COPPABELLA WIND FARM - INVESTIGATION OF POSSIBLE IMPACTS ON BROADCASTING AND RADIOCOMMUNICATION SERVICES

[draft 1]

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L. J. Derrick B. E. (Elec.) ACMA Accreditation No 008
Lawrence Derrick & Associates
Engineering Consultants & RF Frequency Assigners

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DISCLAIMER

This Report has been prepared on the basis of ACMA radiocommunications licensing data and broadcasting information and other reference material available in the public domain at the date of production of the report. The Report does not imply that any conclusions are not subject to change

CONTENTS

BACKGROUND

Goldwind Australia Pty Ltd (GWA) are constructing a wind farm in NSW approximately 35 Km west of Yass and 10 Km south west of the hamlet of Binalong. The wind energy facility site will host up to 79 wind turbines, as well as have on-site infrastructure in the way of access tracks, substations and internal collection circuits involving high voltage (HV) underground and overhead power lines. The wind energy facility is to be connected to existing HV transmission lines with overhead new transmission lines of up to 132 kV and up to 330 kV. Overhead reticulation on the wind farm site will be up to 33 kV. This Report considers the potential impacts of the wind facility on radiocommunications and broadcasting in the area. GWA are proceeding with a Modification Application for the Development Consent addressing the use of Goldwind GW140 turbines based on a100m hub height and a rotor diameter of 140m resulting in a blade tip height of approx 170 m. The impact of the GW140 turbine is considered in this report

A number of existing ACMA registered radiocommunication services are located in the general area. To ensure that the locations of turbines will not degrade the performance of any radio systems crossing the general site area, minimum separation distances and exclusion zones need to be established for the turbine structures. The residences in the area surrounding the wind facility are potentially provided with TV, FM radio and other services from high power transmitters located at Mt Ulandra (South Western Slopes) and Black Mountain (Canberra). Fringe area reception could be available to some residences north of the wind farm from the Central Tablelands stations at Mt Canobolas. A small retransmission station at Harden services the township and surrounding area to the north.

This Report provides an analysis of each of the radio facilities registered near the wind facility and if necessary establishes recommended clearances based on accepted industry criteria for radio links crossing the wind facility and any required buffer zones for other radiocommunications sites. A study of the signal paths from the main TV station to the area surrounding the wind facility has been carried out to identify any potential interference to reception at nearby residences.

2. INTRODUCTION

The NSW Wind Energy Guideline for State significant wind energy development, (Ref. 14)(Ref 15), indicates that the consent authority will give consideration to the risk of electromagnetic interference with telecommunication services in the area, and the adequacy of the measures proposed to ensure the level of service is maintained
Clause 40 of the Development Consent Conditions also states that: If the development results in the disruption to radio or telecommunications services in the area, then the Applicant shall make good any disruption to these services as soon as practicable following the disruption.

This requires the identification of transmitting stations and nearby radio link paths. This report covers the outcomes of a desktop study to identify any potential

issues that may arise from the proposed Coppabella wind farm and makes recommendations on radio link path and radio site clearances.

3. LEGISLATION AND GUIDELINES

3.1 Commonwealth legislation. Under the Australian Radiocommunications Act 1992, "interference" is defined as:

- **In relation to radiocommunications**: Interference to, or with, radiocommunications that is attributable, whether wholly or partly and whether directly or indirectly, to an emission of electromagnetic energy by a device; or

- **In relation to the uses or functions of devices:** Interference to, or with, those uses or functions that is attributable, whether wholly or partly and whether directly or indirectly, to an emission of electromagnetic energy by a device.

In using these definitions, the Radiocommunications Act deals with the radiocommunications interference caused by electromagnetic fields and provides protection for users where such interference is caused. It does not, however, deal with radiocommunications interference caused by physical obstructions.

This report provides best practice guidance about the issues associated with the physical obstruction impacts of wind turbine structures, and details methods for assessing the potential of such impacts. It also advises which stakeholders should be consulted and what sort of information they may require. Mitigation strategies and post-construction monitoring methodologies are also presented. Some guidance has been taken from Appendix F of the Environment Protection and Heritage Council's (EPHC) draft National Wind Farm Development Guidelines (July 2010) (Ref. 9).

Radiated EMI can potentially be generated from wind turbine generators or HV power lines and substations on the site. These issues are also discussed in this report.

3.2 NSW Wind Energy Guidelines DPE 7812 for State significant wind energy development Dec. 2016 (Ref.14). This document includes references to the need to consider electromagnetic interference issues in the design of wind farms. The associated *Wind Energy Framework Standard Secretary's Environmental Assessment Requirements (Ref 15) under the Hazards and Risks heading requires the following:*

Telecommunications – identify possible effects on telecommunications systems, assess impacts and mitigation measures including undertaking a detailed assessment to examine the potential impacts as well as analysis and agreement on the implementation of suitable options to avoid potential disruptions to radio communication services, which may include the installation and maintenance of alternative sites;

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3.3 Clean Energy Council (Auswind) Best Practice Guidelines. Appendix 11 of these Guidelines (Ref. 11) issued in December 2006 also provide guidance on the consideration of the potential impact of wind farms on radiocommunications and broadcasting.

4. DESKTOP STUDY ANALYSIS

A desktop study was carried out to determine the likely impact, if any, of wind turbines and their supporting towers on broadcasting and radiocommunications in the area surrounding the proposed wind facility. This study is based on relevant International Telecommunications Union (ITU) documents and on other professional reports on overseas and Australian experience of wind facility impacts on broadcasting services in the vicinity of any wind turbine structures. For Radiocommunication services sites up to at least 50km from the site need to be considered because of the length of point to point paths of up to or exceeding 100km.

GWA provided the Coppabella wind farm development boundary, proposed turbine locations and turbine dimensions. Data was also obtained from the Australian Communications & Media Authority's (ACMA) RRL and Spectra Databases. This information allowed for an investigation into the potential impacts of the proposed wind facility on radiocommunication services within a 50km radius, as well as determining whether the wind turbine locations would obstruct line-of-sight paths or have any likely detrimental effect on these services. Clearance criteria for ray lines have been indicated for any point to point radio paths encroaching or traversing the Coppabella site.

5. BROADCASTING SERVICES IN THE AREA OF PROPOSED COPPABELLA WIND FARM

From ACMA TV and Sound Broadcasting Station listings, and from a map survey of the area surrounding the proposed wind farm site, the following is a general summary of the broadcast transmitter site locations and radio frequency channels which provide cover of the area. The proposed turbine layout map is provided in Attachment 2, depicting the proximity of turbine locations to the nearest houses in the area of the wind facility.

5.1 Digital Television

Analogue television has been shut down throughout Australia so all television in the area is digital. It is expected that residents in the area surrounding the proposed wind facility generally view digital TV from the SW Slopes National and Commercial main stations located at Mt Ulandra and from the Canberra National and Commercial stations at Black Mountain. Marginal TV reception from the Central Tablelands stations at Mt Canobolas may be available to the north of the wind farm at a few sites. As a general indication Attachments 6 - 8 show ABC predictions for the 3 stations indicating secondary or tertiary coverage in the general area. These stations are approx. 58km, 76km and 162km respectively from the wind facility site centre. There is also a low power retransmission station 25 km away to cover the Harden town and surrounds (Attachment 9). A summary of channels available from the listed stations is provided in Attachment 5. It is expected that TV reception from the VAST satellite service may be used at some dwellings due to the marginal reception from the terrestrial stations listed.

5.2 TV Retransmission Stations

From ACMA TV Broadcasting Data there is one retransmission stations listed at Harden which may receive input signal “off air” probably from the main stations at Mt Ulandra, and/or from satellite sources. Wind farms may cause interference to a signal path that traverses wind turbine locations. The potential impact, if any, of the proposed Coppabella wind farm on these nearby stations is discussed in Section 6.

5.3 FM Sound Broadcasting

National and Commercial Services are radiated from Mt Ulandra and Canberra sites. Based on overseas field and experimental evidence, discussed in Section 8, the proposed wind farm is unlikely to negatively impact these services and therefore FM Stations covering this area have not been investigated in detail.

5.4 AM (Medium Frequency) Sound Broadcasting

AM coverage in the general area of the wind farm is expected to be limited. Based on overseas field and experimental evidence, discussed in Section 8, the proposed wind farm is unlikely to negatively impact Medium Frequency reception and therefore the stations serving the area have not been investigated in detail.

5.6 Satellite Television

Some homesteads in the area may have satellite pay TV or “Free to Air” TV service installations. The signal from the satellite to the subscriber’s antenna arrives at an elevation angle which typically passes well over the top of a turbine. The proposed Coppabella wind farm is unlikely to cause signal obstruction/scattering to satellite TV reception, given that all homesteads are further than 1 km from proposed turbine locations and the satellite dish antenna have narrow reception beam width.

6. RADIOCOMMUNICATIONS SERVICES ANALYSIS

The proposed Coppabella turbine location coordinates, as provided by GWA are listed in Attachment 1.

Maps generated from data in the ACMA database are shown in Attachment 3 and Attachment 4.

- Attachment 3 shows all radio sites and point to point links within at least 50km of the wind facility and with operational frequencies in the range 40 – 999 MHz (VHF & UHF),
- Attachment 4 shows all links in frequency range above 1 GHz (microwave).

6.1 Point to Point

A number of point to point links are registered for operation within 50km of the proposed wind farm. As shown in Attachment 3, there are three UHF/VHF links that traverse the boundaries of the wind facility. Path profiles were generated for each of these 3 links with turbines with blade tip heights of 175 m superimposed at representative positions along the link. As shown in each of the 3 link path

profiles (Attachments 13, 14, and 15) the link paths do not pass over every turbine therefore horizontal clearances are required for at least for the first 2 turbines from site 9452 where the links originate. Sufficient clearance is required between the link ray lines and the centreline of WTG towers of 0.6 X 1st Fresnel zone + WT blade length for each link. A calculation Sheet is shown in Attachment 17 for the GW140 Turbine

Attachment 4 indicates that there are no microwave links (> 1GHz) that traverse the wind facility. There are specific clearance requirements from ray lines to mitigate any turbine interference on microwave links, however the proposed turbines are located outside these exclusion areas and therefore are not going to impact these links. The ray lines crossing the wind facility are shown in zoomed up maps in Attachments 11, and 12. The source ACMA database contains data for sites in the GDA 94 coordinate set. These maps are derived from MapInfo maps which are also displayed in GDA 94 coordinate set.

6.2 Cellular Mobile Base Stations

The nearest Optus/VHA or Telstra cellular mobile base stations are registered at sites 100784, and 130627 which are 6 km, and 11km respectively from the nearest proposed turbine location. These distances are remote enough from the proposed Coppabella wind farm that operation of the wind facility would have no significant impact on antenna patterns and general service area coverage; however it is recommended that Optus and Telstra be advised of the wind facility proposal.

6.3 Two-Way Mobile

A number of private and Public Utility mobile bases exist in the wider area surrounding the proposed Coppabella wind farm site. These bases likely provide cover to mobiles in a 360 degree arc from their location. The proposed Coppabella wind farm is not expected to have any impact on base coverage beyond normal mobile operational performance. The base antennas are remote enough from the proposed turbine locations that an associated negative impact is highly unlikely. However, a mobile transceiver unit communicating with a base station may experience some local performance disruption when the mobile is located within metres of a wind turbine, this disruption is not limited to just wind farms and is experienced near any large building, silo, tower etc and moving a short distance would mitigate and restore performance to normal.

6.4 NSW RFS Base Stations

There are a number of ACMA registrations for VHF base stations in the 50km radius around the proposed Coppabella wind farm site. The closest of these is site 9519 approximately 12.5 km from the nearest proposed wind turbine. These services may experience some very local performance disruption when a portable unit is located in close proximity of a wind turbine, however moving a short distance away would mitigate any performance disruption. It is recommended that the CFA be contacted for their view on the potential impacts.

6.5 CB Radio

CB radios are not individually licensed as the equipment is subject to class licensing only. Therefore no records of location or operators of CB radios exist, and the channels are shared without any right of protection from interference. No significant impact from the wind facility is expected, however as with two-way mobile and CFA Base Stations there may be local performance disruption when a portable unit is located in close proximity of a wind turbine structure, however moving a short distance away would mitigate any performance disruption. It is noted that a CB repeater (CBRS) is licenced to the Hill Tops Council and is located on the Coppabella Hill site 9542 in the centre of the Wind Farm. As the CB mobiles and portables using the repeater will potentially have paths to and from the repeater with wind turbines in both paths some loss of coverage may be experienced.

6.6 Aviation Services

There are three sites associated with aviation services listed within the 50km radius from the proposed Coppabella wind farm site. The AirServices Mt Bobbara Radar site is 11.7 km from the nearest turbine location and has radar and VHF aeronautical equipment licenced. Due to the separation distance the VHF aeronautical service is unlikely to be impacted by turbines. It is expected that an aviation safety consultant has/will be engaged by GWA to examine any issues for aviation including any radar issues. The other 2 sites at Cootamundra and Yass (Council and Private) with VHF licences with no expected impact from WTG's.

6.7 Point to Multipoint (PMP) Systems

There are s ten PMP systems registered in the 50km radius from the proposed Coppabella wind farm development boundary. The PMP base stations are registered in the ACMA database, however the customer/remote ends are generally not registered. As a result the potential impact from turbines on the customer ends could not investigated. Given that most of the base station location are generally remote from the proposed Coppabella wind farm site there is low probability that any path to the remote (subscriber or device) would traverse the proposed wind facility. The Hilltops Council Coppabella Hill site within the wind farm boundaries needs further consideration however. Information from the Council indicates that there are telemetry links between the Jugiong High level reservoir and the Harden Office site via Coppabella Hill. This system operates in the UHF frequency bands and is included in Table 1 below although it was not identified in the ACMA data for Coppabella Hill.

TABLE 1 - POINT TO MULTIPONT SYSTEMS IN THE AREA

Site/Service	Frequency Band MHz	Operator	Comment
9551	450	Goldfields Water	
404919	450	Goldfields Water	
35028	450	Cootamundra Council	
100385	450	Young Shire	
9529	450	Yass Valley	

		Council	
198028	900	Goldfields Water	
35027	900	Goldfields Water	
201821	900	Water NSW	
34853	900	Boorowa Council	
I01225	450	Hilltops (Harden) Council	
9542	450?	Hilltops Council	Advice from Council. - Outstations at Jugiong reservoir and Harden Council Office

It is recommended that the operator of the PMP Services be advised of the wind facility proposal to confirm that no impacts to their services are foreseen

6.8 Radio Sites in Close Proximity to Wind Turbines

One radio site 9542 (Coppabella Hill) is located inside the proposed Coppabella wind farm development envelope. WTG 25 is approximately 72 m from this site and is too close with a blade length of 70.15 m for the GW140 turbine.
The proposed wind facility is located outside any radio buffer zones; the closest radio site is located at least 4km from the nearest turbine and thus it is unlikely to be impacted. There are no TV/Radio broadcasting or emergency services paging facilities near the proposed wind facility. There appears to be an error of approximately 40 m in the ACMA location of this site by comparison with Google Earth Pro.

6.8 Met Bureau Radar and Other Services

No registrations of radar for the Met Bureau were found in the wider area and therefore the proposed Coppabella wind farm is not expected to impact the operation of the Met Bureau.

7. PUBLISHED EMI EFFECTS OF WIND TURBINES

The following is an extract from Ref. 1:

"It is well known that any large structure, whether stationary or moving, in the vicinity of a receiver or transmitter of electromagnetic signals may interfere with those signals and degrade the performance of the transmitter/receiver system. Under certain conditions, the rotor blades of an operating wind turbine may passively reflect a transmitted signal, so that both the transmitted signal and a delayed interference signal (varying periodically at the blade passage frequency) may exist simultaneously in a zone near the turbine. The nature and amount of electromagnetic interference (EMI) in this zone depend on a number of parameters, including location of the wind turbine relative to the transmitter and receiver, type of wind turbine, physical and electrical characteristics of the rotor blades, signal frequency and modulation scheme, receiver antenna characteristics, and the radio wave propagation in the local atmosphere. Other

wind turbine components which have been considered to be potential causes of EMI are towers and electrical systems. However, neither of these has been found to be a significant source of interference. Thus, moving blades are the components of most importance in determining EMI levels.

Digital television interference if severe would result in pixilation or freezing of the picture.

Effects on FM broadcast reception have been observed only in laboratory simulations."

Point to point links in microwave and lower frequency bands will be affected only if the turbine tower or turbine clearance to the line of sight path to the other end of the link is within the second Fresnel zone which is dependent on the operating frequency of the link, the distance of the tower/turbine from the link antenna and the total link distance. D. F. Bacon (Ref. 8) proposes 3 potential degradation mechanisms - near field effects, diffraction and reflection or scattering. The reflection or scattering treatment in the reference suggests greater clearance requirements at positions close to the link terminals than the usually applied to Fresnel Zone clearance for certain links with low antenna gain. This has been taken into account for this study.

8. DISCUSSION OF OVERSEAS EXPERIENCE

Observations and studies have been carried out for a number of years in both the USA and the UK on the effects of wind turbines on TV and other radiocommunication services. In 1976 the US Energy Research and Development Administration (ERDA) funded the RadLab at the University of Michigan for investigations into these effects and this continued for 7 years. Ref. 1 summarises the results of theoretical and field measurements.

The BBC's Research Department in the UK has also investigated this subject in some depth, and in 1983 a report was issued (Ref. 2). Another Report (Ref. 3) was issued in 1992 after the Research Department had carried out observations from test transmissions at existing wind farms in Denmark in 1991.

In 1992 the ITU issued a Recommendation (Ref. 4) on the assessment of impairment caused to television reception by a wind turbine.

In a recent exchange of emails, Mr Chris Gandy of the BBC Research Department summarised the conclusions they had come to on this subject as follows - "…..in the UK the only significant broadcast reception difficulties that have successfully been attributed to wind turbines so far have been associated with UHF analogue television, not FM radio and certainly not MF or LF radio. There may be some potential for effects on digital terrestrial television, but possibly only in cases where turbine blades are between the transmitter and the receiver - cases of reflection from the blades are much more common and in the majority of cases should do little damage to our DTT signals because of the guard interval present in each DVB signal. Of course, there will be the odd case where reception was right on the edge of the 'digital cliff' before the turbines were built. Also we have no record of interference with our Digital Radio transmissions in Band III."

Ref. 5 summarises the results of model measurements of the level of interference signals scattered by turbine blades and the supporting tower and confirms some of the backscatter estimates calculated in Ref. 4.

Metal blades were used for some earlier turbines unlike the modern ones where composite material - fibre glass, carbon fibre, plastics are used. In some cases metal exists in the composite material blades for strength reinforcing or for lightning protection. Some references indicate that the composite blades will have a reduced interference potential, however the BBC view is that at UHF TV frequencies the difference will be small.

It is also indicated in some of the reports that due to variable wind speeds and direction, the resulting changes to turbine blade pitch and turbine facing direction will modify any interference levels at a given location in the service area i.e. interference effects would be time variant.

In relation to domestic TV reception in close proximity to wind turbines Ref. 7 issued by the BBC/Ofcom in the UK states that “In practice rarely does the tower or nacelle have any effect on reception; the impact on reception is solely on account of the rotating turbine blades. As the blades are moving objects, in terms of both their rotational speed and orientation, their effect is variable and hard to predict. When the combined effects of a number of turbines that comprise a wind farm are considered, the result is considerably more difficult to predict.

In May 2011 a new recommendation BT.1893 (Ref. 12) on impairment caused to digital television was issued by the ITU following on from the issue of an ITU Report BT.2142 (Ref. 13) in 2009-2010 which provides an extensive analysis of the effect of the scattering of digital television signals from wind turbines. These new documents indicate that back scatter of signals is higher than forward scatter and that static reflections from the tower itself in addition to the blade scatter is significant. These conclusions appear to differ from the earlier ITU report conclusions which were focused on analogue television. The ITU recommendation BT.1893 in Annex 1 presents a simplified model of impairment caused to television reception by a wind turbine. It however requires measurement or prediction of TV signal levels at the centre of the turbine rotor and at the house locations as well as calculation of a scattering coefficient based on the blade area, signal wavelength and distance from the turbine to the house location.

From a study of the above references and others, the following general conclusions are drawn in regards to global wind farm operations:

(a) No turbine interference effects are expected to MF radio reception.

(b) There is a very low probability of perceptible interference to FM radio reception.

(c) Some interference may be experienced to TV services and particularly where the path to the TV transmitter for a given receiver location is through the wind turbine blades or where there is a partly obstructed path to the transmitter and there is a clear path to a turbine. These effects may be restricted up to a distance

of about 5km from a single wind turbine in forward scatter directions (receiver on opposite side of the wind farm to the TV station). Backscatter may occur up to 0.5km or so however as TV receiving antennas have a reasonable signal rejection to the rear it is unlikely that TV reception at dwellings in the back scatter zone will experience any impairment.

(d) Digital TV services are unlikely to suffer degraded picture quality, e.g., ghosting, where signals have a margin above threshold levels, however a reduction in service area could occur due to time varying reflected signals.

9. COPPABELLA WIND FARM CONCLUSIONS

Drawing from studies discussed in Section 8 and Section 9, as well as taking into account the topography of the surrounding area, the following conclusions regarding the proposed Coppabella wind farm have been made:

9.1 No interference from the wind facility is expected to the MF and FM sound broadcasting services in the area.

9.2 The predictions of terrestrial TV signal coverage of the area around the wind farm indicates that it is a marginal service with the coverage from the SW Slopes station being the strongest. Interference to dwellings in the north east of the wind farm where the signal passes through the turbines to reach residences may be affected.

9.3 It is difficult however to predict where, if any, interference may occur. In general, but dwellings to the north east of the proposed wind facility and in close proximity to turbine locations may have some risk of having interference to TV signals from transmission from Mt Ulandra

9.4 As indicated, digital television is not subject to ghosting degradation in high signal strength areas. However in the area around the wind farm where there are predicted marginal signal levels from the other two potential sources of TV signal, some reduction of service area could result from reflected unwanted signals.

9.5 It is not known however how many residents would already have satellite TV which would be immune from wind turbine effects

9.5 TV rebroadcast stations in the area have been considered. The off air TV reception links are not included on the ACMA database as licensed links, and therefore do not appear on the link mapping should they exist. If their input signals passed near or traverse the proposed Coppabella wind farm, some interference to input signals and therefore to the TV service areas of the station could occur. However two TV rebroadcast stations are believed to exist and one is located at Harden and the other at Cootamundra where the input signals are likely to be from the SW Slopes Stations at Mt Ulandra without the wind farm being in the path. Satellite sources of signals are often used by some of the TV networks.

9.6 For satellite TV services in the area, no interference as a result of the operating wind facility is expected unless in the highly unlikely occurrence that the

dish antennas to the serving satellite is also in line with a turbine. The probability of this being the case is so remote that the predicted impact is considered to be negligible.

9.7 The ACMA RRL and Spectra databases has been studied for services within a radius of 50km from the proposed Coppabella wind farm to determine if any point to point services will have their paths obstructed by the wind turbine blades or the supporting towers. As depicted in Attachment 3 and Attachment 4, three point to point services were found to traverse the project development envelope. The closest off site paths are depicted in Attachment 11 and Attachment 12. Analysis shown in Attachment 16 determines the required Fresnel clearance by turbines for typical microwave and VHF/UHF systems. This analysis established that the proposed turbine locations satisfies the required Fresnel Zone Clearances of all microwave in the area, however there are a number of turbines too close to the ray lines of the VHF/UHF link paths.

9.8 Navigational aids at Cootamundra and Yass and Radar/Ground to Air at Mt Bobbara near Binalong were identified within 50km of the project boundaries. The Navigational aids are not expected to be impacted by moving turbine blades due to the separation distance to the nearest turbine of 12 km. An aviation safety consultant is expected to resolve and radar impacts.

9.9 There are 11 registered Point to Multipoint (PMP) Systems within the study area, however the base stations are general not located close to the proposed wind turbines and therefore the systems not expected to be negatively impacted. The Hilltops Council however have indicated that there are telemetry links from their Harden Office and the Jugiong reservoir via the Coppabella Hill site on the wind farm. This needs to be examined further with the Council and if necessary a remedial solution be developed.

9.10 There are no radio or TV broadcasting facility sites in close proximity to the proposed site. The closest local FM Radio stations are at Young, Yass and Cootamundra and local TV at Harden and Cootamundra the closest being approximately 24km, far outside the usual required buffer zone, therefore the project is unlikely to impact on radio signals. Normally a recommended buffer zone for the location of any wind turbine is a circle of radius 800 metres around a radio tower location.

10. POWER INFRASTRUCTURE ELECTRIC AND MAGNETIC FIELDS

The power generated by the wind turbines will be exported to the transmission grid via purpose built substation/s and high voltage transmission lines using conventional designs to meet standards applying to the State network at large. Substation/s will be designed and sited to reduce the electric and magnetic fields to acceptable levels at the boundary fence.

The internal wind farm reticulation will employ underground cables or overhead transmission lines of up to 33 kV in voltage. The wind farm will be connected to the power grid with purpose built 132 kV powerlines travelling northward. Powerlines and substations are required to meet *Australian Standard AS/NZS 2344: 1997 Amendment 1:2007 Limits for EMI*, which protects broadcasting and radiocommunications reception from unacceptable interference.

Powerlines will be built with buffer zones on either side as required for all HV lines in the State depending on their voltage rating.

13. MITIGATION TECHNIQUES

Any mitigation of interference will involve digital television reception as all analogue TV in Australia was switched off prior to 10th December 2013.

For individuals who experience any degraded FM (unlikely) or TV broadcasting service due to identified interference from the proposed wind facility, possible techniques to reduce the interference to acceptable limits include:

1. Replacement of receiving antenna system with a higher gain more directive model,

2. Reposition antenna in height or horizontally on the dwelling,

3. Install an antenna elsewhere on the property and cable to dwelling,

4. Change the orientation of antennas to receive an alternative station if available,

5. Provision of an alternative satellite service e.g. the Viewer Access Satellite Television (VAST) (Ref. 10) or Austar Pay TV Service,

6. In certain circumstances, consideration could be given to the installation of a TV repeater station to provide service to groups of residents in a shadow zone. However this is only likely to occur in higher density population areas.

Potential point to point system and mobile base coverage conflict is not expected if turbines are located with recommended clearance zones from radio sites or point to point ray lines. As shown in Attachment 17 there are a number of turbines identified too close to VHF/UHF radio links passing close to turbines requiring relocation.

Any minor affects to MF broadcasting would occur within 10's of metres of the turbines only and with a buffer zone of at least 500m to any dwelling, no corrective action will be required.

14. CONCLUSIONS

In relation to the proposed Coppabella wind farm the following conclusions have been drawn:

- Interference to MF and FM sound broadcasting is not expected.

- There are 3 radio system paths which pass through the turbines which require adequate clearances. The current proposed turbine locations with grid references shown in Attachment 1 do not all have acceptable horizontal clearances from currently registered point to point radio links.

- WTG 25 is too close to the Coppabella Hill radio site and needs to be relocated

- The Hilltop Council advised that they operate telemetry links between the Jugiong High level reservoir and the Harden Office site via Coppabella Hill. This is possibly operated under a PMP licence as they did not appear as licenced links in the ACMA database. Clearance from WTG's need checking

- Mobile radio and other radiocommunication services in the area are not expected to be impacted by the wind facility or its operation. Cellular mobile coverage at some individual locations may be affected but the with the robust nature of the transmission system and with alternative base stations available, acceptable grade of service should be maintained

- TV reception at dwellings close to turbines and with reception direction through the turbines could have some probability of noticeable effects at times. This may apply to a few dwellings on the north eastern side of the wind farm. Any degradation of reception experienced may be time variant depending on wind direction and speed.

- Digital TV is not susceptible to visible ghosting degradation where the signal level is above a minimum threshold. The area surrounding the wind facility is predicted as a marginal signal area. There may be individual houses located in shadow areas where other mitigating techniques may need to be applied.

- Alternatively a satellite service could be considered if digital TV reception is unsatisfactory in individual cases. In particular, the Viewer Access Satellite Television (VAST) Service provided by the Government would be available to provide a full complement of digital channels including a regional news channel.

- Overseas experience from operating wind farms indicates that EMI produced by the wind turbines and controls is negligible with reputable world class wind turbine manufacturers, similar to ones proposed for Coppabella wind farm, and therefore no electrical noise measurements from the electrical generators are warranted.

- It is recommended that, PMP operators, Commercial Television Station operators in the area and Broadcast Australia for the ABC and SBS, be advised of the proposed wind facility to enable these organizations to confirm that there are no potential interference issues seen to be relevant to their operations.

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ATTACHMENT 1 – COPPABELLA FARM TURBINE COORDINATES

WTG ID	Approval Locations		Layout 23		Comments
	Easting	Northing	Easting	Northing	
1	641135	6156615	641135	6156615	GDA 94 Zone 55
2	642183	6155309	642183	6155309	
3	641934	6155584	641934	6155584	
4	641683	6155973	641683	6155973	
5	641228	6156306	641228	6156306	
6	644704	6153528	644704	6153528	
7	643949	6154128	643949	6154128	
8	643690	6154400	643690	6154400	
9	642410	6155033	642410	6155033	
10	642697	6154767	642697	6154767	
11	644507	6153820	644507	6153820	
15	643186	6154579	643186	6154579	
16	640374	6156085	640374	6156085	
17	640731	6155502	640731	6155502	
18	640494	6155780	640494	6155780	
19	641174	6155340	641174	6155340	
25	639997	6154114	639997	6154114	
29	641753	6154245	641753	6154245	
30	640070	6154676	640071	6154606	Microsited for WTG spacing
31	640038	6155010	640038	6155010	
32	639618	6154648	639625	6154723	Microsited for WTG spacing
33	639464	6153582	639464	6153582	
34	638607	6154188	638607	6154188	
35	638391	6153940	638391	6153940	
36	639022	6154556	639022	6154556	
37	638704	6154914	638704	6154914	
38	639088	6155044	639065	6155125	Microsited for WTG spacing
39	638176	6153691	638176	6153691	
40	637724	6153002	637709	6152928	Microsited for WTG spacing
41	637724	6152676	637724	6152676	
42	637890	6153483	637890	6153483	
43	638123	6153103	638123	6153103	
44	637501	6153978	637501	6153978	
45	637821	6154164	637821	6154164	
46	638091	6154423	638091	6154423	
47	639088	6152412	639088	6152412	
48	639374	6152965	639374	6152965	
49	639508	6153251	639508	6153251	
50	639733	6152377	639733	6152377	
51	639315	6152655	639315	6152655	
52	637982	6155133	637982	6155133	
53	637955	6154807	638010	6154854	Microsited for WTG spacing

54	637553	6154697	637553	6154697	
55	637558	6155411	637558	6155411	
56	638814	6155310	638814	6155310	Location Error in Consent
57	638692	6155728	638692	6155728	
58	638239	6155953	638321	6155970	Microsited for WTG spacing
59	638546	6156147	638533	6156203	Microsited for WTG spacing
60	637143	6155777	637143	6155777	
61	636904	6155521	636904	6155521	
62	636707	6155235	636707	6155235	
63	636604	6154848	636604	6154848	
73	646131	6150401	646131	6150401	
74	646521	6150162	646521	6150162	
75	645789	6149787	645789	6149787	
76	646174	6149496	646174	6149496	
77	645814	6149346	645814	6149346	
78	644751	6150491	644751	6150491	
79	644471	6150212	644471	6150212	
80	644204	6150650	644204	6150650	
81	643496	6151799	643496	6151799	
82	643622	6152119	643622	6152119	

ATTACHMENT 2 –COPPABELLA WIND FARM LAYOUT MAP

See map on next page

ATTACHMENT 3- Radio Link Map 40- 999 MHz Frequencies
It should be noted that due to the close spacing of adjacent link sites the site number displayed on the map may not be the appropriate one for a given point to point link due to overlaying of site labels. The wind facility nominal envelope is shown as a rectangle and wind turbine locations are also shown.

See map on next page

ATTACHMENT 4 - Radio Link Map above 1000 MHz Frequencies

It should be noted that due to the close spacing of adjacent link sites the site number displayed on the map may not be the appropriate one for a given point to point link due to overlaying of site labels. The wind facility nominal envelope is shown as a rectangle and wind turbine locations are also shown.

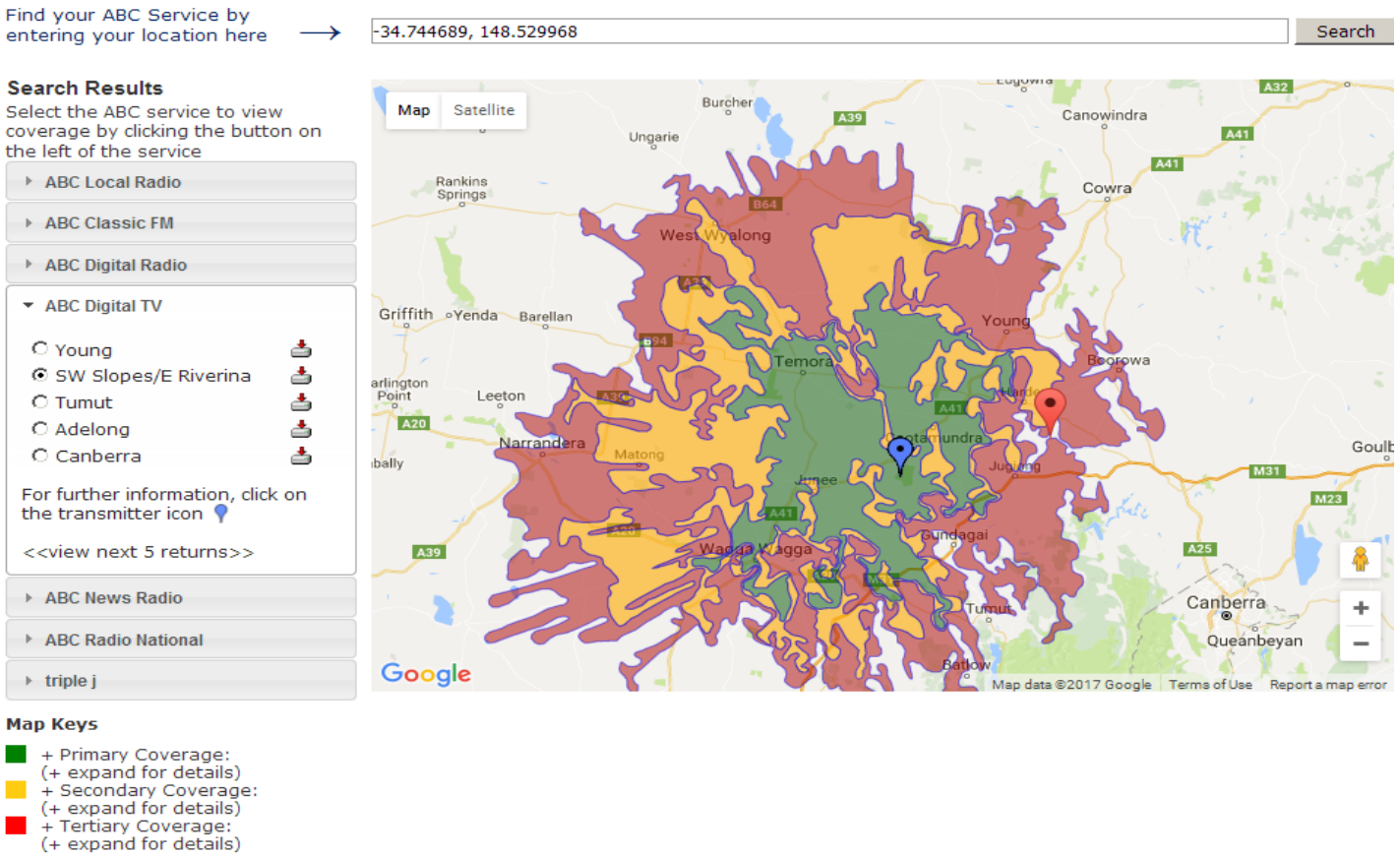
See map on next page

ATTACHMENT 5 - TELEVISION STATIONS & CHANNELS – COPPABELLA WIND FARM AREA

Transmitter Location/service	Operator	Analogue Channels	Digital Channels	Comment
Mt Ulandra/SW Slopes Riverina	SBS		48H	UHF
	ABC		46H	UHF
	CBN		47H	UHF
	CTC		51H	UHF
	WIN		50H	UHF
Black Mountain/Canberra	SBS		7V	VHF
	ABC		8V	VHF
	CBN		12V	VHF
	WIN		11V	VHF
	CTC		6V	VHF
Mt Canobolas./ Central Tablelands	SBS		39H	UHF
	ABC		36H	UHF
	CBN		37H	UHF
	WIN		35H	UHF
	CTC		38H	UHF
Reservoir Kelly St Harden/Harden	SBS		40V	UHF
	ABC		41V	UHF
	CBN		42V	UHF
	WIN		43	UHF
	CTC		44V	UHF

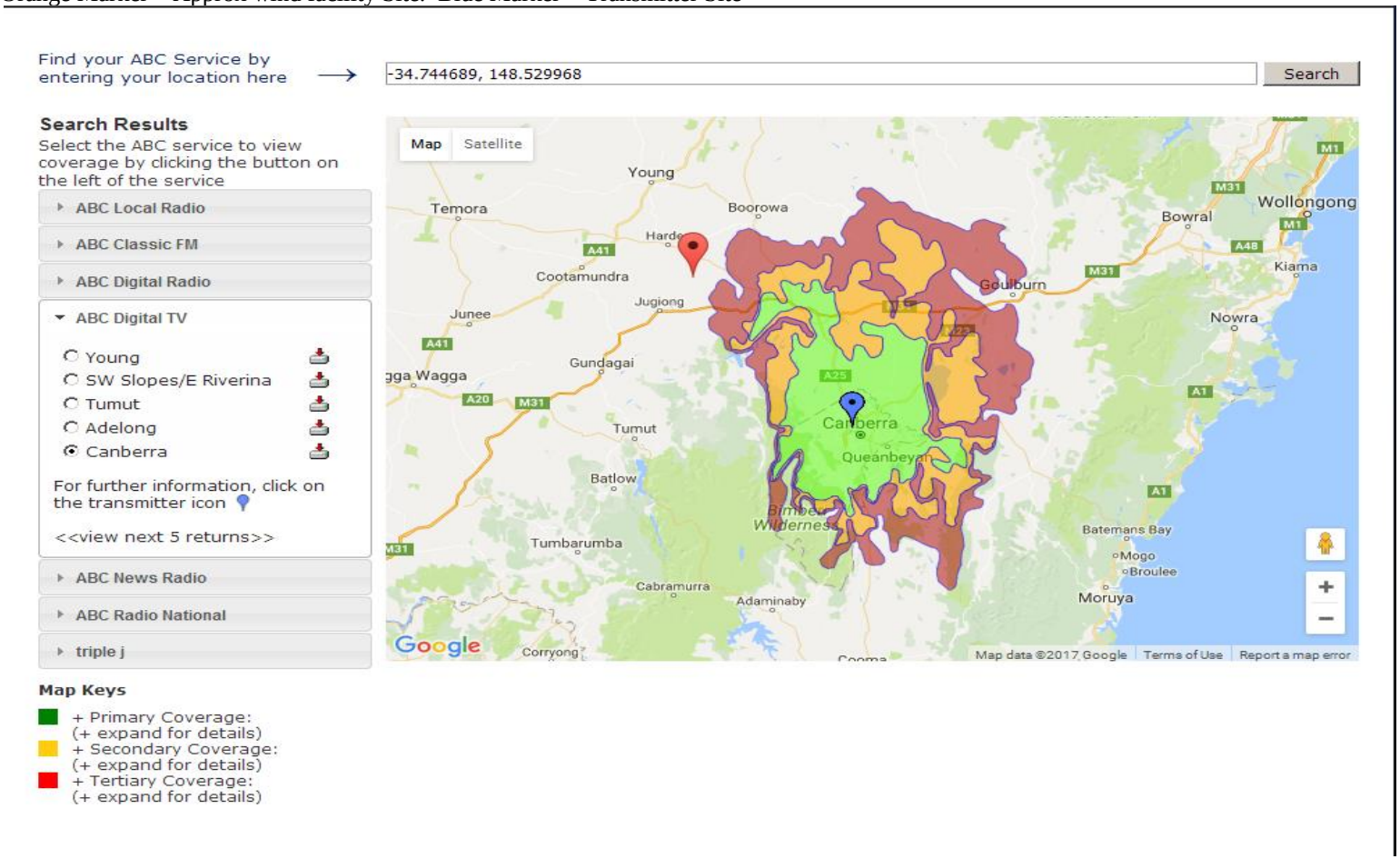
ATTACHMENT 6 SW Slopes/E. Rivervina TV Coverage – ABC Predicted

Orange Marker – Approx wind facility Site. Blue Marker – Transmitter Site



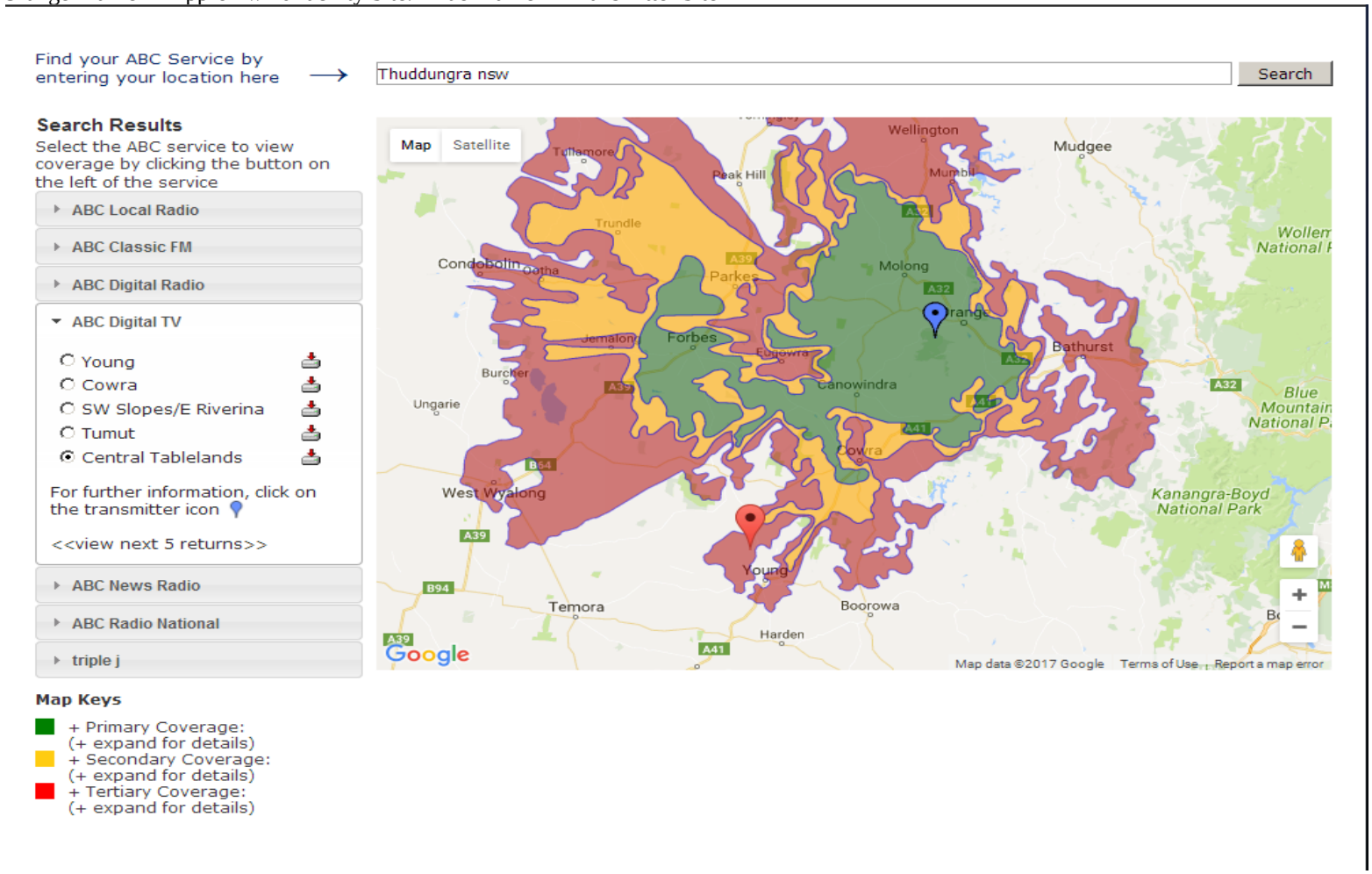
ATTACHMENT 7 Canbera TV Coverage- ABC Predicted

Orange Marker – Approx wind facility Site. Blue Marker – Transmitter Site

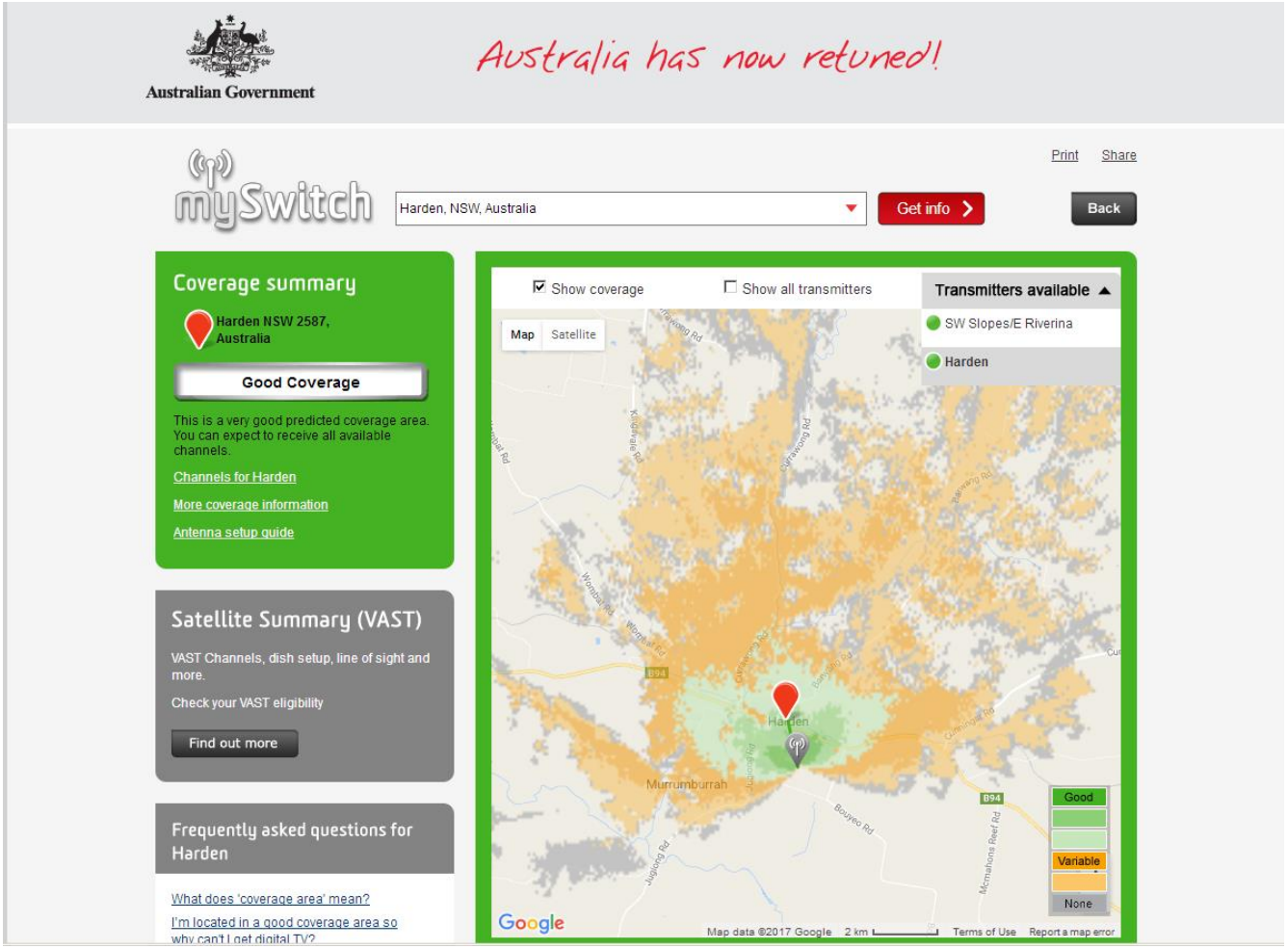


ATTACHMENT 8 Central Tablelands TV Coverage – ABC Predicted

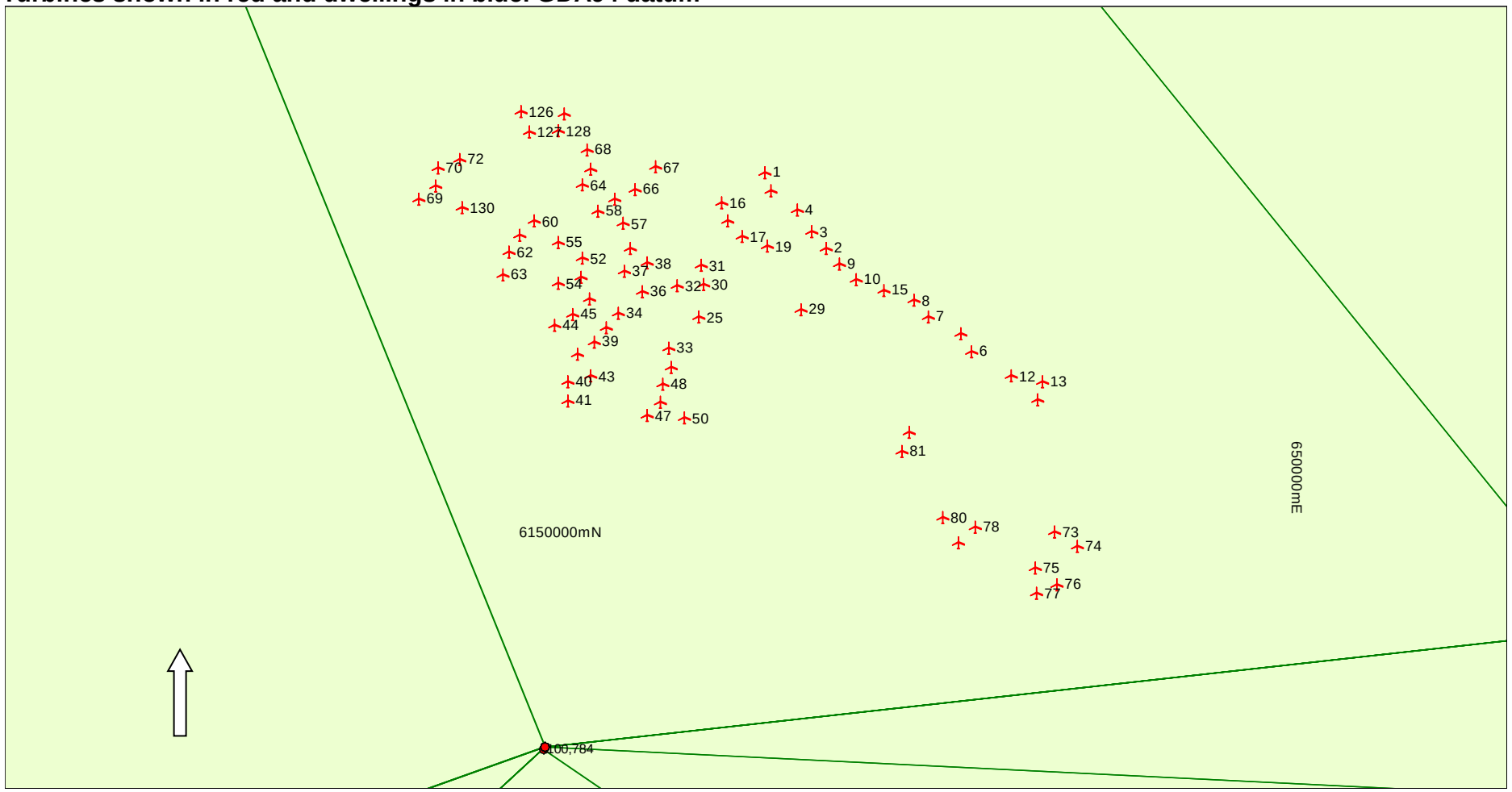
Orange Marker – Approx wind facility Site. Blue Marker – Transmitter Site



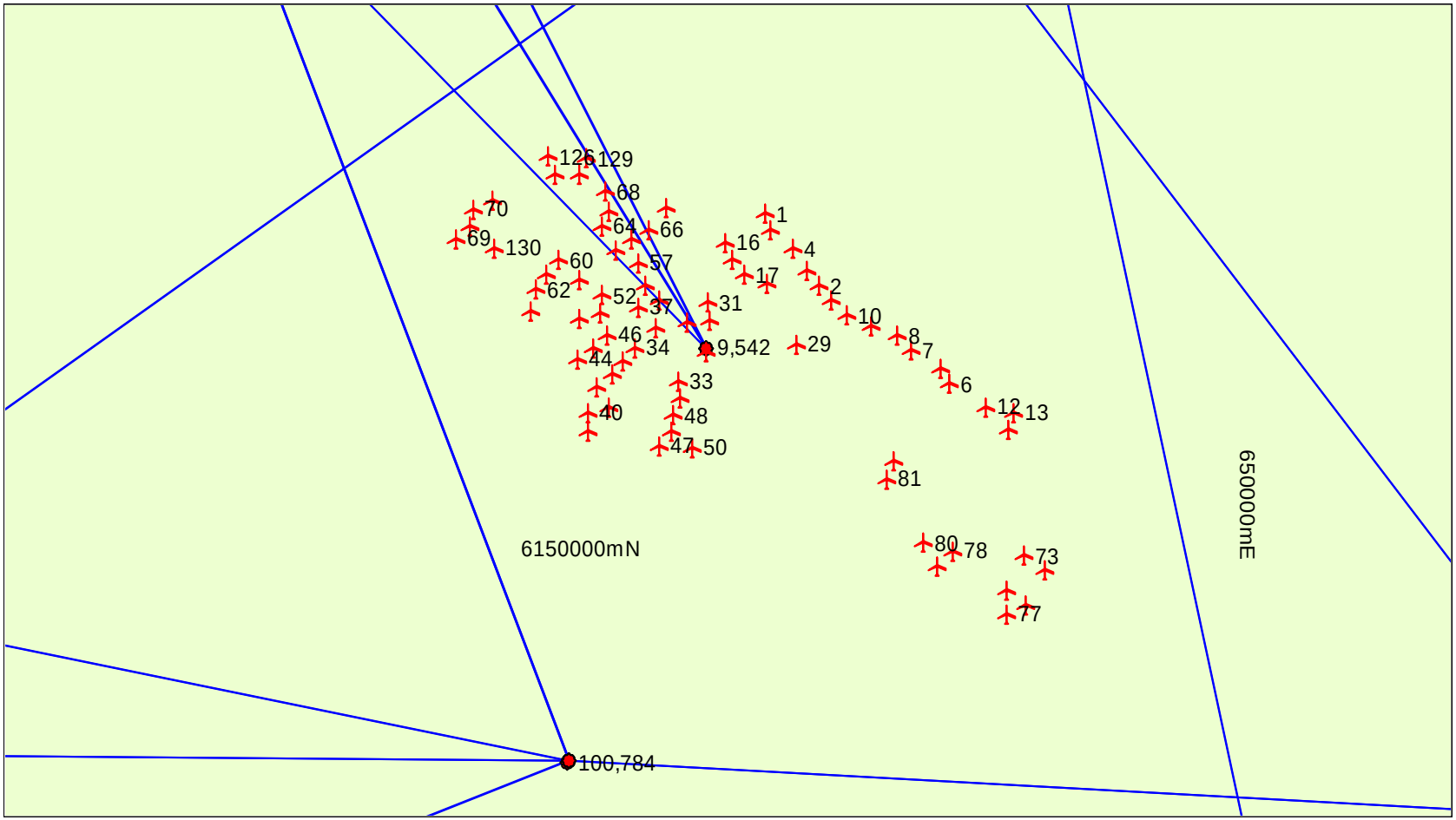
ATTACHMENT 9 Harden TV Coverage – Department of Communications and the Arts mySwitch Prediction



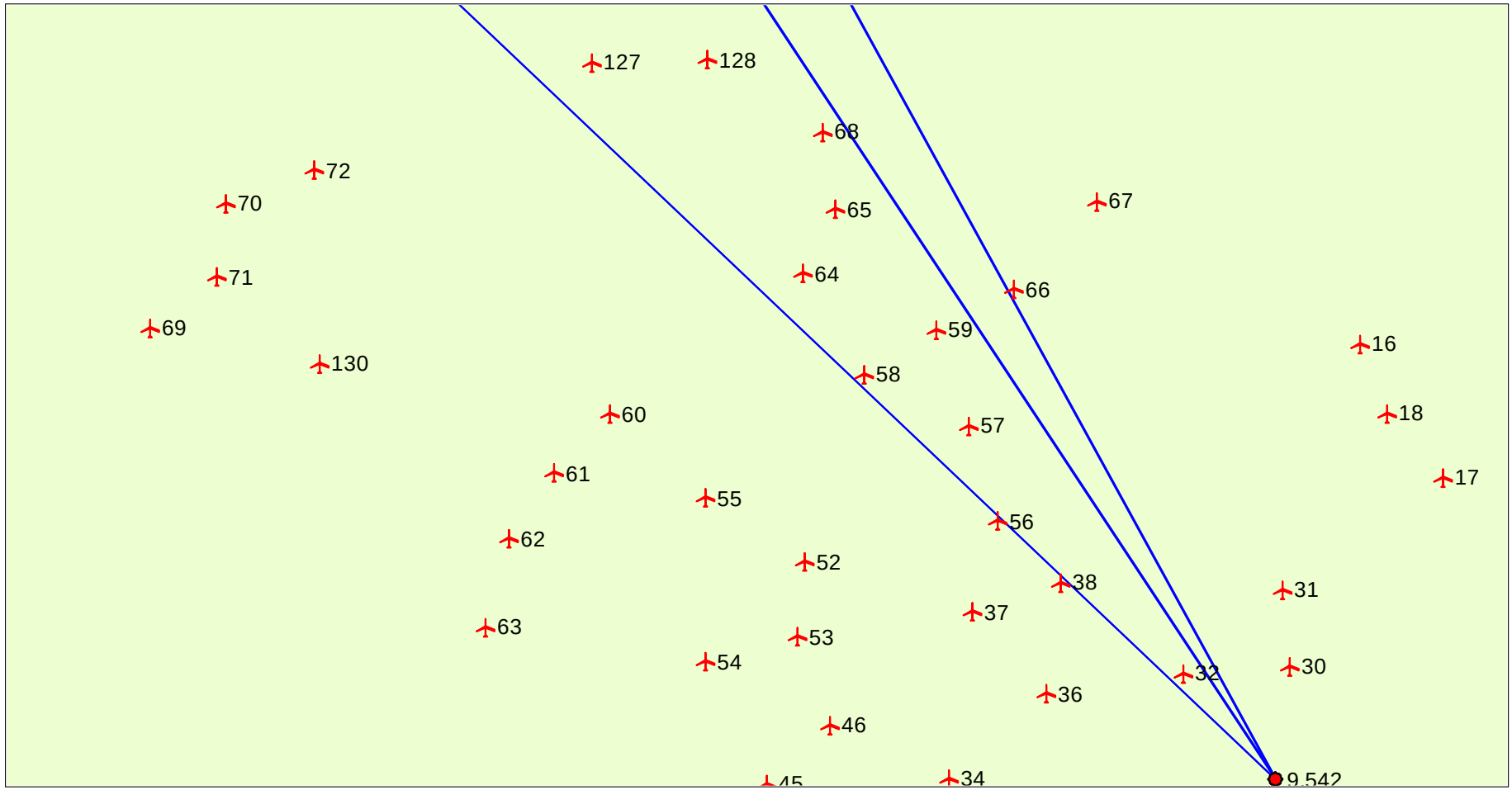
ATTACHMENT 10 – Map of Microwave Radio Link Paths Near Coppabella Wind Farm
Turbines shown in red and dwellings in blue. GDA94 datum



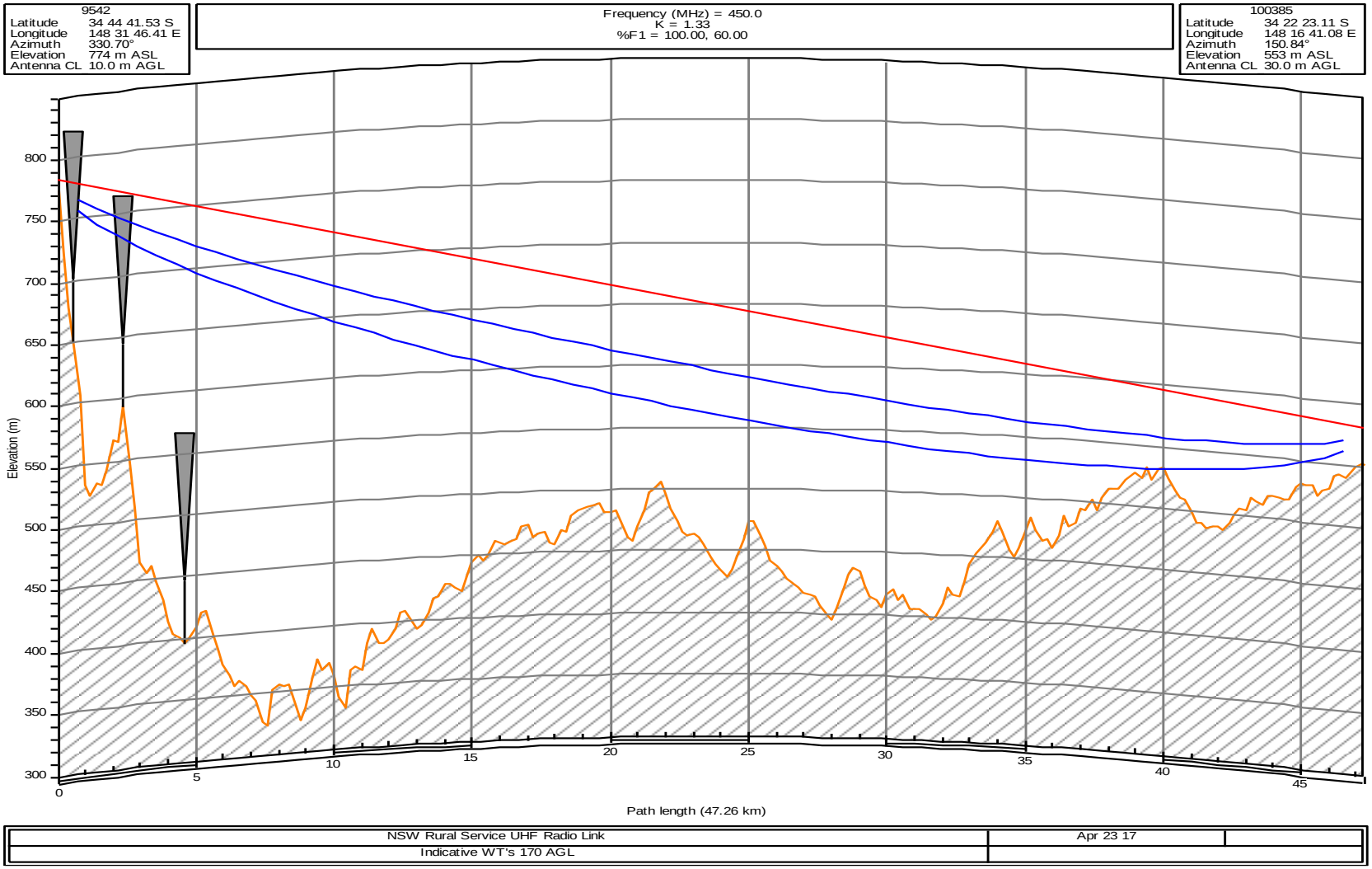
ATTACHMENT 11 – Map of VHF/UHF Radio Links near Coppabella Wind Farm
Turbines shown in red. GDA94 datum



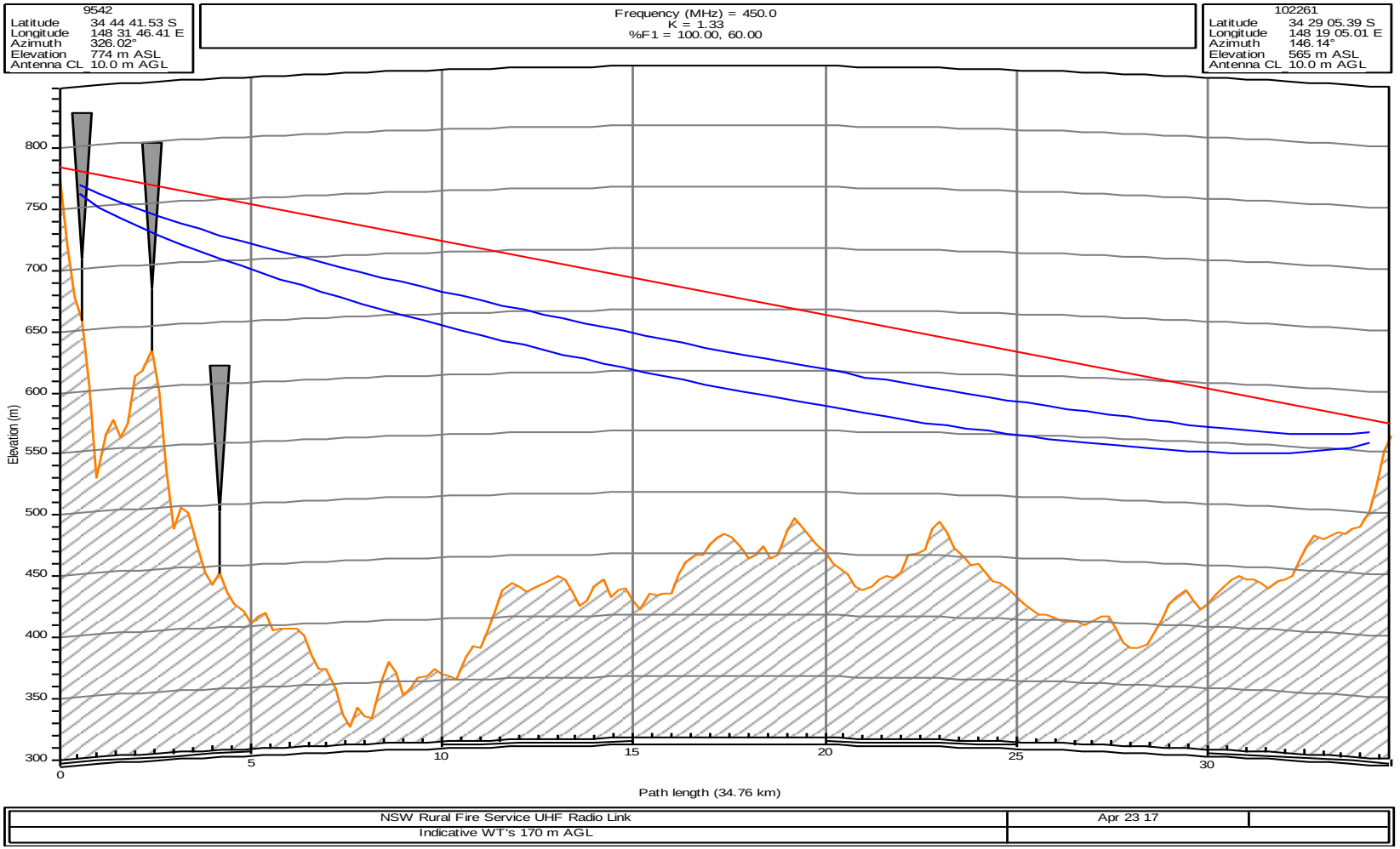
ATTACHMENT 12 – Map of VHF/UHF Radio Links near Coppabella Wind Farm Zoomed Up View
Turbines shown in red. GDA94 datum



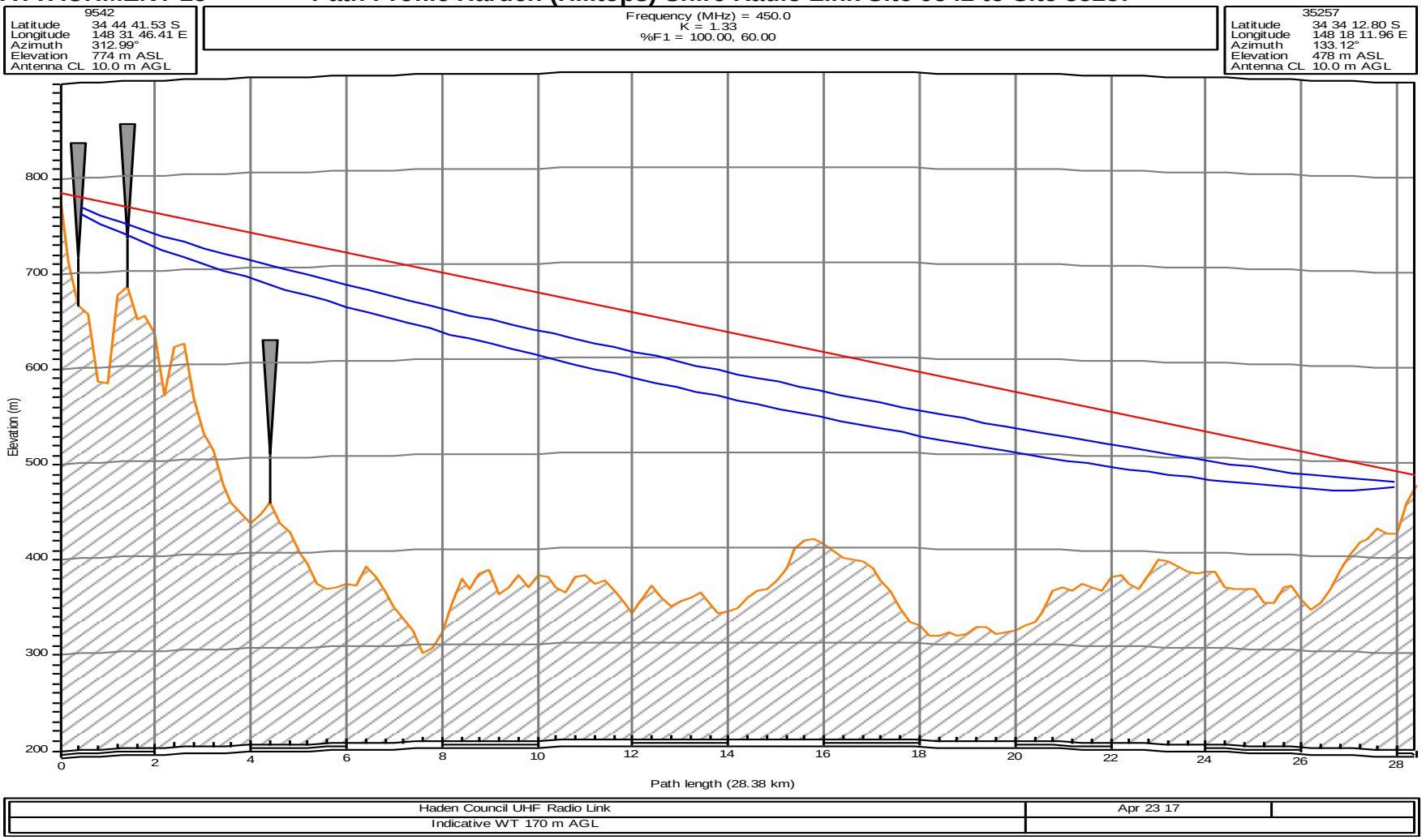
ATTACHMENT 13 Path Profile RFS Radio Link Site 9542 to Site 100385



ATTACHMENT 14 Path Profile RFS Radio Link Site 9542 to Site 102261



ATTACHMENT 15 Path Profile Harden (Hilltops) Shire Radio Link Site 9542 to Site 35257



ATTACHMENT 16– CALCULATION OF RADIO PATH CLEARANCES

In the event of a microwave point to point system passing near a turbine the recommended clearance from link ray line to turbine blade tip is the Second Fresnel zone radius calculated using the following formula:

$$\text{Ymin} = \sqrt{2\lambda D1(1 - D1/D2)} \qquad \text{(Ref. 1)}$$

Example Only

1. Site 1 ID 204434 to Site 2 ID 9001068

   Operator: Optus
   Frequency Band 15000 MHz
   Calculated Path Length: 17.85km
   Clearance to WTG at 3.7km from near site.
   2nd Fresnel Clearance D1

   D1 = SQRT(2 x λ x d1 x (1 – d1/d2))
   =SQRT(2x (300/15000) x 3700(1- 3.7/17.85))
   = 10.83 metres

The required clearance from the ray line to a tower centreline is 50 + 10.83 = 60.83 metres (at 3.7 metres from the microwave tower)

For a VHF/UHF point to point system the recommended clearance from the link ray line to turbine blade tip can be relaxed to 0.6 X Ist Fresnel Zone clearance as there is less disturbance at the lower frequencies due to blade movements or obstructions generally.

Example only

1. Site 1 ID 10712 to Site 2 ID 10652

$$\text{Ymin} = 0.6\sqrt{\lambda D1(1 - D1/D2)}$$

   Operator: NSW Fire
   Frequency Band 450 MHz
   Calculated Path Length: 38.3km
   Clearance at mid path
   0.6 X 1st Fresnel Clearance D1

   D1 = 0.6*SQRT (λ x d1 x (1 – d1/d2))
   = 0.6*SQRT ((300/450) x 19150(1-19.15/38.3))
   = 47.94 metres

The required clearance from the ray line to a tower centreline is 50 + 47.94 = 97.94 metres at mid path (19.15km from either end of link path.)

VHF & UHF LINKS CLEARANCES

								GW140				Site 1 Lat	Long	Site 2 Lat
Site 1	Site 2	Operator	Freq MHz	Total Path m	Dist om Link nd m	2nd fresnel m	0.6 x Ist fresnel m	Blade Length	Turbines	Clearance	Actual clear	GDA		GDA
								Metres		Metres	Metres			
9542	102261	NSW Rural F.S.	450	34760	4370	71.37	30.28	70.15	T68	100.43	92.6	-34.744869	148.529559	-34.48484
9542	102261	NSW Rural F.S.	450	34760	4370	71.37	30.28	70.15	T129	100.43	82.6	-34.744869	148.529559	-34.48484
9542	100385	NSW Rural F.S.	420	47260	4150	73.54	31.20	70.15	T66	101.35	24.7	-34.744869	148.529559	-34.37309
9542	35257	Harden Shire C.	450	28380	5250	75.53	32.05	70.15	T32	102.20	61.3	-34.744869	148.529559	-34.57022
9542	35257	Harden Shire C.	450	28380	5250	75.53	32.05	70.15	T38	102.20	20.6	-34.744869	148.529559	-34.57022
9542	35257	Harden Shire C.	450	28380	5250	75.53	32.05	70.15	T56	102.20	18.6	-34.744869	148.529559	-34.57022
9542	35257	Harden Shire C.	450	28380	5250	75.53	32.05	70.15	T58	102.20	46.8	-34.744869	148.529559	-34.57022

Corrected

ATTACHMENT 18- GLOSSARY OF TECHNICAL TERMS

VHF	Very High Frequency
UHF	Ultra High frequency
EMI	Electromagnetic Interference
VHF Channels	TV Channels 0 to 12 (45 - 230 MHz)
UHF Channels	TV Channels 28 - 46 (526 - 820 MHz)
Band 111	VHF TV Channels 5A - 12
First Fresnel Clearance	Clearance to obstructions from the ray line on a radio Path which does not produce any additional loss above free space loss
FM	Frequency Modulation
AM	Amplitude Modulation
MF	Medium Frequency
LF	Low Frequency (not used for sound broadcasting in Australia)
GSM	European Digital Cellular Mobile System
CDMA	Code Division Multiple Access Cellular Mobile System
ITU	International Telecommunications Union
ACMA	Australian Communications & Media Authority
CB Radio	Citizens Band Radio
VOR	VHF Omnidirectional Range (short range air Navigation aid)
Terrestrial	Earth based i.e. not space based e.g. satellite