APPENDIX 11.2

SOLAR GLARE INTENSITY SUMMARY NOTE

Viadux Phase 2

23 October 2024

GIA No: **19925**

PROJECT DATA:

Client	**ARTAL**
Architect	**Simpson Haugh**
Project Title	**Viadux Phase 2**
Project Number	**19925**

REPORT DATA:

Report Title	**Solar Glare Intensity Summary Note**
GIA Department	**Daylight & Sunlight**
Dated	**23 October 2024**

Prepared by	**KST**
Checked by	**KST**
Type	**ES Appendix**

Revisions	No:	Date:	Notes:	Signed:

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SOURCES OF INFORMATION:

Information Received	**IR-08-19925**
Release Number	**Rel_03_19925_DSD**
Issue Number	**05**
Site Photos	**GIA**
3D models	**VU.CITY**
OS Data	**FIND Maps**

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1 INTRODUCTION

GIA have assessed the proposed scheme in order to ascertain whether solar reflections given off the proposed building's facade will be visible from sensitive viewpoints which may affect road users and train drivers.

1.1 GLARE

Glare is a phenomenon occurring in the eye that is caused by the presence of bright light sources within the visual field. It can lead to visual discomfort and, if the glare source is very bright compared to its surrounding, even be disabling in the sense that objects become hard or impossible to see (Fig. 01 and Fig. 02). This is because they are cloaked by the high intensity glare source, whose light gets scattered within the eye.

The CIE 146:2002 Collection on Glare expresses the latter type of glare more formally as:

"Disability glare is glare that impairs vision (CIE, 1987). It is caused by scattering of light inside the eye [...]. The veiling luminance of scattered light will have a significant effect on visibility when intense light sources are present in the peripheral visual field and the contrast of objects to be seen is low. "

"Disability glare is most often of importance at night when contrast sensitivity is low and there may well be one or more bright light sources near to the line of sight, such as car headlights, streetlights or floodlights. But even in daylight conditions disability glare may be of practical significance: think of traffic lights when the sun is close to them, or the difficulty viewing paintings hanging next to windows."

Glare is of particular concern if it affects drivers of motor vehicles or trains, since it might impair the visibility of signals and traffic signs, potentially putting the driver, passengers or other parties at risk.

1.2 GLARE FROM REFLECTED SUNLIGHT

Whether or not a sun reflection will cause an instance of glare depends upon a number of factors, these are summarised below:

- The location of the observer and his view direction;
- The sun's position in the sky, which changes not only with the hour of the day, but with the seasons too;
- The location and orientation of the reflective surface, e.g. a glazed facade, in relation to the observer's view direction;
- The specific quality of the reflective surface, e.g. sheen, specularity, etc.;
- The observer's physiology, e.g. age and eye pigmentation; and
- The background brightness defining the state of adaptation in the observer's eye;

This final point is an important one as the same brightness which could cause glare against a dark background may be perfectly acceptable when looked against a light one. A typical example of adaptation is illustrated in Fig. 01-02 where the same headlights cause glare at night whereas they do not during daytime hours.

Understanding whether solar glare is likely to occur is based on the observer's position and view direction. Given the transitory nature of the phenomenon, due to the sun's constant movement, any glare assessment should be carried out for a number of representative locations and view directions.

Such studies are often carried out with the help of sun path protractors or with the aid of a full three-dimensional computer simulation.

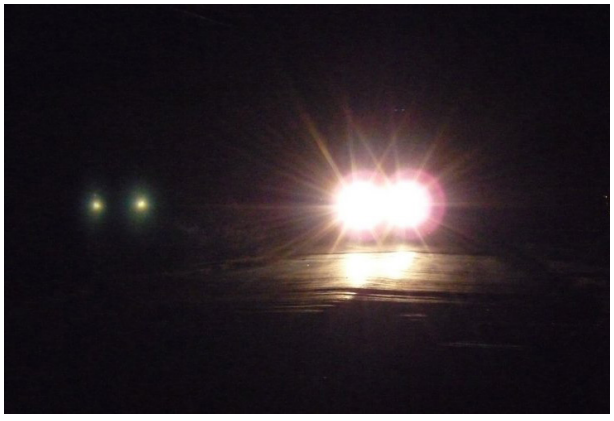


Fig. 01: Headlights at night



Fig. 02: Headlights during day

2 GUIDANCE

In the UK, guidance that is relevant to glare assessments is limited to a short section in the BRE's guidance "Site Layout Planning for Daylight and Sunlight: a guide to good practice" (BR209 - 2022 edition). It suggests that:

"If it is likely that a building may cause solar dazzle the exact scale of the problem should be evaluated. This is done by identifying key locations such as road junctions and windows of nearby buildings, and working out the number of hours of the year that sunlight can be reflected to these points. BRE Information Paper IP 3/87 gives details."

BR IP3/87 provides more detailed instructions on why and how solar dazzle can be calculated:

"Glare or dazzle can occur when sunlight is reflected from a glazed facade. For vertical façades this problem usually occurs only when the sun is low in the sky; but some types of modern design incorporate sloping glazed façades which can, under certain circumstances, reflect unwanted high altitude sunlight into the eyes of motorists, pedestrians and people in nearby buildings."

Both BR 209 and BR IP3/87 only deal with geometrical considerations of glare by identifying when and where reflections occur. However, neither pieces of guidance suggest any threshold values above which reflected sunlight may give rise to an instance of glare. That such a threshold exists in theory becomes clear from the guidance in BR 209:

"... Substituting clear or absorbing glass for reflective glass can also help although sometimes even clear glass may cause reflected glare if, eg. a motorist has the reflected sun close to the centre of their line of sight."

The City of London (CoL) published their own guidance in the from of a Planning Advice Note in July 2017. The aim was to establish "Guidelines and best practice for assessing solar glare in the City of London".

The CoL Guidelines distinguish between discomfort glare and disability glare.

"There are two types of reflected glare problem that can occur. Discomfort glare causes visual discomfort without necessarily affecting the ability to see. Disability glare happens when a bright source of light (such as the reflected sun) impairs the vision of other objects.

"Outdoors, disability glare is easily the more serious problem, as it can affect motorists' ability to drive safely. It is especially important at locations where a driver has to make a key decision, for example approaching a road junction, traffic signal or pedestrian crossing. It can also affect train drivers, particularly if they are looking at illuminated signals.

"Discomfort glare is a less dangerous problem because it does not impair the ability to see. It can be important where work involves continuous viewing of the outdoor space from a fixed vantage point, for example in security surveillance."

Because discomfort glare a) does not impair the ability to see; and b) it only needs to be looked at where work involves continuous viewing of the outdoor space from a fixed vantage point – which is clearly to the case for a train driver – GIA's solar glare assessments do not assess disability glare.

The CoL Guidelines also explains with regard to disability glare that:

"If the reflected sun would be visible close to the driver's line of sight, then either a more detailed calculation of solar glare is required, or measures should be taken to reduce the glare."

However, it does not elaborate how such a more detailed calculation should be carried out. For this, one needs to look elsewhere.

One of the very few paper that addresses intensity levels of solar glare and acceptable thresholds was published by Hassall in 1996. The title of this paper is 'Dealing with Rogue Solar Reflections'. Although published in Australia, the theory, methodology and recommendations it introduced are equally applicable in other countries such as the UK.

The severity of glare can be calculated as the equivalent veiling luminance which is caused by the excess light being scattered in the eye thereby creating a 'veil' through which objects are seen. If the brightness of the veil is sufficiently high compared to that of the actual object, the latter becomes less visible. In very severe cases of disability glare, the object cannot be seen at all.

The veiling luminance can be calculated with a simple empirical formula first proposed by Holladay:

$$L_{seq}\ [cd/m^2] = K*E_{gl}\ /\theta^n < threshold$$

The Holladay glare formula depends on four variables, namely:

- **K**, which is a factor accounting for the observer's sensitivity to glare (eg. age);
- E_{gl}, which is the illuminance from the glare source, measured at the eye of the observer;
- θ, the angle between the line of sight and the glare source;
- **n**, indicating the power with which θ affects the outcome;

An individual's sensitivity to glare is affected primarily by age. We used a K factor of 17.5 in our calculations, which represents a 65-year old driver.

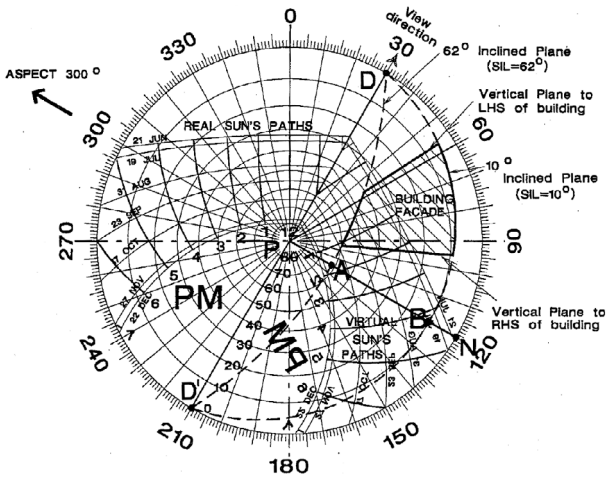


Fig. 03: Hassall's Protractor

According to CIE 146:2002, the n power in Holladay's equation has three angular domains:

- θ^3 for angles between 0.1° and 1°;
- θ^2 for angles between 1° and 30°; and
- θ for angles beyond 30°;

This angular dependency means that a glare source close to the object being looked at has a much more severe impact upon the visibility of that object than a glare source at the periphery of the observer's visual field.

As stated in CIE 146:2002, occurrences at angles beyond 30° would be of little significance in most situations, but may be relevant in exceptional circumstances. When seated in a driving seat of a typical car, for example, the limits of the windscreen would generally obstruct the driver's view at angles beyond 30° from the line of sight. We have therefore adopted the 1° to 30° domain as a reference for our calculations.

Hassall in his paper proposes a threshold value of 500 cd/m^2, which we have adopted as a threshold in our assessments.

Whilst Hassall's approach is based on protractor (Fig. 03) onto which the outline of the proposed building is meant to be drawn by hand, whilst working at GIA, Gil in 2016 picked up on Hassall's methodology and showed how this solar glare assessment could be done with computer software (V L-R Gil: *Evaluation of solar glare from reflective façades: A general method*; Lighting Research & Technology, Vol48, 2016), Fig. 04

GIA have adopted Gil's approach for their Stage 2 solar glare intensity assessments.

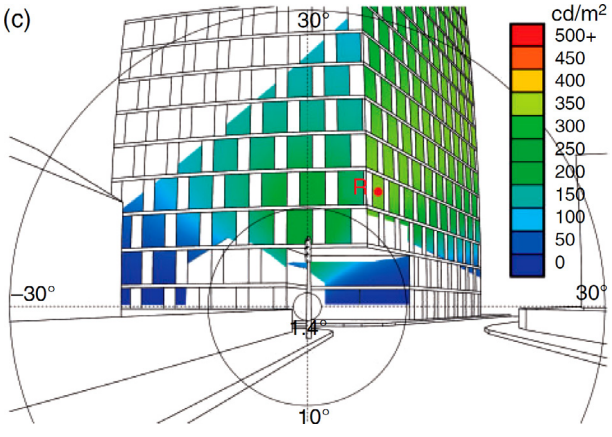


Fig. 04: Gil's (2015) Computerised version to Hassall's Protractor

3 GIA'S APPROACH AND METHODOLOGY

Following the guidance documents referenced above, GIA have developed specialised computer software to undertake reflected glare assessments, which are carried out following a three-stage approach.

The preparation of reflected solar glare assessments is based upon the steps described below:

- The construction of a 3d-computer model that includes the proposed building and its relevant setting (Paragraph 3.1);
- The physically accurate description of the reflective surface properties (Paragraph 3.2);
- Rendering of stills of the solar reflections (Paragraph 3.3);
- Masking the images to represent the Human Field of View (Paragraph 3.4); and
- Image analysis for:
  - » Stage 1 - Static assessment (Paragraph 3.5)
  - » Stage 2 - Potential Intensity of reflections (Paragraph 3.6)
- The limitations of this approach and methodology are set out in Paragraph 3.7.

3.1 3D-COMPUTER MODEL

The detailed geometry of the proposed building, and specifically of its facade and glazing configuration, is provided by the project architects either in 2d format (i.e. plans, sections and elevation drawings) or 3d format as a computer model. The received information is processed by GIA and prepared for assessment with our proprietary software. GIA also prepares the context 3d-model from photogrammetry and high resolution stereoscopic aerial photographs, including details relevant for assessment such rail tracks, sleepers, gantries and signals as well as road junctions and traffic lights. An example of the detailes included in the solar glare context 3d-model is provided in Fig. 05, Fig. 06, Fig. 07 and Fig. 08.



Fig. 06: High-resolution aerial photograph



Fig. 07: High-resolution aerial photograph (close-up)

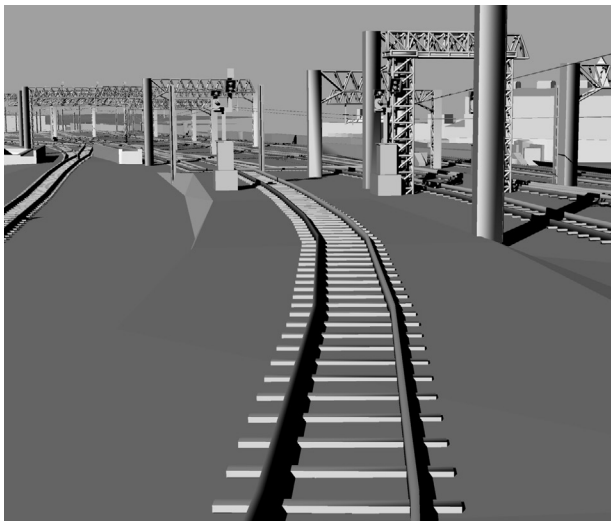


Fig. 05: Computer model of train tracks & signals from photogrammetry



Fig. 08: High-resolution aerial photograph (close-up)

3.2 REFLECTIVE SURFACE PROPERTIES

In order to undertake the glare studies it is necessary to acquire physically accurate computer representations of all materials adopted in the Proposed Development that have the potential of specularly reflecting sunlight, thereby becoming sources of glare. Such materials would include all vertical or sloped glazing, but also certain facade materials such as metal cladding or glazed building tiles.

Diffuse surface reflectance values and object colours can be measured relatively easily however, the same cannot be said of their specular characteristics. These parameters are very hard to estimate yet critical for the study of glare. It is therefore best practice to have samples of the glazing or cladding materials studied in specialised optical laboratories. An example of such a data set is given in Fig. 09. It shows the angular dependency of the reflective properties of a glazed cladding tile.

The City of London guidance states that *"the severity of glare depends on the type of glazing or cladding. The glare caused depends on the specular reflectance of the glazing. This is the mirror-like direct reflection of sunlight. For glasses, the reflection is nearly all specular. Metals often combine specular reflection with diffuse reflection (where the reflected light is scattered in all directions). Surfaces like brick or matt cladding give mainly diffuse reflection, which is unlikely to cause disability glare."*

GIA's approach is based on three stages which vary in level of detail:

- *Stage 1 - Static assessment* assumes all potential reflective portions of the Proposed Development as "mirrors", therefore portraying an absolute worst-case scenario which is however aimed at identifying whether a reflection can occur or not.
- *Stage 2 - Potential Intensity of reflections assessment*, however, is more advanced and considers the bespoke material specifications of the Proposed Development which are necessary to identify the potential intensity of reflections.

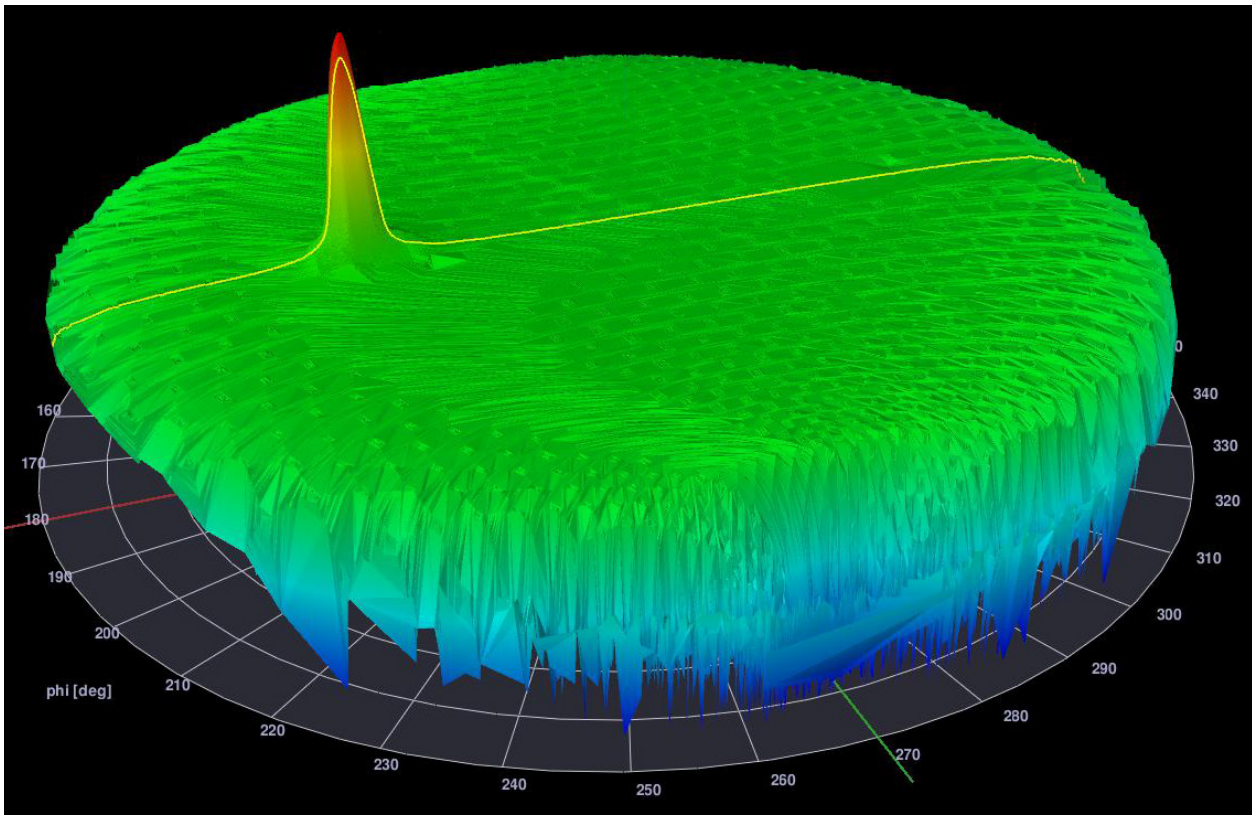


Fig. 09: Reflective properties measurement of a glazed tile

3.3 VIEWPOINTS

Potentially sensitive viewpoints around the site are selected. These viewpoints representing locations where reflected solar glare may cause adverse impacts to those travelling towards the development, such as road users or train drivers. The viewpoints are generally located at the minimum stopping distance and at the driver's eye height. The focal point is a relevant traffic element, such as signals or incoming traffic.

The stopping distance for cars is calculated as the combination of thinking and breaking distances $D_{total} = D_{thinking} + D_{breaking} = V*T + V^2/(2\mu*g)$, where each component is:

- V = Relevant vehicle speed, typically the road speed limit.
- T = Thinking time (0.67 sec)
- μ = Breaking effort (considered 0.65 for cars, 0.5 for buses and 0.031 for trains)
- g = Gravity acceleration.

The height of the viewpoint is considered to be 1.5 m for cars, 2.0 m for buses and 2.75 m for trains.

I.e. A viewpoint for car driving at 30 mph would be placed at 23 m (see Figure 08) from a traffic light and at 1.5 m above the ground.

3.4 HUMAN FIELD OF VIEW

The field of view is the angular extent within which objects can be observed by one or both eyes. Owing to the arrangement of the human eyes, the stereoscopic visual field extends to approximately 60° either side on the vertical and 90° either side on the horizontal.

In the United Kingdom, the minimum field requirement for driving is 60° either side of the vertical meridian, and 20° above and below horizontal.

The fovea centralis is the central area of the retina. It extends about 3° in all directions. The fovea is responsible for sharp vision that is used for reading, driving, and any other activity where visual detail is important. Fig. 11 shows our typical field of view overlay.

The CIE 146:2002 suggests that occurrences at angles beyond 30° would be of little significance in most situations, but may be relevant in exceptional circumstances. Any reflection within 30° is looked at in greater detail in terms of its duration, size of the reflective surface and where appropriate, predicted intensity.

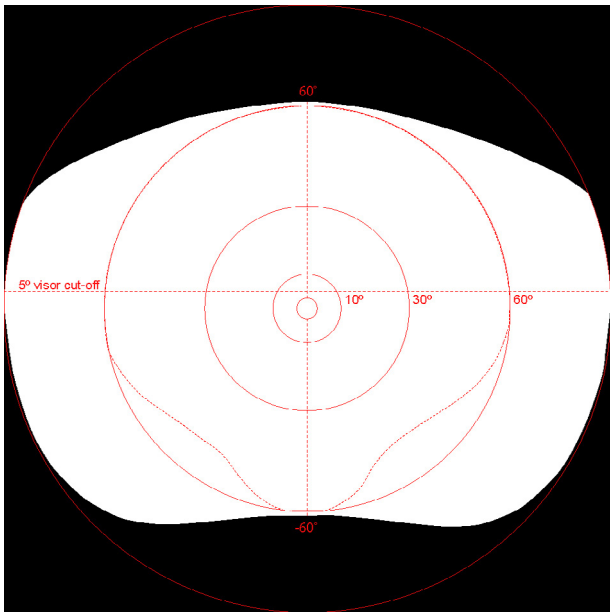


Fig. 10: Typical human field of view

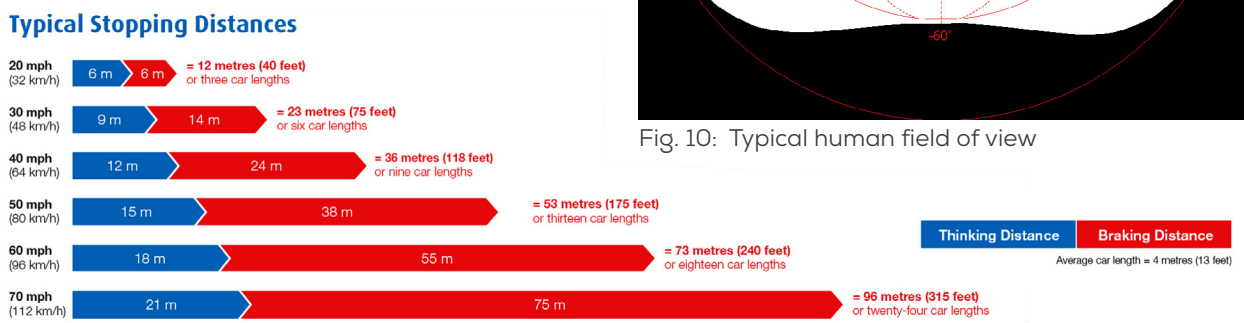


Fig. 11: Typical car stopping distances for various speed limits

3.5 STAGE 1: STATIC ASSESSMENT

The methodology described below is aimed at addressing the occurrence and duration throughout the year and the location of this occurrence in respect of a driver's line of sight. This will inform the necessity of implementing mitigations at either early or detailed design stage.

For this purpose the glazed facade of the Proposed Development is assumed to have the same properties of a mirror, i.e. it is fully reflective and all of its reflected component is specular. This therefore portrays a worst-case scenario.

The potential for reflected solar glare or dazzle from the glazed or reflective façades of the development are assessed using specialist lighting software.

In Stage 1, stills or a computer animation are generated with which the potential for the occurrence of reflected sunlight is evaluated with regards to the times of the year and hours of the day when this may happen, as well as its relative location to the observer's line of sight.

In order to achieve this, the yearly sun path is mapped onto the sky and colour-coded so that the hours of the day and the period of the year can be distinguished. This sun path is picked up by the reflective elements of the proposed buildings in our rendered stills.

Fig. 12 shows the colour coded sunpaths projected onto the sky dome to visualise the time of day and season during which solar reflections occur.

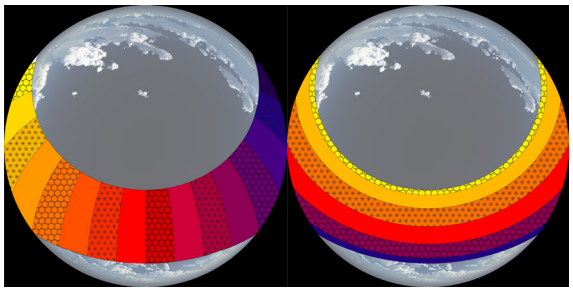


Fig. 12: Stage 1 - Colour coded sunpath for time of day and seasons

Two identical viewpoints are rendered as shown in Fig. 13 and Fig. 14: one focusing on the times of the day when the reflection would be visible, and the second looking at the months throughout the year.

The following guidance is used to determine whether an intensity study is necessary:

- Solar reflections are visible within 30° to 10° of the driver's line of sight for a long period of time (large reflective surface) or between 10° to 5° for a short period of time;
- Solar reflections are visible within 10° and 5° of the driver's line of sight occurring for a long period of time;
- Solar reflections are visible within 5° of a driver's line of sight;

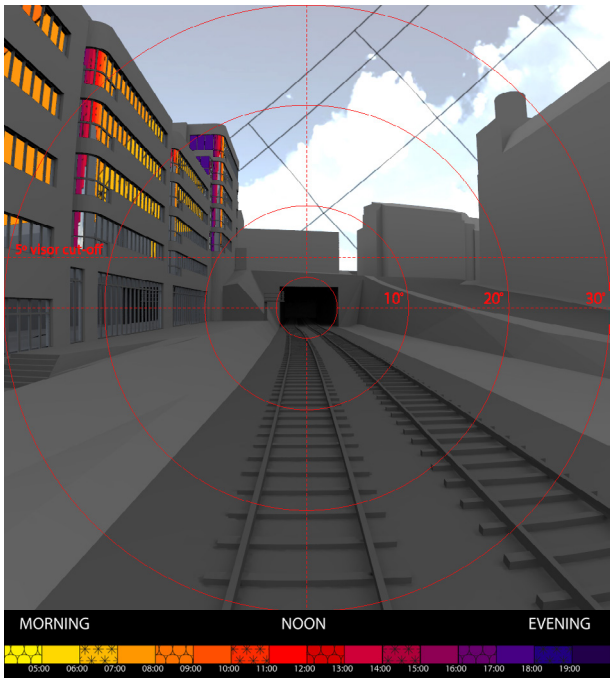


Fig. 13: Stage 1 Example - Hours

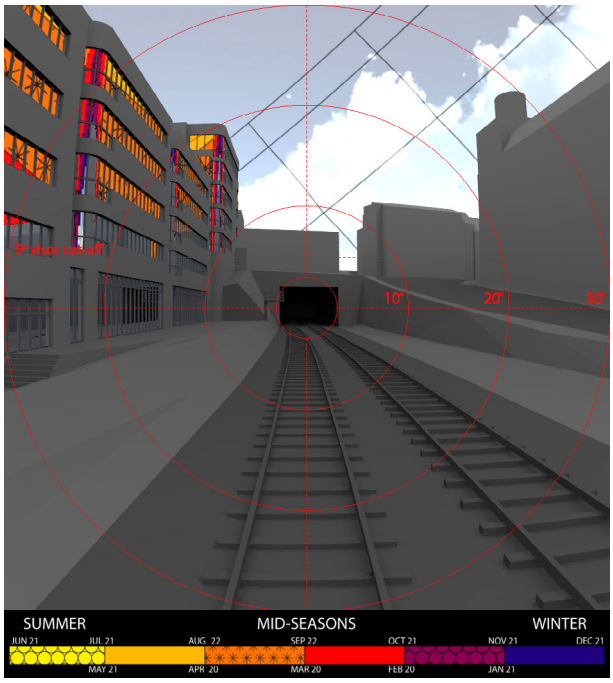


Fig. 14: Stage 1 Example - Months

3.6 STAGE 2: POTENTIAL INTENSITY OF REFLECTIONS

Stage 2 predicts the intensity of the reflected sunlight, using the Holladay formula. An example is provided in Fig. 15.

Any value exceeding 500 cd/m² is further looked into and discussed within the conclusions of our report.

A limitation of this Stage 2 methodology is that it can flag false positives when the reflector, i.e. a window, is too small to actually reflect the full extent of the solar disc. As a result of this, even a single bright pixel in the computer image is capable of producing a peak veiling luminance equivalent to that of the full solar disc.

Our solar glare animations are rendered with a resolution of 1,000x1000 pixels, and cover a field of view of ±30°. With the diameter of the sun being 0.5°, this means that the size of the full solar disc is 8 pixels across, and covers about 52 pixels in area.

To calculate the corrected peak intensity for instances where the reflection is from an area less than the full solar disc, the number of pixels are calculated as a proportion of the full solar disc (i.e. number of pixels/52) and then applied to the equivalent peak veiling luminance reported in the rendered image.

An example of this is provided in Fig. 16 whereby the peak veiling iluminance of 1,140cd/m² occurs from an area of 3 pixels. Therefore the corrected peak veiling luminance is 1,140 cd/m² * 3/52 = 112 cd/m² 66cd/m².

3.7 LIMITATIONS

Great care is taken in identifying typical viewpoints around a new development. However, this does not guarantee that all sensitive locations where reflected solar glare could present a particular risk are covered, especially where these are farther away from the site.

IMPORTANT: The hours shown in the diagrams and described in the text reflect solar time and therefore do not take British Summer Time into account.

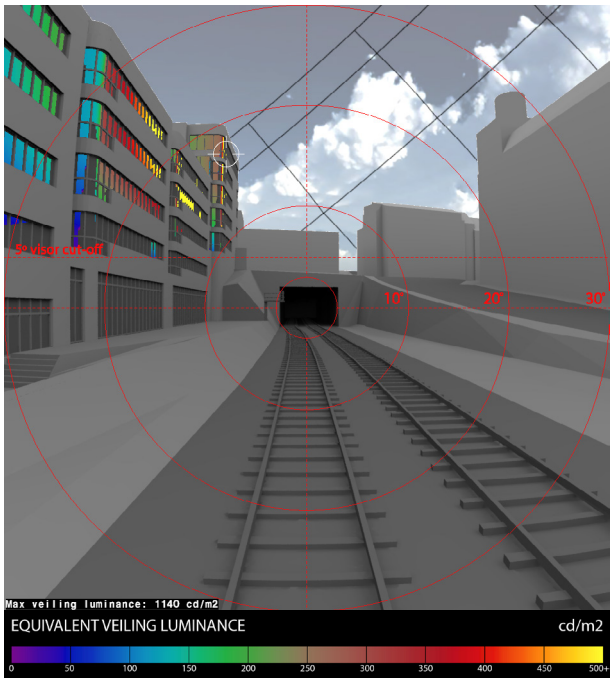


Fig. 15: Stage 2 Example - Veiling Glare Luminance

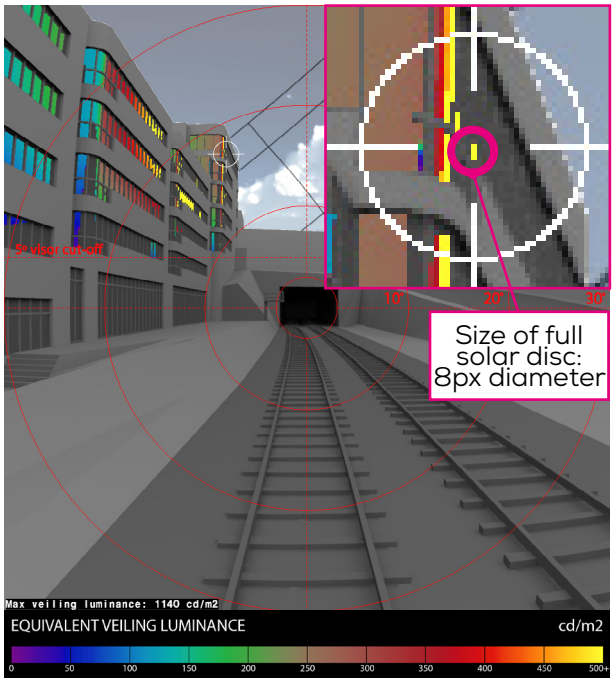


Fig. 16: Stage 2 Example - Solar Disc Diagram

4 GLARE INTENSITY ASSESSMENT

Castle Street (CS1) – Junction with Bridgewater Viaduct

60° FIELD OF VIEW: TIME OF DAY
VIEWPOINT CS1A - LOOKING FORWARD

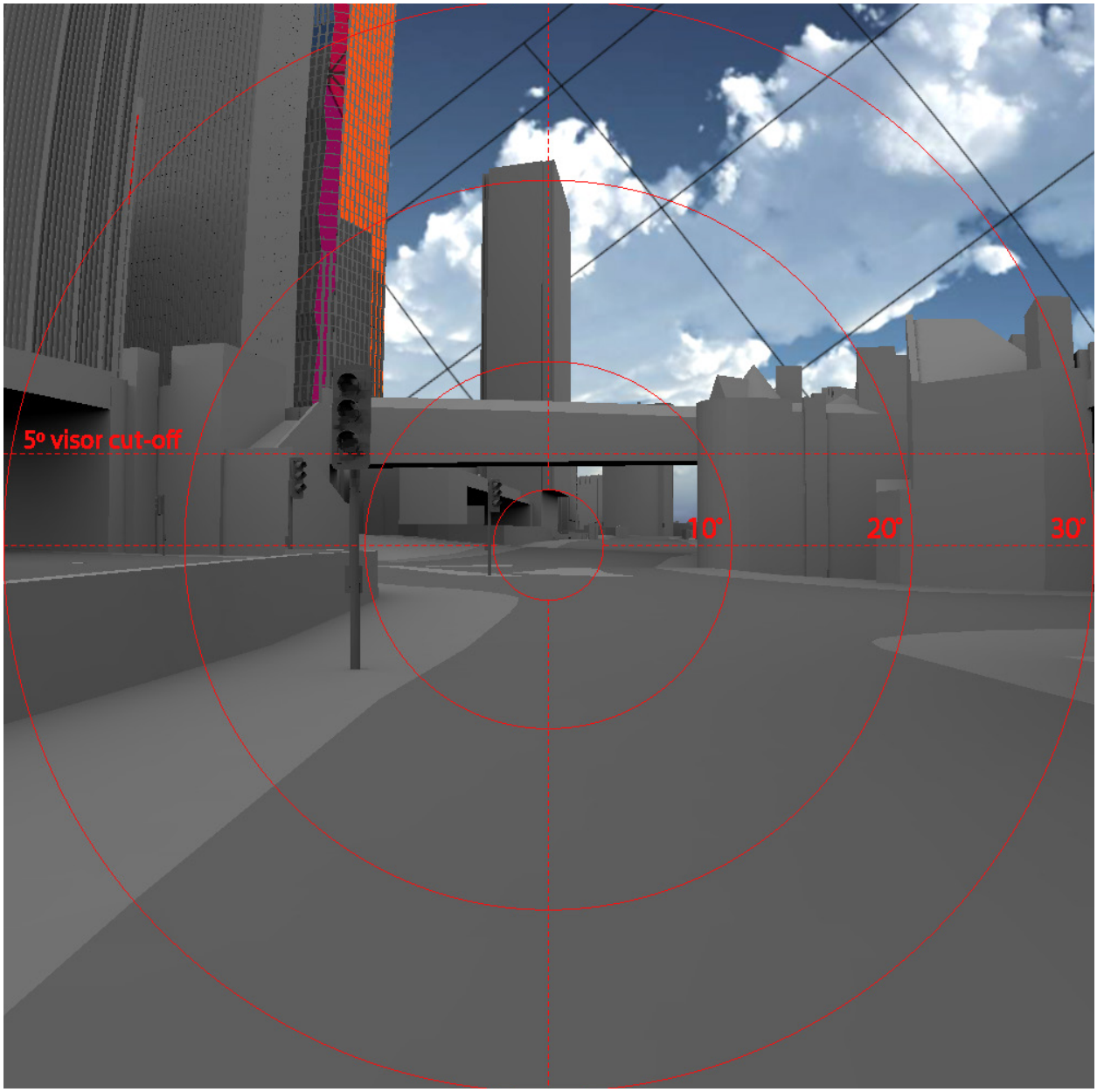
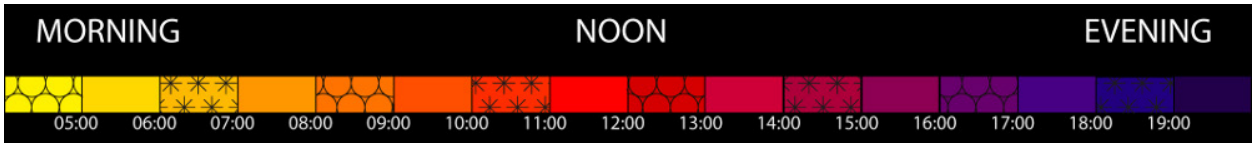


Fig. 17: Solar reflections



60° FIELD OF VIEW: SEASON
VIEWPOINT CS1A - LOOKING FORWARD

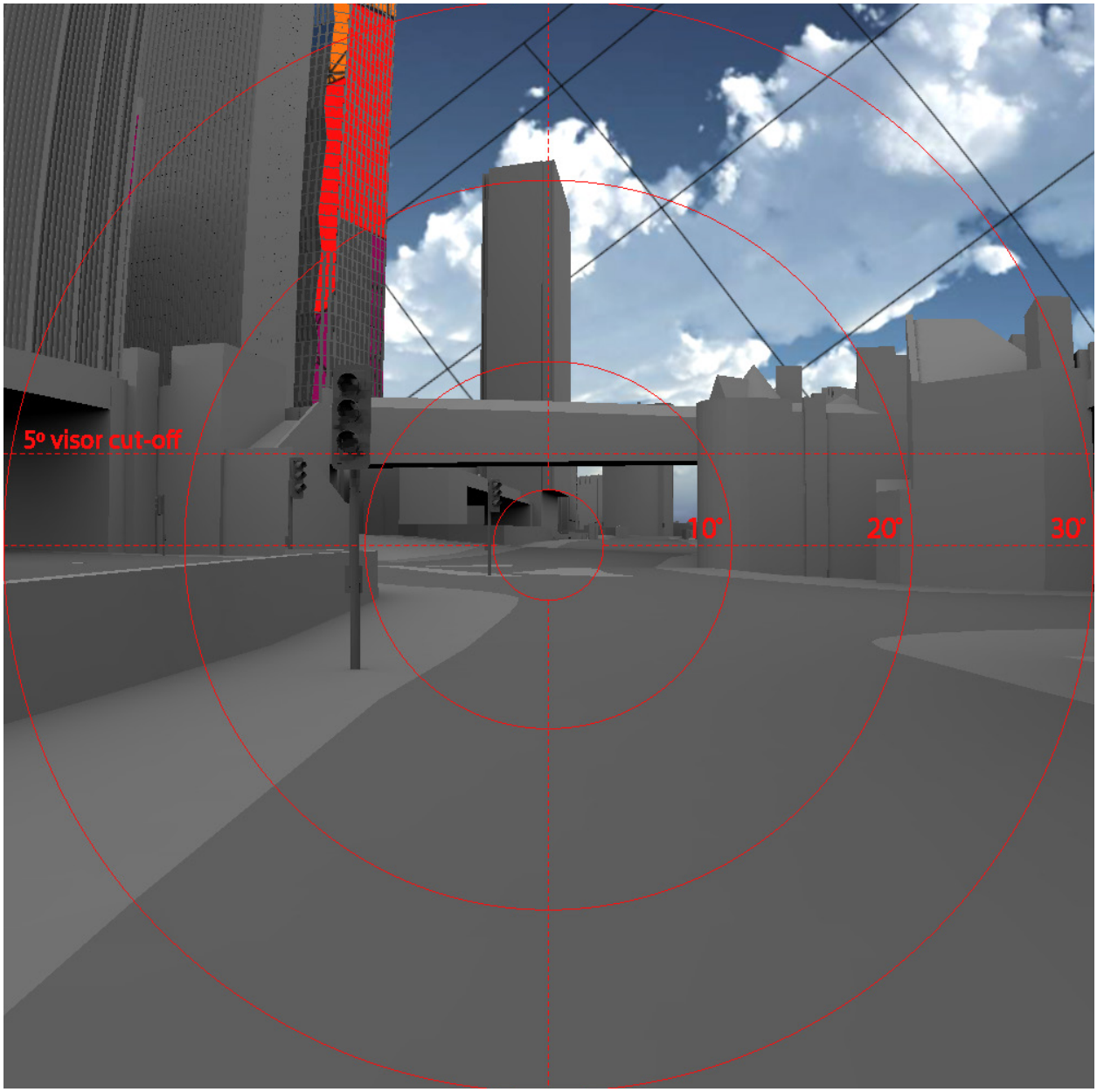


Fig. 18: Solar reflections



STAGE 1: 60° FIELD OF VIEW: TIME OF DAY
VIEWPOINT CS1B - LOOKING AT TRAFFIC LIGHT

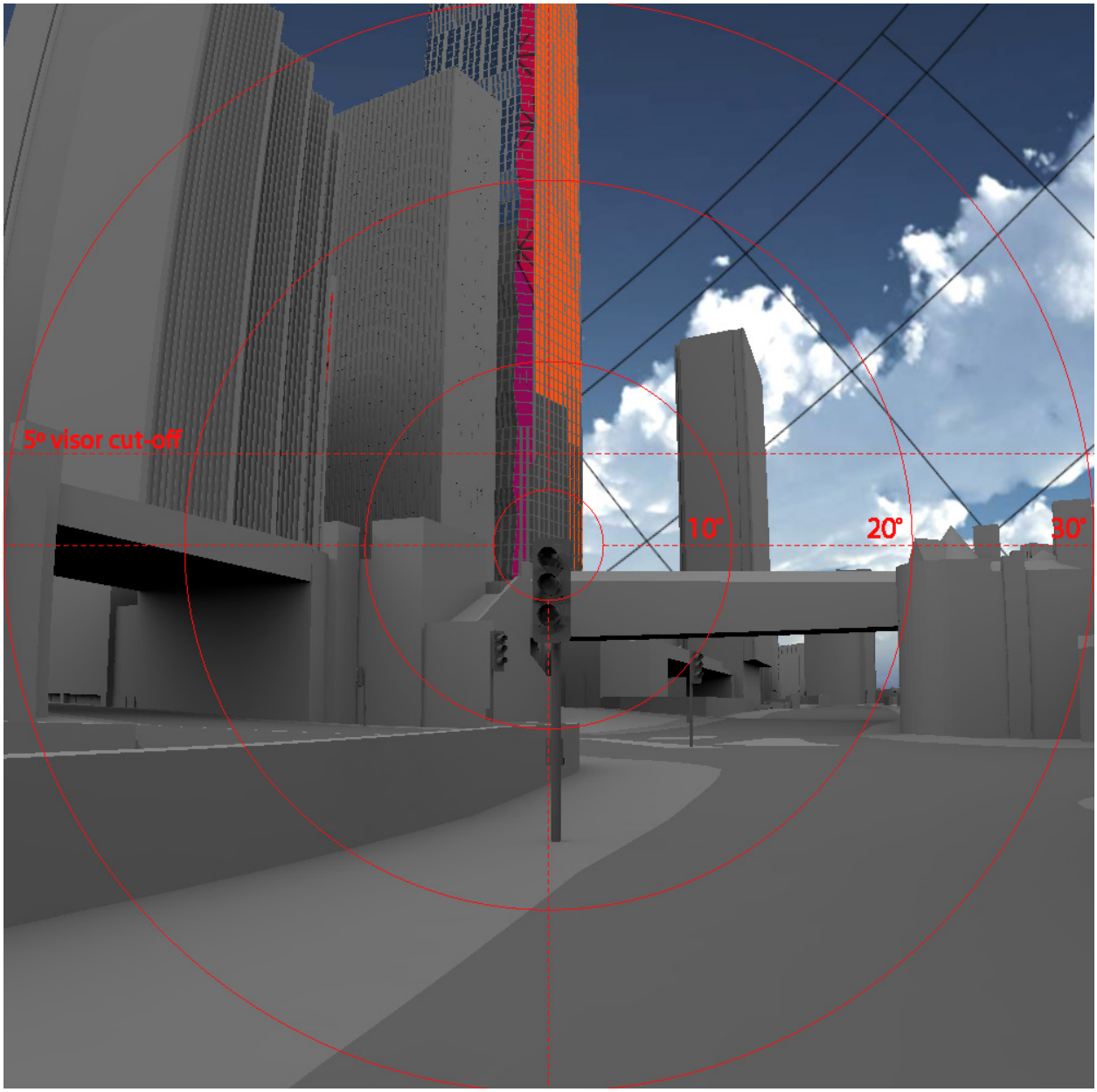
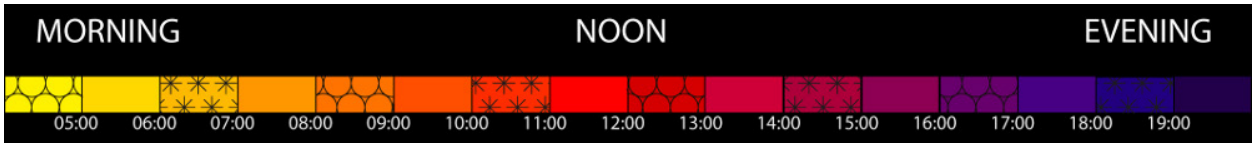


Fig. 19: Solar reflections



STAGE 1: 60° FIELD OF VIEW: SEASON
VIEWPOINT CS1B - LOOKING AT TRAFFIC LIGHT

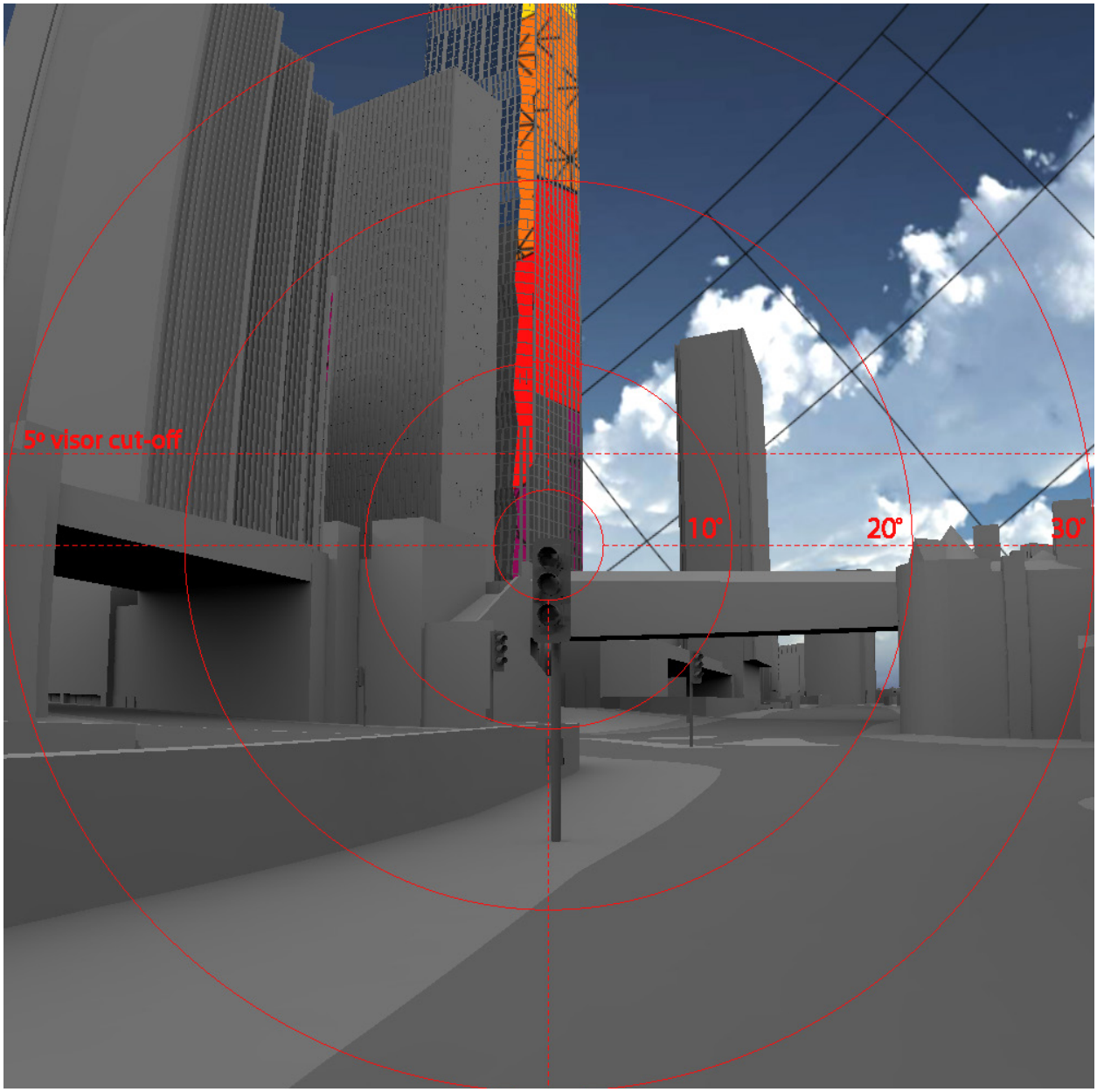


Fig. 20: Solar reflections



STAGE 2: PEAK INTENSITY ASSESSMENT
VIEWPOINT CS1A - LOOKING FORWARD

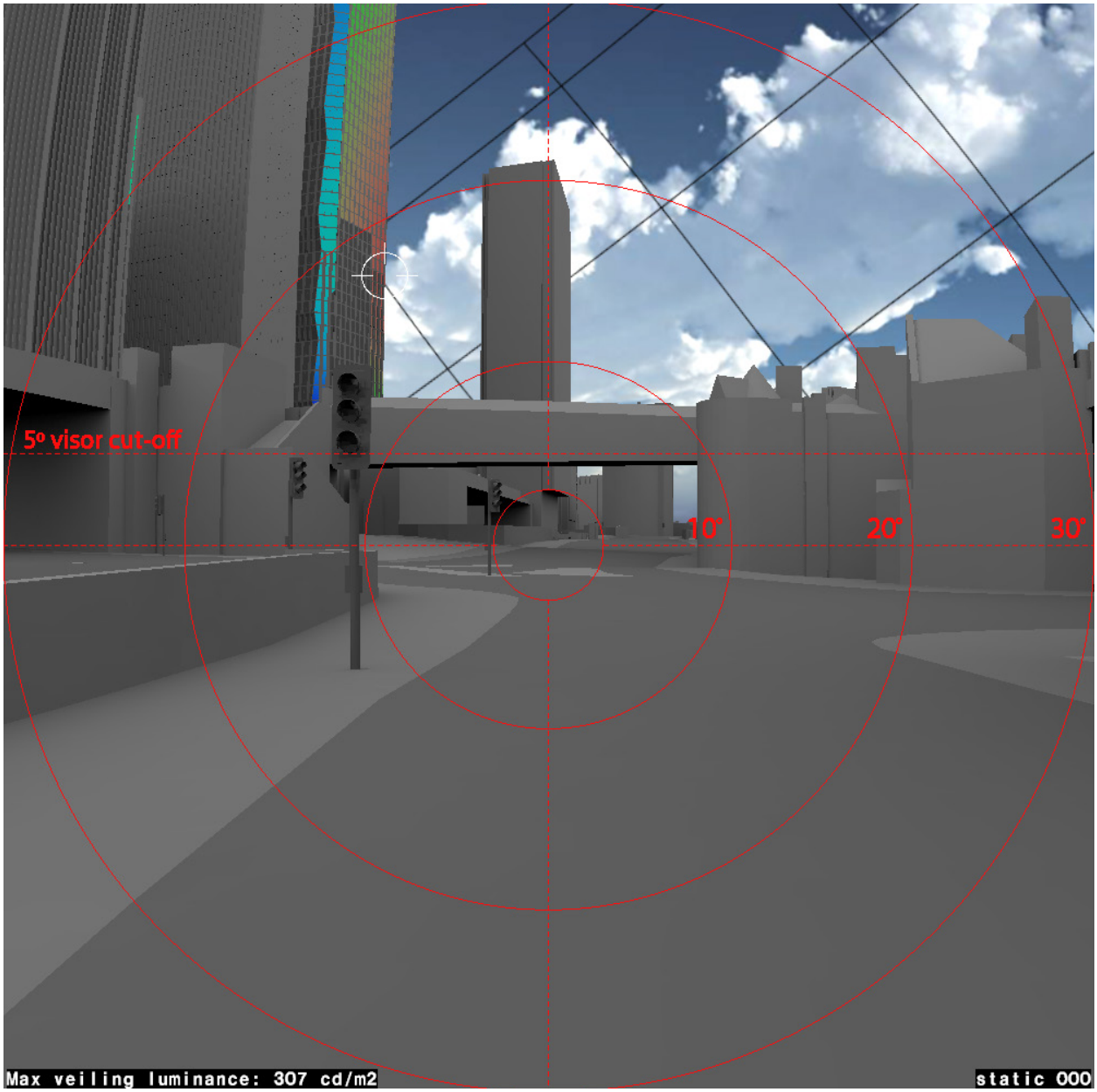
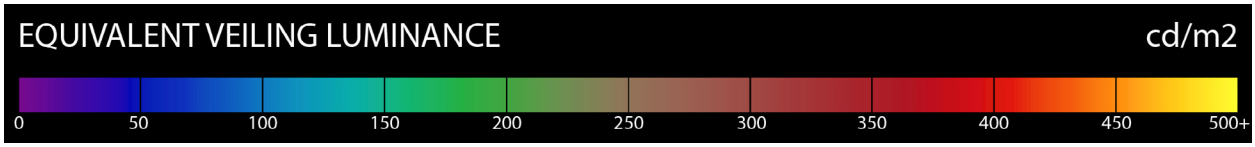


Fig. 21: Peak intensity



STAGE 2: PEAK INTENSITY ASSESSMENT
VIEWPOINT CS1B - LOOKING AT TRAFFIC LIGHT

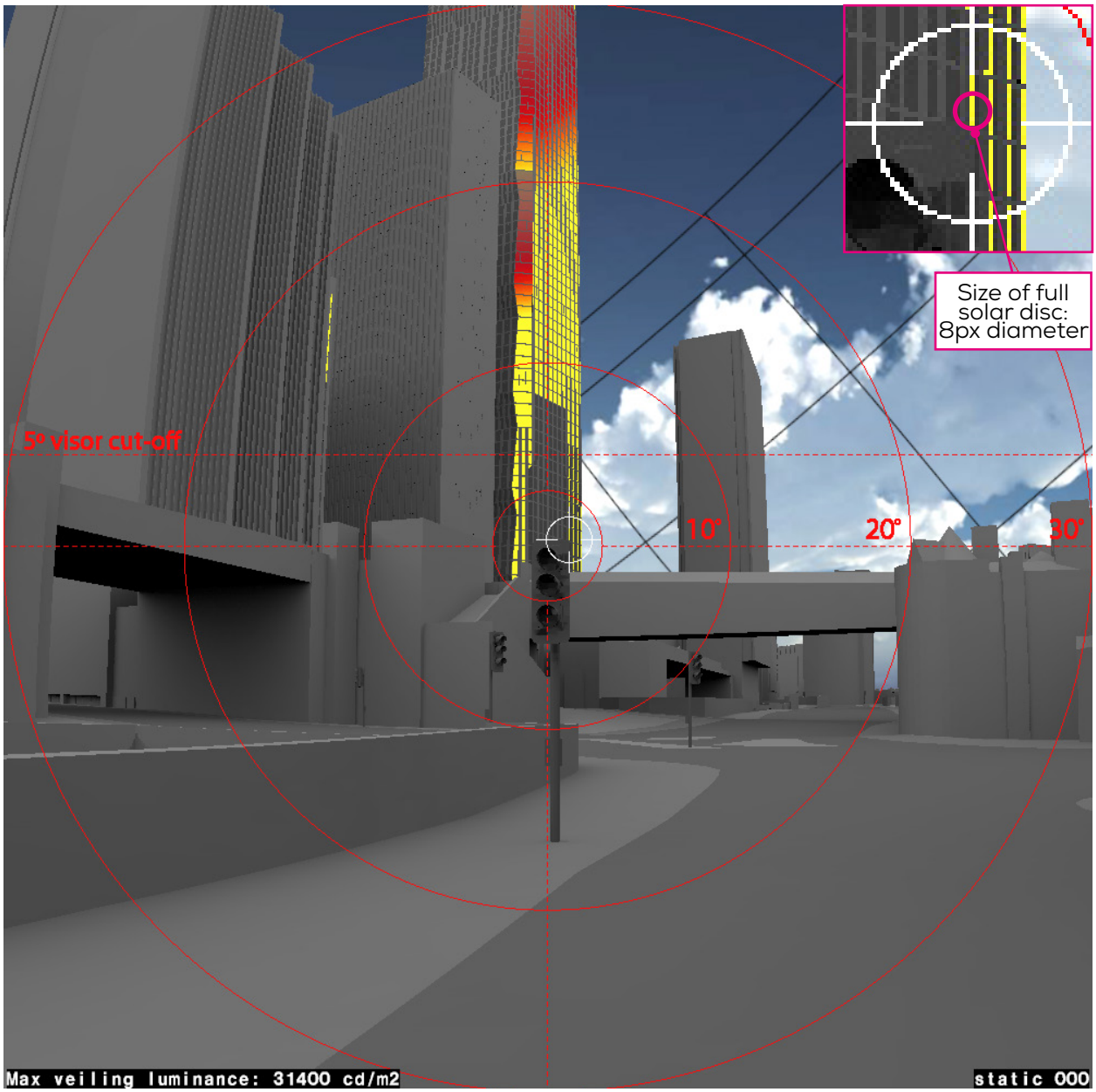
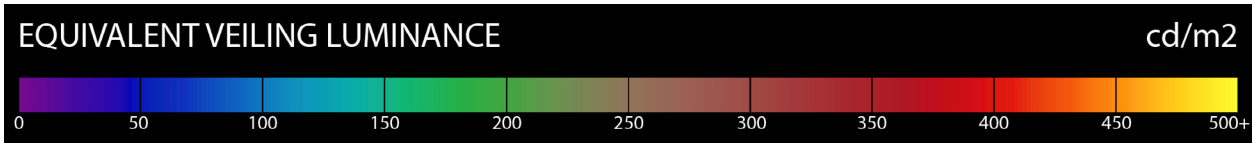


Fig. 22: Peak intensity



Two viewpoints have been assessed at this junction, CS1a and CS1b. Viewpoint CS1a shows the view of drivers looking straight ahead as they approach the junction, whilst viewpoint CS1b shows drivers looking at the left side traffic lights. There is a second traffic light on the opposite side of the junction primarily for use by stationary vehicles.

Stage 1

For viewpoint CS1a, all reflections occur outside 10° of a drivers direct line of sight and so the significance of effect is Minor Adverse.

For viewpoint CS1b, potential reflections occur within 10° of a drivers direct line of sight at this viewpoint from the southern elevation and south-western chamfer of Block A. Potential reflections occur in the morning (09:00-10:00 GMT) and afternoons (15:00-16:00 GMT) during the mid-seasons (mid-January to mid-March and mid-September to mid-November). Reflections occur from very thin strips visible from 1° - 5° and slightly larger strips are visible from 5°, above the visor cut-off line.

In consideration of the mitigating factors outlined in para 11.61 of the ES Chapter, the overall effect in terms of solar glare at this location is considered to be permanent, Moderate Adverse and significant, and so a Stage 2 assessment has been undertaken.

Stage 2

This assessment is based on the following VLR thresholds for the facades visible at this location:

- 8% for Block A Southern Elevation – Level 05-75;
- 8% for Block A South-western chamfer – Levels 05-38;
- 16% for all other glazing visible.

Figure 21 shows the peak intensity for viewpoint CS1a (when drivers are looking straight ahead approaching the junction) is 307cd/m² which is comfortably below the threshold for glare of 500cd/m².

Figure 22 shows the peak intensity of reflections from the proposed development at viewpoint CS1b. At this location, the reflections which generate the peak veiling luminance within viewpoint CS1b are significantly less than the full solar disc. The extent of the reflection is limited to 8 pixels, so only approximately 8/52th of the full solar disc is visible in the reflection. The corrected peak intensity is therefore 31,400 cd/m² * 8/52 = 4,829 cd/m².

As noted, all reflections visible when drivers are looking forward as they approach the junction (viewpoint CS1a) have a low intensity comfortably less than the threshold of 500 cd/m². Therefore, as drivers approach the junction, their vision would not be affected by reflections from the proposed development. When drivers need to rely on the traffic signals at this location during the very short period of time when reflections occur, the intensity of the reflections exceed the recommended threshold for glare with 4,829 cd/m², but would be from just 1-2 thin strips of windows at any one time.

Given the distance of this location from the Proposed Development any reflections that do occur would be for a very short period of time. In addition, given the size of the windows where reflections could occur and the broken up nature of the reflections, those reflections in excess of the glare threshold would only occur for a very short period of time and at a time when the likelihood of the sun shining is 20%-40%. Furthermore, traffic studies at this location have indicated there is a very low traffic volume with just one car every 1.5 minutes and so only a very small number of cars have the potential to be impacted by reflections at this location. Finally, drivers at this location would currently experience much greater glare within their field of view resulting from a direct view of the sun, which would be obscured when the Proposed Development is implemented.

For the above reasons and those set out in para 11.61 of the ES, it is not considered that reflections from the Proposed Development would significantly impact the ability of drivers to safely travel through this location and respond in a safe manner, as necessary, to the traffic signalling. No further mitigation is considered necessary at this location provided the VLR thresholds are adhered to.

5 GLARE INTENSITY ASSESSMENT

Watson Street (WS1) – Junction with Great Bridgewater Street

60° FIELD OF VIEW: TIME OF DAY
VIEWPOINT WS1C - RIGHT LANE, LOOKING FORWARD

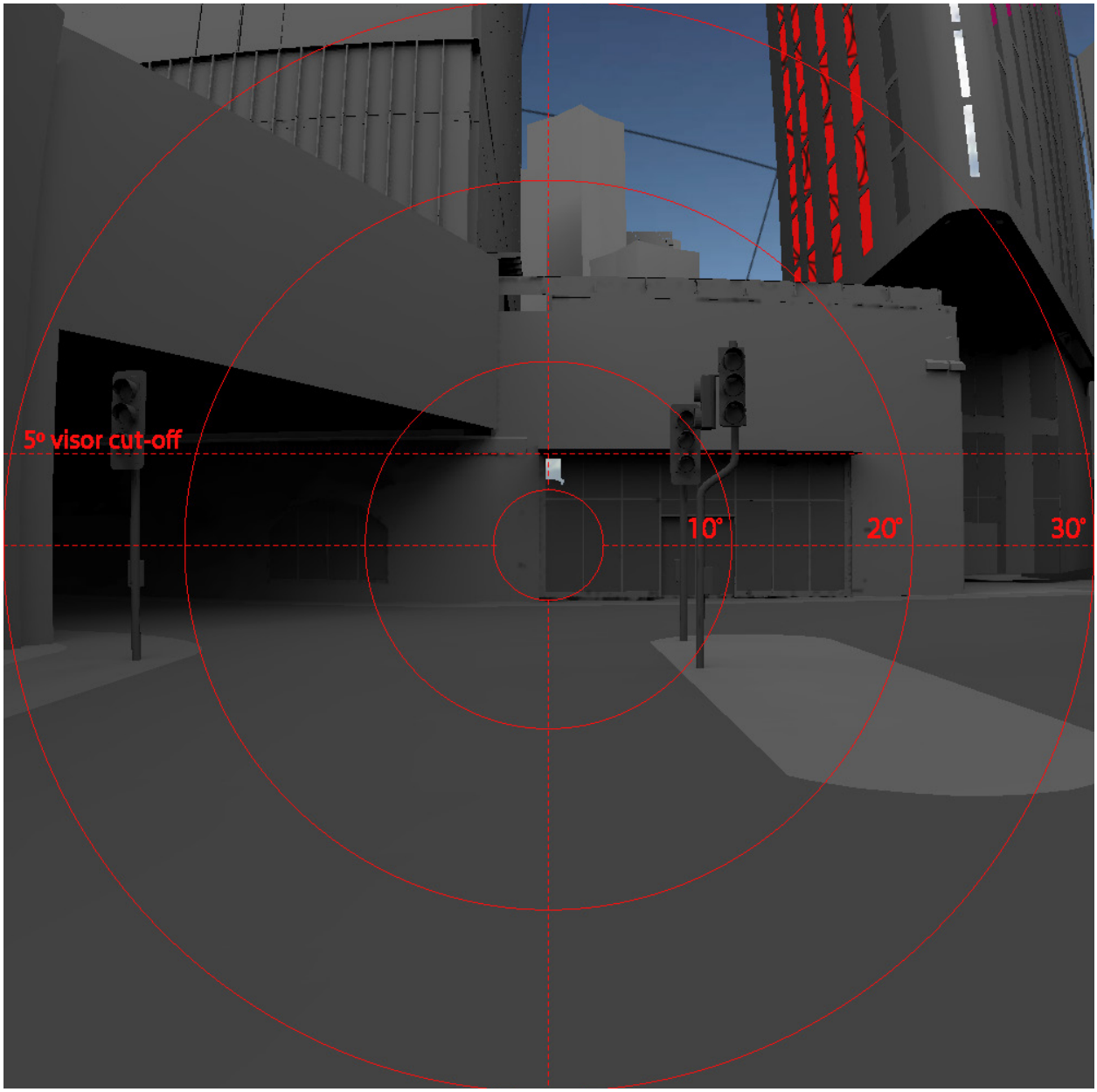
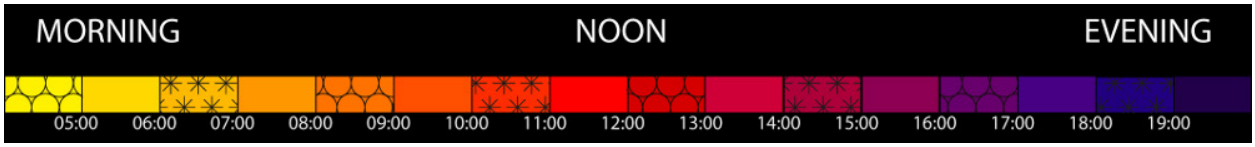


Fig. 23: Solar reflections



60° FIELD OF VIEW: SEASON
VIEWPOINT WS1C - RIGHT LANE, LOOKING FORWARD

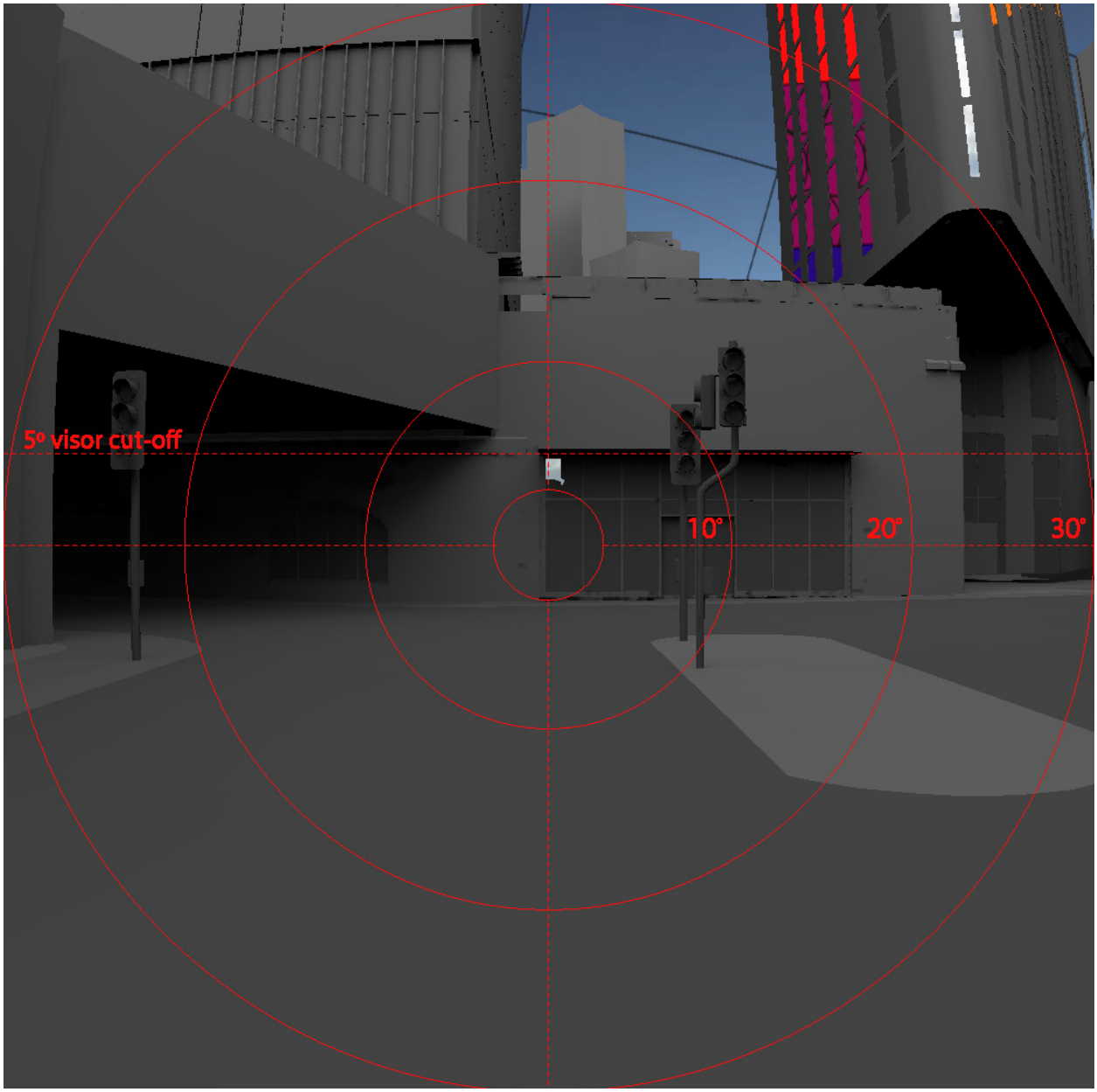


Fig. 24: Solar reflections



STAGE 1: 60° FIELD OF VIEW: TIME OF DAY
VIEWPOINT WS1D - RIGHT LANE, LOOKING AT TRAFFIC LIGHT

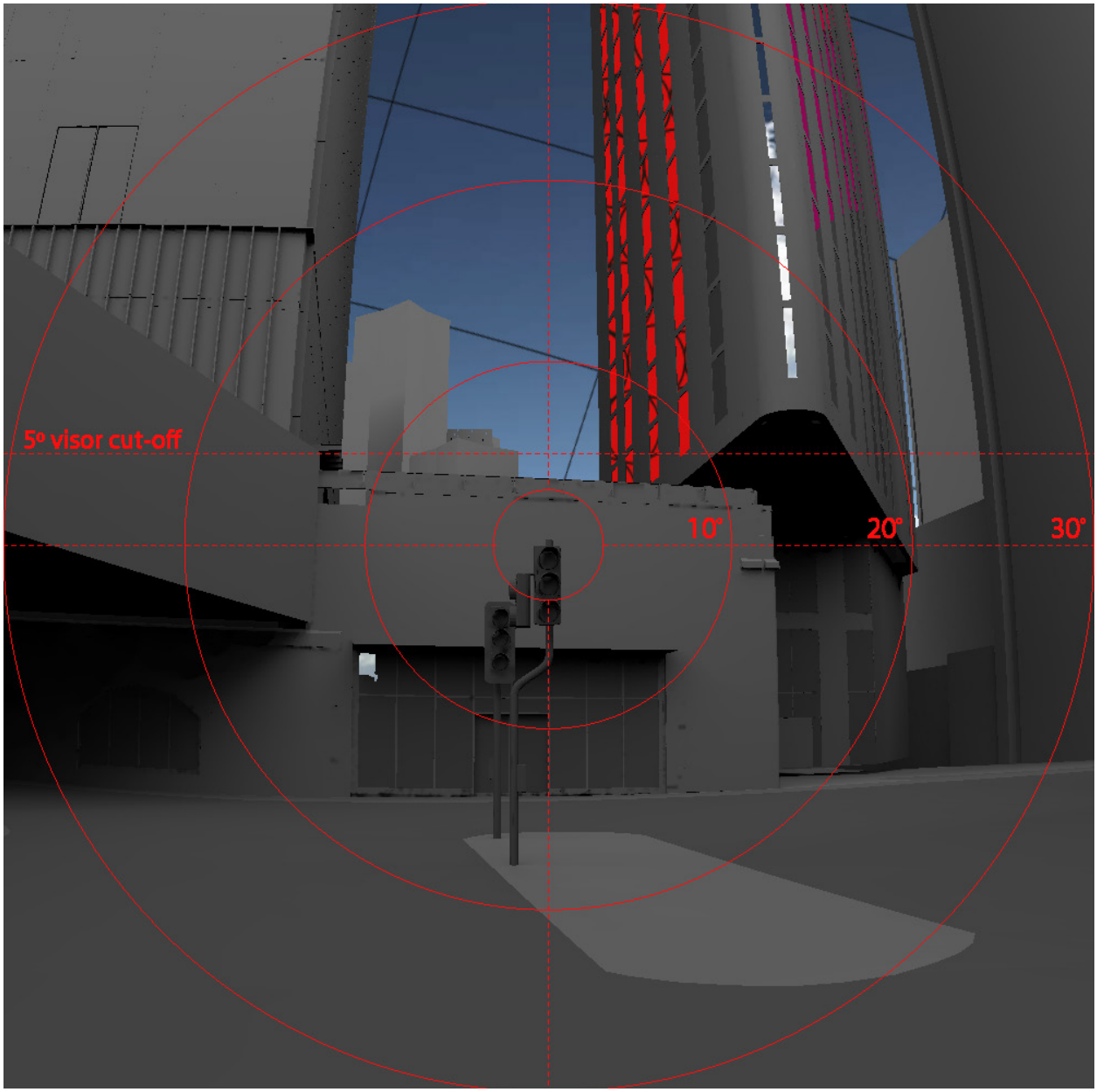
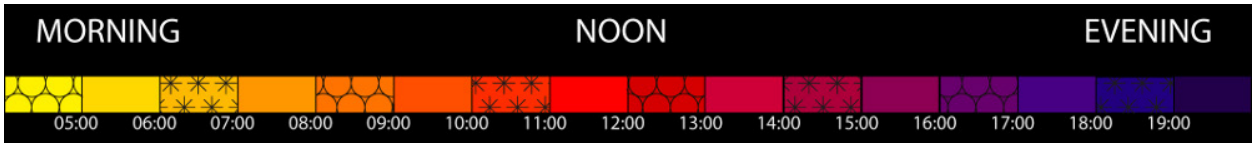


Fig. 25: Solar reflections



STAGE 1: 60° FIELD OF VIEW: SEASON
VIEWPOINT WS1D - RIGHT LANE, LOOKING AT TRAFFIC LIGHT

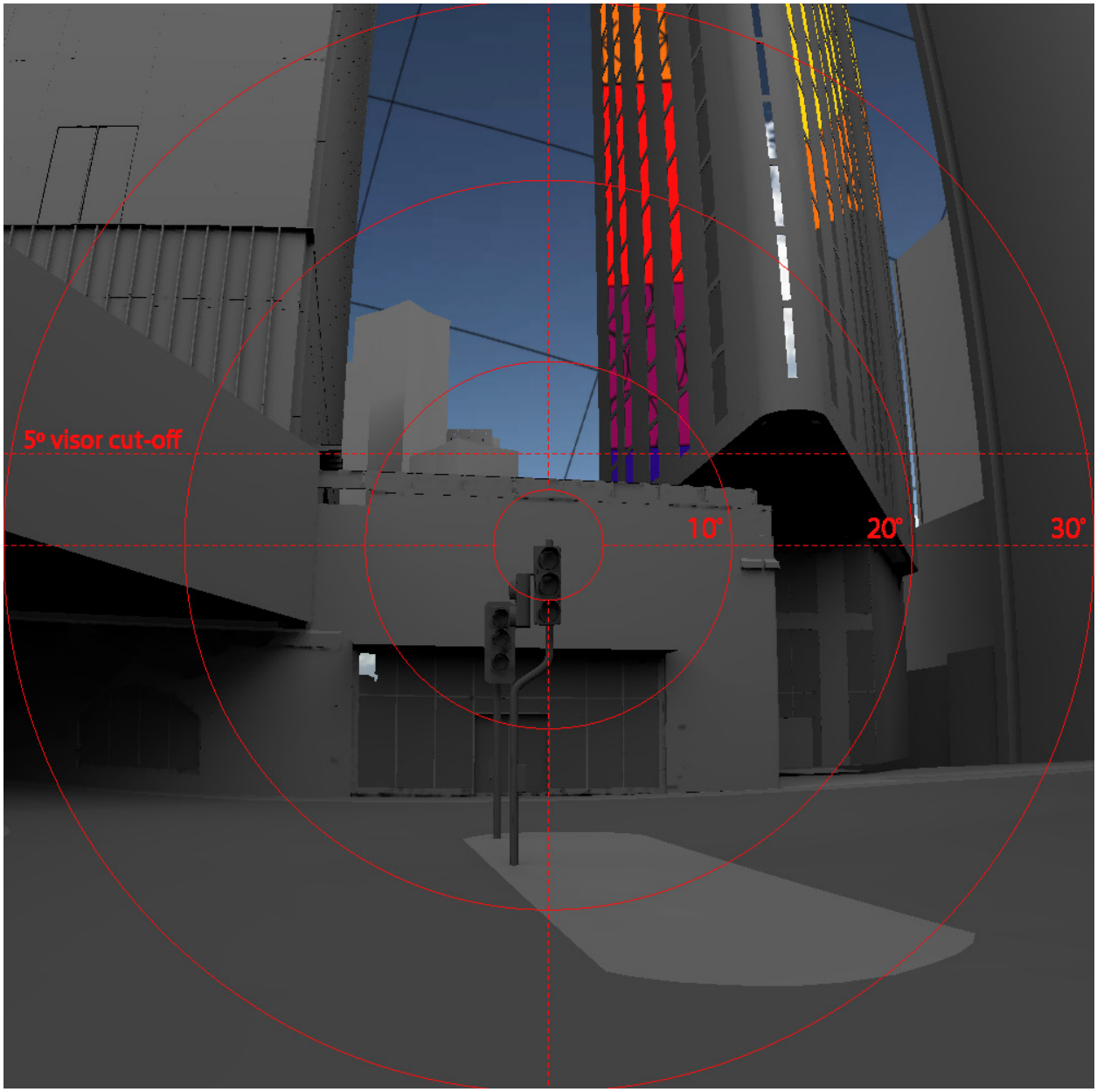


Fig. 26: Solar reflections



STAGE 2: PEAK INTENSITY ASSESSMENT
VIEWPOINT WS1C - RIGHT LANE, LOOKING FORWARD

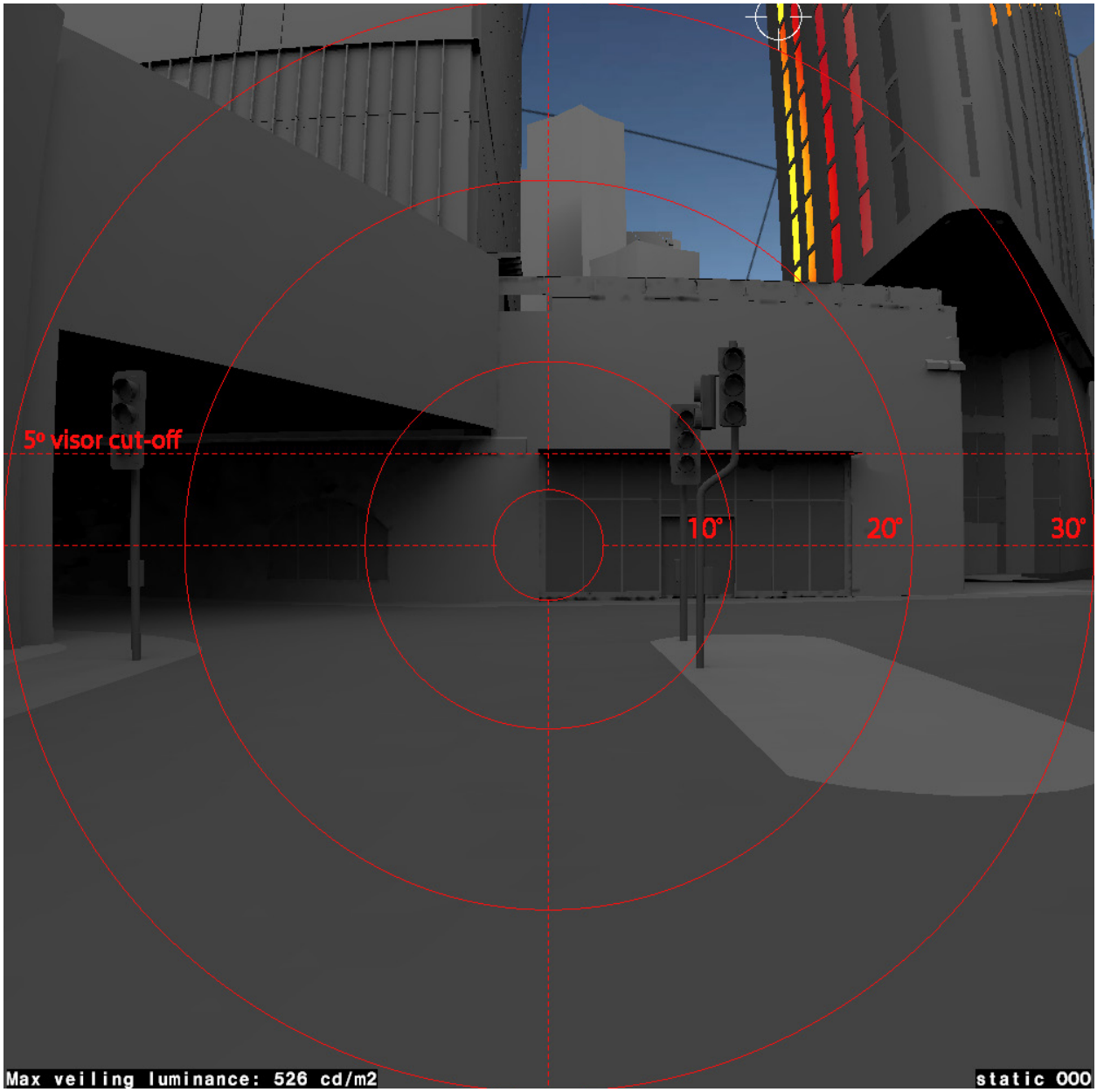
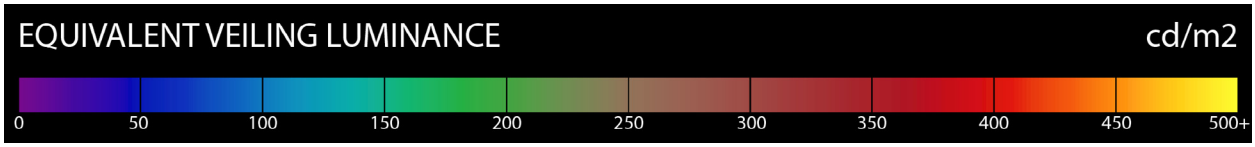


Fig. 27: Peak intensity



STAGE 2: PEAK INTENSITY ASSESSMENT
VIEWPOINT WS1D - RIGHT LANE, LOOKING AT TRAFFIC LIGHT

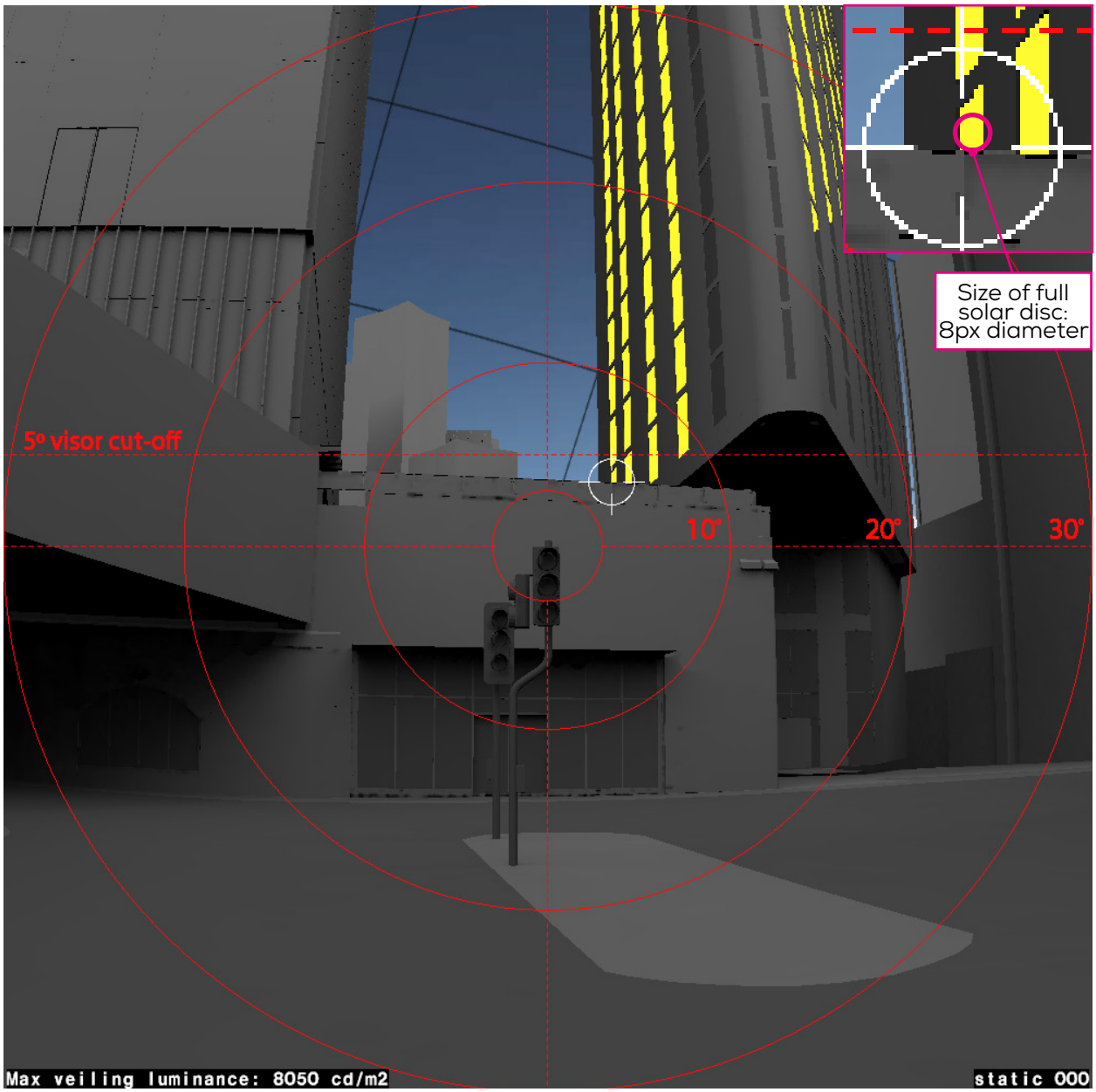
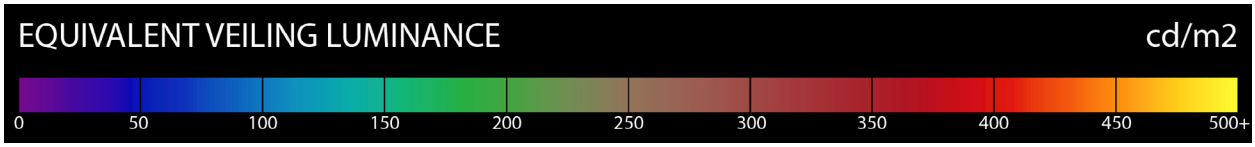


Fig. 28: Peak intensity



Two viewpoints have been assessed at this junction, WS1c and WS1d. Viewpoint WS1c shows the view of drivers in the right lane looking straight ahead as they approach the junction, whilst viewpoint WS1d shows drivers looking at the right side traffic lights. There is an alternative lights on the left side of the road and a second traffic lights on the right side after the crossing primarily for use by stationary vehicles.

Stage 1

For viewpoint WS1c, all reflections occur outside 10° of a drivers direct line of sight and so the significance of effect is Minor Adverse.

For viewpoint WS1d, potential reflections occur within 10° of a drivers direct line of sight at this viewpoint from the eastern elevation of Block B. Potential reflections occur around midday (12:00-13:00 GMT) during the winter months (mid-October to mid-February). Reflections occur from strips of windows from 5° and are mostly above the visor cut-off line.

In consideration of the mitigating factors outlined in para 11.71 of the ES Chapter, the overall effect in terms of solar glare at this location is considered to be permanent, Minor to Moderate Adverse and significant, and so a Stage 2 assessment has been undertaken.

Stage 2

This assessment is based on the following VLR thresholds for the facades visible at this location:

- 8% for Block B Eastern Elevation – Level 02-07;
- 16% for all other glazing visible.

Figure 27 shows the peak intensity for viewpoint WS1c (when drivers are looking straight ahead approaching the junction) is 526 cd/m² which is marginally above the threshold for glare of 500cd/m² and would not cause a concern in terms of glare.

Figure 28 shows the peak intensity of reflections from the proposed development at viewpoint WS1d. At this location, the reflections which generate the peak veiling luminance within viewpoint WS1d are slightly less than the full solar disc. The extent of the reflection is 36 pixels, so approximately 36/52th of the full solar disc is visible in the reflection. The corrected peak intensity is therefore 8,050 cd/m² * 36/52 = 5,573 cd/m².

As noted, all reflections visible when drivers are looking forward as they approach the junction (viewpoint WS1c) have a low intensity just marginally above the threshold of 500 cd/m² and the reflections sit well outside the direct line of sight. Therefore, as drivers approach the junction, their vision would not be affected by reflections from the proposed development. When drivers need to rely on the traffic signals at this location during the very short period of time when reflections occur, the intensity of the reflections exceed the recommended threshold for glare with 5,573 cd/m², but would be from just 1 window at any one time. There would be alternative lights, not impacted by the proposed development, on the left side of the road that drivers could use for the short period of time when reflections do occur.

With the exception of 3 windows, all reflections occur above the visor cut-off line so could be mitigated by the driver lowering their visor.

Given the broken up and glancing nature of the reflections, those reflections in excess of the glare threshold would only occur for a very short period of time and at a time when the likelihood of the sun shining is 30%. Furthermore, traffic studies at this location have indicated there is a low traffic volume with just one car every 2 minutes and so only a very small number of cars have the potential to be impacted by reflections at this location. Finally, drivers at this location would currently experience much greater glare within their field of view resulting from a direct view of the sun, which would be obscured when the Proposed Development is implemented.

For the above reasons and those set out in para 11.71 of the ES, it is not considered that reflections from the Proposed Development would significantly impact the ability of drivers to safely travel through this location and respond in a safe manner, as necessary, to the traffic signalling. No further mitigation is considered necessary at this location provided the VLR thresholds are adhered to.

6 GLARE INTENSITY ASSESSMENT

Portland Street (PS1) – Junction with Oxford Street

60° FIELD OF VIEW: TIME OF DAY
VIEWPOINT PS1C - RIGHT LANE, LOOKING FORWARD

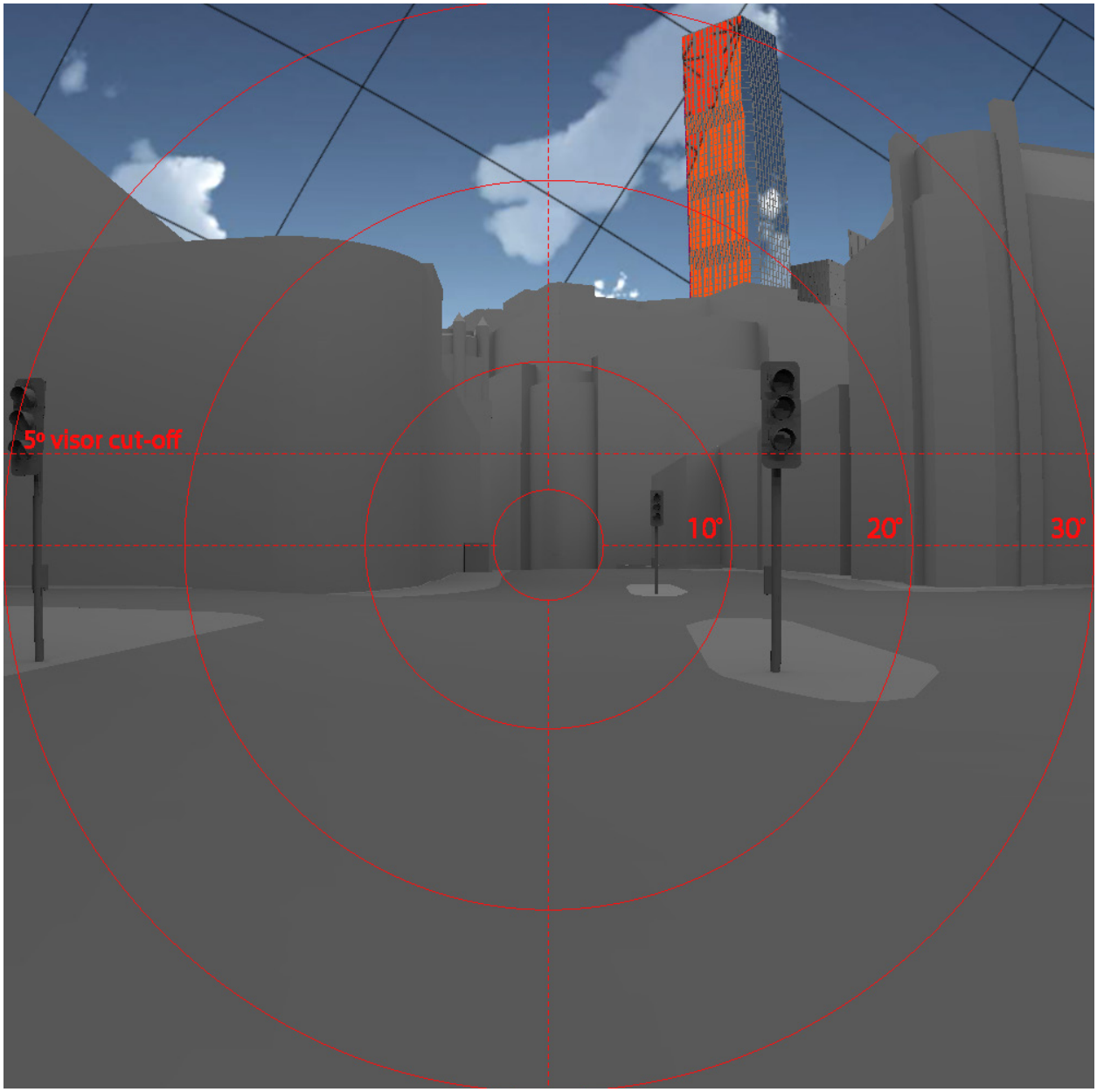
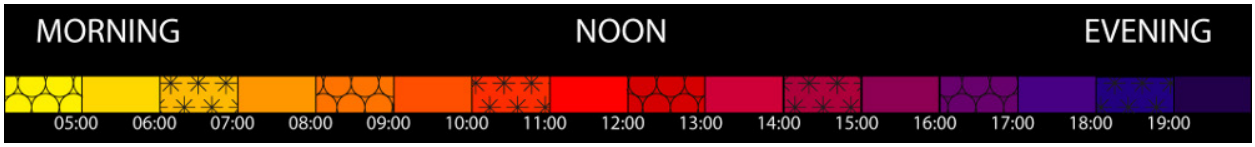


Fig. 29: Solar reflections



60° FIELD OF VIEW: SEASON
VIEWPOINT PS1C -RIGHT LANE, LOOKING FORWARD

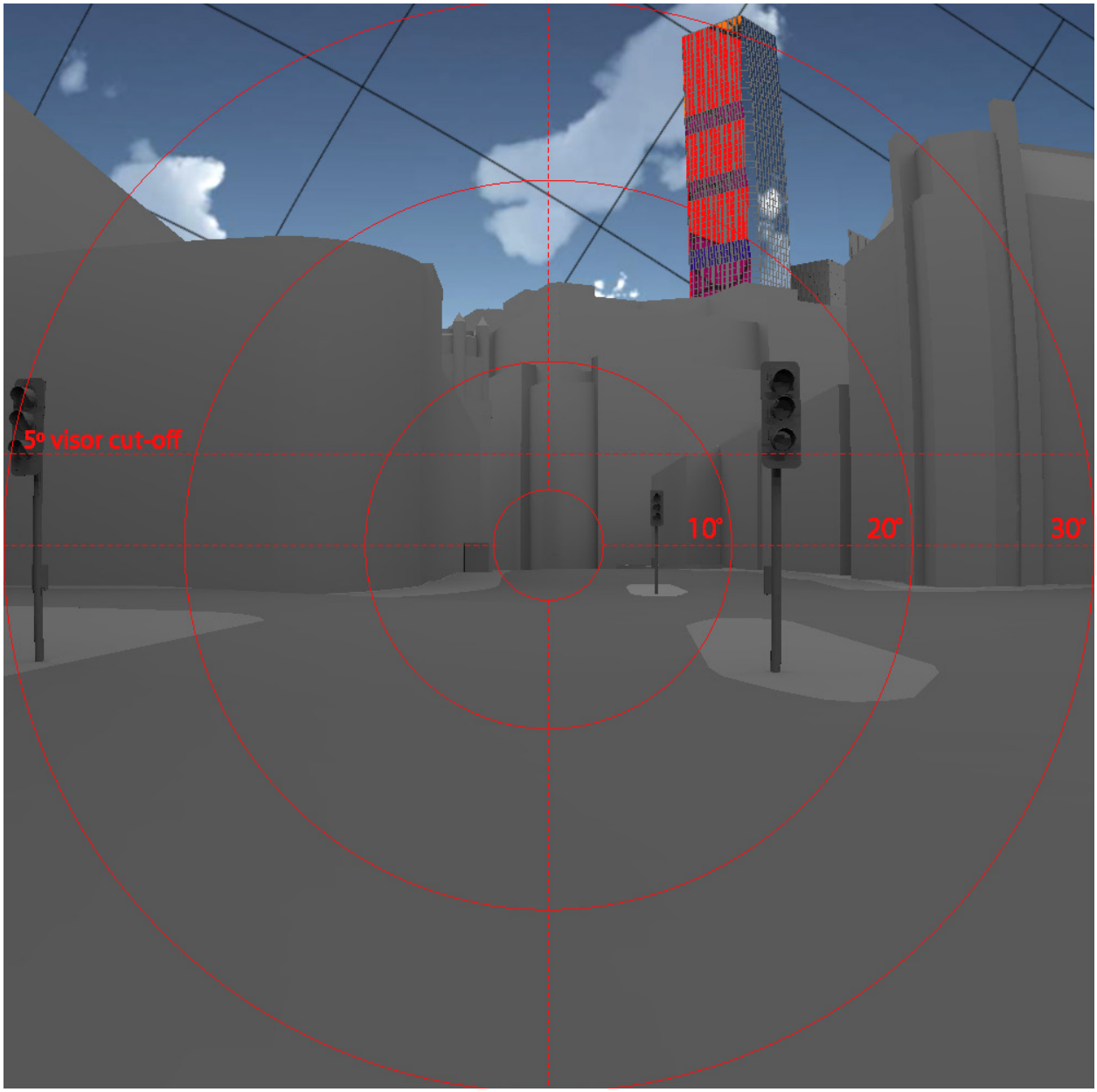


Fig. 30: Solar reflections



STAGE 1: 60° FIELD OF VIEW: TIME OF DAY
VIEWPOINT PS1D - RIGHT LANE, LOOKING AT TRAFFIC LIGHT

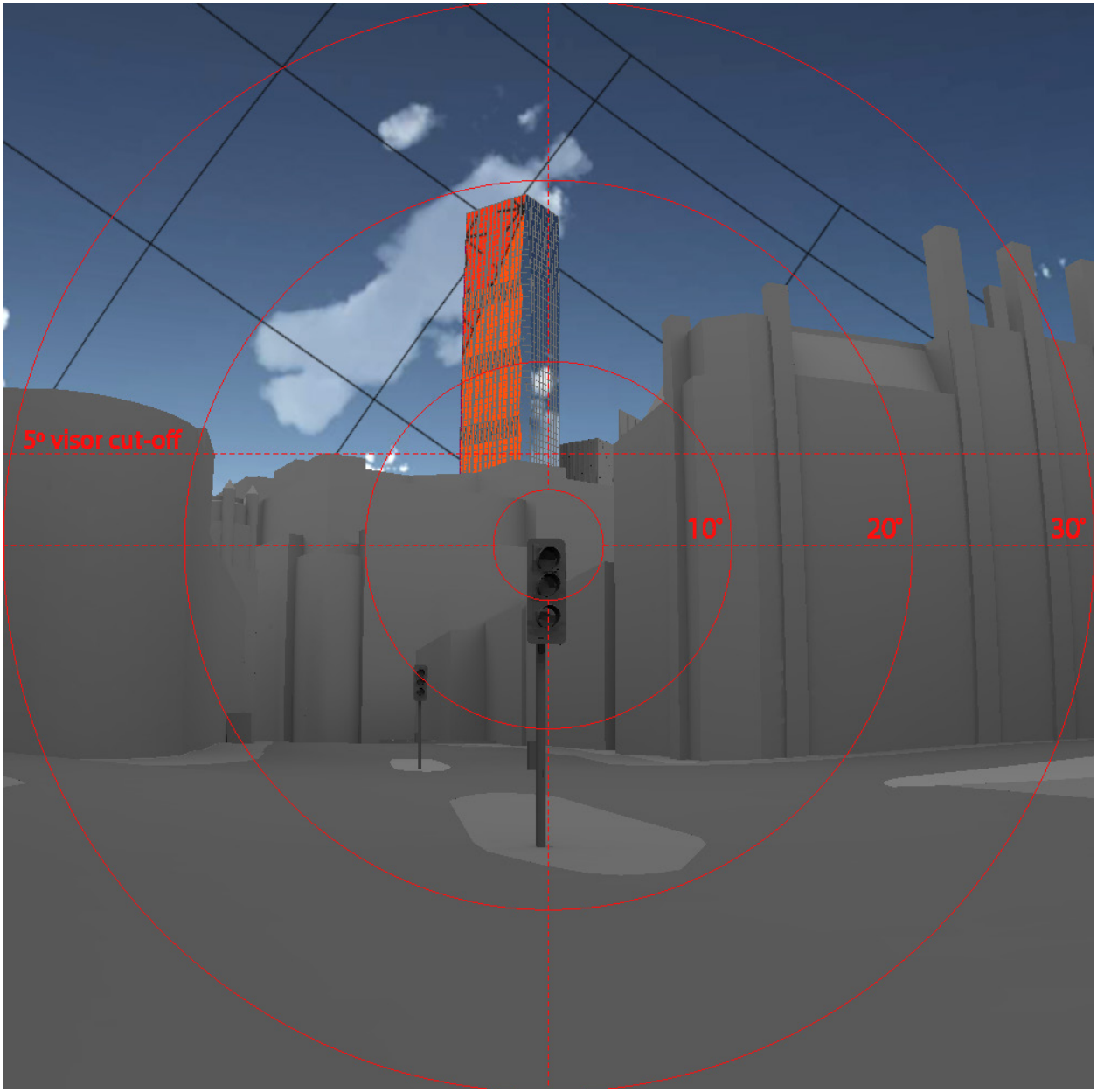
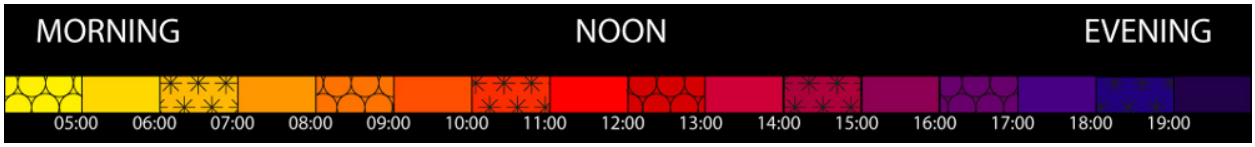


Fig. 31: Solar reflections



STAGE 1: 60° FIELD OF VIEW: SEASON
VIEWPOINT PS1D - RIGHT LANE, LOOKING AT TRAFFIC LIGHT

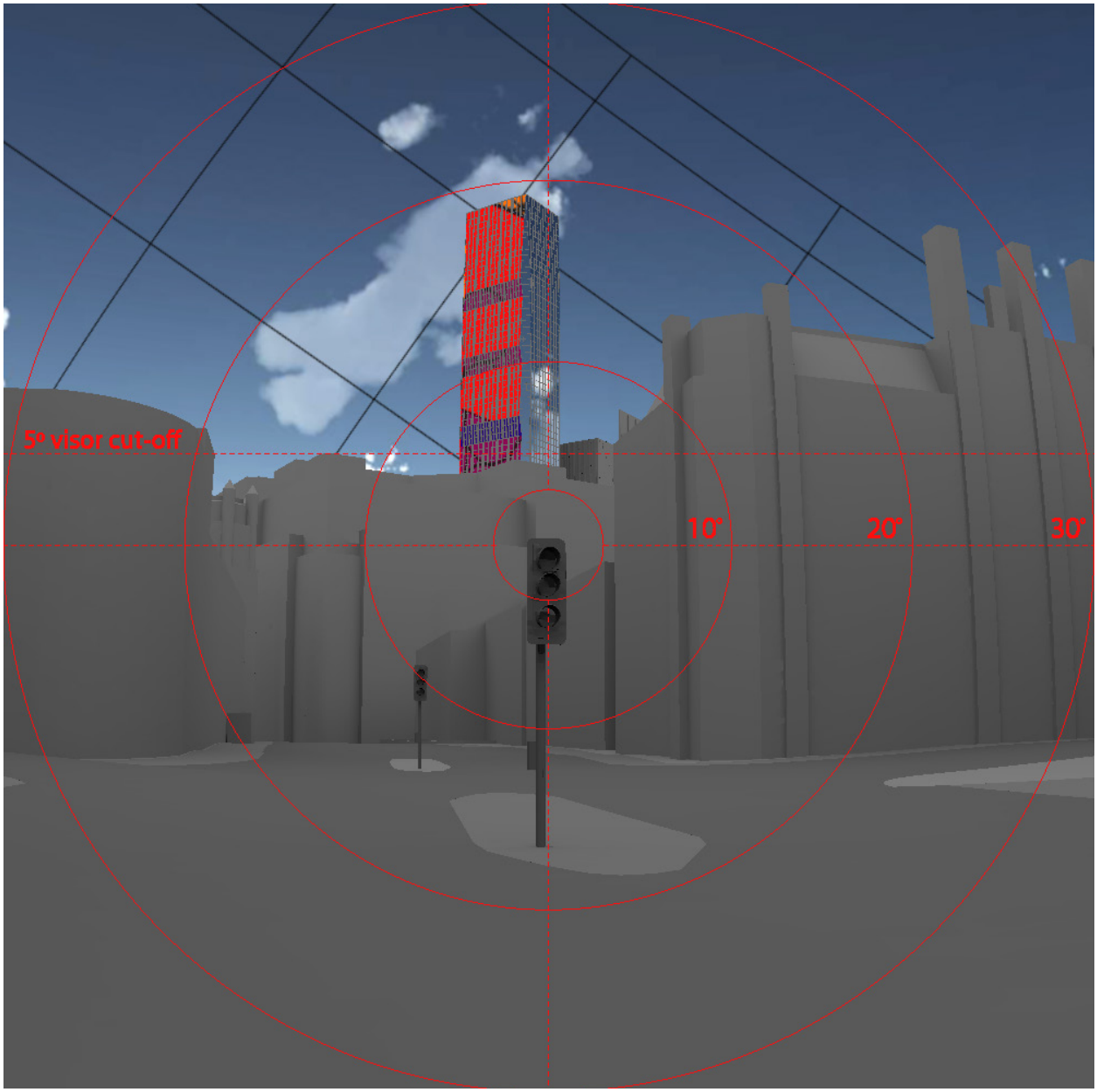


Fig. 32: Solar reflections



STAGE 2: PEAK INTENSITY ASSESSMENT
VIEWPOINT PS1C - RIGHT LANE, LOOKING FORWARD

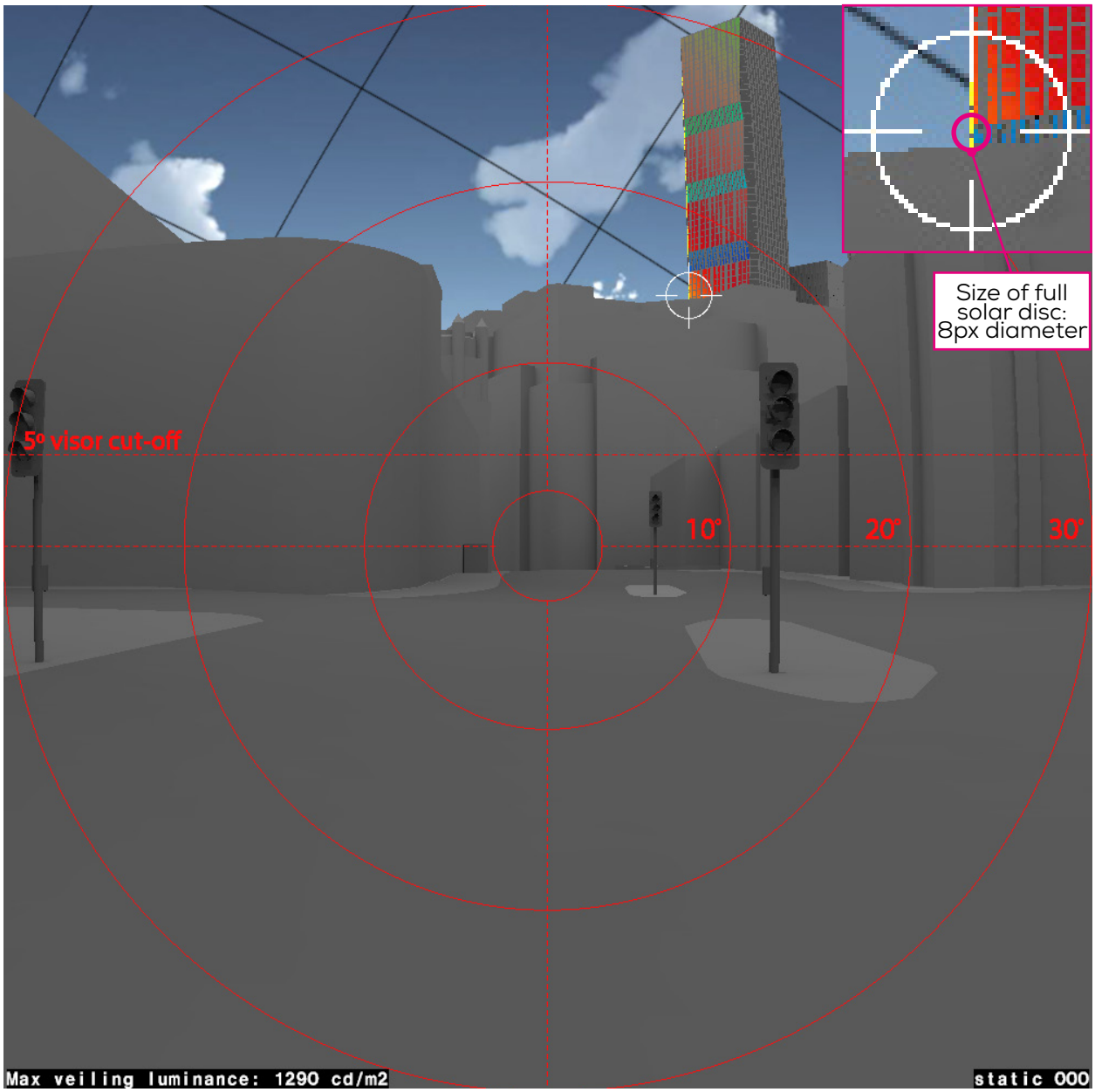
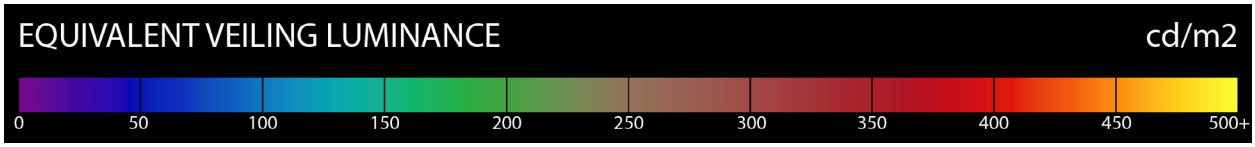


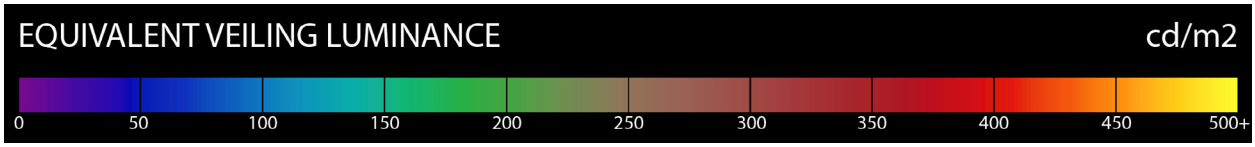
Fig. 33: Peak intensity



STAGE 2: PEAK INTENSITY ASSESSMENT
VIEWPOINT PS1D - RIGHT LANE, LOOKING AT TRAFFIC LIGHT



Fig. 34: Peak intensity



Two viewpoints have been assessed at this junction, PS1c and PS1d. Viewpoint PS1c shows the view of drivers in the right lane looking straight ahead as they approach the junction, whilst viewpoint PS1d shows drivers looking at the right side traffic lights. There is an alternative lights on the left side of the road and a second traffic light on the opposite side of the junction primarily for use by stationary vehicles.

Stage 1

For viewpoint PS1c, all reflections occur outside 10° of a drivers direct line of sight and so the significance of effect is Minor Adverse.

For viewpoint PS1d, potential reflections occur within 10° of a drivers direct line of sight at this viewpoint from the eastern elevation of Block A. Potential reflections occur in the morning (09:00-10:00 GMT) during the winter/mid-seasons (mid-September to mid-March). Reflections occur from 5° and above the visor cut-off line.

In consideration of the mitigating factors outlined in para 11.76 of the ES Chapter, the overall effect in terms of solar glare at this location is considered to be permanent, Moderate Adverse and significant, and so a Stage 2 assessment has been undertaken.

Stage 2

This assessment is based on the following VLR thresholds for the facades visible at this location:

- 12% for Block A Eastern Elevation – Levels 20-25;
- 14% for Block A Eastern Elevation – Level 29-36, Levels 40-47, Levels 51-58, and Levels 62-75;
- 16% for all other glazing visible.

Figure 33 shows the peak intensity for viewpoint PS1c (when drivers are looking straight ahead approaching the junction) is 1,290 cd/m² which is above the threshold for glare of 500cd/m² however the reflections which generate the peak veiling luminance within viewpoint PS1c are from a very thin strip and significantly less than the full solar disc. The extent of the reflection is just 8 pixels, so approximately 8/52th of the full solar disc is visible in the reflection. The corrected peak intensity is therefore 1,290 cd/m² * 8/52 = 198 cd/m² which is comfortably below the threshold for glare.

Figure 34 shows the peak intensity of reflections from the proposed development at viewpoint PS1d. At this location, the reflections which generate the peak veiling luminance within viewpoint PS1d are significantly less than the full solar disc. The extent of the reflection is 16 pixels, so approximately 16/52th of the full solar disc is visible in the reflection. The corrected peak intensity is therefore 7,890 cd/m² * 16/52 = 2,428 cd/m².

As noted, all reflections visible when drivers are looking forward as they approach the junction (viewpoint PS1c) have a low intensity comfortably less than the threshold of 500 cd/m². Therefore, as drivers approach the junction, their vision would not be affected by reflections from the proposed development. When drivers need to rely on the traffic signals at this location during the very short period of time when reflections occur, the intensity of the reflections exceed the recommended threshold for glare with 2,428 cd/m², but would be from just 1-2 thin strips of windows at any one time. There would be alternative lights, not impacted by the proposed development on the left side of the road that drivers could use for the short period of time when reflections do occur.

Most reflections occur above the visor cut-off line so could be mitigated by the driver lowering their visor.

Given the distance of this location from the Proposed Development any reflections that do occur would be for a very short period of time. In addition, given the broken up nature of the reflections, those reflections in excess of the glare threshold would only occur for a very short period of time and at a time when the likelihood of the sun shining is 20%-40%. Furthermore, drivers at this location would currently experience much greater glare within their field of view resulting from a direct view of the sun, which would be obscured when the Proposed Development is implemented.

For the above reasons and those set out in para 11.76 of the ES, it is not considered that reflections from the Proposed Development would significantly impact the ability of drivers to safely travel through this location and respond in a safe manner, as necessary, to the traffic signalling. No further mitigation is considered necessary at this location provided the VLR thresholds are adhered to.

7 GLARE INTENSITY ASSESSMENT

Great Bridgewater Street (GBS1) – Junction with Lower Mosley Street

60° FIELD OF VIEW: TIME OF DAY
VIEWPOINT GBS1A - LEFT LANE, LOOKING FORWARD

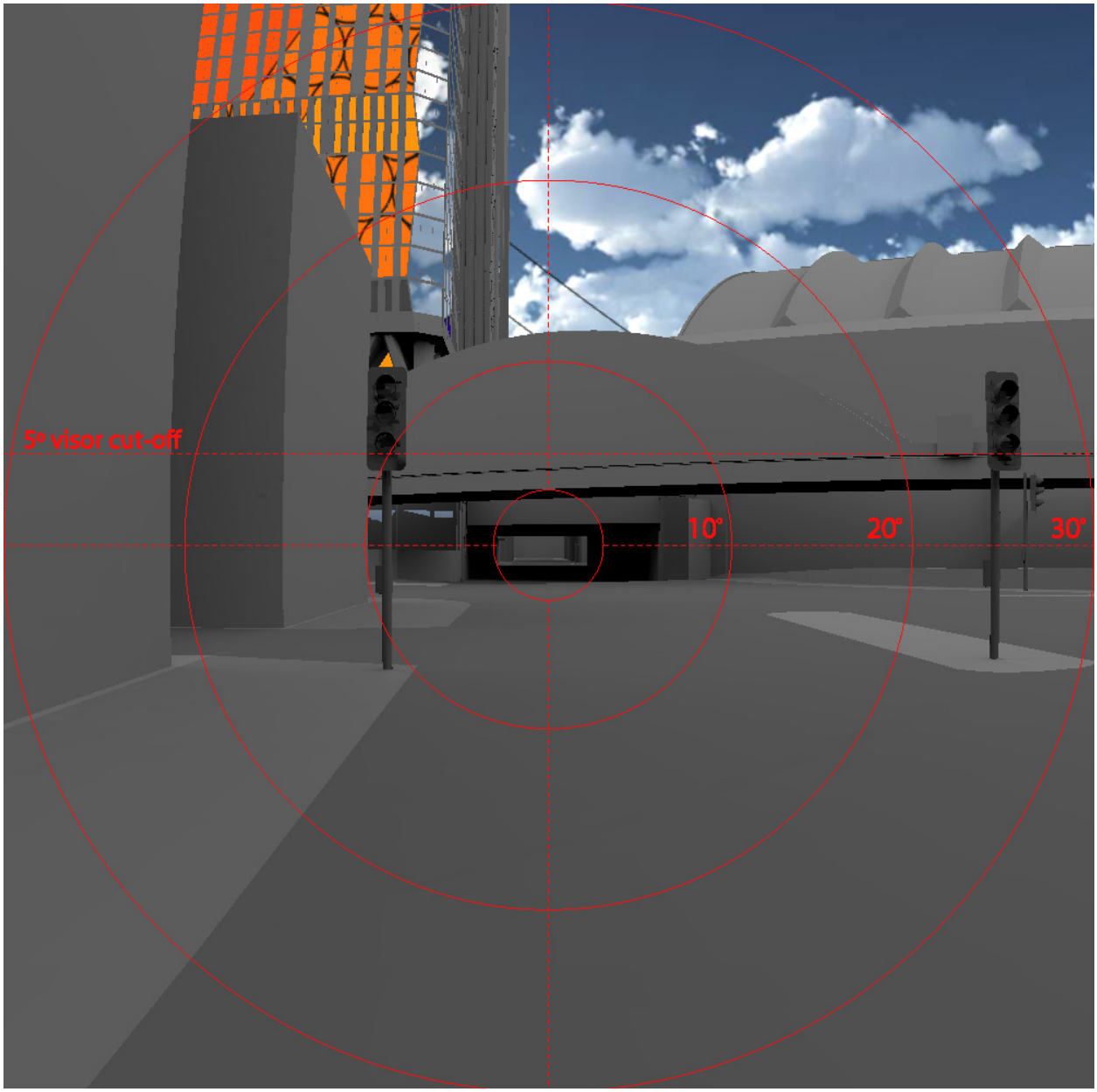
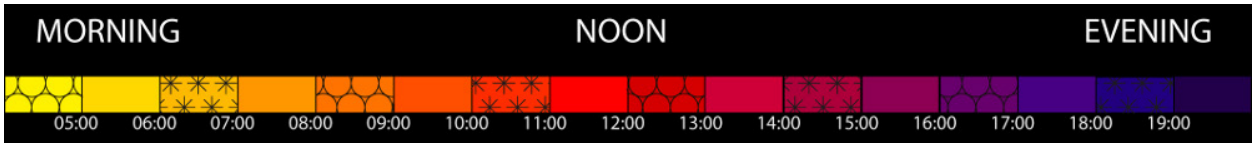


Fig. 35: Solar reflections



60° FIELD OF VIEW: SEASON
VIEWPOINT GBS1A - LEFT LANE, LOOKING FORWARD

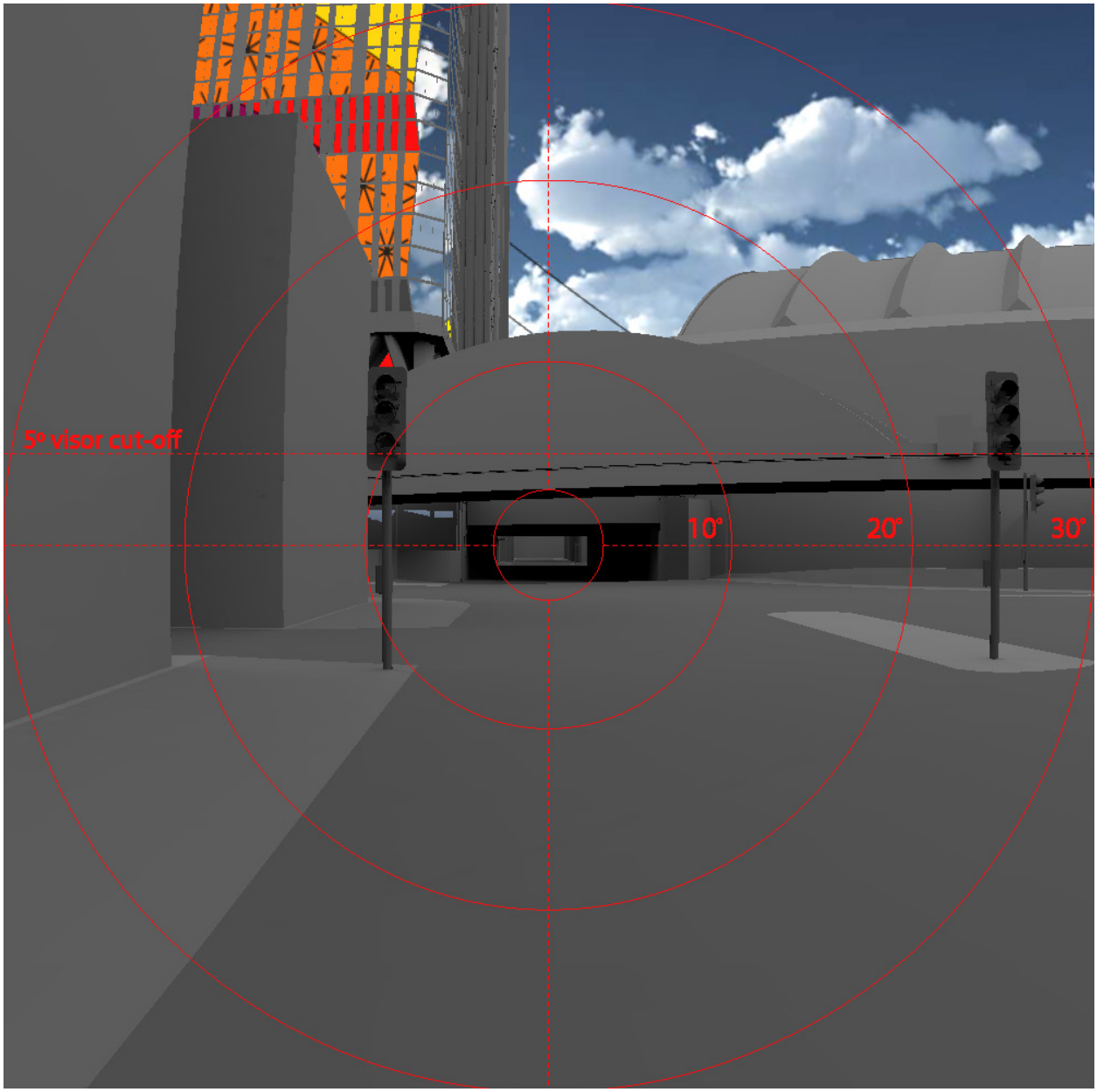


Fig. 36: Solar reflections



STAGE 1: 60° FIELD OF VIEW: TIME OF DAY
VIEWPOINT GBS1B - LEFT LANE, LOOKING AT TRAFFIC LIGHT

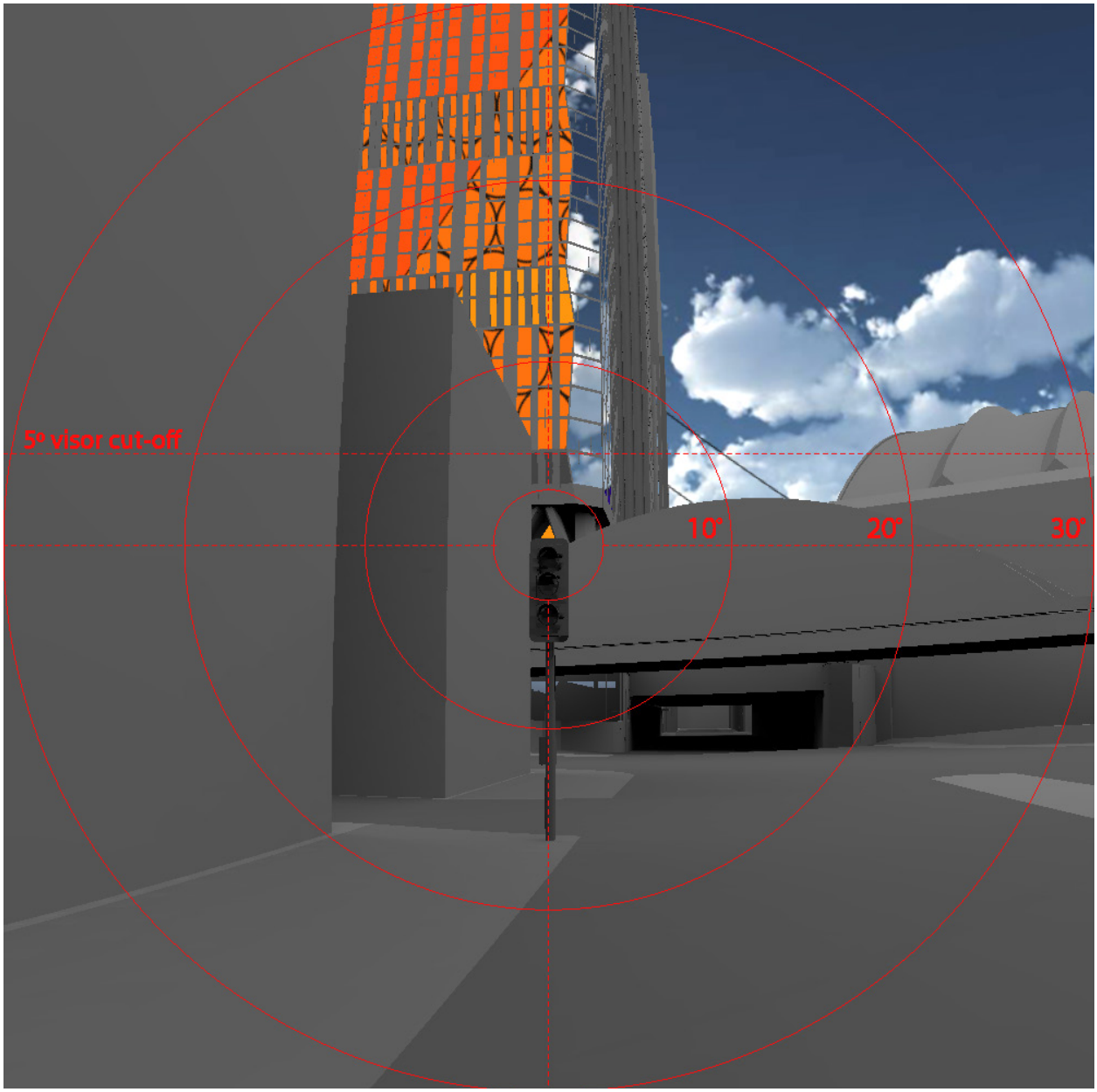
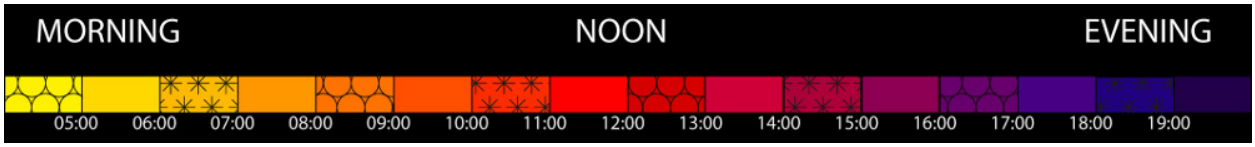


Fig. 37: Solar reflections



STAGE 1: 60° FIELD OF VIEW: SEASON
VIEWPOINT GBS1B - LEFT LANE, LOOKING AT TRAFFIC LIGHT

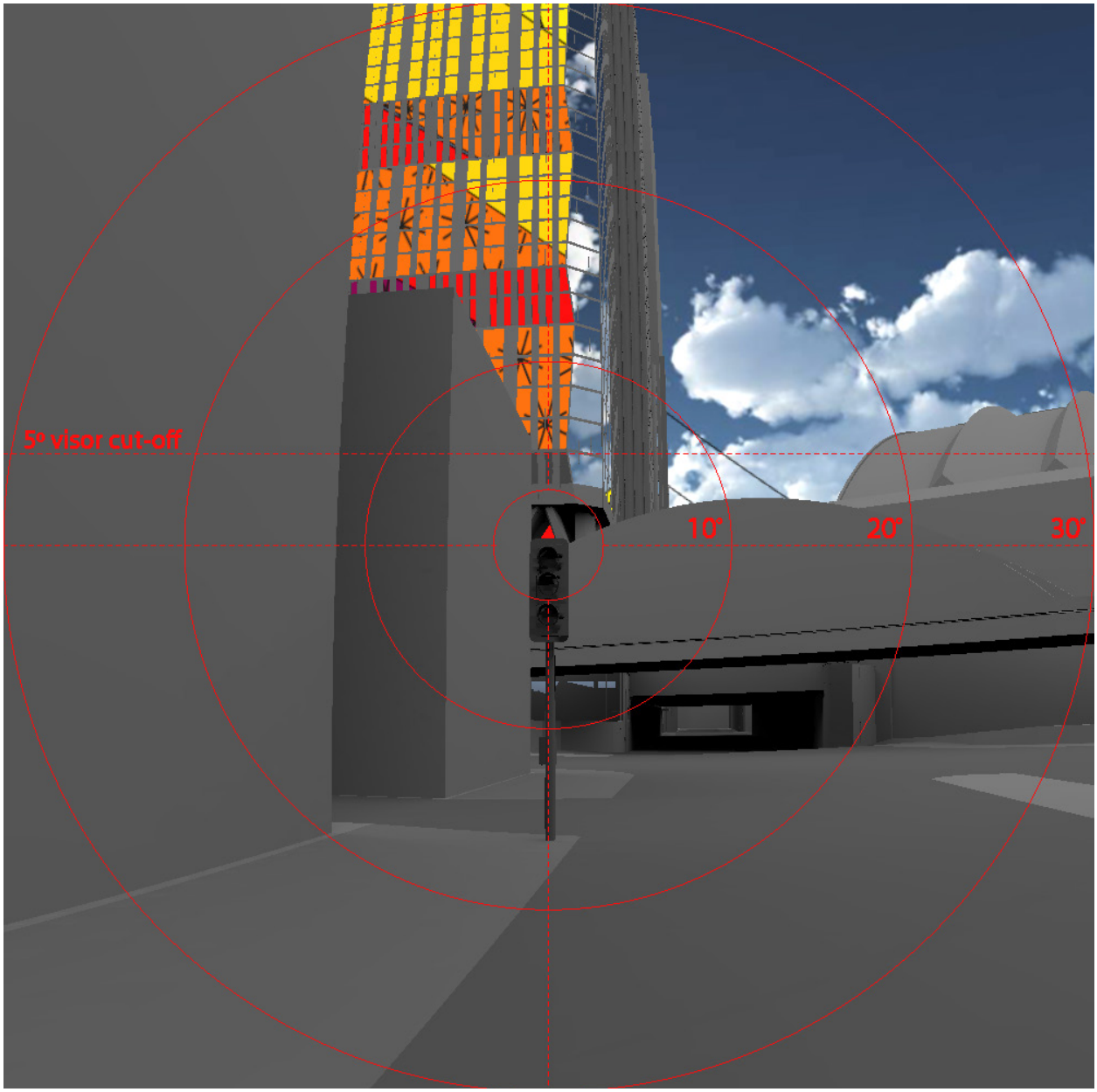


Fig. 38: Solar reflections



STAGE 2: PEAK INTENSITY ASSESSMENT
VIEWPOINT GBS1A - LEFT LANE, LOOKING FORWARD

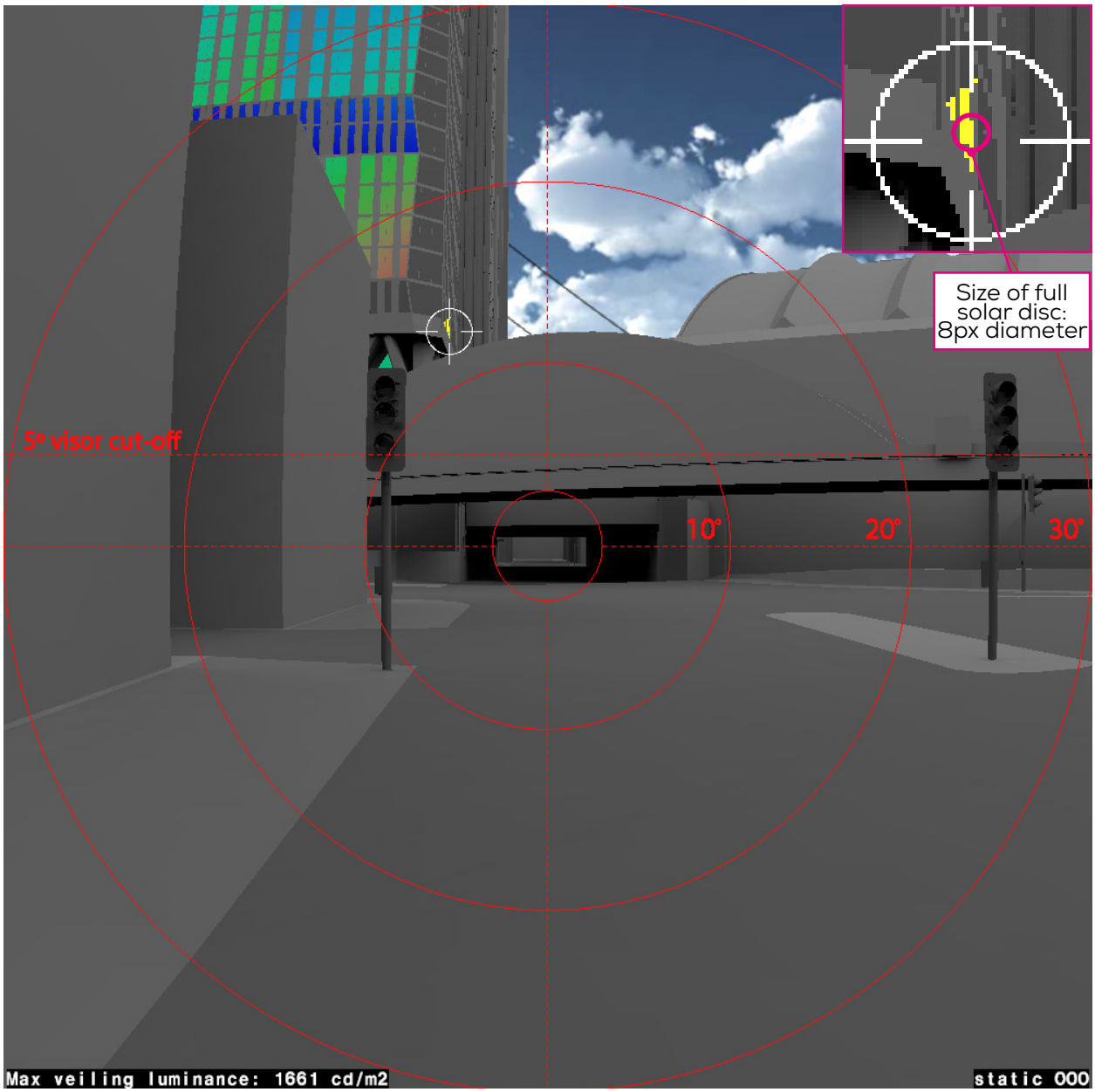
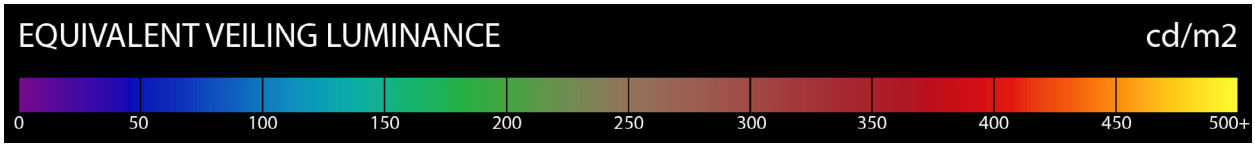


Fig. 39: Peak intensity



STAGE 2: PEAK INTENSITY ASSESSMENT
VIEWPOINT GBS1B - LEFT LANE, LOOKING AT TRAFFIC LIGHT

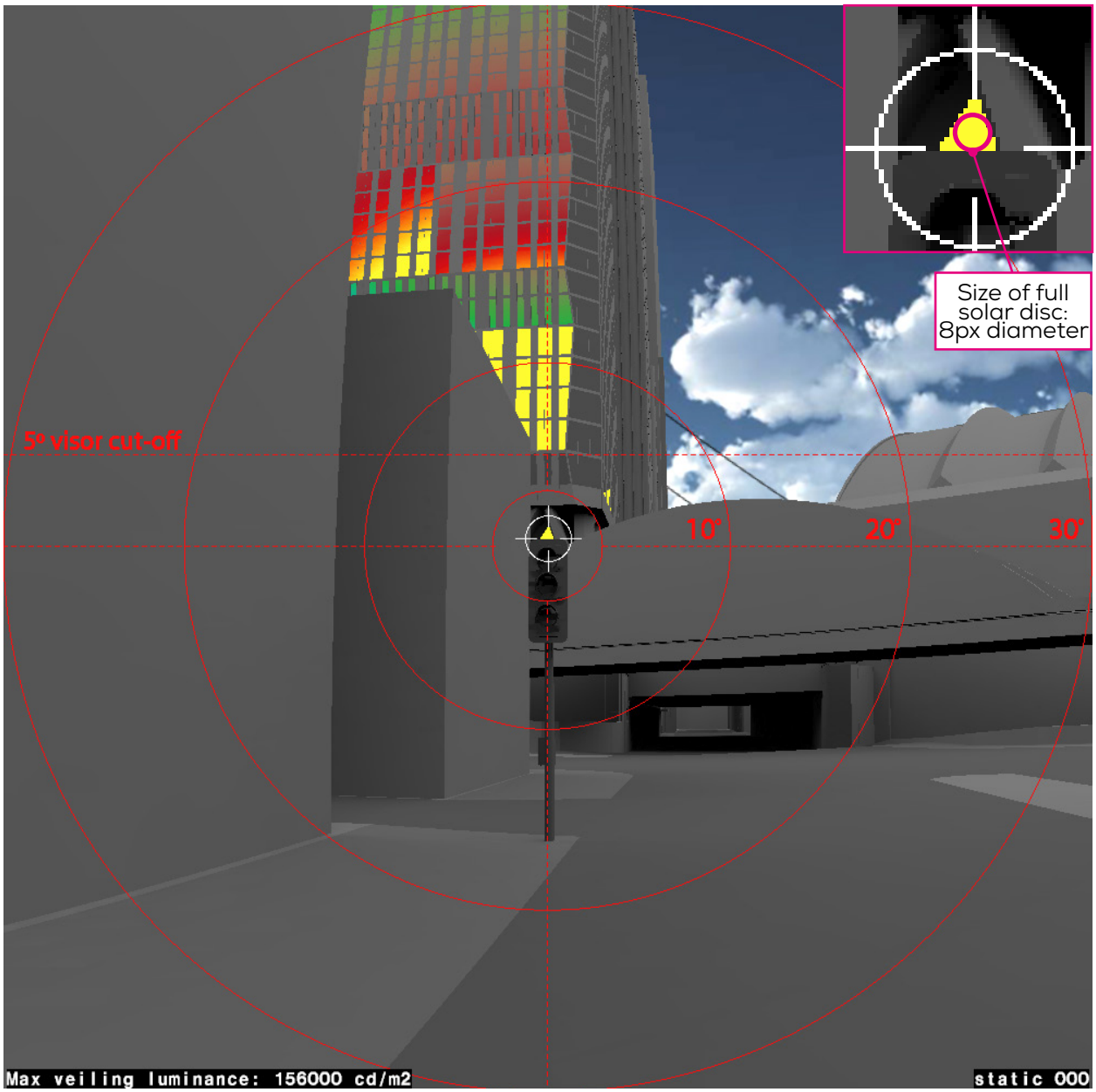
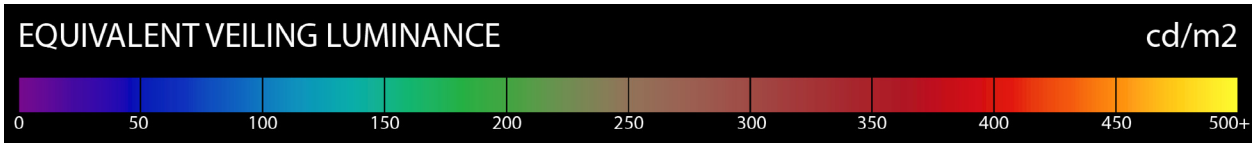


Fig. 40: Peak intensity



STAGE 2: PEAK INTENSITY ASSESSMENT
VIEWPOINT GBS1B - LEFT LANE, LOOKING AT TRAFFIC LIGHT EXCLUDING REFLECTIONS FROM PODIUM & NORTHERN ELEVATION

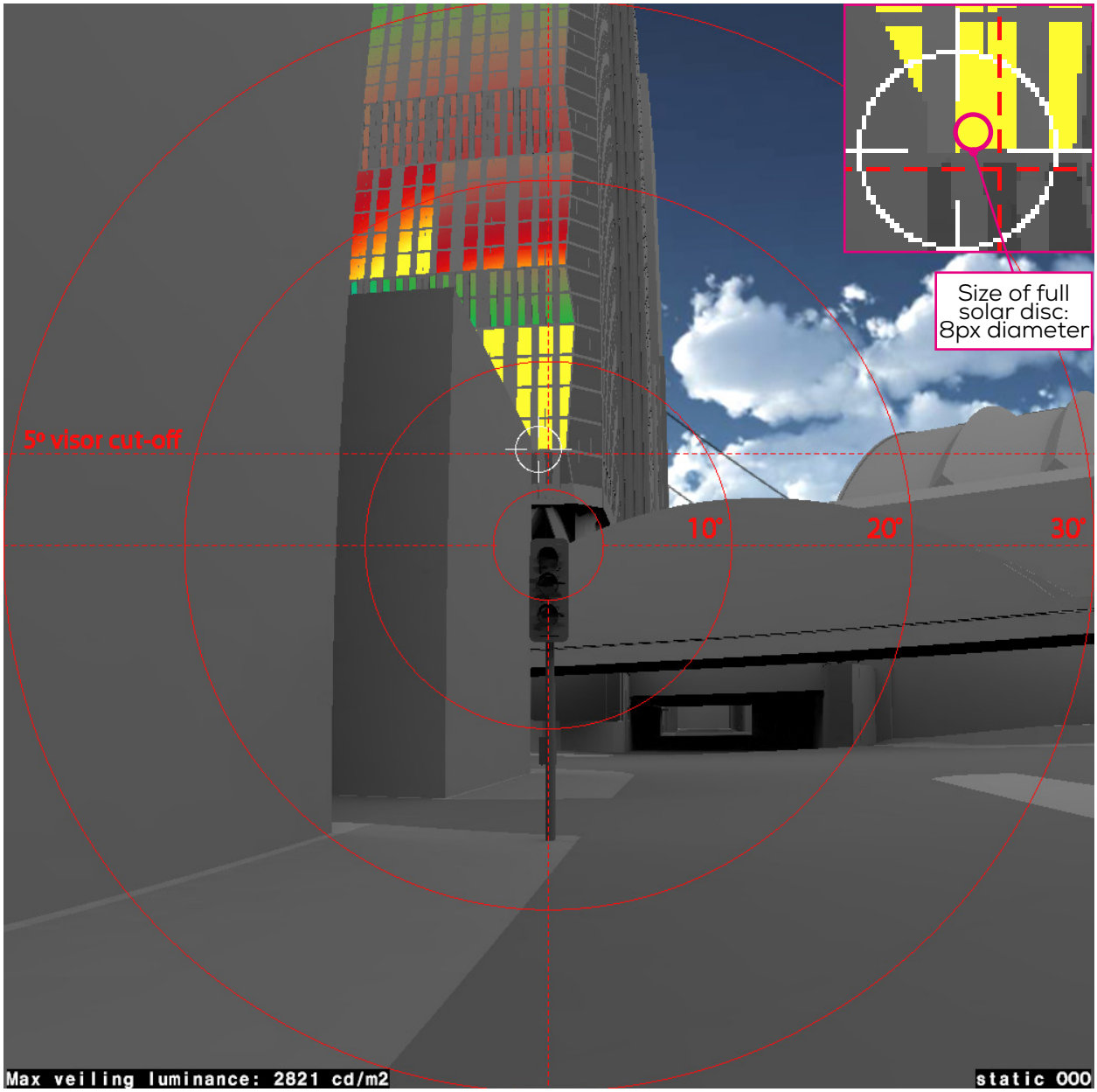
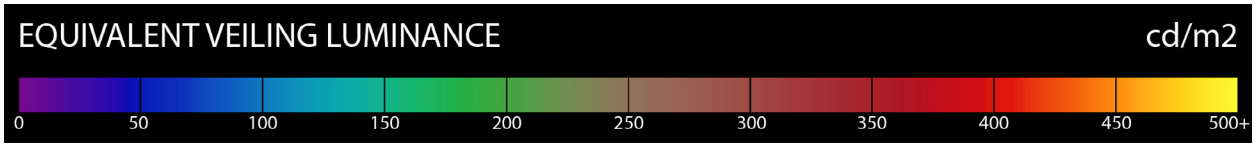


Fig. 41: Peak intensity



Two viewpoints have been assessed at this junction, GBS1c and GBS1d. Viewpoint GBS1c shows the view of drivers in the left lane looking straight ahead as they approach the junction, whilst viewpoint GBS1d shows drivers looking at the left side traffic lights. There is an alternative lights on the right side of the road and a second traffic light on the opposite side of the junction primarily for use by stationary vehicles.

Stage 1

For viewpoint GBS1a, all reflections occur outside 10° of a drivers direct line of sight and so the significance of effect is Minor Adverse.

For viewpoint GBS1b, potential reflections occur within 10° of a drivers direct line of sight at this viewpoint from the northern elevation, eastern elevation (including the podium) and north-eastern chamfer of Block A. Potential reflections occur in the early morning (07:00-09:00 GMT) during the mid-seasons (early-February to mid-April and mid-August to late-October) and in the evening (18:00-19:00 GMT) during the summer months (mid-May to mid-July). Reflections occur from the podium and northern elevation are from very small areas visible from 0° - 5°. All reflections from the up-tilted panels of the eastern elevation are above the visor cut-off line.

In consideration of the mitigating factors outlined in para 11.81 of the ES Chapter, the overall effect in terms of solar glare at this location is considered to be permanent, Major Adverse and significant, and so a Stage 2 assessment has been undertaken.

Stage 2

This assessment is based on the following VLR thresholds for the facades visible at this location:

- 8% for Block A Eastern Elevation – Levels 06-09 (northern half) and Levels 12-16 (northern half);
- 8% for Block A North-eastern chamfer – Levels 05-19;
- 12% for Block A Eastern Elevation – Levels 06-09 (central section), Levels 12-16 (central section) and Levels 20-25;
- 14% for Block A Northern Elevation – Level 05;
- 14% for Block A North-eastern chamfer – Levels 20-25;
- 14% for Block A Eastern Elevation – Level 29-36, Levels 40-47, Levels 51-58 and Levels 62-75;
- 16% for all other glazing visible.

Figure 39 shows the peak intensity for viewpoint GBS1a (when drivers are looking straight ahead approaching the junction) is 1,661 cd/m², occurring from the northern elevation, which is above the threshold for glare of 500cd/m². All reflections from the eastern elevation are below the threshold for glare. The reflections which generate the peak veiling luminance within viewpoint GBS1a are from a very thin strip and significantly less than the full solar disc. The extent of the reflection is just 15 pixels, so approximately 15/52th of the full solar disc is visible in the reflection. The corrected peak intensity is therefore 1,661 cd/m² * 15/52 = 479 cd/m² which is below the threshold for glare.

Figure 40 shows the peak intensity of reflections from the proposed development at viewpoint GBS1b. At this location, the reflections which generate the peak veiling luminance within viewpoint GBS1b are from a small area of podium glazing which is capable of reflecting the full solar disc with an intensity of 156,000 cd/m² due to reflections being located within the direct line of sight. Given the extent of exceedance of the glare threshold, it is recommended that during the detailed design stages, the offending glazed panels are screened or substituted with non-reflective panels to avoid reflections directly behind the traffic lights impacting drivers at this location.

Figure 41 shows the peak intensity of reflections excluding the high intensity reflections from the podium glazing and the northern elevation reflections. The up-tilted panels of the eastern elevation are capable of reflecting the full solar disc with an intensity of 2,821 cd/m². All reflections in excess of the glare threshold are located above the visor cut-off line so could be mitigated by the driver lowering their visor and are at least 9° from the direct line of sight. The full intensity of the solar disc is capable of being reflected by the up-tilted panels, it is recommended that during the detailed design stages further studies are undertaken to reduce the size of visible glazing and thus reduce the intensity of reflections from the up-tilted panels.

As noted, all reflections visible when drivers are looking forward as they approach the junction (viewpoint GBS1a) have a low intensity below the threshold of 500 cd/m². Therefore, as drivers approach the junction, their vision would not be affected by reflections from the proposed development.

When drivers need to rely on the left side traffic signals at this location during the very short period of time when reflections occur, the intensity of the reflections exceed the recommended threshold for glare, however with the offending glazed panels substituted at podium level with non-reflective panels, the exceedance is reduced from significantly to 2,821cd/m². All reflections occurring above the intensity threshold (excluding the podium glazing) are located above the visor cut-off line and so can be mitigated by deploying the visor. Additionally, there would be alternative lights, not impacted by the proposed development, on the right side of the road that drivers could use for the short period of time when reflections do occur.

For the above reasons and those set out in para 11.81 of the ES, it is considered that following the incorporation of additional mitigation at podium and the northern end of the eastern elevation between Levels 06-09, reflections from the Proposed Development would not significantly impact the ability of drivers to safely travel through this location and respond in a safe manner, as necessary, to the traffic signalling. Further detailed testing and mitigation strategies will be determined and embedded in the design prior to installation of any facades.

8 GLARE INTENSITY ASSESSMENT

Lower Mosley Street (LMS2) – Pedestrian Crossing

60° FIELD OF VIEW: TIME OF DAY
VIEWPOINT LMS2A - LOOKING FORWARD

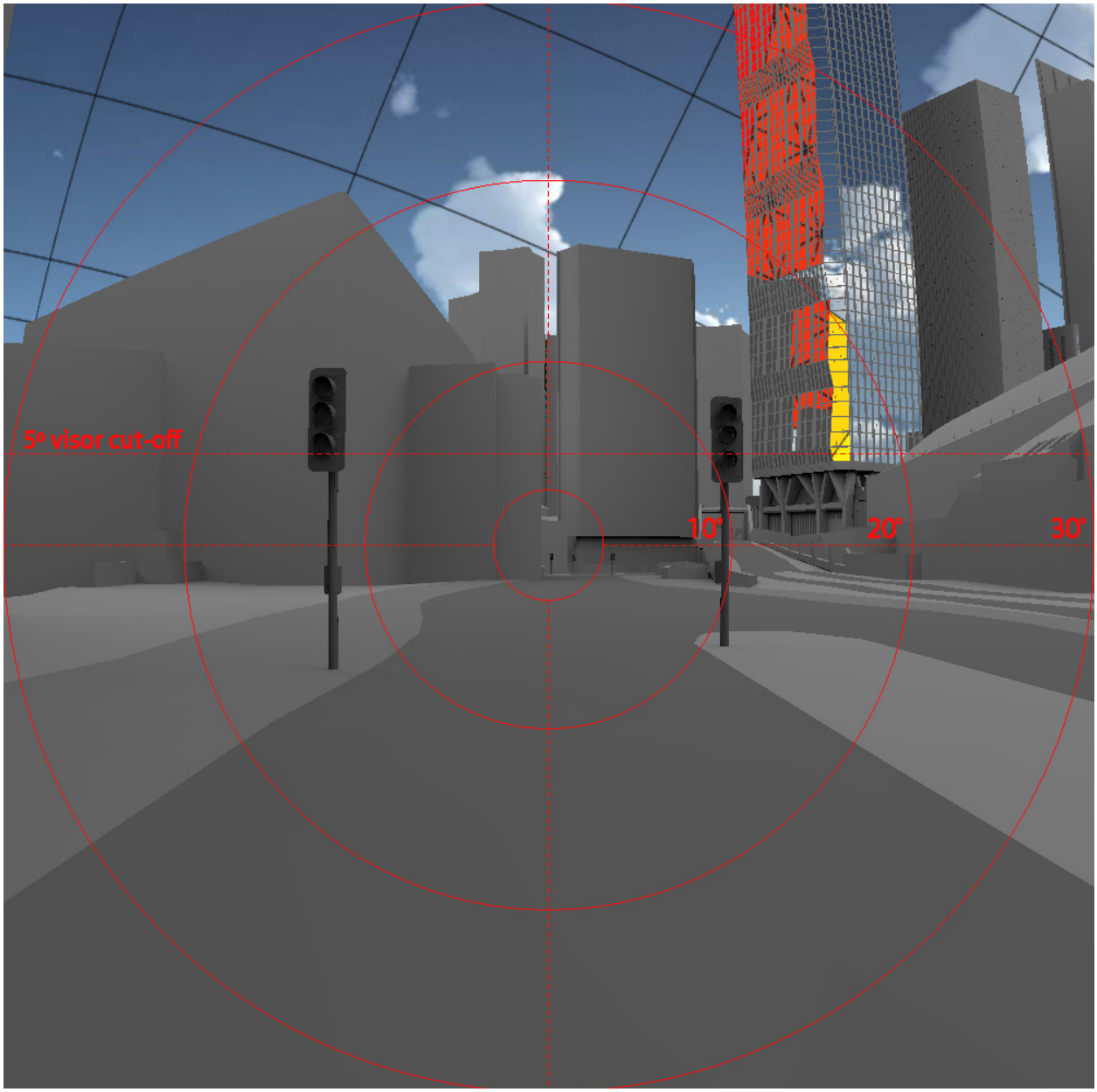
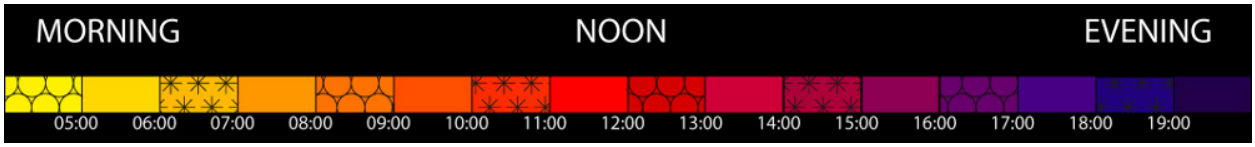


Fig. 42: Solar reflections



60° FIELD OF VIEW: SEASON
VIEWPOINT LMS2A - LOOKING FORWARD

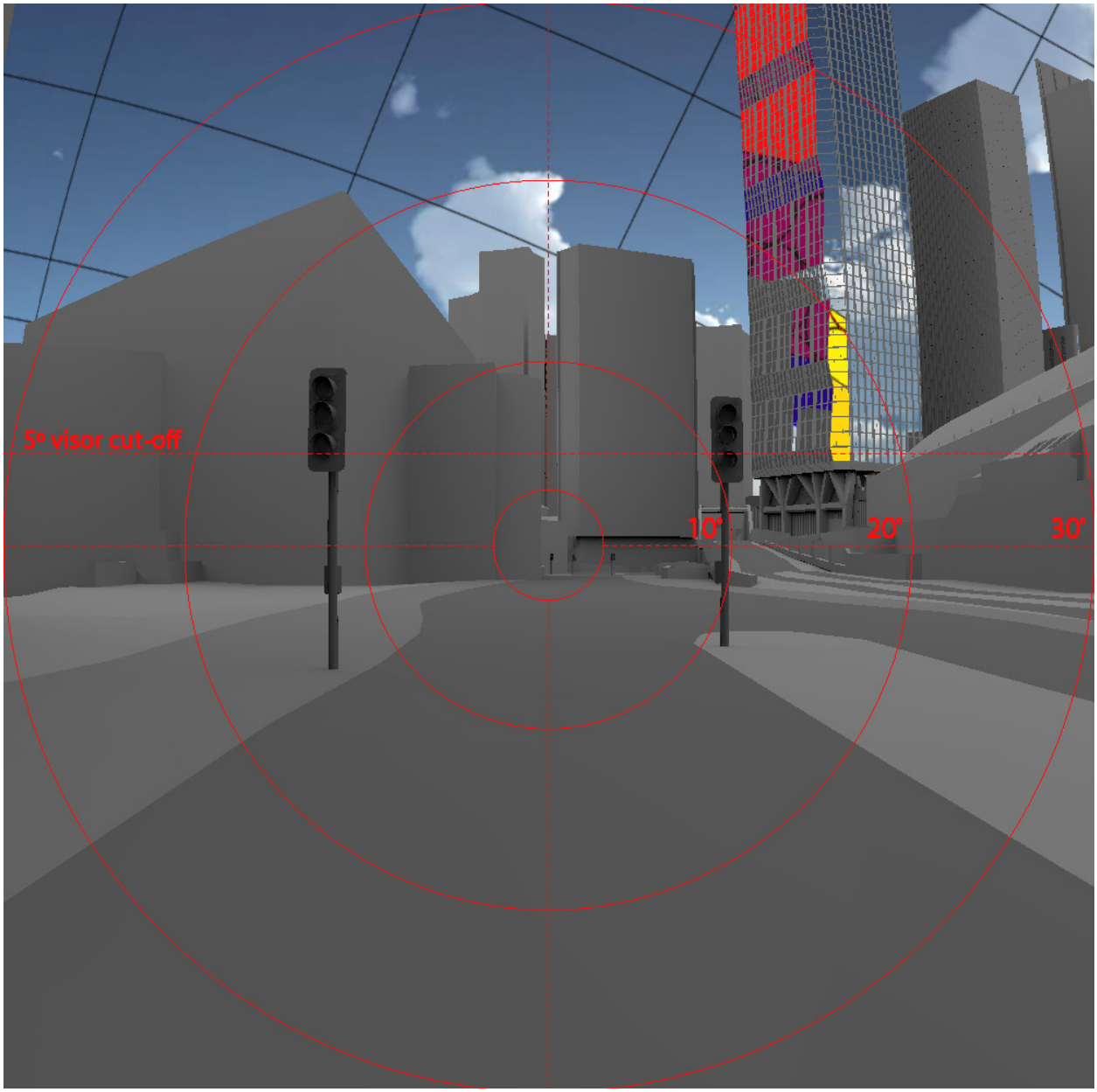


Fig. 43: Solar reflections



STAGE 1: 60° FIELD OF VIEW: TIME OF DAY
VIEWPOINT LMS2C - LOOKING AT TRAFFIC LIGHT

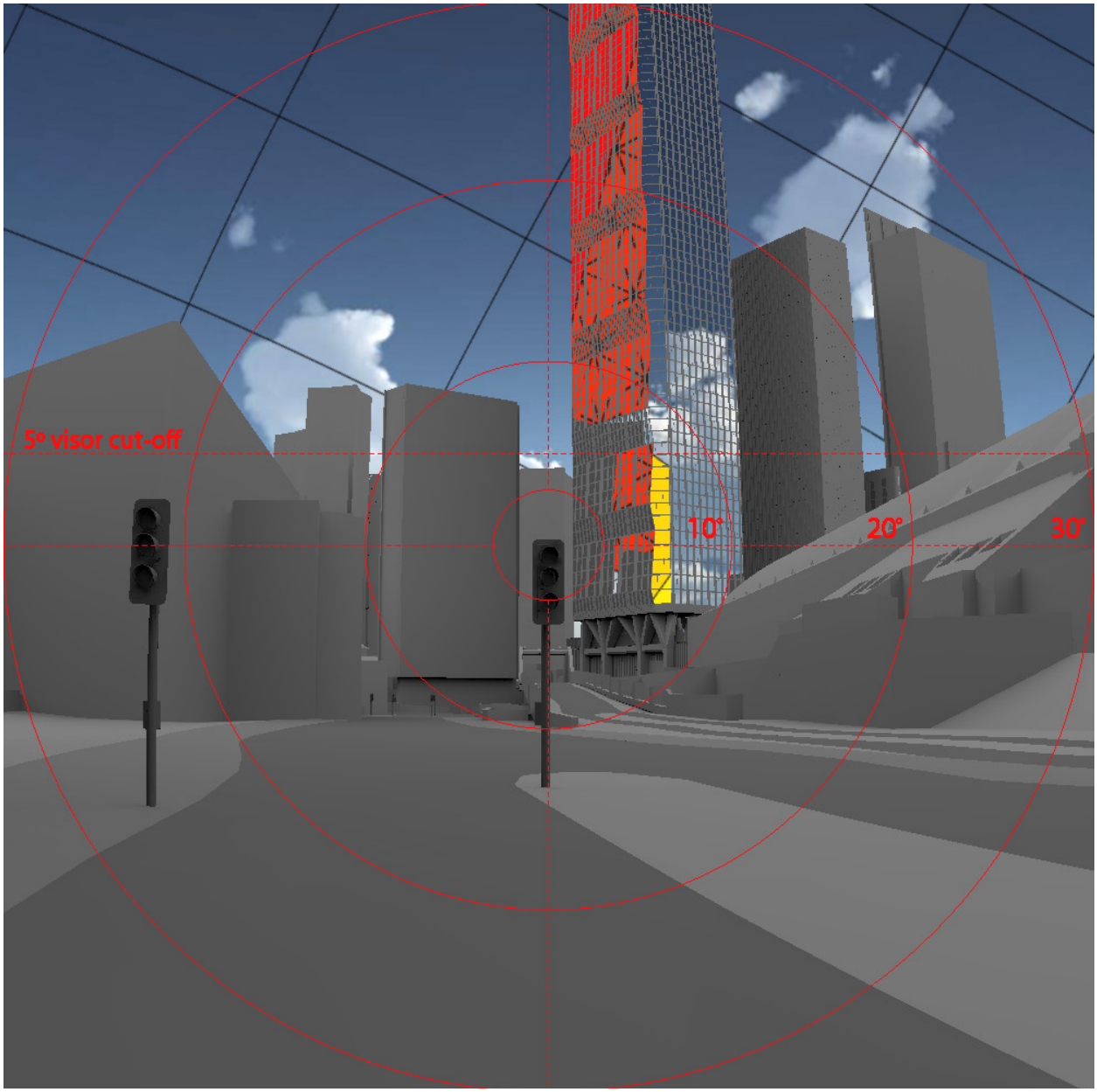
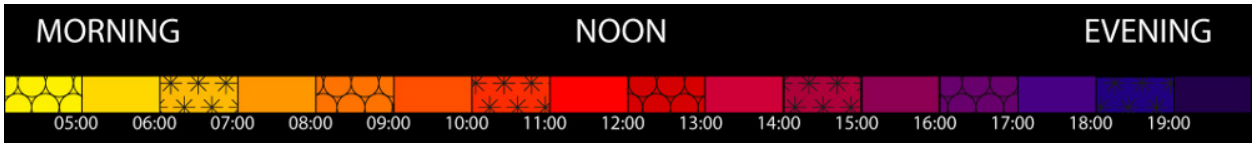


Fig. 44: Solar reflections



STAGE 1: 60° FIELD OF VIEW: SEASON
VIEWPOINT LMS2C - LOOKING AT TRAFFIC LIGHT

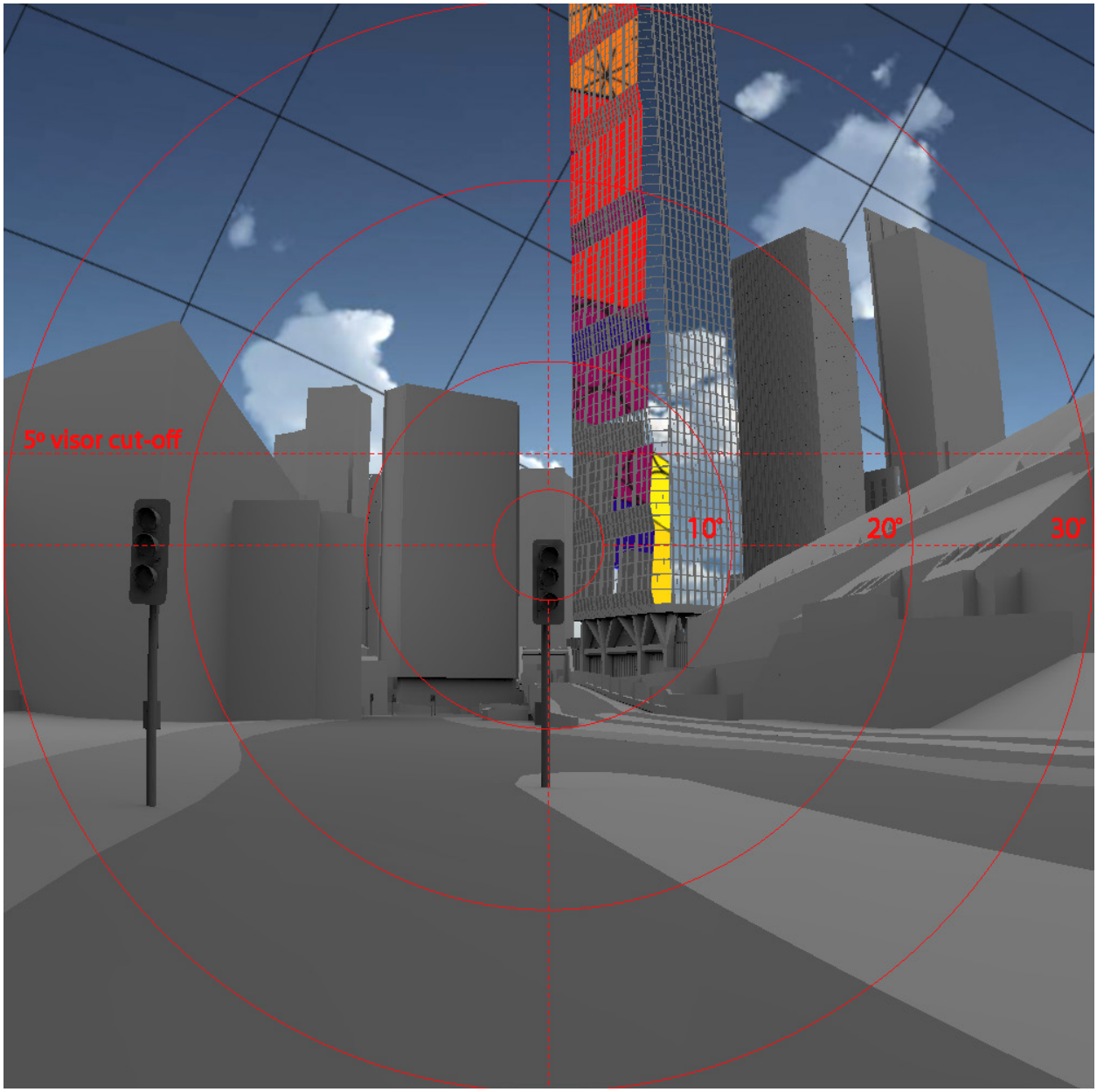


Fig. 45: Solar reflections



STAGE 2: PEAK INTENSITY ASSESSMENT
VIEWPOINT LMS2A - LOOKING FORWARD

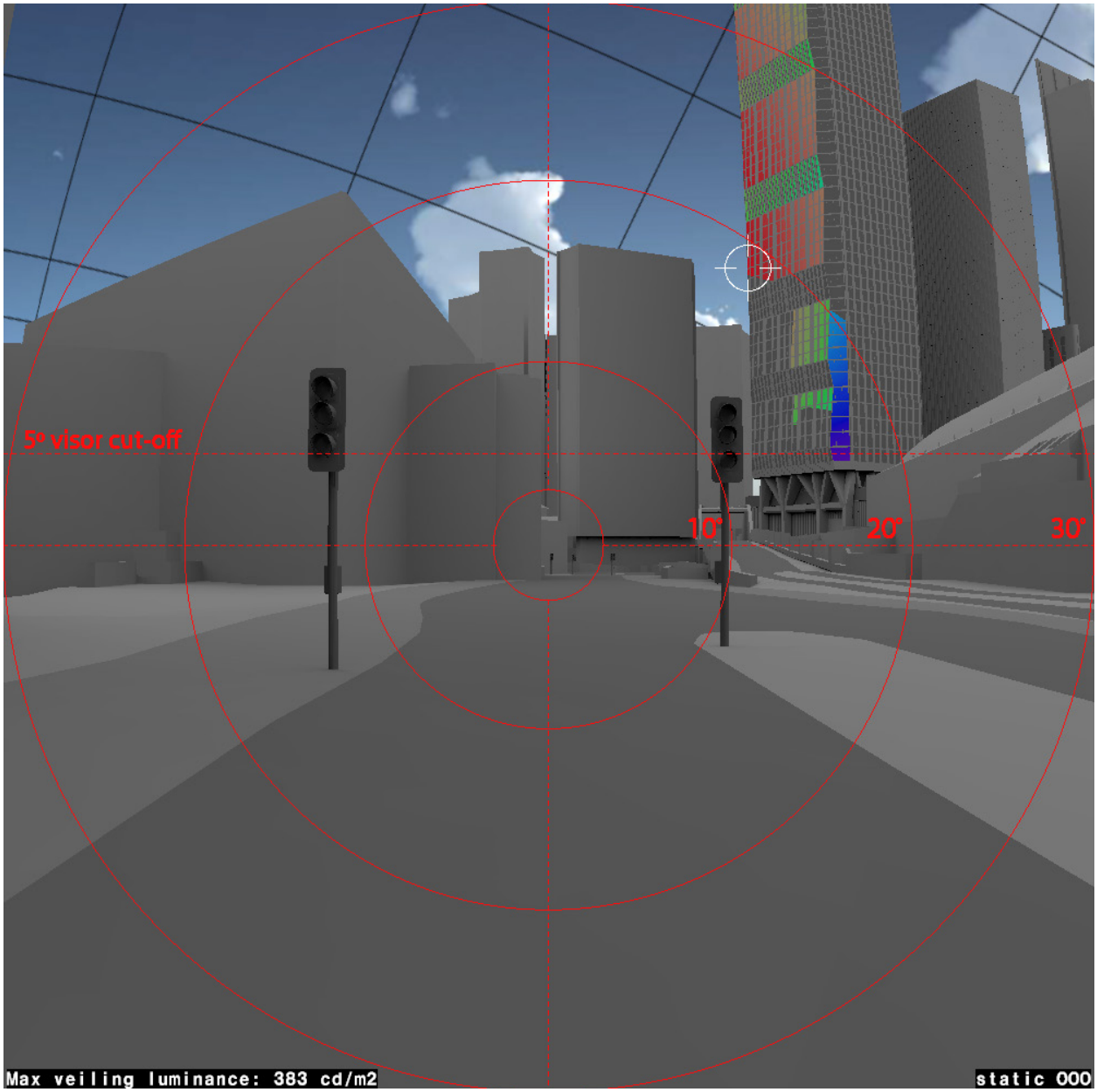
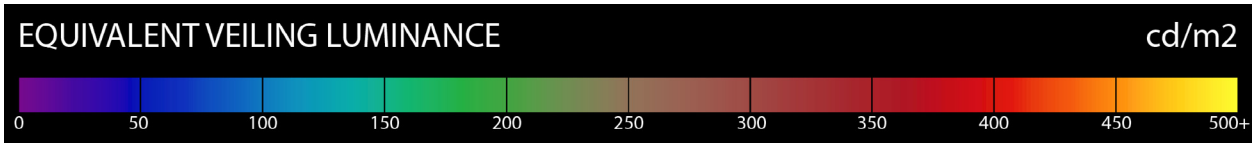


Fig. 46: Peak intensity



STAGE 2: PEAK INTENSITY ASSESSMENT
VIEWPOINT LMS2C - LOOKING AT TRAFFIC LIGHT

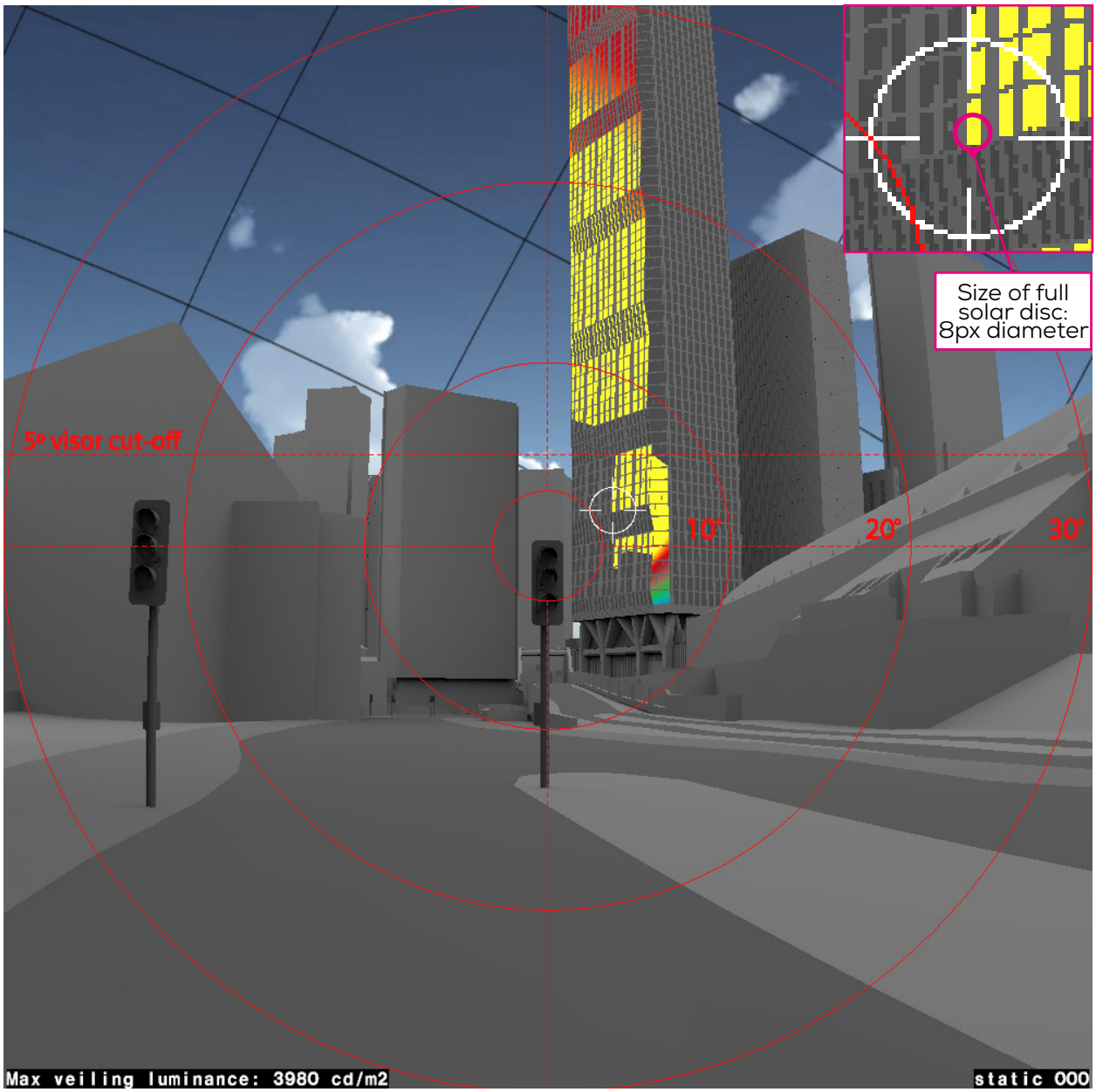
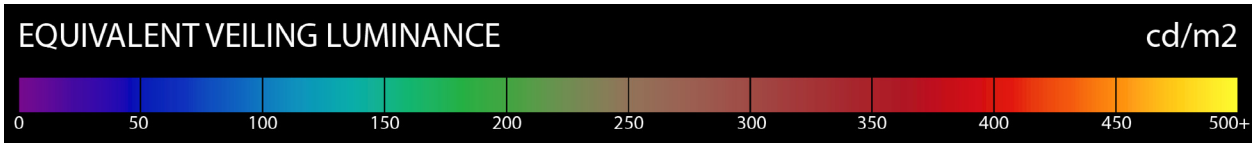


Fig. 47: Peak intensity



Two viewpoints have been assessed at this junction, LMS2a and LMS2c. Viewpoint LMS2a shows the view of drivers in the looking straight ahead as they approach the junction, whilst viewpoint LMS2c shows drivers looking at the right side traffic lights. There is an alternative lights on the left side of the road and a second traffic light on the opposite side of the crossing for use by stationary vehicles.

Stage 1

For viewpoint LMS2a, all reflections occur outside 10° of a drivers direct line of sight and so the significance of effect is Minor Adverse.

For viewpoint LMS2c, potential reflections occur within 10° of a drivers direct line of sight at this viewpoint from the eastern elevation and north-eastern chamfer of Block A. Potential reflections occur in the mid-morning (10:00-11:00 GMT) during the winter months (mid-October to mid-February) and in the early mornings (surise-06:00 GMT) during the summer months (mid-April to mid-August). Reflections occur from 4°, some are from thin strips and some others from a small area above the visor cut-off line.

In consideration of the mitigating factors outlined in para 11.86 of the ES Chapter, the overall effect in terms of solar glare at this location is considered to be permanent, Moderate Adverse and significant, and so a Stage 2 assessment has been undertaken.

Stage 2

This assessment is based on the following VLR thresholds for the facades visible at this location:

- 8% for Block A North-eastern chamfer – Levels 05-19;
- 8% for Block A Eastern Elevation – Levels 06-09 (northern half) and Levels 12-16 (northern half);
- 12% for Block A Eastern Elevation – Levels 06-09 (central section), Levels 12-16 (central section) and Levels 20-25;
- 14% for Block A Eastern Elevation – Level 29-36, Levels 40-47, Levels 51-58, and Levels 62-75;
- 16% for all other glazing visible.

Figure 46 shows the peak intensity for viewpoint LMS2a (when drivers are looking straight ahead approaching the junction) is 383 cd/m² which is comfortably below the threshold for glare of 500cd/m² and would not cause a concern in terms of glare.

Figure 47 shows the peak intensity of reflections from the proposed development at viewpoint LMS2c. At this location, the reflections which generate the peak veiling luminance within viewpoint LMS2c are less than the full solar disc. The extent of the reflection is 18 pixels, so approximately 18/52th of the full solar disc is visible in the reflection. The corrected peak intensity is therefore 3,980 cd/m² * 18/52 = 1,377cd/m².

As noted, all reflections visible when drivers are looking forward as they approach the junction (viewpoint LMS2a) have a low intensity comfortably less than the threshold of 500 cd/m². Therefore, as drivers approach the junction, their vision would not be affected by reflections from the proposed development. When drivers need to rely on the traffic signals at this location during the very short period of time when reflections occur, they have a choice of the lights on the left side or right side, only the lights on the right side are impacted by reflections from the proposed development.

The intensity of the reflections visible when looking at the right lights exceed the recommended threshold for glare with 3,980 cd/m². Given the glancing nature of the reflections, any reflections that do occur would be for a short period of time. In addition, given the size and the broken up nature of the reflections, those reflections in excess of the glare threshold would only occur for a very short period of time and at a time when the likelihood of the sun shining is 20%-50%. Furthermore, drivers at this location would currently experience much greater glare within their field of view resulting from a direct view of the sun, which would be obscured when the Proposed Development is implemented.

Most reflections occur above the visor cut-off line so could be mitigated by the driver lowering their visor.

For the above reasons and those set out in para 11.86 of the ES, it is not considered that reflections from the Proposed Development would significantly impact the ability of drivers to safely travel through this location and respond in a safe manner, as necessary, to the traffic signalling. No further mitigation is considered necessary at this location provided the VLR thresholds are adhered to.

9 GLARE INTENSITY ASSESSMENT

Eastbound Tramline from Cornbrook to Deansgate-Castlefield (TRAM_Eastbound)

60° FIELD OF VIEW: TIME OF DAY
VIEWPOINT TDE - TRAM_EASTBOUND, LOOKING FORWARD

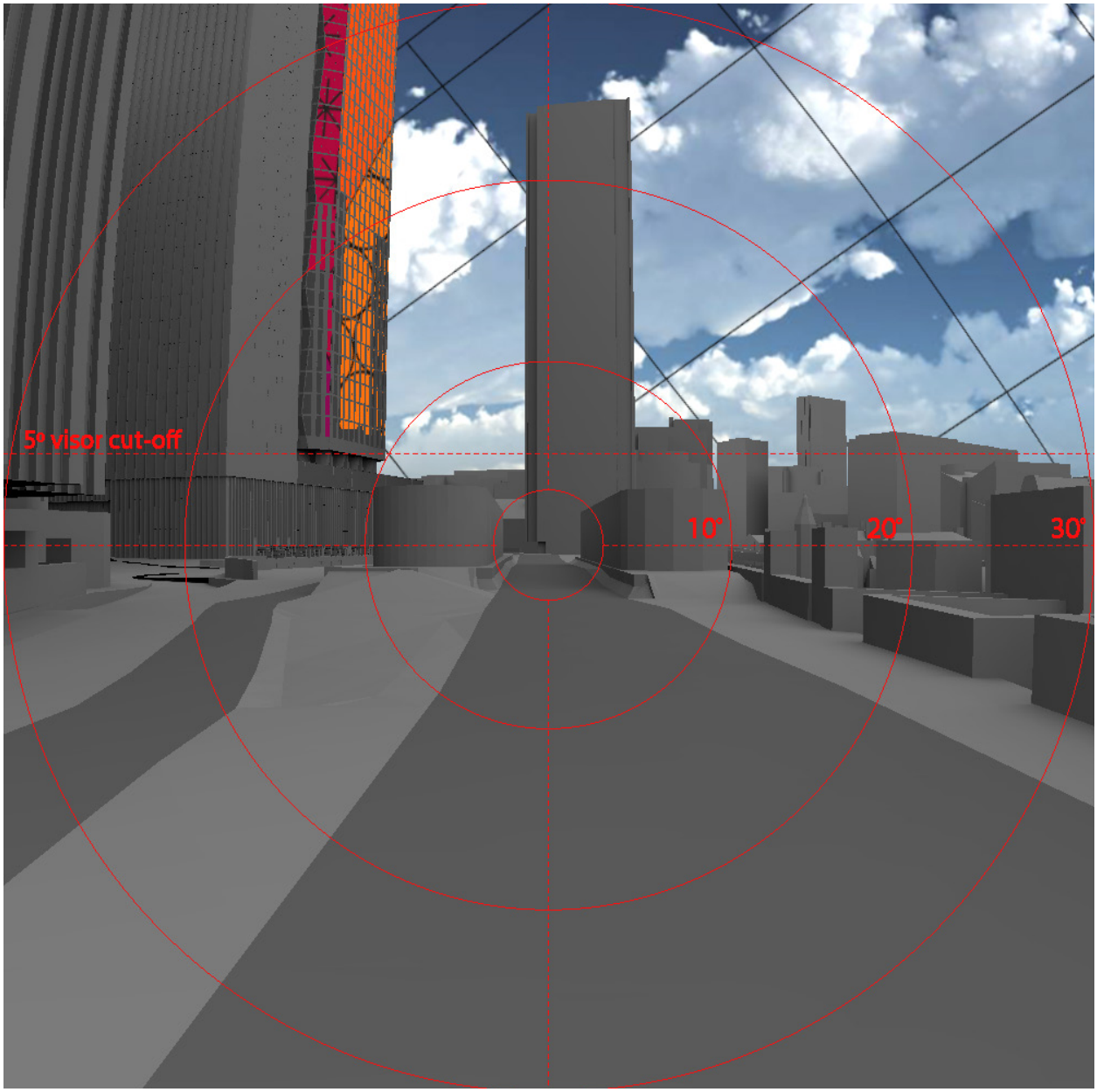
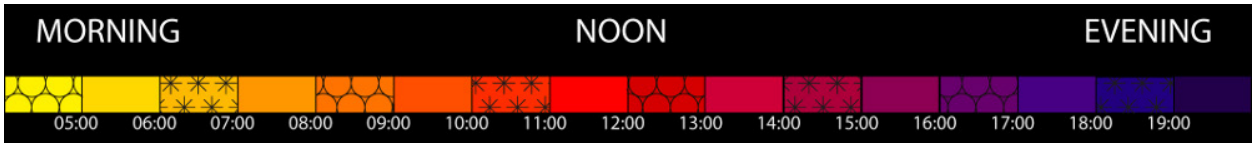


Fig. 48: Solar reflections



60° FIELD OF VIEW: SEASON
VIEWPOINT TDE - TRAM_EASTBOUND, LOOKING FORWARD

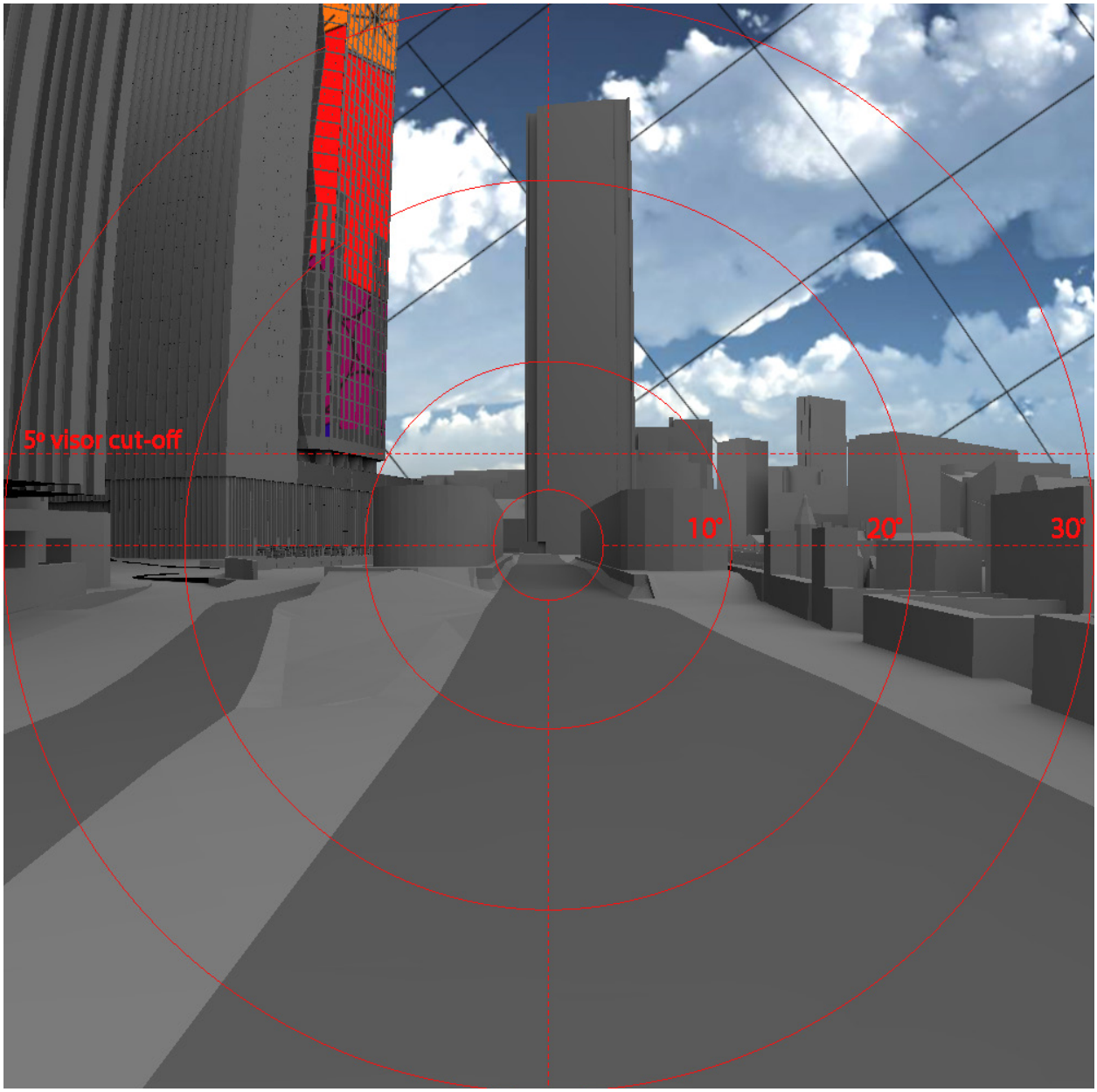


Fig. 49: Solar reflections



60° FIELD OF VIEW: TIME OF DAY
VIEWPOINT TCS - TRAM_EASTBOUND, LOOKING FORWARD

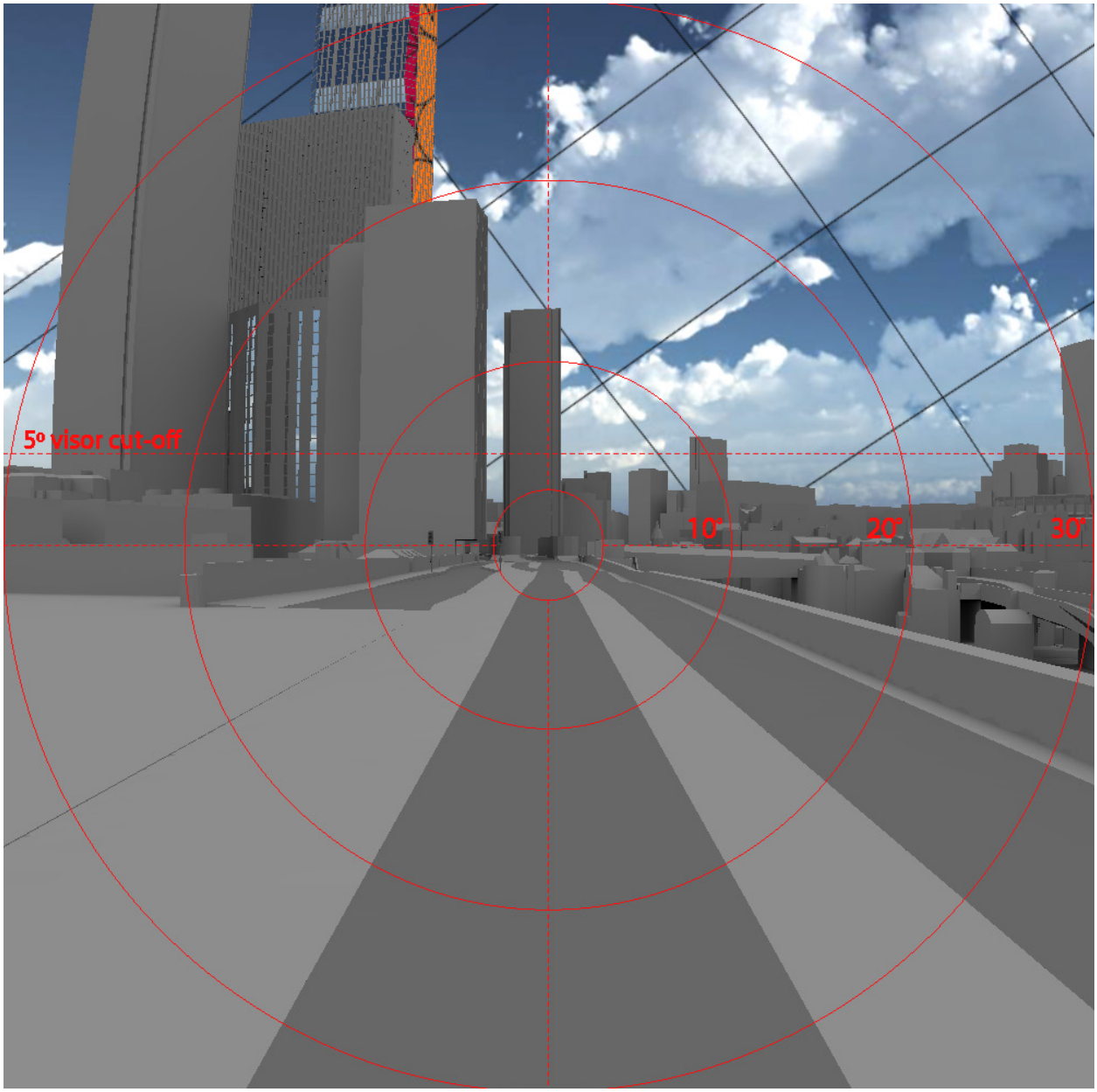
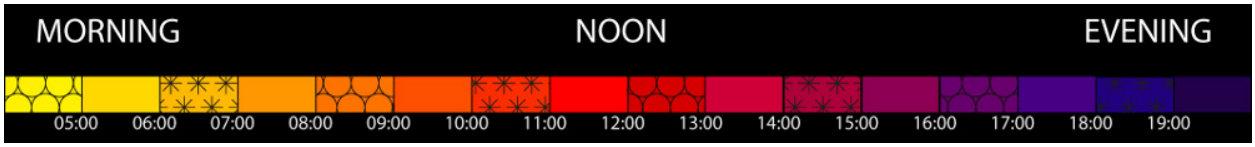


Fig. 50: Solar reflections



60° FIELD OF VIEW: SEASON
VIEWPOINT TCS - TRAM_EASTBOUND, LOOKING FORWARD

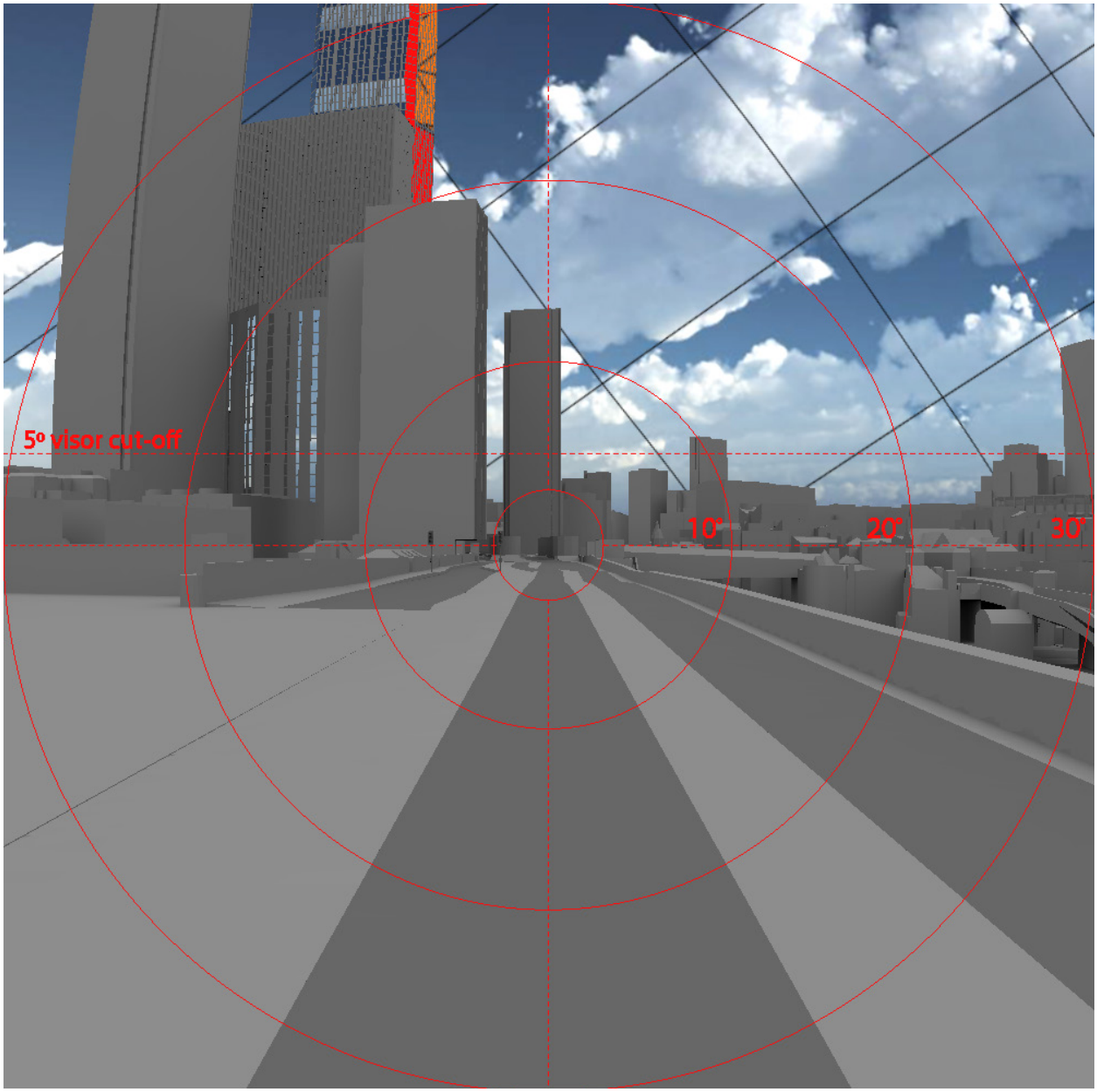


Fig. 51: Solar reflections



STAGE 1: 60° FIELD OF VIEW: TIME OF DAY
VIEWPOINT TDS - TRAM_EASTBOUND, LOOKING FORWARD

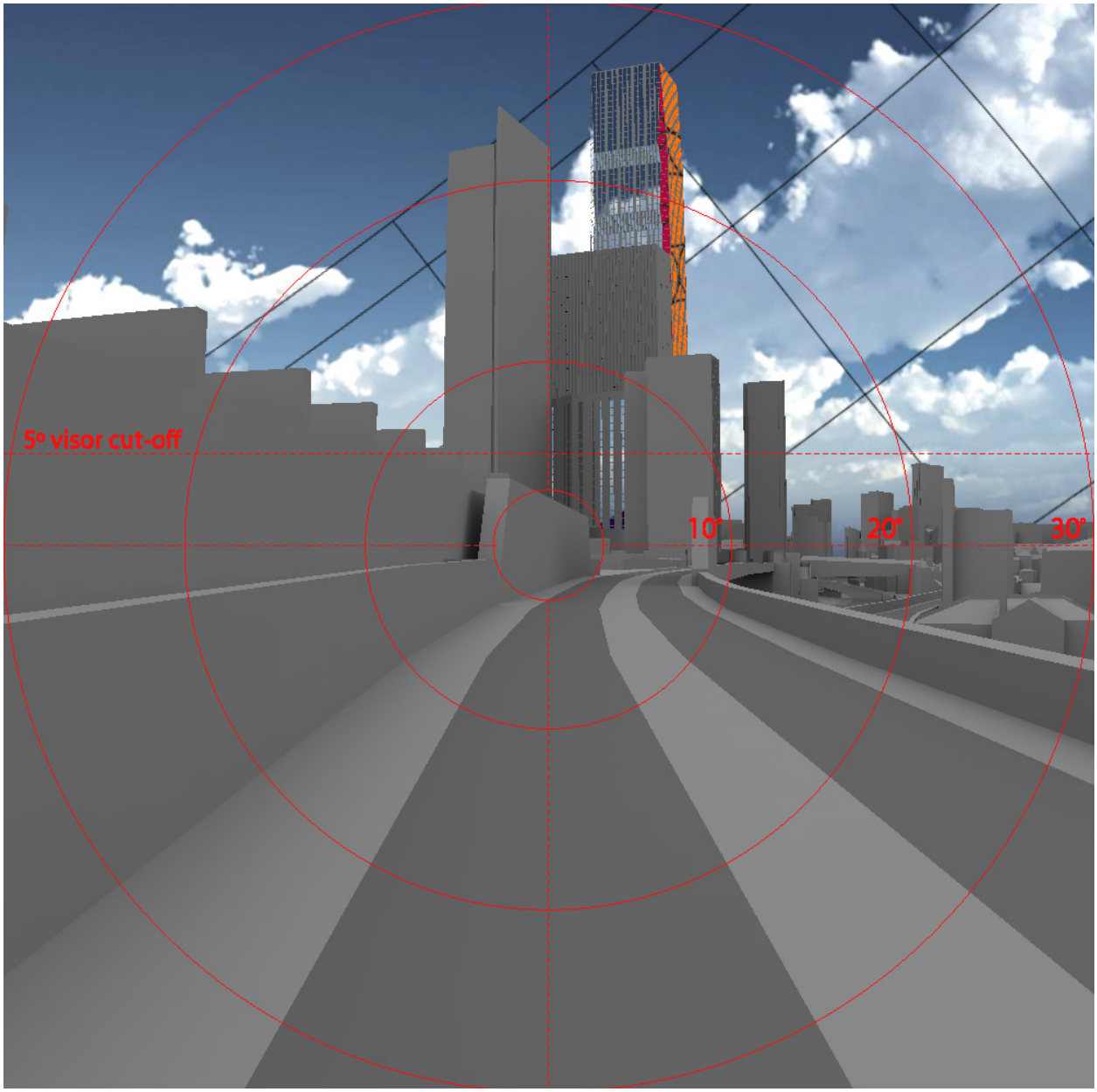
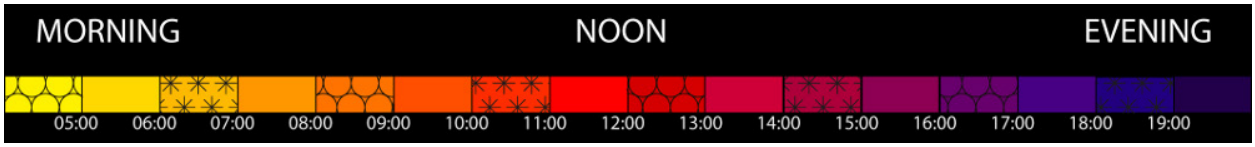


Fig. 52: Solar reflections



STAGE 1: 60° FIELD OF VIEW: SEASON
VIEWPOINT TDS - TRAM_EASTBOUND, LOOKING FORWARD

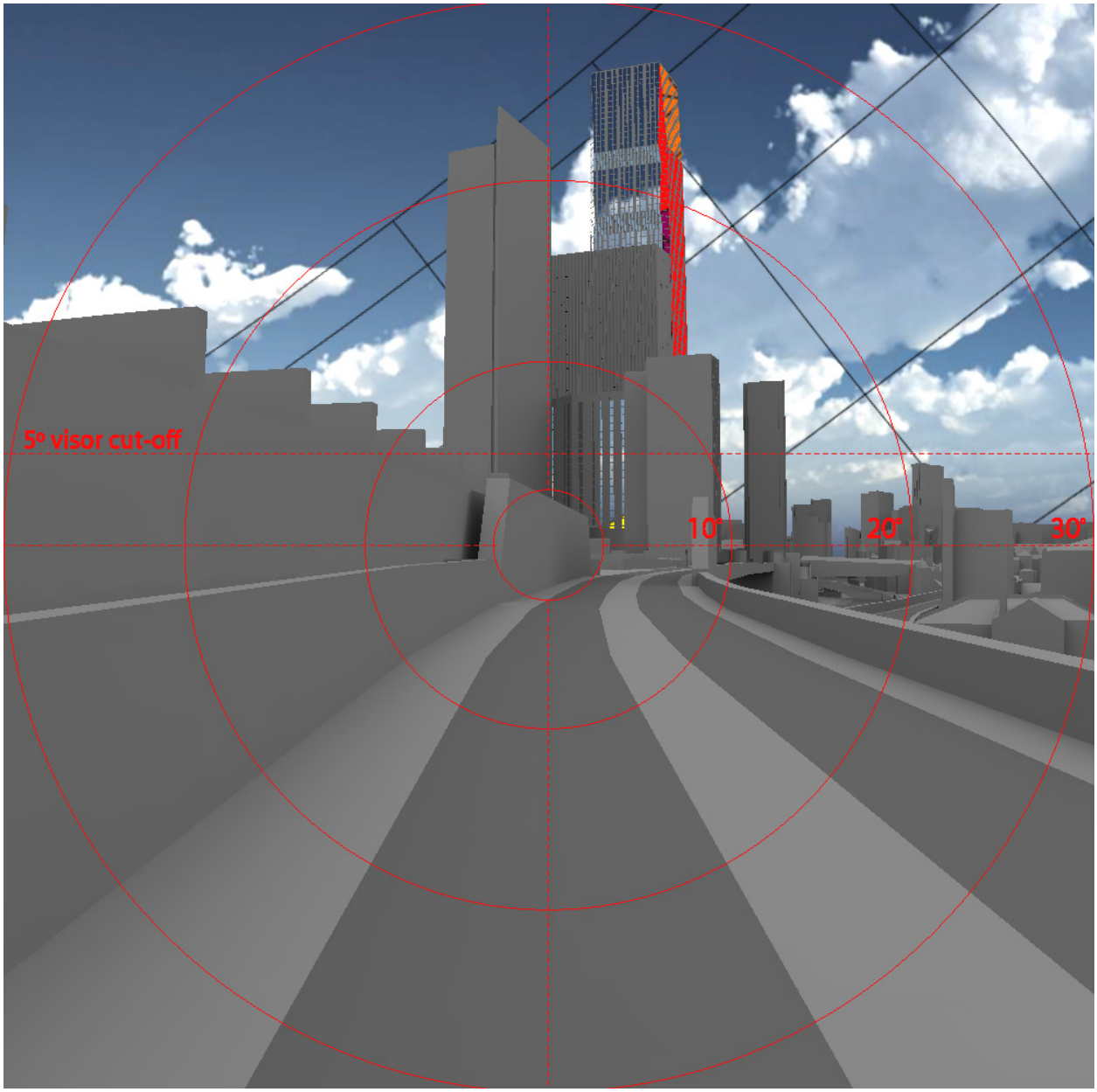


Fig. 53: Solar reflections



STAGE 2: PEAK INTENSITY ASSESSMENT
VIEWPOINT TDE - TRAM_EASTBOUND, LOOKING FORWARD

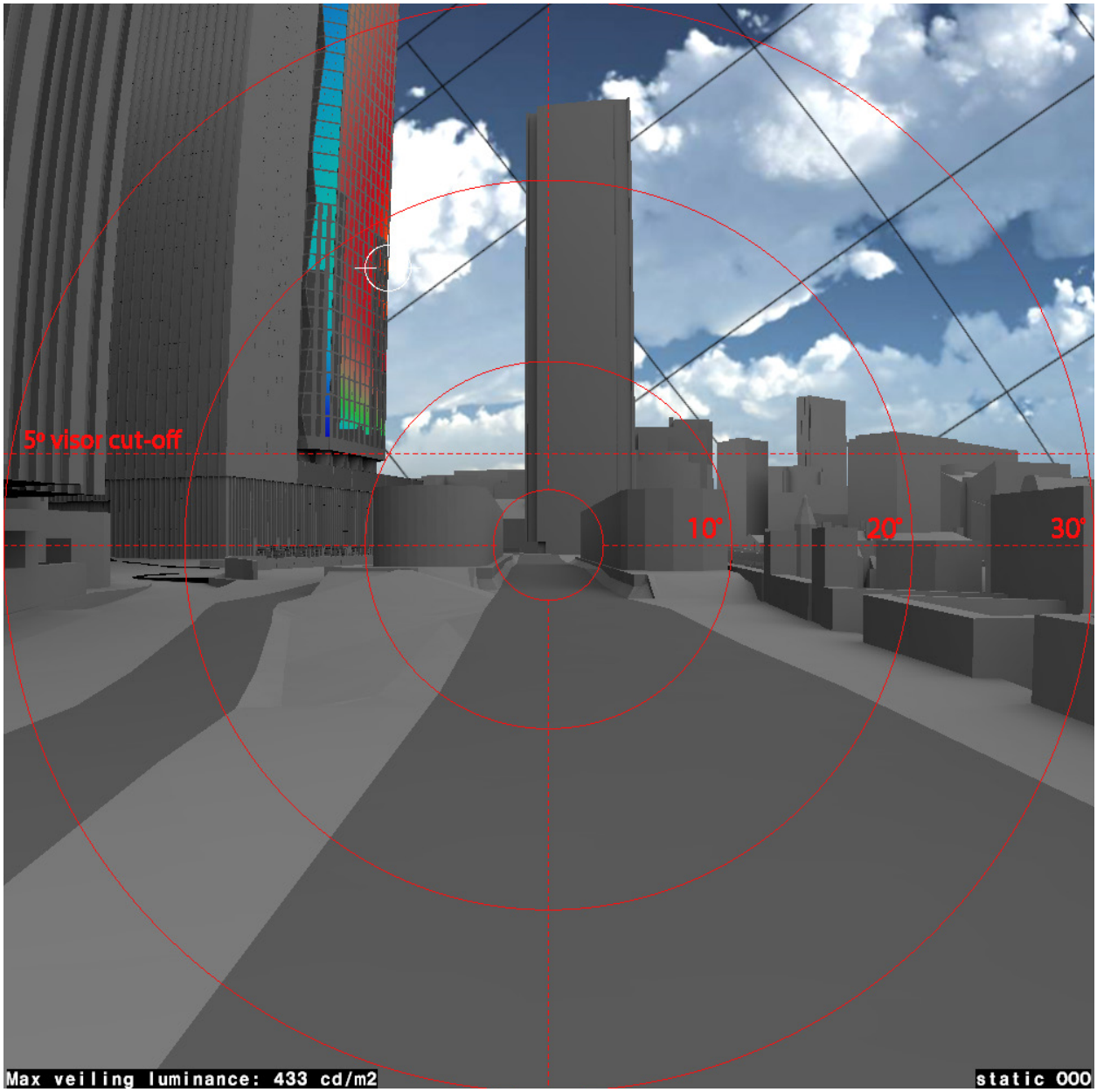
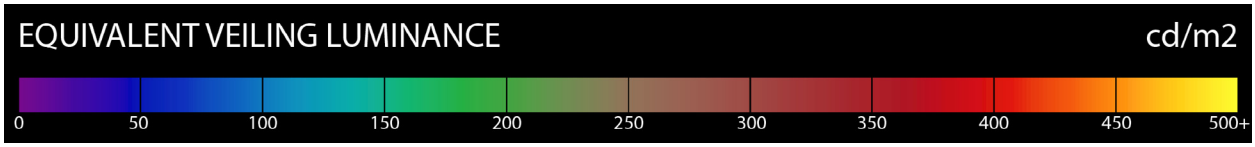


Fig. 54: Peak intensity



STAGE 2: PEAK INTENSITY ASSESSMENT
VIEWPOINT TCS - TRAM_EASTBOUND, LOOKING FORWARD

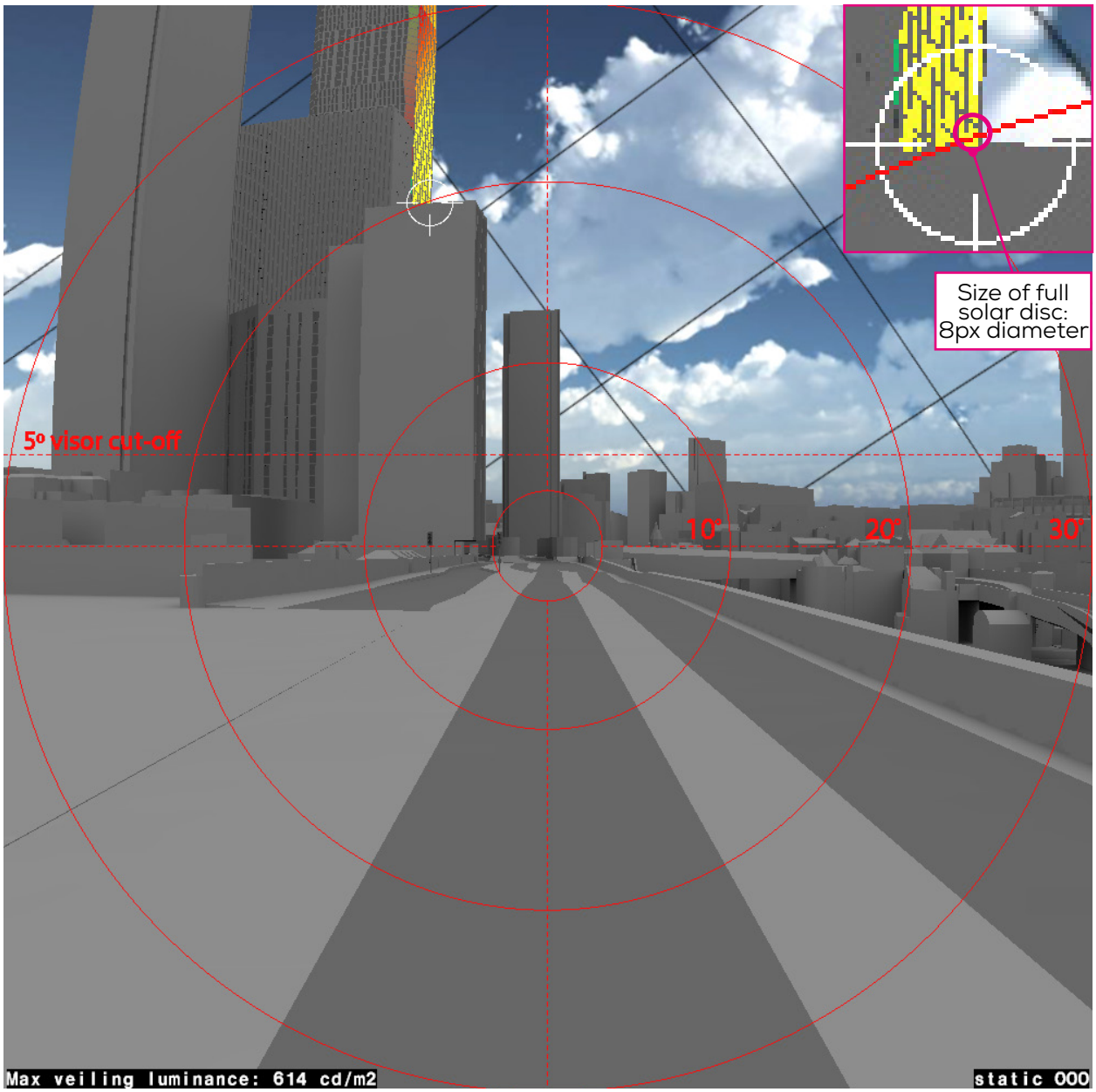
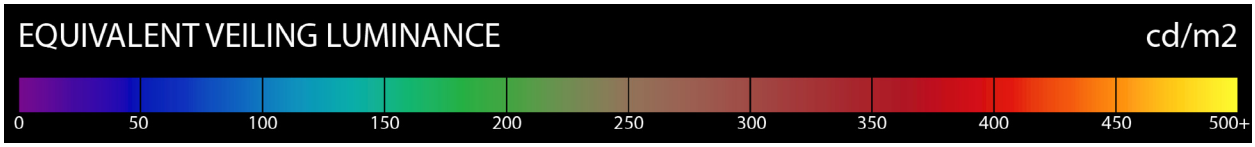


Fig. 55: Peak intensity



STAGE 2: PEAK INTENSITY ASSESSMENT
VIEWPOINT TDS - TRAM_EASTBOUND, LOOKING FORWARD

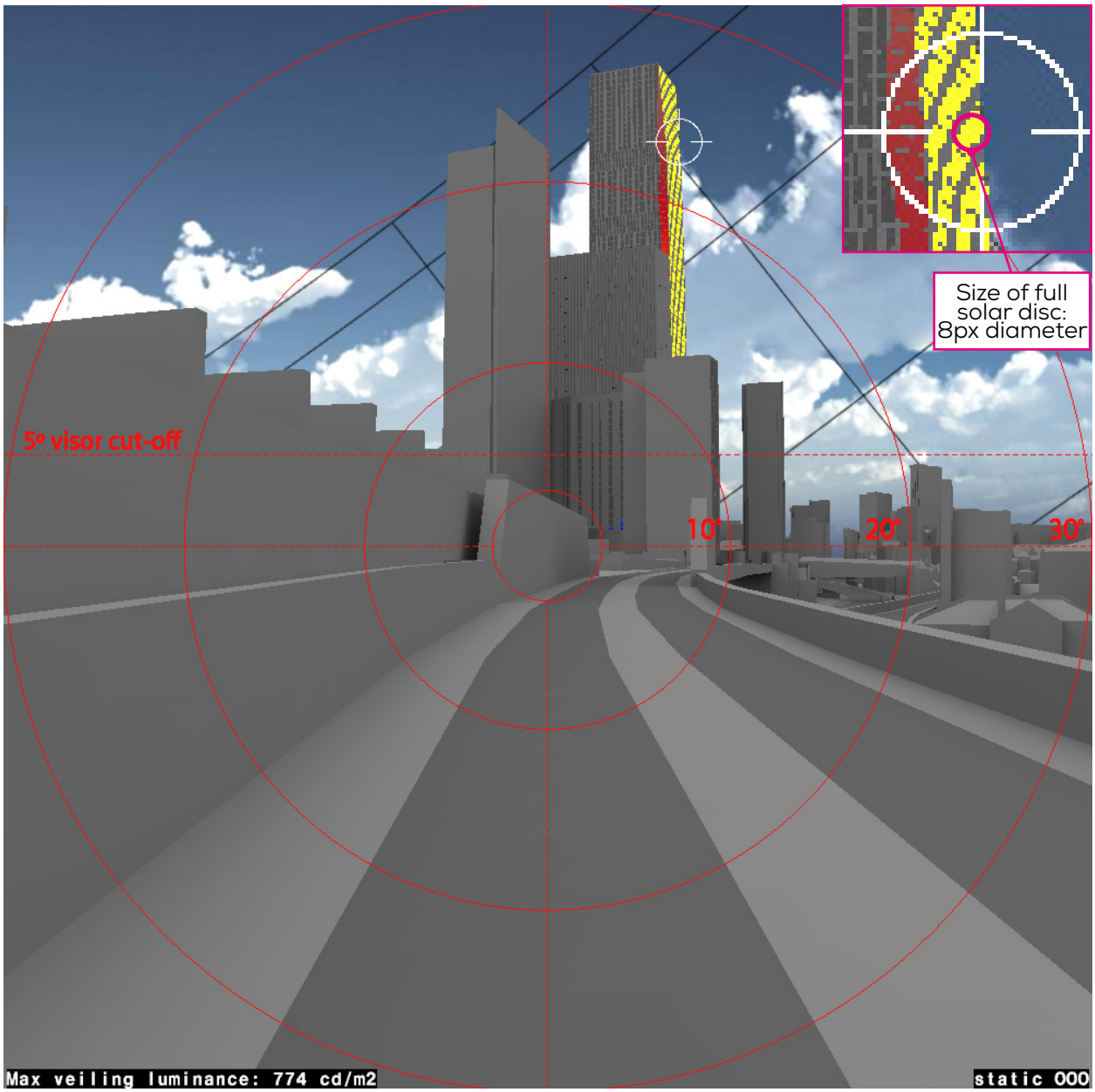
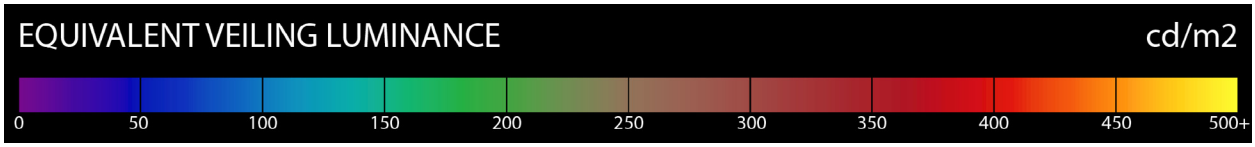


Fig. 56: Peak intensity



Three viewpoints have been assessed along the eastbound tramline with reflections occurring within 10° of a driver's direct line of sight on this track, TRAM_Eastbound. TDS is the view of drivers next to Duke Street, TCS shows the view of tram drivers further along the track as they travel next to the Collier Street Car park and TDE is the view of drivers as they pass over Deansgate on their approach to the Deansgate-Castlefield stop.

Stage 1

For viewpoints TDE and TSC, all reflections occur outside 10° of a drivers direct line of sight and so the significance of effect is Minor Adverse.

For viewpoint TDS, potential reflections occur within 10° of a drivers direct line of sight at this viewpoint from the western elevation of Block B. Potential reflections occur in the evening (19:00 GMT-sunset) during the summer months (mid-May to mid-July). Reflections occur from a very small area visible between 3° - 5°.

In consideration of the mitigating factors outlined in para 11.91 of the ES Chapter, the overall effect in terms of solar glare at this location is considered to be permanent, Minor to Moderate Adverse and significant, and so a Stage 2 assessment has been undertaken.

Stage 2

This assessment is based on the following VLR thresholds for the facades visible at this location:

- 8% for Block A Southern Elevation – Level 05-75;
- 16% for all other glazing visible.

Figure 54 shows the peak intensity for viewpoint TDE is 433 cd/m² which is below the threshold for glare of 500cd/m².

Figure 54 shows a peak intensity of reflections from the proposed development at viewpoint TDE of 433cd/m² which is below the threshold for glare of 500cd/m² and would not cause a concern in terms of glare.

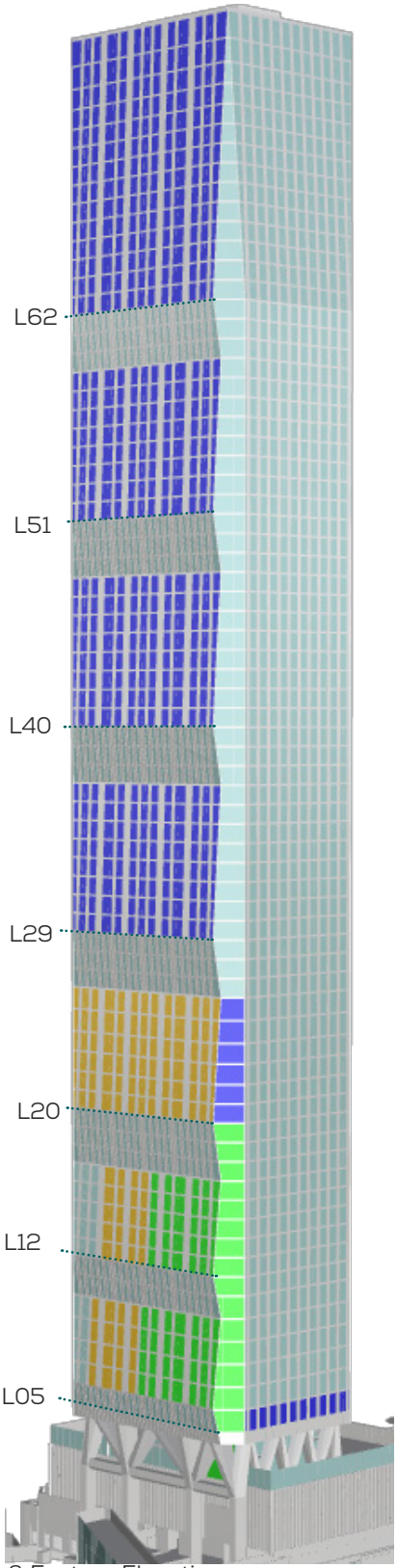
Figure 55 shows the peak intensity of reflections from the proposed development at viewpoint TCS. At this location, the reflections which generate the peak veiling luminance within viewpoint TCS are significantly less than the full solar disc. The extent of the reflection is limited to 15 pixels which are very broken up by the non-reflective facade elements, so only approximately 15/52th of the full solar disc is visible in the reflection. The corrected peak intensity is therefore 614 cd/m² * 15/52 = 177 cd/m².

Figure 56 shows the peak intensity of reflections at viewpoint TDS from the proposed development occurring within 10° are all well below the threshold for glare. Some reflections outside 10° record an intensity is excess of 500 cd/m². At this location, the reflections which generate the peak veiling luminance are significantly less than the full solar disc. The extent of the reflection is limited to 29 pixels which are very broken up by the non-reflective facade elements, so only approximately 29/52th of the full solar disc is visible in the reflection. The corrected peak intensity is therefore 774 cd/m² * 29/52 = 432 cd/m² which is below the threshold for glare and not considered a concern in terms of glare.

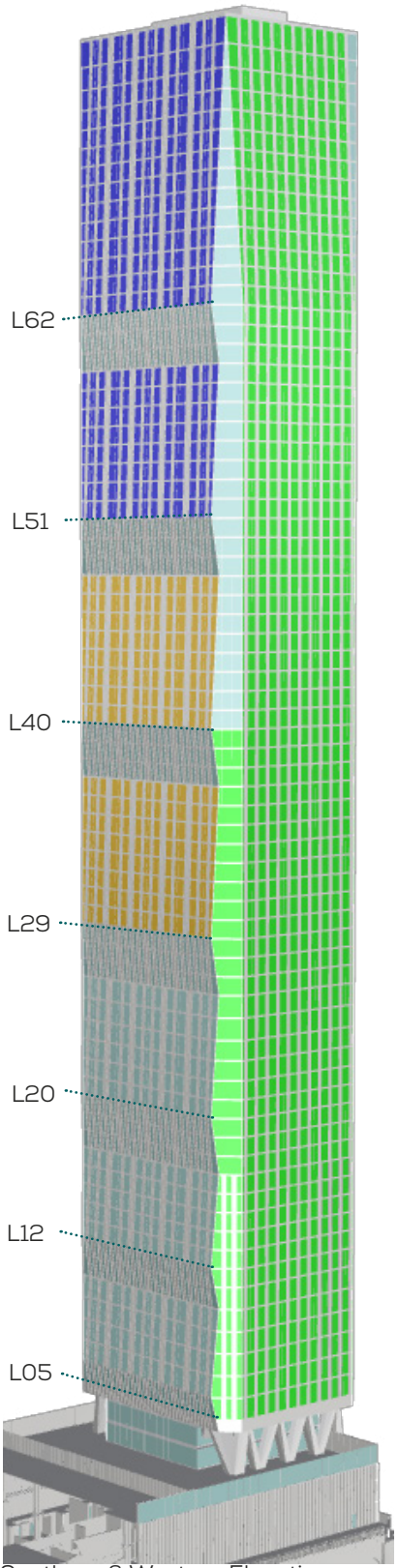
As noted, all reflections visible are below the threshold for glare and not considered a concern in terms of glare. Therefore, as tram drivers travel along this track, their vision would not be significantly affected by reflections from the proposed development.

For the above reasons and those set out in para 11.91 of the ES, it is not considered that reflections from the Proposed Development would significantly impact the ability of drivers to safely travel along this set of tram tracks and respond in a safe manner, as necessary, to the signalling. No further mitigation is considered necessary at this location provided the VLR thresholds are adhered to.

10 VLR FACADE KEY

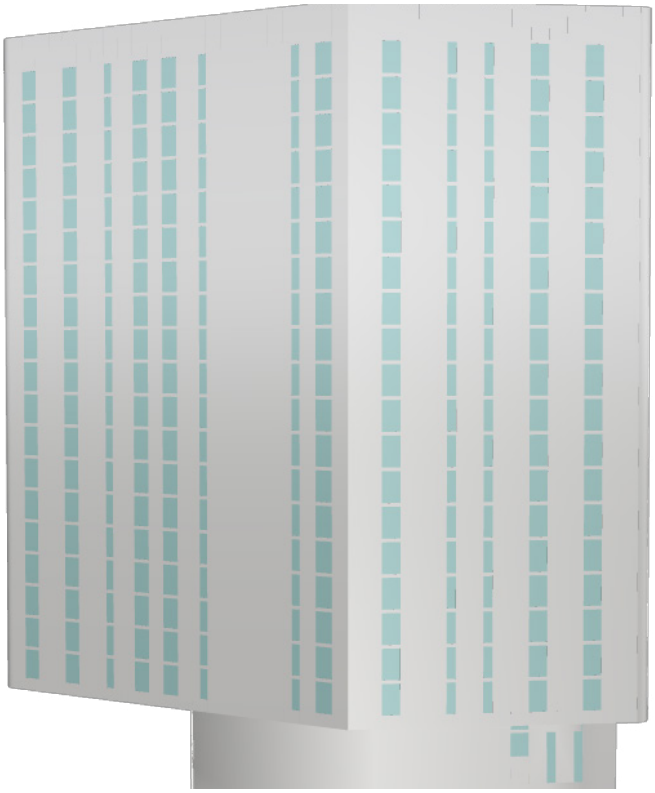


Northern & Eastern Elevations



Southern & Western Elevations

Fig. 57: Block A Low VLR Glazing Thresholds

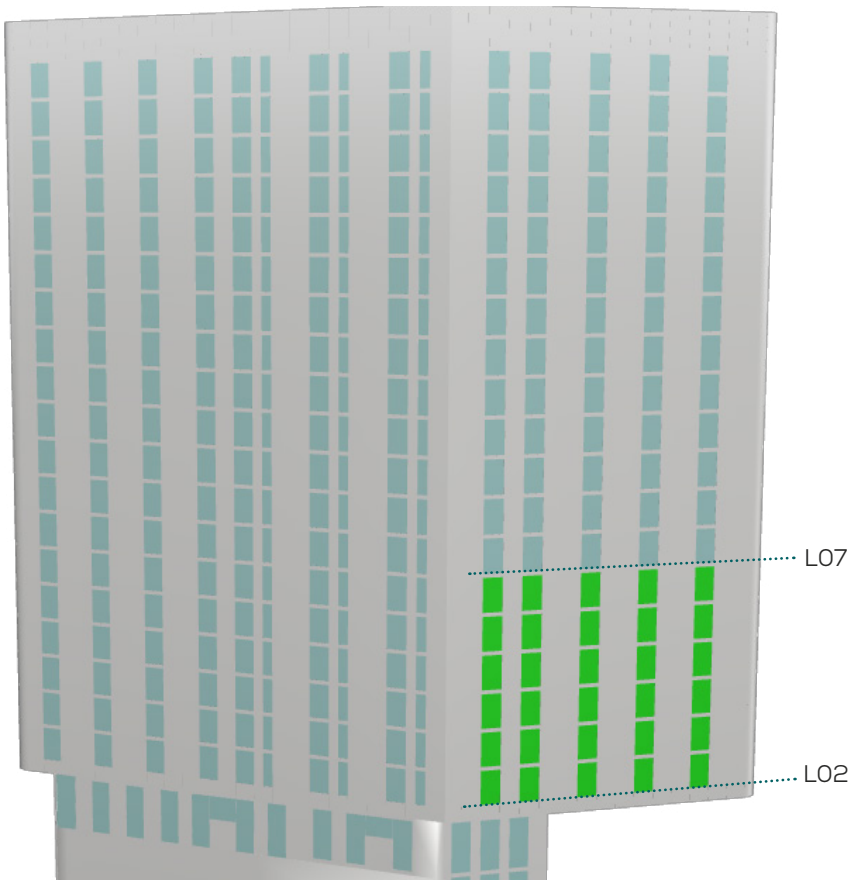


VLR = 8% or less

VLR = 12% or less

VLR = 14% or less

North-Western & Western Elevations



South-Eastern & Eastern Elevations

Fig. 58: Block B Low VLR Glazing Thresholds

gia

What we do:

Building Surveying
Daylight & Sunlight
Light Obstruction Notices
Measured Surveys
Party Wall & Neighbourly Matters
Rights of Light
Solar PV
Wind Analysis

Where we are:

Belfast
Birmingham
Bristol
Dublin
London
Manchester

GIA SURVEYORS LIMITED incorporated and registered in England and Wales with company number **14032506** whose registered office is at **The Whitehouse, Belvedere Road, London SE1 8GA**