Appendix M

Reflectivity Impact Assessment

Sydney Metro West

Hunter Street East Over Station Development Reflectivity Impact Assessment

Appendix M

November 2022

NSW GOVERNMENT

sydney METRO

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Glossary

Term	Definition
2D	Two-dimensional
3D	Three-dimensional
CAD	Computer-aided design
CBD	Central business district
Concept and Stage 1 CSSI Application	Application SSI-10038, including all major civil construction works between Westmead and The Bays, including station excavation and tunnelling, associated with the Sydney Metro West line
Concept SSDA	A concept development application as defined in Section 4.22 of the EP&A Act, as a development application that sets out concept proposals for the development of a site, and for which detailed proposals for the site or for separate parts of the site are to be the subject of a subsequent development application or applications.
Council	City of Sydney
CSSI	Critical State Significant Infrastructure
DCP	Development control plan
DPE	Department of Planning and Environment
EP&A Act	*Environmental Planning and Assessment Act 1979*
FSR	Floor space ratio
GFA	Gross floor area
Hassall's Method	The method outlined in David N. H. Hassall's (1991) 'Reflectivity: Dealing with rogue solar reflections' publication
LV	Veiling luminance
OSD	Over Station Development
SEARs	Secretary's Environmental Assessment Requirements
SSDA	State Significant Development Application
SSI	State Significant Infrastructure
Stage 2 CSSI Application	Application SSI-19238057, including major civil construction works between The Bays and Hunter Street Station
Stage 3 CSSI Application	Application SSI-22765520, including rail infrastructure, stations, precincts and operation of the Sydney Metro West line
Sydney Metro West	Construction and operation of a metro rail line and associated stations between Westmead and the Sydney CBD as described in section 1.1
TfNSW	Transport for New South Wales

Executive summary

This Reflectivity Impact Assessment Report supports a Concept State Significant Development Application (Concept SSDA) submitted to the Department of Planning and Environment (DPE) pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The Concept SSDA is made under section 4.22 of the EP&A Act.

Sydney Metro is seeking concept approval for a commercial tower above the Hunter Street Station eastern site (the site), otherwise known as the over station development (OSD).

The Concept SSDA seeks consent for a building envelope and its use for a commercial and retail premises, a maximum building height of 58 storeys (257.7 m, reduced level 269.10), a maximum gross floor area (GFA) of 84,223 m^2, pedestrian and vehicular access, circulation arrangements and associated car parking and the strategies and design parameters for the future detailed design of development.

This Reflectivity Impact Assessment Report responds specifically to the Secretary's Environmental Assessment Requirements (SEARs) and provides a summary of the risk of "veiling glare", also known as "disability glare", measured by the veiling luminance, for the Hunter Street East OSD (referred to hereafter as the 'proposed development'). For the proposed development, located on the corner of O'Connell Street and Hunter Street the veiling luminance was calculated at discrete points, representative of sensitive receptors traversing routes within the vicinity of the proposed development. Glare impact on nearby buildings is not considered within the assessment due to state of the design, these assessments will be considered in future detailed design deliverables when the materiality has been determined. A conservative approach has been considered by assuming entirely glazed facades without external shading elements on the façade and future developments that might otherwise shield glare.

Three routes were tested, with no routes expected to have veiling luminance impacts above the 500 cd/m^2 criteria.

Calculation of glare impact on pedestrians around the development was considered but deemed irrelevant as hazards introduced by glare risk to pedestrians is significantly lower compared to drivers. Results also indicated that glare risk to drivers is already minimal.

1 Introduction

1.1 Sydney Metro West

Sydney Metro West will double rail capacity between Greater Parramatta and the Sydney Central Business District (CBD), transforming Sydney for generations to come. The once in a century infrastructure investment will have a target travel time of about 20 minutes between Parramatta and the Sydney CBD, link new communities to rail services and support employment growth and housing supply.

Stations have been confirmed at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock, The Bays, Pyrmont and Hunter Street.

Sydney Metro West station locations are shown in Figure 1-1.

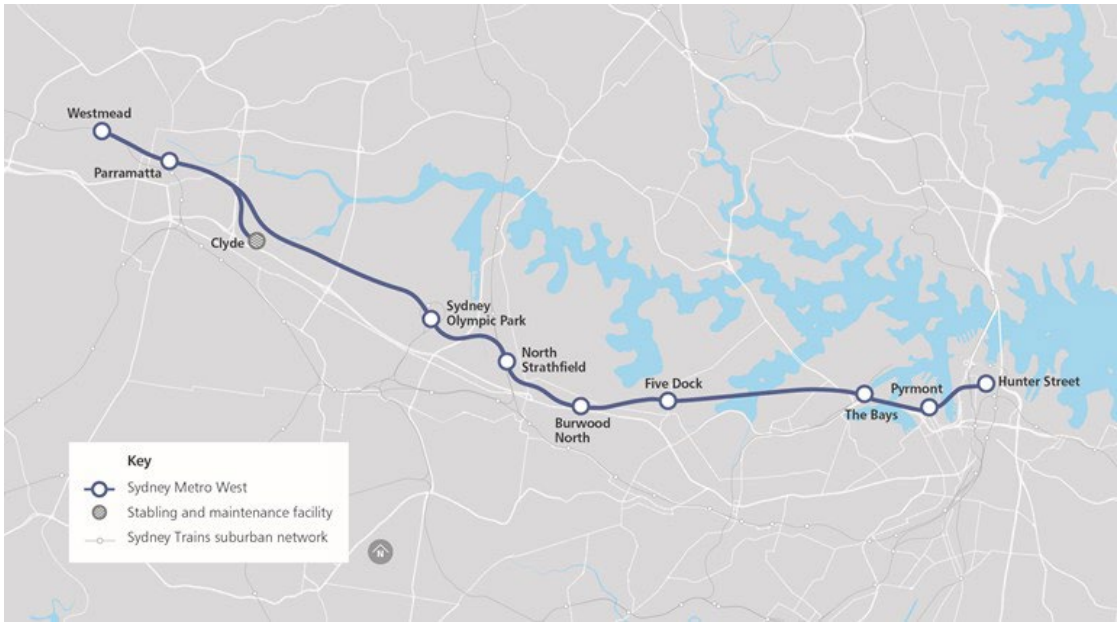

Figure 1-1 Sydney Metro West

1.2 Background and planning context

Sydney Metro is seeking to deliver Hunter Street Station under a two-part planning approval process. The station fit out infrastructure is to be delivered under a Critical State Significant Infrastructure (CSSI) application subject to provisions under Division 5.2 of the EP&A Act, while the over station developments are to be delivered under a State Significant Development (SSD) subject to the provisions of Part 4 of the EP&A Act. It is noted a Planning Proposal request has been submitted to the City of Sydney Council to amend the planning controls on the site (refer to section 1.2.3).

1.2.1 Critical state significant infrastructure

The State Significant Infrastructure (SSI) planning approval process for the Sydney Metro West metro line, including delivery of station infrastructure, has been broken down into a number of planning application stages, comprising the following:

- Concept and Stage 1 CSSI Approval (SSI-10038) – All major civil construction works between Westmead and The Bays including station excavation, tunnelling and demolition of existing buildings (approved 11 March 2021).

- Stage 2 CSSI Application (SSI-19238057) – All major civil construction works between The Bays and Hunter Street Station (approved 24 August 2022).
- Stage 3 CSSI Application (SSI-22765520) – Tunnel fit-out, construction of stations, ancillary facilities and station precincts between Westmead and Hunter Street Station, and operation and maintenance of the Sydney Metro West line (under assessment).

1.2.2 State significant development application

The SSD will be undertaken as a staged development with the subject Concept SSDA being consistent with the meaning under section 4.22 of the EP&A Act and seeking conceptual approval for a building envelope, land uses, maximum building heights, a maximum gross floor area, pedestrian and vehicle access, vertical circulation arrangements and associated car parking. A subsequent Detailed SSDA is to be prepared by a future development partner which will seek consent for detailed design and construction of the development.

1.2.3 Planning proposal

A Planning Proposal request has been submitted to the City of Sydney Council to amend the planning controls that apply to the Hunter Street Station under the Sydney Local Environmental Plan 2012 (LEP). Hunter Street Station includes both an eastern site (this application) and a western site.

The Planning Proposal request seeks to enable the development of a commercial office building on the site that would:

- comprise a maximum building height of between reduced level (RL) 257.7m and RL 269.10m (as it varies to comply with the relevant sun access plane controls)
- Deliver a maximum gross floor area (GFA) of 84,287m^2 (resulting in a maximum floor space ratio (FSR) of 22.82:1), measured above ground level.
- Facilitate the adaptive reuse of the existing Former Skinners Family Hotel within the overall development.
- include site specific controls which ensure the provision of employment and other non-residential land uses
- Require the mandatory consideration of a site-specific Design Guideline.
- Allow for the provision of up to 70 car parking spaces.
- Establish an alternative approach to design excellence.

The Planning Proposal request was submitted to the City of Sydney in May 2022 and is currently under assessment.

1.3 Purpose of the report

This Reflectivity Impact Assessment Report supports a Concept SSDA submitted to the Department of Planning and Environment (DPE) pursuant to Part 4 of the EP&A Act. The Concept SSDA is made under section 4.22 of the EP&A Act.

This report has been prepared to specifically respond to the Secretary's Environmental Assessment Requirements (SEARs) issued for the Concept SSDA on 8 August 2022 which states that the environmental impact statement is to address the following requirements.

SEARs requirements	Where addressed
Assess amenity impacts on the surrounding locality, including lighting impacts, reflectivity, solar access, visual privacy, visual amenity, view loss and view sharing, overshadowing and wind impacts. A high level of environmental amenity for any surrounding residential or other sensitive land uses must be demonstrated	Section 4 – The proposal

This Reflectivity Impact Assessment Report assesses the proposal for any glare resulting from sun light glancing off the façade and any impact on vehicles and pedestrians moving around the site and/or on nearby roads.

2 The site and proposal

2.1 Site location and description

Hunter Street Station is in the northern part of the Sydney CBD, within the commercial core precinct of Central Sydney and within the Sydney Local Government Area (LGA). The Hunter Street Station includes two sites – the eastern site and the western site. This report relates to the eastern site only.

The Hunter Street Station eastern site (the site) is on the corner of O'Connell Street, Hunter Street and Bligh Street adjacent to the existing CBD and South East Light Rail that extends from Circular Quay to Moore Park, Kensington and Kingsford. The east site is adjacent to the new Martin Place Station which forms part of the Sydney Metro City and Southwest, Australia's biggest public transport project connecting Chatswood to Sydenham and extending to Bankstown. The remainder of the site is currently occupied by commercial office buildings and a range of ground floor business premises including retail, restaurants and cafes.

The site area is 3,694 m^2 and will be cleared of all buildings and utilities prior to commencement of station construction activities. The site location is shown in Figure 2-1.

Figure 2-1 Location of the site

Table 2-1 sets out the address and legal description of the parcels of land that comprise the site.

Table 2-1 Site legal description

Address	Lot and DP
28 O'Connell Street, Sydney	Lot 1, DP217112
28 O'Connell Street, Sydney	Lot 1, DP536538
28 O'Connell Street, Sydney	Lot 1, DP1107981
48 Hunter Street, Sydney	Lot 1, DP59871
48 Hunter Street, Sydney	Lot 2, DP217112
33 Bligh Street, Sydney	Lot 1, DP626651
37 Bligh Street, Sydney	CP and Lots 1-14, 21-31, 33-36, and 40, SP58859
37 Bligh Street, Sydney	CP and Lots 41-49, SP61852
37 Bligh Street, Sydney	CP and Lots 50-57, SP61922
37 Bligh Street, Sydney	CP and Lots 58-65, SP61923
37 Bligh Street, Sydney	CP and Lots 66 and 67, SP63146
37 Bligh Street, Sydney	CP and Lots 67-70, SP63147
37 Bligh Street, Sydney	CP and Lot 72, SP74004
37 Bligh Street, Sydney	CP and Lots 75-82, SP87437
37 Bligh Street, Sydney	CP and Lots 73-74, SP87628
	Total Area: 3,694 sqm

2.2 Overview of this proposal

The Concept SSDA will seek consent for a building envelope above the site (the proposed development). As detailed in Table 2-2 and Figure 2-2.

Table 2-2 Proposed development overview

Built form component	Proposed development outcome
Site area	3,694m^2
Height	Building height of 257.7m (RL 269.10)
Gross floor area	Up to 84,223m^2
Land use(s)	Commercial office and retail
Carparking	Up to 70 car parking spaces

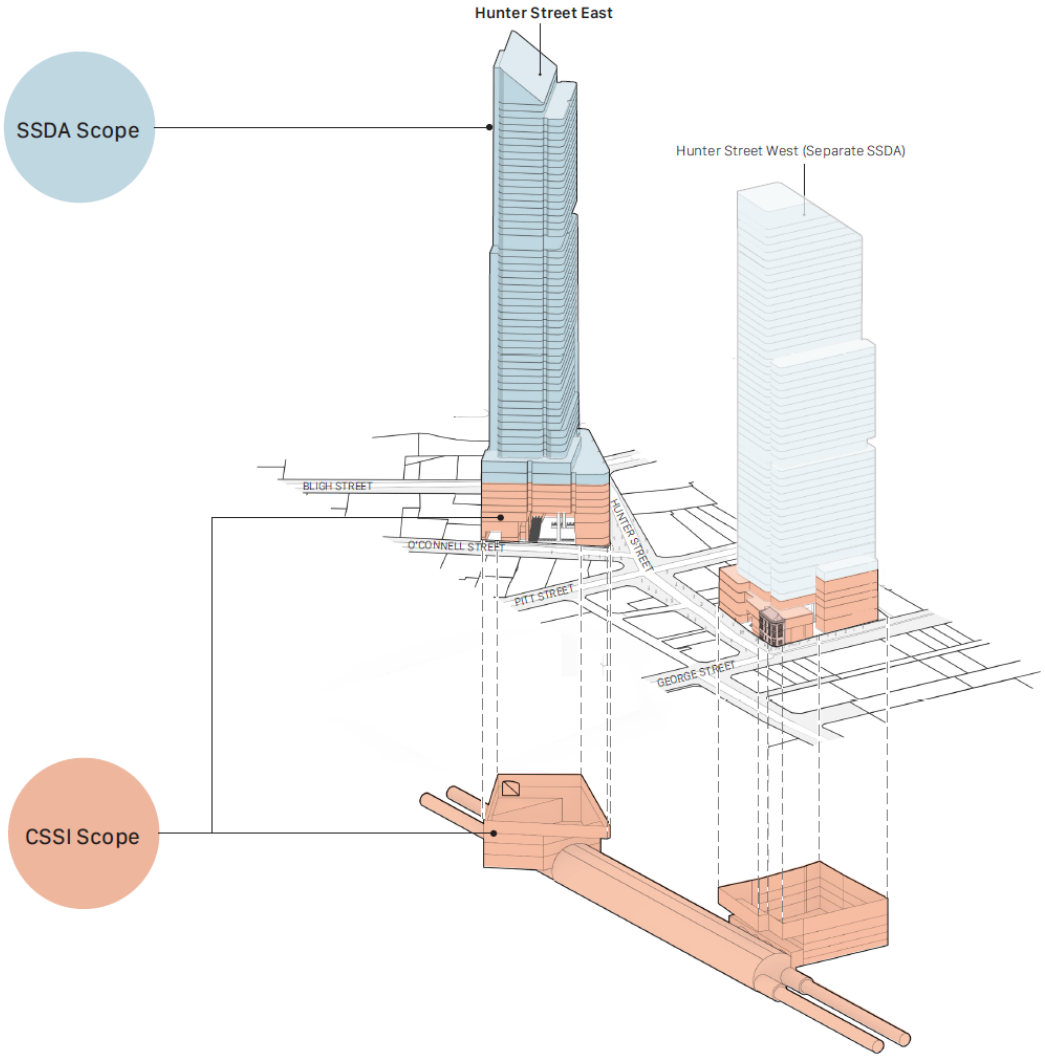

Figure 2-2 Proposed Concept SSDA development and CSSI scope

3 Scope of assessment

The built form and surrounding developments are shown below in Figure 3-1. This assessment only considers the potential reflectivity impacts from the proposed development shown in blue. The analysis assumes that the facades are fully glazed and without any obstructions by way of external elements. Therefore, the risk of glare hazard for drivers can be understood.

Glare analysis simulations were completed across three different local road routes for drivers. Luminescence values across the year are calculated and are presented for each route for the site.

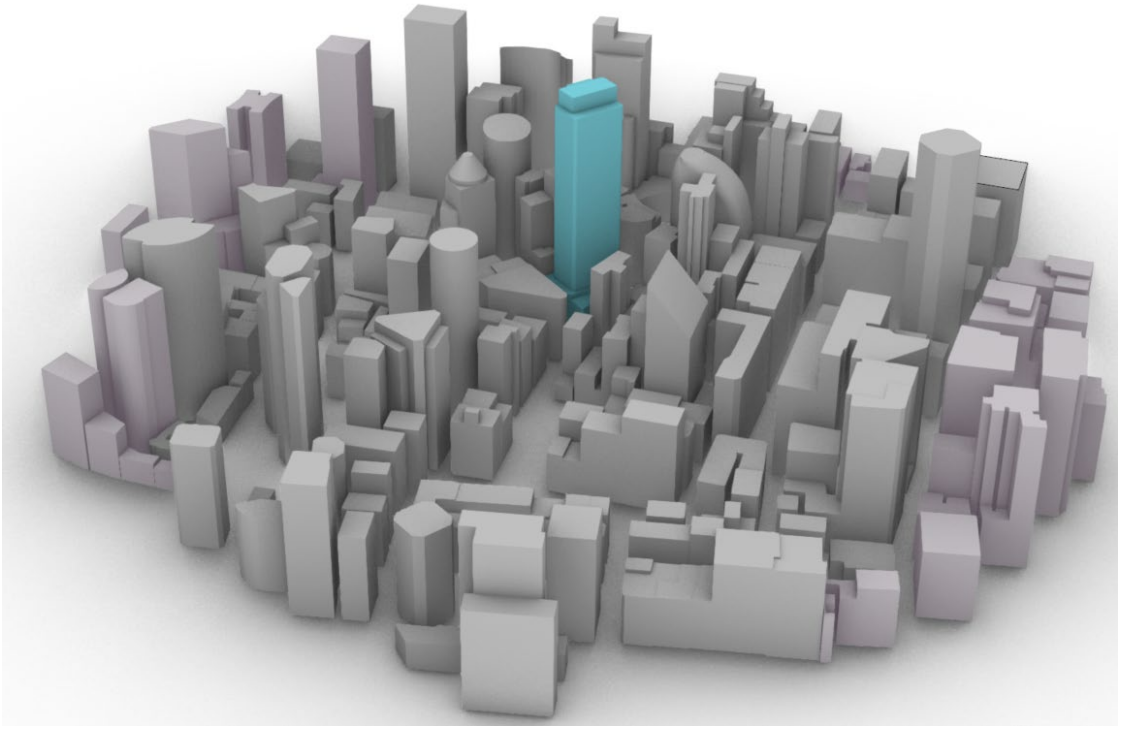

Figure 3-1 Site and surrounds model

3.1 Assessment criteria

The City of Sydney's development consent conditions have been considered, with the relevant sections reproduced below, when preparing this report.

This document has a provision to address reflections from glazed facades. However, it does not prescribe a value or description around what constitutes a reflectivity impact or what would be considered a dangerous level of glare from the development. Therefore, the Hassall method and criterion (refer to section 4) will be used to quantify the reflectivity impact from the development and to show that the development can be formed and constructed in such a way that any potential glare can be mitigated such that it does not cause discomfort or threaten the safety of drivers.

3.1.1 City of Sydney's - Development Control Plan

The Council's standard development conditions acknowledge the requirements outlined in the December 2012 City of Sydney development control plan (DCP), being the most developed and relevant to the proposed development.

Reflectivity

Objectives

(a) Minimise the reflection of sunlight from buildings to surrounding areas and buildings.

(b) Ensure that building materials do not lead to hazardous, undesirable or uncomfortable glare to pedestrians, motorists or occupants of surrounding buildings.

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%.

(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%.

4 Assessment

4.1 Glare characteristics

The term “glare” describes adverse visual effects caused by large contrasts of luminance in the visual field. As such, glare is likely more significantly felt at times of low background luminance (e.g. during dawn and dusk hours) as compared to those of high background luminance (e.g. high noon), even if the amount of solar reflections from building surfaces remain the same.

There are many different types of glare, the impacts of which may range from causing mild discomfort to temporary blindness, illustrated in Figure 4-1. For this proposed development, the type of glare of concern is “veiling glare”, also known as “disability glare”. It is caused by multiple reflections and the scattering within the eye by direct light from a bright source. It produces a perception that a thin veil has been overlaid on the visual scene, which can reduce the luminance contrast, impair visual tasks, and at times cause temporary blindness.

It is critical that sensitive receptors and particularly that of a driver, views are unaffected by disability glare, as this has the potential to cause road accidents. The Hassall methodology focuses on prediction of this glare by calculating veiling luminance.

Figure 4-1 Illustration of potential disability glare

Source: CBS58, 2020

4.2 Methodology

The method for this study is based on David N. H. Hassall's (1991) 'Reflectivity: Dealing with rogue solar reflections' (Hassall's Method), which is widely used to assess reflections off building projects in Sydney. The following steps were followed to undertake this assessment:

- Performed a high-level desktop assessment of at-risk drivers with the potential to experience disability glare from the proposed development by assessing site aerial imagery
- Created a simplified three-dimensional (3D) model of the proposed building and surrounding context, including buildings, roads, topography and any other significant structure that may impact the reflectivity of the site (refer to Figure 3-1) The model excludes small scale details such as joints, any expressed framing profiles, downpipes, etc. as they subtend insufficient angles in the visual field to reflect a large enough portion of the sun disk to cause unacceptable glare
- Selectively identified sensitive receptor (driver) locations based on possible routes of approach and retreat from the development
- Undertook parametric modelling (refer to section 4.2.3) to assess reflectivity impacts of the proposed development on sensitive receptors based on sun paths in NSW
- When the sun is reflected towards any observer, the equivalent veiling luminance in the eye of the observer is calculated and evaluated against the maximum allowed level of 500 cd/m^2, as per Hassall's Method. This involves calculations of the strength of solar illumination, the position of the sun, the apparent position of the sun reflected in the façade, and the reflected solar illumination received by the observer.

4.2.1 Calculating veiling luminance

Veiling luminance (LV) is a parameter used to predict veiling glare (Van Derlofske, n.d.). Hassall (1991) proposed a workflow to estimate this by tracking solar geometry, estimating sun intensity, establishing actual façade reflectance, and numerically calculating a measure for the veiling effect. Veiling luminance is measured in cd/m² (candela per metre squared) and is a representation of apparent brightness to the human eye. The veiling luminance accounts for the angular distance of the glare source from the centre of focus.

4.2.2 Assumptions and limitations

The analysis and results presented in this report are only accurate and valid for the design assessed.

The following assumptions have been made.

- Glare risk hierarchy is considered by the following precedence: driver > tram operator > pedestrian. If low luminescence values for drivers are present, testing for tram driver and pedestrian reflectivity is not necessary
- The built form (mass/scale and orientation) and surrounding development was developed from the Reference Scheme Drawings (Appendix H of the EIS). This was then converted for use in Rhino software
- Surface roughness and small details have a negligible impact
- All facades are glazed

- Drivers are looking ahead in the direction of the road they are driving on
- Assessment heights are based on the assumed eye level of the person: vehicle driver – 2 m (Aberdeenshire Council, 2015)
- No reflections from other buildings within the vicinity
- No obstructions from the streetscape (e.g. vegetation, signage, etc.) within the vicinity
- Reflections from construction methods (e.g. metal rivets, etc.) are not considered
- Cloud coverage is not included, ensuring assessment of the worst-case scenarios
- Only select routes are assessed
- Base case assumes sun visors are not used, which determines the worst-case scenario
- Glare analysis of nearby buildings will not be included as the glare experienced by these buildings is typically lower, and the risk is lower
- Distance between assessment points on the façade of the building is 7 m, due to the size of the building facades, this distance between points allows for a high resolution and a high façade point density so that results are accurate
- For the base case, the visible light external reflectance (VLR) is 20%, with an angular specular reflectivity specification (S_R) that changes with the angle of incidence (I) as shown in Table 4-1.

Table 4-1 Assumed reflectivity of glazed surfaces with angle of incidence

I (deg)	0	10	20	30	40	50	60	70	80
S_R	0.19	0.183	0.181	0.184	0.194	0.212	0.247	0.332	0.542

Source: Hassall 1991

4.2.3 Parametric modelling

The method outlined by Hassall (1991) was implemented in a parametric modelling (Grasshopper and Ladybug (version 1.2.0) within Rhino 7) framework to consider the shielding effects of surrounding buildings, and hence provide a more realistic approach. Parametric modelling also enables the assessment of different days and times throughout the year to be automated. Thus, allowing the assessment at one-hour intervals throughout the entire year.

Grasshopper is a visual programming language and environment that runs within the Rhinoceros 3D computer-aided design (CAD) application. Ladybug imports standard EnergyPlus Weather files (.EPW) into Grasshopper. It provides a variety of two-dimensional (2D) and three-dimensional interactive climate graphics that support the decision-making process during the early stages of design. Ladybug also supports the evaluation of initial design options through solar radiation studies, view analyses, sunlight-hours modelling, and more. Integration with visual programming environments allows instantaneous feedback on design modifications and a high degree of customization.

Grasshopper can be used to undertake ray tracing and automate the calculation methods outlined by Hassall (1991). The ray tracing method in Grasshopper determines the position of the sun, for every hour of the year, the direction that the ray of light will impact the façades of the building and the direction of the reflected ray from the building facades (Figure 4-2). Using this information, it can be determined if the reflected sun ray intersects with the sensitive receiver and what the overall impact will be, based on Hassall's method.

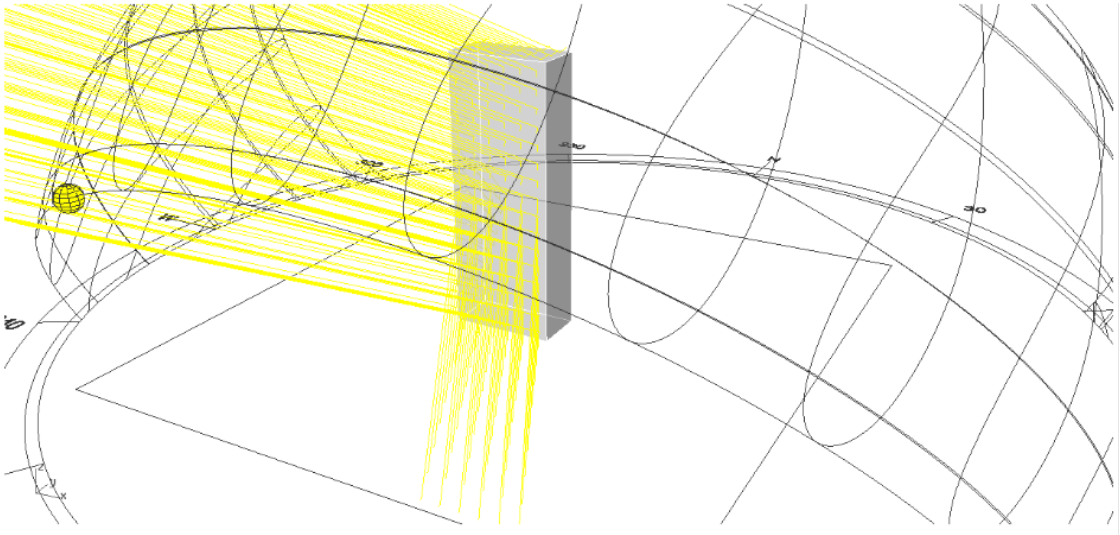

Figure 4-2 Ray tracing within Rhino using Grasshopper/Ladybug Tools

4.2.4 Assessment criteria

The impact of glare is subjective as it varies for different people, what may be considered as mildly annoying for one person could cause temporary blindness in another. As such, Hassall (1991) proposed a veiling luminance limit of 500 cd/m², based on the Holladay formula, would be a practical and acceptable amount of reflected solar glare to which a driver should be exposed. Where this is exceeded, solar reflections are considered as potentially causing disability glare. This approach has been adopted in the present assessment and accepted as industry best practice.

4.3 Impact assessment

4.3.1 Rationale for route definition

There are many approach routes for passenger vehicles (drivers) to the site. Three assessment routes were selected based on these approach routes and their likelihood of being impacted by reflections from the proposed development as identified on a solar diagram for the site. The selected routes are shown below in Figure 4-3 and include the paths:

- Route 1: Drivers travelling south Bligh Street
- Route 2: Drivers travelling east along Hunter Street
- Route 3: Drivers travelling west along Hunter Street.

Adding an additional route for drivers travelling south along O'Connell Street was also investigated. However, angle of the sun with respect to the façade and receiver combined with the shading context of surrounding high-rise buildings would result in minimal glare to drivers on this route.

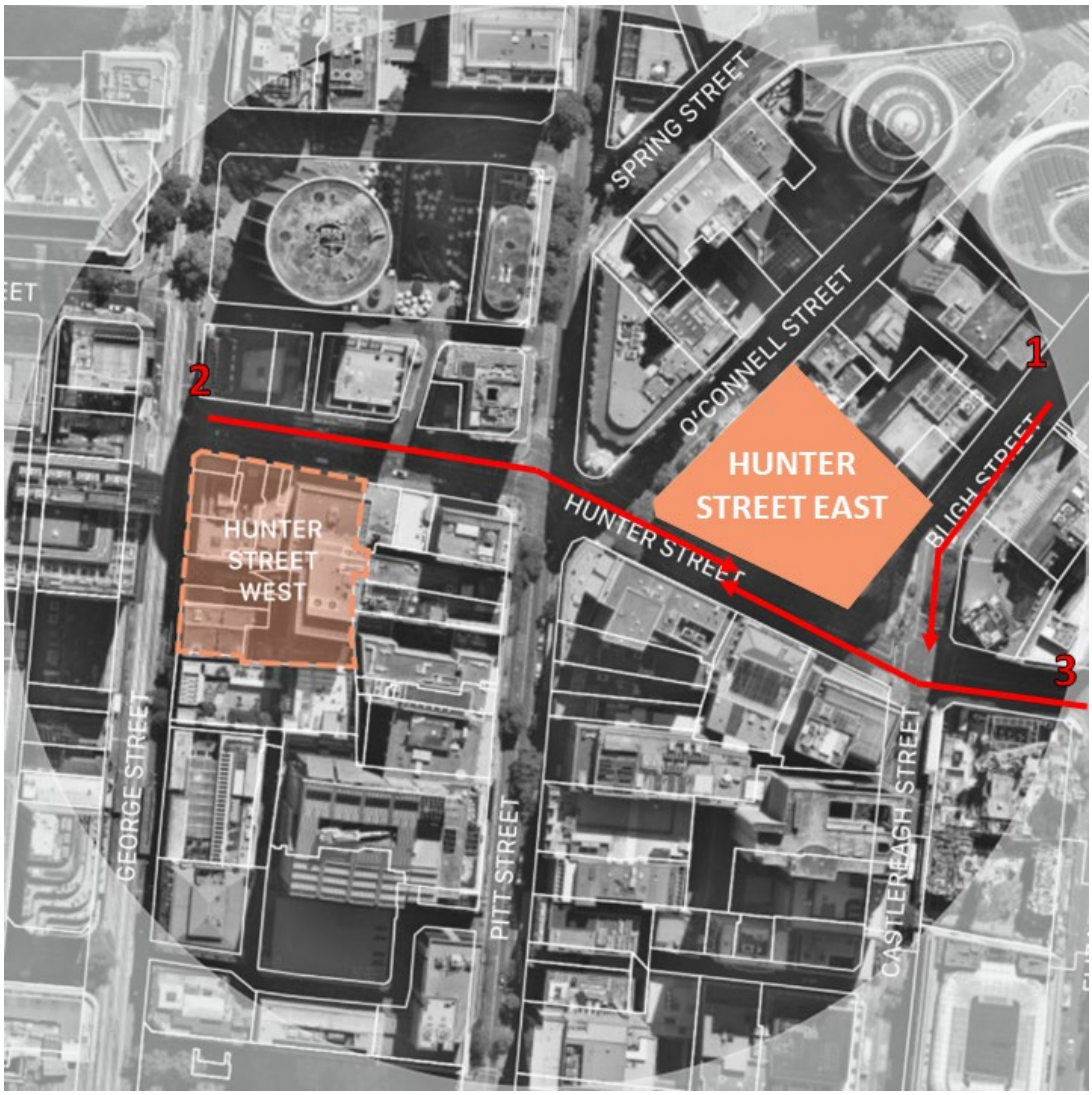

Figure 4-3 Assessment routes of the site

For each assessment route, 11 locations equidistantly spaced along the route are assessed. With the first assessment location originating at the start of the route and the last at the end of the route. Assessment point locations can be seen within Figure 4-4 to Figure 4-6, with the assessment locations labelled inclusively 1 (start) through to 11 (end).

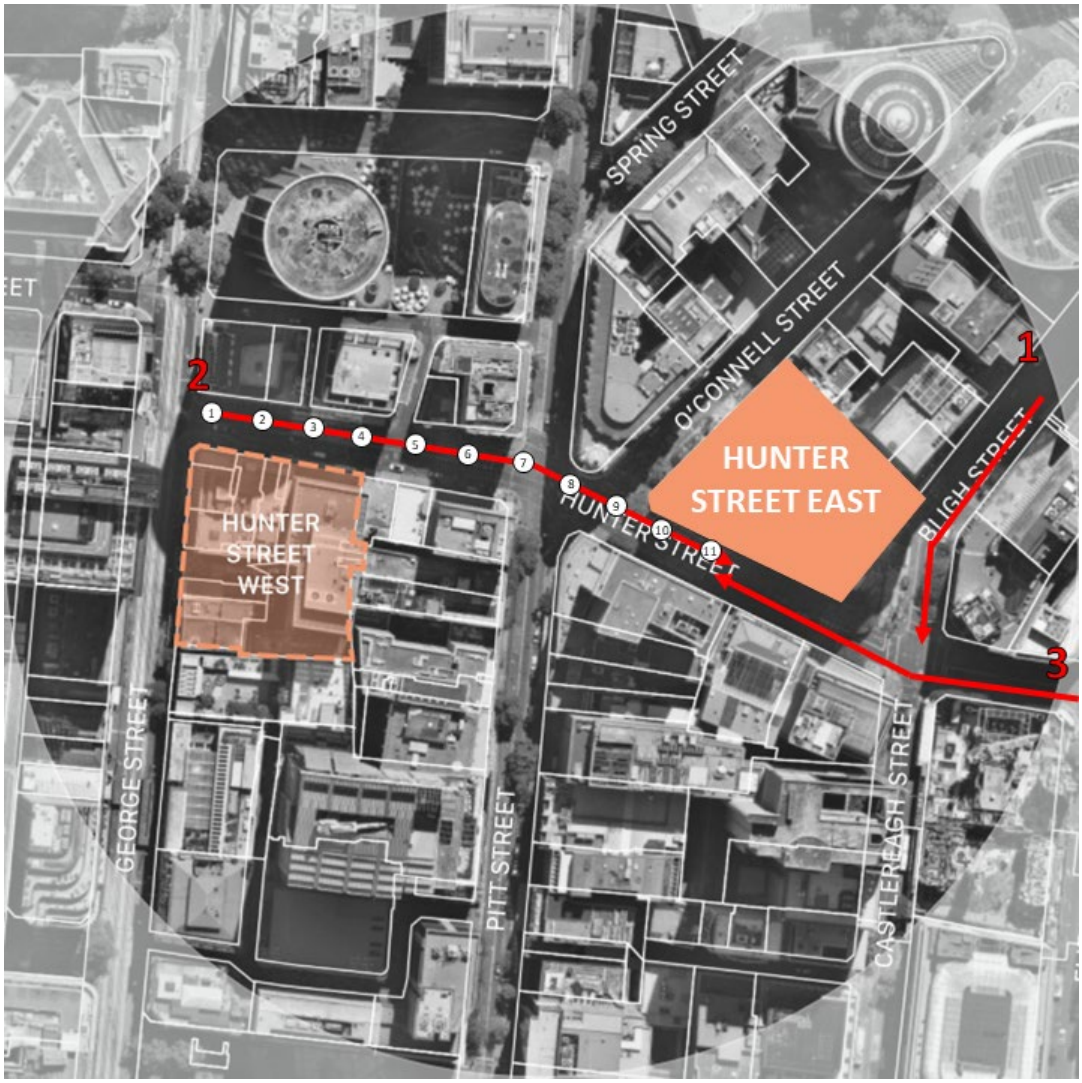

Figure 4-4 Site assessment locations for route 1

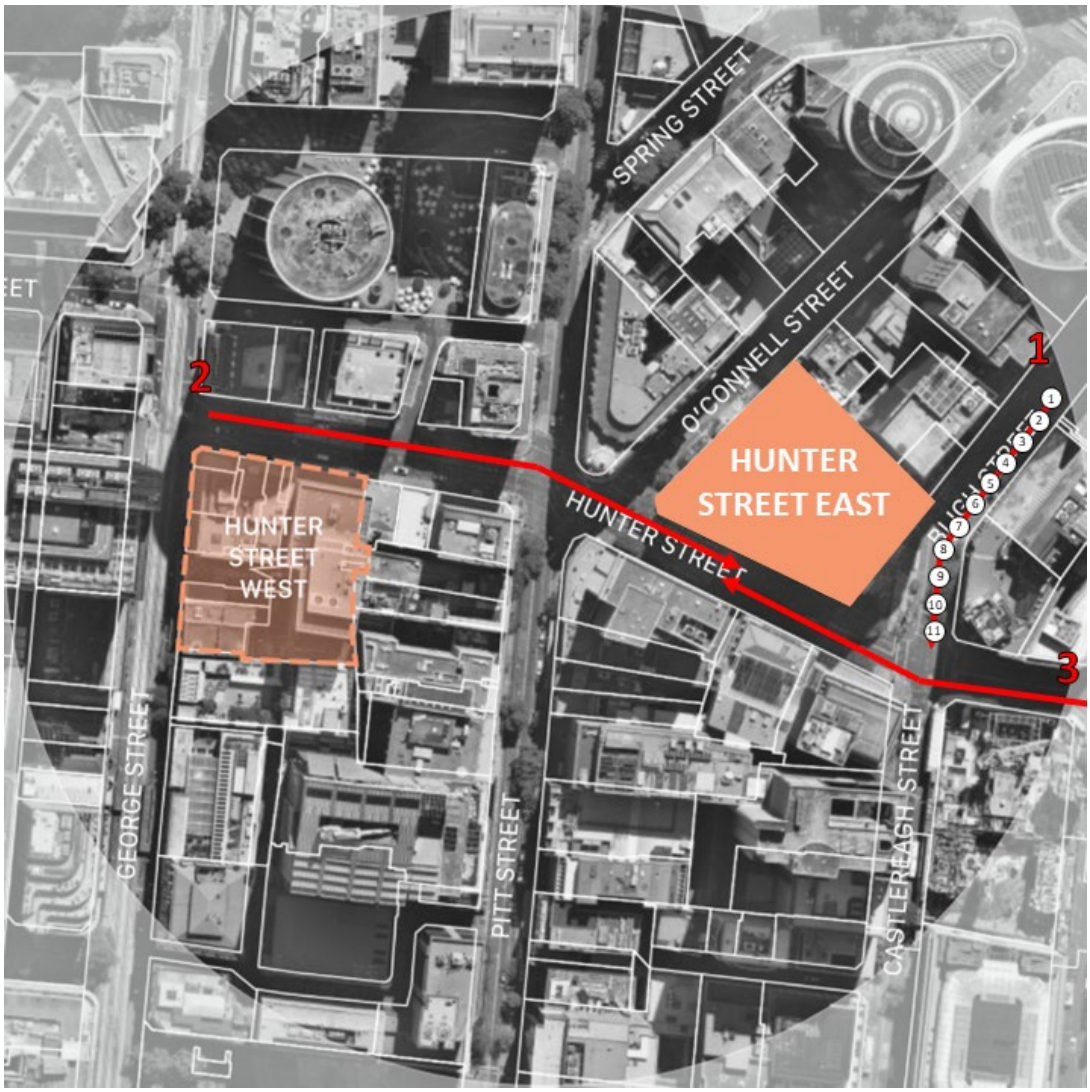

Figure 4-5 Site assessment locations for route 2

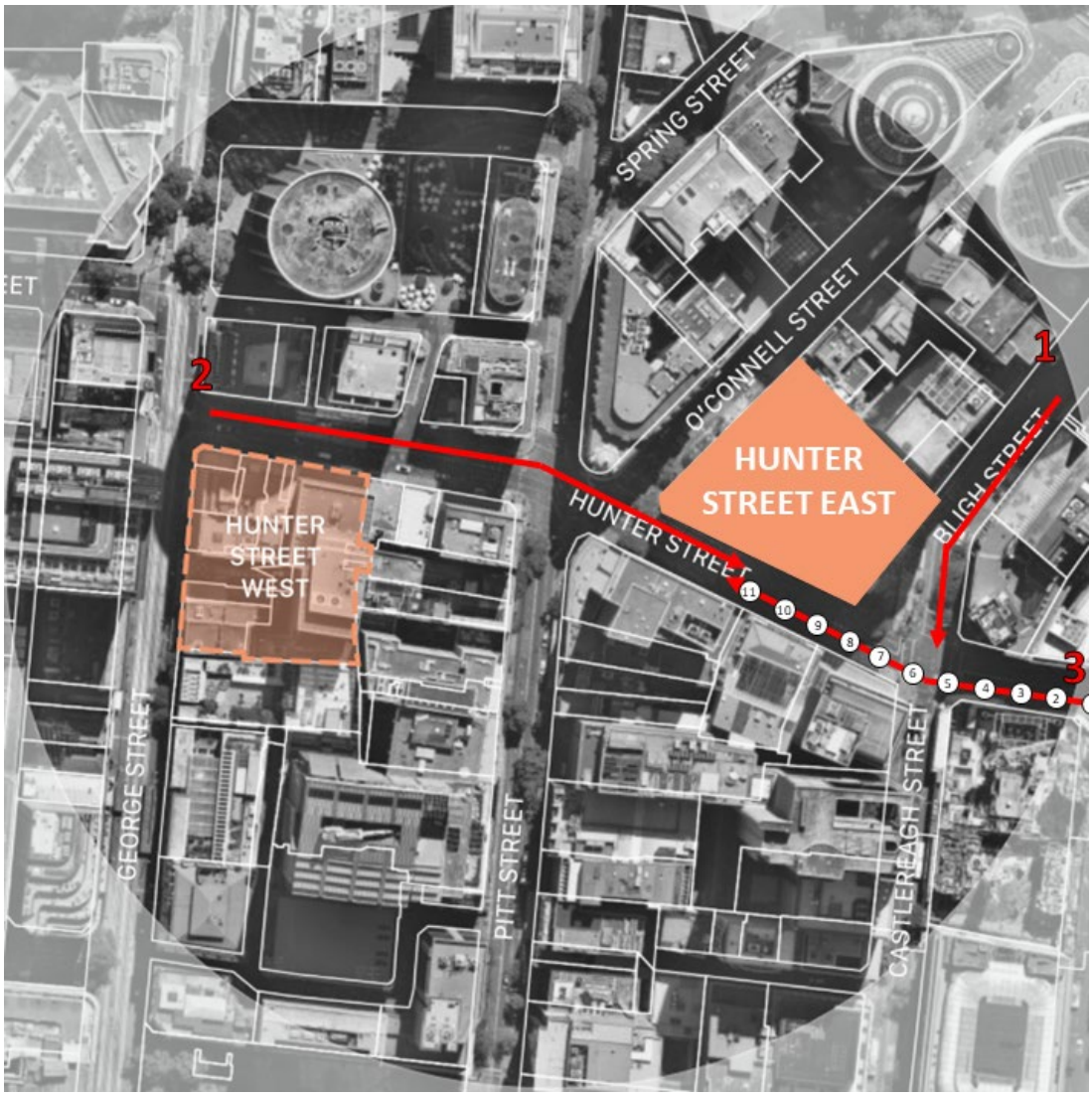

Figure 4-6: Site assessment locations for route 3

4.4 Results and discussion

The base case assumes that standard glazing is used for all façades. For the three routes simulated, there was no disability glare/exceedances of 500 cd/m^2 for drivers along those routes at any point during the day.

Maximum veiling luminescence for a particular route, building and driver is determined by several factors:

- density of the surrounding buildings
- reflectivity values of the façade in place
- driver orientation with respect to the façade
- sun path and trajectory, hourly throughout the year
- angles between the sun, the façade, and the driver
- shading of reflective traces from other buildings, trees, or general obstructions.

Maximum veiling luminescence can be seen as zero due to a strong combination of multiple above factors. For the location and setting of the proposed development, the main factors contributing to a low maximum veiling luminescence are:

- driver orientation with respect to the façade

- angles between the sun, the façade, and the driver
- sun path and trajectory, hourly across 365 days
- shading of reflective traces from other buildings, trees, or general obstructions.

The City of Sydney is a highly dense, built-up environment, with many nearby buildings masking rays of light from the sun either before contact with the façade of interest, after, or a combination of both. Consequently, angles which may contribute to a large source of reflection for the receiver are limited by the angle path in tandem with the suns path. The path of the sun can be observed within Figure 4-7.

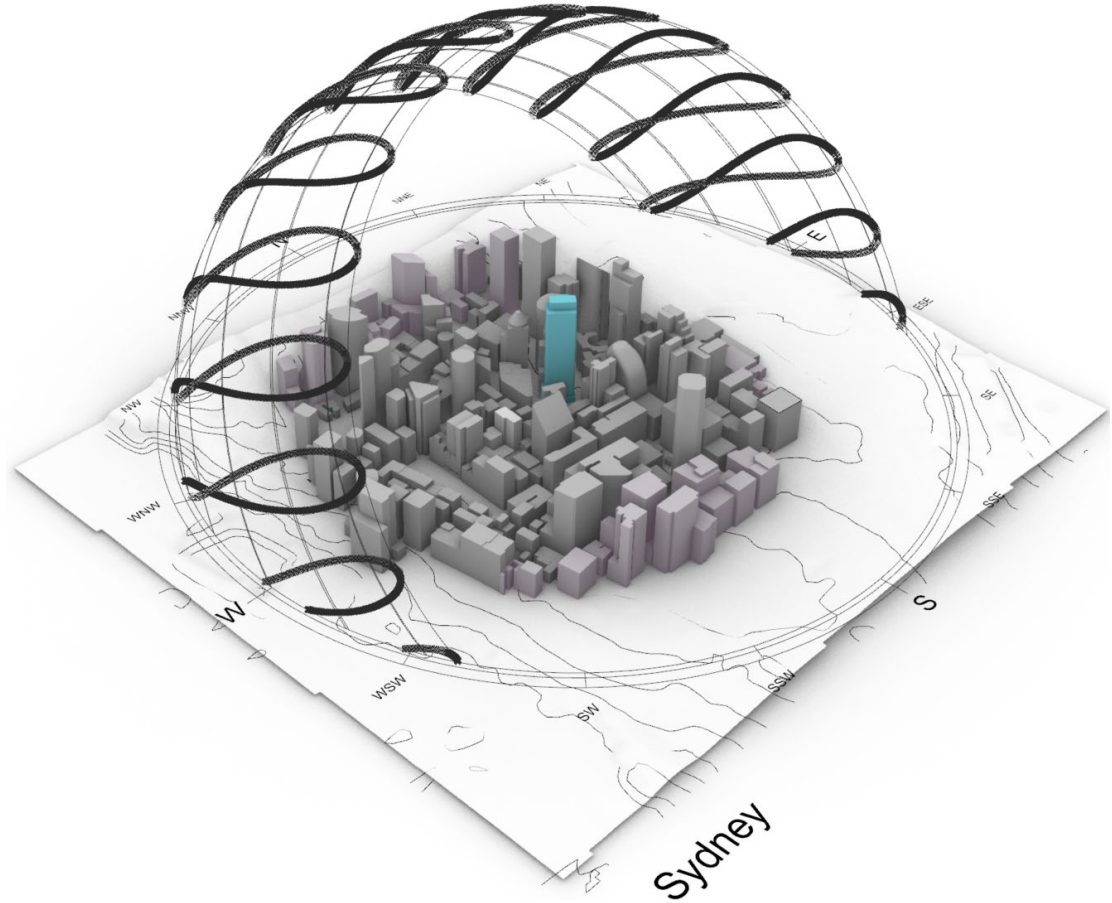

Figure 4-7 Sun path over the year

Table 4-2 Summary of reflectivity simulations

Route assessed	Maximum veiling luminance (cd/m²)	Maximum number of hours LV is at risk of exceeding 500 cd/m² in a day	Comment
Route 1	0	0	No disability glare risks identified
Route 2	0	0	No disability glare risks identified
Route 3	0	0	No disability glare risks identified

5 Conclusion

A reflectivity analysis has been carried out assessing the potential for hazardous glare from the proposed development.

Veiling luminance was calculated at discrete points, representative of sensitive receptors for drivers traversing routes within the vicinity of the development. Only vehicles moving within the vicinity of the site were considered as adverse reflections will have the biggest impact on them. Impacts on neighbouring buildings were not considered as the risk was deemed to be minimal and these will be considered at a future detailed design stage when the materiality has been resolved.

A conservative approach has been considered by assuming entirely glazed facades without external shading elements on the façade and future developments that might otherwise shield glare. For all assessments undertaken, a veiling luminance limit of 500 cd/m^2 was adopted as the acceptable amount of reflected solar glare to which a driver should be exposed.

It was found that none of the proposed routes had assessment locations that were expected to exceed the 500 cd/m^2 limit at points along any of the three routes tested. Therefore, it will not adversely create any reflectivity impacts.

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