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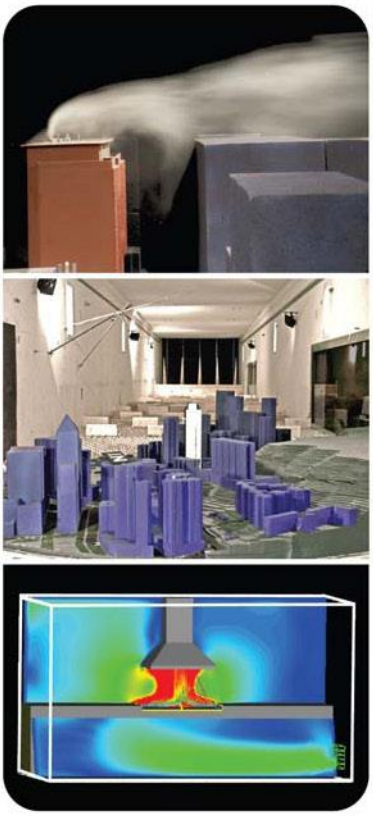
WIND ENGINEERING AND AIR QUALITY CONSULTANTS

# SYDNEY INTERNATIONAL CONVENTION, EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP), THE HAYMARKET: SOUTH-WEST PLOT



Reflectivity Report

Stage 2 State Significant Development Application (SSDA 5)

Sydney, Australia

CPP Project 6908

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Final Report Rev 1

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## EXECUTIVE SUMMARY

Cermak Peterka Petersen Pty. Ltd. has been engaged by Lend Lease to assess the proposed Haymarket Precinct of Sydney International Convention Centre, Exhibition and Entertainment Precinct (SICEEP) in terms of Solar Reflectivity. This report supports a State Significant Development (SSD) Development Application (DA) submitted to the Minister for Planning and Infrastructure pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

This report addresses the List of Deliverables for SSDA5, Façade Reflectivity Statement i.e. 'Addresses reflectivity impacts to the surrounding area. A high level of environmental amenity must be demonstrated'.

This report makes reference to the Sydney Development Control Plan 2012, Section 3 General Provisions – Section 3.2.7 Reflectivity. Specifically, Section 3.2.7 states that "A Reflectivity Report that analyses potential for solar glare from the proposed building design may be required for tall buildings".

Lend Lease will ensure all exterior façade elements used throughout the development will limit light reflectivity to 20% or less as required under the Sydney Development Control Plan 2012.

This report quantifies the potential for solar reflectivity glare impact upon motorists using roadways intersecting and surrounding the SICEEP Haymarket precinct with focus on the South West Plot in this report. 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 to be cast onto surrounding motorway receiver locations. Pedestrian impacts are assessed more broadly in this report in terms of amenity and usability of the site. This report does not assess solar glare impact onto surrounding buildings nor glare from artificial lighting.

With the measures adopted by the designers as described in this report regarding choice of façade materials and façade articulation, the proposed South West Plot development does not present a driver hazard in terms of solar glare and will meet the Sydney Development Control Plan 2012 controls for reflectivity.

## TABLE OF CONTENTS



## LIST OF FIGURES

# 1. INTRODUCTION

Cermak Peterka Petersen Pty. Ltd. has been engaged by Lend Lease to assess the proposed Haymarket Precinct of Sydney International Convention Centre, Exhibition and Entertainment Precinct (SICEEP) in terms of Solar Reflectivity. This report supports a State Significant Development (SSD) Development Application (DA) submitted to the Minister for Planning and Infrastructure pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

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# 2. CLIENT PROVIDED INFORMATION

## 2.1. Introduction

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

The Application (referred to as SSDA 5) follows the submission of a staged SSD DA (SSDA 2) submitted in March 2013 to the Department of Planning and Infrastructure that set out a Concept Proposal for a new mixed use residential neighbourhood at Darling Harbour known as 'The Haymarket'. The Haymarket forms part of the Sydney international convention, exhibition and entertainment precinct (SICEEP) Project, which will deliver Australia's global city with new world class convention, exhibition and entertainment facilities and support the NSW Government's goal to "make NSW number one again".

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

## 2.2. Overview of Proposed Development

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

Under the Concept Proposal DA, the South-West Plot will accommodate a mixed use podium and three residential buildings (SW1, SW2, and SW3) above and within the podium structure. More specifically, this SSD DA seeks approval for the following components of the development:

- Staged demolition of existing site improvements, including the existing Sydney Entertainment Centre (SEC), Entertainment car park, and part of the pedestrian footbridge connected to the Entertainment car park;
- Associated tree removal and planting;
- Construction and use of a five storey mixed use podium, including:
  - retail and IQ Hub floor space and residential lobbies on Ground Level;

  - above ground parking; and
  - residential apartments.
- Construction and use of three residential buildings above podium:
- Public domain improvements, including:
  - provision (part) of a new north-south pedestrian connection (known as the Boulevard) eventually linking Quay Street to Darling Harbour;
  - provision (part) of a new east-west pedestrian laneway (known as Dickson's Lane) linking Darling Drive to the Boulevard; and
  - upgrade of Hay Street (part) to provide for a pedestrian shareway;
  - modification of retained pedestrian footbridge and provision of lift and stair access to the Goods Line;.
- provision of vehicle access to the development from Hay Street;
- Landscaping works and communal facilities to the podium roof level; and
- Extension and augmentation of physical infrastructure / utilities as required.

## 2.3. Background

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

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

## 2.4. Public Private Partnership SSD DA (SSD 12_5752)

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

## 2.5. The Haymarket Concept Proposal (SSD 13_5878)

The Haymarket Concept Proposal SSD DA (SSDA 2) establishes the vision and planning and development framework which will be the basis for the consent authority to assess detailed development proposals within the Haymarket Site.

- Staged demolition of existing site improvements, including the existing Sydney Entertainment Centre (SEC), Entertainment Centre Car Park, and part of the pedestrian footbridge connected to the Entertainment car park and associated tree removal;
- A network of streets, lanes, open space areas and through-site links generally as shown on the Public Domain Concept Proposal, to facilitate reintegration of the site into the wider urban context and connection with the broader SICEEP Site;
- Street layouts;
- Development plot sizes, development plot separation, building envelopes (maximum height in RLs), building separation, building depths, building alignments and a benchmark for natural ventilation and solar provision for the precinct;
- Land uses across the site, including residential and non-residential uses;
- A maximum total gross floor area (GFA) across The Haymarket Site of 197,236m$^2$ for the mixed use development (excluding ancillary above ground car parking), comprising of:
  - A maximum of 49,545m$^2$ non-residential GFA; and
  - A maximum of 147,691m$^2$ residential GFA;
- Above ground parking including public car parking;
- Residential car parking rates to be utilised in the subsequent detailed (Stage 2) Development Applications, being:
  - Zero (0) spaces per studio apartment;
  - Maximum one (1) space per two (2) one bedroom apartments;
  - Maximum one (1) space per one bedroom + study apartment, plus one (1) additional space per five (5) apartments;
  - Maximum one (1) space per two bedroom apartment, plus one (1) additional space per five (5) apartments; and
  - Maximum two (2) spaces per 3+ bedroom apartment.

- Design Guidelines to guide future development and the public domain; and
- A remediation strategy.

This report has been prepared to support a detailed Stage 2 SSD DA for a mixed use commercial and public car park development and associated public domain works within The Haymarket (SSDA 5), consistent with the Concept Proposal SSD DA.

## 2.6. Site Description

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

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

The Haymarket Site is:

- located in the south of the SICEEP Site, within the northern portion of the suburb of Haymarket;
- bounded by the Powerhouse Museum to the west, the Pier Street overpass and Little Pier Street to the north, Harbour Street to the east, and Hay Street to the south; and
- irregular in shape and occupies an area of approximately 43,807m2.


Figure 1: Aerial Photograph of the SICEEP Site

The Concept Proposal DA provides for six (6) separate development plots across the Haymarket Site (refer to Figure 2):

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

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


Figure 2: Concept Proposal Development Plots

## 2.7. Planning Approvals Strategy

The SICEEP Project will result in the lodgement of numerous SSD DAs for the various components of the redevelopment project. SSD DAs have already been lodged for the PPP component of the SICEEP Project (comprising the convention centre, exhibition centre, entertainment facility and ancillary commercial premises and associated public domain upgrades), and the Stage 1 Concept Proposal for The Haymarket. Separate 'Stage 2' SSD DAs for the development of the North West Plot and the Western Plot (Darling Drive) and associated public domain works will be lodged concurrently with this application. Future applications will be lodged for the Hotel complex, and the remaining development plots of The Haymarket Site.

## 3. REFLECTIVITY IMPACT CONSIDERATIONS

To assess the impacts of the proposal, this report considers the Sydney Development Control Plan 2012, Section 3 General Provisions – Section 3.2.7 Reflectivity, specifically:

Provisions

(1) A Reflectivity Report that analyses potential for 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%.

(3) For buildings in the vicinity of arterial roads/major roads and Sydney Airport, proof of light reflectivity is required and is to demonstrate that light reflectivity does not exceed 20%.

As outlined under 3.2.7, Lend Lease will ensure all exterior façade elements used throughout the SW Plot development will limit light reflectivity to 20% or less. For glazing producing specular type reflections this is defined as the percentage solar reflection when light strikes and reflects normal to the façade plane. When incident solar rays strike near parallel to the façade plane (large incident angle of typically greater than 70° also referred to as glancing reflections), it is known that the reflectivity of all glazing types increases dramatically towards the properties of a mirror, Figure 3.

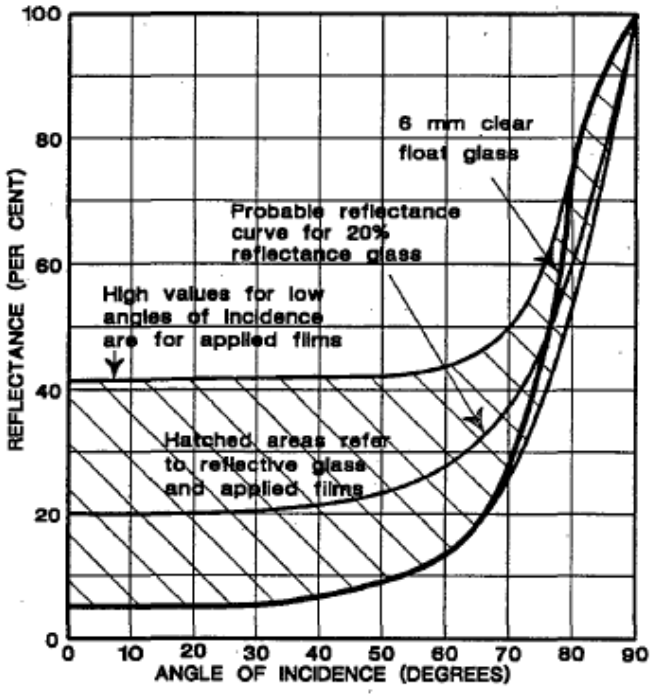


Figure 3: Façade Reflectivity versus angle of incidence (Hassall, 1991)

Thus, even for glazing with low reflectivity coefficients, the potential for glare increases significantly when incoming solar rays can impact on a building close to parallel to the plane of the glazing, i.e. a glancing reflection. The following 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 SW Plot latitude and longitude and the relative angle between incident solar rays and façade orientation.
- Reflectivity coefficients of the external glazing being used.
- Roadway receiver locations of interest; the alignment of adjoining public roads.

Where the combination of these factors suggests there is potential for hazardous rogue reflections to impact on surrounding areas, the potential magnitude of reflections can be quantified and compared with acceptability criterion described below. This report quantifies the potential for solar reflectivity glare impact upon motorists using roadways intersecting and surrounding the SW Plot. 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. In many instances the potential for a façade to generate rogue reflections can be eliminated without the need for calculation by taking into account the above factors as well as shading offered by surrounding building massing.

Pedestrian impacts are less likely to be of safety concern and are assessed more broadly in this report in terms of general amenity and usability of the site. A pedestrian can more readily divert their viewing angle away from the glare source or halt walking momentarily. It must be appreciated it is impractical to mitigate potential solar reflections at all potential pedestrian receiver locations across and surrounding the precinct.

Similarly, this report does not assess the impact of reflected solar glare onto surrounding building windows. Notwithstanding, designers have no glass sloping toward the sky in order to minimise solar reflections back onto surrounding multi-storey buildings, i.e. all glass is either aligned vertically or sloping downward toward the ground.

## 4. GLARE ACCEPTABILITY CRITERION

Consider an object that is just visible in the absence of glare. The object will no longer be visible when glare is introduced and it will be necessary to increase the contrast to make the object visible again. Threshold Increment (TI) is the percentage by which the contrast must be increased to make the object just visible and is the parameter calculated in this study to assess the acceptability or otherwise of potential reflectivity glare events.

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 % 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 glazing materials. Other building materials including surface fritted glazing, masonry, brickwork, tiles, and metal deck roofing 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 glare reflections than glazing.

## 5. REFLECTIVITY IMPACT RESULTS

The South West Plot buildings are tall relative to surrounding roadways, so reflections from the facades are able to extend significant distances; especially early morning and late afternoon events when the solar altitude angle is low. Also important is the solar shading available from surrounding and proposed developments and the massing of the Sydney CBD.

Darling Drive, The Boulevard/ Quay Street and Hay Street were considered most at risk to solar glare from the development and were primarily assessed for reflectivity impact in this report. With reference to the Holladay formula (Hassall, 1991); the greatest potential for glare impact upon drivers is when the angle between the centre of the glare source and line of sight is small. Therefore the greatest potential for glare impacts is for motorists travelling *toward* the SW Plot site.

Hay Street SW Plot travelling west toward the site

The greatest potential for the proposed SICEEP Haymarket SW Plot developments to generate reflections onto westbound motorists on Hay Street is solar interaction with the southern facades of SW3, including Hay street locations west and east of George Street.

The highest TI values calculated for this facade were caused by late afternoon reflection conditions. Evening (around 6pm daylight savings time) low altitude solar rays during the mid-season months strike mid to upper levels of the southern facades of SW3 from the west with reflections towards the east along Hay Street.

An example of this reflection condition is on March 24th, which is illustrated in Figure 4 showing reflections off the south façade of SW3 between the roadway and roof levels. The impact point is on Hay Street at the bend turning north.

| | | |
|---|---|---|
| reflections start | 6:10 pm | TI = 30 |
| reflections cease | 6:30 pm | TI = 18 |

The highest TI levels are in excess of the criterion. It is noted the altitude angle of the incident solar rays is low being about 10 degrees and in the line of sight of a driver travelling westward, contributing to the high TI value (refer Holladay formula).

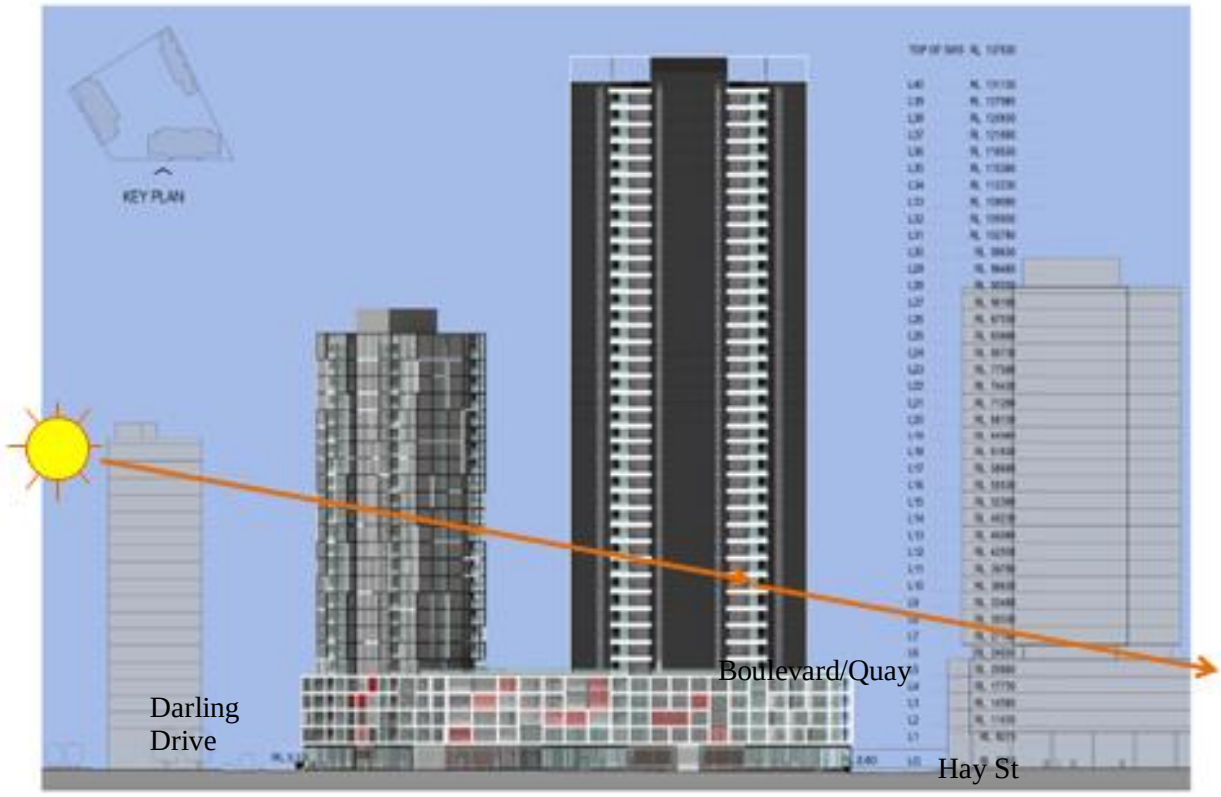


Figure 4: Afternoon reflection condition off SW3

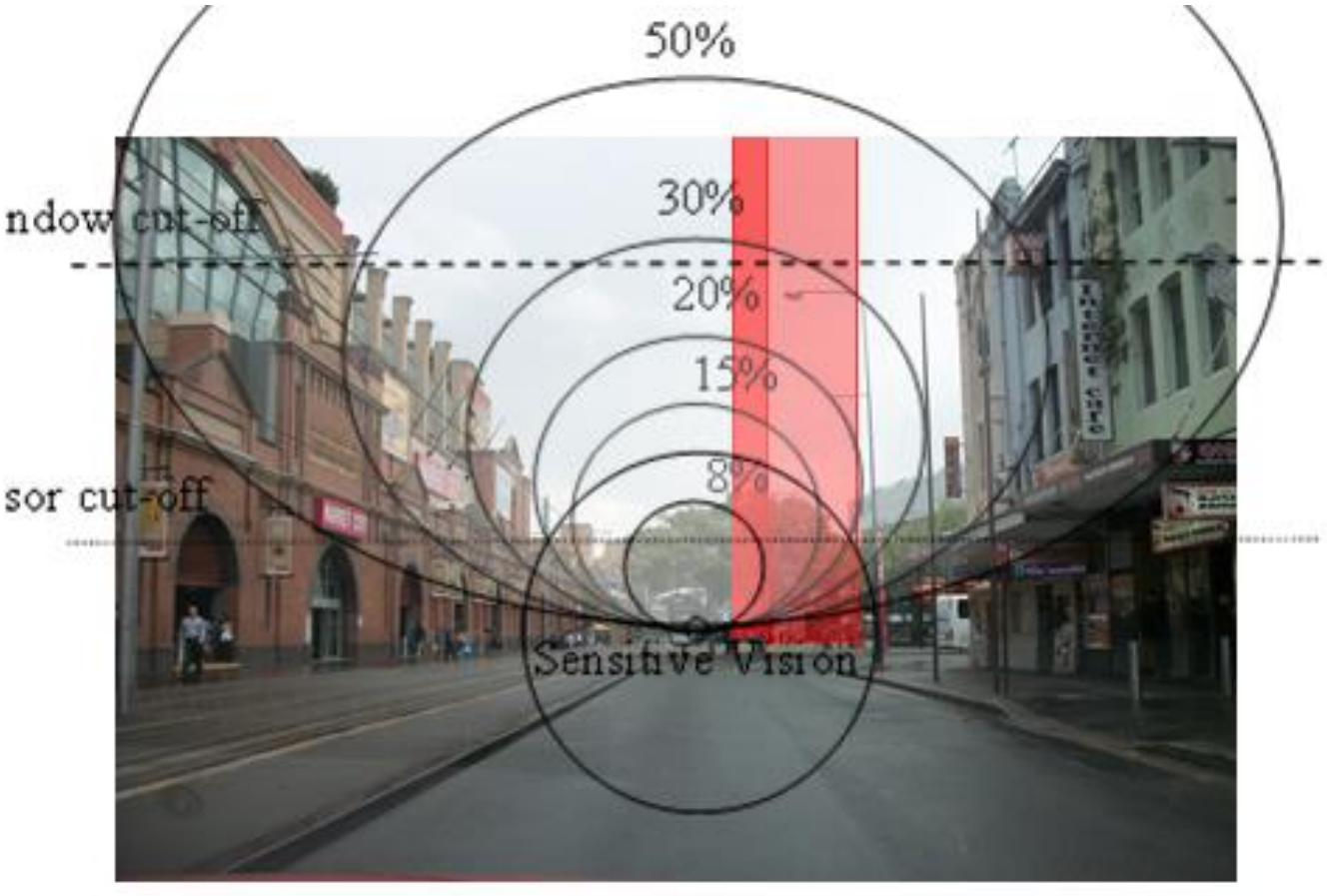


Figure 5: Glare protractor on Hay Street at the bend turning north, westward view.

A Hassall glare protractor is used to investigate potential solar glare impacts on the westbound motorist. With reference to Figure 5, it is evident that reflections from the southern facade of SW3 fall within the sensitive vision zone.

The southern façade of SW3 will comprise mostly painted concrete with minimal potential for reflective glare. Living rooms and balconies protruding from the southern façade contain glazing elements in the form of windows and balustrades, Figure 4.

Whilst the glazing to the SW3 southern façade is minimised, the potential for glare to be generated from these glazing elements increases significantly when incoming solar rays can impact on a building close to parallel to the plane of the glazing, i.e. a glancing reflection. Designers have therefore incorporated vertically aligned opaque elements against the facade to block high incident angle solar reflections able to impact on the sensitive vision zone of approaching motorists. The vertical elements will need to run perpendicular to the façade line over the height of the tower and be spaced horizontally.

A depth ratio of 1:6 was calculated to provide sufficient solar blockage and is being adopted whereby the element needs a depth of 1 unit for every 6 units of glazing width being protected; for example a mullion extending 100 mm proud of the glazing line will need to be placed at 600 mm horizontal centres. The final dimensions will be chosen during detailed design but will comply with this ratio. Designers will comply through a combination of reverse mullions and sufficient reveal depths to the Living room south glazing to provide this ratio. Balustrades will be fritted or solid to eliminate reflectivity.

<u>The Boulevard/Quay Street travelling north toward the site</u>

The greatest potential for the proposed SICEEP Haymarket SW Plot developments to generate reflections onto the Boulevard/Quay Street is solar interaction with the eastern facades of SW2.

The highest TI values calculated for this facade were caused by midday reflection conditions. Higher altitude solar rays during the winter months strike the eastern façade of SW2 from the north with reflections towards the south along the Boulevard. TI values were found to be below criterion levels of 20 due largely to the relatively high altitude of the sun (refer Holladay formula). Further, at midday the altitude angle of incident solar rays is high enough to be cut off by the windscreen roof of most vehicles.

Darling Drive

The greatest potential for the proposed SICEEP Haymarket SW Plot developments to generate reflections onto Darling Drive is solar interaction with the western facades of SW1.

The highest TI values calculated for this facade were caused by early afternoon reflection conditions. Higher altitude solar rays during the winter months strike the western façade of SW1 from the north with reflections towards the south along Darling Drive. Again, TI values were found to be below criterion levels of 20 due largely to the relatively high altitude of the sun (refer Holladay formula). Further, at midday the altitude angle of incident solar rays is high enough to be cut off by the windscreen roof of most vehicles.

Other Surrounding Locations

Given the height of the SW3 tower, there is potential for facades to cast solar reflections beyond the roadways listed above, but TI values will be low. For example, southbound traffic on Harbour Street approaching Pier Street for the north; some mid-morning winter events were identified but below the TI criterion level.

Lend Lease will ensure all exterior façade elements used throughout the development will limit light reflectivity to 20% or less as required under the Sydney Development Control Plan 2012. Low glazing reflectivity coefficient on these facades will also be of benefit to pedestrian users of the precinct in areas such as the Chinese Gardens.

Diffuse Reflections

Other façade and roof ancillaries to be developed during detailed design should each be assessed for potential to generate nuisance reflections. Elements such as external louvers, metallic awnings, photovoltaic arrays, signage, blade walls, and masonry walls have potential to generate localised glare of both a diffuse and specular nature. Assessment of these is not made in the current study but will be assessed during detailed design.

## 6. CONCLUSIONS

Lend Lease will ensure all exterior façade elements used throughout the development will limit light reflectivity to 20% or less as outlined under the Sydney Development Control Plan 2012.

To meet the qualitative requirements of the Sydney Development Control Plan 2012, this reflectivity analysis has assessed the potential for the proposed developments to cause adverse glare events at surrounding motorway locations.

In summary, with the measures adopted by the designers as described in this report regarding choice of façade materials and façade articulation, the proposed SICEEP Haymarket South West Plot development does not present a driver hazard in terms of solar glare and will meet the Sydney Development Control Plan 2012 controls for reflectivity.

## 7. REFERENCES

Australia/New Zealand Standard AS/NZS 1158.1.1:2005 "Lighting for Roads and Public Spaces" Part 1.1: Vehicular Traffic (Category V) lighting – Performance and design requirements".

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

### Architectural Drawings

Assessment of reflectivity in this report has been based upon DCM architectural drawings dated May 2013.