

**ASSESSMENT OF ELECTROMAGNETIC
INTERFERENCE ISSUES FOR THE
CROOKWELL 3 WIND FARM**

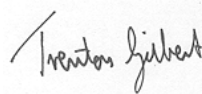
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EXECUTIVE SUMMARY

Garrad Hassan Pacific Pty Ltd (GH) has been commissioned by Crookwell Development Pty Ltd (CDPL) to independently assess the electromagnetic issues associated with the proposed Crookwell 3 wind farm. This report summarises the results of an EMI assessment conducted at the site. Up to date information relating to nearby telecommunication licences has been obtained from the Australian Communications and Media Authority (ACMA) [1].

The Director-General's Requirements for the proposed Crookwell 3 wind farm, issued pursuant to Section 75F of the Environmental Planning and Assessment Act 1979, state the following with regard to potential electromagnetic interference caused by the wind farm.

Hazard/Risks– ... Potential hazards and risks associated with electric and magnetic fields ... must be assessed.

This document assesses the potential risks regarding interference with radiocommunications services operating in the vicinity of the wind farm, and makes the findings and recommendations discussed below.

Radiocommunications is used as a broad term in this report to encompass all services that rely on electromagnetic or radio waves to transfer information. There are many methods of transmitting information via radiocommunication. Radiocommunications services operating in the vicinity of the proposed Crookwell 3 wind farm, and their susceptibility to interference from the wind farm, are discussed in this document.

If not properly designed, wind farms have the potential to cause interference to analogue television broadcast signals and microwave signals. Analogue broadcast signals are still commonly used to transmit domestic television, while microwave signals 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.

For analogue television broadcast signals (point-to-area) large scale interference can generally be avoided by placing the wind turbines distant from the broadcast tower. A clearance of at least 1 km is recommended. No analogue television broadcast tower has been identified within 1 km of the Crookwell 3 wind farm, with the nearest broadcast tower being at least 16 km from the site, at Wades Hill, Crookwell. It is still possible however for interference to analogue television to occur at residences in and around a wind farm site, and the potential for this interference has been assessed here. However, analogue television is gradually being replaced by digital television which is less susceptible to interference from wind turbines. Digital television signals from Canberra and Goulburn currently service parts of the area around the Crookwell 3 wind farm, however there are known to be areas where digital reception is marginal.

Wind turbines can potentially cause interference to point-to-point microwave signals through diffraction, scattering or near-field effects. However it is possible to design around this issue, as the path and interference zone of point-to-point signals is generally well known. The nearest transmission tower with fixed licences of point-to-point type is at least 12 km from the proposed Crookwell 3 wind farm. It has been found that three microwave links pass within 1 km of the site, with two links crossing the proposed wind farm site. The three microwave links have been considered in this

assessment. An exclusion zone has been established around each point-to-point link based on a standard industry methodology. None of the turbines proposed for the Crookwell 3 site are located within these exclusion zones, therefore interference to the links from the wind farm is highly unlikely.

Wind turbines can also cause interference with point-to-multipoint microwave signals; however it is not possible to identify the locations of paths for point-to-multipoint links as only the base-station is licensed and contained in the ACMA Radiocommunications Database [1]. The closest point-to-multipoint base station has been identified at approximately 22 km southeast of the Crookwell 3 wind farm. Although it is unlikely that stations at this distance will be servicing customers in the vicinity of the wind farm, the operators of all stations within approximately 50 km of the site have been contacted and, to date, none have advised that their services are likely to be affected by the wind farm.

In general, Very High Frequency (VHF) and Ultra High Frequency (UHF) frequency band radio signals, and digital voice based technologies such as cellular phones (often called Global System for Mobile Communications, or GSM phones), and third generation phones (often called 3G or Next G mobiles) are essentially unaffected by wind farm development. This includes land mobile repeaters, radio, the audio component of analogue television, and mobile phones.

Emergency services operating radiocommunications assets in the vicinity of the proposed Crookwell 3 wind farm have been identified and contacted to determine if their services are likely to be affected by the wind farm. To date no concerns have been raised.

A number of residents in the vicinity of the Crookwell 3 wind farm use a wireless internet service provided by Cirrus Communications. This service utilises a series of towers that communicate with equipment installed at each customers' house in order to provide access to the internet. Although the system is expected to be generally robust to interference, there is the potential for interference if a turbine intercepts the signal between a tower and customer. Cirrus Communications has been contacted to determine if their service is likely to be affected by the wind farm, however to date no response has been received.

It is possible that wind turbines could cause interference to satellite television and internet services if a wind turbine intercepts the signal between a satellite and ground based receiver. For the Crookwell 3 wind farm, interference is not likely to occur to satellite internet services. There is a very low probability of interference to satellite television services at two dwellings; however this is highly unlikely as it would require the residents of these dwellings to be receiving television signals from satellites that are not commonly used in Australia.

Broadcast radio signals do not generally suffer from interference from wind turbines. AM radio signals are very unlikely to be affected by wind farms. FM radio signals may experience interference in the form of low level hiss or distortion, but generally only in close proximity to the wind turbines. Any reception difficulties are likely to be easily rectified through the installation of a high quality antenna.

Wind turbines have the potential to interfere with meteorological and aviation radars. Reflection off turbine blades may give false readings or create a radar "shadow" behind the turbines. Due to the distance from radar assets, and the high probability that the turbines will lie below the radar line-of-

sight, it is unlikely that the proposed Crookwell 3 wind farm will cause interference to aviation radar, or any significant interference to meteorological radar.

The Crookwell 3 wind farm is proposed within a region of high wind farm development activity and is adjacent to the existing Crookwell 1 and approved Crookwell 2 wind farms. Cumulative EMI impacts of the three wind farms have been assessed and are discussed in more detail in Section 4 of the report.

Conclusions and recommendations from this analysis have been made in Section 5 of this report.

1 INTRODUCTION

Crookwell Development Pty Ltd is developing the Crookwell 3 Wind Farm in New South Wales, Australia. CDPL has instructed Garrad Hassan Pacific Pty Ltd (GH) to carry out an independent analysis of the potential electromagnetic interference issues associated with the proposed wind farm. The results of the work are reported here. This document has been prepared pursuant to the GH proposal P955/PP/01 Issue B dated 01 Feb 2010, and is subject to the terms and conditions contained therein.

In order to conduct the EMI assessment, up to date information regarding radiocommunication licences in the vicinity of the wind farm have been obtained from the Australian Communication and Media Authority (ACMA) database [1].

This assessment investigates the impact of the proposed wind farm on:

- Point-to-point microwave links,
- Point-to-multipoint microwave links,
- Radiocommunications assets belonging to emergency services,
- Aviation and meteorological radar,
- Trigonometrical stations,
- Citizens Band (CB) radio and mobile phones,
- Wireless internet
- Broadcast radio,
- Satellite television and internet,
- Broadcast television.

Eight prospective turbine types have been considered in this analysis and are detailed in Table 1. However the EMI assessment has been conducted based only on the wind turbine with the maximum dimensions. The potential for interference is proportional to the turbine dimensions, and as such, the largest turbine is likely to have the most significant impact on radiocommunications services.

2 DESCRIPTION OF THE SITE AND PROJECT

2.1 General site description

The site is located approximately 15 km southeast of Crookwell town in the Upper Lachlan Shire Council as shown in Figure 1.

The proposed Crookwell 3 site (the site) is located in the southern section of the Great Dividing Range, New South Wales. The site is located on two separate land parcels known as Crookwell 3 East (with an area of 1100 Hectares) and Crookwell 3 South (with an area of 400 Hectares). Adjacent to the Crookwell 3 East site are the existing Crookwell 1 and approved Crookwell 2 wind farms.

The site consists of simple terrain with undulating ridges and waterways, with site elevation ranging between 780 m and 930 m amsl. The land use in the area is primarily for agricultural purposes such as wool, lambs, beef cattle, seed potatoes and more recently for small scale vineyards and flower farms.

2.2 The Project

CDPL, the proponent, is seeking project approval for the construction and operation of a wind energy facility to be known as the Crookwell 3 Wind Farm (the project).

The project comprises a number of elements, including:

- 30 individual wind turbines standing up to 152 m at top of blade tip with a capacity of up to 3.4 MW each (some of the turbines may be fitted with obstacle lighting as required);
- 30 individual kiosks for the housing of 33 kV Transformers and 33 kV Switchgears and associated control systems to be located in the vicinity of the wind turbine towers (in some turbine models being considered the kiosk's equipment are integrated within the tower or nacelle);
- internal unsealed tracks for turbine access;
- upgrades to local road infrastructure as necessary to provide access to the site;
- An underground electrical and communication cable network linking turbines to each other within the site boundary and then using either an underground or overhead connection between the Crookwell 3 site boundaries and the Crookwell 2 site boundary to reach the substation approved as part of the Crookwell 2 Wind Farm;
- up to 3 wind monitoring masts fitted with various instruments such as anemometers, wind vanes, temperature gauge and potentially other electrical equipment; and
- The project will also require a maximum of two temporary concrete batching plants during the construction phase only, to supply concrete for the foundations of the turbines and other associated structures;

Grid connection will be achieved via a connection to the 330kV transmission line which bypasses the site. The project will utilise and be connected to the single substation, control room and facilities for the grid connection, approved as part of the Crookwell 2 Wind Farm.

Figure 1 shows the proposed indicative layout of the project and is subject to further detailed design.

Crookwell 3 East and Crookwell 3 South may be developed in stages.

A turbine layout comprising 30 turbines has been provided by UF [3] and has been used for the purpose of the EMI study.

2.3 Community Concerns Identified

Door-to-door consultation meetings with the community have been undertaken to gather a general idea of the public's concerns in regards to potential EMI impacts that could arise from the development of Crookwell 3 wind farm [4]. To date, the main issues raised have been the potential interference of the turbines with analogue television, satellite television and internet. Concerns have also been expressed in relation to telecommunication mobile coverage and also radio reception which is described as of excellent signal quality at present. Cumulative impacts due to the turbines of Crookwell 1 and 2 wind farms are also of concern to the community.

2.4 Planning guidelines

In NSW there are no specific guidelines for the assessment of the electromagnetic impact of wind turbines.

The Environmental Protection and Heritage Council (EPHC), in conjunction with Local Governments and the Planning Ministers Council released a draft version of the National guidelines for wind farm development in October 2009 [5]. The draft guidelines cover a range of issues spanning over the different stages of wind farm development.

The main purpose of the draft guideline is to provide detailed methodologies to assess issues related to wind farms including community consultations, shadow flicker, noise monitoring, electromagnetic interference, impacts on landscapes, and flora and fauna. Other issues that are covered to a lesser extent in the draft guidelines include aircraft safety, blade glint, risk of fire and indigenous heritage.

In relation to EMI, the draft guidelines provide advice and methodologies to identify likely affected parties, assess the EMI impacts, consult with affected parties and develop mitigation steps to address the likely EMI impacts. As the draft guidelines remain in draft form only, they are likely to be subject to change.

3 METHODOLOGY, ANALYSIS AND RESULTS

If not properly designed, wind farms have the potential to interfere with radiocommunications services. Two services that are most likely to be affected include analogue television broadcast signals and microwave signals. Analogue broadcast signals are still commonly used to transmit domestic television, while microwave 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 methodology for assessing the potential radiocommunications interference is to locate all of the telecommunication towers within 50 km of the proposed wind farm, and then assess the telecommunications the subject of the telecommunication licences attached to these towers.

Other services with the potential to experience interference from the project have also been identified, and the potential for interference to those services discussed.

Cumulative radiocommunication impacts from the project and the existing Crookwell 1 and approved Crookwell 2 Windfarms have also been assessed.

3.1 Telecommunication towers

An image of the ACMA database dated May 2010 was used for this assessment [1]. From the database, there are 916 telecommunication towers within a nominal 50 km of the wind farm. This is an appropriate distance to ensure that all transmission vectors are captured in the licence survey. The locations of these telecommunication towers are shown in Figure 4 relative to the proposed wind farm.

3.2 Fixed licences of point-to-point (microwave) type

3.2.1 Diffraction

Wind turbines can potentially cause interference, or diffraction, of point-to-point microwave signals. It is possible to design around this issue as the path and interference zone of microwave signals are well known. The frequency of common microwave signals varies from approximately 500 MHz to 50 GHz. Microwave 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 criteria used for avoiding diffraction effects of point-to-point signals are normally based on an exclusion zone of circular cross-section around the direct path from the transmitter to the receiver (often called boresight) [5,6,7]. This exclusion zone is defined in terms of Fresnel zones. The n^{th} Fresnel zone is comprised of all points for which, if the radio 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.

To avoid interference to point-to-point signals, wind turbines, including the blades, should be kept outside the second Fresnel zone. The radius of the 2nd Fresnel zone varies along the length of the signal, and is given by:

$$R_{F2} = \sqrt{\frac{2\lambda d_1 d_2}{D}}$$

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, i.e. $d_1+d_2 = D$

The registered communications licences for each tower according to the ACMA database were analysed to determine the transmission paths of licence links that may experience interference from wind turbines (i.e. for frequencies greater than UHF). Each individual link is given an “Assignment ID” by the ACMA so it can be readily identified. The paths resulting from the towers analysed are shown in Figure 5. 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 Country Fire Authority (CFA) towers.

A review of the ACMA database shows that there are two links passing over the proposed wind farm site and an additional third link passing at 1 km northeast of Crookwell 3 south. These links are shown in greater detail in Figure 6.

References [5,6,7] state that turbines should be located outside of either the first or second Fresnel zones in order to avoid interference to that link. For each of the identified links around the site, an exclusion zone has been established based on their operating frequencies, the 2nd Fresnel zone plus the blade length for turbines of an assumed 104 m rotor diameter. The potential exclusion zones are also shown in Figure 6.

It is common practice to have multiple assignment ID’s for the same physical link to cover practicalities such as licensing for sending and/or receiving signals. Accordingly, the Fresnel zone setback has been calculated on the Assignment ID with the lowest frequency. Details of the links are provided in Table 3.

As indicated in Figure 6, there are no turbines in the proposed layout that lie within the potential exclusion zones. The exclusion zones have been determined based on the maximum blade length and Figure 6 thus represents the worst-case scenario. However, the third link, passing at 1 km northeast of Crookwell 3 South, crosses the Crookwell 1 and 2 wind farms.

GH has contacted the operators of two links, Optus Mobile and Radio Goulburn, to determine whether their services are likely to be impacted by the wind farm. This consultation involved an initial request for feedback and follow-up correspondence if no response was received. According to Optus mobile, their services won’t be affected provided all turbines are located outside the Fresnel zone of the link [6]. To date, no formal response has been received from Radio Goulburn. The operator of the third link, AirServices Australia, has been contacted by Aviation projects and they have indicated that it is unlikely that the wind farm would have an impact on their links [10].

3.2.2 Near field effects and scattering

The recently released draft National Wind Farm development Guidelines [5] mention the possibility of interference to point-to-point microwave links from two additional mechanisms, near field effects and scattering.

According to the draft guidelines, near field effects are usually limited to approximately 720 m from a communication tower and it is recommended that consultation is required if a turbine is within 1 km of a telecommunication site. The draft guidelines also state that scattering is best avoided by placing wind turbines more than 2 km from a communication tower.

The communication tower closest to any proposed wind turbines is the “Telstra Radio Terminal” at Crookwell. The nearest turbine is located approximately 11.4 km from the tower; therefore the proposed Crookwell 3 wind farm is not expected to cause interference due to near field effects or scattering.

3.3 Fixed licences of point-to-multipoint type

Fixed licences of the point-to-multipoint type are a variation of 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 licence register. A point-to-multipoint licence allows communication between one or more static sites and multiple points or between the points. The point-to-multipoint type is usually licensed for a defined operational area.

Administratively, the ACMA database details the location of the static station for a fixed licence of point-to-multipoint type. Hence, the location of the transmission vectors is not readily identifiable. A review of fixed licences of point-to-multipoint types was undertaken and 19 Assignment ID's were identified within approximately 50 km of the proposed turbines. These licences are shown in Figure 7. The details of the licence holders as per the ACMA database are provided in Table 4.

The nearest point-to-multipoint station is located at Mount Gray near Goulburn, approximately 22 km to the southeast of the site (Assignment ID 1138949-2209652). This station is owned by Telstra Corporation Limited and GH has contacted Telstra to determine if there is likely to be any interference to their services due to the Crookwell 3 wind farm. Telstra has indicated that the wind farm is not likely to have any impact to their services, provided Telstra is contacted to obtain the location of the plant prior to the commencement of construction work on the Crookwell 3 site [2]. Other point-to-multipoint stations have been identified within 50 km of the wind farm, operated by Australian Rail Track Corporation and Country Energy, have been contacted to determine if the proposed wind farm is likely to have an impact on their services. This consultation involved an initial request for feedback and follow-up correspondence if no response was received. Australian Rail Track Corporation have indicated that there are no foreseeable impacts on their communication network. To date, no formal response has been received from Country Energy.

3.4 Other licence types

A review of the ACMA database for other licences with transmission frequencies of the UHF band or higher was conducted. The licences identified can be broadly described as base to mobile station style communications, including radio broadcasting, commercial and private mobile telephony. These licences are shown in Table 5. 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. Should reception difficulty be encountered, the amelioration method consists of the user simply moving to receive a clearer signal.

3.5 Emergency Services

A review of the ACMA database was conducted to identify emergency services with licences for radiocommunications assets operating in the UHF range or greater. Five groups were identified and are listed below:

- New South Wales Fire Brigades,
- NSW Rural Fire Service,
- Ambulance Service of NSW,
- NSW Police Force,
- Australian Federal Police, and
- NSW State Emergency Service.

These six groups have been contacted to determine if there is potential for interference to their radiocommunications assets as a result of the proposed Crookwell 3 wind farm. To date, no issues have been raised. No response has yet been received from the NSW Rural Fire Service or the Ambulance Service of NSW.

3.6 Aviation radar

Primary surveillance radar (PSR) is used for air traffic control and requires line-of-sight to the target object for successful detection. PSR transmits a pulse of energy that is reflected back to the radar receiver by the target object. Some combinations of turbine orientation and blade angle can cause significant Doppler returns to the illuminating radar, thereby creating false targets on the radar screen. The sporadic nature of these false positives makes them difficult to filter with current radar software. Further, turbines may create a radar obstruction or “shadow” where aircrafts are not detected. In Australia, PSR installations are located at major airports and typically have a range of approximately 50 nautical miles (93 km).

Secondary surveillance radar (SSR) is less vulnerable to interference from wind turbines as SSR does not rely on reflections from objects for detection. Aircraft are required to carry a transponder, which replies to radar interrogations. However, SSR may still be affected by a wind farm as an aircraft transponder may respond to a reflected signal and give a false position reading, or SSR may be obstructed by a wind farm similar to PSR. SSR installations are also typically located at major airports, and have a range of approximately 250 nautical miles (463 km) when detecting aircraft at high altitude. However, at or near ground level, the range of SSR is expected to be less.

The draft national wind farm development guidelines released by the EPHC recommend that radar operators be notified of the development of wind farms within 250 nautical miles (463 km) of aviation radar operators [5]. Radar installations are typically located at major airports. The proposed Crookwell 3 wind farm is located approximately 86 km from Canberra airport, 166 km from the Sydney international airport and 547 km from Melbourne international airport. GH understands that there is no radar installation at Goulburn airport, which is located 27 km from the site.

Due to the significant distance from major airports, and the high probability that the turbines will lie below the radar line-of-sight, it is unlikely that the Crookwell 3 wind farm will cause interference with aviation radar. Consultations with Airservices Australia, Civil Aviation Safety Authority (CASA), the Department of Defence, Aerial Agricultural Association, Rural Fire Service, Goulburn Airport and Upper Lachlan Shire Council have been undertaken by Aviation projects. At present, the Department of Defence, CASA, Upper Lachlan Shire Council, Goulburn Airport, Airservices Australia and Rural fire Service have responded that their services are unlikely to be affected by EMI issues related to the proposed wind farm [6, 10]. The Aerial Agricultural Association has advised that their response would

be as per the Wind Farm policy available on their website [11], however this document does not raise any specific concerns regarding impacts to radar or other radiocommunications services.

3.7 Meteorological radar

The Bureau of Meteorology (BoM) operates a network of weather stations across Australia and uses radar instruments for measuring wind speeds in the upper atmosphere (known as wind finding radar), and determining rain and storm activity (known as weather watch radar).

The “wind finding” radar uses radar echoes from a target to determine the wind speeds and direction. The radar target is attached to a balloon and tracked by the ground radar. The “weather watch” radar, or “weather surveillance” radar, consists of a rotating antenna located on a building, and kept free from any physical obstruction. The antenna is used to direct a thin beam of radio energy upward into the atmosphere which is then reflected back by a cloud mass. The location of the cloud is then determined by the direction and travel time of the reflected beam.

Wind profile measurements are 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. “Weather watch” radars monitor weather situations and are able to indicate the possibility of severe storms out to as distance of 250 km or more. Hence, whilst 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.

Wind farms located at distances greater than 5 km from a BoM field station are unlikely to affect wind finding operations [5]. However, wind farms can impact upon weather watch radar when located within several hundred kilometres of a radar station. Generally, the optimal coverage area for “weather watch” radar extends approximately 200 km from the radar installation at a height of approximately 3000 m [26, 27], and approximately 100 km at a height of 1000 m [27]. Due to the curvature of the earth, and intervening terrain, the range at or near ground level is generally less.

According to the draft set of guidelines for wind farm developments issued by the Environment Protection and Heritage Council (EPHC), consultations with operators of weather stations within 250 nautical miles of the proposed wind farm should be undertaken [5]. It has been identified that the BoM operates five weather stations within that range with the closest station “Sydney Appin” located 115 km northeast of the proposed Crookwell 3 wind farm site. The details of each station can be found in Table 7.

It is not expected that the wind farm will cause interference with BoM radar installations, as given the distance between the site and radar installations, and the nature of the intervening terrain, it is likely that radar signals will be intercepted before they are able to be influenced by the wind farm. Consultation with the BoM head office has been undertaken by GH to determine the likely impact of the wind farm on the BoM’s radar installations, but no formal response has been received to date. This consultation involved an initial request for feedback and follow-up correspondence when no response was received.

3.8 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 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 to 5 km while microwave systems can measure distances up to 150 km. However, such systems are not limited by the line of sight or affected by visibility [12].

The Australian Fiducial Network (AFN) is fundamental to the whole Geodetic network of Australia [13]. The AFN consists of eight permanent stations equipped with EDM devices and GPS receivers and transmit data to GeoScience Australia via phone lines, internet and/or satellite [14]. A review of the AFN has been undertaken by GH and the closest station is found in Canberra, approximately 140 km away from the proposed wind farm. Due to the significant distance of the station from the wind farm, it is unlikely that the station would be impacted by the wind farm.

GH has also undertaken a review of the Primary Geodetic Network of Australia [15] and it has been observed that the proposed Crookwell 3 wind farm is located in the region of second-order triangulation. First-order triangulation depends on trigonometrical stations of known positions, baselines and heights, with the highest degree of accuracy. Points determined from first-order triangulation will then be used for second-order triangulation network and so forth, with the degree of accuracy decreasing for subsequent networks.

According to the database from Geoscience Australia [16], there are 47 trig points within 30 km of the Crookwell 3 site boundary. The details of all 47 trig points are provided in Table 6 and illustrated in Figure 9. Consultation with staff from Geoscience Australia revealed that the stations could either be operated by Geoscience Australia or by the New South Wales Land and Property Management Authority (LPMA). Both the LPMA and Geoscience Australia have been contacted to determine whether the trigonometrical stations are likely to be impacted by the wind farm development. This consultation involved an initial request for feedback and follow-up correspondence when no response was received. Geoscience Australia has advised that out of the 47 stations identified, the stations operated by them do not have GPS equipment installed and shall not be impacted by EMI issues associated with the wind farm. Although no response has been received from LPMA, however the feedback from Geoscience Australia indicates the interference to trigonometrical stations is unlikely.

3.9 Citizens 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. 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.

CB radio service can be used for voice communications activities, telemetry and telecommand applications. The radio service operates on two frequency bands, namely the High Frequency (HF) band at between 26.965 MHz and 27.405 MHz, and the Ultra High Frequency (UHF) band at between 476.425 MHz and 477.400 MHz.

The 27 MHz CB radio service was legalised in Australia in the 1970s as a temporary move to switch to UHF CB over the following five years. 27 MHz CB transmit signals in either AM 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 27 MHz CB radio service has declined and has been replaced by UHF CB radio service.

UHF CB radio service is unique in Australia and uses the FM transmission mode. It provides clear communication over 5-20 km and is less susceptible to power line noise. However, UHF CB radio service requires "line-of-sight" and is easily hindered by hilly terrain and forested areas. If located on a hilltop, CB radio signals can be transmitted over at least 50 km. Repeater stations are 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.

Since users of CB radio service 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. The impact of the Crookwell 3 wind farm on CB radio service is expected to be minimal. In the event of interference from the wind turbines, simple steps such as moving a short distance until the signal strength improves would help to mitigate the impact.

3.10 Mobile phones

Mobile phone networks operate at frequencies of either between 800 and 900 MHz, or between 1800 and 2100 MHz. At such frequencies, signals are likely to be affected by physical obstructions such as buildings and wind turbines. However, those 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, wind turbines could cause some interference to the signal. Mobile phone network coverage maps have been obtained for Telstra and Optus [17, 18]. Figure 10 and Figure 11 show the Telstra and Optus network coverage for the Crookwell area. The overall site area has little mobile GSM coverage for Telstra and in some locations, only mobile satellite coverage is available. The Optus mobile network coverage in the area is also marginal with most locations requiring an external antenna. For those areas, the signal might be susceptible to interference if a wind turbine intercepts the signal between a mobile phone and the tower. Telstra NextG network coverage is generally good in the area with some locations requiring an external antenna. Figure 12 shows the NextG network coverage for the Crookwell 3 wind farm development area.

In cases of marginal network coverage, simple mitigation procedures such as moving a short distance to a new location until the signal strength improves or installing an external antenna are expected to help to improve the signal quality.

3.11 Wireless Internet

Discussion with landowners at the Crookwell 3 site has indicated that a number of dwellings in the vicinity of the wind farm obtain internet access from a wireless internet service provider operating in the region. This service was originally provided by Wirefree Networks [19], and has been recently acquired by Cirrus Communications [20].

According to Cirrus Communications the service utilises technology provided by Motorola which is similar to the cellular telephone network. The system consists of towers throughout the coverage area with a height of approximately 8 m. Customers install an external antenna which connects to the towers via a link at a frequency of 900 MHz. A line-of-site connection to the towers is preferred, but not essential. Backhaul links operate between the towers at a frequency of approximately 5 GHz.

As the Cirrus network relies on packet-based technology similar to the mobile phone network, it is expected that the system will be relatively robust to interference. Additionally, the Cirrus Communications network coverage map for the Goulburn area [20], suggests that there are multiple base stations around the Crookwell area. As such, if interference is experienced when connected to a

particular base station, it is possible that an acceptable signal could be obtained by reorienting the antenna to point to a different base station.

The towers operated by Cirrus Communications are typically approximately 8 m in height, and therefore, in many cases, the links between the towers and customers are likely to pass underneath the turbine rotors. The most likely potential cause of electromagnetic interference is therefore the turbine towers which are limited in size, static, and only likely to cause interference if they intercept the link between the tower and customer. However, it is not possible to confirm the potential for interference without knowing the locations of Cirrus Communication's towers and customers.

Cirrus Communications has been contacted to determine if they expect their service to be affected by the proposed Crookwell 2 wind farm. This consultation involved an initial request for feedback and follow-up correspondence when no response was received. To date, no formal response has been received.

3.12 Satellite Television and Internet

In some rural or remote areas, television and internet access can be provided through satellite only. Satellite television is delivered via a communication satellite to a satellite dish connected to a set-top box. The satellite transmits television signals to the user's antenna at two frequency bands; the C band at between 4 GHz and 8 GHz, and the K_u band at 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 while signals in the K_u band are most likely to be affected by rain which acts as an excellent absorber of microwave signals at this frequency. GH understands that there are currently 23 satellites that provide television to the east coast of Australia [21].

In the case of satellite internet, the user's computer is connected to a satellite modem which is in turn linked to a satellite dish/antenna mounted on the building roof. When the user browses a webpage, a request is sent to the operation centre of the satellite internet provider via the satellite antenna. The webpage information is then sent back to the user's computer via the same path as shown in the figure below.



2 way connection to the Internet via Satellite [22]

A number of residents in the vicinity of the Crookwell 3 wind farm have access to satellite television and internet [4]. According to the Australian ISP directory [23], there are five satellite ISPs in the area and all of them are using a single IPSTAR satellite, Thaicom 4 [24].

A review of the line of sight between all usable TV and internet satellites and houses identified in the region of Crookwell 3 wind farm has been undertaken. It has been found that no turbines intercept the line-of-sight of the internet satellite or TV satellites commonly used in Australia. It has been found that six turbines in the Crookwell 3 East site intercept the line of sight of two TV satellites for Houses 66 and 67. However, it is highly unlikely that the two houses would be receiving television from these

two satellites, as they primarily broadcast channels intended for African, Asian and Middle Eastern audiences.

3.13 Radio broadcasting

GH has assumed that broadcast radio includes both Amplitude Modulation (AM) and Frequency Modulation (FM) radio used to broadcast audio signals. In Australia, AM radio operates in the Medium Wave (MW) band at frequencies of between 520 kHz and 1610 kHz, while FM radio operates in the very high frequency band (VHF) at between 87.5 MHz and 108 MHz. The locations of the AM and FM broadcast transmitters in the vicinity of the proposed Crookwell 3 wind farm are shown in Figure 8.

3.13.1 AM Radio

AM radio waves are diffracted by the ground as they propagate, such that they follow the curvature of the earth, and are also 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 relatively small physical obstructions on the surface of the earth (such as wind turbine), however they do not propagate easily through some dense building materials such as brick, concrete and aluminium.

The distance over which AM radio waves 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.

As AM radio signals are able to propagate around obstructions such as turbines, it is expected that a wind farm would not cause significant interference for a receiver. Additionally, due to the long wavelength of the signal, interference is only likely in the immediate vicinity of a turbine [25]. Any interference problems are likely to be easily resolved through the installation of a high quality antenna and/or amplifier.

3.13.2 FM Radio

FM radio waves are more suited to short range broadcasting. Unlike lower frequency signals, they are not reflected or refracted off the ionosphere. The waves are slightly refracted by the atmosphere and curve back towards the earth, meaning they can propagate slightly beyond the visual horizon, however they may be blocked by significant terrain features. FM radio stations therefore tend to have only local coverage and this 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. Reflection or scattering of radio waves by physical structures can reduce 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 cause hissing or distortion to be heard by a listener. However, generally any interference will only be likely in the immediate vicinity of the wind turbine [25], and should be easily rectified through the installation of a high quality antenna and/or amplifier.

3.13.3 Digital Radio

Digital radio services have been introduced in metropolitan licence areas from 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 [32]. According to the digital radio coverage map available on the ABC website [33], digital radio is not yet available in the Crookwell region.

3.14 Television Broadcasting

3.14.1 Analogue Television

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

- proximity of wind turbines to television broadcast tower;
- proximity of wind turbines to receivers (dwellings);
- location of wind turbines in relation to dwellings and television broadcast towers;
- the rotor blade material, rotor speed and rotor blade direction (always into the wind);
- type of receiving antenna (e.g. directional and height); and
- frequency and power of the television broadcast signal.

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

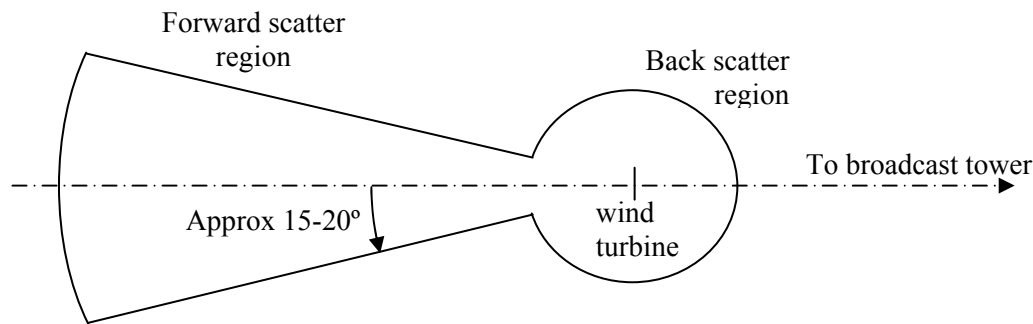
The Broadcast Transmitter Database [28] was examined to identify broadcasters nearby to the proposed wind farm, with those found shown in Figure 13.

Local interference to analogue television could potentially occur to individual houses in and around the proposed wind farm. A wind turbine has the potential to scatter analogue television waves both forward and back.

Forward scatter will only occur if a wind turbine is located approximately between the dwelling and the broadcast site. The forward scatter region is as shown in the following figure, and generally does not extend further than 5 km for the worst combination of factors [6, 29]. Interference may extend beyond 5 km if the dwellings are screened from the broadcast tower, but do have line-of-sight to the wind turbines. The effect of the forward scatter is to potentially cause the brightness of the television picture to vary with the rotation of each blade. Modern television sets usually incorporate Automatic Gain Compensators (AGC) which act to lessen or eliminate variations in picture gain or brightness.

Back scattered signals arrive at the dwelling delayed relative to the source signal from the broadcast tower. The back scatter region is as shown in the figure next page, and generally does not extend further than 500 m [6, 29]. If a dwelling is within 500 m of a wind turbine and its receiving antenna is not sufficiently directional to discriminate between the original and delayed signal, then a pulsating ghost or secondary signal may appear on the television screen.

The combination of the forward and back scatter regions, as shown in the following figure, resembles a keyhole.



Potential analogue 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.

As an alternative, it is best to identify those dwellings or areas that are most likely to experience potential analogue television interference based on the forward and back scatter regions. This is often referred to as the keyhole approach. The keyhole approach methodology is to combine multiple keyholes that are placed over each turbine location. The union of each individual keyhole forms a region where there may be the potential for television interference. The keyhole approach usually results in only a few areas of potential impact.

To assist in identifying those houses that may be subject to television interference due to the proposed Crookwell 3 wind farm, both back and forward scatter regions have been determined based on the proposed wind farm layout.

The nearby broadcast towers were examined through interaction with landowners at the Crookwell 3 site. It was apparent that the preferred source of television signals for the area around the wind farm is Black Mountain in Canberra. However based on the reception coverage maps provided on the ABC Reception Advice website [30] it is possible that residents in the area may also receive analog television signals from either the Central Tablelands transmitter at Mount Canobolas, the Crookwell ABC transmitter at Crookwell, the Goulburn transmitter at Mount Gray or the Canberra transmitter.

Therefore, the regions where there may be the potential for television interference have been identified using the keyhole approach based on Central Tablelands, Crookwell, Goulburn and Canberra broadcast towers, with the results shown in Figure 14, Figure 15, Figure 16 and Figure 17. Each figure also shows the location of nearby dwellings as provided by CDPL [31].

As shown in the figures, there are several dwellings that fall within the potential analogue TV EMI regions based on each broadcast tower and a list of houses likely to be affected by one or several of the towers is shown in Table 8. It should be mentioned that some houses affected by the TV EMI zone from one specific transmitter may already be tuned to another transmitter.

The potential for impact may be reduced if some of the houses are already using set top boxes to receive digital television, as a digital TV signal is less susceptible to interference from a wind farm.

The method used here to assess the potential interference to analogue television signals from the Crookwell 3 wind farm represents a simplified approach which is expected to capture locations where interference is most likely to occur. This simplified analysis is deemed appropriate as the implications of potential analogue television interference are minimal given the large range of mitigation options available, as discussed in the following section.

3.14.2 Digital television

The introduction of digital television broadcasts provides an attractive amelioration option for dwellings in and around wind farms as digital television signals are generally unaffected by wind turbines. GH has experience in situations where dwellings were able to receive adequate digital television reception in an area of adequate signal strength where the digital television signal is passing through a wind farm.

However, a recent published by the UK telecommunications regulator Ofcom [34], states the following with regard to interference to digital television 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”.

GH has drawn two conclusions from this report:

- Firstly that digital television is very robust and does not suffer from ghosting. In most cases digital television should be a satisfactory amelioration option for wind farm developments.
- Secondly, that areas of weak signal can experience interruptions to their reception should new reflections appear, such as those from nearby wind turbines.

According to the ABC Reception Advice website [30], the area around the Crookwell 3 wind farm is likely to be able to receive a digital television signal from either the Goulburn Mt Gray transmitter, or the Canberra Black Mountain transmitter. However, in both cases, the Crookwell area is close to the outer edge of the area identified as having adequate coverage, meaning there may be areas around the site where digital reception is marginal. Based on the ABC Reception Advice website, it is not expected that adequate digital television signals will be available from the Central Tablelands transmitter, and the Crookwell ABC transmitter does not currently broadcast a digital signal.

Discussions with residents in the vicinity of the wind farm has confirmed that digital reception is marginal at some of the existing residences. In the event that the wind farm causes interference to digital television signals, the mitigation options below may be used to rectify the problem.

3.14.3 Mitigation Options

As television interference from wind turbines is readily identifiable, appropriate mitigation measures can be readily taken if required.

In the event that TV interference is an issue during wind farm construction or after wind farm commissioning, there are several amelioration options available, in approximate order of cost:

1. Realigning the householder's TV antenna more directly towards their existing transmitter;
2. Tuning the householder's antenna into alternative sources of the same or suitable TV signal;
3. The installation of more directional and/or higher gain antenna at the affected dwelling;
4. Relocating the antenna to a less affected position;
5. The installation of a digital set top box (and UHF antenna if required);
6. The installation of cable/satellite TV at the affected dwelling; and
7. Installation of a TV relay station.

In the event that digital TV does not provide an acceptable amelioration option, satellite television represents another potential amelioration option. Satellite based television comprises of both free to air and subscription based broadcasts.

4 CUMULATIVE IMPACT

As mentioned in Section 2, the proposed Crookwell 3 wind farm sites are located to the south and east of the existing Crookwell 1 and approved Crookwell 2 wind farms. CDPL has also provided the layouts of Crookwell 1 and 2 wind farms [3] and these have been used here in conjunction with Crookwell 3 layout to assess the cumulative EMI impacts.

4.1 Fixed point-to-point microwave links

Sensible design of a wind farm will avoid the path of point-to-point links which are generally well known. The current layout proposed for the Crookwell 3 wind farm does not intercept any point-to-point links. Turbines on the Crookwell 1 and 2 wind farms intercept with one point-to-point link belonging to Radio 2GN as shown in Figure 6. Radio 2GN has been contacted to determine whether this link is likely to be affected by the wind turbines but, to date, no formal response has been received.

4.2 Point-to-multipoint microwave links

Given the distance of point-to-multipoint stations from the site, and consultations with the operators of the stations within 50 km of the site, it is not expected that the proposed Crookwell 3 wind farm will cause interference for any of the point-to-multipoint stations considered. Therefore, it is expected that there will be no cumulative impacts to these stations from the proposed development.

4.3 Other Licence Types

These licences types are not generally affected by the presence of wind turbines, and therefore there are not expected to be any cumulative impacts from the wind farm.

4.4 Emergency Services

No issues have been raised regarding the potential for interference to radiocommunications assets operated by emergency services in the vicinity of the proposed Crookwell 3 wind farm, therefore there are not expected to be any cumulative impacts from the wind farm.

4.5 Aviation and Meteorological Radar

Given the distance of the site from radar installations, and consultations with the operators of those radar installations, it is not expected that the proposed Crookwell 3 wind farm will cause interference to radar services. Therefore, it is expected that there will be no cumulative impacts to radar services from the proposed development.

4.6 Trigonometrical stations

Based on consultation with Geoscience Australia, it is not expected that there will be any electromagnetic inference to trigonometrical stations in the vicinity of the proposed Crookwell 3 wind farm. Therefore, it is expected that there will be no cumulative impacts to trigonometrical stations from the proposed development.

4.7 Citizens Band Radio and Mobile Phones

It is possible that the potential for interference to CB radio systems and mobile phone services could be increased due to cumulative impacts from multiple wind farms. The greater the number of turbines

between two CB transceivers, or between a mobile phone user and tower, the greater the potential for interference. However, as discussed previously, it should be possible to rectify interference problems to these services by moving to a location where signal strength and quality are improved, or through the use of an external antenna.

4.8 Wireless Internet

Although the provider of the wireless internet service operating in the vicinity of the proposed wind farm (Cirrus Communications) has been consulted, to date, no response has been received regarding the potential for interference to their service. It is therefore not possible to assess whether there will be any cumulative impact on the service.

4.9 Satellite Television and Internet

As discussed previously, it is unlikely that satellite television and internet signals will experience interference from the Crookwell 3 wind farm. Only signals received from two satellites that are low on the horizon are likely to be affected, and will only be affected by turbines close to the potentially affected houses. As such, there is not expected to be any impact from surrounding wind farms on the signals received at the potentially affected houses.

4.10 Radio Broadcasting

The impact of the wind farm on radio broadcasting services is expected to be minimal, and any interference encountered is likely to be easily rectified through the installation of a high quality antenna. As such, cumulative impacts from the wind farm are not expected to be significant.

4.11 Analogue television

The potential zones of interference to analogue television reception are presented in Section 3.12 for the proposed Crookwell 3 wind farm in isolation.

A similar analysis, if repeated for the two adjacent wind farms, may potentially add to these zones of interference. However, it is expected that any interference to analogue television can be mitigated by improving the equipment at a dwelling, tuning into an alternate source of the same signal, utilising digital television or other options as discussed in section 3.14.3.

Television EMI zones from the four main sources of analogue television signals are shown in Figure 18. For dwellings on all sides of the proposed Crookwell 3 wind farm, it may be possible to mitigate any cumulative impact on analogue television signals due to the proposed wind farm by tuning into an alternate source of the same signal. Therefore it is expected that those dwellings located between the three wind farms, where the signal from all analogue broadcast transmitters passes turbine locations are most likely to be susceptible to cumulative impact from the three wind farms. Table 9 lists all the houses with the potential to be impacted by television EMI zones due to Crookwell 1, 2 and 3 wind farms.

For dwellings whose analogue television reception from all transmitters is degraded by the cumulative impact of multiple wind farms, possible amelioration options include switching to digital or satellite television or utilising better equipment including higher quality set-top boxes, aerials and cabling. Cumulative impact is therefore expected to be minimal as there are a number of options available to mitigate any reception issues.

4.12 Digital television

As already mentioned in Section 3.14.2, digital television is generally unaffected by wind turbines. However, the previously discussed reference [28] shows reception maps that indicate that the dwellings around the Crookwell 3 wind farm may receive their digital television signal from potentially two different transmitters (Goulburn or Canberra), all of which provide “adequate” to weak signals. Therefore, it should be noted that due to the high level of wind farm development activity in the area and the existing signal strengths, digital television may not provide a satisfactory solution for all dwellings in all areas. In these cases, the additional amelioration options discussed in Section 3.14.3 would be available.

5 CONCLUSION AND RECOMMENDATIONS

Broadcast towers and transmission paths around the proposed Crookwell 3 wind farm were investigated to see if EMI would be experienced as a result of the development of the proposed Crookwell 3 wind farm. The proposed wind farm would involve the installation of 30 turbines, with a hub height of up to 105 m, rotor diameter of up to 104 m, and maximum blade tip height of 152 m.

5.1 Fixed point-to-point microwave links

Two point-to-point microwave links (involving three fixed licences in total) were identified with a path over the proposed wind farm. A third link was identified 1 km northeast of Crookwell 3 South. Further analysis showed that those links passed close enough to the ground over the proposed wind farm site such that turbines could potentially interfere with the signal. The interference zones around these point-to-point links have been identified and it has been found that no turbines from the Crookwell 3 wind farm are expected to cause interference to those links.

5.2 Point-to-multipoint microwave links

Several point-to-multipoint type fixed licences were identified proximate to the Crookwell 3 wind farm site. The nearest licence is approximately 22 km from the site, at Mt Gray near Goulburn and is operated by Telstra Corporation. Telstra has been contacted and has indicated that they should be contacted to obtain the location of the plant before any construction work is undertaken at the Crookwell 3 site. Other operators of point-to-multipoint stations within 50 km of the Crookwell 3 site have been contacted, and none have indicated that interference with their services is likely.

5.3 Other licence types

A review of other licences with transmission frequencies of the UHF band or higher was conducted. The licences identified can broadly be described as base to mobile station style communication, and include radio broadcasting, commercial and private mobile telephony. 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. Should reception difficulty be encountered, the amelioration method consists of the user simply moving to receive a clearer signal.

5.4 Emergency Services

No issues have been raised regarding the potential for interference to radiocommunications assets operated by emergency services in the vicinity of the proposed Crookwell 3 wind farm.

5.5 Aviation radar

The proposed Crookwell 3 wind farm is located approximately 86 km from Canberra airport, 166 km from Sydney international airport and 547 km from Melbourne international airport. Due to the significant distance of the major airports to the wind farm and the high probability that the turbines will lie below the aviation radar line-of-sight, it is unlikely that the proposed Crookwell 3 wind farm will have an impact on aviation radar.

5.6 Meteorological radar

GH has also undertaken an assessment of the BoM radar stations operating in the vicinity of the proposed wind farm and the closest station is located at approximately 115 km northeast of the site. Due to the distance between the station and the site, and the intervening terrain, it is unlikely that the wind farm would have an impact on meteorological radar operations.

5.7 Trigonometrical stations

A total of 47 trigonometrical stations have been identified in the vicinity of the proposed wind farm. Correspondence with staff from Geoscience Australia showed that the stations could either be operated by them or by the New South Wales Land and Property Management Authority. Geoscience Australia has advised GH that the stations operated by them shall not be impacted by the wind farm while no formal response has been received by LPMA to date.

5.8 Citizens Band Radio

Users of Citizen Band radio do not require a licence and GH is not able to identify the users of the service and their locations. The channels are shared equally among the different users without the right of protection from interference. If interference is experienced it should be possible to improve signal quality by moving a short distance. It is therefore considered that the impact of the wind farm on the CB radio service shall be minimal.

5.9 Mobile phones

A review of the mobile GSM and NextG network coverage has been undertaken for the proposed wind farm. It has been found that area around the Crookwell 3 wind farm has marginal network coverage and in some areas, turbines may potentially cause some interference to the signal. In such cases, the installation of an external antenna or moving a short distance until the signal strength improves will help to improve the signal quality.

5.10 Wireless Internet

Consultation with landowners of Crookwell 3 wind farm revealed that a number of dwellings obtain internet access from a wireless internet service provider, Cirrus Communications. A review of the service indicates that it is possible that the turbines at Crookwell 3 could cause some impact to the service if they are located between the communication tower and the customers. GH has contacted Cirrus Communications to assess the likely impact of the wind farm on their services but no formal response has been received to date.

It is recommended that if interference to this service is encountered following construction of the wind farm, CDPL should work with Cirrus Communications to resolve any interference problems caused by the wind farm. Possible amelioration methods may include:

- *Installation of improved or higher antenna at affected dwellings; or*
- *Installation of a new base station to service dwellings in affected areas.*

5.11 Satellite Television and Internet

Residents in the vicinity of the wind farm also have access to satellite television and internet. GH has reviewed the line-of-sight of all usable satellite TV and internet and it has been found that no turbine intercepts the line-of-sight of the internet satellite or the most common TV satellites used in Australia.

5.12 Radio broadcasting

An examination of the likely impact of the wind farm on radio broadcasting has also been carried out. It is unlikely that the proposed wind farm will have an impact on AM radio as the signals are able to propagate around obstructions and buildings. FM signals however may be susceptible to interference from objects such as wind turbines, resulting in hissing and distortion of the signal. This can be

mitigated by the installation of a high quality antenna. At present, digital radio is available only in the metropolitan areas. However, once implemented in the Crookwell region, it is unlikely that the wind farm will have an impact on digital radio provided adequate signal quality is available.

5.13 Television Broadcasting

Broadcast towers around the proposed Crookwell 3 wind farm were investigated to see if television interference would be an issue for the current proposal. Television interference mechanisms are complex to calculate and can have limited predictive accuracy. Television interference around wind turbines is generally limited to less than 5 km and is a function of the visibility of the wind turbines and the transmitter from the receptor.

Work presented here highlights the areas around the proposed Crookwell 3 wind farm site where television interference could potentially occur. A total of 6 houses could potentially experience interference when tuned to the Central Tablelands transmitter, 7 houses if tuned to the Crookwell transmitter, 31 houses if tuned to the Mt Gray transmitter at Goulburn and 22 houses if tuned to the Canberra transmitter.

It is recommended that pre- and post-construction surveys be conducted to determine signal strength and quality of the television signal received at dwellings identified as having the potential to experience television interference due to the proposed Crookwell 3 wind farm.

Should interference be encountered that is attributable to the wind farm, the amelioration options below should be followed in order to rectify the problem:

- 1. Realigning the householders TV antenna more directly towards their existing transmitter;*
- 2. Tuning the householders into alternative sources of the same or suitable TV signal;*
- 3. The installation of a more directional and/or higher gain antenna at the affected building;*
- 4. Relocating the antenna to a less affected position;*
- 5. The installation of a digital set top box (and UHF antenna, if required);*
- 6. The installation of a cable or satellite TV receiver at the affected dwelling; and*
- 7. Installation of a TV relay station.*

5.14 Cumulative Impacts

Crookwell 3 wind farm is adjacent to the existing Crookwell 2 and approved Crookwell 3 wind farms. Cumulative EMI impacts of the proposed Crookwell 3 wind farm are expected to be low for the majority of the services considered. There is some potential for cumulative impacts to television services however there are multiple mitigation options should interference be encountered.

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	1	2	3	4	5	6	7	8
Turbine Model	V90	MM9 2	V10 0	N10 0	2.5xl	E100	SWT101	3XM
No of Turbines	30							
Turbine capacity	2.0	2.0	1.8	2.5	2.5	3.0	2.3	3.3
Hub Height Options (m)	80	80	80	80	75	80	80	80
	95	100	95	100	85	90	90	100
	105				100	100		
Rotor blade length (m)	44	46	49	49	49	49	49	51
Rotor diameter (m)	90	93	100	100	100	100	101	104
Total Height to tip (m)	125	127	130	130	125	130	131	132
	140	147	145	150	135	140	141	152
	150				150	150		
Total Wind Farm Capacity (MW)	50 / 70	50 / 70	45 / 63	63 / 88	63 / 88	75 / 105	58 / 81	83 / 116

Table 1 Turbine options under consideration by CDPL

Turbine ID	Easting¹ (m)	Northing¹ (m)	Site
A1	740910	6175065	CW3 - East
A2	741318	6175038	CW3 - East
A3	741739	6174961	CW3 - East
A4	742142	6174888	CW3 - East
A5	742545	6174793	CW3 - East
A6	741385	6174600	CW3 - East
A8	741992	6174487	CW3 - East
A9	742420	6174375	CW3 - East
A10	742163	6174009	CW3 - East
A12	742793	6173382	CW3 - East
A13	743466	6173101	CW3 - East
A15	744163	6173538	CW3 - East
A16	743023	6172812	CW3 - East
A17	743851	6172845	CW3 - East
A18	744369	6173123	CW3 - East
A19	744768	6173016	CW3 - East
A20	743049	6172311	CW3 - East
A21	743818	6172439	CW3 - East
A22	743634	6172076	CW3 - East
A23	742689	6171800	CW3 - East
A24	743097	6171718	CW3 - East
A25	743605	6171669	CW3 - East
A26	733928	6171235	CW3 - South
A27	734391	6171227	CW3 - South
A28	733966	6170569	CW3 - South
A29	734365	6170720	CW3 - South
A30	734198	6170212	CW3 - South
A31	734648	6170173	CW3 - South
A32	735268	6170853	CW3 - South
A33	735649	6170525	CW3 - South

Note: 1. Coordinate system used is Zone 55 H, GDA94 datum

Table 2 Proposed turbine layout for Crookwell 3 wind farm

Assignment ID	Licence Number	Frequency (Hz)	Postal Address
<i>Point-to-point link crossing Crookwell 3 EAST</i>			
1103596-1103415	1105613	7685250000	Air Services Australia PO Box 367 Canberra ACT 2601
1103597-1103415	1105613	7524250000	
1103596-1103416	1105613	7685250000	
1103597-1103416	1105613	7524250000	
<i>Point-to-point link crossing Crookwell 3 SOUTH</i>			
1232633-1226018	1228782	7662500000	Optus Mobile Pty Ltd Singtel Optus Pty Ltd C/O T.Ho & J.Wickramasinghe PO Box 888 North Ryde NSW 1670
1232634-1226018	1228782	7501500000	
1232633-1226019	1228782	7662500000	
123634-1226019	1228782	7501500000	
<i>Point-to-point link crossing 1 km buffer zone around Crookwell 3 SOUTH</i>			
8153601-8144617	1622766	849800000	Radio Goulburn Pty Ltd Radio 2GN PO Box 115 Goulburn NSW 2580
8153601-8144618	1622766	849800000	
<i>Point-to-point link crossing Crookwell 3 SOUTH</i>			
8245468-8266084	1918104	7821825000	Optus Mobile Pty Ltd Singtel Optus Pty Ltd C/O T.Ho & J.Wickramasinghe PO Box 888 North Ryde NSW 1670
8245476-8266106	1918104	8133145000	
8245468-8266104	1918104	7821825000	
8245476-8266105	1918104	8133145000	

Table 3 Details of point-to-point links in the vicinity of Crookwell 3 wind farm

Assignment ID	ACMA Licence No	Site ID	Location ¹	Contact Details
1138944-2209650	1136431	9493	752849 E 6150221 N	Telstra Corporation Ltd Attn R.Curtis 15/242-282 Exhibition Street Melbourne VIC 3000
1138945-2209650	1136431	9493	752849 E 6150221 N	
1138946-2209651	1136431	9493	752849 E 6150221 N	
1138947-2209651	1136431	9493	752849 E 6150221 N	
1138948-2209652	1136431	9493	752849 E 6150221 N	
1138949-2209652	1136431	9493	752849 E 6150221 N	
1203252-1202161	1202981	9377	230756 E 6199614 N	
1203529-1202161	1202981	9377	230746 E 6199614 N	
1203253-1202154	1202983	200515	774300 E 6201900 N	
1203520-1202154	1202983	200515	774300 E 6201900 N	
1203254-1202133	1202984	200514	239110 E 6196722 N	
1203485-1202133	1202984	200514	239110 E 6196722 N	
1206014-1205301	1204710	10409	230350 E 6213820 N	
1207879-1205301	1204710	10409	230350 E 6213820 N	
1217653-1213351	1234158	202399	703000 E 6149000 N	Australian Rail Track Corporation LTD PO Box 10343 Gouger St Adelaide SA 5000
1217654-1213351	1234158	202399	703000 E 6149000 N	
8254352-8277894	1921347	9534	706300 E 6217500 N	CountryTell Management Pty Ltd CountryTell community Broadband 378 Burma Road Tabletop NSW 2640
424260-1419213	1429638	404074	749890 E 6148994 N	Country Energy Telecommunications Department C/O H Overmyer PO Box 718 Queanbeyan NSW 2620
1424261-1419213	1429638	404074	749890 E 6148994 N	

Note: 1. Coordinate system used is Zone 55H, AGD66 datum

Table 4 Details of point-to-multipoint licences within 50 km of Crookwell 3 wind farm

Licence Type	Licence Category	Number of Instances
ACA	ACA Assigned	1
Broadcasting	Broadcast Service	50
Land mobile	Ambulatory System	1
PTS	PMTS Class B	136
Radiodetermination	Radiodetermination	4
Scientific	Scientific Assigned	1
Spectrum	800 MHz Lower Band	103
Spectrum	800 MHz Upper Band	90
Spectrum	1.8 GHz Upper Band	3
Spectrum	2 GHz Upper Band A	3
Spectrum	2 GHz Upper Band B	3

Table 5 Details of other licences identified within 50 km of the proposed Crookwell 3 wind farm for frequencies greater than 500 MHz

Trig Point	Easting (m)¹	Northing (m)¹
Boxer	755240.0	6146760.0
Breadalbane	726006.2	6147781.0
Malton	742802.0	6148262.0
Parkesbourne	732978.0	6149234.0
Wood	751453.6	6149064.0
Gray	752815.3	6150074.0
Rossi	745960.5	6150499.0
Rocky	750422.4	6150486.0
Goldsmith	748402.0	6151390.0
Kinghorne	738799.6	6151929.0
Governor	752536.0	6152166.0
Goulburn	750465.3	6152717.0
Cullarin	719232.8	6154766.0
Cullarin	719233.9	6154768.0
Mountain Ash	724872.9	6154663.0
Kingsdale	747315.6	6154199.0
Kenmore	750527.1	6154493.0
Narrangarril	755443.6	6154971.0
Baw Baw	742691.8	6156431.0
Evandale	733353.4	6156710.0
Brian	718300.0	6158200.0
Gurrundah	722904.0	6160228.0
Sugarloaf	727852.9	6160156.0
Gap Range	753516.0	6159873.0
Rockfield	732918.5	6160536.0
Meldrum	750277.1	6161109.0
Kingsdale North	748078.8	6163080.0
Wayo	741993.4	6165786.0
Pomeroy	729688.2	6166498.0
Fitton	725001.9	6167830.0
Kialla	733265.5	6168409.0
Hobbs	749751.9	6168387.0
Podmore	738667.9	6171017.0
Cameron	755515.2	6172571.0
Butts	729125.0	6173798.0
Peach	744178.0	6173764.0
Highest Point	723553.5	6175560.0
Pejar	732996.7	6175417.0
Harvey	738986.8	6176966.0
Miller	751711.0	6178049.0
Wattman	721898.3	6181145.0
Trinity	730400.0	6181500.0
Maryville	7383560	6181498.0
Willigam	745353.0	6181758.0
Crookwell	722608.4	6184395.0
McAlister	752801.6	6184423.0
Redbank	735724.4	6186864.0

Note: 1. Coordinate system used is Zone 55 H, AGD66 datum

Table 6 Trigonometrical Stations in the vicinity of Crookwell 3 wind farm

BoM Radar site	Location ¹	Distance from Crookwell 3 wind farm/km
Canberra (Captains Flat)	S35.660° E149.510°	119.8
Sydney (Terrey Hills)	S33.701° E151.210°	170.8
Sydney (Appin)	S34.260° E150.870°	115.1
Newcastle	S32.730° E152.027°	298.1
Wagga	S35.170° E147.470°	200.8

Note: 1. Coordinate system used is Lat/Long GDA94 datum

Table 7 BoM Radar sites in the vicinity of Crookwell 3 wind farm

House ID	Contact	Location ¹	Within TV EMI zone from Broadcast tower			
			Central Tablelands	Crookwell	Goulburn	Canberra
House 1		731647 E 6172983 N			√	
House 2	Phil Keary	731698 E 6172026 N			√	
House 8	Steve & Kylie Ward	733838 E 6172296 N			√	
House 16		737882 E 6167951 N		√		
House 18	John Blewit	736232 E 6171276 N				√
House 19	Peter & Brenda Perusic	735698 E 6171835 N				√
House 20	Norbert & Margaret Williams	735970 E 6172727 N				√
House 22	Tom & Mary Prell	733964 E 6173999 N			√	
House 23	Jeff Prell	736342 E 6174616 N				√
House 24	Charlie & Kristine Prell	736082 E 6174316 N				√
House 25		736368 E 6174580 N				√
House 26	Bianca Bill	736458 E 6174487 N				√
House 27	Richard Drury	736496 E 6174408 N				√
House 28		736395 E 6174209 N				√
House 29	Alex & Pam Turner	738978 E 6167634 N		√		
House 30	Donna Dooley	739244 E 6167665 N		√		
House 32	Peter Keith	739063 E 6168245 N		√		
House 41		738995 E 6167592 N		√		
House 58		741473 E 6171450 N	√			
House 59		741415 E 6171733 N	√			

Note 1: Coordinate system used is Zone 55 H, GDA94 datum

Table 8 List of houses with the potential to experience EMI to analogue television from Central Tablelands, Crookwell and Goulburn broadcast towers for the Crookwell 3 wind farm only (continued).

House ID	Contact	Location ¹	Within TV EMI zone from Broadcast tower			
			Central Tablelands	Crookwell	Goulburn	Canberra
House 61	Guy Dowling	741369 E 6171908 N	√			
House 62	Richard & Sally Bird	741337 E 6172055 N	√			
House 63	Tom Haig	741181 E 6173622 N	√		√	
House 64	David Manning	740395 E 6174100 N			√	
House 65	Wayne Flint	740315 E 6174217 N			√	
House 66	Neil & Carol Bolton	743524 E 6174343 N		√	√	√
House 67	Elaine Bolton	743724 E 6174675 N			√	√
House 68	Vernon Robertson	739684 E 6175594 N			√	
House 69	James, Bryon, Ross Robertson	740191 E 6175752 N			√	
House 71		739396 E 6176926 N			√	
House 72	Mark Dawson	739448 E 6177340 N			√	
House 73	Paul & Lynn Dawson	739184 E 6177867 N			√	
House 74	Norm & Janine Hannan	739107 E 6178738 N			√	
House 75	Michael Hannan	739013 E 6178876 N			√	
House 76		739250 E 6178840 N			√	
House 79	Joyce Rabjohns	740830 E 6174323 N			√	
House 80	Matthew & Leanne Donoghoe	741434 E 6172956 N	√			
House 81	Norm & Janine Hannan	739537 E 6178821 N			√	
House 82	Norm & Janine Hannan	739732 E 6178548 N			√	
House 91		748820 E 6171555 N		√		
House 99		747850 E 6176725 N				√
House 100		747569 E 6176543 N				√
House 102		746121 E 6177583 N				√
House 103	Donald & Rod McInnes	745231 E 6178338 N				√
House 104	Grant Winberg	743973 E 6176996 N			√	√
House 105		743875 E 6177928 N			√	√

Note 1: Coordinate system used is Zone 55 H, GDA94 datum

Table 8 List of houses with the potential to experience EMI to analogue television from Central Tablelands, Crookwell and Goulburn broadcast towers for the Crookwell 3 wind farm only (continued).

House ID	Contact	Location ¹	Within TV EMI zone from Broadcast tower			
			Central Tablelands	Crookwell	Goulburn	Canberra
House 106	Colin & Jan Dooley	742598 E 6176726 N			√	√
House 107	Peter King	743258 E 6178256 N			√	√
House 108	Richard Hill	742847 E 6178538 N				√
House 109		740622 E 6178917 N			√	
House 110	Richard & Lisa Opie	740029 E 6179174 N			√	
House 111		739678 E 6179037 N			√	
House 112		739674 E 6179055 N			√	
House 113		742622 E 6178593 N				√
House 114		743051 E 6177981 N			√	√
House 115		739626 E 6179103 N			√	
House 116	Norm & Janine	739578 E 6179174 N			√	

Table 8 List of houses with the potential to experience EMI to analogue television from Central Tablelands, Crookwell and Goulburn broadcast towers for the Crookwell 3 wind farm only (concluded).

House ID	Contact	Location	Central Tablelands			Crookwell			Goulburn Mt Gray			Canberra		
			CW1	CW2	CW3	CW1	CW2	CW3	CW1	CW2	CW3	CW1	CW2	CW3
House 1		731647 E 6172983 N												√
House 2	Phil Keary	731698 E 6172026 N												√
House 8	Steve & Kylie	733838 E 6172296 N	√	√			√							√
House 16		737882 E 6167951 N								√				
House 17	Dudley & Ida	736692 E 6171234 N		√			√							
House 18	John Blewitt	736232 E 6171276 N		√			√							√
House 19	Peter & Brenda Perusic	735698 E 6171835 N		√			√							√
House 20	Norbert & Margaret	735970 E 6172727 N		√			√							√
House 21	David & Annette	734279 E 6174723 N	√				√			√				
House 22	Tom & Mary Prell	733964 E 6173999 N	√	√			√				√			
House 23	Jeff Prell	736342 E 6174616 N		√		√	√			√			√	√
House 24	Charlie & Kristine	736082 E 6174316 N	√	√		√	√			√			√	√
House 25		736368 E 6174580 N	√	√		√	√			√			√	√
House 26	Bianca Bill	736458 E 6174487 N	√	√		√	√			√			√	√
House 27	Richard Drury	736496 E 6174408 N	√	√		√	√			√			√	√
House 28		736395 E 6174209 N	√	√		√	√			√				√
House 29	Alex & Pam Turner	738978 E 6167634 N												√
House 30	Donna Dooley	739244 E 6167665 N												√
House 32	Peter Keith	739063 E 6168245 N		√										√
House 33	Heather Shepherd	739518 E 6168420 N		√										
House 34	Bryan Pettit	739270 E 6168600 N		√										

Table 9 Cumulative TV EMI zones from Crookwell 1, 2 and 3 wind farms (continued)

House ID	Contact	Location	Central Tablelands			Crookwell			Goulburn Mt Gray			Canberra		
			CW1	CW2	CW3	CW1	CW2	CW3	CW1	CW2	CW3	CW1	CW2	CW3
House 35	Jeremy Goodman	739384 E 6168786 N		√										
House 36		739709 E 6169363 N		√										
House 37	John Castro	738567 E 6169756 N		√				√						
House 38		738011 E 6170209 N		√				√						
House 39		737919 E 6170298 N		√				√						
House 40		739452 E 6169668 N		√										
House 41		738995 E 6167592 N								√				
House 50	Victoria & Peter	741118 E 6167758 N		√										
House 51		740840 E 6167997 N		√										
House 52		741178 E 6167993 N		√										
House 53		740567 E 6168992 N		√				√						
House 54	Johnathon & Rhonda Jackson	740557 E 6169539 N		√				√						
House 55		741001 E 6169408 N		√				√						
House 56	EJ & KJ Young	740550 E 6169310 N		√				√						
House 57		740578 E 6170029 N		√				√						
House 58		741473 E 6171450 N				√		√						
House 59		741415 E 6171733 N				√		√						
House 60	Nicolas Rowe	740389 E 6172231 N		√				√						
House 61	Guy Dowling	741369 E 6171908 N				√		√						
House 62	Richard & Sally	741337 E 6172055 N				√		√						
House 63	Tom Haig	741181 E 6173622 N				√		√						√

Table 9 Cumulative TV EMI zones from Crookwell 1, 2 and 3 wind farms (continued)

House ID	Contact	Location	Central Tablelands			Crookwell			Goulburn Mt Gray			Canberra		
			CW1	CW2	CW3	CW1	CW2	CW3	CW1	CW2	CW3	CW1	CW2	CW3
House 64	David Manning	740395 E 6174100 N					√				√		√	
House 65	Wayne Flint	740315 E 6174217 N					√				√		√	
House 66	Neil & Carol	743524 E 6174343 N							√		√			√
House 67	Elaine Bolton	743724 E 6174675 N									√			√
House 68	Vernon Robertson	739684 E 6175594 N									√		√	
House 69	James, Bryon, Ross Robertson	740191 E 6175752 N									√		√	
House 70	Chris & Amanda	739339 E 6175736 N					√						√	
House 71		739396 E 6176926 N									√		√	
House 72	Mark Dawson	739448 E 6177340 N									√		√	
House 73	Paul & Lynn	739184 E 6177867 N									√		√	
House 74	Norm & Janine	739107 E 6178738 N									√		√	
House 75	Michael Hannan	739013 E 6178876 N									√		√	
House 76		739250 E 6178840 N									√		√	
House 77		738837 E 6180318 N											√	
House 79	Joyce Rabjohns	740830 E 6174323 N						√			√		√	
House 80	Matthew & Leanne	741434 E 6172956 N			√			√						
House 81	Norm & Janine	739537 E 6178821 N									√		√	
House 82	Norm & Janine	739732 E 6178548 N									√		√	
House 84	Jeff & Victoria	741184 E 6168967 N		√				√						
House 91		748820 E 6171555 N												√

Table 9 Cumulative TV EMI zones from Crookwell 1, 2 and 3 wind farms (continued)

House ID	Contact	Location	Central Tablelands			Crookwell			Goulburn Mt Gray			Canberra		
			CW1	CW2	CW3	CW1	CW2	CW3	CW1	CW2	CW3	CW1	CW2	CW3
House 99		747850 E 6176725 N												√
House 100		747569 E 6176543 N												√
House 102		746121 E 6177583 N												√
House 103	Donald & Rod McInnes	745231 E 6178338 N												√
House 104	Grant Winberg	743973 E 6176996 N									√			√
House 105		743875 E 6177928 N									√			√
House 106	Colin & Jan Dooley	742598 E 6176726 N									√		√	√
House 107	Peter King	743258 E 6178256 N									√			√
House 108	Richard Hill	742847 E 6178538 N												√
House 109		740622 E 6178917 N									√		√	
House 110	Richard & Lisa Opie	740029 E 6179174 N									√		√	
House 111		739678 E 6179037 N									√		√	
House 112		739674 E 6179055 N									√		√	
House 113		742622 E 6178593 N												√
House 114		743051 E 6177981 N									√			√
House 115		739626 E 6179103 N									√		√	
House 116	Norm & Janine Hannan	739578 E 6179174 N									√		√	

Table 9 Cumulative TV EMI zones from Crookwell 1, 2 and 3 wind farms (concluded)

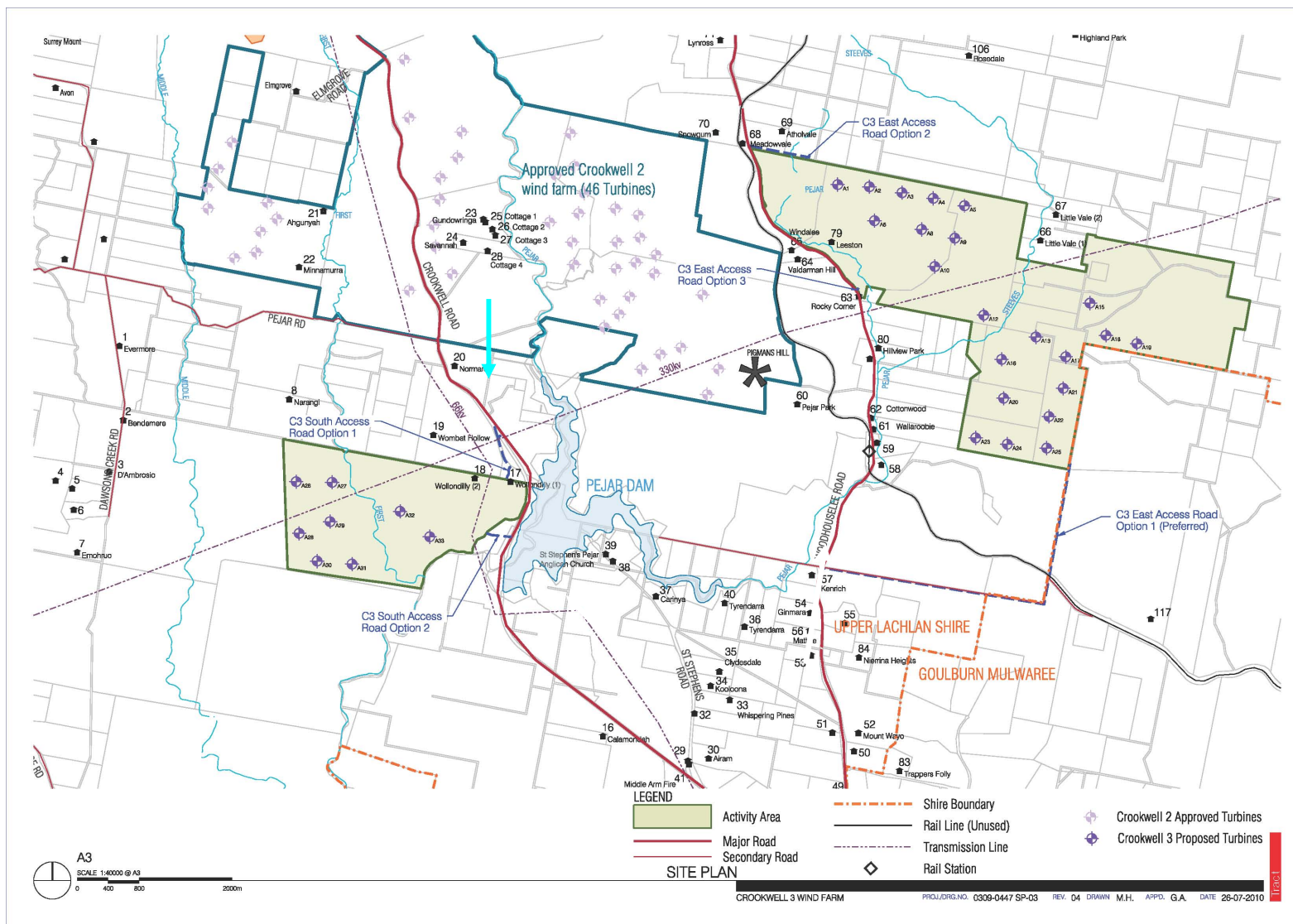


Figure 1 Location of Crookwell 1, 2 and 3 wind farms

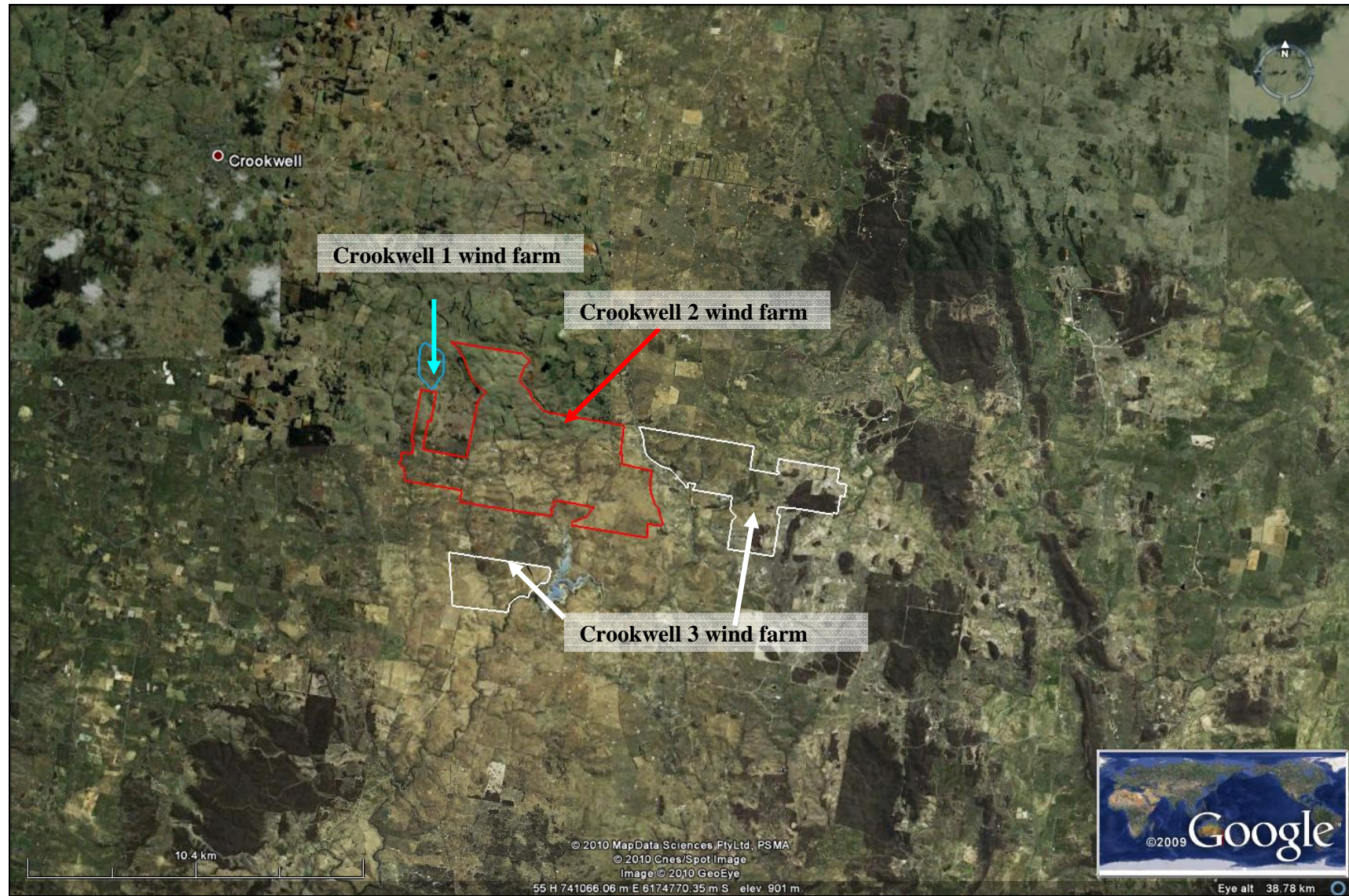


Figure 2 Location of Crookwell 1, 2 and 3 wind farms

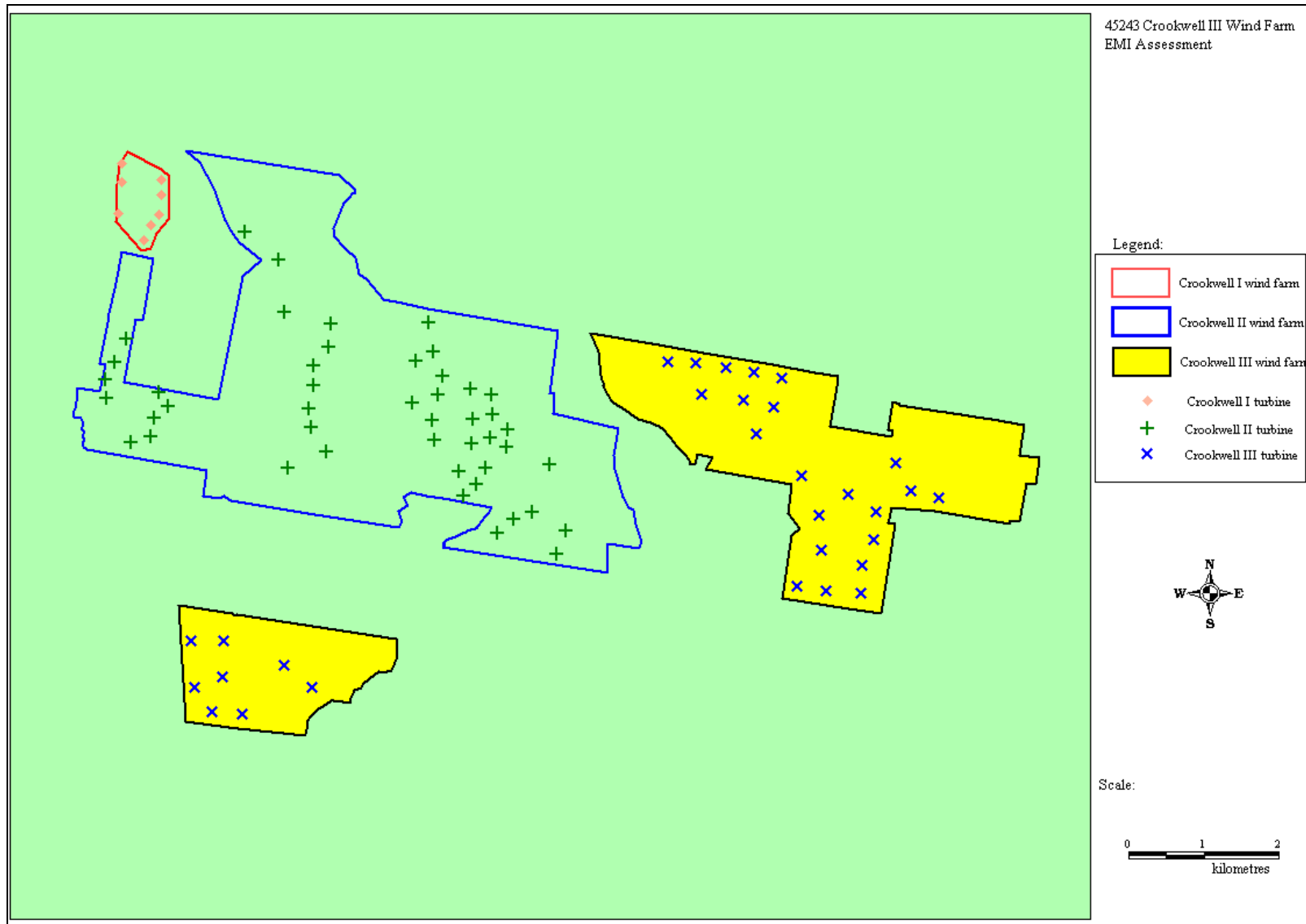


Figure 3 Layout of Crookwell 1, 2 and 3 wind farms

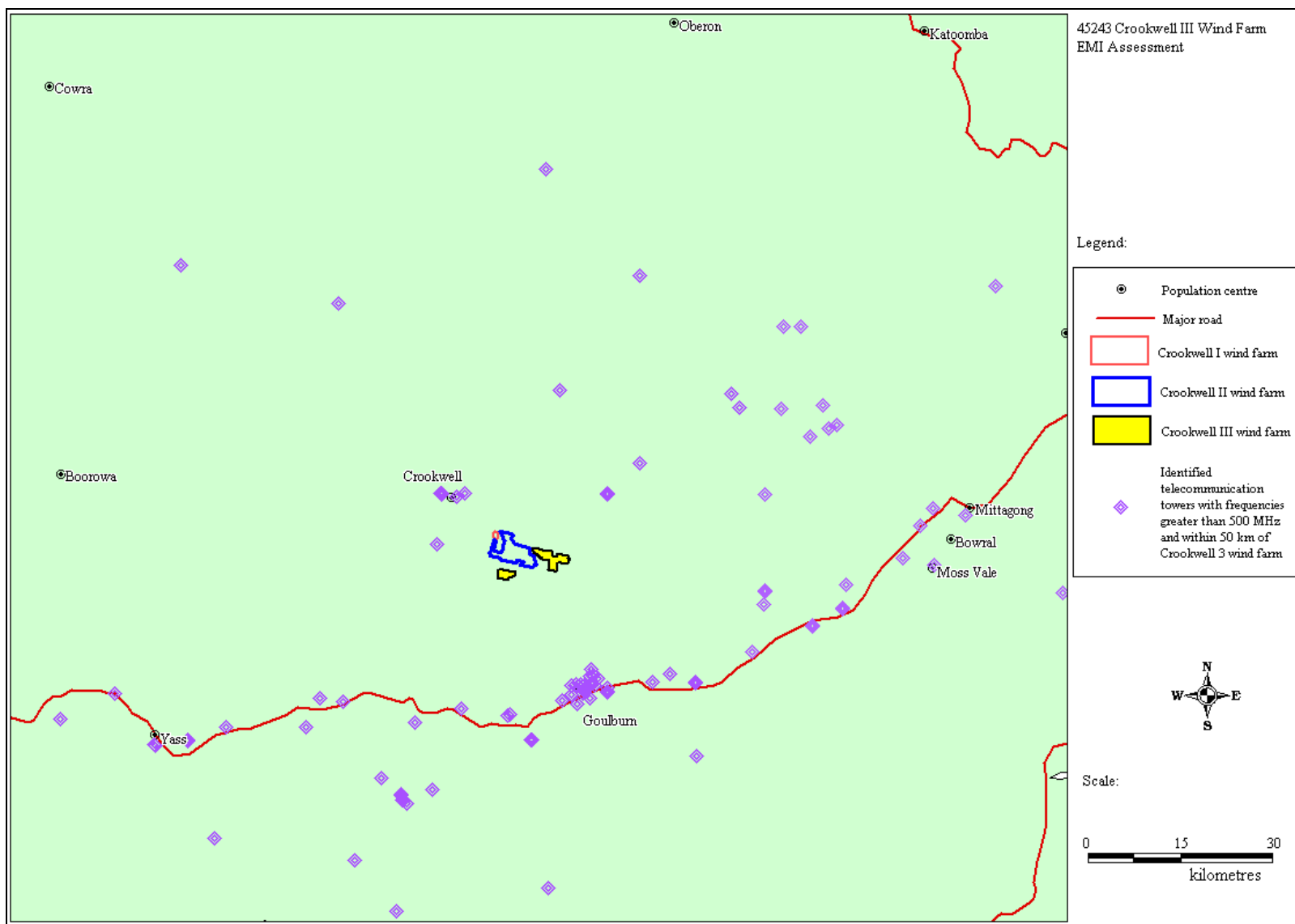


Figure 4 Location of identified proximate radiocommunication sites

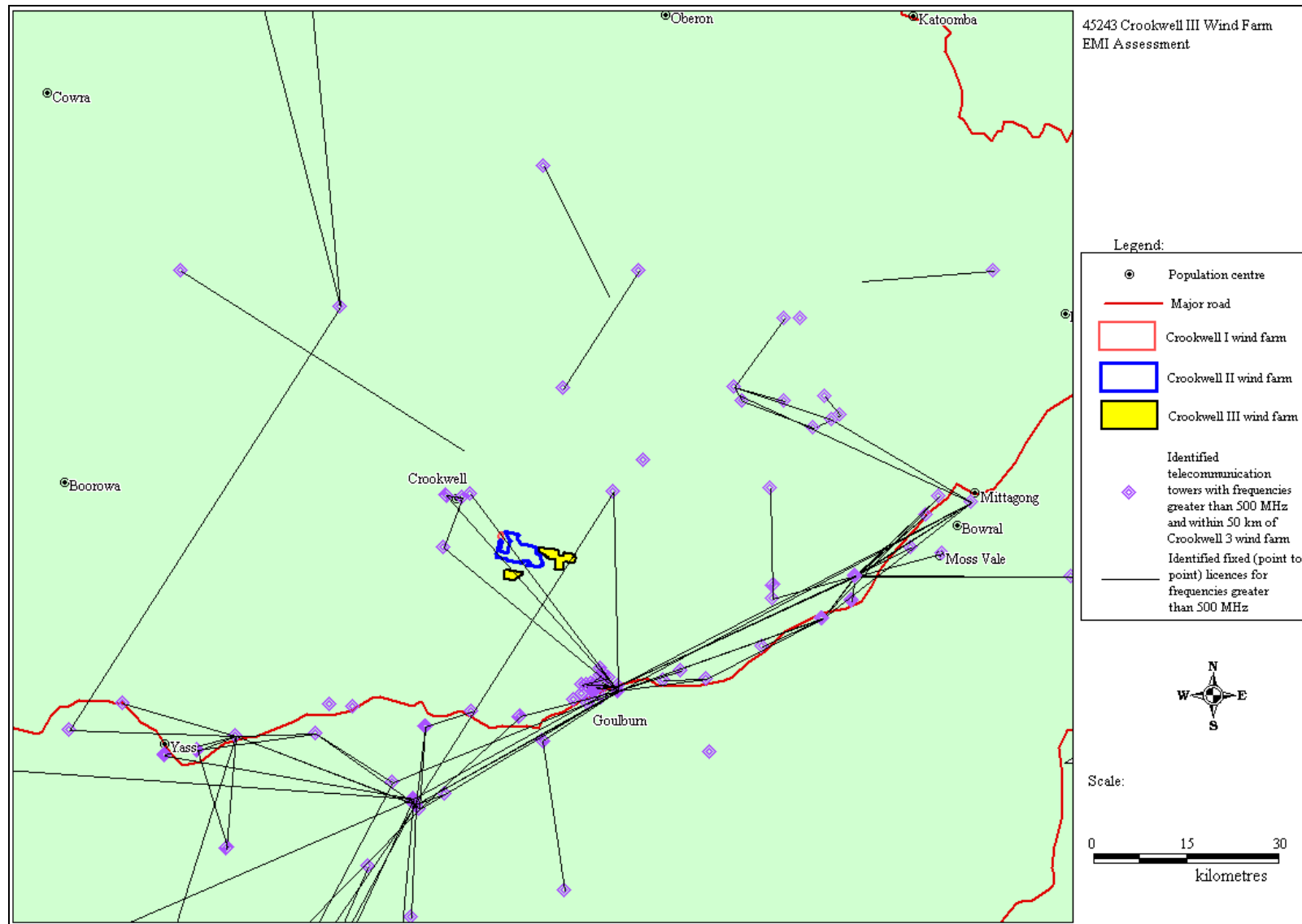


Figure 5 Identified transmission vectors for fixed licences of point-to-point type proximate to Crookwell 3 wind farm

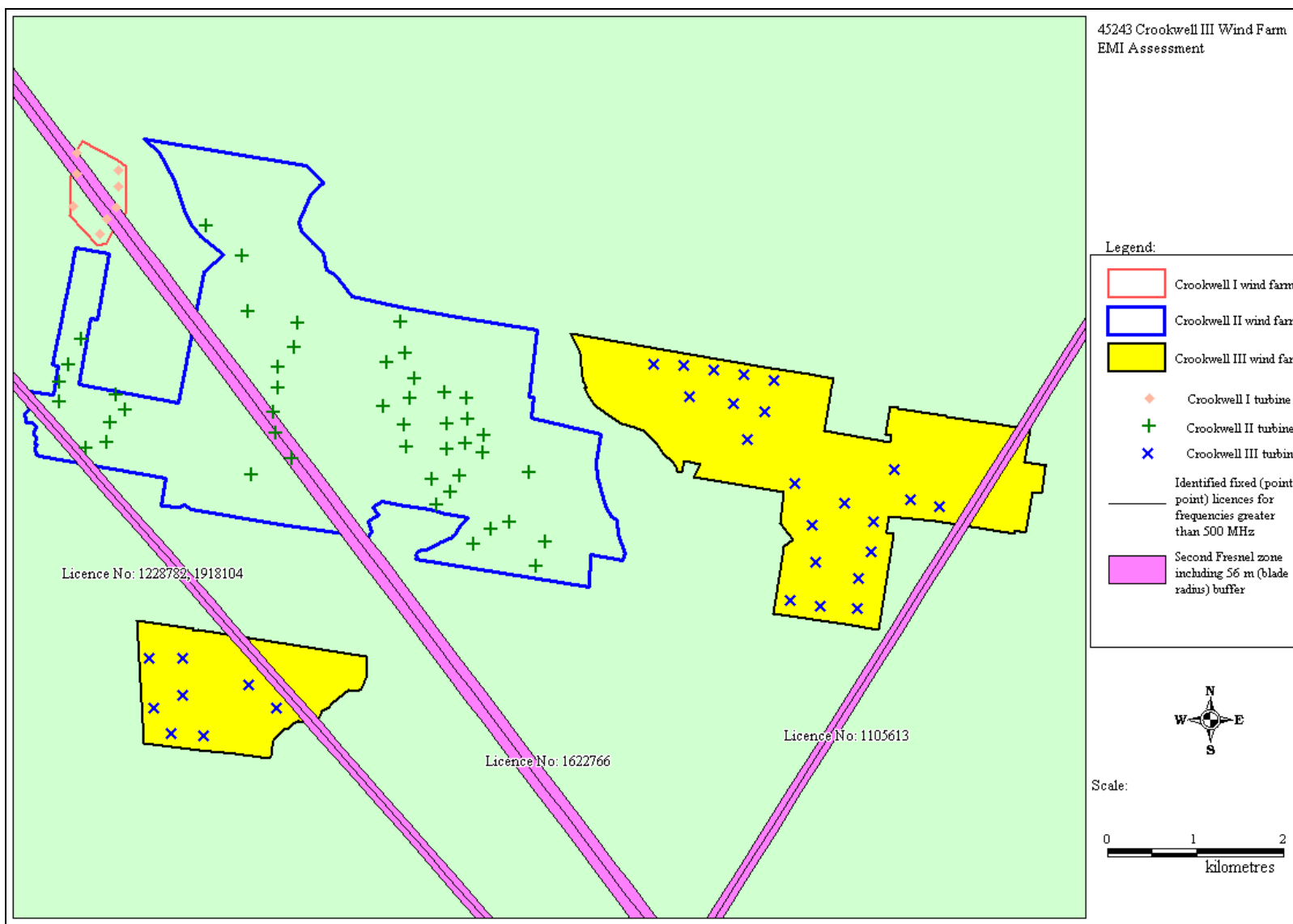


Figure 6 Identified telecommunication vectors and 2nd Fresnel zones plus 56 m buffer for the proposed Crookwell 3 wind farm

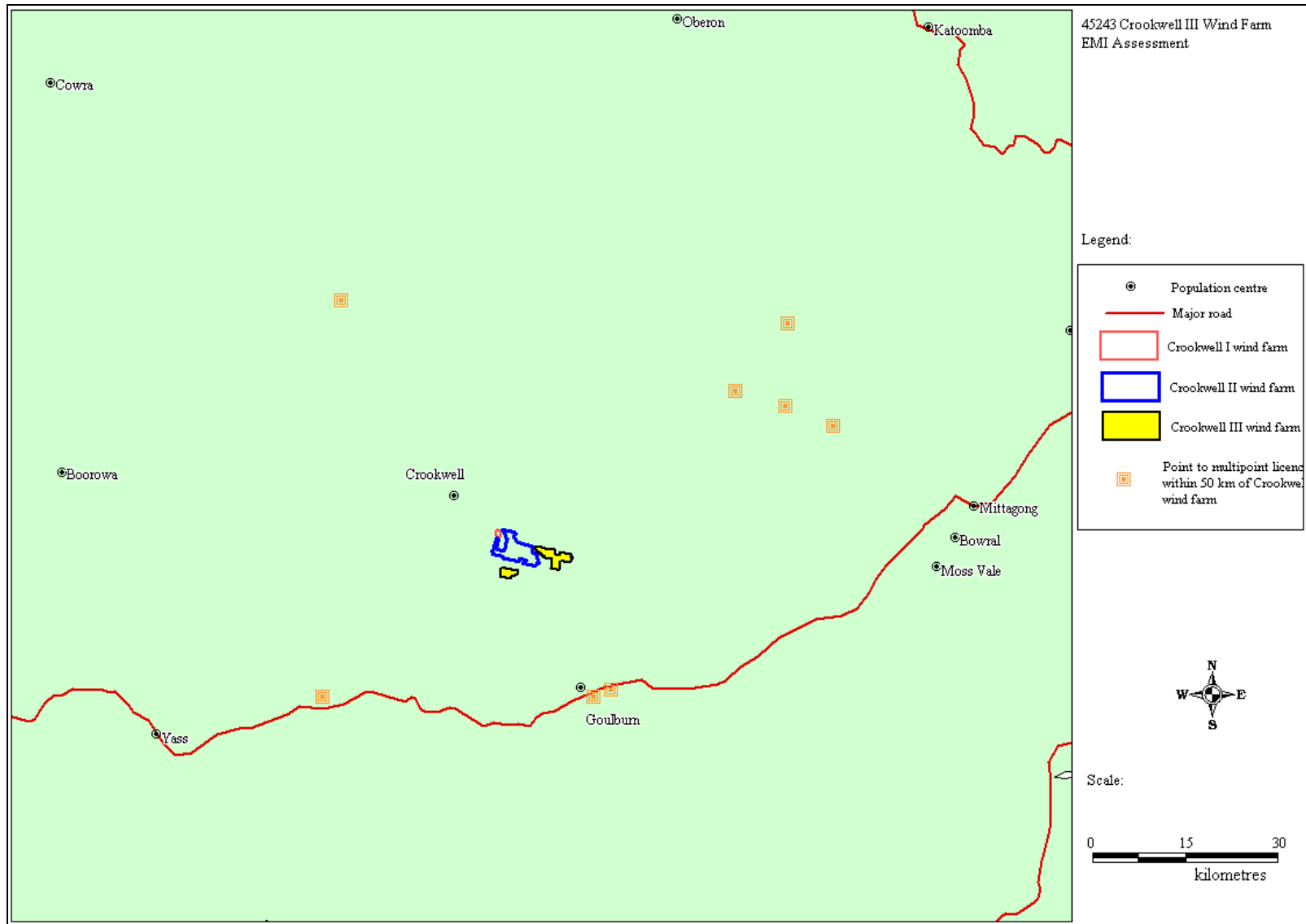


Figure 7 Location of point-to-multipoint stations within 50 km of Crookwell 3 wind farm

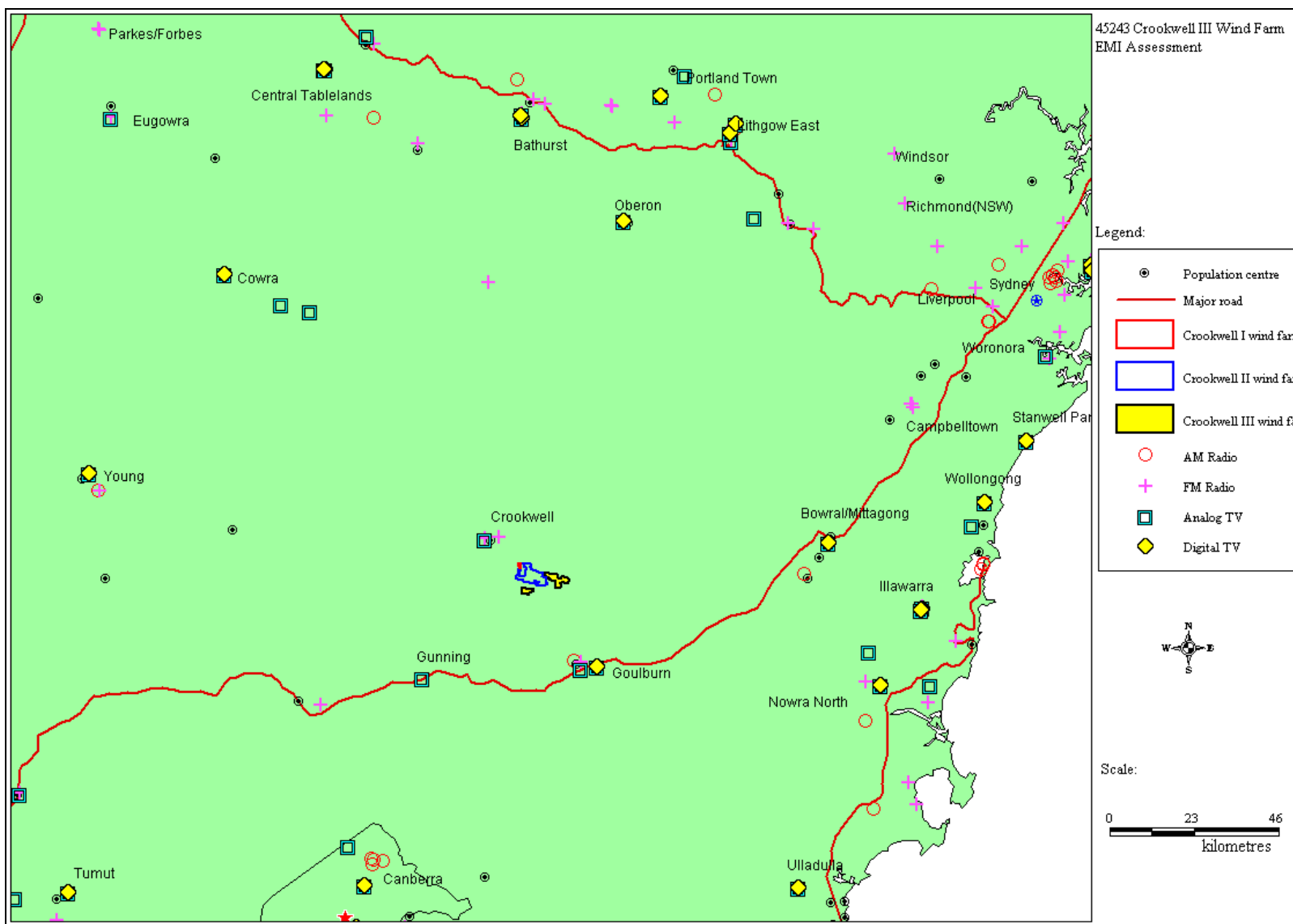


Figure 8 Location of broadcast transmitters in the vicinity of Crookwell 3 wind farm

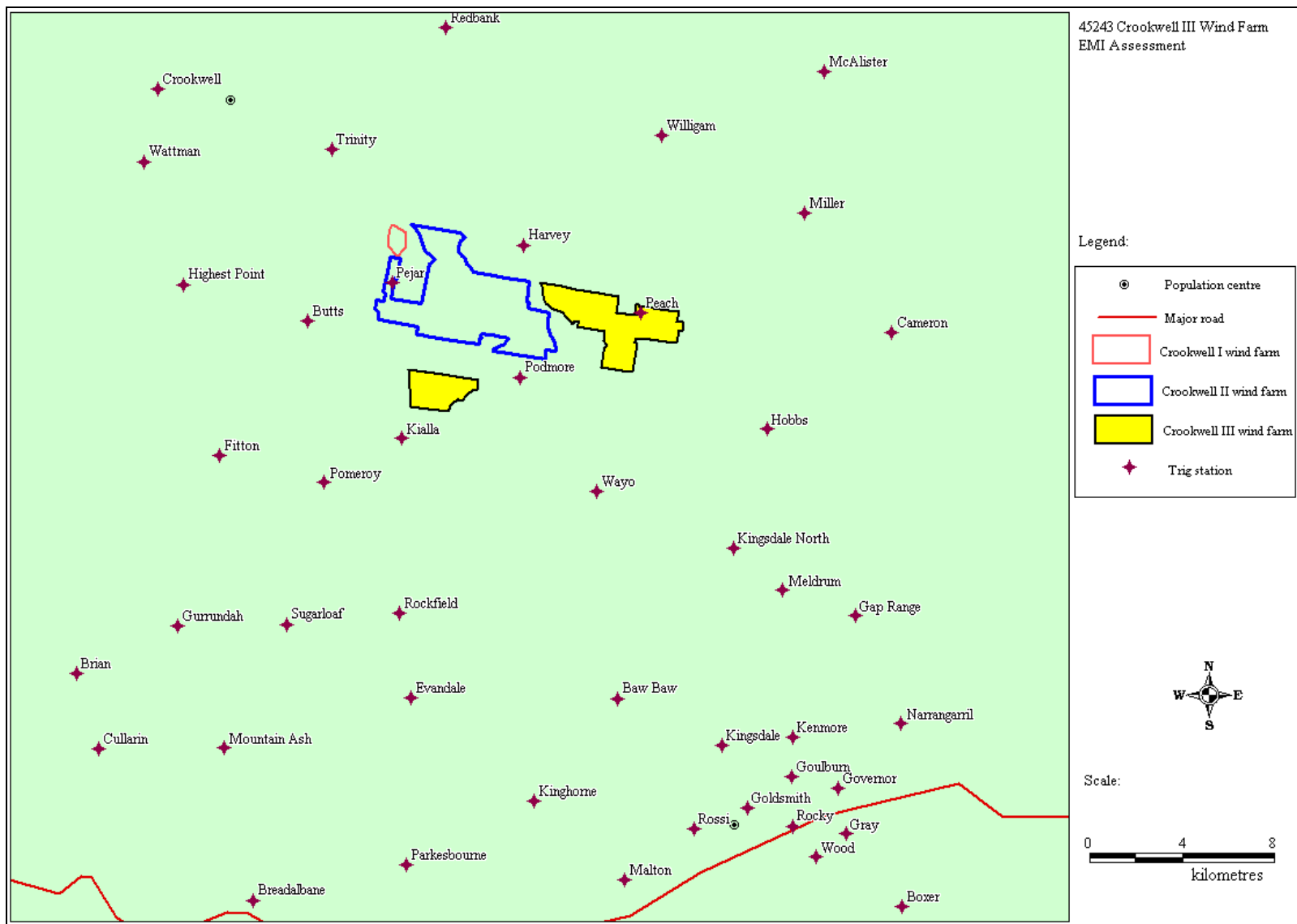


Figure 9 Location of Trig stations within 50 km of Crookwell 3 wind farm

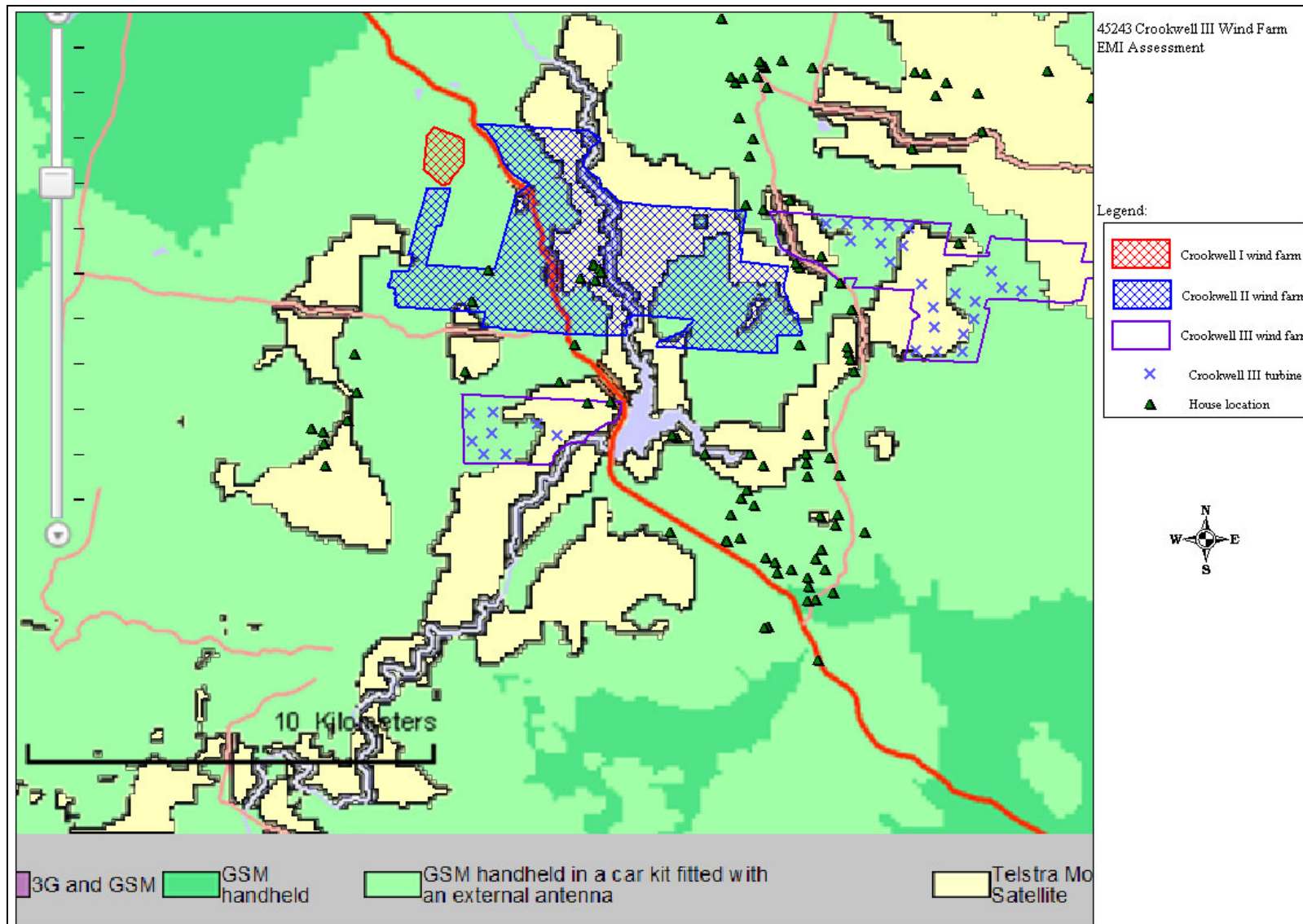


Figure 10 Telstra GSM Mobile phone coverage for Crookwell 3 wind farm

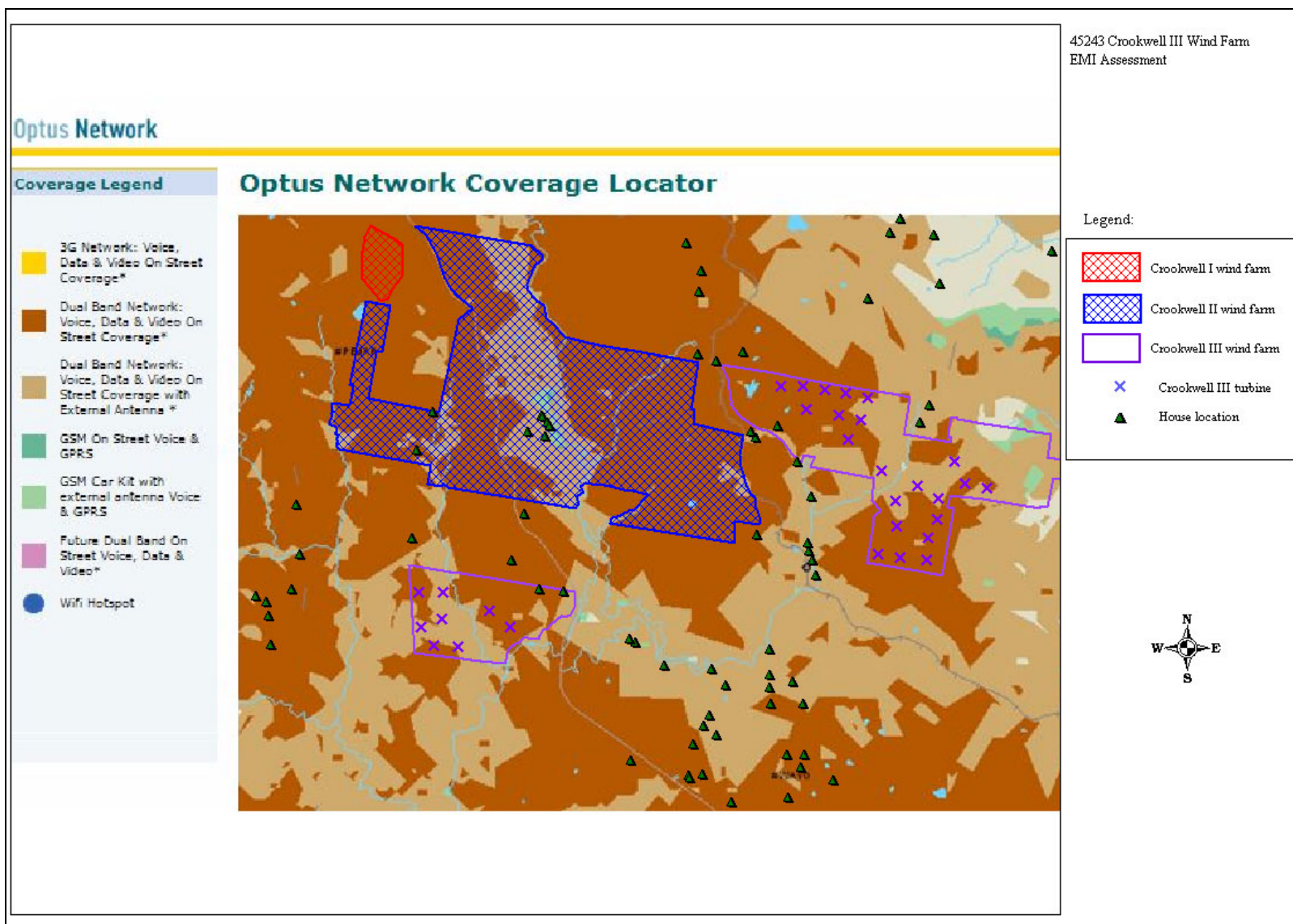


Figure 11 Optus GSM Mobile phone coverage for Crookwell 3 wind farm

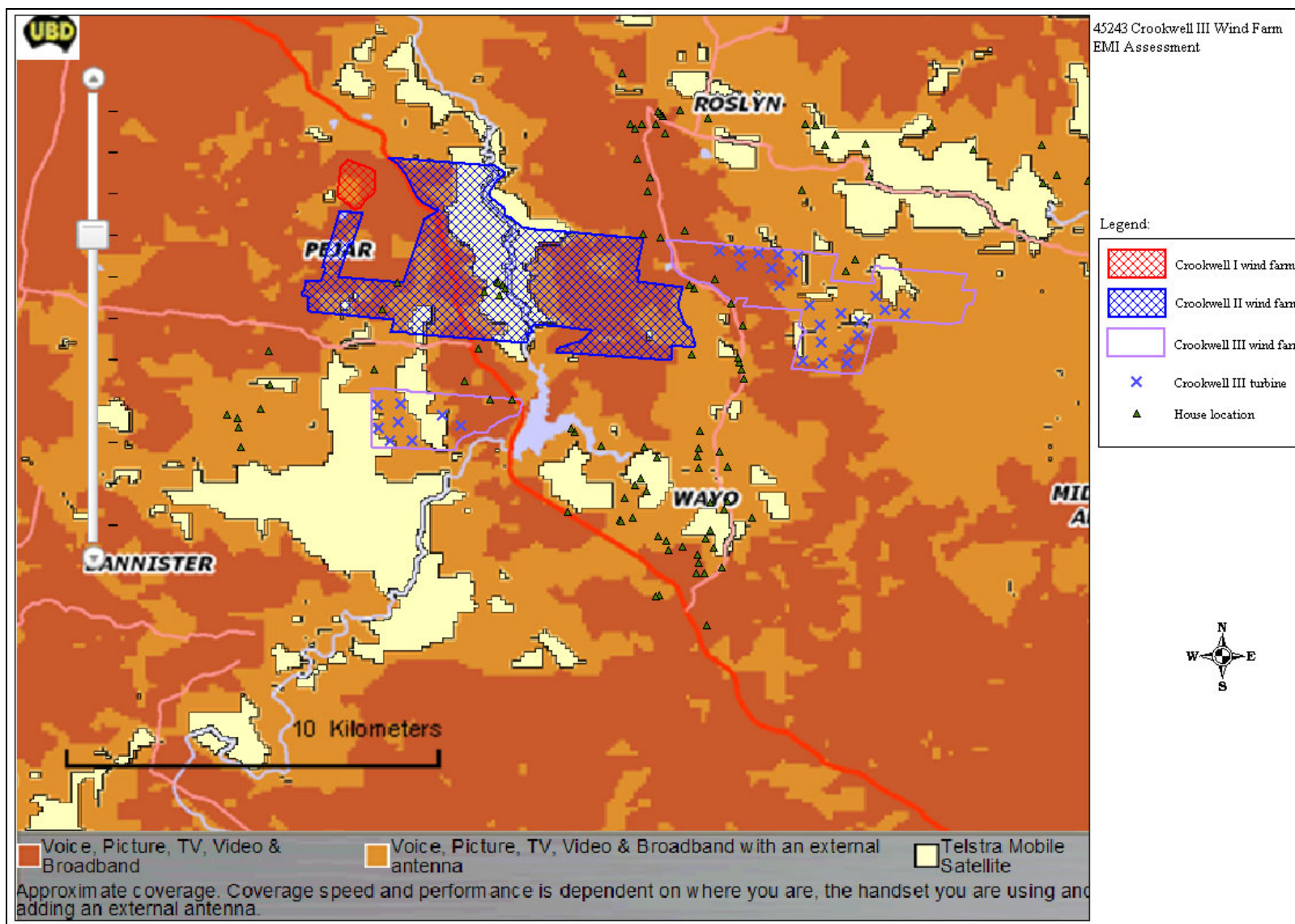


Figure 12 Telstra NextG network coverage map

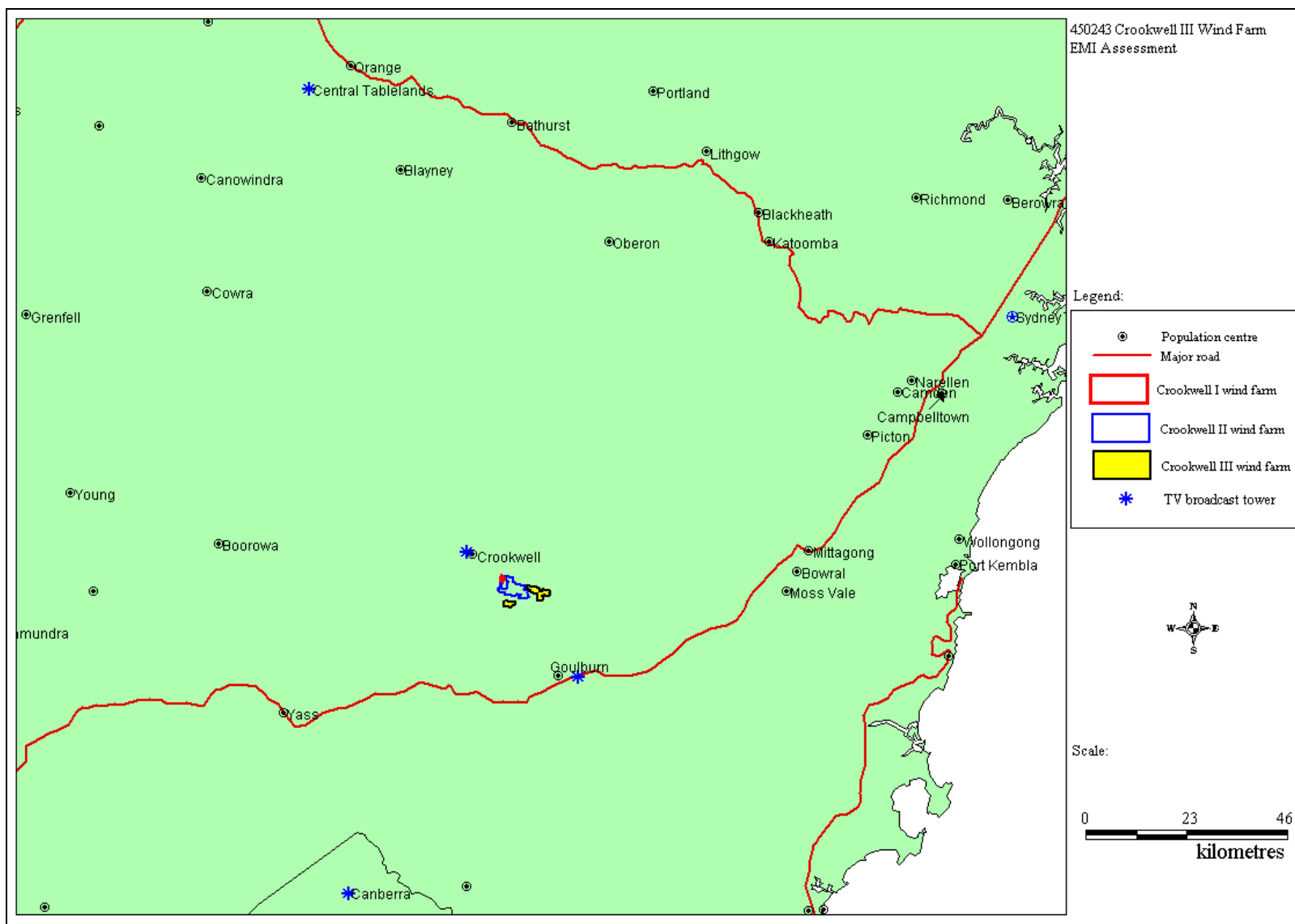


Figure 13 Location of analogue television broadcast towers in the vicinity of Crookwell 3 wind farm

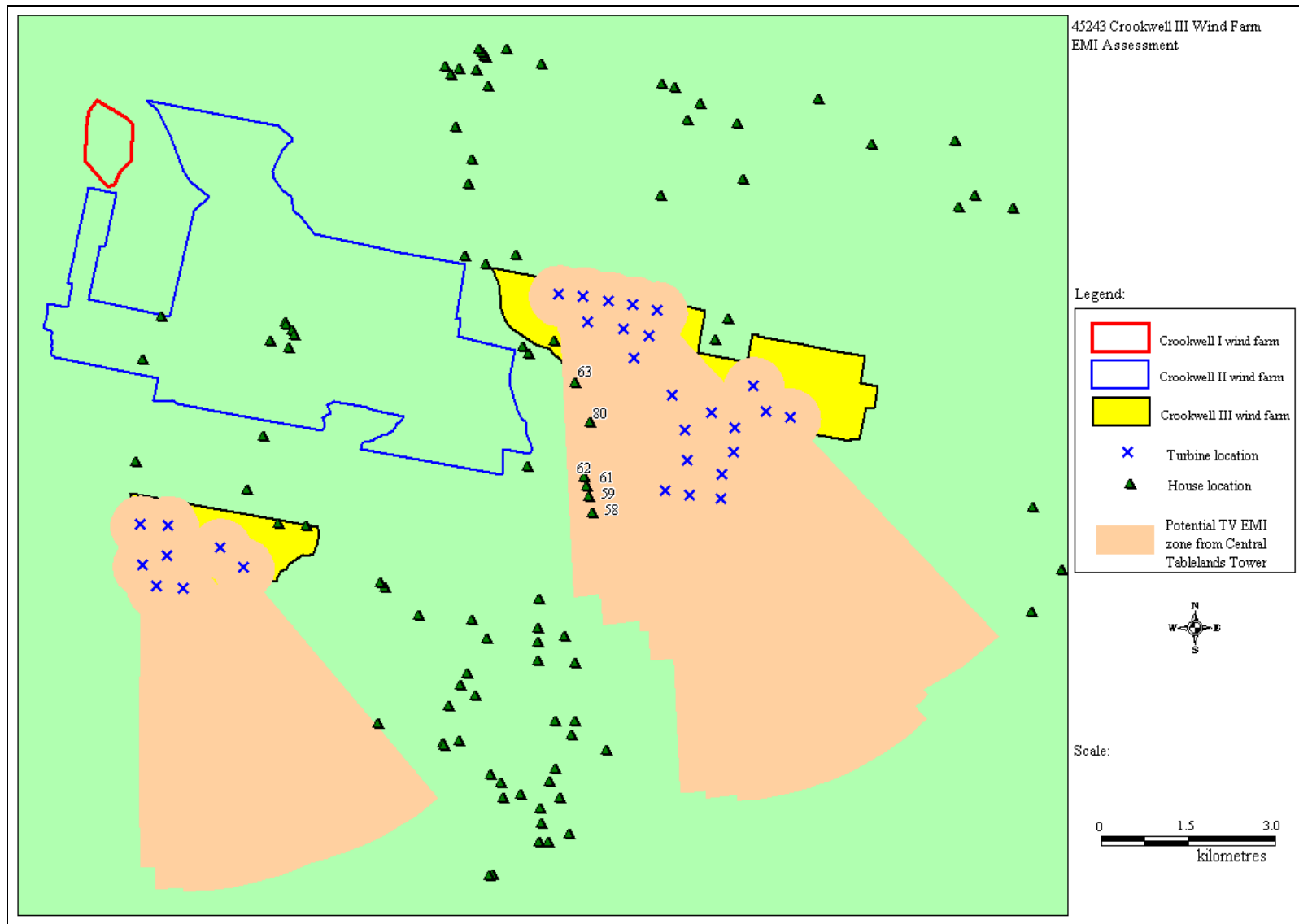


Figure 14 Potential TV EMI zone from Central Tablelands transmitter

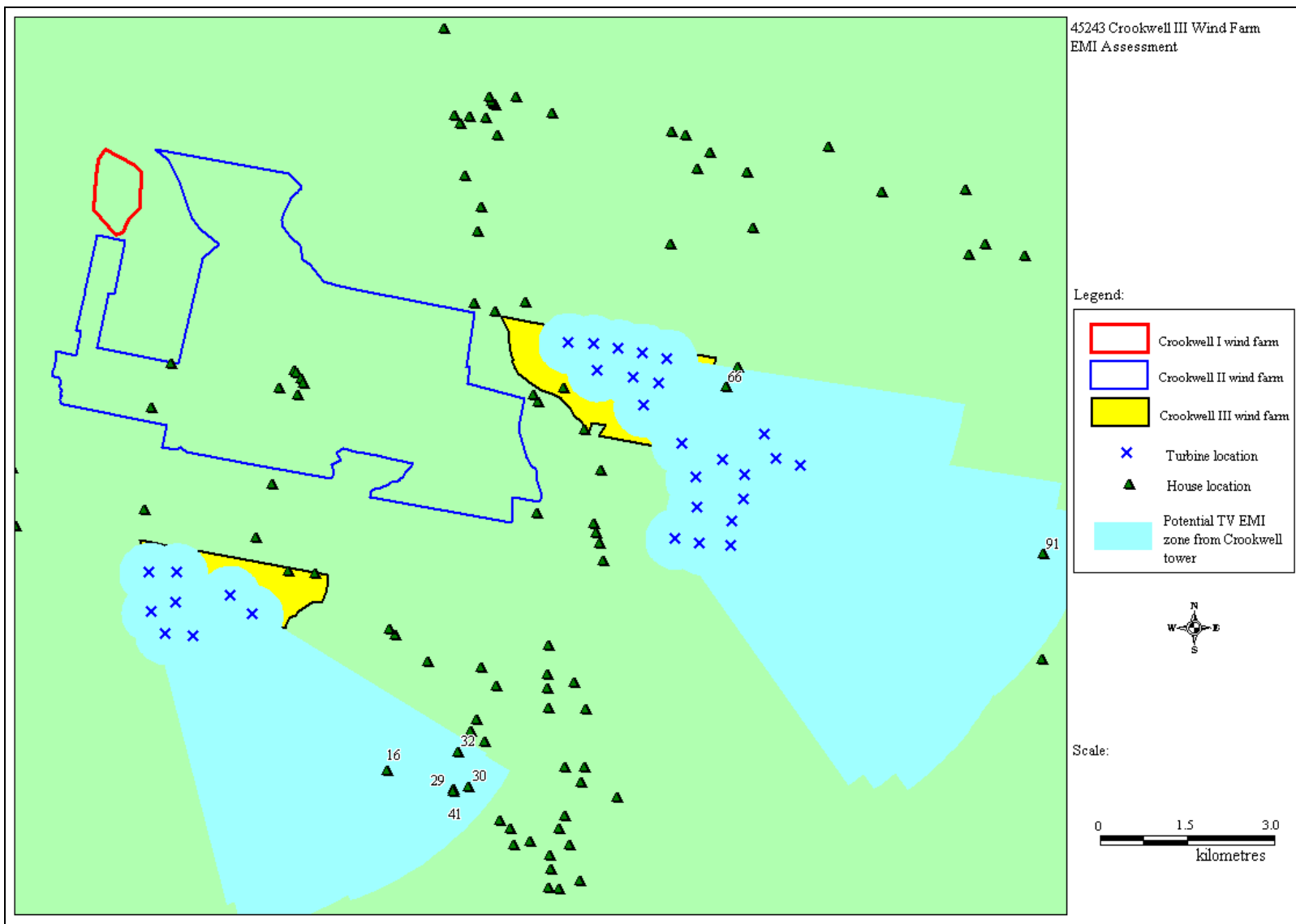


Figure 15 Potential TV EMI zone from Crookwell transmitter

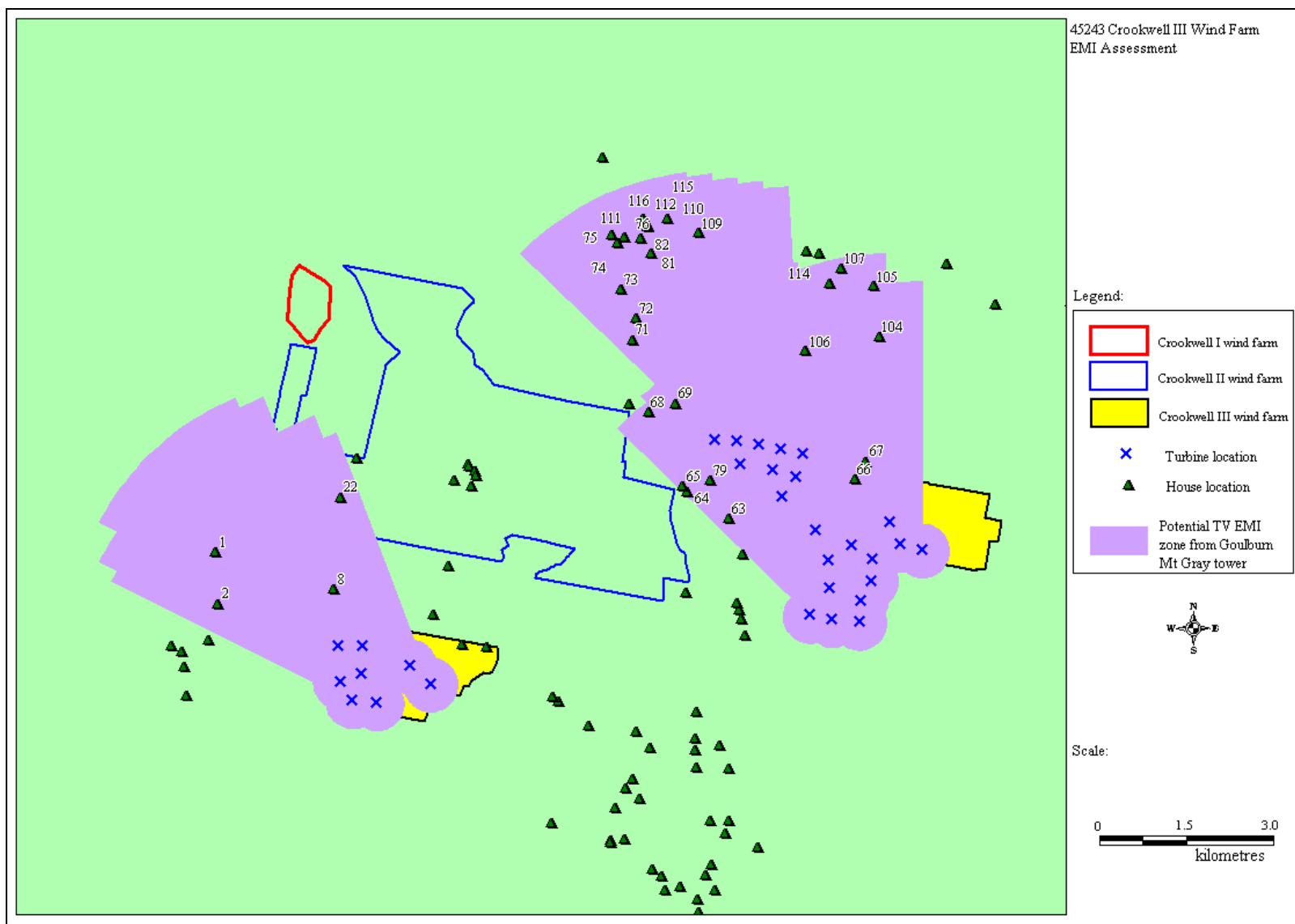


Figure 16 Potential television EMI zone from Goulburn transmitter

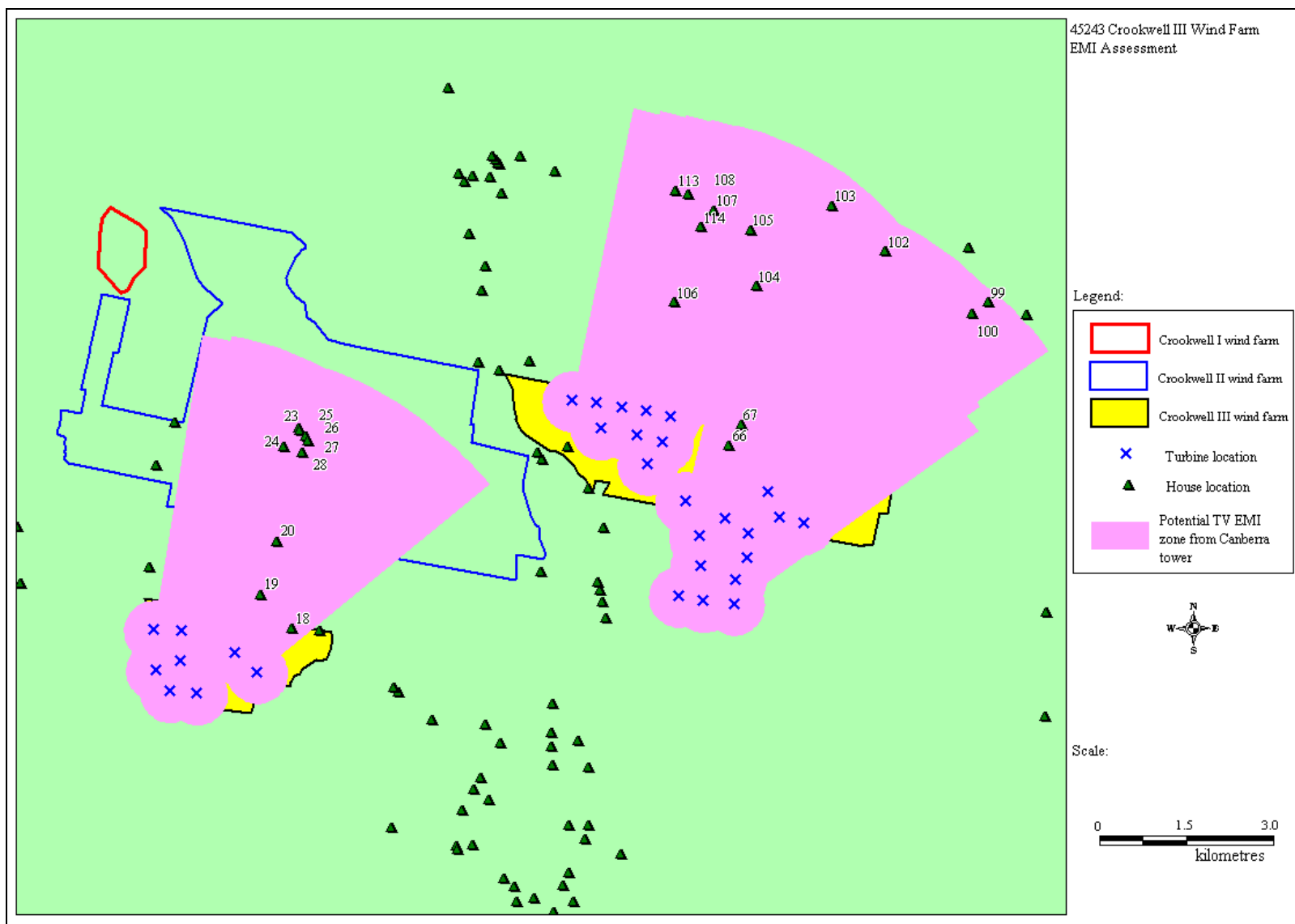


Figure 17 Potential television EMI zone from Canberra transmitter

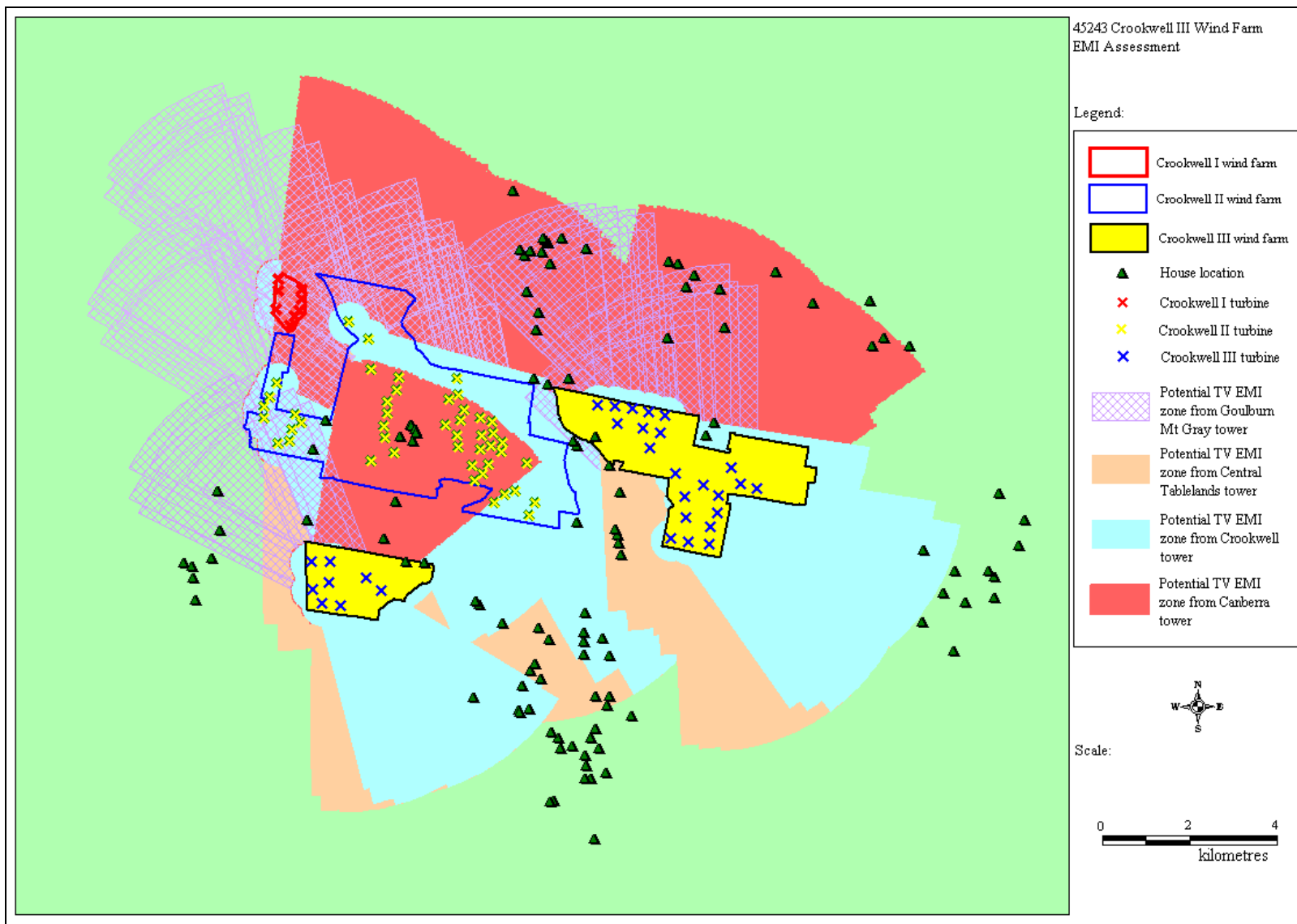


Figure 18 Cumulative analogue television EMI zones for Crookwell 1, 2 and 3 wind farms