Windtech's analysis of the adverse solar glare impact from the subject development is based on the assessment methodology by Hassall (1991) that does not involve the calculation of the veiling luminance, rather it is based on a limiting veiling luminance of 500 cd/m2 and allows the user to assess the acceptability of the reflected solar glare in terms of maximum normal specular reflectance values (%) of the glare source; i.e. the subject development.

The limiting veiling luminance of 500 cd/m^2 was calculated by the Holladay formula and suggested by Hassall (1991) to be a practical limit to reflected solar glare for the comfort of motorists.

Hassall (1991) has developed a glare protractor that provides information about angular limits to glare caused by solar reflections off a glare source (i.e. the virtual sun from the subject development) including a "zone of sensitive vision"; which is an area that is sensitive to adverse glare from a ±10° field of view in both axes (corresponding to azimuth and altitude) of the direct sight-line of the driver vision, and ISO-glare loops indicated for a range of normal specular reflectance values based on the limiting veiling luminance of 500 cd/m2.

The glare protractor is then overlayed onto site photographs obtained from a calibrated camera taken from various sight-lines of motorists around the subject development. The locations were determined by the check zone sun chart procedure by Hassall (1991) and outlined in Section 1.1 of the report. An analysis of the potential impact is then undertaken, whereby recommendations are then provided; to avoid any adverse glare to motorists and pedestrians on the surrounding streets, occupants of neighbouring buildings, in terms of limitations to the maximum normal specular reflectance of visible light of the external façade glazing.

The study point locations were determined through the procedure outlined in Section 1.1 of the report and summarised as follows:

1. *The critical aspects of the subject development that can reflect solar glare were determined. This is indicated in Figure 1 of the report.*

2. *Check zone sun charts were derived for the critical aspects that highlight the areas that are potentially affected by solar reflections from each of the critical aspect. The check zones highlight the areas that are potentially affected by solar reflections from each critical glazed aspect. The check zones were derived from the method published by Hassall (1991) and are based on a virtual sun altitude of up to 10°; which represents the limit of the zone of sensitive vision from the direct sight-line of motorists and occurs when the sun is close to the horizon during the early morning and late afternoon periods. The check zone sun charts for each critical aspect are indicated in Appendix B of the report.*

3. *The check zones derived from the Point above are overlayed onto the site image of the subject development and its surroundings as indicated in Figure 2 of the report.*

4. *Study Point locations were then determined based on the direct sight-line of motorists, and in conjunction (within) the check zones of the critical aspects of the subject development. The study point locations are also indicated in Figure 2 of the report.*

5. *Site survey photographs for the various study point locations were then taken using a specially calibrated camera with additional photographs/study point locations taken where deemed necessary by the site survey.*

Once the site survey photographs were taken, the Hassall glare protractor is overlayed onto the photograph and positioned to the viewpoint of the motorist. The visible general outline/critical

aspects of the subject development are also modelled on the photographs. This is indicated in Appendix A for the various study point locations.

The analysis of the solar glare and recommendations is then undertaken following a methodical approach summarised as follows:

- *Is the view of the development obstructed by buildings, trees etc.? if the view is obstructed then there is no adverse glare reflected onto the motorist.*
- *Is the view of the development (critical aspects) within the zone of sensitive vision? If the view is of the development within the zone of sensitive vision, then there may be potential adverse glare reflected off the development.*
- *Is the study point location within the check zone for any of the visible development? If the study point lies outside the check zone for the visible critical aspect, then there won't be adverse glare reflected off that aspect onto the motorists and vice versa.*
- *Consider if there are factors such as surrounding features or conditions that can impact the reflected solar glare off the critical aspect. This can include:*
    a. *The reflective surfaces of the subject development. This is described further in Section 3 of the report.*
    b. *The obstruction from surrounding features; such as buildings, that may block the incident sun ray to create the reflection of the aspect.*
    c. *Similarly, are there obstructions or shading elements on the subject development that can mitigate the incident sun ray or reflected glare. The sun subtends an angular width 0.5degree arc from the earth's surface. As such obstructions or shading elements that minimises the view of the sun below this angular width can also reduce the intensity of the glare.*
    d. *The sun's path position required for the incident sun ray to reflect off the aspect onto the motorist. The sun chart for the Sydney region is indicated in Appendix C of the report. The sun flows in a curvature bands throughout the year in an east to north to west direction. As such required sun positions in a general east (~55^{o} to 119^{o}) or west direction (~242^{o} to 305^{o}) will produce incident sun ray whereas sun positions outside these ranges will not.*
    e. *Will the actual sun be visible in the motorist's zone of sensitive vision? As a general rule, the actual sun is likely to be visible within the zone of sensitive vision for motorist heading in a general east and west direction (with the likely sun position as mentioned in the point above) and occurs during the early morning and late afternoon period. With the sun visible in the zone of sensitive vision, the intensity of the sun would be more severe than the reflected glare from the aspect to the motorist. Note that this does not mean that the reflectance of the aspect is left unchecked as recommendations will be provided for scenarios where the visible sun may be obscured by surrounding features.*
- *Utilise all of the above to determine the limitations to the maximum normal specular reflectance of visible light of the critical aspects of the subject development.*

The analysis of the solar glare for the various study point locations and recommendations within Section 1.2 of the report follows the methodical approach above. It has been structured to present the relevant information and minimise the convolution of the analysis.
For example, for study point locations where the headings are in the eastern/western directions where the direct sun can be observed within the zone of sensitive vision in the opposite direction, the analysis discussion did not expand on the sun path as according the sun chart in Appendix C, it can be seen that the direct sun would be in the operational range to be visible at the study point locations. According to Appendix C, the sun path operates east and west direction throughout the year within

an approximate range of 55° to 119° and 242° to 305° respectively.
Furthermore, although the intensity of the direct sun would be more severe than the reflected glare off the aspect, our analysis does also provide a recommendation for the normal specular reflectance of the aspect for when the direct sun may be obscured but reflected glare is still possible (e.g. for Figure A.4 we recommend the critical southern aspect to have a maximum normal specular reflectance of 20%).

Commentary has been provided regarding the risk of glare to motorists using the roundabout at the intersection of Good Street and Cowper Street. Please find our response as follow:

- *For motorists heading south along Good Street at the roundabout, the view of the subject development would be outside the zone of sensitive vision and close to perpendicular to the motorists sight-line. Hence, they would not be exposed to adverse glare reflected off the subject development and is the reason why there were no study point locations analysed at this heading.*
- *Similarly, for motorists heading east along Cowper Street at the roundabout, the view of the subject development would be outside the zone of sensitive vision and close to perpendicular to the motorists sight-line.*
- *For motorists heading west along Cowper Street at the roundabout, please refer to the analysis for Study Point location 04 and Figure A.4. Please note the additional commentary provided above regarding the queries about the direct sun/reflected glare and our response regarding recommended reflectance values.*
- *For motorists heading north along Good Street at the roundabout, there was no study point included for this location as from our initial analysis the eastern façade of the subject development has a setback deep enough from Good Street that it would not be within the zone of sensitive vision of motorists at the roundabout. Furthermore, for glare to be reflected off the eastern aspect at this heading, the sun required sun position would outside the sun path for the region as indicated in Appendix C. This is confirmed by the analysis for Study Point location 6 located further south along Good Street, that has the eastern aspect visible within the zone of sensitive vision.*

Date: August 13, 2020

Reference: WE905-08F02(rev0)- SR Memo

To: Starryland NSW Pty Ltd

C/- Property Development Solutions (Aust) Pty Ltd
Level 1, 63 York Street, Sydney, NSW 2000

RE: GRAN CENTRAL, 134-142 PARRAMATTA ROAD, 26-38 GOOD STREET & 56-61 COWPER STREET, GRANVILLE
SOLAR LIGHT REFELCTIVITY RESPONSE MEMO

This memo provides comments on the responses provided by Flux(report ref: DA_655_2019 - 134-142 Parramatta Road Granville, dated 12th May, 2020); on behalf of the City of Parramatta Council, in relation to the Solar Reflectivity Report prepared by Windtech (report ref: WE905-02F01(rev0)- SR Report, dated 18th October, 2019) and subsequent Response Statement (Windtech - SR E-mail Response, issued 16th March 2020), for the subject development known as Gran Central, 134-142 Parramatta Road, 26-38 Good Street and 59-61 Cowper Street, Granville. Since the time of the study, design changes were made to the subject building to incorporate additional effective glare mitigation elements into the subject development; as indicated in the latest architectural drawings prepared by the project architects PBD Architects received August 2020.

Windtech has the following comments on the responses by the peer reviewer Flux:

1 Methodology

Windtech would like to clarify that our response was to convey that Windtech's solar reflectivity analysis does not involve the calculation of the veiling luminance and that it was based on the use of the Glare Protractor developed by Hassall methodology, and the provisional threshold of 500cd/m2; as stated by the peer reviewer.

Windtech agrees with the peer reviewer that the Hassall method allows the calculation of the veiling luminance. The use of the glare protractor provides a streamline alternative in lieu to the calculation of the veiling luminance values via an overlay with ISO-glare loops indicating the percent reflectance of the surface involved above or below a provisional threshold veiling luminance of 500cd/m2. As such, the glare protractor has been adopted as a basis of assessing the glare impact from the subject development with the limiting veiling luminance of 500 cd/m2 as a practical threshold/criterion.

Windtech agree with the peer reviewer with the use of glare protractor for angle of incidences under or above 40° and will be taken into account in the reanalysis of the study point locations as indicated in Section 3 of this memo. Photographs have been taken from the viewpoint of motorists at each study point location using a calibrated camera. A scaled glare protractor has been superimposed over each

viewpoint image. The study point locations and check zone areas from the initial report (report ref: WE905-02F01(rev0)- SR Report, dated 18th October, 2019) are indicated in Figure 1 and Table 1 below.

Figure 1: Check Zones and Study Point Locations
(the check zones are the areas where glare could potentially be observed)

Table 1: Aspects of the Development that could reflect Solar Glare to Each Study Point for Motorists

Study Point	Location and Viewpoint	Aspect(s) of the Development
01	Enid Avenue, heading north.	Eastern aspect.
02	Memorial Drive, heading north-west.	Eastern and southern aspects.
03	Cowper Street, heading north-west.	Eastern and southern aspects.
04	Cowper Street, heading north-west.	Eastern and southern aspects.
05	South Street, heading north.	Eastern aspect.
06	Good Street, heading north-east.	Eastern and southern aspects.
07	Parramatta Road, heading north-west.	Northern aspect.
08	Parramatta Road, heading north-west.	Northern aspect.
09	Parramatta Road, heading south-east.	Northern and western aspects.
10	Parramatta Road, heading south-east.	Northern and western aspects.
11	Cowper Street, heading south-east.	Western aspect.
12	Cowper Street, heading south-east.	Western aspect.

2 Assumptions

Windtech have noted the peer reviewer's disagreement with the 10-degree vertical cut-off angle. The reanalysis as indicated in Section 3 of this memo will extend beyond the 10-degree vertical cut off angle and account for be undertaken for the in the visible subject development at the various study point locations.

Windtech have noted the peer reviewer's disagreement with the limiting the analysis to the zone of sensitive vision. Similar to the 10-degree cut-off angle, the reanalysis as indicated in Section 3 of this memo will extend beyond the zone of sensitive vision and account for be undertaken for the in the visible subject development at the various study point locations.

3 Results of the Reanalysis

A review of the results of the initial report (report ref: WE905-02F01(rev0)- SR Report, dated 18th October, 2019) indicated the glare risk from the subject building at a majority of the study point locations; 1, 4, 5, 6, 7, 8, 10, 11 and 12, is not expected to be adverse to motorists and a general recommendation of the glazing to have a specular reflectance value of 20% would be applicable. The initial analysis focused on the visible façade of the subject building within the +/- 10-degree zone of sensitive vision. A reanalysis has been undertaken that takes into account the entire visible façade of the subject building at the various study point locations. The results of the reanalysis indicate that with the expanded area of assessment, the glare risk from the subject building at the above-mentioned study point locations; 1, 4, 5, 6, 7, 8, 10, 11 and 12, would still not be adverse to motorists. This is because the veiling luminance decreases the further away into the peripheral vision the building façade is; i.e. away from the direct sightline and zone of sensitive vision. However, for study points 2, 3 and 9, the results of the initial analysis indicated there was a glare risk at these locations with motorists potentially exposed to adverse reflected solar glare from the subject building. A reanalysis of these study point locations is detailed in the following subsections. Note that calibrated image of the viewpoint of motorists at this location has been overlaid with a scaled glare meter, as shown in the Appendix of this memo.

3.1 Point 02 - Motorists heading south-east along Memorial Drive

The reanalysis of the viewpoint at Point 02 indicates that portions of the eastern (Tower B) and southern (Tower A and B) and will be visible at this location. The study point location is within the check zone of the eastern and southern facades of the subject development. The angle of incidences to the eastern façade is less than 40° whereas the angle of incidences from to the southern façade is greater than 40°. The glare risk assessment of the visible facades is summarised as follows:

- Eastern Facade - The angle of incidences from the eastern facade is less than 40°. An inspection of the latest architectural drawings indicates the visible eastern façade of Tower B will be comprised of rendered cladding and narrow width windows. It should be noted the tower form of Tower B is connected to Tower A at all levels and as such the incident sun rays would be obstructed by Tower A. Hence there is be no adverse solar glare risk to motorists from the visible eastern façade.

- Southern Facade - The angle of incidences from the southern facade is greater than 40°. An inspection of the latest architectural drawings indicate the visible southern façades of Towers A and B is comprised of a combination of rendered cladding, narrow glazed windows on the main building façade and apartments with south-facing balconies. Furthermore, the architectural drawings indicate the latest design has incorporated glare mitigations along the southern façade. These include extending the full-height blade walls along the balcony perimeter edge of the south-facing balconies and inclusion of vertical fins at the eastern and western ends of the narrow-glazed windows. Hence there is be no adverse solar glare risk to motorists from the visible eastern façade.

3.2 Point 03 - Motorists heading north-west along Cowper Street

The reanalysis of the viewpoint at Point 03 indicates that portions of the eastern facade (Tower A) and southern (Podium, Tower A and B) will be visible at this location. The study point location is within the check zone of the eastern and southern facades of the subject development. The angle of incidences to the eastern façade is less than 40^{o} whereas the angle of incidences from to the southern façade is greater than 40^{o}. The glare risk assessment of the visible facades is summarised as follows:

- Eastern Facade - The angle of incidences from the eastern facade is less than 40^{o}. An inspection of the latest architectural drawings indicates the visible eastern façade of Tower B will be comprised of a combination of rendered cladding, narrow-width glazed windows on the main building façade and apartments with east-facing balconies. The glare risk from the Podium Levels are expected to be minimal due to the shielding provided by the surrounding buildings and the proposed landscaping; in the form of trees and planters as indicated in the architectural drawings. Although the remaining upper podium levels do not benefit from the obstruction afforded by the adjacent buildings and proposed landscaping, the narrow-width windows and balcony-facing glazed systems benefits from the recession into the podium building footprint.
  The tower façade does not benefit from the obstruction afforded by the adjacent buildings and proposed landscaping. The veiling luminance can vary along the tower façade from 1300cd/m^2 from southern edge to under 500cd/m^2 at the northern edge for a reflectance value of 11%. The latest design of the development has incorporated a number of glare mitigation strategies to minimise the glare risk onto the motorists, summarised as follows:

    - Reducing the glazed surface area along the eastern building façade wall abutting the balcony, through the addition of nib solid walls; strategically placed at the southern section of façade.

    - The inclusion of full-height 'MP' screens along the eastern perimeter edge of the balconies/ narrow-width windows to obstruct the incident sun and mitigate the reflected glare. The full-height 'MP' screens further assists by reducing the angular widths of the visible glazed systems under 0.5^{o}. As the sun subtends an angular width of 0.5^{o}, the full-height 'MP' screens minimise the possibility of the full intensity of the solar glare from being observed off these visible glazed systems.

    - The use of glazing along the eastern main building façade and glazed balustrades with low specular reflectance values of 11% and 8% respectively.

- Southern Facade - The angle of incidences from the southern facade is greater than 40^{o}. An inspection of the latest architectural drawings indicate the visible southern façades of Towers A and B is comprised of a combination of rendered cladding, narrow glazed windows on the main building façade and apartments with south-facing balconies. For solar glare to be reflected off the southern facade of the Tower A and Tower B, this would occur at certain times of the year in the late afternoon. However, during late afternoon period when the reflected solar glare can be observed, the direct sun will also be visible to motorists at this location. Hence the intensity of the

direct sun would be a more severe hazard and glare risk to motorists than the reflected glare off the southern façade.

3.3 Point 09 - Motorists heading south-east along Parramatta Road

The reanalysis of the viewpoint at Point 09 indicates that portions of the western (Podium and Tower B) and northern facade (Podium and Tower B) will be visible at this location. The study point location is within the check zone of the western and northern facades of the subject development. The angle of incidences to the western façade is less than 40° whereas the angle of incidences from to the northern façade is greater than 40°. The glare risk assessment of the visible facades is summarised as follows:

- Western Facade - The angle of incidences from the eastern facade is less than 40°. An inspection of the latest architectural drawings indicates the visible podium façade is comprised is comprised of entirely of cladding with no glazed systems, hence there will be no glare risk to the motorists from the podium façade. The visible eastern façade of Tower B is be comprised of a combination of rendered cladding, narrow-width glazed windows on the main building façade and apartments with west-facing balconies. The veiling luminance can vary along the tower façade from 700cd/m^2 from northern edge to under 500cd/m^2 at the southern edge for a reflectance value of 11%. A further investigation indicates the tower façade sections that is above the 500cd/m^2 is comprised of rendered cladding. At the glazed systems locations, the veiling luminance reduces to 460cd/m^2 . Hence the glazing along the western main building façade is recommended to have a specular reflectance value of 11%.

- Northern Facade - The angle of incidences from the northern facade is greater than 40°. An inspection of the latest architectural drawings indicate the northern façades of the Podium and Tower B is comprised of a combination of rendered cladding, narrow glazed windows on the main building façade and apartments with north-facing balconies. For solar glare to be reflected off the northern facade of the of the Podium and Tower B, this would occur at certain times of the year in the early morning. However, during early morning period when the reflected solar glare can be observed, the direct sun will also be visible to motorists at this location. Hence the intensity of the direct sun would be a more severe hazard and glare risk to motorists than the reflected glare off the southern façade. Furthermore, the proposed landscaping along the Parramatta Road frontage of the site is effective in obstructing the view of the northern podium façade to the motorists.

4 Conclusion

In summary, the results of the initial report identified the glare risk from the subject building at a majority of the study point locations would not be adverse to motorists. The report also identified areas where there was potential adverse glare that may be reflected off the subject building onto the motorists on the surrounding streetscape and a series of recommendations were provided. A further reanalysis has been undertaken based on an expanded area of analysis beyond the zone of sensitive vision from the direct sightline of the motorists and a review of the latest architectural drawings prepared by the project architects PBD Architects received August 2020.

The results of the reanalysis indicate, to avoid any adverse glare to motorists and pedestrians on the surrounding streets, occupants of neighbouring buildings, and to comply with the abovementioned planning control requirements, it is recommended the following strategies are incorporated into the design of the subject development:

- The inclusion of the proposed façade elements; that are effective in glare mitigation such as the full-height 'MP' screens, vertical fins along the narrow-width windows and full-height blade walls along the balcony perimeter edge as indicated in the architectural drawings.
- The inclusion of the proposed landscape in the form of densely foliating trees and planters as indicated in the architectural drawings.
- The maximum specular reflectance value on the main building façade (glazing and building material finishes) along the eastern aspect of Tower B is 11%.
- The maximum specular reflectance value on the balustrades along the eastern aspect of Tower B is 8%.
- The maximum specular reflectance value on the main building façade (glazing and building material finishes) along the western aspect of Tower A is 11%.
- The maximum specular reflectance value on the balustrades (glazing and building material finishes) along the western aspect of Tower A is 11%.
- The maximum specular reflectance value on the main building façade (glazing and building material finishes) and balustrades along the remaining aspect of the subject building is 20%.

DOCUMENT CONTROL

Date	Revision History	Issued Revision	Prepared By (initials)	Instructed By (initials)	Reviewed & Authorised by (initials)
13 August, 2020	Initial.	0	TH	AFM	TH/AFM

The work presented in this document was carried out in accordance with the Windtech Consultants Quality Assurance System, which is based on International Standard ISO 9001.

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Appendix – Glare Overlays for the Critical Sight-Lines

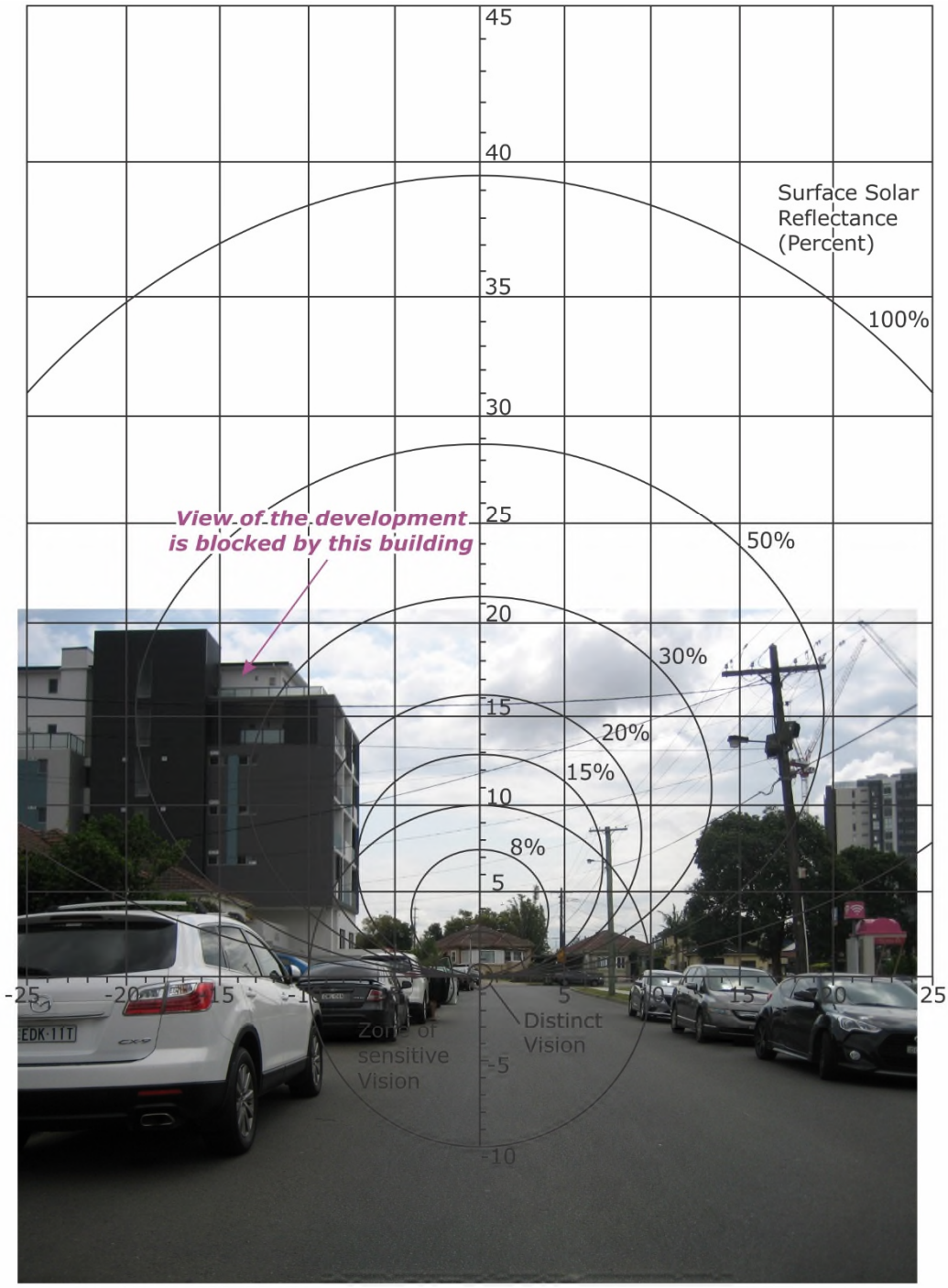

Figure1: Glare Overlay of the Viewpoint at Point 01

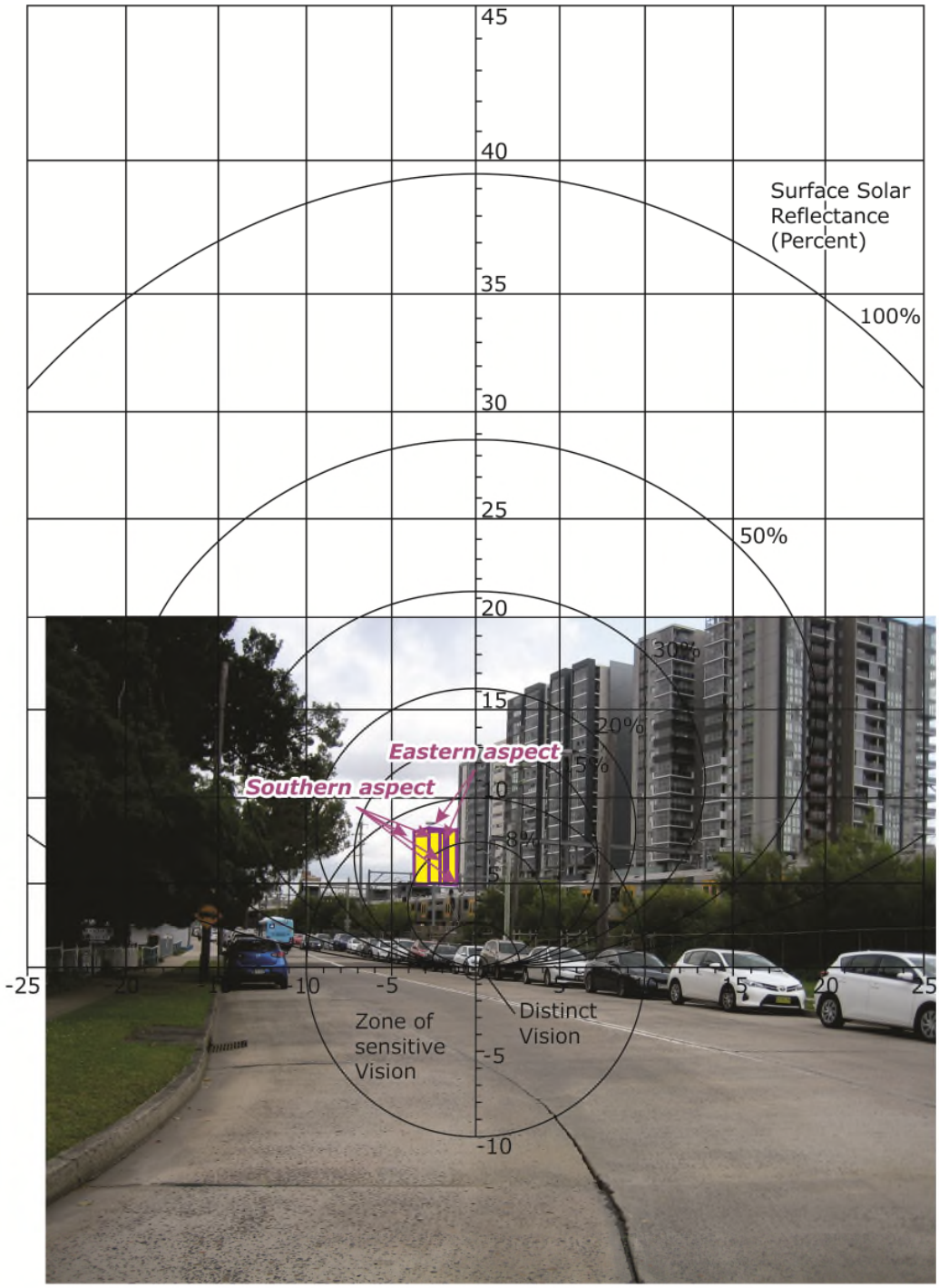

Figure A.2: Glare Overlay of the Viewpoint at Point 02

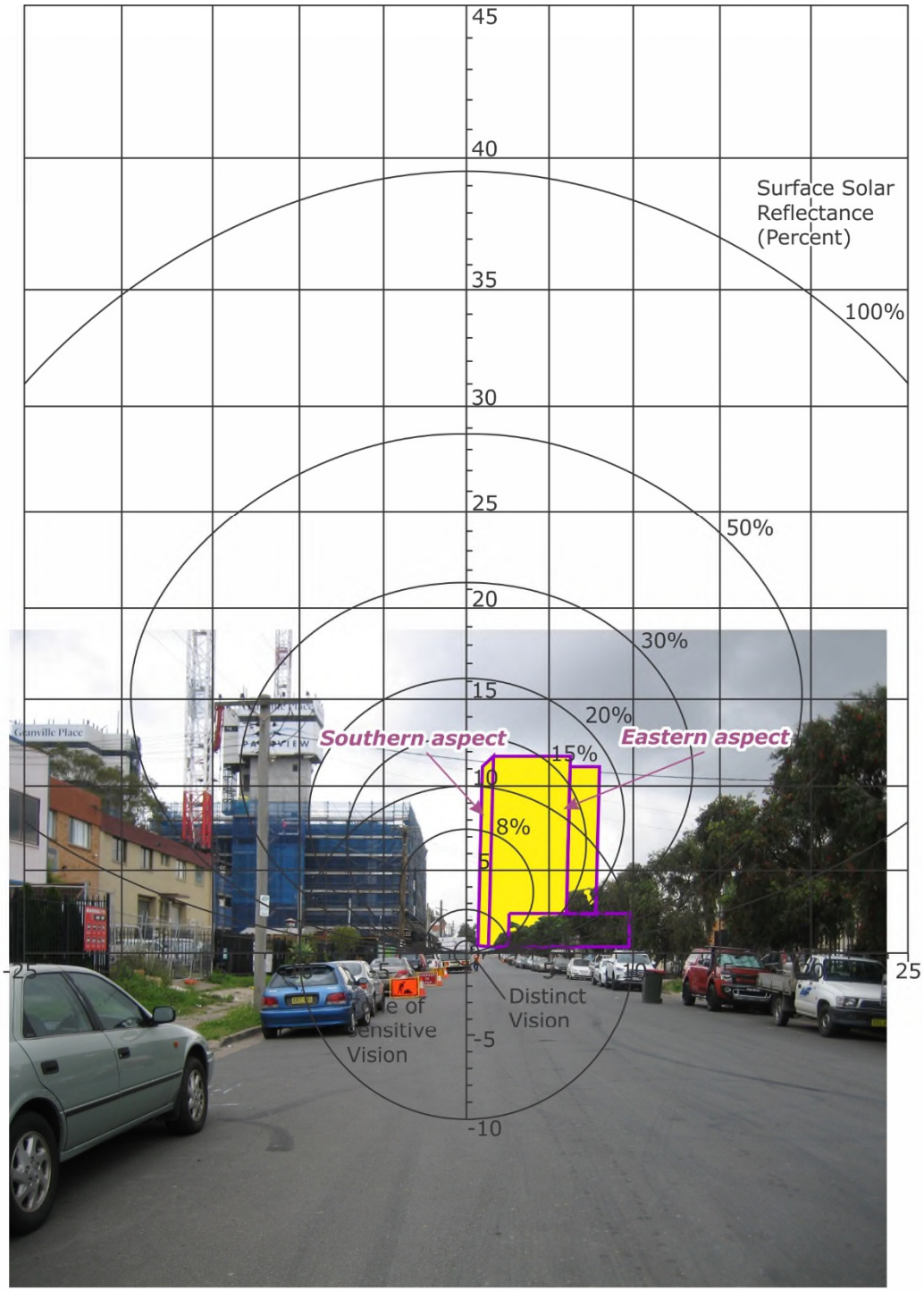

Figure A.3: Glare Overlay of the Viewpoint at Point 03

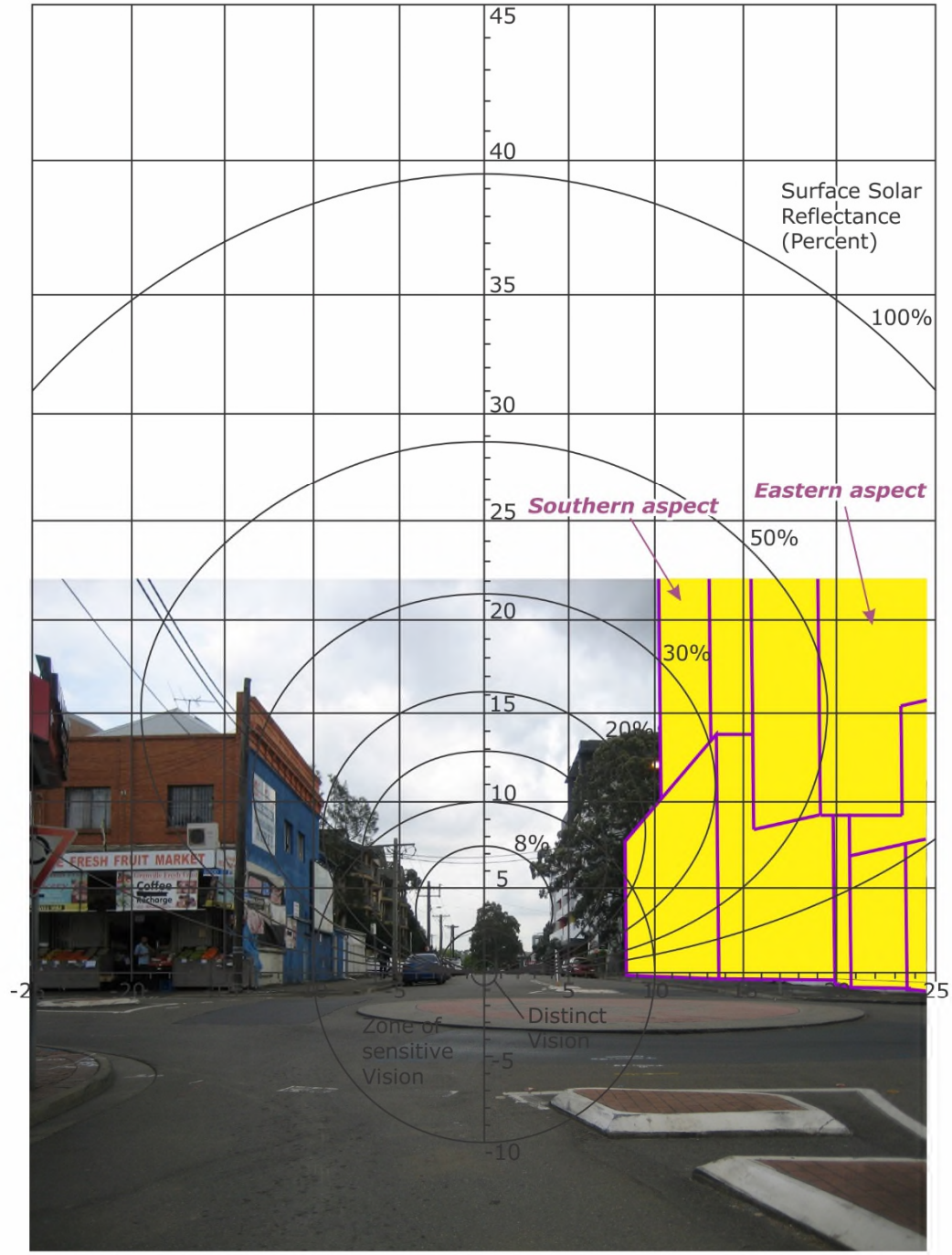

Figure A.4: Glare Overlay of the Viewpoint at Point 04

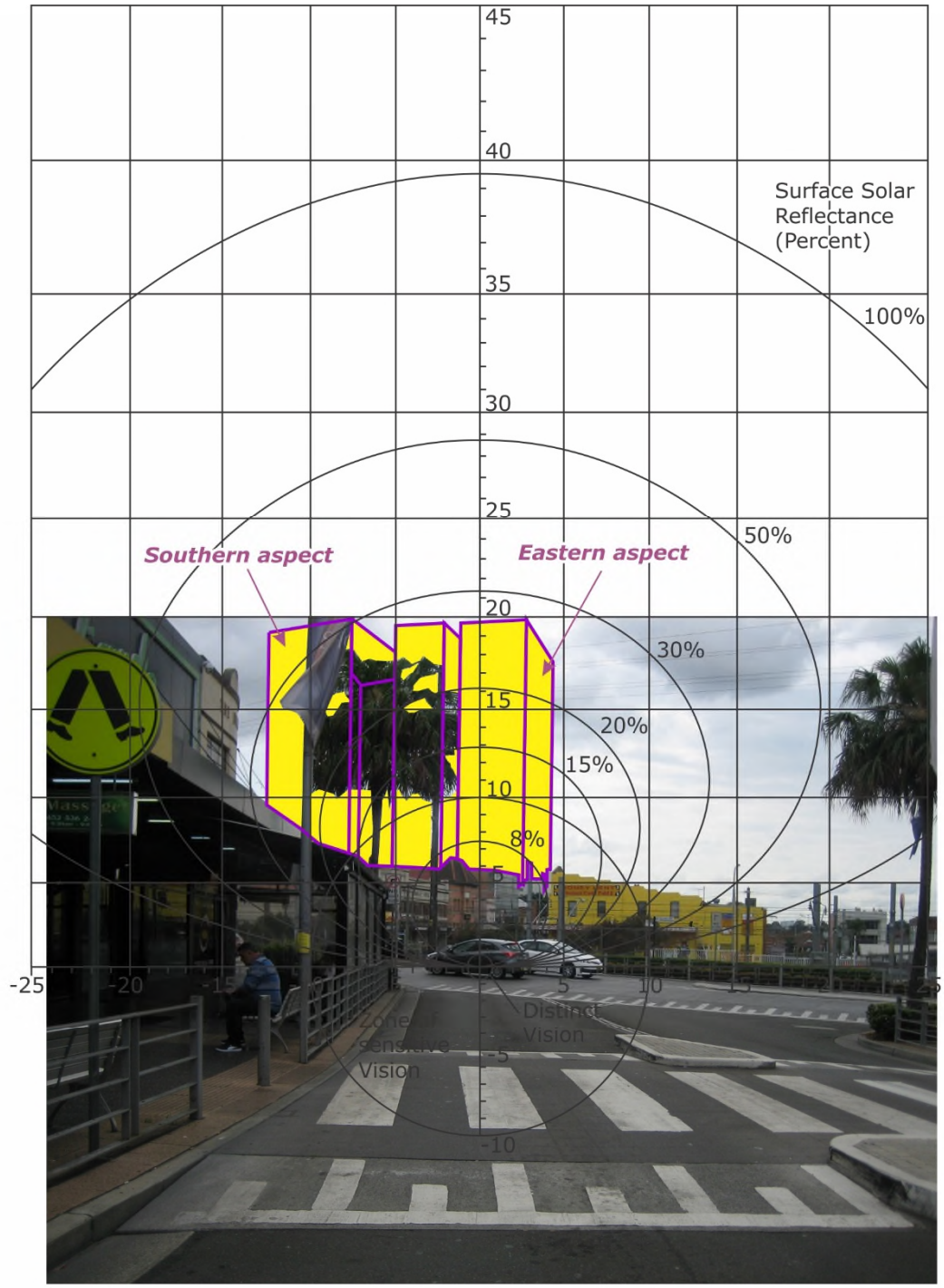

Figure A.5: Glare Overlay of the Viewpoint at Point 05

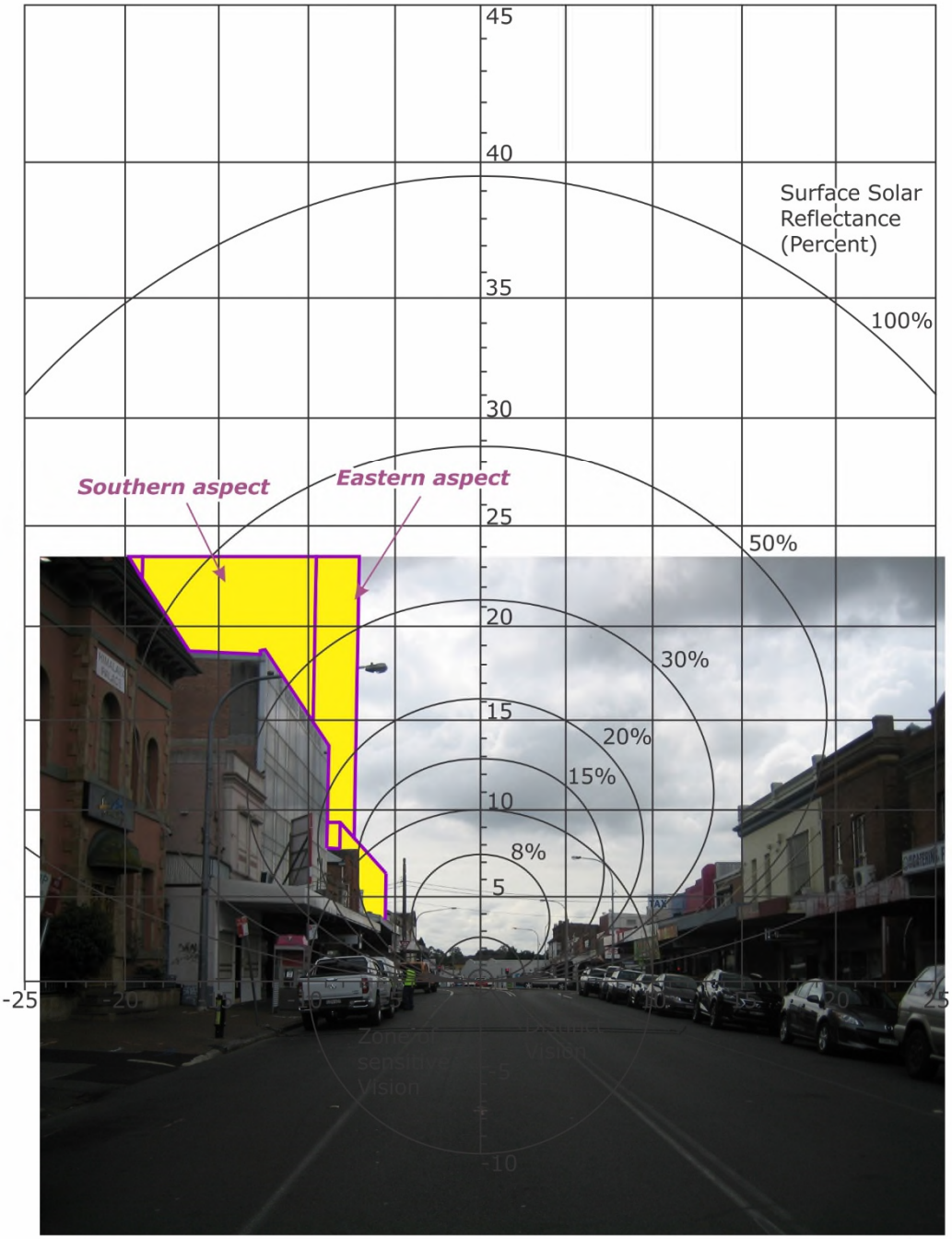

Figure A.6: Glare Overlay of the Viewpoint at Point 06

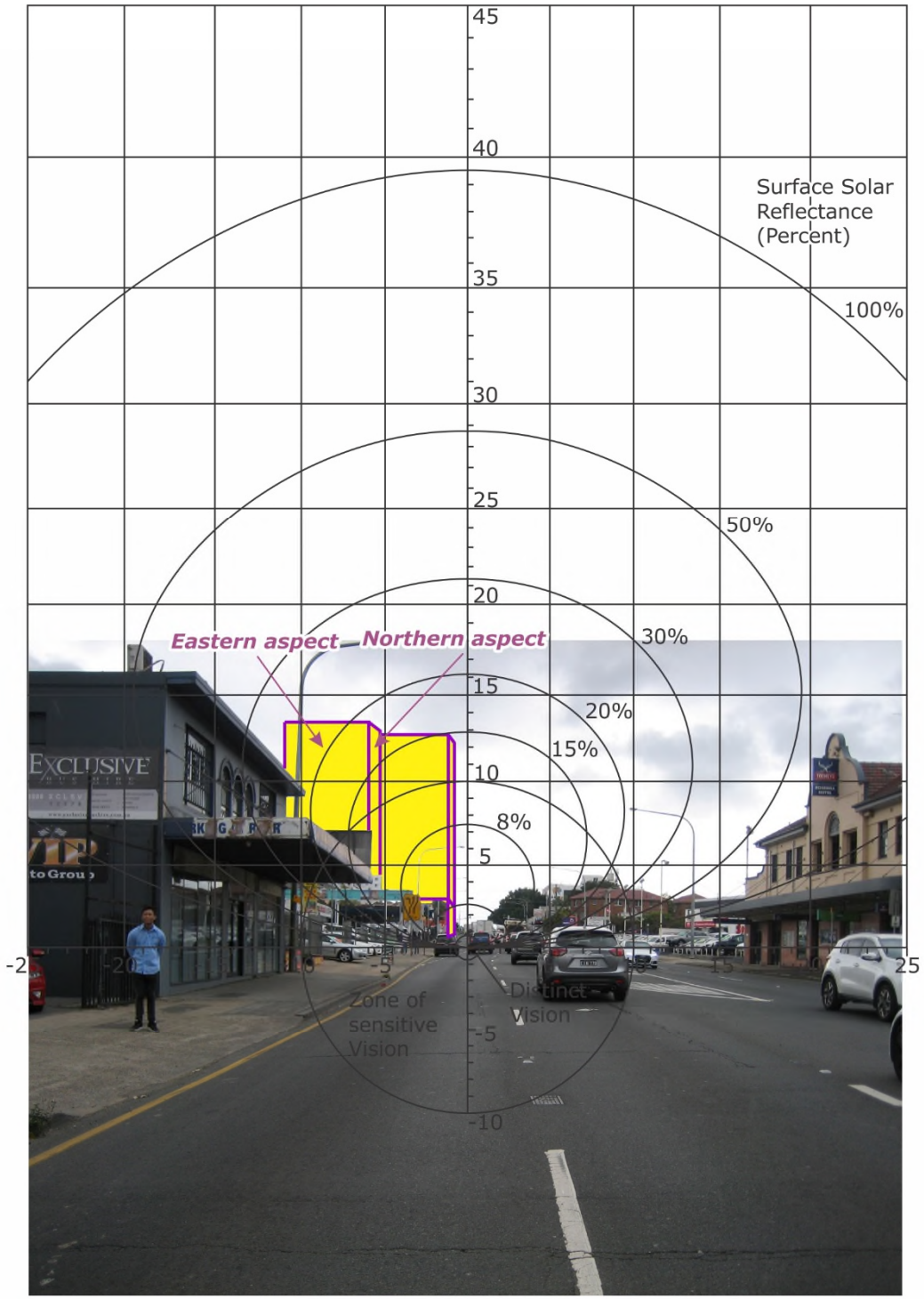

Figure A.7: Glare Overlay of the Viewpoint at Point 07

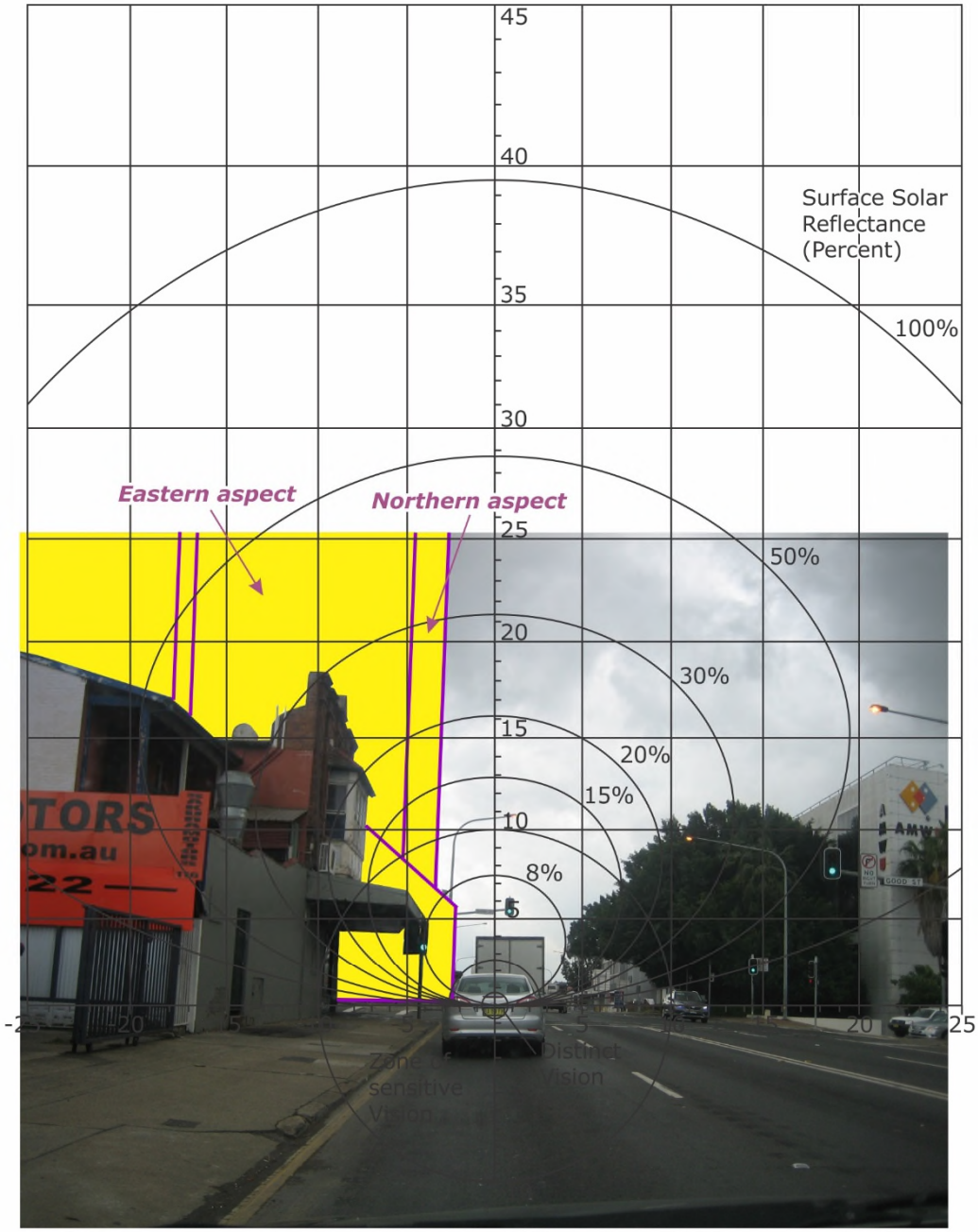

Figure A.8: Glare Overlay of the Viewpoint at Point 08

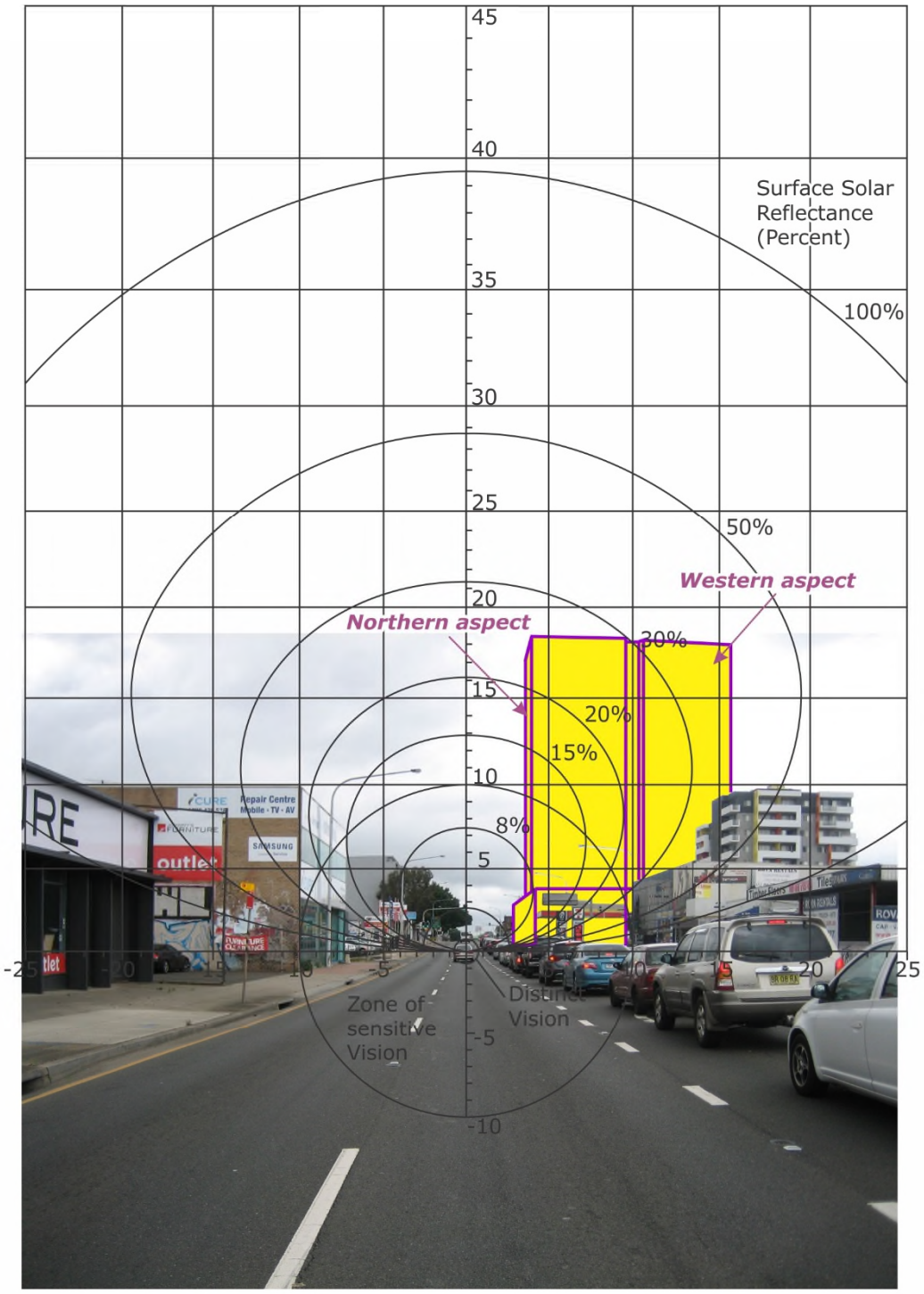

Figure A.9: Glare Overlay of the Viewpoint at Point 09

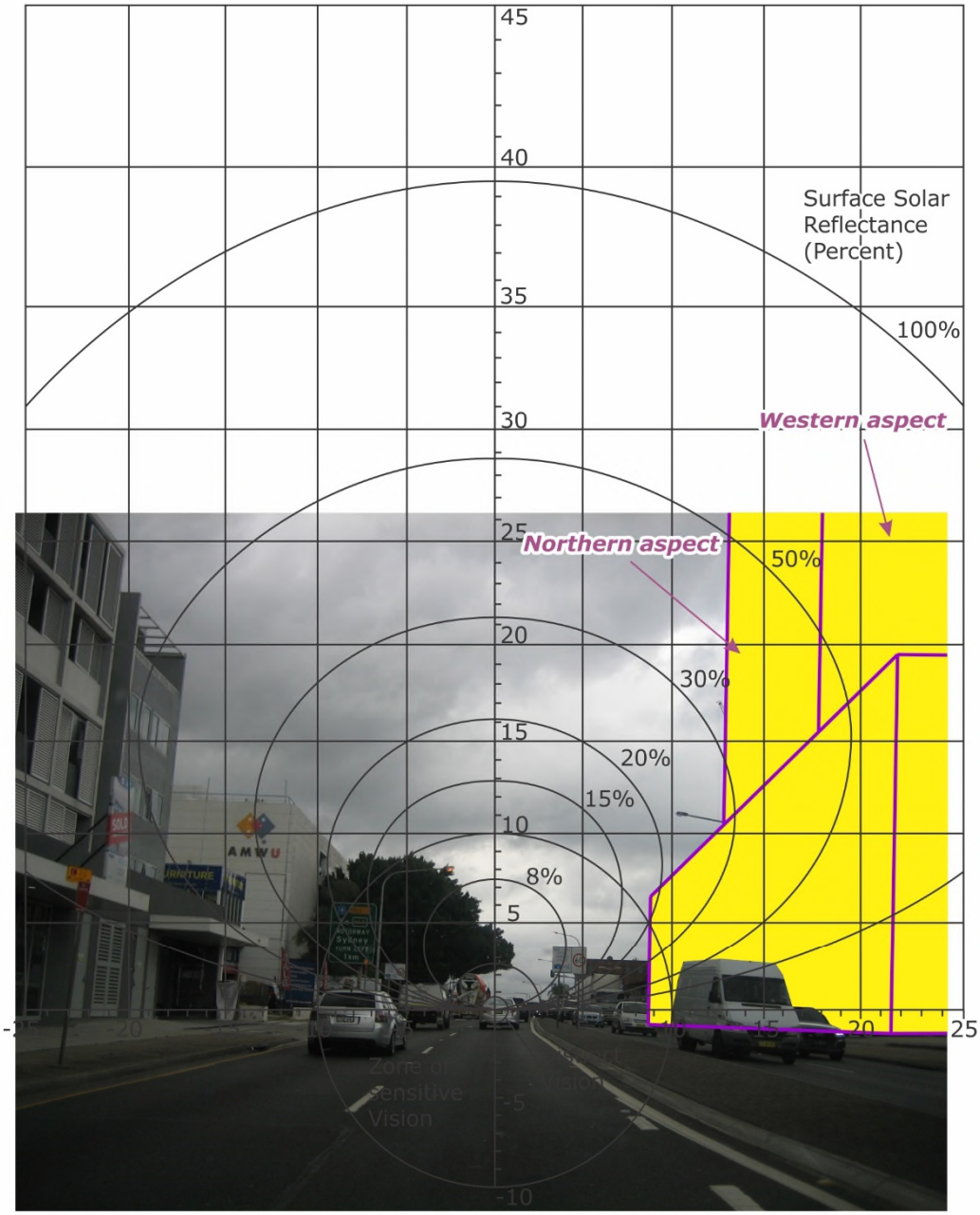

Figure A.10: Glare Overlay of the Viewpoint at Point 10

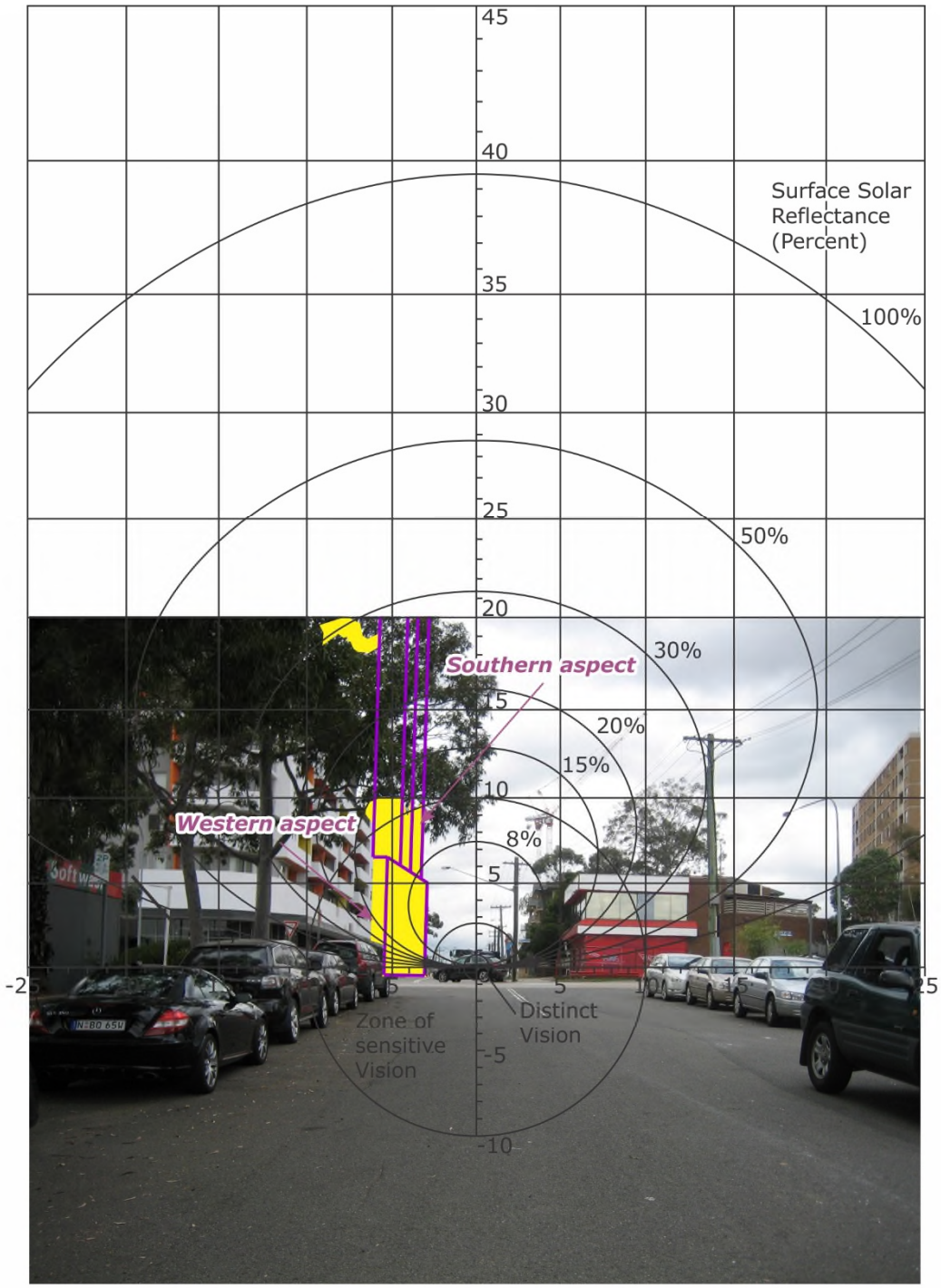

Figure A.11: Glare Overlay of the Viewpoint at Point 11

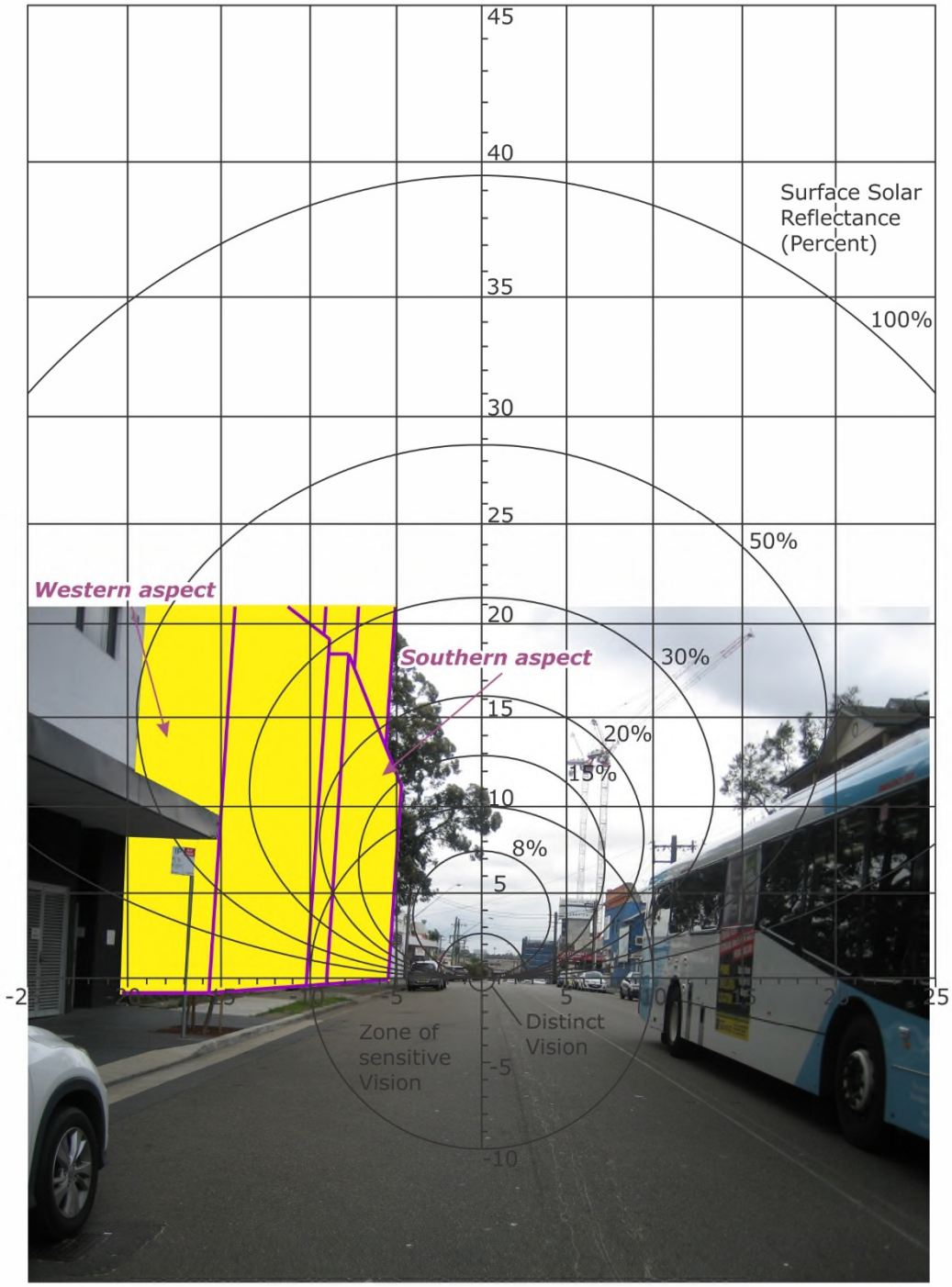

Figure A.12: Glare Overlay of the Viewpoint at Point 12