

Reflectivity Report

Alexandria Health Centre

Centuria Healthcare

Prepared for

Centuria Healthcare

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Contents

Executive Summary	1
1. Introduction	2
1.1 Purpose of this Report	2
1.2 Development Description	2
1.3 Site Location	3
1.3.1 Site Orientation	4
1.4 Stereographic Sun Chart	5
1.5 Referenced Drawings	5
2. Assessment Methodology	7
2.1 Analysis Philosophy	7
2.2 Virtual Sun Location	7
2.3 Glare Assessment	7
2.4 Discussion of the Hassall method	9
3. Results	10
3.1 General	10
3.2 Viewpoint 1	10
3.3 Viewpoint 2	10
3.4 Viewpoint 3	11
3.5 Viewpoint 4	11
4. Conclusion	12
Appendix A – Detailed Results	14

Executive Summary

This reflectivity study has been prepared for the Alexandria Health Centre project on Bourke Road.

This reflectivity study has been carried out to verify that the façade of the proposed project will not cause an unacceptable risk of solar reflections causing disability glare to drivers and pedestrians.

The project has been assessed from 4 viewpoints from drivers and 0 from pedestrians (as there are no marked crossings from which the development is visible) to determine areas where there is a risk of a reflected image of the sun being formed. The methodology proposed by David Hassall has been used to assess where there is a risk of disability glare as calculated by the Holladay formula.

Images have been taken from Google maps and computer models where required.

The analysis has been carried out based on the architectural drawings for DA.

All viewpoints considered have been analysed and it has been determined that the risk of rogue reflections causing disability glare are limited and acceptable where:

- Glazing is limited to a maximum normal specular reflectivity of 20%.
- East elevation cladding is limited to a maximum normal specular reflectivity of 15%

1. Introduction

1.1 Purpose of this Report

This report details the results of a reflectivity study that aims to identify the potential for adverse reflected solar glare that may affect drivers and pedestrians within the proximity of the Alexandria Health Centre site located at Alexandria Health Centre. It has been prepared in response to the Concept Design condition of concept B39.

A maximum normal specular reflectivity of 20% has been used as the upper limit for all of façade materials considered in this assessment. Each viewpoint has also been assessed for disability glare to drivers and any additional measures for compliance have been identified in this report.

This report should be read in conjunction with the Architectural documents prepared by Warren and Mahony and referenced in Section 1.5.

1.2 Development Description

The application seeks consent for the following in accordance with the Concept SSDA approval:

- Site establishment including earthworks.
- Construction of the Alexandria Health Centre:
 - Total GFA of 11,436sqm
 - Maximum FSR of 3.85:1
 - Maximum height of 34.95m, Max RL. 45.4
- Ancillary development including:
 - Car parking – 77 car parking spaces distributed across basement, ground, and ground mezzanine levels.
 - Utility infrastructure and services connections.
 - Building identification signage and wayfinding signage.
 - Stormwater management
 - Landscaping
- Laneway for vehicle and pedestrian access along with western boundary of the site
- Operation of the Alexandria Health Centre as a mental health hospital and medical centre with ancillary uses.

1.3 Site Location

The site has been assessed to determine appropriate viewpoints where drivers (red), are able to see the building façade in their direct line of vision. It has been assessed that there are no marked pedestrian crossings from which the facade of the development will be visible.

Viewpoints where a driver would be required to be travelling the wrong way down a street have not been considered in this assessment. It has been assumed that this condition will not change.

It has been assessed that the building is visible to drivers from the following locations:

- Travelling North-east on Bourke Road (VP1)
- Travelling South-East on Bowden Street, and turning onto Bourke Road (VP2)
- Travelling West on Bourke Road (VP3)
- Travelling North-east on O'Riordan Street (VP4)

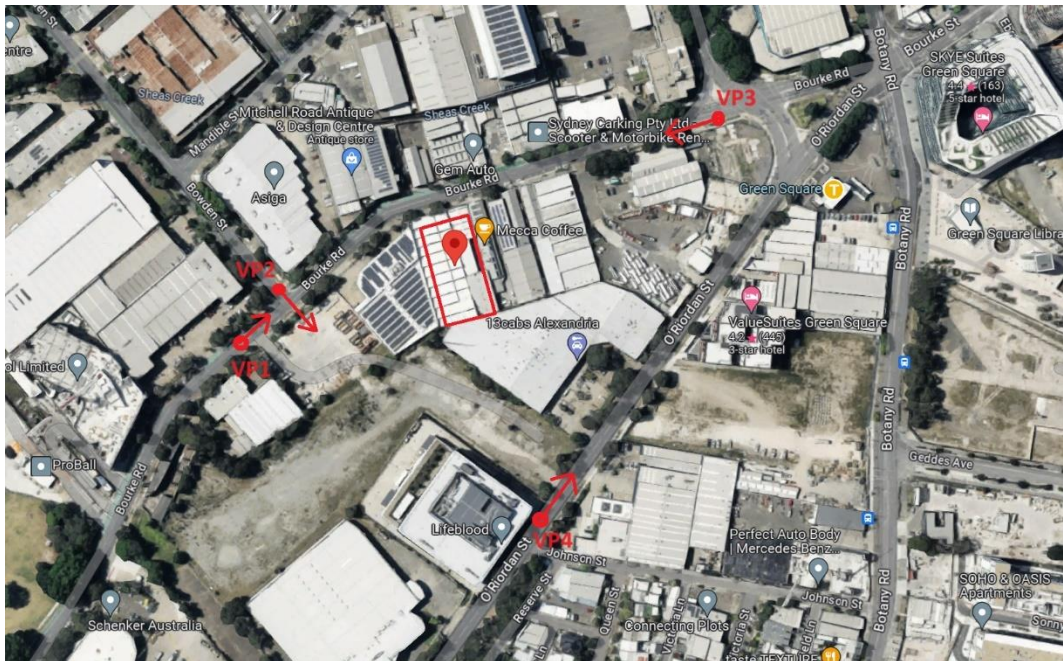


Figure 1 - Satellite Image with Viewpoints¹

¹ Image from Google Maps

1.3.1 Site Orientation

Facade Aspects that are visible (ie not immediately adjacent to another structure) are shown marked up on Figure 3. Note that the curved/faceted north elevation facade has not been included as it is not directly visible from any of the identified Viewpoints.



Figure 2 – Level Ground to 3 Floor Plan with Façade Aspects

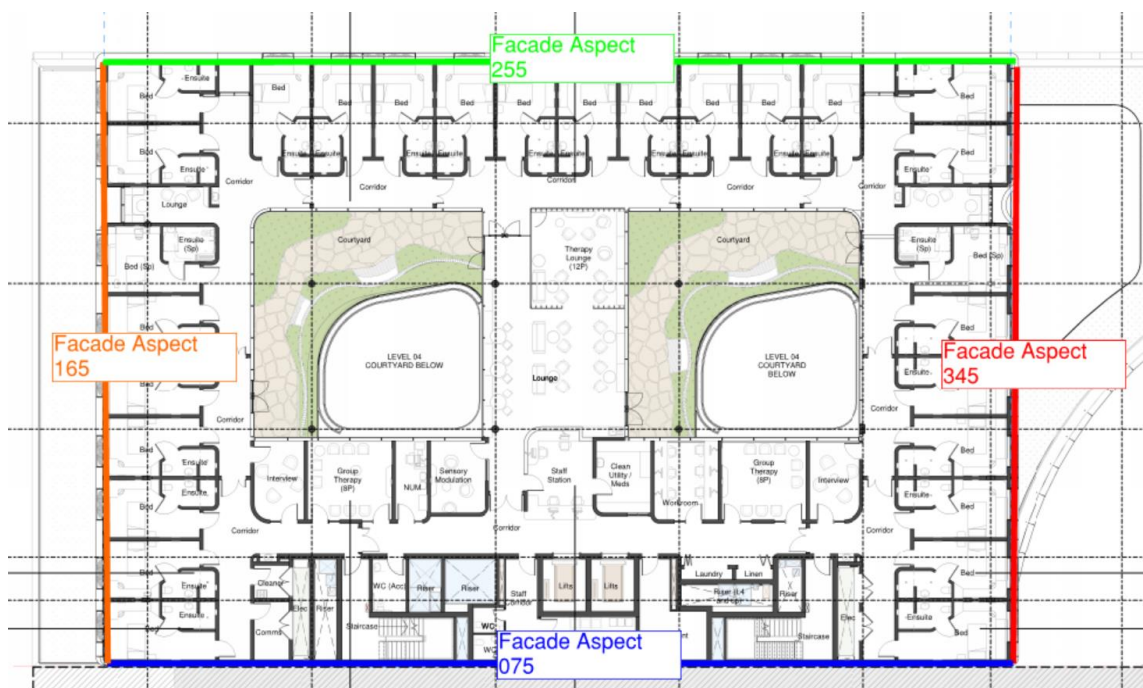


Figure 3 – Level 4 to 6 Floor Plan with Façade Aspects

List of façade aspects:

- Facade Aspect 075°
- Facade Aspect 165°
- Facade Aspect 255°
- Facade Aspect 345°

1.4 Stereographic Sun Chart

The position of the sun in the sky throughout the year varies depending on the latitude of the location of assessment. A stereographic sun chart is a two dimensional representation of this path of the sun for a particular line of latitude.

This chart is used in order to determine the location of a virtual reflected sun in accordance with the Hassall methodology in order to assess the potential for glare. Refer to Section 2 of this report for more detailed information on the assessment methodology

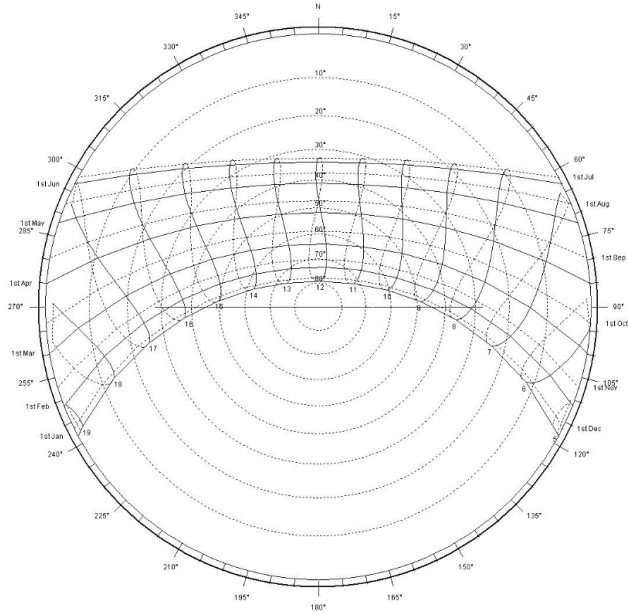


Figure 4 – Stereographic Sun Chart for Sydney (34 degree latitude)

1.5 Referenced Drawings

Drawing Number	Revision	Authoring Company
DA.A01.002	A	Warren and Mahoney
DA.A10.101	A	Warren and Mahoney
DA.A10.107	A	Warren and Mahoney
DA.A10.B01	A	Warren and Mahoney
DA.A11.108	A	Warren and Mahoney
DA.A20.002	A	Warren and Mahoney
DA.A20.003	A	Warren and Mahoney
DA.A20.004	A	Warren and Mahoney
DA.A30.001	A	Warren and Mahoney
DA.A01.001	A	Warren and Mahoney
DA.A02.001	A	Warren and Mahoney
DA.A05.001	A	Warren and Mahoney
DA.A05.002	A	Warren and Mahoney
DA.A10.100	A	Warren and Mahoney
DA.A10.100M	A	Warren and Mahoney
DA.A10.102	A	Warren and Mahoney
DA.A10.103	A	Warren and Mahoney

DA.A10.104	A	Warren and Mahoney
DA.A10.105	A	Warren and Mahoney
DA.A10.106	A	Warren and Mahoney
DA.A20.001	A	Warren and Mahoney
DA.A30.002	A	Warren and Mahoney

2. Assessment Methodology

2.1 Analysis Philosophy

The glare assessment has been carried out as per the methodology outlined in the technical bulletin "Reflectivity: Dealing with Rogue Solar Reflections" written by David Hassall from the Faculty of Architecture at the University of New South Wales.

This methodology defines a glare (I_v) limit of 500 candelas/m², calculated to the Holladay formula, to which a driver can be exposed without causing disability.

Viewpoints have been defined from which it is expected that either drivers or pedestrians where they are crossing the road, are able to see the building. A stereographic sun path diagram and the building geometry are then used to determine whether a viewpoint will be subject to the reflected sun during the year.

A glare protractor, oriented in the direction of drivers or pedestrians as appropriate, is used to determine the glare based on the reflectivity of the surface and the apparent angle of viewing.

2.2 Virtual Sun Location

The virtual suns location is determined with the stereographic sun chart for the project location.

This is completed by plotting the virtual sun on the stereographic sun chart based on the orientation of the facade. The apparent reflective surface of the facade is plotted based on the bounding horizontal and vertical angles from the viewpoint.

2.3 Glare Assessment

In order to allow assessment of buildings for glare David Hassall has developed a glare protractor that provides a diagrammatic limit of 500 candelas/m² based on viewing angle and inclination and reflectivity of the viewing surface. This glare protractor is shown in Figure 6 and is used where the stereographic sun path indicates that there is glare to a particular viewpoint.

A brief description of the calculation of the glare (equivalent veiling luminance) is provided below for reference. The glare protractor has thereafter been used in this assessment.

The equivalent veiling luminance (I_v) is calculated based on the Holladay formula (1), which defines the illumination of a viewer's eye based on a calculated illuminance perpendicular to the surface (EG) and a factor based on the angle of viewing (θ).

$$I_v = 10 \times EG \div \theta^2 \quad (1)$$

The angle of viewing (θ) is based on the angle between the direct line of sight and the glare source (α) and the inclination between a viewing normal and the glare source (β). This is calculated with trigonometry based on Equation 2 below and is shown diagrammatically in Figure 5.

$$\theta = \text{ATAN} \times [\sqrt{\tan^2(\beta) + \sin^2(\alpha)} \div \cos(\alpha)] \quad (2)$$

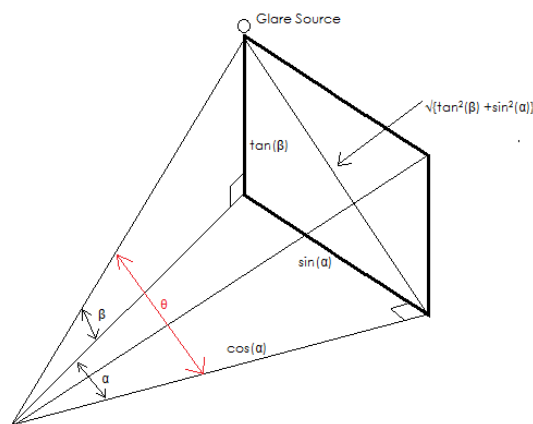


Figure 5 – Diagrammatic Angle of Viewing Calculation

The illumination of the viewer's eye normal to the light source (EG) is calculated based on the solar illumination (E), the reflectivity of the surface (R) and the angle of viewing (θ) calculated in Equation 2. The solar illumination is calculated in Equation 4 based on the solar power (W), which is dependent on the inclination of the virtual sun (β) and the luminance efficacy (I_e).

$$EG = E \times R \times \cos(\theta) \quad (3)$$

$$E = W \times I_e \quad (4)$$

The solar power is determined as 50 watts per degree up to 10 degrees and 15 watts per degree thereafter.

The luminance efficacy is 90 lumens/watt at 7.5° and 117 lumens/watt at 25° and is interpolated for other angles.

The glare protractor by Hassall joins points at incremental reflectivity (iso-glare loops) with varying α and β values in order to set a limit where the equivalent veiling luminance is limited to 500 candelas/m².

By overlaying the glare protractor on a photo or computer generated image in the direction of viewing and aligning the verticals with the building it is possible to graphically determine the maximum reflectivity to not cause disability glare.

As the normal specular reflectivity of all building materials is limited to 20% a limit is taken such that any area viewed with a vertical bearing angle above 16° is adequate without need for further studies.

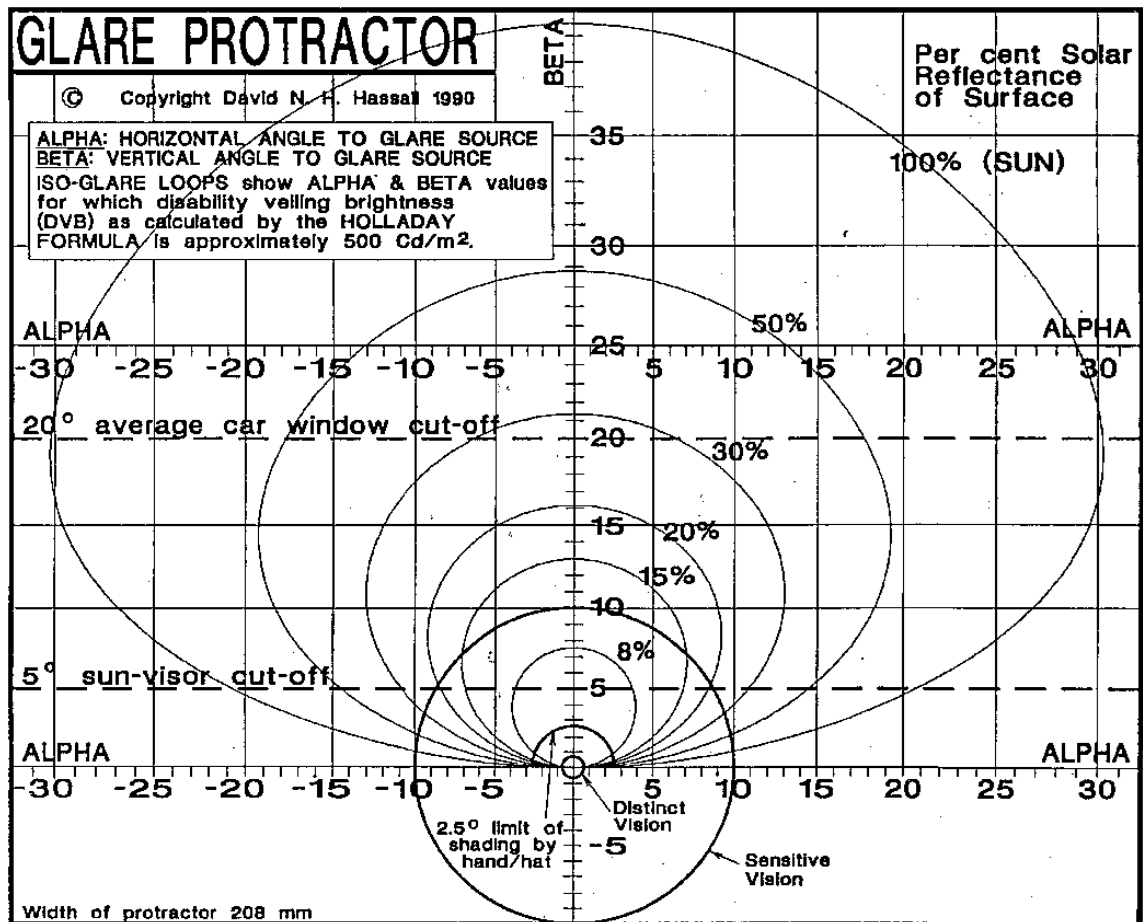


Figure 6 – Glare Protractor²

² "Reflectivity: Dealing with Rogue Solar Reflections" – David Hassall

2.4 Discussion of the Hassall method

The Hassall method applies a limit of 500 Candelas/m² as the maximum solar glare to which a driver should be exposed. This is consistent with research for maximum limits of solar glare for drivers on overcast and winter days; only during pre-dawn and post-twilight periods is there expected to be a lower threshold of solar glare from increased contrast. As such the method accounts for the worst-case background luminance.

The Hassall method sets out in its limitations that it is only valid for angles of incidence up to approximately 40°, which is the point at which the reflection of glazed elements typically begins to increase with the angle. By definition, the protractor (and the calculations that generate it) has a limit of 39.5° vertically, beyond which reflections at 100% specular reflectivity will not cause disability glare. Therefore, the sun cannot have an angle of incidence greater than 40° based on its vertical bearing and the method is valid for normal reflectivity of glass.

There is the potential for the angle of incidence of 40° to be exceeded based on the horizontal bearing of the sun relative to the assessed surface. This is addressed in this study where the horizontal bearing leads to an angle of incidence greater than 40° on a case by case basis.

3. Results

3.1 General

The façade has been assessed from each viewpoint identified in Section 1 of the report.

Where it is identified that there is reflected image the glare protractor is applied in order to determine the maximum reflectivity allowable on the facade surface to achieve a maximum equivalent veiling luminance of 500 candelas/m².

Detailed results have been included as part of Appendix A. A summary of these results is provided in this section.

3.2 Viewpoint 1

Viewpoint 1 is taken from the viewpoint of a driver travelling North East on Bourke Road. The viewing angle of the driver is 48°.

The following facade aspects are visible from the Viewpoint in a 180° segment oriented to the direction of viewing and the distance to the corners of the aspect in brackets:

- Facade Aspect 255

There is no risk of rogue reflections from this viewpoint and no further studies are required.

3.3 Viewpoint 2

Viewpoint 2 is taken from the viewpoint of a driver travelling South East on Bowden Street. The viewing angle of the driver is 138° and it is assumed that at the corner they will look in a 90° arc in each direction.

The following facade aspects are visible from the Viewpoint in a 180° segment oriented to the direction of viewing and the distance to the corners of the aspect in brackets:

- Facade Aspect 255

Based on the assessment there is the potential for sun light to reach Viewpoint 2 from Facade Aspect 255. This is assessed with an image from the Viewpoint as shown below and it can be seen that there is potential for rogue reflections causing disability glare from the lower part of the building even with a very low specular reflectivity of glass (~10%).

On the basis that:

1. A driver would be stationary at this location when looking at cars approaching the intersection,
2. It can be seen that no part of the building would be visible below the cut-off of a car sun-visor which can be lowered while the driver is stationary,
3. There is tree foliage along the road that obstructs the view of the building,
4. The potential for reflections is limited to a period of 530 to 7pm from October to March,
5. There are 350mm deep horizontal shades spaced 420mm vertically for the lower portion of the facade, which will prevent the complete image of a sun forming to a driver at this viewpoint, and
6. A maximum normal specular reflectivity of 20% is maintained,

It is considered that the risk of rogue reflections causing disability glare to a driver located at this viewpoint is limited and acceptable.

3.4 Viewpoint 3

Viewpoint 3 is taken from the viewpoint of a driver travelling West on Bourke Road. The viewing angle of the driver is 254°.

The following facade aspects are visible from the Viewpoint in a 180° segment oriented to the direction of viewing and the distance to the corners of the aspect in brackets:

- Facade Aspect 075
- Facade Aspect 345

On the basis that the east elevation is not glazed and the normal specular reflectivity is less than 15%. There is no risk of rogue reflections from this viewpoint and no further studies are required.

3.5 Viewpoint 4

Viewpoint 4 is taken from the viewpoint of a driver travelling North East on O'Riordan Street. The viewing angle of the driver is 35°.

The following facade aspects are visible from the Viewpoint in a 180° segment oriented to the direction of viewing and the distance to the corners of the aspect in brackets:

- Facade Aspect 165

There is no risk of rogue reflections from this viewpoint and no further studies are required.

4. Conclusion

This reflectivity study has been carried out in response to the Concept Design Condition of Consent B39 in order to address the potential for disability glare to pedestrians and drivers caused by this project.

The analysis has been completed based on the architectural drawings for SSDA.

The glare assessment has been carried out as per the methodology outlined in the technical bulletin "Reflectivity: Dealing with Rogue Solar Reflections" written by David Hassall.

A total of 4 viewpoints have been selected for this study to represent possible views from drivers and pedestrians of the proposed project.

All viewpoints considered have been analysed and it has been determined that the risk of rogue reflections causing disability glare are limited and acceptable where:

- Glazing is limited to a maximum normal specular reflectivity of 20%.
- East elevation cladding is limited to a maximum normal specular reflectivity of 15%

Appendix A

Appendix A – Detailed Results

Viewpoint 1

Viewpoint 1 is taken from the viewpoint of a driver travelling North East on Bourke Toad. The viewing angle of the driver is 48°.

The distances of the viewpoint to the façade are:

- Nearest corner = 150m

The following facade aspects are visible from the Viewpoint in a 180° segment oriented to the direction of viewing and the distance to the corners of the aspect in brackets:

- Facade Aspect 255

In the Figure below yellow lines have been drawn to represent the bearing angles to the visible portions of the building. The red arrow indicates the direction of travel and viewing.

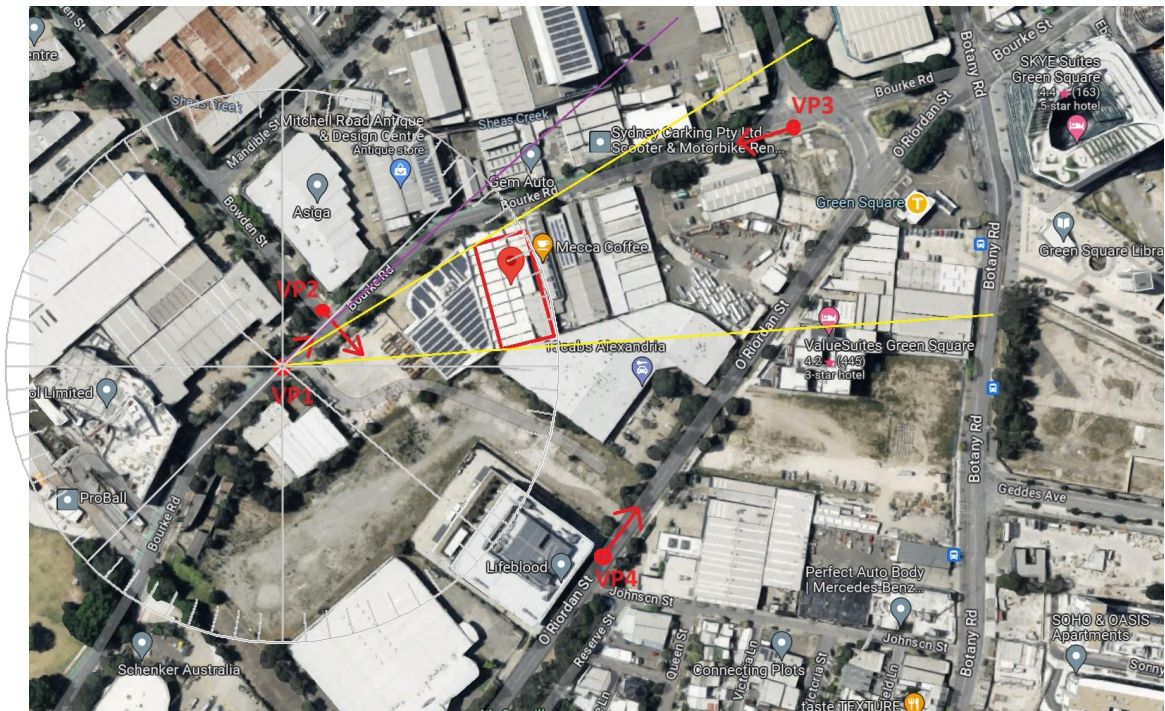


Figure 7 – Viewpoint 1 horizontal bearing angles

The vertical bearing angles have been calculated for each facade zone that is visible from Viewpoint 1 with building heights as nominated above.

$$\begin{aligned} \beta &= \tan^{-1}(34\text{m} \div 150\text{m}) \\ &= 12.8^\circ \end{aligned}$$

	Vertical Bearing Angle		Horizontal Bearing Angle (0° at North)	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Facade Aspect 255	0°	12.8°	58°	85°

These bearing angles have been plotted on the reflected sun path diagrams in the Figures below.

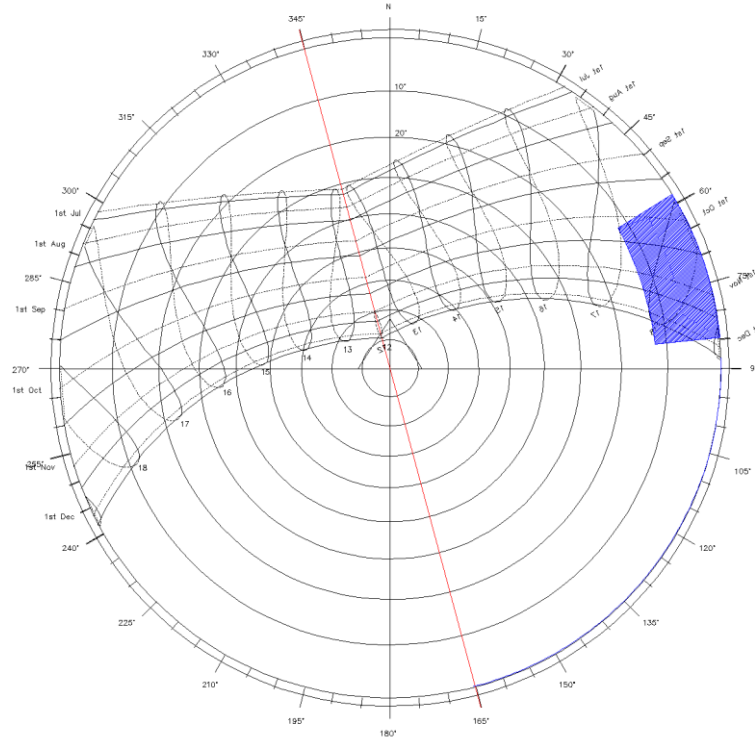
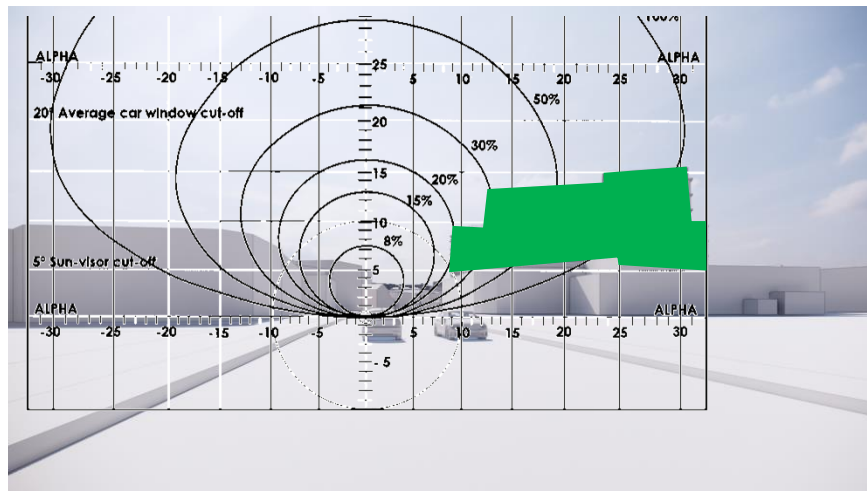


Figure 8 – 255° Facade Aspect Reflected Virtual Sun from Viewpoint 1

Based on the assessment there is the potential for sun light to reach Viewpoint 1 from Facade Aspect 255. This is assessed with an image from the Viewpoint as shown below.



It can be seen that when facing in the direction of travel that the facade is outside of the 20% isoloop.

Viewpoint 2

Viewpoint 2 is taken from the viewpoint of a driver travelling South East on Bowden Street and turning onto Bourke Road. The viewing angle of the driver is 138° and it is assumed that at the corner they will look in a 90° arc in each direction.

The distances of the viewpoint to the façade are:

- Nearest corner = 100m

The following facade aspects are visible from the Viewpoint in a 180° segment oriented to the direction of viewing and the distance to the corners of the aspect in brackets:

- Facade Aspect 255

In the Figure below yellow lines have been drawn to represent the bearing angles to the visible portions of the building. The red arrow indicates the direction of travel and viewing.

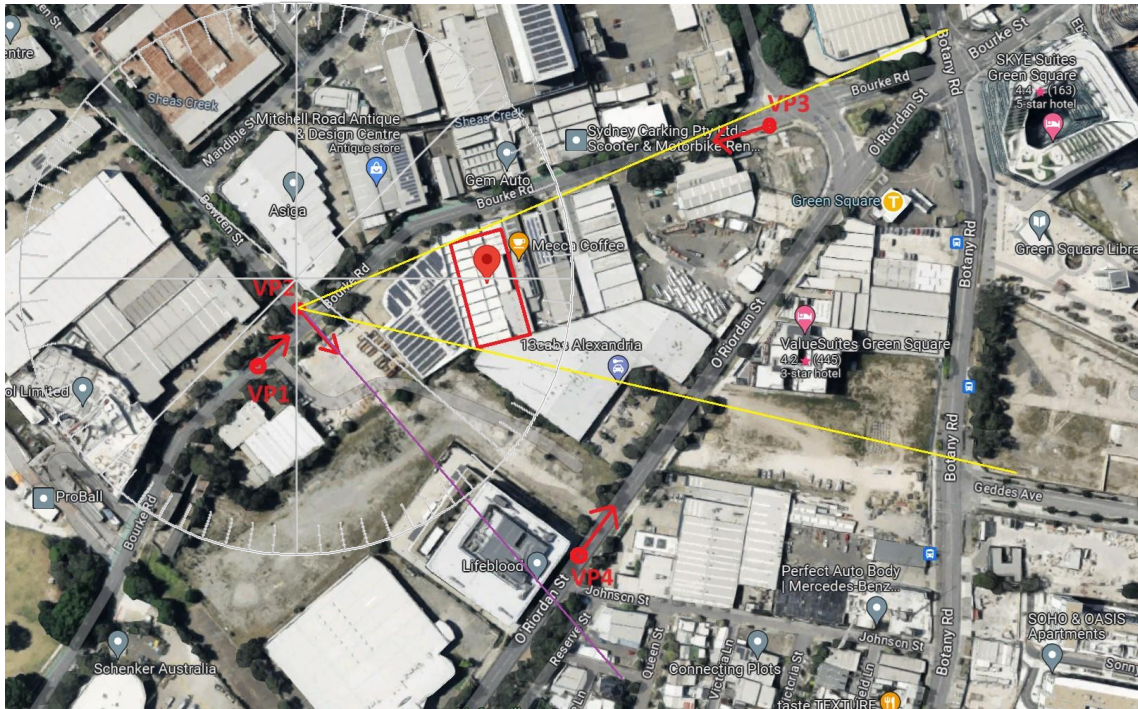


Figure 9 – Viewpoint 2 horizontal bearing angles

The vertical bearing angles have been calculated for each facade zone that is visible from Viewpoint 2 with building heights as nominated above.

$$\beta = \tan^{-1}(34m \div 100m)$$

$$= 18.8^\circ$$

	Vertical Bearing Angle		Horizontal Bearing Angle (0° at North)	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Facade Aspect 255	0°	18.8°	67°	103°

These bearing angles have been plotted on the reflected sun path diagrams in the Figures below.

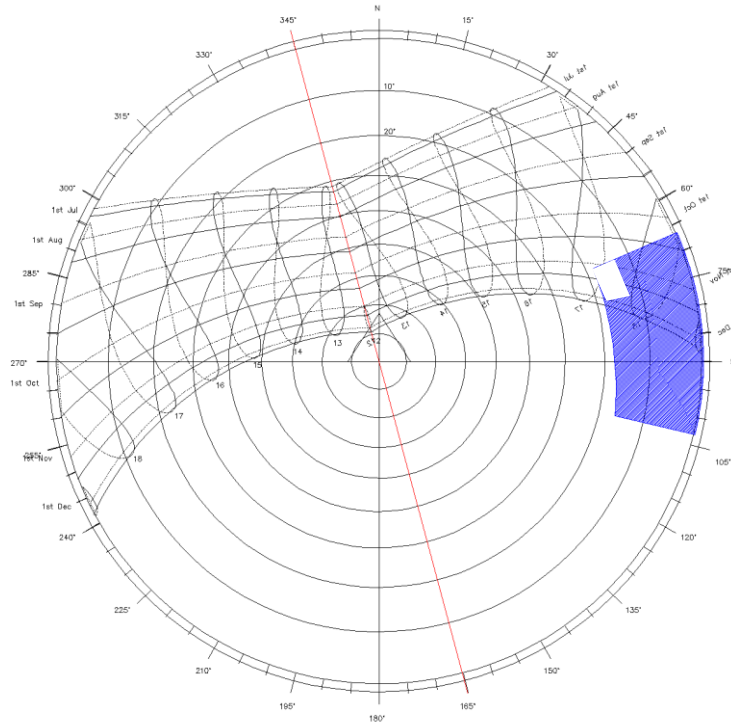
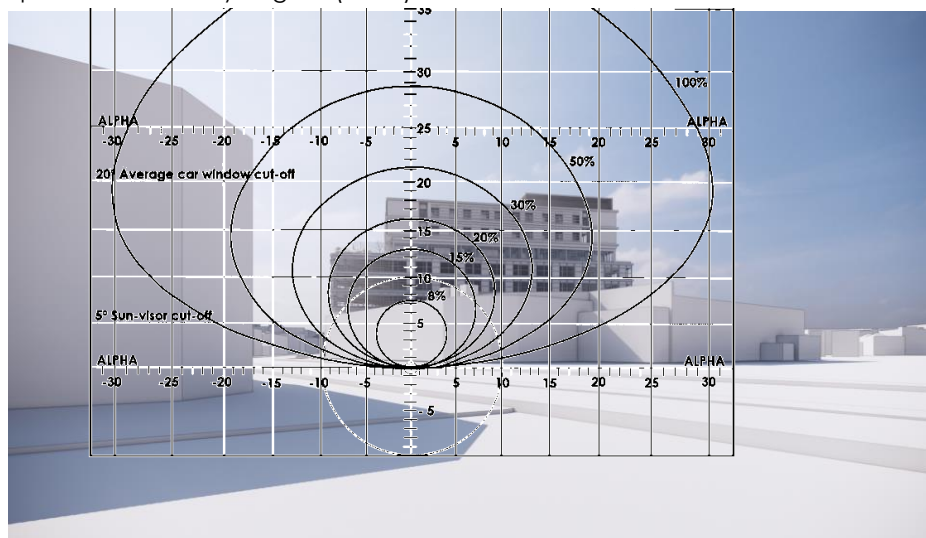


Figure 10 – 255° Facade Aspect Reflected Virtual Sun from Viewpoint 2

Based on the assessment there is the potential for sun light to reach Viewpoint 2 from Facade Aspect 255. This is assessed with an image from the Viewpoint as shown below and it can be seen that there is potential for rogue reflections causing disability glare from the lower part of the building even with a very low specular reflectivity of glass (~10%).



On the basis that:

1. A driver would be stationary at this location when looking at cars approaching the intersection,
2. It can be seen that no part of the building would be visible below the cut-off of a car sun-visor which can be lowered while the driver is stationary,
3. There is tree foliage along the road that obstructs the view of the building,
4. The potential for reflections is limited to a period of 530 to 7pm from October to March,
5. There are 350mm deep horizontal shades spaced 420mm vertically for the lower portion of the facade, which will prevent the complete image of a sun forming to a driver at this viewpoint, and
6. A maximum normal specular reflectivity of 20% is maintained,

It is considered that the risk of rogue reflections causing disability glare to a driver located at this viewpoint is limited and acceptable.

Viewpoint 3

Viewpoint 3 is taken from the viewpoint of a driver travelling West on Bourke Road. The viewing angle of the driver is 254°.

The distances of the viewpoint to the façade are:

- Nearest corner = 168m

The following facade aspects are visible from the Viewpoint in a 180° segment oriented to the direction of viewing and the distance to the corners of the aspect in brackets:

- Facade Aspect 075
- Facade Aspect 345

In the Figure below yellow lines have been drawn to represent the bearing angles to the visible portions of the building. The red arrow indicates the direction of travel and viewing.

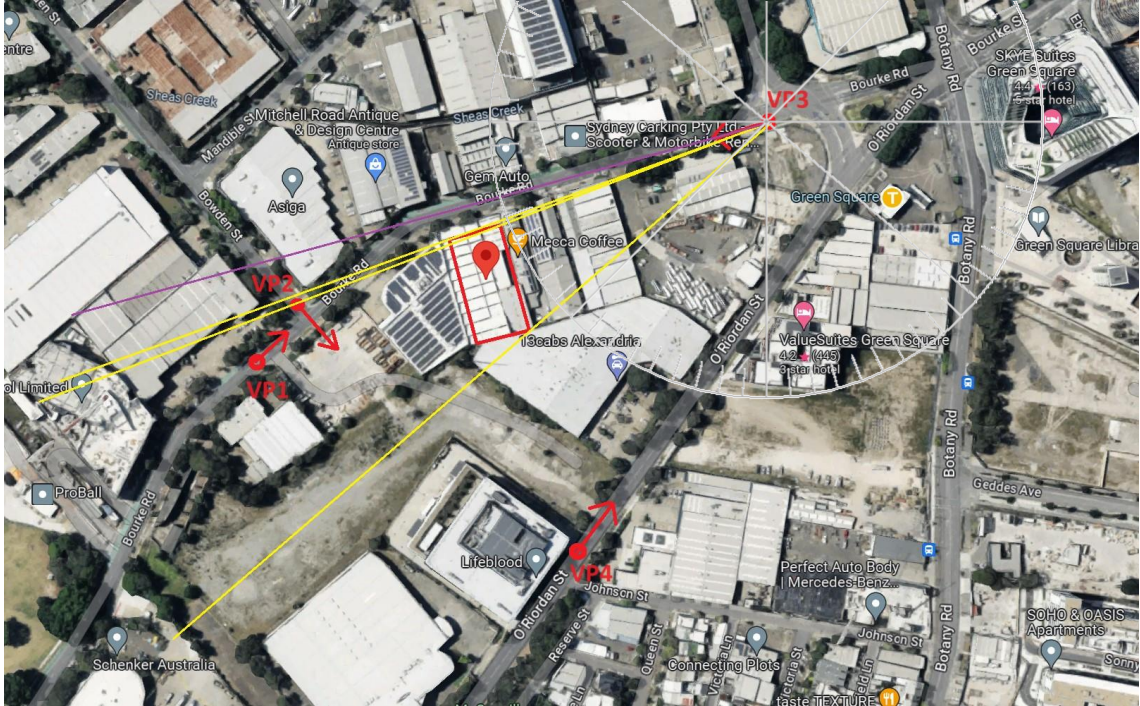


Figure 11 – Viewpoint 3 horizontal bearing angles

The vertical bearing angles have been calculated for each facade zone that is visible from Viewpoint 3 with building heights as nominated above.

$$\begin{aligned} \beta &= \tan^{-1}(34\text{m} \div 175\text{m}) \\ &= 11.0^\circ \end{aligned}$$

	Vertical Bearing Angle		Horizontal Bearing Angle (0° at North)	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Facade Aspect 075	0°	11°	228°	249°
Facade Aspect 345	0°	11°	249°	250°

These bearing angles have been plotted on the reflected sun path diagrams in the Figures below.

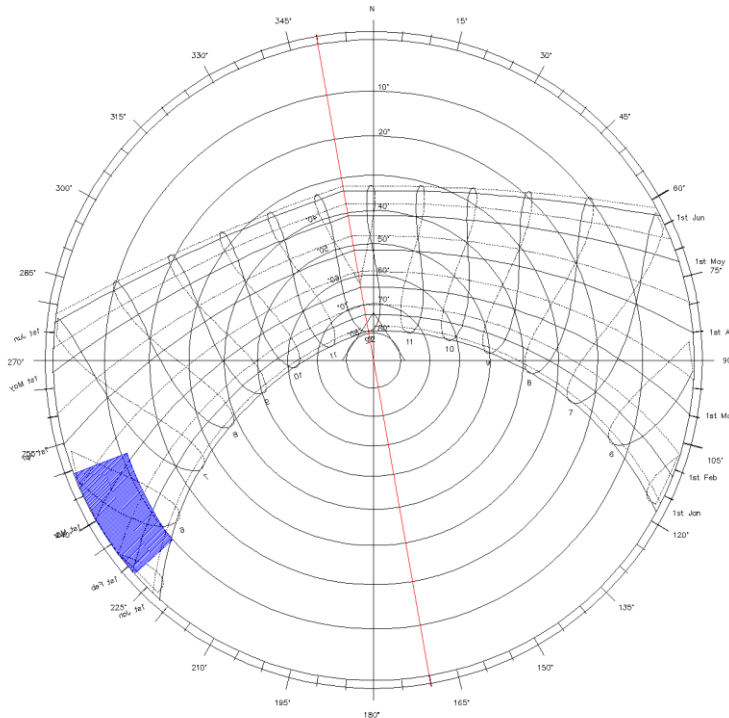
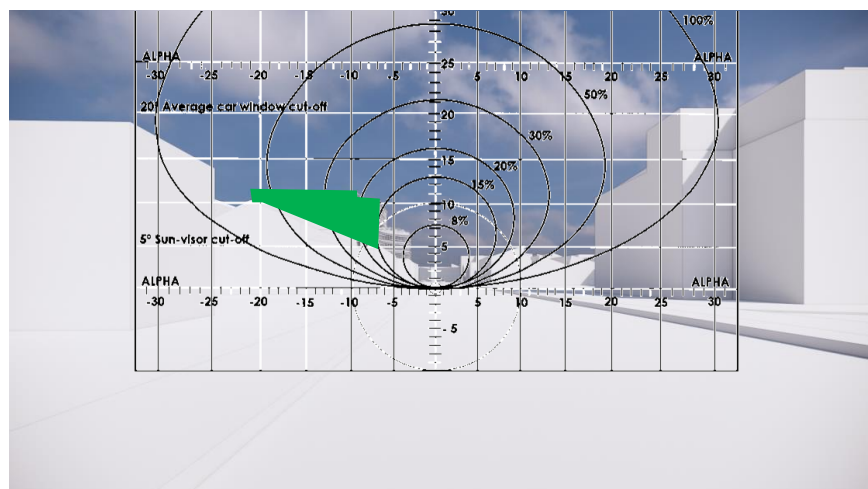


Figure 12 – 075° Facade Aspect Reflected Virtual Sun from Viewpoint 3

Based on the assessment there is the potential for sun light to reach Viewpoint 3 from Facade Aspect 075. This is assessed with an image from the Viewpoint as shown below. The elevation is highlighted in green.



It can be seen that when facing in the direction of travel that the facade is outside of the 15% isoloop. Therefore the normal specular reflectivity of the east elevation should be limited to 15%.

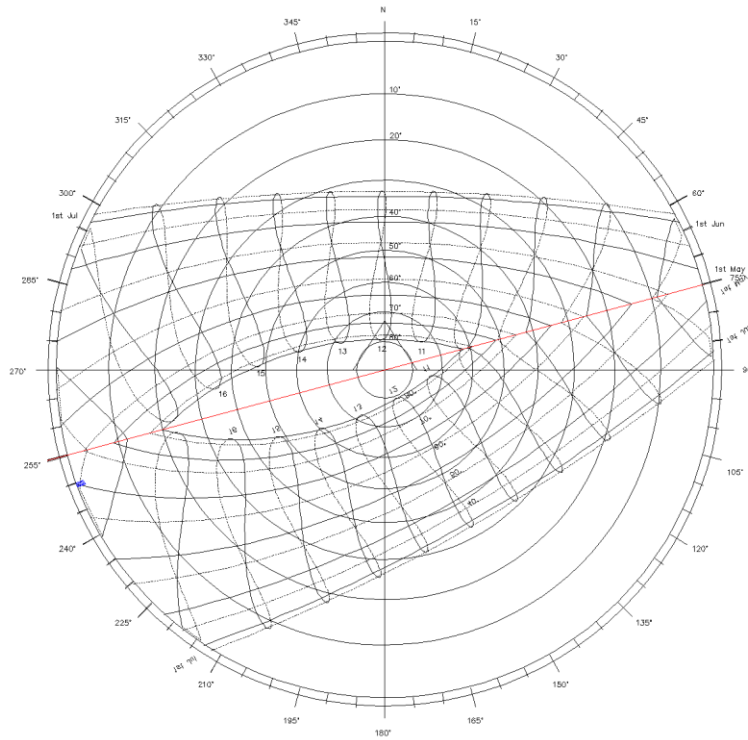
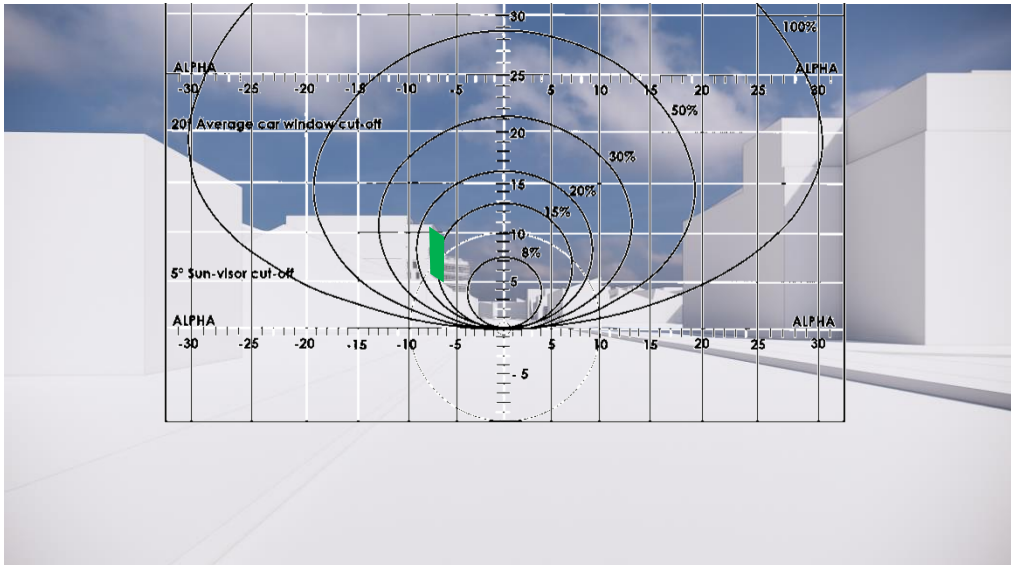


Figure 13 – 345° Facade Aspect Reflected Virtual Sun from Viewpoint 3

Based on the assessment there is the potential for sun light to reach Viewpoint 3 from Facade Aspect 345. This is assessed with an image from the Viewpoint as shown below. The elevation is highlighted in green.



As the sun will be in the direct view of the driver and the view of this facade is limited, with a maximum duration of reflection of 10 minutes, the risk of reflections causing disability glare is considered to be limited and acceptable.

Viewpoint 4

Viewpoint 4 is taken from the viewpoint of a driver travelling North East on O’Riordan Street. The viewing angle of the driver is 35°.

The distances of the viewpoint to the façade are:

- Nearest corner = 130m

The following facade aspects are visible from the Viewpoint in a 180° segment oriented to the direction of viewing and the distance to the corners of the aspect in brackets:

- Facade Aspect 165

In the Figure below yellow lines have been drawn to represent the bearing angles to the visible portions of the building. The red arrow indicates the direction of travel and viewing.

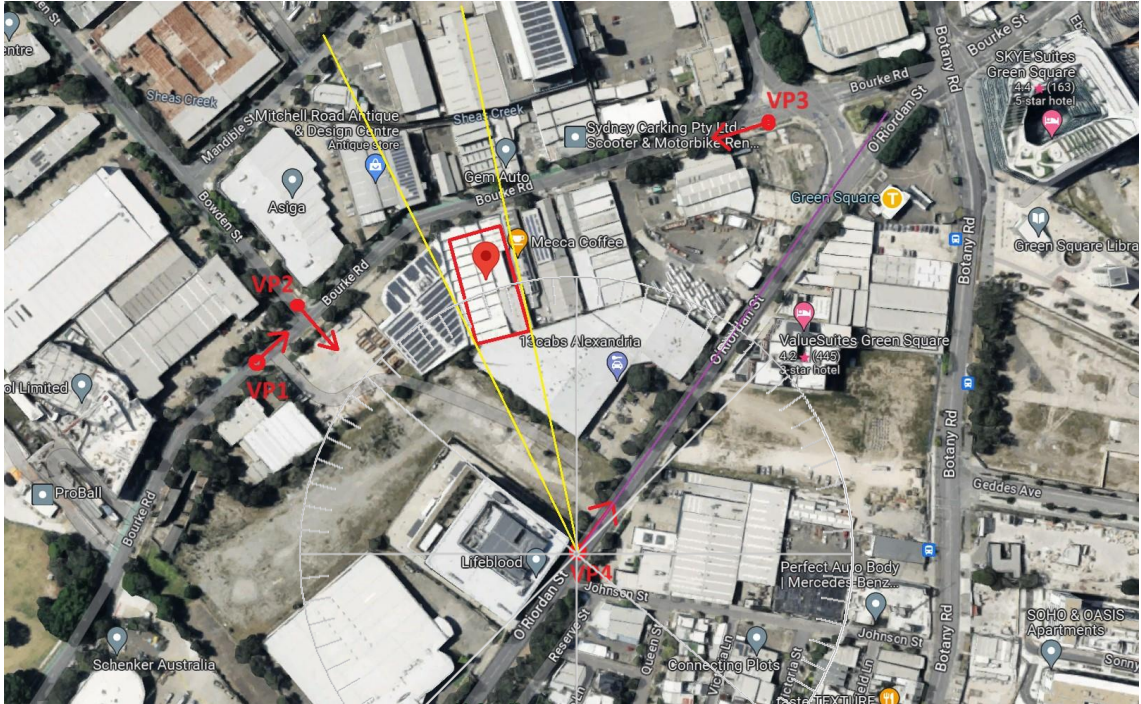


Figure 14 – Viewpoint 4 horizontal bearing angles

The vertical bearing angles have been calculated for each facade zone that is visible from Viewpoint 4 with building heights as nominated above.

$$\begin{aligned} \beta &= \tan^{-1}(34\text{m} \div 130\text{m}) \\ &= 14.6^\circ \end{aligned}$$

	Vertical Bearing Angle		Horizontal Bearing Angle (0° at North)	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Facade Aspect 165	0°	14.6°	334°	348°

These bearing angles have been plotted on the reflected sun path diagrams in the Figures below.

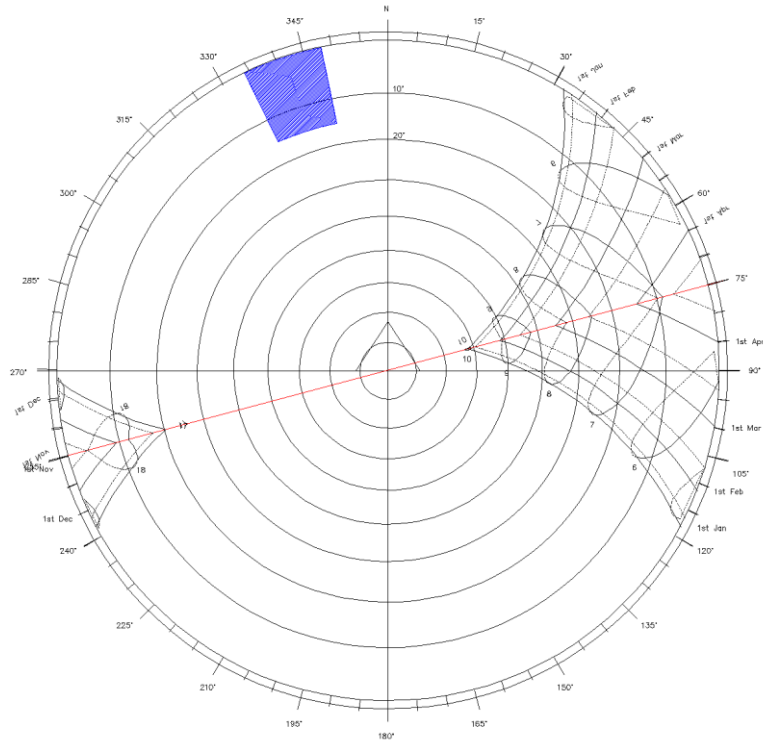


Figure 15 – 165° Facade Aspect Reflected Virtual Sun from Viewpoint 4

There is no reflected image of the sun that reaches Viewpoint 4 from Facade Aspect 165 of the building. No further studies are required.