Technical Appendix 15.1: Glint and Glare Report

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Bowshiel Solar

Glint & Glare Assessment

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Basis of Report

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1.0 Introduction

1.1 Study area

This report undertaken by SLR examines the potential glint and glare (G&G) effects arising from the installation of solar photovoltaic (PV) arrays on the proposed solar farm on the land adjacent to the A1 (Great North Road) and located approximately 2 km south of Cockburnspath, Scotland, United Kingdom (herein "the Proposed Development"). The National Grid reference for the site is 378393, 668130 (Easting, Northing).

This G&G study is informed by the design undertaken and information provided by Voltalia UK Ltd (herein "the Client") *('Bowshiel - BOW01-DV-AS-DRA-GEN_IMP-01-10 (1).pdf' and 'Bowshiel - Fig 08 - PV Structure Detail (1) (1).pdf'*).

Figure 1-1 shows the PV module development area (red polygon) in the context of the surrounding land.

Figure 1-1: Satellite Photography of the Proposed Development and Surroundings

(Source: Google Earth Pro, 2025)

1.2 PV array details

The Proposed Development has considered fixed PV module with a tilt angle of 12° and south orientation. Table 1-1 illustrates the module specifications for the Proposed Development, summarising the parameters used within the report.

Table 1-1: Module specifications

Parameter	Details
Mounting details	Fixed tilt (no tracking)
Module tilt	12°
Module orientation	180° (South)
PV material category	Category 1. Defined as smooth glass with anti-reflective coating.
Slope error value	A value of 'varies' to imply that this depends on the PV material selected. In this case, material Category 1 was selected.
Reflectivity value	A value of 'varies' to imply that this depends on the PV material selected. In this case, material Category 1 was selected.

1.3 Definitions

Glint, glare and dazzle are often used interchangeably but are defined in this report as described in Table 1-2 below.

Table 1-2: Definition of Glint, Glare and Dazzle

Name	Description
Glint	Glint is a momentary flash of bright light.
Glare	Glare is a more continuous source of bright light.
Dazzle	This is an effect caused by intense glint and glare, which can cause distraction and, if strong enough, reduce the ability of the receptor (pilot or driver, or otherwise) to distinguish details and objects.
Specular Reflections	Specular reflections are direct reflections of the Sun's light off smooth surfaces, such as glass, steel, and calm water.
Diffuse Reflections	Diffuse reflections are scattered reflections of light produced from rougher surfaces such as concrete, tarmac, and vegetation.

It is noted that different organisations and agencies apply slightly different definitions to these terms, and some refer to the terms glint and glare interchangeably. In this report, in line with the Forge Solar modelling software, the term 'glare' is used as an umbrella term to cover glint and glare effects.

Figure 1-2 illustrates the difference between specular reflection, produced as a direct reflection of the sun on to a smooth surface and diffused reflection, which is a scattered reflection of light.

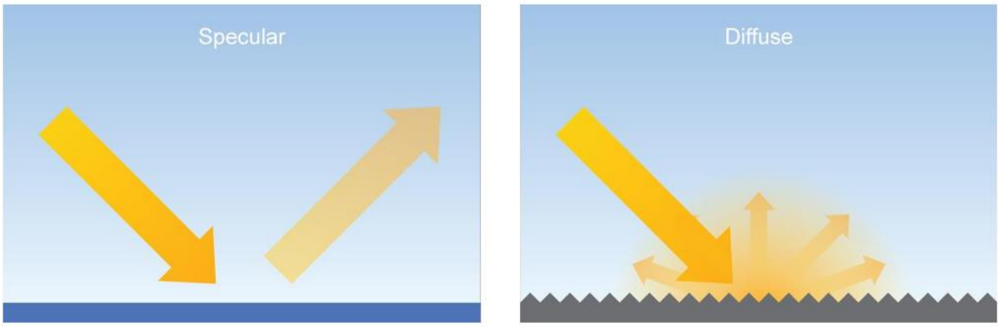

Figure 1-2: Types of Reflection: Specular (left) and Diffused (right)

(Source: Federal Aviation Administrator, 2018[1])

The perceived intensity of glare will vary depending on the ambient light levels (influenced by the time of the day as well as weather patterns), orientation and inclination of the panels, and the distance to the receptor.

The ForgeSolar software output defines glare under a traffic light system, as 'green glare', 'yellow glare' and 'red glare'. This is explained in Table 1-3 below.

Table 1-3: Types of glares

Name	Description
Green glare	'Green glare' is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Yellow glare	'Yellow glare' is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Red glare	'Red glare' has potential to cause retinal burn (permanent eye damage). Retinal burn is typically not possible for PV glare since the reflected light is not focused on a concentrated point.

Temporary after-image is the phenomenon whereby an image remains momentarily visible on the retina after looking away from a bright light source.

1.4 The reflectivity of solar panels

Solar PV panels are designed to absorb sunlight and convert it into electricity; they are not designed to reflect light, although there may still be a small unavoidable reflective component present. The glass which forms the surface layer of solar panels is specifically designed with a low iron content to aid the absorption of daylight and thus has a much lower level of reflectivity than the glass typically seen in conventional windows.

For example, with a 75° angle of incidence, less than 9% of the total incident visible light is reflected, while normal glass reflects approximately 19% of light. If the panels have an anti-reflective coating applied, reflectivity drops to about 5%. Thus, reflectance levels from a given solar site will be much lower than the reflectance generated by standard glass and other common reflective surfaces in the surrounding environment, although reflectance characteristics will also vary with the incidence angle, which changes as the sun moves across the sky.

[1] FAA, '*Technical Guidance for Evaluating Selected Solar Technologies on Airports*', V1.1, Apr 2018, https://www.faa.gov/sites/faa.gov/files/airports/environmental/FAA-Airport-Solar-Guide-2018.pdf

Solar panels have a comparable reflectivity to calm water and are considerably less reflective than other natural materials such as snow. Any glare that may occur would be less intense than that seen when flying over a reservoir on a calm day or a snow-covered landscape on a bright day. As can be seen from Figure 1-3, the reflectivity of light incident on solar glass is considerably less than light reflections from many other materials found in the built and natural environment, and approximately half that of standard glass.

As the distance from the glint and glare source increases, the intensity of the event drops appreciably. This is due to a combination of factors, including the diffraction of light after it reflects off the panel; atmospheric weather conditions such as the presence of particulates, haze, or low cloud; and the diminishing subtended viewing angle.

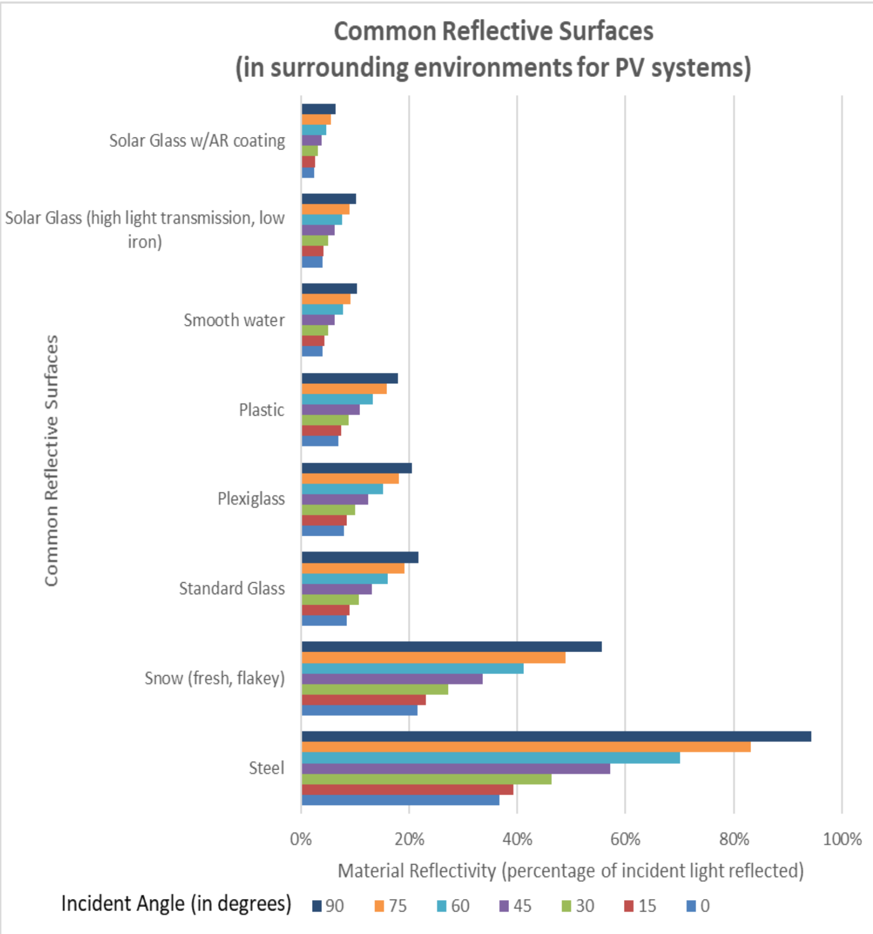

Figure 1-3: Reflectivity of Common Materials at Varying Angles of Incidence

(Based on data from SunPower Corporation, 2009)

1.5 Occurrence of Glint & Glare

Glint and glare can only occur when direct sunlight reaches the solar panels. Diffused lighting, caused by weather conditions such as cloud, fog, and mist, cannot result in glint due to the low energy intensity of the light incident on the panels.

2.0 Planning policy, legislation & guidance

Specific policy, legislation and guidance relating to assessing glint and glare effects from solar parks have been considered as part of this assessment and are summarised below.

National Planning Framework 4 (NPF4) requires G&G studies to be considered, stating that solar arrays should be supported if the planning authority is satisfied G&G does not result in adverse impacts. However, there is no explicit guidance on the proximity of receptors to the development that should be considered for the assessment within NPF4.

The National Planning Policy Guidance (NPPG) (planning policy for England but still serving as a useful reference) notes that large scale solar farms "could have a damaging effect on the landscape…particularly in undulating landscapes" and that the "visual impact of a well-planned and well-screened solar farm can be properly addressed within the landscape if planned sensitively" (Paragraph 007: ID 5-007-20140306 & Paragraph 013: ID 5-013-20150327). There is no explicit guidance on the proximity of receptors to the development that should be considered for assessment either.

The British Research Establishment (BRE) [2] states that "the sensitivities associated glint and glare, and the landscape/visual impact and the potential impact on aircraft safety, should be a consideration. In some instances, it may be necessary to seek a glint and glare assessment as part of a planning application." It does not define a proximity to the development that receptors should be considered.

Both the NPPG and BRE guidance highlight the additional importance of a G&G study if solar tracking systems are used, whereby solar PV modules rotate to follow the sun's path to maximise power generation. These can cause "additional impacts" such as "differential diurnal and/or seasonal" variations of G&G[3]. The Proposed Development utilises a fixed mounting structure, rather than a tracking system, therefore these specific notes relating to solar tracking systems are not applicable.

Regarding air-based receptors, the UK Civil Aviation Authority (CAA) states "consideration of glint and glare should be made over a wider area" and indicates a range of up to 2 km from an Aerodrome Reference Point (ARP) [4] as an area of most concern.

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[2] BRE (2013) *Planning guidance for the development of large scale ground-mounted solar PV systems*. Available at https://www.bre.co.uk/filelibrary/pdf/other_pdfs/KN5524_Planning_Guidance_reduced.pdf

[3] Department for Energy Security & Net Zero (2023) *national Policy Statement for Renewable Energy Infrastructure (EN-3)*. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147382/NPS_EN-3.pdf

[4] UK CAA (2022) *CAST Guidance Note – Safeguarding Guidance to GA Aerodrome Managers and Operators*. Available at: https://www.caa.co.uk/search?query=glint

3.0 Methodology

3.1 Glint & glare analysis

A geometric analysis is conducted to study where and when glint and glare events may occur. This examines receptors present at ground level, such as dwellings, roads, national waymarked trails, and railway lines. Receptors are identified using available mapping, aerial photography, and street level imagery.

The G&G analysis is completed in several stages using various methods, software models and tools to progressively assess the potential for effects, while building an understanding of the local environmental conditions, either existing or proposed, that impact the potential for glare in the local area.

3.2 Assessment of effects

The detailed geometric analysis uses a software model to make a prediction on the dates, times and durations of G&G effects at fixed positions over the course of a year. The software used is the GlareGauge tool that was originally developed in the United States by the Sandia National Laboratory and since improved upon and licensed to ForgeSolar. The times reported as to when G&G may occur are reported in Coordinated Universal Time (UTC) and thus any relevant daylight savings should be considered when observing the results.

The computer model predicts whether glare effects are possible at a 1-minute temporal resolution over the course of a full year. The model accounts for the maximum panel height, the area taken up by the panels and a fixed observer height. Any glare that is predicted is classified as either 'green glare', 'yellow glare' or 'red glare', as described previously in Table 1-3.

It is important to understand certain limitations within the model. The model calculates results based on the geometric relationship between the observation point at a fixed height, the reflective plane (panels) at a fixed height, and the position of the sun at each time interval as it progresses across the sky. It, therefore, takes no account of any screening features whatsoever. It does not account for surface features such as buildings or trees, or intervening topography. The software also assumes it is sunny, at the maximum intensity possible, 365 days per year. Since the computer model indicates when glare 'can' happen, not when it 'will' happen, it considerably overstates the realistic glare duration, which is why further interpretation is essential.

The following steps were followed to assess the impacts of glint and glare (G&G) arising from the Proposed Development:

- **Identify receptors required for the assessment**: In this case, the main focus is on the railway lines, main roads, ground-based receptors and air-based receptors closest to the Proposed Development.
- **Input receptor and solar PV plant details**: Details such as location and area of coverage were entered into the ForgeSolar modelling tool, and simulations were run.
- **Assess the results**: The simulation results were analysed to assess the duration, intensity, and potential impact of G&G on all identified receptors. While the model has inherent limitations (e.g., the model does not consider objects such as trees and buildings), existing and planned screening measures—such as trees and hedgerows—were manually incorporated into the simulation. These were identified via Google Earth Pro and the Site Layout Plan. This allowed for a more realistic representation of the anticipated conditions.

4.0 Receptor identification

The following section highlights the receptors considered for the assessment.

4.1 Ground based receptors

The study area is determined as a 5 km radius from the Proposed Development for all ground-based receptors (railway lines, roads, and fixed receptors). See Figure 4-1 for more details.

Figure 4-1: Aerial view of Proposed Development (red), rail (green), road (dark blue) and fixed receptors (light blue)

(Source: Google Earth Pro, 2025)

4.1.1 Rails

There is one railway line in close proximity on the east side of the Proposed Development (highlighted in yellow in Figure 4-1 above), which has been considered in the study. The objective is to assess the possible impacts of the proposed solar PV panels on the railway line’s operation.

4.1.2 Roads

There are numerous roads and small country lanes within the 5 km study area of the Proposed Development. G&G study has focused on the main road (Great North Road - A1) that is east and in close proximity to the proposed solar farm.

4.1.3 Fixed Receptors

There are a number of dwellings and commercial premises within the study area. In some cases, the identified location is considered to be representative of several discrete receptors in close proximity. The locations of interest include:

- Buildings in the south, west and north of proposed solar farm, adjacent to farm.

There is a total of 38 ground-based observation points (OP) which represent the buildings. These are all offsite residential and commercial dwellings of single or two storeys.

4.2 Air based receptors

There is no airport within a 10 km radius of the Proposed Development and therefore no air-based receptors have been considered for the study.

5.0 G&G assessment

The following section details the results of the simulation in the ForgeSolar tool, including the model assumptions used.

5.1 ForgeSolar model

A single array of solar PV panels has been modelled in the software to estimate the glint and glare effects. There are a total of three sets of modelling assumptions required for the simulation, detailed in Table 5-1, Table 5-2 and Table 5-3 below:

Table 5-1: Site configuration parameters

Parameter	Details
Subtended angle of the sun	9.3mrad (0.5°). This is the default setting given by the software.
Direct Normal Irradiance (DNI)	DNI scales with the position of the sun and has a peak value of 1000W/m².
Ocular transmission coefficient	This is the radiation absorbed in the eye before reaching the retina. Value of 0.5 (default figure recommended by the software).
Pupil diameter	This is the diameter of the pupil when daylight is present. Value of 2mm (default figure recommended by the software).
Eye focal length	This is the projected image size on the retina from a given glare source for a given subtended angle. Value of 1.7cm This is the default figure recommended by the software.
Time interval	Value of 1 to represent 1 minute

Table 5-2: PV array parameters

Parameter	Details
Mounting details	Fixed tilt (no tracking).
Module tilt	12°
Module orientation	180° (South)
PV material category	Category 1. Defined as smooth glass with anti-reflective coating.
Capacity	170 MW
Slope error value	A value of ‘varies’ to imply that this depends on the PV material selected. In this case, material category 1 was selected.
Reflectivity value	A value of ‘varies’ to imply that this depends on the PV material selected. In this case, material category 1 was selected.

Table 5-3: Receptor parameters

Parameter	Details
Route receptors	Two routes including one railway line and one main road
Azimuthal viewing angle	50°. This is the default setting and assumes the person can see 50° to the left and right during their approach. In addition, the software considers the road has two directions.
Observation points	38 OPs, all of them offsite.
Obstructions	Range of trees and buildings scattered around site.

5.2 Modelling limitations

It is important to understand certain limitations within the model.

- The geometry of the entire system is not considered, such as gaps between panels and heights of the mounting structures and individual panels. Therefore, a module height above ground of 2.33 meters assumes this is the only elevation at which sunlight reflects from the module (i.e. the lower and higher portions of the array are not considered).
- The shape of surrounding obstacles and obstructions (such as trees, electricity poles and fences) are not fully considered. For example, a tree is considered as uniform in its circumference from its tip to the ground as opposed to thinner at the bottom from the trunk and widest in the middle. This can lead to an obstacle's ability to shield a receptor from G&G being both under and overestimated. Further, the precise height of shading obstacles is not known, and estimates are therefore made.
- The model does not consider daily variations in weather conditions (e.g. cloud cover) and instead uses a typical clear day as a default. The software also assumes it is sunny, at the maximum intensity possible, 365 days per year. Since the computer model indicates when glare 'can' happen, not when it 'will' happen, it considerably overstates the realistic glare duration, which is why further interpretation is essential. This also overestimates the impacts of glint and glare.
- Only ten obstructions can be modelled. As a result, many existing obstructions such as tree and hedgerows and other buildings may not be present in the model. G&G is therefore overestimated in this instance

5.3 Simulation results

The following section details the results of the G&G simulation, along with implications for the site and limitations of the study. Note that further details can be found in the following G&G simulation reports:

- *Appendix A - ForgeSolar_Bowshiel Analysis Report v2.pdf*

Table 5-4 highlights the total duration and magnitude of G&G experienced by all affected receptors across the day and year. It is worth noting that the remaining receptors are not impacted by G&G from the PV array.

To clarify:

- Green glare indicates a low potential for after-image formation and poses minimal risk to health and safety.
- Yellow glare, while indicating some potential for after-image, has an impact comparable to common reflective materials like glass, windows, or metallic surfaces.

Table 5-4: Duration and diurnal/seasonal patterns of G&G

Receptor	G&G hazard summary	Time/maximum duration of daily G&G
Trainline	Green	From 18:30 to 20:00 from mid-April to August, up to 15 mins per day; with no yellow glare
A1	Yellow	From 19:00 to 20:00 from mid-May to July, up to 20 mins per day; with 4 minutes of green glare on average per day from mid-April to August
OP2	Green	From 05:00 to 06:00 from mid-May to July, up to 4 mins per day; with no yellow glare
OP5	Yellow	From 18:00 to 19:30 from April to early September, up to 35 mins per day; with around 8 mins of yellow glare on average per day.
OP15	Green	From 18:30 to 19:30 from mid-May to July, up to 8 mins per day; with no yellow glare
OP16	Green	From 18:30 to 19:30 from mid-May to July, up to 5 mins per day; with no yellow glare
OP23	Green	From 05:30 to 06:30 during mid-March to mid-April and mid-August to September, up to 15 mins per day; with no yellow glare

5.4 Discussion and implication of results

5.4.1 Routes

The G&G Assessment evaluated two routes: a trainline and a main road (A1). Existing screening measures, such as trees, hedgerows, have been incorporated into the simulation as detailed in Figure 5-1. Note that the planned screening, if any, has not been included in the modelling.

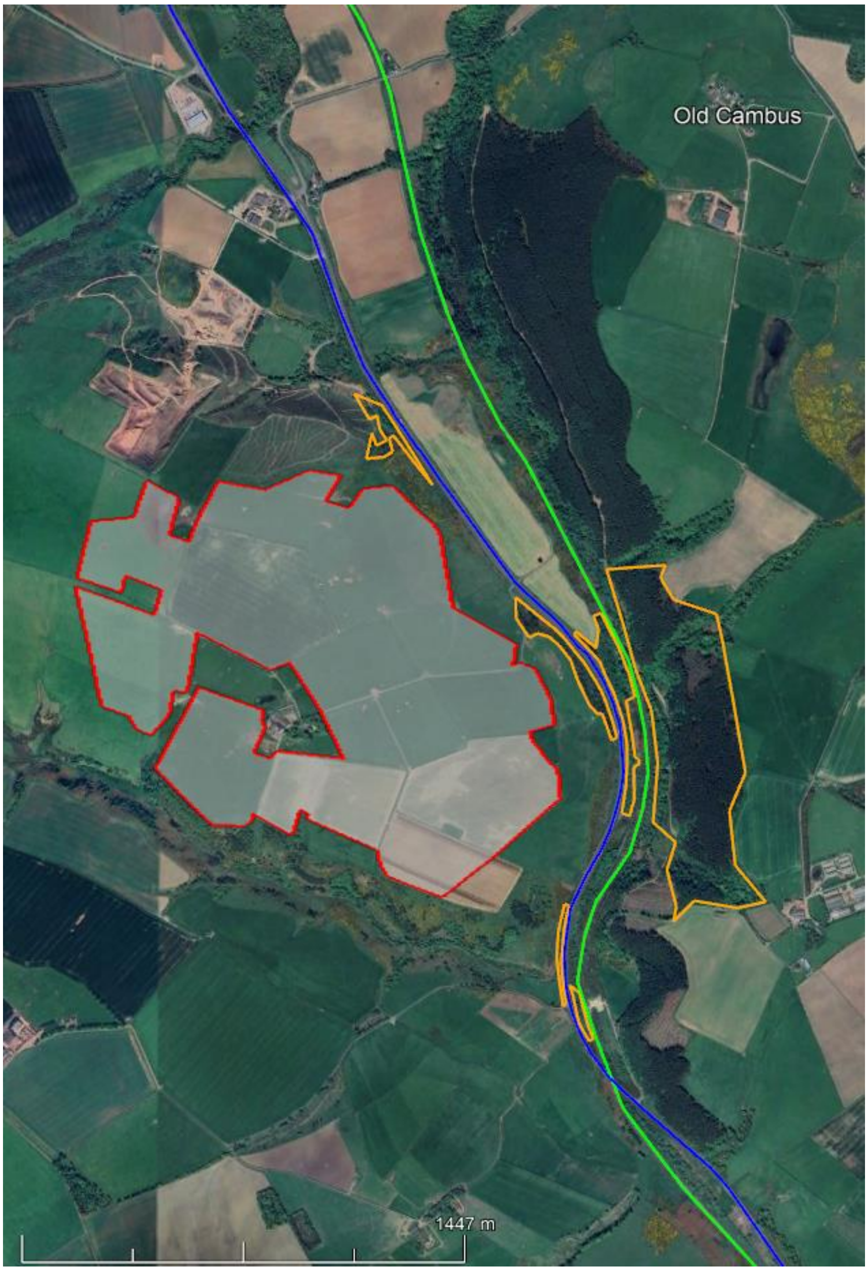


Figure 5-1: Existing screening (orange) along the route receptors included in simulation

(Source: Google Earth Pro, 2025)

5.4.1.1 Trainline

As shown in Table 5-4, the Trainline is predominantly affected by green glare, with the potential for no yellow glare. The simulation indicates that green glare may occur in the evening (from 18:30 to 20:00) for up to 15 minutes per day between mid-April and August. See Figure 5-2 for more details.

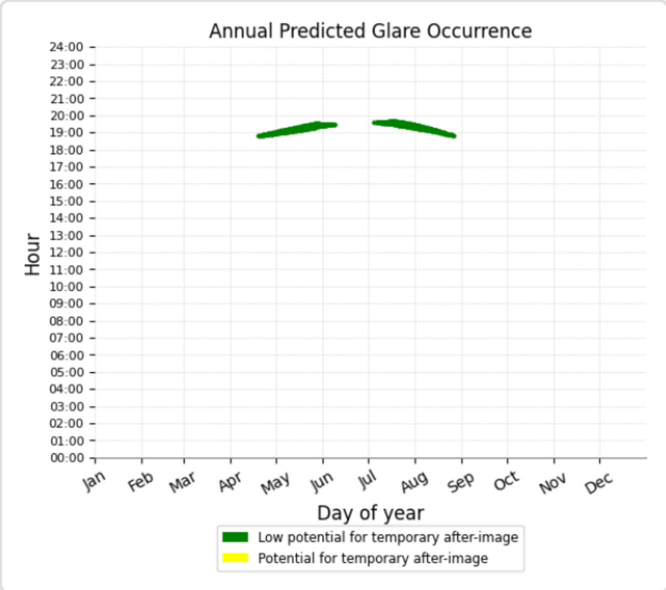


Figure 5-2: Annual Predicted Glare Occurrence at Trainline from PV Array

(Source: Appendix 1, ForgeSolar 2024))

Figure 5-3 and Figure 5-4 illustrate where the G&G emanates from, and which part of the train route is affected by it.

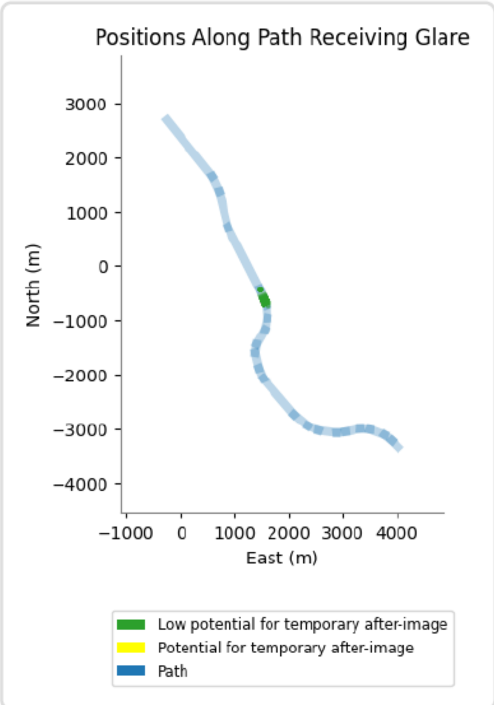


Figure 5-3: Positions Along the Trainline Receiving Glare from PV Array

(Source: Appendix 1, ForgeSolar Report)

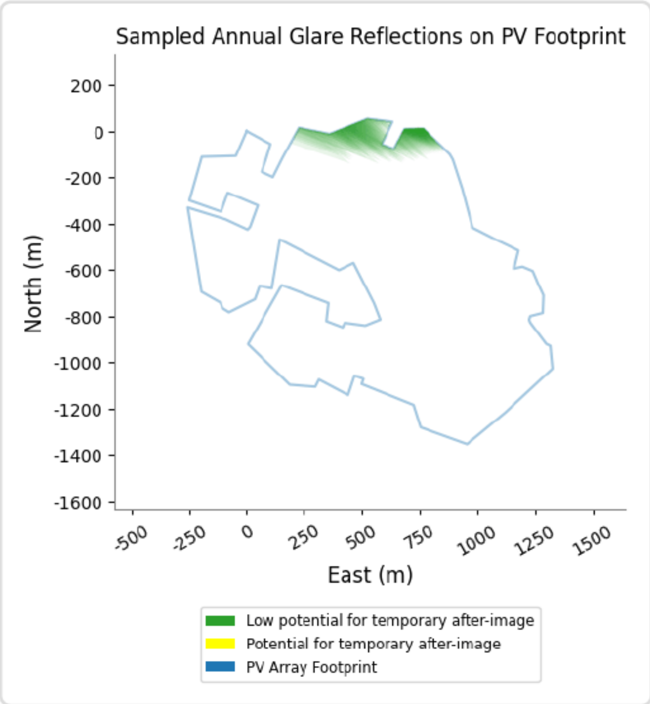
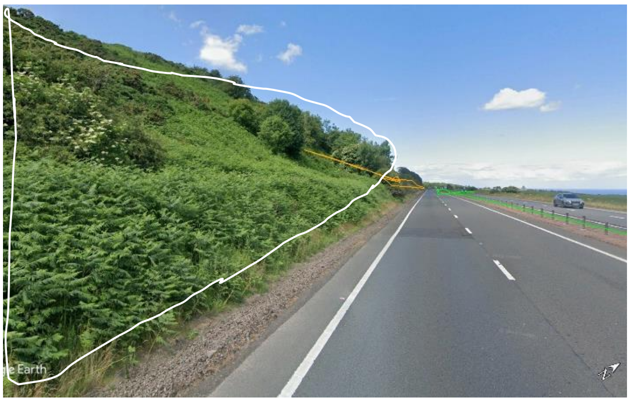


Figure 5-4: Area of PV Array where the glare emanates from

(Source: Appendix 1, ForgeSolar Report)

While existing hedgerows are already in place and have been included in the simulation, additionally there are other existing screenings such as intervening topography as shown in white polygon in Figure 5-5. This screening, lying in between the PV array and the point on the train line where G&G occur, would partially obstruct the glare under real-life conditions. However, this obstruction could not be included in the assessment due to software limitations (up to a maximum of 10 screenings).

Satellite imagery



Street view

Figure 5-5: Existing screening (white) along Trainline but not included in simulation

(Source: Google Earth Pro)

Given the transient nature of G&G effects as vehicles approach or move away from the PV arrays, combined with the mitigating effect of screenings (trees, hedgerows) between PV array and Trainline, the overall impact is assessed to be minimal to none.

It is also important to note that the simulation assumes sunny conditions every day, as outlined in Section 1.4 and Section 1.5 above. In reality, glare does not occur during diffuse reflection (e.g. on overcast days), meaning that the results are conservatively overestimated.

In conclusion, the combination of short exposure durations, no yellow glare, and existing mitigation measures means that the potential G&G impact on Trainline is **negligible** and unlikely to pose a risk to safety of railways.

5.4.1.2 Main road – A1

As shown in Table 5-4, the main road A1 is predominantly affected by yellow glare, with the potential for 4 minutes of green glare in the evening on average per day from mid-April to August. This amounts to a total of 533 minutes of green glare over the year.

The simulation indicates that yellow glare may occur in the evening (19:00 to 20:00) for up to 20 minutes per day between mid-May to July. This amounts to a total of 712 minutes of yellow glare over the year. See Figure 5-6 for more details.

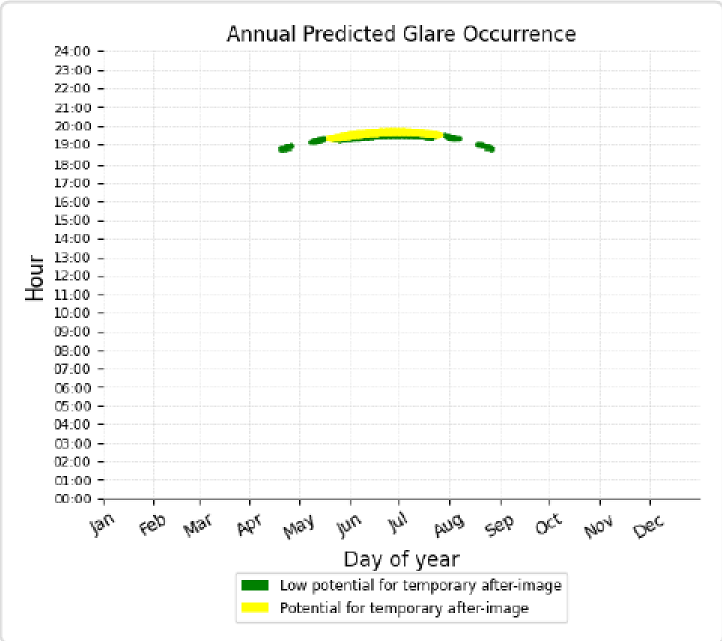


Figure 5-6: Annual Predicted Glare Occurrence at A1 from PV Array

(Source: Appendix 1, ForgeSolar 2024)

Figure 5-7 and Figure 5-8 illustrate where the G&G emanates from, and which part of the route is affected by it.

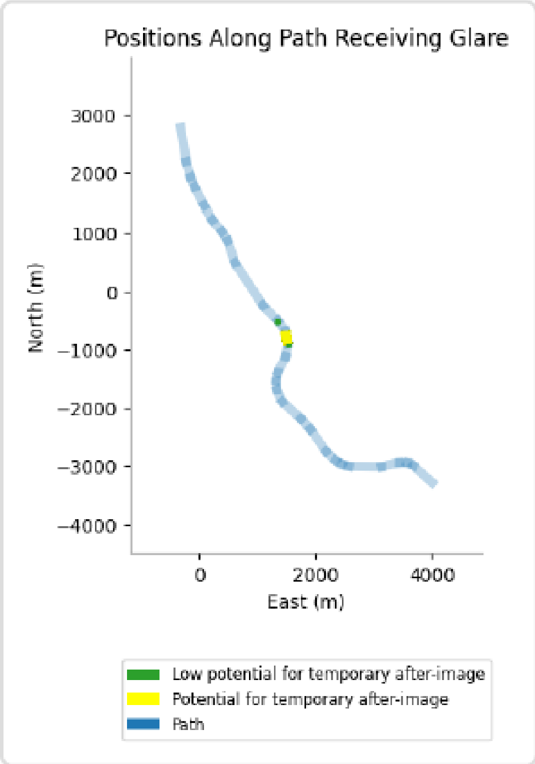


Figure 5-7: Positions Along A1 Receiving Glare from PV Array

(Source: Appendix 1, ForgeSolar Report)

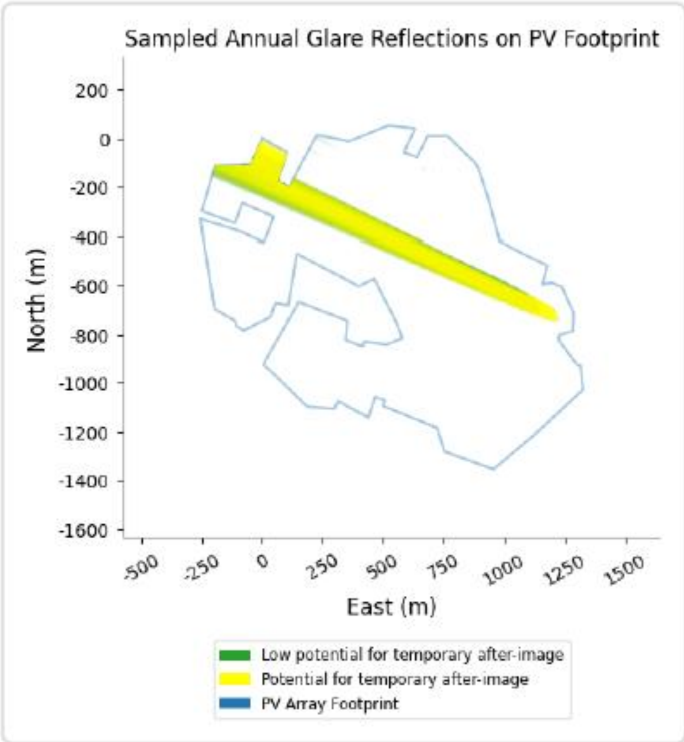


Figure 5-8: Area of PV Array where the glare emanates from

(Source: Appendix 1, ForgeSolar Report)

In addition to existing screenings (orange polygon) that have been modelled in the simulation, there are other existing screenings, such as the hilly topography shown by the white polygon in Figure 5-9 that would obstruct the glare under real-life conditions. This screening lies in between the PV array and the point on A1 where G&G occurs. However, this obstruction could not be included in the assessment and the software does not consider intervening topography, as explained in Section 5.2. Moreover, the G&G effects are transient in nature as vehicles approach or move away from the PV array.

Satellite imagery | Street View

Figure 5-9: Existing screenings along A1 but not included in simulation

(Source: Google Earth Pro)

In conclusion, the potential G&G impact on A1 is considered **negligible** and unlikely to pose a risk to safety given the fact that G&G effects are transient in nature as vehicles approach or move away from the PV array, existing mitigation measures are in place that will screen the G&G in real life conditions and the G&G occurs on a small section of main road A1.

5.4.2 Fixed Ground Receptors

Out of the 38 fixed ground receptors, or Observation Points (OPs), included in the modelling, five of them are impacted by G&G as indicated in Table 5-4.

- Observation point OP5 is predominately affected by green glare with occasional yellow glare occurring from April to early September during evening hours. This is due to the sun's position moving westward, resulting in eastward reflections. The yellow glare at OP5 occurs for an average of up to 8 minutes per day during this period.
- Other four observation points OP2, OP15, OP16, and OP23 are predominately affected by green glare with no yellow glare. OP2 experience green glare in the early morning hours from mid-May to July. OP23 experience green glare in the morning during mid-March to mid-April and mid-August to September. On the other hand, OP15 and OP 16 experience green glare in the evening from mid-May to July.

Figure 5-10 below shows the location of the fixed receptor (OP5) affected mostly by green glare, as well as examples of how the reflections occur in the morning for this receptor.

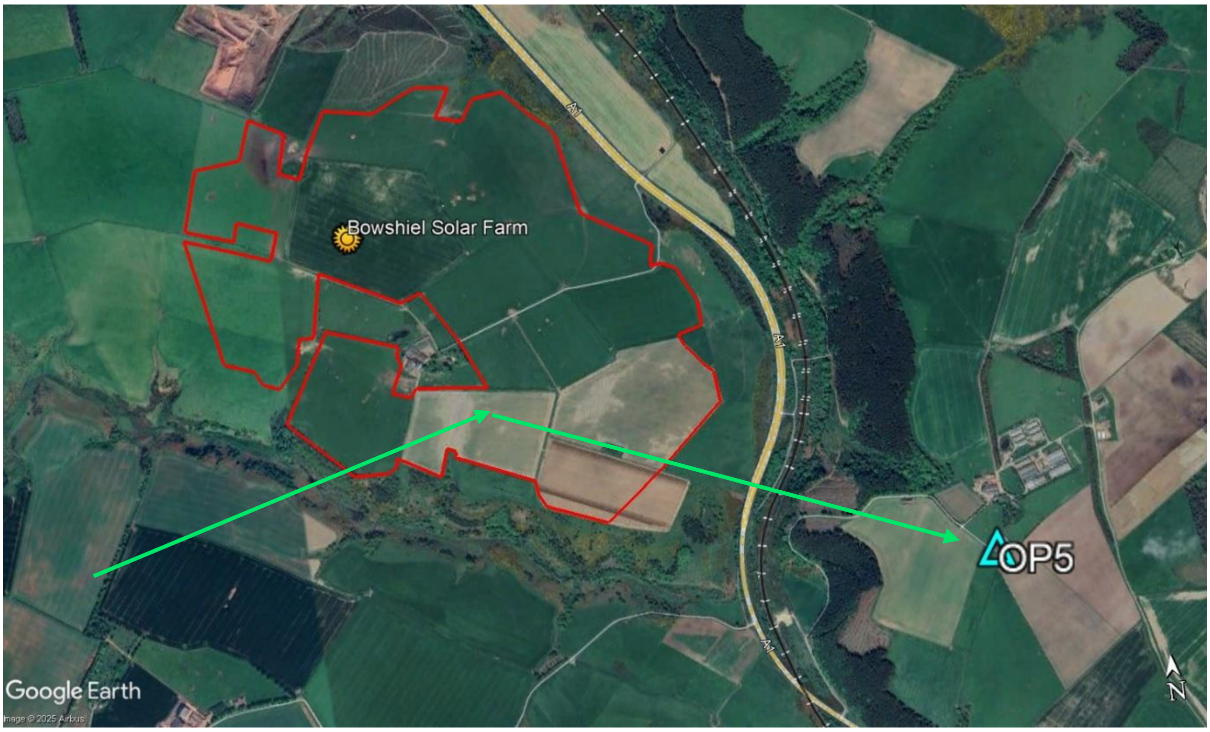


Figure 5-10: Demonstration of reflectance across the Proposed Development, showing eastward reflections in the evening for receptor (green arrows).

(Source: Google Earth Pro, 2025)

In addition, Figure 5-11 illustrates the areas of the Proposed Development from which the glare affecting OP5 emanates.

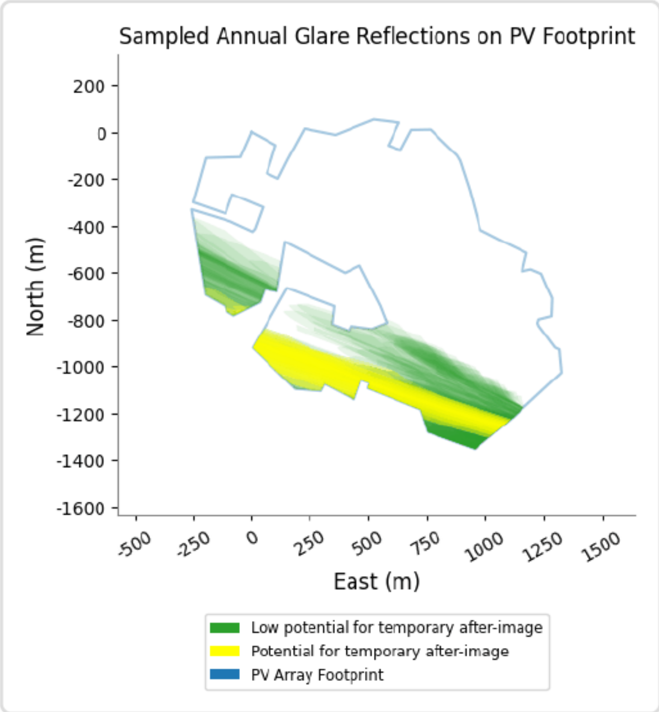


Figure 5-11: Areas of PV Array affecting fixed receptor (OP5) affected by yellow glare

(Source: Appendix 1, ForgeSolar 2024)

Existing screening measures such as trees, scrub planting, hedgerows, and other obstructions were included in the simulation where applicable to provide a realistic assessment of G&G effects.

Although parts of the PV array are still visible from OP5, due to its elevated position on a nearby hill (see Figure 5-12 and Figure 5-13), the real-world impact is likely reduced. This is because additional screening and intervening topography, not fully accounted for in the simulation, may further mitigate glare.

Figure 5-12: View of the Proposed Development (in red) hill from OP5.

(Source: Google Earth Pro, 2025)

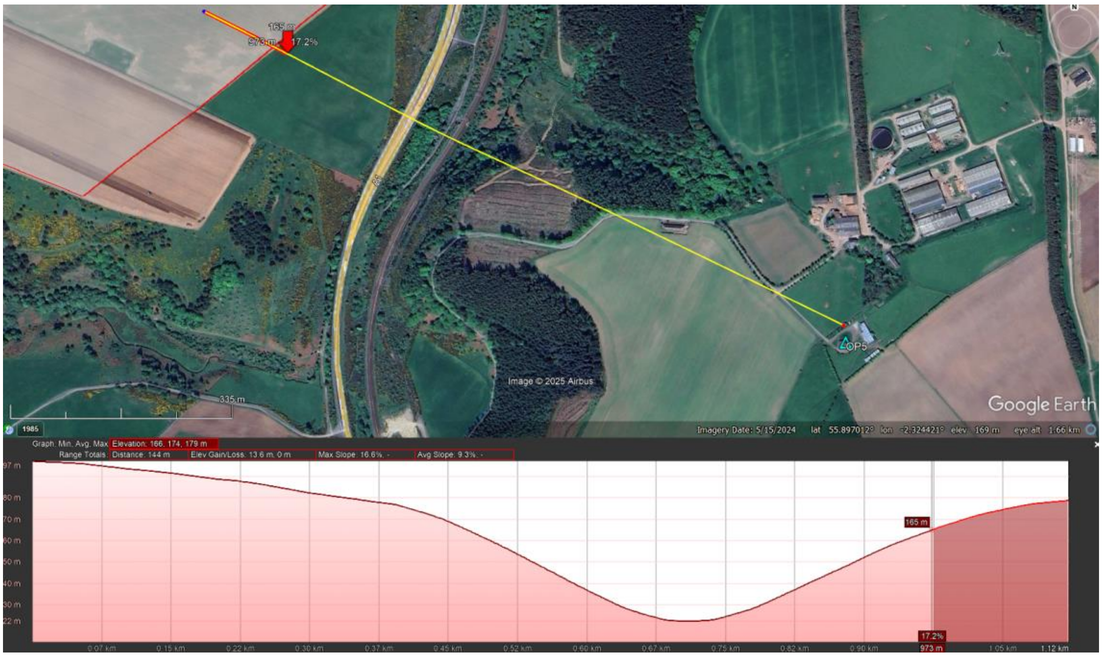


Figure 5-13: Elevation profile from OP5 (left side of the profile) to the Proposed Development (right side of the profile).

(Source: Google Earth Pro, 2025)

The overall impact on OP5 is considered **negligible** due to the short duration of yellow glare, the presence of existing screening, and the distance between the PV array and the receptor.

The overall impact on the rest of the receptors identified above is minimal due to the short duration and low intensity of the glare. Even in the worst-case scenario, glare lasts only up to 15 minutes per day for OP23 and 4 to 8 minutes per day for the remaining affected receptors, with no occurrence outside of the March to September timeframe. The green magnitude G&G observed at these receptors indicates a low potential for after-image formation and poses **no significant risk** to health or safety.

6.0 Conclusion

The purpose of this G&G assessment is to consider the effects of glint and glare arising from the proposed solar farm on receptors around the Proposed Development. Particular attention is paid to the train line and main road (A1), as these are considered to be more sensitive. The train line is sensitive because the G&G can impact the signalling equipment and affect the operation and safety of the railway. On the main road, motorists travel at speed, and therefore, G&G is considered a safety risk. Other less sensitive receptors include nearby residential and commercial buildings (a total of 38 fixed ground-based receptors).

For glare to occur, there must be viable weather conditions, the geometrical alignment for glint (i.e. reflected light must physically arrive at the receptor, given the relative position of the sun in the sky and the panels), and there must be visibility of the panels (i.e. no intervening landform, or surface features (buildings/trees/hedgerows etc).

The software used for the simulation (GlareGauge tool by ForgeSolar) has some limitations (which are discussed in the report), such as treating the circumference of trees at ground and tip height as uniform, despite the trunks of trees being much smaller than the body of the tree. Additionally, G&G can only occur under sunny conditions, which the software does not explicitly account for, potentially leading to overestimations of its occurrence and impact. This can also affect the assessment of how obstacles mitigate G&G on sensitive receptors.

For the train line, the impact is assessed as negligible due to no yellow glare, short duration of low intensity glare, the transient nature of train movement, and existing mitigation measures such as hedgerows, trees and hilly topography. The results suggest that glare effects are unlikely to pose a safety risk.

For the A1 (Great North Road), a low impact has been identified due to the short duration of yellow glare, existing screenings, transient nature of vehicle movement, and the fact that G&G occurs on a small patch of main road.

In all cases, any glare would be no worse than seeing sunlight reflection from a window or still water, as solar panels have lower reflective properties than these materials. Drivers regularly experience conditions where the sun is low in the sky, which is more intense than any glare effect from solar panels.

Among the fixed ground receptors, one observation point (OP5) is primarily affected by green glare in the evening hours from April to September. The overall impact on receptor (OP5) is considered negligible due to the short duration of yellow glare, existing screenings between the PV array and the receptor and the large distance from the PV array and the receptor.

The remaining fixed ground receptors experience only green glare, with limited exposure durations, resulting in no risk to health and safety.

Existing screening measures, along with conservative modelling assumptions, indicate that these impacts are overstated and unlikely to cause any significant impacts.

In summary, the analysis demonstrates that the G&G impacts from the Proposed Development are minimal and effectively mitigated by existing screening measures.

Appendix A ForgeSolar Analysis Report

Bowshiel Solar

Glint & Glare Assessment

Voltalia UK Ltd

SLR Project No.: 405.065782.00001

15 April 2025

The simulation results from the ForgeSolar software are provided separately in PDF format, under the document name '*Appendix A - ForgeSolar_Bowshiel Analysis Report v2'.*

FORGESOLAR GLARE ANALYSIS

Project: **Bowshiel Solar PV**
Site configuration: **Bowshiel V2**

Client: Voltalia

Created 06 Aug, 2024
Updated 27 Mar, 2025
Time-step 1 minute
Timezone offset UTC0
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 100 MW to 1 GW
Site ID 126045.21466

Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
PV analysis methodology V2

Summary of Results

Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	12.0	180.0	6,561	109.3	916	15.3	-

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
A1	533	8.9	712	11.9
Trainline	814	13.6	0	0.0
OP 1	0	0.0	0	0.0
OP 2	93	1.6	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	3,926	65.4	204	3.4
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 14	0	0.0	0	0.0
OP 15	449	7.5	0	0.0
OP 16	299	5.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	447	7.5	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0
OP 38	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 12.0°
Orientation: 180.0°
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	55.909471	-2.351110	227.99	2.33	230.32
2	55.908509	-2.351861	227.01	2.33	229.34
3	55.908473	-2.354222	227.67	2.33	230.00
4	55.906777	-2.355080	211.06	2.33	213.39
5	55.906344	-2.352891	209.90	2.33	212.23
6	55.907077	-2.352419	216.58	2.33	218.91
7	55.906584	-2.350338	216.16	2.33	218.49
8	55.905754	-2.350874	208.79	2.33	211.12
9	55.905646	-2.351046	208.03	2.33	210.36
10	55.906043	-2.352569	208.18	2.33	210.51
11	55.906500	-2.355187	208.20	2.33	210.53
12	55.903228	-2.354243	187.73	2.33	190.06
13	55.902807	-2.352934	187.65	2.33	189.98
14	55.902591	-2.352784	185.75	2.33	188.08
15	55.902434	-2.352333	183.18	2.33	185.51
16	55.902940	-2.350542	188.90	2.33	191.23
17	55.903454	-2.350214	193.32	2.33	195.65
18	55.903358	-2.349372	192.41	2.33	194.74
19	55.905259	-2.348813	206.98	2.33	209.31
20	55.904068	-2.344714	202.81	2.33	205.14
21	55.904345	-2.343706	203.95	2.33	206.28
22	55.902788	-2.342290	195.88	2.33	198.21
23	55.902151	-2.341850	191.60	2.33	193.93
24	55.901916	-2.342886	191.43	2.33	193.76
25	55.902024	-2.344313	193.99	2.33	196.32
26	55.901847	-2.344457	193.20	2.33	195.53
27	55.902091	-2.345584	194.64	2.33	196.97
28	55.902788	-2.345445	196.88	2.33	199.21
29	55.903486	-2.348685	194.10	2.33	196.43
30	55.901194	-2.351013	171.62	2.33	173.95
31	55.899612	-2.348127	172.40	2.33	174.73
32	55.899534	-2.346356	173.22	2.33	175.55
33	55.899817	-2.346099	178.86	2.33	181.19
34	55.899215	-2.344082	167.50	2.33	169.83
35	55.899967	-2.343631	175.51	2.33	177.84
36	55.899841	-2.343009	174.89	2.33	177.22
37	55.899643	-2.343138	173.09	2.33	175.42
38	55.898830	-2.339544	176.54	2.33	178.87
39	55.897958	-2.339050	167.58	2.33	169.91
40	55.897306	-2.335835	167.94	2.33	170.27
41	55.898545	-2.333174	174.07	2.33	176.40
42	55.900242	-2.329923	161.91	2.33	164.24
43	55.901126	-2.330073	161.29	2.33	163.62
44	55.901204	-2.330352	162.95	2.33	165.28
45	55.902034	-2.331457	164.32	2.33	166.65
46	55.902142	-2.331535	163.82	2.33	166.15
47	55.902283	-2.331460	162.08	2.33	164.41
48	55.902410	-2.330591	154.16	2.33	156.49
49	55.903092	-2.330543	148.60	2.33	150.93
50	55.903553	-2.330921	149.22	2.33	151.55
51	55.904034	-2.331286	149.03	2.33	151.36
52	55.904203	-2.331994	151.99	2.33	154.32
53	55.904131	-2.332574	156.51	2.33	158.84
54	55.904828	-2.332273	148.17	2.33	150.50
55	55.905237	-2.333775	155.29	2.33	157.62
56	55.905718	-2.335449	167.99	2.33	170.32
57	55.907258	-2.336179	162.10	2.33	164.43
58	55.908364	-2.336822	158.43	2.33	160.76
59	55.908569	-2.337037	158.58	2.33	160.91

Route Receptors

Name: A1
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	55.934394	-2.356085	64.73	1.50	66.23
2	55.929147	-2.354615	87.44	1.50	88.94
3	55.926776	-2.353419	85.56	1.50	87.06
4	55.925291	-2.352335	98.01	1.50	99.51
5	55.922406	-2.349707	105.13	1.50	106.63
6	55.920350	-2.347432	104.49	1.50	105.99
7	55.918608	-2.344764	115.72	1.50	117.22
8	55.917198	-2.343149	116.58	1.50	118.08
9	55.913783	-2.341132	117.57	1.50	119.07
10	55.907254	-2.333488	128.63	1.50	130.13
11	55.904920	-2.329433	128.36	1.50	129.86
12	55.903309	-2.327352	125.18	1.50	126.68
13	55.901360	-2.326708	124.71	1.50	126.21
14	55.899393	-2.327309	128.59	1.50	130.09
15	55.896963	-2.329465	125.37	1.50	126.87
16	55.895620	-2.329862	122.99	1.50	124.49
17	55.894213	-2.329669	119.42	1.50	120.92
18	55.892396	-2.328209	124.45	1.50	125.95
19	55.889761	-2.323102	129.92	1.50	131.42
20	55.888176	-2.320539	121.96	1.50	123.46
21	55.884746	-2.316140	126.27	1.50	127.77
22	55.883368	-2.313523	122.01	1.50	123.51
23	55.882790	-2.311806	119.73	1.50	121.23
24	55.882501	-2.309843	120.57	1.50	122.07
25	55.882428	-2.300931	119.44	1.50	120.94
26	55.883025	-2.296103	116.84	1.50	118.34
27	55.883001	-2.293978	113.60	1.50	115.10
28	55.882592	-2.292274	112.90	1.50	114.40
29	55.879980	-2.287006	117.19	1.50	118.69

Name: Trainline
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	55.933624	-2.355001	63.20	1.50	64.70
2	55.924308	-2.341740	80.63	1.50	82.13
3	55.921855	-2.339658	84.42	1.50	85.92
4	55.915901	-2.337058	87.38	1.50	88.88
5	55.905698	-2.327804	113.77	1.50	115.27
6	55.902955	-2.325723	118.65	1.50	120.15
7	55.900868	-2.325427	119.57	1.50	121.07
8	55.898917	-2.326224	121.07	1.50	122.57
9	55.896523	-2.328670	123.61	1.50	125.11
10	55.895091	-2.329078	120.35	1.50	121.85
11	55.892553	-2.328005	124.21	1.50	125.71
12	55.890871	-2.326707	125.62	1.50	127.12
13	55.884892	-2.317582	124.67	1.50	126.17
14	55.883020	-2.313580	119.93	1.50	121.43
15	55.882262	-2.310233	119.43	1.50	120.93
16	55.881865	-2.304975	117.89	1.50	119.39
17	55.882033	-2.302418	117.52	1.50	119.02
18	55.882539	-2.297880	117.44	1.50	118.94
19	55.882409	-2.295090	123.28	1.50	124.78
20	55.881530	-2.290917	116.46	1.50	117.96
21	55.880589	-2.288772	113.03	1.50	114.53
22	55.879499	-2.286862	114.65	1.50	116.15

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	55.892753	-2.364369	232.40	4.00
OP 2	2	55.893692	-2.355458	217.90	4.00
OP 3	3	55.884101	-2.369645	193.30	4.00
OP 4	4	55.887272	-2.336697	211.80	4.00
OP 5	5	55.895269	-2.317331	195.90	4.00
OP 6	6	55.882807	-2.310966	120.50	4.00
OP 7	7	55.882765	-2.309598	122.30	4.00
OP 8	8	55.882777	-2.309029	122.10	4.00
OP 9	9	55.882810	-2.307962	121.70	4.00
OP 10	10	55.883505	-2.304212	129.40	4.00
OP 11	11	55.883289	-2.303027	128.50	4.00
OP 12	12	55.883415	-2.302227	131.30	4.00
OP 13	13	55.882943	-2.302807	125.10	4.00
OP 14	14	55.880497	-2.284774	127.50	4.00
OP 15	15	55.885911	-2.283913	159.10	4.00
OP 16	16	55.884569	-2.282818	155.10	4.00
OP 17	17	55.860973	-2.342422	202.40	4.00
OP 18	18	55.872442	-2.384169	215.30	4.00
OP 19	19	55.871419	-2.383703	215.60	4.00
OP 20	20	55.871072	-2.382238	220.30	4.00
OP 21	21	55.891907	-2.359674	229.00	4.00
OP 22	22	55.891827	-2.359995	229.60	4.00
OP 23	23	55.906567	-2.386153	178.20	4.00
OP 24	24	55.908733	-2.385374	167.20	4.00
OP 25	25	55.909244	-2.384720	164.90	4.00
OP 26	26	55.916124	-2.367300	121.30	4.00
OP 27	27	55.916474	-2.365452	118.00	4.00
OP 28	28	55.915924	-2.368851	123.10	4.00
OP 29	29	55.917600	-2.344729	120.60	4.00
OP 30	30	55.918034	-2.346119	121.20	4.00
OP 31	31	55.917425	-2.346341	123.70	4.00
OP 32	32	55.920714	-2.302830	105.10	4.00
OP 33	33	55.918113	-2.313834	153.80	4.00
OP 34	34	55.918336	-2.314392	152.30	4.00
OP 35	35	55.918687	-2.313239	144.90	4.00
OP 36	36	55.920681	-2.321330	163.60	4.00
OP 37	37	55.920819	-2.321974	163.70	4.00
OP 38	38	55.919950	-2.319898	164.80	4.00

Obstruction Components

Name: Obstruction 1
Top height: 8.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.906222	-2.332509	132.17
2	55.905662	-2.332412	138.91
3	55.905031	-2.331737	142.56
4	55.905097	-2.331039	137.54
5	55.904514	-2.329762	135.85
6	55.902036	-2.327391	128.93
7	55.902012	-2.327112	126.27
8	55.902986	-2.327617	128.86
9	55.904820	-2.329430	129.52
10	55.906222	-2.332509	132.17

Name: Obstruction 10
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.904177	-2.322096	163.57
2	55.902757	-2.324714	122.12
3	55.899100	-2.324199	133.18
4	55.897837	-2.324607	149.12
5	55.896839	-2.323770	173.88
6	55.897284	-2.319328	191.92
7	55.899257	-2.321002	182.19
8	55.900953	-2.319822	195.44
9	55.904177	-2.322096	163.57

Name: Obstruction 2
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.905614	-2.328335	113.81
2	55.905638	-2.327831	113.95
3	55.903323	-2.326104	119.01
4	55.899814	-2.326157	122.71
5	55.899724	-2.326769	125.60
6	55.901955	-2.326587	122.54
7	55.904397	-2.327874	121.40
8	55.905131	-2.329365	125.54
9	55.904818	-2.328142	119.26
10	55.905614	-2.328335	113.81

Name: Obstruction 3
Top height: 8.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.898851	-2.327501	126.01
2	55.898647	-2.326949	121.11
3	55.897564	-2.328043	124.09
4	55.896421	-2.329057	123.99
5	55.897290	-2.328923	123.69
6	55.898851	-2.327501	126.01

Name: Obstruction 4
Top height: 7.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.912149	-2.340207	131.39
2	55.910285	-2.337482	136.41
3	55.910176	-2.337943	145.82
4	55.910321	-2.340121	176.82
5	55.911078	-2.339509	149.05
6	55.912149	-2.340207	131.39

Name: Obstruction 5
Top height: 8.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.897431	-2.329631	128.60
2	55.896517	-2.330200	127.75
3	55.894568	-2.330168	120.48
4	55.894658	-2.329986	120.09
5	55.895687	-2.329996	123.92
6	55.896824	-2.329642	125.52
7	55.897371	-2.329353	126.46
8	55.897431	-2.329631	128.60

Name: Obstruction 6
Top height: 3.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.894092	-2.329375	119.60
2	55.894242	-2.329198	119.15
3	55.893126	-2.328388	119.61
4	55.893060	-2.328560	120.26
5	55.894092	-2.329375	119.60

Name: Obstruction 7
Top height: 8.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.894670	-2.354336	206.43
2	55.894573	-2.354437	207.60
3	55.893632	-2.352892	211.29
4	55.893373	-2.356712	220.86
5	55.893121	-2.356851	222.49
6	55.893376	-2.355795	219.96
7	55.893551	-2.352404	210.27
8	55.893656	-2.352442	209.67
9	55.894670	-2.354336	206.43

Name: Obstruction 8
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.887371	-2.288871	133.89
2	55.887479	-2.291843	137.10
3	55.885632	-2.293270	129.65
4	55.884266	-2.294149	117.67
5	55.885211	-2.291017	129.47
6	55.887371	-2.288871	133.89

Name: Obstruction 9
Top height: 8.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.892283	-2.359700	228.51
2	55.891796	-2.360397	229.86
3	55.893215	-2.364957	232.69
4	55.895826	-2.361749	220.65
5	55.895730	-2.361384	220.72
6	55.893227	-2.364421	232.82
7	55.892030	-2.360644	229.95
8	55.892391	-2.360086	228.77
9	55.892283	-2.359700	228.51

Glare Analysis Results

Summary of Results Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	12.0	180.0	6,561	109.3	916	15.3	-

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
A1	533	8.9	712	11.9
Trainline	814	13.6	0	0.0
OP 1	0	0.0	0	0.0
OP 2	93	1.6	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	3,926	65.4	204	3.4
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	449	7.5	0	0.0
OP 16	299	5.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	447	7.5	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0
OP 38	0	0.0	0	0.0

PV: PV array 1 potential temporary after-image

Receptor results ordered by category of glare

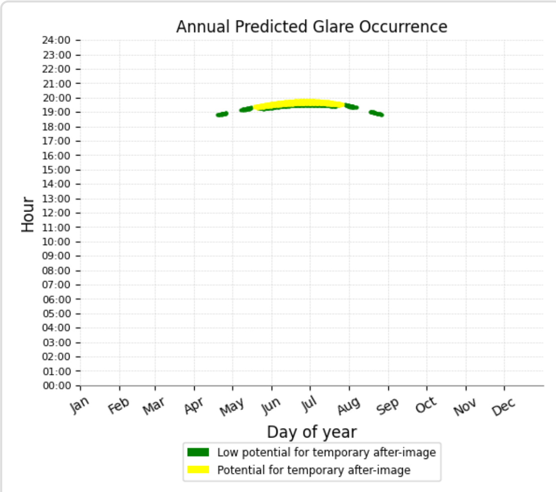
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
A1	533	8.9	712	11.9
Trainline	814	13.6	0	0.0
OP 5	3,926	65.4	204	3.4
OP 2	93	1.6	0	0.0
OP 15	449	7.5	0	0.0
OP 16	299	5.0	0	0.0
OP 23	447	7.5	0	0.0
OP 1	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0

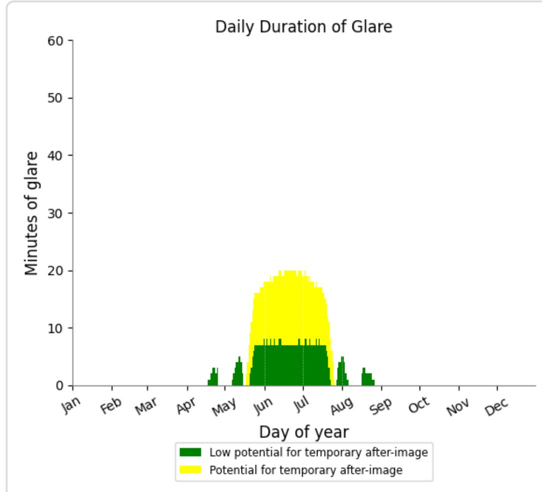
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0
OP 38	0	0.0	0	0.0

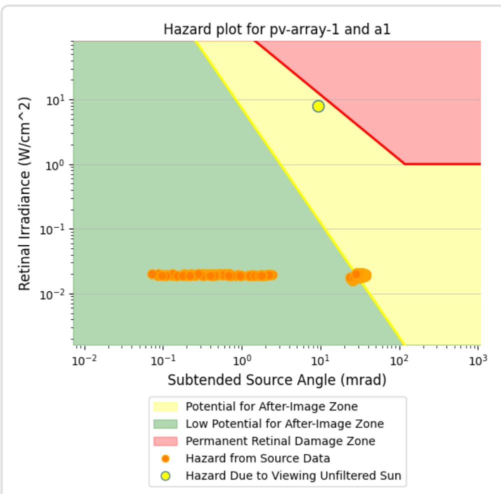
PV array 1 and Route: A1

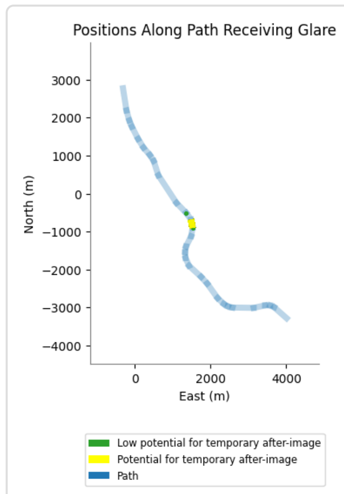
Yellow glare: 712 min.

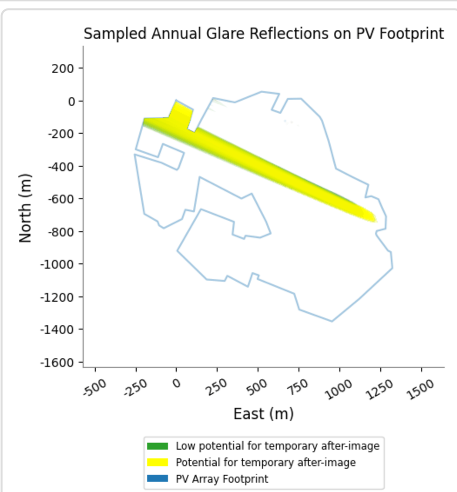
Green glare: 533 min.





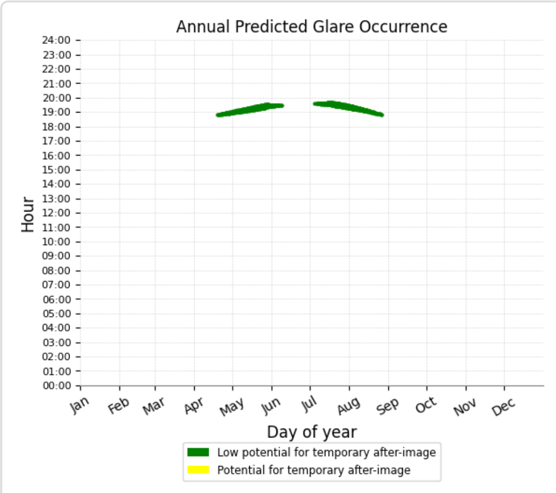


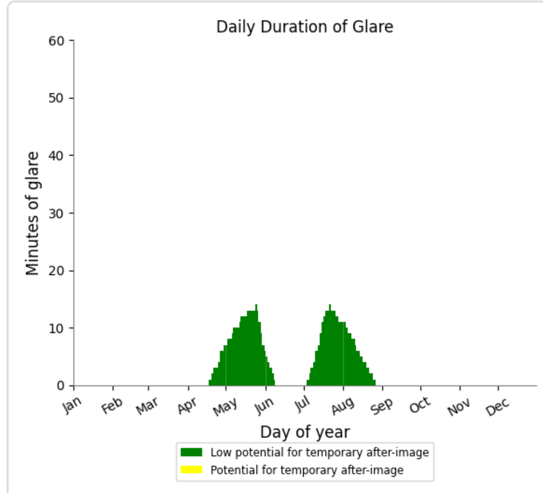


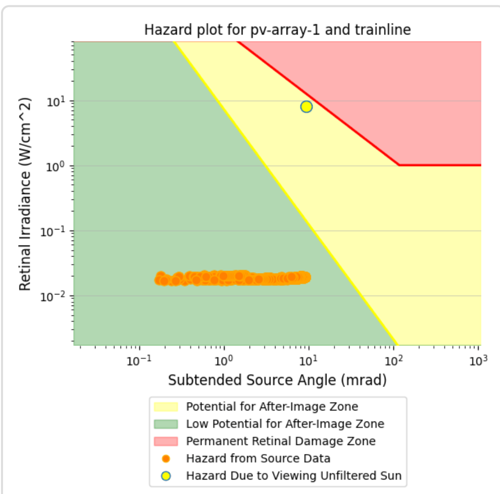


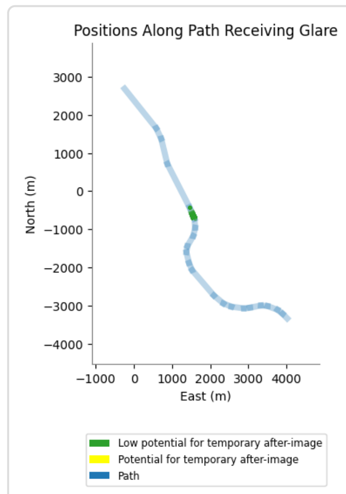
PV array 1 and Route: Trainline

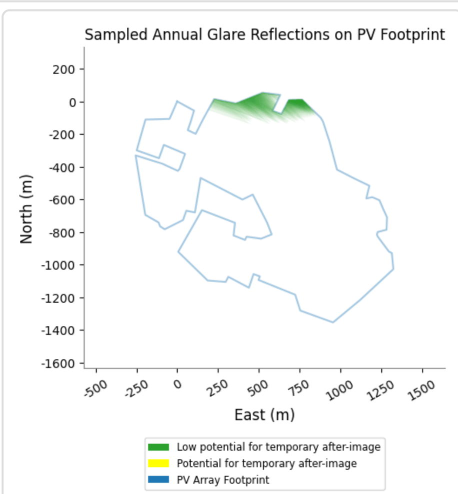
Yellow glare: none
Green glare: 814 min.







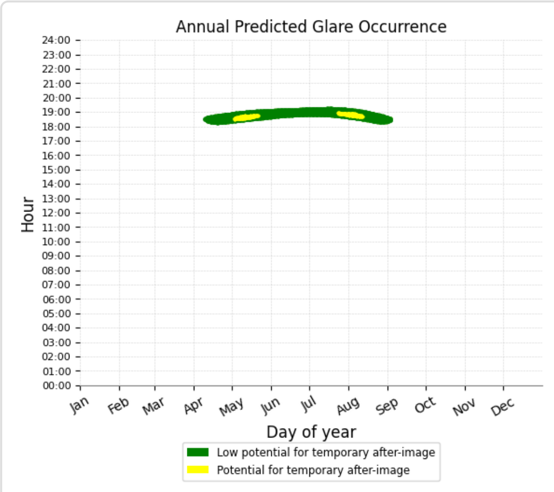


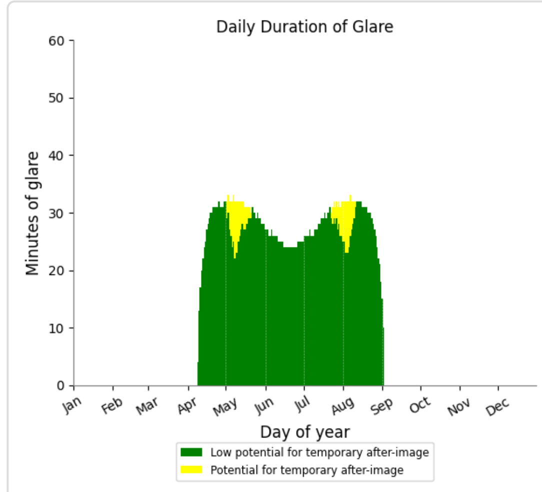


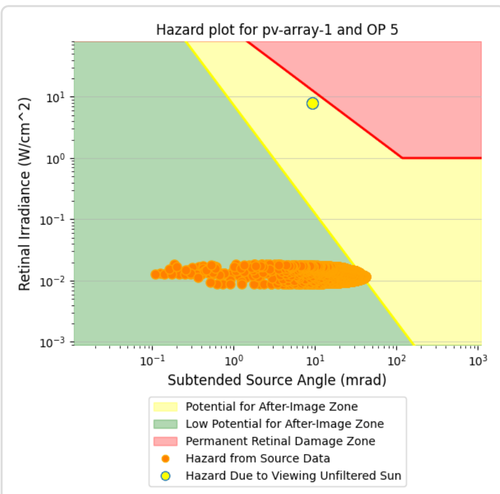
PV array 1 and OP 5

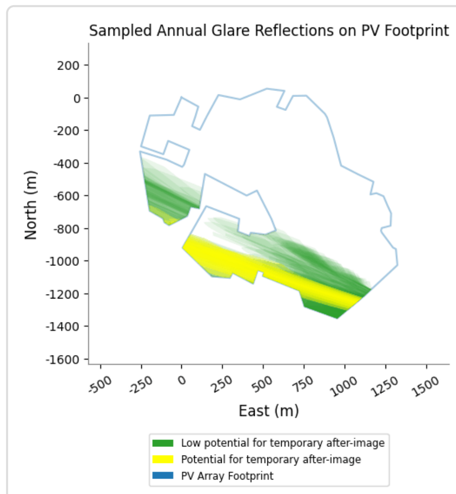
Yellow glare: 204 min.

Green glare: 3,926 min.



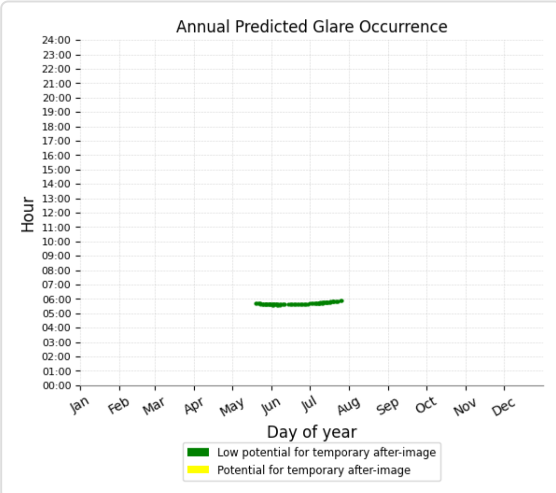


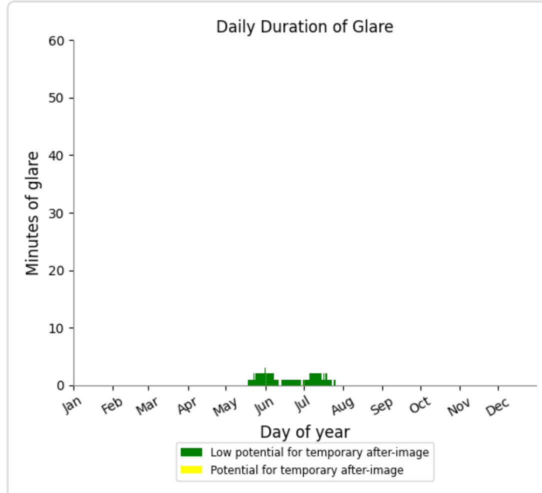


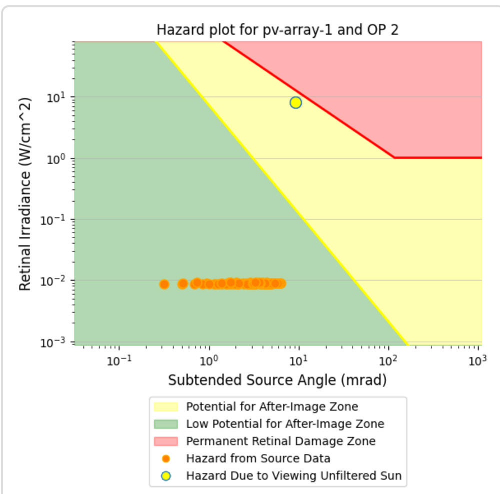


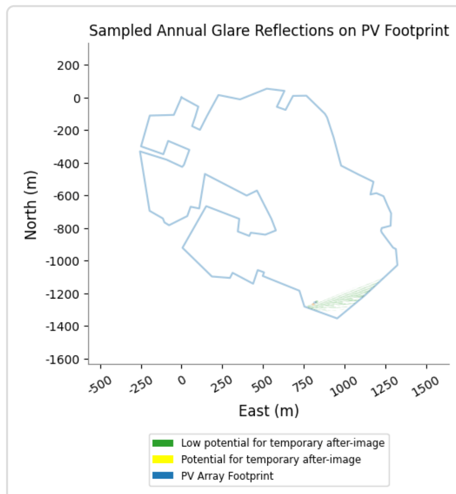
PV array 1 and OP 2

Yellow glare: none
Green glare: 93 min.





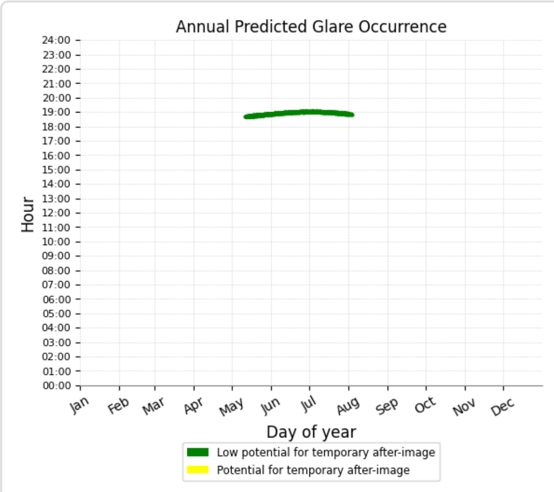


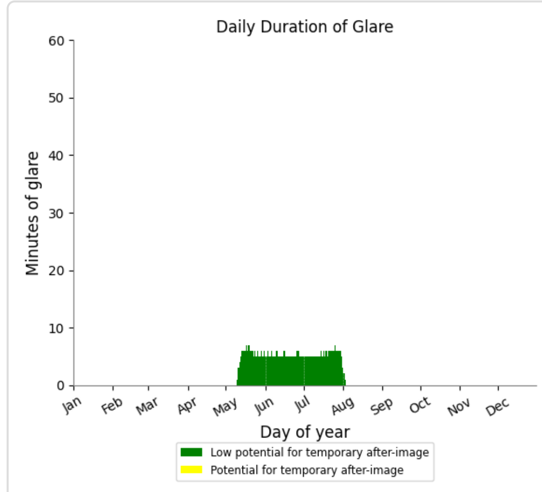


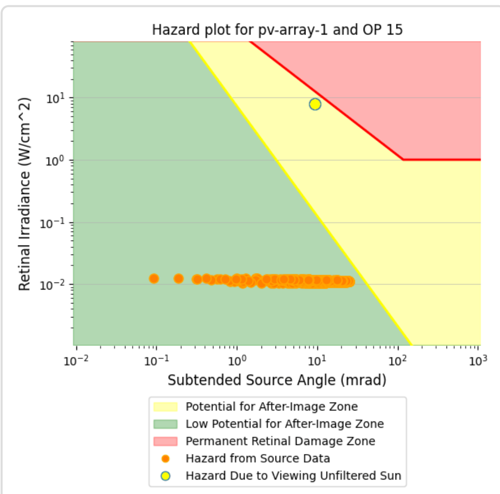
PV array 1 and OP 15

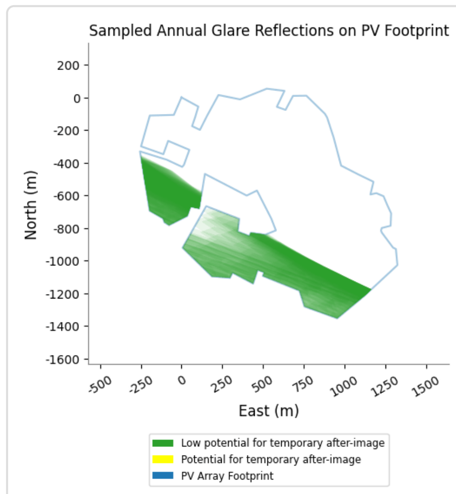
Yellow glare: none

Green glare: 449 min.





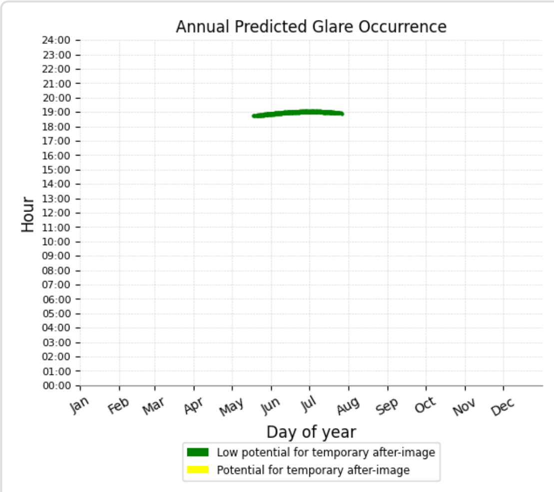


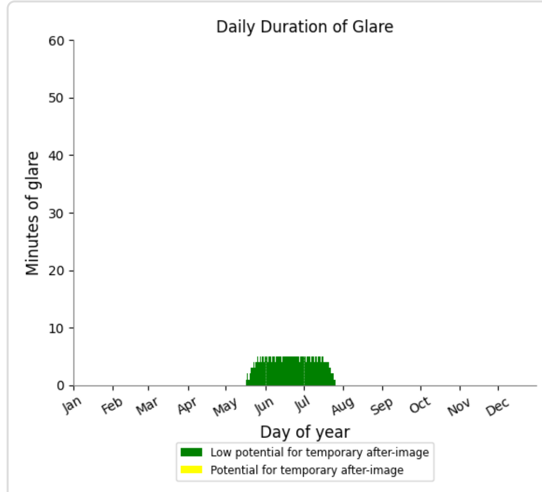


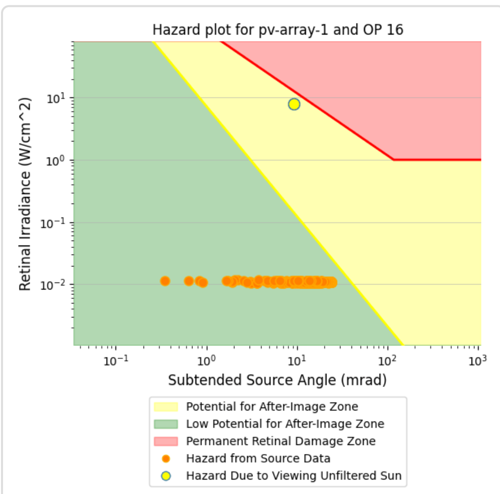
PV array 1 and OP 16

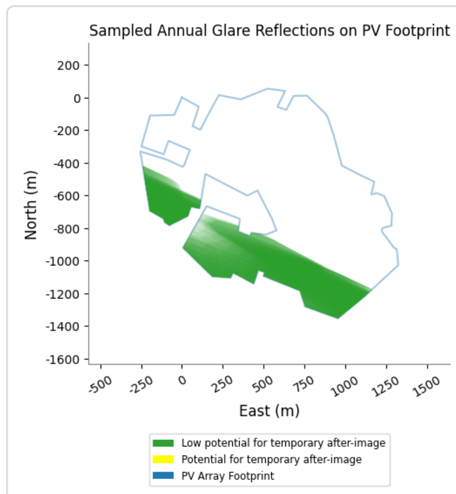
Yellow glare: none

Green glare: 299 min.





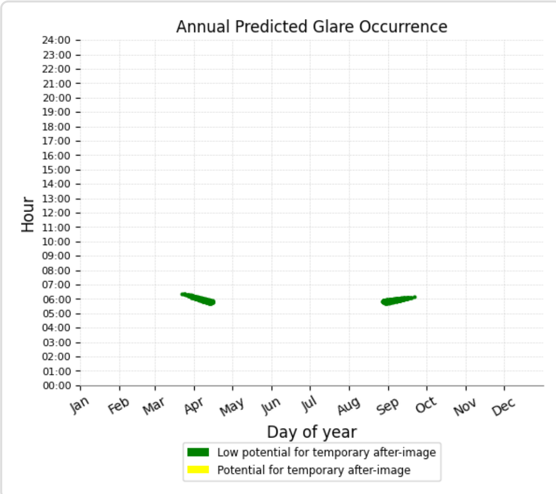


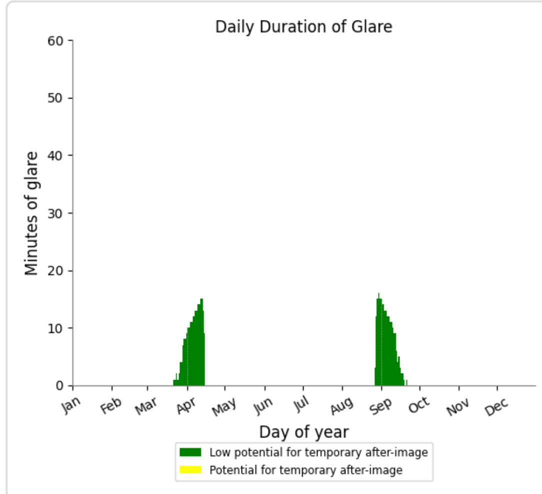


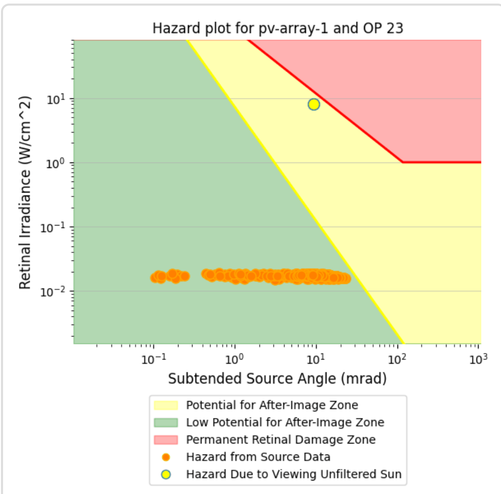
PV array 1 and OP 23

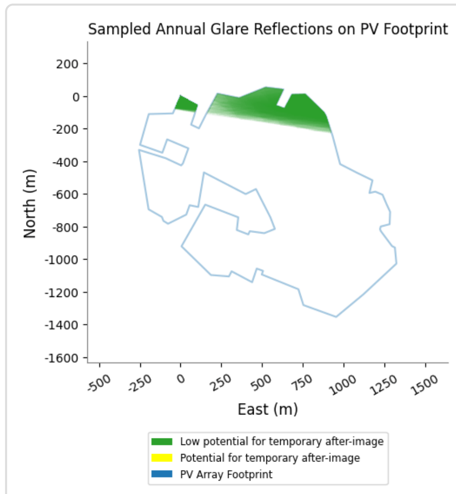
Yellow glare: none

Green glare: 447 min.









PV array 1 and OP 1

No glare found

PV array 1 and OP 3

No glare found

PV array 1 and OP 4

No glare found

PV array 1 and OP 6

No glare found

PV array 1 and OP 7

No glare found

PV array 1 and OP 8

No glare found

PV array 1 and OP 9

No glare found

PV array 1 and OP 10

No glare found

PV array 1 and OP 11

No glare found

PV array 1 and OP 12

No glare found

PV array 1 and OP 13

No glare found

PV array 1 and OP 14

No glare found

PV array 1 and OP 17

No glare found

PV array 1 and OP 18

No glare found

PV array 1 and OP 19

No glare found

PV array 1 and OP 20

No glare found

PV array 1 and OP 21

No glare found

PV array 1 and OP 22

No glare found

PV array 1 and OP 24

No glare found

PV array 1 and OP 25

No glare found

PV array 1 and OP 26

No glare found

PV array 1 and OP 27

No glare found

PV array 1 and OP 28

No glare found

PV array 1 and OP 29

No glare found

PV array 1 and OP 30

No glare found

PV array 1 and OP 31

No glare found

PV array 1 and OP 32

No glare found

PV array 1 and OP 33

No glare found

PV array 1 and OP 34

No glare found

PV array 1 and OP 35

No glare found

PV array 1 and OP 36

No glare found

PV array 1 and OP 37

No glare found

PV array 1 and OP 38

No glare found

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects V1 analyses of path receptors.
Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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