Lawrence Derrick & Associates

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

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ATTACHMENTS

1. BACKGROUND

Infigen Energy is planning the development of an extension to the existing Capital wind farm located north of Bungendore in NSW and about 60 km north east of Canberra. This will involve the construction of an additional 55 wind turbines, which will consist of tapered cylindrical metal towers of up to 100 metre in height with three bladed rotors of up to 113.3 metres in diameter mounted to generators in nacelles on top. As part of the environmental study of the proposal, the potential for disruption to radiocommunications and broadcasting in the wind farm area is being assessed. Clearance distances between any point to point microwave link paths and the turbines are also required to position turbines to avoid any degradation to the performance of the links. Buffer zones from radio sites within or close to the boundaries of the wind farm are also to be specified where necessary.

2. INTRODUCTION

It is considered necessary to include an assessment of impacts of the wind turbines on TV and sound broadcasting reception in the general area of the wind farm for the TV transmitting stations received by residents and to determine if any of the turbines are close to radio point to point system paths traversing the wind farm site. This report covers the outcomes of a desktop study as outlined below.

3. DESKTOP STUDY

A desk top study has been carried out on the likely impact of typical wind farm turbines and their supporting towers on broadcasting and radiocommunications in the area surrounding the wind farm. This study is based on relevant International Telecommunications Union (ITU) documents and on other professional reports on overseas and Australian experience of wind farm impacts on broadcasting services in the vicinity of any wind turbine structures. For Radiocommunication services radio sites up to at least 50 Km from the wind farm need to be considered because of the length of point to point paths of up to 100 Km.

Using data from the Australian Communications & Media Authority's (ACMA) RADCOM Database, checks have been made on radiocommunication services within at least a 50 km radius of the wind farm to determine if any of the turbine towers could obstruct line-of-site paths or have any likely detrimental affect on these services. Clearance criteria for ray lines have been indicated for any point to point radio paths crossing or near the wind farm site. A check has also be made that any radiocommunications or broadcasting sites close to the wind farm have adequate clearance to wind turbines to prevent any significant degradation of services operating from the sites.

4. BROADCASTING SERVICES IN THE AREA

From ACMA TV and Sound Broadcasting Station listings, and from a map survey of the area surrounding the Capital 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.

4.1 Analogue Television

It is expected that residents in the area surrounding the wind farm location generally view analogue TV from the Canberra National and Commercial main stations located at Black Mountain which is approx. 50 km from the wind farm site centre. In addition coverage of some locations could be available from the Central Tablelands, Goulburn, Illawarra and even Sydney stations. This is based on the ABC's web site TV service area predictions for the Tarago 2580 Postcode. The station utilised by individual residents for TV reception will depend on the least obstructed path to the transmitters and in some locations reception of channels from more than one station will be possible. In addition to analogue TV channels digital channels are also available from these transmitting locations as discussed in 4.2. A summary of possible channels available from the stations listed is shown in Attachment 2

4.2 Digital Television

Digital television signals are also currently being radiated from the same locations listed in 4.1 under the current transition to digital television around Australia which commenced in 2001. According to the ABC's TV coverage predictions reception of digital TV may be possible in the 2580 postcode in some locations from the Canberra, Goulburn and Illawarra stations.

The Government has announced that digital only transmission in Canberra and other Regional NSW markets in this area will be achieved by 30th June 2012. It is therefore considered that any remedial action necessary for interference to analogue TV reception should focus on a digital solution where possible.

4.3 FM Sound Broadcasting

Canberra FM Services are radiated from Black Mountain and other FM services are available in the area from Goulburn, Illawarra and other sites.

4.4 MF Sound Broadcasting

As indicated below, wind farm effects on MF radio are highly unlikely and therefore the stations serving the area have not been listed.

4.5 Satellite Pay Television

Some homesteads in the area may have satellite pay TV service or free-to-air antenna installations. Unless a particular subscribers antenna reception direction and elevation is closely aligned with a turbine, which is highly unlikely, no impacts on TV reception is expected.

5. RADIOCOMMUNICATIONS SERVICES

The wind turbine current grid coordinates of the initial layout for CWF II and for the existing wind farm are listed in Attachment 1. Maps generated from data in the ACMA database are shown in Attachments 3 & 4. MapInfo maps were generated and PDF versions were taken at particular zoom levels. Attachment 3 shows all radio sites and point to point links within at least 50 Km of the wind farm and with operational frequencies in the range 40 – 999 MHz. Attachment 4 is a similar map for links in frequency range above 1 GHz. It should be pointed out that due to the close spacing of adjacent link sites the site number displayed on the PDF maps at the particular scale used may not be the appropriate one for a given point to point link due to overlaying of site labels. The wind farm site is shown as a rectangle. At higher zoom levels the turbine locations are also displayed in the MapInfo mapping..

5.1 Point to Point

A large number of point to point links are registered for operation within 50 km of the wind farm site. As shown in map in Attachment 3 there are two UHF links which traverse the boundaries of the wind farm. Attachment 4 indicates that there are two microwave links (> 1GHz) with potential turbine proximity issues. Clearance requirements are required to ensure turbines are not located close to the ray lines of these four links to avoid any impact on their performance. The ray lines passing near the wind turbines are shown in zoomed maps in Attachments 5 & 6 with the turbine locations shown in blue for this project and in red for the existing wind farm. Path profiles for these links are shown Attachment 7 to determine if there is sufficient vertical clearance to the radio link ray lines. Any link paths with sufficient vertical clearance over the tip of turbine blades will not require any horizontal clearance to be specified.

5.1 Point to Point Multipoint and MDS Stations

A number of Point to Multipoint (PMP) and Multipoint Distribution Systems (MDS) are registered in the general study area typically for Telstra and Austar services at major sites such as Black Mountain and Mt Gray. While the base stations are registered for these types of service the remote customer ends are not. It is therefore not possible to determine the existence of paths between the base stations and customer end. The major base station locations are some distance from the wind farm so the probability of turbine obstruction on these paths is low. Should any obstruction occur consideration would need to be given to alternative base station locations, repeaters or relocation of customer antennas.

5.2 Cellular Mobile Base Stations

No cellular mobile base stations are registered at sites in the close vicinity of the wind farm.

5.3 Two-Way Mobile

A number of private and Public Utility Point to Multipoint and mobile bases exist in the area surrounding the wind farm site. Site 9008455 on the wind farm site is for a mobile radio base station registered to Suzlon Energy, the builder of the currently operational wind farm. These bases potentially provide cover to mobiles in a 360 degree arc from their bases. No significant impact from the wind farm on

base coverage beyond normal mobile operational performance is predicted in view of the geographic separation between the base antennas and the turbine structures. Of course a mobile unit communicating with a base station when the mobile is located within metres of the wind turbine structures (or indeed near any large building, silo, tower etc) may experience some very local performance change, however moving a short distance would restore performance to normal.

5.4 CB Radio

CB radios are not individually licensed, the equipment being 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 impact from the wind farm is predicted except perhaps for very local effects to portable or mobile units in the immediate vicinity of the turbines which could be avoided by a small location change of the unit.

5.5 Other Services

The nearest airport at Canberra has radar and other aviation communications and navigational aids located at Mt Majura about 40 km away. The adjacent operational Capital wind farm has some wind turbines closer to this radar site.

6. 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.

Television Interference from wind turbines is characterised by video distortion that generally occurs in the form of a jittering of the picture that is synchronised with the blade passage frequency.

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 site 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 Fresnel Zone clearance for certain links with low antenna gain.

Recent correspondence with David Bacon (the Author of Ref. 8) indicates that his view is that the second Fresnel zone clearance is very conservative for point to point radio systems in the VHF/ UHF frequency range and that a reduction to 0.6 x 1st Fresnel zone is a more realistic criteria. He further believes that some incursion of turbine blades into this zone may be acceptable with arbitrary criteria of the aggregate area of all turbine blades not exceeding 10% of this zone area. This would apply to line of site systems. For systems normally operating with terrain obstructions (e.g. SCADA systems) however a different criteria would be required. A ray line clearance for turbines blades of 0.6 x 1^{St} Fresnel zone has been adopted in this report for the UHF links passing through the wind farm site.

7. DISCUSSION OF OVERSEAS EXPERIENCE

Observations and studies have been carried 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.

It is believed that metal blades were used on the 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 ie interference effects would be time variant.

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”

From a study of the above references and others, the following general conclusions are drawn:

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

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

(c) Some interference may be experienced to analogue 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 5 km from the wind farm in forward scatter directions (receiver on opposite side of the wind farm to the TV station).

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

8. CAPITAL II WIND FARM SITUATION

From overseas experience, calculations using the University of Michigan method and the topography of the area:

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

8.2 Theoretical estimates outlined in Attachment 9, of reflections of the typical analogue VHF and UHF TV transmissions from Black Mountain and other transmitting sites by the turbine blades indicate that some possibility of TV picture degradation exists at times for dwellings located such that wind turbines exist within a +/- 20 degree sector (Ref. 6) from the TV antenna nominal direction of reception, and up to about 2 km for VHF and 5 km for UHF TV channels from the turbines. Estimates of typical scattering from the blades are based on available data for three blades each have a one sided projected surface area of 110 sq. metres (52 metres long), that the turbine towers will be tapered steel columns about 100 metres high and on using the method outlined in Ref.1. Measurements overseas indicate that the calculations using the alternative ITU method (Ref.4) over estimate the scattering/reflection so this method has not been used. It is also difficult to estimate the additive effects of a number of turbines distributed over some distance and on the effect of the undulating terrain on the ratio of the reflected signal to the main wanted TV signal. Some properties in the area surrounding or in the wind farm are predicted to have some probability of perceptible TV picture degradation for a percentage of time depending on the direction and speed of the wind. At some unfavourably located properties within about 5 km of turbines there is a probability of perceptible analogue TV picture degradation for a percentage of time depending on the direction and speed of the wind.

8.3 Due to the undulating terrain around the wind farm and the possible individual choice of multiple TV transmitting stations it is difficult to predict where interference may occur.

8.4 Any cumulative effects on television reception from the proposed nearby Woodlawn wind farm and the existing Capital wind farm have been generally considered in conjunction with this project. As most residents in the Capital wind farm vicinity receive TV signals from Black Mountain their receiving antennas front to back ratio will provide a reasonable rejection to any low level back scattered signals from the Woodlawn wind turbines. A few residents close to the Capital wind farms may be in unfavorable locations to have additive analogue interference TV from the current turbines and the CWF II turbines.

8.5 As indicated above, digital television is not subject to ghosting degradation in high signal strength areas, however some reduction of service area could result from reflected unwanted signals at the limits of the service area. There may be some isolated areas which are shadowed by local hills resulting in reduced signal levels however it is difficult to predict whether digital reception will be impaired in specific locations.

8.6 There are no TV rebroadcast stations listed in the area surrounding the wind farm. The turbines will, therefore, have no impact on rebroadcast signal quality.

8.7 For satellite TV services in the area of the wind farm interference to these services is unlikely to occur due to the high angle of elevation of the satellite antennas and the very high operating frequency

8.8 The ACMA RADCOM database has been studied for services within at least 50 km of the wind farm to determine if any point to point services will have

their paths obstructed by the wind turbine blades or the supporting towers. Maps derived from the ACMA database showing radio sites and links in the general area surrounding the site are shown in Attachments 3 & 4. Four Radio links have been identified as crossing the boundary of the wind farm site. Attachment 8 provides calculations of the clearance required to achieve 2nd Fresnel zone clearance for microwave links near the turbines. However three of the link path have sufficient vertical clearance over the turbines as shown in Attachment 7. The Optus microwave link does not have sufficient vertical clearance and therefore will require horizontal clearance to the wind turbines as indicated.

8.9 The Air Services facility at Mt Majura includes aircraft radar which is about 40 km from the wind turbines .The adjacent Capital wind farm has turbines at a lesser distance. On the basis that the currently operating Capital wind farm is acceptable to Airservices it is unlikely that there would be any objection to the CWF II wind turbines at similar distances from Mt Majura. Other Airservices radio systems on Mt Majura and on other sites around the Canberra airport are also unlikely to be impacted by turbines due to the separation distance and the nature of the services which are ground to aircraft communications or localized navigational aids where the wind turbines 40 km away will not obstruct the radio signal path to aircraft at operational heights above ground. It is recommended that all appropriate Aviation Authorities be advised of the project to confirm that no interference is foreseen.

9. FORTUITOUS RECEPTION OF BROADCAST SIGNALS

On some previous projects Responsible Authorities have imposed conditions such as:
"if the qualitative survey establishes any detrimental increase in interference to reception or transmission measures must be taken to mitigate the interference to return the affected reception or transmission to pre-construction quality"
(Waubra Vic Planning Permit No PL-SP/05/0150),
This raises two issues, the first being the criteria for interference assessment and the second being the protection of reception of some services outside their designed coverage area - termed fortuitous reception. For analogue television reception which is the most vulnerable service for turbine interference it is proposed to use the ITU grade 4, of a 5 grade impairment scale as the limit of acceptance, which is described as "perceptible but not annoying". On the second point, the ACMA's attitude to protection of reception outside designed service areas is understood to be that the reception is fortuitous and will not be protected. They will therefore plan for reuse of frequencies for new stations which in future may impair reception in areas where it is currently acceptable or useable, often for at least part of the time.

This is, of course, difficult for individuals to accept who, due to their particular location, cannot receive an acceptable service from their planned station. Others may use distant stations to avail themselves of diverse programs. It is not reasonable to attempt to protect these services which are likely to be of low signal level and may vary in quality of reception depending on time of day, weather patterns and season. It is therefore not recommended to mitigate any reception which may be impacted by turbine effects where the receivers are clearly outside the ACMA planned coverage area for the particular service being received.

10. MITIGATION TECHNIQUES

For individuals who experience a degraded FM or TV broadcasting service due to identified interference from the wind farm, 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, e.g. Illawarra or Goulburn instead of Canberra.

5. Use available digital TV Channels instead of analogue (requiring a digital Set Top Box or digital TV set), and change the orientation of antennas to receive an alternative station if available, e.g. Illawarra or Goulburn instead of Canberra.

6. Provision of an alternative satellite service eg, Free to Air, VAST Service (Ref. 9) or Austar Pay TV Service.

7. Where feasible, consideration could be given to the installation of a TV or FM Repeater station to provide service to groups of residents in a shadow zone.

8. Potential point to point system and mobile base coverage conflict is not predicted with turbines being located with recommended clearance zones from radio sites or point to point ray lines. There is one Optus microwave link which does not have sufficient vertical clearance over the turbines and requires a horizontal clearance to the tip of any wind turbine blade of 15.2 metres as derived in Attachment 8.

9. 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.

11. CONCLUSIONS

Interference to MF and FM sound broadcasting is not expected.

No potential conflicts between point to point radio systems and the wind turbines have been identified which cannot be avoided by using adequate clearances. The current wind turbine locations have sufficient clearance to the radio link paths however any micro siting will require the minimum clearances derived in Attachment 8. to be maintained.

Mobile radio and other radiocommunication services in the area are not expected to be significantly impacted by the wind farm or its operation.

Analogue TV reception at dwellings up to 5 km of the wind farm turbines and with antennas having turbines located with +/- 20 degrees angle of their reception direction will have some probability of noticeable ghosting at times. Any ghosting 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 farm is expected to be a medium level signal area however there may be individual houses located in shadow areas where other mitigating techniques may need to be applied.

For any confirmed wind farm analogue interference problems where TV receiving antenna system improvements are unsuccessful, the use of a set top box with reception of the available digital channels may be the best solution. Existing Digital TV services are expect to provide unimpaired picture to any houses near the turbines which may have experienced picture quality problems as a result of ghosting on analogue TV services from the turbines as long as the signal levels have a suitable margin above a threshold level. In view of the transition to Digital TV in Australia as indicated above analogue transmissions will cease by mid 2012 in this area. Provision of digital TV solutions to any degraded analogue reception is simply advancing an inevitable transition to digital reception.

Alternatively a satellite service could be considered if digital TV reception is found to be unsatisfactory in individual cases. The VAST satellite delivered service recently announced by the Government (Ref. 9) will provide digital TV services to viewers in eastern Australia who cannot receive terrestrial digital TV.

Overseas experience indicates that EMI produced by the wind farm generators and controls is not a problem with reputable world class wind turbine manufacturers and therefore no electrical noise measurements from the electrical generators are warranted.

REFERENCES

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7. BBC, Ofcom, UK, The Impact of Large Buildings and Structures (Including Wind Farms) on Terrestrial Television Reception

8. D. F. Bacon, A Proposed Method for Establishing an Exclusion Zone around a Terrestrial Fixed Link outside of which a Wind Turbine will cause Negligible Degradation of the Radio Link, Ofcom UK Report Ver 1.1, 28 Oct 2002

9. Senator the Hon. Stephen Conroy, Media Release, Digital Television Australia Wide, 5th January 2010

ATTACHMENT 1 –CAPITAL WIND FARM TURBINE COORDINATES

CWF II (Extension) Layout "A" Locations

	UTM WGS84 S Zone 55		
Description	X	Y	Z
A1	727045	6117169	
A2	726999	6117020	
A3	726957	6116873	
A4	726913	6116724	
A5	726871	6116575	
A6	726832	6116427	
A7	726785	6116277	
A8	726747	6116126	
A9	726701	6115972	
A10	726657	6115827	
A11	726497	6115695	
A12	726336	6115563	
A13	726176	6115431	
A14	726015	6115299	
A15	727166	6112396	
A16	727180	6112088	
A17	727179	6111759	
A18	727183	6111459	
A19	725794	6111190	
A20	725700	6111049	
A21	725613	6110911	
A22	725519	6110770	
A23	725432	6110632	
A24	725351	6110492	
A25	725267	6110351	
A26	725179	6110214	
A27	725103	6110076	
A28	725187	6109821	
A29	725272	6109567	
A30	725357	6109313	
A31	725200	6109026	
A32	724719	6107786	
A33	724658	6107643	
A34	724602	6107497	
A35	724540	6107347	
A36	724481	6107202	
A37	724423	6107056	
A38	724370	6106908	
A39	724310	6106762	
A40	724248	6106615	

A41	724188	6106475	
A42	724130	6106324	
A43	724041	6106094	
A44	723981	6105950	
A45	723918	6105801	
A46	723861	6105656	
A47	723812	6105519	
A48	723755	6105385	
A49	724934	6105352	
A50	724857	6105223	
A51	724776	6105095	
A52	724702	6104969	
A53	724623	6104843	
A54	724546	6104714	
A55	724466	6104586	

CWF (As Built) Locations

	UTM WGS84 S Zone 55		
Description	X	Y	Z
WTG 01	725671	6113442	728.6
WTG 02	725719	6113183	735
WTG 03	725582	6112927	736.7
WTG 04	726736	6112904	750
WTG 05	726656	6112620	743.5
WTG 06	729110	6113888	780.8
WTG 07W	729052	6113676	780.6
WTG 08	729025	6113433	799.7
WTG 09	729171	6113174	799.4
WTG 10W	728992	6113050	783.2
WTG 11	728838	6112884	782.6
WTG 12W	728635	6112788	793.6
WTG 13	728460	6112657	822
WTG 14W	728504	6112435	805.6
WTG 15	728556	6112222	796.8
WTG 16W	728162	6112208	759.5
WTG 17W	728142	6112007	749.7
WTG 18	725106	6108763	728.2
WTG 19W	725039	6108551	747.3
WTG 20W	724962	6108341	762.6
WTG 21	724879	6108127	742.3
WTG 22	726499	6107927	834
WTG 23	726084	6107776	788
WTG 24W	726007	6107558	769.3
WTG 25W	725702	6107385	762.3
WTG 26	725604	6107203	766.7

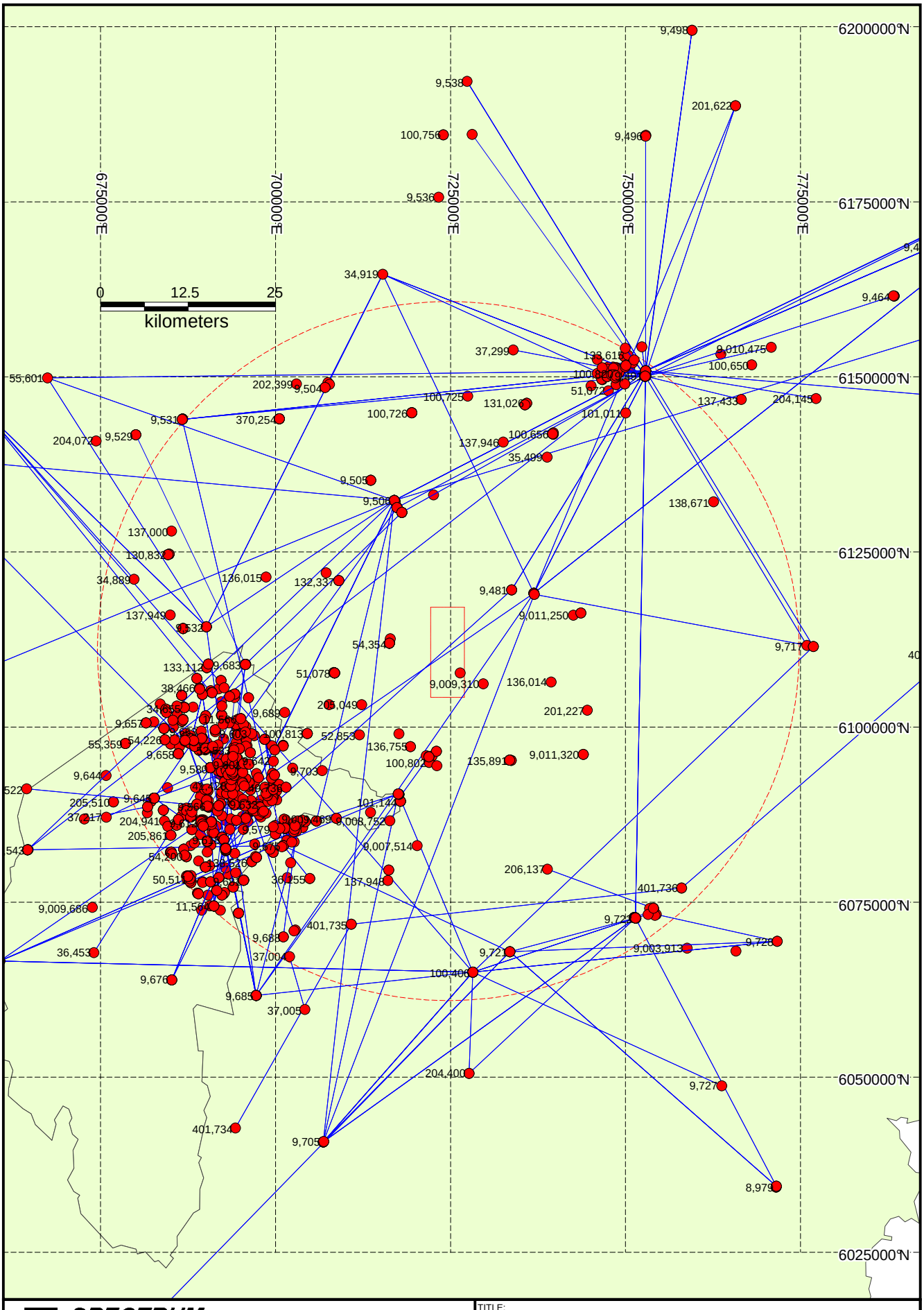
WTG 27	725768	6106865	768
WTG 28	725619	6106610	760.1
WTG 29W	725505	6106377	769.2
WTG 30	725573	6106179	763.5
WTG 31W	725532	6105954	743.1
WTG 32	725541	6105717	742.9
WTG 35	729805	6108752	814.9
WTG 36	730224	6108632	836.3
WTG 37W	730235	6108404	843
WTG 38	730188	6108199	855.6
WTG 39	731399	6107915	846.8
WTG 40W	731225	6107737	847.1
WTG 41	731167	6107491	859.9
WTG 42	730691	6107554	864.7
WTG 43W	730682	6107324	862.4
WTG 44	730523	6107169	857.6
WTG 45	730149	6107219	858.9
WTG 46W	730068	6106999	869
WTG 47	730199	6106606	868.7
WTG 48	729796	6106460	921.4
WTG 49W	729779	6106248	924.2
WTG 50	729643	6106078	915
WTG 51W	729639	6105897	914.4
WTG 52	729500	6105785	897.7
WTG 53W	729348	6105629	875.1
WTG 54	729281	6105415	869.2
WTG 55W	729149	6105233	858.8
WTG 56	729077	6104989	849.5
WTG 57	729527	6105164	859
WTG 58	729444	6104806	893.3
WTG 59W	729363	6104597	888.8
WTG 60	728861	6104606	854.8
WTG 61	729226	6104411	888.5
WTG 62W	729254	6104169	882.4
WTG 63	729230	6103969	884
WTG 64	725709	6114356	758
WTG 65	725658	6114675	761
WTG 66	725784	6114913	746.1
WTG 67	725855	6115168	740.7
WTG 68	726011	6113992	746
WTG 69	726856	6113198	730.6

ATTACHMENT 2 - TELEVISION STATIONS & CHANNELS IN THE AREA

Transmitter Location/service	Operator	Analog Channels	Digital Channels	Comment
Black Mountain/ Canberra	SBS	28H	30H	UHF
	ABC	9V	9AV	VHF
	WIN	31H	11V	UHF/VHF
	CBN	34H	12V	UHF/VHF
	CTC	7V	6V	VHF
Knights Hill /Illawarra	SBS	53H	54H	UHF
	ABC	56H	51H	UHF
	WIN	59H	36H	UHF
	CBN	65H	38H	UHF
	CTC	62H	37H	UHF
Mt Gray / Goulburn	SBS	58V	59V	UHF
	ABC	55V	56V	UHF
	WIN	61V	62V	UHF
	CBN	64V	65V	UHF
	CTC	10V	68V	VHF/UHF
Mt Canobolas / Central Tablelands	SBS	30H	Reception?	UHF
	ABC	1V	Reception?	VHF
	WIN	40H	Reception?	UHF
	CBN	8V	Reception?	VHF
	CTC	33H	Reception?	UHF

ATTACHMENT 3 - Radio Link Map 40- 999 MHz Frequencies

Displayed on following page



SPECTRUM ENGINEERING AUSTRALIA *Pty Limited A.C.N. 008 642 028*

Radiocommunications Planning and Design

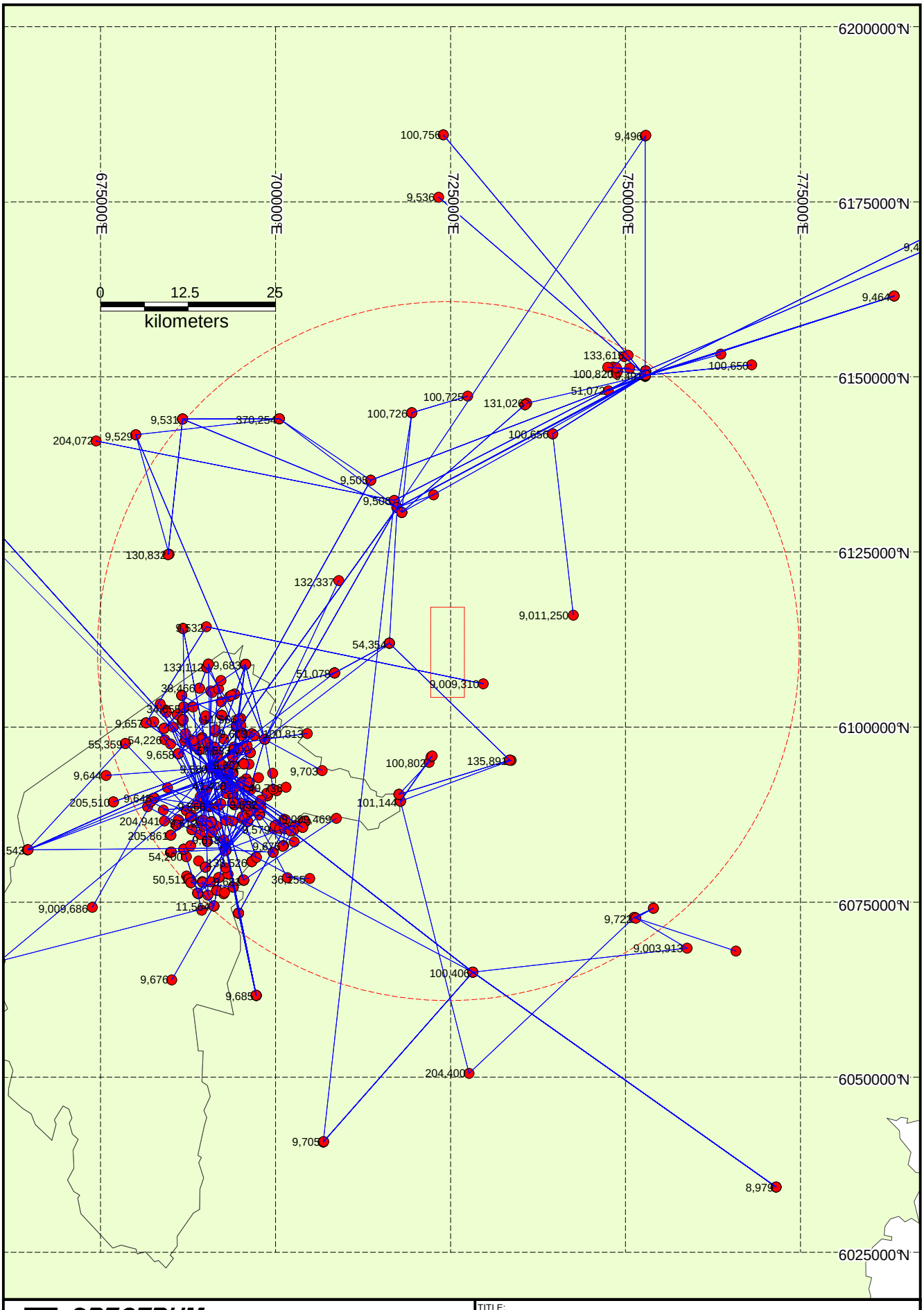
Postal: P.O. Box 3213, BELCONNEN ACT 2617
Telephone: 02 6253 2555
Facsimile: 02 6253 2800

TITLE: **40 - 999 MHz Assignment**
As Extracted from RRL Database

FILENAME:	40 - 999 MHz Capital II Windfarm	DATE:	7/5/2010
PROJECT:	Capital II Windfarm	SCALE:	N/A
DRWG NO:	1 of 2	BY:	SEA

ATTACHMENT 4 - Radio Link Map above 1 GHz Frequencies

Displayed on following page



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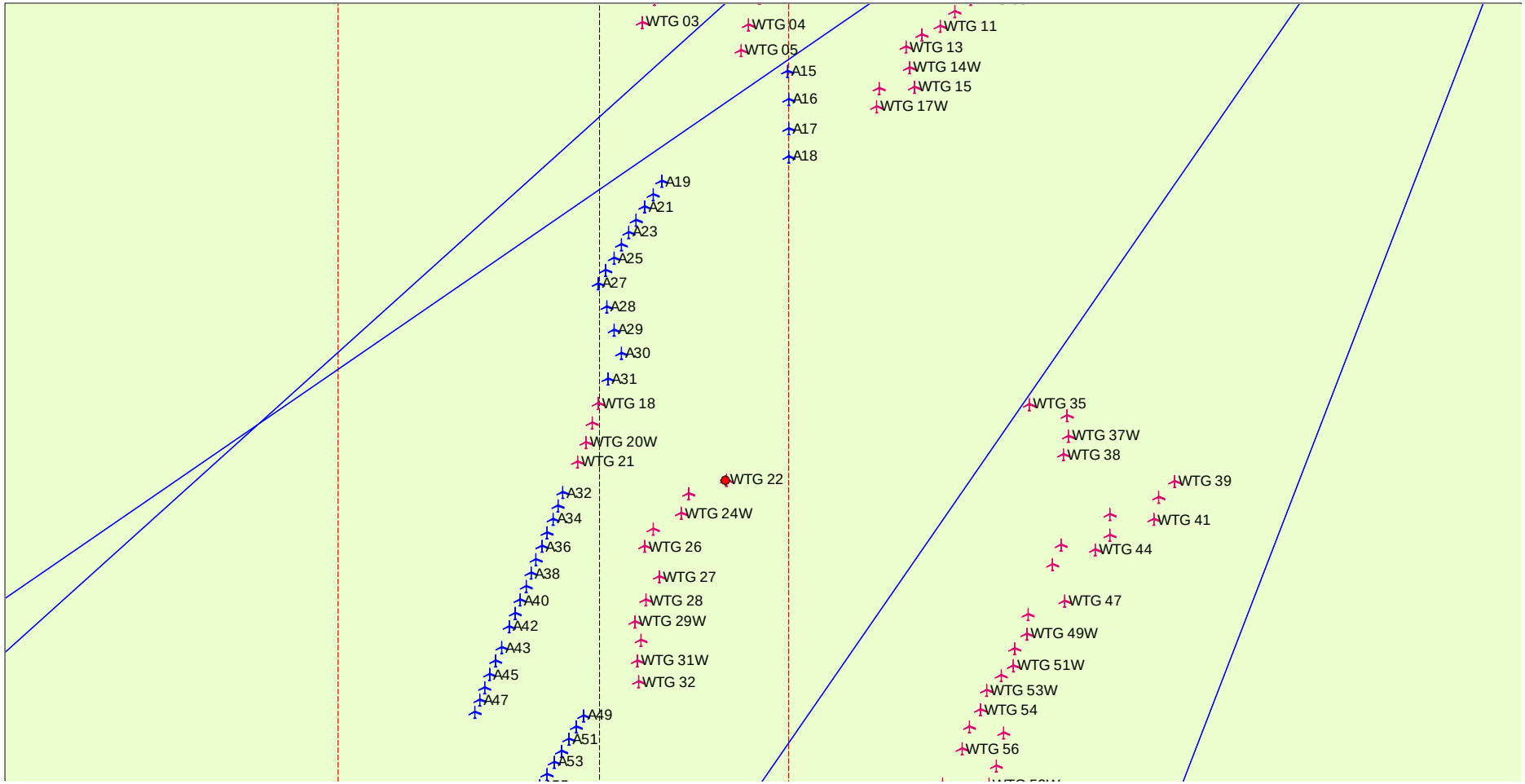
Postal: P.O. Box 3213, BELCONNEN ACT 2617
Telephone: 02 6253 2555
Facsimile: 02 6253 2800

TITLE: **Above 1 GHz Assignment**
As Extracted from RRL Database

FILENAME:	Above 1 GHz Capital II Windfarm	DATE:	7/5/2010
PROJECT:	Capital II Windfarm	SCALE:	N/A
DRWG NO:	2 of 2	BY:	SEA

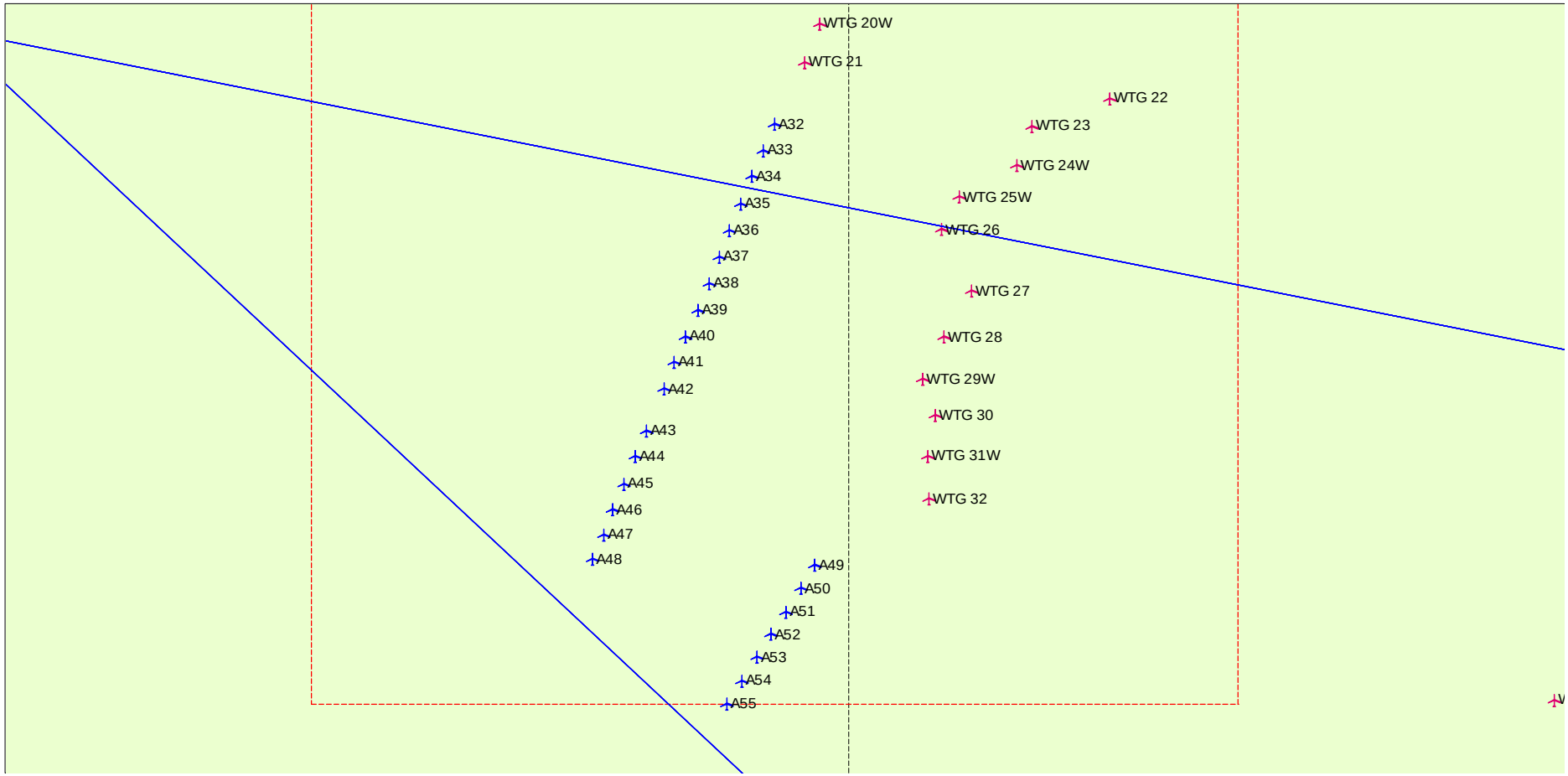
ATTACHMENT 5 - MAP OF VHF/UHF LINKS CROSSING WIND FARM

CWF TURBINES IN BLUE

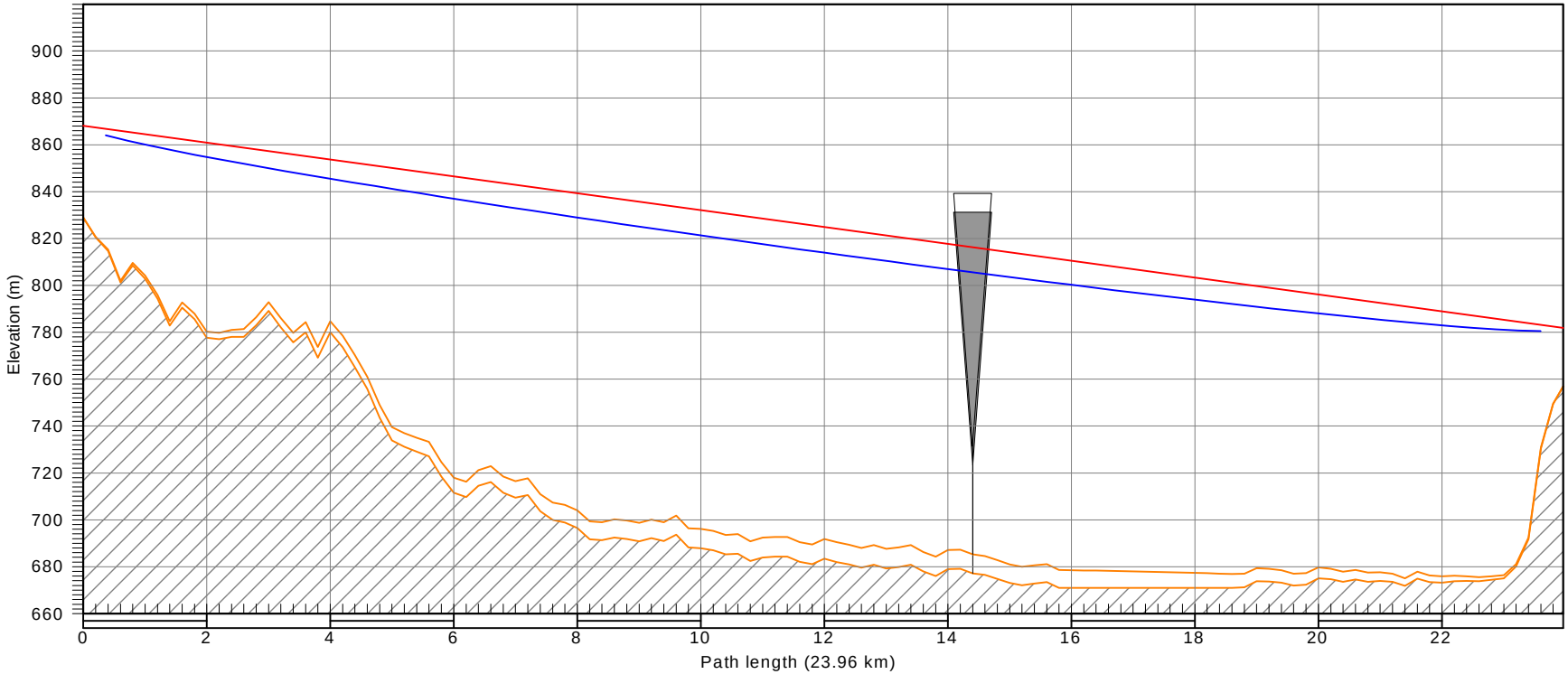


ATTACHMENT 6 - MAP OF MICROWAVE LINKS CROSSING WIND FARM

CWF TURBINES IN BLUE



ATTACHMENT 7 – PATH PROFILES OF RADIO LINKS CROSSING WIND FARM



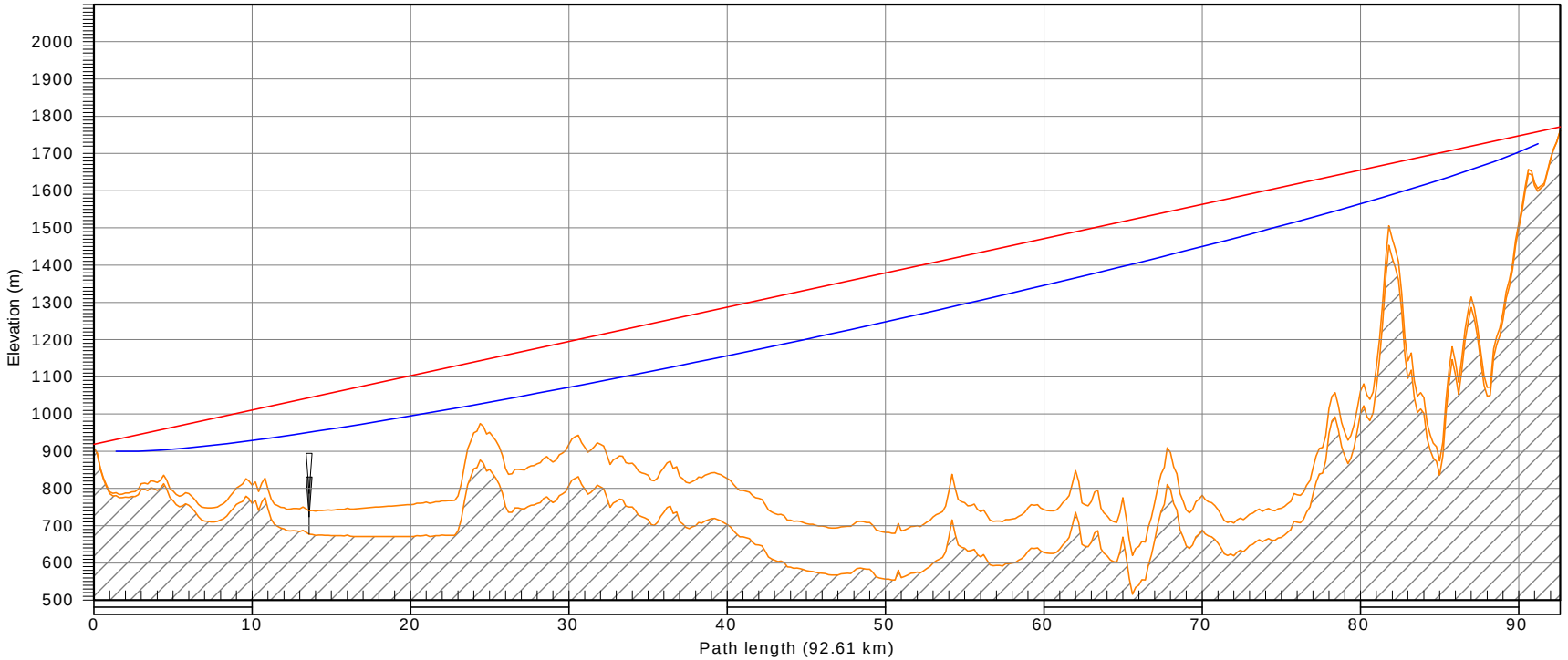
204727	
Latitude	35 15 24.85 S
Longitude	149 34 02.36 E
Azimuth	312.71°
Elevation	829 m ASL
Antenna CL	39.0 m AGL

Frequency (MHz) = 15000.0
K = 1.33
%F1 = 100.00

Lawrence Derrick & Associates

54354	
Latitude	35 06 36.91 S
Longitude	149 22 27.13 E
Azimuth	132.82°
Elevation	757 m ASL
Antenna CL	25.0 m AGL

	Sep 14 10	



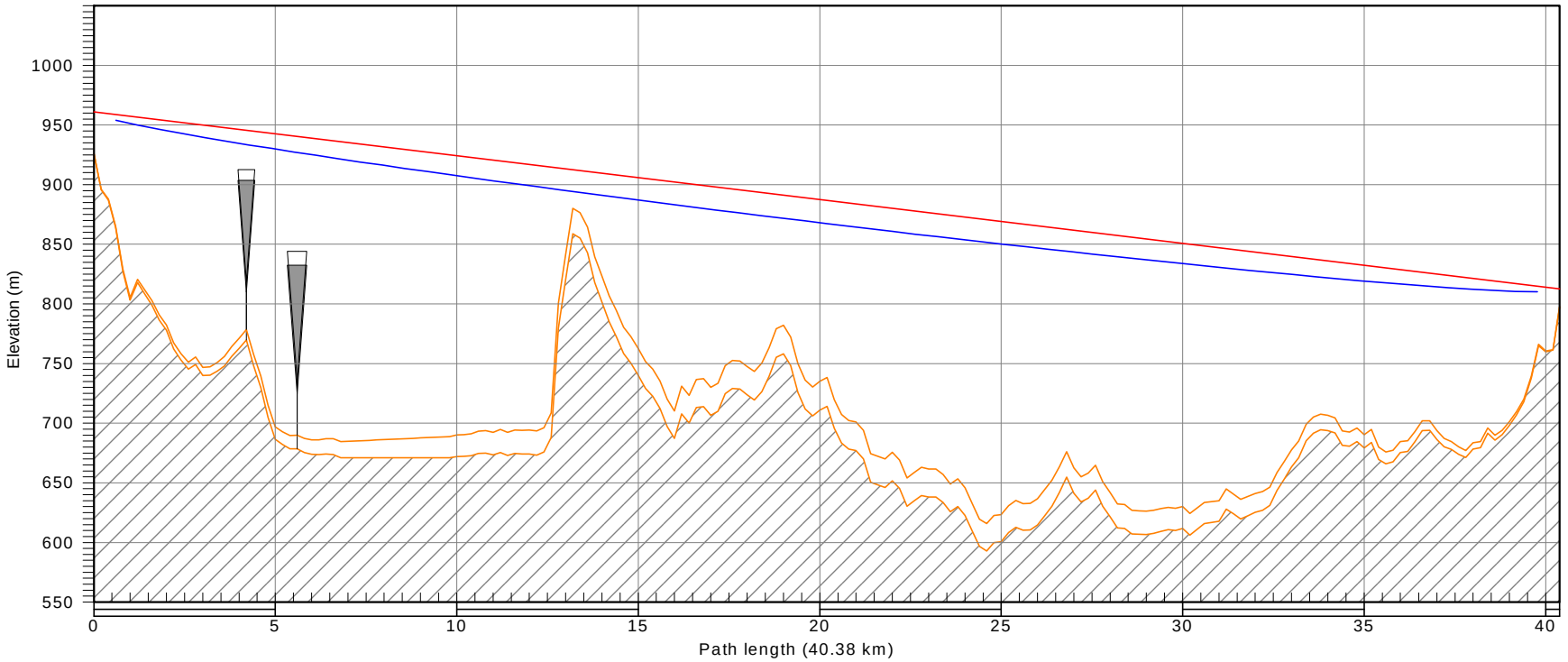
201623	
Latitude	35 02 28.87 S
Longitude	149 35 54.13 E
Azimuth	233.97°
Elevation	909 m ASL
Antenna CL	10.0 m AGL

Frequency (MHz) = 400.0
K = 1.33
%F1 = 100.00

11542	
Latitude	35 31 46.39 S
Longitude	148 46 21.40 E
Azimuth	54.45°
Elevation	1761 m ASL
Antenna CL	10.0 m AGL

Lawrence Derrick & Associates

	Sep 14 10	



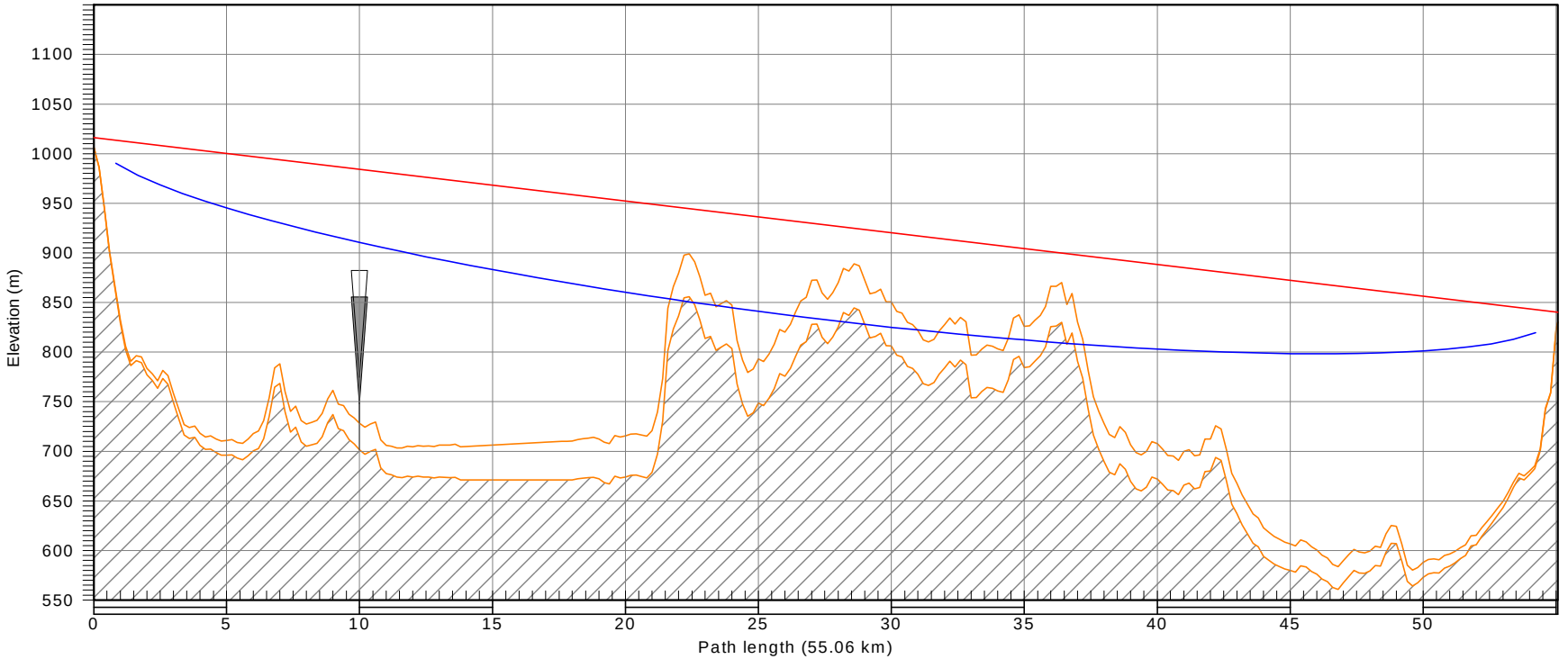
9009310	
Latitude	35 09 33.84 S
Longitude	149 31 21.50 E
Azimuth	280.18°
Elevation	926 m ASL
Antenna CL	35.0 m AGL

Frequency (MHz) = 8000.0
K = 1.33
%F1 = 100.00

9532	
Latitude	35 05 39.39 S
Longitude	149 05 12.34 E
Azimuth	100.43°
Elevation	798 m ASL
Antenna CL	15.0 m AGL

Lawrence Derrick & Associates

CWF I & CWF II Turbines shown	Sep 14 10	



9481	
Latitude	35 02 15.63 S
Longitude	149 33 48.99 E
Azimuth	226.49°
Elevation	1006 m ASL
Antenna CL	10.0 m AGL

Frequency (MHz) = 450.0
K = 1.33
%F1 = 100.00

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9619	
Latitude	35 22 42.90 S
Longitude	149 07 26.86 E
Azimuth	46.74°
Elevation	830 m ASL
Antenna CL	10.0 m AGL

	Sep 14 10	

ATTACHMENT 8 – RADIO LINK DATA AND CLEARANCES

A search of the AMCA Radcom Data Base indicates that there are four Point to Point Links which require consideration in maintaining adequate clearance to the wind turbines and their towers for the proposed CWF II wind farm layout. From the path profiles shown in Attachment 7 three of the links have sufficient vertical clearance over the tip of the blade at 157 metres above ground level. The remaining microwave link operated by Optus needs to have adequate horizontal clearance between its ray line and the tip of the blade of turbines

In the event of a point to point microwave 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:

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

The second Fresnel zone clearance is normally applied to microwave systems (> 1000 Mhz operation) [For VHF and UHF systems a "Free Space" clearance of 0.6 times the first Fresnel zone distance is considered appropriate due to the bending of radio waves around objects at these lower frequencies].

In this case the details of the link are:

1. Site 204727 to Site 54354

   Operator: Optus
   Frequency Band 15 GHz
   Calculated Path Length : 23.96 km
   Distance to nearest turbine from radio site 14.44 km
   Clearance to WTG 2nd Fresnel Clearance D1

   D1 = SQRT(2λ x d1 x (1 – d1/d2)

   =SQRT((2x300/15000) x 14440(1- 14.44/23.96))

   = 15.15 metres

The clearance to the tip of 57 metre blades for the closest turbine is therefore required to be 15.15 metres ie the tower centreline is required to be 57 + 15.15 = 72.15 metres from the ray line. A clearance corridor of 2 x 72.15 = 144.3 metres in total width is therefore required. This calculated clearance is for the current turbine layout at the location of the line of turbines closest to the rayline. The greatest clearance required for any link occurs at the centre point of the link path and in this case at 11.98 km from either end. The maximum clearance is calculated to be 15.48 metres.

SUMMARY OF CLEARANCE REQUIREMENTS

LINK Site 1 to Site 2	TOTAL CORRIDOR WIDTH Metres	Bearing from Site 1 ˚T	Coordinates of Site 1 WGS 84 Zone 54
204727 (Bungendore) to 54354(Gearys Gap)	144.3	312.71	E733564 N6095445

ATTACHMENT 9 – PREDICTED INTERFERENCE LEVELS TO TELEVISION RECEPTION

The estimates below of reflection of TV signals from generator blades use the formulas in Ref.1 and the details of a REpower 3.xm generator has been used as a typical example. This is a three bladed 52 metre radius rotor on a tower of 90 metres in height. REpower data suggests that the blades have the following planform area. Other blade details are assumed from other types of blades where data was available:

Planform Area of each Blade approx 110 m² (calculated)
Coning Angle 4.3 degrees (assumed)
Twist of Blade 9.9 degrees (assumed)
Lightning Protection bus inside Blade 60mm² stainless steel (assumed)

Signal Scattering Efficiency η_S

η_S = 0.8x0.41 x exp(- 2.3Δβ) for non-metallic blades

$\Delta\beta$ = total blade twist = 9.9/180 x π

η_S = 0.8 x 0.41 x 0.67206

= 0.2204

lightning protection 60mm² cable could increase efficiency by 20% so

η_S = 0.264

For VHF TV at on say Channels 7 & 9 (190 MHz)

Effective Number of Blades for receiver in the back and forward scattering zones

$$B_e = 1 + \sin c\left\{\frac{2\pi R}{\lambda}\sin(2\theta)\cos(k)\right\} \le B_e \max$$

$k = \phi_{RT}/2$ for backward scatter zone

$k = 2\phi_{RT}$ for forward scatter zone

$$B_e = 1 + \sin c\left\{\frac{2\pi 52}{300/190}\sin 2x4.3\right\}$$

= 1 – 0,01473 = 1 (approx)

where $B_e \max = 1 + \frac{\lambda R}{A_P}$ (Note 1.)

= 1 + 300/190x52/110 = 1.746

therefore B_e = 1.0 is applicable

$$Z_I = \eta_S \frac{B_e A_P}{\lambda D}\cos(k)$$

= 0.264x1x110x190/(300x1000) for D = 1km for the maximum directions

= 0.018392

= -34,07db
= 0.264x1 x110x190/(300x250) for D = 250m for the maximum directions
= .073568
= -22.65db

The required wanted to unwanted signal ratio for a just perceptibly degraded TV picture as a function of the time difference between the wanted and unwanted signals is shown in Fig. 2 of Ref. 4 and varies between 28db (<1μs delay) and 34db(>5μs delay). If it was assumed that the wanted signal strength at the residents' TV antennas was the same as at the generator centre, from the above signal scatter ratio estimates perceptible TV picture degradation would occur up to near 1000 metres from generators in the forward scatter area. No TV receiving antenna discrimination is possible in the forward scatter case. As, in fact, the signals at the lower height TV antennas in the close in areas will be lower than at the 90m generator height by, for example 6 db, perceptible interference up to 2.0 Km is predicted.

Similar estimates have been made for other UHF channels. The signal scatter ratios for representative UHF channels are summarised below:
Channel 65 (765 MHz) at 2Km $Z_I = -28.63db$
Channel 34 (570 MHz) at 2Km $Z_I = -31.19db$

The calculations also show that at 3Km
Channel 65, $Z_I = -32.15db$.
Channel 34, $Z_I = -34.71db$.

With assumption that the TV signal at the turbine height may be 6 dB greater than at the residents antenna these figures indicate that there is a potential for interference for the UHF channels up to and beyond 5 Km from the generators in the forward scatter region.

Scatter from multiple generators would be additive to some degree at each receiver.

These estimates do not take into account any terrain profile influences where wind turbines or the TV transmitting station may or may not both be in the line of sight from the TV receiving antenna

Note 1. The formula for $B_{e,\max}$ was established for a 3 bladed generator in a recent exchange of emails with Prof. Sengupta, of the University of Michigan, USA, one of the Authors of Ref.1.

ATTACHMENT 10- 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
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
SCADA	Supervisory Control and Data Acquisition