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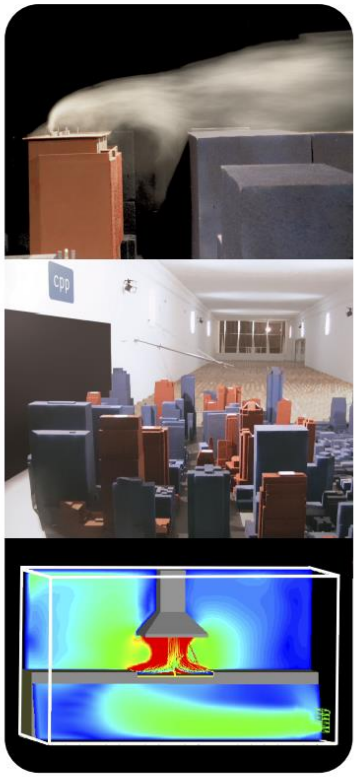
FINAL REPORT



Solar Reflectivity Assessment for:

LANDS AND EDUCATION BUILDINGS

Sydney, Australia

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INTRODUCTION

An assessment of the Lands and Education Buildings in Sydney was carried out to analyse the potential for solar reflectivity glare impacts on surrounding public roadways.

The development site is located toward the northeast corner of the Sydney CBD, and to the west of Governor Philip Tower. The site is bounded by Bridge, Young, Bent, and Gresham Streets with Loftus Street dividing the two buildings, Figure 1.The proposed changes to the existing buildings include the establishment of a glass roof on the Lands Building, and an additional three storeys on the Education Building, Figure 2.

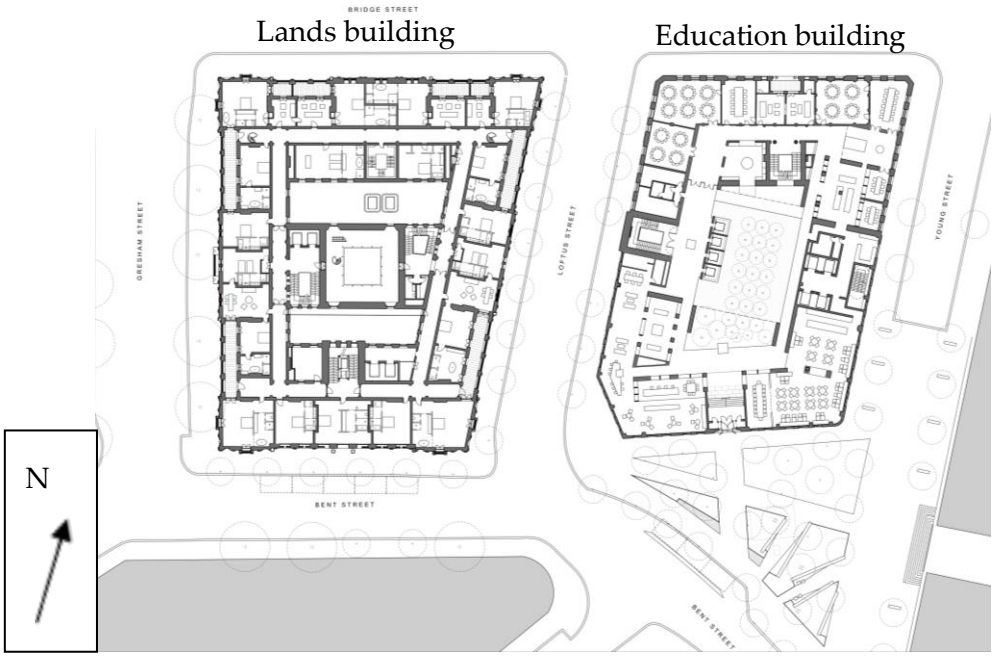

Figure 1: Location and ground floor layout of development site

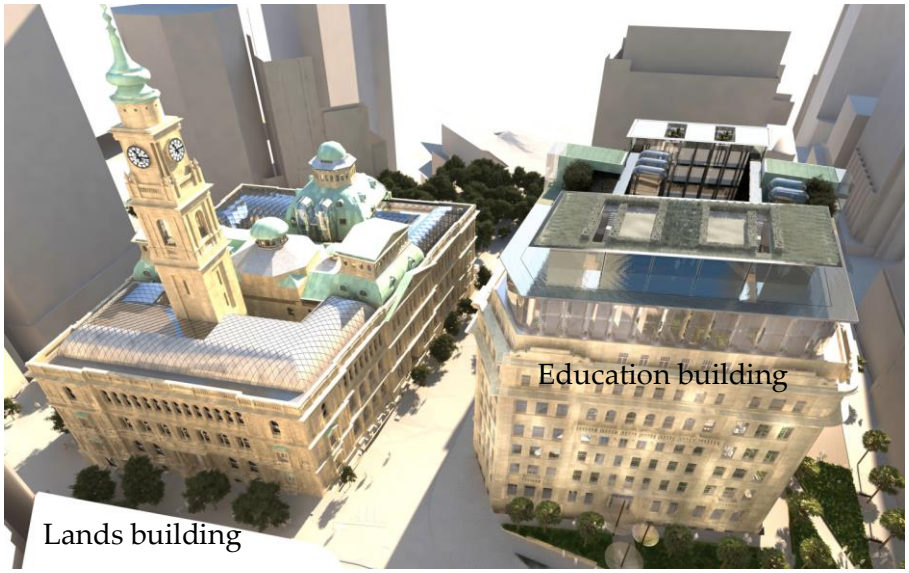

Figure 2: 3D renderings of proposed changes to the developments viewed from the south

REFLECTIVITY

Reflectivity Impact Considerations

Sydney Development Control Plan 2012 specifies the requirements for the assessment for potential specular and diffuse reflections emanating from proposed developments. To assess the solar impacts of the Lands and Education Buildings, this report considers Sydney DCP 2012, General Provisions, Section 3.2.7 Reflectivity, specifically:

Provisions

(1) A Reflectivity Report that analyses potential solar glare from the proposed building design may be required for tall buildings.

(2) Generally, light reflectivity from building materials used on facades must not exceed 20%.

As required under 3.2.7, Tristar Sandstone Pty Ltd will ensure exterior elements on the facades studied in this report will have a reflectivity coefficient of 20% or less. This is defined as the percentage solar reflection when light strikes and reflects normal to the façade plane.

This report quantifies potential for solar reflections of all incident angles on glazing to impact upon the surrounds taking into consideration:

- Seasonal and diurnal solar paths (sun altitude and azimuth) at the Sydney altitude and the relative angle of the solar ray (reflectivity coefficients of glazing increase with increasing incident angle)
- An assumed reflectivity coefficient of 20% for the external glazing being used and the incident angle of the solar ray (allowance is made for reflectivity coefficients of glazing to increase with increasing incident angle).
- Receiver locations of interest; the alignment of adjoining public road and pathways being of particular interest.

CPP use, in part, methodology developed by Hassall (1991) and the concept of veiling glare and contrast when quantifying the potential for hazard rogue reflections onto surrounding receiver locations. Threshold Increment (TI) is the percentage by which the contrast must be increased to make the object just visible due to the addition of glare and is the parameter calculated in this study to assess the acceptability of potential reflectivity glare events. Proprietary software was used to calculate TI values at expected maximum impact locations of vehicles travelling in the directions as marked in Figure 3. The analysis assumes in the first instance that the buildings are isolated with no shielding from neighbouring buildings.

TI is a parameter used in the design of Road Lighting, e.g. AS/NZS 1158.1.1:2005 where a maximum TI value of 20% is used for all roadway lighting categories and is the TI acceptability criterion adopted in this study for assessing solar glare impact on passing traffic.

Where high TI values are identified it is useful to investigate the angular limits of façade reflections relative to the motorist observer using a glare protractor (Hassall 1991). The glare protractor comprises a series of loops indicating whether a glare source will be above a predetermined veiling glare limit for the resultant percentage level of cladding reflectivity.

Calculations in this report assume specular type reflective façade surfaces, where the reflected ray angle is equal to the incident solar ray angle; being valid for most smooth surface materials. Each facade of the development assessed in this report was modelled as a vertical plane from the ground level to roof height. In this case, the setback position of the additional storeys on the

Education Building was modelled. The building was modelled in isolation from surrounding buildings, including the adjacent Lands Building.

Certain building materials other than glass, including metallic framing and supports, and convex surfaces produce diffuse components of reflection that are not directly quantified by the methodology adopted in this report. By definition, diffuse reflections have a greater scatter of reflected angles with lower concentration of reflected light in any given direction and are generally less likely to cast hazardous distant disability glare reflections than flat surface glazing. Notwithstanding, these materials and surfaces have potential to produce discomfort glare, and it is recommended that all non-glazed surfaces adopt low lustre, matte finishes.

Convex glazing surfaces such as the proposed glass dome-like structures on the roof of the Lands Building and corners of the additional storeys proposed for the Education Building have the potential to produce diffuse reflections. The impacts of the diffuse reflections onto the investigated locations in Figure 3 are discussed later in the report. The horizontal sections of the proposed rooftop glazing are not expected to produce disability glare onto motor vehicles in the surrounding public roadways.

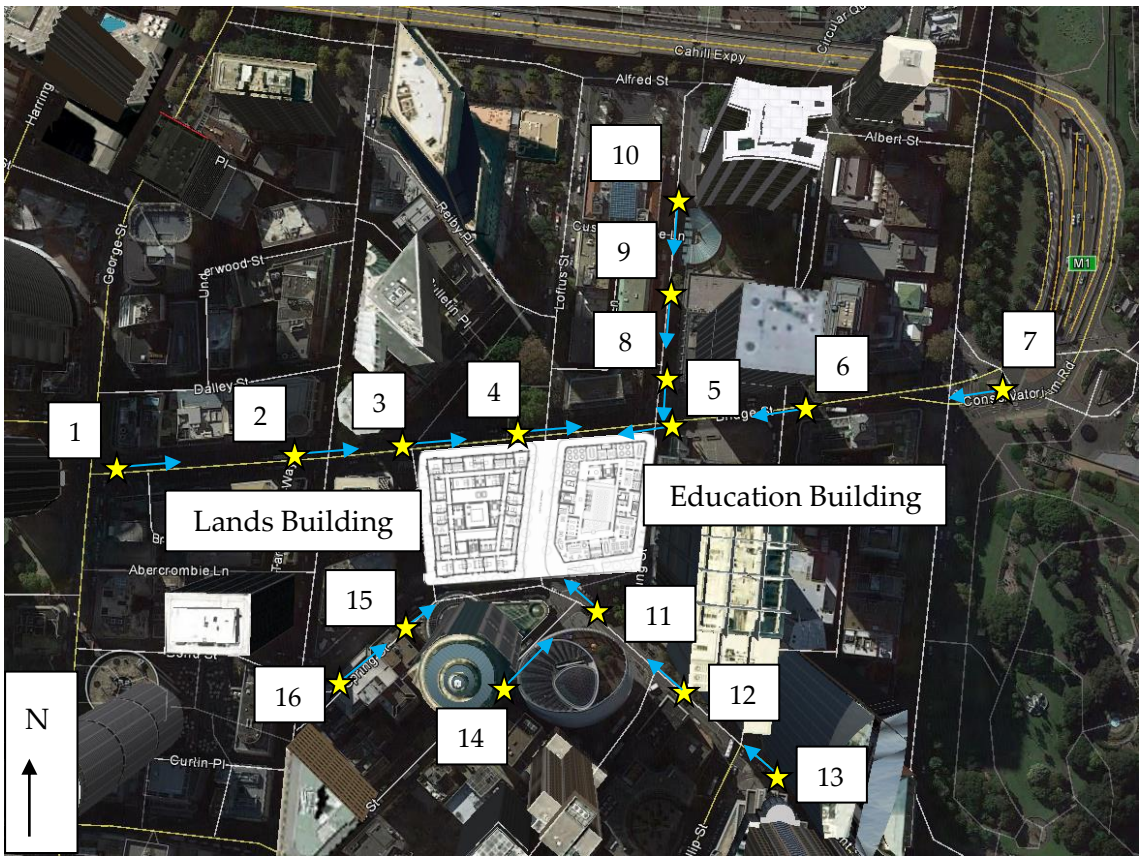

Figure 3: Investigated impact locations of vehicles and trains travelling in indicated directions

Reflectivity Impacts Results

Specular Reflections

Assessment has shown the proposed additional storeys of the Education Building have the potential to produce solar reflections onto Bridge, Young, and Spring Streets at considerable distances from the site. The facades of the Education Building were modelled as vertical glazed facades, and the entire building as an isolated entity including the exclusion of the adjacent Lands Building. The assessment also accounted for the setback position of the proposed additional storeys.

Bridge Street

Motor vehicles at investigated Locations 1 to 4, Figure 3, travelling east toward the development were found to experience low levels of solar reflection emanating from the north face of the proposed additional storeys of the Education Building, depicted in Figure 4, during the early morning periods early in the autumn season.

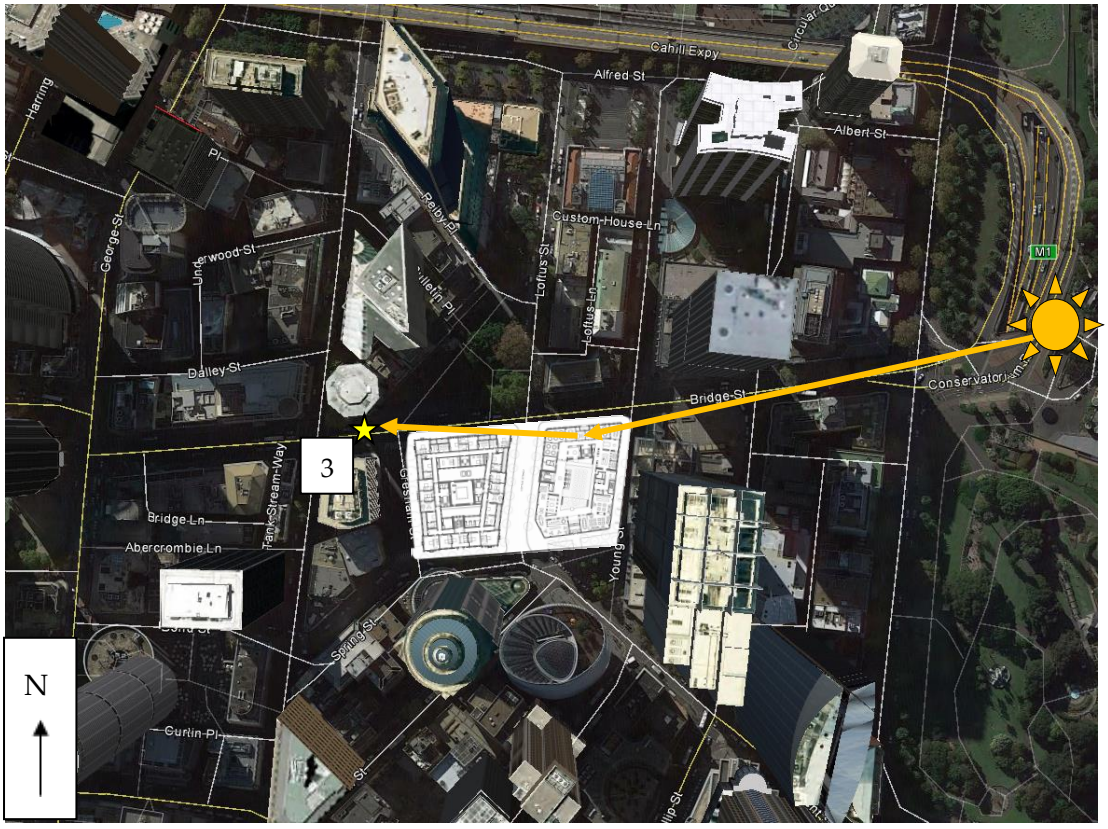

Figure 4: Incident and reflection of solar rays emanating from the Education Building

As an example, analysis showed an eastbound motor vehicle at Location 3 experienced reflections emanating from the north face of the additional storeys between 7:15 am and 7:45 am. In this time, TI values experienced peaked at 16%. This TI level is lower than the TI limit described above for public roadways.

The remaining investigated locations along Bridge Street to the west of the site showed similar levels of solar reflections during similar periods of time, and it is expected the north face of the additional storeys proposed for the existing Educations Building will not produce significant disability glare, for vehicles travelling east along Bridge Street toward the development site.

Motor vehicles at investigated Locations 1 to 4, Figure 3, travelling east toward the development were found to experience considerable levels of solar reflection emanating from the west face of the proposed additional storeys of the Education Building, depicted in Figure 5, during late afternoon periods early in the autumn season.

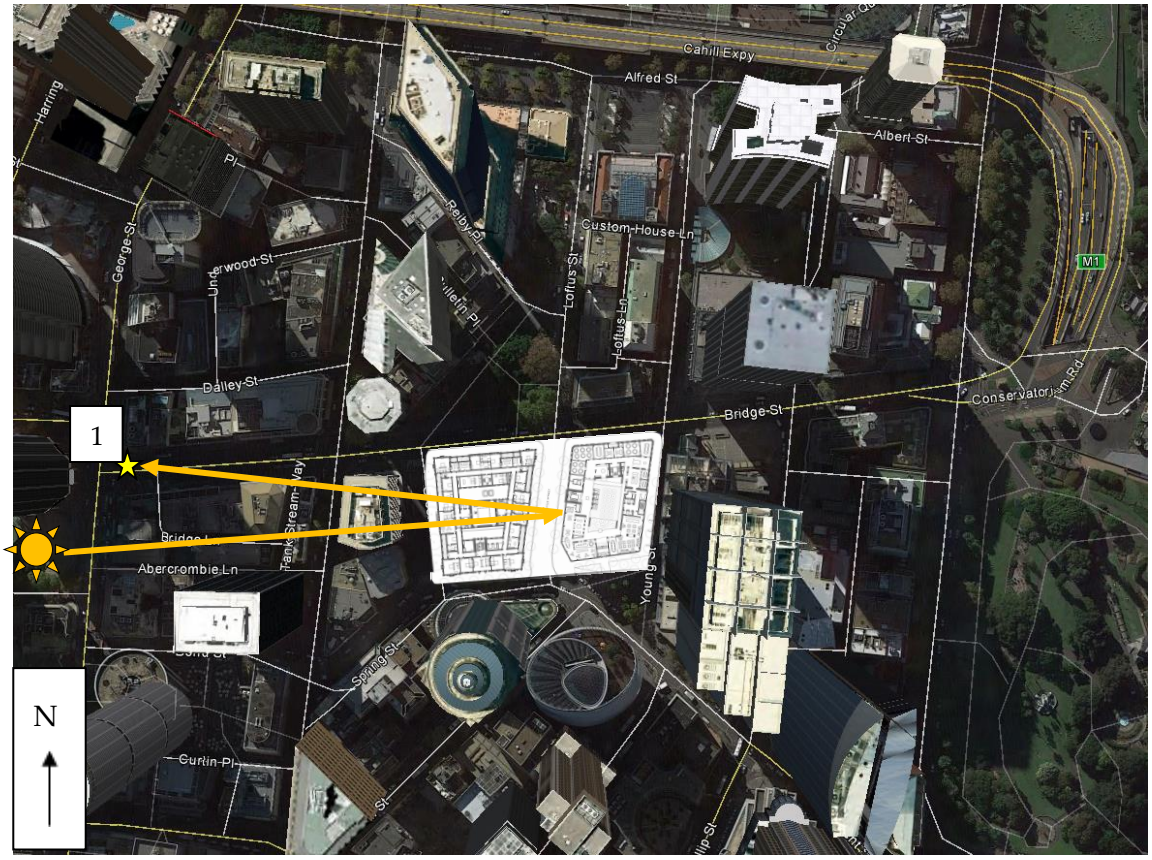

Figure 5: Incident and reflection of solar rays emanating from the Education Building

As an example, analysis showed an eastbound motor vehicle at Location 1 experienced reflections emanating from the west face of the additional storeys between approximately 5:00 pm and 5:15 pm. In this period of time, TI values experienced peaked at 22%. This TI level is marginally higher than the TI limit described above for public roadways. During this time period, the Sun's altitude is low and the incident rays coming from the west will be blocked by the multiple tall CBD buildings to the west. Furthermore, Figure 6 shows the line of sight of a motor vehicle at Location 1 in the direction of the development site. It is evident drivers' views of the Education Building is largely blocked by the existing Lands Building.

The remaining investigated locations along Bridge Street to the west of the site showed similar or lower levels of solar reflections for similar Sun altitudes. The additional storeys proposed for the existing Educations Building is not expected to produce significant disability solar glare from the west face for vehicles travelling east along Bridge Street toward the development site due to solar ray blockage.

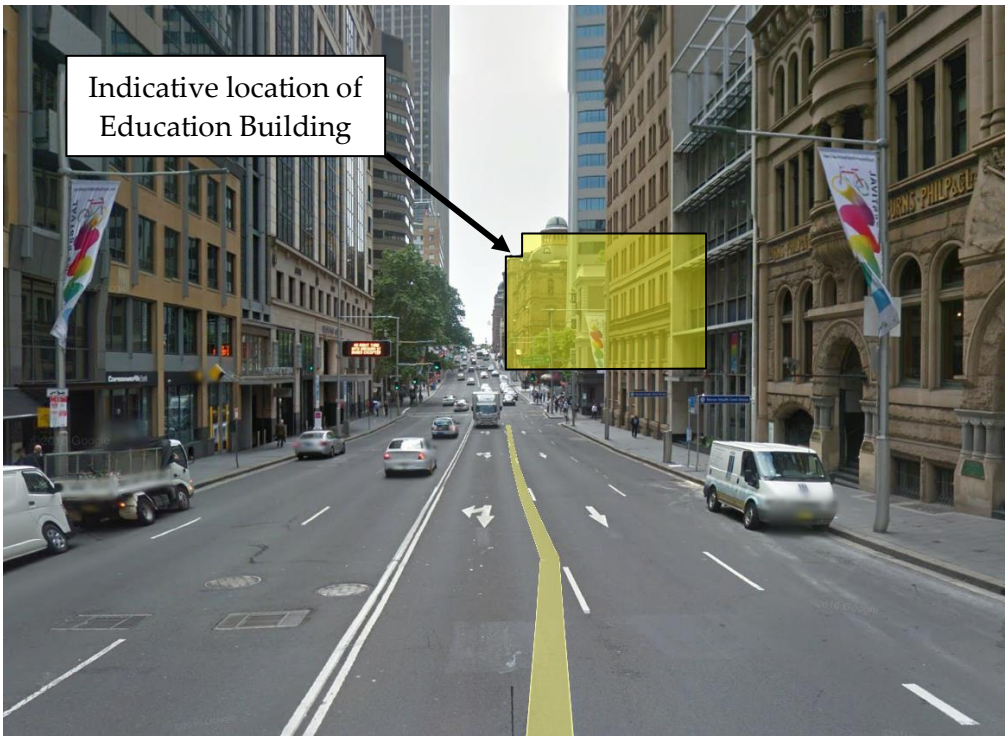

Figure 6: Point of view of motor vehicle at investigated Location 1

Motor vehicles at Locations 5 to 7, Figure 3, travelling west toward the development were found to experience considerable levels of solar reflection from the north face of the proposed additional storeys of the Education Building during the late afternoon periods late in the winter season, Figure 7.

Figure 7: Incident and reflection of solar rays emanating from the Education Building

As an example, analysis showed a westbound motor vehicle at Location 6 experienced reflections from the north face of the additional storeys between approximately 5:00 pm and 5:30 pm. In this period of time, TI values experienced peaked at 27%. This TI level is higher than the TI limit described above for public roadways. During this time period the Sun's altitude will be low and the incident rays coming from the west will be blocked by the multiple tall CBD buildings to the west. The incident solar rays are not expected to reach the development site.

The remaining investigated locations along Bridge Street to the east of the site showed similar levels of solar reflections for similar Sun altitudes and it is expected the north face of the additional storeys proposed for the existing Educations Building will not produce significant disability solar glare for vehicles travelling west along Bridge Street toward the development site due to incident solar ray blockage.

Motor vehicles at Locations 5 to 7, Figure 3, travelling west toward the development were found to experience considerable levels of solar reflection from the east face of the proposed additional storeys of the Education Building during early morning periods late in the winter season, Figure 8.

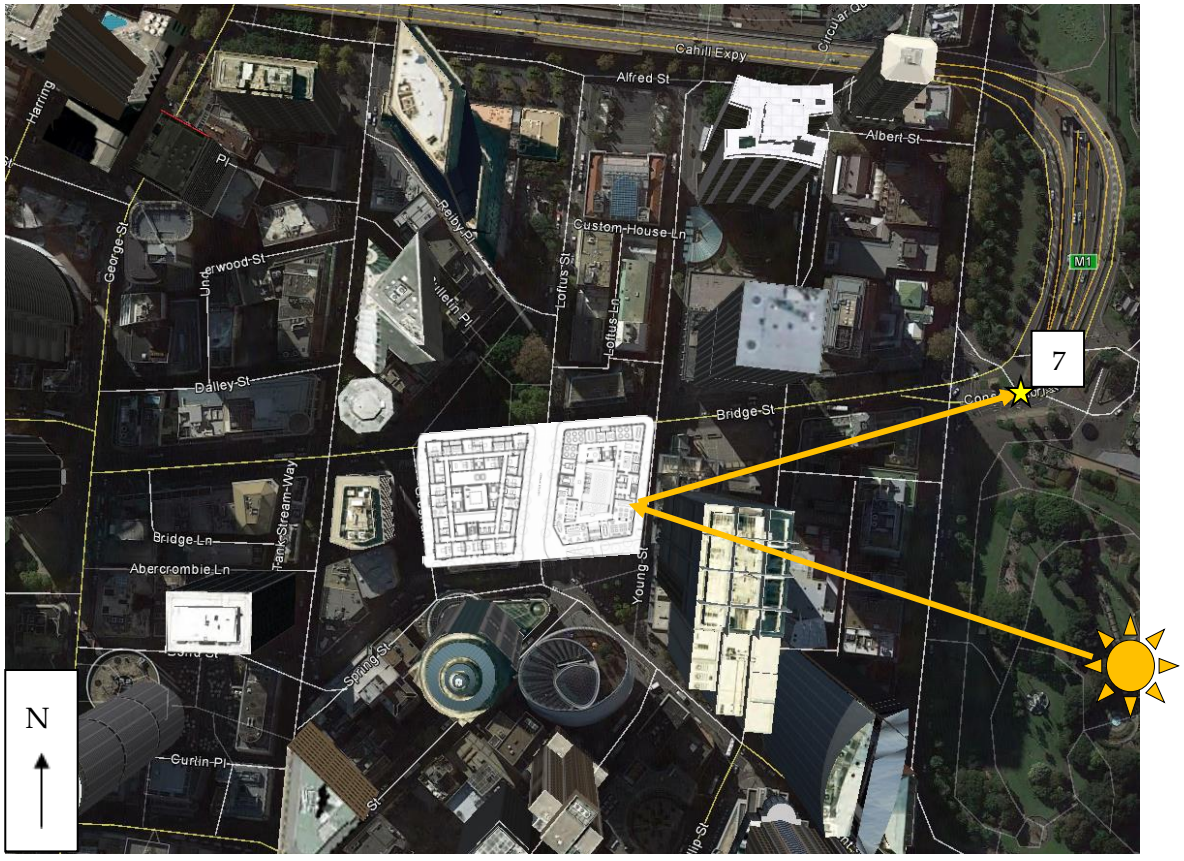

Figure 8: Incident and reflection of solar rays emanating from the Education Building

As an example, analysis showed an eastbound motor vehicle at Location 7 experienced reflections emanating from the east face of the additional storeys between approximately 5:30 am and 6:00 am. In this period of time, TI values experienced peaked at 27%. This TI level is higher than the TI limit described above for public roadways. During this time period, the Sun's altitude will be low and the incident rays from the east will be blocked by Governor Philip Tower. Furthermore, Figure 9 shows the line of sight of a motor vehicle at Location 7 in the direction of the development site. It is evident drivers' views of the Education Building is blocked by the existing Industrial Relations Commissions Court.

The remaining investigated locations along Bridge Street to the east of the site showed similar or lower levels of solar reflections for similar Sun altitudes and it is expected the additional storeys proposed for the existing Educations Building will not produce disability glare from the east face for vehicles travelling west along Bridge Street toward the development site due to solar ray blockage.

Figure 9: Point of view of motor vehicle at investigated Location 7

Young Street

Motor vehicles at investigated Locations 8 to 10, Figure 3, travelling south toward the development were found to experience low levels of solar reflections from the north face of the proposed additional storeys of the Education Building during afternoon periods in autumn, Figure 10.

As an example, analysis showed a southbound motor vehicle at Location 9 experienced reflections emanating from the north face of the additional storeys between approximately 2:00 pm and 3:00 pm. In this period of time, TI values experienced peaked at 6%. This TI level is lower than the TI limit described above for public roadways.

The remaining investigated locations on Young Street showed similar levels of solar glare, hence the north face of the additional storeys proposed for the existing Educations Building is not expected to produce significant disability glare for vehicles travelling south along Young Street toward the development site.

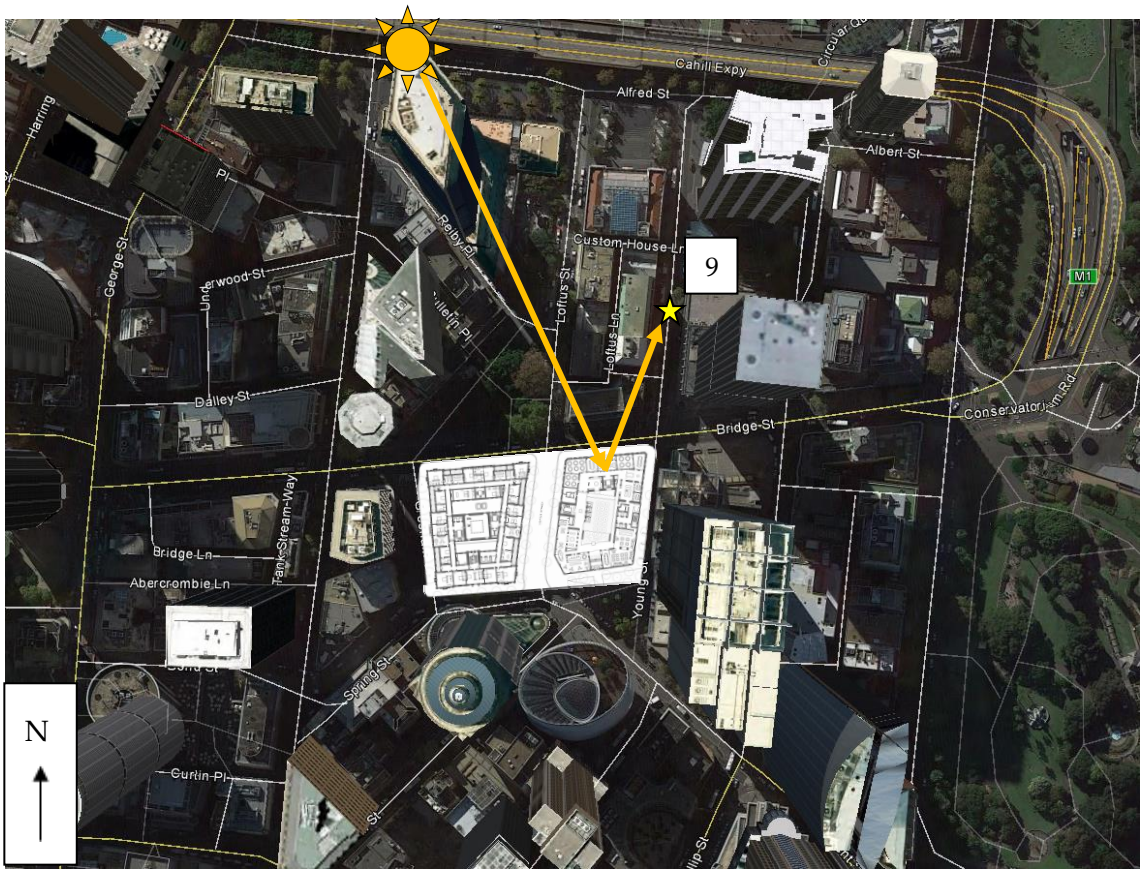

Figure 10: Incident and reflection of solar rays emanating from the Education Building

Bent Street

Solar analysis of Locations 11 to 13 showed no disability glare from the proposed additional storeys of the Education Building was experience by motor vehicles travelling toward the development site along Bent Street.

O'Connell Street

Solar analysis of Location 14 showed no disability glare from the proposed additional storeys of the Education Building was experience by motor vehicles travelling toward the development site along O'Connell Street.

Spring Street

Motor vehicles at Locations 15 and 16, Figure 3, travelling north-east toward the development were found to experience low levels of solar reflections emanating from the west face of the proposed additional storeys of the Education Building during afternoon periods in autumn, Figure 11.

As an example, analysis showed a northeast bound motor vehicle at Location 9 experienced reflections emanating from the additional storeys between approximately 2:30 pm and 3:00 pm. In this period of time, TI values experienced peaked at 11%. This TI level is lower than the TI limit described above for public roadways.

The remaining investigated location on Spring Street showed similar levels of solar glare during similar time periods and it is expected the west face of the additional storeys proposed for the existing Educations Building will not produce significant disability glare for vehicles travelling northeast along Spring Street toward the development site.

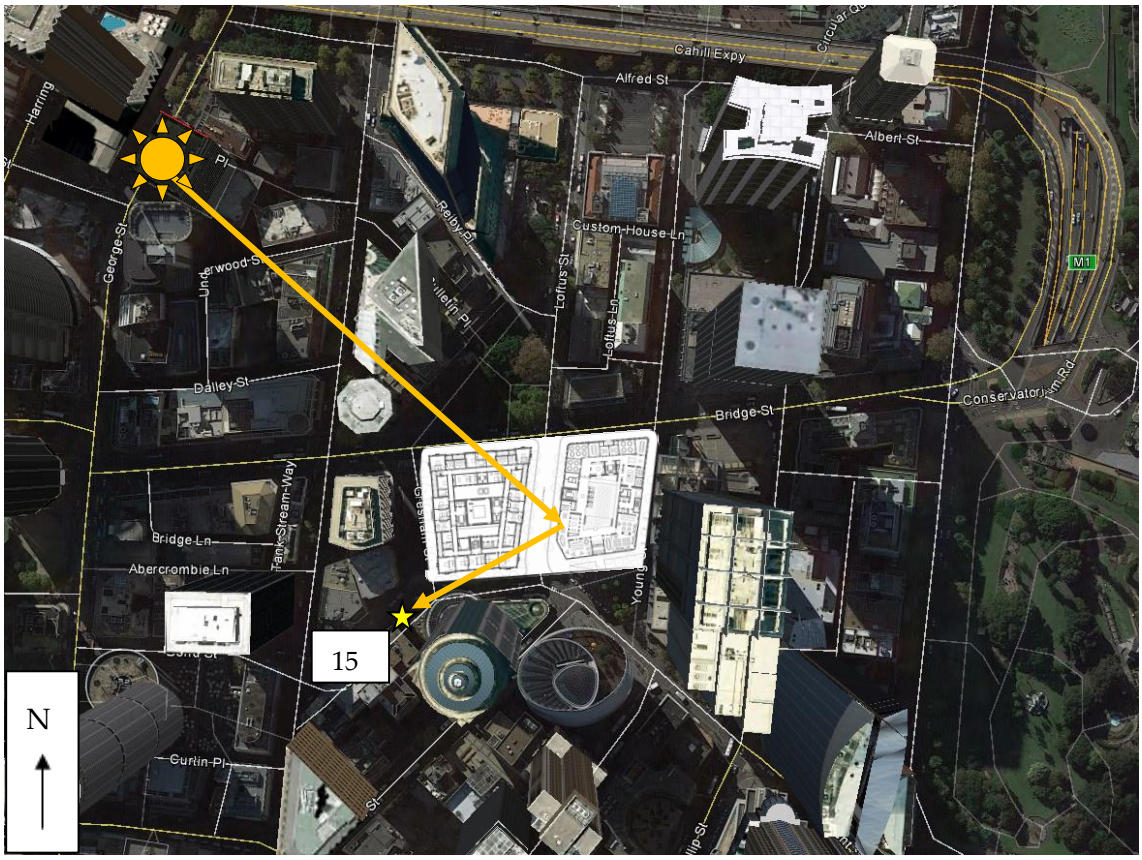

Figure 11: Incident and reflection of solar rays emanating from the Education Building

Diffuse Reflections

Lands Building

The diffuse solar reflections that will emanate from the convex surfaces of the proposed rooftop glazing on the Lands Building will, by definition, diverge into different directions and continually shift throughout the day. The divergent nature of the solar reflections are considered less substantial than direct solar reflections from flat surfaces, or concave surfaces, since divergent solar reflections are not concentrated in one direction and do not last over a long period of time. Notwithstanding, diffuse solar reflections have the potential to produce discomfort glare and to help reduce the potential for discomfort it is recommended the material used for the proposed rooftop glazing possesses a reflectivity coefficient of 20% or less.

Education Building

Similar to the surfaces of the proposed rooftop glazing, the curved glazing on the additional storeys proposed for the Education Building will produce diffuse solar glare, and to reduce their potential to produce discomfort for oncoming motor vehicles it is recommended the material used possess a reflectivity coefficient of 20% or less.

Non-glazed Façade Elements

Non-glazed façade elements to be developed during detailed design should each be assessed for potential to generate nuisance reflections. Elements such as metallic framing and supports have the potential to generate localised glare of both a diffuse and specular nature that can produce a discomfort glare and affect the amenity of the site. All these elements should have a reflectivity

coefficient of less than 20% as stipulated in the Sydney DCP 2012. Furthermore, it is recommended that any proposed non-glazed cladding utilise low lustre, matte finishes.

CONCLUSIONS

The proposed structural additions to the existing Lands and Education Buildings in Sydney have been assessed for the potential to cause adverse glare events onto surrounding roadway locations.

Assessment has shown the additional three storeys proposed for the Education Building is not expected to produce significant disability glare onto motor vehicles travelling toward the development along the adjacent public roadways.

The proposed rooftop glazing for the Lands Building has the potential to produce more diffuse reflections than specular. Although possessing a lower concentration of glare than specular, the diffuse reflections have potential to cause discomfort for drivers and it is recommended an exterior reflectance coefficient of less than 20% is adopted as required under the Sydney DCP 2012. It is also recommended non-glazed elements adopt low lustre, matte finished surfaces.

With these assumptions, the proposed additions to the Lands and Education buildings in Sydney is not expected to produce significant disability glare onto oncoming motor vehicles.

REFERENCES

New South Wales State Government, Council of the City of Sydney, Sydney Development Control Plans, Section 5, 18/03/2015

Hassall (1991) “Reflectivity, Dealing with Rogue Solar Reflections” Faculty of Architecture, University of NSW.