SICEEP - Sydney International Convention, Exhibition & Entertainment Precinct

Darling Square North East Plot

Reflectivity Study

Rev. 02 | 3 November 2014

Job number 239054-10

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Contents

1 Project Description

1.1 Introduction

This report supports a State Significant Development (SSD) Development Application (DA) submitted to the Minister for Planning pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The Application (referred to as SSDA 7) follows the approval of a staged SSD DA (SSDA 2) in December 2013. SSDA 2 sets out a Concept Proposal for a new mixed use residential neighbourhood at Haymarket referred to as “Darling Square”, previously known as “The Haymarket”. Darling Square forms part of the Sydney International Convention, Exhibition and Entertainment precinct (SICEEP) Project, which will deliver Australia’s global city with new world class convention, exhibition and entertainment facilities and support the NSW Government’s goal to “make NSW number one again”.

More specifically this subsequent DA seeks approval for mixed use development within the North East development plot of Darling Square and associated public domain works. The DA has been prepared and structured to be consistent with the Concept Proposal DA.

1.2 Overview of Proposed Development

The proposal relates to a detailed (‘Stage 2’) DA for a mixed use residential development in the North East Plot of Darling Square together with associated public domain works. The Darling Square Site is to be developed for a mix of residential and non-residential uses, including but not limited to residential buildings, commercial, retail, community and open space. The North East Plot is one of six development plots identified within the approved Concept Proposal.

Under the Concept Proposal, the North East Plot is planned to accommodate a mixed use podium and three residential buildings (NE1, NE2, and NE3) above and within the podium structure. More specifically, this SSD DA seeks approval for the following components of the development:

- Demolition of existing site improvements, including the existing Sydney Entertainment Centre (SEC);
- Associated tree removal and planting;
- Construction and use of a predominantly 6 storey mixed use podium, including:
  - retail floor space and residential lobbies on Ground Level;
  - above ground parking;
  - residential apartments; and
  - communal facilities.
- Construction and use of three residential buildings above podium;
- Public domain improvements surrounding the site, including interim works;
- Provision of vehicle access to the development from Harbour Street;

- Landscaping works to the podium roof level; and
- Extension and augmentation of physical infrastructure / utilities as required.

1.3 Background

The NSW Government considers that a precinct-wide renewal and expansion of the existing convention, exhibition and entertainment centre facilities at Darling Harbour is required, and is committed to Sydney reclaiming its position on centre stage for hosting world-class events with the creation of SICEEP.

Following an extensive and rigorous Expressions of Interest and Request for Proposals process, a consortium comprising AEG Ogden, Lend Lease, Capella Capital and Spotless was announced by the NSW Government in December 2012 as the preferred proponent to transform Darling Harbour and create SICEEP.

Key features of the Preferred Master Plan include:

- Delivering world-class convention, exhibition and entertainment facilities, including:
  - Up to 40,000m^2 exhibition space;
  - Over 8,000m^2 of meeting rooms space, across 40 rooms;
  - Overall convention space capacity for more than 12,000 people;
  - A ballroom capable of accommodating 2,000 people; and
  - A premium, red-carpet entertainment facility with a capacity of 8,000 persons.
- Providing a hotel complex at the northern end of the precinct.
- A vibrant and authentic new neighbourhood at the southern end of the precinct, now called 'Darling Square', including apartments, student accommodation, shops, cafes and restaurants.
- Renewed and upgraded public domain that has been increased by a hectare, including an outdoor event space for up to 27,000 people at an expanded Tumbalong Park; and
- Improved pedestrian connections linking to the proposed Ultimo Pedestrian Network drawing people between Central, Chinatown and Cockle Bay Wharf as well as east-west between Ultimo/Pyrmont and the City.

On 21 March 2013 a critical step in realising the NSW Government's vision for the SICEEP Project was made, with the lodgement of the first two SSD DAs with the (now) Department of Planning and Environment. The key components of these proposals are outlined below.

Public Private Partnership SSD DA (SSD 12_5752)

The Public-Private Partnership (PPP) SSD DA (SSDA 1) includes the core facilities of the SICEEP Project, comprising the new, integrated and world-class convention, exhibition and entertainment facilities along with ancillary commercial premises and public domain upgrades. SSDA1 was approved on 22 August 2013.

Concept Proposal (SSD 13_5878)

The Concept Proposal SSD DA (SSDA 2) establishes the vision and planning and development framework which will be the basis for the consent authority to assess detailed development proposals within the Darling Square Site. SSDA2 was approved on 5 December 2013. The Stage 1 Concept Proposal approved the following key components and development parameters:

- Indicative staging of demolition and development of future development plots;
- Land uses across the site including residential and non-residential uses;
- Street and laneway layouts and pedestrian routes;
- Open spaces and through-site links;
- Six separate development plots, development plot sizes and separation, building envelopes, building separation, building depths, building alignments, and benchmarks for natural ventilation and solar access provisions;
- A maximum total gross floor area of 197,236m^2 (excluding ancillary above ground parking), comprised of:
  - A maximum of 49,545m^2 non-residential GFA; and
  - A maximum of 147,691m^2 residential GFA
- Above ground car parking including public car parking;
- Residential car parking rates;
- Design Guidelines to guide future development and the public domain; and
- A remediation strategy.

In addition to the approval of SSDA1 and SSDA2, the following approvals have been granted for various stages of Darling Square site:

- Darling Drive (part) development plot (SSDA3) for the construction and use of a residential building (student accommodation) and the provision of associated public domain works approved on 7 May 2014;
- North-West development plot (SSDA4) for the construction and use of a mixed use commercial development and public car park building and associated public domain works approved on 7 May 2014; and
- South-West development plot (SSDA5) – construction and use of a mixed use residential development and associated public domain works approved on 21 May 2014.

Approval was also granted on 15 June 2014 for SSDA6 which includes the construction and use of the International Convention Centre (ICC) Hotel and provision of public domain works.

This report has been prepared to support a detailed Stage 2 SSD DA for mixed use development and associated public domain works within Darling Square (SSDA 7), consistent with the approved Concept Proposal (SSDA 2).

1.4 Site Description

The SICEEP Site is located within Darling Harbour. Darling Harbour is a 60 hectare waterfront precinct on the south-western edge of the Sydney Central Business District that provides a mix of functions including recreational, tourist, entertainment and business.

With an area of approximately 20 hectares, the SICEEP Site is generally bound by the light rail Line to the west, Harbourside shopping centre and Cockle Bay to the north, Darling Quarter, the Chinese Garden and Harbour Street to the east, and Hay Street to the south (refer toFigure 1). The Darling Square Site is:

- located in the south of the SICEEP Site, within the northern portion of the suburb of Haymarket;
- bounded by the Powerhouse Museum to the west, the Pier Street overpass and Little Pier Street to the north, Harbour Street to the east, and Hay Street to the south; and
- irregular in shape and occupies an area of approximately 43,807m^2.

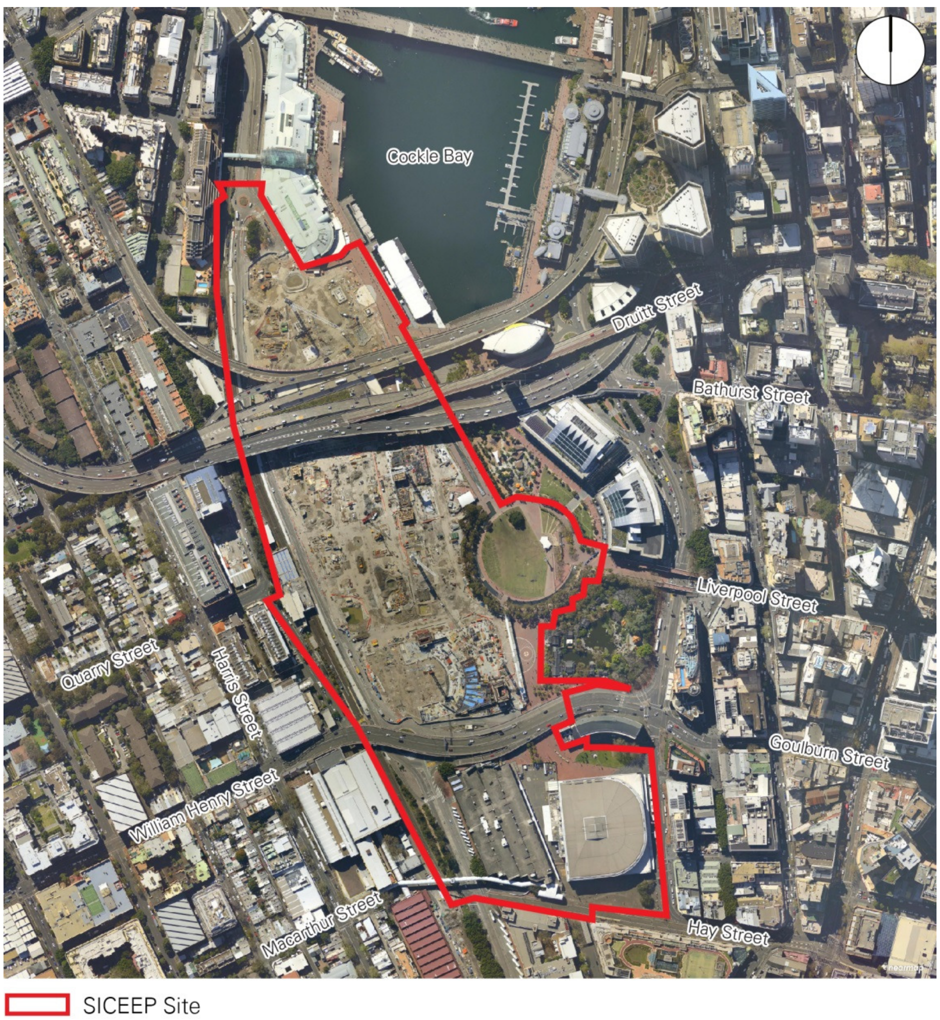


Figure 1: Aerial Photograph of the SICEEP Site

The Concept Proposal DA provides for six (6) separate development plots across the Darling Square Site (refer toFigure 2):

1. North Plot;
2. North East Plot;
3. South East Plot;
4. South West Plot;
5. North West Plot; and
6. Western Plot (Darling Drive).

The Application Site area relates to the North East Plot and surrounds as detailed within the architectural and landscape plans submitted in support of the DA.

Figure 2: Concept Proposal Development Plots

1.5 Planning Approvals Strategy

The SICEEP Project has resulted in the lodgement of numerous SSD DAs for the various components of the redevelopment project. Future applications will continue to be lodged in accordance with the Concept Proposal SSD DA for the remaining development plots of Darling Square Site.

2 Executive Summary

This reflectivity study assesses the impact of solar reflections on pedestrians and road traffic participants in the area surrounding the proposed buildings on the North East Plot of the Darling Square development in terms of reduced visibility of visual tasks, to address the qualitative requirements of the Central Sydney DCP 2012 Provision 3.2.7. As per this provision, the report focuses on the impact to traffic participants. This assessment is performed following the methodology of David N.H. Hassall of the University of New South Wales[1].

The buildings covered by the scope of this assessment are located within the North East plot and are as follows:

- Tower NE1 - 19 level building (including podium)
- Tower NE2 - 8 level building (including podium)
- Tower NE3 - 41 level building (including podium)
- Podium - 6 levels

The proposed buildings have been found to perform well in terms of solar reflectivity, and reflections have not been found to cause unacceptable glare according to the Hassall methodology, as long as glazing reflectivity is kept within the following limits:

- **North east facing glazing and west facing façade on NE3 (L08-22): 12%**
- **All other glazed facades and balustrades: 20%**

This result is obtained in spite of worst case assumptions about the extent of reflective facade cladding, and not taking into account obscuring effects from hard to assess smaller façade elements and surrounding vegetation.

Pedestrians are easily able to adjust their view in any location where unwanted reflections may be received, reducing the impact of the reflections, and move at a rate significantly slower than that of a vehicle. For this reason it is acceptable to assume that it will be safe for pedestrians to divert their vision in order to avoid glare.

The reflectance limits noted above will also serve to reduce potential glare reflections that may occasionally be produced towards other buildings.

[1] Hassall, D. N. H. (1991): *Reflectivity. Dealing with Rogue Solar Reflections*, Faculty of Architecture, University of New South Wales, ISBN 0 646 07086 X

3 Aim and Methodology

3.1 General

Figure 3: Perspective of NE plot from north east. Image courtesy of Tzannes Associates

Arup has been commissioned by SICEEP - Sydney International Convention, Exhibition & Entertainment Precinct to carry out a reflectivity study of the proposed North East plot development. This reflectivity study assesses the impact of solar reflections on pedestrians and road traffic participants in the area surrounding the site. It is intended to address the qualitative requirements of the Sydney DCP 2012 Provision 3.2.7.

The assessment in this report is performed following the methodology of David N.H. Hassall of the University of New South Wales, which contemplates potential rogue reflections giving more detailed consideration to geometry, viewing angles, and sun positions. It is described in more detail in section 3.4.

3.2 Reviewed buildings

The North East Plot comprises a 6-storey podium and three residential towers (Tower NE1: 19 storeys, Tower NE2: 8 storeys, Tower NE3: 41 storeys).

The buildings are bounded by the South East Plot to the south, the North West and South West plots to the west, Little Pier Street to the north, and Harbour Street to the east. The tower buildings rise above the neighbouring properties, such that all of their principal elevations can be seen from road level. They are however located in a densely built up area of the CBD, and view towards the buildings is restricted mostly to the streets that lead directly past the site and areas to the north of the site where building density is reduced around Darling Harbour.

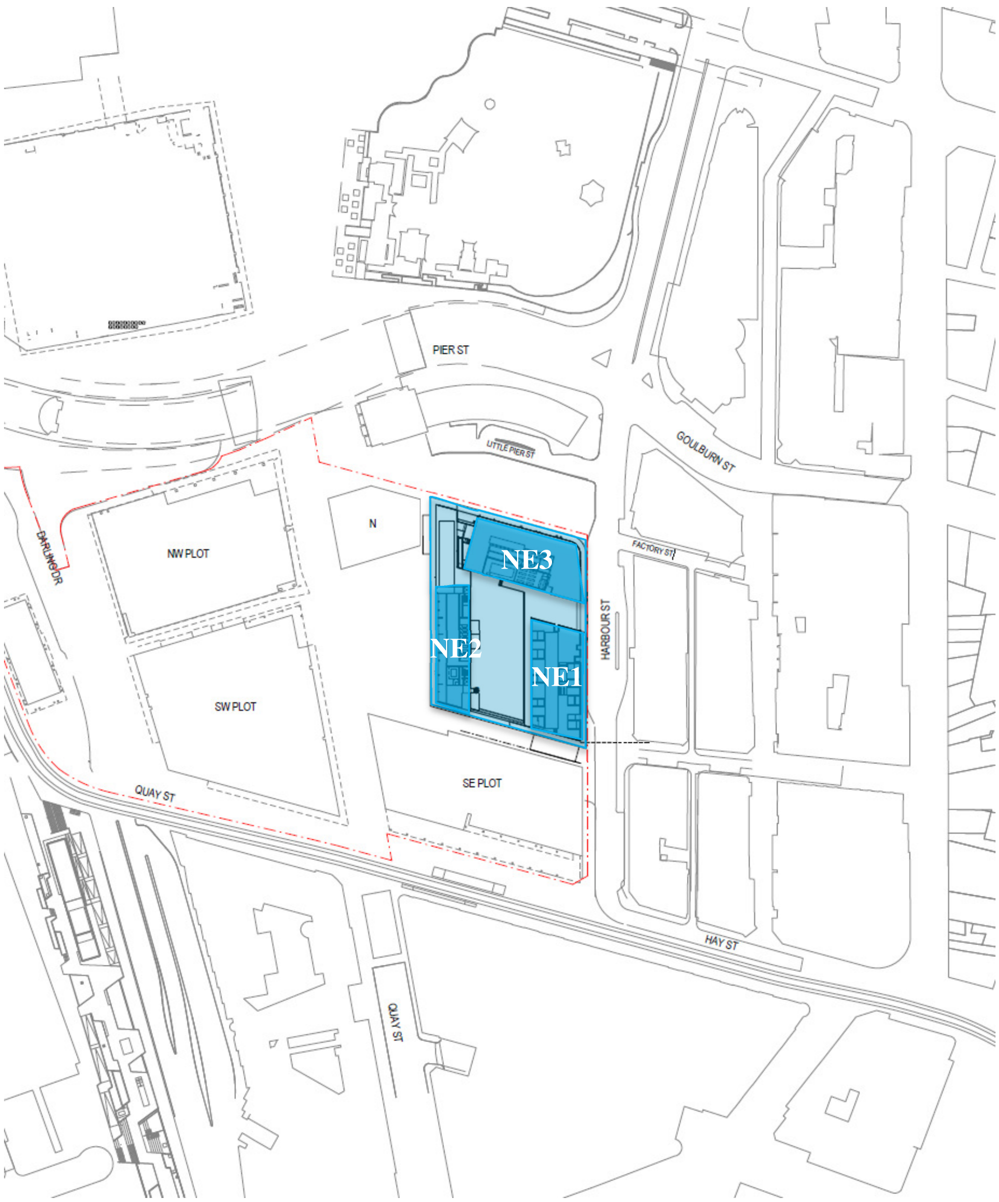


Figure 4: Site plan of North East plot. New tower buildings highlighted in blue. The podium covers the area highlighted in light blue.

3.3 Description of Facades

The façade design is detailed in the SSDA 7 Design Report and the Architectural Drawings referenced in Appendix B1.

For the purposes of reflected glare analysis, façade elements to be considered are those that have a specular (i.e. mirror-like) reflection component. The primary specular reflective elements of the proposed building designs are window and balcony glazing and colourback glazed opaque façade elements.

The facades of the buildings are articulated with steps in and out creating residential balconies. The intent for windows and full height glazing behind balconies is aluminium framed glazing. Balustrades are intended to be glass. Some solid wall areas mainly on the south and west elevations of NE3 will be clad with opacified glass.

All glazing will have a normal specular reflectivity no higher than 20% as per council requirements.

Other areas of solid façade are faced with non-reflective precast, render, or brick. Brick facades include feature areas using glazed bricks. While a glazed finish is specularly reflective, the surface flatness of glazed bricks is not comparable to float glass, and the overall geometry of glazed brick walls with numerous edges and typical alignment tolerances results in reflected light being significantly scattered when viewed from a distance. Glazed brick façade areas have thus not assumed to pose a risk of reflected glare.

3.4 Criteria for Assessment

The method for this study follows that of David N. H. Hassall of the University of New South Wales, which has been widely used to assess reflections off building projects in Sydney. This method quantifies reflections and classifies reflections using the terms disability glare and discomfort glare. These are defined in the Hassall methodology as follows:

- Disability glare – glare from reflections which impact the observer in a way that they are unable to perform a visual task, such as reading or driving, without taking evasive action (such as turning away or raising a hand to shield the eyes). It is critical that a driver's view is unaffected by disability glare as this has the potential to cause road accidents. Note that the term 'Disability' indicates temporary impact on the ability to perform visual tasks and does not imply that the glare effect leads to long-term disability in any form.
- Discomfort glare – glare from reflections causing the observer psychological annoyance.

Calculations following this method centre on equivalent veiling luminance in the eyes of observers due to solar reflections. The terms 'veiling luminance' and 'veiling glare' refer to the effect of multiple reflection and scattering within the eye of direct light from a bright source. This produces a perception similar to a thin veil being overlaid on the visual scene, and reduces the contrast in the scene, potentially impairing visual tasks.

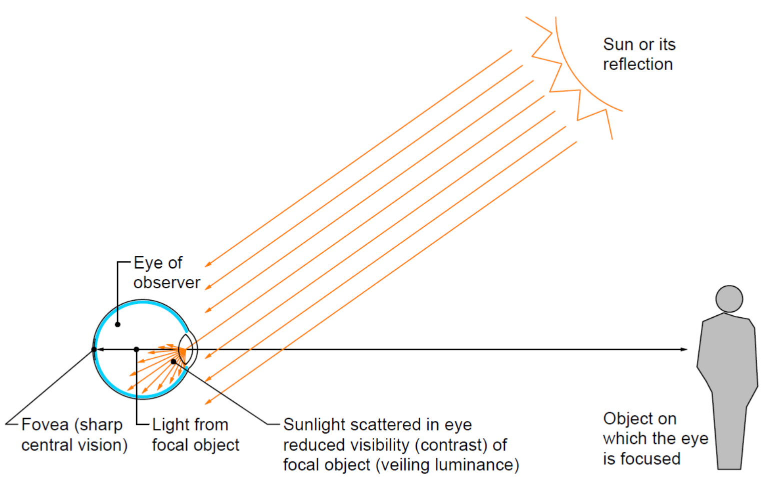


Figure 5: Bright sunlight falling into the eye reduces contrast and visibility of objects. This effect can be quantified by the equivalent veiling luminance measure.

A prerequisite for veiling glare is thus that reflections of the sun are visible relatively close to the direction of view of an observer.

The equivalent veiling luminance is a measure of this effect, and hence considered a measure of the visual impact of glare. Luminance is measured in Cd/m² (candela per metre squared) and is a representation of how bright a surface will appear to the human eye. Where the equivalent veiling glare figure exceeds the level of 500Cd/m², the solar reflection is considered excessive (potentially causing disability glare) in accordance with the Hassall methodology.

3.5 Methodology

The assessment of undesirable solar reflections is based on the methodology described by Hassall. This involves several steps, as outlined below.

- The size, orientation and extent of reflective objects on each facade are determined by examination of drawings provided by the architect, the site and surrounds, and expected glazing materials.
- Several observer locations are chosen for critical facades, representing locations from which traffic participants may observe the facades.
- Times at which the sun is reflected off the facade are determined, as well as the directions in which it is reflected.
- If the sun is reflected towards any observer, the equivalent veiling luminance in the eye of the observer is calculated and evaluated against the maximum allowed level of 500 Cd/m² according to Hassall. This involves calculations of the strength of solar illumination, the position of the sun in front of the facade, the apparent position of the sun reflected in the facade, and the reflected solar illumination received by the observer. If the limit is exceeded, further assessment is carried out to evaluate if other factors such as facade shading make the situation acceptable or not.

3.6 Assumptions

- For initial assessment, all glazed facades have been assumed to have a reflectivity of 20% as the worst case allowable value.
- It is assumed that to carry out the visual tasks required for traffic participation, drivers and pedestrians face parallel to the ground, and parallel to their direction of travel.

3.7 Modelling and Assessment Approach

This reflectivity study used a 3D model of the North East Plot buildings and the surrounding topography. The 3D model was developed from the architectural 3D model as a simplified massing model, however retaining accurate orientations of façade surfaces. Relative road elevation information was taken from available 3D topography.

Facades have been analysed in true elevation angles as provided with 3D model information by Tzannes Associates. Small scale details such as joints, any expressed framing profiles, downpipes, etc has been omitted from the model. They subtend insufficient angles in the visual field to reflect a large enough portion of the sun disk to cause unacceptable glare.

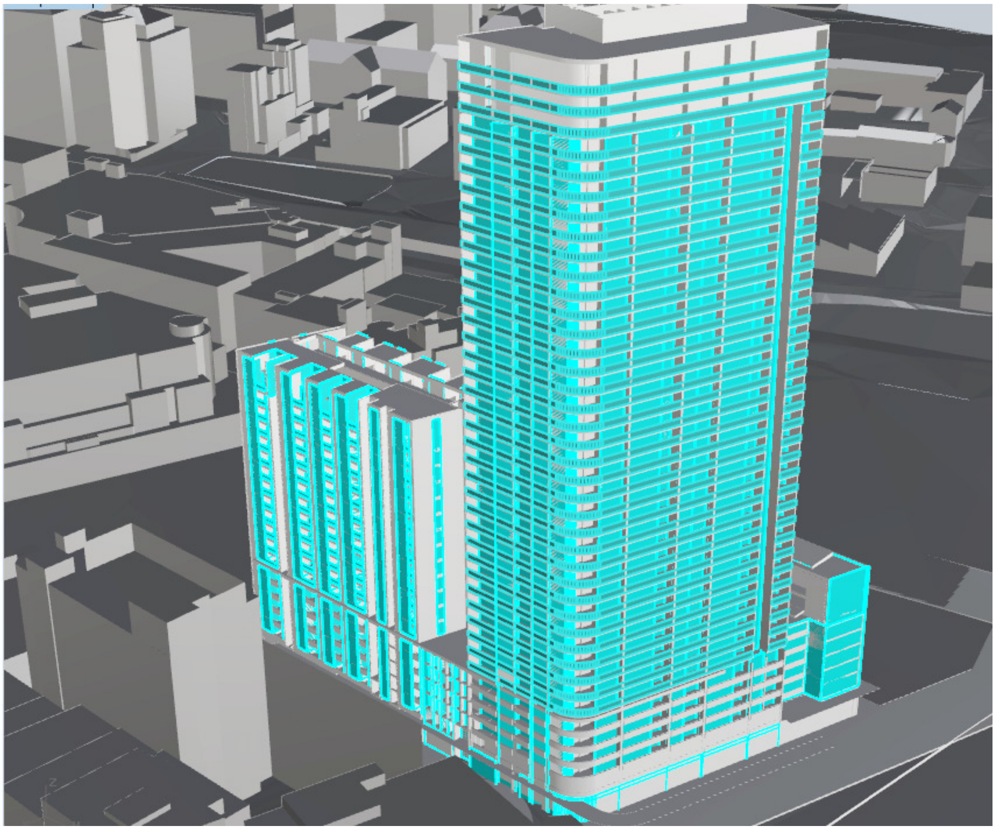


Figure 6: Image of the 3D building and context model. Surfaces shown in blue have been assumed as specular reflective in the analysis.

This model was used to interrogate the view of the building and solar reflections originating from it along the paths shown in Figure 7.

Ref.	Road	Dir.
A	Harbour St	S
B	Goulburn St	W
C	Pier St	E
D	Darling Drive along ramp to Harbour St	S turning E
E	Harbour St	N
F	Hay St	W
G	Little Hay St	W
H	Dixon St	N turning W
I	Quay St	N
J	George St	S

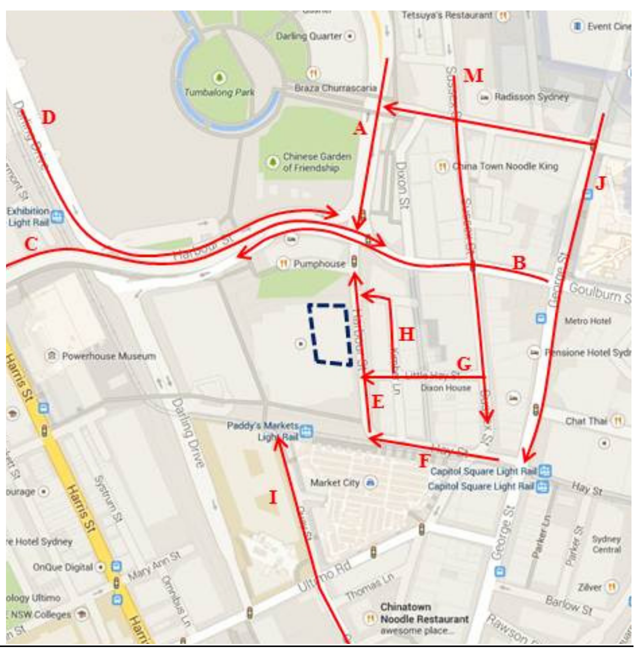


Figure 7: Site map showing observer paths from which glare has been assessed

4 Assessment Results

4.1 Results for Analysed Traffic Travel Paths

Observed model analysis outcomes for each of the travel paths are summarised below. Indicative perspective views and reflected sun charts are shown for a single viewpoint on these paths. Note however the modelled paths have been reviewed along their entire lengths.

The sun charts indicate the times of the year when solar reflections are visible from each view location. The coloured region on each chart shows the projected façade. Where this region intersects the reflected sun path, the façade can reflect the sun's light towards the location.

The equivalent veiling luminance of these reflections is calculated with respect to a driver's heading direction, and is colour coded in projected facades in sun charts and in perspective views. Façade areas are shown orange to red where reflections exceed the Hassall limit of 500Cd/m². Reflections off projected façade area shown in blue to cyan are below this limit in intensity.

A. Traveling south on Harbour Street

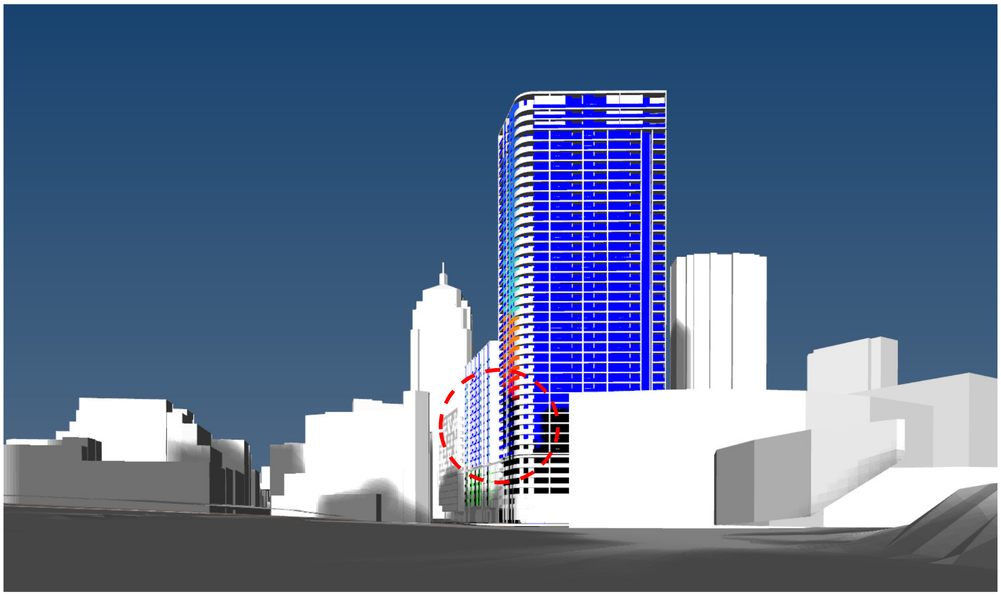


Figure 8: Perspective view from road (reflections at 20% reflectivity)

Viewed from locations along this stretch of road the potions of glazing rotated towards the north east at the north east corner of the NE3 building façade, approximately between levels 10 and 22, can reflect the sun towards drivers at the following times:

- November and February, between 6am – 7am, for up to approximately 5min

The equivalent veiling luminance of reflections at 20% normal glass reflectivity would theoretically reach up to 1000 Cd/m² i.e. exceed the Hassall threshold at the furthest point where the facades can reflect the full sun disk (approx. 260m from the building). Further away the effective intensity of reflections drops off as the sun disk would only be reflected partially.

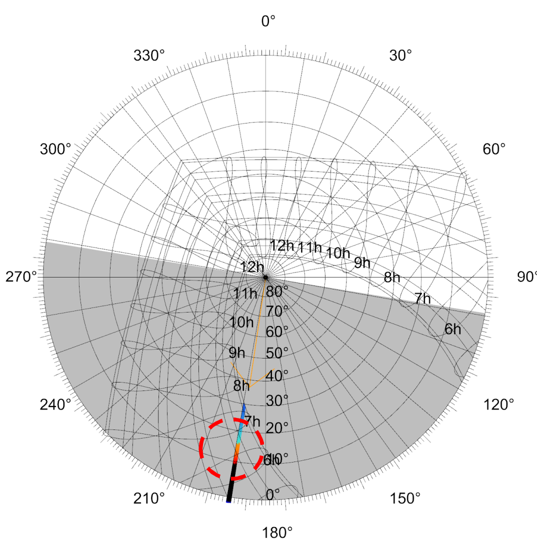


Figure 9: Stereographic sun chart of north east facades

However, if the normal glass reflectivity is reduced to 12% the equivalent veiling luminance drops below the Hassall threshold.

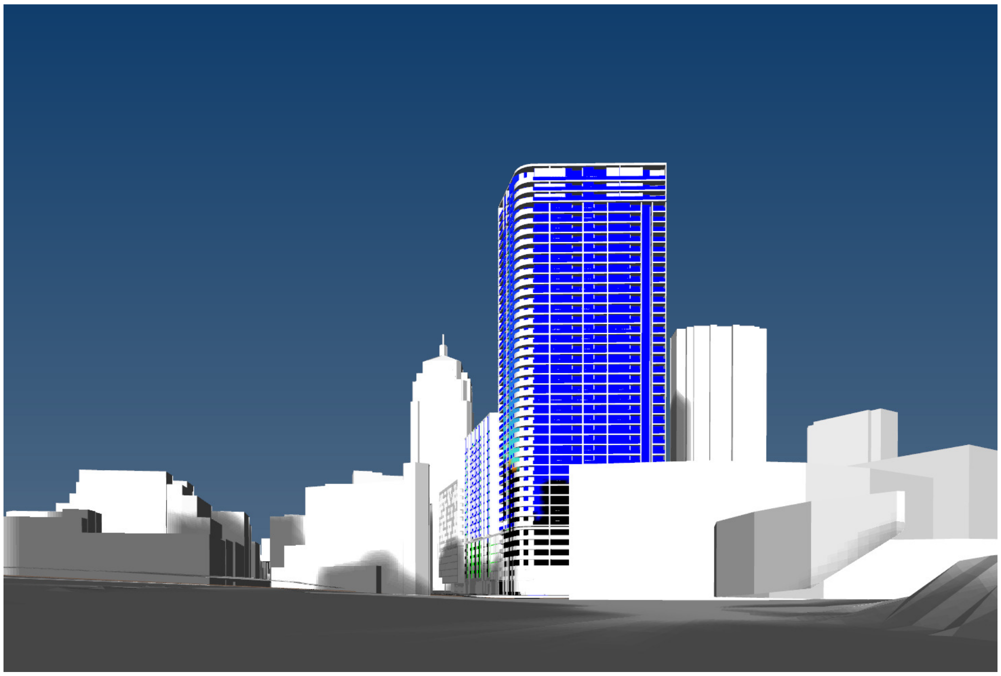


Figure 10: perspective view from road (reflections at 12% reflectivity)

Reflections from the facades towards this observer path have thus been found to pose minimal risk of glare, if glass with no more than 12% normal reflectivity is used on the north east facing façade sections of NE3.

B. Traveling west on Goulburn Street

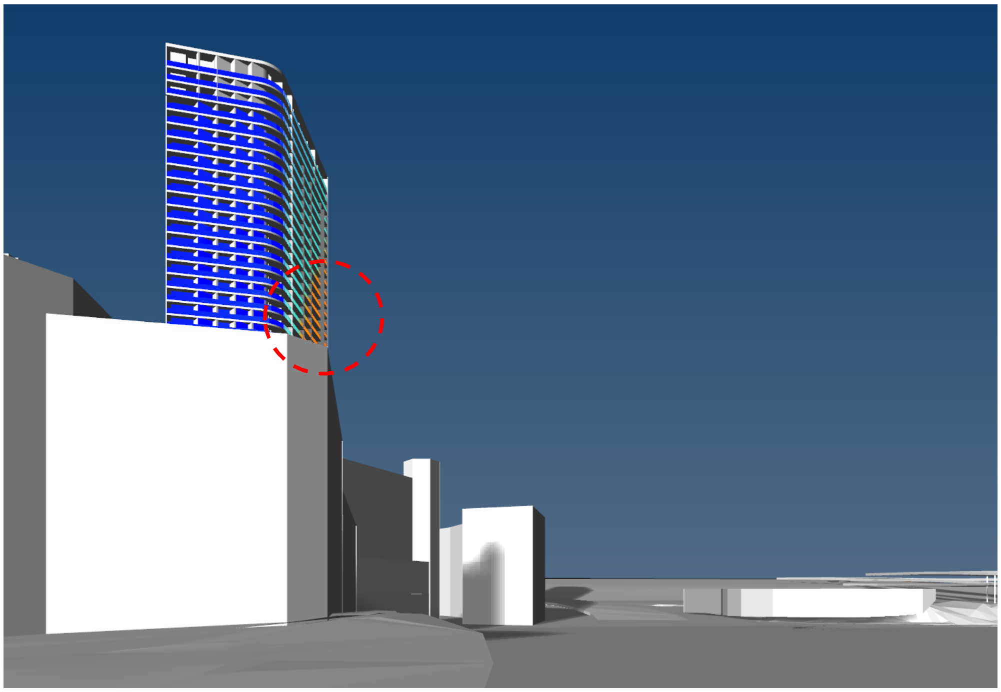


Figure 11: Perspective view from road

Viewed from locations along this stretch of road the northern façade planes of the NE3 building can reflect the sun towards drivers for intervals of up to 5 minutes during mid seasons at 2pm. At 20% normal glass reflectivity the equivalent veiling luminance of approximately 630 Cd/m² exceeds the Hassall threshold.

However, these reflections only occur at shallow glancing angles of incidence, such that balcony return walls shade the full height window glazing and sun reflections at tower levels would only be visible on the balustrade glazing. Viewed from the locations where high intensities are found, these do not subtend a large enough angle in the visual field to reflect the full sun disk (approx. 0.3° compared to 0.53° of the sun disk), and maximum intensities can be assumed to be reduced by approximately 30%. They thus fall below the Hassall threshold.

It is further noted that shallow angle reflections would be significantly scattered by tolerances in the flatness and alignment of glass surfaces. Also as traffic participants are moving close to parallel to the façade, the direct sun would be visible at a similar angle from the view direction and remain the primary source of potential glare, such that the façade reflection arguably does not increase the likelihood of glare.

Reflections from the facades towards this observer path have thus been found to pose minimal risk of glare.

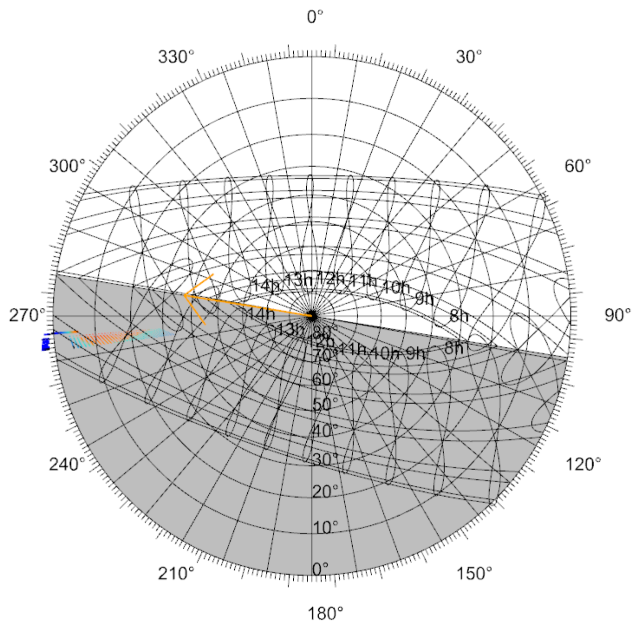


Figure 12: Stereographic sun chart of north facades

C. Traveling east on Pier Street

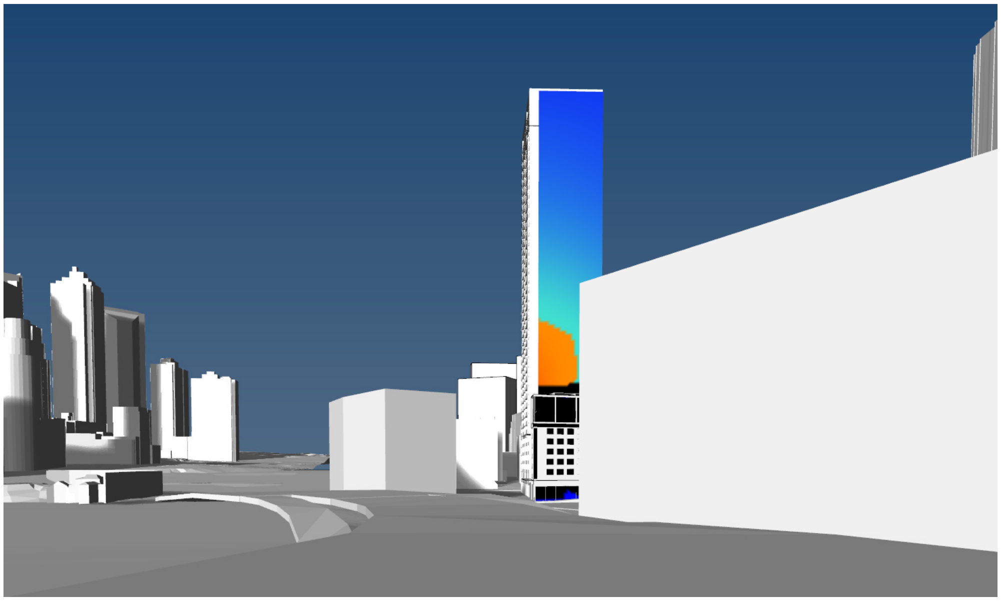


Figure 13: Perspective view from road (reflections at 20% reflectivity)

Viewed from locations along this stretch of road the west façade planes of the NE3 tower building, approximately between levels 8 and 20, can theoretically reflect the sun towards drivers for intervals of up to 5 minutes between 6am and 7pm throughout mid summer months. At 20% normal glass reflectivity the equivalent veiling luminance of 650Cd/m² exceeds the Hassall threshold.

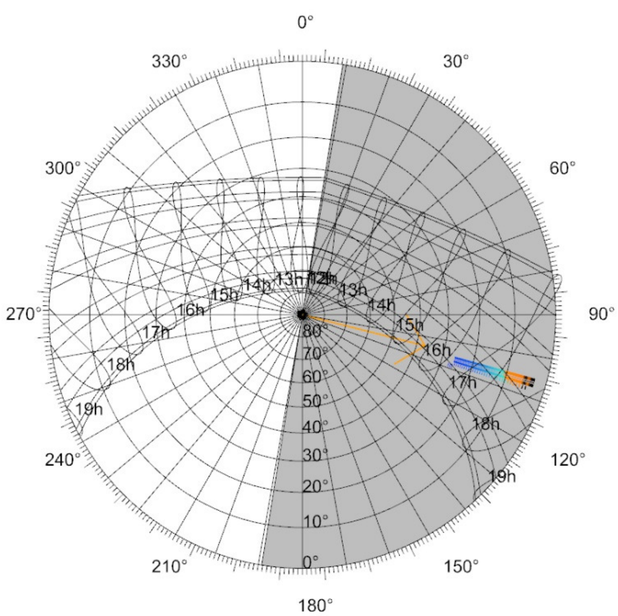


Figure 14: Stereographic sunchart of NE3 west facade

However, if the normal glass reflectivity is reduced to 12% the equivalent veiling luminance drops below the Hassall threshold.

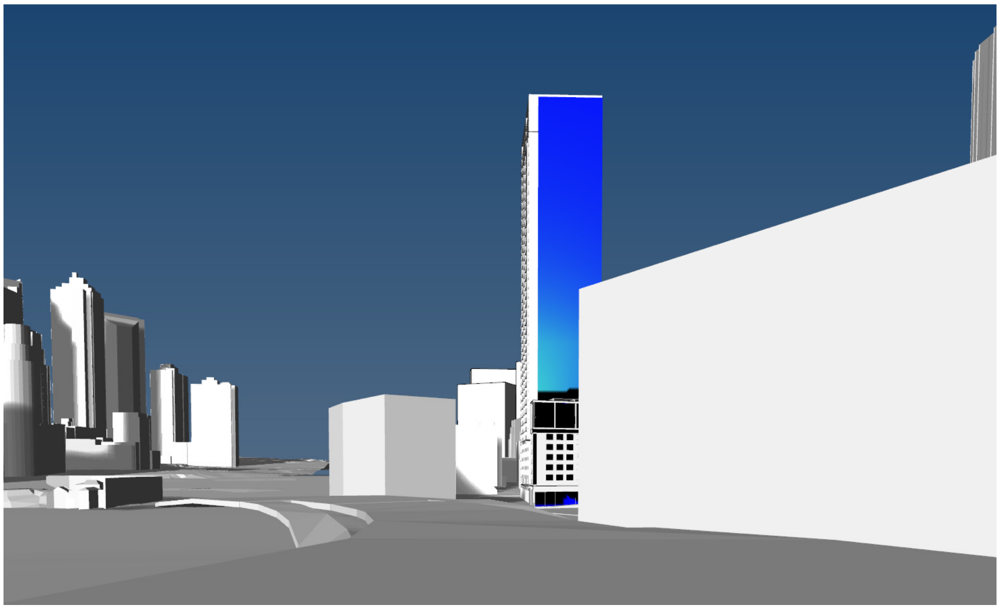


Figure 15: Perspective view from road (reflections at 12% reflectivity)

Reflections from the facades towards this observer path have thus been found to pose minimal risk of glare, if glass with no more than 12% normal reflectivity is used on the west facades of NE3.

D. Traveling south turning east on Darling Drive (upper)

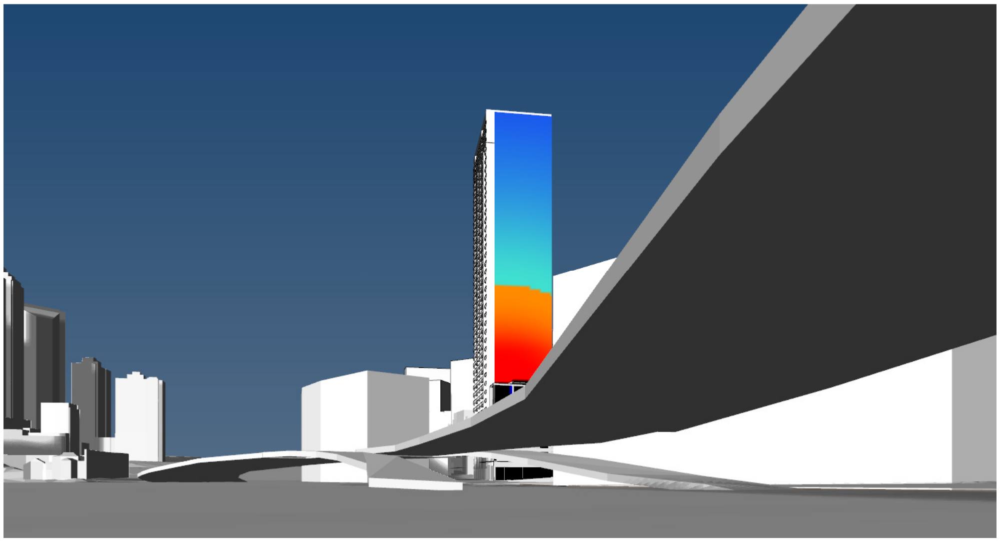


Figure 16: Perspective view from road

Viewed from locations along this stretch of road the west facades of the NE3 building can reflect the sun towards drivers for up to approximately 15 minutes between 5 and 7pm on March/April and August/September evenings.

The equivalent veiling luminance of reflections at 20% normal glass reflectivity would theoretically reach up to 1180 Cd/m², exceeding the Hassall threshold. At 12% normal reflectivity as per recommendation under item C, this maximum would be reduced to approximately 700 Cd/m².

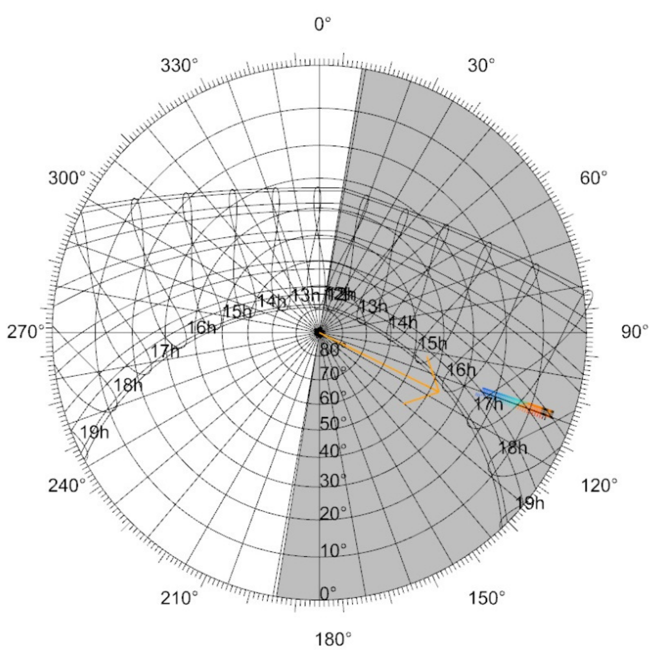


Figure 17: Stereographic sun chart of facades with 20% glazing reflectivity

However, the excessive reflections are only visible at angles of approx. 7° and more above the plane of vision of drivers on this stretch of road. Given the short stretch of road towards which these reflections are cast occurs after exit from a roundabout and driver speeds can be assumed not to be very high, it is acceptable to assume that drivers can use the car sun visor to block reflections per the Hassall methodology.

Reflections from the facades towards this observer path have thus been found to pose minimal risk of glare.

E. – J. Other travel paths

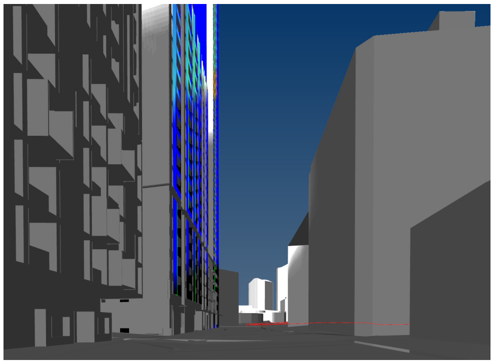


Figure 18: Perspective view from E - Traveling north on Harbour St

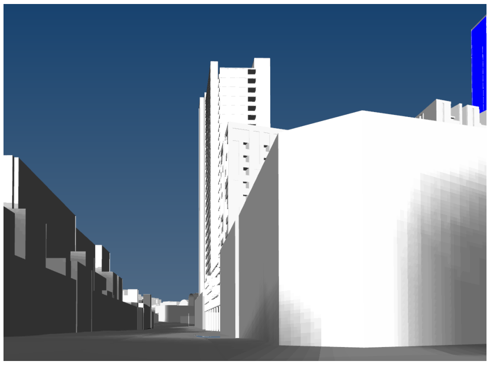


Figure 19: Perspective view from F - Traveling west on Hay St

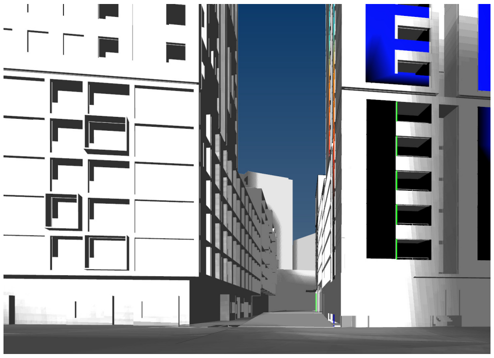


Figure 20: Perspective view from G - Traveling west on Little Hay St

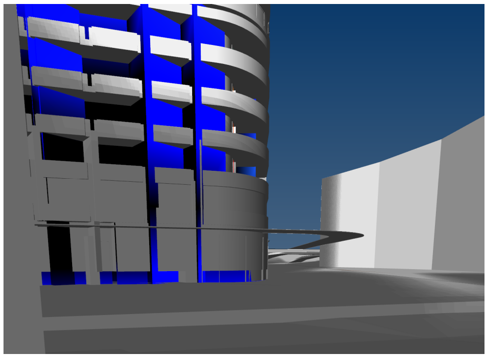


Figure 21: Perspective view from H - Traveling west on Dixon Street

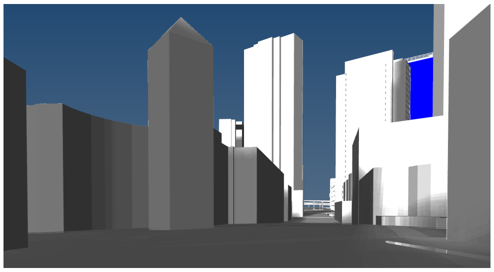


Figure 22: Perspective view from I - Traveling north on Quay St

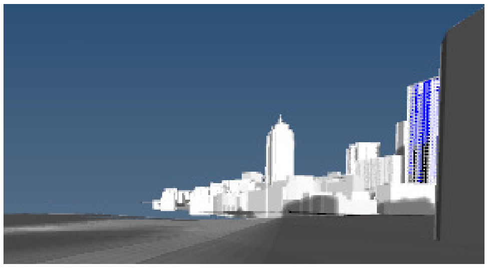


Figure 23: Perspective view from J - Traveling south on George St

For all other analysed travel paths E. – J. listed above it has been found that visible equivalent veiling reflections fall well below the Hassall threshold of 500Cd/m².

Reflections from the facades towards the observer paths E to J have thus been found to pose minimal risk of glare.

Summary

Reference	Road	Driving direction	Maximum Lv identified at 20% reflectivity	Allowable specular reflectivity for glazed surfaces to limit reflection to ≤ 500 Cd/m²
A	Harbour St	S	1,000 Cd/m²	12% for north east oriented glazing on building NE3 L10-22; 20% elsewhere
B	Goulburn St	W	630 Cd/m²*	20%
C	Pier St	E	650 Cd/m²	12% for west facing glazing on building NE3 L08-20; 20% elsewhere
D	Darling Drive (upper) along ramp to Harbour St	S turning E	1,180 Cd/m²	Use of sun visor to block excessive reflections possible
E	Harbour St	N	400 Cd/m²*	20%
F	Hay St	W	0 Cd/m²	20%
G	Little Hay St	W	120 Cd/m²	20%
H	Dixon St	N turning W	110 Cd/m²	20%
I	Quay St	N	0 Cd/m²	20%
J	George St	S	60 Cd/m²	20%

* = theoretical values. Small area of reflection and shallow angles of incidence in these cases mean that actual intensity of reflections will be significantly reduced.

Table 1: Summary of roads reviewed for sun reflections

4.2 Impact on Traffic in Other Locations

From further afield e.g. on hill areas in other suburbs it may be possible that other locations exist where the building can be seen from road level. These would however be at a distance where typical glazing surfaces of the building would subtend angles significantly smaller than the sun disk, and scattering effects from small misalignments e.g. due to construction tolerances would reduce the observable intensity of reflections, so that it is not expected to be high enough to create unacceptable glare.

4.3 Impact on Pedestrians

From the perspective of pedestrians moving along roadways, the incidence of reflections from the building is generally similar to the examined road traffic locations. Glare from reflections is therefore expected in similar locations.

Furthermore, pedestrian observers are easily able to adjust their view and thus reduce the glare impact of reflections. They move at a rate significantly slower than that of a vehicle. For this reason it can be assumed that it will be safe for pedestrians to divert their vision in order to avoid glare.

4.4 Impact on Surrounding Buildings

Solar reflections off the facade may reach surrounding buildings in the CBD area. This may occur for limited time periods throughout the day, i.e. during the morning sun may be reflected off the east facades towards buildings further to the east, and afternoon sun may be reflected towards buildings further west.

In general, reflections from facades with external reflectance below 20% are much less likely to cause discomfort to occupants of surrounding buildings than facades with strongly reflective glazing. The proposed building is targeting a glass reflectance below 20% in accordance with the Central Sydney DCP, which will serve to reduce potential glare reflections that may occasionally be produced towards other buildings.

The limited visible light transmittance of glazing in surrounding office buildings (in existing buildings commonly below 50-60%) will further reduce the intensity of any reflections.

For the above reasons it is expected that the development will have little or no solar reflection impact on the occupants of surrounding buildings.

5 Conclusion

The proposed Darling Harbour Live North East Plot buildings perform well in terms of solar reflectivity, and reflections have not been found to cause unacceptable glare according to the Hassall methodology under the below assumptions.

Reflected glare risk from facades visible to traffic participants could be discounted for either of the following reasons:

- Facades do not reflect any portion of the sun's path towards traffic participants; or
- Any reflections found were below the assumed limit of acceptability as set out by Hassall; or
- Reflections with intensities theoretically above the threshold occur at shallow angle of incidence, such that the direct sun is visible at the same time as the reflections and presents a higher risk of glare than the reflections; or
- Expressed vertical columns and mullions would block most or all of the sun reflections

These findings are valid as long as glazing reflectivity is kept within the following limits:

- **North east facing glazing and west facing façade on NE3 (L08-22): 12%**
- **All other glazed facades and balustrades: 20%**

This result is obtained in spite of worst case assumptions about the extent of reflective facade cladding, and not taking into account obscuring effects from hard to assess smaller façade elements and surrounding vegetation.

Pedestrians are easily able to adjust their view in any location where unwanted reflections may be received, reducing the impact of the reflections, and move at a rate significantly slower than that of a vehicle. For this reason it is acceptable to assume that it will be safe for pedestrians to divert their vision in order to avoid glare.

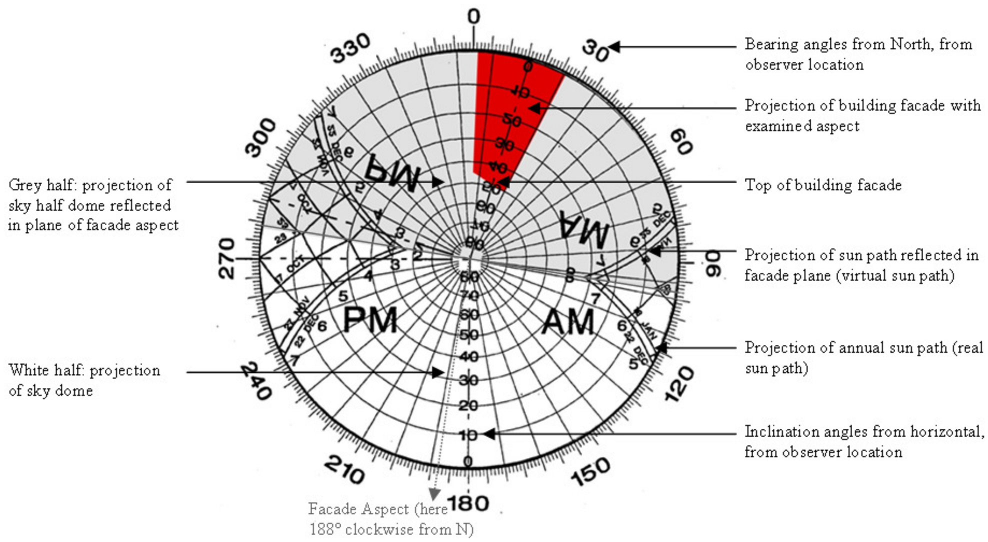
The reflectance limits noted above will also serve to reduce potential glare reflections that may occasionally be produced towards other buildings.

Appendix A

Notes on Diagrams

A1 Reading Virtual Sun Path Diagrams

These diagrams combine a projection of the sky dome with the sun's annual path across it with a projection of the sky and sun path as it would be reflected in an infinite plane with the aspect of the facade being examined. The building facade outline as seen from the observer location examined is then plotted onto the diagram. If the reflected sun path intersects the projection of the building facade, the sun would be reflected from this facade towards an observer at this location. The sun path marks indicating months and times of day provide an indication of the times at which reflections would be cast towards the observer.



Example virtual sun path diagram

Appendix B

Reference Information

B1 Architectural Drawings

The reflectivity study presented in this report was based on 3D model information and drawings provided by Tzannes Associates in September 2014 and updated for the building geometry as per the following DA Architectural plans by Tzannes Associates:

Drawing No.	Title	Revision
DHL_AD020100	Floor Plan Ground	G
DHL_AD020200	Floor Plan NE2 Mezz	F
DHL_AD030100	Floor Plan Level 01	F
DHL_AD030200	Floor Plan Level 02 – 04	F
DHL_AD030300	Floor Plan Level 05	F
DHL_AD030400	Floor Plan Level 06 – Podium	F
DHL_AD030500	Floor Plan Level 07	F
DHL_AD030600	Floor Plan Level 08 – 18	F
DHL_AD030700	Floor Plan Level 19	F
DHL_AD030800	Floor Plan Level 20 – 37	F
DHL_AD030900	Floor Plan Level 38 – 40	F
DHL_AD031000	Floor Plan Level 41 – Roof	F
DHL_AD041000	South Elevation	G
DHL_AD042000	West Elevation	G
DHL_AD043000	North Elevation	G
DHL_AD044000	East Elevation	G
DHL_AD050100	Section AA	G
DHL_AD050200	Section BB	G

B2 References

Hassall, D. N. H. (1991): *Reflectivity. Dealing with Rogue Solar Reflections*, Faculty of Architecture, University of New South Wales, ISBN 0 646 07086 X