Floodlighting Design Report
Sydney Showground Main Arena Redevelopment
Royal Agricultural Society of NSW

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aurecon

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Contents

1. Introduction

1.1 General

Aurecon have been engaged to provide the floodlighting design for the Sydney Showground Main Arena Redevelopment to cater for AFL games and a range of sporting events. The report accompanies a Major Project application.

The purpose of this report is to address the Director Generals requirements relating to lighting emissions for the Redevelopment of the Sydney Showground Main Arena Project. The report defines the design criteria for the upgrade of sports lighting as specified by Australian Standards; Industry best practice, International standards and AFL guidelines and where compliance will be met.

2. Existing lighting system

2.1 Floodlighting

2.1.1 General

The original floodlighting installation was completed in 1997 prior to the Sydney Olympic Games. The existing floodlighting installation comprises of:

- 6 roof support column light poles each fitted with 34 floodlights;
- 2 free-standing light poles each fitted with 46 floodlights; and
- 24 floodlights mounted along the grandstand roof edge.

Each light pole is supported by a dedicated distribution boards complete with lighting controls. The lighting controls switch banks of lights to allow 6 different lighting modes:

1. General training
2. General events
3. Peak events
4. Baseball training
5. Baseball practice
6. Baseball televised game

2.1.2 Light poles

There are two types of light poles currently used around the arena:

1. roof support column light pole;
2. free standing light pole

The free standing light poles, currently located on the spectator grass area at the northern end of the arena are designed by Riverton Engineering Co specifically to support a maximum of 52 floodlights and associated control gear panel. The poles are approximately 50m tall (including headframe).

The roof support light poles are an integral part of the stand roof structure and the load capacity of the poles are unknown at this point. The poles are approximately 55m tall (including headframe).

2.1.3 Sports field lighting levels

Ultimate Lighting International was commissioned to complete an 'Illumination Survey Report' in July 2008. Lighting measurements were taken in accordance with AS2560 to check the compliance with the lighting levels detailed in AS2560 part 2.3 and FreeTV Operational Practice OP-31.

In summary, the measured lighting levels only complied with the ball and training modes minimum requirements of AS 2560 and did not comply with any other part of the above standard and practice requirements.

2.1.4 Obtrusive lighting

There has been no documentation observed detailing that any obtrusive lighting measurements or report has been undertaken to ensure compliance of the Australian Standard AS4282:1997 'Control of the obtrusive effects of outdoor lighting'.

There has been a number of alterations to the existing 1997 floodlighting installation which includes the addition of floodlights and re-aiming of existing floodlights. These works have been done since the inclusion of the standard AS4282 in 1997 and are assumed to comply with the standard.

2.1.5 Luminaires and Lamps

Luminaires

The existing floodlights are a Sylvania Lighting Stadium Pro II with the lamps rated at 2kW.

3. Design parameters

3.1 Floodlighting

The proposed design at the Showground Main Arena floodlighting for colour television is governed by:

- The Australian Standards:
  - AS 2560 - Sports lighting Part 1 General principles
  - AS 2560 – Guide to sports lighting Part 2.3 Specific applications – Lighting for football (all codes)
  - AS 4282 – Control of the obtrusive effects of outdoor lighting
- best practice:
  - FreeTV Australia operational practice OP-31 (lighting requirement for colour television)
  - FreeTV Australia operational practice OP-33 (TV coverage plan for AFL matches)
- International lighting standard
  - CIE169 – Practical design guidelines for the lighting of sports events for colour television and filming
- AFL standards

- AFL minimum standards, AFL venues 2009

3.2 Stadia lighting

There will be supplementary lighting to the floodlights to ensure safe movement of people within the stadium and stands:

- Australian Standard:
  - AS 1158 – Lighting for public roads and public space set
  - AS 1158 part 3.1 – Lighting for roads and public spaces set – Pedestrian area (Category P) lighting – Performance and design requirements

3.3 AS 2560 part 2.3:2002

AS 2560 contains recommendations and requirements for the lighting of sporting grounds and aims to provide suitable and comfortable light levels for players and spectators. Part 2.3 outlines the minimum recommendations and requirements specifically for football, where the term football refers to rugby league, rugby union, Australian rules and soccer. This standard does not cover obtrusive lighting or colour television broadcasting requirements.

AS2560 part 2.3 details 3 different professional modes of lighting for:

- Ball and physical training (100 lux average)
- Match practice (200 lux average)
- Professional competition (500 lux average)

The sports field floodlighting design will comply with the minimum requirements of AS2560.

3.4 AS 4282:1997

AS 4282 contains recommendations regarding control of obtrusive lighting to neighbouring areas. The standard considers three factors;

- illuminance at neighbouring residential and commercial properties,
- luminous intensity of luminaires (brightness of luminaires when viewed from neighbouring properties), and
- threshold increment which is a measure of disability glare caused by the lighting to pedestrians and motorists.

The standard takes into account factors such as the level of ambient lighting existing in the area and pre-curfew and curfew hours.

The standard specifically excludes lighting systems which are installed for the purposes of colour television broadcasting from the scope of the standard (detailed in section 1.1 Scope).

Table 3.1 details the relevant limiting values of spill lighting during non-televised events, assuming RAS Showground is at the boundary of commercial and residential area.

Table 3.1 – AS 4282 obtrusive lighting limiting levels

Lighting criteria	Pre-curfew	Curfew hours
Illuminance in vertical plane	25Lux	4Lux
Luminous intensity emitted by luminaires	7,500cd	2,500cd
Threshold increment	20%of 10 cd/m2	20%of 10 cd/m2

Further discussions relating to AS4282 is provided in section 4.3

3.5 Free TV Australia OP-31

OP-31 outlines minimum lighting performance requirements for colour television broadcasting. It has been developed from the international standard CIE 57:1989 and CIE 169:2005.

The sports field floodlighting will comply with the FreeTV OP-31 requirements.

3.6 CIE 169:2005

International standard CIE 169:2005 outlines the minimum requirements for sports lighting performance for the comfort of players and spectators and for colour television broadcasting.

The sports field floodlighting design will primarily comply with AS2560 and FreeTV OP-31 requirements. The FreeTV OP-31 is based on the CIE 169 but has some minor differences.

3.7 ALF standards

The ALF Minimum Standards (AFL Venues 2009) section 16 Ground Lighting:

Should the venue be required to host a night match, sufficient lighting is required in accordance with Australian Standards – AS2560 part 2.3 that being:-

(a) for a non-televised practice match – minimum 500 lux; and

(b) for any other match – minimum 1200 lux

3.8 AS/NZS 1158:2005

AS/NZS 1158 contains recommendations regarding the control of lighting to allow the safe movement of people within public spaces and reduce the occurrence and effectiveness of crime.

4. Proposed Lighting Design and Specification

4.1 Introduction

This section will outline the lighting design criteria based upon the reference codes of the previous section.

Three modes of lighting have been developed to accommodate the different levels of lighting required for:

- televised matches;
- non-televised matches; and
- ball and physical training.

The different modes will achieve energy cost savings and provide compliance with the obtrusive lighting code during non-televised matches and ball and physical training.

4.1.1 Televised matches

The televised lighting mode will be designed to use all of the floodlights mounted around the ground to comply with the minimum requirements in the FreeTV OP-31, FreeTV OP-33, AS 2560 and AFL minimum standards, AFL venues 2009.

The lighting level will meet or exceed the minimum criteria within Australian Standard AS 2560.2.3 for professional competition.

4.1.2 Non-televised match

The lighting for non-televised matches will be designed for an average lighting level of 500 lux. The lighting will exceed the minimum criteria within Australian Standard AS 2560.2.3 for professional competition.

4.1.3 Ball and physical training

The lighting for ball and physical training will be designed for an average lighting level of 250 lux. The lighting will exceed the minimum criteria within Australian Standard AS 2560.2.3 for professional level ball and physical training.

4.2 Lighting poles

4.2.1 Support column light poles

The existing support column light poles are in fixed positions and cannot be relocated.

The lighting design will require additional floodlights to be mounted on the headframe. The design is considering removing the existing lighting control gear mounted on the headframe and installing the new lighting control gear in a dedicated room on ground. This will reduce the overall impact on the structural loading of the headframe and allow the installation of the additional quantity of floodlights.

The existing light poles have been shown on the Showground layout in Appendix A.

4.2.2 Free-standing light poles

The free-standing light poles are located at the northern end of the arena and will have to be replaced. The height of the light pole does not comply with AS2560 requirements and makes compliance with AS4282 very difficult. The number of floodlights must be increased from 52 to approximately 75 and the headframe does not have the spare physical capacity.

AS2560 and AFL guideline recommend the light pole be located within a certain zone of the ground. This zone is shown on the Showground layout in Appendix A. The proposed light pole has been incorporated into the architectural features of the new stand and appears very similar to the existing light poles.

4.2.3 Light pole heights

The light poles should be tall enough to ensure the lowest floodlight is located above the minimum requirements detailed in AS2560 part2.3. The minimum height ensures the limited impact of glare on the player in the arena and spill light to surrounding areas.

The existing support-column lighting poles comply with the above requirements and the new free standing lighting poles will be designed to comply.

4.3 Obtrusive lighting

4.3.1 General

AS4282 details the limits of the lighting design can have on surrounding environments (ie: residential, commercial and roadways). The standard breaks down the lighting impact components to:

- Spill light – light emitted which falls outside the boundaries of a property on which the installation is sited.
- Threshold Increment – The measure of disability glare between an object and its background. Mainly calculated on roadways for limiting the glare for drivers.
- Luminous Intensity – intensity of light emitted from a luminaire in the principal plane when aimed in accordance with the installation design.

AS4282 details two sets of parameters for compliance: pre-curfew and curfew parameters. Pre curfew hours are typically 6am to 11pm and less stringent than the curfew parameter requirements.

4.3.2 Spill

The Showground main arena is surrounded by pavilions and access roads which comprise of the 'Showground Precinct'. The obtrusive lighting calculations are based on then precinct boundary being: Australian Avenue; Kevin Coombes Avenue and Railway station (refer to appendix B for spill boundaries shown in plan).

All boundaries are assumed to be commercial, with a maximum permissible value of 25 lux. This is calculated to a height of 5m, based on unity light loss factor.

Table 4.1 Training mode boundary Spill lighting

Training mode (250 lux design)	Standards requirements	Calculated Lighting level (vertical)
Spill Boundary 1	≤25 Lux	1 lux
Spill Boundary 2	≤25 Lux	0.15 lux
Spill Boundary 3	≤25 Lux	0.5 lux

Table 4.2 Non-televised mode boundary Spill lighting

Non-televised matches mode (500 lux design)	Standards requirements	Calculated Lighting level (vertical)
Spill Boundary 1	≤25 Lux	2 lux
Spill Boundary 2	≤25 Lux	0.3 lux
Spill Boundary 3	≤25 Lux	1 lux

Spill light calculation is based on an open area with no allowance for building obstructions and trees etc. Obstructions will further reduce spill light.

The tables above illustrate that the current design philosophy complies with the requirements of AS4282.

4.3.3 Threshold increment

Threshold Increment has been calculated on three surrounding roadways:

- Australia Avenue
- Kevin Coombes Avenue
- Grand Parade

As the surrounding roadways are well illuminated, the threshold increment (in accordance with table 2.1 from AS4282-1997) is assumed an adaption luminance of 10 Cd/m².

Table 4.3 Training mode threshold increment

Training mode (250 lux design)	Standards requirements	Calculated Lighting level (vertical)
Australia Ave	≤20 %	0.3 %
Kevin Coombes Ave	≤20 %	0.1 %
Grand Parade	≤20 %	0.1 %

Table 4.4 Non-televised matches mode threshold increment

Non-televised matches mode (500 lux design)	Standards requirements	Calculated Lighting level (vertical)
Australia Ave	≤20 %	0.3 %
Kevin Coombes Ave	≤20 %	0.1 %
Grand Parade	≤20 %	0.1 %

The tables above illustrate that the current design philosophy complies with the requirements of AS4282.

4.3.4 Luminous intensity

The luminous intensity calculation is based on the type and distance from the field of surrounding properties and broken down into two categories:

- Level 1 control; and

- Level 2 control.

The floodlighting design is based on the Sylvania Siteco R3 Maxi floodlight which has seven available beam distributions. The 250 and 500 lux lighting design uses beam distributions 6 and 7.
Level 1 control is the highest form of control afforded to luminous Intensity and applies to applications where the surrounding properties are very close to the field of play and are residential in nature. As the precinct boundaries are some distance from the main arena, Level 1 control is not required for this design.

Level 2 control applies to applications which are not defined by level 1 control.

The luminous intensity, per luminaire, is calculated to comply with Level 2 Control in accordance with Table 2.2 from AS4282-1997, is 100,000 Cd.

Table 4.4 Luminous intensity comparison

Floodlight (Beam type)	Level 1 control (max angle)	Level 2 control (max angle)	Calculated Lighting angle
Beam type 6	54º	68º	56º
Beam type 7	45º	60º	43º

The lighting design complies with the level 2 control requirements as detailed in AS4282.

4.3.5 Compliance with AS4282

AS 4282 specifically excludes lighting systems which are installed for the purposes of colour television broadcasting from the scope of the standard. The sports lighting at the Showground is therefore technically exempt when operating in 'full' lighting mode for televised events. However, the stadium lighting will make all reasonable attempts to minimise spill lighting into neighbouring residential properties during televised events as it does for comply during non-televised events.

The lighting design will comply with the Australian standard AS4282 regarding obtrusive lighting for non-televised matches and ball and physical training modes pre-curfew.

4.4 Lamps

Current generation luminaires utilise smaller, double ended lamps to provide greater control of the light, reducing spill outside the stadium hence reducing wasted light and improving conditions for local residents and traffic. The more efficient control gear within current generation luminaires will also provide greater efficiency. The power factor of the luminaires is to be 0.9.

Double ended, 2000W, metal halide lamps will be specified for their high performance in light output and colour rendering properties.

The new lamps will meet the following criteria:

Lamp criteria	Requirements
Colour rendering index	≥90
Lamp correlated colour temperature	≥5500 K

4.4.1 Hot re-strike

To maintain safety and security at the stadium, 10% of the luminaires will be provided with hot re-strike control gear spread over the 4 towers. This will enable 10% of the luminaires to restart immediately upon return of mains power. Luminaires with hot re-strike control gear will have a reduced

lamp life, are approximately double the cost of standard luminaires and have a greater size and weight than standard luminaires, increasing the load on the towers.

Following a power interruption metal halide lamps require approximately 10 to 15 minutes to cool down before re-striking and also have a warm-up period of in the order of 10-15 minutes for the lamps to come to full brilliance.

4.5 Stadia lighting

Supplementary lighting will be provided to comply with AS/NZS 1158 Table 2.7 lighting category P6 (average horizontal >= 21 lux and point vertical illuminance >= 7 lux).

The areas where the standard will comply are:

- Stands seating and access;
- Main access corridors;
- New pedestrian walkways within the Showground complex adjoining public facilities (ie: carpark, buses, railway, etc)

5. Summary

The electrical floodlighting design for the Showground main arena will comply with Australian Standards AS2560, AS4282, FreeTV OP-31 and OP-33 and AFL Lighting Guidelines, except for the guideline of pole locations around the stadia.

The number of floodlights will increase per light pole headframe with new luminaires installed. The 6 roof support light poles must remain in the existing location and two new light poles integrated into the stand structure will replace two existing light poles located at the northern end of the arena.

Computer modelling calculations are available to confirm compliance with AS2560 and AS4282 lighting levels (refer to Appendix C for results).

Appendix A
Showground light pole layout

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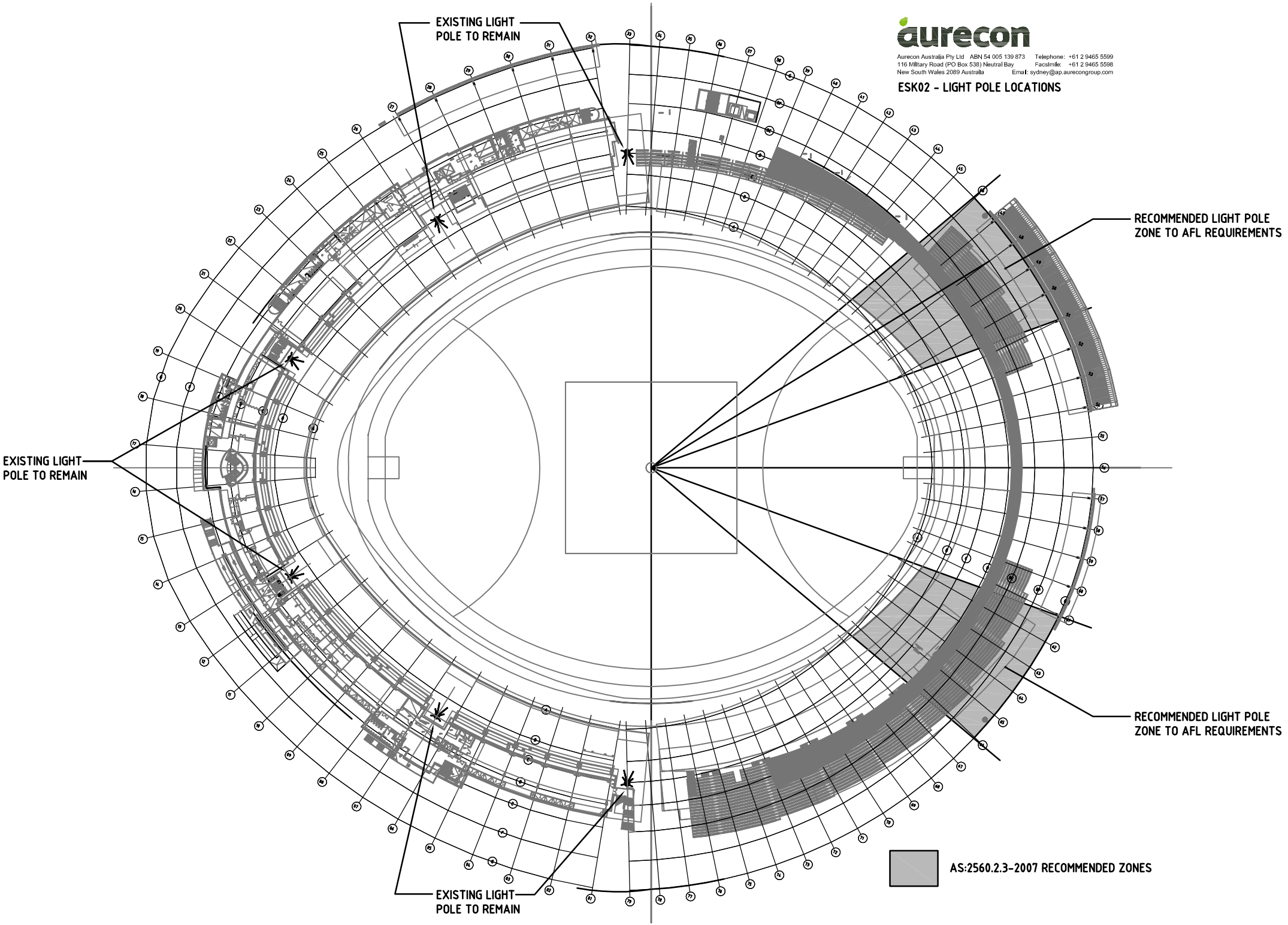
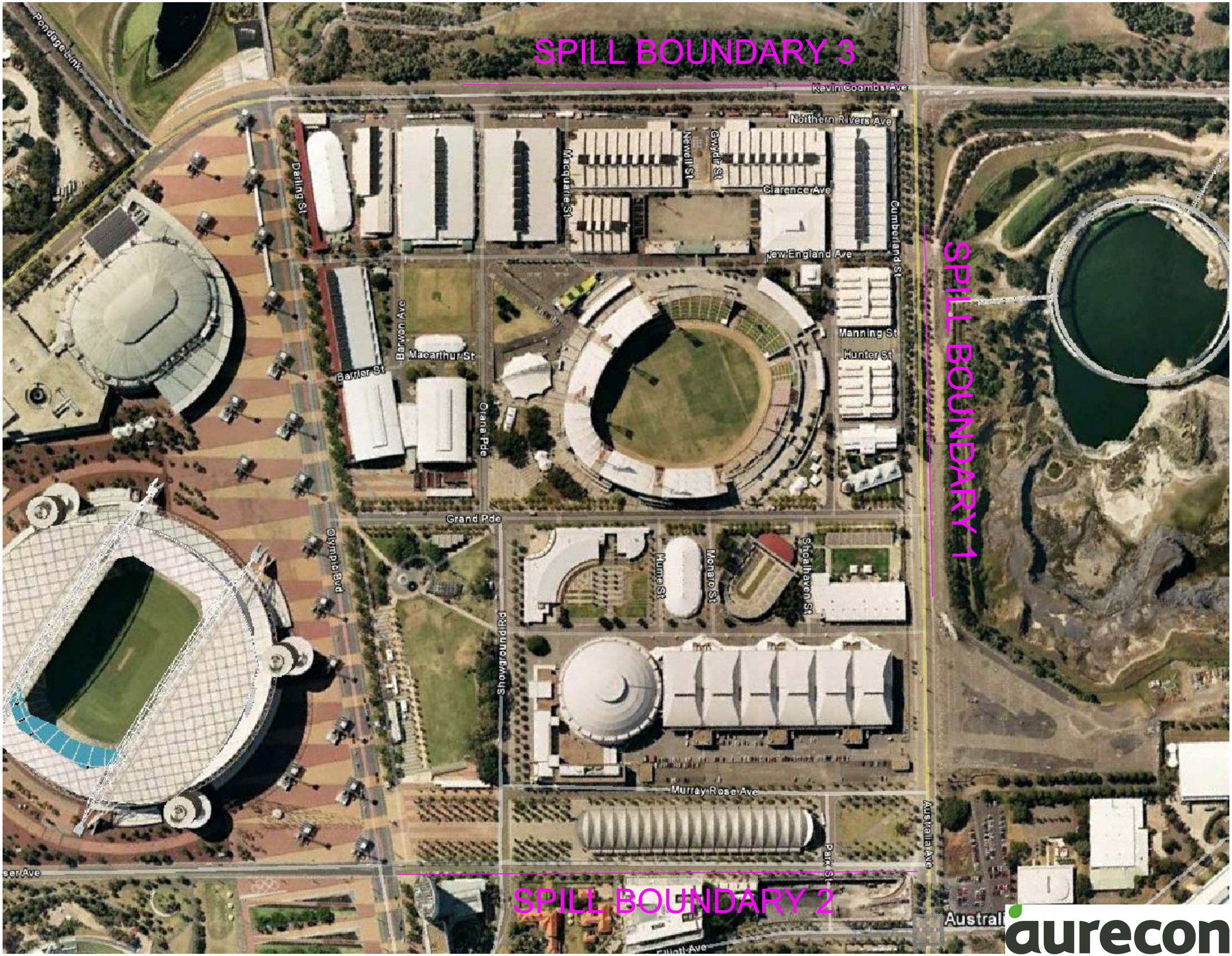
ESK02 - LIGHT POLE LOCATIONS



Appendix B
Showground precinct boundary


SPILL BOUNDARY 3
SPILL BOUNDARY 1
SPILL BOUNDARY 2
Pondage Link
Kevin Coombs Ave
Northern Rivers Ave
Darling St
Macquarie St
Newell St
Gwydir St
Clarence Ave
Cumberland St
New England Ave
Manning St
Hunter St
Barwon Ave
Macarthur St
Barrier St
Oriana Pde
Grand Pde
Olympic Blvd
Showground Rd
Hume St
Monaro St
Shoalhaven St
Murray Rose Ave
Park St
Australia Ave
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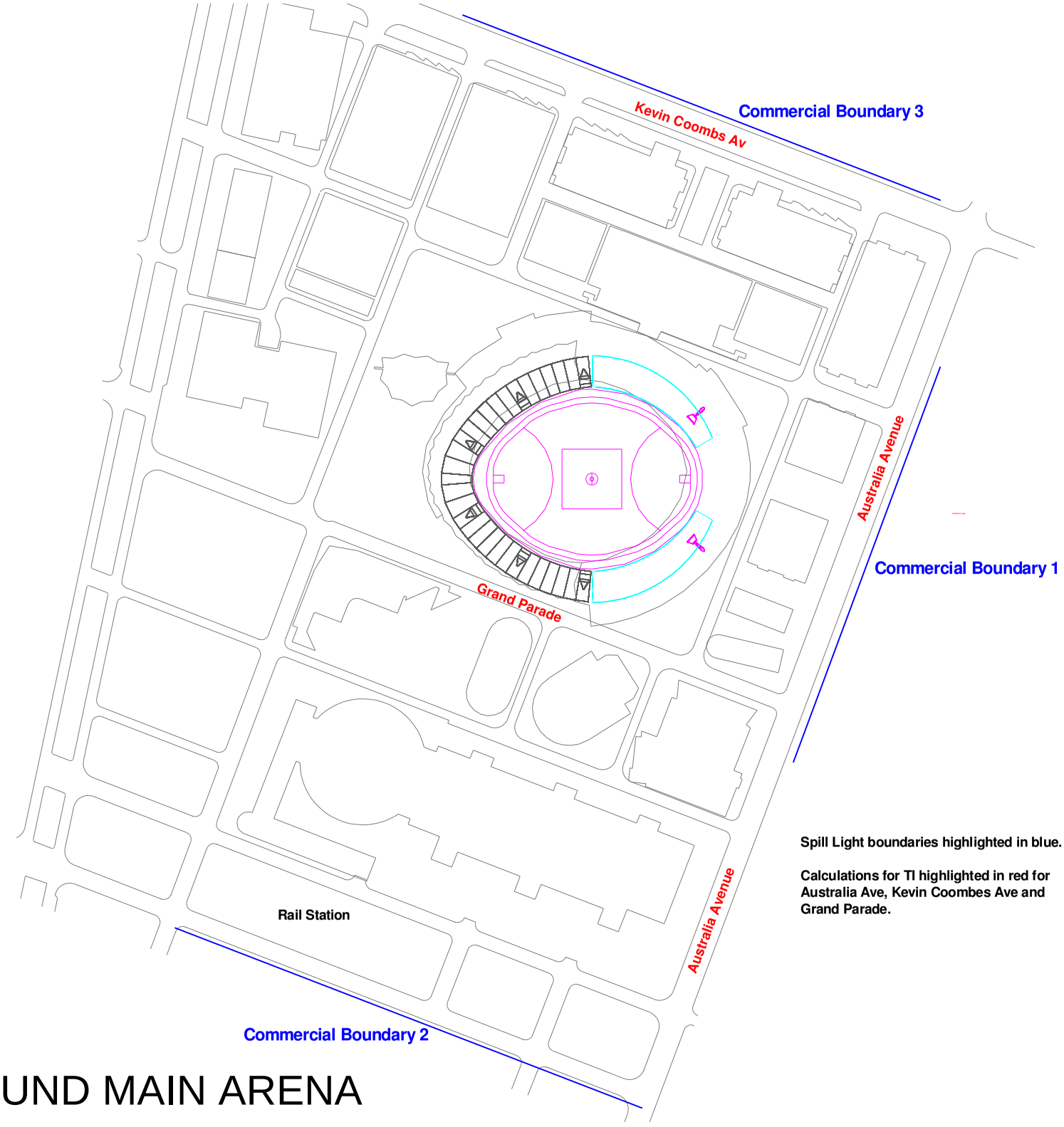
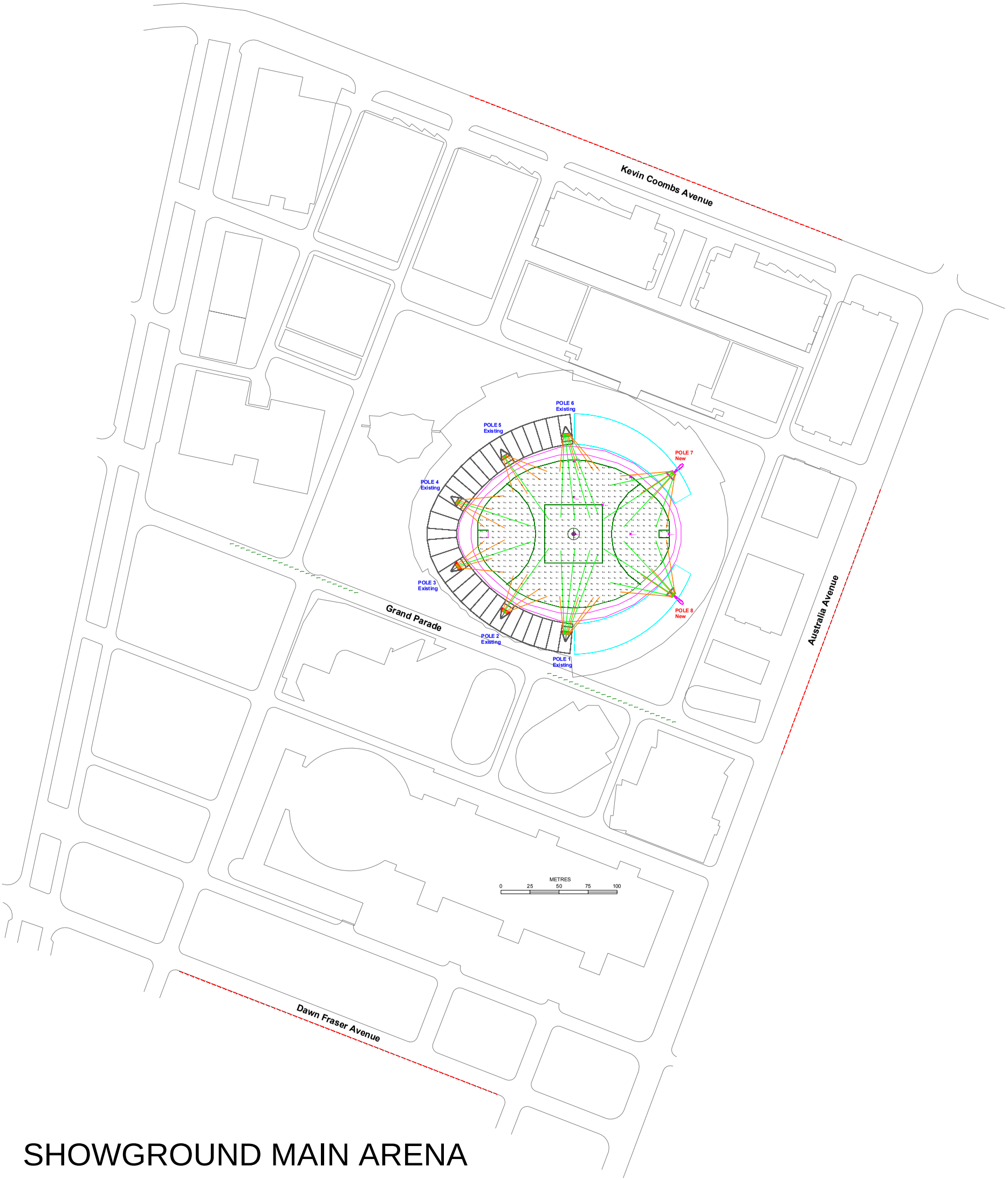


Spill Light boundaries highlighted in blue.

Calculations for TI highlighted in red for Australia Ave, Kevin Coombes Ave and Grand Parade.

SHOWGROUND MAIN ARENA

Appendix C
Lighting modelling results



Lighting Levels & Luminaire Details
-> Switching Mode 500 lux Eh
-> 104 x Siteco R3 Maxi 2000w HSI-TD
-> Mounting Heights 50m & 51.4m above pitch level

Luminaire Schedule						
Qty	Symbol	Label	Description	Lumens	LLF	Filename
40		R3 T6	Siteco R3 Maxi 2000W HQI-TS Type 6	200000	0.800	5NA75601WP61.ies
64		R3 T7	Siteco R3 Maxi 2000W HQI-TS Type 7	200000	0.800	5NA75601WP71.ies

Calculation Summary														
Label	CalcType	Units	Avg	Max	Min	Min/Avg	Min/Max	PtSpcLr	PtSpcTb	Meter Type	UG	Obs Label	Obs X	Obs Y	Obs Z
AFL Eh	Illuminance	Lux	523.98	619	438	0.83	0.71	5	5	Horizontal	1.18	N.A.	N.A.	N.A.	N.A.
Australia Ave Ev Spill	Illuminance	Lux	N.A.	1.7	1.0	N.A.	N.A.	5	1	Normal	N.A.	N.A.	N.A.	N.A.	N.A.
Kevin Coombs Ave Ev Spill	Illuminance	Lux	N.A.	0.8	0.3	N.A.	N.A.	5	1	Normal	N.A.	N.A.	N.A.	N.A.	N.A.
Dawn Fraser Ave Ev Spill	Illuminance	Lux	N.A.	0.3	0.2	N.A.	N.A.	5	1	Normal	N.A.	N.A.	N.A.	N.A.	N.A.
AFL Glare Rating	Glare Rating	N.A.	N.A.	34.1	10.0	N.A.	N.A.	5	5	Horizontal	N.A.	Obs 1	0	0	1.5
AFL Glare Rating	Glare Rating	N.A.	N.A.	28.5	10.0	N.A.	N.A.	5	5	Horizontal	N.A.	Obs 2	49	0	1.5
AFL Glare Rating	Glare Rating	N.A.	N.A.	21.4	10.0	N.A.	N.A.	5	5	Horizontal	N.A.	Obs 3	82	0	1.5
AFL Glare Rating	Glare Rating	N.A.	N.A.	31.9	10.0	N.A.	N.A.	5	5	Horizontal	N.A.	Obs 4	0	31.5	1.5
AFL Glare Rating	Glare Rating	N.A.	N.A.	15.7	10.0	N.A.	N.A.	5	5	Horizontal	N.A.	Obs 5	0	63	1.5
AFL Glare Rating	Glare Rating	N.A.	N.A.	33.1	10.0	N.A.	N.A.	5	5	Horizontal	N.A.	Obs 6	25	25	1.5
AFL Glare Rating	Glare Rating	N.A.	N.A.	18.2	10.0	N.A.	N.A.	5	5	Horizontal	N.A.	Obs 7	49	49	1.5
Grand Parade Tl Obs 1_Lv	L_Veiling	Cd/Sq.M.	N.A.	0.01	0.01	N.A.	N.A.	5	1	Normal	N.A.	N.A.	N.A.	N.A.	N.A.
Grand Parade Tl Obs 2_Lv	L_Veiling	Cd/Sq.M.	N.A.	0.02	0.02	N.A.	N.A.	5	1	Normal	N.A.	N.A.	N.A.	N.A.	N.A.

A maintenance factor of 0.8 has been applied to all luminaires.
A maintenance policy should be adopted to support the maintenance factor of 0.8.

Maximum glare rating is 34 for observer locations as per Figure 6 AS2560.2.3 2007.
Glare ratings are based on a diffuse playing surface reflectance of 25%.

AS4282 1997 - "Control of the obtrusive effects of outdoor lighting"

LIGHT TECHNICAL PARAMETERS - Pre-curfew hours
-> Ev Commercial Areas - 25 lux maximum
-> Ev Residential Areas - 10 lux maximum
-> Luminous Intensity Emitted - Level 1 & Level 2 control (refer Table 2.2)
-> Threshold Increment - 20% maximum

DESIGN ASSESSMENT - All luminaires switched on

Vertical spill illuminance has been calculated on the surrounding boundaries as shown from 1.5m to 5.5m above ground level. The maximum calculated vertical illuminance is 1.7 lux maintained (2.1 lux initial).

The maximum luminous intensity emitted per luminaire has been assessed using a large controlling dimension of >75 metres. The maximum elevation used in the design is 56 degrees which results in a maximum luminous intensity within Level 2 control limits.

Threshold increment has been calculated on the surrounding roads as shown. The threshold increment calculated is 0.2% based on an assumed roadway adaptation luminance of 10 cd/m2 (commercial areas).

There have been no obstructions such as trees, fences or buildings included in this lighting calculation.

SHOWGROUND MAIN ARENA

22.10.10