DPT Operator Pty Ltd & DPPT Operator Ltd

Cockle Bay Park Development

Reflectivity Report for DA

REP/238566/REF002

Issue 3 | 17 August 2017

Job number 238566-00

Arup
Arup Pty Ltd ABN 18 000 966 165

Arup
Level 10 201 Kent Street
PO Box 76 Millers Point
Sydney 2000
Australia
www.arup.com

ARUP

Document Verification

ARUP

Job title		Cockle Bay Park Development			**Job number** 238566-00
Document title		Reflectivity Report for DA			**File reference**
Document ref		REP/238566/REF002			
Revision	**Date**	**Filename**	20170725 CBP DA Reflectivity Report DRAFT.docx		
Draft 1	25 Jul 2017	**Description**	First draft		
			Prepared by	Checked by	Approved by
		Name	Daniel Harris	Jorg Kramer	Steve Colomb
		Signature			
Issue 1	28 Jul 2017	**Filename**	20170725 CBP DA Reflectivity Report Issue 1.docx		
		Description	Issue		
			Prepared by	Checked by	Approved by
		Name	Daniel Harris	Jorg Kramer	Steve Colomb
		Signature			
Issue 2	3 Aug 2017	**Filename**	20170803 CBP DA Reflectivity Report Issue 2.docx		
		Description	Revised issue		
			Prepared by	Checked by	Approved by
		Name	Daniel Harris	Jorg Kramer	Steve Colomb
		Signature			
Issue 3	17 Aug 2017	**Filename**	20170817 CBP DA Reflectivity Report Issue 3.docx		
		Description	Issue for Development Application		
			Prepared by	Checked by	Approved by
		Name	Daniel Harris	Jorg Kramer	Steve Colomb
		Signature			
				Issue Document Verification with Document	✓

Contents

Appendices

Executive summary

This report supports the Response to Submissions and amended Concept Proposal associated with a State Significant Development Application (SSDA 7684) submitted to the Minister for Planning and Infrastructure pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

The study assesses the impact of solar reflections on pedestrians and road traffic participants in the area surrounding the proposed Cockle Bay Park Development. 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.

The current Application is for a Stage 1 Concept Envelope. As such the geometry of the envelope is not final. However, the geometry provided by FJMT Architects and documented in drawings accompanying the Application has been taken as representative of a potential building form and assessed for reflectivity, in order to test by example if it is possible to place a building within the proposed concept envelope without unacceptable reflected glare impact. Note: this potential building form and design may be subject to change following a Design Excellence process.

It is found that a building within the proposed concept envelope is able to perform well in terms of solar reflectivity. Glare affecting drivers on surrounding streets is not expected to exceed the constraints of acceptability according to the Hassall methodology, as long as the external normal specular reflectivity of glazing and cladding is kept within **20%.**

Reflected glare risk to traffic participants in all analysed locations could be discounted for all visible facades for either of the following reasons:

- The intensity of any reflections will be below the limit of acceptability set out by Hassall (500 Cd/m²);
- Surrounding buildings and topology or other parts of the building itself will be blocking reflections that could cause glare to drivers; or
- The position of reflections within the visual field is not critical and would allow traffic participants blocking with sun visor.

[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

This result is obtained despite using 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 assumed 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.

This report has provided an assessment of one design of building that could be delivered within the Concept Envelope. A Stage 2 Development Application will follow a design excellence process, and a further assessment of reflectivity will be required to support this DA.

1 Introduction

1.1 General

This report supports the Response to Submissions and amended Concept Proposal associated with a State Significant Development Application (SSDA 7684) submitted to the Minister for Planning and Infrastructure pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

DPT Operator Pty Ltd and DPPT Operator Pty Ltd (the Proponent) are seeking approval for a Concept Proposal for the redevelopment of the Cockle Bay Wharf Building and the surrounding area to create new open space and a commercial, retail and tourist precinct in the heart of the CBD (now referred to as Cockle Bay Park). The amended Concept Proposal includes:

- A large area 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 project will add new open space to the Sydney CBD and help to reconnect the city to the Darling Harbour waterfront. Cockle Bay Park will take its place in a revitalised Sydney CBD and speaks directly to local government objectives to create a 'Green, Global and Connected City' (City of Sydney) as well as the strategic vision outlined in 'Towards Greater Sydney 2056' to grow the "developing central city". The vision for this project was developed with consideration for the NSW Government objectives to support and "grow the knowledge industry", double tourism expenditure and "strengthen our local environment and communities" as outlined in 'NSW 2021: A Plan to Make NSW Number One'.

Please note that all plans, diagrams, images and graphics within this report and the supporting documentation (excluding the amended Concept Proposal Envelope Plans prepared by Francis-Jones Morehen Thorp Pty Ltd) are indicative only and have been included to communicate the intent of the amended Concept Proposal, including representative building shapes, forms, locations, layouts and relationships. It is proposed that these representations, together with acceptance of the building envelopes and massing, and associated design principles, will then be used to inform the Design Excellence process to follow the Stage 1 SSD Determination. Design Excellence outcomes will form the basis of the Stage 2 SSDA.

1.2 Background

The Proponent controls the lease of the Site, and also of the adjacent Darling Park precinct. The Darling Park site is a successful premium grade office precinct located on the west of the Sydney CBD, the associated Crescent Garden, located to the west of the three existing Darling Park towers, is a key area of open space in this part of the city.

The Proponent has recognised a number key issues with the existing layout of the Darling Park and Cockle Bay precinct, these being:

- The existing Cockle Bay Wharf building is not well integrated with the city, the Western Distributor freeway currently acts as a barrier to separate this area from the CBD;
- Publicly accessible open space is limited to the existing Crescent Garden in Darling Park; and
- The existing Cockle Bay Wharf building is outdated and is not in keeping with the future of Darling Harbour area as a vibrant entertainment and tourist destination.

The Cockle Bay precinct is at risk of being left behind and undermining the significant investment being made in Darling Harbour that will see it return to the world stage as a destination for events and entertainment. Accordingly, the Proponent is taking a carefully considered and staged approach to the complete revitalisation of the site and its surrounds. The envisaged development, which will be facilitated by the proposed building envelopes will:

- Reconnect the city with the Darling Harbour waterfront;
- Create new publicly accessible open space in the heart of the Sydney CBD;
- Create new public land above the Western Distributor;
- Provide new access routes between the city and the ICC Sydney / Darling Harbour Live precinct;
- Support the Sydney economy by providing a new premium commercial building; and
- Refresh and renew an existing entertainment and tourist destination.

1.3 Site Description

The 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.

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 also located within the City of Sydney local government area (LGA). A locational context area plan and location plan are provided at Figure 1 below.

The project Site area has been slightly amended by this Response to Submissions, a comparison of the exhibited and now-proposed Site area is provided as Figure 2, and the now proposed Site area is shown below as Figure 3.

The Darling Harbour precinct is undergoing significant redevelopment as part of the SICEEP, Darling Square, and IMAX renewal projects. The urban, built form and public transport / pedestrian context for the proposed Harbourside development will fundamentally change as these developments are progressively completed.

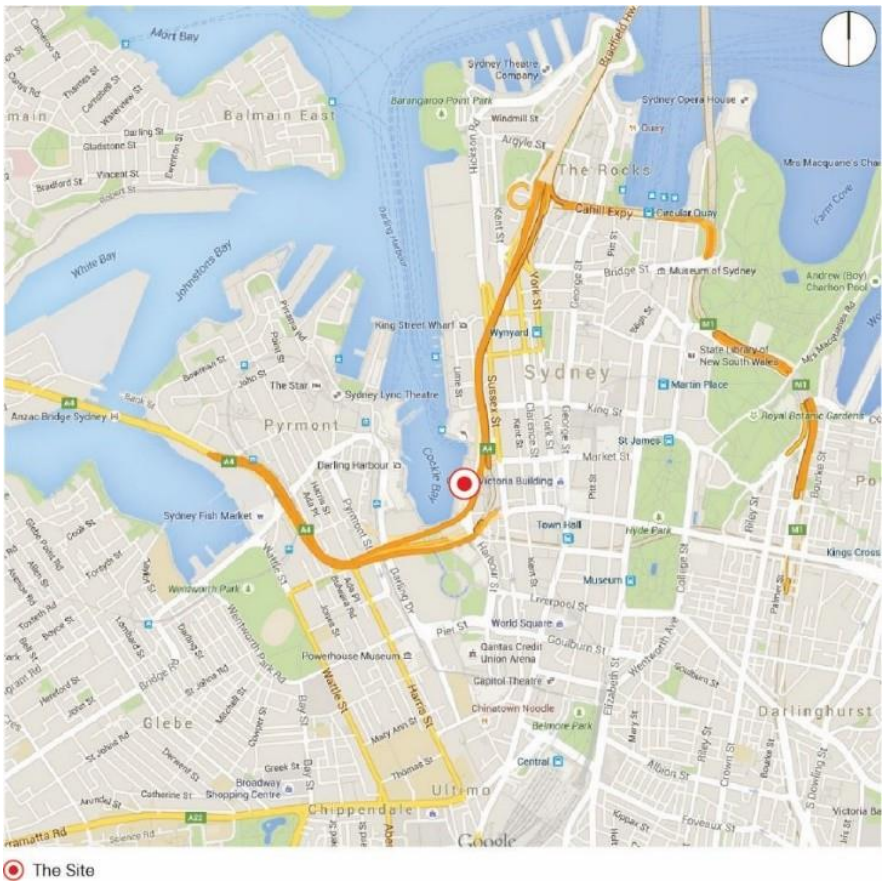

Figure 1: Location plan context area

Figure 2: Location plan (revised site area in yellow)

Figure 3: Amended location plan

1.4 Overview of Proposed Development

The proposal relates to a staged SSDA and seeks to establish amended concept proposal details for the renewal and re-imagining of the Cockle Bay precinct. The amended Concept Proposal establishes the vision, planning and development framework which will be the basis for the consent authority to assess future detailed development proposals. The Cockle Bay Park Site is to be developed for a mix of Retail, Cultural and Commercial (Office) uses including retail and restaurants, offices, and publicly accessible open space.

The amended Concept Proposal seeks approval for the following key components and development parameters:

- Demolition of existing site improvements, including the existing Cockle Bay Wharf building complex, pedestrian bridge links across the Western Distributor, and obsolete monorail infrastructure;
- Building envelopes;
- Land uses across the Site;
- A maximum total Gross Floor Area (GFA) across the Cockle Bay Park of 75,000m2 for commercial development and 14,000m2 for retail (including food and beverage) development;
- Urban Design and Public Realm design principles to provide a Design Excellence framework; and
- Strategies for utilities and services provision, drainage and flooding, and ecological sustainable development.

2 Assessment of Façade Reflections

2.1 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 (Hassall, 1991). 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.

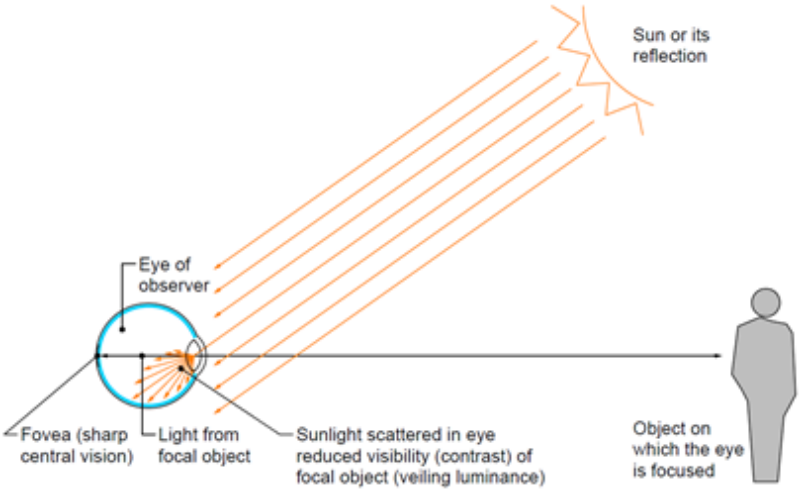

Figure 4: Bright sunlight falling into the eye reduces contrast and visibility of objects. This effect can be quantified by the equivalent veiling luminance measure.

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/m² (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/m². Where this is exceeded, solar reflections are considered as potentially causing disability glare.

2.2 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 tower.

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/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. 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.

2.3 Building Envelope

The current Application is for a Stage 1 Concept Envelope. As such the geometry of the envelope is not final. However, the geometry provided by FJMT Architects and documented in drawings accompanying the Application has been taken as representative of a potential building form and assessed for reflectivity, in order to test by example if it is possible to place a building within the proposed concept envelope without unacceptable reflected glare impact. Note: this potential building form and design may be subject to change following a Design Excellence process.

The envelope of the Concept Proposal has been revised and now provides a maximum building tower height of 195m and a maximum podium and land bridge height of 19m.

The podium setback from the water has been revised and now provides an average setback clearance of 8m and a minimum setback of 6m. This setback allows the podium setback to maintain the existing width of public thoroughfare along the foreshore promenade. The Concept Proposal includes provision for the existing on-water structures to be extended to cover the entire length of the site frontage, thereby increasing the overall width of public thoroughfare past the site.

The Concept Proposal's setbacks to Pyrmont Bridge to the north, and to 'The Ribbon' development at the south, have also been revised as part of the revised scheme.

2.4 Representative Building Geometry

The current Application is for a Stage 1 Concept Envelope. As such the geometry of the envelope is not final. However, the geometry provided by FJMT Architects and documented in drawings accompanying the Application has been taken as representative of a potential building form and assessed for reflectivity, in order to test by example if it is possible to place a building within the proposed concept envelope without unacceptable reflected glare impact. Note: this potential building form and design may be subject to change following a Design Excellence process.

For purposes of this assessment, the podium facades are assumed to be full height vision glazing. The envelope of the retail tenancy volume on level 4 of the podium has sloped glazing on the north, east and west, with opaque façade towards the south.

The representative building form is rectangular and close to square in plan, with chamfered corners. It shows oversailing glazing of the main elevations at the corners. Façade planes slope outwards at the lower tower levels and inwards on the upper tower levels. The core on the east elevation has a vertical façade.

The predominant reflecting elements of the façade are assumed to be vision and spandrel glazing at both podium and tower levels. The image below shows the geometry that has been assessed, with reflecting elements shown in blue.

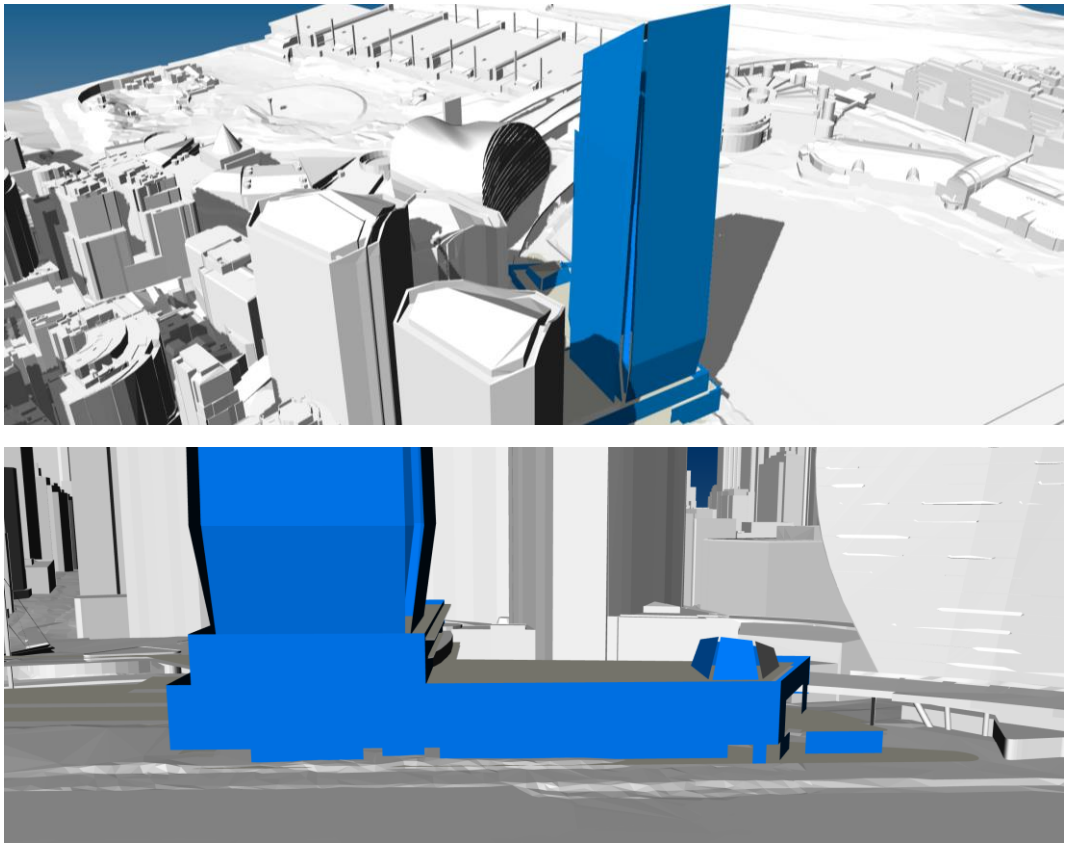

Figure 5: Modelled tower and podium geometry

2.5 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.
- The building geometry is based on the reference scheme 3d model issued by FJMT Architects 21 July 2017, as an example geometry of a building within the proposed Concept Envelope.
- Rounded podium façade corners are assumed to be curved (bent) rather than faceted glass and have not been modelled, as convex curved glass disperses reflections and is not assumed to be critical for reflected glare.
- 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 redevelopment has been included in the modelled geometry as overshadowing buildings to the north of the site.

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

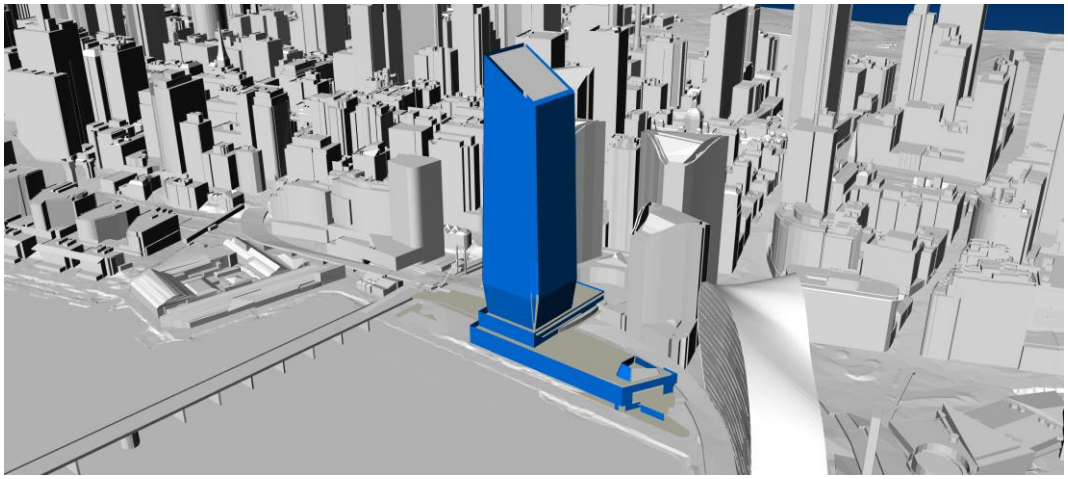

Figure 6: Image of the reference scheme podium, tower and context 3D model. Surfaces shown in blue have been assumed as specular reflective in the analysis. Surrounding buildings are included as overshadowing elements.

2.6 Observer locations

This model was used to interrogate the view of the building and solar reflections originating from it along the paths listed in Table 1 and shown in **Figure 7**.

Ref.	Road	Driving direction
A	Western Distributor	E
B	Pier St	E
C	Harbour St	N
D	Park St / Druitt St	W
E	Market St	W
F	Western Distributor	S
G	Hickson Road	S
H	Barangaroo Avenue	S
I	Union St / Darling Dr	E

Table 1: List of observer paths from which glare has been assessed

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

3 Results

3.1 General

Sections below identify viewing locations at which reflections from the development can exceed the limit of acceptability set out by Hassall (500 Cd/m²), and discusses potential glare impact on traffic.

Indicative perspective views are shown for a single viewpoint on these paths. Note however the modelled paths have been reviewed along their entire lengths.

The equivalent veiling luminance of reflections is colour coded in projected facades in perspective views. Façade areas are shown orange to red where reflections exceed the Hassall limit of 500Cd/m² for prevention of disability glare. Reflections off projected façade area shown in blue to cyan are below this limit in intensity.

Reflected glare risk to traffic participants in other locations could be discounted for all visible facades for either of the following reasons:

- The intensity of any reflections will be below the limit of acceptability set out by Hassall (500 Cd/m²);
- Surrounding buildings and topology or other parts of the building itself will be blocking reflections that could cause glare to drivers.

3.2 Route D – Park St / Druitt St

Travelling west on Park St / Druitt St, the east façade of the reference scheme tower can cast solar reflections above 500 the Cd/m^2 threshold towards drivers for up to 15 minutes within 2 weeks each in February and November between 6am and 7am.

Refer to perspective views shown below.

However, from this viewing direction all excessive reflections occur above the 5° sun visor cut off angle. Given that the speed limit on this road is 40km/h, it can be assumed that it is safe for drivers to adjust the sun visor to control glare per the Hassall methodology.

For the above reason, reflections are not expected to result in unacceptable glare towards drivers in this location.

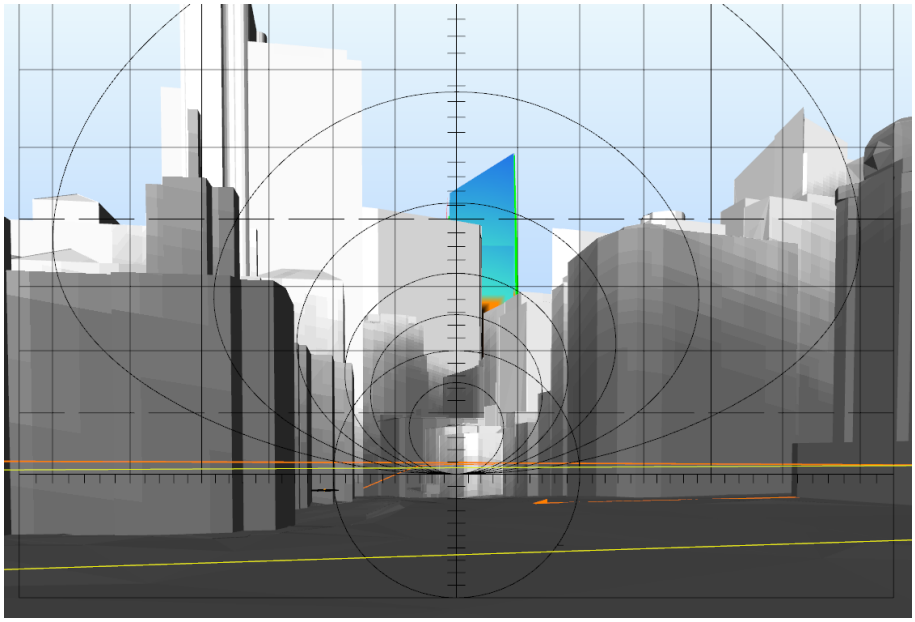

Figure 8: Perspective view from road – Druitt St

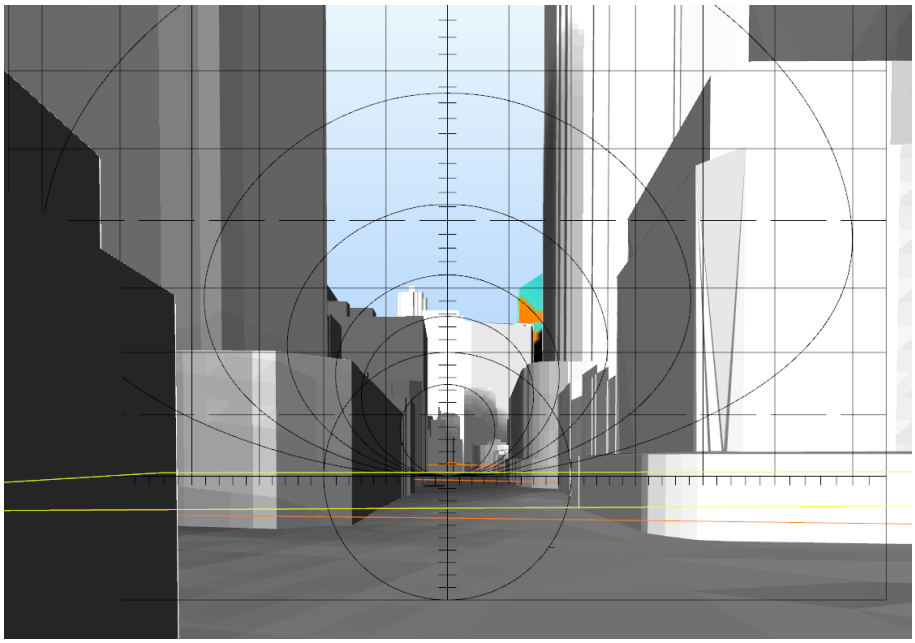

Figure 9: Perspective view from road - Park St

3.3 Route I – Union St Pyrmont

Travelling east on Union Street, the west façade of the reference scheme tower can cast solar reflections above 500 the Cd/m^2 threshold towards drivers for up to 30 minutes within 3 weeks each in February and October-November between 4.45pm and 6pm.

The north façade may reflect grazing angle reflections for up to 5-10 min within 3 weeks each in February and October-November between 7.30 and 8.30am.

Refer to the perspective view shown below.

However, from this viewing direction all excessive reflections occur above the 5° sun visor cut off angle. Given that the speed limit on this road is 40km/h, it can be assumed that it is safe for drivers to adjust the sun visor to control glare per the Hassall methodology.

For the above reason, reflections are not expected to result in unacceptable glare towards drivers in this location.

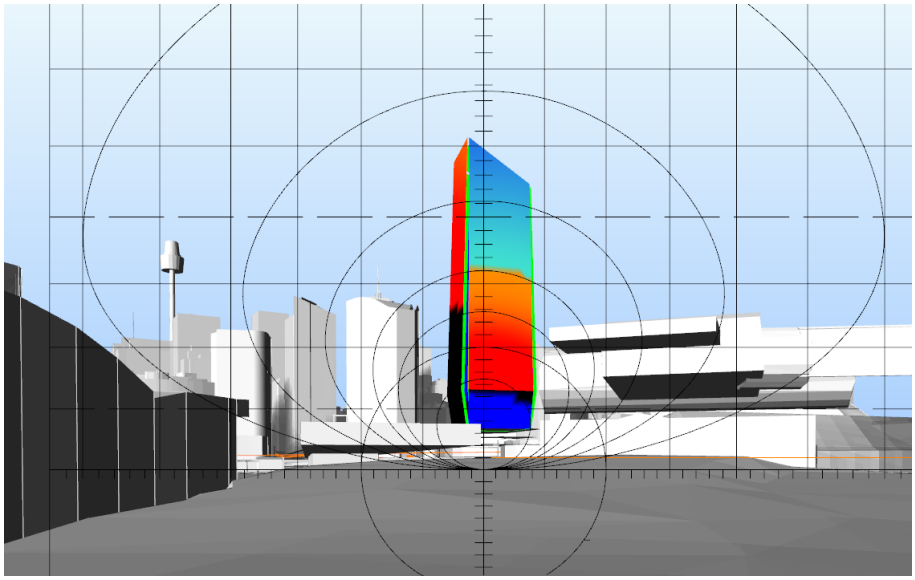

Figure 10: Perspective view from road

3.4 Summary

The following table summarises the outcome of the reflectivity assessment for individual roads reviewed.

Ref.	Road	Driving direction	Maximum L_v identified @ 20% refl. [Cd/m²]	Note
A	Western Distributor	E	150	Within acceptable intensity limit
B	Pier St	E	60	Within acceptable intensity limit
C	Harbour St	N	450	Within acceptable intensity limit
D	Park St / Druitt St	W	1,050	Reflections that occur can be mitigated using sun visor which is deemed acceptable by Hassall for comparable situations (Hassall, 1991). (Note impacts may also be mitigated in the Stage 2 design.)
E	Market St	W	290	Within acceptable intensity limit
F	Western Distributor	S	370	Within acceptable intensity limit
G	Hickson Road	S	0	Within acceptable intensity limit
H	Barangaroo Avenue	S	0	Within acceptable intensity limit
I	Union St / Darling Dr	E	2,800	Reflections that occur can be mitigated using sun visor which is deemed acceptable by Hassall for comparable situations (Hassall, 1991). (Note impacts may also be mitigated in the Stage 2 design.)

Table 2: Summary of roads reviewed for sun reflections

3.5 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.

3.6 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.

3.7 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.

4 Conclusion

Using the reference scheme geometry provided by FJMT Architects as a representative building form, it is found that a building within the proposed concept envelope is able to perform well in terms of solar reflectivity. Glare affecting drivers on surrounding streets is not expected to exceed the constraints of acceptability according to the Hassall methodology, as long as the external normal specular reflectivity of glazing and cladding is kept within **20%.**

Reflected glare risk to traffic participants in all analysed locations could be discounted for all visible facades for either of the following reasons:

- The intensity of any reflections will be below the limit of acceptability set out by Hassall (500 Cd/m²);
- Surrounding buildings and topology or other parts of the building itself will be blocking reflections that could cause glare to drivers; or
- The position of reflections within the visual field is not critical and would allow traffic participants blocking with sun visor.

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 assumed 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.

This report has provided an assessment of one design of building that could be delivered within the Concept Envelope. A Stage 2 Development Application will follow a design excellence process, and a further assessment of reflectivity will be required to support this DA.

Appendix A

Reference Information

A1 Architectural Drawings

The reflectivity study presented in this report was based on 3D model information provided by FJMT on 21.07.2017 and the following drawings dated 24.07.2017:

Drawing Number	Drawing Title
SK-15.22	Massing 6F Floorplans
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

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