Lend Lease (Millers Point) Pty Limited

Barangaroo South - R8 and R9 Residential Buildings

Reflectivity Study - Project Application

Barangaroo South - R8 and R9 Residential Buildings

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1 Introduction

This report has been prepared by Arup for Lend Lease (Millers Point) Pty Ltd to support a Project Application for construction of two residential building (known as Buildings R8 and R9) and associated works at Barangaroo South.

1.1 Purpose of this Report

This Reflectivity Report assesses the impact of solar reflections off the proposed development on traffic in the surrounding area of the Barangaroo site, in terms of reduced visibility of visual tasks, to address the qualitative requirements of the Central Sydney DCP 1996 Provision 4.5.3. As per this provision, the report focuses on the impact on pedestrians and motorists. This assessment is performed following the methodology of David N.H. Hassall of the University of New South Wales (Hassall 1991).

The reflectivity study presented in this report was performed with three-dimensional building and site models based on architectural drawings received from Lend Lease (see Appendix A1).

1.2 Description of Proposed Facades

The proposed buildings R8 and R9 comprise ground floor retail areas and 7 levels of residential apartments (R8 and R9) with a loft level and a 3-storey penthouse (R8). Drivers, pedestrians, and neighbouring building occupants will observe the building's facades predominantly from the east (Lime St frontage), north, and south.

Figure 1 and Figure 2 show typical residential floor plans of the buildings.

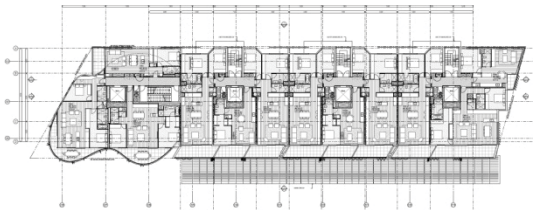

Figure 1: R8 level 1 floor plan

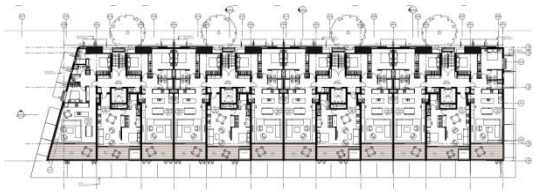

Figure 2: R9 level 1 floor plan

The road facades of the buildings feature steps and recesses introducing additional facade planes at 45° and 90° to the main elevation. The north end section of Building R8 including the penthouse has a curved plan geometry. Cladding in this area has been assumed as curved and thus dispersing reflected light.

The facades of the proposed buildings feature numerous opaque, non-specular areas, glazing joints, framing, balconies, etc that likely mitigate any adverse reflections off the facade. However, as these mitigating effects are difficult to quantify, for the purpose of this exercise they have been ignored and all facades have been considered fully glazed with an external reflectivity of 20% to model a worst case allowable condition. Actual glazing to be selected for the project is likely to have a lower reflectivity.

The proposed buildings are likely to be partly overshadowed by future buildings on the Barangaroo South development site, e.g. commercial buildings C3, C4, and C5. However, in case R8 or R9 are constructed before these are completed, any overshadowing effect by these other proposed buildings potentially mitigating any reflection issues has not been considered in this study. Similarly, future landscaping including tree planting around the site may have a mitigating effect on any problematic low-level reflections but has not been taken into account.

Assumptions about facade reflectivity and overshadowing / obscuring are thus conservative in several ways and reflect a worst case scenario.

2 Assessment of Facade Reflections

2.1 Background – Assessment Criteria

This report assesses the likelihood of undesirable solar reflections that affect nearby roadways and traffic. The assessment follows the methodology of David N. H. Hassall of the University of New South Wales. This methodology is detailed in Section 2.2 of this report.

Any glazed building has the potential to cause solar reflections in many directions at any time at which the sun is visible. The study will assess the importance of these reflections in terms of '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.

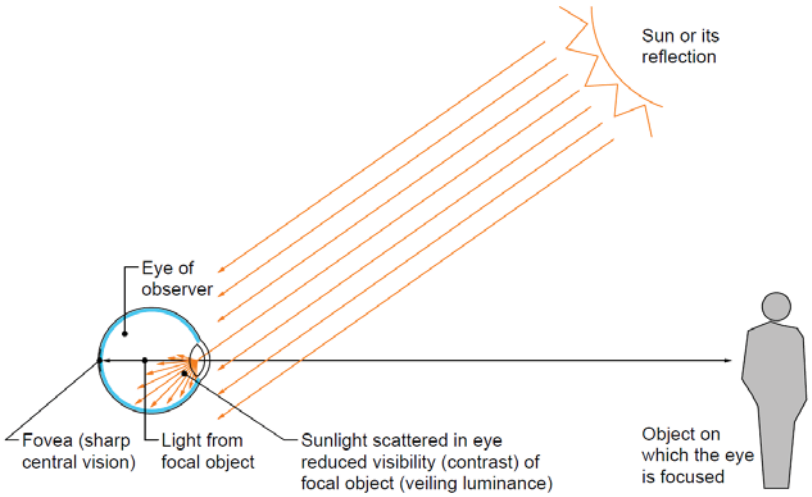

Figure 3: Diagram of 'veiling glare'

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.

2.2 Detailed Methodology

The assessment of undesirable solar reflections is based on the methodology described by David N. H. Hassall [1]. This methodology involves several steps, as outlined below.

1. 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.
2. Several observer locations are chosen for critical facades, representing locations and directions from which traffic participants may observe the facades.
3. Times at which the sun is reflected off the facade are determined, as well as the directions in which it is reflected.
4. For each observer, the equivalent veiling luminance in the eye of the observer is calculated. 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.
5. The calculated equivalent veiling luminance is compared with the maximum allowed level of 500Cd/m². Veiling luminance in excess of this limit is considered to potentially cause glare impairing visual tasks (disability glare) and thus pose a risk to traffic if it cannot be effectively blocked.
6. In some situations, high veiling luminance may be caused by grazing reflections, when the sun itself is close to its reflection in the observer's field of view. In this case the impact of the reflection is considered minimal when compared to that of the actual sun. Consequently, grazing reflections, where the angle between the observer direction and the real sun is less than 20°, are not included in the results.
7. With knowledge of the impact of solar reflections on numerous observers for each facade, the investigation is generalised for all similar observers within sight of each facade.
8. For calculation purposes, it is assumed that to carry out the visual tasks required for traffic participation drivers and pedestrians generally face parallel to the ground, and parallel to their direction of travel.

A number of assumptions were made for the purposes of the calculations:

- A nominal glazing and cladding specular reflectance of 20% has been considered, as this the allowable limit under the provisions of the Central Sydney DCP 1996 Provision 4.5.2. Where the results show that no disabling reflections are produced by this glass, no disabling reflections will be produced by glass or cladding of a lesser reflectivity.
- Each glazed facade area is assumed to be 100% glazed as a worst case assumption. Opaque facade areas, glazing joints, framing, balconies, etc theoretically reduce the reflectivity of the facades, but this effect is difficult to quantify in detail.

Each of the above assumptions is considered appropriate in this case, and the Hassall methodology is considered best practice for such analysis.

2.3 Model / analysis approach

Plans provided by Lend Lease formed the basis of the 3d model developed for the reflectivity analysis, together with mass modelling of the surrounding topology and structures.

Arup has developed in-house 3d software that calculates the worst case equivalent veiling luminance values after Hassall's definition produced towards the current observer location throughout the entire year, from a grid of locations on analysed facades. The observer location can be dynamically updated, allowing checking of reflections along full length ofroad pathways.

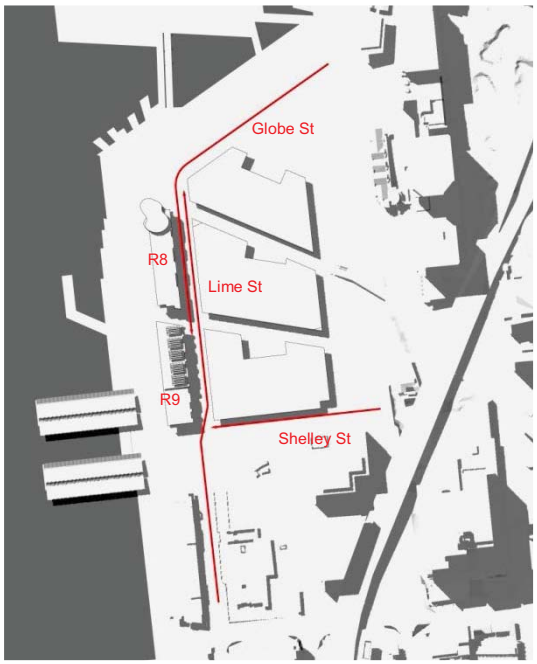

Figure 4: Plan view showing extent of surroundings modelled and roads leading towards site

Following a review of the site plan, perspective studies were undertaken along road lines where the buildings are visible. These included Lime and Globe Street, and the Shelley St extended onto the Barangaroo site. Dynamic perspective analysis was undertaken along the entire length of paths along these roads as shown as red lines in Figure 3.

Reflections to other surrounding streets were found to be either entirely blocked by other buildings or not falling close to traffic participants' expected view directions, thus not reaching a concerning level of equivalent veiling luminance.

All images used in this report use the following colour coding:

- Any areas on the facades reflecting the sky only towards the observer are highlighted in **blue**
- Any areas on the facades producing sun reflections towards the observer that are deemed tolerable i.e. below the 500Cd/m² threshold are highlighted in **blue to cyan**
- All areas where the equivalent veiling luminance exceeds the 500Cd/m² threshold are highlighted in **orange to red**

3 Results

3.1 Lime Street and Globe Street

Lime St connects to Globe St, leading onto the Barangaroo site from the south, and past the eastern side of Buildings R8 and R9.

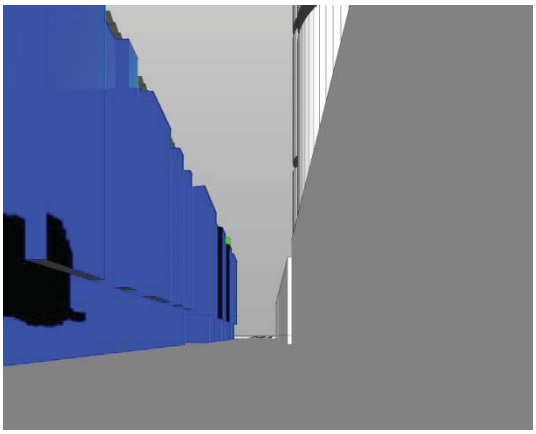

Figure 5: Lime St looking north

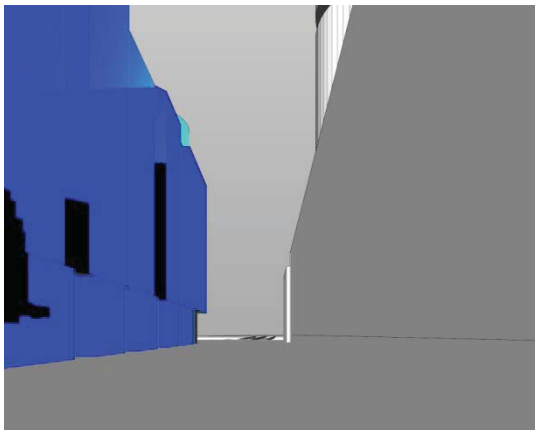

Figure 6: Lime St looking north

Figure 4 and Figure 5 show representative perspective views from Lime St heading north, at approximately 20 m and 100 m after the intersection with Shelley St.

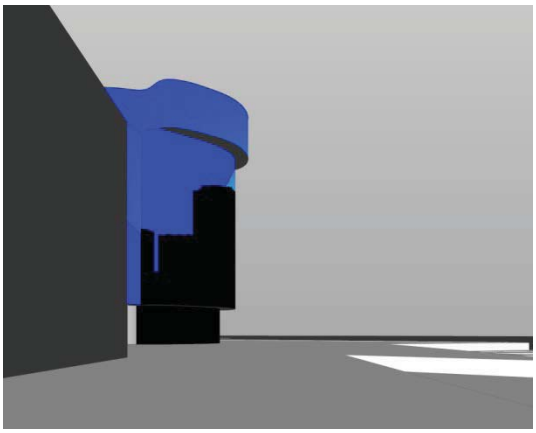

Figure 7: Globe St looking south west

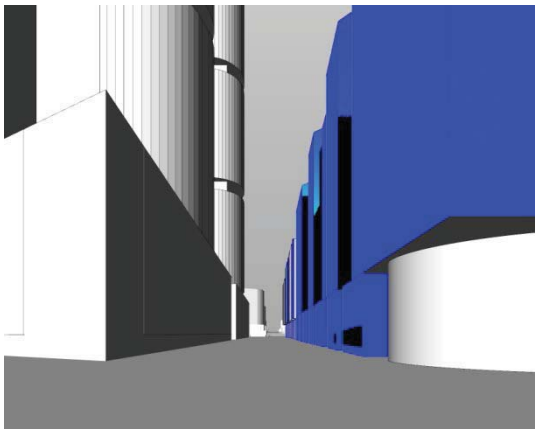

Figure 8: Lime St looking south

Figure 6 shows a representative perspective view from Globe St heading south west, before the turn to the south, at approximately 50 m from the corner of Building R8. Figure 7 shows a representative perspective view from Lime St heading south after the turn.

In either direction, the assessment has shown no reflections exceeding the acceptable threshold along the assessed pathway.

Excessive reflections causing glare in Lime / Globe St were therefore discounted.

3.2 Shelley St

Shelley St is intended to be extended along the southern edge of the Barangaroo site, where it will run parallel to the south facade of Buildings C5 and R9.

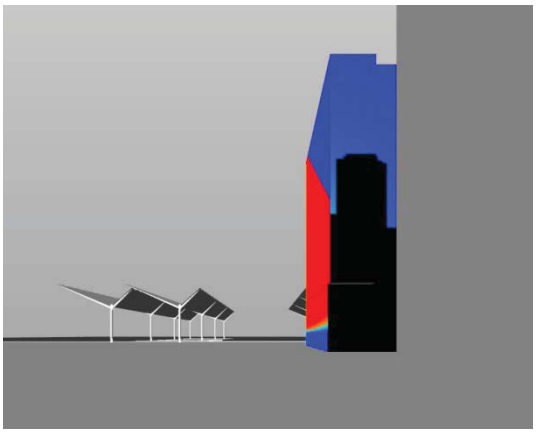

Figure 9: Shelley St extension looking west

Figure 8 shows reflections off the building facade in perspective from Shelley St heading west, at approximately 35m from Building R9.

The analysis has identified that glazing in the plane assumed to follow the development boundary on the south corner could produce reflections above the threshold of 500Cd/m² to locations along the assumed roadway. These occur approximately at the following times:

- Aug-Apr, between 4.30 – 6.00 pm – for up to 30 min intervals

Any reflections theoretically above the threshold are however produced at shallow glancing angles. As the facades are parallel to the driver heading direction, the real sun will be visible at the same angle from the view ahead as the reflections. At any instances when the sun is reflected in the facade, the direct sun already produces illumination above the glare threshold, such that the effect of the reflections is unlikely to increase the incidence of glare.

Excessive reflections causing glare on Shelley Street were therefore discounted.

4 Qualitative Considerations

4.1 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 close to the viewing direction is therefore not expected in these locations.

In other locations accessible to pedestrians where any glare from reflections may occur, the observer is easily able to adjust their view and thus reduce the glare impact of reflections. Pedestrians 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.

4.2 Impact on Surrounding Buildings

Solar reflections off the facade will reach surrounding buildings in the local Barangaroo South site area (podium buildings of C4 and C5 Commercial Buildings).

This may occur for short intermittent time periods during the morning, when low angle sun occasionally falls through gaps between the Barangaroo towers and CBD buildings and is reflected off east facade windows of R8 and R9. Reflections can further occur towards the south west corner of the low-rise section of C4 from the PV installation proposed on the roof of building R9 (intermittently between November and February, approximately between 3.30 and 4.30pm, for up to 30 min).

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. Buildings R8 and R9 will have glazing reflectivity below 20% which will serve to reduce potential glare reflections that may occasionally be produced towards other buildings. In addition, non-reflective facade areas, balconies, and other obscuring elements will further limit reflections towards other buildings. PV glazing is generally of low reflectivity to maximise absorbed light. The limited visible light transmittance of glazing in surrounding buildings will further reduce the intensity of any reflections.

Building occupants do not perform visual tasks as demanding as those required of drivers, so that they are capable of altering their direction of view during these brief periods. Reflections would be visible only from limited locations within any affected buildings.

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 Residential Buildings R8 and R9 perform well in terms of solar reflectivity, and glare affecting motorists on surroundings streets is not expected exceed the limits of acceptability according to the Hassall methodology.

Glare risks have been discounted for the different façade aspects, either because it could be shown that these do not reflect the sun towards traffic, or the intensity of reflections will be below the limit of acceptability as set out by Hassall, or because reflections do not appear unless the sun is directly visible and are thus considered not to be an additional cause of glare to drivers.

The study has found that each façade aspect can have a maximum external specular reflectance of 20% in accordance with council regulations without causing unacceptable glare. This result was obtained making worst case assumptions about the reflectivity of the facade, not taking into account any overshadowing effects from future proposed buildings on the Barangaroo South site and surrounding vegetation, or reduction of facade reflectivity through non-reflective cladding elements, and reduced external glass reflectivity.

Pedestrians are easily able to adjust their view in any location where unwanted reflections may be received, reducing the impact of the reflections. Pedestrians 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 glass reflectance below 20% and further mitigating factors in the facade construction will also serve to reduce potential glare reflections that may occasionally be produced towards other buildings.

Appendix A

Reference Information

A1 Reference Information

A1.1 Architectural Drawings

The following architectural plan drawings prepared by FJMT Architects and PTW Architects received from Lend Lease were used to provide facade geometry information for this reflectivity study:

Table 1: Reference Architectural Drawings

Drawing No.	Title	Revision
BR8ASKPA100	R8 Ground Floor Plan	08
BR8ASKPA101	R8 Level 1 Floor Plan	07
BR8ASKPA102	R8 Level 2 Floor Plan	05
BR8ASKPA103	R8 Level 3 Floor Plan	05
BR8ASKPA104	R8 Level 4 Floor Plan	05
BR8ASKPA105	R8 Level 5 Floor Plan	05
BR8ASKPA106	R8 Level 6 Floor Plan	06
BR8ASKPA107	R8 Level 7 Floor Plan	05
BR8ASKPA108	R8 Level 8 Floor Plan	05
BR8ASKPA109	R8 Level 9 Floor Plan	03
BR8ASKPA110	R8 Level 10 Floor Plan	03
BR8ASKPA120	R8 East Elevation	02
BR8ASKPA122	R8 North and South Elevation	02
BR9ASKPA100	R9 Ground Floor Plan	05
BR9ASKPA101	R9 Level 1 Floor Plan	05
BR9ASKPA102	R9 Level 2 Floor Plan	05
BR9ASKPA103	R9 Level 3 Floor Plan	05
BR9ASKPA104	R9 Level 4 Floor Plan	05
BR9ASKPA105	R8 Level 5 Floor Plan	05
BR9ASKPA106	R9 Level 6 Floor Plan	05
BR9ASKPA107	R9 Level 7 Floor Plan	05
BR9ASKPA108	R9 Level 8 Floor Plan	05
BR9ASKPA120	R9 North Elevation	05
BR9ASKPA121	R9 East Elevation	05
BR9ASKPA122	R9 South Elevation	05

A1.2 References

[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