, turbines are situated within exclusion/interference zones for the links operated by Western Power and Telstra. For the links operated by Telstra, three turbines are within the diffraction exclusion zones calculated for two links. Telstra has been approached for consultation on potential interference to these links, but no response has been received at the time of writing. For the links operated by Western Power, one turbine is within the diffraction exclusion zone for one link, and three turbines are within the potential reflection/scattering zone for three links. Western Power has responded with no concerns for interference to these links by turbines at the Project.

Water Corporation and Western Power have been contacted to seek feedback regarding potential for interference to their point-to-multipoint services in the vicinity of the Project. Responses have been received from both operators with no concerns raised.

Turbines at the Project may interfere with point-to-area style services such as mobile phone signals, radio broadcasting, and terrestrial television broadcasting, particularly in areas with poor or marginal signal coverage. Dwellings within approximately 5-10 km of the Project are within interference zones calculated for the Augusta and Bunbury television broadcast transmitters. Dwellings that are currently receiving weak signals from these transmitters may experience interference to their services. However, most dwellings within the interference zones for both television broadcast transmitters may not be currently receiving signals from these transmitters. Telstra, Optus and Vodafone/TPG mobile phone signal coverage by is generally available throughout most of the Project area, and is unlikely to experience interference. If interference to these services is experienced, a range of options are available to rectify difficulties.

Interference to signals from geostationary satellites that transmit programs intended for international audiences is also possible at one dwelling, but it is considered unlikely that residents will be receiving signals from these satellites.. For the same dwelling, interference is also possible to signals from geostationary satellites intended for Australian audiences. DNV recommends that

the proponent of the Project engages with the owner of this dwellings prior to construction of the Project to determine whether it is currently inhabited or expected to be inhabited during the lifetime of the Project and whether the residents are currently receiving or intending to receive signals from the NBN Sky Muster satellites, and to establish an understanding of how any impact to those services may be mitigated.

Since it is not possible to determine the potential EMI impacts on point-to-multipoint links 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. To date, no concerns have been raised. Further consultation will be undertaken to enable the proponent of the Project to ensure that the Project remains compliant with all relevant standards and community expectations.

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

Table 6 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	2 towers within 2 km of proposed turbine locations, operated by: **Site ID 10002490** Electricity Networks Corporation (Western Power) **Site ID 28122** Optus Mobile Pty Limited (Optus) Telstra Limited (Telstra) Western Australia Police (WA Police) TPG Internet Pty Ltd (TPG)	**Western Power, Optus and WA Police:** No concerns raised **Telstra:** No response received **TPG:** DNV intends to consult	**Point-to-point links:** *See Fixed point-to-point links* **Land mobile services operated by Western Power:** Low likelihood of interference **All other services:** Unlikely to cause interference	**Point-to-point links:** *See Fixed point-to-point links* **Land mobile services operated by Western Power:** If required - increasing the signal strength from the affected tower or alternative towers, or installing additional towers in the vicinity of the Project **All other services:** None required
Fixed point-to-point links	10 links crossing Project boundary, operated by: Western Power (3 links) Optus (1 link) Telstra (4 links) WA Police (2 links) **Western Power links:** 1 turbine in diffraction zones, 3 turbines in potential reflection/scattering zones, no turbines in potential near-field zones **Optus links:** no turbines in calculated interference zones **Telstra links:** 3 turbines in diffraction zones, 3 turbines in potential reflection/scattering zones, no turbines in potential near-field zones **WA Police links:** no turbines in calculated interference zones	**Western Power, Optus and WA Police:** No concerns raised **Telstra:** No response received	**Western Power:** Low likelihood of interference through reflection/scattering **Telstra links:** High likelihood of interference through diffraction **Optus and WA Police links:** Unlikely to cause interference	**Western Power:** If required – reroute affected links, install additional towers, replace affected links with alternative technologies **Telstra links:** Relocate turbines to be outside of interference zones, reroute affected links, install additional towers, replace affected links with alternative technologies **Optus and WA Police:** none required
Fixed point-to-multipoint links	52 assignments within 75 km of Project boundary 2 base stations within 20 km of Project boundary, operated by: Western Power Water Corporation	**Western Power and Water Corporation:** No concerns raised	Unlikely to cause interference	None required

Table 6 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
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:** 2 WA Police links crossing boundary (see above) **Point-to-area style communications:** unlikely to be affected	**WA Police:** No concerns raised **Other operators:** DNV intends to consult	**Point-to-point links:** None **Point-to-area style communications:** Unlikely to cause interference	**Point-to-point links:** none required **Point-to-area style communications:** if required – increase signal strength from affected tower or alternative towers, install signal repeater, install additional tower
Meteorological radar	Nearest radar: 204 km from Project	**Bureau of Meteorology:** 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 **Survey marks:** unlikely to be affected	**Geoscience Australia:** No concerns raised	None	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	**NBN and Optus:** no concerns raised **Telstra:** No response received **Vodafone/TPG:** DNV intends to consult	Unlikely to cause interference	If required – increase signal strength from affected tower or alternative towers, install additional tower

Table 6 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	**Wireless broadband service providers:** Mobile JV Pty Ltd, mobile phone networks, NBN Co **NBN:** available as a fixed wireless and satellite service	**NBN and Optus:** no concerns raised **Telstra:** No response received **Vodafone/TPG, Mobile JV Pty Ltd:** DNV intends to consult	**Wireless broadband services**: see findings for mobile phones **NBN fixed wireless service:** Low likelihood of interference	**Wireless broadband services:** as for mobile phones **NBN fixed wireless service:** none required
Satellite television and internet	**Geostationary satellites:** signals from NBN Sky Muster satellite intercepted at one dwelling; signals from 7 satellites providing services intended for international audiences intercepted at one dwelling **Low Earth orbit (LEO) satellites:** unlikely to be affected	Consultation with operators not considered necessary	**Geostationary satellites:** *Services intended for international audiences* – low likelihood of interference *NBN Sky Muster* – potential for interference at one dwelling **LEO satellites:** unlikely to cause interference	**Geostationary satellites:** if required – redirect satellite dish to alternative satellite, install larger or higher-quality satellite dish, change location or height of satellite dish **LEO satellites:** none required
Radio broadcasting	**AM and FM signals:** may experience interference in close proximity to turbines **Digital radio signals:** Project is outside the intended coverage area	Consultation not considered necessary	**AM and FM signals:** low likelihood of interference **Digital radio signals:** None	**FM and AM signals:** if required – install higher-quality antenna at affected location and/or move antenna to a new location **Digital radio signals:** none required

Table 6 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
Television broadcasting	May experience interference in areas with poor or marginal reception **Augusta transmitter:** *'variable' coverage throughout most of the site, with no coverage to the east of the boundary.* 8 dwellings in potential interference zone **Bunbury transmitter:** *'variable' to no coverage throughout most areas in and around the site, with pockets of poor coverage.* 17 dwellings in potential interference zone	Consultation yet to commence	Unlikely to cause 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

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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 [43] 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 [50]. Both of these effects can potentially degrade the DTV signal quality.

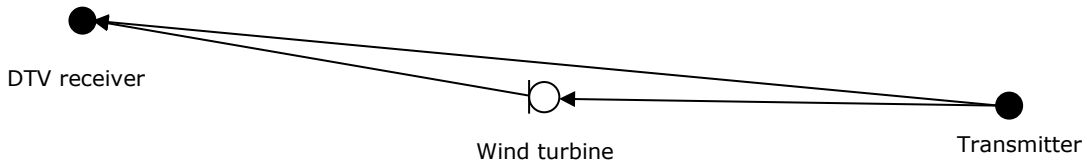

Figure A.1 Forward scatter signal path for DTV signals

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).

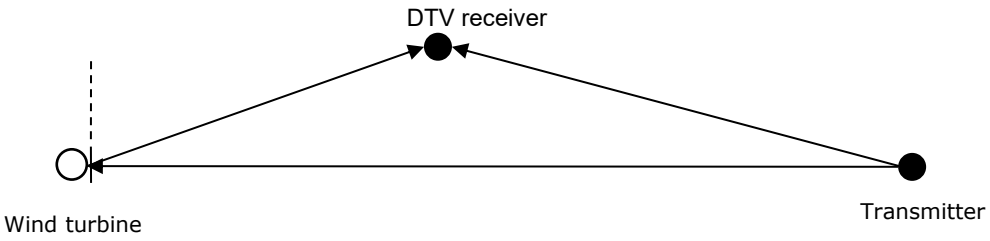

Figure A.2 Back scatter signal path for DTV signals

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 [50].

According to Ofcom [43], the forward scatter region does not typically extend further than 5 km for the worst combination of factors [9, 53]. Interference may extend beyond 5 km if the dwellings are screened from the broadcast transmitter, but do have line-of-sight to the turbines [43]. 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 ±15° to ±20°, 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 [9, 43], 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 be larger.

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

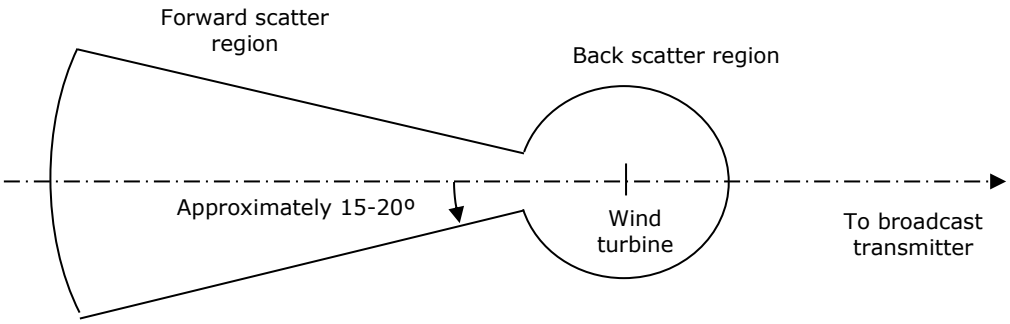

Figure A.3 Potential television interference zones around a wind turbine

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 [54] 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 (±60° 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 [51] 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 [51].

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 [55]. 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 [54], 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 [43]. The combination of these areas forms a region where there is an increased likelihood of interference to television signals occurring.

LIST OF TABLES

Table 7 Proposed turbine layout for the Project [2]

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation[2] [m]	Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation[2] [m]
T1	341139	6216361	53	T11	340892	6210690	27
T2	340788	6215511	53	T12	342468	6210421	34
T3	341918	6215414	40	T13	345295	6209960	27
T4	345088	6214693	37	T14	340962	6209852	25
T5	343988	6214375	38	T15	344918	6209441	27
T6	343099	6213971	37	T16	343578	6209171	32
T7	343657	6211891	37	T17	341748	6209111	22
T8	345138	6211671	38	T18	343608	6208447	33
T9	341438	6211431	32	T19	342821	6208138	31
T10	343229	6211313	37	T20	343192	6207618	33

1. Coordinate system: MGA zone 50, 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 8 Dwellings within 5 km of the proposed Project boundary [3]

Dwelling ID[1]	Easting[2] [m]	Northing[2] [m]	Status	Distance to nearest turbine [km]
1	339932	6218619	Non-Involved	2.6
2	340680	6218530	Non-Involved	2.2
3	340855	6218800	Non-Involved	2.5
4	341014	6219025	Non-Involved	2.7
5	341242	6219104	Non-Involved	2.7
6	341068	6218431	Non-Involved	2.1
7	*341527*	*6217915*	*Involved*	*1.6*
8	*342039*	*6218907*	*Involved*	*2.7*
9	342688	6218167	Non-Involved	2.4
10	343565	6218307	Non-Involved	3.1
11	*343528*	*6214481*	*Involved*	*0.5*
12	340600	6214582	Non-Involved	0.9
13	338388	6215121	Non-Involved	2.4
14	*338448*	*6214372*	*Involved*	*2.6*
15	*338563*	*6213866*	*Involved*	*2.8*
16	*338732*	*6213356*	*Involved*	*3.0*
17	*340917*	*6213802*	*Involved*	*1.7*
18	*341403*	*6213390*	*Involved*	*1.8*
19	*338803*	*6211698*	*Involved*	*2.3*
20	340478	6207561	Non-Involved	2.0
21	340817	6207343	Non-Involved	2.0
22	341297	6207231	Non-Involved	1.8
23	341566	6206853	Non-Involved	1.8
24	341485	6206577	Non-Involved	2.0
25	*342441*	*6208725*	*Involved*	*0.7*
26	*344714*	*6209163*	*Involved*	*0.3*
27	*345036*	*6210145*	*Involved*	*0.3*
28	347593	6209195	Non-Involved	2.4
29	*347668*	*6208486*	*Involved*	*2.8*
30	346779	6204570	Non-Involved	4.7
32	341222	6207694	Non-Involved	1.5
33	341233	6207285	Non-Involved	1.8
34	339818	6217837	Non-Involved	2.0

1. Involved dwellings are indicated by *underlined italic text*.
2. Coordinate system: MGA zone 50, 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 9 Details of point-to-point links crossing the proposed Project

Link no.	Licence number	Assignment ID	Frequency [Hz]	Licence owner
1	10133104/1	2147012	460525000	Electricity Networks Corporation Western Power GPO Box L921 Attn: Comms Operations & Maintenance PERTH WA 6842
		2147013	460525000	
		2147014	451025000	
		2147015	451025000	
2	11749220/1	9441791	6800000000	
		9441792	6800000000	
		9441793	6460000000	
		9441794	6460000000	
3	11749221/1	9441795	6800000000	
		9441796	6800000000	
		9441797	6460000000	
		9441798	6460000000	
4	10183685/1	2403549	11245000000	Optus Mobile Pty Limited LTE TXN 1 Lyonpark Road MACQUARIE PARK NSW 2113
		2403550	11245000000	
		2403551	10755000000	
		2403552	10755000000	
5	10213242/1	2498979	8177620000	TELSTRA LIMITED Telstra - Radio Transport Engineering Locked Bag 3501 BRISBANE QLD 4001
		2498980	8177620000	
		2498981	7866300000	
		2498982	7866300000	
6	10239100/2	3227125	8103495000	
		3227126	8103495000	
		3227127	7792175000	
		3227128	7792175000	
7	1608507/1	841815	155462500	
		841816	155462500	
		841817	150862500	
		841818	150862500	
8	1613233/1	843877	414200000	
		843878	414200000	
		843879	404750000	
		843880	404750000	
9	9967194/1	1477318	8073845000	WESTERN AUSTRALIA POLICE Radio & Electronic Services Unit 21 Swanbank Road Att: Phillip Manna MAYLANDS WA 6051
		1477319	8073845000	
		1477320	7762525000	
		1477321	7762525000	
10	9967216/1	1477334	7704500000	
		1477335	7704500000	
		1477336	7543500000	
		1477337	7543500000	

Table 10 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
1307021	602740	1620441/1	-33.6313	115.3390	60	BUREAU OF METEOROLOGY Bureau of Meteorology 700 Collins Street Docklands VIC 3008
1307024	602740	1620441/1	-33.6313	115.3390	60	
1307025	601341	1620446/1	-33.9122	115.9003	62	
1307028	601341	1620446/1	-33.9122	115.9003	62	
6343155	10018734	10901283/1	-33.6359	115.1112	61	CITY OF BUSSELTON Attn: Busselton-Margaret River Airport Operations Locked Bag 1 BUSSELTON WA 6280
6343158	10018734	10901283/1	-33.6359	115.1112	61	
1241522	9017384	1958446/1	-33.6619	115.4265	58	Cable Sands (WA) Pty Ltd PO Box 133 BUNBURY WA 6231
1241525	9017384	1958446/1	-33.6619	115.4265	58	
9441812	10002490	11749225/1	-34.1946	115.2710	Within Project boundary	Electricity Networks Corporation Western Power GPO Box L921 Attn: Comms Operations & Maintenance PERTH WA 6842
9441813	10002490	11749225/1	-34.1946	115.2710	Within Project boundary	
3593382	28102	9867006/2	-33.9683	115.1561	25	
3593383	28102	9867006/2	-33.9683	115.1561	25	
9441816	10030892	11749226/1	-34.2147	115.7787	42	
9441817	10030892	11749226/1	-34.2147	115.7787	42	
9441820	10030893	11749227/1	-33.8837	115.7975	56	
9441821	10030893	11749227/1	-33.8837	115.7975	56	
3593386	44905	9867007/2	-33.6163	115.0442	65	
3593387	44905	9867007/2	-33.6163	115.0442	65	
7611187	600315	11195358/1	-33.5710	115.5281	70	
7611188	600315	11195358/1	-33.5710	115.5281	70	
1234777	603278	1569719/1	-34.3261	116.1107	73	
1234778	603278	1569719/1	-34.3261	116.1107	73	
9441824	603278	11749228/1	-34.3261	116.1107	73	
9441825	603278	11749228/1	-34.3261	116.1107	73	
903849	139557	1930781/1	-34.3970	115.9629	61	Millwood Holdings Pty Ltd Delroy Orchards PO Box 439 MELVILLE WA 6956
903852	139557	1930781/1	-34.3970	115.9629	61	

Table 10 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
1250336	47280	1616772/1	-34.3124	115.1549	13	Water Corporation Water Corporation PO Box 100 (OT ? Dinesh Raghu) LEEDERVILLE WA 6902
1250339	47280	1616772/1	-34.3124	115.1549	13	
7100214	47280	11002711/1	-34.3124	115.1549	13	
7100217	47280	11002711/1	-34.3124	115.1549	13	
1250332	28098	1616749/1	-33.9520	115.0758	30	
1250335	28098	1616749/1	-33.9520	115.0758	30	
9496532	9008840	11777613/1	-34.0066	115.7895	48	
9496535	9008840	11777613/1	-34.0066	115.7895	48	
1250286	600049	1614255/1	-33.6416	115.1512	60	
1250289	600049	1614255/1	-33.6416	115.1512	60	
9496528	600049	11777612/1	-33.6416	115.1512	60	
9496531	600049	11777612/1	-33.6416	115.1512	60	
1250829	9009515	1910866/1	-33.5932	115.0690	67	
1250832	9009515	1910866/1	-33.5932	115.0690	67	
9496540	9009515	11777615/1	-33.5932	115.0690	67	
9496543	9009515	11777615/1	-33.5932	115.0690	67	
1251172	9016487	1952764/1	-33.9073	115.9733	68	
1251175	9016487	1952764/1	-33.9073	115.9733	68	
9496548	9016487	11777617/1	-33.9073	115.9733	68	
9496551	9016487	11777617/1	-33.9073	115.9733	68	
1249568	9000922	1145110/1	-34.4470	116.0363	69	
1249571	9000922	1145110/1	-34.4470	116.0363	69	
9496520	9000922	11777610/1	-34.4470	116.0363	69	
9496523	9000922	11777610/1	-34.4470	116.0363	69	
1398515	9027192	9892646/1	-33.7961	115.9782	75	
1398518	9027192	9892646/1	-33.7961	115.9782	75	

Table 11 Details of other licences identified within 75 km of the proposed Project

Licence category	Licence type	Number of assignment IDs
1800 MHz Band	Spectrum	675
2 GHz Band	Spectrum	375
2.3 GHz Band	Spectrum	5760
2.5 GHz Band	Spectrum	270
3.4 GHz Band	Spectrum	2884
700 MHz Band	Spectrum	963
800 MHz Band	Spectrum	506
850/900 MHz Band	Spectrum	404
AWL - FSS Only	Spectrum	32
Aeronautical Assigned System	Aeronautical	16
Amateur Repeater	Amateur	24
Ambulatory System	Land Mobile	42
CBRS Repeater	Land Mobile	4
Commercial Radio	Broadcasting	4
Commercial Television	Broadcasting	12
Community Broadcasting	Broadcasting	1
Earth Receive	Earth Receive	5
Fixed Earth	Earth	5
Land Mobile System - > 30MHz	Land Mobile	376
Land Mobile System 0-30MHz	Land Mobile	100
Limited Coast Assigned System	Maritime Coast	14
Narrowband Area Service station(s)	Broadcasting	2
Narrowcasting Service (Fixed Tax)	Broadcasting	1
Narrowcasting Service (LPON)	Broadcasting	23
National Broadcasting	Broadcasting	18
PMTS Class B	PTS	176
Radiodetermination	Radiodetermination	1
Retransmission	Broadcasting	3
Temporary Community Broadcasting	Broadcasting	2

Table 12 Emergency services with radiocommunication assets in the vicinity of the proposed Project

Emergency service	Contact details	Distance from closest site to Project boundary [km]
Australian Maritime Safety Authority	AUSTRALIAN MARITIME SAFETY AUTHORITY Australian Maritime Safety Authority GPO Box 2181 Attn: Response Division Administration, Client ID 20000768 Canberra ACT 2601	18
Department Of Biodiversity Conservation and Attractions	DEPARTMENT OF BIODIVERSITY CONSERVATON AND ATTRACTIONS Department of Biodiversity Conservation and Attractions Att: Coordinator, Telecommunications Systems Locked Bag 104 Office of Information Management BENTLEY DC WA 6983	19
Department of Fire and Emergency Services Of WA	Department of Fire and Emergency Services of WA Attn Manager Radio Communications PO Box P1174 PERTH WA 6844	13
Marine Rescue Busselton	MARINE RESCUE BUSSELTON Busselton Volunteer Marine Rescue Group Inc. BUSSELTON VOLUNTEER MARINE RES 889 Geographe Bay Road BUSSELTON WA 6280	59
St John Ambulance Western Australia Ltd.	ST JOHN AMBULANCE WESTERN AUSTRALIA LTD. ST JOHN AMBULANCE AUSTRALIA (WESTERN AUSTRALIA) INC. PO Box 183 BELMONT WA 6104	12
St. John Ambulance Australia Incorporated	ST. JOHN AMBULANCE AUSTRALIA INCORPORATED Technical Services 601-609 Blackburn Road NOTTING HILL VIC 3168	31
Surf Life Saving Western Australia Inc	SURF LIFE SAVING WESTERN AUSTRALIA INC PO Box 700 Balcatta WA 6021	16
Western Australia Police	WESTERN AUSTRALIA POLICE Radio & Electronic Services Unit 21 Swanbank Road Att: Phillip Manna MAYLANDS WA 6051	Within Project boundary

Table 13 Bureau of Meteorology radar sites in the vicinity of the proposed Project

Site ID	Site name	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]
138152	Bureau of Meteorology across the road from runway Lot 164 (286) Yangedi Rd HOPELAND	-32.3917	115.8670	205
140115	Bureau of Meteorology Met Office Albany Airport ALBANY	-34.9418	117.8164	241
44829	Walnut Rd BICKLEY	-32.0077	116.1349	253
601351	Bureau of Meteorology Office Northern Perimeter Road PERTH AIRPORT	-31.9274	115.9765	257
10000625	Off Lake Grace-Newdegate Road NEWDEGATE	-33.0970	119.0087	363
10000627	BOM Station Approximately 1.2km South of Fire Road SOUTH DOODLAKINE	-31.7770	117.9529	364
10000636	Off Edawa Road	-30.3600	116.2896	433

Table 14 Trigonometrical stations in the vicinity of the proposed Project

Station name	Datum	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]
A 394	GDA94	-34.2999	115.1580	12
A 396	GDA94	-34.2838	115.1616	11
A 397	GDA94	-34.2603	115.1671	9
A 424	GDA94	-34.3638	115.1558	16
Alouarn	AGD66, AGD84, GDA94	-34.4053	115.1946	18
Augusta 1	AGD66, AGD84, GDA94	-34.1617	115.4039	8
Augusta 14	GDA94	-34.1628	115.2400	3
Augusta 16	GDA94	-34.1600	115.2573	2
Augusta 23	GDA94	-34.1627	115.3130	2
Augusta 24	GDA94	-34.1898	115.3216	0.3
Augusta 25	GDA94	-34.2164	115.3228	0.5
Augusta 3	AGD66, AGD84, GDA94	-34.0429	115.2853	15
Augusta 30	GDA94	-34.1602	115.3365	4
Augusta 38	GDA94	-34.1925	115.1164	14
Augusta 6	GDA94	-34.3070	115.1576	12
Augusta 7	GDA94	-34.3274	115.1674	13
Augusta 73	GDA94	-34.3742	115.1367	18
Castles	AGD66, AGD84, GDA94	-34.1791	115.1667	9
Clubhouse	AGD66, AGD84, GDA94	-34.2996	115.0963	17
Dearle	AGD66, AGD84, GDA94	-34.2384	115.3537	3
Dunnet	AGD66, AGD84, GDA94	-34.3126	115.3821	9
Hillside	AGD66, AGD84, GDA94	-34.3150	115.0965	17
Ledge	AGD66, AGD84, GDA94	-34.3113	115.2349	7
Leeuwin	AGD66, AGD84, GDA94	-34.3762	115.1350	18
Leeuwin Tx Mast	AGD66, AGD84	-34.3752	115.1344	18
Prosser	AGD66, AGD84, GDA94	-34.2659	115.4678	14
Roberts	AGD66, AGD84, GDA94	-34.2885	115.3350	4
SR 16	AGD66, GDA94	-34.2853	115.2477	4
SR 1G	AGD66, AGD84, GDA94	-34.2450	115.1524	11
Snake	AGD66, AGD84, GDA94	-34.3154	115.3342	6
Strucel J	AGD66, AGD84, GDA94	-34.2439	115.2441	2
Swamp	AGD66, AGD84, GDA94	-34.3496	115.4302	15
The Cross	AGD66, AGD84, GDA94	-34.3025	115.3321	5

Table 15 Satellite vectors with potential to be intercepted by the proposed Project

Intercepted satellite	Services provided [56]	Affected dwellings[1]
Apstar 9 (MySat 1), BRIsat, Inmarsat-4F1 (Inmarsat 4-F1, I4F1, PAC-W), JCSat 16, JCSat 18 (Kacific-1), PSN 6 (PSN VI, Nusantara Satu), Superbird C2 (Superbird 7)	Programs intended for international audiences	*26*
NBN-Co 1B (Sky Muster II)	NBN satellite internet for Australian audiences	*26*

1. Involved dwellings are indicated by *underlined italic text*.

Table 16 Dwellings with increased potential to experience EMI to DTV from television broadcast transmitters

Dwelling ID[1]	Easting[2] [m]	Northing[2] [m]	Located in potential interference zone	
			Bunbury	Augusta
7	*341528*	*6217917*		*X*
8	*342040*	*6218908*		*X*
9	342689	6218169		X
10	343566	6218309		X
11	*343529*	*6214483*	*X*	*X*
12	340601	6214584	X	
15	*338564*	*6213868*	*X*	
16	*338733*	*6213357*	*X*	
17	*340918*	*6213803*	*X*	
18	*341404*	*6213392*	*X*	
19	*338804*	*6211699*	*X*	
20	340479	6207562	X	
21	340818	6207345	X	
22	341298	6207232	X	
23	341567	6206855	X	
24	341486	6206578	X	
25	*342442*	*6208726*	*X*	
26	*344715*	*6209164*	*X*	*X*
27	*345037*	*6210146*	*X*	*X*
28	347594	6209196		X
32	341223	6207695	X	
33	341234	6207287	X	

1. Involved dwellings are indicated by *underlined italic text*.
2. Coordinate system: MGA zone 50, 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 17 Summary of service operators contacted by DNV and responses received to date
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	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
1	Fixed point-to-point: three links crossing the Project site Point-to-point link #1 - #2: one turbine (T2) in potential reflection/scattering interference zone established by DNV Point-to-point link #3: one turbine (T4) in diffraction exclusion zone established by DNV, two turbines (T4, T5) in potential reflection/scattering interference zone established by DNV Fixed point-to-multipoint: Within the Project boundary Land mobile: Within the Project boundary	Electricity Networks Corporation (Western Power) 10532262-AUMEL-L-01-A	<u>Response received by email on 19 December 2024:</u> *"The near-field exclusion zone with respect to the Telecommunications structure at BNP has been calculated… The exclusion zone around the BNP structure is therefore a circle of radius approximately 230m and there is no impact from the proposed wind farm…* *To avoid diffraction effects cause by penetration of rotor blades into the microwave link path, the second Fresnel zone must remain clear. The closest turbines to the BNP – R149 and BNP – R286 links respectively and there has been no penetration of the second Fresnel zone found on either link.* *It should be noted, that based on the coordinates and turbine parameters provided, the rotor tip of Turbine 4 is approximately 4m from the maximum 2nd Fresnel zone radius of the BNP – R286 link, with less than 20m clearance with respect to the actual 2nd Fresnel zone, perpendicular to the LoS. Care should be taken by the Customer to ensure this turbine is placed accurately to the coordinates given...* *...The proposed Synergy Milyeannup (Beenup) Wind Farm should not cause any EMI impact on existing Telecommunications links and services out of BNP. This conclusion assumes locations of the BNP telecommunications structure (under construction as at the time of this analysis) and the proposed wind turbines are accurate and are constructed as proposed..."*
2	Fixed point-to-point: two links crossing the Project site Point-to-point link #9 - #10: no turbines in interference zones established by DNV	Western Australia Police (WA Police) 10532262-AUMEL-L-02-A	<u>Response received by email on 03 December 2024:</u> *"The Change Team has reviewed your submission and the outcome has been designated as approved based on documents/information submitted."*

Table 17 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
3	Fixed point-to-point: four links crossing the Project site Point-to-point #5: no turbines in interference zones established by DNV Point-to-point link #6: three turbines (T4, T5, T6) in reflection/scattering interference zone established by DNV Point-to-point link #7: one turbine (T8) in diffraction exclusion zone established by DNV Point-to-point link #8: two turbines (T10, T13) in diffraction exclusion zone established by DNV	Telstra Corporation Limited (Telstra) 10532262-AUMEL-L-03-A	Turbine layout provided on 26 November 2024, no response received to date
4	Fixed point-to-point: one link crossing the Project site Point-to-point link #4: no turbines in interference zones established by DNV PMTS/spectrum (mobile phone): Within the Project boundary	Optus Mobile Pty Ltd (Optus) 10532262-AUMEL-L-04-A	Response received by email on 03 December 2024: *"Our technical team has reviewed this proposal and advised no interference issues with Optus equipment."*
5	Fixed point-to-multipoint: 13 km from the Project boundary	Water Corporation 10532262-AUMEL-L-05-A	Response received by email on 25 February 2025, following advice from DNV that there may be a potential for interference to a link if it is within 300 meters of the wind farm boundary: *"…as of now, we do not have any sites within a 300-meter radius of the wind farm boundaries"*

Table 17 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	Meteorological radar: 204 km from Project boundary	Bureau of Meteorology (the Bureau) 10532262-AUMEL-L-13-A	<u>Response received by email on 10 December 2024:</u> *"The Bureau of Meteorology's assessment of the proposed Beenup wind farm is now complete, which indicates manageable impact to our neighboring assets, under normal weather propagation conditions.* *The Bureau requests that the owner/operator of the Beenup wind farm:* • *informs the Bureau of any changes in the wind farm, including varying the layout of the farm, changing the location of a turbine more than 100 meters, or altering turbine height* • *informs the Bureau at least 2 weeks, if practical, 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* • *collaborates with the Bureau in the event of severe weather conditions to assist in matters of community safety.* *A letter from Beenup Wind farm accepting the above is needed to finalize the work for this wind farm."*
7	Trigonometrical station: 0.3 km from the Project boundary GNSS station: 16 km from Project boundary	Geoscience Australia 10532262-AUMEL-L-14-A	<u>Response received by email on 11 November 2024:</u> *"Geoscience Australia do not foresee any interference to our GNSS infrastructure as a result of the proposed Beenup Wind Farm"*

Table 17 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
8	PMTS/spectrum (mobile phone): 5.8 km from the Project boundary	NBN Co 10532262-AUMEL-L-15-A	<u>Response received by email on 05 December 2025:</u> *"…have reviewed the data provided based on the proposed wind farm location; several of the proposed towers are inside existing nbn wireless coverage boundaries and there is one existing nbn customer inside the wind farm boundary. However, the proposed wind tower locations pose no risk of introducing a physical obstruction along any customer RF profiles.* *It is also noted that none of the wind tower locations are in, or near, any boresight paths of existing nbn microwave links…* *…please provide information on any RF transmission equipment planned to be used during construction or permanently installed so a potential interference impact can be assessed. This information should include as a minimum the operating transmission frequency and transmit power, channel bandwidths, antenna types and radiation patterns as well as the exact location with antenna height, boresight azimuth and tilt (mechanical and electrical tilt)…* *…We confirm that NBN Co Spectrum Pty Ltd (**nbn Spectrum**) has a number of spectrum licenses within 75 km of the proposed Beenup Wind Farm.* *nbn have 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.* *nbn will be forced to consider its position as part of the planning should there an interference issue.* *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…"*

LIST OF FIGURES

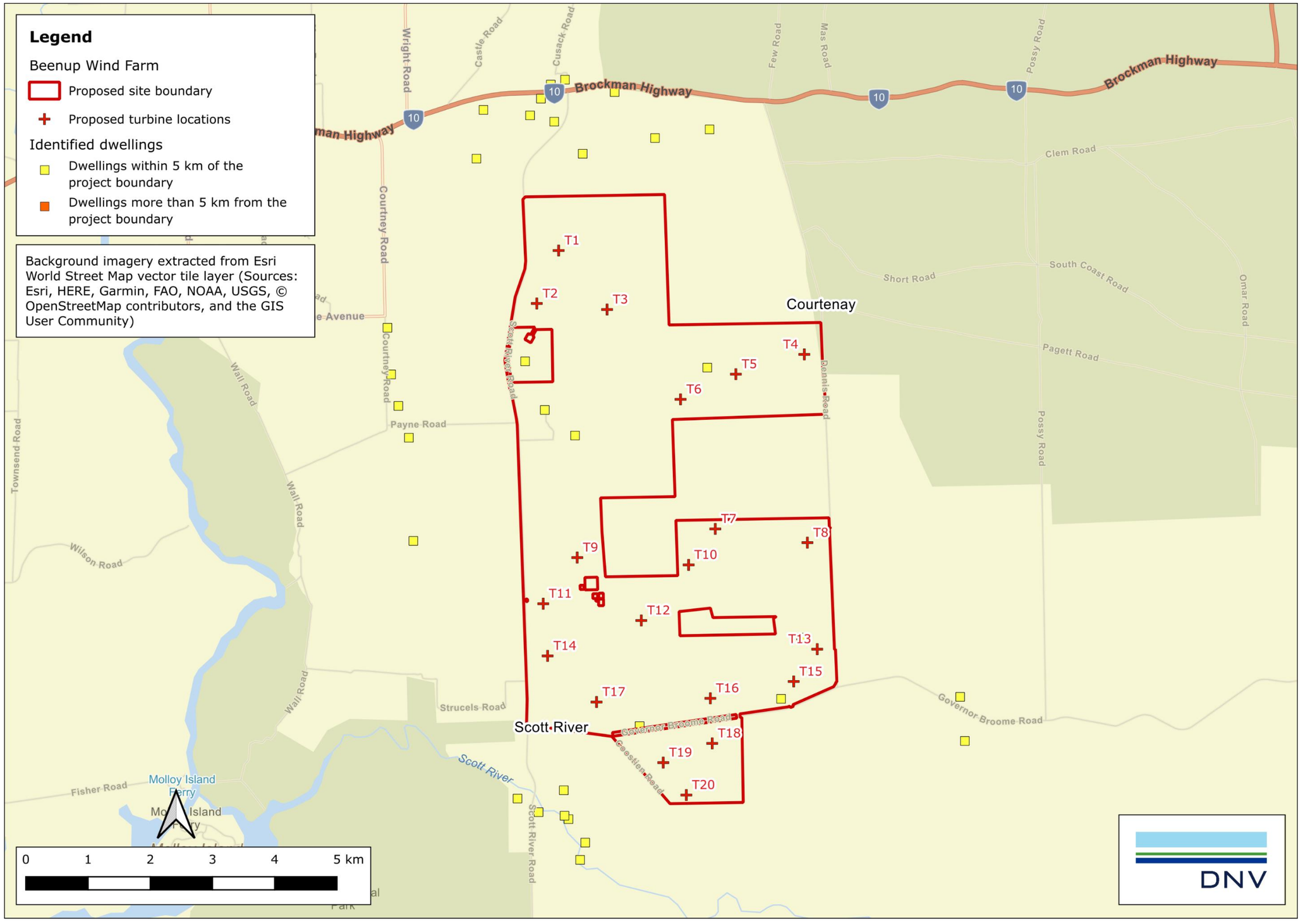

Figure 1 Map of the proposed Project, showing proposed boundary, turbine locations, and locations of nearby dwellings

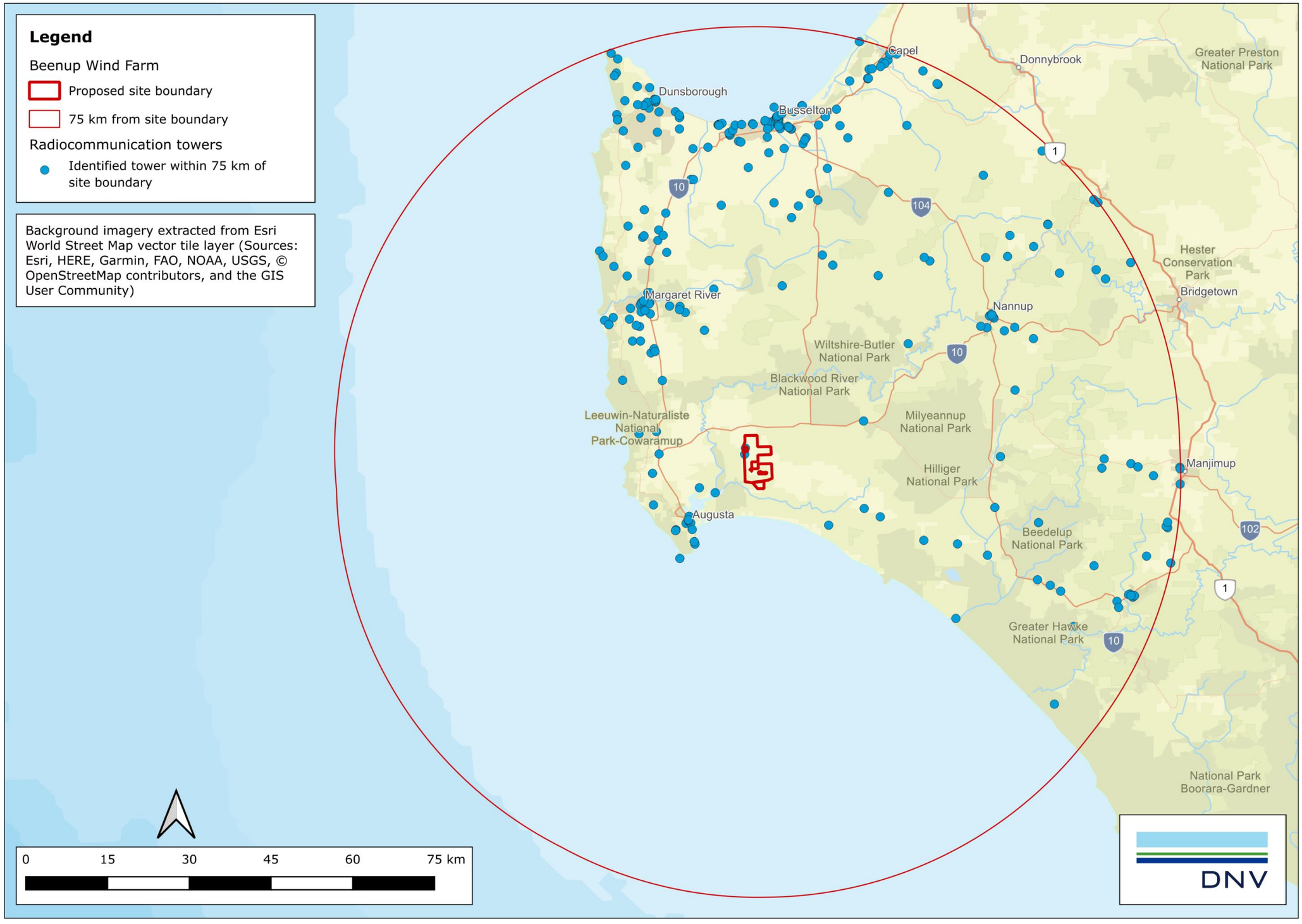

Figure 2 Location of the proposed Project and identified nearby radiocommunication sites

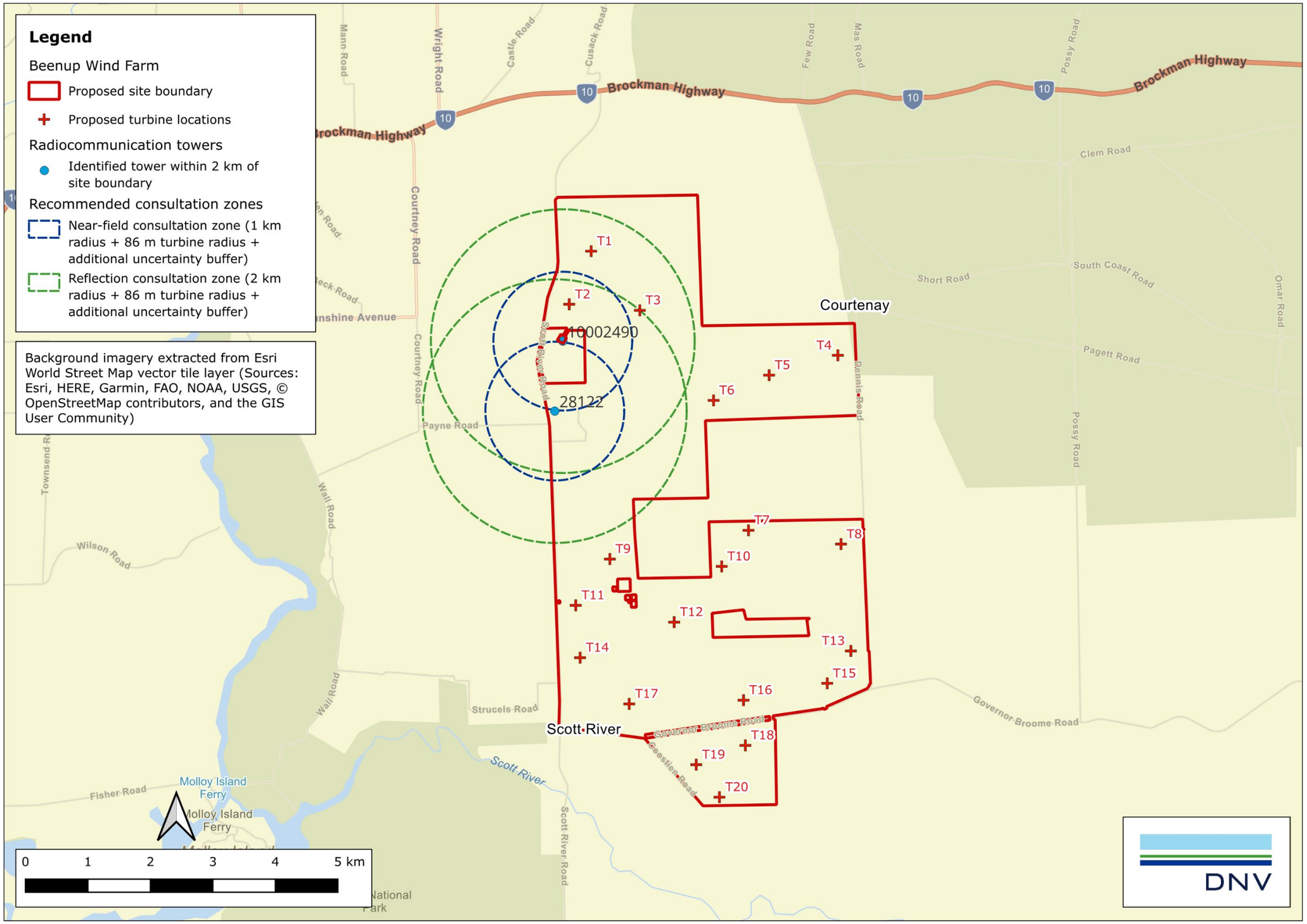

Figure 3 Identified radiocommunication sites within 2 km of the turbine locations for the proposed Project

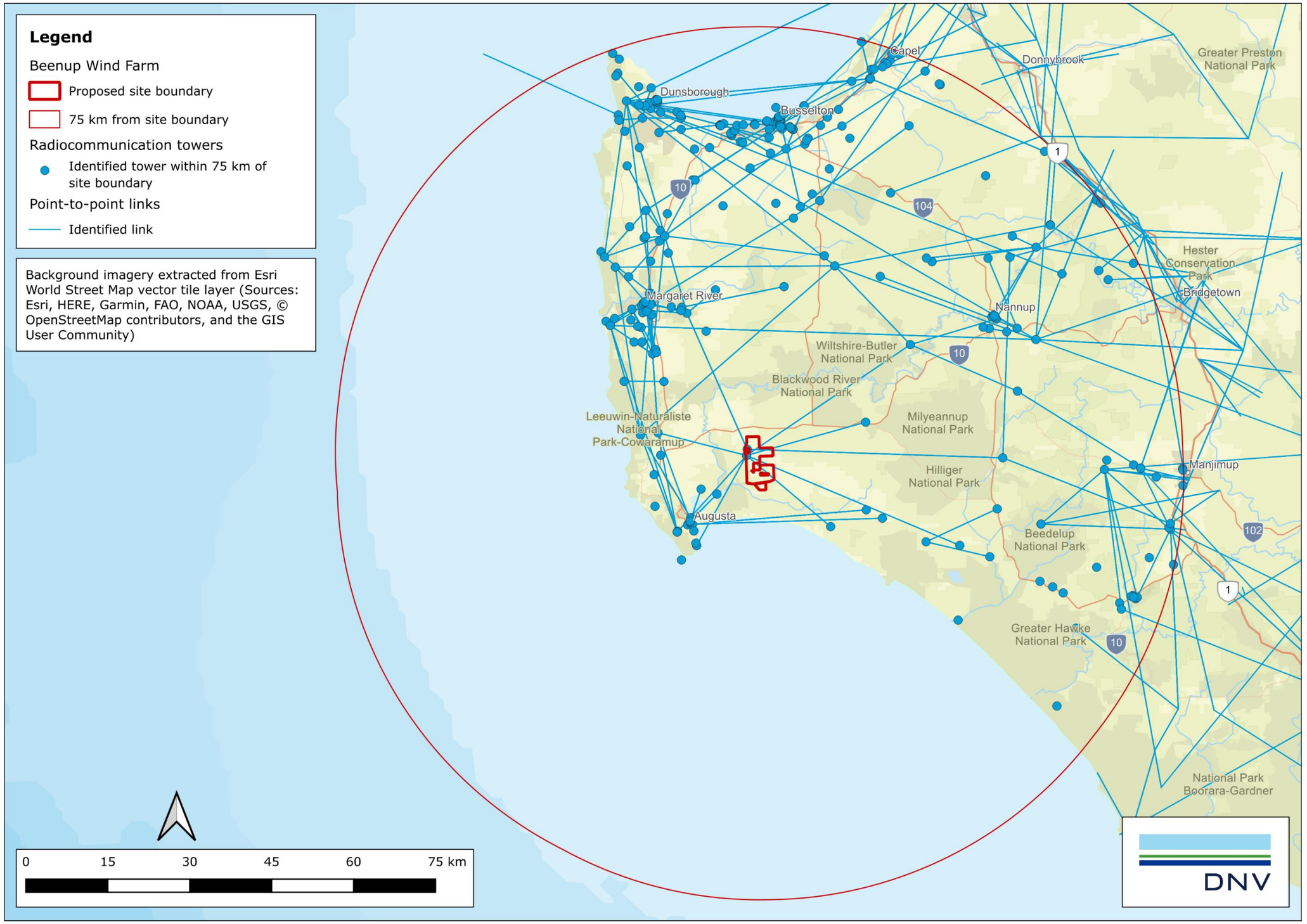

Figure 4 Identified transmission vectors for fixed licences of point-to-point type in the vicinity of the proposed Project

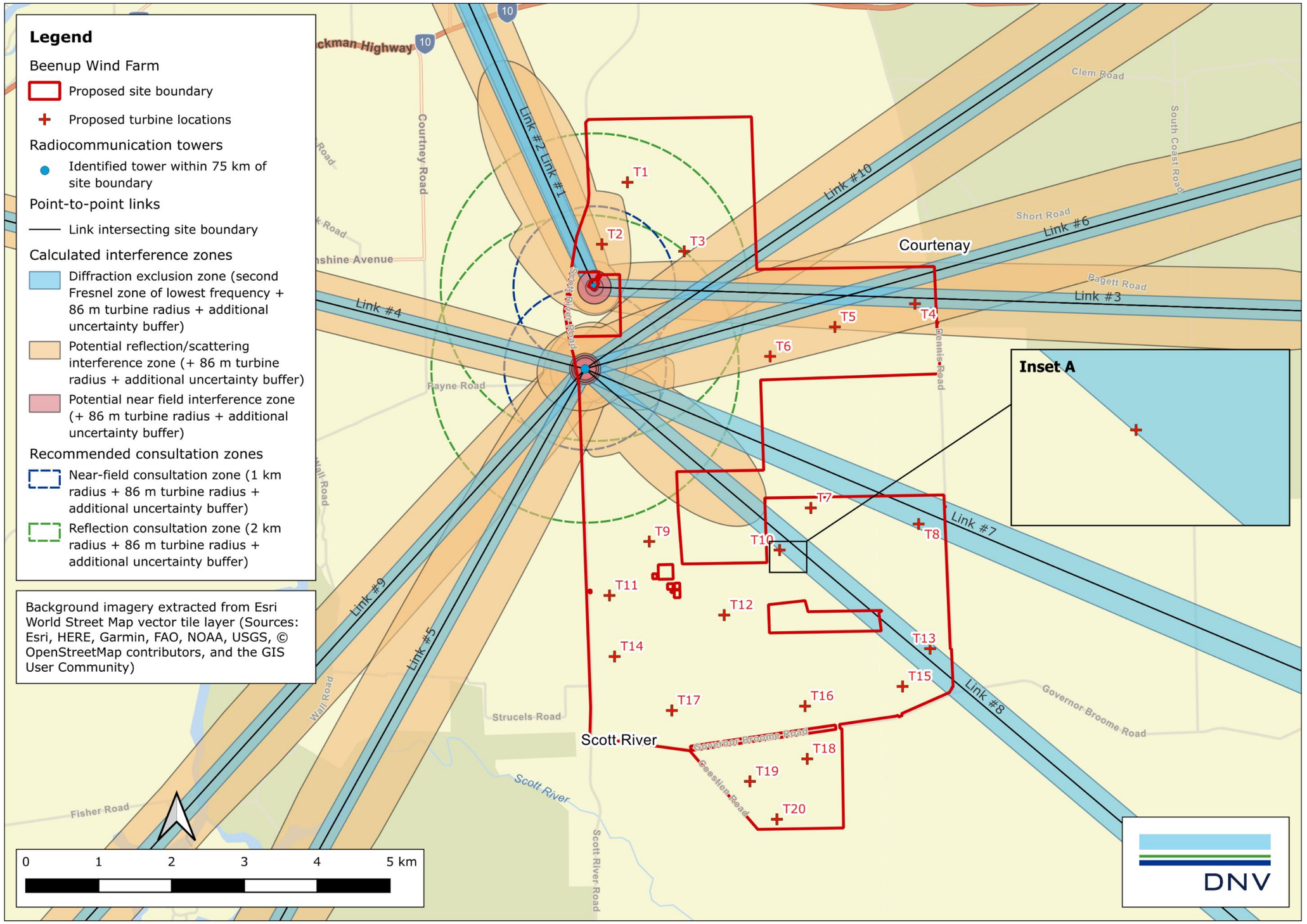

Figure 5 Identified point-to-point radiocommunication vectors crossing the proposed Project and calculated interference zones

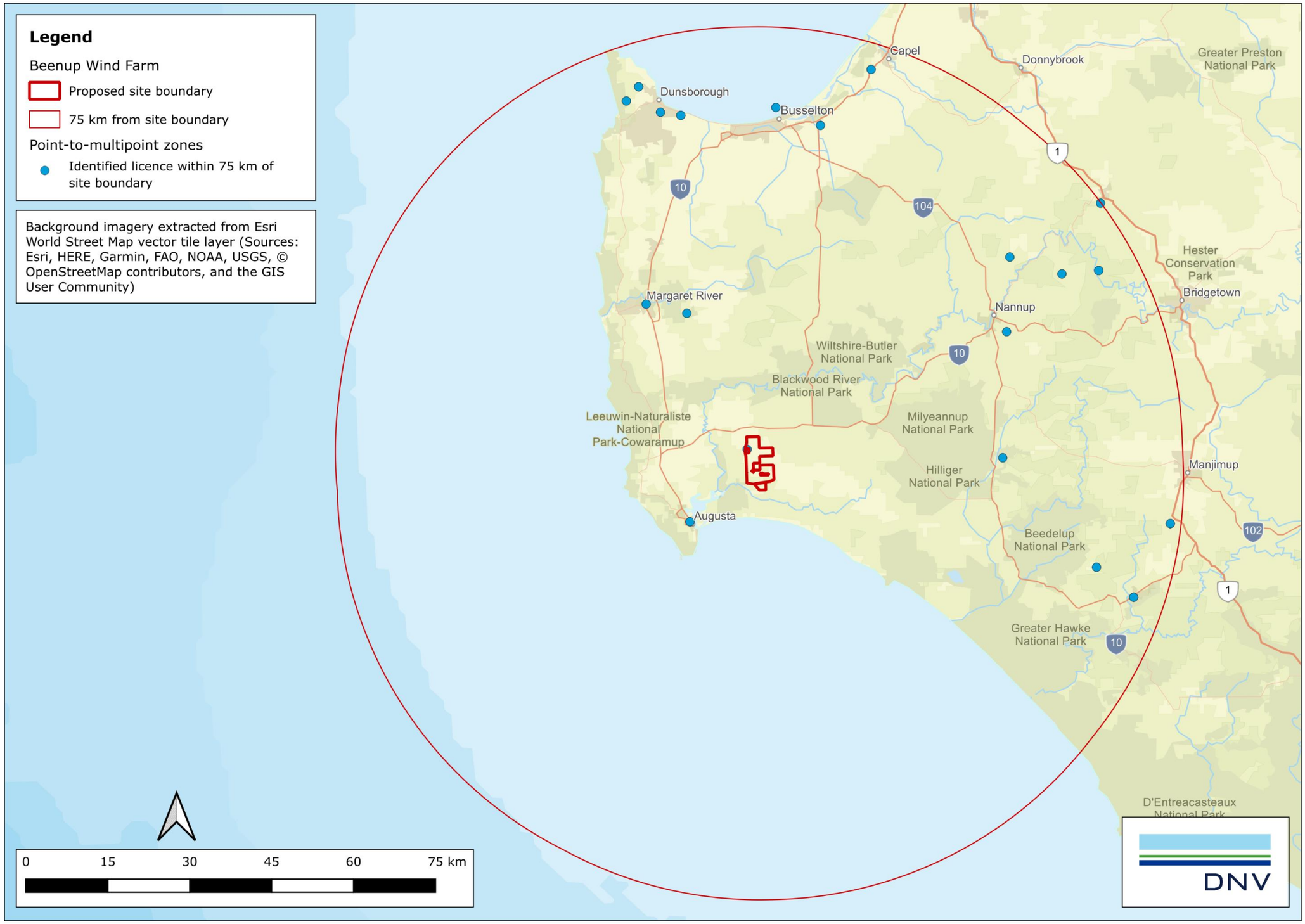

Figure 6 Location of point-to-multipoint licences in the vicinity of the proposed Project

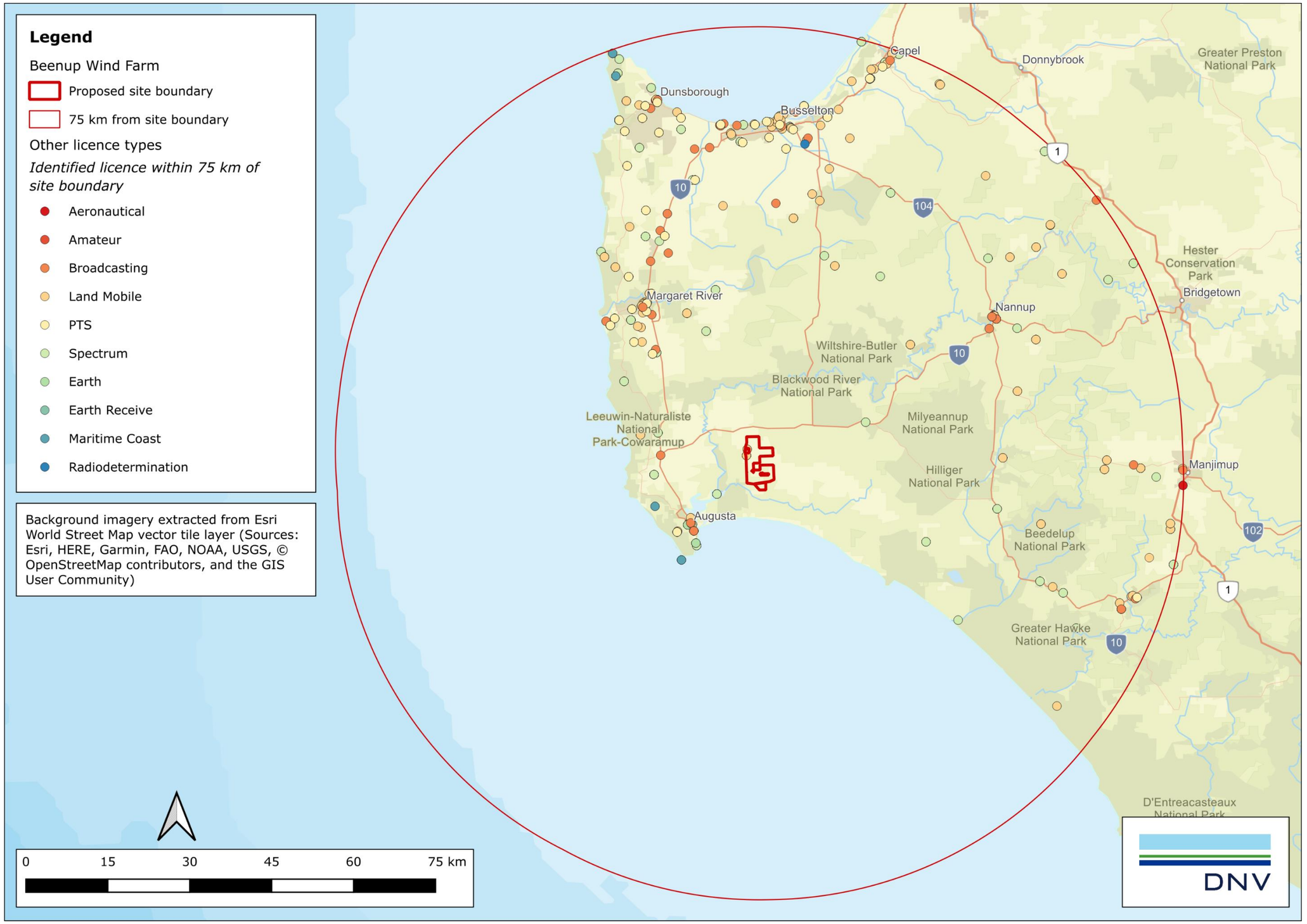

Figure 7 Location of other licence types within 75km of the proposed Project

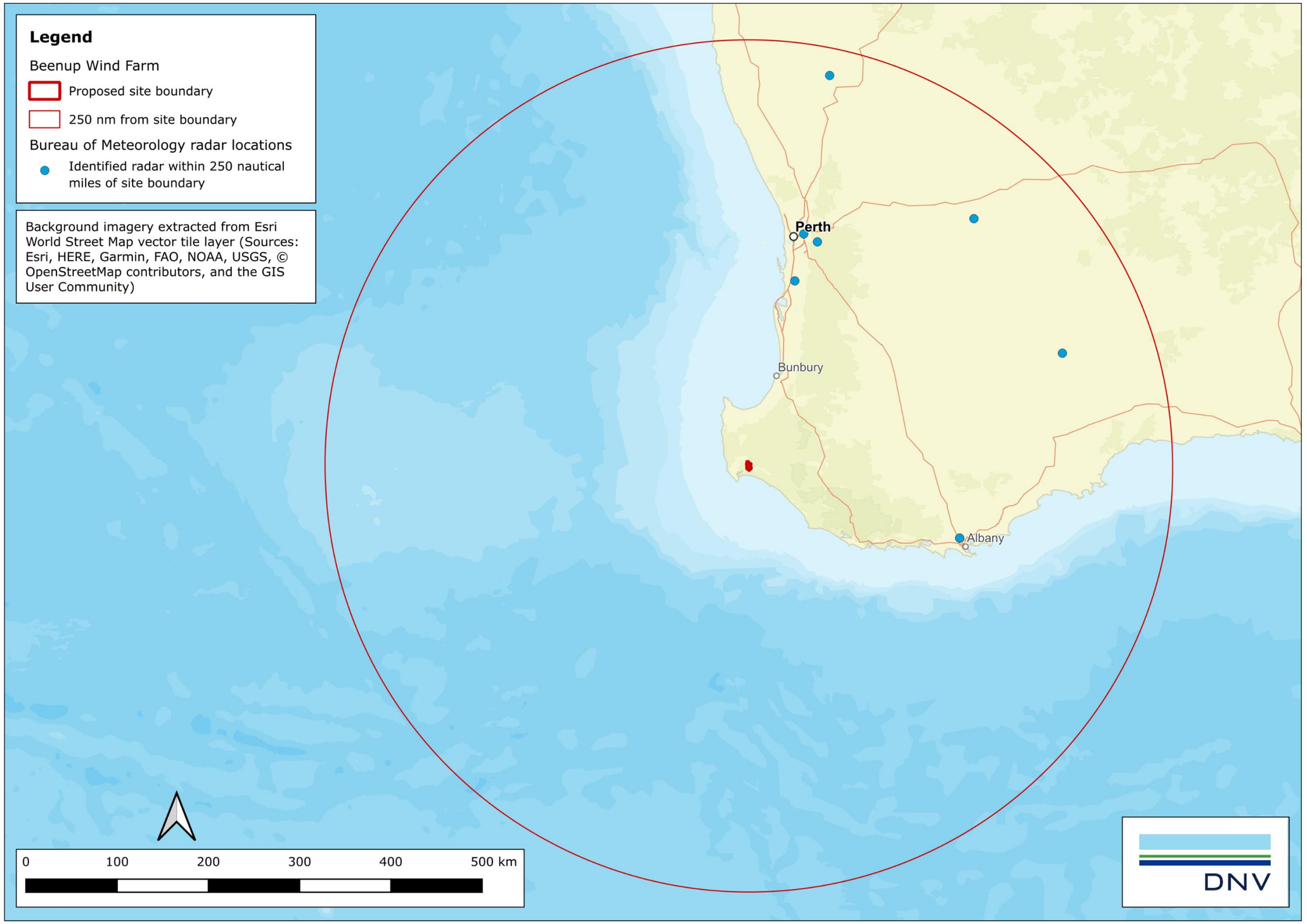

Figure 8 Location of meteorological radar sites within 250 nautical miles of the proposed Project

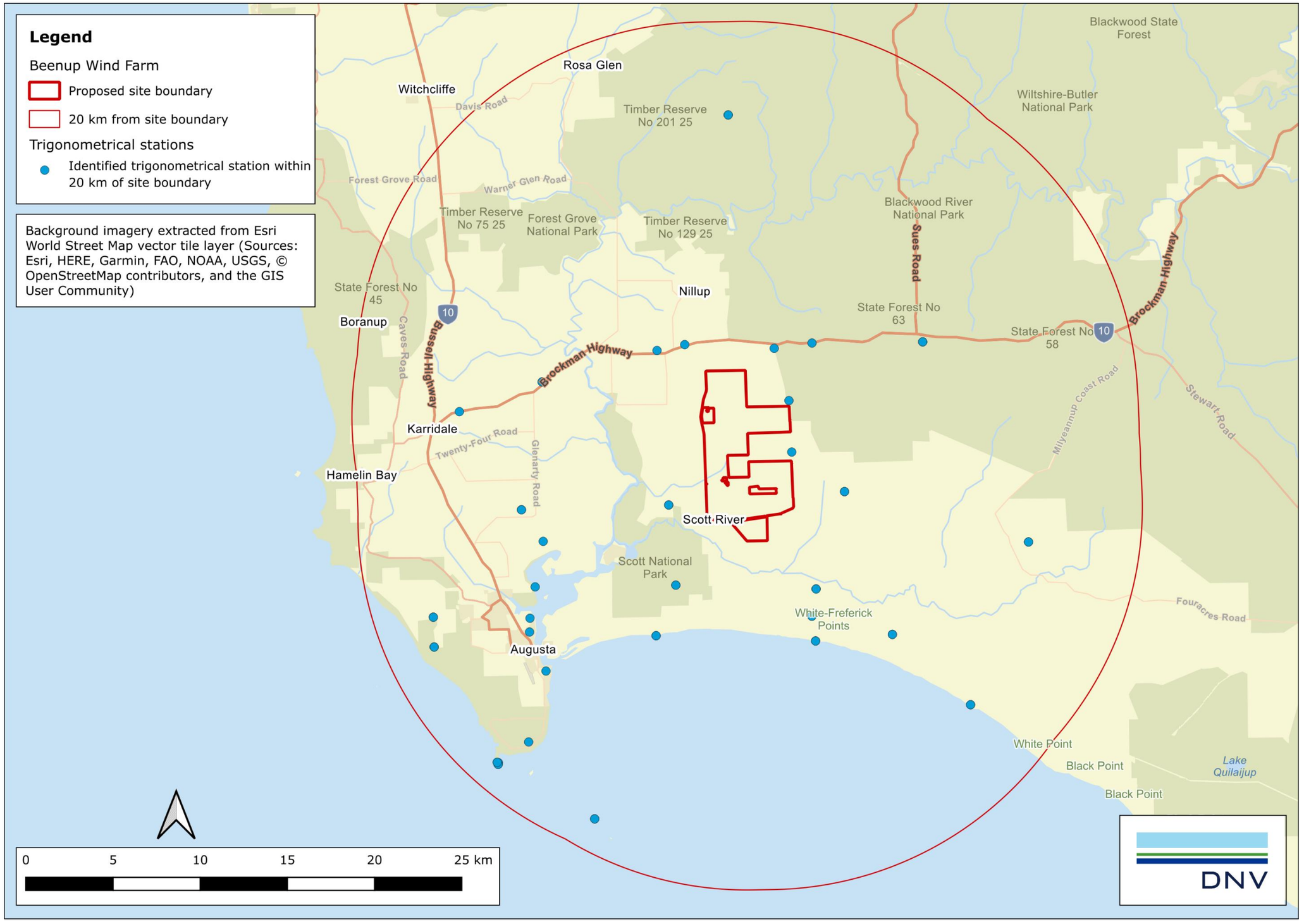

Figure 9 Location of trigonometrical stations within 20 km of the proposed Project

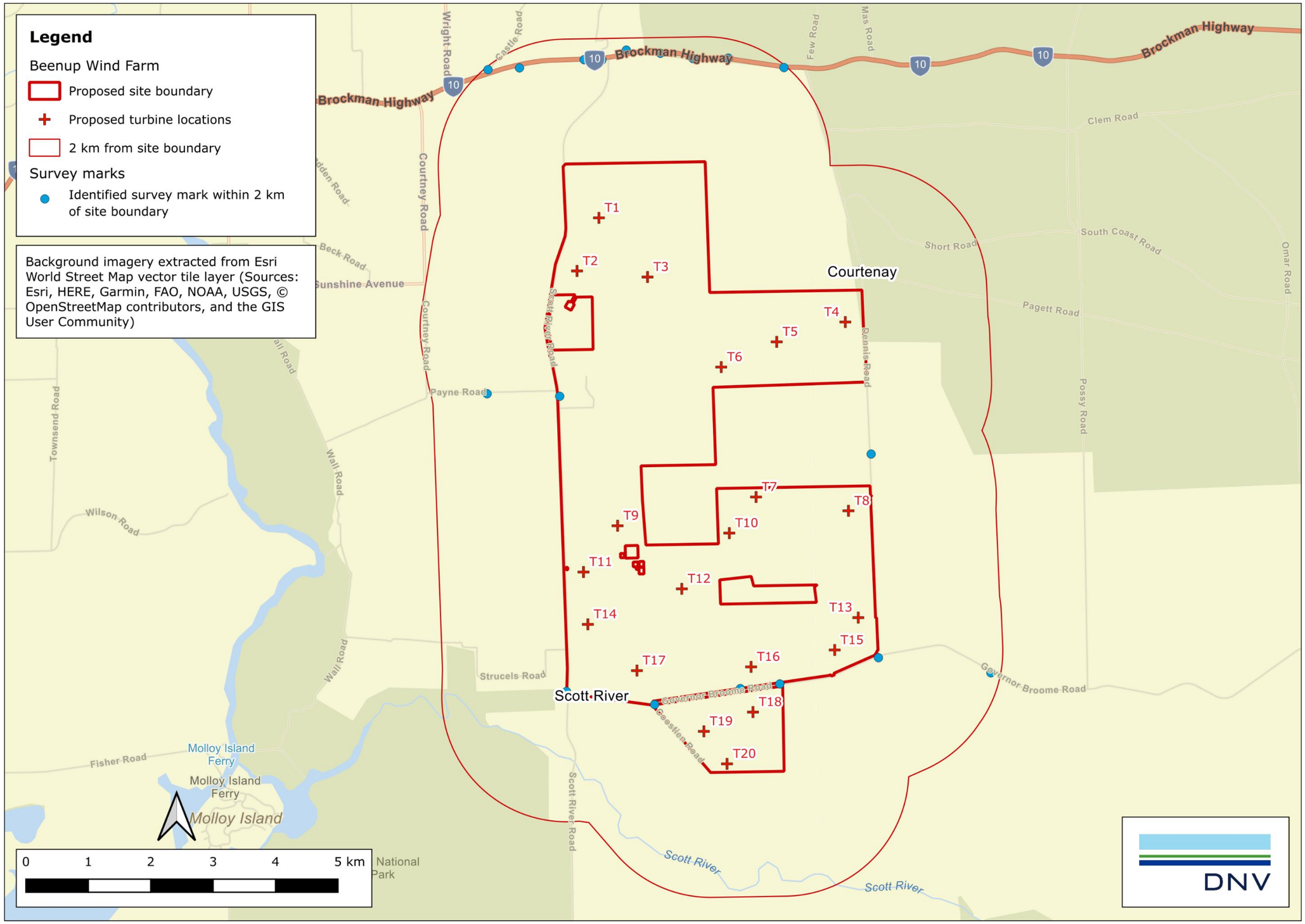

Figure 10 Location of permanent survey marks within 2 km of the proposed Project boundary

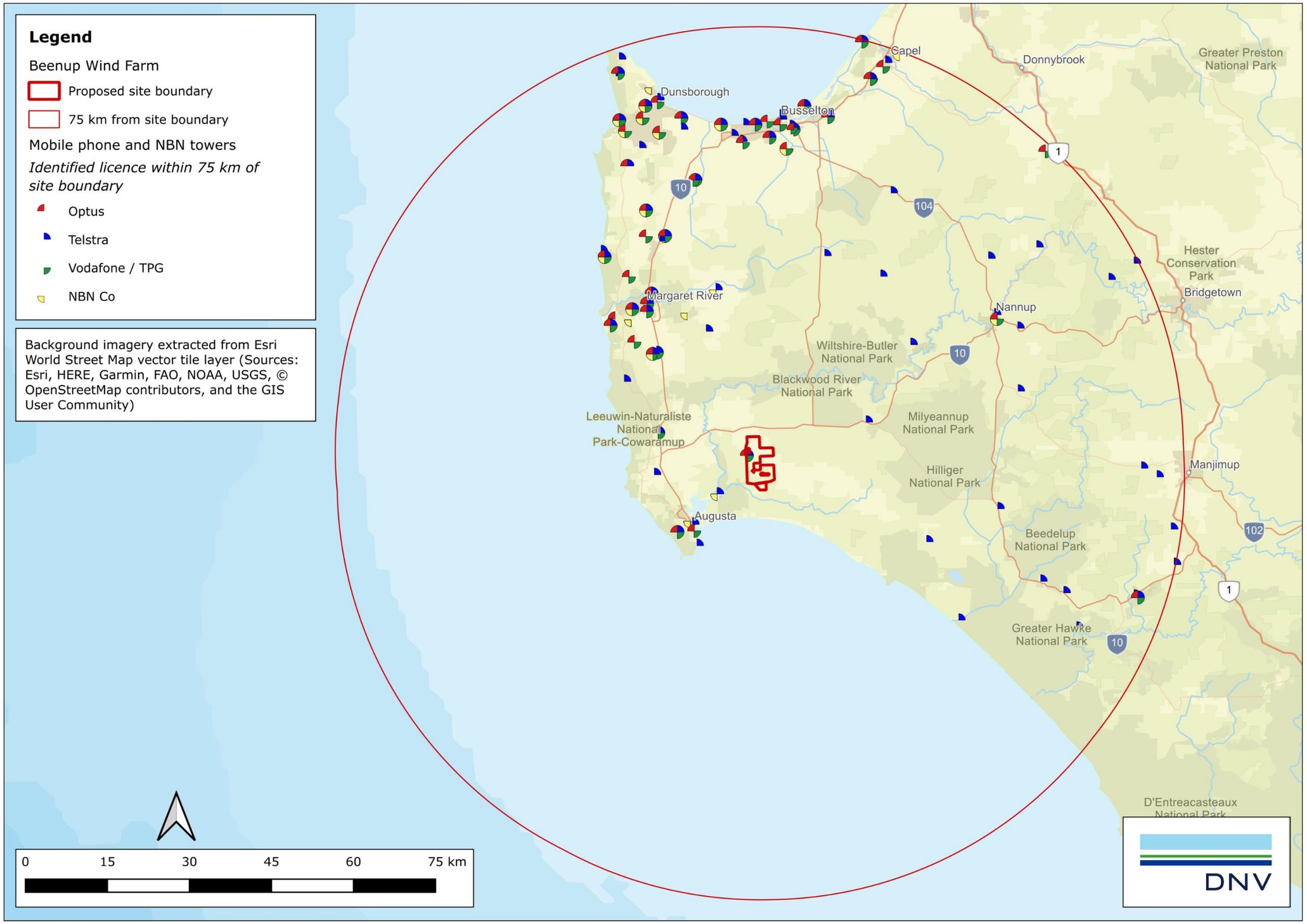

Figure 11 Location of mobile phone and NBN towers within 75 km of the proposed Project

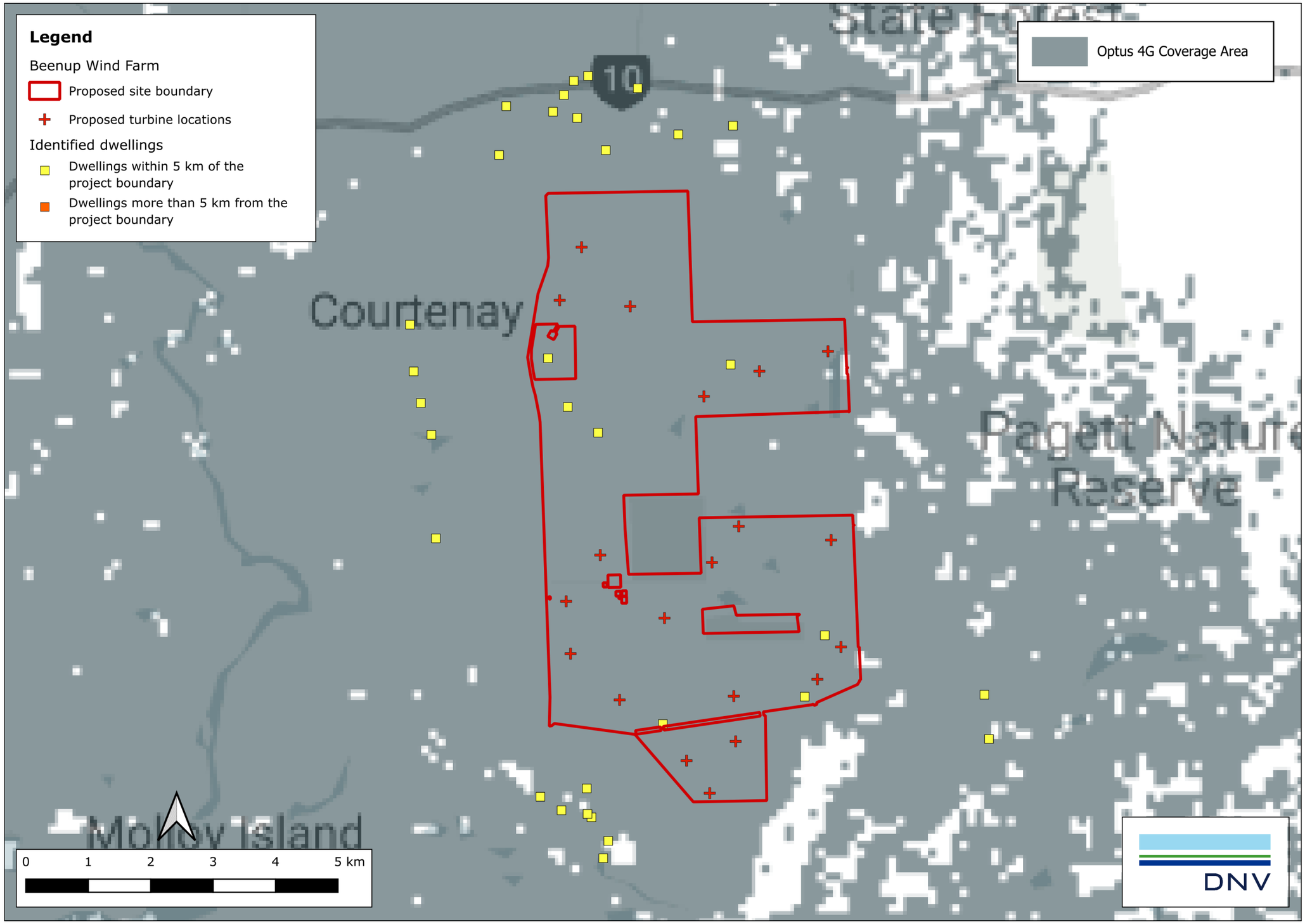

Figure 12 Optus Mobile 4G network coverage for the proposed Project

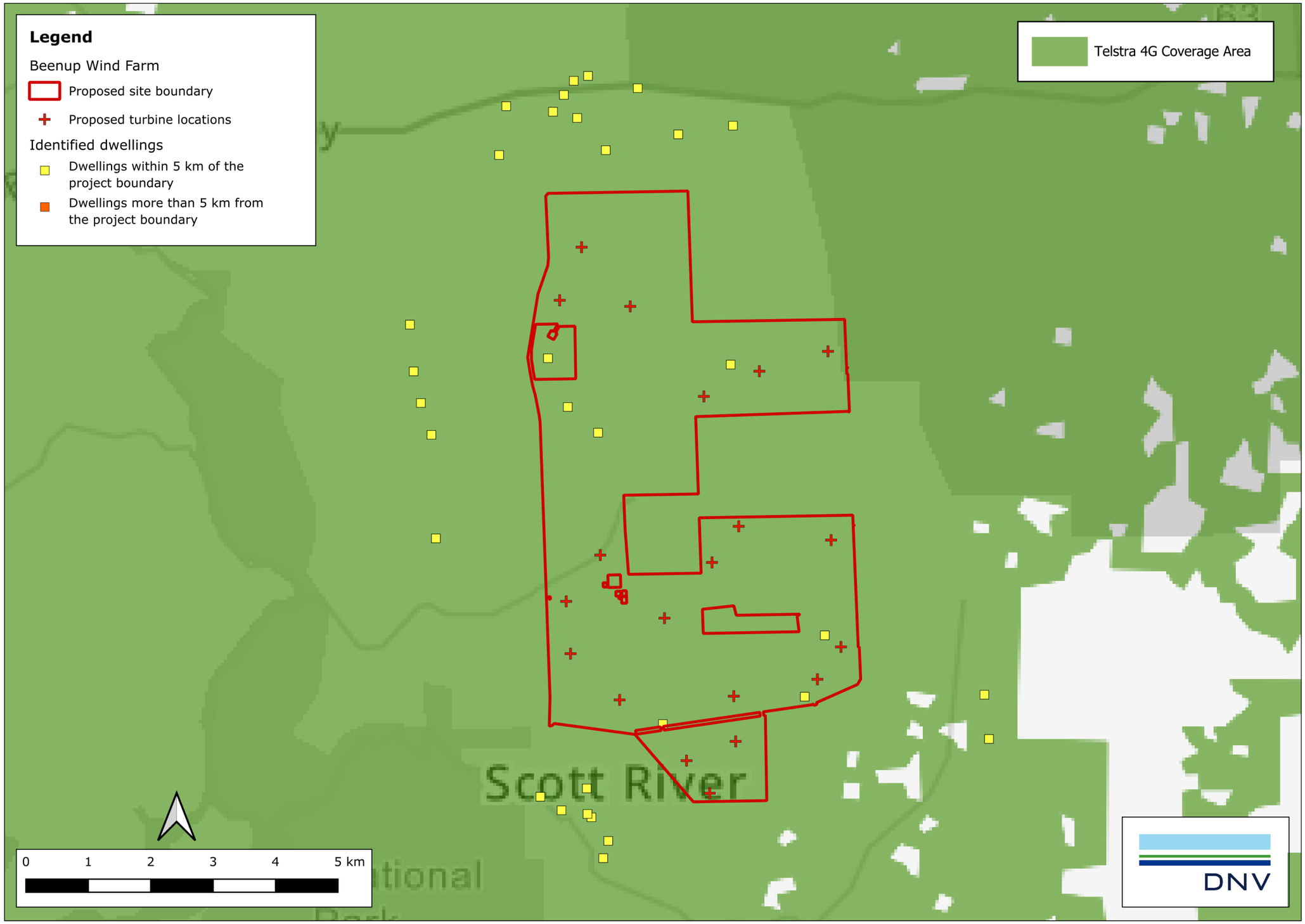

Figure 13 Telstra 4G network coverage for the proposed Project

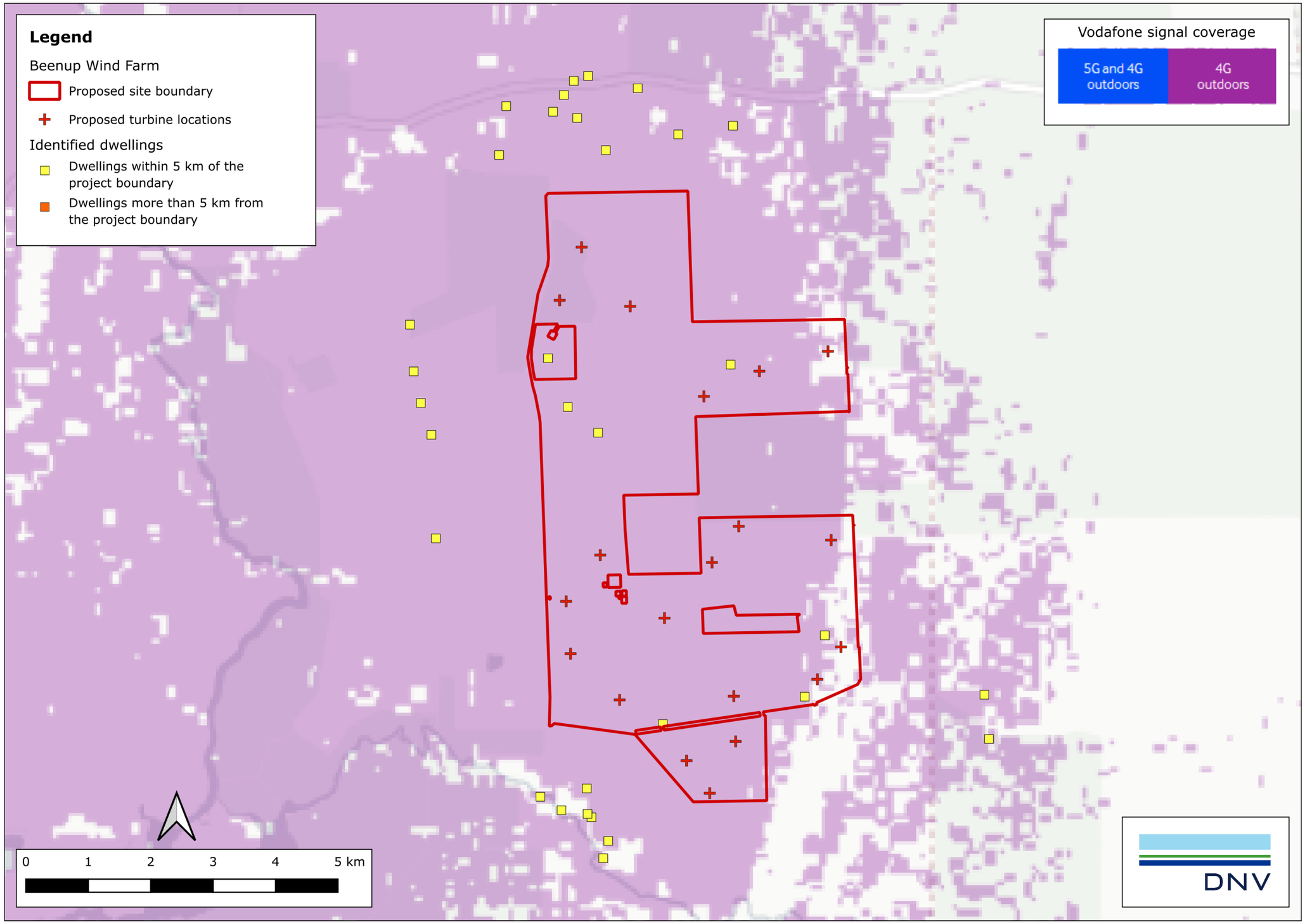

Figure 14 Vodafone/TPG network coverage (Apple iPhone 13 handset) for the proposed Project

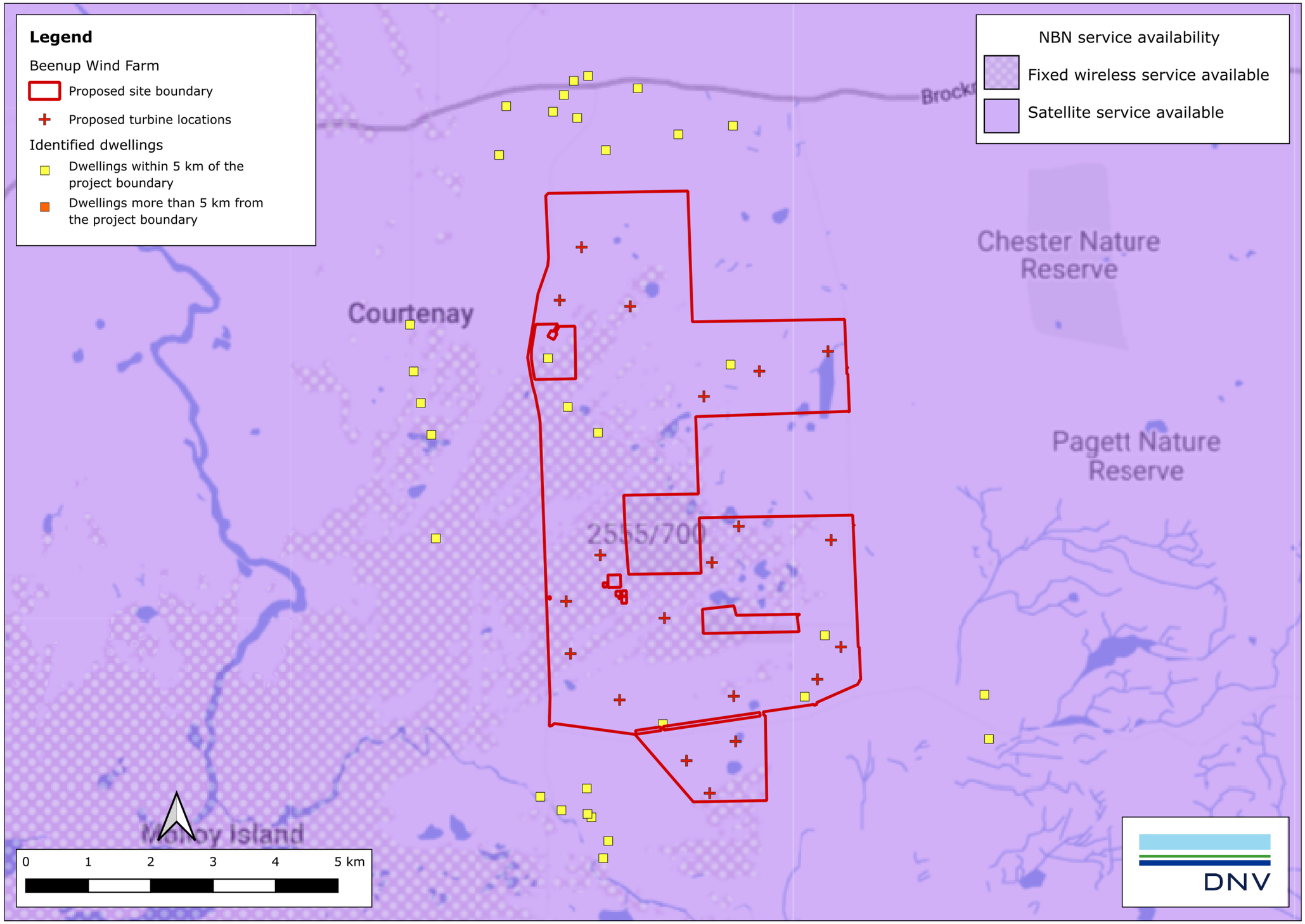

Figure 15 NBN internet coverage in the vicinity of the proposed Project

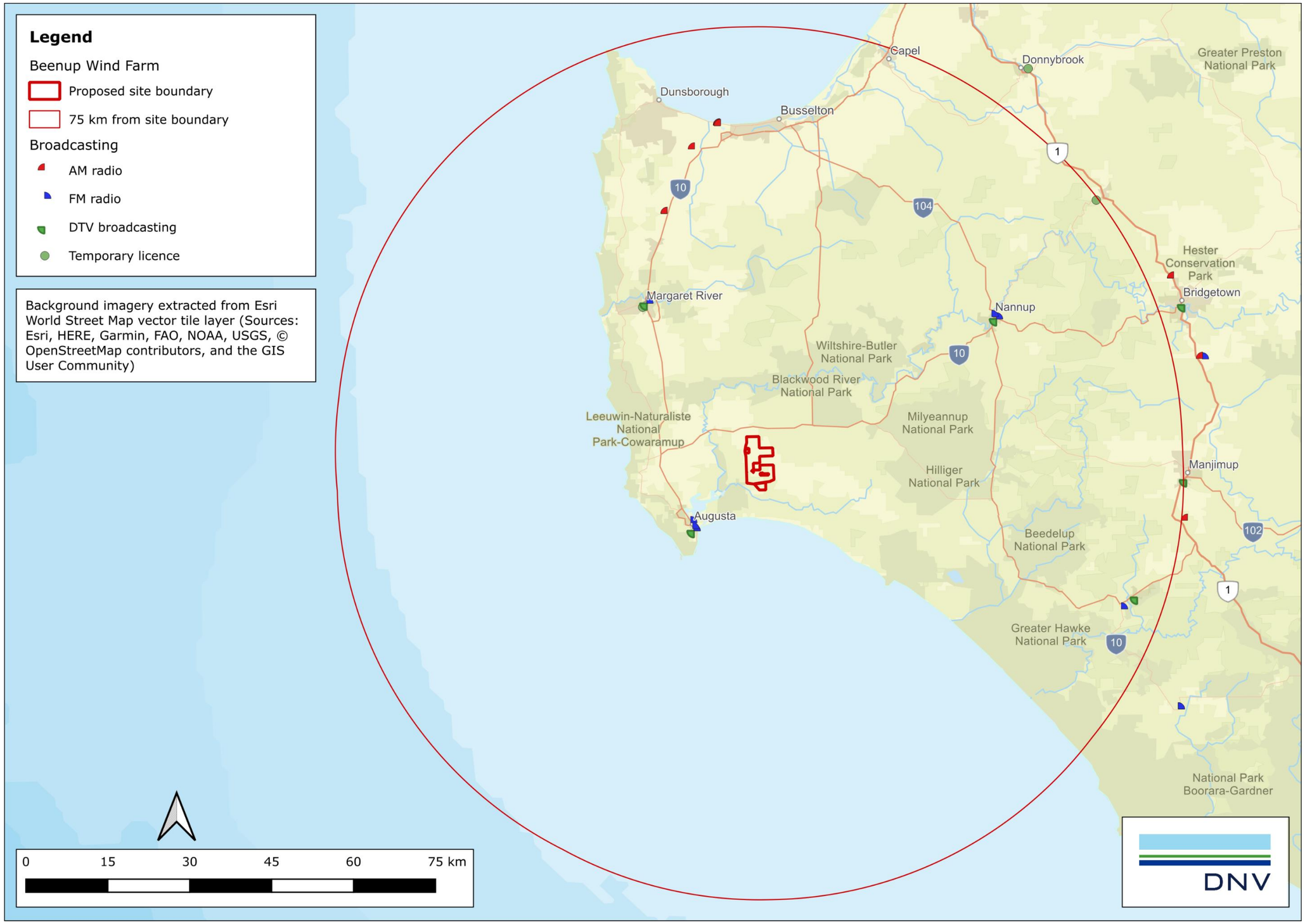

Figure 16 Location of broadcast transmitters in the vicinity of the proposed Project

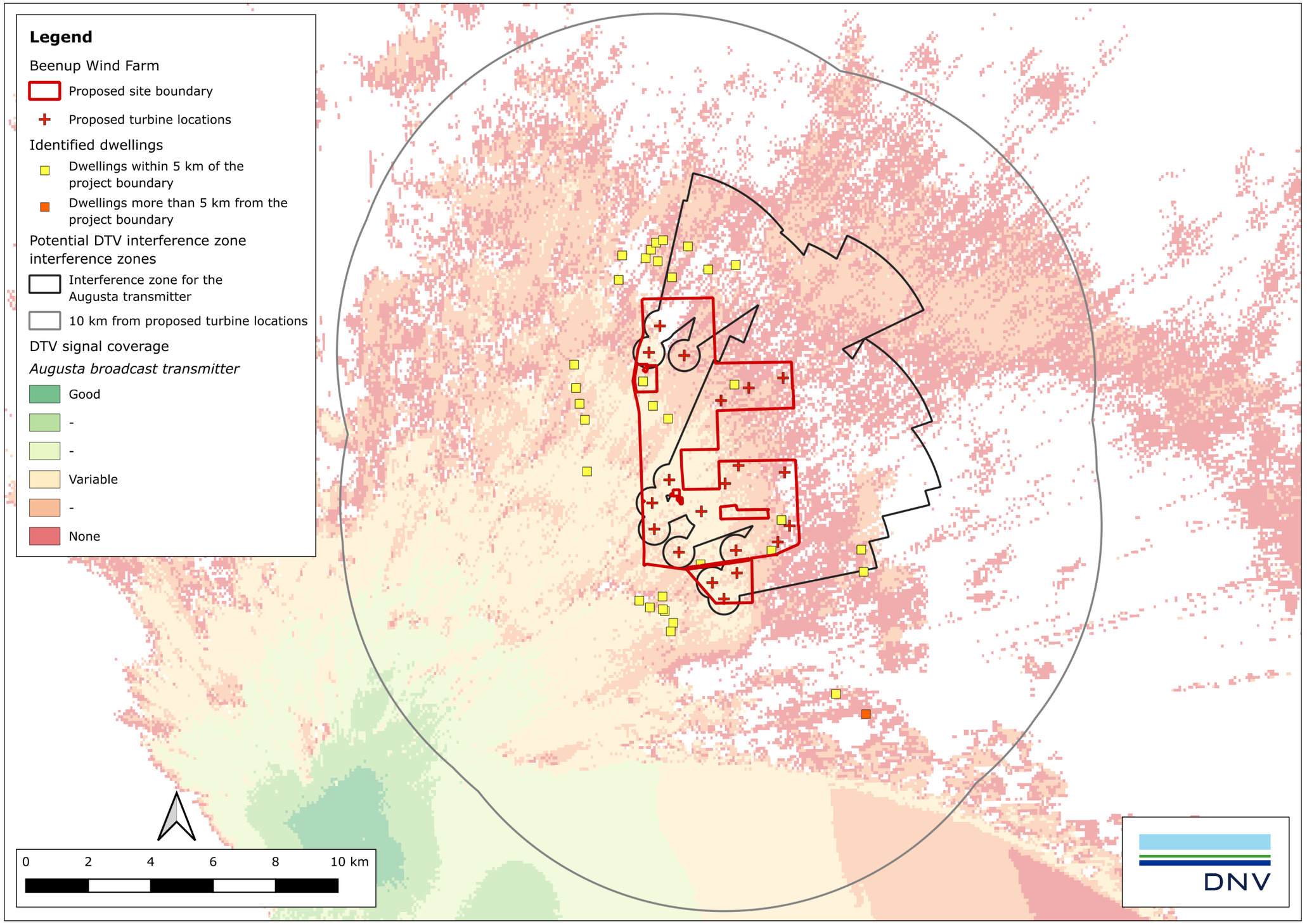

Figure 17 Potential television EMI zones for the Augusta broadcast transmitter from the proposed Project

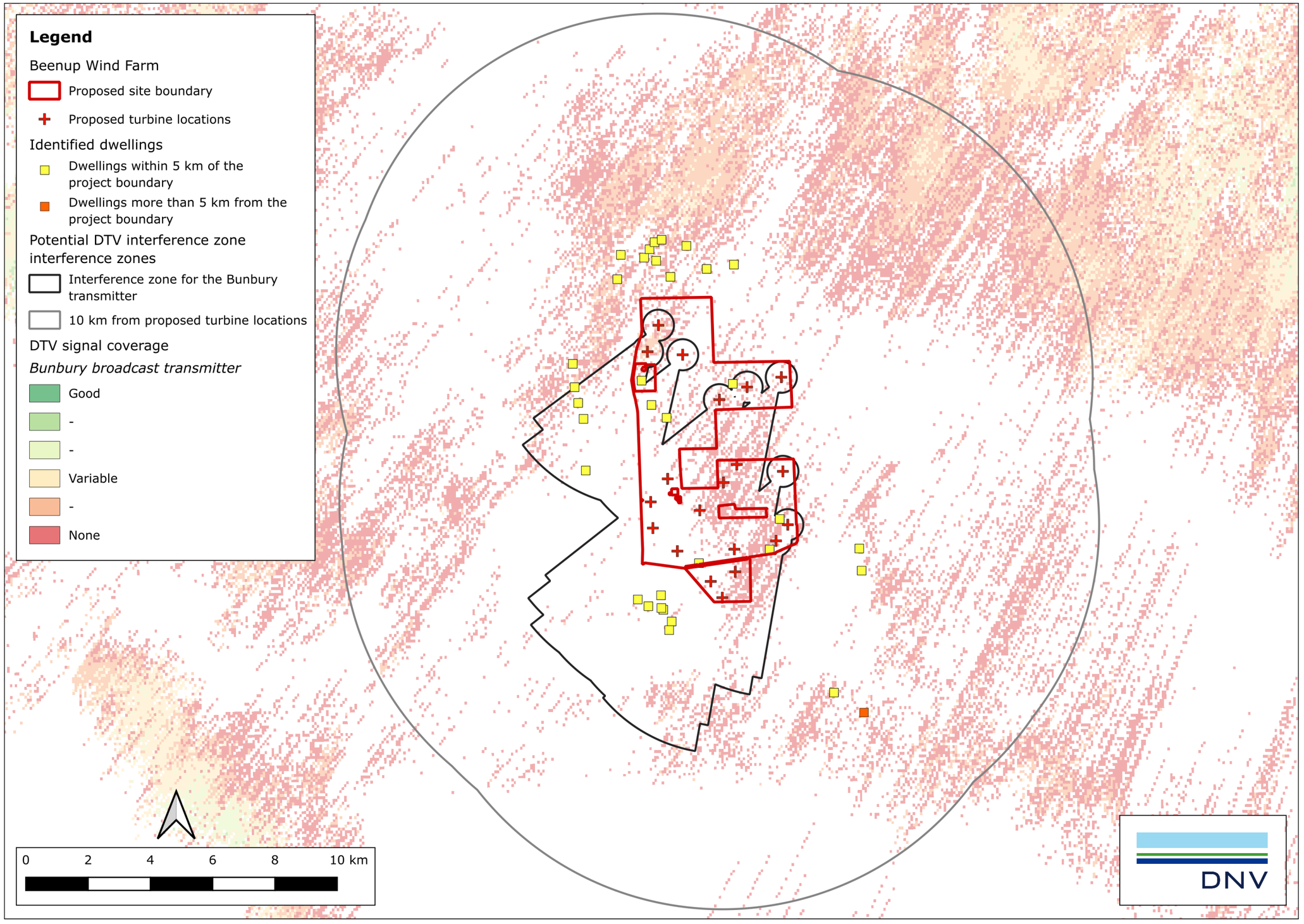

Figure 18 Potential television EMI zones for the Bunbury broadcast transmitter from the proposed Project

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.

Whether assessing a new ship design, optimising the performance of a wind farm, analysing sensor data from a gas pipeline or certifying a food company's supply chain, DNV enables its customers and their stakeholders to make critical decisions with confidence.

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