Digital Transformation Group
Operational Technology

DESIGN STANDARD DS 42-03

SCADA Radio Equipment and Installation

VERSION 4
REVISION 0

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FOREWORD

The intent of Design Standards is to specify requirements that assure effective design and delivery of fit for purpose Water Corporation infrastructure assets for best whole-of-life value with least risk to Corporation service standards and safety. Design standards are also intended to promote uniformity of approach by asset designers, drafters and constructors to the design, construction, commissioning and delivery of water infrastructure and to the compatibility of new infrastructure with existing like infrastructure.

Design Standards draw on the asset design, management and field operational experience gained and documented by the Corporation and by the water industry generally over time. They are intended for application by Corporation staff, designers, constructors and land developers to the planning, design, construction and commissioning of Corporation infrastructure including water services provided by land developers for takeover by the Corporation.

Nothing in this Design Standard diminishes the responsibility of designers and constructors for applying the requirements of WA OSH Regulations 1996 (Division 12, Construction Industry – consultation on hazards and safety management) to the delivery of Corporation assets. Information on these statutory requirements may be viewed at the following web site location:

https://www.legislation.wa.gov.au/legislation/statutes.nsf/law_s4665.html

Enquiries relating to the technical content of a Design Standard should be directed to the Principal SCADA Engineer, Operational Technology, Digital Transformation Group. Future Design Standard changes, if any, will be issued to registered Design Standard users as and when published.

Manager, Operational Technology

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Users should use and reference the current version of this document.

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REVISION STATUS

The revision status of this standard is shown section by section below:

REVISION STATUS						
SECT.	**VER./ REV.**	**DATE**	**PAGES REVISED**	**REVISION DESCRIPTION (Section, Clause, Sub-Clause)**	**RVWD.**	**APRV.**
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DESIGN STANDARD DS 42-03
SCADA Radio Equipment and Installation

CONTENTS

1 PRELIMINARIES

1.1 Purpose

The purpose of this standard is to define SCADA radio equipment installation requirements that will ensure the provision of reliable and robust radio communications links

1.2 Scope

This standard shall apply to the installation of all SCADA UHF Narrowband, NextG cellular and Spread Spectrum radio equipment at Water Corporation sites.

UHF Narrowband radios shall include licensed 12.5, 25 and 50 kHz narrowband radio modems and analogue radios with internal or external modems operating in the 400 – 520 MHz band, nominally referred to as the 450 MHz band throughout this Standard.

NextG radio installations shall include data modems that connect to the Telstra NextG 3G cellular network.

Spread Spectrum radios shall include unlicensed frequency hopping radios operating in the 915 – 928 class license band.

This Standard refers to Water Corporation drawings contained in Drawing Planset JT17 – see References. The Drawings are referred to as the "JT17 Drawings" throughout this Standard. All SCADA radio equipment and installations shall conform to these Drawings, which shall constitute part of this Design Standard.

For SCADA radio design standards, refer to DS 42-02 SCADA Radio Network Design.

This standard complies with ACMA regulations that were applicable at the time of writing. The designer shall ensure compliance with future relevant changes to ACMA regulations.

1.3 Structure

The main body of this standard is divided into two separate portions. Sections 2 and 3 respectively cover external plant equipment, and earthing, bonding and lightning protection,

Appendix A includes lightning risk assessments sheets for SCADA sites. Appendix B contains antenna safe radiation distance drawings and Appendix C includes an ACMA medium density map for the Perth Metropolitan area. Appendix D summarises the changes from the previous version of this standard.

1.4 References

DS 21	Design Standard – Major Pump Station – Electrical
DS 22	Design Standard – Ancillary Plant and Small Pump Stations – Electrical
DS 40-09	Field Instruments
DS 26-09	Design Standard – Type Specifications – Electrical Type Specifications for Low Voltage Switchboards – General Requirements
DS 42-02	Design Standard – SCADA Radio Network Design
PATHLOSS	Contract Telecommunication Engineering Pty Ltd, Canada
RALI FX16	ACMA Frequency Assignment Requirements for the Point to Multipoint Service in the 400 MHz and 900 Mhz Bands dated 14/02/2018
RALI FX17	ACMA Frequency Assignment Requirements for Narrowband Single Channel Two Frequency Point-to-Point Services in the 400 Mhz and 900 Mhz Bands dated 21/02/2018

Planset JT17 Standards Drawings - Radio Communications

1.5 Definitions

ACMA	Australian Communications and Media Authority
AS/NZS	Australian Standard/New Zealand Standard
Corporation	Water Corporation (of Western Australia)
Feeder cable	A cable that connects the antenna to the radio system
JT17 Drawings	Planset JT17 Standards Drawings – Radio Communications
Low profile antenna	A unity gain antenna that is mounted directly onto a building or cubicle.
MHz	Mega Hertz, as applicable to radio operating frequencies
PP	Point to Point
PMP	Point to Multipoint
RALI	(ACMA) Radiocommunications Assignment and Licensing Instruction
450 MHz Band	Shall be meant to include the 400 – 520 MHz frequency band in this Standard

2 EXTERNAL PLANT EQUIPMENT

External plant equipment includes antennas, antenna support structures, antenna feeder cables, surge suppressors, cable ladders and trays, catenaries or metal conduits connecting an antenna support structure to an equipment area, earths and external bonding cables.

Equipment mounted externally, or in locations subjected to external conditions, shall:

(a) Withstand wind forces and remain stable under wind force conditions defined in AS/NZS 1170 Part ll assuming a mean return interval for the design wind velocity of 100 years.

(b) Withstand seismic conditions corresponding to an intensity level of 6 on the Mercalli Scale.

Refer to Section 3 of this standard for full details of earthing and bonding requirements for lightning protection.

2.1 Antenna Support Structures

2.1.1 Free Standing Poles

Note: The use of antenna poles over 10 metres high must be approved by the Principal SCADA Engineer

Free standing poles may be rigid or hinged – see Section 2.1.2 for hinged poles. Unless otherwise stated, “free standing poles” shall mean rigid poles in this Standard.

Free standing antenna poles shall consist of steel columns of varying height similar to the INGAL EPS ‘Park’ range of octagonal columns.

The free standing pole shall be mounted on a galvanised steel screw pile, or reinforced concrete foundation.

The free standing pole shall not be fitted with climbing rungs.

Note: The non-use of climbing rungs is required by the Regions for safety reasons.

Antenna feeder cables running down a hollow type antenna support shall be run inside the pole, with a top exit pipe and gland fitting that will support the full length of cable inside the pole such that no excessive stress is exerted on the cable and the cable minimum bending radius is not exceeded.

Note: The SI and ICE Alliances have adopted different designs for supporting cables. Examples are contained in the JT17 Standards Drawings. Alternative methods need to be approved by the Water Corporation.

An earth strap connection shall be provided at the bottom of the pole adjacent to the antenna feeder cable entry. Where required the pole shall provide cable entry points for the feeder cable(s). All holes for cable entries shall be equipped with glands or rubber grommets to protect cables passing through the openings.

All feeder cables from free standing steel poles shall be run underground in medium duty white non-metallic conduit, unless specified otherwise. The cable entry at the shelter shall be sealed to prevent water entering the shelter.

The free standing pole shall include the communications earth - see Section 3.3.1.

2.1.2 Hinged Poles

Note: The use of antenna poles over 10 metres high must be approved by the Principal SCADA Engineer

Rigid free standing poles shall be used in preference to hinged poles unless either of the following two circumstances is evident:

(a) The pole is located in a position that has unsound or uneven ground that would make the use of a cherry picker or similar personal lifting equipment dangerous;

(b) The location of the mast pole is such that it would not be economical or efficient to arrange the use of a cherry picker or similar personal lifting equipment.

Under the above conditions, the use of hinged antenna support poles shall be permitted provided **all** of the following conditions are met:

(c) The pole height is ≤ 20m; and

(d) The antenna feeder cable is flexible coaxial cable, for example CNT400; and

> **Note:** The use of rigid Corrugated Heliax cable such as LDF4-50 is not permitted under any circumstances with hinged poles.

(e) The antenna feeder cable is installed and internally supported such that no excessive stress is exerted on the cable at any stage, including during pole lowering; and

(f) There are no antenna feeder cable in-line connectors, for example at the hinged point; and

(g) It is not necessary to disconnect and remove the antenna feeder cable from the base of the pole and/or from an underground conduit at the lower end, in order to lower the pole; and

(h) The installer can demonstrate that the above conditions are met to the satisfaction of the Water Corporation.

An earth strap connection shall be provided at the bottom of the pole adjacent to the antenna feeder cable entry. Where required the pole shall provide a cable entry point for the underground feeder cable. All holes for cable entries shall be equipped with glands or rubber grommets to protect cables passing through the openings.

All feeder cables from hinged poles shall be run underground in medium duty white non-metallic conduit, unless specified otherwise. The cable entry at the shelter shall be sealed to prevent water entering the shelter.

The hinged pole shall include the communications earth - see Section 3.3.1.

2.1.3 Distance between Pole and Building or Cubicle

Free standing and hinged poles shall be located as close as possible to the building or cubicle containing the radio equipment. Long external feeder cable runs shall be avoided.

> **Note:** The feeder cable shall not be run under a road between a pole and a cubicle located on the opposite side.

2.1.4 Pole Attached to Non-Metallic Building

An antenna feeder cable running down a pole type antenna support shall be run inside the pole. The pole shall be bonded to the communications earth - see Section 3.4.

2.1.5 Pole Attached to Metallic Building or Cubicle

An antenna feeder cable running down a pole type antenna support shall be run inside the pole. The pole shall be electrically connected to the metal frame of the building or cubicle - see Section 3.4.

2.1.6 Pole Attached to Ground Water Tank or Water Tower

Mounting arrangements for a pole attached to a ground water tank, elevated water tower or any associated structural member such as a railing shall be designed and certified as structurally acceptable by suitably qualified personnel.

Safe radiation clearances shall be provided for any personnel using adjacent walkways or work areas. See Appendix B for safe radiation distances.

The pole shall be bonded to the ground water tank or elevated water tower earthing system – see Section 3.4.

Antenna feeder cables shall be run down the outside of a ground water tank and the inside of an elevated water tank, with an earth bonding strap connection at the bottom of the vertical run. Cables shall be supported as specified in Section 2.7.

Where there is not an existing cable ladder or tray, a new cable ladder or tray shall be installed. Mounting arrangements for a cable ladder or tray attached to a ground water tank, elevated water tower or any associated structural member such as a railing shall be designed and certified as structurally acceptable by suitably qualified personnel. The design shall include the type and maximum depth of fasteners (as a minimum).

2.1.7 Towers and Guyed Masts

Towers and guyed masts will normally only be used for SCADA in exceptional circumstances. The contractor shall submit plans for the design and construction of any proposed tower or guyed mast, including the proposed means of running feeder cables, to the Water Corporation for approval.

The tower legs or mast and guys shall be bonded to the communications earth – see Section 3.4.

2.2 Antennas

All antennas shall be mounted to provide safe radiation clearances in all directions as per the diagrams in Appendix B.

The antenna shall be installed in accordance with AS/NZS 1417.1. Adequate protection against corrosion due to dissimilar metals shall be provided.

All yagi, side mounted dipole and dipole array antennas shall be of stainless steel construction.

Note: The use of aluminium yagi, side mounted dipole or dipole array antennas is not permitted at any location.

Vertically polarised yagi antennas shall be installed with the drain holes pointing downwards.

The antenna shall be mounted in accordance with the manufacturer's instructions, using suitable hardware provided by the manufacturer. In particular, the mounting arrangement shall minimise the interference from the adjacent structural elements.

All yagi antennas with more than 9 elements shall be braced both vertically and horizontally.

2.2.1 Point to Multipoint Antennas

The requirements for point to multipoint antennas are as follows:

(a) The base station antenna shall be a vertically polarised omnidirectional antenna with a maximum gain of 8.2 dBi;

(b) For a remote station the following types of directional antenna should be used:

- In the 450 MHz band: a directional antenna with a mid-band gain of at least 11 dBi, a minimum front-to-back ratio of 16 dB and a maximum beamwidth (in E-plane) of 36°;

(c)
- A low profile panel mounted omnidirectional antenna may be used where the design shows that a suitable fade margin will be obtained.

The Water Corporation requires that base station high gain omnidirectional antennas shall be of the following types:

(d) Dipole Array where:

- The base station repeater is critical to the protection and reliable operation of SCADA;

  Note: A PMP base station is critical if there are five or more remote stations and/or the radio network carries SCADA control links.

- A reliable antenna horizontal radiation pattern is required;
- High antenna bandwidth is required;
- The cost of replacement and/or the risk of lightning damage are high;
- The antenna is not readily accessible for maintenance;
- The antenna is mounted in an obstructed position, for example off the side of a mast or tower.

(e) Collinear where the antenna is not required to meet any of the requirements listed under (d) above.

The antenna support structure and mounting arrangements for a dipole array shall be designed and certified as structurally acceptable by suitably qualified personnel.

2.2.2 Point to Point Antennas

Point to point antennas shall meet the following ACMA RALI FX17 requirements:

In High and Medium Spectrum Density Areas:

(a) In the 450 MHz band: a directional antenna with a mid-band gain of at least 13 dBi, a minimum front-to-back ratio of 17 dB and a maximum beamwidth (in E-plane) of 36°;

Outside of High and Medium Spectrum Density Areas:

(b) In the 450 MHz band: a directional antenna with a mid-band gain of least 9 dBi, a minimum front-to-back ratio of 15 dB and a maximum beam width (in E-plane) of 45°;

> **Note:** The Perth Metropolitan area is designated by ACMA as a medium spectrum density area (as seen in Appendix C), while everywhere else in WA can be considered to be outside of high and medium spectrum density areas.

2.2.3 Antenna Types - Preferred Equipment List

The preferred antenna types shall be included in the Water Corporation Approved Equipment List (AEL) which is produced by Operational Technology

The preferred antenna types shall meet all of the requirements specified in Section 2.2 of this Standard.

2.3 Transmitted Power

For all new 450 MHz systems the following radio equipment design parameters shall be used:

(a) PMP Base Radio TX Power - ACMA Limit = 40W EIRP into the antenna:

- +37dBm (5W);

(b) PMP Remote Radio TX Power - ACMA Limit = 20W EIRP into the antenna:

- +34dBm (2.5W) assuming 2dB typical losses and a 6 element yagi or;

(c) PP Link TX Power (into the antenna):

- +30dBm (1W) or;
- +20dBm (100mW) where the path is less then 10km

During commissioning the radio TX power shall be:

- Entered on the “as constructed” Communications Details drawing;
- Recorded in the radio configuration file and loaded into the MDT Autosave database for future maintenance.

2.4 Feeder Cables

Antenna coaxial cable feeder cables shall meet the following requirements:

(a) External antenna feeder cable shall be provided between the antenna and coaxial lightning surge suppressor.

The type of external feeder cable shall be selected from the following:

- For low loss applications: Andrew Corrugated Heliax or equivalent, eg LDF4-50;
- For all other applications: Andrew CNT400 10mm low loss coaxial or equivalent.

Note: These cables meet at least the following generic specifications:

- 50 Ohm impedance;
- UV stabilised, non-contaminating sheath;
- Shielding effectiveness >90dB;
- Suitable mechanical strength and minimum bending radius.

(b) Andrew Corrugated Heliax or equivalent shall be used for all base station repeater cables;

(c) A short flexible tail will normally be used to make the connection to the radio equipment and the antennas. The point where the feeder cable is connected to the short flexible tail shall be well supported to prevent strain on the connectors. It is acceptable to use the surge suppressor as the connection point between the feeder and tail;

(d) For internal connection to the radio equipment, flexible 50 Ohm coaxial cable tails shall be provided. The cable shall be:

- RFI CellFoil Type 9006 coaxial or equivalent where the cable loss permits;
- CNT400 10mm low loss coaxial or equivalent where low cable loss is required;
- Andrew Corrugated Heliax FSJ type or equivalent where high RF decoupling and/or flexibility is required, eg FSJ1-50 where the cable loss permits or FSJ2-50 where low cable loss is required.

(e) The minimum bending radius of the cables shall be fifteen times the cable diameter unless the manufacturer recommends a greater bending radius;

(f) Connections to the short flexible tail on the antenna should be made in the horizontal plane, where possible. The connection shall be wrapped in self-amalgamating tape and further wrapped with electrical tape to ensure that the connection is protected against the ingress of moisture and chemicals;

(g) Where the antenna tail and connecting feeder are exposed, they shall be protected from bird attack and abrasion by stainless steel or hard plastic flexible tubing;

(h) Feeder cables shall be supported as specified in Section 2.7;

(i) The cable entry at the shelter shall be sealed to prevent water entering the shelter. Above ground cables shall be installed to have a drip point prior to the entry to the shelter;

(j) Surplus feeder cable shall be removed and the cable re-terminated;

Note: Under no circumstance shall surplus feeder cable be coiled at any location.

(k) All holes for cable entries to poles, buildings, cubicles, cabinets or cabinet compartments shall be equipped with a gland or rubber grommet to protect the cable passing through the opening.

2.5 Connectors

The connectors used for the antenna feeders shall:

(a) Be of professional quality and shall be designed for use with the chosen cable and to match the equipment to which they connect;

Note: Connectors and cables from different manufacturers are generally not interchangeable.

(b) Be impedance matched to the cable and the equipment;

(c) Have an installed VSWR of 1.1 or less;

(d) Be hermetically sealed to prevent the ingress of moisture;

(e) All external connections shall be wrapped in self-amalgamating tape and further wrapped with electrical tape to ensure weather proofing of the connector.

2.6 Conduits

All conduits and marker tapes shall meet the following requirements:

(a) Medium duty non-metallic conduit shall be used for mechanical protection of antenna feeder cables run underground or in exposed above-ground positions, unless specified otherwise;

(b) Where specified for mechanical protection, galvanised iron pipe shall be used for underground antenna feeder cables;

Note: AS/NZS 3000 specifies that metal conduit is not suitable for underground use.

(c) All conduits shall be a minimum 50 mm diameter and all bends shall be sweep bends to facilitate cable installation and possible replacement;

(d) All non-metallic conduits shall be white colour;

(e) Conduit separation and burial depth, and use of marker tapes shall meet the requirements of AS/NZS 3000;

Note: Orange marker tape shall not be used for communications cable.

(f) After installation the inside of the conduits shall be cleaned so they are free of water, dirt and debris.

2.7 Cable Support Requirements

The following cable support requirements shall be observed:

(a) Long vertical coaxial cable runs exceeding 3 metres shall be secured using coaxial cable hanger kits at intervals not exceeding 2 metres or as per the coaxial cable manufacturer recommendation;

Note: This requirement does not apply to cables run inside of rigid free standing poles. Cables run inside rigid poles shall be secured at the upper and lower cable entry points. Cables run inside hinged poles shall be secured as specified in Section 2.1.2.

(b) Short vertical coaxial cable runs not exceeding 3 metres, eg up the outside of a pole, shall be secured using stainless steel clamps at intervals not exceeding 0.5 metre;

(c) Where an antenna cable tail joins the main feeder cable at the top of a pole, the vertical cable run shall be secured to the pole using stainless steel cable ties. For yagi antennas the horizontal run to the driven element shall be secured to the horizontal antenna boom using ultra violet resistant non-metallic cable ties.

Note: Exposed cable at the top of a pole shall be protected as specified in Section 2.4.

(d) Above ground antenna feeder cable runs shall be run on steel trays or in steel conduits, at a height of more than 2.5m above ground level to the building cable entry point;

(e) Horizontal and vertical runs of coaxial cable that are required to be attached to a surface (eg walls, columns, etc) shall be supported or installed on a cable tray or steel conduit secured at intervals not exceeding 600 mm;

2.8 Labels

Radio equipment labels shall be provided in accordance with the requirements of Design Standard DS 26-09 and the JT17 Drawings.

2.9 Protection from Vandalism and Theft

In order to protect the antenna from vandalism and/or theft, a free standing pole of minimum 6m height shall be installed at an unfenced site.

Note: This requirement does not apply where a low profile antenna is used or where a site is fenced and a short pole attached to a building, cubicle or ground water tank will provide sufficient antenna height.

3 EARTHING, BONDING AND LIGHTNING PROTECTION

Earthing and bonding shall be provided in accordance with DS 21, DS 22 or DS 28 with the additional requirement that, at sites where one or more external radio antennas are installed, a separate communications earth and bonding system shall be provided for lightning protection.

Lightning protection shall be provided in accordance with AS/NZS 1768 and DS 40-09, except where varied in Sections 3.2 to 3.5 of this Standard.

3.1 Background

The lightning protection specified in this Standard is based on the risk assessment procedures and spreadsheet tool, and structural earthing information contained in AS/NZS 1768. These are covered in more detail the following two sections.

3.1.1 Risk Assessment

The risk assessment compares calculated risks with levels of risk that are acceptable to the Water Corporation. Where the calculated risk exceeds the acceptable risk, lightning protection measures shall be implemented. Conversely, where the calculated risk is less than the acceptable risk, additional lightning protection measures are not required.

The risk assessment at typical Water Corporation SCADA radio sites shows that many, but not all, lightning protection measures contained in AS/NZS 1768 should be provided. Appendix A contains two typical risk assessments using the spreadsheet from AS/NZS 1768. The first is for a SCADA radio repeater and the second for a SCADA local site. Similar results are obtained for all areas of the State, where the number of annual thunderdays varies from 10 to 80.

The risk assessment spreadsheets show the following:

(a) The risk of loss of human life due to a direct or indirect lightning strike is negligible and well below the level of acceptable risk;

(b) The risk of loss of essential services and economic loss due to a direct lightning strike is likewise negligible and well below the level of acceptable risk;

(c) The risk of loss of essential services, and in some cases the economic loss, due to an indirect lightning strike is significant and higher than the level of acceptable risk.

Based on this risk assessment:

(d) AS/NZS 1768 mandates that protection measures shall be taken to minimise the risk of loss of essential services and economic loss due to an indirect lightning strike. The lightning protection measures include comprehensive equipotential bonding and use of surge protection devices on all SCADA equipment.

(e) AS/NZS 1768 does not require that additional measures should be undertaken to protect the site from a direct lightning strike. In particular:

- It is not required that a lightning protection earth resistance of $\leq$ 10 ohms should be provided;
- It is assumed that metal support structures such as poles, masts and towers are electrically bonded throughout and will provide low surge impedance to lightning strikes, i.e. there is no requirement for additional bonding between structural members;
- It is assumed that support structure foundations and metal bases will provide relatively good earth terminating points for lightning protection. This item is covered further in the following section.

3.1.2 Earthing of Antenna Support Structures

Antenna support structures such as free standing poles, towers or guyed masts are inherently good lightning downconductors and their foundations/bases provide relatively good earth terminating points for lightning protection. As a result, there is no requirement for the installation of separate lightning protection downconductors or earth terminations such as earth rods or trenched conductors.

Each free standing pole, tower or guyed mast will utilise a reinforced concrete foundation or in the case of some poles, a metallic screw pile base. The latter is used for poles of ≤ 20m height where structural loading permits and soil conditions allow the base to be mechanically screwed into the ground using a hydraulic rig. A concrete foundation is required for higher structures, and where the structural loading is too high and/or the soil is too hard for a screw pile base. Concrete foundations require mechanical excavation of the soil to 1m depth or more.

A reinforced concrete foundation or metal screw pile base will provide an adequate earth termination for a lightning protection system. The metal screw pile base has a large area that is in direct contact with the earth. Section 4.5.2.4 of AS/NZS 1768 states that concrete foundations are deep in the mass of earth and the resistivity of concrete is generally comparable with that of clay or other moderately conductive ground and that concrete foundations themselves will constitute a satisfactory earth termination point.

The structure mounting bolts that are cast in situ into the concrete base will provide lightning discharge paths from the structure to the steel reinforcing rods. The mounting bolts and reinforcing rods, welded or tied together by steel tie wire at splice points, will provide a multiplicity of parallel discharge paths to earth via the concrete.

3.2 General Arrangements for Communications Lightning Protection

The JT17 Drawings include general mandatory communications earthing and bonding arrangements to assist with the implementation of the following requirements.

3.3 Earthing Requirements

The Corporation has a variety of enclosures and structures that are used to house the communications equipment and provide appropriate antenna support structures respectively. The most common installations are addressed below.

The communications earth types are as follows:

(a) Type 1: antenna support structure provides the communications earth;

(b) Type 2: a separate communications earth is required;

(c) Type 3: the communications earth is combined with the station earth.

3.3.1 Type 1 Communications Earth

For a free standing pole, tower or guyed mast the communications earth termination point shall comprise, as a minimum, a reinforced concrete foundation or metal screw pile base.

> **Note:** It will not be necessary to install earth rods or trenched conductors for the communications earth.

A communications earth connection point shall be provided at the base of the free standing pole, tower or guyed mast for bonding to the station earth and other metallic points - see Section 3.4. This connection point shall be known as the “communications earth”.

> **Note:** The communications earth connection point may be incorporated into the structure, for example using a welded spigot or an earth bar inside of a pole, provided the connection is adequately protected from corrosion and damage.

3.3.2 Type 2 Communications Earth

For a pole attached to a non-metallic building such as a brick building, a separate communications earth shall be provided. This communications earth shall be bonded to the station earth.

The communications earth shall comprise one of the following:

(a) A single 1.2m copper coated steel earth rod driven into the ground as close as practicable to the pole, with a copper bracket welded to the rod for attaching bonding cables;

Note: The copper bracket may be welded to the earth rod prior to installation.

(b) Where it will be unsafe or impractical to drive or otherwise install a 1.2m earth rod due to existing underground plant or rock, a trenched communications earth shall be installed comprising a minimum 5m length 70 mm^2 bare hard drawn copper cable buried to not less than 0.5m.

Where an alternative communications earthing and bonding system is proposed, details shall be submitted to the Principal SCADA Engineer for approval.

3.3.3 Type 3 Communications Earth

In the following situations the communications earth shall be the station earth:

(a) For a pole attached to the metal frame of a metallic building or cubicle;

(b) For a pole attached to a ground water tank, elevated water tower or any associated structural member such as a railing;

(c) For a low profile antenna;

(d) For an internal cubicle within a building or elevated water tower.

In all situations the combined earthing and bonding system shall meet all of the lightning protection requirements contained in this Standard.

3.3.4 Earth Bonding Points

For a Type 1 communications earth, there shall be provision for a separate isolated connection for the bonding cable at both the communications and station earths.

For a Type 2 communications earth, a communications earth pit shall be provided for connecting bonding cables to the communications earth. As a minimum, there shall be provision for separate isolated connections at the communications earth for bonding cables to:

(a) The antenna support structure; and

(b) The station earth.

3.3.5 SCADA Equipment Earth Connection

The negative terminal of the SCADA equipment power supply and battery bank shall be connected to the radio cubicle/cabinet earth bar. The point of connection at the earth bar shall be a suitable isolation point for fault finding and maintenance.

All equipment negative or earth points shall be connected via a suitable distribution bus and cables to the negative terminal of the battery and/or power supply.

3.3.6 Station earth

Prior to bonding to a Type 1, 2 or 3 communications earth, the station earth shall be inspected and tested to confirm that is complies with the relevant electrical standards, including the measurement of the station earth resistance where relevant.

Note: There is no need to retest the station earth where there is documentary evidence that the earth has been tested within the past two years and meets the relevant electrical standards.

Where the station earth is found to be noncompliant, the matter shall be referred to the relevant regional office for corrective action.

3.4 Bonding

All equipment shall be suitably bonded to ensure that lightning strikes are given a direct path into the mass of the earth and to minimise the effects of electrical surges, potential differences and flashovers during a lightning strike, in accordance with the following requirements.

3.4.1 Structural Bonding

(a) In a concrete foundation, the structure mounting bolts shall be electrically bonded to the steel reinforcing bars and all reinforcing bars shall be electrically bonded together at all splice points;

(b) The structure shall be secured to the foundation mounting bolts so as to provide good electrical connectivity;

(c) All guy anchor points of a guyed mast shall be bonded by a minimum 35 mm^2 bare hard drawn copper cable to the communications earth. The bonding cable shall be directly connected to each metallic guy to provide good electrical bonding, bypassing ohmic junctions on joints, turnbuckles or pins;

(d) A minimum 35 mm^2 bare hard drawn copper cable buried earth ring shall be provided to bond all legs of a free standing tower together and to the communications earth;

> **Note:** Buried earth rings are not required for free standing poles with either galvanised steel screw piles or reinforced concrete foundations.

(e) For a pole attached to any building, metallic cubicle, water tank or elevated water tower the antenna support structure shall be directly connected by a minimum 35 mm^2 insulated copper cable to the station earth;

> **Note:** Bonding is not required where the antenna support pole is secured to, and makes good electrical connection to a metallic structural member that is connected to the station earth.

(f) External cable trays, catenaries or metal conduits connecting an antenna support structure to an equipment area shall be bonded by a minimum 16 mm^2 insulated copper cable to the structure and the communications earth;

> **Note:** Bonding is not required where the external cable trays, catenaries or metal conduits are secured to, and make good electrical connection to the structure.

(g) The metalwork of internal cubicles, cable trays, equipment racks and cabinets shall be bonded together and to the station earth by a minimum 6 mm^2 insulated copper cable.

> **Note:** For Item (g) bonding conductors shall be directly connected to the station earth or to another point on the earthing system that is connected to the station earth.

3.4.2 Earth Bonding

(a) Type 1 and 2 communications earths shall be directly bonded to the station earth by a minimum 35 mm^2 bare hard drawn copper cable;

(b) The cable shall be run to the station earth by the shortest practical route and shall not be bonded to another point that is connected to the station earth;

(c) Where the cable is exposed to mechanical damage and it is not possible to use conduit for protection, for example over a concrete slab, bare hard drawn copper cable may be used;

(d) Where the cable enters a building and/or a switchboard it shall be insulated.

> **Note:** Bare copper earth bonding cable shall not be run inside a building or switchboard.

3.4.3 Surge Suppression Bonding

(a) Antenna feeder surge suppressors shall be bonded by a minimum 6 mm^2 insulated copper cable to the station earth;

> **Note:** The bonding cable shall be directly connected to the station earth or to another point on the earthing system that is connected to the station earth.

(b) Metal feeder entry gland plates shall be bonded by a minimum 16 mm^2 insulated copper cable to the station earth.

> **Note:** The bonding cable shall be directly connected to the station earth or to another point on the earthing system that is connected to the station earth.

3.4.4 Antenna and Feeder Cable Bonding

(a) Antennas shall be mounted to provide good electrical bonding to the support structure;

> **Note:** This requirement is not applicable to some low profile antennas.

(b) Each external antenna feeder cable shall be bonded to the support structure in at least one place, namely just before the bend to the horizontal at the bottom of the structure. The earth bonding connections shall be wrapped in self-amalgamating tape and further wrapped with electrical tape to ensure that the connection is protected against the ingress of moisture and chemicals.

> **Note:** For a pole attached to a non-metallic building, metallic building or cubicle it is not necessary to provide a feeder cable earth strap connection at the bottom adjacent to the cable entry.

3.4.5 Bonding General

(a) All bonding cables shall follow the shortest and most direct path to earth and shall not be coiled;

(b) The maximum volt drop across all bonding connections at 25 Amp shall be less than 0.1 volt;

(c) Earth cables shall be kept as far away as possible from steel trays or structures to ensure that the lightning current surge impedance is a low as possible;

(d) All external earth connections shall be protected from the weather by suitable applied coatings of anti-oxidant and protective coating such as self amalgamating tape, Denso grease and Denso tape;

(e) All connections and bonding shall be protected from galvanic corrosion due to chemical reaction between dissimilar metals;

(f) Lugs shall be used for all bonding cable connections.

3.4.6 Underground Bonding Cable

(a) All bonding cables connecting to the communications earth at the base of the antenna support structure shall be run through a concrete foundation in at least 50 mm diameter medium duty non-metallic white conduit and all bends shall be sweep bends;

(b) Elsewhere, earthing and bonding cables shall be directly buried in the ground unless specified otherwise. The separation of buried cable from other underground services, burial depth, and use of marker tapes shall meet the requirements of AS/NZS 3000;

> Note: Orange marker tape shall not be used for earthing or bonding cables.

(c) Where specified for mechanical protection, medium duty non-metallic white conduit shall be used for earthing and bonding cables.

3.5 Lightning Surge Suppressors

In accordance with DS 40-09, surge suppressors shall be fitted to protect all SCADA equipment from lightning surges generated by direct and indirect lightning strikes.

In addition, a coaxial in line surge suppressor with an earth terminal shall be installed in each antenna feeder cable, including each low profile antenna, as shown in the JT17 Drawings.

The antenna feeder surge suppressor shall be mounted in one of the following locations:

(a) Metal feeder entry gland plate;

(b) Affixed to the metalwork of an internal cable tray;

(c) Where an equipment cubicle or cabinet is free standing, at the point of entry into the cubicle or cabinet or within the cubicle or cabinet as near to the entry point as possible;

(d) Where an equipment cubicle is mounted on an antenna support pole, inside the base of the pole affixed to the earth bar bracket;

(e) Where a low profile antenna is used, at a suitable location between the antenna and radio equipment.

The antenna feeder surge suppressor earth terminal shall be bonded to the station earth as per the requirements of Section 3.4.3.

4 APPENDIX A LIGHTNING ASSESSMENT SHEETS

Risk Assessment for Lightning Protection

Standards Australia Version 1.3 Date: 03/12/2003

Structure Identification: SCADA Radio Repeater

Structure Dimensions

Length (m)	5
Width (m)	5
Height (m)	30

Structure Attributes

Risk of Fire or Physical Damage	Low
Risk of Dangerous Discharge	Low
Internal Wiring Type	Unscreened

Service Lines

Power Line

Service	Overhead
Cable Type	Unscreened
Transformer at Structure	No Transformer

Other Overhead Services

Number	0
Cable Type	Unscreened

Other Underground Services

Number	1
Cable Type	Unscreened

Loss Categories

Category 1 - Loss of Human Life

Special Hazard	1	Fire Damage Factor	0	Overvoltage Damage Factor	0

Category 2 - Loss of Essential Services

Fire Damage Factor	0.1	Overvoltage Damage Factor	0.01

Category 3 - Loss of Cultural Heritage

Fire Damage Factor	0

Category 4 - Economic Loss

Fire Damage Factor	0.2	Acceptable Risk of Economic Losses	1.E-03
Overvoltage Damage Factor	1.E-03	Step & Touch Potential Damage Factors	0

Environment

Thunderdays per year	50
Environmental Factor	Isolated on Hill
Service Line Density	Sparse

Protection Measures

Efficiency of Building Protection	0.8	Surge Protection at Point of Entry	Yes
Fire Protection	None	Surge Protection on All Equipment	No

Overall Risk

	Calculated Risk (R)	Acceptable Risk (Ra)	Direct Strike Risk (Rd)	Indirect Strike Risk (Ri)
Loss of Human Life	5.80E-08	1.0E-05	5.80E-08	2.23E-12
Loss of Essential Services	8.05E-03	1.0E-03	3.51E-05	8.02E-03
Loss of Cultural Heritage	0.00E+00	1.0E-03	0.00E+00	0.00E+00
Economic Loss	8.06E-04	1.0E-03	4.17E-06	8.02E-04

Risk Assessment for Lightning Protection

Standards Australia Version 1.3 Date: 03/12/2003

Structure Identification: SCADA Local Site

Structure Dimensions

Length (m)	3
Width (m)	3
Height (m)	6

Structure Attributes

Risk of Fire or Physical Damage	Low
Risk of Dangerous Discharge	Low
Internal Wiring Type	Unscreened

Environment

Thunderdays per year	50
Environmental Factor	Similar Height
Service Line Density	Sparse

Service Lines

Power Line

Service	Overhead
Cable Type	Unscreened
Transformer at Structure	No Transformer

Other Overhead Services

Number	0
Cable Type	Unscreened

Other Underground Services

Number	1
Cable Type	Unscreened

Loss Categories

Category 1 - Loss of Human Life

Special Hazard	1	Fire Damage Factor	0	Overvoltage Damage Factor	0

Category 2 - Loss of Essential Services

Fire Damage Factor	0.1	Overvoltage Damage Factor	0.01

Category 3 - Loss of Cultural Heritage

Fire Damage Factor	0

Category 4 - Economic Loss

Fire Damage Factor	0.2	Acceptable Risk of Economic Losses	1.E-03
Overvoltage Damage Factor	1.E-03	Step & Touch Potential Damage Factors	0

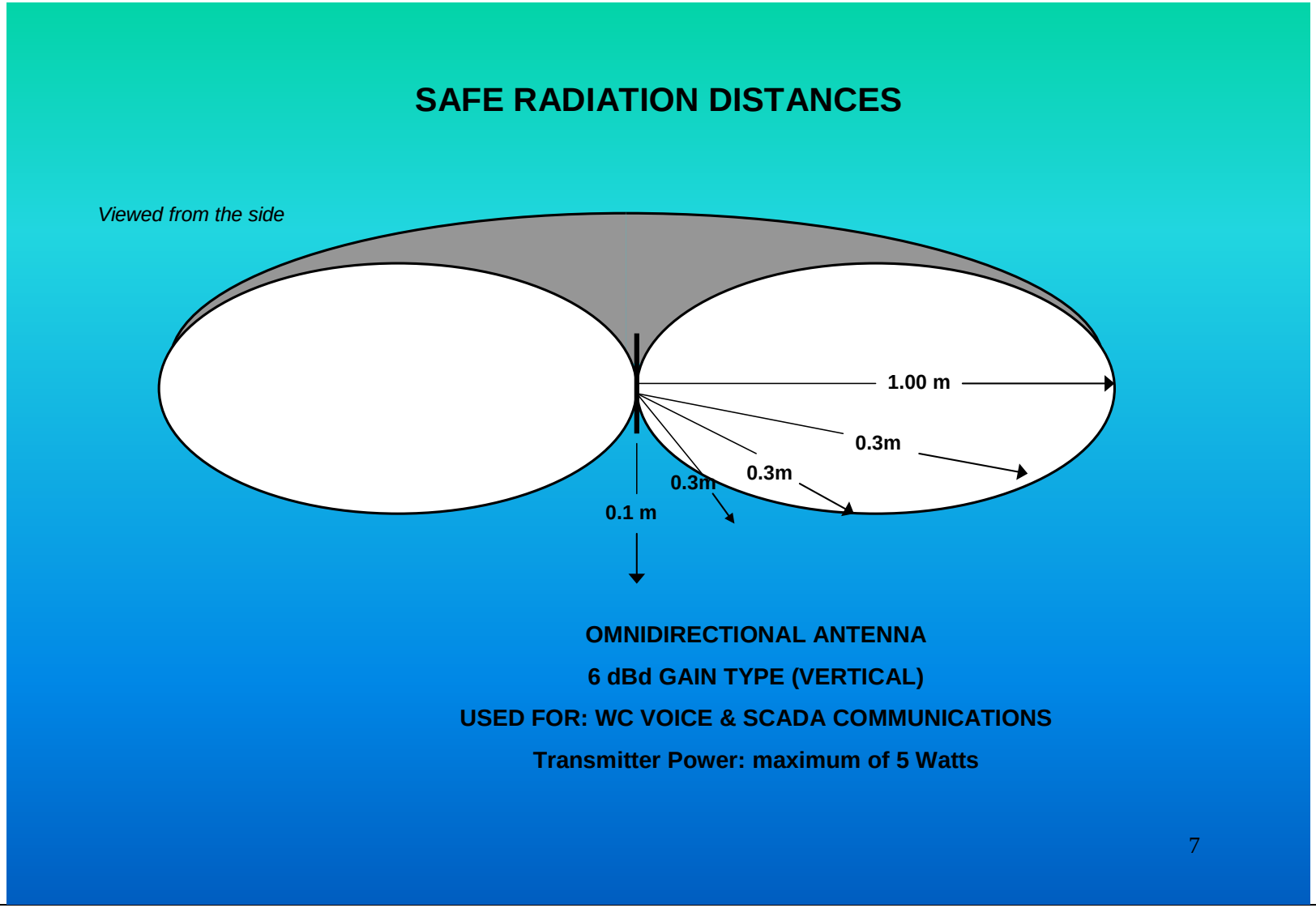
Protection Measures

Efficiency of Building Protection	0.8	Surge Protection at Point of Entry	Yes
Fire Protection	None	Surge Protection on All Equipment	No

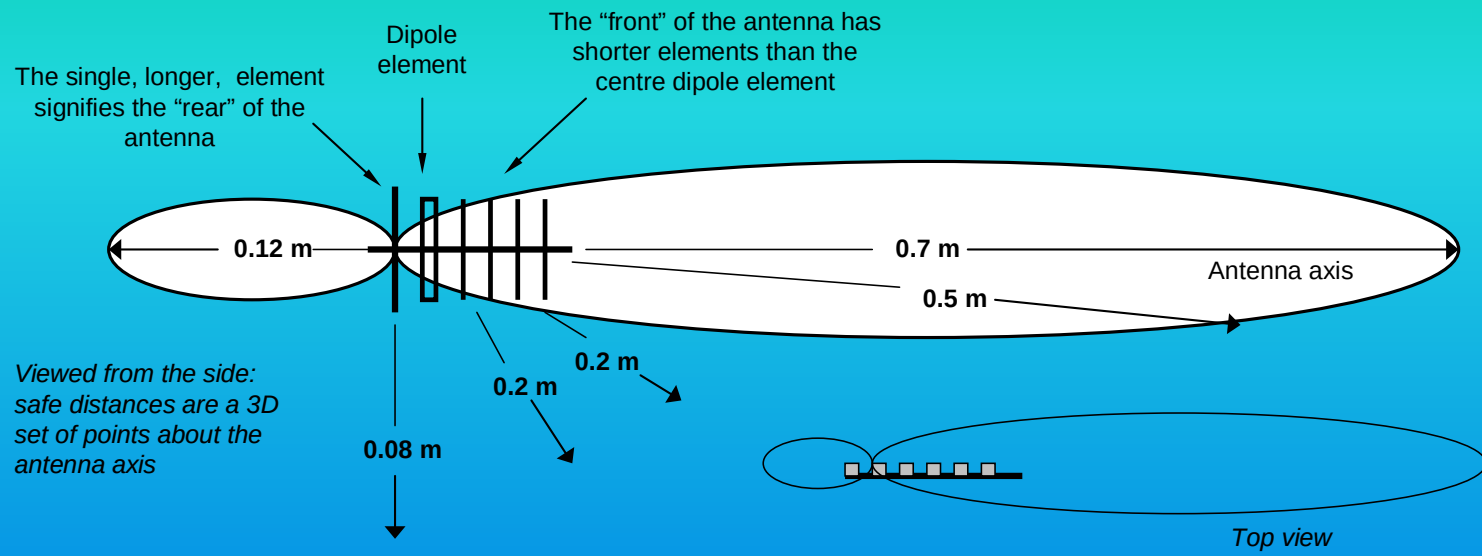
Overall Risk

	Calculated Risk (R)	Acceptable Risk (Ra)	Direct Strike Risk (Rd)	Indirect Strike Risk (Ri)
Loss of Human Life	3.33E-10	1.0E-05	3.30E-10	2.40E-12
Loss of Essential Services	8.02E-03	1.0E-03	2.00E-07	8.02E-03
Loss of Cultural Heritage	0.00E+00	1.0E-03	0.00E+00	0.00E+00
Economic Loss	8.03E-04	1.0E-03	2.38E-08	8.03E-04

5 APPENDIX B SCADA ANTENNA SAFE RADIATION DISTANCES



SAFE RADIATION DISTANCES



YAGI ANTENNA

6 ELEMENT TYPE

USED FOR: WC VOICE AND SCADA COMMUNICATIONS

Transmitter Power: maximum of 1 Watt

"6 element" means 6 vertical members including the dipole element as illustrated above

Arrows show minimum safe distance for:

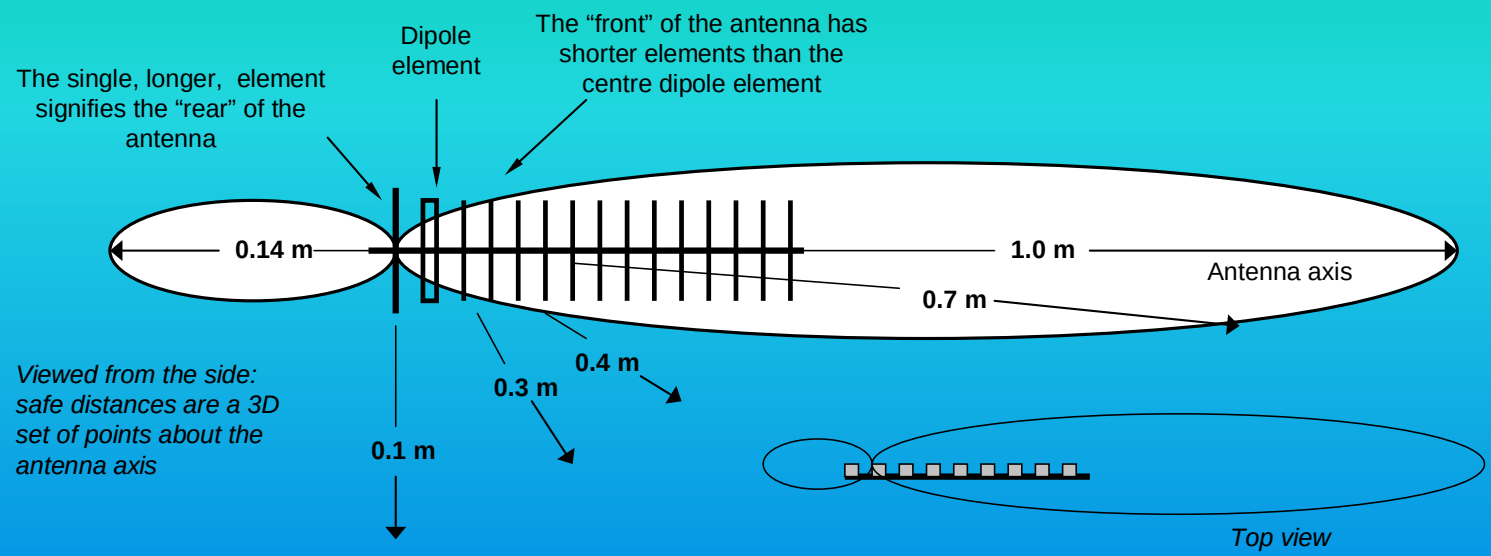
- 0 degrees (straight on)
- 22.5 degrees
- 45 degrees
- 67.5 degrees
- 90 degrees (below)

and apply equally about the antenna

Ver 1.2 1/3/99

5

SAFE RADIATION DISTANCES



YAGI ANTENNA

15 ELEMENT TYPE

USED FOR: WC VOICE AND SCADA COMMUNICATIONS

Transmitter Power: maximum of 1 Watt

"15 element" means 15 vertical members including the dipole element as illustrated above

Arrows show minimum safe distance for:

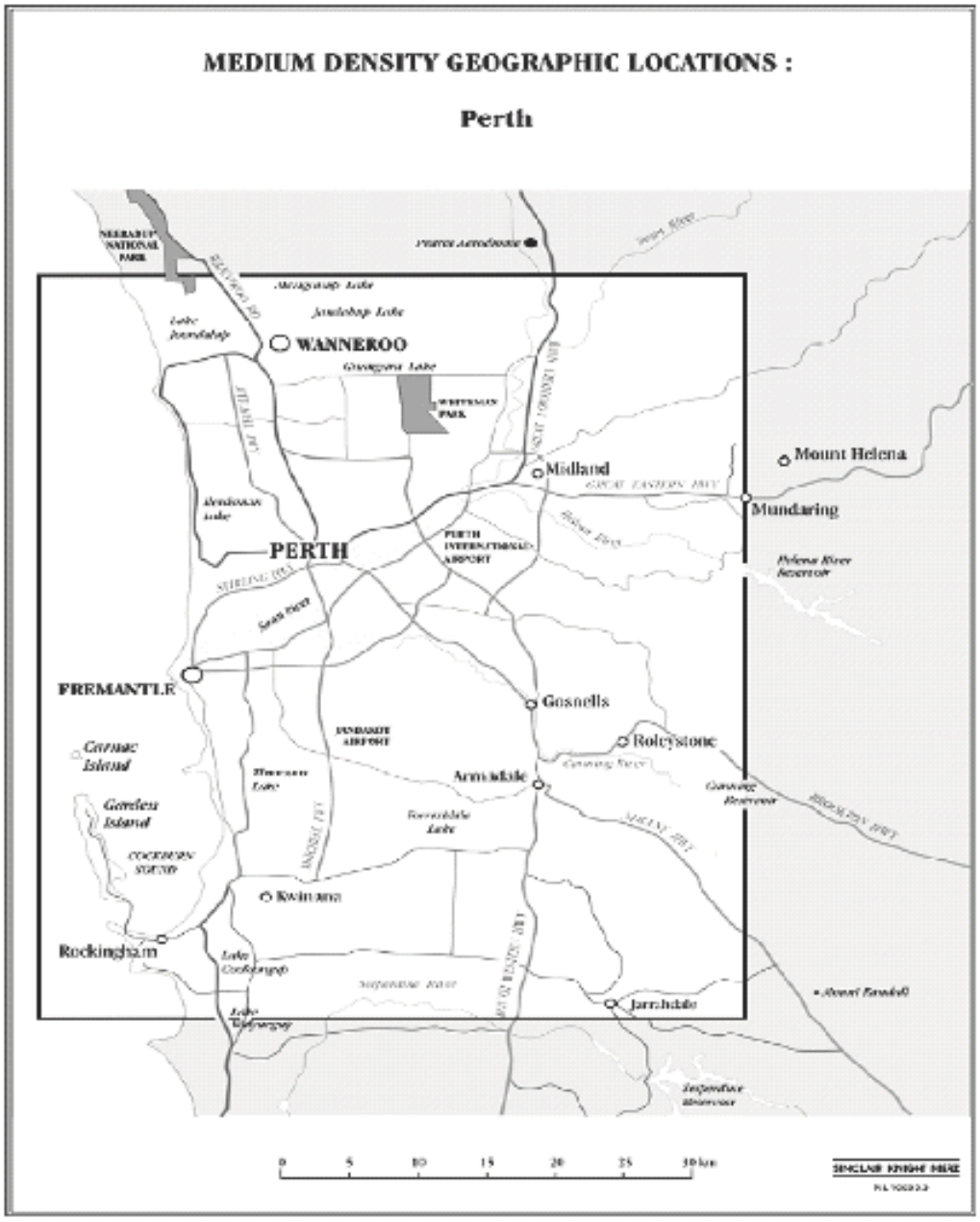
- 0 degrees (straight on)
- 22.5 degrees
- 45 degrees
- 67.5 degrees
- 90 degrees (below)

and apply equally about the antenna

6

Ver 1.2 1/3/99

6 APPENDIX C ACMA MEDIUM DENSITY GEOGRAPHIC LOCATIONS



Coordinates

Point number	Zone	Easting	Northing
1	50	370000	6420000
2	50	370000	6490000
3	50	425000	6490000
4	50	425000	6420000

END OF DOCUMENT