APPENDIX 17

Boco Rock NSW Wind Farm – Investigation of Possible Impacts on Radiocommunication Services

Lawrence Derrick & Associates

BOCO ROCK NSW WIND FARM - INVESTIGATION OF POSSIBLE IMPACTS ON RADIOCOMMUNICATION SERVICES

[final]

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

CONTENTS

1 EXECUTIVE SUMMARY

Wind Prospect are considering a proposal for the construction of a wind farm at Boco Rock near Nimmitabel in NSW.

A large number of existing ACMA registered radiocommunication services are located in the general area and a few point-to-point radio services cross the wind farm nominal site boundaries. To ensure that the locations of turbines will not potentially degrade the radio services minimum separation distances and exclusion zones are to be established for the turbine structures. The area surrounding the wind farm is also provided with TV, FM Sound and other services from transmitters located on Brown Mountain and other sites. Identification of the TV/Sound broadcasting stations providing service to the area is required to facilitate correspondence with the organisations involved to request an impact assessment on these services.

This Report provides an analysis of each of the radio facilities registered near the wind farm and establishes recommended clearances based on accepted industry criteria for radio links crossing the wind farm and any required buffer zones for other radiocommunications sites.

2 INTRODUCTION

This Report considers the potential impact on radiocommunications systems existing in the area of the proposed Wind Prospect wind farm at Boco Rock and includes the specification of necessary clearances to be maintained between the ray lines of point-to-point radio systems which cross or approach the wind farm boundaries. The potential impact relates to the physical presence of the wind turbine structures including the towers, nacelle and the blades in the vicinity of the radio path or the radio terminal sites. Electromagnetic radiation from the generators and the power distribution system has not found to be an issue for modern installations and is not considered in detail in this Report.

3 EMI EFFECTS OF WIND TURBINES

The following is an extract from Ref. 6:

"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. 1) 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.

4 METHOD OF ANALYSIS

The preliminary wind farm site boundaries provided by Wind Prospect are shown in Attachment 1. For simplicity in the analysis the coordinates of the North Eastern and South Western ends of the wind farm have been used to define a rectangle to determine the radio links crossing or approaching the site.

4.1 Objective of this Study

The objective of this study and Report is to determine the clearance requirements for the radio services in the area to allow a turbine layout to be planned so that there will be no detrimental effects on the performance of the existing services. The object also is to derive a minimum required buffer zone for the omnidirectional services including mobile radio base stations and any TV/ FM Broadcasting transmitting station while ensuring an acceptable grade of protection.

4.2 Scope

The criteria for clearance of obstructions from point to point link ray lines has been well established in the literature including for the specific case of rotating turbines. For omnidirectional mobile and other services however any need for a buffer zone is usually dismissed on the basis of the accepted variability of coverage to/from the mobile or hand held terminals in the normal operational environment. The known exception to this is the SA DTEI guidelines prepared by Telstra where an exclusion zone for the SA – GRN 400 MHz mobile radio base stations has been derived. This Report considers the factors involved in the specific services in the area and proposes what are considered to be acceptable clearance zones.

The possible impact on Free-to Air TV and radio Broadcasting services to residents near the wind farm is outside the scope of this Report however the appropriate Organisations operating these services which cover the general proximity of the wind farm have been identified for contact with them.

4.3 Assumptions

The source of data for the existing services in the area is the ACMA data base for licensed radiocommunication services both from the latest issued CD and the ACMA public web site. The accuracy of the location of towers is that contained in the data base, shown in some cases to be within 10 metres and in the others within 100 metres. No check survey has been carried out.

It is also assumed that modern wind generators are well shielded to international standards and are not the source of any significant generated electromagnetic interference in the frequency bands used in radio services in the area. This report considers the reflection, scattering or obstruction of signals to the radio services, potentially caused by close spacing of the turbines to these services.

5 WIND TURBINE IMPACTS ON RADIO COMMUNICATIONS

The paper by D. F. Bacon in 2002, Ref. 1, appears to have become the most used reference by the industry for the calculation of clearance zones from turbines to the ray line and antennas for point to point links. The Paper identifies three principal mechanisms which are relevant to a wind turbine in proximity to a microwave link. These are:

5.1 Near-field Effects

A transmitting or receiving antenna has a near-field zone where local inductive fields are significant, and within which it is not simple to predict the effect of other objects. Bacon's paper provides the well known formulae for calculation of the near-field distance depending on the gain or physical aperture of antenna. The near field distance is a function of frequency and the physical dimensions or gain of the antenna

5.2 Diffraction

An object detrimentally modifies an advancing wavefront when it obstructs the wave's path of travel Here the formula applied is for the classical Fresnel zone distance where diffraction will be insignificant if obstructions are kept outside a volume of revolution around a radio path.

5.3 Reflection

The physical structure of the turbine and in particular the rotating turbine blades reflects interfering signals into the receiving antenna of a fixed link. A formula is given to derive a distance from the radio path where any reflected/scattered signal will be of an amplitude sufficiently smaller than the direct signal arriving at the receiver. The acceptable Carrier/Interference (C/I) ratio will depend on the modulation and coding schemes of the link. Bacon's Paper provides formulas to calculate the distance from the link path where the C/I will be below a desirable level depending on the link parameters.

The calculation of the scattering level of RF signals from turbines is complex and varies with RF frequency, physical dimensions of the turbine blades and their twist, tilt and orientation. Radar Cross-section (RCS) values are used in the Bacon paper and elsewhere to account for the scattering characteristics of individual turbines. A wide spread of values appear in the literature for typical modern turbines which makes the estimation of the scattered signal levels uncertain. It is noted that the Bacon Paper uses an RCS value of 30 m² whereas the SA DTEI guidelines uses a value of 480 m² which is the total area of the 3 blades based on an assumed width of 4 metres each and lengths of 40 metres. In another British, study Ref. 3, the RCS of turbines were modelled and validated with actual field measurements. This study was focused on the aviation radar signatures of wind farms and measurements were carried out with radar in the 1 to 3 GHz range. Peak RCS values can significantly exceed the physical area of the turbine but they will occur over narrow arcs. The wind generator nacelle and the general shape of the tower itself can make significant contributions. A 100metre tall tower with 45metre turbine blades was estimated to have a maximum peak RCS of 25000 m². According to the Report this high peak was probably associated with a particular style of nacelle and tower. For the purposes of this study a peak of 1000 m² associated with the blades is considered appropriate. The RCS will of course vary with wind direction, blade pitch and other design factors including rotor tilt and coning angle. Multiple turbine interference from a wind farm will also be additive on a power basis due to the uncoordinated sources from physically separated locations.

5.4 Omnidirectional Services

The Bacon paper was written for the point to point radio link situation and no omnidirectional system (eg mobile radio base station) was considered. The DTEI guidelines have been developed for omnidirectional mobile services from the Bacon paper by applying the formula for the point to point link reflection/scattering case to an omnidirectional service. It further derives another criteria for the case where the remote mobile/portable unit is located at points where a turbine is in line with the transmission path to the base station. A criteria of no more than 10% of the fresnel zone width being blocked by a blade width of 4 metres appears to have been employed to derive an exclusion zone. This purports to limit signal variations as a result of the turbine to 0.5 dB

6 EXISTING SITUATION/ENVIRONMENT

From the latest ACMA database maps have been prepared showing registered radio sites and point to point links in the area. Attachment 2 shows the situation for system with frequencies below 1000 MHz with zoomed views in Attachments 3 & 4. Attachment 5 shows the links and sites for systems operating on frequencies above 1000 MHz . Typical calculations of required clearances are shown in Attachment 6 using the formulas in Bacon's paper

6.1 Point to Point Systems

There are 3 Point to Point links in the 400/450 MHz bands operated by Alinta Gas, NSW Rural Fire and NSW Rural Ambulance on 2 paths which cross the site. 4 other links on 3 paths operated by NSW Police, Telstra and Soul Pattinson which are near but outside the site boundaries have also been identified.. A summary of the calculated Near Field and 2nd Fresnel zone clearance at mid-path and at 1 KM are shown below.

PATH ACMA Site ID's	Total Path Dist. km	ANTENNA Dia. or Gain/ frequency	Near Field Distance M	Mid Path Fresnel Zone Distance M	1 Km Fresnel Zone Distance M
9778-9803	89.41	14.2dB/450 Mhz	5.8	172.6	36.3
9778-9803	89.41	14.2dB/400 MHz	6.6	183.1	38.5
401732-401733	54.84	14.2dB/450 MHz	5.8	135.2	36.2
9795-12086	71.74	16.2dB/900 MHz	4.6	109.3	25.7
9795-9001014	13.27	0.6M/ 18GHz	64.8	10.5	5.6
9795-9790	26.11	3.7M/ 6.7GHz	917.2	24.1	9.2

9795-9790	26.11	1.2M/ 1500MHz	21.6	51.1	19.6

The large near field distance calculated of 917.2 metres for the Telstra 6.7GHz link is due to the high gain antennas used. According to the Bacon paper a 360 deg. zone of this radius around each end of the link ends should be kept clear of obstructions. This seems a very conservative constraint for a high gain dish antenna where most of the energy exists in a narrow beam. However as the link sites are remote from the site boundaries this clearance is not an issue for this project.

The calculation of the reflection/scattering zone using the Bacon formula requires iteration with increasing values of the distance from the path bore sight at each distance from the terminal until the required C/I value is reached. This process is very tedious. For the three UHF links which cross the wind farm two on path 9778-9803 have sites well separated from the site and the scattering effect will be negligible. The link 401732 – 401733 has one site closer to the wind farm boundaries. A path profile shown in Attachment 7indicates that the path is not line of site (LOS) being obstructed by the terrain. This suggests that this may be a SCADA link as they are able to operate on non LOS paths and in this case for pipeline monitoring/control. Turbines on the ray line and for significant distances off the path may cause rhythmical increases of the received signal level with unacceptable link performance. Further study is required to estimate the clearance zone necessary and Alinta may need to be consulted. A path profile is shown in Attachment 8 for the LOS path across the site

6.2 TV & FM Broadcasting Services on Brown Mountain

A main National TV and FM Broadcasting stations are located on Brown Mountain (ACMA Site ID 9795). and is about 8 km from the nominal eastern site boundary

Site/Service	Antenna Gain/frequency	Near Field Distance M	Scattering Clearance M
9795/189.5 MHz ABC TV Broadcasting	Omnidirectional assume gain of 13 dB	10.5	300*
9795/99.3 MHz, 100.1 MHz & 100.9 Mhz FM Broadcasting	Omnidirectional assume gain of 10 dB	10	300*

- C/I of > 30dB

6.3 Air Services Radar

An Air Services Radar facility near Cooma is registered on site 200411.which is about 22 km from the NW corner of the wind farm site. As wind turbines can create false echoes for radar consideration of this site is required. A path profile suggests that due to the terrain the turbines will not be in line of site of the radar and therefore should not be an issue.

6.4 Other Radio Sites

The following table lists sites which are adjacent to the wind farm site boundaries and need to be considered from a buffer zone point of view

Site/Service	Antenna Gain/frequency	Near Field Distance M	Scattering Clearance M
9779 / 450 MHz NSW SES Mobile Radio Base	Omnidirectional 8.2 dBi gain 2.8 M length, 476.6 MHz/	1.38	200*
402457 / 400 MHz NSW Rural Fire Mobile Radio Base	Omnidirectional 2.2 dBi gain, 450 MHz	0.37	200*
9001014 / 800 MHz Telstra Cellular base	Omnidirectional 12.5 dB gain, 900 MHz	2.0	300**

9791 / 1.5 GHz Telstra link site	1.8 metre dish	48.6	N/A
9795/ 3.4 GHz Telstra Point to Multipoint	Omnidirectional 10 dB gain, 3.4 GHz	0.3	300**
9795 / 120 MHz Airservices Air-Ground base	Omnidirectional 120 MHz	N/A	N/A

* C/I of >26 dB
**C/I of >30 dB

7 POTENTIAL IMPACTS

The Calculations for the scattering cases summarised above are based on a reasonable high RCS for the turbines and represent a peak level, bearing in mind that the scattering from a turbine will vary with its orientation which changes with wind direction and speed. For the near field calculations a conservative factor of 3 has been applied as suggested by Bacon. Also the Bacon suggested second Fresnel zone clearance has been used which is also reasonably conservative, although Ref. 6 has suggest that 3 times the first Fresnel zone distance could be applied. No account has been taken of the topography of the area including possible obstructions to either the wanted signal or turbine locations at specific locations where portable or mobile units may be used or where FM broadcast receivers in cars or residences may be operated. In the final clearance zone recommendations below an additional allowance for the additive effects of multiple turbines and for a safety margin has been included.

7.1 Omnidirectional Services

The Telstra SA – GRN Guideline has an additional criteria for omnidirectional services which covers the case of mobile or portable radio units being operated in a situation where the path to/from the base station has a turbine in the first Fresnel zone on the radio path. This of course applies to both ends of the link ie near the base station and near the mobile/ portable unit. The 1200metres zone proposed in the guideline would equally apply throughout the mobile service area which could be 30 Km in radius. The outcome of this is that operation of the terminals would need to be protected within 1200 metres from each turbine wherever it was located in the mobile service area. A clearance zone from a base station site for this criteria is therefore not considered feasible A review of a number of reports available on radio system clearances to wind farm have not considered this issue. For example two reports, Refs 4 & 5 which considered base station clearances to turbines derived the clearances required using the scattering criteria. In one (Ref. 5, BCL NZ) a clearance of 600 metres was derived for VHF mobile base stations and the other (Ref. 4, Kordia NZ) 320 metres for both VHF and UHF mobile bases. Differences in assumptions about turbine RCS and safety margins appear to account for the differences in distance in these two reports.

7.2 Point to Point Links

The clearance distance from the link sites can be theoretical controlled by the near field distance for example one link on site 9795 requires a buffer zone of 917 Metres which strictly applies to in all angles of azimuth. As shown in the table above link paths require Fresnel zone clearance of between 10 and 183 metres at mid path of the link depending on path length and operating frequency. The Fresnel zone clearance is tapered, increasing from 0 at both ends of the links with the maximum at the mid path points. The systems on the two paths which cross or are very close to the boundaries of the wind farm site are single channel analogue or low capacity data links in the UHF band. Although it is accepted that a second Fresnel clearance should be applied to higher frequency microwave links of multi-channel capacity and is desirable for the low frequency links it could be argued that it is not essential to apply it to the UHF links on the grounds of small impact on these links. If the application of these calculated corridor widths significantly reduces the utility of the site because of reduced number of turbines possible these clearances should be reviewed in conjunction with the link operators.

7.3 TV & FM Broadcasting Services

These are omnidirectional services and have similar requirements to mobile base stations with regard to clearance zones for scattering. Based on the controlling scattering criteria a clearance of 300 metres is estimated as having negligible impact on the service coverage. For TV there is the possibility of ghosting or other effects occurring over a significant part of the service area from close spaced towers or turbines to the transmitters. It is believed in the case of the ABC TV service from Brown Mountain that there is sufficient spacing to the nearest turbines to have negligible effects. There will however be a potential to have TV reception impaired at residences close to the turbines as there will indeed be for other TV services being radiated from all other sites.

7.4 Mobile Base Stations

Once again the controlling criteria is the Scattering mechanism. 200 metres has been calculated for the SES and Rural Fire base stations. A higher C/I ratio has been used for the Telstra cellular base station resulting in a 300 metre clearance.

8 MANAGEMENT/MITIGATION

As there are two paths which cross or are very close to the site corridor clearances for those are summarised below. Although the Fresnel zone clearance requirement is tapered, increasing from low values near the link ends to maximum at mid path it is proposed that that a simple fixed width corridor be defined. Corridor widths of the mid path clearances should be employed which will cover the scattering clearances which apply close to the link end points and are larger than the Fresnel clearances at these end locations. For the two links the following corridor clearances should be maintained: Please note the comments in 6.1 above regarding a review of the clearance distances if they are too restrictive on the site layout.

LINK A - B	TOTAL CORRIDOR WIDTH Metres Note 1	SITE A COORDS AMG 66 Z55	SITE B COORDS AMG 66 Z55
9778 - 9803	366 m	669250E 5993050N	792880E 5910200N
401732 – 401733	270 m*	704309E 5934413N	692340E 5987940N

*Probably a SCADA non LOS system – Further consideration of the required scattering mode clearance is required

Note 1 No part of a turbine should protrude into the corridors. With a turbine rotor diameter of say 90 metres the centre line of the turbine towers should be at least 183 + 90/2 = 228 metres from the 1st Link ray line or 135 + 90/2 = 180 metres from the 2nd Link ray line.

8.1 General Buffer Zone

Taking into account all omnidirectional services scattering zone requirements and the near field clearances required for the longer distance Links a clearance circle centred on the radio towers of radius 917 metres is the clearance zone required from the worst case (site 9795) theoretical calculations. However due to the uncertainty in the turbine RCS assumptions and allowing for multiple turbine contributions to interference to any location it is proposed to increase the clearance radius to a recommended 1000 metres. All radio sites are greater than 1000 metres from the wind farm nominal boundaries so no buffer zones are required.

It is recommended that Air Services Australia be advised of the wind farm proposal and be requested to comment on any issues on Radar or Ground – Air links in the area.

8.2 Possible Interference to Television Transmissions

Television services in the area are provided by:

ABC Bega – Cooma, Bega, Cooma/Monaro, Bombala services from Brown Mountain, Mumbulla Mtn, Mt Roberts & Bonbala respectively

SBS Bega service from Mumbulla Mountain

CBN - Prime Television (Southern) Pty Ltd-Bega, Cooma/Monaro & Bombala Services from Mumbulla Mountain, Mt Roberts & Bombala respectively

CTC - Australian Capital Television Pty Ltd - Bega , Cooma/Monaro & Bombala Services from Mumbulla Mountain, Mt Roberts & Bombala respectively

WIN - WIN Television NSW Pty Ltd – Bega, Cooma/Monaro & Bombala Services from Mumbulla Mountain, Mt Roberts & Bombala respectively

It is recommended that these organisations be advised of the wind farm proposal and be requested to comment on any issues they have from a TV coverage impact point of view.

9 REFERENCES

[1] Fixed-Link wind-turbine exclusion zone method, Version 1.1, 28 October 2002, D.F. Bacon, OFCOM UK

[2] Guidelines for Minimizing the Impact of Wind Farms on the SAGRN, Issue 1, 22 October 2003, Rohan Fernandez, Telstra SA, Document TR049-SA

[3] Wind Farms Impact on Radar Aviation Interests-Final Report, September 2003, FES W/14/00614/00/REP, Contractor QinetiQ Prepared by Gavin J Poupart.

[4] Mahinerangi Wind Farm, Compatibility with Radio Services, 3 April 2007, Anton Pereira & Richard Brown, Kordia NZ

[5] Project Hayes, Compatibility with Radio Services, 7 July 2006, Duncan Chisholm, BCL NZ

[6] Electromagnetic Interference from Wind Turbines, Sengupta & Senior, Chapter 9, Wind Turbine Technology Ed. David E. Spera ASME Press 1994

10 GLOSSARY OF TECHNICAL TERMS

ACMA Australian Communications & Media Authority

Coning Angle Angle of turbine blades from 90 deg to shaft

FM Frequency Modulation

Fresnel Zone Clearance to obstructions from the ray line on a radio path which does not produce any additional loss above free space loss

GRN Government Radio Network (SA)

Nacelle Housing for wind generator on top of turbine tower

Omnidirectional Transmission in 360 degrees of azimuth with equal radiated power

RCS Radar Cross section

SA DTEI South Australian Department of Transport, Energy & Infrastructure

SCADA Supervisory Control & Data Acquisition

UHF	Ultra High Frequency

ATTACHMENT 1

WIND FARM SITE MAP BOCO ROCK

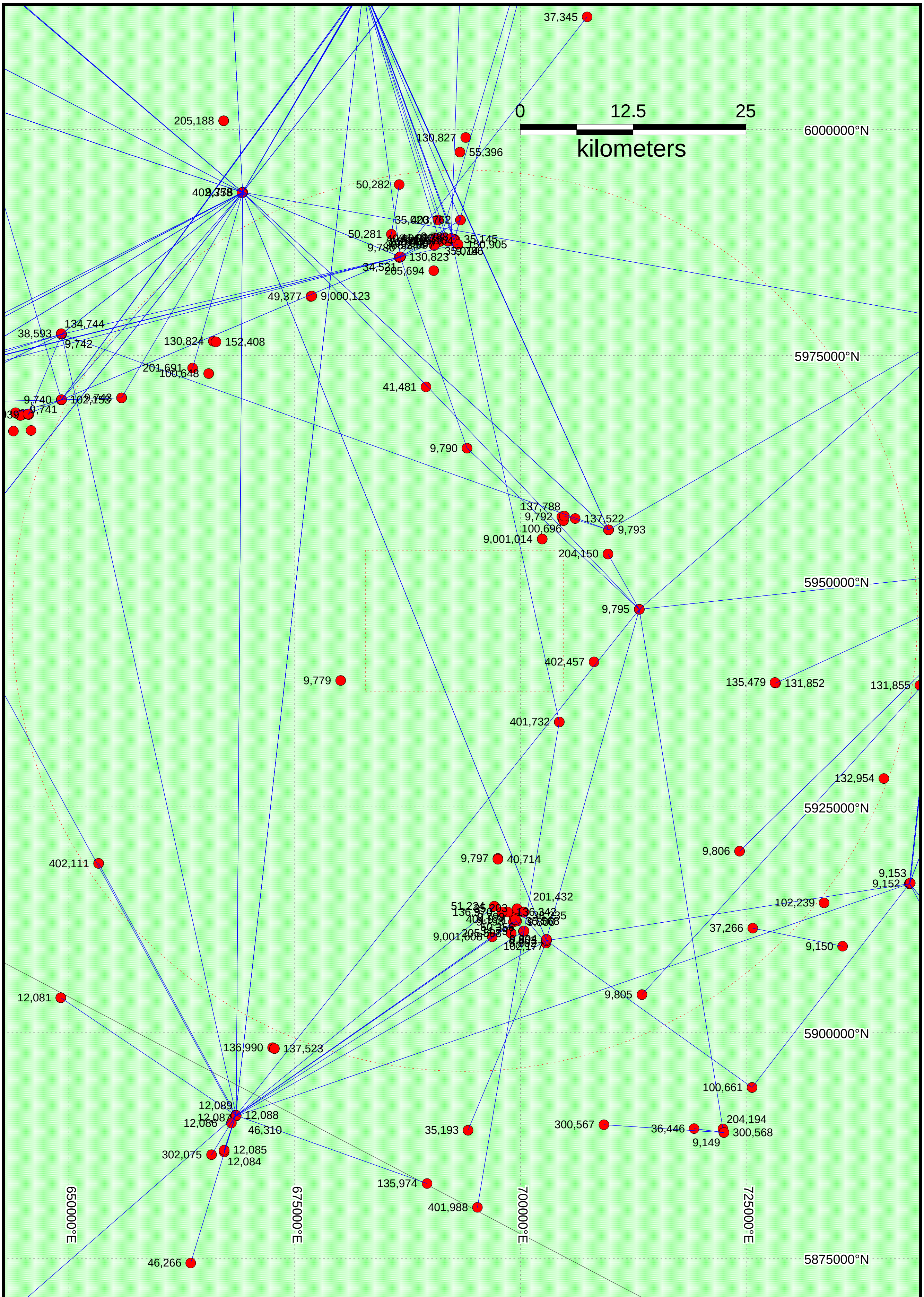
LEGEND	
●	Communication Mast
- - -	Communication Link
▭	Site Boundary

SCALE BAR: 0 — 15 — 30 kilometers

COMPANY	WIND PROSPECT CWP PTY LTD
TITLE	NSW - SITE LOCATION AND COMMUNICATION LINKS
DATE	26 AUG 2008
SCALE	1:50,000
DWG NO	WP_GEN005
REV	A
DRAWN BY	D.ROBERTS
CHECKED BY	E.MOUNSEY
SHEET	1 OF 1
SIZE	A3

ATTACHMENT 2

MAP OF RADIO LINKS & SITES OPERATING BELOW 1000 MHz



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

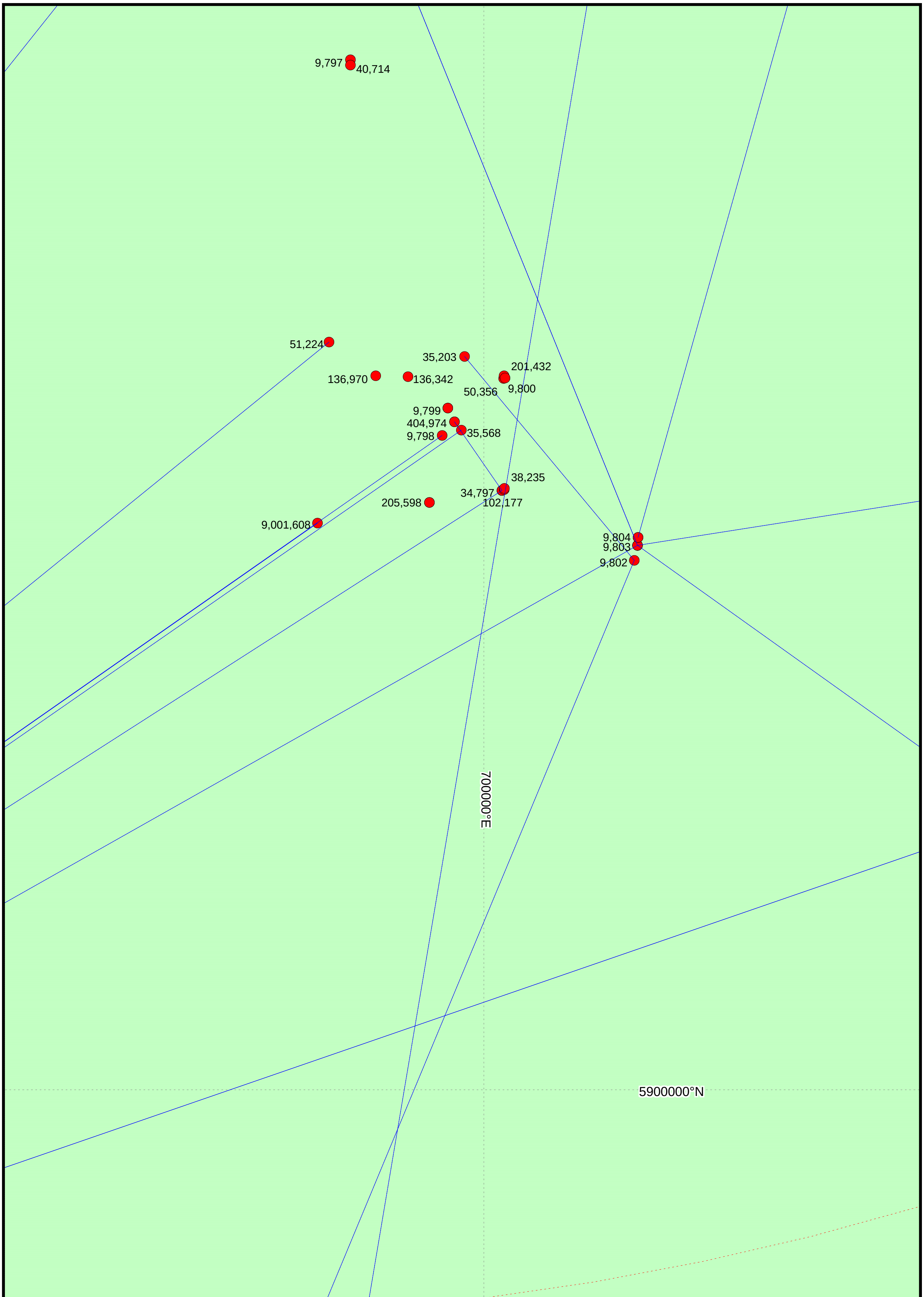
Radiocommunications Planning and Design

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

TITLE:	**40-999 MHz Assignments As Extracted from RRL Database**
FILENAME: Boco Rock 40-999 MHz	DATE: 10/10/2008
PROJECT: Boco Rock	SCALE: N/A
DRWG NO: 1	BY: SEA

ATTACHMENT 3

MAP OF RADIO LINKS & SITES OPERATING BELOW 1000 MHz – DETAIL A



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

Radiocommunications Planning and Design

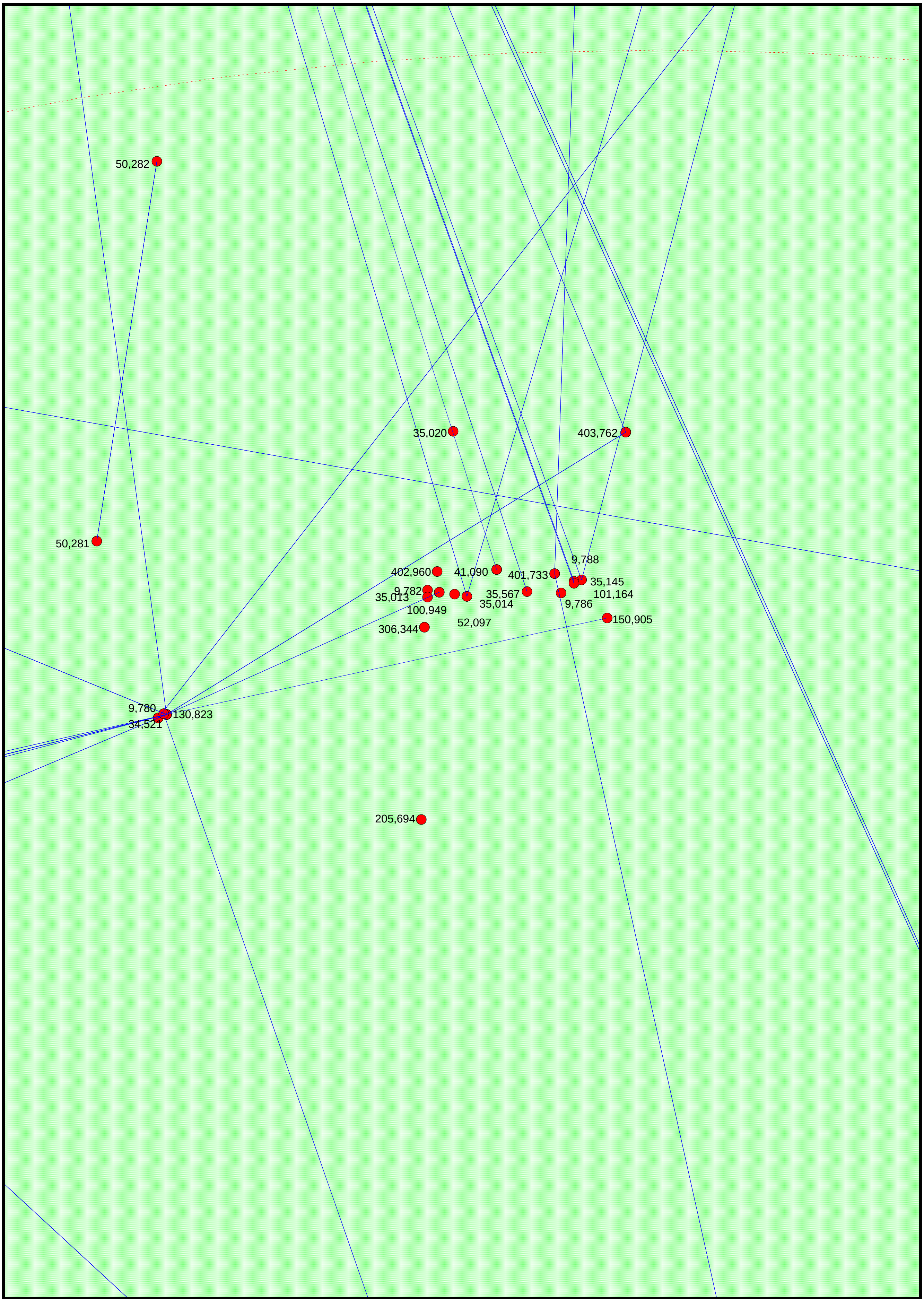
Postal: P.O. Box 3213, BELCONNEN ACT 2617
Telephone: 02 6253 2555
Facsimile: 02 6253 2800

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

FILENAME:	Boco Rock 40-999 MHz	DATE:	10/10/2008
PROJECT:	Boco Rock	SCALE:	N/A
DRWG NO:	1-A	BY:	SEA

ATTACHMENT 4

MAP OF RADIO LINKS & SITES OPERATING BELOW 1000 MHz – DETAIL B



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

Radiocommunications Planning and Design

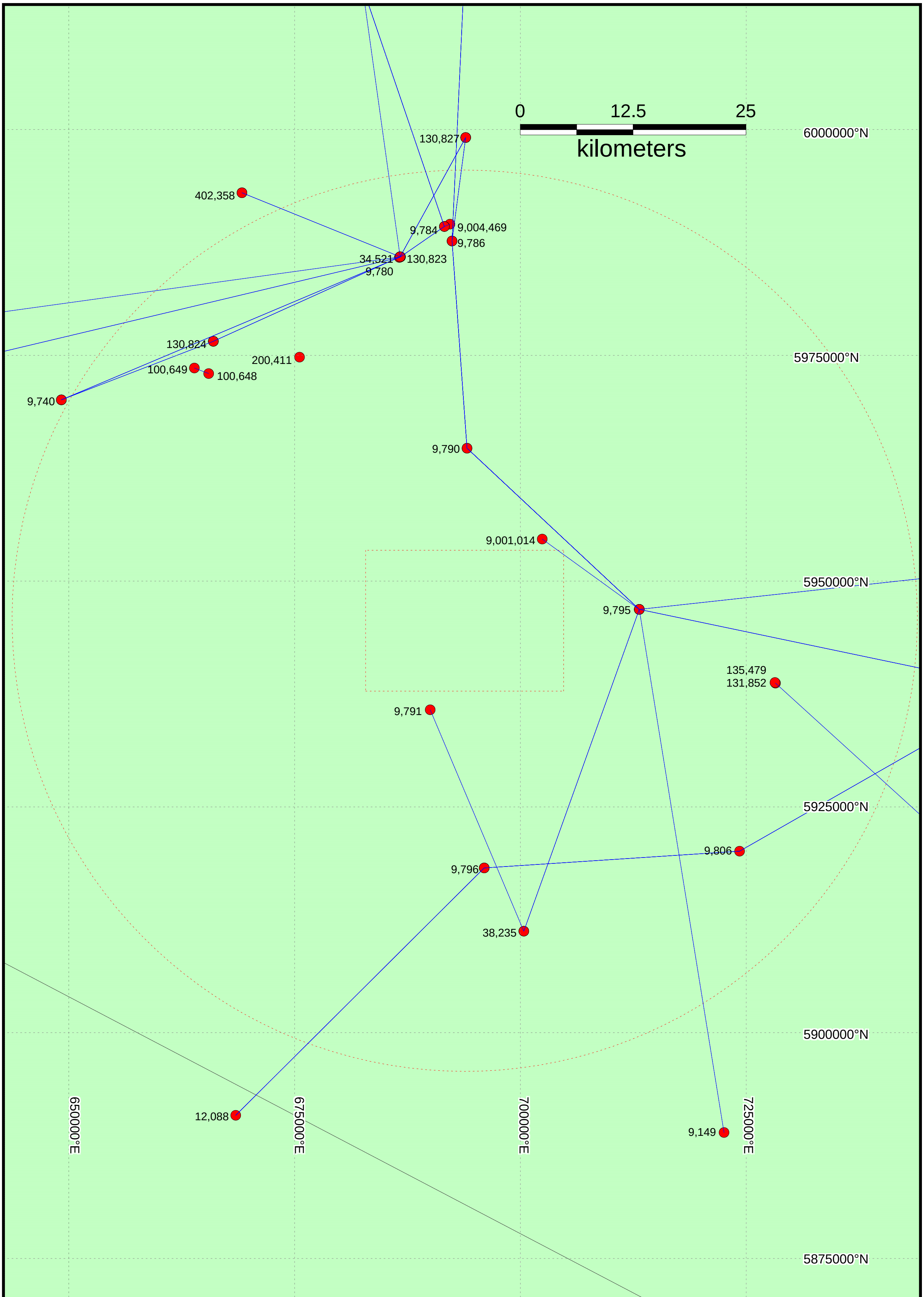
Postal: P.O. Box 3213, BELCONNEN ACT 2617
Telephone: 02 6253 2555
Facsimile: 02 6253 2800

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

FILENAME:	Boco Rock 40-999 MHz	DATE:	10/10/2008
PROJECT:	Boco Rock	SCALE:	N/A
DRWG NO:	1-B	BY:	SEA

ATTACHMENT 5

MAP OF RADIO LINKS & SITES OPERATING ABOVE 1000 MHz



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:
Above 1 GHz Assignments
As Extracted from RRL Database

FILENAME:	Boco Rock Above 1 GHz	DATE:	10/10/2008
PROJECT:	Boco Rock	SCALE:	N/A
DRWG NO:	2	BY:	SEA

ATTACHMENT 6 - SAMPLE CALCULATIONS OF CLEARANCE ZONES

The calculations below are examples for near field, second Fresnel zone and scattering clearances for the point to point and omnidirectional services.. The results of all calculations are in tables in the body of the Report. The formulas used are taken from Ref. 1

1. Point to Point Link 9778 to 9803 NSW Rural Ambulance Service

(a) Near Field Zone

Frequency 400 MHz

Antenna Gain 14.2 dB

$$D_{nf} = 0.1\ 10^{0.1G} / f$$
$$= 0.1x\ 10^{0.1 \times 14.2} / 0.400$$
$$= 6.6 \text{ metres}$$

Second Fresnel Clearance

Path Distance 89.41km

Mid Path distance 44.705km

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

$$= \sqrt{2x(300/400)x44705x44705/89410}$$

....=183. metres (mid path)

$$= \sqrt{2x(300/400)x1000x88410/89410}$$

= 38.5 metres @ 1km from tower

(b) Reflection/Scattering Clearance Zone

The ratio, expressed in dB, of the wanted signal level received from the direct T-R path divided by the worst-case signal level received from the indirect T-W-R path, is given by:

$$R_{ci} = 71 + S + 20\log(s_1\ s_2) - 20\log(D_p) + G_1(0) + G_2(0) - G_1(\theta_1) - G_2(\theta_2) \quad \text{(dB)}$$

where:

$s_{1,2}$	=	$\sqrt{d_{1,2}{}^2 + D_s{}^2}$	(km)
S	=	$10\log(\sigma)$	(dB)
σ	=	Worst-case radar cross section of turbine	(m^2)
$G_{1,2}(0)$	=	Antenna boresight gains	(dBi)
$G_{1,2}(\theta_{1,2})$	=	Antenna gain at off-boresight angles θ	(dBi)
$\theta_{1,2}$	=	angle (D_s , $d_{1,2}$)	

For each pair of $d_{1,2}$ values, equations above are used to evaluate R_{ci} for D_s incremented from zero (from a non-zero but small distance in the vicinity of the terminals) upwards in suitably small increments until the required value of C/I ratio, given by R_{ci}, is obtained. A guide as to a suitable increment for D_s is that the resulting zone should be defined by a smooth curve.

Antenna Type RFI YB9-65(H)

Turbine Radar Cross Section (RCS) assumed 1000 metres²

C/I Ratio required >40dB

An Excel spread sheet was set up to with the formulas above implemented to carry out the iteration required for d_1, d_2 values for increasing values of D_s. At 0.75km from the tower a C/I value of 40 dB was achieved at 400 metres off the rayline. Beyond 1 km the C/I value is achieved even on boresight. These indicates that scattering can be ignored 1 km and beyond the end sites. The published Radiation Pattern Envelope (RPE) for the antenna types for the actual link was used in the calculation

2. **Mobile Radio Base Stations – Omnidirectional Covera**ge

(a) Near Field Zone

Frequency 403.6MHz

Antenna Gain 8.2dB

$$D_{nf} = 0.1\ 10^{0.1G} / f$$
$$= 0.1x\ 10^{0.1x8.2}/0.403.6$$
$$= 1.64 \text{ metres}$$

(b) Reflection/Scattering Clearance Zone

Turbine RCS = 1000 m²

Wanted C/I >30dB

The C/I ratio is:

$$r_{ci} = \frac{l_i}{l_d} = \frac{4\pi s_1^2 s_2^2 g_1(0)\, g_2(0)}{\sigma D_p^2 g_1(\theta_1)\, g_2(\theta_2)}$$

For the omnidirectional case $g_1(0) = g_1(\theta)$ & $g_2(0) = g_2(\theta)$

It can also be assumed that S_1 will approx equal D_p

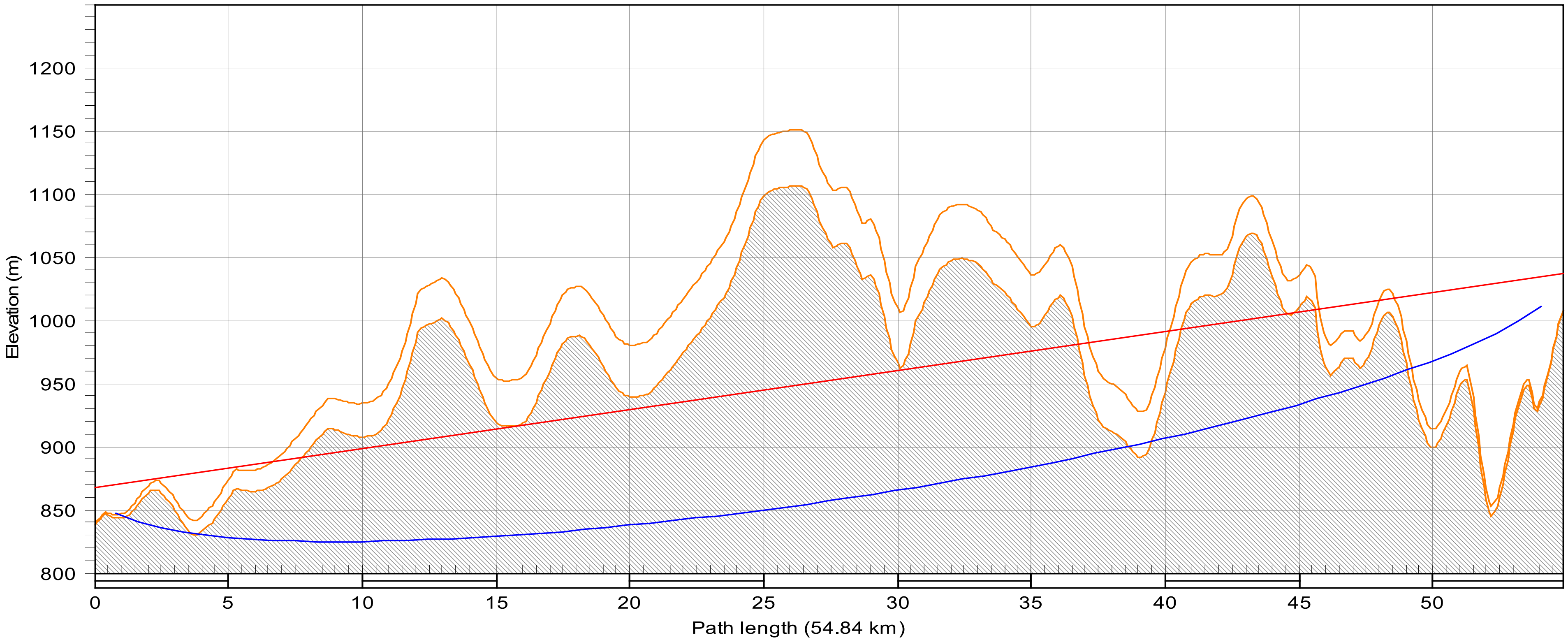
then

$$r_{ci} = \frac{l_i}{l_d} = \frac{4\pi S_2^2}{\sigma}$$

$= 4x\ \pi \text{ x } 300^2/1000$

$=1130$ or 30.5dB at 300 metres

ATTACHMENT 7 - PATH PROFILE SITE 401733 – SITE 401732



401733	
Latitude	36 13 57.42 S
Longitude	149 08 29.38 E
Azimuth	166.12°
Elevation	838 m ASL
Antenna CL	30.0 m AGL

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

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401732	
Latitude	36 42 44.41 S
Longitude	149 17 19.41 E
Azimuth	346.03°
Elevation	1007 m ASL
Antenna CL	30.0 m AGL

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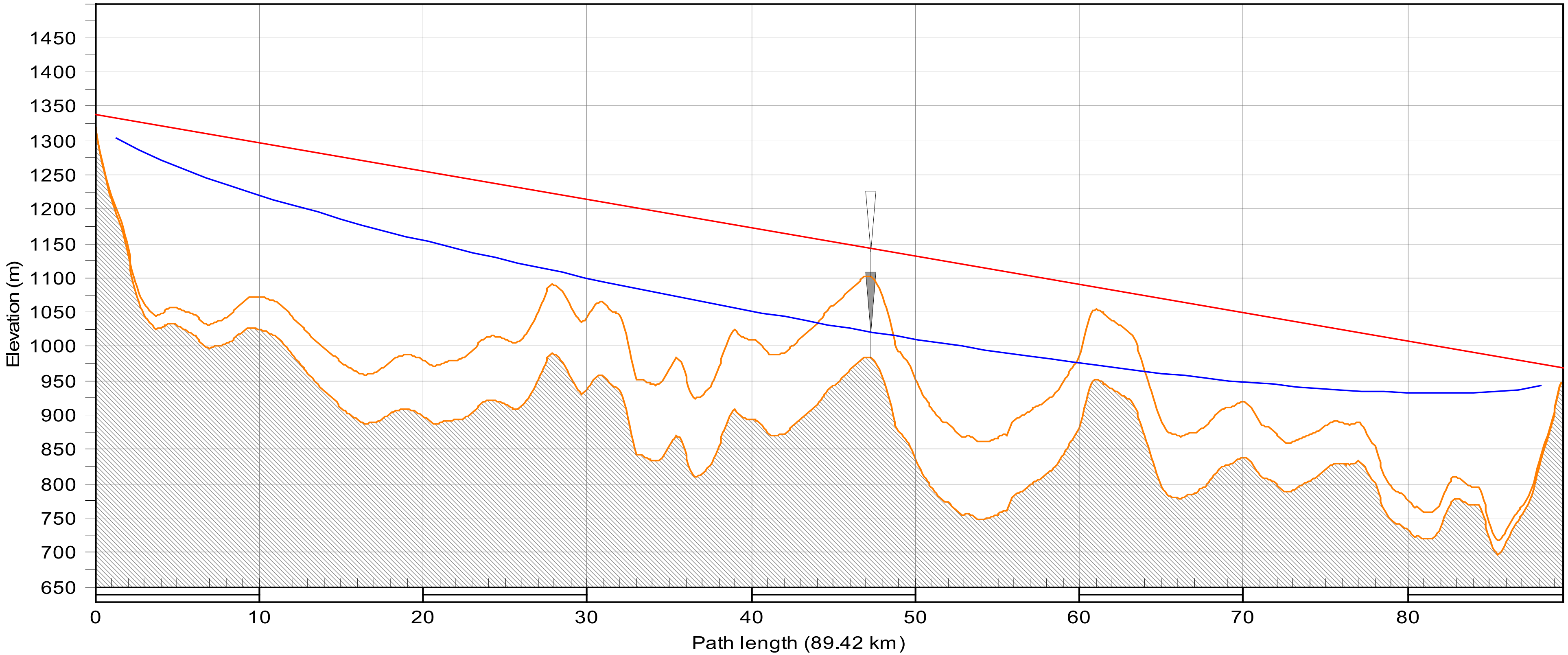
ATTACHMENT 8 - PATH PROFILE SITE 9778 – SITE 9803



9778	
Latitude	36 11 27.22 S
Longitude	148 53 00.93 E
Azimuth	156.78°
Elevation	1319 m ASL
Antenna CL	20.0 m AGL

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

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9803	
Latitude	36 55 50.67 S
Longitude	149 16 45.12 E
Azimuth	336.55°
Elevation	948 m ASL
Antenna CL	20.0 m AGL

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