Reflectivity Assessment

Arup

Appendix U

[HELP1][HELP2][HELP3]

DPT Operator Pty Ltd & DPPT Operator Ltd

Cockle Bay Wharf Redevelopment

Reflectivity Report for DA Stage 1

Rep/238566

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Contents

1 Executive summary

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

The SSDA is for building envelopes only at this stage (Stage 1), with detailed development applications (Stage 2) to follow. The relevant outcomes and recommendations made in this report are to be included in the Stage 2 DA, with the final Stage 2 design being reassessed at the appropriate time.

The study assesses the impact of solar reflections on pedestrians and road traffic participants in the area surrounding the proposed Cockle Bay Wharf Redevelopment. The study seeks to address requirements for limiting reflectivity impact similar to those noted in local council development controls (e.g. Sydney DCP 2012 Provision 3.2.7). As per this provision, the report focuses on the impact to traffic participants (e.g. vehicle drivers, cyclists and pedestrians).

This assessment is performed following the methodology of David N.H. Hassall of the University of New South Wales[1]. The Hassall methodology proposes a limit of acceptability of equivalent veiling luminance of façade reflections for traffic of 500Cd/m². Where this is exceeded, solar reflections are considered as potentially causing disability glare.

In summary, vision and spandrel glazing for both tower and podium will be limited to no more than 20% normal external reflectivity. As a result, the development is expected to have limited impact on pedestrians and occupants in neighbouring buildings.

The current podium proposal generally performs well in terms of reflected glare towards assessed travels paths, with some minor design options to be explored to limit reflections towards Harbour Street. For example, limiting normal reflectivity of the podium glazing in this location to 10% or less, revising local geometry or introducing local shading.

For both Tower Option 1 and 2, there are various mitigation measures that can be introduced to limit glare towards drivers along assessed travel paths. The measures identified for Tower Option 2 will also mitigate glare towards pedestrians travelling east on Pyrmont Bridge.

During the next design stage, the following mitigations measures will be explored to reduce glare caused by reflections from specific facades:

[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

- Reducing normal external reflectivity of glazing with specific orientations to below 20%. For example, maximum reflectivity of 16% for north west glazing in Tower Option A. For Option B, limiting west and south west façade glazing to 15% normal reflectivity.
- Alternatively or additionally, introducing vertical fins at specific tower locations to obscure reflections from glazing. For example, 250mm deep fins at 1000mm spacing to the north façade of Tower Option A.

The relevant outcomes and recommendations made in this report are to be included in the design prior to the Stage 2 DA.

2 Introduction

Arup have been engaged by DPT Operator Pty Ltd & DPPT Operator Ltd to review the potential of glare due to external reflectivity of the proposed redevelopment at Cockle Bay Wharf, Sydney.

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

The SSDA is for building envelopes only at this stage (Stage 1), with detailed development applications (Stage 2) to follow. The relevant outcomes and recommendations made in this report are to be included in the Stage 2 DA, with the final Stage 2 design being reassessed at the appropriate time.

This study responds to Section 3.2.7 of the Sydney DCP 2012. This section seeks to limit reflected glare from sunlight through the following controls:

- General limitation of the specular reflectivity of façade materials to 20%
- Where required, analysis of potential solar glare from the proposed building design

In order to address the more detailed investigation referred by the second point above, this report comments on the nature of expected reflections and our expectation of their potential to cause glare to drivers, pedestrians and building occupants in the area surrounding the site. The statement is based on desktop studies following the Hassall methodology for detailed glare analysis and our opinion from experience on numerous previous reflectivity studies.

2.1 Project description

The concept proposal will include up to 12,000m² of publicly accessible open space; new retail outlets, including new food and beverage destinations; new cultural and entertainment destinations; and a new commercial office tower.

The Site is located to the immediate south of Pyrmont Bridge, within the Sydney CBD on the eastern side of the Darling Harbour precinct. The Site is located within the City of Sydney local government area (LGA).

Figure 1Indicative site area of Cockle Bay Wharf Redevelopment provided by JBA planning.

2.2 Façades

The podium consists of flat and curved glass, assumed to be full height vision panels. Corners are assumed to be curved (bent) rather than faceted glass.

Two massing options for the tower are currently being explored:

- Tower Option 1 - The tower consists of an oval plan volume. The convex, curved elevations are faceted with a rectangular glazing facet, with predominately full height glazing. Spandrel areas are assumed to be the same glazing as for the vision area.
- Tower Option 2 - The tower consists of a polygonal plan volume. Main elevations are straight and the corners are convex, curved elevations faceted with a rectangular glazing facet, with predominately full height glazing. Spandrel areas are assumed to be the same glazing as for the vision area.

The predominant reflecting elements of the façade consist of vision and spandrel glazing at both podium and tower levels. The image below shows the geometry options that have been assessed, with reflecting elements shown in blue.

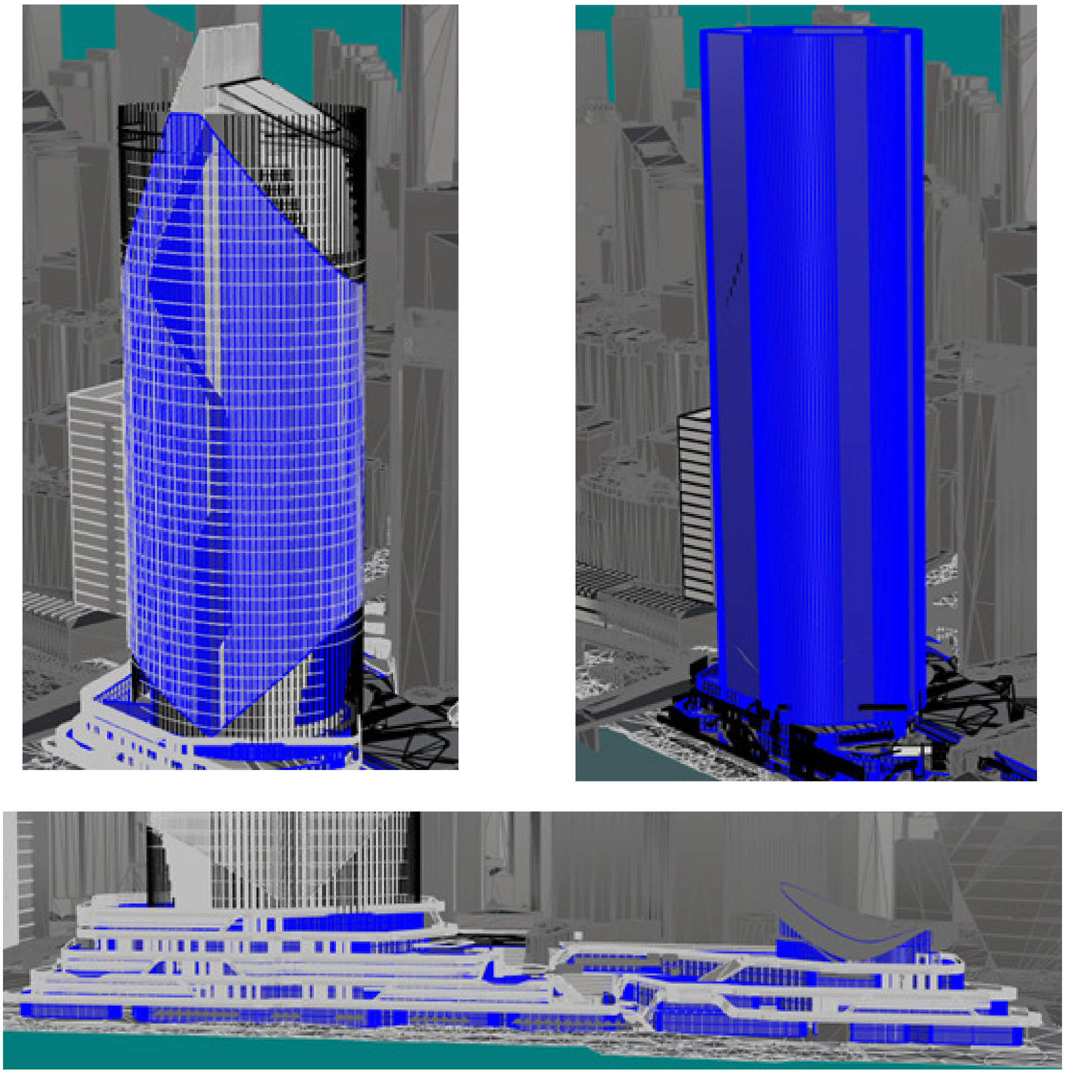


Figure 2 Tower Option 1 (left), Tower Option 2 (right) and podium (bottom)

3 Assessment of Façade Reflections

3.1 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. It has been specifically developed for the purpose of reviewing the potential glare impact of solar reflections from facades on traffic in detail, beyond a nominal facade material reflectivity limit.

The term "glare" describes adverse visual effects caused by large ratios of luminance in the visual field. Glare can generally be defined in two ways by its impact on observers (these may coincide):

- Discomfort glare – resulting in psychological annoyance, desire to avert view
- Disability glare –impacting the ability to recognise objects in the visual field and thus ability to carry out visual tasks (such as reading or driving)

It is critical that a driver's view is unaffected by disability glare as this has the potential to cause road accidents, thus the Hassall methodology focuses on prediction of this aspect of glare.

It further singles out veiling glare as the predominant mode of glare that can occur from façade reflections towards traffic. Veiling glare is defined in this context as glare due 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. A prerequisite for veiling glare is thus that reflections of the sun are visible relatively close to the direction of view of an observer.

Veiling glare is a form of perceptive effect of glare; whether it leads to discomfort or disability glare depends on the intensity of the effect.

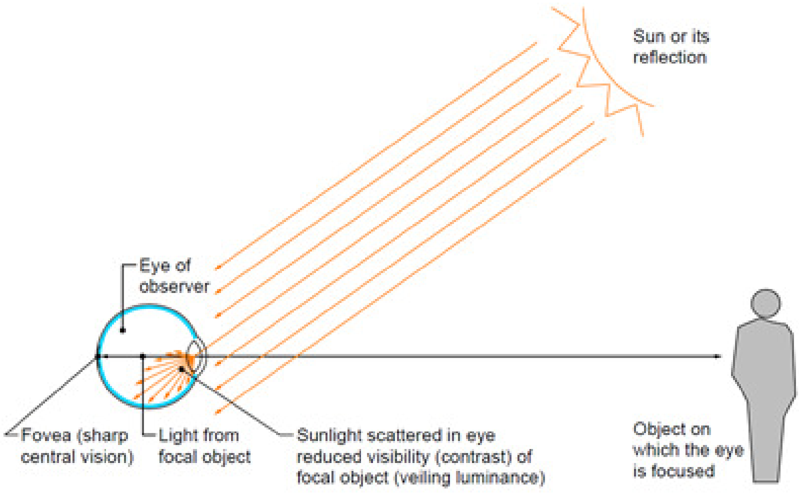


Figure 3 Bright sunlight falling into the eye reduces contrast and visibility of objects. This effect can be quantified by the equivalent veiling luminance measure.

Hassall proposes a workflow to track solar geometry, estimate sun intensity, establish actual façade reflectance, and numerically calculate a measure for the veiling effect. This measure, the equivalent veiling luminance, measured in Cd/m^2 (candela per metre squared), is a representation of apparent brightness to the human eye corrected for the angular distance of the glare source from the focus of vision, which reduces the veiling effect.

The Hassall methodology further proposes a limit of acceptability of equivalent veiling luminance of façade reflections for traffic of $500Cd/m^2$. Where this is exceeded, solar reflections are considered as potentially causing disability glare.

3.2 Methodology

Arup use in-house developed software to carry out the Hassall calculation based on 3d models, capable of checking for annual worst case reflections anywhere off the façade towards locations along a stretch of road. We have applied this software to a simplified model of the faceted glazing planes for the podium and for both Tower Option 1 and Tower Option 2.

This involves several steps, as outlined below:

- The size, orientation and extent of reflective objects on each facade are determined by examination of drawings / 3d models 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/m^2 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. Within his methodology, Hassall discusses situations where an undesirable amount of veiling glare is experienced but reflections fall outside the cone of sensitive vision and / or can be blocked by sun visor, hand or hat.
- On the multifaceted facades, the sun is only reflected by individual panels at a given time. Observed from a larger distance these do not reflect the full sun disk. In these cases it is reasonable to assume that the intensity of reflections off a panel is proportionally diminished with the percentage of the sun disk solid angle that is reflected by the same panel.

3.3 Assumptions

- For the purposes of this assessment, all glazed facades have initially been assumed to have a reflectivity of 20% (external specular reflectivity at normal incidence). Where glass reflectivity needs to be limited below this in order to mitigate veiling glare, commentary is provided.
- Building geometry based on FJMT Revit model issued 15 July 2016 and 1 September 2016.
- For both Tower Options, tower glazing is assumed to comprise faceted glazing instead of truly curved glass.
- Podium glazing is assumed to comprise curved (bent) rather than faceted glass at corner locations.
- 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.
- The new Hyatt Regency has been included in the modelled geometry as overshadowing buildings redevelopment to the north of the site.

Facades have been analysed in true elevation angles as provided with 3D model information by FJMT. 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.

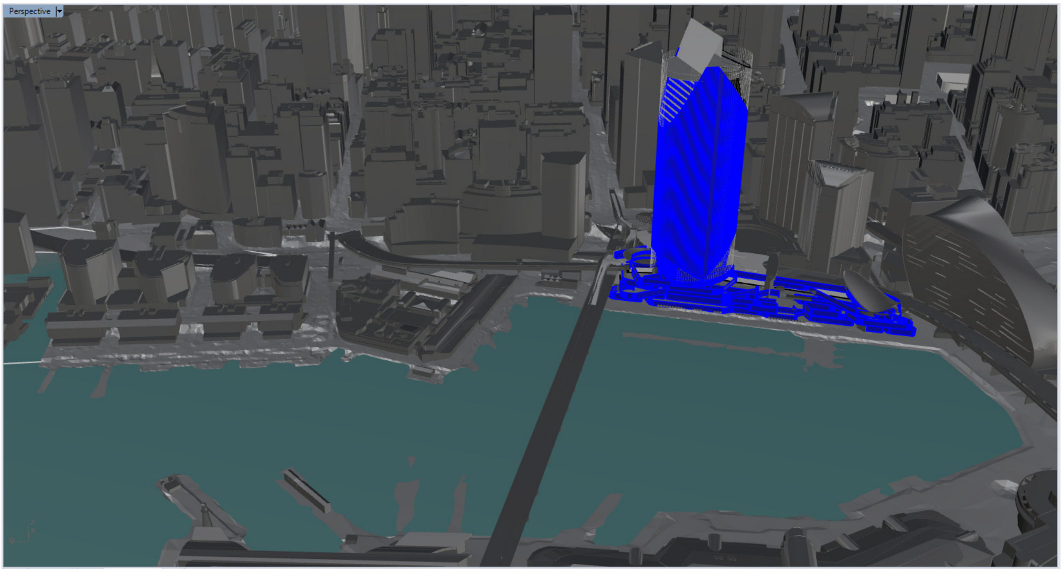


Figure 4 Image of the 3D building for podium, Tower Option 1 and context model. Surfaces shown in blue have been assumed as specular reflective in the analysis. Surrounding buildings are included as overshadowing elements.

This model was used to interrogate the view of the building and solar reflections originating from it along the paths shown in Figure 5.

Ref.	Road	Dir.
A	Western Distributor	East
B	Pier St	East
C	Harbour St	North
D	Park St / Druitt St	West
E	Market St	West
F	Western Distributor	South
G	Hickson Road	South
H	Barangaroo Avenue	South
I	Union St / Darling Dr	East

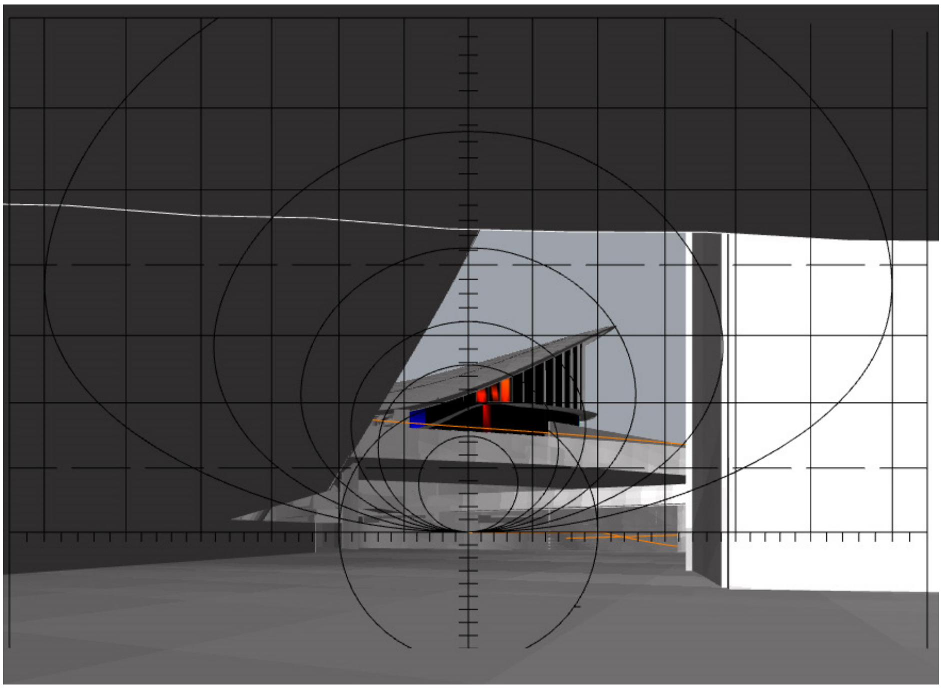
Figure 5 Site map showing observer paths from which glare has been assessed, with Cockle Bay redevelopment highlighted in blue.

4 Results

The following identifies viewing locations at which reflections from the development may cause glare and summarises potential mitigation strategies to be explored during the next design stage. The final Stage 2 design will be reassessed prior to the Stage 2 DA.

4.1 Podium

- Route C - Traveling north on Harbour Street, the south east façade of the podium at level 4 reflects sun towards drivers for approximately 10 to 15 minutes during February and October between 6am and 7am. Refer to the perspective view shown below.



Intensity of reflections for this viewing direction falls below the Hassall threshold of 500 Cd/m² if normal reflectivity of the podium glazing in this location is limited to **10%** or less.

4.2 Tower Option 1

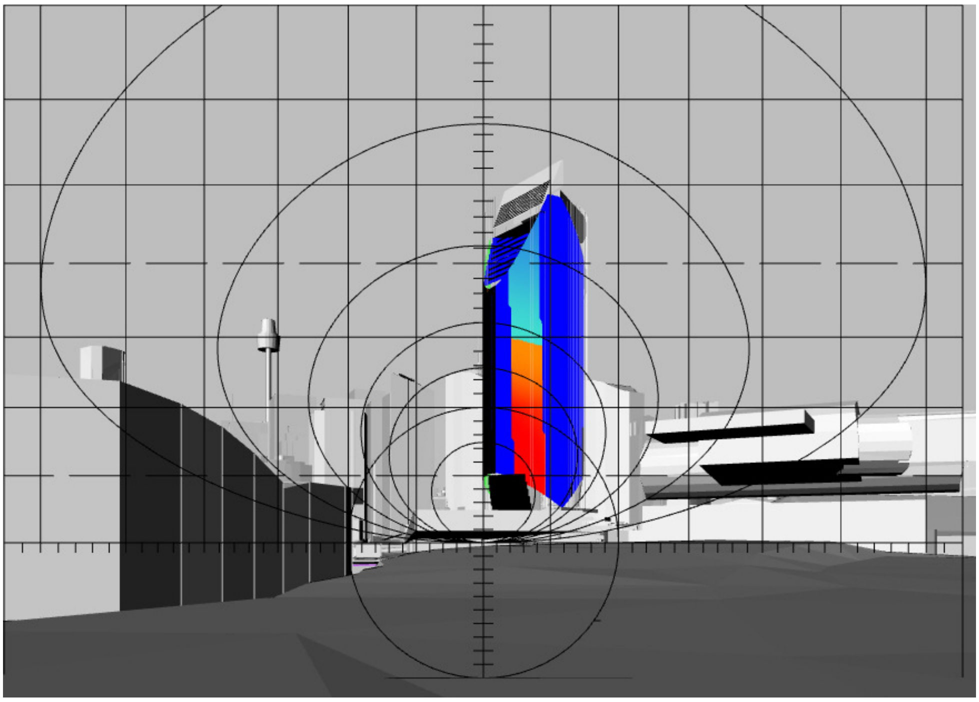
Generally, the design of Tower Option 1 is such that reflections occur across the width of one glazed panel at a time, for short durations of a few minutes during any one day.

- Route C – Traveling north on Harbour Street, at various points along the road, the south west of the tower reflects sun towards drivers for approximately 1 to 2 minutes from May through to September between 3pm and 5pm.

- Route D - Traveling west on Park Street, the south east façade of the tower reflects sun towards drivers for approximately 1 to 2 minutes during January and December between 6pm and 7pm.
- Route F - Traveling south on the Western Distributor, the north façade of the tower reflects sun towards drivers for approximately 1 to 2 minutes during January, February and December between 6pm and 7pm.
- Route G - Traveling south on the Hickson Road, the north east façade of the tower reflects sun towards drivers for approximately 1 to 2 minutes during February and December between 6am and 7am.
- Route H - Traveling south on Barangaroo Avenue (proposed road at Barangaroo development site), the north east façade of the tower reflects sun towards drivers for approximately 1 to 2 minutes during March and November between 6pm and 7pm.

For all viewing directions listed above, due to the distance between the viewer and the façade panel, the angle subtended by the visible reflection is so small as to reduce the equivalent veiling luminance to below that of the Hassall threshold if normal reflectivity of the tower glazing is limited to 20% or less.

- Route I - Traveling east on Union Street / Darling Drive, the north west façade of the tower reflects sun towards drivers for approximately 2 to 3 minutes during February and October between 5pm and 6pm. Refer to the perspective view shown below.



Intensity of reflections for this viewing direction falls below the Hassall threshold of 500 Cd/m² if normal reflectivity of the tower glazing with north west orientation is limited to **16%** or less.

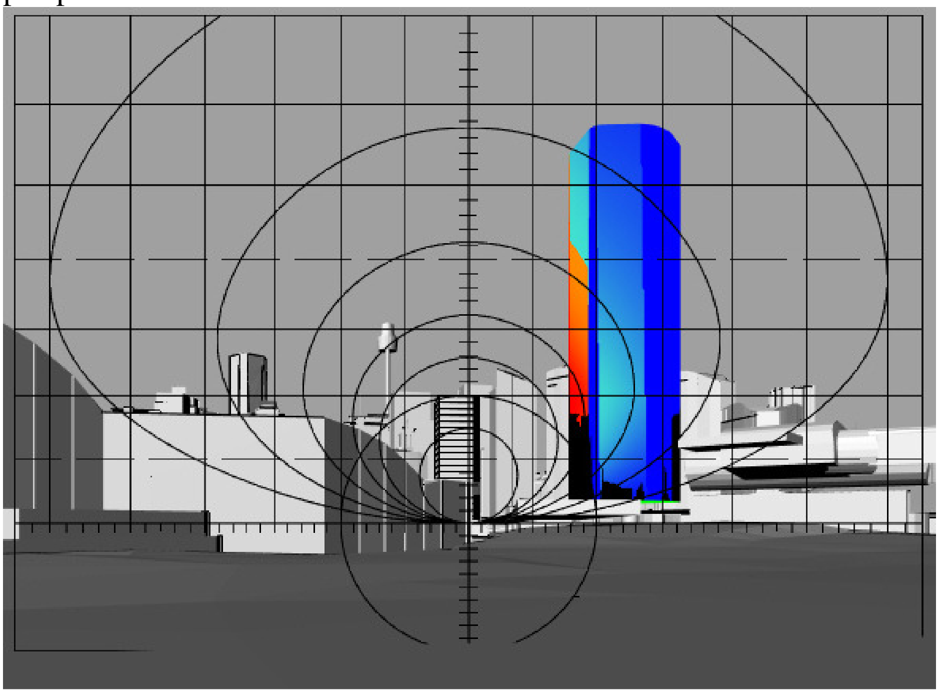
4.3 Tower Option 2

The design of Tower Option 2 is such that reflections generally occur in similar locations to that of Tower Option 1. In addition to the reflections identified above, the following are worth noting for Tower Option 2:

- Route C - Traveling north on Harbour Street, at various points along the road, the south west of the tower reflects sun towards drivers for approximately 5 to 10 minutes from May through to September between 4pm and 6pm.

Due to the distance between the viewer and the façade panel, the angle subtended by the visible reflection is so small as to reduce the equivalent veiling luminance to below that of the Hassall threshold if normal reflectivity of the south west façade of the tower glazing is limited to **15%** or less.

- Route I - Traveling east on Union Street / Darling Drive, the north and north west façade of the tower reflects sun towards drivers for approximately 10 minutes during January and October between 8am and 10am and during February and October between 5pm and 7pm, respectively. Refer to the perspective view shown below.



It is recommended that north façade orientation is rotated by at least 8 degrees anticlockwise to reduce glare caused by reflections from this façade. Alternatively, vertical fins projecting at least 250mm could be introduced spaced at every 1000mm on the north facade.
In addition, the normal reflectivity of the west façade of the tower glazing is recommended to be limited to **15%** or less to mitigate glare caused by reflections from this façade.

4.4 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.

4.5 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.

As such, the reflections identified for driving Route I for Tower Option 2 are expected to be experienced by pedestrians travelling east on the Pyrmont Bridge. The recommended mitigation measures to the north, north west and west facades for this route will act to reduce glare towards pedestrians.

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.

4.6 Impact on Surrounding Buildings

Solar reflections off the facade may reach surrounding buildings in the CBD area, as would be expected for any glazed façade in an urban context that can be reached by sunlight.

In general, reflections from façade with normal 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 Sydney DCP 2012, which will serve to reduce any potential glare reflections that may occasionally be produced towards pedestrians and other buildings.

5 Conclusion

In summary, vision and spandrel glazing for both tower and podium will be limited to no more than 20% normal external reflectivity. As a result, the development is expected to have limited impact on pedestrians and occupants in neighbouring buildings.

The current podium proposal generally performs well in terms of reflected glare towards assessed travels paths, with some minor design options to be explored to limit reflections towards Harbour Street. For example, limiting normal reflectivity of the podium glazing in this location to 10% or less, revising local geometry or introducing local shading.

For both Tower Option 1 and 2, there are various mitigation measures that can be introduced to limit glare towards drivers along assessed travel paths. The measures identified for Tower Option 2 will also mitigate glare towards pedestrians travelling east on Pyrmont Bridge.

During the next design stage, the following mitigations measures will be explored to reduce glare caused by reflections from specific facades:

- Reducing normal external reflectivity of glazing with specific orientations to below 20%. For example, maximum reflectivity of 16% for north west glazing in Tower Option A. For Option B, limiting west and south west façade glazing to 15% normal reflectivity.
- Alternatively or additionally, introducing vertical fins at specific tower locations to obscure reflections from glazing. For example, 250mm deep fins at 1000mm spacing to the north façade of Tower Option A.

The relevant outcomes and recommendations made in this report are to be included in the Stage 2 DA, with the final Stage 2 design being reassessed at the appropriate time.

Appendix A

Reference Information

A1 Architectural Drawings

The reflectivity study presented in this report was based on 3D model information provided by FJMT on 15 July and 1 September 2016 and the following drawings dated 21.06.16:

Drawing Number	Drawing Title
SK-101	Tower Grid Setout
SK-102	Site Plan
SK-103	Ground Level
SK-104	Level 1 Podium
SK-105	Level 1 Mezzanine
SK-106	Level 2 Podium
SK-107	Level 2 Mezzanine
SK-108	Level 3 Podium Top Terrace
SK-109	Level 4
SK-111	Level 10 Tower Low Typical
Sk-4.13	Concept Massing – 2000 Elevations (29.04.16)

A2 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