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SICEEP Darling Harbour

Interactive Display System Obtrusive
Lighting Impact Review

Issue 9 | 27 April 2016

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number

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1 Executive summary

This report includes information about the obtrusive impact of the proposed lighting integrated within the facade signage design of Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP) at Darling Harbour. To complete the review, the relevant Australian Standards have been identified as to quantify any potential adverse effects from the installation upon the nearby stakeholders.

The stakeholders considered are:

- Road users (RMS, SEPP 64, Transport for NSW) – a separate study is conducted for this assessment and is outside the scope of this report
- Aviation authority
- Adjacent residential properties

The concealed indirect lighting for static signage is not included in the scope of this report, as in Table 1 Appendix C.

The relevant Secretary's of Environmental Assessment Requirements (SEARs) have been addressed within this report.

Furthermore, for the cumulative lighting impact assessment, only a report on the obtrusive lighting assessment – ICC hotel Façade Lighting Review is considered and taken into account in this report.

This report concludes that the lighting installation integrated with the signage in the facade design does not result in any unacceptable impacts as per Australian Standards which protect against the potential obtrusive effects that may be caused by outdoor lighting.

2 Introduction

Arup has been requested by Darling Harbour Live to undertake a review of the impact of obtrusive spill lighting integrated with the proposed façade of Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP) at Darling Harbour public realm development; and to evaluate the assessment with Australian Standards and any adverse effects on the surrounding infrastructure or stakeholders.

This report considers:

- Site location review and analysis
- Collation and review of technical specifications of the comparable LED screen systems as considered and proposed by the Audio Systems Logic
- Consideration and summary of relevant codes, standards and requirements regarding the potential obtrusive effects of outdoor lighting;
- Calculated lighting performance estimates based upon the specification of the proposed lighting system against relevant standards; and
- Cumulative impact of neighbouring development (ICC Hotel).

3 Technical lighting terminology and definitions

Within this report the following technical lighting terminology is used. This section provides definitions of those terms.

Illuminance (E): The physical measure of illumination is illuminance. It is the luminous flux arriving at a surface divided by the area of the illuminated surface. Unit: lux (lx)

Luminance (L): The physical quantity corresponding to the brightness of a surface (e.g. Luminaire or reflecting material such as the road surface) when viewed from a specified direction. Unit: candela per square metre (cd/m^2)

Luminance Intensity (I): The concentration of luminous flux emitted in a specified direction. Unit: candela (cd)

Obtrusive Light: Spill light which, because of quantitative, directional or spectral attributes in a given context, gives rise to annoyance, discomfort, distraction or a reduction in the ability to see essential information

Threshold Increment (TI): The measure of disability glare expressed as the percentage increase in contrast required between a standard object and its background for it to be seen equally as well with the source of glare present as with it absent, derived in the specified manner

Pre curfew hours: Illuminance and luminaire limits apply to a specific time of day at relevant boundaries of nearby residential properties, in a vertical plane parallel to the relevant boundary, to a height commensurate with the height of the potential affected dwellings. A typical pre-curfew period is between sunset and 11:00pm

Curfew hours: Limits apply in the plane of the windows of habitable rooms of dwellings on nearby residential property. As above. A typical curfew period is between 11:00pm and 6am.

4 Identification of applicable standards

Arup recommends that the following standards are relevant in the assessment of the Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP) façade lighting, at Darling Harbour, as they protect against potentially obtrusive effects caused by illuminated structures and direct views of luminaires.

4.1 Australian standards (including road users)

The following Australian Standard provides recommendations for the control of outdoor lighting to limit potentially obtrusive effects:

- AS/NZS4282 1997 Control of the obtrusive effects of outdoor lighting

AS/NZS4282-1997 provides design recommendation for the potential impact of lighting installation adjacent to residential and mixed use developments in terms of illuminance (amount of luminous flux arriving at a site boundary/residential window), luminous intensity (the perceived brightness of a light source) and threshold increment (the potential glare that may affect a nearby transport system), all during night time.

AS/NZS4282-1997 recommends design benchmarks based on the surrounding environment in which a building element is located. Based on the assessment of the area, it was determined that the applicable category is as follows:

- Commercial area or at [the] boundary of commercial areas and residential areas

The determination of the above category is based upon the following clarification within the standards:

“Applies to residential accommodation in commercial areas or at the boundary between commercial and residential areas. The term ‘commercial’ is used as a generic description for zoning which provides for urban uses other than residential”

Based on this description, the Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP) is a commercial zone.

Within a commercial built environment, AS/NZS4282 recommends that during pre-curfew hours a maximum illuminance level of 25 lux is permitted in the vertical plane at the boundaries of nearby residential properties. Within curfew hours this level is reduced to 4 lux.

For luminous intensity, the maximum recommended value per luminaire is 100,000 cd during pre-curfew hours as determined in Table 2.2 of the standard and the determination that the minimum distance to the nearest residential premises is above 75m away. For curfew hours a limit of 2,500 cd is recommended. Refer to Appendix B for a full extract of AS4282 with the target recommendations highlighted.

Threshold increment concerns transport/road users and recommends to not exceed 20% during both curfew and non-curfew hours.

As stated in the Standard, it currently excludes:

- a) Internally illuminate advertisement signs
- b) The obtrusive effects of brightly lit surfaces e.g. floodlit buildings, and externally lit advertising signs

- c) Lighting systems which are of a cyclic or flashing nature

Clarification c) above suggests that the proposed façade lighting to the Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP) would in fact be excluded from compliance with the Australian Standard. While the standard would not apply to the facade lighting because it is intended to potentially ‘cyclic’, the recommended limits remain a relevant local benchmark in reducing obtrusive effects in residential/mixed used environments.

4.2 The Civil Aviation Safety Authority (CASA)

The CASA Manual of Standards Part 139 – Aerodromes restricts the maximum brightness of luminaires above the horizontal plain that are within a 6km radius of an aerodrome.

These restrictions are covered in Chapter 9 of the manual, and summarised in the below figure 9.21-1: Maximum lighting intensities

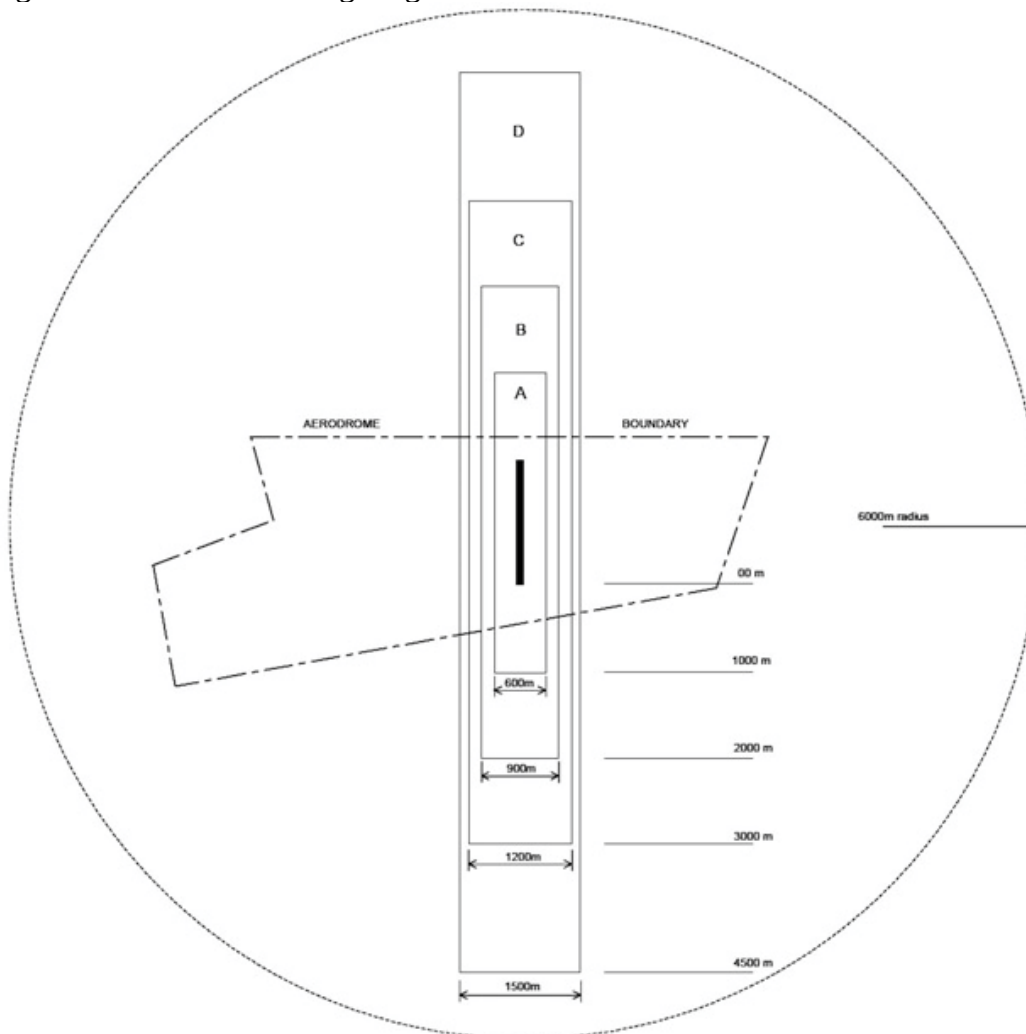


Figure 1 CASA diagram showing restrictions applicable to 6km radius

The proposed site of the Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP) falls outside of the restricted area.

5 Site appraisal

The below diagram illustrates the proposed location of the Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP)

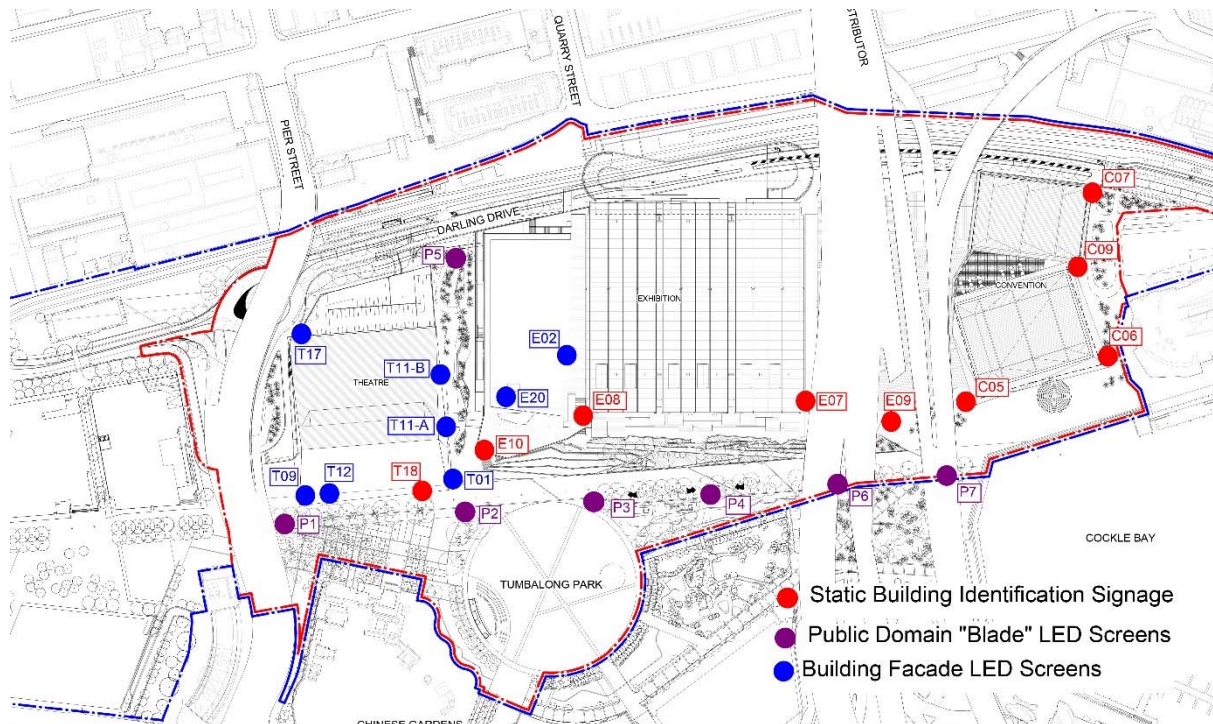


Figure 2 Proposed site and lit façade summary

The potential maximum viewing angles and distances of the Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP) to the surrounding district are further evaluated in Appendix C.

6 Luminaire details

All analysis has been based upon the technical data from Daktronics which, as confirmed by Audio Systems Logic, is considered comparable to the proposed LED screens and signage to be installed.

It should be noted that Arup has not inspected a physical sample and all analysis is based upon data supplied by the client.

7 Lighting control and content

The lighting installation is proposed to operate within the standard pre-curfew and curfew hours as recommended within the Australian Standards.

Each of the LED screens will have redundant environmental sensing so that the brightness of the screens will never exceed the desired brightness ratio to that of the natural ambient light levels present.

All LED screens will be commissioned and operated utilising local environment sensing technology. This will ensure that the optimum contrast ratio and brightness level is present at all times in comparison to local ambient light. This will ensure that the screens are not impacting the surrounding at night time with excess luminance.

8 Secretary's Environmental Assessment Requirements (SEARs)

The following requirements have been prepared with relation to the Secretary's Environmental Assessment Requirements dated 24 June 2015 proposed façade lighting:

SEAR Key Issue No.5 requirement	Arup response
The visual impacts of the proposed illumination/lighting of the signage from the surrounding residential properties and key vantage points in the public domain and surrounding the site	Compliance to be demonstrated by meeting the requirements of the Australian Standard as detailed in this report
The impacts of the proposed illumination/lighting on the light rail corridor	Separate study recommended. Not included in the scope of this report.
The operational hours of the proposed lighting	The maximum operational output to be expected from the LED screens to be 30%; the operation hours are proposed to be as follows: - Monday to Sunday – dusk to 11.00pm 30% Reduced Operational output - Monday to Sunday – 11.00pm to dusk Further 10% Reduced Operational output - Operate to 1.00am during special events Special events may include Christmas Eve, Christmas Day, New Year's Eve, Australia Day, festival days or one-off or special events during the year.

9 Cumulative Lighting Review Analysis

For the cumulative lighting impact assessment research was undertaken in identifying relevant lighting reports for the surrounding area. Only the relevant report on 'ICC Hotel – Façade Lighting Review' has been identified. No further lighting assessment was found relevant for the neighbouring buildings.

9.1 ICC Hotel – Façade Lighting impact assessment

Based on the luminaire data, installation and architectural information of the proposed façade lighting evaluated in the report, the below desktop study confirmed that the theoretical maximum vertical illuminance that may be potentially received by vertical surfaces surrounding the hotel, do not exceed the permissible lighting units approved in Australian standards.

The intent of this exercise is to understand the worst case vertical illuminance that may enter a residential window. This theoretical study is therefore rigorous in its findings and recommendations.

Along with the relevant assumptions, the following lux contours were inferred from the report:



Figure 3 Theoretical illuminance contour diagram

The above diagram indicates the theoretical maximum achievable illuminance from each façade at various distance. As per section 4.1 of this report the maximum permissible illuminance recommended to reach residential properties within the Australian Standard is 25 lux. This is during non-curfew hours. During curfew hours the maximum is 4 lux.

These lux contours along with the theoretical desk study of the proposed signage demonstrate compliance with the Australian Standards.

10 Lighting impact analysis

Based upon the luminaire technical specification the following requirements have been investigated as part of the lighting impact analysis.

- Illuminance
- Luminous intensity
- Threshold increment

Full details and calculation assumptions can be found in Appendix C.

10.1 Illuminance (Adjacent residential stakeholders)

Based on the luminaire data and client information of the proposed luminaire type, a desktop study has been completed to estimate the theoretical maximum vertical illuminance that may be potentially received by vertical surfaces surrounding the precinct.

To complete this exercise a number of significant assumptions have to be made to ensure the worst case (highest light output) scenarios. This theoretical study is therefore rigorous in its findings and recommendations.

The assumptions are as follows:

- The peak intensity emitted from the luminaires has been adapted for the calculations
- In the areas shown the calculation assumes that the entire lighting installation is visible from a single location

This is further evaluated based on individual signs, attached in Appendix C outlining the impact of the signage at different viewing distances.

10.2 Luminous intensity

The luminous intensity is based upon the light emitted by the luminaires. The peak intensity of the selected luminaire is assumed to be 1000 cd per 365x365 mm. Full details of this can be found in Appendix B.

Using this approach the installation falls significantly below the maximum recommendations of 100,000 cd for pre curfew hours and 2,500 cd for curfew hours as detailed in section 4.1 of this report.

10.3 Threshold increment

The calculation of threshold increment is not included in this report. The effect of lighting installations on transport users, needs further evaluation as a separate study to consider the surrounding roads and relevant assessment of glare source for vehicles.

11 Lighting Calculations

11.1 Illuminance Parameters

The illuminance contours are spaced at 100m intervals to study the impact of the incident light of the signage. The viewing angles are considered to be direct to view the signage, considering that as a worst case scenario, while practically the signage would be viewed at lower angles than the direct perpendicular incident ray of light.

This report includes the desktop theoretical study, and the analysis of various signage screens is attached in Appendix C.

11.1.1 Output of digital sign

For the lighting calculation purpose, the maximum allowable intensity for the proposed digital advertising sign is considered to have 30% allowable operational output.

The 30% operational output reduction is the anticipated mean percentage of screen brightness capacity that will be required to produce acceptable contrast ratios for viewing content.

The LED screen technology is based upon using red, green and blue (RGB) LED's. These are then dimmed at different levels to mix and create different colours and visual content. The luminaire test data is based upon each of these LED's operating at 100%. When RGB LED's mix in approximately equal levels they create a white light. Therefore is each LED within the screen was operating at 100% the visual effect would be a planar white screen. During operation the LED screens will very rarely ever produce this effect. Therefore when assessing LED screen brightness an operational output of 30% is typically used. This value describes the mean output when imagery, test video, etc. is produce. As such the data supplied by the LED manufacturer is reduced to 30% to provide a more accurate assessment.

As advised by Acoustic Logic the LED screens shall also be dimmed at night to account for the less bright night time visual environment. This is because a lower luminance can be used to meet the same contrast ratio and visibility. The advised level of operational output this purpose is 10% of the maximum output.

11.1.2 Composition of Sign in Calculations

Different sizes of the signs is taken into consideration and the datasheet is attached in appendix C.

11.1.3 Maintenance Factor

For the lighting calculation purpose, a maintenance factor of 1 is used. This represents the worst case scenario when the digital advertising sign is initially installed. In practice, as time progress, the output of each module of the sign will deteriorate, therefore impacting any potential obtrusive lighting effect on adjacent residential properties.

12 Compliance summary with Australian Standards and design requirements

12.1 Australian Standards

Based on the calculations and assumptions, the theoretical desktop illuminance study complies with Australian Standards (as set in Appendix A parameters).

12.2 Threshold increment (Road users/ SEPP 64/ Transport of NSW)

STATE ENVIRONMENTAL PLANNING POLICY (SEPP) NO. 64-ADVERTISING AND SIGNAGE as per the table below falls under Zone 1, and has no luminance restrictions.

- Table 3: LUMINANCE LEVELS FOR DIGITAL ADVERTISEMENTS				
- LUMINANCE LEVELS - Luminance means the objective brightness of a surface as measured by a photometer, expressed in candelas per square meter (cd/m2). Levels differ as digital signs will appear brighter when light levels in the area are low. Luminance levels should comply with Australian Standard AS4282 Control of the Obtrusive Effects of Outdoor Lighting which recommends the following levels:				
- Lighting Condition	- Zone 1	- Zones 2 and 3	- Zone 4	-
- Full Sun on face of Signage	- No limit	- Maximum Output	- Maximum Output	-
- Day Time Luminance		- 6000 cd/m2	- 6000 cd/m2	
- Morning and Evening - Twilight and Inclement Weather		- 700 cd/m2	- 500 cd/m2	
- Night Time	-	- 350 cd/m2	-	-

The signage luminance levels criteria set for Zone 1 are attached in Appendix D. Signage impact on transport is not within the scope of this report.

12.3 CASA

The site location is outside of the 6km restriction radius around aerodrome and therefore the proposals comply with this restriction.

13 Conclusion

Whilst the Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP) signage lighting is visible from a number of residential buildings, the detailed analysis demonstrates that there is no impact of the signage greater than what is allowable in AS4282. The intensity from the signage and the resultant illuminance reaching these buildings has a low impact compared to the recommended limits as stated within the relevant Australian Standard for commercial areas.

The site conditions suggest that the evaluated summary of this report outlines the potential impact of spill lighting incident in worse case scenarios, thus provides a comprehensive analysis. The conclusion is that the proposal is compliant to the standards addressed in the report.

14 Appendices

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Appendix A1 & A2

AS 4282 Control of the
obtrusive effects of outdoor
lighting - reference tables

A1 AS4282 Table 2.1

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AS 4282—1997

TABLE 2.1
RECOMMENDED MAXIMUM VALUES OF LIGHT TECHNICAL PARAMETERS
FOR THE CONTROL OF OBTRUSIVE LIGHT
(See Clause 2.7)

1	2	3	4	5
Light technical parameter	Application or calculation conditions: (see also Figure 2.1 and Section 5)	Recommended maximum values		
		In commercial areas or at boundary of commercial and residential areas [*]	Residential areas:	
			Light surrounds [†]	Dark surrounds [‡]
Illuminance in vertical plane (E_v)	<i>Pre-curfew:</i> Limits apply at relevant boundaries of nearby residential properties, in a vertical plane parallel to the relevant boundary, to a height commensurate with the height of the potentially affected dwellings. Values given are for the direct component of illuminance	25 lx	10 lx	10 lx
	<i>Curfewed hours:</i> Limits apply in the plane of the windows of habitable rooms of dwellings on nearby residential properties. In the absence of development (i.e. vacant allotment), the limits apply on the potentially affected property, in a vertical plane parallel to the relevant boundary, at the minimum setback permitted for a dwelling, to a height commensurate with land use zoning provisions. Values given are for the direct component of illuminance	4 lx	2 lx	1 lx
Luminous intensity emitted by luminaires (I)	<i>Pre-curfew:</i> Limits apply to each luminaire (irrespective of the number on a head frame) in the principal plane, for all angles at and above the control direction, when aimed in accordance with the installation design	Limits as determined from Table 2.2. Alternatively, the limits and method of assessment associated with curfewed hours may be applied, at the discretion of the designer (see Clauses 2.7.1 and 2.7.2)		
	<i>Curfewed hours:</i> Limits apply in directions where views of bright surfaces of luminaires are likely to be troublesome to residents, from positions where such views are likely to be maintained, i.e. not where momentary or short-term viewing is involved	2 500 cd	1 000 cd	500 cd
Threshold increment (TI)	Limits apply at all times where users of transport systems are subject to a reduction in the ability to see essential information. Values given are for relevant positions and viewing directions in the path of travel	20% based on adaptation luminance ($\bar{L}$) of 10 cd/m ²	20% based on adaptation luminance ($\bar{L}$) of 1 cd/m ²	20% based on adaptation luminance ($\bar{L}$) of 0.1 cd/m ²

^{*} Applies to residential accommodation in commercial areas or at the boundary between commercial and residential areas. The term 'commercial' is used as a generic description for zoning which provides for urban uses other than residential.

[†] Where the affected property abuts roads that are lit to Category V5 or higher in accordance with AS/NZS 1158.1.1.

[‡] Where the affected property abuts roads that are lit to Category B1 or lower in accordance with AS 1158.1, or where there is no lighting.

A2 AS4282 Table 2.2

AS 4282—1997

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TABLE 2.2
MAXIMUM LUMINOUS INTENSITY PER LUMINAIRE
FOR PRE-CURFEW OPERATING TIMES
(See Table 2.1)

1	2	3	4
Area description		Maximum luminous intensity from each luminaire*	
Size of area	Controlling dimension (Figure 5.1)	Level 1 control (Note 1)	Level 2 control (Note 2)
Large	>75 m	7 500 cd	100 000 cd
Medium	≥25 m ≤75 m	7 500 cd	50 000 cd
Small	<25 m	2 500 cd	25 000 cd

* Limits apply to each luminaire (irrespective of the number on a head frame) in the principle plane, for all angles at and above the control direction, when aimed in accordance with the installation design (see Clause 5.3.2.1).

NOTES:

- 1 Level 1 control is appropriate for development control of environmentally sensitive areas, i.e. where the existing environment is of high quality, where abutting properties are close to the installation, where they are residential in nature, where the existing ambient light levels are low and where the community requires the best available environmental safeguards to be applied.

As the use of Type C cut-off luminaires† is likely to be necessary for Level 1 control, the implementation of this level of control will normally be possible only for lighting applications that require relatively high illuminances over areas that are small to medium in size, e.g. lighting for tennis courts or hockey fields. However, Level 1 control may also be suitable for larger areas where lower illuminances are appropriate, e.g. for car parks and outdoor storage areas.

- 2 Level 2 control will permit the use of a wide range of currently used lighting techniques but will limit intensities in the control direction to what might reasonably be expected by careful attention to design and the selection and aiming of luminaires, especially for applications involving Type A luminaires†.

Appendix B

Assumed Luminaire technical
summary

B1 Assumed Luminaire Specifications

DAKTRONICS

DVX-1800-10MN-N PRODUCT SPECIFICATION

Pixel Configuration	RGB 3-in-1 SMD
Line and Column Spacing	0.4 inches - 10.16 millimeters
Module Configuration - Pixels (RxC)	36 x 36 pixels
Module Dimensions (HxW)	14.4 x 14.4 inches - 365.76 x 365.76 mm
Maximum Power per Module ¹	74.1312 Watts
Average Power per Module ¹	19 Watts
Display Weight per Module ²	17.45 pounds - 7.92 kilograms
Processing	22 bit Distributed
Color Capacity	16 bit (281 Trillion Colors)
Dimming	256 levels
Color Temperature	3,000°-10,000° kelvin (adjustable)
Calibration	Full depth, LED to LED
LED Refresh Rate	4800 hertz
LED Lifetime	100,000 hrs
Calibrated Intensity (measured at 6,500 deg K)	6000 nits (cd/sm)
Horizontal Viewing Angle	160°
Vertical Viewing Angle (Up/Down)	+25/-45°
Contrast Ratio	1200:1
Service Access	Front or Rear
Cabinet Depth	8.884 inches - 225.652 millimeters
Cabinet Construction	Steel and Aluminum (corrosion resistant)
Ingress Protection Rating	IP-66 Components
Working Temperature Rating ³	-40° to 122° F - -40° to 50° C
Ventilation	Fan, Vent Panel
Data Transmission to Display	Direct: Fiberoptic Cable Remote: Internet/Network (IP)

Note 1: Power draw varies depending on display ventilation.

Note 2: Display Weight per Module factors in cabinet, but not the structure.

Note 3: Temperature range is based on typical usage (100% daytime brightness, 50% content, 250W/m2 solar, no wind).

Display will operate above listed temp range but will see greater rates of dimming. Range is based on low-temp configuration.

Note 4: Ventilation solution may require external supplemental A/C in some areas of the world. Please consult your Daktronics representative regarding your area.

Note 5: Consistent with Daktronics policy of continuing product improvement, specifications shown on this document are subject to change without notice.



Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations and / or measurements included in this document are traceable to Australian / national standards.
Accreditation No. 2258.

Test Report No. LL17820

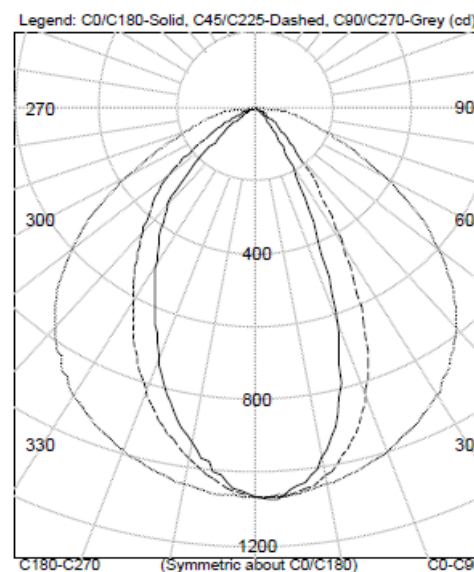
Daktronics Australia LED Panel. Product ID: Large LED Luminaire.

Black moulded fascia, heatsink and control gear, extent ~ 365 x 365 x 102 mm deep.

Lateral fins separate rows of LEDs. Array of 1176 (red, green and blue) LEDs, recessed ~ 5 mm.

DA-1487-6009 (Daktronics PC-105824) PCB controller. Daktronics A-2467E 240V 50Hz electronic LED driver.

Daktronics VIP-4060 LED controller (power used by controller not included, controller settings by client, "100% white"). Tested at 240 V 50 Hz, face horizontal, C0 half plane above beam. Measured I = 274 mA.



INTENSITY SUMMARY (cd)

Gamma	C-Plane					Flux (lm)
	C0	C22.5	C45	C67.5	C90	
0.0	1072	1072	1072	1072	1072	
5.0	1055	1065	1067	1071	1067	99
10.0	979	992	1027	1052	1049	
15.0	822	865	949	1017	1029	259
20.0	593	663	823	968	1000	
25.0	350	422	652	899	961	323
30.0	190	243	463	809	918	
35.0	97	130	295	702	861	307
40.0	50	70	178	574	794	
45.0	26	36	103	444	711	247
50.0	12	18	57	324	616	
55.0	5	7	29	218	499	157
60.0	2	3	13	142	382	
65.0	1	2	4	88	276	83
70.0	1	1	2	53	193	
75.0	1	1	1	22	135	34
80.0	0	1	1	7	95	
85.0	1	0	1	2	56	7
90.0	0	0	0	0	5	

ZONAL FLUX AND PERCENTAGES

Zone	Flux (lm)	% Lamp	% Luminaire
0-30	681	N / A	45.0
0-40	988	N / A	65.2
0-60	1392	N / A	91.8
0-90	1515	N / A	100.0
40-90	527	N / A	34.8
60-90	124	N / A	8.2
90-180	0	N / A	0.0
0-180	1516	N / A	100.0

Light Output Ratio = N / A

CERTIFIED BY: *K Monaghan*
Kevin Monaghan
Authorised Signatory

Date of test 24-Jul-2014
Date of report 30-Jul-2014

Appendix C

Lighting calculation summary

C1 Calculation Summary

Formulae used:

Luminance (Brightness) - cd/m2 received from Audio Systems Logic
Area - Height & Width - received from Audio Systems Logic
Cut-off angle - cos θ: +/-0 deg. (cos0) = 1 (For worst case scenario)
Peak Intensity - Luminance (Brightness) * Area * Cos 0
Distance from the screen – As per site conditions; 100m assumed contour location
Illuminance = Intensity / (Distance)2

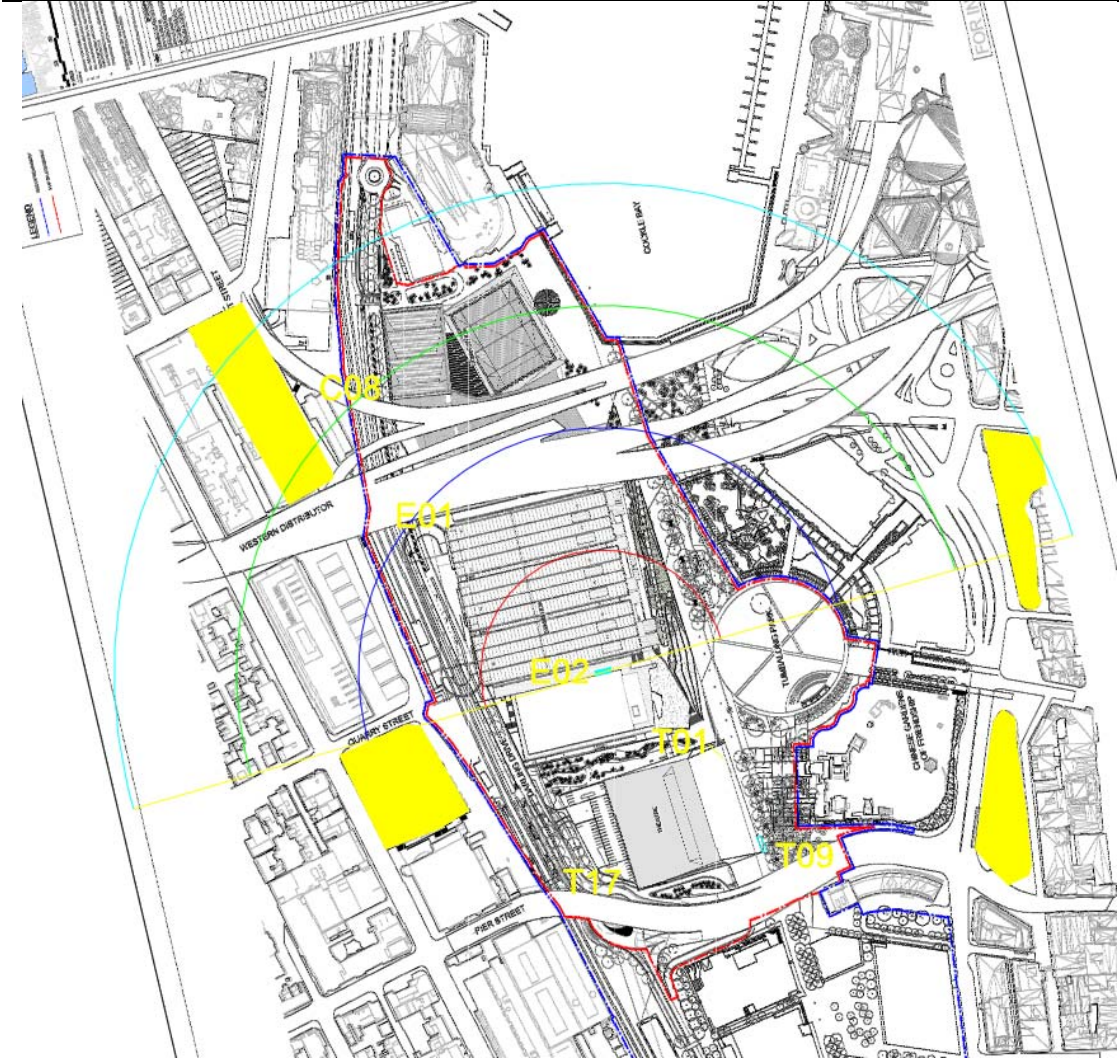
As per the site conditions, the following is concluded:

SIGNAGE NO.	LOCATION	MOUNTING HEIGHT AFL (m)	COMMENTS
E02*	FACING OUTWARDS BOUNDARY	HIGH	FURTHER CALCULATIONS WITH CONTOURS
T09*	NEAR BOUNDARY LINE	HIGH	FURTHER CALCULATIONS WITH CONTOURS
T11 (A&B)	WITHIN TUMBALONG LANE	LOW	NO CONTOURS EVALUATION
T12	WITHIN SITE CONSTRAINTS & BEHIND VEGETATION	LOW	NO CONTOURS EVALUATION
T17*	NEAR BOUNDARY LINE	HIGH	FURTHER CALCULATIONS WITH CONTOURS
P1-P7	BLADE SIGNAGE IN CLUSTERS	LOW; WITHIN SITE BOUNDARY WITH VEGETATION & SITE OBSTRUCTION	NO CONTOURS EVALUATION
T01*	AT THEATRE ENTRANCE	LOW; MOUNTED AT ANGLE WITH INCIDENT LIGHTING TOWARDS GROUND	NOT INCLUDED IN CALCULATIONS/ CONTOURS EVALUATED
E20	WITHIN LOUNGE AREA	LOW; MOUNTED UNDER CANOPY	NOT INCLUDED IN CALCULATIONS
C05-C09	STATIC SIGNAGE	INDIRECT LIGHTING CONCEALED BEHIND OPAQUE METALLIC SIGNS	NOT INCLUDED IN CALCULATIONS
E07-E10	STATIC SIGNAGE	INDIRECT LIGHTING CONCEALED BEHIND OPAQUE METALLIC SIGNS	NOT INCLUDED IN CALCULATIONS
T18	STATIC SIGNAGE	INDIRECT LIGHTING CONCEALED BEHIND OPAQUE METALLIC SIGNS	NOT INCLUDED IN CALCULATIONS
* - FURTHER CONTOURS ATTACHED			

Table 4 Details of Signage

E02 – At 100m distance incident illuminance 20.8lux; All compliant; Calculation Summary & Contour diagram below:

Unit LED Panel	Size of Unit LED Panel			Area of proposed LED signage			Signage	PEAK INTENSITY	Max. Luminous Intensity (cd) check			Distance	Illuminance (lux) check			AS4282 Compliance check	
Intensity (cd)	L (mm)	W (mm)	Area of unit LED Panel (m2)	HEIGHT (m)	WIDTH (m)	Area of signage (m2)	Total area of LED Panels	PEAK INTENSITY	30% RGB Dimmable (lux)	10% Dimmable (lux) Night time	Max. Luminous Intensity <100,000cd	Distance from Signage (m)	Illuminance (lux)	30% RGB Dimmable (lux)	10% Dimmable (lux)	Pre-Curfew <25lux	Post-Curfew <4lux
1000.0	0.365	0.365	0.133	12.8	7.2	92.16	691.76	691762.06	207528.62	20752.86	Yes	100.0	69.2	20.8	2.08	Yes	Yes
1000.0	0.365	0.365	0.133	12.8	7.2	92.16	691.76	691762.06	207528.62	20752.86	Yes	200.0	17.3	5.2	0.52	Yes	Yes
1000.0	0.365	0.365	0.133	12.8	7.2	92.16	691.76	691762.06	207528.62	20752.86	Yes	300.0	7.7	2.3	0.23	Yes	Yes
1000.0	0.365	0.365	0.133	12.8	7.2	92.16	691.76	691762.06	207528.62	20752.86	Yes	400.0	4.3	1.3	0.13	Yes	Yes
1000.0	0.365	0.365	0.133	12.8	7.2	92.16	691.76	691762.06	207528.62	20752.86	Yes	500.0	2.8	0.8	0.08	Yes	Yes

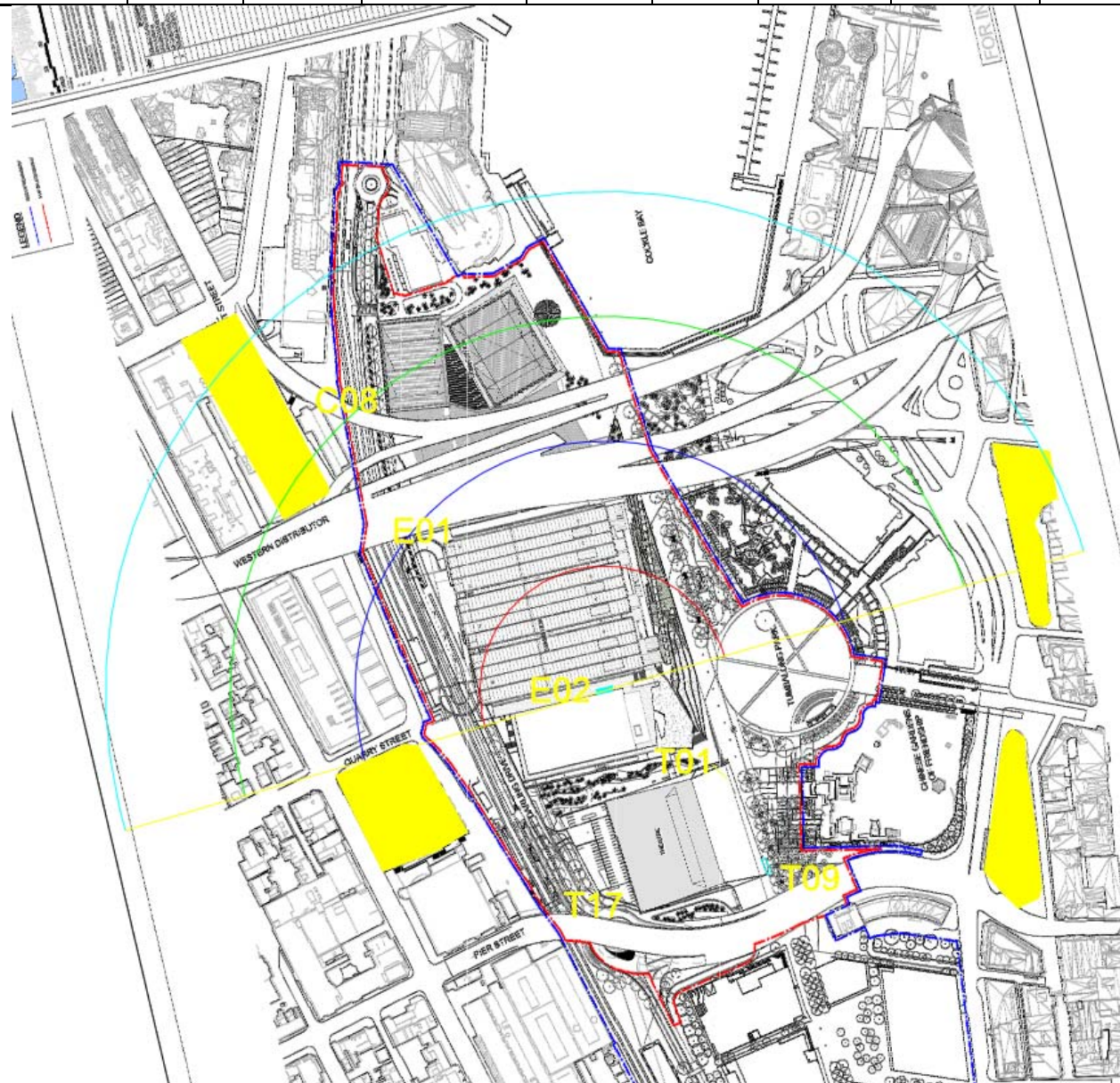


CONTOUR LEGEND

- 100m RADIUS CONTOUR
- 200m RADIUS CONTOUR
- 300m RADIUS CONTOUR
- 400m RADIUS CONTOUR

E02 – At 100m distance incident illuminance 20.8lux; All compliant; Calculation Summary & Contour diagram below:

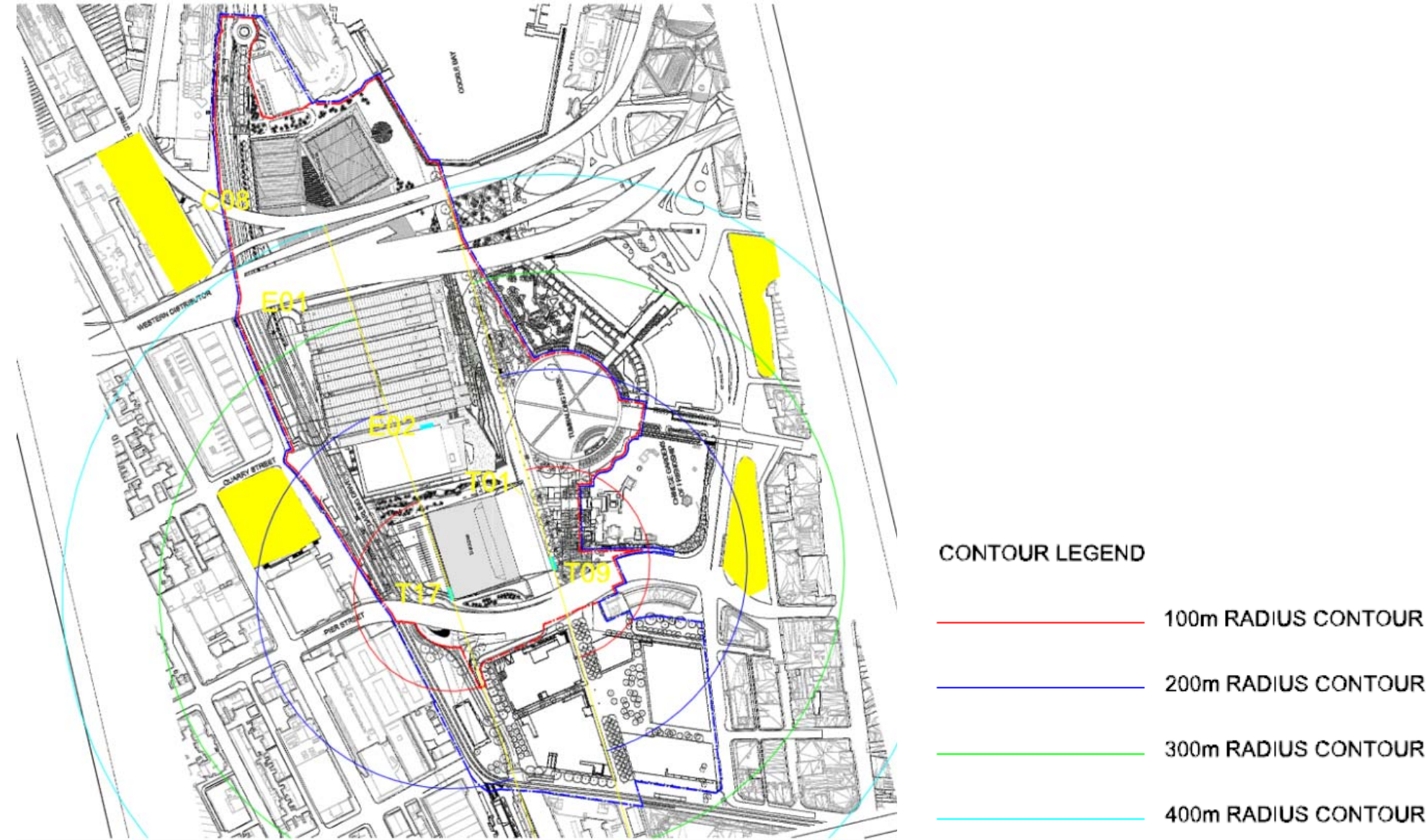
Unit LED Panel	Size of Unit LED Panel			Area of proposed LED signage			Signage	PEAK INTENSITY	Max. Luminous Intensity (cd) check			Distance	Illuminance (lux) check			AS4282 Compliance check	
Intensity (cd)	L (mm)	W (mm)	Area of unit LED Panel (m2)	HEIGHT (m)	WIDTH (m)	Area of signage (m2)	Total area of LED Panels	PEAK INTENSITY	30% RGB Dimmable (lux)	10% Dimmable (lux) Night time	Max. Luminous Intensity <100,000cd	Distance from Signage (m)	Illuminance (lux)	30% RGB Dimmable (lux)	10% Dimmable (lux)	Pre-Curfew <25lux	Post-Curfew <4lux
1000.0	0.365	0.365	0.133	12.8	7.2	92.16	691.76	691762.06	207528.62	20752.86	Yes	100.0	69.2	20.8	2.08	Yes	Yes
1000.0	0.365	0.365	0.133	12.8	7.2	92.16	691.76	691762.06	207528.62	20752.86	Yes	200.0	17.3	5.2	0.52	Yes	Yes
1000.0	0.365	0.365	0.133	12.8	7.2	92.16	691.76	691762.06	207528.62	20752.86	Yes	300.0	7.7	2.3	0.23	Yes	Yes
1000.0	0.365	0.365	0.133	12.8	7.2	92.16	691.76	691762.06	207528.62	20752.86	Yes	400.0	4.3	1.3	0.13	Yes	Yes
1000.0	0.365	0.365	0.133	12.8	7.2	92.16	691.76	691762.06	207528.62	20752.86	Yes	500.0	2.8	0.8	0.08	Yes	Yes

**CONTOUR LEGEND**

- 100m RADIUS CONTOUR
- 200m RADIUS CONTOUR
- 300m RADIUS CONTOUR
- 400m RADIUS CONTOUR

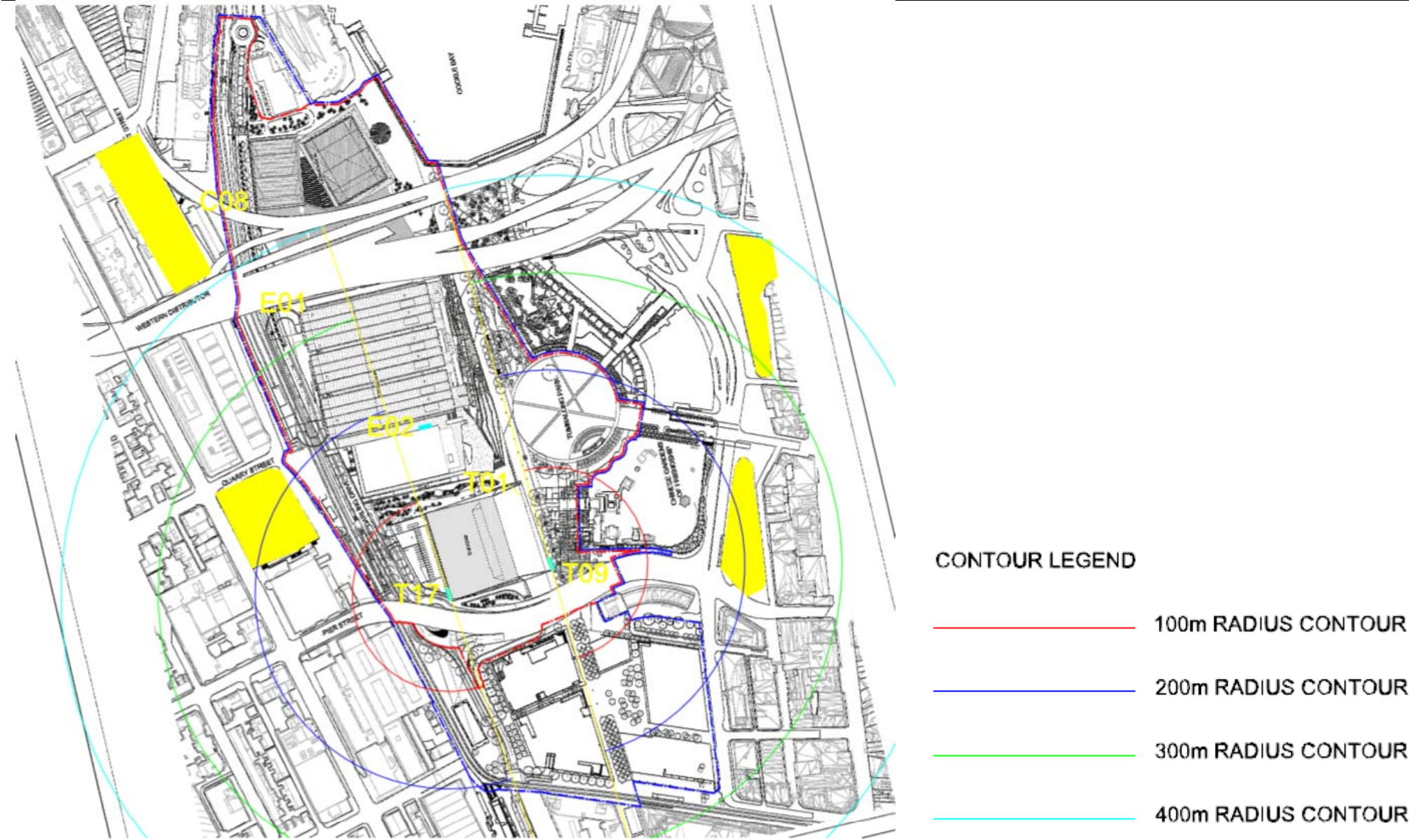
T17 – At 100m distance incident illuminance 20.3lux; All compliant; Calculation Summary & Contour diagram below:

T17																	
Unit LED Panel	Size of Unit LED Panel			Area of proposed LED signage			Signage	PEAK INTENSITY	Max. Luminous Intensity (cd) check			Distance	Illuminance (lux) check			AS4282 Compliance check	
Intensity (cd)	L (mm)	W (mm)	Area of unit LED Panel (m2)	HEIGHT (m)	WIDTH (m)	Area of signage (m2)	Total area of LED Panels	PEAK INTENSITY	30% RGB Dimmable (lux)	10% Dimmable (lux) Night time	Max. Luminous Intensity <100,000cd	Distance from Signage (m)	Illuminance (lux)	30% RGB Dimmable (lux)	10% Dimmable (lux)	Pre-Curfew <25lux	Post-Curfew <4lux
1000.0	0.365	0.365	0.133	18.0	5.0	90.00	675.55	675548.88	202664.67	20266.47	Yes	100.0	67.6	20.3	2.03	Yes	Yes
1000.0	0.365	0.365	0.133	18.0	5.0	90.00	675.55	675548.88	202664.67	20266.47	Yes	200.0	16.9	5.1	0.51	Yes	Yes
1000.0	0.365	0.365	0.133	18.0	5.0	90.00	675.55	675548.88	202664.67	20266.47	Yes	300.0	7.5	2.3	0.23	Yes	Yes
1000.0	0.365	0.365	0.133	18.0	5.0	90.00	675.55	675548.88	202664.67	20266.47	Yes	400.0	4.2	1.3	0.13	Yes	Yes
1000.0	0.365	0.365	0.133	18.0	5.0	90.00	675.55	675548.88	202664.67	20266.47	Yes	500.0	2.7	0.8	0.08	Yes	Yes



T09 – At 100m distance incident illuminance 9lux; All compliant; Calculation Summary & Contour diagram below:

Unit LED Panel	Size of Unit LED Panel			Area of proposed LED signage			Signage	PEAK INTENSITY	Max. Luminous Intensity (cd) check			Distance	Illuminance (lux) check			AS4282 Compliance check	
Intensity (cd)	L (mm)	W (mm)	Area of unit LED Panel (m2)	HEIGHT (m)	WIDTH (m)	Area of signage (m2)	Total area of LED Panels	PEAK INTENSITY	30% RGB Dimmable (lux)	10% Dimmable (lux) Night time	Max. Luminous Intensity <100,000cd	Distance from Signage (m)	Illuminance (lux)	30% RGB Dimmable (lux)	10% Dimmable (lux)	Pre-Curfew <25lux	Post-Curfew <4lux
1000.0	0.365	0.365	0.133	10.0	4.0	40.00	300.24	300243.95	90073.18	9007.32	Yes	100.0	30.0	9.0	0.90	Yes	Yes
1000.0	0.365	0.365	0.133	10.0	4.0	40.00	300.24	300243.95	90073.18	9007.32	Yes	200.0	7.5	2.3	0.23	Yes	Yes
1000.0	0.365	0.365	0.133	10.0	4.0	40.00	300.24	300243.95	90073.18	9007.32	Yes	300.0	3.3	1.0	0.10	Yes	Yes
1000.0	0.365	0.365	0.133	10.0	4.0	40.00	300.24	300243.95	90073.18	9007.32	Yes	400.0	1.9	0.6	0.06	Yes	Yes
1000.0	0.365	0.365	0.133	10.0	4.0	40.00	300.24	300243.95	90073.18	9007.32	Yes	500.0	1.2	0.4	0.04	Yes	Yes



T01 – No peak intensity calculated as all the incident lighting is directed towards ground; No residential buildings in the vicinity of 100m.
Contour diagram as below:



CONTOUR LEGEND

- 100m RADIUS CONTOUR
- 200m RADIUS CONTOUR
- 300m RADIUS CONTOUR
- 400m RADIUS CONTOUR

E20

Unit LED Panel	Size of Unit LED Panel			Area of proposed LED signage			Signage	PEAK INTENSITY	Max. Luminous Intensity (cd) check			Distance	Illuminance (lux) check			AS4282 Compliance check	
Intensity (cd)	L (mm)	W (mm)	Area of unit LED Panel (m2)	HEIGHT (m)	WIDTH (m)	Area of signage (m2)	Total area of LED Panels	PEAK INTENSITY	30% RGB Dimmable (lux)	10% Dimmable (lux) Night time	Max. Luminous Intensity <100,000cd	Distance from Signage (m)	Illuminance (lux)	30% RGB Dimmable (lux)	10% Dimmable (lux)	Pre-Curfew <25lux	Post-Curfew <4lux
1000.0	0.365	0.365	0.133	1.8	1.1	1.98	14.86	14862.08	4458.62	445.86	Yes	100.0	1.5	0.4	0.04	Yes	Yes
1000.0	0.365	0.365	0.133	1.8	1.1	1.98	14.86	14862.08	4458.62	445.86	Yes	200.0	0.4	0.1	0.01	Yes	Yes
1000.0	0.365	0.365	0.133	1.8	1.1	1.98	14.86	14862.08	4458.62	445.86	Yes	300.0	0.2	0.0	0.00	Yes	Yes
1000.0	0.365	0.365	0.133	1.8	1.1	1.98	14.86	14862.08	4458.62	445.86	Yes	400.0	0.1	0.0	0.00	Yes	Yes
1000.0	0.365	0.365	0.133	1.8	1.1	1.98	14.86	14862.08	4458.62	445.86	Yes	500.0	0.1	0.0	0.00	Yes	Yes

T12

Unit LED Panel	Size of Unit LED Panel			Area of proposed LED signage			Signage	PEAK INTENSITY	Max. Luminous Intensity (cd) check			Distance	Illuminance (lux) check			AS4282 Compliance check	
Intensity (cd)	L (mm)	W (mm)	Area of unit LED Panel (m2)	HEIGHT (m)	WIDTH (m)	Area of signage (m2)	Total area of LED Panels	PEAK INTENSITY	30% RGB Dimmable (lux)	10% Dimmable (lux) Night time	Max. Luminous Intensity <100,000cd	Distance from Signage (m)	Illuminance (lux)	30% RGB Dimmable (lux)	10% Dimmable (lux)	Pre-Curfew <25lux	Post-Curfew <4lux
1000.0	0.365	0.365	0.133	8.7	3.0	26.10	195.91	195909.18	58772.75	5877.28	Yes	100.0	19.6	5.9	0.59	Yes	Yes
1000.0	0.365	0.365	0.133	8.7	3.0	26.10	195.91	195909.18	58772.75	5877.28	Yes	200.0	4.9	1.5	0.15	Yes	Yes
1000.0	0.365	0.365	0.133	8.7	3.0	26.10	195.91	195909.18	58772.75	5877.28	Yes	300.0	2.2	0.7	0.07	Yes	Yes
1000.0	0.365	0.365	0.133	8.7	3.0	26.10	195.91	195909.18	58772.75	5877.28	Yes	400.0	1.2	0.4	0.04	Yes	Yes
1000.0	0.365	0.365	0.133	8.7	3.0	26.10	195.91	195909.18	58772.75	5877.28	Yes	500.0	0.8	0.2	0.02	Yes	Yes

T11 (A & B)

Unit LED Panel	Size of Unit LED Panel			Area of proposed LED signage			Signage	PEAK INTENSITY	Max. Luminous Intensity (cd) check			Distance	Illuminance (lux) check			AS4282 Compliance check	
Intensity (cd)	L (mm)	W (mm)	Area of unit LED Panel (m2)	HEIGHT (m)	WIDTH (m)	Area of signage (m2)	Total area of LED Panels	PEAK INTENSITY	30% RGB Dimmable (lux)	10% Dimmable (lux) Night time	Max. Luminous Intensity <100,000cd	Distance from Signage (m)	Illuminance (lux)	30% RGB Dimmable (lux)	10% Dimmable (lux)	Pre-Curfew <25lux	Post-Curfew <4lux
1000.0	0.365	0.365	0.133	7.4	2.1	15.54	116.64	116644.77	34993.43	3499.34	Yes	100.0	11.7	3.5	0.35	Yes	Yes
1000.0	0.365	0.365	0.133	7.4	2.1	15.54	116.64	116644.77	34993.43	3499.34	Yes	200.0	2.9	0.9	0.09	Yes	Yes
1000.0	0.365	0.365	0.133	7.4	2.1	15.54	116.64	116644.77	34993.43	3499.34	Yes	300.0	1.3	0.4	0.04	Yes	Yes
1000.0	0.365	0.365	0.133	7.4	2.1	15.54	116.64	116644.77	34993.43	3499.34	Yes	400.0	0.7	0.2	0.02	Yes	Yes
1000.0	0.365	0.365	0.133	7.4	2.1	15.54	116.64	116644.77	34993.43	3499.34	Yes	500.0	0.5	0.1	0.01	Yes	Yes

P1 – P7

Unit LED Panel	Size of Unit LED Panel			Area of proposed LED signage			Signage	PEAK INTENSITY	Max. Luminous Intensity (cd) check			Distance	Illuminance (lux) check			AS4282 Compliance check	
Intensity (cd)	L (mm)	W (mm)	Area of unit LED Panel (m2)	HEIGHT (m)	WIDTH (m)	Area of signage (m2)	Total area of LED Panels	PEAK INTENSITY	30% RGB Dimmable (lux)	10% Dimmable (lux) Night time	Max. Luminous Intensity <100,000cd	Distance from Signage (m)	Illuminance (lux)	30% RGB Dimmable (lux)	10% Dimmable (lux)	Pre-Curfew <25lux	Post-Curfew <4lux
1000.0	0.365	0.365	0.133	4.0	2.0	8.00	60.05	60048.79	18014.64	1801.46	Yes	100.0	6.0	1.8	0.18	Yes	Yes
1000.0	0.365	0.365	0.133	4.0	2.0	8.00	60.05	60048.79	18014.64	1801.46	Yes	200.0	1.5	0.5	0.05	Yes	Yes
1000.0	0.365	0.365	0.133	4.0	2.0	8.00	60.05	60048.79	18014.64	1801.46	Yes	300.0	0.7	0.2	0.02	Yes	Yes
1000.0	0.365	0.365	0.133	4.0	2.0	8.00	60.05	60048.79	18014.64	1801.46	Yes	400.0	0.4	0.1	0.01	Yes	Yes
1000.0	0.365	0.365	0.133	4.0	2.0	8.00	60.05	60048.79	18014.64	1801.46	Yes	500.0	0.2	0.1	0.01	Yes	Yes

3.2.5 Illumination and reflectance

An illuminated sign refers to any sign illuminated by an artificial source. Illuminated signs include variable message signs, video and/or animated signs and any conventional billboard illuminated by fluorescent and/or incandescent bulbs.

In addition to design guidelines in relation to illumination and its effects (Section 2), the following assessment criteria are used to ensure that illumination and reflectance qualities of signs do not cause a road safety hazard.

- (a) Advertisements must comply with the following luminance rules shown below.
- (b) The maximum night-time luminance of the aforementioned signs in this section must be one-quarter of the above prescribed values.
- (c) For night time use, the sign (whether internally illuminated or lit from its exterior) must not cast a shadow on areas that were previously lit and that have a special lighting requirement, e.g. pedestrian crossings.

- (d) The light sources for illuminated signs must focus solely on the sign and:
 - (i) be shielded so that glare does not extend beyond the sign; and,
 - (ii) with the exception of back lit neon signs, have no light source visible to passing motorists with a light output greater than that of a 65W incandescent bulb.
- (e) The level of reflectance of an advertisement, and its content, is not to exceed the 'Minimum coefficients of Luminous intensity per unit area for Class 2A Material', as set out in Australian Standard AS/NZS 1906.1:2007. Flashing illuminated advertisements will not be approved.

Information in relation to Street Name Signs that are illuminated is also available in the RTA document *Management of Illuminated Street Name and Advertising Sign proposals – January 2000* (Ref TM P99/3).

Appendix D

SEPP 64 TABLE

TABLE 4: MAXIMUM ALLOWABLE DAYTIME LUMINANCE OF ILLUMINATED ADVERTISEMENTS					
<i>Illuminated Area (sq m)</i>	<i>Zone 1</i>	<i>Zone 2 (cd/sq m)</i>	<i>Zone 3 (cd/sq m)</i>	<i>Zone 4 (cd/sq m)</i>	<i>Zone 5</i>
up to 0.5	no limit	2900	2000	1000	no limit
0.5 to 2.0		2300	1600	800	
2.0 to 5.0		2000	1200	600	
5.0 to 10.0		1500	1000	600	
over 10.0		1200	800	400	
Luminance means the objective brightness of a surface as measured by a photometer, expressed in candelas per square meter. Zone 1 covers areas with generally very high off-street ambient lighting, e.g. display centres similar to Kings Cross, central city locations Zone 2 covers areas with generally high off-street ambient lighting eg. some major shopping/commercial centres with a significant number of off-street illuminated advertising devices and lights. Zone 3 covers areas with generally medium off-street ambient lighting e.g. small to medium shopping/commercial centres. Zone 4 covers areas with generally low levels of off-street ambient lighting e.g. most rural areas, many residential areas. Zone 5 covers areas within underground railway stations and areas fully contained within station buildings which are visible only from within the Rail Corridor.					