TATHRA WIND FARM

EMI Assessment

Urbis Ltd

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EXECUTIVE SUMMARY

DNV has been commissioned by Urbis Ltd (or "Urbis") to independently assess potential electromagnetic interference (EMI) impacts associated with the development and operation of the proposed Tathra 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 140 wind turbines with a rotor diameter of 180 m, and upper tip height of 250 m has been considered. These dimensions represent the maximum tip height and maximum rotor diameter under consideration for the Project.

There are 19 identified dwellings within 5 km of the Project, 3 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.

In its current configuration, the Project has the potential to interfere with two point-to-point links crossing the proposed Project boundary operated by the Department of Biodiversity, Attractions and Conservation, and the Electricity Networks Corporation (Western Power). DNV has calculated the potential interference zones for these links and have identified several turbines at the Project situated within the recommended exclusion zones of both links.

Feedback has been provided by Western Power and no concerns have been raised regarding their point-to-point links crossing the Project. The Department of Biodiversity, Attractions and Conservation have been contacted regarding potential impacts to their point-to-point links crossing the Project boundary, although feedback has not yet been received. DNV recommends that in the absence of feedback from the Department of Biodiversity, Attractions and Conservation the turbines be relocated to be outside the diffraction exclusion zone established in this assessment to avoid the potential for impact to the links.

Through consultation, the Bureau of Meteorology (the Bureau) has raised concerns about the potential for the Project to interfere with their meteorological radar at Watheroo, and the associated impacts to their operations and services. DNV recommends that the proponent of the Project engages further with the Bureau to understand the nature of the potential impacts and how these might be mitigated.

Turbines at the Project may also 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. Coverage maps for these transmitters indicate that most of the identified dwellings are unlikely to be receiving signals from the DTV transmitters nearest to the Project. However, if any dwellings are currently receiving signals from these transmitters there may be potential for those dwellings to receive a stronger reflected signal from a turbine and therefore to experience interference. If interference to these types of services is experienced, a range of options are available to rectify difficulties.

Since it is not possible to determine the potential EMI impacts on point-to-multipoint links, emergency services and wireless internet services without obtaining further information from the relevant operators, DNV has consulted with organisations operating services that may be affected by the Project. Responses have been received from several operators and to date, no concerns have been raised.

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

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
Radio-communication towers	No towers within 2 km of proposed turbine locations	Consultation not considered necessary	None	None required
Fixed point-to-point links	2 links crossing Project boundary, operated by: Department of Biodiversity, Attractions and Conservation Electricity Networks Corporation (Western Power) **Department of Biodiversity, Attractions and Conservation link:** 7 turbines in diffraction zones **Western Power link:** 3 turbines in diffraction zones	**Western Power:** No concerns raised **Department of Biodiversity, Attractions and Conservation:** No response received	Likely to cause interference	If required - relocate turbines to be outside interference zones, reroute affected links, install additional towers, replace affected links with alternative technologies
Fixed point-to-multipoint links	54 assignments within 75 km of Project boundary 3 base stations within 20 km of Project boundary, operated by: Water Corporation Western Power Iluka Resources Limited	**Western Power and Water Corporation:** No concerns raised **Iluka Resources Limited:** No response received	Potential for interference if link paths cross the Project near turbines	If required – reroute affected links, install additional towers, replace affected links with alternative technologies
Other licence types	**Point-to-area style communications:** see findings for emergency services, mobile phones, radio broadcasting, and television broadcasting	-	-	-
Emergency services	**Point-to-point links:** 1 Department of Biodiversity, Attractions and Conservation link crossing boundary (see above) **Point-to-area style communications:** unlikely to be affected	**Department of Fire and Emergency Services of WA:** no concerns raised **Other operators:** No response received	**Point-to-point links:** Likely to cause interference **Point-to-area style communications:** Unlikely to cause interference	**Point-to-point links:** as for point-to-point links **Point-to-area style communications:** if required – increase signal strength from affected tower or alternative towers, install signal repeater, install additional tower
Meteorological radar	Nearest radar: 90 km from Project	Likely to cause interference to Watheroo radar	Likely to cause interference to Watheroo radar	To be determined through consultation with the Bureau of Meteorology

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
Trigonometrical stations	**Trigonometrical stations:** unlikely to be affected **Survey marks:** unlikely to be affected	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	**Optus and Vodafone:** No concerns raised **Telstra:** No response received	Unlikely to cause interference	If required – increase signal strength from affected tower or alternative towers, install additional tower
Wireless internet	**Wireless broadband service providers:** mobile phone networks, NBN Co **NBN:** available as a satellite service only	No concerns raised	**Wireless broadband services**: see findings for mobile phones **NBN:** None	**Wireless broadband services:** as for mobile phones **NBN:** none required
Satellite television and internet	**Geostationary satellites:** no signals intercepted by turbines **Low Earth orbit (LEO) satellites:** Starlink signals unlikely to be affected	Consultation with operators not considered necessary	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
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	**AM and FM signals:** if required – install higher-quality antenna at affected location **Digital radio signals:** none required

1 INTRODUCTION

Urbis Ltd (or "Urbis") has commissioned DNV to independently assess the potential electromagnetic interference (EMI) related impacts associated with the proposed Tathra Wind Farm ("the Project") in Western Australia. The results of this work are reported here. This document has been prepared in accordance with the Urbis Sub Consultancy Agreement "Tathra Wind Farm Project: Provision of services by DNV Australia Pty Ltd, dated 15 April 2025 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 Project description

The following information has been provided by the Customer:

"Synergy Renewable Energy Developments (referred to as SynergyRED or the Proponent) proposes to develop a renewable energy project in the mid-west of Western Australia, referred to as the Tathra Wind Farm. The site is located within the Shire of Carnamah, approximately 15 km east of Eneabba town site and approximately 300 km north of Perth, Western Australia.

The project is proposed to include up to 140 wind turbine generators (WTGs) (total capacity of up to 1,000 MW across the site), 500 MW in solar and 500 MW in battery storage, with supporting infrastructure (the Proposal). The Proposal, located on predominantly cleared land currently used for agriculture will connect into the South-West Interconnected System (SWIS) via the existing 330 kV transmission lines which are situated within the development envelope.

The associated infrastructure for the Proposal comprises of the following:

- *Up to 140 wind turbine generators (WTGs) with a total capacity of up to 1,000 MW across the site.*
- *Up to 500 MW capacity in solar and 500 MW in battery energy storage systems (BESS), including associated roads, foundations and drainage.*
- *Associated turbine foundations and hard stand areas.*
- *A turbine design comprising:*
  - *Blade length up to 90 m.*
  - *Tower/hub height between 110 m and 160 m; and*
  - *Turbine tip height up to 250 m.*
- *Site entrances from public roads and internal access roads between wind turbines and supporting infrastructure.*
- *Overhead transmission poles or tower and power lines, and underground electrical cables.*
- *Electrical substations and switchyards, including ancillary electrical equipment (e.g. STATCOM).*
- *Operations and maintenance buildings, workshops, and associated car parking.*
- *Temporary construction facilities, including site offices, construction compounds, laydown areas, gravel borrow pits and concrete batching plant.*
- *Water abstraction bore(s) for construction activities and associated infrastructure (dams/turkey's nests).*
- *Fire water tanks.*
- *Communication towers and monitoring masts (meteorological masts) up to 150 m tall."*

2.2 Project details used in this assessment

2.2.1 Proposed wind farm layout

The Project is proposed to consist of 140 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 3.

2.2.2 Dwelling locations

The locations of dwellings in the vicinity of the Project have been provided by Urbis [3]. There are 19 dwellings located within 5 km of the Project boundary, 3 of which are involved dwellings. The coordinates of these dwellings are presented in Table 4, 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 Urbis. For the purposes of this assessment, DNV has assumed that all considered 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 140 wind turbines, as outlined in Table 3.

For the purpose of the EMI assessment, a hypothetical turbine with a rotor diameter of 180 m and an upper tip height of 250 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 180 m or less
- an upper tip height of 250 m or less

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

To conduct the EMI assessment, information regarding radiocommunications licences in the vicinity of the Project was obtained from a copy of the Australian Communications and Media Authority (ACMA) Register of Radiocommunications Licences (RRL) database dated 2 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 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 11.

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 225 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 no radiocommunication towers located within 2 km of the proposed turbine locations.

The nearest tower is located approximately 3 km west of the nearest proposed turbine location. Therefore, it is not expected that the Project will cause interference to the radiocommunications associated with that tower through near-field effects or reflection or scattering of the signals.

4.3 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 identified in this assessment 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 3. 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 two point-to-point links recorded in the ACMA RRL database that pass over the proposed Project boundary, operated by Department of Biodiversity Conservation and Attractions and Electricity Networks Corporation (Western Power). The details of the links are provided in Table 5, and the link paths are shown in greater detail in Figure 4 based on information obtained from the ACMA RRL database, and extracted from aerial or satellite imagery. To simplify reporting, each link has been assigned a unique identifier (e.g. Link #1) so that it can be easily distinguished.

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. Feedback obtained from the operators of the links, including their recommended clearance zones to reduce the potential for interference, 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, 6, 7], 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 [6], or potentially 60% of the first Fresnel zone for links below 1,000 MHz with a clear line of sight as suggested in [8] (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 4. Each exclusion zone includes the rotor radius for turbines with a 180 m rotor diameter, and an additional buffer of 25 m to account for potential inaccuracies in the tower locations given in the ACMA RRL database.

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

There are seven turbines located within the exclusion zone for the point-to-point link operated by Department of Biodiversity Conservation and Attractions, and three turbines located within the exclusion zone for the link operated by Western Power.

Table 1 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 Diffraction interference zones Horizontal and vertical plane
1	Department of Biodiversity Conservation and Attractions	7 turbines: 15_TS, 26_TS, 29_TS, 3_TN, 44_ES, 45_ES, 47_ES
2	Western Power	3 turbines: 16_ES, 37_ES, 43_ES

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) [6].

Reference [6] describes a methodology for calculating the C/I ratio that might be expected at a receiver in the presence of a reflected or scattered signal from a wind turbine at a specified location. By evaluating the C/I ratio for incremental changes in the distances between the transmitter, receiver, and wind turbine, and comparing this to the required C/I ratio, a potential interference zone can be defined.

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

4.3.1.3 Interference caused by near-field effects

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

Reference [6] presents an equation for estimating the radius of the near-field zone for a point-to-point link from the properties of the transmitting or receiving antenna.

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

4.3.2 Stakeholder consultation

DNV has contacted the operators of the point-to-point links crossing the proposed Project boundary to determine the likelihood that the proposed Project will cause interference to their operations and services through diffraction, reflection or scattering, or near-field effects. A response has been received from Western Power, as summarised in Table 11, and no concerns have been raised to date. No response has been received from the Department of Biodiversity Conservation and Attractions.

4.3.3 Mitigation options

To avoid the potential for interference to the Department of Biodiversity Conservation and Attractions point-to-point links crossing the Project boundary, DNV recommends that turbines 15_TS, 26_TS, 29_TS, 3_TN, 44_ES, 45_ES and 47_ES be moved outside of the diffraction exclusion zone established by DNV and shown in Figure 4. Alternative mitigation options would need to be confirmed through consultation with the Department of Biodiversity Conservation and Attractions.

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

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 54 point-to-multipoint Assignment IDs within approximately 75 km of the proposed Project boundary. These licences are shown in Figure 5. The details of the licence holders as given in the ACMA RRL database are provided in Table 6.

There are three point-to-multipoint base stations within 20 km of the Project boundary, operated by Water Corporation, Western Power and Iluka Resources Limited. There are also several point-to-multipoint base stations located more than 20 km from the Project.

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

4.4.2 Stakeholder consultation

DNV has contacted the operators of potentially affected base stations identified within approximately 60 km of the Project, to determine the likelihood that the proposed Project will cause interference to their operations and services. A response has been received from Western Power, as summarised in Table 11, and no concerns have been raised to date. No responses have been received from the remaining operators to date.

4.4.3 Mitigation options

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

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 6 and Table 7.

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 8 along with their contact details. The nearest licence is associated with a tower located approximately 7 km from the Project boundary.

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

All other licences operated by emergency services in the vicinity of the Project are mobile telephony licences used for mobile radio and paging systems, or maritime radiocommunication licences that are restricted to coastal areas. 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 [8] 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 [9].

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

4.6.2 Stakeholder consultation

DNV has contacted the operators of potentially affected licences identified within approximately 60 km of the Project, to seek feedback on any potential impact that the Project could have on their operations and services. A response has been received from the Department of Fire and Emergency Services of WA, as summarised in Table 11, and no concerns have been raised. No response has been received from the remaining operators.

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, there is no potential for impacts to point-to-point links operated by emergency services, and 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 [10].

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 [11, 12].

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 [13, 14], and approximately 100 km at a height of 1000 m [14]. 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 [15, 16]. 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 six weather radars within 250 nautical miles of the proposed Project, with the closest radar located approximately 90 km southeast of the Project near the township of Watheroo. The locations of these radars are shown in Figure 7 and the details of each radar are given in Table 9.

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 feedback received from the Bureau based on the preliminary turbine layout indicated that the Project is likely to interfere with signals from the Watheroo radar and may therefore impact on the Bureau's operations and services. To address this potential for impact, the Bureau has advised that they require a detailed assessment of the likely impacts on their services and possible mitigation measures. DNV recommends that the proponent of the Project engages further with the Bureau to understand the nature of the potential impacts and how these might be mitigated.

4.8.3 Mitigation options

Mitigation options to address the impacts of interference to the Watheroo radar will need to be determined through consultation with the Bureau but may include the installation of additional weather monitoring equipment, such as rain gauges, automatic weather stations, wind profiling devices, or a new meteorological radar.

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 [17].

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 [18]. 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) [19], 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 [20], there are 24 trig points within 20 km of the Project boundary. Two trig points, Log 1 and Dongara 7, are located inside the Project boundary approximately 113 m east and 323 m southwest of nearest proposed turbine locations, respectively. The details of these trig points are provided in Table 10 and their locations are illustrated in Figure 8.

There are also 12 permanent survey marks within 2 km of the Project boundary [21] as shown in Figure 9. The closest survey mark is located 110 m east of the nearest turbine.

DNV has reviewed the primary geodetic network of Australia [22] and observed that the Project is located within the high-density trilateration region. Trilateration depends on distances measured from trigonometrical stations of known positions, baselines and heights, with a high degree of accuracy, to determine the location of the site being surveyed.

The closest GNSS station is located approximately 79 km north of the Project, at Minginew [23]. 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 stating that they do not foresee any interference to their GNSS infrastructure as a result of the Project.

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 10. The nearest mobile phone tower is located approximately 7 km southwest of the Project boundary.

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

Figure 11 shows the Optus Mobile network coverage for the Project area [24]. Optus 4G coverage is available to the west of the Project area, with pockets of no coverage at localised areas of lower elevation particularly along a valley traversing from the southeast to the centre of the Project area. Coverage to the east of the Project is limited.

Figure 12 shows the Telstra network coverage for the Project area [25]. Telstra 4G coverage is generally available throughout the Project area particularly surrounding the township of Eneabba. There are pockets of no coverage in areas of lower elevation particularly along a valley traversing from the southeast to the centre of the Project area.

Figure 13 shows the Vodafone/TPG network coverage for the Project area [26]. Vodafone 4G coverage is generally available to the west of the Project area, with pockets of no coverage at localised areas of lower elevation particularly along a valley traversing from the southeast to the centre of the Project area. Coverage to the east of the Project is limited.

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 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, Telstra, and Vodafone/TPG to inform them of the proposed Project and to seek feedback on any potential impact that the Project could have on their services. Responses have been received from several operators, as summarised in Table 11. Responses have been received from Optus and Vodafone with no concerns raised. No response has been received from Telstra to date.

4.11.3 Mitigation options

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

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, Optus, and Vodafone/TPG, as discussed in Section 4.11.2, to seek feedback on any potential impact that the Project could have on their services. Responses have been received from several operators, as summarised in Table 11. Specifically, responses have been received from Optus and Vodafone with no concerns raised. No response has been received from Telstra to date.

4.12.1.3 Mitigation options

If interference to the wireless broadband services provided by mobile phone networks occurs, the mitigation options given in Section 4.11.3 may be applicable. Specifically, 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 range between 14 km and 29 km [27, 28]. Consequently, the signals may be affected by physical obstructions such as terrain, vegetation, and wind turbines [29].

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 [30] indicates that the network is currently only available as a satellite internet service using the NBN SkyMuster I and II satellites in the areas surrounding the Project.

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 11, and no concerns have been raised to date.

4.13 Satellite television and internet

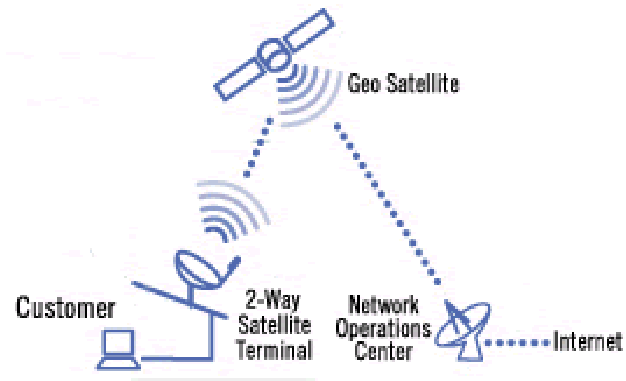
In some rural or remote areas, television and internet access can only be provided through satellite signals. There are two types of satellite that are typically used to provide commercial telecommunication services: geostationary satellites and low Earth orbit (LEO) satellites.

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 [31]. 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 [32, 33].

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 [34]

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 analysis has shown that satellite signals to dwellings in the vicinity of the Project are not expected to be intercepted by turbines.

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 [31]. 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 [35], 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 [36, 37].

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 [38]. 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 [39], 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.

Based on this analysis, turbines at the Project are not expected to obstruct Starlink signals at any nearby inhabited dwellings. 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 and therefore will not pose an obstruction.

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 [40].

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 [41], and are shown in Figure 14.

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 [42]. 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 [40, 43].

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 [42]. 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 [44].

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 [41], and are shown in Figure 14.

The closest FM broadcast transmitter is located approximately 7 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 [45]. 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 [42] 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 [46], 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 [47]. 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 [47], and are shown in Figure 14. The Project is outside the intended service area for DTV 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

The closest DTV transmitter to the Project is the Carnamah transmitter which is approximately 37 km away. Therefore, it is considered unlikely that the Project will cause large scale interference to signals from this 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 [48], DVB-T reception quality may not be substantially affected in the forward scatter region.

The ITU [49] 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 [50].

DNV

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 140 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 180 m or less, and an upper tip height of 250 m or less.

The results of this assessment, including feedback obtained from relevant stakeholders, are summarised in Table 2.

In its current configuration, the Project has the potential to interfere with two point-to-point links crossing the proposed Project boundary operated by the Department of Biodiversity, Attractions and Conservation, and Western Power. DNV has calculated the potential interference zones for these links and have identified several turbines at the Project situated within the recommended exclusion zones of both links.

Feedback has been provided by Western Power and no concerns have been raised regarding their point-to-point links crossing the Project. The Department of Biodiversity, Attractions and Conservation have been contacted regarding potential impacts to their point-to-point links crossing the Project boundary, although feedback has not yet been received. DNV recommends that the turbines be relocated to be outside the Department of Biodiversity, Attractions and Conservation diffraction exclusion zone established in this assessment to avoid the potential for impact to the links.

Through consultation, the Bureau of Meteorology (the Bureau) has raised concerns about the potential for the Project to interfere with their meteorological radar at Watheroo, and the associated impacts to their operations and services. DNV recommends that the proponent of the Project engages further with the Bureau to understand the nature of the potential impacts and how these might be mitigated.

Turbines at the Project may also 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. Coverage maps for these transmitters indicate that most of the identified dwellings are unlikely to be receiving signals from the DTV transmitters nearest to the Project. However, if any dwellings are currently receiving signals from these transmitters there may be potential for those dwellings to receive a stronger reflected signal from a turbine and therefore to experience interference. If interference to these types of services is experienced, a range of options are available to rectify difficulties.

Since it is not possible to determine the potential EMI impacts on point-to-multipoint links, emergency services and wireless internet services without obtaining further information from the relevant operators, DNV has consulted with organisations operating services that may be affected by the Project. Responses have been received from several operators and to date, no concerns have been raised.

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

Table 2 Summary of EMI assessment results for the proposed Project

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Radio-communication towers	No towers within 2 km of proposed turbine locations	Consultation not considered necessary	None	None required
Fixed point-to-point links	2 links crossing Project boundary, operated by: Department of Biodiversity, Attractions and Conservation Electricity Networks Corporation (Western Power) **Department of Biodiversity, Attractions and Conservation link:** 7 turbines in diffraction zones **Western Power link:** 3 turbines in diffraction zones	**Western Power:** No concerns raised **Department of Biodiversity, Attractions and Conservation:** No response received	Likely to cause interference	If required - relocate turbines to be outside interference zones, reroute affected links, install additional towers, replace affected links with alternative technologies
Fixed point-to-multipoint links	54 assignments within 75 km of Project boundary 3 base stations within 20 km of Project boundary, operated by: Water Corporation Western Power Iluka Resources Limited	**Western Power and Water Corporation:** No concerns raised **Iluka Resources Limited:** No response received	Potential for interference if link paths cross the Project near turbines	If required – reroute affected links, install additional towers, replace affected links with alternative technologies
Other licence types	**Point-to-area style communications:** see findings for emergency services, mobile phones, radio broadcasting, and television broadcasting	-	-	-
Emergency services	**Point-to-point links:** 1 Department of Biodiversity, Attractions and Conservation link crossing boundary (see above) **Point-to-area style communications:** unlikely to be affected	**Department of Fire and Emergency Services of WA:** no concerns raised **Other operators:** No response received	**Point-to-point links:** Likely to cause interference **Point-to-area style communications:** Unlikely to cause interference	**Point-to-point links:** as for point-to-point links **Point-to-area style communications:** if required – increase signal strength from affected tower or alternative towers, install signal repeater, install additional tower
Meteorological radar	Nearest radar: 90 km from Project	Likely to cause interference to Watheroo radar	Likely to cause interference to Watheroo radar	To be determined through consultation with the Bureau of Meteorology

Table 2 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
Trigonometrical stations	**Trigonometrical stations:** unlikely to be affected **Survey marks:** unlikely to be affected	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	**Optus and Vodafone:** No concerns raised **Telstra:** No response received	Unlikely to cause interference	If required – increase signal strength from affected tower or alternative towers, install additional tower
Wireless internet	**Wireless broadband service providers:** mobile phone networks, NBN Co **NBN:** available as a satellite service only	No concerns raised	**Wireless broadband services**: see findings for mobile phones **NBN:** None	**Wireless broadband services:** as for mobile phones **NBN:** none required
Satellite television and internet	**Geostationary satellites:** no signals intercepted by turbines **Low Earth orbit (LEO) satellites:** Starlink signals unlikely to be affected	Consultation with operators not considered necessary	Unlikely to cause interference	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	**AM and FM signals:** if required – install higher-quality antenna at affected location **Digital radio signals:** none required

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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 [42] 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 [48]. Both of these effects can potentially degrade the DTV signal quality.

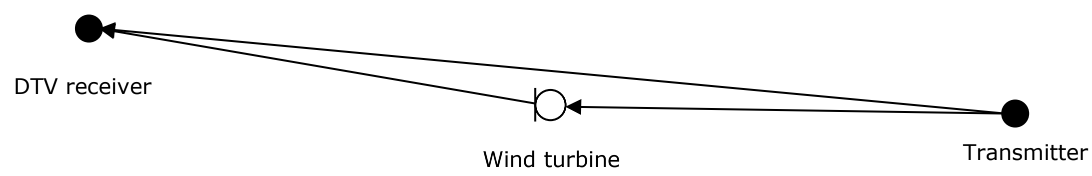

Figure A.1 Forward scatter signal path for DTV signals

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).

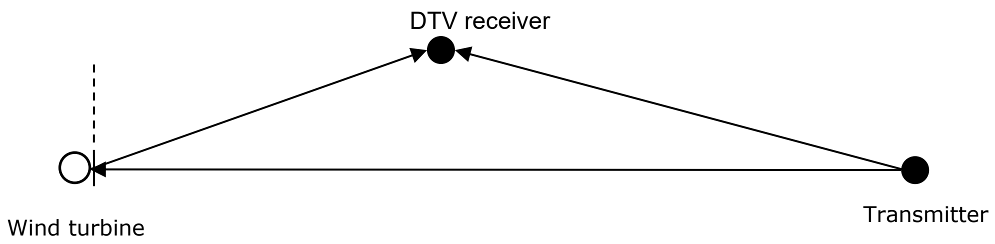

Figure A.2 Back scatter signal path for DTV signals

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 [48].

According to Ofcom [42], the forward scatter region does not typically extend further than 5 km for the worst combination of factors [7, 51]. Interference may extend beyond 5 km if the dwellings are screened from the broadcast transmitter, but do have line-of-sight to the turbines [42]. 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 [7, 42], 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.

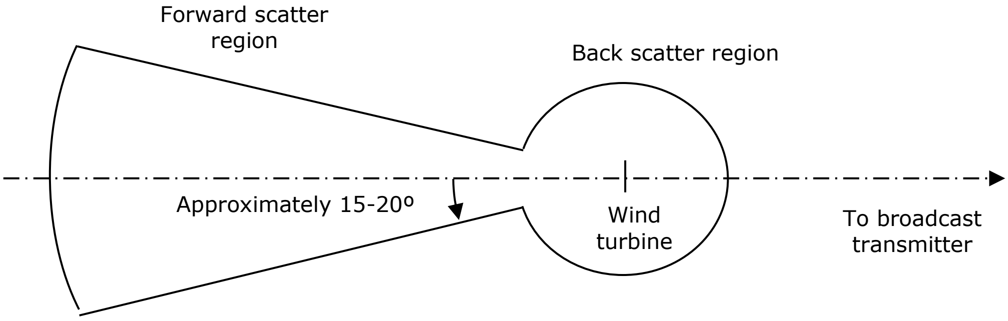

Figure A.3 Potential television interference zones around a wind turbine

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 [52] 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 [49] 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 [49].

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 [53]. 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 [52], 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 [42]. The combination of these areas forms a region where there is an increased likelihood of interference to television signals occurring.

LIST OF TABLES

Table 3 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]
1_ES	346079	6705430	230	16_ES	348179	6699530	227
1_TN	349779	6698650	235	17_TN	354679	6696350	286
1_TS	344819	6690530	231	17_TS	347999	6694130	208
2_ES	346199	6706310	237	17_ES	348319	6699010	220
2_TN	350639	6698310	256	18_TN	354839	6697810	289
2_TS	344819	6691390	211	18_ES	348319	6705090	260
3_ES	346239	6703770	206	18_TS	348019	6690950	217
3_TN	351599	6698950	248	19_TS	348139	6695870	219
3_TS	345039	6690050	219	19_TN	354999	6695390	285
4_TN	351619	6697610	244	19_ES	348339	6698370	221
4_TS	345135	6692805	255	20_ES	348359	6701530	233
4_ES	346259	6704930	234	20_TS	348319	6696770	226
5_TS	345159	6690950	219	20_TN	355339	6698990	292
5_ES	346304	6706704	234	21_TN	355419	6694110	281
5_TN	351879	6698490	253	21_TS	348379	6690330	231
6_TS	345421	6692229	235	21_ES	348399	6702850	225
6_ES	346519	6704430	225	22_ES	348519	6706270	276
6_TN	352499	6697910	260	22_TN	355919	6696230	311
7_TS	345666	6693106	237	22_TS	348679	6692270	231
7_TN	353059	6695170	242	23_TS	348779	6689690	237
7_ES	346699	6702650	234	23_TN	355999	6694270	274
8_TN	353339	6697950	273	23_ES	348927	6704647	272
8_ES	346919	6703510	226	24_TN	356059	6699030	288
8_TS	346099	6691530	211	24_ES	348998	6703577	255
9_TN	353539	6698990	250	24_TS	348779	6697430	240
9_ES	347059	6705650	232	25_ES	349099	6705550	285
9_TS	346199	6689990	206	25_TN	356179	6696890	316
10_TN	353779	6694630	247	25_TS	348899	6695530	251
10_ES	347479	6706670	244	26_TN	356219	6695410	291
10_TS	346559	6689550	227	26_ES	349259	6706890	273
11_TN	353799	6696190	270	26_TS	348959	6694510	238
11_ES	347659	6705650	257	27_TN	356219	6698370	301
11_TS	347199	6693090	201	27_ES	349279	6706370	269
12_TN	353819	6698470	275	27_TS	349099	6693370	253
12_TS	347219	6690670	217	28_ES	349699	6703990	289
12_ES	347699	6704110	237	28_TS	349119	6696910	254
13_TS	347259	6691650	216	28_TN	356459	6697650	313
13_ES	347899	6702190	237	29_TS	349579	6696350	241
13_TN	353939	6697210	294	29_TN	356519	6693950	264
14_TN	354279	6694990	273	29_ES	349719	6704970	308
14_ES	348059	6700910	223	30_TS	349619	6690390	256
14_TS	347539	6689570	212	30_TN	356539	6696210	309
15_ES	348139	6706830	264	30_ES	350079	6702290	263
15_TS	347699	6693470	216	31_TS	349739	6689610	264
15_TN	354419	6697450	309	31_ES	350379	6704870	304
16_TN	354479	6699010	272	31_TN	356719	6694650	279
16_TS	347879	6692330	219	32_ES	350539	6702550	273

Table 3 Proposed turbine layout for the Project [2] (continued)

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation[2] [m]	Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation[2] [m]
32_TS	349819	6691590	263	41_ES	352559	6704410	262
32_TN	356999	6699030	313	42_TS	350999	6690970	301
33_ES	350859	6705070	284	42_ES	352599	6703470	247
33_TS	349999	6695370	262	43_ES	353599	6705110	257
33_TN	357019	6698130	319	43_TS	351499	6692330	286
34_TN	357019	6697250	301	44_ES	353859	6702470	252
34_ES	350959	6702870	282	44_TS	351519	6690330	282
34_TS	350279	6694450	270	45_TS	351579	6693650	254
35_ES	351059	6704190	302	45_ES	353999	6703470	250
35_TS	350339	6693070	265	46_TS	351719	6689570	277
35_TN	357119	6695550	294	46_ES	354139	6704390	243
36_TS	350419	6690830	269	47_TS	352039	6692730	267
36_TN	357179	6694150	263	47_ES	354139	6702930	269
36_ES	351379	6703550	292	48_TS	352059	6690870	272
37_ES	351639	6702890	277	49_TS	352499	6689850	261
37_TS	350519	6693650	262	50_TS	352679	6691730	289
38_ES	351759	6702370	266	51_TS	352959	6692230	284
38_TS	350859	6694790	262	52_TS	353019	6691230	267
39_ES	351779	6704190	285	53_TS	353099	6690070	260
39_TS	350879	6695870	251	54_TS	353199	6692730	260
40_ES	352019	6705090	281	55_TS	353579	6690370	253
40_TS	350919	6691870	282	56_TS	353759	6691550	254
41_TS	350939	6696430	237	57_TS	354159	6690530	252

1. Coordinate system: MGA zone 50, GDA94 datum. Coordinates were provided by Urbis 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 4 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]
R 10	339662	6702381	Non-involved	6.7
R 12	339870	6704213	Non-involved	6.3
R 16	343328	6705484	Non-involved	2.8
R 17	*344750*	*6703990*	*Involved*	*1.5*
R 18	344981	6708695	Non-involved	2.4
R 19	345168	6688459	Non-involved	1.6
R 20	345389	6700617	Non-involved	2.4
R 21	345401	6696678	Non-involved	2.9
R 22[3]	*345549*	*6692946*	*Involved*	*0.2*
R 33	347695	6687379	Non-involved	2.2
R 34	347741	6687438	Non-involved	2.1
R 35	347793	6687280	Non-involved	2.3
R 43	*350094*	*6700567*	*Involved*	*1.7*
R 52	353587	6709527	Non-involved	4.4
R 56[3]	*354936*	*6698942*	*Involved*	*0.4*
R 59	*355264*	*6692623*	*Involved*	*1.5*
R 62	356879	6690065	Non-involved	2.8
R 63	356891	6690017	Non-involved	2.8
R 68	358465	6701662	Non-involved	3.0
R 69	*358857*	*6686591*	*Involved*	*6.1*
R 74	*360774*	*6692287*	*Involved*	*4.0*

1. Involved dwellings are indicated by *underlined italic text*.
2. Coordinate system: MGA zone 50, GDA94 datum. Coordinates were provided by Urbis in a different coordinate system and/or datum and have been converted using mapping software, which may result in small discrepancies depending on the software and transformation approach used.
3. The Customer has advised that two dwellings, R_22 and R_56, will not be inhabited while the wind farm is operational [54]. These dwellings have been excluded from this analysis.

Table 5 Details of point-to-point links crossing the proposed Project

Link no.	Licence number	Assignment ID	Frequency [Hz]	Licence owner
1	263026/1	1193305	460175000	Department of Biodiversity Conservation and Attractions Att: Coordinator, Telecommunications Systems Locked Bag 104 Office of Information Management BENTLEY DC WA 6983
		1193306	460175000	
		1193307	450675000	
		1193308	450675000	
2	1945813/1	1235726	460068750	Electricity Networks Corporation Western Power GPO Box L921 Attn: Comms Operations & Maintenance PERTH WA 6842
		1235727	460068750	
		1235728	450568750	
		1235729	450568750	

Table 6 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
1306969	602186	1616602/1	-29.1090	115.3186	72	Bureau of Meteorology 700 Collins Street Docklands VIC 3008
1306972	602186	1616602/1	-29.1090	115.3186	72	
3782206	30780	1930149/2	-29.4634	115.1412	41	Beach Energy Ltd Level 8 80 Flinders Street ADELAIDE SA 5000
3782207	30780	1930149/2	-29.4634	115.1412	41	
6480428	30813	10913042/1	-29.4053	115.1412	47	DBNGP (WA) Nominees Pty Ltd Dampier Bunbury Pipeline Att: Dane Coetzee PO Box Z5267 SAINT GEORGES TERRACE WA 6831
6480431	30813	10913042/1	-29.4053	115.1412	47	
1235528	30649	1924995/1	-29.9785	115.3332	9	Electricity Networks Corporation Western Power GPO Box L921 Attn: Comms Operations & Maintenance PERTH WA 6842
1235531	30649	1924995/1	-29.9785	115.3332	9	
12896945	47231	12722255/1	-29.5991	115.6808	26	
12896946	47231	12722255/1	-29.5991	115.6808	26	
1235614	30661	1939590/1	-29.7921	116.1704	63	
1235617	30661	1939590/1	-29.7921	116.1704	63	
12896941	31418	12722254/1	-29.3174	115.8796	63	
12896942	31418	12722254/1	-29.3174	115.8796	63	
1236077	132419	1971924/1	-30.2760	116.0903	68	
1236080	132419	1971924/1	-30.2760	116.0903	68	
6341786	10018716	10900455/1	-29.8907	115.2999	9	Iluka Resources Limited GPO Box U 1988 PERTH WA 6845
6341789	10018716	10900455/1	-29.8907	115.2999	9	
1720164	10000361	10061534/1	-29.3068	115.0930	58	Mepau Perth Basin Pty Ltd Arc Energy NL PO Box 574 WEST PERTH WA 6872
1720167	10000361	10061534/1	-29.3068	115.0930	58	
1295118	9024270	9832211/1	-29.3159	115.0665	59	
1295121	9024270	9832211/1	-29.3159	115.0665	59	
1249589	9001010	1146008/1	-29.7983	115.7164	19	Water Corporation PO Box 100 (OT ? Dinesh Raghu) LEEDERVILLE WA 6902
1249590	9001010	1146008/1	-29.7983	115.7164	19	
11946913	9001010	12344612/1	-29.7983	115.7164	19	
11946914	9001010	12344612/1	-29.7983	115.7164	19	
1250447	602629	1619641/1	-29.5330	115.6745	32	
1250450	602629	1619641/1	-29.5330	115.6745	32	
1250613	602629	1623666/1	-29.5330	115.6745	32	
1250616	602629	1623666/1	-29.5330	115.6745	32	
11889585	602629	12328849/1	-29.5330	115.6745	32	
11889588	602629	12328849/1	-29.5330	115.6745	32	

Table 6 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
1250609	404813	1623665/1	-29.6855	115.9028	40	
1250612	404813	1623665/1	-29.6855	115.9028	40	
11889581	404813	12328848/1	-29.6855	115.9028	40	
11889584	404813	12328848/1	-29.6855	115.9028	40	
1250626	404812	1623671/1	-29.8591	116.0346	49	
1250627	404812	1623671/1	-29.8591	116.0346	49	
11946917	404812	12344613/1	-29.8591	116.0346	49	
11946918	404812	12344613/1	-29.8591	116.0346	49	
1250617	404814	1623667/1	-29.1972	115.4437	62	
1250620	404814	1623667/1	-29.1972	115.4437	62	
10434097	404814	12009699/1	-29.1972	115.4437	62	
10434100	404814	12009699/1	-29.1972	115.4437	62	
11927795	602631	12336157/1	-29.3188	115.8826	63	
11927796	602631	12336157/1	-29.3188	115.8826	63	
1250881	9009773	1912453/1	-30.2847	116.0170	64	
1250884	9009773	1912453/1	-30.2847	116.0170	64	
12688031	9009773	12655310/1	-30.2847	116.0170	64	
12688032	9009773	12655310/1	-30.2847	116.0170	64	
1250873	9009751	1912450/1	-30.5031	115.0718	72	
1250876	9009751	1912450/1	-30.5031	115.0718	72	
12688046	9009751	12655313/1	-30.5031	115.0718	72	
12688049	9009751	12655313/1	-30.5031	115.0718	72	

Table 7 Details of other licences identified within 75 km of the proposed Project

Licence category	Licence type	Number of assignment IDs
1800 MHz Band	Spectrum	36
2 GHz Band	Spectrum	47
2.3 GHz Band	Spectrum	112
2.5 GHz Band	Spectrum	70
3.4 GHz Band	Spectrum	26
700 MHz Band	Spectrum	359
800 MHz Band	Spectrum	208
850/900 MHz Band	Spectrum	140
AWL - FSS Only	Spectrum	30
AWL - Standard	Spectrum	4
Aeronautical Assigned System	Aeronautical	2
Ambulatory System	Land Mobile	6
CBRS Repeater	Land Mobile	6
Commercial Radio	Broadcasting	9
Commercial Television	Broadcasting	9
Earth Receive	Earth Receive	2
Land Mobile System - > 30MHz	Land Mobile	346
Land Mobile System 0-30MHz	Land Mobile	124
Limited Coast Assigned System	Maritime Coast	2
Narrowcasting Service (LPON)	Broadcasting	12
National Broadcasting	Broadcasting	12
PMTS Class B	PTS	26
Paging System - Interior	Land Mobile	1
Radiodetermination	Radiodetermination	10
Retransmission	Broadcasting	30

Table 8 Emergency services with radiocommunication assets in the vicinity of the proposed Project

Emergency service	Contact details	Distance from closest site to Project boundary [km]
Department of Biodiversity Conservation and Attractions	Department of Biodiversity Conservation and Attractions Att: Coordinator, Telecommunications Systems Locked Bag 104 Office of Information Management BENTLEY DC WA 6983	31
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	7
Jurien Bay Volunteer Marine Rescue Group Inc	Jurien Bay Volunteer Marine Rescue Group Inc PO Box 462 JURIEN BAY WA 6516	35
Metropolitan Health Service	METROPOLITAN HEALTH SERVICE Dongara Health Service Board PO Box 242 DONGARA WA 6525	71
St John Ambulance Western Australia Ltd.	ST JOHN AMBULANCE WESTERN AUSTRALIA LTD. PO Box 183 BELMONT WA 6104	21
St. John Ambulance Australia Incorporated	ST. JOHN AMBULANCE AUSTRALIA INCORPORATED Technical Services 601-609 Blackburn Road NOTTING HILL VIC 3168	73
Surf Life Saving Western Australia Inc	SURF LIFE SAVING WESTERN AUSTRALIA INC PO Box 700 Balcatta WA 6021	71
Western Australia Police	WESTERN AUSTRALIA POLICE Radio & Electronic Services Unit 21 Swanbank Road Att: Phillip Manna MAYLANDS WA 6051	7

Table 9 Bureau of Meteorology radar sites in the vicinity of the proposed Project

Site ID	Site name	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]
10000636	Off Edawa Road	-30.3600	116.2896	89
139890	Geraldton Met Bureau Radar Arthur Road GERALDTON	-28.8047	114.6973	126
601351	Bureau of Meteorology Office Northern Perimeter Road PERTH AIRPORT	-31.9274	115.9765	228
44829	Walnut Rd BICKLEY	-32.0077	116.1349	240
138152	Bureau of Meteorlogy across the road from runway Lot 164 (286) Yangedi Rd HOPELAND	-32.3917	115.8670	277
10000627	BOM Station Approximately 1.2km South of Fire Road SOUTH DOODLAKINE	-31.7770	117.9529	312

Table 10 Trigonometrical stations in the vicinity of the proposed Project

Station name	Datum	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]
Aw 12	AGD66, AGD84, GDA94	-29.6257	115.4963	15
Bishops	AGD66, AGD84	-29.6259	115.3684	15
Davies	AGD66, AGD84	-30.0099	115.3705	10
Dongara 10	AGD66, AGD84, GDA94	-29.9489	115.3640	4
Dongara 11	AGD66, AGD84, GDA94	-29.7611	115.2566	13
Dongara 13	AGD66, GDA94	-29.8187	115.2761	11
Dongara 14	AGD66, GDA94	-29.8239	115.2652	12
Dongara 59	GDA94	-29.9114	115.2519	13
Dongara 6	AGD66, AGD84, GDA94	-29.8584	115.2533	13
Dongara 7	AGD66, AGD84, GDA94	-29.8593	115.5106	Within Project boundary
Dongara 8	AGD66, AGD84, GDA94	-29.7548	115.4771	2
Dongara 9	AGD66, AGD84, GDA94	-29.9820	115.5387	9
Dookanooka	AGD66, AGD84	-29.6692	115.5892	15
LS	AGD66, AGD84, GDA94	-29.6638	115.3030	14
Log 1	AGD66, AGD84	-29.7779	115.4451	Within Project boundary
Log 2	AGD66, AGD84	-29.7748	115.3193	7
Log 3	AGD66, AGD84	-29.8042	115.4121	0.2
NS	AGD66, AGD84, GDA94	-29.6813	115.4284	8
Ocean Hill	AGD66, AGD84, GDA94	-29.8331	115.3331	7
One Tree East	AGD66, AGD84	-29.6312	115.4588	14
Perenjori 23	AGD84, GDA94	-29.8422	115.6248	10
Win 2	AGD66, AGD84	-29.7844	115.6908	17
Win 3	AGD66, AGD84	-29.8308	115.6112	9
Wyy	AGD66, AGD84, GDA94	-29.7135	115.6696	18

Table 11 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
1	Fixed point-to-point: 1 links crossing the Project site Point-to-point link #1: 7 turbines in diffraction exclusion zone established by DNV Emergency services point-to-area: 31 km from Project boundary	Department of Biodiversity Conservation and Attractions 10565442-AUMEL-L-01-A	No response received to date
2	Fixed point-to-point: 1 links crossing the Project site Point-to-point link #2: 3 turbines in diffraction exclusion zone established by DNV,	Electricity Networks Corporation 10565442-AUMEL-L-02-A	Response received by email on 04 August 2025: *"The proposed Tathra Wind Farm turbines should not cause any EMI impact on any Western power's existing and currently proposed point to point Radio links. One of the Point to multipoint DA remote radio service may have EMI impact on the link. Advisable that Western power to cut over the mentioned remote DA unit to nearby DA base from Dookanooka DA base to any other nearby DA base, which is the best solution to be considered.* *Conclusion assumes (based on current data and analysis) that the proposed 140 wind turbine locations for Tathra Wind Farm could be constructed as proposed."*
3	Fixed point-to-multipoint: 41 km from Project boundary	Beach Energy Ltd 10565442-AUMEL-L-03-A	No response received to date
4	Fixed point-to-multipoint: 47 km from Project boundary	DBNGP (WA) Nominees Pty Ltd 10565442-AUMEL-L-04-A	No response received to date
5	Fixed point-to-multipoint: 9 km from Project boundary	Iluka Resources Limited 10565442-AUMEL-L-05-A	No response received to date
6	Fixed point-to-multipoint: 9 km from Project boundary	Water Corporation 10565442-AUMEL-L-06-A	Response received by email on 22 July 2025: *"We have carefully reviewed the list of Water Corporation sites you provided and can confirm that none of our sites are located in close proximity to the wind farm. Additionally, based on their geographic locations and operating parameters, we can confirm there is no likelihood of interference with the wind farm's operations. Our nearest site is 15KM apart from the windfarm boundary."*
7	Emergency services point-to-area: 7 km from Project boundary	Department of Fire and Emergency Services	Response received by email on 09 July 2025:

Table 11 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
		10565442-AUMEL-L-07-A	*"I have assessed this proposal and conclude this should have only a minimal effect on the Department of Fire and Emergency Services (DFES) VHF high-band communication in this region.* *DFES do not have any point-to-point links that would be affected by the proposal, however DFES do have a number of standalone VHF services from several sites where this proposed wind farm falls inside the coverage radius of these services. From my understanding it is unlikely that these would experience any degradation, but I will flag these are current services that do not experience any issues currently."*
8	Emergency services point-to-area: 21 km from Project boundary	St John Ambulance Western Australia 10565442-AUMEL-L-08-A	No response received to date
9	Emergency services point-to-area: 7 km from Project boundary	Western Australia Police 10565442-AUMEL-L-09-A	No response received to date
10	Meteorological radar: 89 km from Project boundary Fixed point-to-multipoint: 72 km from Project boundary	Bureau of Meteorology 10565442-AUMEL-L-10-A	Response received by email on 04 August 2025:

Table 11 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
			"Our assessment of the current Tathra wind farm proposal has determined that, under normal atmospheric conditions, it poses a significant risk to the Watheroo weather radar. *To proceed without objection, the Bureau requires a comprehensive technical assessment of potential impacts and possible mitigation measures for your development.* *This service is charged at $45,000.00 (excl. GST) per assessment and will cover the following components:* • *Electromagnetic interference (EMI) and propagation modelling of the proposed development* • *Evaluation of potential impacts on Bureau services* • *Identification of mitigation options to restore services and maintain quality, proposed as development requirements rather than detailed designs.* *The delivered summary letter will stand whilst the relevant technical details of the project remain the same (footprint, number of turbines, hub and tip height etc.). We aim to complete the assessment within 8 weeks from commissioning.* *You may have this work undertaken by another consultant, but The Bureau will need to review it prior to any endorsement from us. We won't be providing advice regarding wind farm developments without a very clear understanding of the potential for impacts on our services."*
11	Trigonometrical station: two within Project boundary GNSS station: 78 km from Project boundary	Geoscience Australia 10565442-AUMEL-L-11-A	Response received by email on 01 June 2025: *"Geoscience Australia do not foresee any interference to our GNSS infrastructure, as a result of the proposed Tathra Wind Farm"*
12	PMTS/spectrum (mobile phone): 7 km from Project boundary	Optus 10565442-AUMEL-L-12-A	Response received by email on 02 June 2025: *"Optus confirm that there are no Optus microwave link paths in proximity to the identified turbine sites."*
13	PMTS/spectrum (mobile phone): 7 km from Project boundary	Telstra 10565442-AUMEL-L-13-A	No response received to date
14	PMTS/spectrum (mobile phone): 70 km from Project boundary	Vodafone 10565442-AUMEL-L-14-A	Response received by email on 04 July 2025:

Table 11 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
			"…The nearest TPG/Vodafone existing, or near future Public Mobile Telephone Coverage site, is over 70km from the proposed locations of the wind farm turbines. As such, there is no prohibitive or significant near field impact to our Public Mobile Telephone coverage. *It is noted that Optus have sites located near the proposed windfarm boundary that are used by Vodafone customers as part of our Regional Sharing Agreement with Optus. It is expected that Optus will be consulted as part of the EMI assessment to determine whether their Mobile infrastructure assets are impacted…* *… there is no impact to our existing transmission network…"*
15	PMTS/spectrum (mobile phone): 52 km from Project boundary	NBN 10565442-AUMEL-L-15-A	Response received by email on 02 June 2025: *"I have reviewed the data provided based on the proposed wind farm location ; there are no areas of the wind farm boundary overlapping with existing nbn wireless coverage boundaries. There are also no existing nbn customers inside the wind farm boundary. The proposed wind tower locations poses 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...* *…Once known, 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]…."*

LIST OF FIGURES

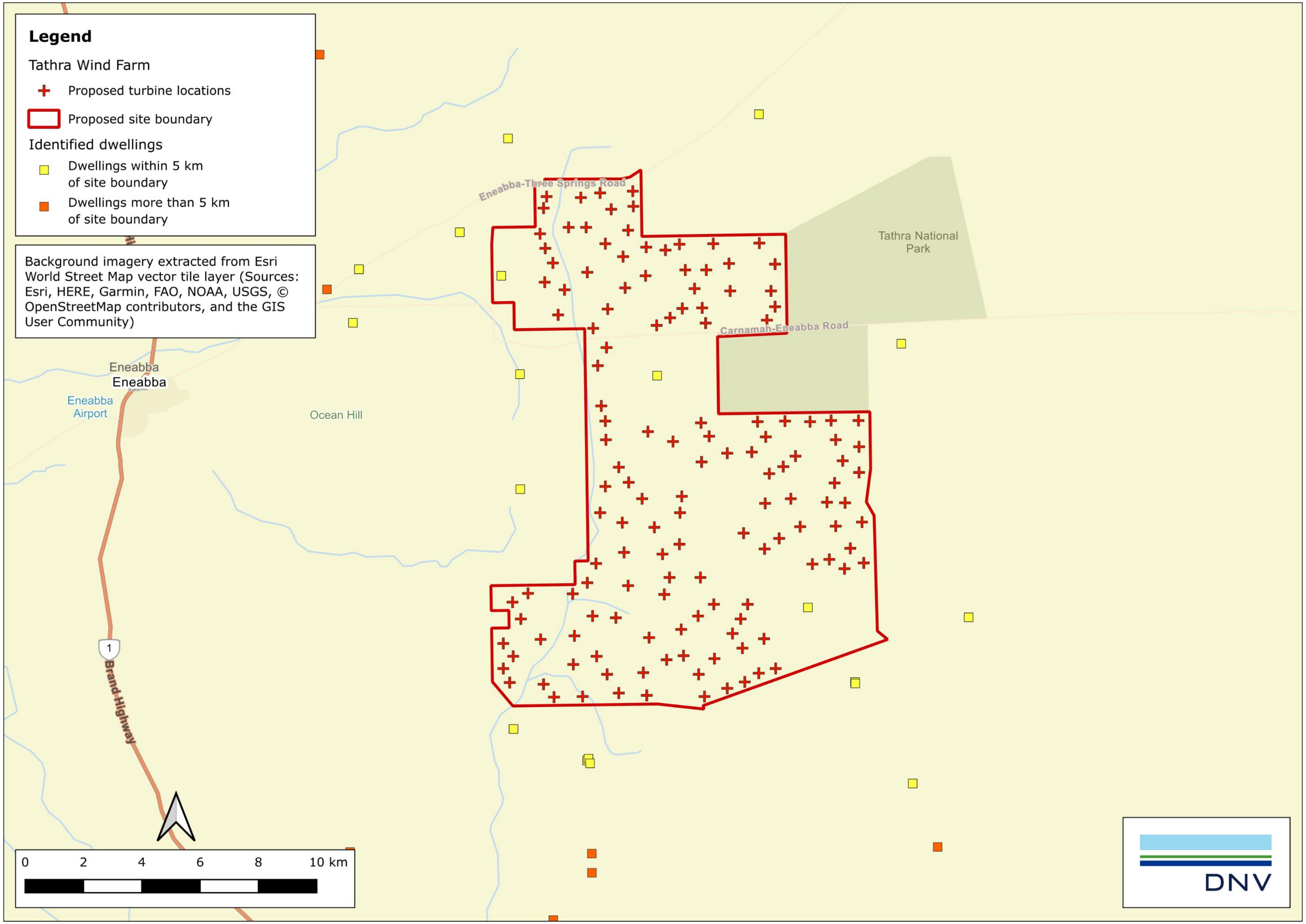

Figure 1 Map of the proposed Project, showing proposed boundary, turbine locations, and locations of nearby dwellings

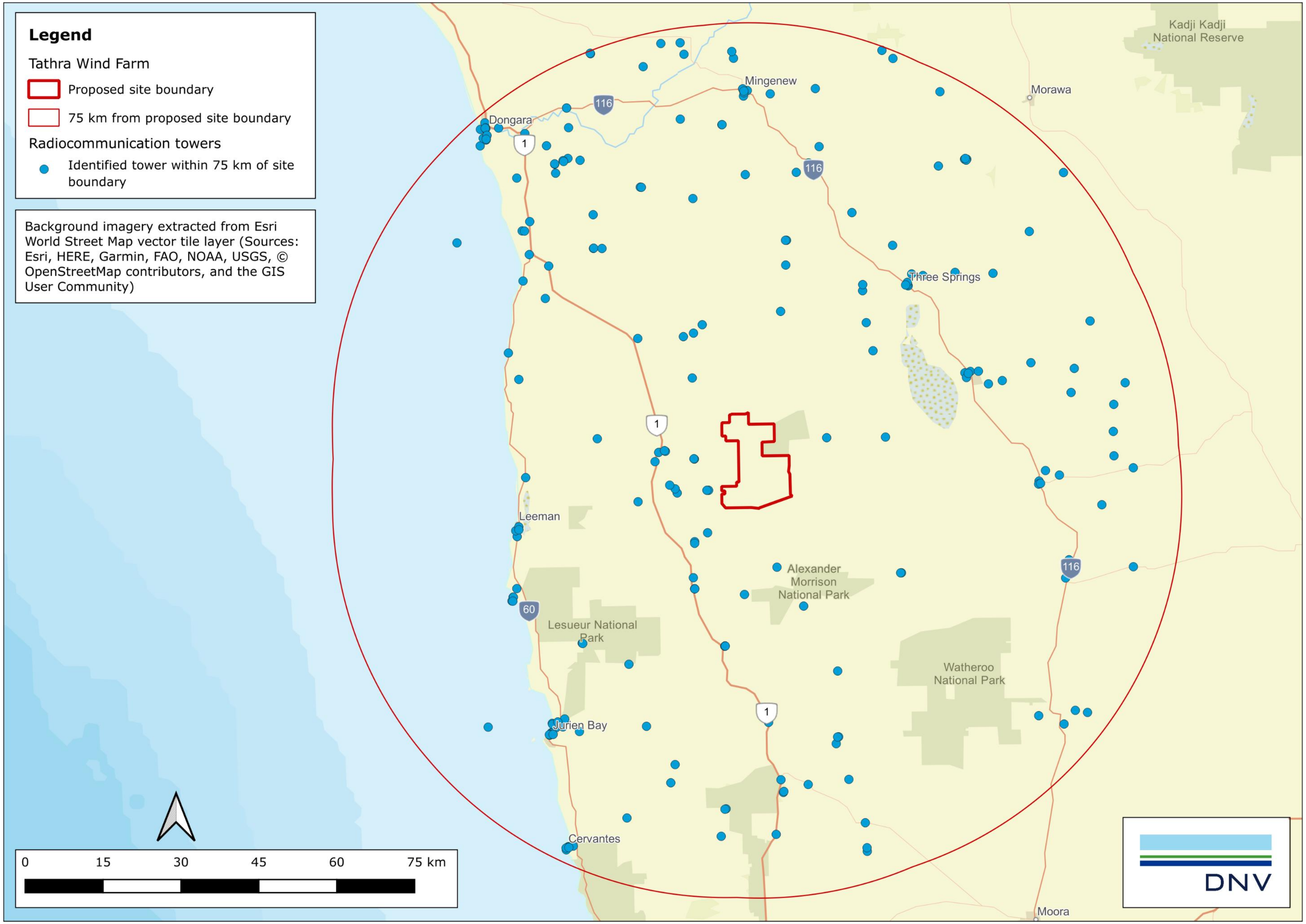

Figure 2 Location of the proposed Project and identified nearby radiocommunication sites

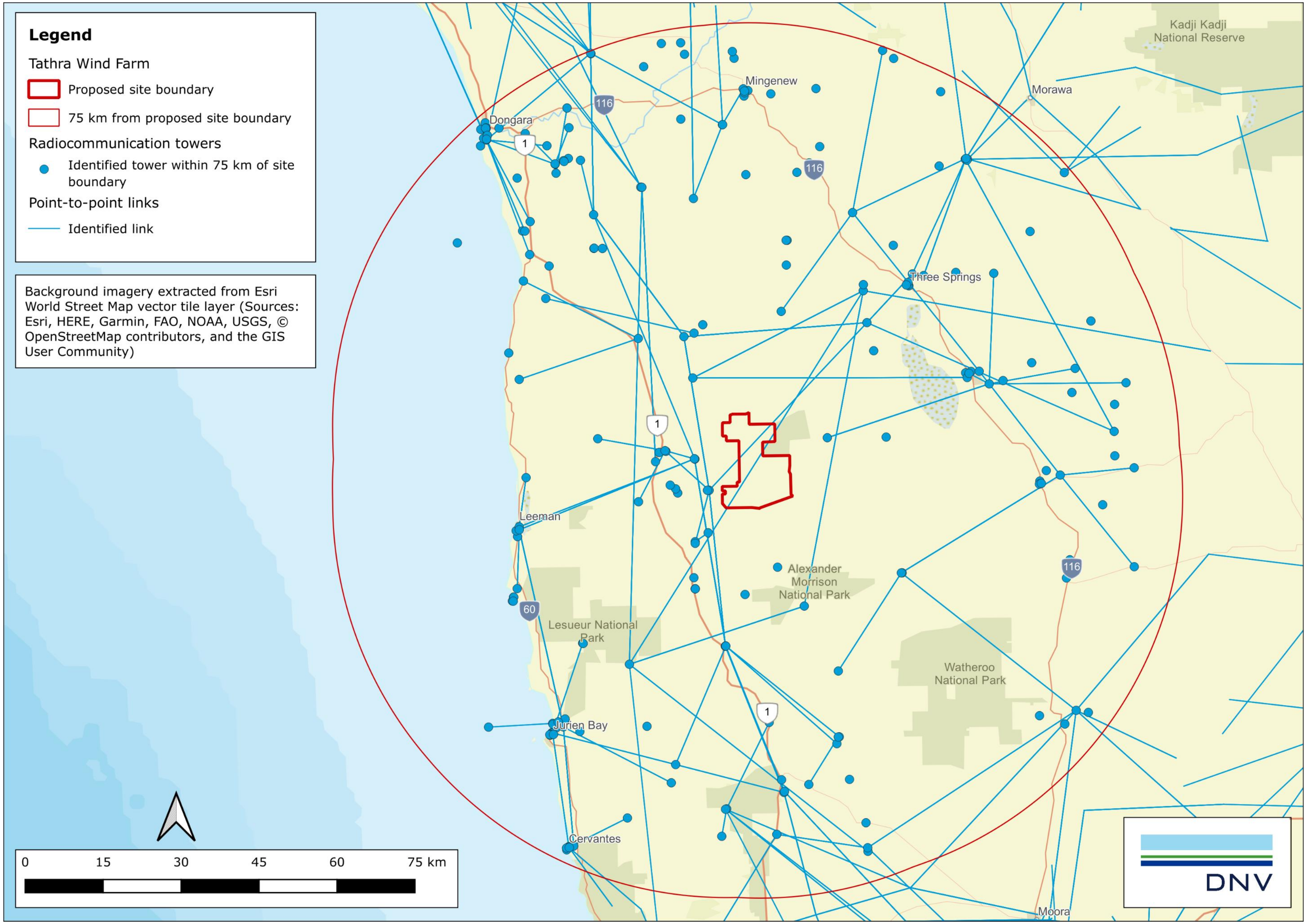

Figure 3 Identified transmission vectors for fixed licences of point-to-point type in the vicinity of the proposed Project

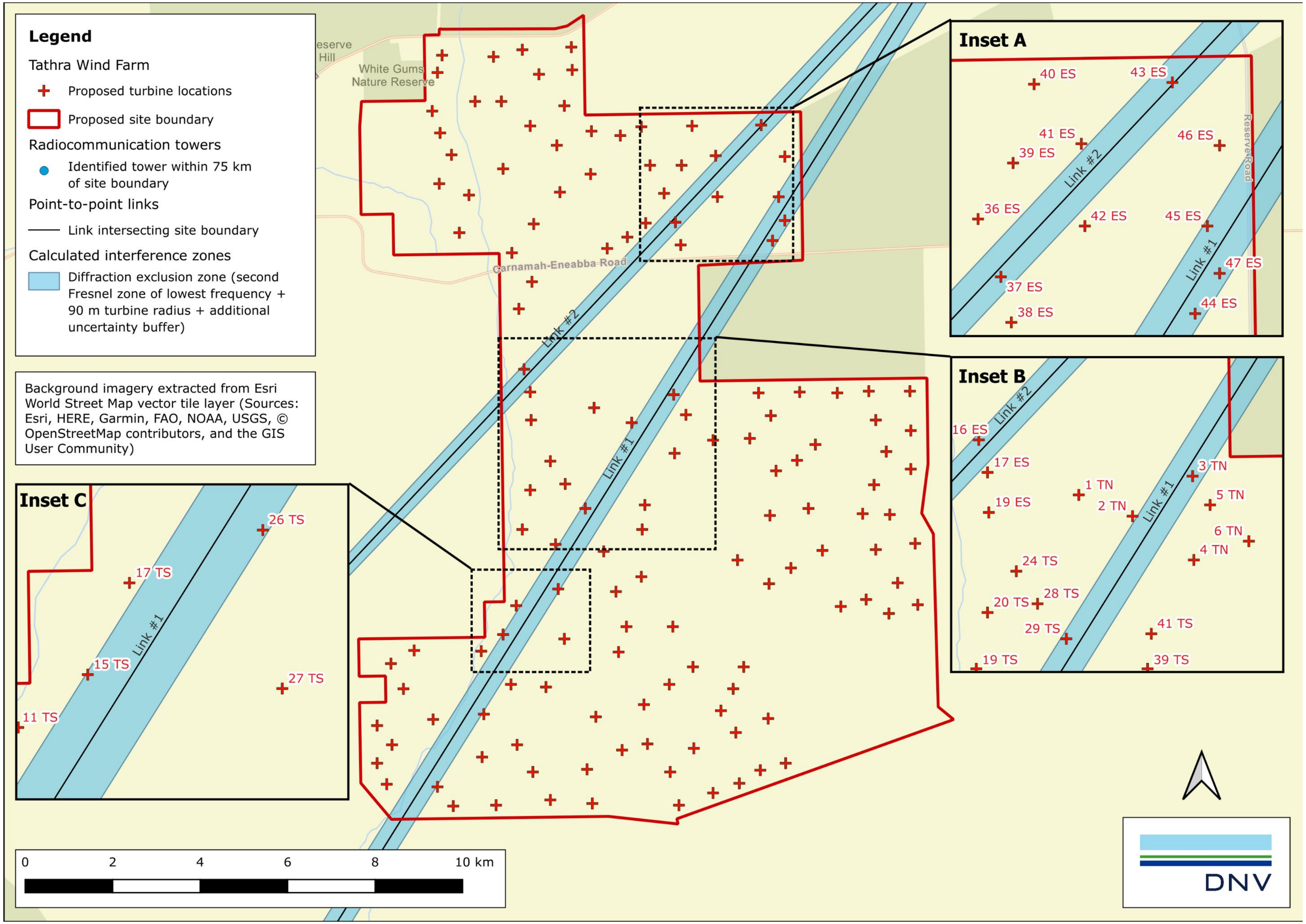

Figure 4 Identified point-to-point radiocommunication vectors crossing the proposed Project and calculated interference zones

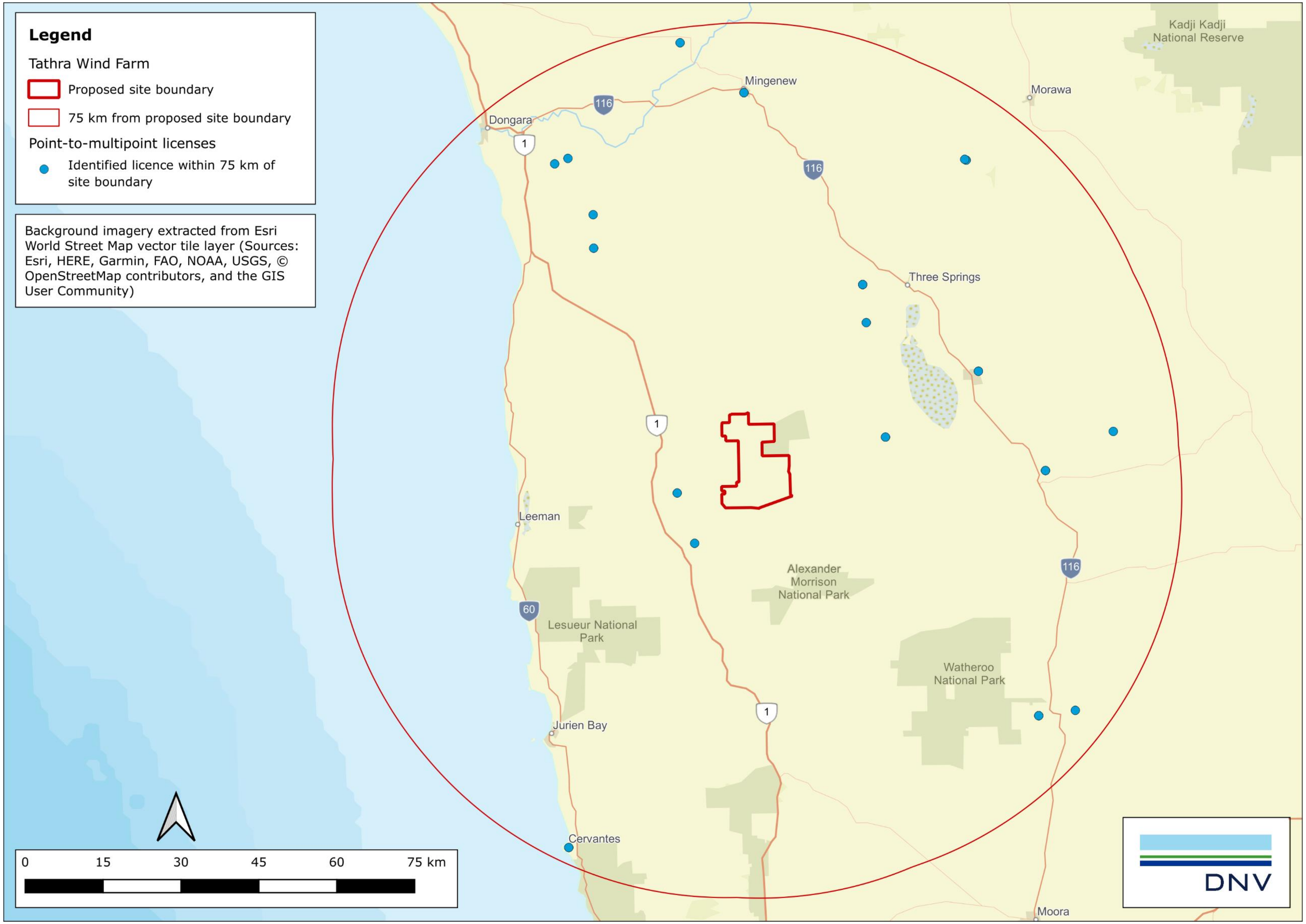

Figure 5 Location of point-to-multipoint licences in the vicinity of the proposed Project

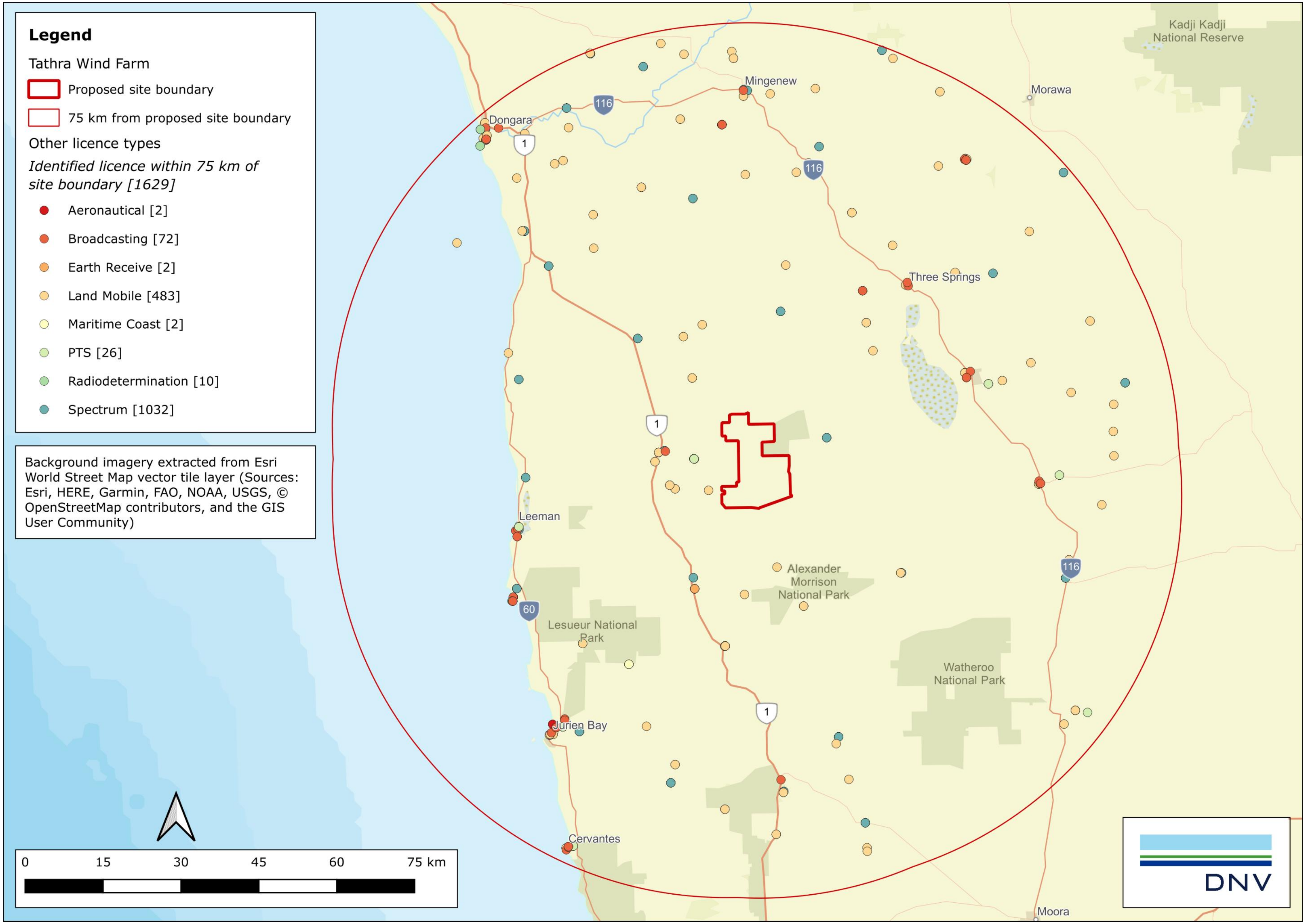

Figure 6 Location of other licence types within 75km of the proposed Project

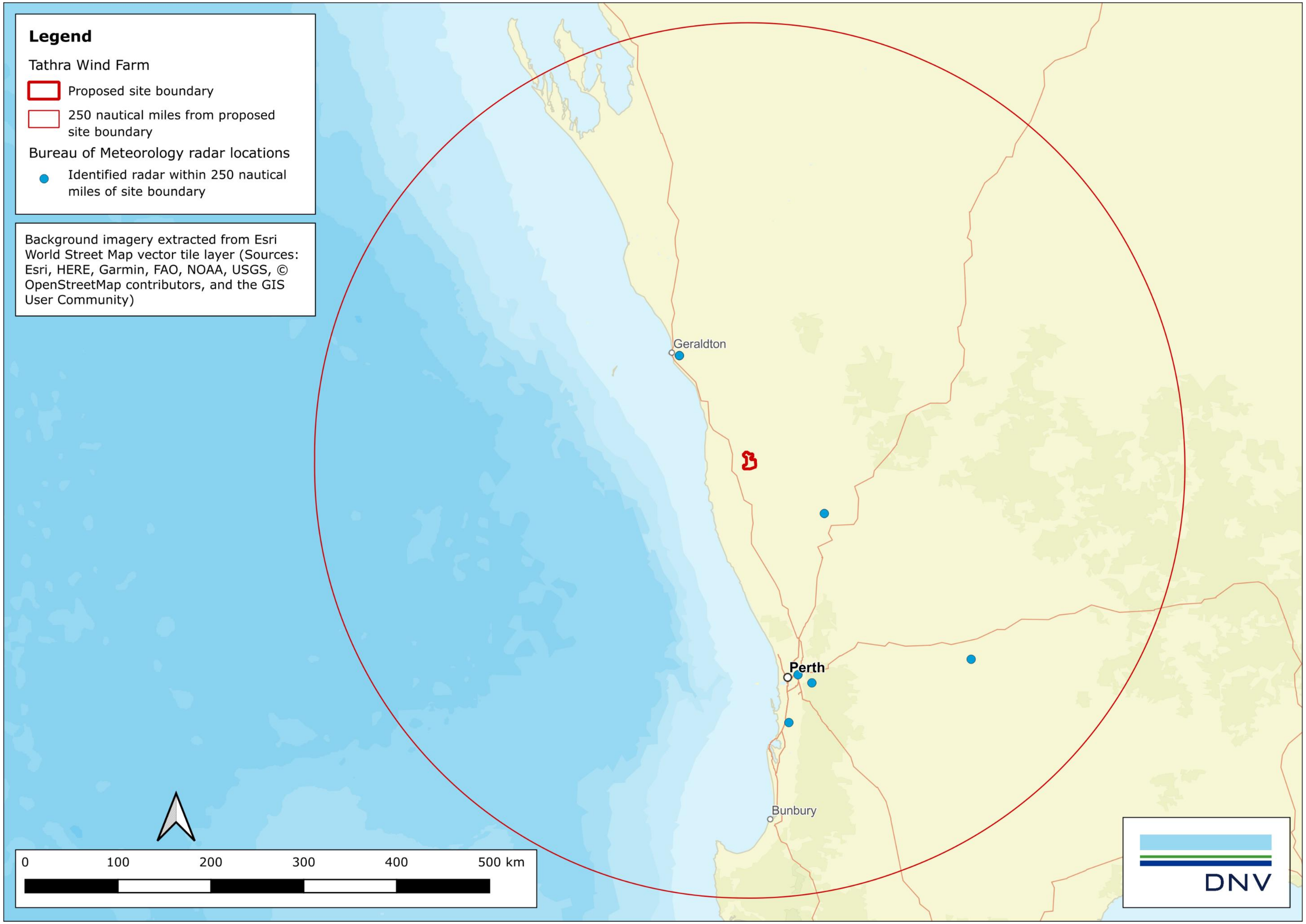

Figure 7 Location of meteorological radar sites within 250 nautical miles of the proposed Project

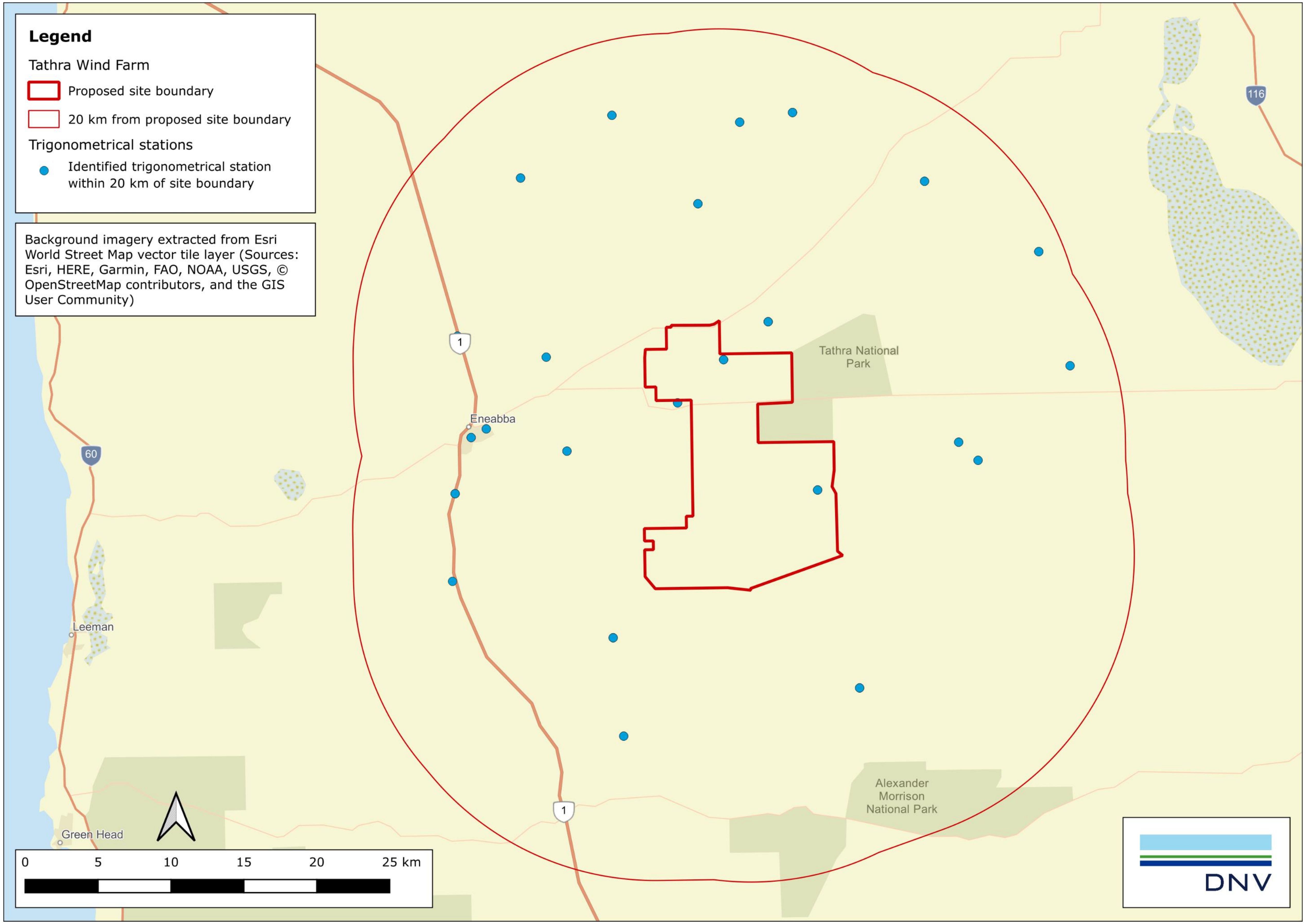

Figure 8 Location of trigonometrical stations within 20 km of the proposed Project

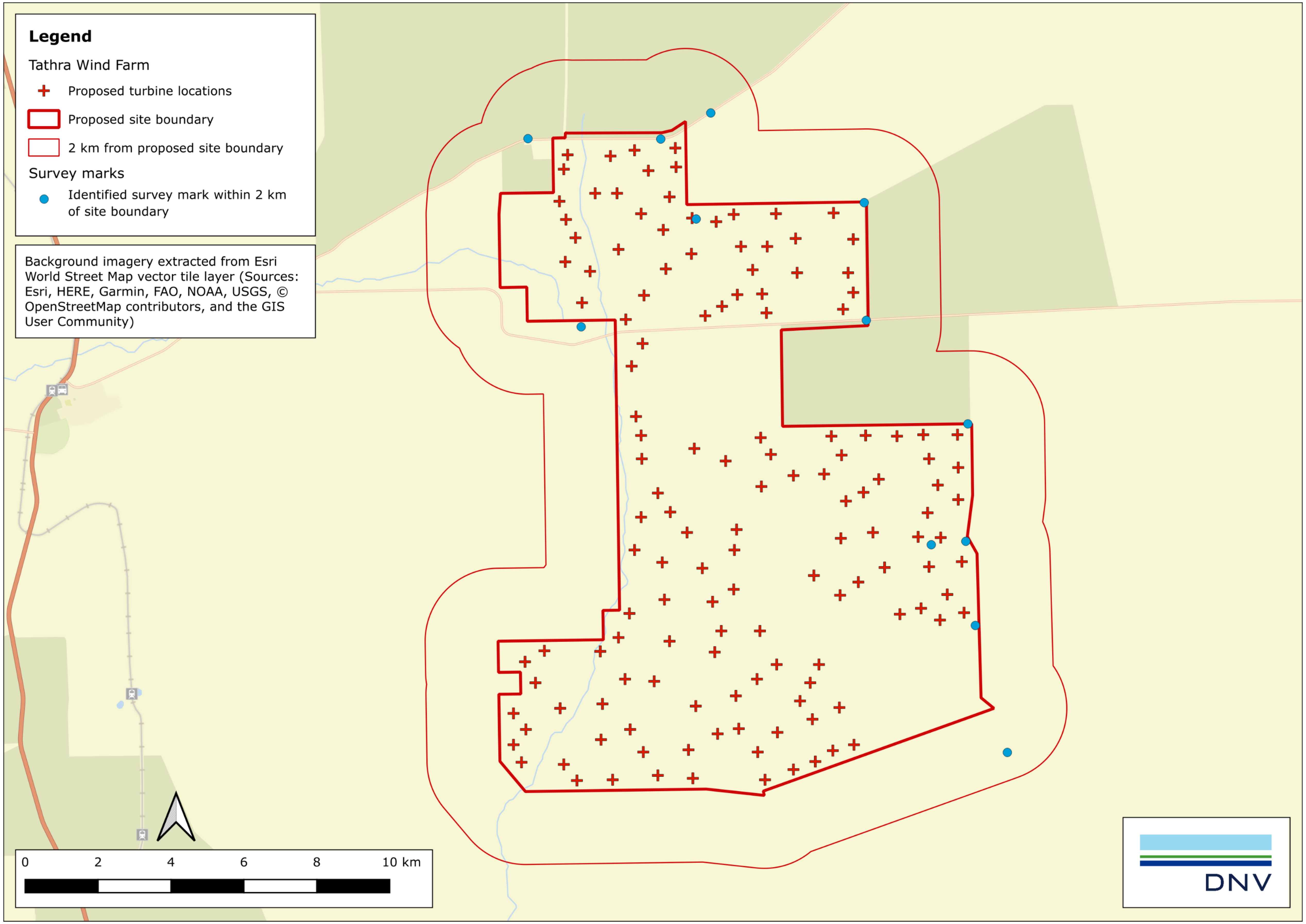

Figure 9 Location of permanent survey marks within 2 km of the proposed Project boundary

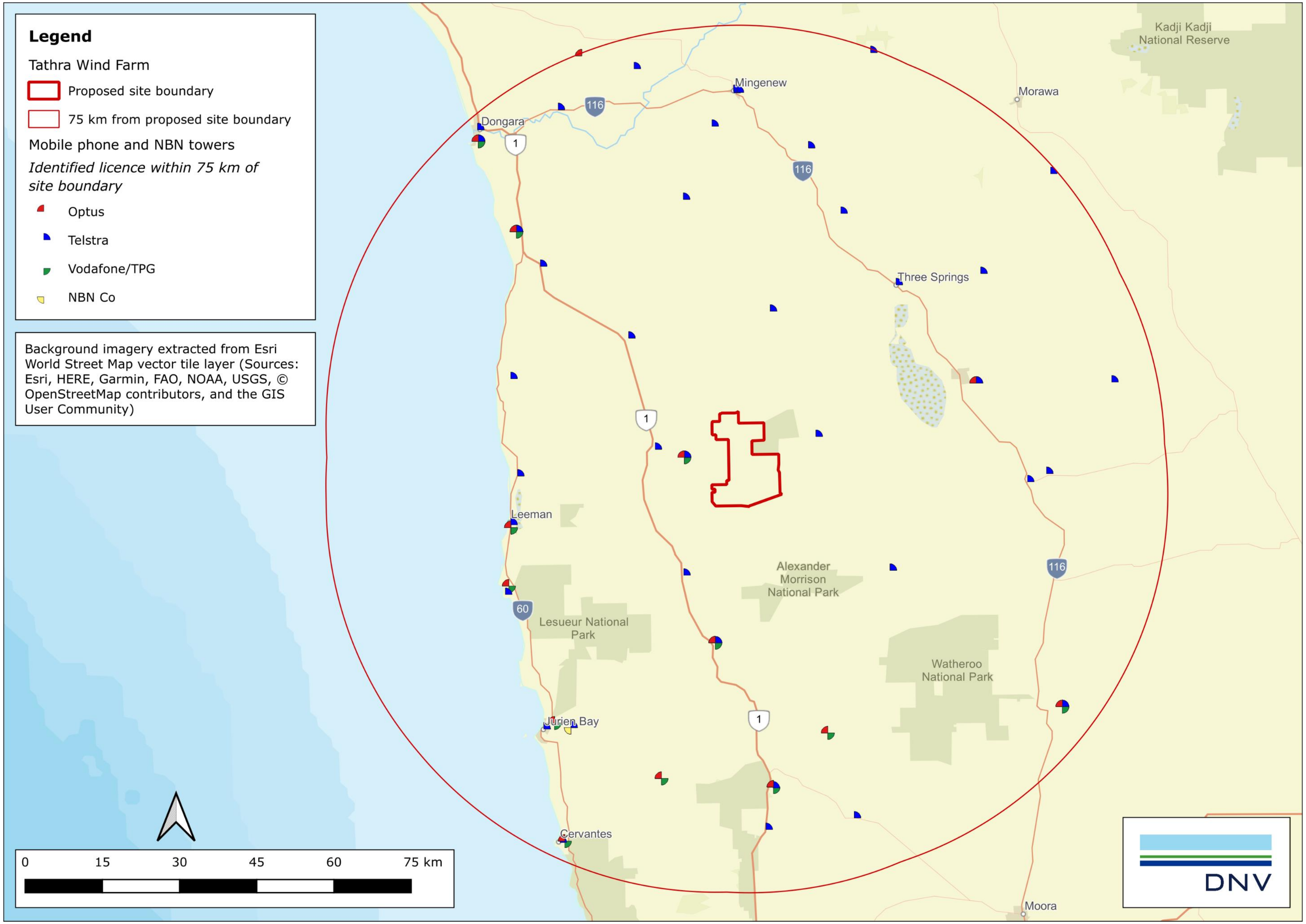

Figure 10 Location of mobile phone and NBN towers within 75 km of the proposed Project

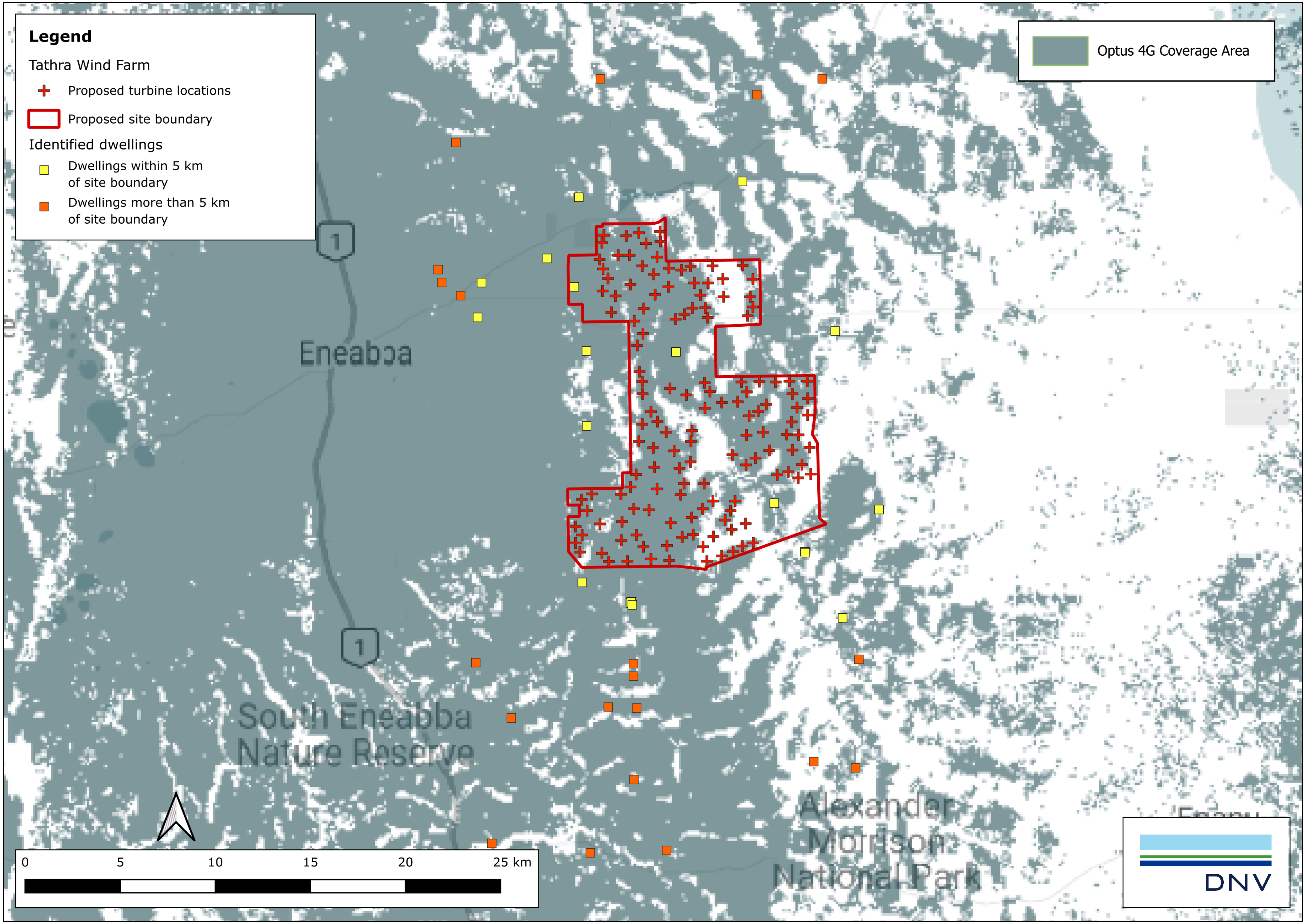

Figure 11 Optus Mobile 4G network coverage for the proposed Project

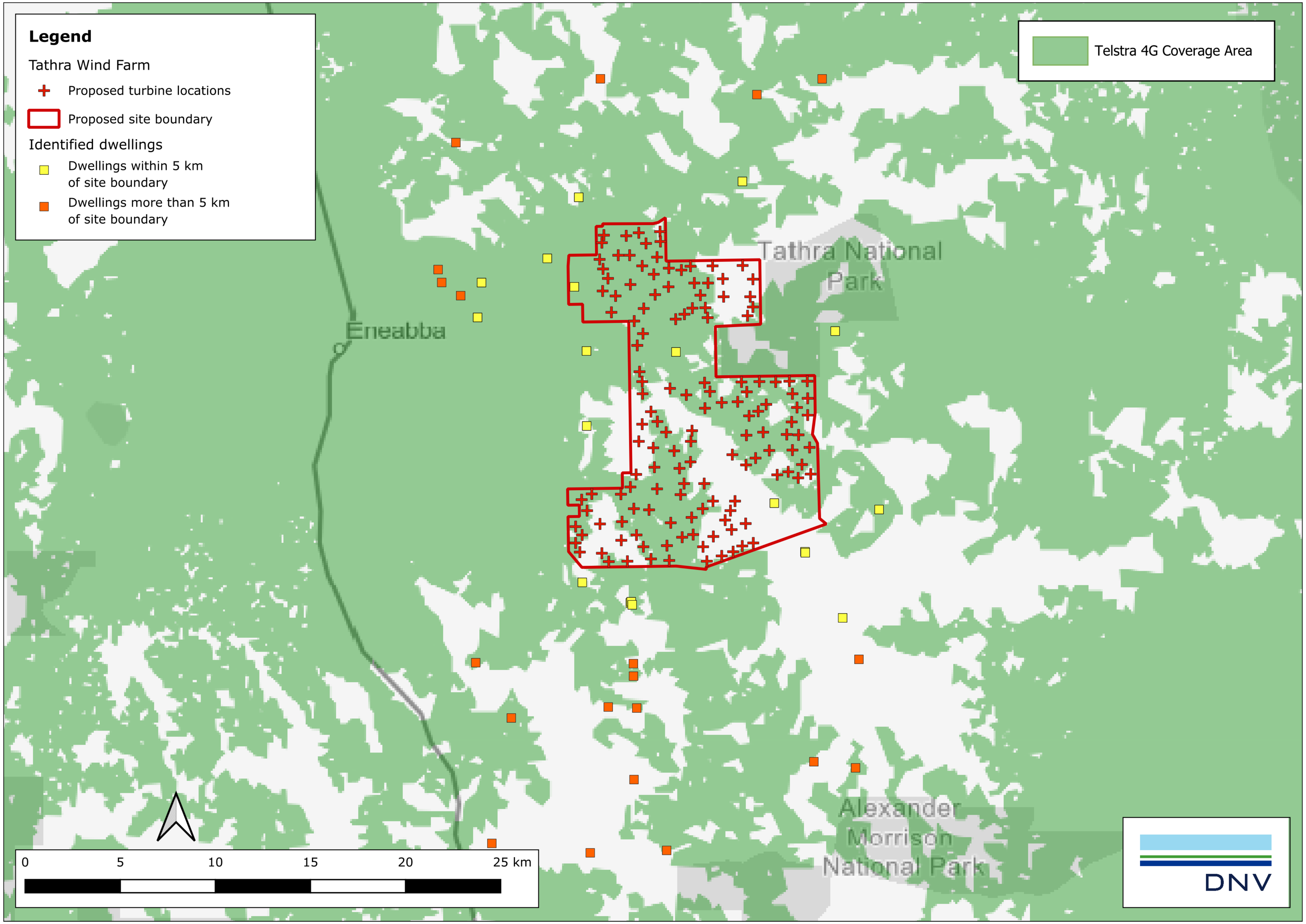

Figure 12 Telstra 4G network coverage for the proposed Project

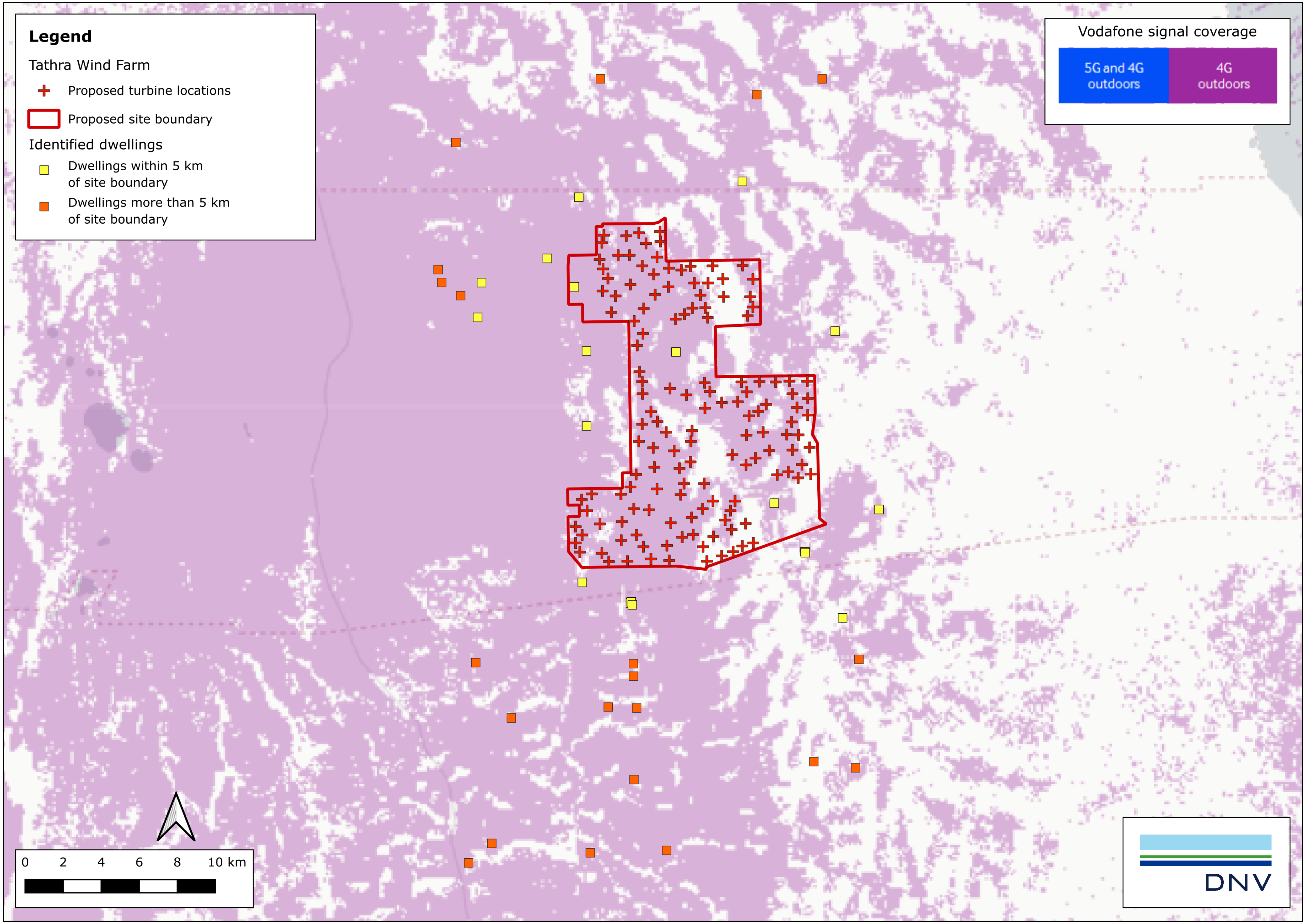

Figure 13 Vodafone network coverage (Apple iPhone 13 handset) for the proposed Project

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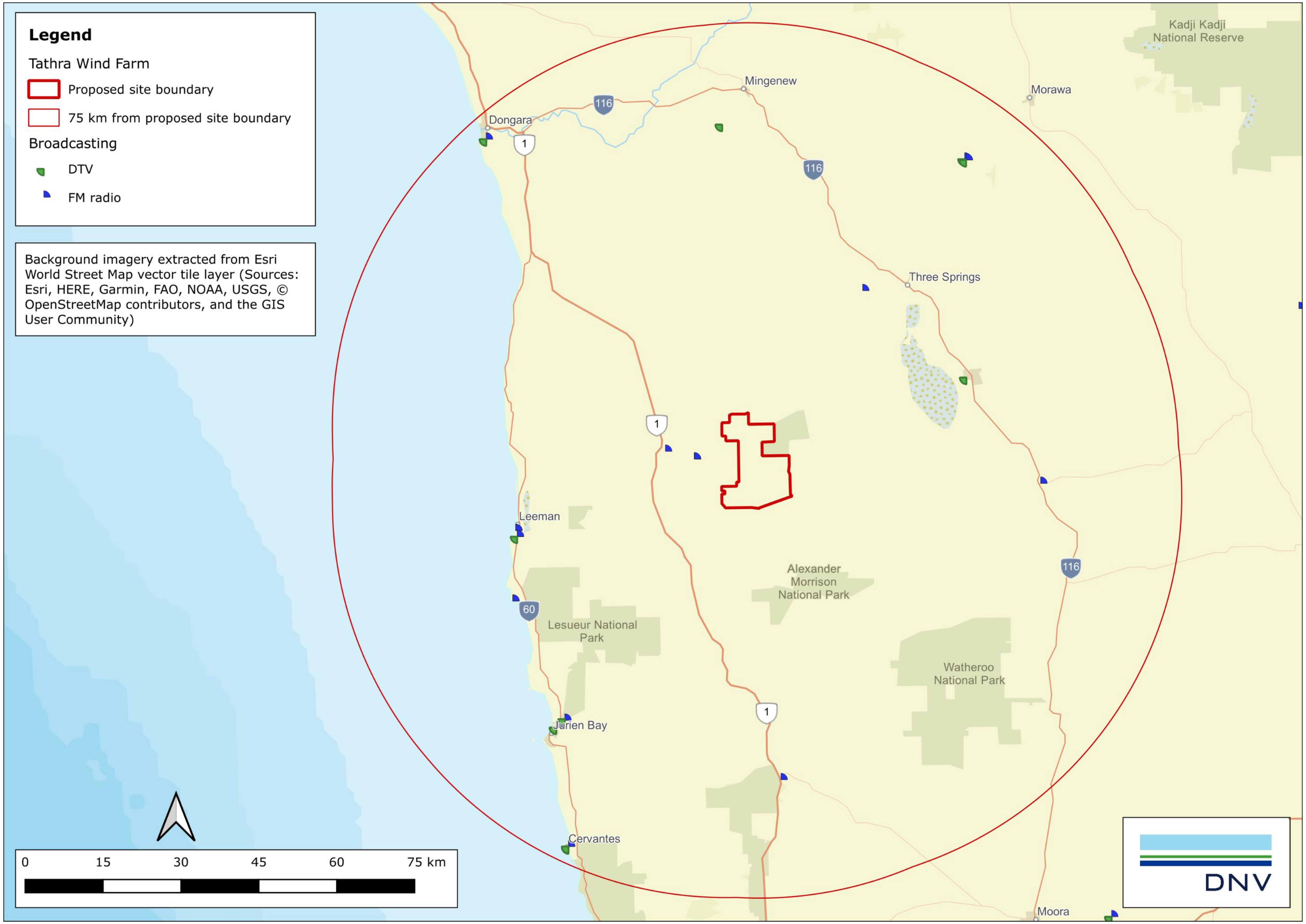

Figure 14 Location of broadcast transmitters in the vicinity of the proposed Project

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.

Driven by its purpose, to safeguard life, property, and the environment, DNV helps tackle the challenges and global transformations facing its customers and the world today and is a trusted voice for many of the world's most successful and forward-thinking companies.