TWIN HILLS WIND FARM

EMI Assessment

Twin Hills Wind Farm Pty Ltd

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EXECUTIVE SUMMARY

DNV has been commissioned by Twin Hills Wind Farm Pty Ltd ("the Customer") to independently assess potential electromagnetic interference (EMI) impacts associated with the development and operation of the proposed Twin Hills Wind Farm ("the Project") in mid-west 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 93 wind turbines with a rotor diameter of 200 m, upper tip height of 300 m, and lower tip height of 60 m has been considered. These dimensions represent the maximum and minimum overall tip heights and maximum rotor diameter under consideration for the Project. The turbine layout assessed in this report is referred to as the "current turbine layout". Previous consultation with radiocommunication licence operators in the vicinity of the Project was based on an earlier version of the layout, referred to as the "preliminary turbine layout".

There are 14 identified dwellings within 5 km of the Project, 2 of which are stakeholder dwellings.

Outcomes of the assessment

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

Analysis undertaken by the Bureau of Meteorology (the Bureau) has suggested that turbines at the Project have the potential to materially impact on the operation of their Watheroo radar, located approximately 101 km southeast of the Project, and the associated weather monitoring and prediction services. The Bureau's response was based on the preliminary turbine layout and most turbines identified to cause interference have since been relocated or removed. The Bureau has been provided the current turbine layout for review, and no response has been received to date. Based on the preliminary turbine layout, the Bureau has proposed a detailed assessment of potential impacts be completed, including consideration and suggestion of mitigation options to restore impacted services and maintain service quality. DNV recommends further engagement with the Bureau to determine appropriate mitigation measures, if required based on the current turbine layout. Potential mitigation measures may include the installation of additional weather monitoring equipment such as automatic weather stations, wind profiling devices, or a new meteorological radar.

Turbines at the Project may interfere with point-to-area style services such as mobile phone signals, radio broadcasting, and terrestrial television broadcasting, particularly in areas with poor or marginal signal coverage. Dwellings within approximately 5-10 km of the Project that are currently receiving weak signals from the Morawa and Geraldton television broadcast transmitters may experience interference to those services. However, BAI Communications has been consulted and based on the preliminary turbine layout advised that while the Project will likely cause interference to signals from the Morawa transmitter, there are no dwellings within the potential interference zones modelled by BAI Communications. No response has been received to date regarding the current turbine layout. If interference to these services is experienced, a range of options are available to rectify difficulties.

There is a potential for interference to geostationary satellite internet signals intended for Australian audiences at one dwelling. DNV recommends engaging with the owners or residents of this dwelling to confirm the potential for interference and establish an understanding of how any impact may be mitigated. Interference to signals from geostationary satellites that transmit programs intended for private communications and international audiences is also possible at the same individual dwelling, but it is considered unlikely that residents will be receiving signals from these satellites.

It is not possible to determine the potential EMI impacts on emergency services and point-to-multipoint links without obtaining further information from the relevant operators.

DNV understands that the Customer has consulted with select organisations operating point-to-multipoint services that may be affected by the Project. Electricity Networks Corporation (Western Power) previously raised concerns regarding three point-to-multipoint links that cross the site. However, they have since advised that two of the link paths are planned to be re-routed to be clear of the proposed turbine locations. DNV has modelled near field and diffraction exclusion zones based on the second Fresnel zone for the re-routed links. The calculated exclusion zones are clear of turbines. Additionally, Western Power has indicated that the risk of interference is low and have noted that alternative communication methods can be explored if interference is experienced once the Project becomes operational. The Customer has also consulted with Water Corporation, who operate point-to-multipoint licences in the vicinity of the Project. Water Corporation advised that none of their assets are located close to the Project, with the nearest site situated more than 13 km from the Project area.

DNV has contacted other operators of potentially affected point-to-multipoint and emergency services licences regarding the Project to seek feedback on whether interference to their operations and services is likely. To date, no concerns have been raised based on the preliminary turbine layout.

Potential EMI impacts on other services considered in this assessment, point-to-point links, 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

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	6 links crossing Project boundary, operated by: Electricity Networks Corporation (Western Power) The Department of Fires and Emergency Services of WA (DFES WA) Shire of Three Springs The Department of Biodiversity Conservation and Attractions (DBCA) **All links:** No turbines in diffraction zones	**Shire of Three Springs:** No response received **DBCA:** interference considered unlikely **DFES WA:** low potential for interference **Western Power:** no concerns raised	Unlikely to cause interference	If required, reroute affected links, install additional towers, replace affected links with alternative technologies
Fixed point-to-multipoint links	66 assignments within 75 km of Project boundary 3 base stations within 20 km of Project boundary, operated by: Western Power Water Corporation	**Water Corporation, Beach Energy, Iluka Resources Limited**: No concerns raised **Western Power:** point-to-multipoint link paths crossing the site, no turbines within requested clearance zones **Other operators:** No response received	**Western Power, Beach Energy, Iluka Resources Limited, Water Corporation:** None	**Western Power, Beach Energy, Iluka Resources Limited, Water Corporation:** none required **Other operators:** 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	-	-	-

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
Emergency services	**Point-to-point links:** 2 DFES WA and DBCA links crossing boundary (see above) **Point-to-area style communications:** unlikely to be affected	**DBCA:** interference considered unlikely **DFES WA:** low potential for interference **Western Australia Police:** No concerns raised **St John Ambulance Western Australia Ltd**: No response received	**Point-to-point links:** Unlikely to cause interference **Point-to-area style communications:** Unlikely to cause interference	**Point-to-point links:** as for point-to-point links **Point-to-area style communications:** if required – increase signal strength from affected tower or alternative towers, install signal repeater, install additional tower
Meteorological radar	Nearest radar: 101 km from Project	Based on the preliminary turbine layout: likely to cause significant interference to the Watheroo radar Current turbine layout has been provided and no response has been received to date	To be confirmed through consultation with the Bureau, based on the current turbine layout	To be determined through consultation with the Bureau of Meteorology. Mitigation options may include the installation of automatic weather stations, wind profiling devices, or a new meteorological radar
Trigonometrical stations	**Trigonometrical stations:** unlikely to be affected **Survey marks:** unlikely to be affected	No concerns raised	Unlikely to cause interference	None required
Citizen's band radio	Unlikely to be affected	Consultation not considered necessary	Unlikely to cause interference	None required
Mobile phone services	Unlikely to be affected in areas with good coverage, may experience interference in areas with marginal coverage	**Optus:** No response received **Other operators:** No concerns raised	Low likelihood of 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 phone services	**Wireless broadband services:** as for mobile phone services **NBN:** none required

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

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
			NBN: None	
Satellite television and internet	**Geostationary satellites:** signal from 1 satellite providing services intended for Australian audiences, 2 satellites providing services intended for international audiences, and 1 satellite providing services intended for private communications intercepted at 1 dwelling **Low Earth orbit (LEO) satellites:** unlikely to be affected	Consultation with residents recommended	**Geostationary satellites:** potential for interference to services intended for Australian audiences at one dwelling **LEO satellites:** unlikely to cause interference	**Geostationary satellites:** if required – redirect satellite dish to alternative satellite, install larger or higher-quality satellite dish, change location or height of satellite dish **LEO satellites:** none required
Radio broadcasting	**AM and FM signals:** may experience interference in close proximity to turbines **Digital radio signals:** none	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
Television broadcasting	May experience interference in areas with poor or marginal reception **Morawa transmitter:** *'variable' to 'good' coverage* northeast of the Project site; variable coverage to the north and south. 9 dwellings in potential interference zone **Geraldton transmitter:** *'none' to 'variable' coverage* to the west of the Project site that increases to the northwest. Coverage is non-existent across other parts of the Project 6 dwellings in potential interference zone	Potential for interference to signals from the Morawa transmitter. However, there are no dwellings within the potential interference zone.	Low likelihood of interference, as dwellings may not be currently receiving a signal	If required – re-align antenna at affected dwelling to existing tower, re-direct antenna to alternative tower, install more directional or higher gain antenna, change location of antenna, install cable or satellite television, install relay transmitter

1 INTRODUCTION

Twin Hills Wind Farm Pty Ltd ("the Customer") has commissioned DNV to independently assess the potential electromagnetic interference (EMI) related impacts associated with the proposed Twin Hills Wind Farm ("the Project") in mid-west Western Australia. The results of this work are reported here. This document has been prepared in accordance with DNV proposal OPP-00392036-AUMEL-P-01 Issue C, dated 7 February 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 The site

The Project is located approximately 250 km north of Perth and 17 km northeast of Eneabba. The site is predominantly comprised of cleared agricultural land used for livestock and farming, with pockets of forest and shrubs throughout.

2.2 The Project

2.2.1 Proposed wind farm layout

The Project is proposed to consist of 93 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 5**.**

2.2.2 Dwelling locations

The locations of dwellings in the vicinity of the Project have been provided by the Customer [2]. There are 14 dwellings located within 5 km of the Project boundary, 2 of which are stakeholder dwellings. Coordinates of these dwellings are presented in Table 6, and the dwellings and Project boundary considered in this assessment are shown in Figure 1.

For the purposes of this assessment, DNV has evaluated the potential for EMI-related impacts at identified dwellings within 5 km of the Project boundary. The locations of identified dwellings more than 5 km from the Project boundary have also been shown, where available, but impacts at these dwellings have not been considered in detail.

DNV has not carried out a detailed and comprehensive survey of building locations in the area and is relying on information provided by the Customer. Buildings listed as "dilapidated" or "shed" have not been considered in this assessment [3]. For the purposes of this assessment, DNV has assumed that all listed dwellings are inhabited.

3 REGULATORY REQUIREMENTS

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

The EPHC, in conjunction with Local Governments and the Planning Ministers' Council released a draft version of the National Wind Farm Development Guidelines in July 2010 (Draft National Guidelines) [1]. The Draft National Guidelines cover a range of issues across the different stages of wind farm development.

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

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

4 EMI CAUSED BY THE PHYSICAL PRESENCE OF WIND TURBINES

4.1 Assessment approach

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

The Customer has asked DNV to complete this assessment based upon a layout provided for the Project consisting of 93 wind turbines, as outlined in Table 5.

For the purpose of the EMI assessment, a hypothetical turbine with a rotor diameter of 200 m, an upper tip height of 300 m, and a lower tip height of 60 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 200 m or less
- an upper tip height of 300 m or less
- a lower tip height of 60 m or more.

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 9 March 2026 [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. The Customer has consulted with select organisations operating point-to-multipoint services that may be affected by the Project. Additionally, DNV has consulted with other 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 15. Consultation with these operators has been undertaken in two stages:

1. consultation with all identified organisations based on a previous turbine layout consisting of up to 110 turbines with a rotor diameter of 200 m and an upper tip height of 300 m ("the preliminary turbine layout")
2. further consultation with those organisations that had had not previously responded or had requested to be contacted if the turbine layout changed, based on the turbine layout and dimensions considered in this assessment ("the current turbine layout", consisting of up to 93 turbines with a rotor diameter of 200 m and an upper tip height of 300 m).

The radiocommunication licences and services with potential to experience EMI-related impacts from the proposed Project are considered in the following sections. Each section contains a brief overview of the relevant technology, followed by an assessment of the identified licences and services in the area around the Project and the expected potential for interference. Details of any potential mitigation options are also included where appropriate.

4.2 Radiocommunication towers

Wind turbines located close to radiocommunication sites have the potential to cause interference through near-field effects or reflection or scattering of the signals. According to the Draft National Guidelines [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 249 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 2.9 km north of the nearest turbine. 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 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 six point-to-point links recorded in the ACMA RRL database that pass over the proposed Project boundary, operated by Electricity Networks Corporation (Western Power), the Department of Fires and Emergency Services of WA (DFES WA), the Shire of Three Springs, and the Department of Biodiversity Conservation and Attractions (DBCA). The details of the links are provided in Table 7, 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.

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

4.3.1.1 Interference caused by diffraction

The potential for interference to a fixed point-to-point link through diffraction or obstruction of the signal can usually be avoided by keeping clear of an exclusion zone of circular cross-section around the link path from the transmitter to the receiver [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 200 m rotor diameter, and an additional buffer to account for potential inaccuracies in the tower locations. The size of the uncertainty buffer in each case is based on the deviations between the tower locations given in the ACMA RRL database and the apparent locations determined from aerial or satellite imagery.

As shown in Figure 4, there are no turbines located within the diffraction exclusion zone for the point-to-point links passing over proposed Project site. Therefore, it is not expected that the Project will cause interference to the point-to-point link through diffraction of the signals.

4.3.1.2 Interference caused by reflection or scattering

Interference due to reflection or scattering of a fixed point-to-point link can occur when the signal produced by the transmitting antenna is reflected, scattered, or re-radiated by an intervening object into the corresponding receiver antenna. If the reflected or scattered signal is sufficiently strong that the ratio of the direct signal to the indirect signal is lower than the required carrier-to-interference (C/I) ratio, or protection ratio, for the link, the link performance can be degraded. The extent to which an object such as a wind turbine will reflect or scatter electromagnetic waves is characterised by its radar cross section (RCS) [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 links 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 links 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 and the Customer has contacted the operators of the point-to-point links crossing the proposed Project boundary to determine the likelihood that the proposed Project will cause interference to their operations and services through diffraction, reflection or scattering, or near-field effects. Responses have been received from Western Power, DFES WA, and the DBCA, based on the preliminary turbine layout, as summarised Table 15.

The DBCA has noted that some turbines in the preliminary turbine layout aligned with one of their point-to-point links and has indicated that they are uncertain of the potential for interference. However, they have reviewed the preliminary turbine locations in relation to the diffraction exclusion zone calculated by DNV for the link path, and advised that they understand that the interference zone aligns with the relevant standards and therefore consider interference unlikely. Further to this, the proposed turbine locations in the current turbine layout have been removed from the vicinity of this link path. DNV has provided the current turbine layout to the DBCA for review, and to date no response has been received.

The DFES WA advised that the Project does pose some risk to their point-to-point link crossing the Project. However, the DFES WA noted that the turbine locations are outside of the diffraction, reflection and scattering and near field interference zones. They have concluded that there is low potential for interference from the proposed Project.

Western Power have been provided the preliminary turbine layout for review and did not raise concerns regarding their point-to-point links.

The current turbine layout has been shared with the Shire of Three Springs who had not previously provided feedback and no response has been received to date.

4.3.3 Mitigation options

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

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 66 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 8.

There are 3 point-to-multipoint base stations within 20 km of the Project boundary, operated by Western Power and Water Corporation. There are also several point-to-multipoint base stations located more than 20 km from the Project.

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

The Customer contacted Western Power and Water Corporation to seek feedback on whether their services are likely to be affected by the Project. Responses shared with DNV highlighted that Western Power operate three fixed links that cross the site boundary near the turbine locations and could therefore be impacted. The feedback received from Western Power and Water Corporation and the potential for interference to their links is discussed in further detail in Section 4.4.2.

4.4.2 Stakeholder consultation

The Customer has consulted with Western Power to provide the preliminary turbine layout and request feedback on their point-to-multipoint services that may be affected by the Project.

DNV understands that Western Power previously raised concerns regarding three of their point-to-multipoint links that cross the site. However, through correspondence with the Customer, Western Power have advised that two of the link paths are planned to be re-routed to be clear of the proposed turbine locations. The location of the re-routed links is between Site ID 47231 and two remote base stations (Site ID PID_002925407 and 30720). These link paths are shown in Figure 6.

DNV has modelled the proposed link paths and diffraction exclusion zones based on the second Fresnel zone for these links, as requested by Western Power and explained in Section 4.3.1.1. The exclusion zones are shown in Figure 6. As shown in Figure 6, no turbines are located within the calculated diffraction exclusion zones for any of the links. DNV has also modelled the exclusion zones based on the near field zone for these links, as requested by Western Power and explained in Section 4.3.1.3. As shown in Figure 6, no turbines are located within the near field exclusion zone for the tower within the Project site. Western Power have noted that alternative communication methods can be explored if interference is experienced once the Project becomes operational. DNV recommends that the results of this analysis are shared with Western Power as requested.

The Customer has also consulted with Water Corporation, who operate point-to-multipoint licences in the vicinity of the Project. Water Corporation advised that none of their assets are located in close proximity to the wind farm, with the nearest site situated more than 13 kilometres from the Project area.

DNV has contacted the operators of other point-to-multipoint licences in the vicinity of the proposed Project to determine the likelihood that the Project will cause interference to their operations and services. Responses received to date have been summarised in Table 15. No

concerns have been raised by Beach Energy Pty Ltd and Iluka Resources Limited based on the preliminary turbine layout, and further consultation with these operators is not considered necessary. The current turbine layout has been shared with the Bureau of Meteorology (the Bureau), DBNGP (WA) Nominees Pty Ltd, and Mepau Perth Basin Pty Ltd to request feedback on the potential for interference, but no responses have been received to date.

4.4.3 Mitigation options

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

4.5 Other licence types

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

4.5.1 Locations of other licences and potential for interference

DNV has identified a number of other licences in the ACMA RRL database within 75 km of the proposed Project boundary. The locations of these licences and number of associated Assignment IDs for each licence type are shown in Figure 7 and Table 9.

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 10 along with their contact details. The nearest licence is associated with a tower located approximately 4.3 km from the Project boundary.

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

All other licences operated by emergency services in the vicinity of the Project are mobile telephony licences used for mobile radio and paging systems, 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 emergency services mobile telephony and maritime licences from the Project, DNV considers it unlikely that the Project will cause interference to 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. Responses have been received based on the preliminary turbine layout from DFES WA and the DBCA, as summarised in Table 15.

As described in section 4.3.2., DFES WA advised that the Project does pose some risk to their point-to-point link crossing the Project. However, they noted that the turbine locations are outside of the diffraction, reflection and scattering and near field interference zones. They have concluded that there is low potential for interference from the proposed Project.

The DBCA's response relating to their point-to-point link path is detailed in section 4.3.2. The DBCA has requested clarification on what mitigation measures would be implemented should interference occur once the Project is operational. DNV recommends the Customer continues engagement with the DBCA as the Project progresses.

Western Australia Police have confirmed that they do not have concerns regarding current turbine layout. St John Ambulance Western Australia Ltd have been provided the current turbine layout for review and no response has been received to date.

4.6.3 Mitigation options

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

As noted above, interference with mobile telephony services is considered unlikely. If 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 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 6 weather radars within 250 nautical miles of the proposed Project, with the closest radar located approximately 101 km northeast of the Project at Edawa Road near Miling. The locations of these radars are shown in Figure 8 and the details of each radar are given in Table 11.

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

4.8.2 Stakeholder consultation

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

The response received from the Bureau based on the preliminary turbine layout indicated that the Project has potential to materially impact the operation of their radar at Watheroo. Specifically, analysis undertaken by the Bureau suggested that seven turbines from the preliminary turbine layout have the potential to pose significant risk to the radar. Several of the identified turbines have since been relocated in the current turbine layout. However, turbine 93 has not been relocated. To address this potential for impact and based on the preliminary turbine layout, the Bureau has proposed to undertake a detailed assessment of the likely impacts on their services and possible mitigation measures. DNV has provided the current turbine layout to the Bureau for review and no response has been received to date. DNV recommends further engagement with the Bureau to better understand the potential for interference and possible mitigation options.

4.8.3 Mitigation options

The Bureau has been provided the current turbine layout, however no feedback has been received to date. Should interference remain a concern, mitigation measures to address potential impacts on the Watheroo radar will need to be determined through further consultation with the Bureau and 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 31 trig points within 20 km of the Project boundary. Four trig points (Aw 12, Dookanooka, NS, and One Tree East) are located inside the Project boundary, with the nearest trig point, Aw 12, located approximately 217 m northeast of the nearest proposed turbine location. The details of these trig points are provided in Table 12 and their locations are illustrated in Figure 9.

There are also 11 permanent survey marks within 2 km of the Project boundary [21] as shown in Figure 10. The closest survey mark is located 404 m west 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 121 km northwest of the Project, at Geraldton [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 based on the preliminary turbine layout has been received from Geoscience Australia, as summarised in Table 15, and no concerns have been raised. Further consultation is not considered necessary.

4.10 Citizen's band radio

Citizen's band radio, also known as CB radio, is a class-licensed two-way, short distance communication service that can be used by any person in Australia for private or work purposes. It is commonly used in rural areas for emergency communications, road safety information, communication between recreational travellers, and general conversation. The class licence implies

that all users of the CB radio operate within the same frequency range on a shared basis and no individual licence is required.

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

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

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

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

4.10.1 Locations of CB radio devices and potential for interference

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

4.10.2 Mitigation options

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

4.11 Mobile phones

Mobile phone networks typically operate at frequencies of either between 700 and 900 MHz, or between 1800 MHz and 2600 MHz, however some new services may operate at up to 3500 MHz. At such frequencies, signals may be affected by physical obstructions such as buildings and wind turbines. However, mobile phone networks are designed to operate in such conditions and in most

cases, if there is sufficient mobile network coverage and signal strength, the presence of wind turbines is unlikely to cause any interference.

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

4.11.1 Availability of mobile phone services and potential for interference

DNV has reviewed the locations of mobile phone towers in the vicinity of the proposed Project. The locations of these towers are shown in Figure 11. The nearest mobile phone tower is located approximately 2.5 km north of the Project boundary.

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

Figure 12 shows the Optus Mobile network coverage for the Project area [24]. Signal coverage is broad southwest of the site, particularly in the direction of Eneabba which is approximately 18 km southwest of the Project boundary. However, coverage across the Project and neighbouring townships, including Kadathinni, is patchy, with some areas lacking Optus service, particularly around the township of Three Springs approximately 20 km northeast of the Project boundary.

Figure 13 shows the Telstra network coverage for the Project area [25]. There is broad extent of service coverage across the Project region, with limited to no coverage in some pockets southeast, west and south of the site. There is increased coverage towards the towns of Eneabba and Three Springs.

Figure 14 shows the Vodafone/TPG network coverage for the Project area [26]. Signal coverage is generally good towards the southwest of the site toward Eneabba. Coverage across the Project and neighbouring townships Kadathinni is mixed with patchy coverage.

In general, for areas with good coverage, interference to mobile phone signals is unlikely. However, for areas where the reception is likely to be marginal, such as those where an external antenna is required, the possibility for interference exists if a wind turbine intercepts the signal between a mobile phone and the tower.

4.11.2 Stakeholder consultation

DNV has contacted Optus, 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 based on the preliminary turbine layout from Telstra and Vodafone/TPG, as summarised in Table 15, and no concerns have been raised to date. The current turbine layout has been provided to all operators for review and no responses have been received to date.

4.11.3 Mitigation options

As noted above, interference with mobile phone signals is considered unlikely in areas of good coverage. 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. Based on the preliminary turbine layout, no concerns have been raised to date. The current turbine layout has been provided to all operators for review and no responses have been received to date.

4.12.1.3 Mitigation options

As noted above, interference with wireless broadband services is considered unlikely. If interference to the wireless broadband services provided by mobile phone networks occurs, the mitigation options given in Section 4.11.3 may be applicable. Specifically, localised interference can often be rectified by the user moving a short distance or using an external antenna to improve signal reception. For interference over a larger area, or in cases where it would not be possible or practical for the user to change their location, mitigation options may include increasing the signal strength from the affected tower or alternative towers, or installing a signal repeater or additional tower on the opposite side of the Project.

4.12.2 National Broadband Network

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

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

NBN fixed wireless services are available in many rural and regional areas. The signals operate by line of sight between an NBN tower and the user's antenna, with a maximum range of 14 km [27]. Consequently, the signals may be affected by physical obstructions such as terrain, vegetation, and wind turbines [28].

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 [29] 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. NBN Co's responses based on the preliminary and current turbine layouts are summarised in Table 15. No concerns have raised and they have advised that there are no NBN customers that are within the Project boundaries that would be impacted by the proposed Project.

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.

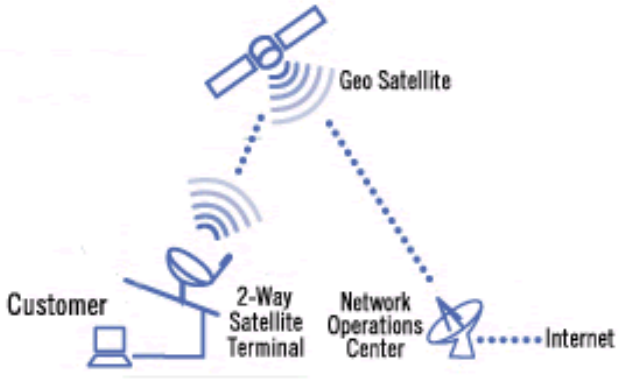
4.13.1 Geostationary satellite communication services

Geostationary satellites orbit the earth directly above the equator, at a height of 35,786 km above the Earth's surface [30]. 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 [31, 32].

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 [33]

4.13.1.1 Locations of geostationary satellite vectors and potential for interference

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

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

The results of this analysis are shown in Table 13 and summarised in Table 1. Based on these results, turbines at the Project may intercept signals from four satellites at one nearby stakeholder dwelling (D77). DNV understands that one of these satellites, NSS9, provides services that may be intended for Australian audiences. However, if the residents of D77 do not use services provided by the NSS9 satellite there will be no potential for impact to that service.

DNV understands that all other potentially affected satellites provide television signals intended for international audiences and private communications, and considers it unlikely that residents in the vicinity of the Project will currently be receiving signals from these satellites. Many of these satellites have a low angle of elevation above the horizon at the Project site location, and so degradation caused by atmospheric effects or interference from terrain or other obstacles may already prevent the signals from being received at the affected dwellings. For some of these satellites, the programs transmitted on the beam footprints that cover Australia may also be available through other satellite services which have a higher angle of elevation above the horizon and are not expected to be intercepted by turbines at the Project. If residents are not currently receiving signals from these satellites, either by choice or because those signals are not available

due to existing degradation or interference, there will be no potential for the Project to impact on those services.

Table 1 Number of satellites with potential for signals to nearby dwellings to be intercepted by the proposed Project

Satellite service	Number of potentially affected satellites	Number of potentially affected dwellings
Services intended for Australian audiences	1	1 stakeholder dwelling (D77)
Services intended for private communications	1	1 stakeholder dwelling (D77)
Services intended for international audiences	2	1 stakeholder dwelling (D77)

4.13.1.2 Stakeholder consultation

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

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

4.13.1.3 Mitigation options

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

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 [30]. 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, LEO satellites used for telecommunications usually operate as part of a large network or "constellation" of multiple satellites that work together to provide continuous coverage to large areas simultaneously. As satellites within the constellation move through the field of view of a satellite dish on Earth, the dish detects and connects to the satellite with the strongest signal and then automatically switches over to another satellite as the first moves out of view. Nevertheless, these services may be sensitive to physical obstructions such as terrain, vegetation, buildings, and other structures such as wind turbines, which can unexpectedly interrupt the signal from the connected satellite and cause the service to temporarily drop out until a new satellite can be found.

4.13.2.1 Availability of low Earth orbit services and potential for interference

Starlink is the only LEO satellite internet service currently available to customers in Australia. The current Starlink LEO constellation consists of several thousand satellites orbiting the Earth at a height of approximately 550 km [34], 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 [35, 36].

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 [37]. 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 [38], 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 300 m.

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

4.14 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 [39].

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 [40], and are shown in Figure 15.

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 [41]. 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 [39, 42].

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 [41]. 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 [43].

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 [40], and are shown in Figure 15.

The closest FM broadcast transmitter is located approximately 13 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 [44]. 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 [41] 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 Australian Broadcasting Corporation (ABC) website [45], 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 [46]. 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 [46], and are shown in Figure 15. The main DTV transmitter used by residents in the vicinity of the Project is the Morawa transmitter. However, according to the Australian Government mySwitch website [47], it is also possible that residents in the vicinity of the Project are able to receive DTV signals from the Geraldton transmitter.

The DTV broadcast transmitters likely to be servicing the area around the Project are summarised in Table 2 below. Coverage maps for these broadcast transmitters are reproduced in Figure 16 to Figure 17.

Table 2 DTV broadcast transmitters servicing the Project area

DTV broadcast transmitter	Signal coverage in the vicinity of the Project	Figure containing coverage map
Morawa	Good to variable coverage to the northeast of the Project site; patchy coverage to the north and south. Variable coverage within the east of the Project boundary; no coverage elsewhere	Figure 16
Geraldton	Poor to variable coverage to the west of the Project site that is stronger in the northwest direction towards Geraldton. Coverage is non-existent across other parts of the Project.	Figure 17

4.15.1.1 Interference caused by large scale effects

For broadcast signals, large scale interference can generally be avoided by placing the wind turbines at some distance from the transmitter. Broadcast transmitters may be either relay or primary transmitters. Relay transmitters are more commonly found in rural areas. Primary transmitters are higher power and are more commonly located near large urban areas. A clearance of at least 1 km is recommended for relay transmitters, while a clearance of at least 6 km is recommended for primary transmitters [7].

The closest DTV transmitter to the Project is the Carnamah primary transmitter, which is approximately 27 km away. Therefore, it is considered unlikely that the Project will cause large scale interference to signals from this transmitter. Additionally, although the Carnamah broadcast transmitter is located near the Project area, coverage maps indicate that it is unlikely to be serving users in the vicinity of the Project.

4.15.1.2 Interference caused by reflection or scattering

Although DTV signals are generally unlikely to be susceptible to interference from wind turbines in areas of adequate coverage, interference could be encountered in areas where coverage is marginal and antennas at dwellings may receive a reflected signal from a turbine that is of sufficient power to interfere with the signal received directly from the transmitter. Based on the coverage maps for the area around the Project, it is possible that some areas could be deemed to have marginal reception and interference could be encountered.

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

The results of the analysis can be seen in Table 14 and Figure 16. The dwellings most likely to be susceptible to interference include those within the possible interference zones, as summarised in Table 3.

Note that if the signal received at a dwelling from the transmitter is sufficiently weak, or an antenna with insufficient directional discrimination is installed (i.e., a low gain or omni-directional antenna), interference may still occur at dwellings outside of the identified interference zones. Circumstances under which interference may occur outside the interference zones typically established using the 'keyhole' approach are discussed further in Section A.2 of Appendix A. In particular, although DNV has considered the potential for interference to DTV signals at dwellings within 5 km of the proposed turbine locations, previous advice received from BAI Communications, who are responsible for broadcasting of national public television services in Australia, has indicated that interference to DTV broadcasting may be experienced at distances of up to 10 km from turbines. For comparison, Figure 16 also shows the area within 10 km of the proposed turbine locations. DNV recommends contacting BAI Communications, as discussed in Section 4.15.2 to confirm the potential for interference to DTV signals received at dwellings outside the 'keyhole' interference zones.

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

DTV broadcast transmitter	Number of dwellings in potential interference zone	Signal coverage in potential interference zone
Morawa	9 (2 stakeholder dwellings)	Variable to none – dwellings in the potential interference zone may not be receiving signals from this transmitter
Geraldton	6 (2 stakeholder dwellings)	Limited to none – dwellings in the potential interference zone are unlikely to be receiving signals from this transmitter

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

4.15.2 Stakeholder consultation

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

Based on the preliminary turbine layout, BAI Communications has assessed the potential for turbines at the Project to interfere with DTV signals from the Mt Campbell (Morawa) transmitter [48]. The method used by BAI Communications involved modelling the reflection or scattering of DTV signals from the wind turbines and identifying locations within 10 km of the Project where the resulting C/I ratio for a directional antenna oriented towards the transmitter of interest would be less than required for adequate signal reception.

From the results of their modelling, BAI Communications have advised that there is potential for interference to signals from the Morawa transmitter. However, BAI Communications also completed a review of satellite imagery and advised that there are no dwellings within the potential interference areas. In the event that interference to DTV signals is experienced by residents, BAI Communications have advised that they expect any necessary mitigation to be undertaken as part of the Project.

The current turbine layout has been provided to BAI Communications for review, and no response has been received to date.

4.15.3 Mitigation options

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

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

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

In the case of forward scatter, the antenna will be pointed towards both the original and scattered signal and hence a more aligned or directional antenna may not alleviate a forward scatter issue. Alternative mitigation measures to resolve issues caused by forward scatter could include tuning the antenna into an alternative signal (if one is available) or installing cable or satellite television at the affected dwelling. However, as noted in [49], DVB-T reception quality may not be substantially affected in the forward scatter region.

The ITU [50] 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 [51].

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 93 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 200 m or less, an upper tip height of 300 m or less, and a lower tip height of 60 m or more.

The results of this assessment are summarised in Table 4.

Analysis undertaken by the Bureau has suggested that turbines at the Project have the potential to materially impact on the operation of their Watheroo radar, located approximately 101 km southeast of the Project, and the associated weather monitoring and prediction services. The Bureau's response was based on the preliminary turbine layout and most turbines identified to cause interference have since been relocated or removed. The Bureau has been provided the current turbine layout for review, and no response has been received to date. Based on the preliminary turbine layout, the Bureau has proposed a detailed assessment of potential impacts be completed, including consideration and suggestion of mitigation options to restore impacted services and maintain service quality. DNV recommends further engagement with the Bureau to determine appropriate mitigation measures, if required based on the current turbine layout. Potential mitigation measures may include the installation of additional weather monitoring equipment such as automatic weather stations, wind profiling devices, or a new meteorological radar.

Turbines at the Project may interfere with point-to-area style services such as mobile phone signals, radio broadcasting, and terrestrial television broadcasting, particularly in areas with poor or marginal signal coverage. Dwellings within approximately 5-10 km of the Project that are currently receiving weak signals from the Morawa and Geraldton television broadcast transmitters may experience interference to those services. However, BAI Communications has been consulted and based on the preliminary turbine layout advised that while the Project will likely cause interference to signals from the Morawa transmitter, there are no dwellings within the potential interference zones modelled by BAI Communications. No response has been received to date regarding the current turbine layout. If interference to these services is experienced, a range of options are available to rectify difficulties.

There is a potential for interference to geostationary satellite internet signals intended for Australian audiences at one dwelling. DNV recommends engaging with the owners or residents of this dwelling to confirm the potential for interference and establish an understanding of how any impact may be mitigated. Interference to signals from geostationary satellites that transmit programs intended for private communications and international audiences is also possible at the same individual dwelling, but it is considered unlikely that residents will be receiving signals from these satellites.

It is not possible to determine the potential EMI impacts on emergency services and point-to-multipoint links without obtaining further information from the relevant operators.

DNV understands that the Customer has consulted with select organisations operating point-to-multipoint services that may be affected by the Project. Western Power previously raised concerns regarding three point-to-multipoint links that cross the site. However, they have since advised that two of the link paths are planned to be re-routed to be clear of the proposed turbine locations. DNV

has modelled near field and diffraction exclusion zones based on the second Fresnel zone for the re-routed links. The calculated exclusion zones are clear of turbines. Additionally, Western Power has indicated that the risk of interference is low and have noted that alternative communication methods can be explored if interference is experienced once the Project becomes operational. The Customer has also consulted with Water Corporation, who operate point-to-multipoint licences in the vicinity of the Project. Water Corporation advised that none of their assets are located close to the Project, with the nearest site situated more than 13 km from the Project area.

DNV has contacted other operators of potentially affected point-to-multipoint and emergency services licences regarding the Project to seek feedback on whether interference to their operations and services is likely. To date, no concerns have been raised based on the preliminary turbine layout.

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

Table 4 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	6 links crossing Project boundary, operated by: Electricity Networks Corporation (Western Power) The Department of Fires and Emergency Services of WA (DFES WA) Shire of Three Springs The Department of Biodiversity Conservation and Attractions (DBCA) **All links:** No turbines in diffraction zones	**Shire of Three Springs:** No response received **DBCA:** interference considered unlikely **DFES WA:** low potential for interference **Western Power:** no concerns raised	Unlikely to cause interference	If required, reroute affected links, install additional towers, replace affected links with alternative technologies
Fixed point-to-multipoint links	66 assignments within 75 km of Project boundary 3 base stations within 20 km of Project boundary, operated by: Western Power Water Corporation	**Water Corporation, Beach Energy, Iluka Resources Limited**: No concerns raised **Western Power:** point-to-multipoint link paths crossing the site, no turbines within requested clearance zones **Other operators:** No response received	**Western Power, Beach Energy, Iluka Resources Limited, Water Corporation:** None	**Western Power, Beach Energy, Iluka Resources Limited, Water Corporation:** none required **Other operators:** 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	-	-	-

Table 4 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
Emergency services	**Point-to-point links:** 2 DFES WA and DBCA links crossing boundary (see above) **Point-to-area style communications:** unlikely to be affected	**DBCA:** interference considered unlikely **DFES WA:** low potential for interference **Western Australia Police:** No concerns raised **St John Ambulance Western Australia Ltd**: No response received	**Point-to-point links:** Unlikely to cause interference **Point-to-area style communications:** Unlikely to cause interference	**Point-to-point links:** as for point-to-point links **Point-to-area style communications:** if required – increase signal strength from affected tower or alternative towers, install signal repeater, install additional tower
Meteorological radar	Nearest radar: 101 km from Project	Based on the preliminary turbine layout: likely to cause significant interference to the Watheroo radar Current turbine layout has been provided and no response has been received to date	To be confirmed through consultation with the Bureau, based on the current turbine layout	To be determined through consultation with the Bureau of Meteorology. Mitigation options may include the installation of automatic weather stations, wind profiling devices, or a new meteorological radar
Trigonometrical stations	**Trigonometrical stations:** unlikely to be affected **Survey marks:** unlikely to be affected	No concerns raised	Unlikely to cause interference	None required
Citizen's band radio	Unlikely to be affected	Consultation not considered necessary	Unlikely to cause interference	None required
Mobile phone services	Unlikely to be affected in areas with good coverage, may experience interference in areas with marginal coverage	**Optus:** No response received **Other operators:** No concerns raised	Low likelihood of interference	If required – increase signal strength from affected tower or alternative towers, install additional tower

Table 4 Summary of EMI assessment results for the proposed Project (continued)

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Wireless internet	**Wireless broadband service providers:** mobile phone networks, NBN Co **NBN:** available as a satellite service only	No concerns raised	**Wireless broadband services**: see findings for mobile phone services **NBN:** None	**Wireless broadband services:** as for mobile phone services **NBN:** none required
Satellite television and internet	**Geostationary satellites:** signal from 1 satellite providing services intended for Australian audiences, 2 satellites providing services intended for international audiences, and 1 satellite providing services intended for private communications intercepted at 1 dwelling **Low Earth orbit (LEO) satellites:** unlikely to be affected	Consultation with residents recommended	**Geostationary satellites:** potential for interference to services intended for Australian audiences at one dwelling **LEO satellites:** unlikely to cause interference	**Geostationary satellites:** if required – redirect satellite dish to alternative satellite, install larger or higher-quality satellite dish, change location or height of satellite dish **LEO satellites:** none required
Radio broadcasting	**AM and FM signals:** may experience interference in close proximity to turbines **Digital radio signals:** none	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
Television broadcasting	May experience interference in areas with poor or marginal reception **Morawa transmitter:** *'variable' to 'good' coverage* northeast of the Project site; variable coverage to the north and south. 9 dwellings in potential interference zone **Geraldton transmitter:** *'none' to 'variable' coverage* to the west of the Project site that increases to the northwest. Coverage is non-existent across other parts of the Project 6 dwellings in potential interference zone	Potential for interference to signals from the Morawa transmitter. However, there are no dwellings within the potential interference zone.	Low likelihood of interference, as dwellings may not be currently receiving a signal	If required – re-align antenna at affected dwelling to existing tower, re-direct antenna to alternative tower, install more directional or higher gain antenna, change location of antenna, install cable or satellite television, install relay transmitter

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

A.1 Susceptibility of DTV signals to reflection or scattering

The United Kingdom telecommunications regulator Ofcom [41] 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 [49]. Both of these effects can potentially degrade the DTV signal quality.

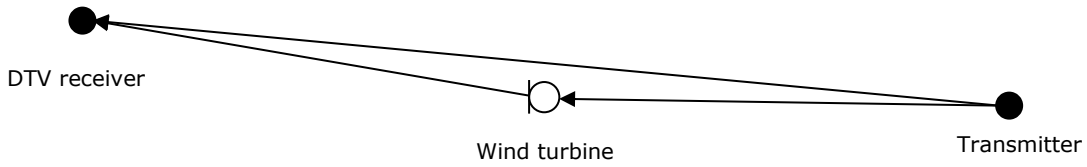

Figure A.1 Forward scatter signal path for DTV signals

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).

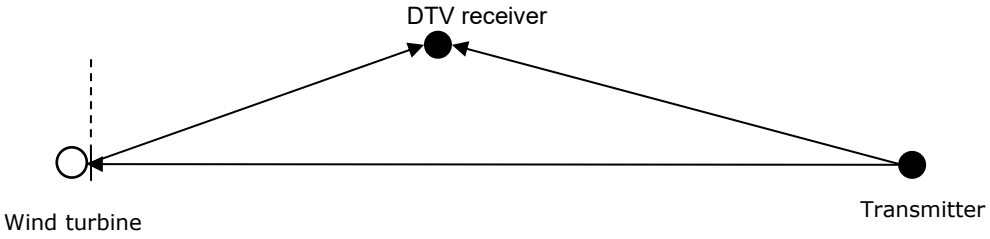

Figure A.2 Back scatter signal path for DTV signals

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 [49].

According to Ofcom [41], the forward scatter region does not typically extend further than 5 km for the worst combination of factors [7, 52]. Interference may extend beyond 5 km if the dwellings are screened from the broadcast transmitter, but do have line-of-sight to the turbines [41]. 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, 41], 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.

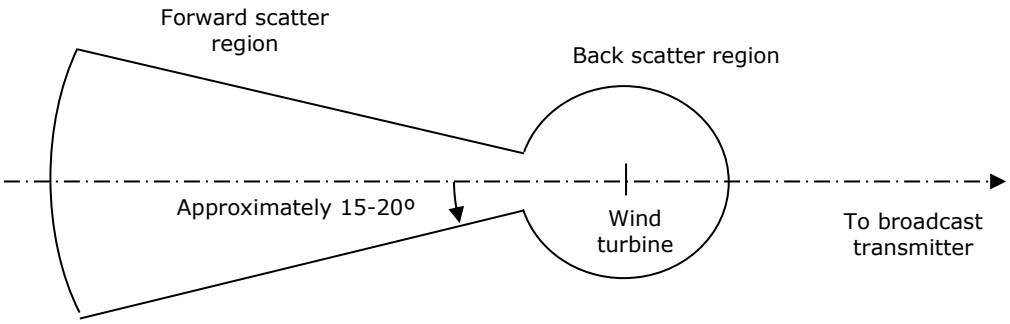

Figure A.3 Potential television interference zones around a wind turbine

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 [53] 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 [50] 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 [50].

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 [54]. 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 [53], 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 [41]. The combination of these areas forms a region where there is an increased likelihood of interference to television signals occurring.

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Table 5 Proposed turbine layout for the Project [55]

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation[2] [m]	Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation[2] [m]
T1	343660	6718700	160	T48	352077	6722748	240
T2	343802	6716230	230	T49	352239	6721444	273
T3	343817	6717832	190	T50	352360	6723222	230
T4	343862	6715125	237	T51	352743	6722036	268
T5	344073	6717185	207	T52	352983	6724172	227
T6	344186	6715573	238	T53	352991	6720966	281
T7	344333	6718139	169	T54	353211	6722818	250
T8	344506	6716327	214	T55	353324	6721424	290
T9	344637	6717473	188	T56	353479	6722100	266
T10	344865	6716752	191	T57	353545	6723307	245
T11	345154	6717780	173	T58	354054	6723671	254
T12	345660	6716655	187	T59	354104	6722655	270
T13	345747	6718050	180	T60	354155	6720992	290
T14	345796	6717190	190	T61	354282	6724184	260
T15	347002	6722233	190	T62	354311	6721559	290
T16	347307	6716989	234	T63	355028	6724227	268
T17	347453	6717910	231	T64	355031	6720976	274
T18	347833	6721498	220	T65	355766	6721040	280
T19	347992	6722057	220	T66	355930	6723823	280
T20	348101	6717023	245	T67	356323	6724247	288
T21	348254	6717797	260	T68	356429	6723002	275
T22	348311	6719393	240	T69	356581	6721031	260
T23	348321	6716293	291	T70	356683	6721904	278
T24	348419	6720744	221	T71	357167	6724248	280
T25	348472	6715583	294	T72	357245	6722856	260
T26	348617	6722948	230	T73	357265	6721251	270
T27	348743	6722132	220	T74	357299	6723450	270
T28	348795	6718118	280	T75	357334	6722055	260
T29	349012	6718706	276	T76	357335	6719894	260
T30	349134	6716365	290	T77	357717	6719248	278
T31	349215	6715713	287	T78	358057	6718539	263
T32	349274	6720999	255	T79	358167	6719598	290
T33	349552	6722720	250	T80	358297	6720144	265
T34	349584	6723316	244	T81	358547	6718911	270
T35	349600	6717128	290	T82	358599	6717205	275
T36	349747	6721579	255	T83	358614	6716608	288
T37	349852	6717780	290	T84	359038	6719335	271
T38	350158	6716227	273	T85	359078	6720158	290
T39	350159	6715612	280	T86	359387	6717130	280
T40	350271	6723415	230	T87	359680	6719533	267
T41	350330	6722078	260	T88	359717	6717948	280
T42	350428	6722762	243	T89	359880	6720101	273
T43	350604	6717154	287	T90	360497	6718980	264
T44	350762	6716454	272	T91	360614	6720177	282
T45	351149	6723443	222	T92	360800	6719501	274
T46	351239	6722763	235	T93	361399	6720156	290
T47	351942	6722160	259				

1. Coordinate system: MGA zone 50, GDA94 datum. Coordinates were provided by the Customer in a different coordinate system and/or datum and have been converted using mapping software, which may result in small discrepancies depending on the software and transformation approach used.
2. Base elevations have been determined by DNV based on publicly available SRTM1 data.

Table 6 Dwellings within 5 km of the proposed Project boundary [2]

Dwelling ID[1]	Easting[2] [m]	Northing[2] [m]	Status	Distance to site boundary [km]
D2	345006	6723594	Non-stakeholder	1.7
D6	341679	6716563	Non-stakeholder	1.2
D19	345268	6713551	Non-stakeholder	1.3
D20	345567	6720018	Non-stakeholder	0.8
D47	354012	6713833	Non-stakeholder	3.2
D48	351519	6726891	Non-stakeholder	2.6
D49	355360	6722363	*Stakeholder*	0.0
D51	364251	6722753	Non-stakeholder	2.3
D77	351059	6721114	*Stakeholder*	0.0
D78	357777	6714919	Non-stakeholder	1.3
D81	364571	6718003	Non-stakeholder	0.2
D84	346119	6714923	Non-stakeholder	0.2
D95	357000	6714570	Non-stakeholder	2.1
D93	337914	6718889	Non-stakeholder	5.0
D96	357622	6714788	Non-stakeholder	1.5

1. Stakeholder dwellings are indicated by *underlined italic text*.
2. Coordinate system: MGA zone 50, GDA94 datum. Coordinates were provided by the Customer in a different coordinate system and/or datum and have been converted using mapping software, which may result in small discrepancies depending on the software and transformation approach used.
3. Buildings listed as "shed" or "dilapidated" have not been considered in this assessment [3].

Table 7 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	1936960/1	911272	460881250	Department of Fire and Emergency Services of WA DFES- Radio Communications Manager PO Box P1174 PERTH WA 6844
		911273	460881250	
		911274	451381250	
		911275	451381250	
3	12422937/2	12393632	6212065000	Electricity Networks Corporation Western Power GPO Box L921 Attn: Comms Operations & Maintenance PERTH WA 6842
		12393633	6212065000	
		12393634	5960025000	
		12393635	5960025000	
4	1612749/1	1234936	7620500000	
		1234937	7620500000	
		1234938	7459500000	
		1234939	7459500000	
5	1945813/1	1235726	460068750	
		1235727	460068750	
		1235728	450568750	
		1235729	450568750	
6	1612855/1	843655	461000000	Shire of Three Springs PO Box 117 THREE SPRINGS WA 6519
		843656	461000000	
		843657	451500000	
		843658	451500000	

Table 8 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	56	Bureau of Meteorology 700 Collins Street Docklands VIC 3008
1306972	602186	1616602/1	-29.1090	115.3186	56	
1306965	602183	1616597/1	-29.0363	115.5542	63	
1306968	602183	1616597/1	-29.0363	115.5542	63	
1306973	602187	1616603/1	-29.0657	115.0984	68	
1306976	602187	1616603/1	-29.0657	115.0984	68	
3782206	30780	1930149/2	-29.4634	115.1412	31	Beach Energy Ltd Level 8 80 Flinders Street ADELAIDE SA 5000
3782207	30780	1930149/2	-29.4634	115.1412	31	
6480428	30813	10913042/1	-29.4053	115.1412	35	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	35	
14376304	47231	12722255/2	-29.5991	115.6808	9	Electricity Networks Corporation Western Power GPO Box L921 Attn: Comms Operations & Maintenance PERTH WA 6842
14376305	47231	12722255/2	-29.5991	115.6808	9	
14376332	30720	12857890/2	-29.8868	115.3626	22	
14376333	30720	12857890/2	-29.8868	115.3626	22	
1235528	30649	1924995/1	-29.9785	115.3332	33	
1235531	30649	1924995/1	-29.9785	115.3332	33	
14376300	31418	12722254/2	-29.3174	115.8796	45	
14376301	31418	12722254/2	-29.3174	115.8796	45	
14376328	30747	12857889/2	-30.1579	115.3905	52	
14376329	30747	12857889/2	-30.1579	115.3905	52	
1235614	30661	1939590/1	-29.7921	116.1704	57	
1235617	30661	1939590/1	-29.7921	116.1704	57	
14376336	30814	12857891/2	-29.1249	115.1404	60	
14376337	30814	12857891/2	-29.1249	115.1404	60	
6341786	10018716	10900455/1	-29.8907	115.2999	24	Iluka Resources Limited GPO Box U 1988 PERTH WA 6845
6341789	10018716	10900455/1	-29.8907	115.2999	24	
1720164	10000361	10061534/1	-29.3068	115.0930	46	MEPAU PERTH BASIN PTY LTD ARC ENERGY NL PO Box 574 WEST PERTH WA 6872
1720167	10000361	10061534/1	-29.3068	115.0930	46	
1295118	9024270	9832211/1	-29.3159	115.0665	47	
1295121	9024270	9832211/1	-29.3159	115.0665	47	

Table 8 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
1250447	602629	1619641/1	-29.5330	115.6745	14	Water Corporation PO Box 100 (OT ? Dinesh Raghu) LEEDERVILLE WA 6902
1250450	602629	1619641/1	-29.5330	115.6745	14	
1250613	602629	1623666/1	-29.5330	115.6745	14	
1250616	602629	1623666/1	-29.5330	115.6745	14	
11889585	602629	12328849/1	-29.5330	115.6745	14	
11889588	602629	12328849/1	-29.5330	115.6745	14	
1249589	9001010	1146008/1	-29.7983	115.7164	18	
1249590	9001010	1146008/1	-29.7983	115.7164	18	
11946913	9001010	12344612/1	-29.7983	115.7164	18	
11946914	9001010	12344612/1	-29.7983	115.7164	18	
1250609	404813	1623665/1	-29.6855	115.9028	30	
1250612	404813	1623665/1	-29.6855	115.9028	30	
11889581	404813	12328848/1	-29.6855	115.9028	30	
11889584	404813	12328848/1	-29.6855	115.9028	30	
1250617	404814	1623667/1	-29.1972	115.4437	45	
1250620	404814	1623667/1	-29.1972	115.4437	45	
10434097	404814	12009699/1	-29.1972	115.4437	45	
10434100	404814	12009699/1	-29.1972	115.4437	45	
11927795	602631	12336157/1	-29.3188	115.8826	45	
11927796	602631	12336157/1	-29.3188	115.8826	45	
1250626	404812	1623671/1	-29.8591	116.0346	47	
1250627	404812	1623671/1	-29.8591	116.0346	47	
11946917	404812	12344613/1	-29.8591	116.0346	47	
11946918	404812	12344613/1	-29.8591	116.0346	47	
1250435	602593	1619431/1	-29.0728	115.3574	60	
1250438	602593	1619431/1	-29.0728	115.3574	60	
7537647	602593	11186361/1	-29.0728	115.3574	60	
7537650	602593	11186361/1	-29.0728	115.3574	60	
7646291	602593	11198489/1	-29.0728	115.3574	60	
7646292	602593	11198489/1	-29.0728	115.3574	60	
4870585	30799	10624024/1	-29.1126	115.1057	63	
4870588	30799	10624024/1	-29.1126	115.1057	63	
1250443	602628	1619640/1	-29.4063	116.2261	66	
1250446	602628	1619640/1	-29.4063	116.2261	66	
11914925	602628	12333766/1	-29.4063	116.2261	66	
11914928	602628	12333766/1	-29.4063	116.2261	66	

Table 9 Details of other licences identified within 75 km of the proposed Project

Licence category	Licence type	Number of assignment IDs
1800 MHz Band	Spectrum	12
2 GHz Band	Spectrum	32
2.3 GHz Band	Spectrum	48
2.5 GHz Band	Spectrum	72
3.4 GHz Band	Spectrum	8
700 MHz Band	Spectrum	289
800 MHz Band	Spectrum	176
850/900 MHz Band	Spectrum	110
AWL - FSS Only	Spectrum	31
AWL - Standard	Spectrum	4
Aeronautical Assigned System	Aeronautical	4
Ambulatory System	Land Mobile	78
CBRS Repeater	Land Mobile	6
Commercial Radio	Broadcasting	9
Commercial Television	Broadcasting	9
Earth Receive	Earth Receive	284
Fixed Earth	Earth	246
Land Mobile System - > 30MHz	Land Mobile	370
Land Mobile System 0-30MHz	Land Mobile	156
Limited Coast Assigned System	Maritime Coast	2
Narrowcasting Service (LPON)	Broadcasting	12
National Broadcasting	Broadcasting	11
PMTS Class B	PTS	14
Paging System - Interior	Land Mobile	1
Radiodetermination	Radiodetermination	14
Retransmission	Broadcasting	22
Scientific Assigned	Scientific	1

Table 10 Emergency services with radiocommunication assets in the vicinity of the proposed Project

Emergency service	Contact details	Distance from closest site to Project boundary [km]
Australian Maritime Safety Authority	Australian Maritime Safety Authority PO Box 2181 GPO Box 2181 CANBERRA ACT 2601 Attn: Response Division Administration, Client ID 316698 CANBERRA ACT 2601	63
Department of Biodiversity Conservation and Attractions	Department of Environment and Conservation Att: Coordinator, Telecommunications Systems Locked Bag 104 Office of Information Management BENTLEY DC WA 6983	13
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	4
Jurien Bay Volunteer Marine Rescue Group Inc	Jurien Bay Volunteer Marine Rescue Group Inc PO Box 462 JURIEN BAY WA 6516	58
St John Ambulance Western Australia Ltd.	St John Ambulance Western Australia LTD. St John Ambulance Australia (Western Australia) Inc. PO Box 183 BELMONT WA 6104	13
St John Ambulance Australia Incorporated	St John Ambulance Australia Incorporated Technical Services 601-609 Blackburn Road NOTTING HILL VIC 3168	63
Surf Life Saving Western Australia Inc	Surf Life Saving Western Australia Inc PO Box 700 Balcatta WA 6021	60
Western Australia Police	Western Australia Police Radio & Electronic Services Unit 21 Swanbank Road Att: Phillip Manna MAYLANDS WA 6051	17

Table 11 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	101
139890	Geraldton Met Bureau Radar Arthur Road GERALDTON	-28.8047	114.6973	114
601351	Bureau of Meteorology Office Northern Perimeter Road PERTH AIRPORT	-31.9274	115.9765	253
44829	Walnut Rd BICKLEY	-32.0077	116.1349	264
138152	Bureau of Meteorlogy across the road from runway Lot 164 (286) Yangedi Rd HOPELAND	-32.3917	115.8670	302
10000627	BOM Station Approximately 1.2km South of Fire Road SOUTH DOODLAKINE	-31.7770	117.9529	324

Table 12 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	Within Project boundary
Dookanooka	AGD66, AGD84	-29.6692	115.5892	Within Project boundary
NS	AGD66, AGD84, GDA94	-29.6813	115.4284	Within Project boundary
One Tree East	AGD66, AGD84	-29.6312	115.4588	Within Project boundary

Table 13 Satellite vectors with potential to be intercepted by the proposed Project

Intercepted satellite	Services provided [56]	Affected dwellings[1]
Inmarsat-3F3 (Inmarsat 3F3, I3F3, POR), Intelsat 18 (IS-18)	Programs intended for international audiences	*D77*
Inmarsat-GX3 (Inmarsat 5F3, I5-POR, GX3)	Private communications	*D77*
NSS 9	Programs intended for Australian audiences	*D77*

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

Table 14 Dwellings with increased potential to experience EMI to DTV from television broadcast transmitters

Dwelling ID[1]	Easting[2] [m]	Northing[2] [m]	Located in potential interference zone	
			Geraldton	Morawa
D6	355360	6722363		X
D19	341679	6716563	X	X
D20	345268	6713551		X
D47	345567	6720018	X	
D49	*354012*	*6713833*	*X*	*X*
D77	*351059*	*6721114*	*X*	*X*
D78	357777	6714919		X
D81	364571	6718003	X	
D84	346119	6714923	X	X
D95	357622	6714788		X
D96	357000	6714570		X

1. Stakeholder dwellings are indicated by *underlined italic text*.
2. Coordinate system: MGA zone 50, GDA94 datum. Coordinates were provided by the Customer in a different coordinate system and/or datum and have been converted using mapping software, which may result in small discrepancies depending on the software and transformation approach used.

Table 15 Summary of service operators contacted by DNV and responses received to date

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
1	Fixed point-to-point: 1 link crossing the Project site Point-to-point #1: No turbines in diffraction exclusion zone established by DNV Emergency services point-to-area: 13 km from Project boundary	Department of Biodiversity Conservation and Attractions (DBCA) 10552824-AUMEL-L-01-A	<u>Response based on the preliminary turbine layout received by email on 19 December 2025:</u> *"As we are aware of the many wind farms currently operating this region that are in line within a number of our communication assets. To date there has been no evidence of…any EMI effects from the existing wind farms that are in a similar proximity to our communication assets and feel the impact may be minimal, if at all…* *…I've noted that the proposed location appears to be directly in line with the RF link pathway between the sites in question. At this stage, we are uncertain about the potential effects…on this UHF link. Your proposed mitigation measures and exclusion zones seem to align well within the required standards, and we believe this is unlikely to pose an issue. However, if interference does become evident, what measures will be implemented to eliminate or minimize its impact [?]."* **Further consultation is not considered necessary. Proposed turbine locations in the current turbine layout have been removed from the vicinity of this link path.**

Table 15 Summary of service operators contacted by DNV and responses received to date

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
2	Fixed point-to-point: 1 link crossing the Project site Point-to-point #2: No turbines in diffraction exclusion zone established by DNV Emergency services point-to-area: 4 km from Project boundary	Department of Fire and Emergency Services of WA (DFES WA) 10552824-AUMEL-L-02-A	Response based on the preliminary turbine layout received by email on 17 December 2025: *"I have assessed this proposal and conclude this may have a detrimental effect on the Department of Fire and Emergency Services (DFES) VHF high-band communication and a UHF point to point link in this region.* *DFES do have a number of VHF repeater services from several sites where this proposed wind farm falls inside the coverage radius of these services.* *…One site that is a possible concern is the 30722 – Twin Hills ENEABBA WA 6519 site that is only about 5 Km from the nearest turbine. You've previously noted that 3Km is regarded as a good buffer to avoid near field and reflection issues.* *As well, this proposal does represent some risk for the DFES radio communications 450/460Mhz point to point RF link that transverses directly through the proposed boundary connecting the 30731 – Kadathinna Hill site with the 30722 – Twin Hills ENEABBA. Drilling in further the path does appear to miss the turbine main structures by around 250m or more, however location accuracy may see this potentially closer than can be identified on the map. Even with the coordinate corrections it appears the link path should be out of what I'd understand as the interference zones for diffraction, reflection/scattering and near field effects of the turbines, if this can be confirmed…* *…My response is based on the data provided for this in that there is a low probability of this proposal causing degradation to the DFES services by EMI and turbine diffraction, reflection/scattering and note these services are not experiencing any issue currently…"* **Further consultation has been completed to confirm that the coordinates used to assess the point-to-point link are correct and no adjustment was needed.** **Further consultation is not considered necessary.**

3	Fixed point-to-point: 3 links crossing the Project site Point-to-point #3 - #5: No turbines in diffraction exclusion zone established by DNV Fixed point-to-multipoint: 9 km from Project boundary	Electricity Networks Corporation (Western Power)	<u>Contacted by the Customer, response received by email, based on the preliminary turbine layout, on 14 May 2025:</u> [Response based on a series of questions asked by the Customer. The response included an attachment to a document that detailed the requested second Fresnel zone exclusion zone calculation and near field calculation method that has been used in this assessment (described in sections 4.3.1.1 and 4.3.1.3).] *"Are there any additional details for the assets listed in the attached excel workbook that are worth noting?* - *The detail in the spreadsheet should be enough.* - *Do you have any general feedback on the potential for wind turbines and associated infrastructure to cause interference to these assets?* - *See attached example. We look at Near-Field Exclusion Zone and Diffraction Exclusion Zone.* - *Is there a required distance buffer between wind turbines and these assets (primarily the P2P links and P2MP links) the that must be maintained?* - *See attached example.* - *Other than distance buffers, are there other mitigation measures to avoid or minimise the risk of EMI between wind turbines and these assets?* - *Distance buffers only."* <u>Contacted by the Customer, response received by email, based on the preliminary turbine layout, on 6 August 2025:</u> *"…We have reviewed internally and I can inform you that we are currently looking for re-homing below two remotes to our base at R34 Eneabba site (ACMA Site ID: 30720) under a project currently in progress. As per our current schedule, we expect to complete the work by Dec-2027. I would appreciate if you could evaluate and confirm whether the new paths are free from EMI issues for those two remotes…* *…Unfortunately, for the 1st remote (Alias_ID: PID_002925407) still the best base is R49 Dookanooka Rd. Therefore, we are not in a position to rehome to a different base. We believe the risk of EMI interference is low and therefore we will not initiate any design changes at this point. If we face EMI issues, we may have to connect the remote via a 3rd party network (such as Telstra), instead of connecting directly to one of our bases. Please let us know whether there is a better alternative regarding this remote…"* **DNV recommends further engagement to share the results of the point-to-multipoint assessment described in section 4.4.2.**
4	Fixed point-to-point: 1 link crossing the Project site	Shire of Three Springs 10552824-AUMEL-L-03-A	No response received to date

Table 15 Summary of service operators contacted by DNV and responses received to date

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
	Point-to-point #6: No turbines in diffraction exclusion zone established by DNV		
5	Fixed point-to-multipoint: 56 km from Project boundary Meteorological radar: 101 km from Project boundary	Bureau of Meteorology 10552824-AUMEL-L-04-A	<u>Response based on the preliminary turbine layout received by email on 9 January 2026:</u> *"Our assessment of the current Twin Hills wind farm proposal has determined that, under normal atmospheric conditions, it poses a significant risk to the Watheroo radar. Specifically, 7 turbines out of the 110 proposed [turbines] contribute to this significant risk. If there is any scope to remove or relocate these turbines, the proposal could be considered a manageable risk to the Bureau...* *...If removal or relocation of turbines is not feasible, the Bureau will require 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 findings 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."* <u>Current turbine layout has been provided, and no response has been received to date</u>
6	Fixed point-to-multipoint: 31 km from Project boundary	Beach Energy Ltd 10552824-AUMEL-L-05-A	<u>Response based on the preliminary turbine layout received by email on 30 May 2025:</u> *"No concerns that I can see. All of our wells are within 10km of the blue dot, which is 40km away from the proposed wind farm. We won't have any radio signals anywhere close to the wind farm."* **Further consultation is not considered necessary.**

Table 15 Summary of service operators contacted by DNV and responses received to date

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
7	Fixed point-to-multipoint: 35 km from Project boundary	DBNGP (WA) Nominees Pty Ltd 10552824-AUMEL-L-06-A	No response received to date
8	Fixed point-to-multipoint: 24 km from Project boundary	Iluka Resources Limited 10552824-AUMEL-L-07-A	Response based on the preliminary turbine layout received by email on 26 December 2025: "Iluka has no radio communication activity within this area" **Further consultation is not considered necessary.**
9	Fixed point-to-multipoint: 46 km from Project boundary	Mepau Perth Basin Pty Ltd 10552824-AUMEL-L-08-A	No response received to date
10	Fixed point-to-multipoint: 14 km from Project boundary	Water Corporation	Contacted by the Customer, response based on the preliminary turbine layout received by email on 30 May 2025: *"…We have reviewed the list of Water Corporation sites you provided and can confirm that none of our assets are located in close proximity to the wind farm. The nearest of our sites is situated more than 13 kilometers from the wind farm boundary.* *With regard to providing licence information for Water Corporation assets, please note that this is not a straightforward process. We are required to go through the relevant internal teams and obtain approval before any such information can be shared. If you require this information, I'm happy to check with the appropriate team to understand the process and next steps…"* Contacted by the Customer, response received by email on 24 June 2025: *"…Moreover, have you conducted a RF spectrum analysis for your project. We primarily operate in the 450Mhz licensed spectrum and if you have the RF info for the impact on 450Mhz, then we can look to investigate further…"* ***DNV recommends the Customer engage further with the operator to address any outstanding queries relating to spectrum analysis.***
11	Emergency services point-to-area: 13 km from Project boundary	St John Ambulance Western Australia Ltd 10552824-AUMEL-L-11-A	No response received to date
12	Emergency services point-to-area: 17 km from Project boundary	Western Australia Police 10552824-AUMEL-L-12-A	Response based on the current turbine layout received by email on 12 March 2026: *"Based on the information supplied, WA Police does not have concerns about the revised location of the turbines.."*

Table 15 Summary of service operators contacted by DNV and responses received to date

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
13	Trigonometrical station: within the Project boundary GNSS station: 121 km from Project boundary	Geoscience Australia 10552824-AUMEL-L-13-A	Response based on the preliminary turbine layout received by email on 4 December 2025: *"Thank you very much for sharing this information with us. Geoscience Australia does not foresee any interference to our GNSS infrastructure as a result of the proposed Twin Hills Wind Farm."* **Further consultation is not considered necessary.**
14	PMTS/spectrum (mobile phone): 16.5 km from Project boundary	Optus 10552824-AUMEL-L-14-A	No response received to date

Table 15 Summary of service operators contacted by DNV and responses received to date

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
15	PMTS/spectrum (mobile phone): 2.5 km from Project boundary	Telstra 10552824-AUMEL-L-15-A	<u>Response based on the preliminary turbine layout received by email on 16 December 2025:</u> *"To provide a better understanding of potential impacts to Telstra infrastructure a desktop assessment was undertaken. The results were as follows:* *There are no expected impacts to Telstra's Mobile network due to this wind farm based on the turbine locations provided.* *Based on the turbine locations provided and information regarding Telstra's existing point to point radio links obtained from Waypoint and maprad.io, the proposed wind farm should not impact on any of Telstra's existing point to point radio links.* *A detailed analysis of the full power coordination impact (Low Frequency Induction (LFI) and/or Earth Potential Rise (EPR)) of the wind farm development is required. This includes location of the wind farm switch yard, the route and potential of any associated HV transmissions lines and the LFI and EPR impact on any Telstra plant they may affect.* *It is recommended that you contact Before You Dig Australia, so you are aware of the underground assets in the area. They will provide you with the location of Telstra's as well as any other utilities' underground assets.* *Based on this assessment, to minimise potential interference to Telstra's telecommunications network, Telstra requires the developer to confirm its agreement to the conditions and matters set out in the above points.* *The developer also confirms its role as the proponent and ultimate owner of the proposed wind farm and that it has the authority to ensure that the conditions set out above are implemented and complied with. If the agreement of any other person or entity is required to ensure the conditions set out in this letter are complied with, the developer undertakes to obtain that agreement in writing and to provide it to Telstra prior to lodging a development application for the wind farm.* *If the proposed plans and specifications of the development are altered or amended, Telstra reserves the right to request further conditions and amendments to the development."* <u>Current turbine layout has been provided, and no response has been received to date</u>

Table 15 Summary of service operators contacted by DNV and responses received to date

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
16	PMTS/spectrum (mobile phone): 16.5 km from Project boundary	Vodafone/TPG 10552824-AUMEL-L-16-A	Response based on the preliminary turbine layout received by email on 21 December 2025: *"The nearest TPG/Vodafone existing, or near future Public Mobile Telephone Coverage site, is approx. 200km 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/turbines 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…* *…[redacted name], from our Transmission team has responded internally and advised that there is no impact to our existing transmission network."* Current turbine layout has been provided, and no response has been received to date

Table 15 Summary of service operators contacted by DNV and responses received to date

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
17	Spectrum (wireless internet): 73 km from Project boundary	NBN Co 10552824-AUMEL-L-17-A	<u>Response based on the preliminary turbine layout received by email on 9 December 2025:</u> *"I have reviewed the data provided based on the proposed wind farm location; there are no sections of the wind farm within existing nbn wireless coverage boundaries. There are also no current nbn customers inside the wind farm boundary that would be impacted by the proposed wind tower locations…* *Nor is there any impact on any existing or planned nbn microwave links in this area…* *… 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]…* *A standard nbn response for wind farm applications regarding potential interference impact on the nbn Fixed Wireless network is as follows:* *Potential Impacts of the Proposed Twin Hills Wind Farm on NBN Co Spectrum Communication Assets* *Referring to your email dated 2nd Dec 2025 regarding the application for the Twin Hills Wind Farm.* *We confirm that NBN Co Spectrum Pty Ltd (nbn Spectrum) has a number of spectrum licenses within 75 km of the proposed Twin Hills Wind Farm.* *nbn have strict obligations to provide internet services to the community, and this area has been determined as a FW service area where the footprint of this service is now in place.* *nbn will be forced to consider its position as part of the planning should there an interference issue.* *If the Application is amended before it is lodged, we request that we are sent any amended Application so we can determine whether we have any objections to the amended Application..."* <u>Response based on the current turbine layout received by email on 9 December 2026:</u> *"The team has advised the new turbine locations make no material difference to nbn and the previous response still applies."*

Table 15 Summary of service operators contacted by DNV and responses received to date

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
18	DTV broadcasting: 27 km from Project boundary	BAI Communications 10552824-AUMEL-L-18-A	Response based on the preliminary turbine layout received by email on 4 January 2026: *"Interference analysis predicts that DTV services from Mt Campbell will be affected by the proposed wind farm. If there is any impact, remediation that is required to rectify DTV degradation to the viewers, is expected to form part of the wind farm project…* *…Population analysis was done on the potentially impacted area (ABS Census 2021 Data) and showed only 1 person is at low risk… of having degraded digital television reception. Upon closer inspection on Google Earth of the predicted interference, no households were observed to be contained within the low risk or high risk areas."* Current turbine layout has been provided, and no response has been received to date

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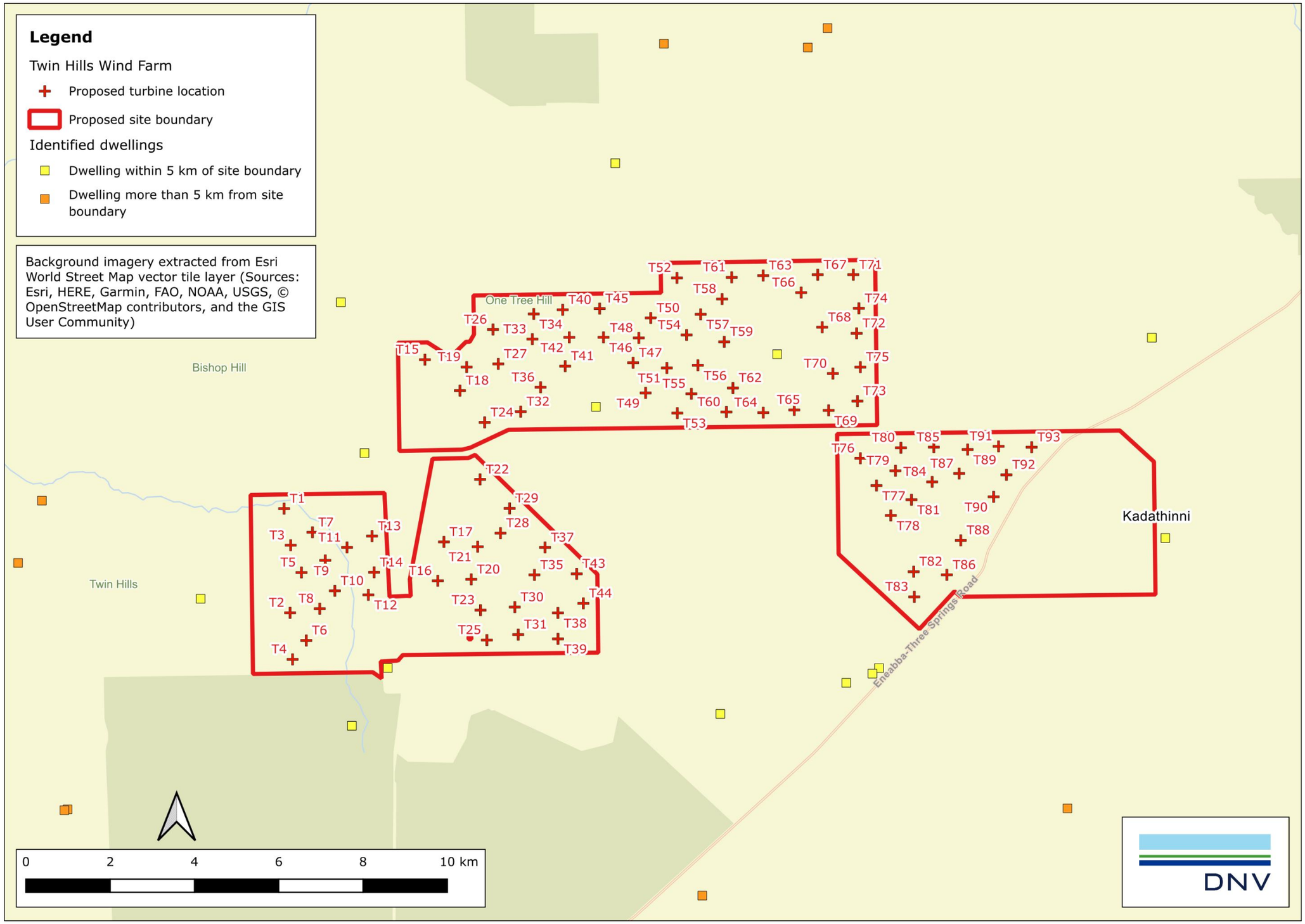

Figure 1 Map of the proposed Project, showing proposed boundary, turbine locations, and locations of nearby dwellings

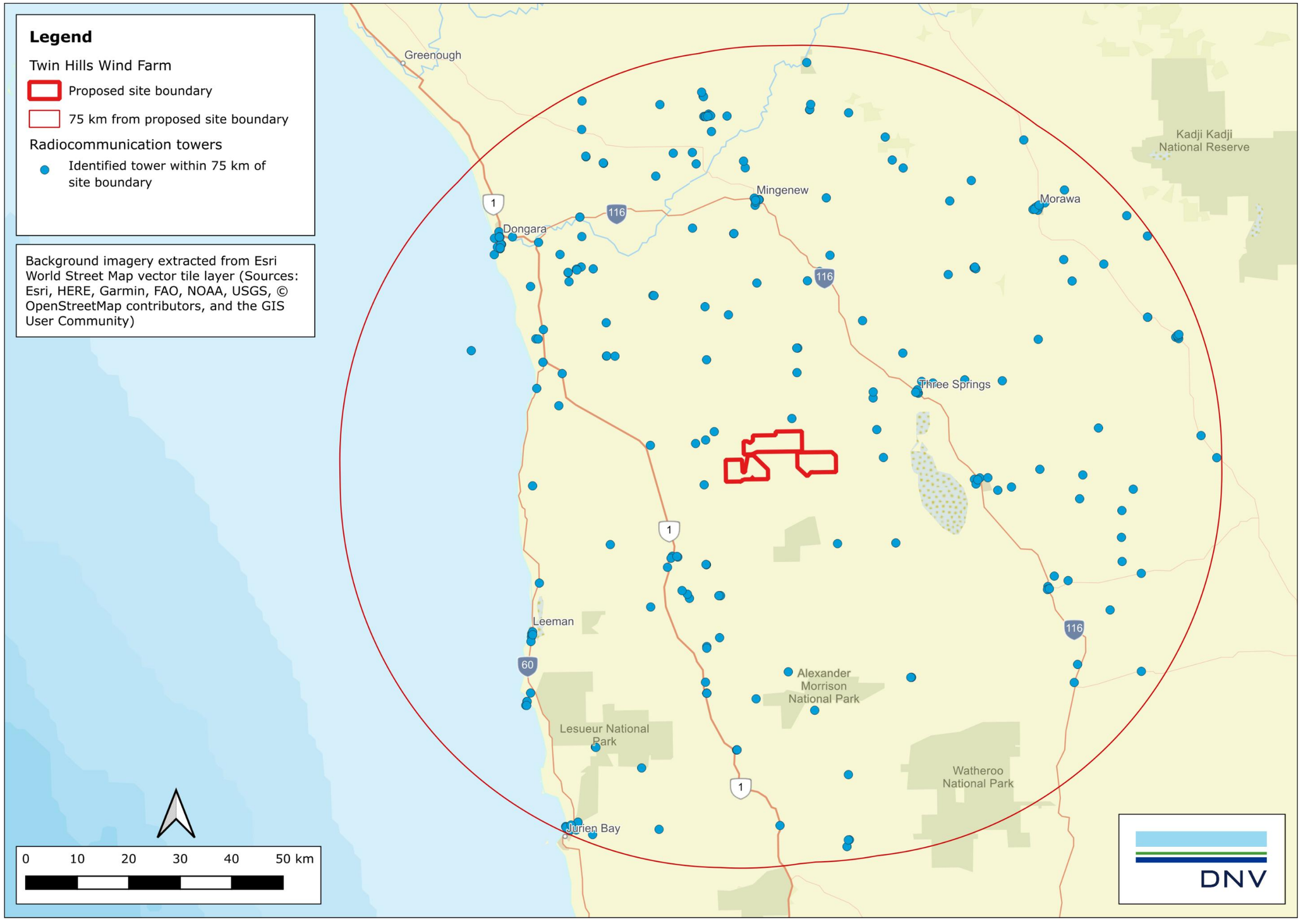

Figure 2 Location of the proposed Project and identified nearby radiocommunication sites

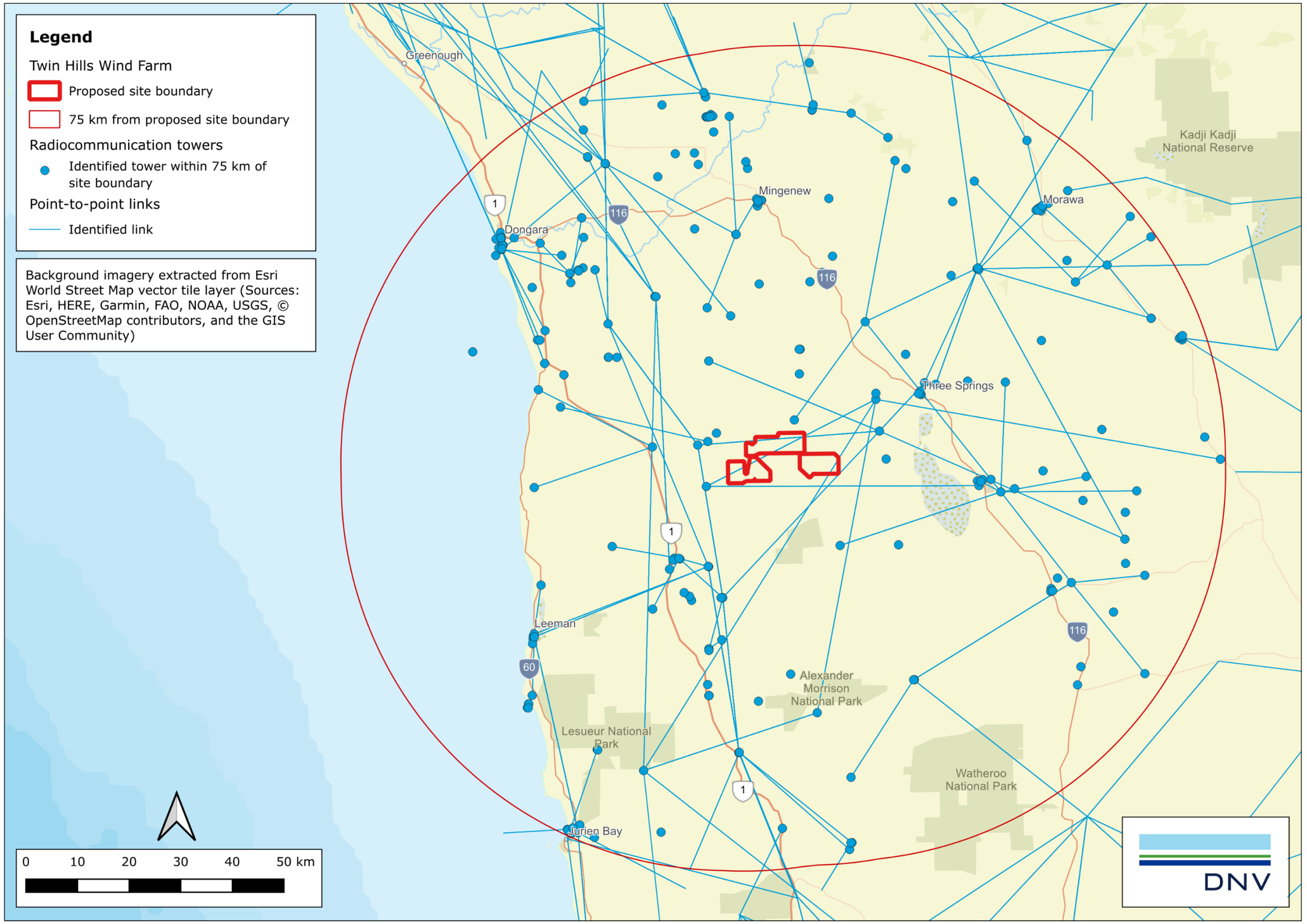

Figure 3 Identified transmission vectors for fixed licences of point-to-point type in the vicinity of the proposed Project

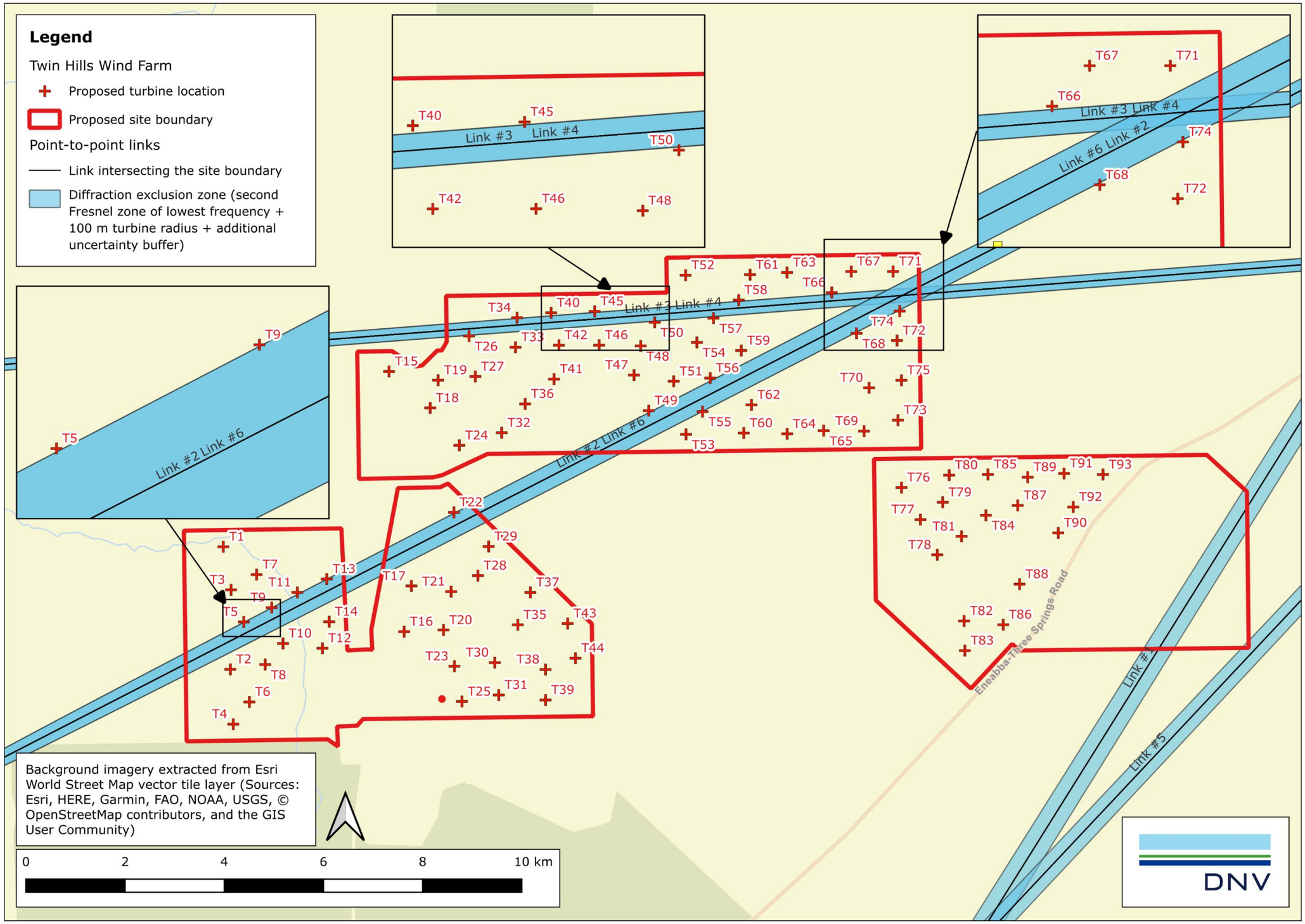

Figure 4 Identified point-to-point radiocommunication vectors crossing the proposed Project and calculated interference zones

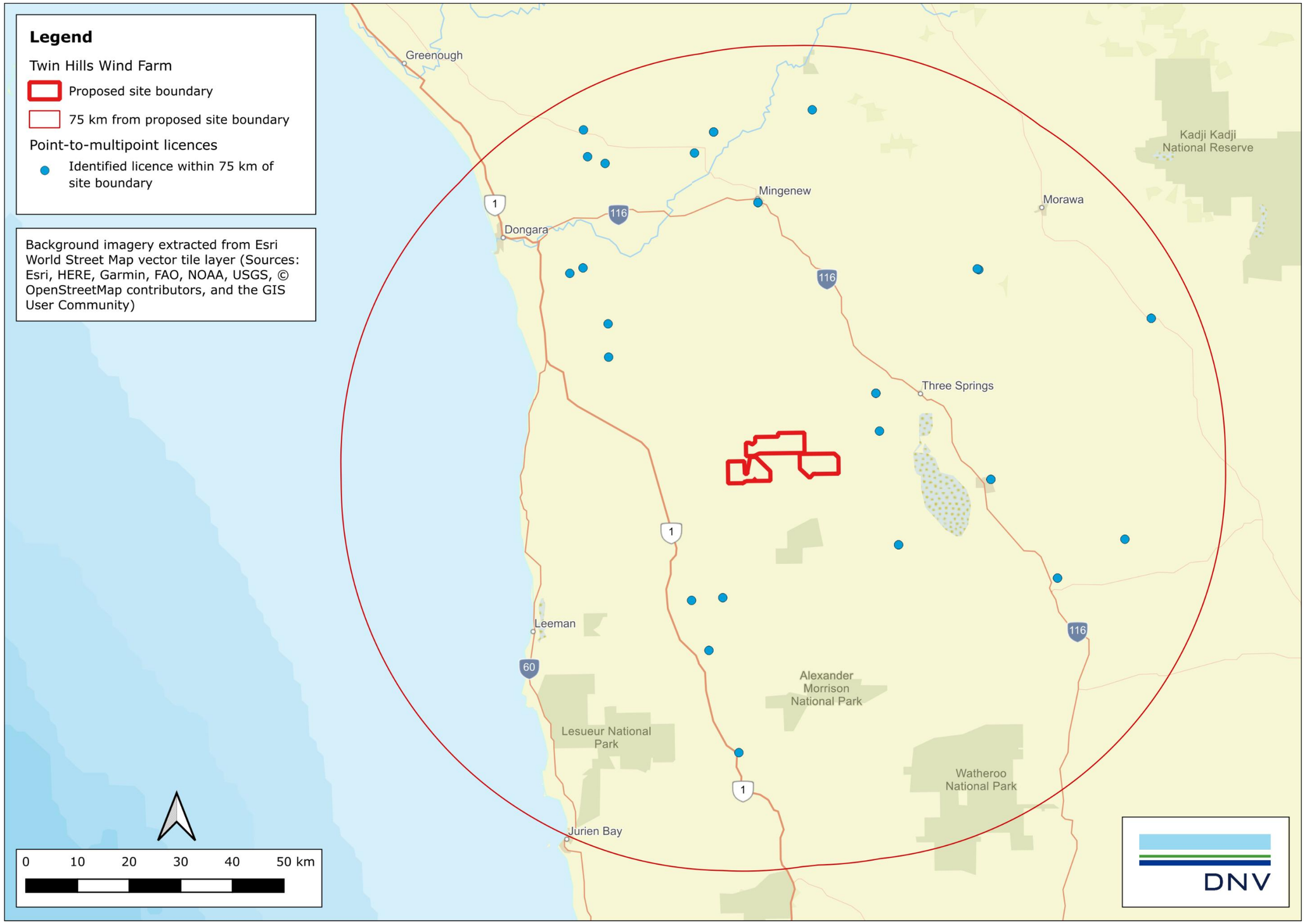

Figure 5 Location of point-to-multipoint licences in the vicinity of the proposed Project

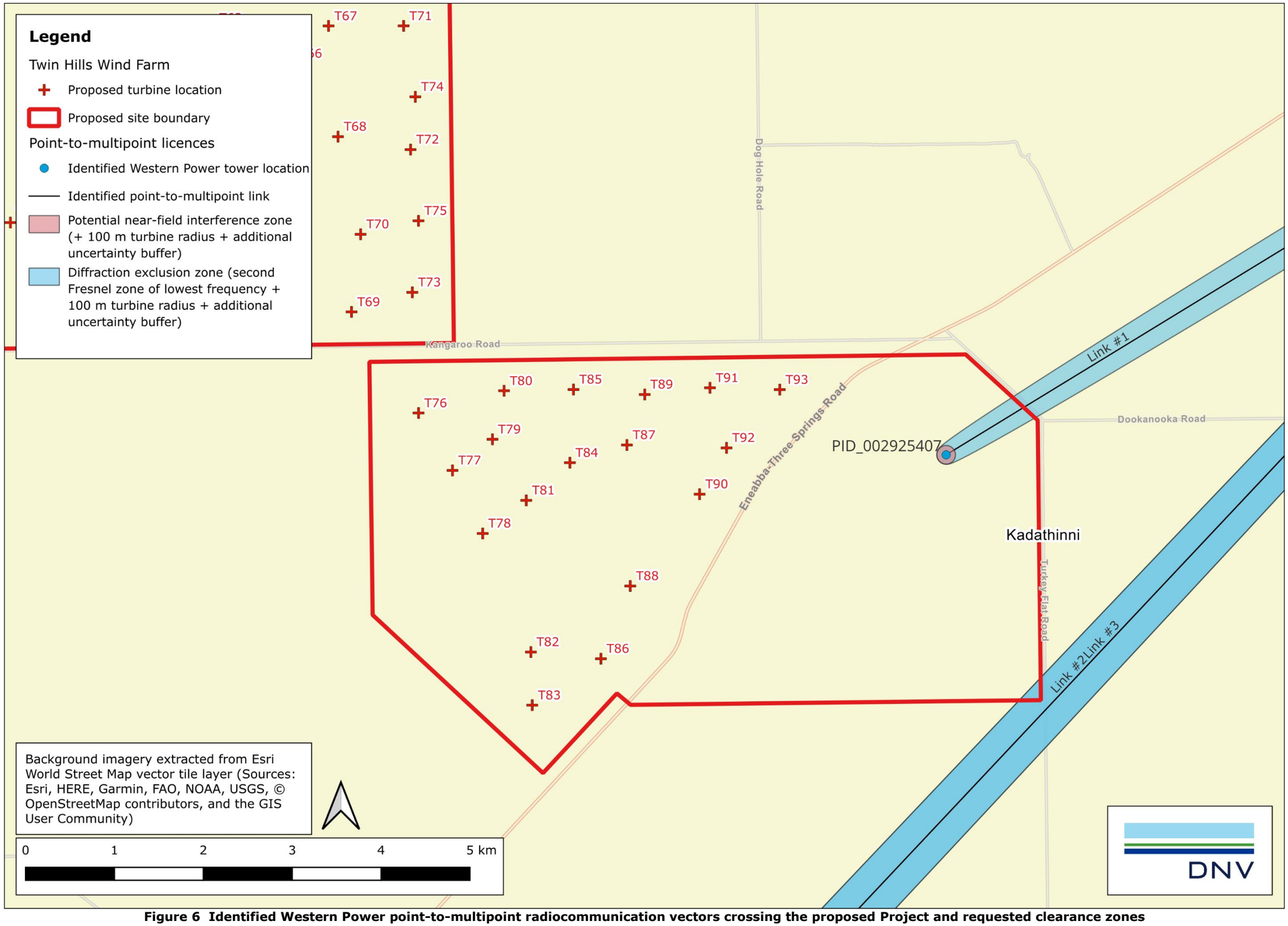

Figure 6 Identified Western Power point-to-multipoint radiocommunication vectors crossing the proposed Project and requested clearance zones

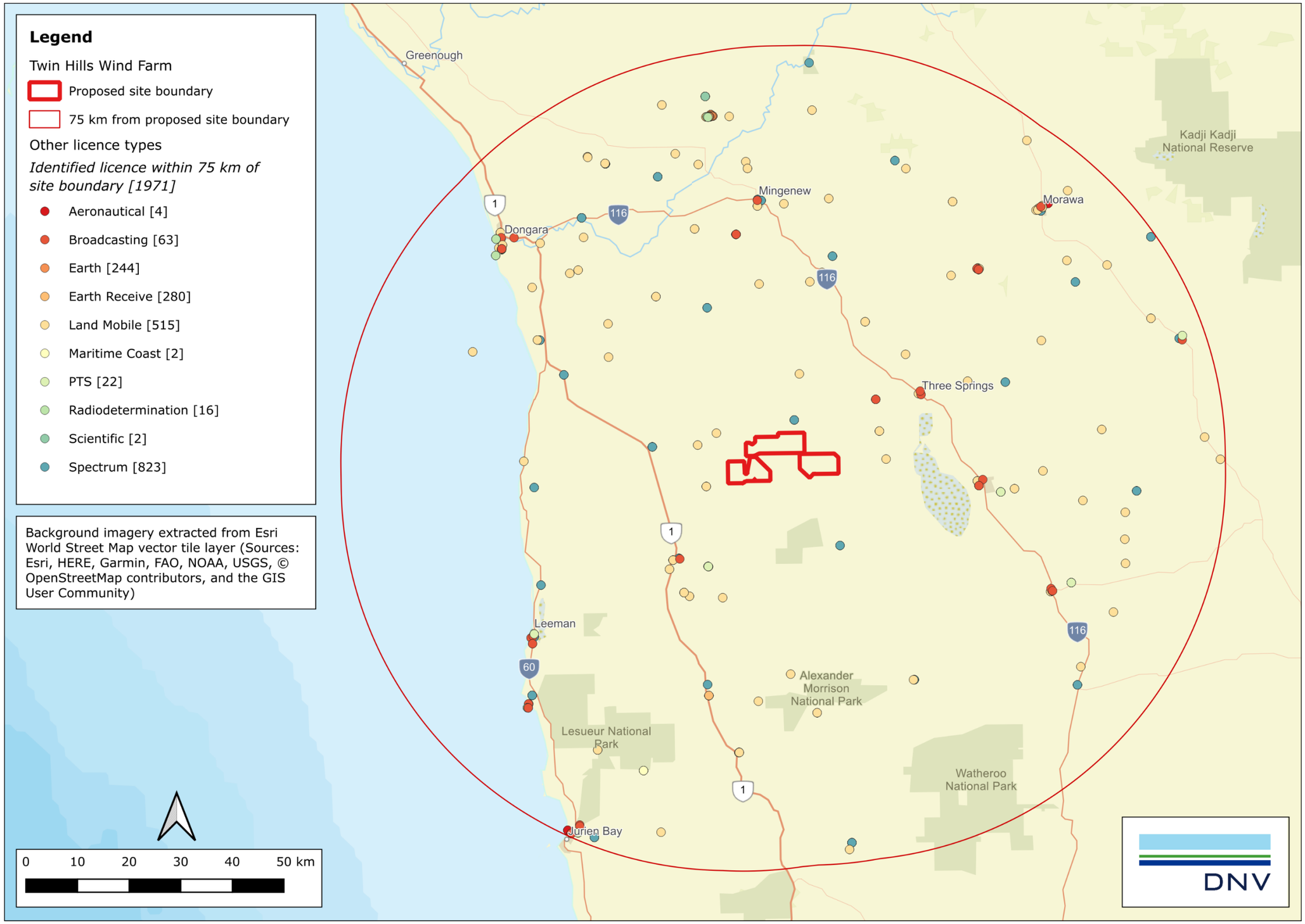

Figure 7 Location of other licence types within 75km of the proposed Project

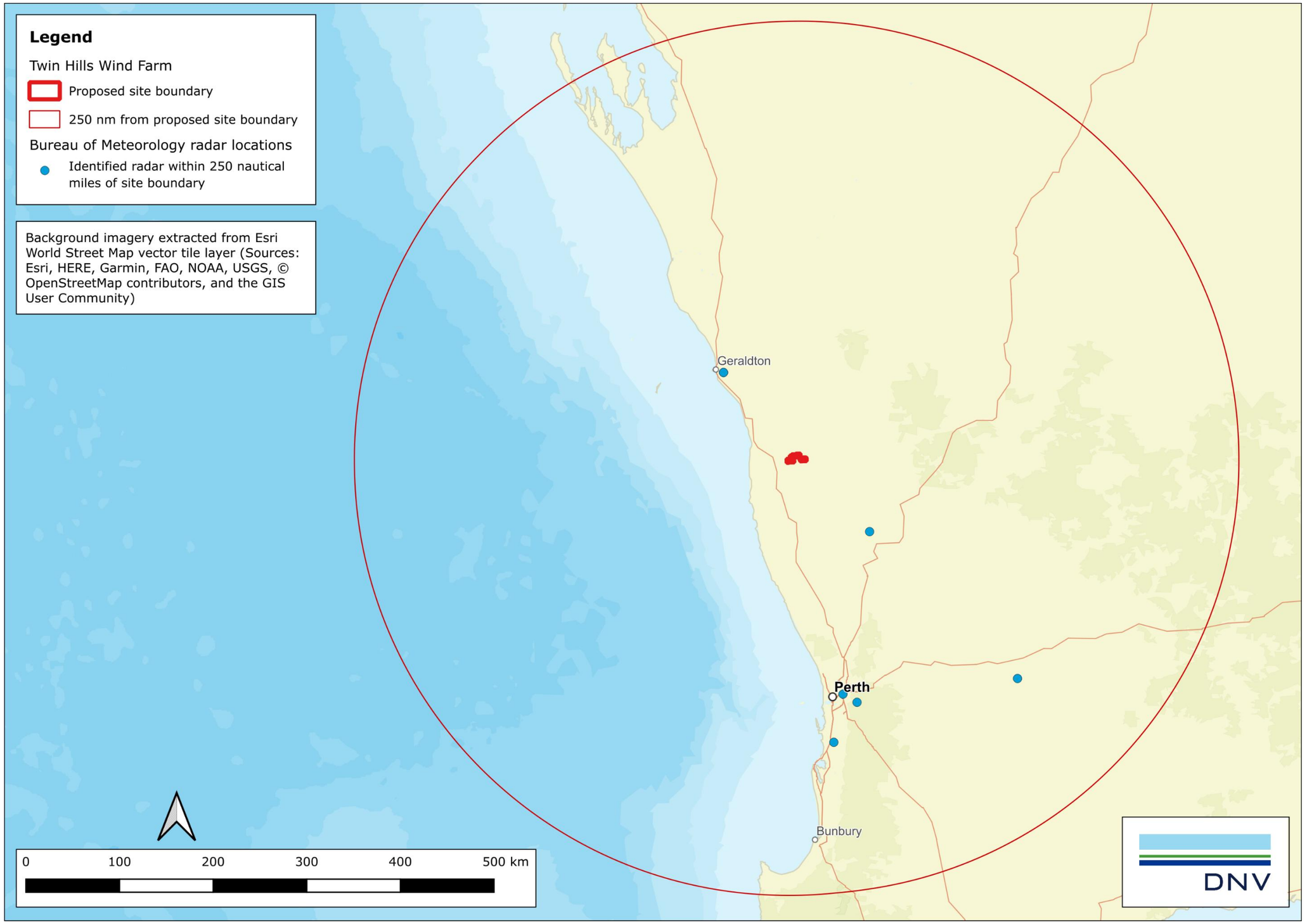

Figure 8 Location of meteorological radar sites within 250 nautical miles of the proposed Project

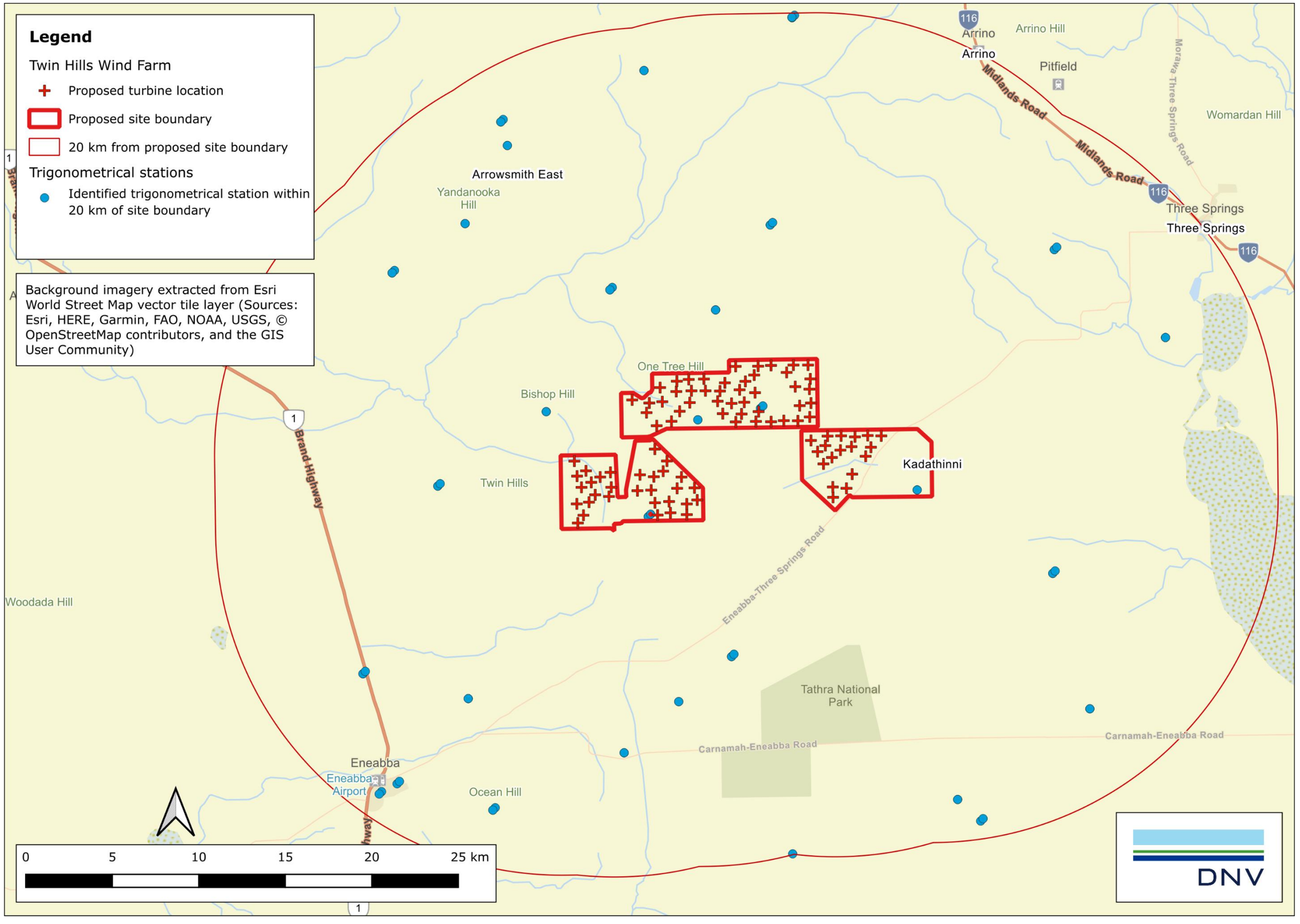

Figure 9 Location of trigonometrical stations within 20 km of the proposed Project

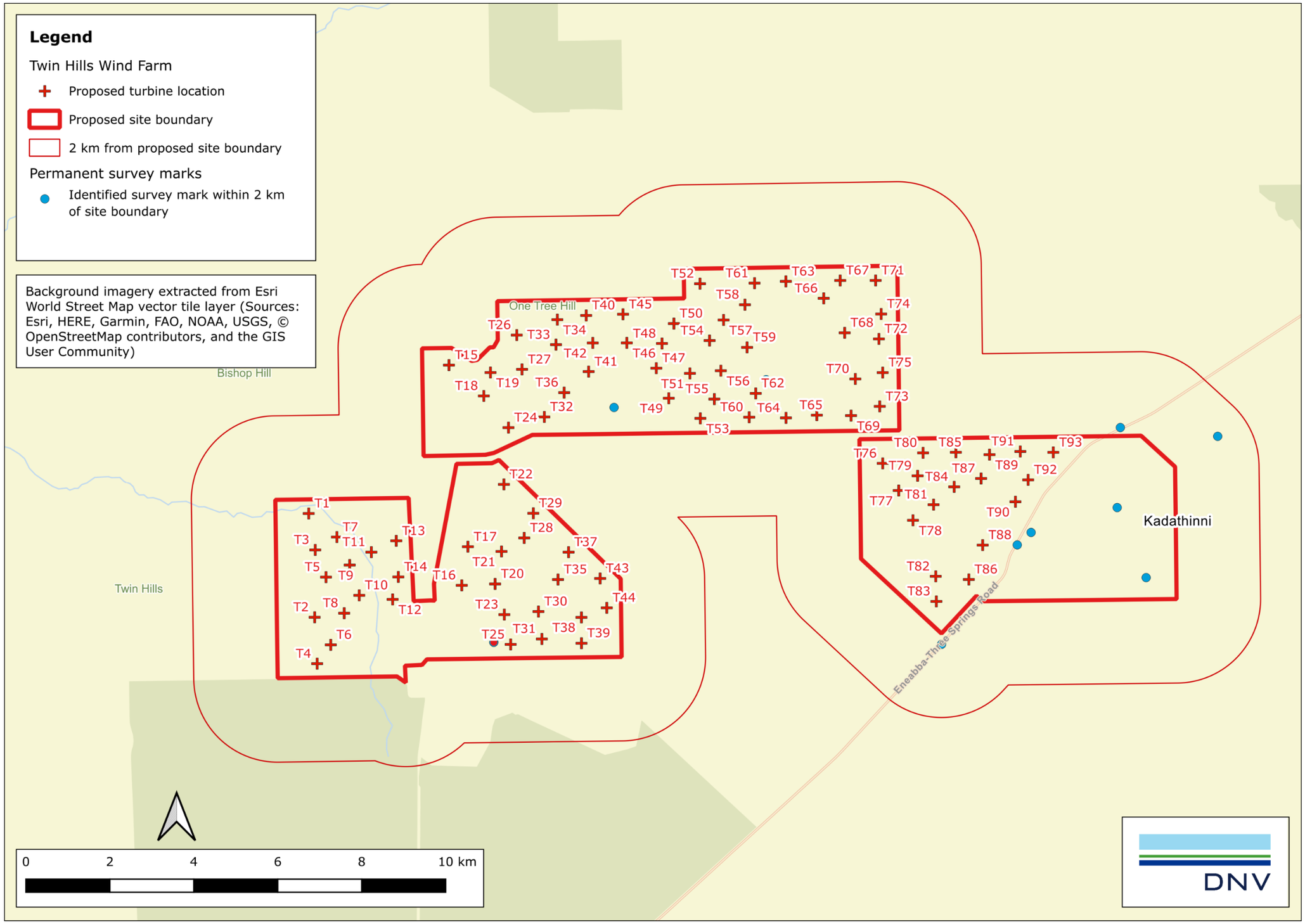

Figure 10 Location of permanent survey marks within 2 km of the proposed Project boundary

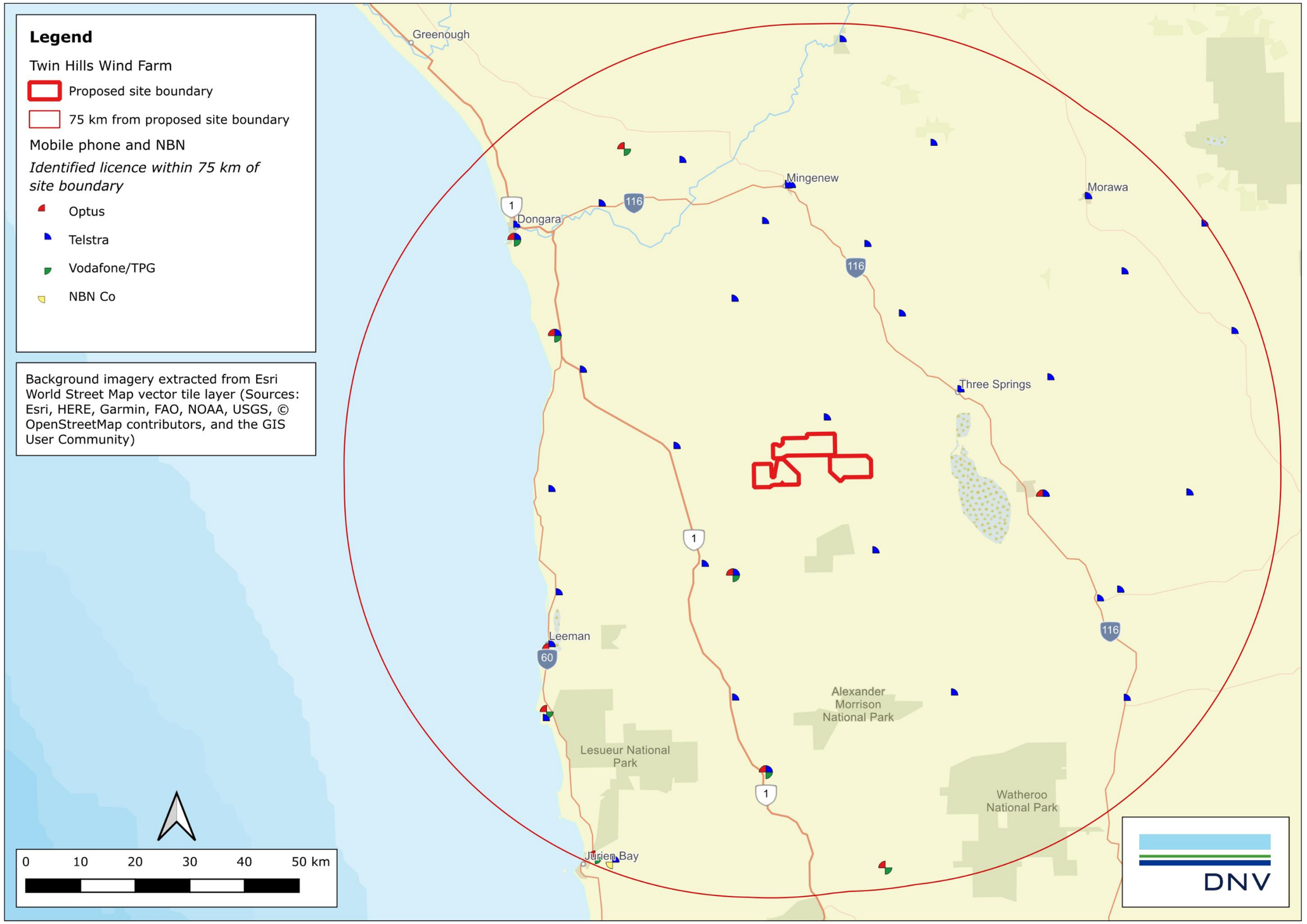

Figure 11 Location of mobile phone and NBN towers within 75 km of the proposed Project

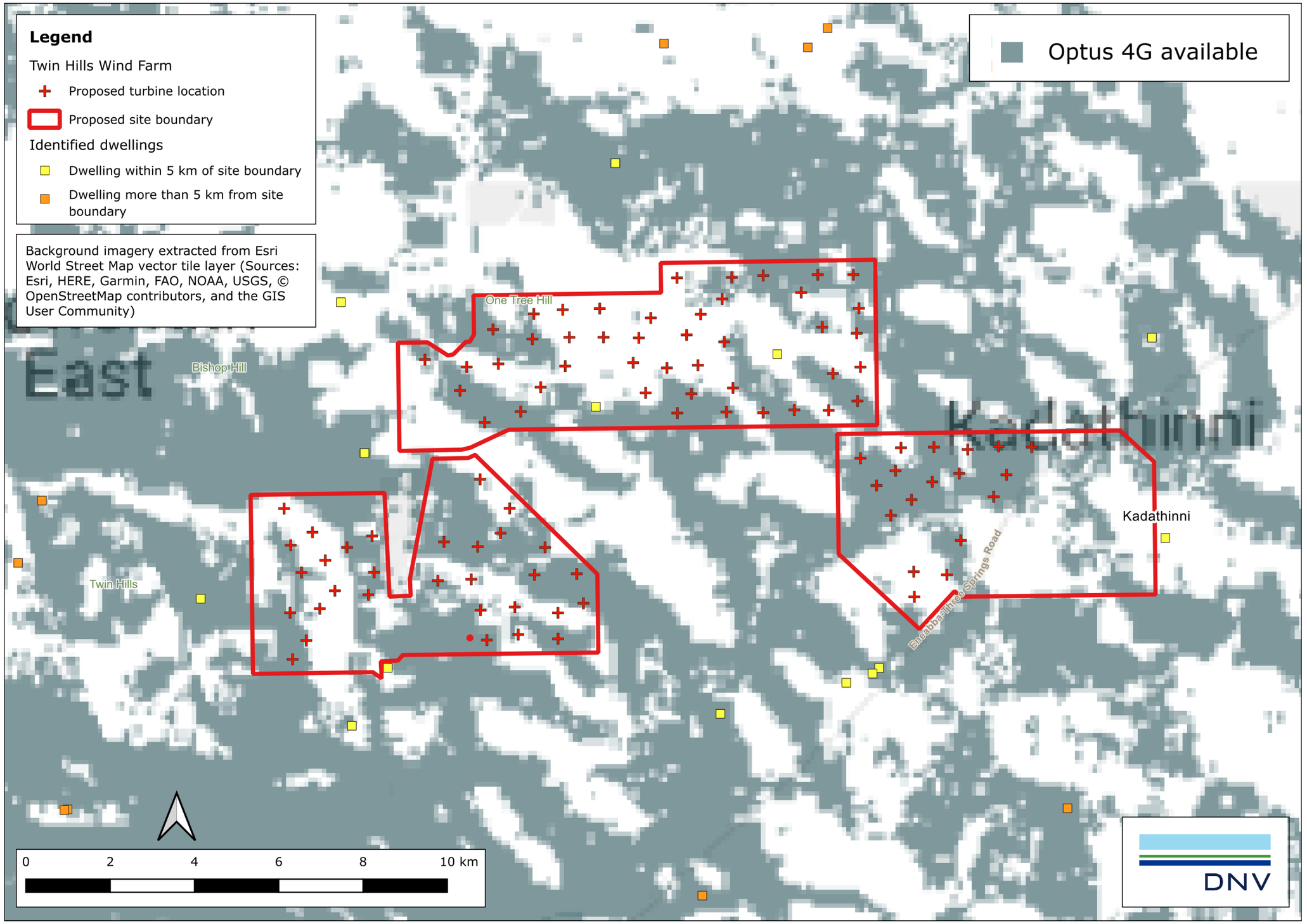

Figure 12 Optus Mobile 4G network coverage for the proposed Project

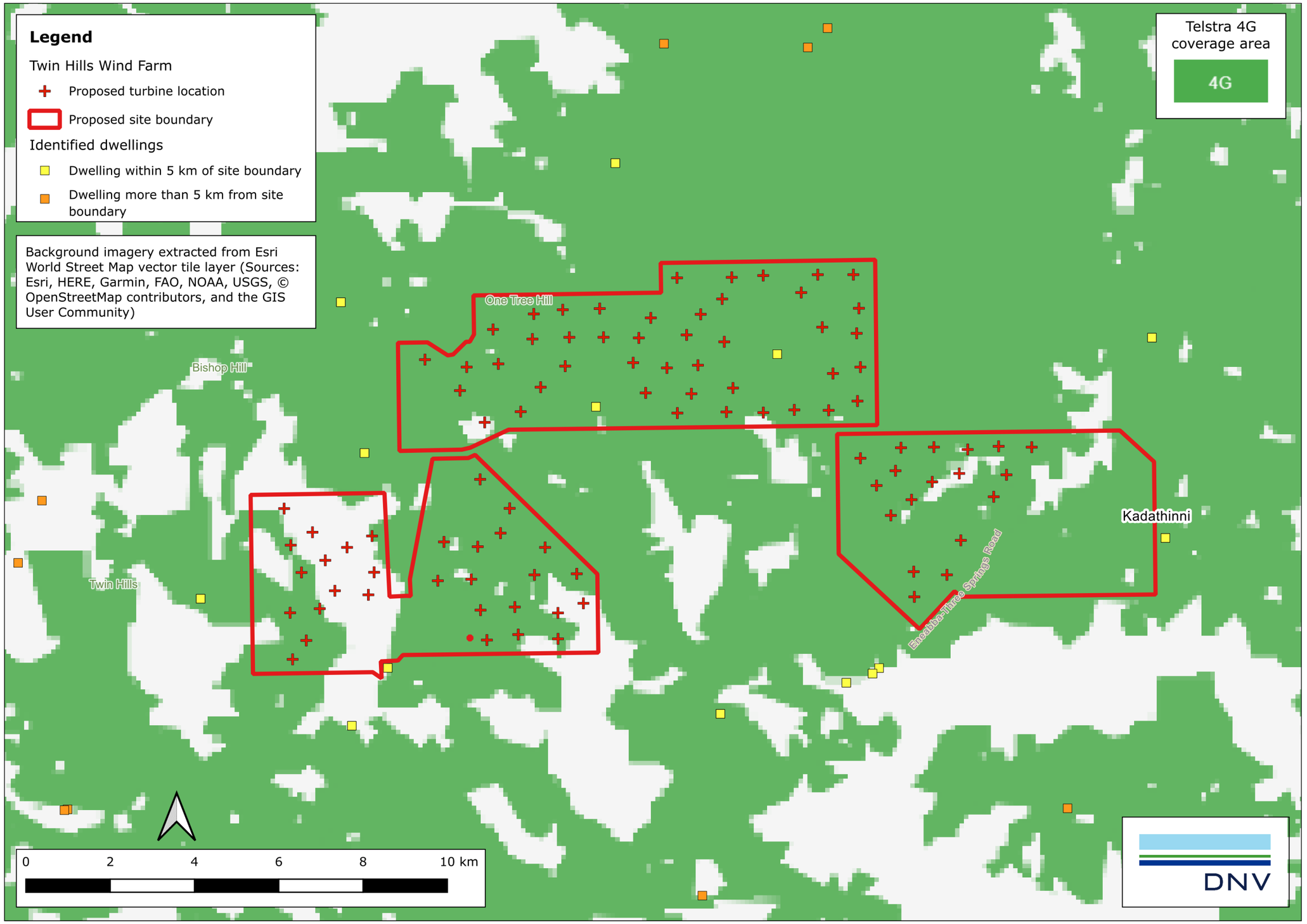

Figure 13 Telstra 4G network coverage for the proposed Project

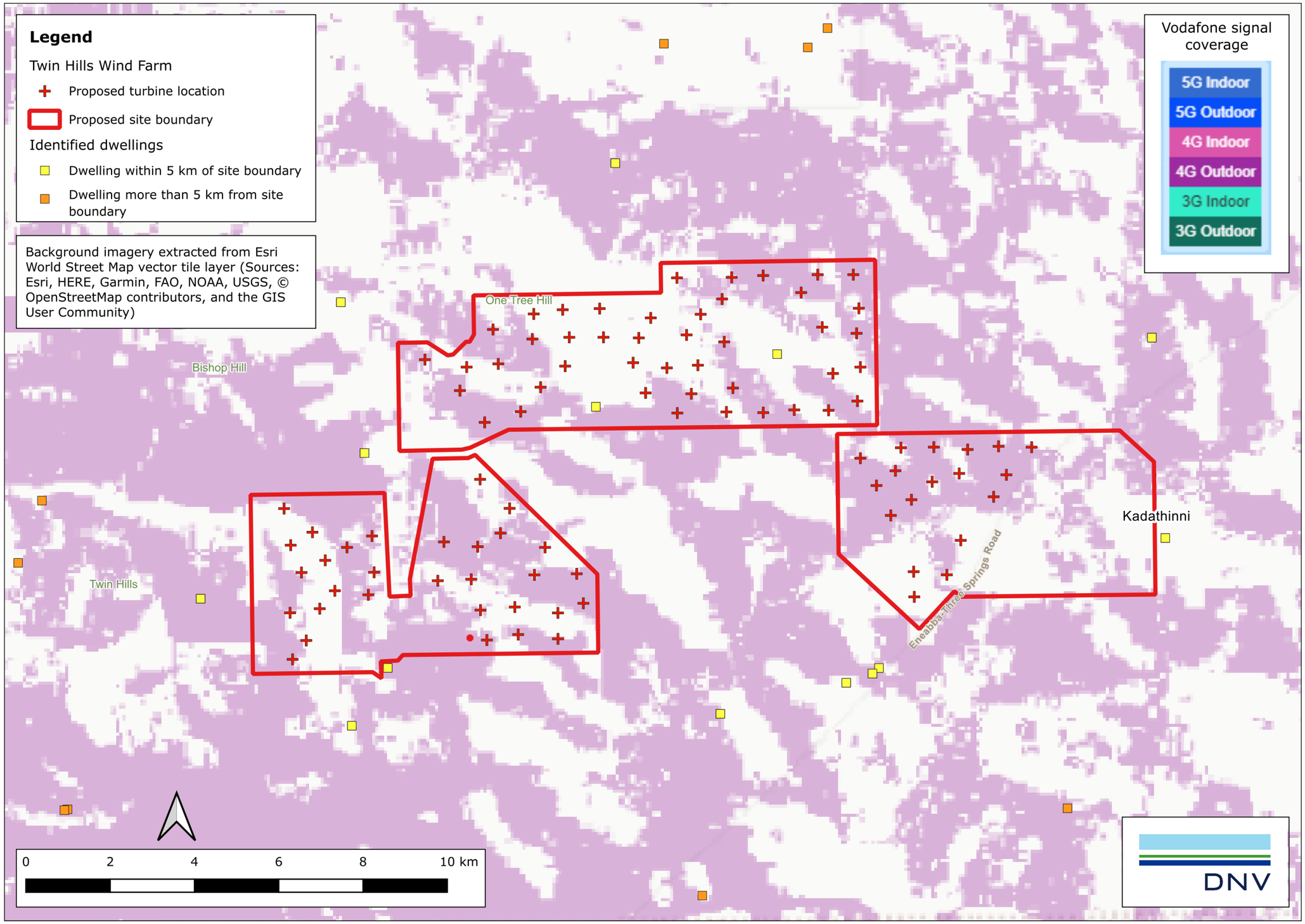

Figure 14 Vodafone network coverage for the proposed Project

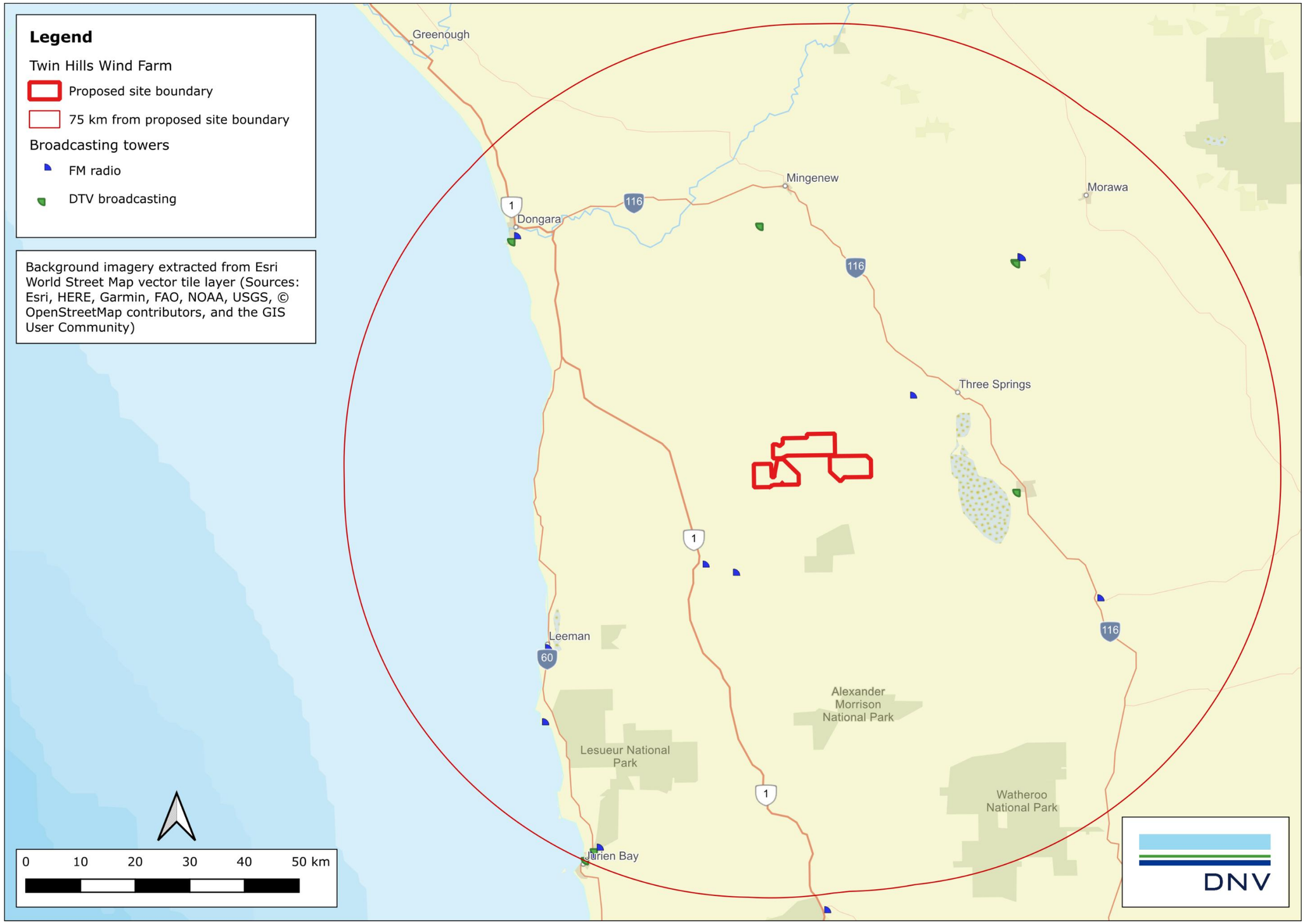

Figure 15 Location of broadcast transmitters in the vicinity of the proposed Project

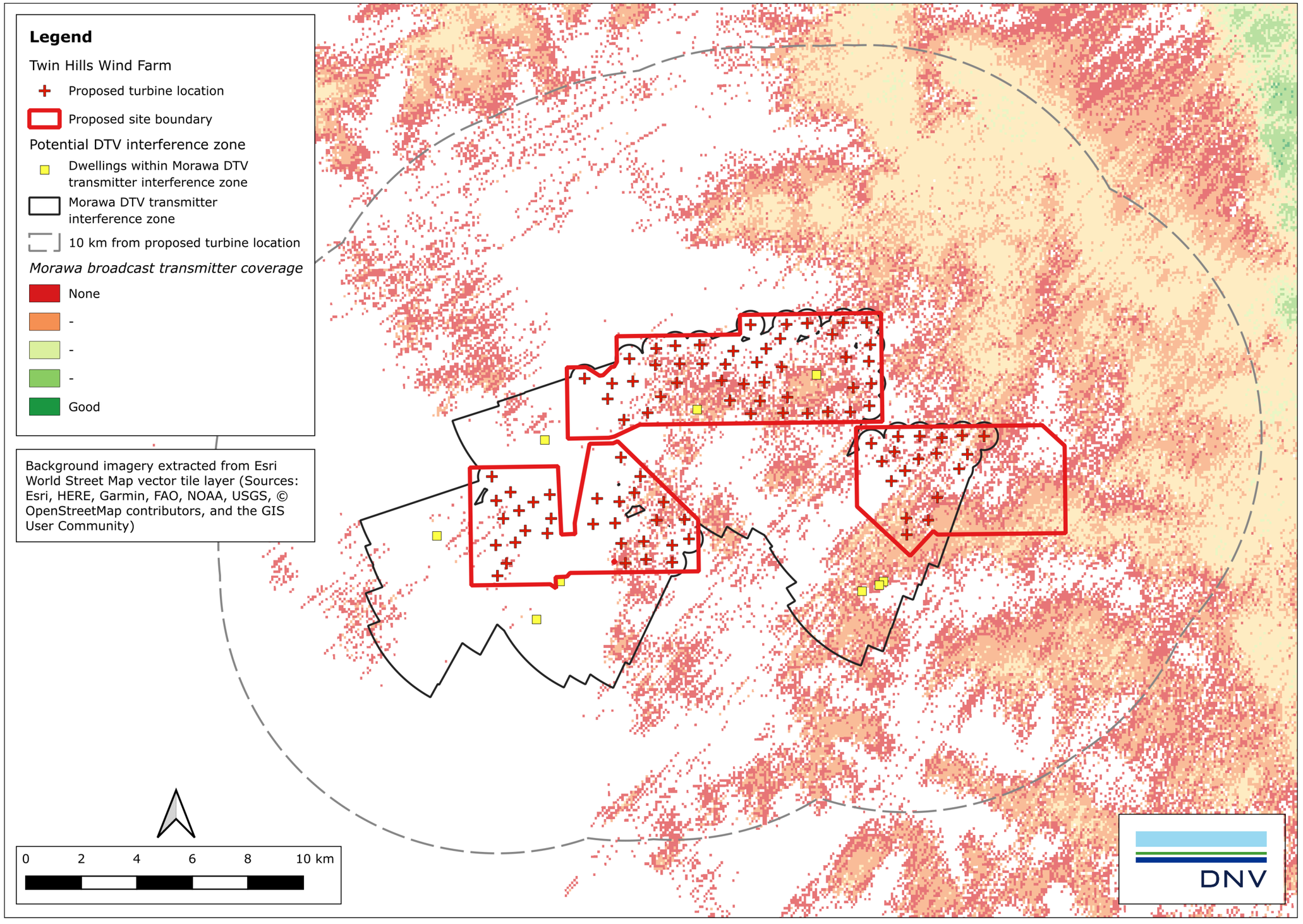

Figure 16 Potential television EMI zones for the Morawa broadcast transmitter from the proposed Project

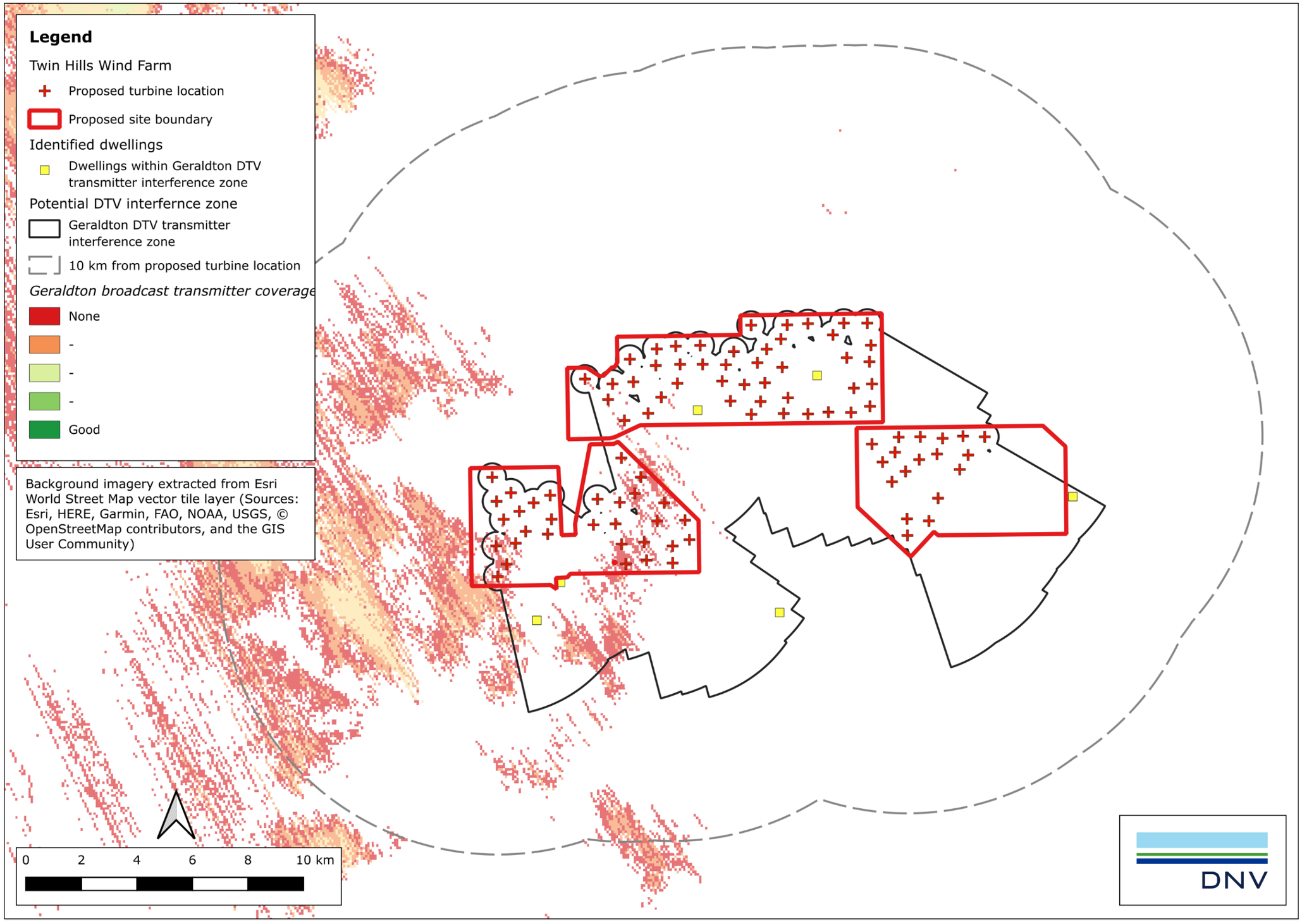

Figure 17 Potential television EMI zones for the Geraldton broadcast transmitter from the proposed Project

About DNV

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

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