Technical Appendix 15.1: Glint and Glare Report

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Springfield Solar

Glint & Glare Assessment

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Basis of Report

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Appendices

Appendix A ForgeSolar Report

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 located approximately 7.8km south-east of Dunbar and north of Oldhamstocks in East Lothian, Scotland, United Kingdom (herein "the Proposed Development"). The National Grid reference for the site is 374679, 671678 (Easting, Northing).

This G&G study is informed by the design undertaken and information provided by Voltalia UK Ltd (herein "the Client).

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

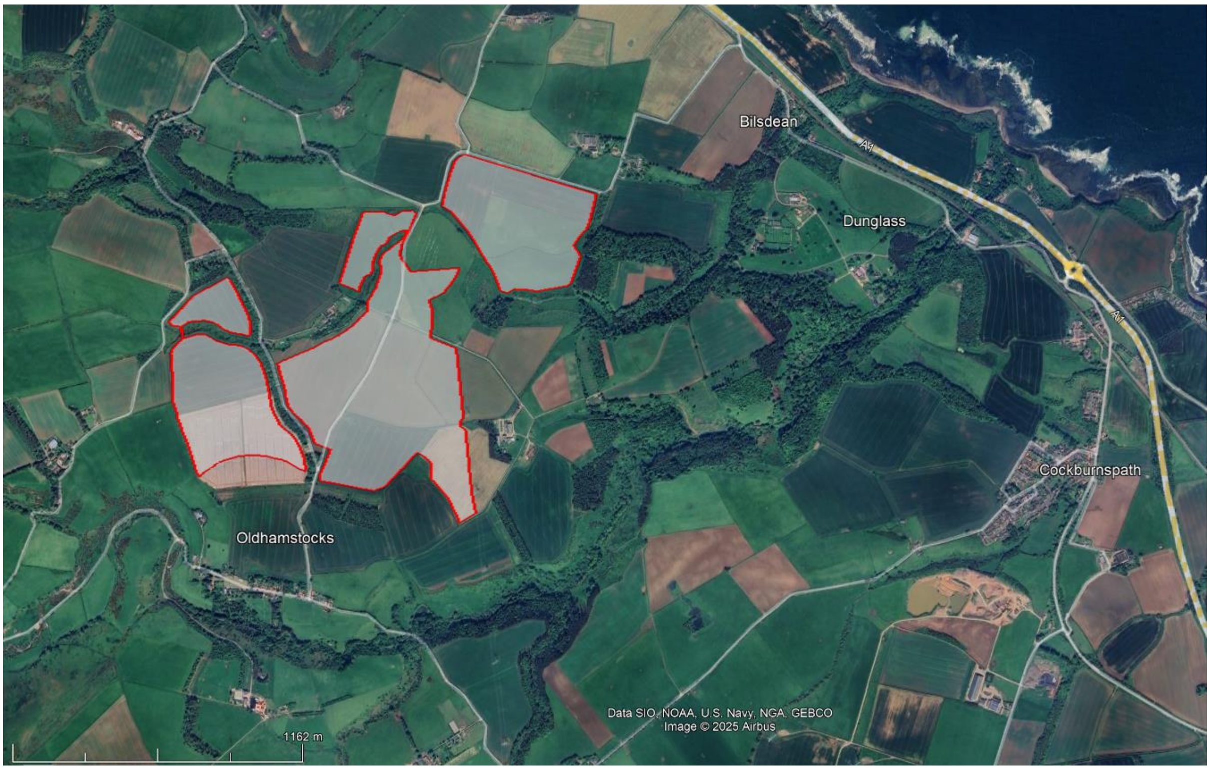

Figure 1-1: Satellite Photography of the Proposed Development and Surroundings

(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°

Parameter	Details
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.

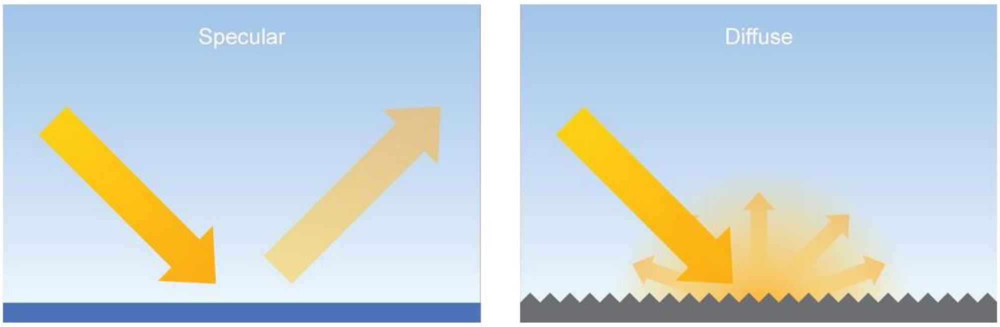

Figure 1-2: Types of Reflection: Specular (left) and Diffused (right)

(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

[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 [Accessed 06/02/2025]

characteristics will also vary with the incidence angle, which changes as the sun moves across the sky.

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.

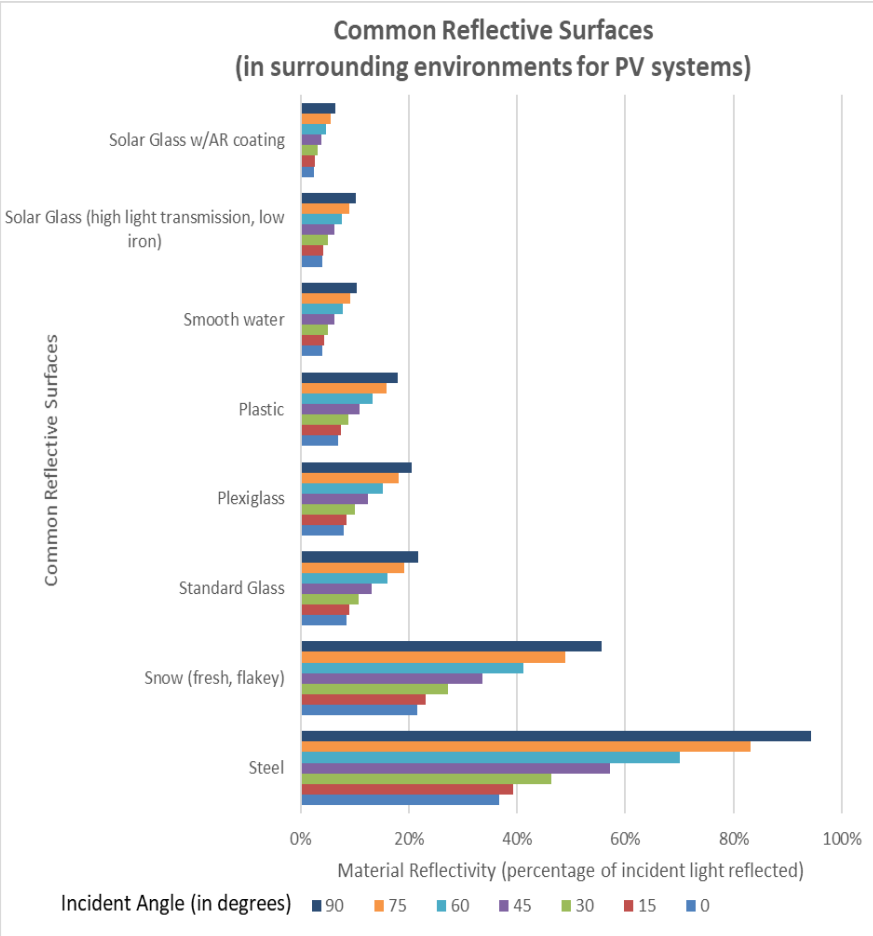

Figure 1-3: Reflectivity of Common Materials at Varying Angles of Incidence

(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 3 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 to the north 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 Development on the railway line's operation.

4.1.2 Roads

There are numerous roads and small country lanes within the study area of the Proposed Development. G&G study has focused on the main road (Great North Road - A1) that is north and in close proximity to the Proposed Development, and two country lanes (Route 1 and Route 2) which run through and are adjacent to the Proposed Development.

Other minor country lanes that bisect the Proposed Development were not included in the visual simulation, as they are very rural in nature and experience low traffic volumes. The assessment has therefore concentrated on the more significant routes with higher usage and a greater likelihood of experiencing visual interaction with the Proposed Development. While these additional lanes have not been simulated, they will be referenced in the discussion of results to ensure a balanced and inclusive evaluation.

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, east and north of the Proposed Development, adjacent to farm.

There is a total of 40 ground-based observation points (OP) which represent the buildings. These are all offsite residential dwellings of single or two storeys. These were chosen to provide broad spatial coverage and to reflect potential variations in visibility and exposure across the study area.

Some properties located in close proximity to the Proposed Development were not included as observation points due to the presence of surrounding vegetation, particularly tree coverage, which significantly restricts views toward the development. Additionally, given the limit of 40 fixed receptors, priority was given to locations with clearer lines of sight and broader representativeness.

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

Three (3) arrays of solar PV panels have 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	165 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	Four routes including one train line, one main road and two country lanes
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	40 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: Appendix _ Forge Solar_Springfield 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	PV Area	Cumulative (when impacted from different PV areas)
Trainline	Green	From 18:00 to 19:00 during first half of April and mid-August to mid-September, up to 9 minutes per day; with no yellow glare	PV array 1	**Green glare:** From 17:30 to 19:30 from mid-March to May, and mid-August to September, up to 19 minutes per day
	Green	From 17:30 to 19:30 from mid-March to mid-May, and August to September, up to 19 minutes per day; with no yellow glare	PV Array 2	
	Green	From 17:30 to 19:00 from mid-March to May and mid-August to September, up to 11 minutes per day; with no yellow glare	PV Array 3	
A1	Green	From 18:00 to 19:00 during first half of April and mid-August to mid-September, up to 9 minutes per day; with no yellow glare	PV Array 1	**Green glare:** From 17:30 to 19:30 from mid-March to September, up to 15 minutes per day
	Green	From 17:30 to 19:30 during second half of March, May, mid-July to mid-August and second half of September, up to 15 minutes per day; with no yellow glare	PV Array 2	
	Green	From 17:30 to 18:30 during second half of March and second half of September, up to 5 minutes per day; with no yellow glare	PV Array 3	
Route 1	Yellow	From 05:00 to 16:30 from January to December, up to 520 mins per day; with 105 minutes of green glare on average per day during the whole year	PV Array 1	**Yellow glare:** From 04:30 to 18:30 from January to December, up to 520 mins per day
	Yellow	From 04:30 to 18:30 from January to December, up to 500 mins per day; with 318 minutes of green glare on average per day from mid-January to November	PV Array 2	
	Green	From 19:00 to 20:00 from May to mid-August, up to 25 minutes per day; with no yellow glare	PV Array 3	
Route 2	Green	From 05:00 to 07:00 from mid-March to mid-September, up to 29 minutes per day; with no yellow glare	PV Array 1	**Yellow glare:** From 04:30 to 08:00 from March to mid-October, up to 120 mins per day
	Yellow	From 04:30 to 07:30 from March to mid-October, up to 50 mins per day; with 13 minutes of green glare on average per day from March to mid-October	PV Array 2	
	Yellow	From 04:30 to 08:00 from mid-March to September, up to 120 mins per day; with 23 minutes of green glare on average per day from April to September, during first half of January and December	PV Array 3	
OP1	Green	From 04:30 to 06:00 from mid-May to July, up to 35 mins per day; with no yellow glare	PV Array 2	N/A
OP6	Yellow	From 18:00 to 19:30 from April to mid-September, up to 20 minutes per day; with 4 minutes of green glare on average per day from April to mid-September	PV Array 2	**Yellow glare:** From 18:00 to 19:30 from April to mid-

Receptor	G&G hazard summary	Time/maximum duration of daily G&G	PV Area	Cumulative (when impacted from different PV areas)
	Green	From 18:00 to 19:00 during April and mid-August to mid-September, up to 10 minutes per day; with no yellow glare	PV Array 3	September, up to 20 minutes per day
OP13	Green	From 04:30 to 05:30 from mid-May to July, up to 31 mins per day; with no yellow glare	PV Array 2	N/A
OP14	Green	From 05:00 to 06:00 from May to mid-August, up to 27 mins per day; with no yellow glare	PV Array 1	**Yellow glare:** From 05:00 to 07:00 from April to mid-September, up to 30 mins per day
	Yellow	From 05:00 to 07:00 from April to mid-September, up to 18 mins per day; with 7 minutes of green glare on average per day from mid-March to September	PV Array 2	
	Yellow	From 05:00 to 07:00 from April to mid-September, up to 30 mins per day; with 8 minutes of green glare on average per day from mid-March to September	PV Array 3	
OP15	Green	From 05:00 to 06:00 from May to mid-August, up to 27 mins per day; with no yellow glare	PV Array 1	**Yellow glare:** From 05:00 to 07:00 from mid-March to mid-September, up to 25 mins per day
	Yellow	From 05:00 to 07:00 from mid-March to May and mid-July to mid-September, up to 18 mins per day; with 9 minutes of green glare on average per day from March to September	PV Array 2	
	Yellow	From 05:00 to 07:00 from mid-March to mid-September, up to 25 mins per day; with 5 minutes of green glare on average per day from mid-March to September	PV Array 3	
OP16	Green	From 05:00 to 06:30 from May to mid-August, up to 27 mins per day; with no yellow glare	PV Array 1	**Yellow glare:** From 05:00 to 07:00 from March to September, up to 18 mins per day
	Yellow	From 05:00 to 07:00 from mid-March to May and mid-July to mid-September, up to 18 mins per day; with 9 minutes of green glare on average per day from March to September	PV Array 2	
	Yellow	From 05:00 to 07:00 from March to September, up to 14 mins per day; with 8 minutes of green glare on average per day from March to September	PV Array 3	
OP17	Green	From 06:30 to 07:30 during first half of March and mid-September to mid-October, up to 10 mins per day; with no yellow glare	PV Array 1	N/A
OP23	Green	From 18:00 to 19:00 during first half of April and mid-August to mid-September, up to 5 mins per day; with no yellow glare	PV Array 1	N/A
OP24	Green	From 18:00 to 19:00 during first half of April and mid-August to mid-September, up to 5 mins per day; with no yellow glare	PV Array 1	N/A
OP25	Green	From 18:00 to 19:00 during first half of April and mid-August to mid-September, up to 5 mins per day; with no yellow glare	PV Array 1	N/A

Receptor	G&G hazard summary	Time/maximum duration of daily G&G	PV Area	Cumulative (when impacted from different PV areas)
OP29	Green	From 18:00 to 19:30 from April to mid-September, up to 5 mins per day; with no yellow glare	PV Array 2	**Green glare:** From 18:00 to 19:30 from April to mid-September, up to 5 mins per day
	Green	From 18:00 to 19:00 from April to mid-May and August to mid-September, up to 5 mins per day; with no yellow glare	PV Array 3	
OP30	Green	From 18:00 to 19:30 from April to mid-September, up to 11 mins per day; with no yellow glare	PV Array 2	**Green glare:** From 18:00 to 19:30 from April to mid-September, up to 11 mins per day
	Green	From 18:00 to 19:00 during April and August to mid-September, up to 4 mins per day; with no yellow glare	PV Array 3	
OP31	Green	From 18:00 to 19:30 from April to mid-May and August to mid-September, up to 19 mins per day; with no yellow glare	PV Array 2	**Green glare:** From 18:00 to 19:30 from April to mid-May and August to mid-September, up to 19 mins per day
	Green	From 18:00 to 19:00 during April and mid-August to mid-September, up to 2 mins per day; with no yellow glare	PV Array 3	
OP32	Green	From 18:00 to 19:00 during April and mid-August to mid-September, up to 19 mins per day; with no yellow glare	PV Array 2	**Green glare:** From 18:00 to 19:00 during April and mid-August to mid-September, up to 19 mins per day
	Green	From 18:00 to 19:00 during April and mid-August to mid-September, up to 4 mins per day; with no yellow glare	PV Array 3	
OP33	Green	From 18:00 to 19:00 from April to mid-May and August to mid-September, up to 15 mins per day; with no yellow glare	PV Array 2	**Green glare:** From 18:00 to 19:00 from April to mid-May and August to mid-September, up to 15 mins per day
	Green	From 18:00 to 19:00 from April to mid-May and August to mid-September, up to 10 mins per day; with no yellow glare	PV Array 3	
OP34	Green	From 05:00 to 06:00 from mid-May to mid-July, up to 23 mins per day; with no yellow glare	PV Array 1	N/A
OP35	Green	From 18:00 to 19:30 from April to mid-September, up to 7 mins per day; with no yellow glare	PV Array 2	**Green glare:** From 18:00 to 19:30 from April to mid-September, up to 7 mins per day
	Green	From 18:00 to 19:00 from April to mid-May and August to mid-September, up to 5 mins per day; with no yellow glare	PV Array 3	
OP37	Green	From 05:00 to 06:00 from mid-May to July, up to 22 mins per day; with no yellow glare	PV Array 1	**Yellow glare:** From 04:30 to 06:30 from April to mid-September, up to 40 mins per day
	Yellow	From 05:00 to 06:30 from April to mid-September, up to 25 mins per day; with 6 minutes of green glare on average per day from mid-March to mid-September	PV Array 2	
	Yellow	From 04:30 to 06:30 from May to mid-August, up to 40 mins per day; with 17 minutes of green glare on average per day from April to mid-September	PV Array 3	

5.4 Discussion and implication of results

5.4.1 Routes

The G&G Assessment evaluated four routes: one train line, one main road (A1) and two country lanes. Although some minor rural lanes within the Proposed Development were not included in the simulation due to their low traffic levels and presence of existing screening in some sections, they will be considered in the results discussion to provide a more complete assessment. Existing screening measures, such as trees, hedgerows, have been incorporated into the simulation as detailed in Figure 5-1. Note that planned screening measures have not been included in the modelling. However, these have been considered for the results discussions.

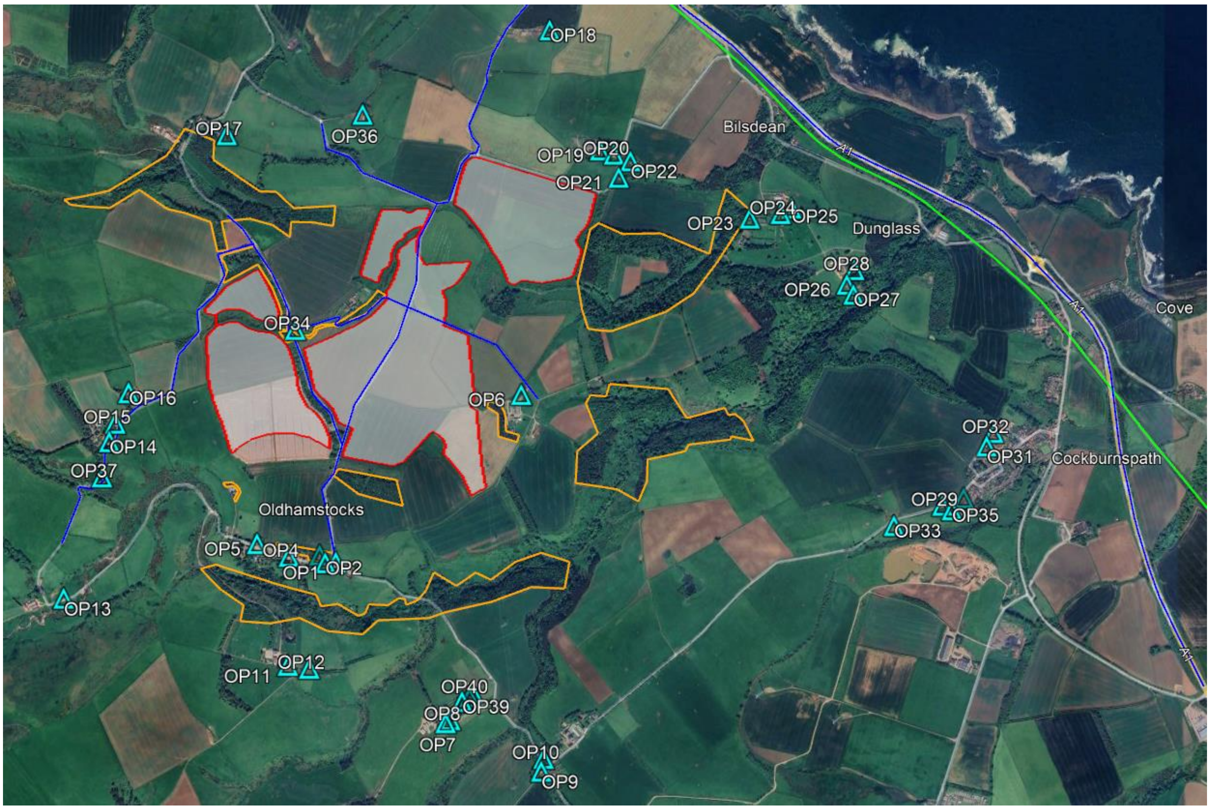


Figure 5-1: Existing screening (orange) along the route and fixed receptors

(Source: Google Earth Pro, 2025)

5.4.1.1 Route 1

As shown in Table 5-4, Route 1 is affected by both yellow and green glare. Yellow glare is observed from PV Arrays 1 and 2, while only green glare is associated with PV Array 3.

Simulation results indicate that yellow glare may occur throughout the year, primarily between 04:30 and 18:30, with a maximum of up to 520 minutes per day. The total annual duration of yellow glare along Route 1 is approximately 115,199 minutes (or 1,920 hours).

In comparison, green glare occurs less frequently, with a total of 165,152 minutes annually (equivalent to 2,753 hours), and is distributed across all three arrays. See Figure 5-2 for more details.

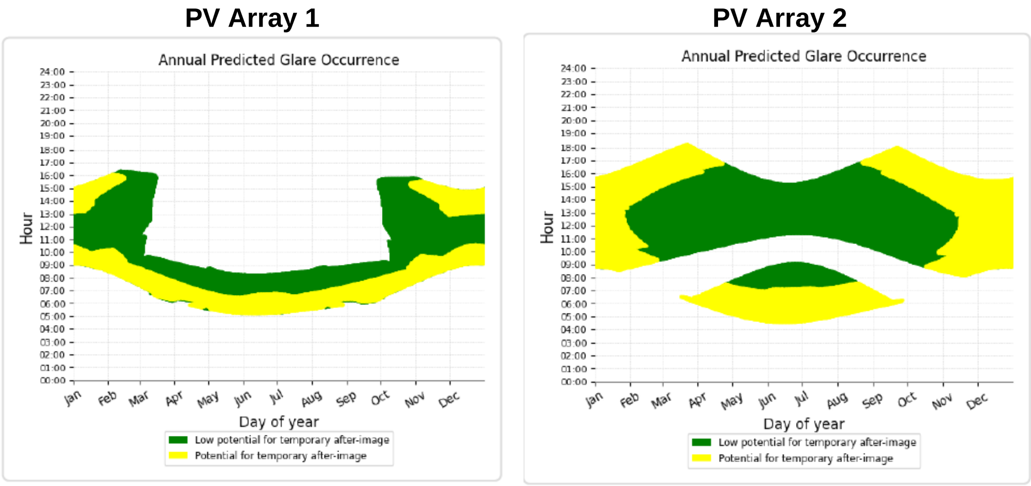


Figure 5-2: Annual Predicted Glare Occurrence at Route 1 from PV Arrays

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

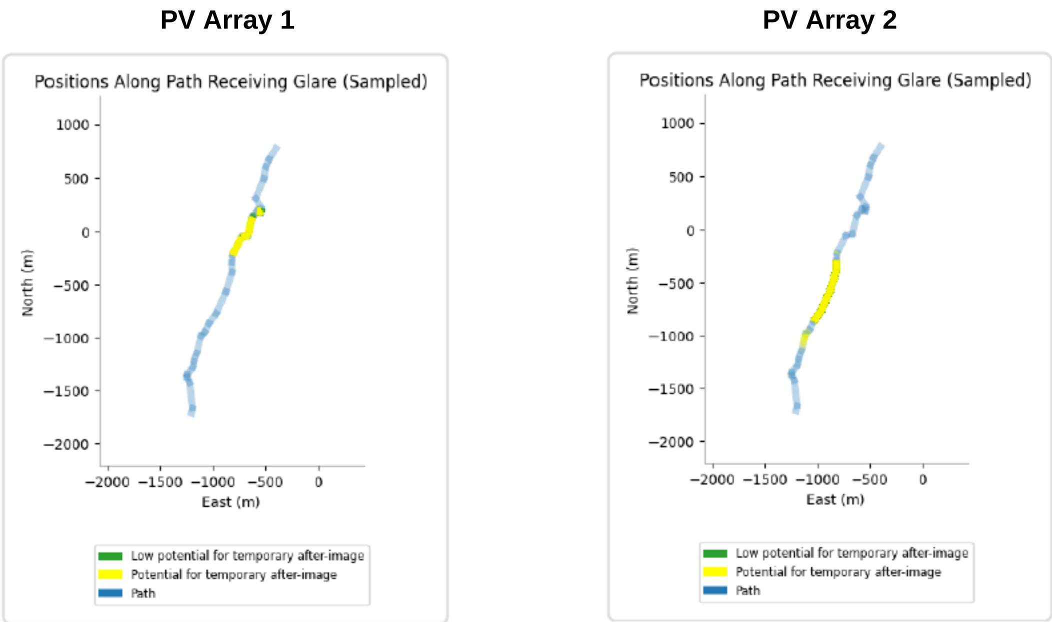


Figure 5-3: Positions Along Route 1 Receiving Glare from PV Arrays

PV Array 1 **PV Array 2**

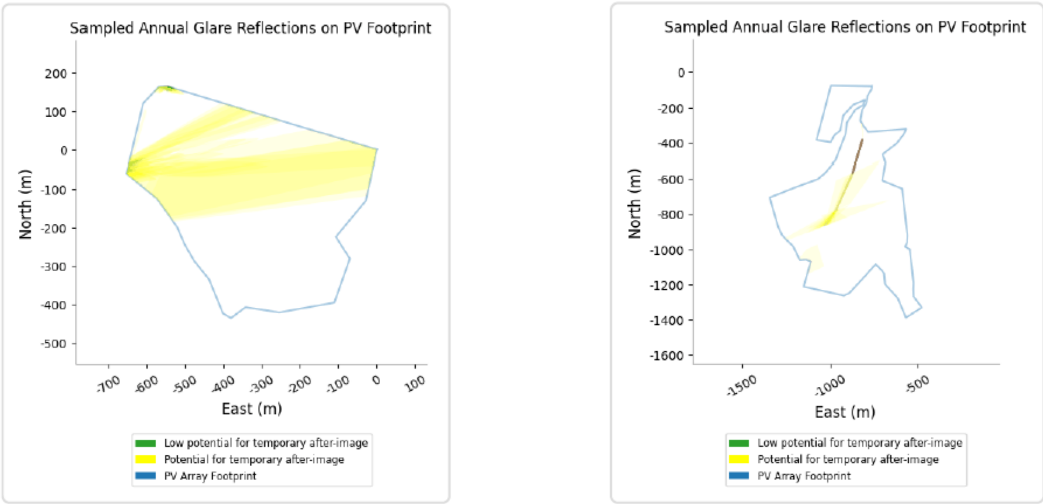


Figure 5-4: Area of PV Arrays where the glare emanates from

Due to Route 1 running in close proximity to PV Arrays 1 and 2, the visual effects of yellow glare are more pronounced, especially during times of high solar intensity. Unlike fixed receptors, where glare can persist in a specific direction, road users experience glare as short, intermittent flashes as they move along the affected segments.

Some existing hedgerows along Route 1 provide partial screening; however, gaps in the vegetation allow glare to be visible in certain sections. The proposed Landscape Management Plan has taken potential G&G effects along Route 1 into account and includes the planting of native hedgerows, as well as the management and enhancement of existing ones to increase their height around all PV areas. It also proposes the addition of a woodland block, as illustrated in Figure 5-5 below.

While the hedgerows are being established and growing to the desired height, it would be possible to install temporary shade netting along the Proposed Development's fence line. This is an inexpensive and effective interim measure to ensure potential G&G effects are reduced or eliminated once the Proposed Development becomes operational. Further details about this mitigation measure are provided in Section 6.0.

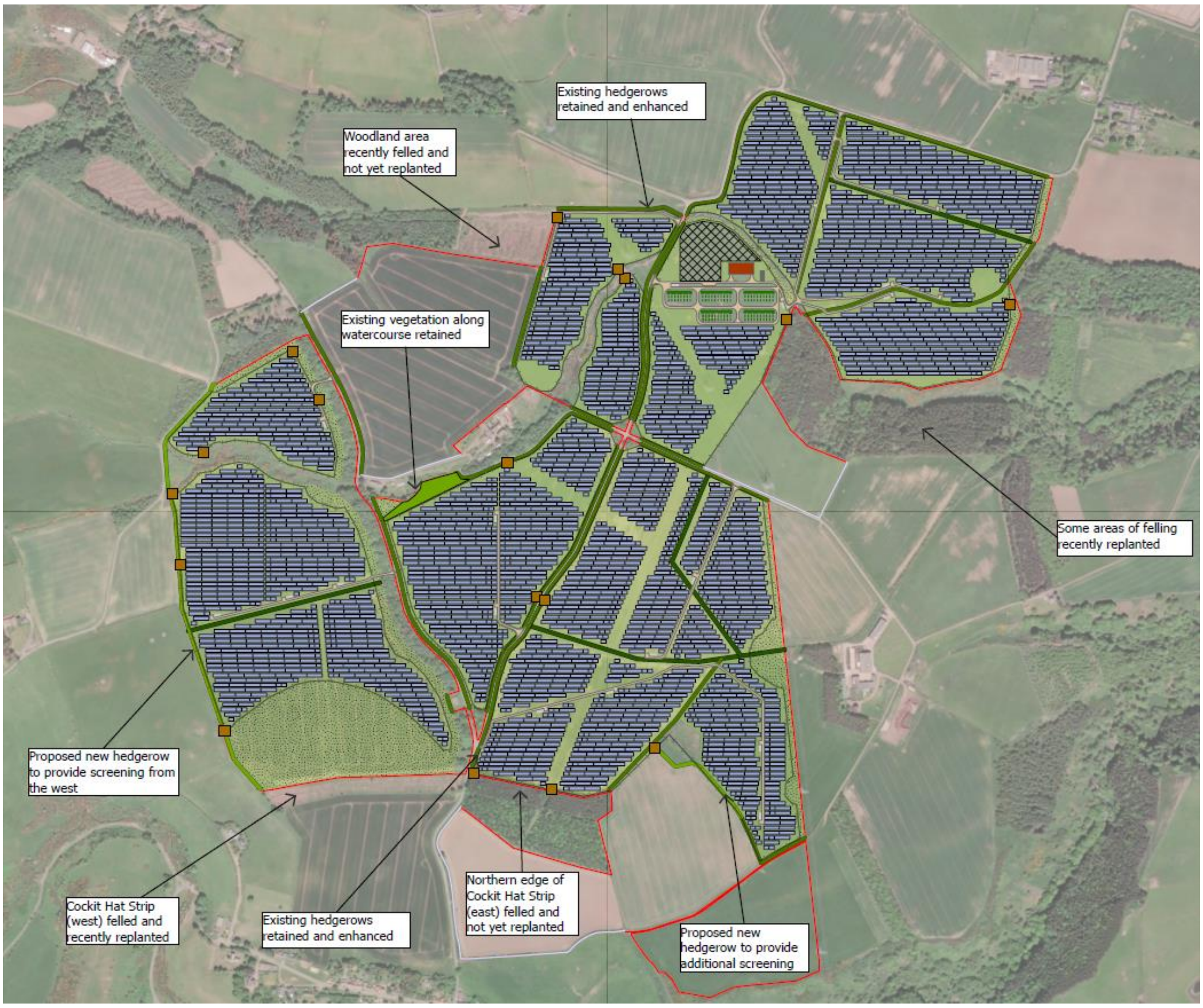


Figure 5-5: Proposed Landscape Management Plan

These measures are expected to significantly reduce the visibility of glare from the road. Although the modelling shows a notable duration of yellow glare, Route 1 is a low-traffic rural road, primarily used by local residents and agricultural vehicles. This context, combined with the proposed screening measures, suggests that the real-world impact is likely to be minimal.

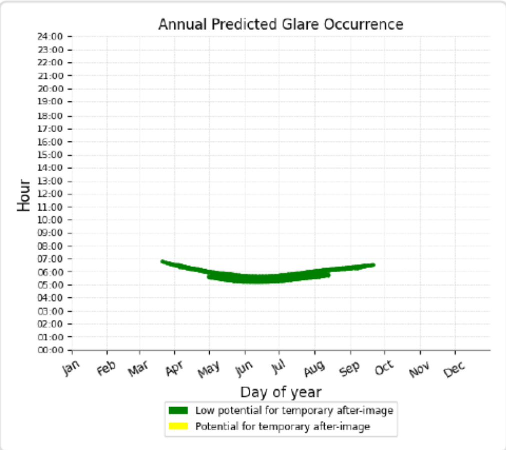
If the recommended mitigation is implemented in full, the overall impact of glare along Route 1 is expected to be reduced to a **negligible or minor level**.

5.4.1.2 Route 2

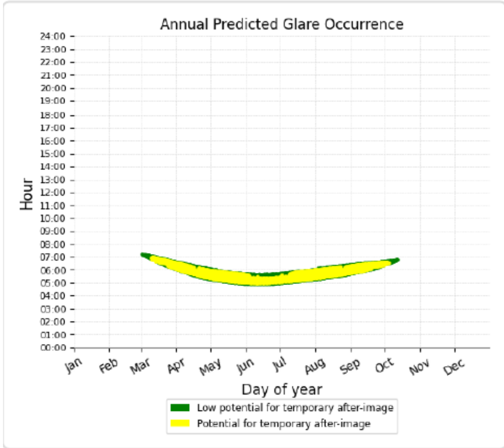
As shown in Table 5-4, Route 2 is predominantly affected by yellow glare from PV arrays 2 & 3, whereas only green glare occurs from PV array 1.

Simulation results show that yellow glare on Route 2 occurs as a cumulative effect from PV Arrays 2 and 3. It is concentrated in the early morning hours (04:30 to 08:00) and is observed between March and mid-October. The maximum daily duration of yellow glare is up to 120 minutes, with a total annual duration of approximately 22,694 minutes (or 378.2 hours). In comparison, green glare from all three arrays is relatively limited, totalling 10,564 minutes annually (or 176 hours). More detailed information on the predicted annual glare exposure is presented in Figure 5-6.

PV Array 1



PV Array 2



PV Array 3

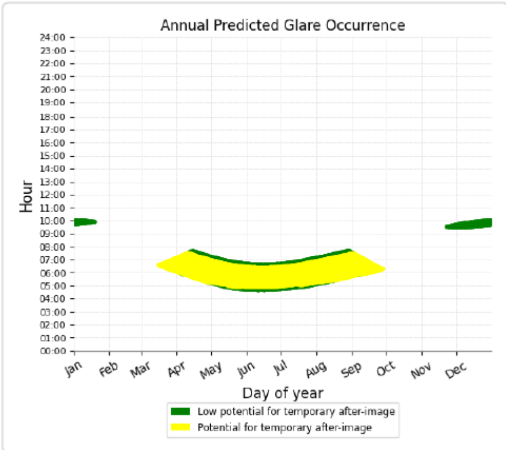


Figure 5-6: Annual Predicted Glare Occurrence at Route 2 from PV Arrays

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

PV Array 1 **PV Array 2** **PV Array 3**

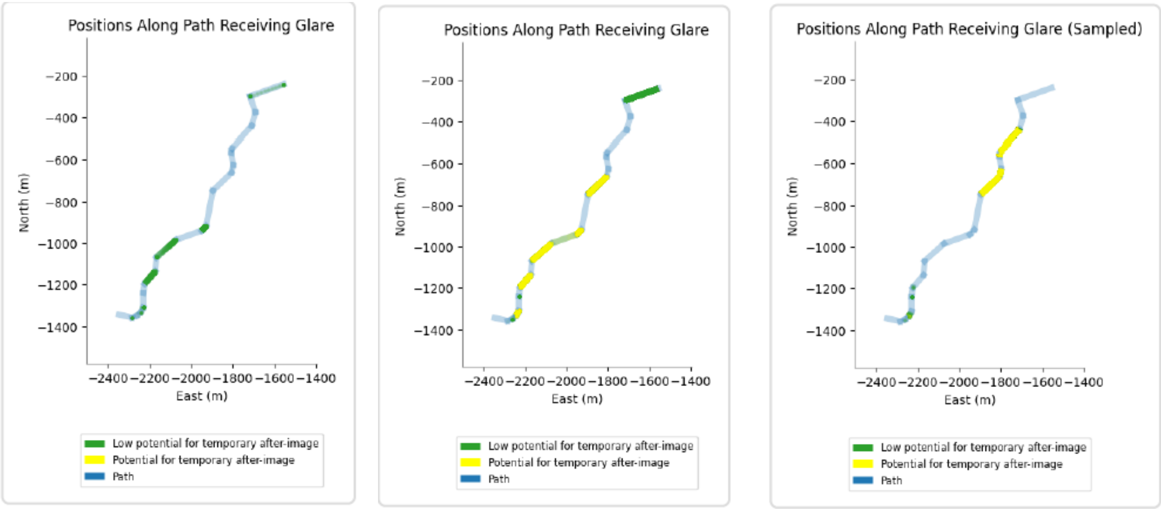
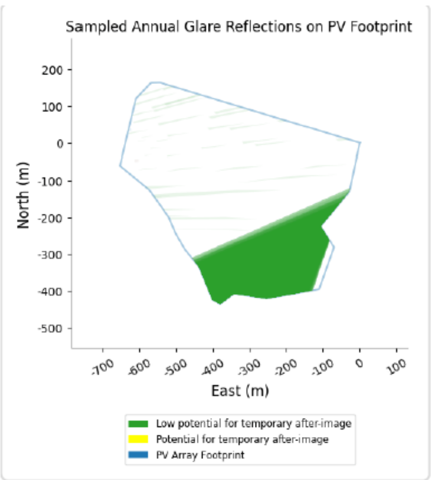
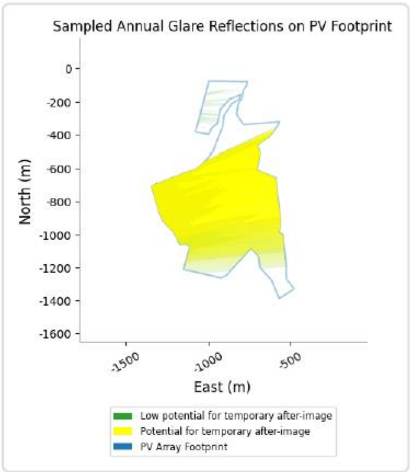


Figure 5-7: Positions Along Route 2 Receiving Glare from PV Arrays

PV Array 1



PV Array 2



PV Array 3

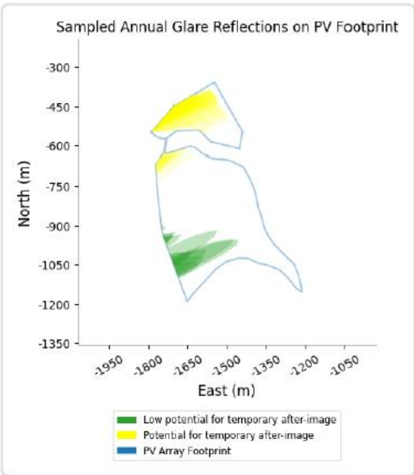


Figure 5-8: Area of PV Arrays where the glare emanates from

The simulation accounts for existing screening features, such as hedgerows, scrub planting, trees, and other obstructions where applicable, to provide a realistic assessment of G&G effects. Similar to Route 1, the proposed Landscape Management Plan addresses potential G&G impacts along Route 2 by including the planting of native hedgerows and the enhancement of existing ones to increase their height around all PV areas. The Plan also includes a new woodland block, as shown in Figure 5-5.

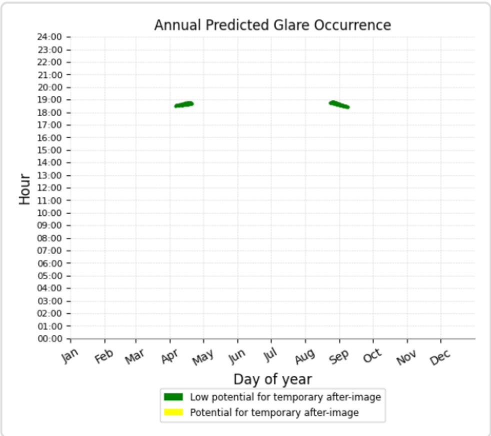
To mitigate effects during the establishment period of the planting, temporary shade netting could be installed along the Proposed Development's fence line. This low-cost, short-term measure would help reduce or eliminate G&G impacts from the outset of operation. Additional information on this mitigation is provided in Section 6.0.

If the recommended screening measures are fully implemented, the visual impact of glare along Route 2 is expected to be significantly reduced and could be brought down to a **minimal** level.

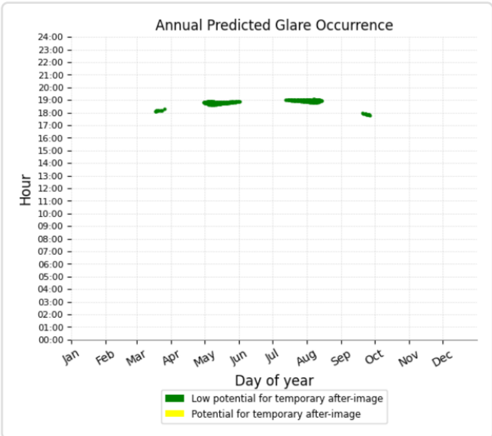
5.4.1.3 Main road – A1

The main road A1 is predominantly affected by green glare, with no potential for yellow glare, as shown in Table 5-4. The simulation indicates that green glare may occur in the early evening (17:30 to 19:30) for up to 15 minutes per day from mid-March to September, as a cumulative effect from all three PV arrays. A total of 705 minutes (11.8 hours) over the whole year. See Figure 5-9 for more details.

PV Array 1



PV Array 2



PV Array 3

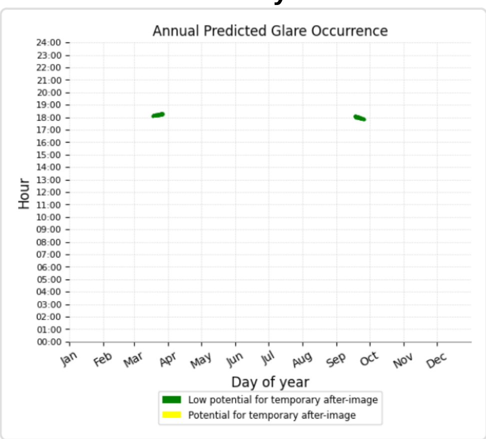
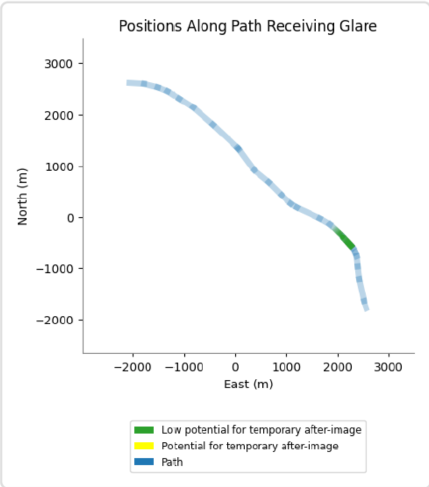


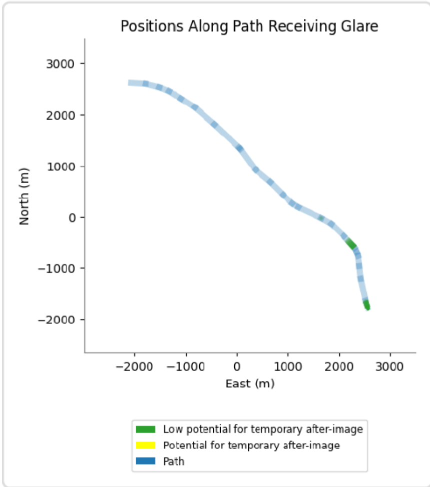
Figure 5-9: Annual Predicted Glare Occurrence at the A1 from PV Arrays

Figure 5-10 and Figure 5-11 illustrate where the G&G emanates from, and which part of the route is affected.

PV Array 1



PV Array 2



PV Array 3

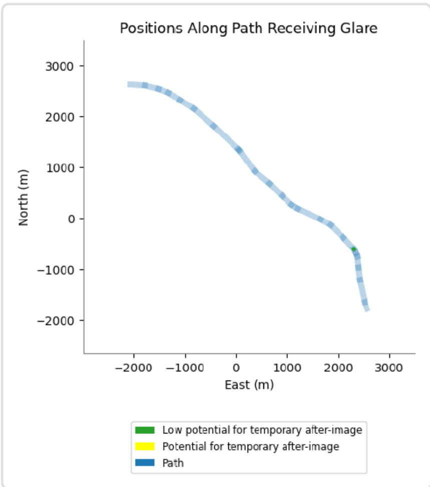
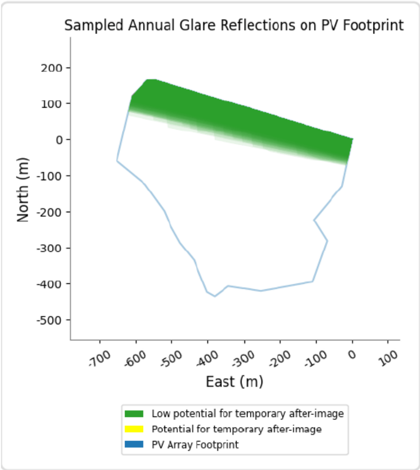
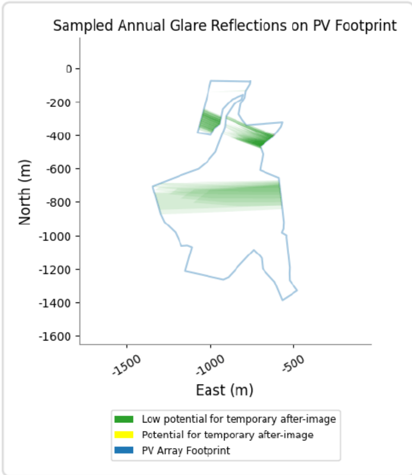


Figure 5-10: Positions Along the A1 Receiving Glare from PV Arrays

PV Array 1



PV Array 2



PV Array 3

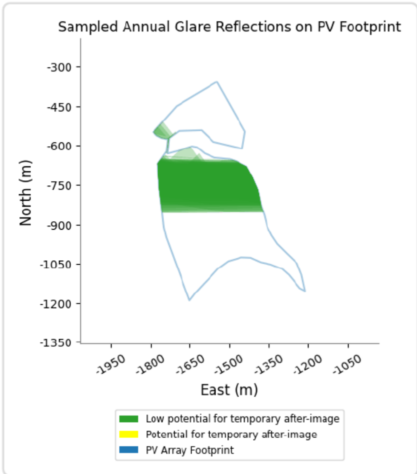


Figure 5-11: Area of PV Arrays where the glare emanates from

In addition to the existing screenings included in the simulation, there are several existing screenings, such as trees, hedgerows, buildings as shown above in Figure 5-15 that would partially obstruct the glare on A1 under real-life conditions. However, this obstruction could not be included in the assessment due to software limitations.

In conclusion, the combination of short exposure durations of low intensity glare, no occurrence of yellow glare, transient nature of vehicle movement and existing mitigation measures means that the potential G&G impact on A1 is **negligible** and unlikely to pose a risk to health or safety.

5.4.1.4 Other Rural Lanes

In addition to the assessed routes, there are several minor rural lanes within the study area, some of which bisect or pass close to the PV areas. These lanes were not included in the simulation due to their low traffic volumes.

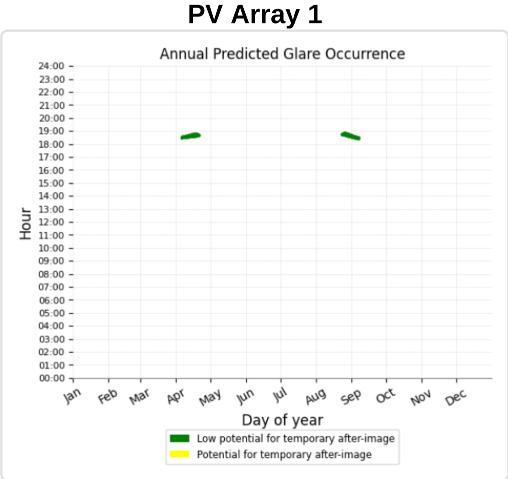
However, their potential for G&G effects has been considered qualitatively. Given the rural character of these lanes and the infrequent use by vehicles, the potential for significant visual impact is considered low. Moreover, the proposed Landscape Management Plan, which includes planting native hedgerows, enhancing existing ones to increase their height, and introducing a woodland block, will further reduce the potential for G&G along these routes.

During the establishment period of the planting, temporary shade netting along the perimeter fencing of the Proposed Development can be deployed as an interim measure. This will help ensure that any residual G&G effects along these minor routes are minimised or eliminated from the outset of operation. Overall, the combination of low traffic levels and proposed mitigation measures supports the conclusion that visual impacts on these rural lanes are likely to be **minimal**.

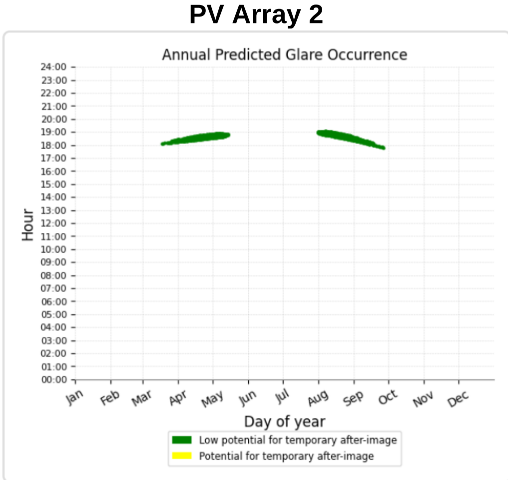
5.4.1.5 Train line

As shown in Table 5-4, the trainline is predominantly affected by green glare from all three PV arrays, with the potential for no yellow glare. The simulation indicates that the green glare may occur in the early evening (17:30 to 19:30) for up to 19 minutes per day between mid-March to May, and mid-August to September, as a cumulative effect from all three PV arrays. A total of 2,064 minutes (34.4 hours) of green glare over the whole year. See Figure 5-12 for more details.

PV Array 1



PV Array 2



PV Array 3

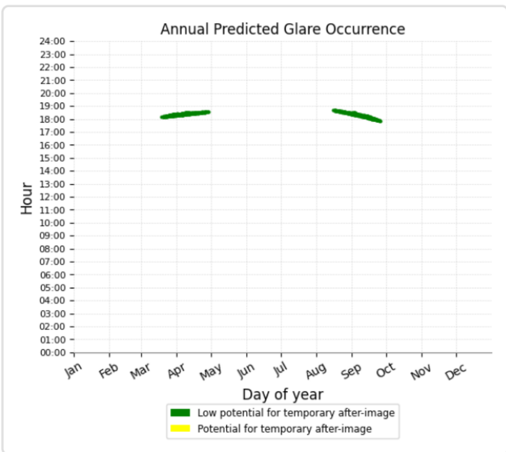
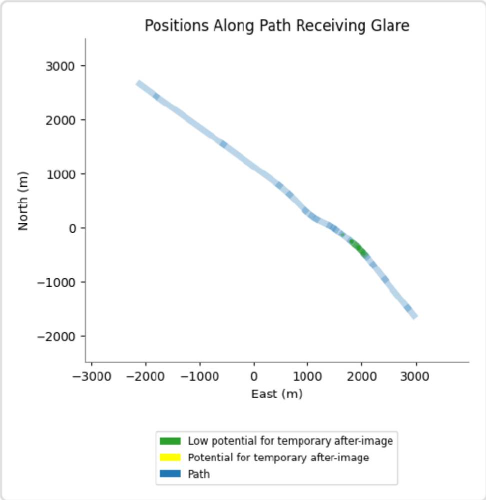


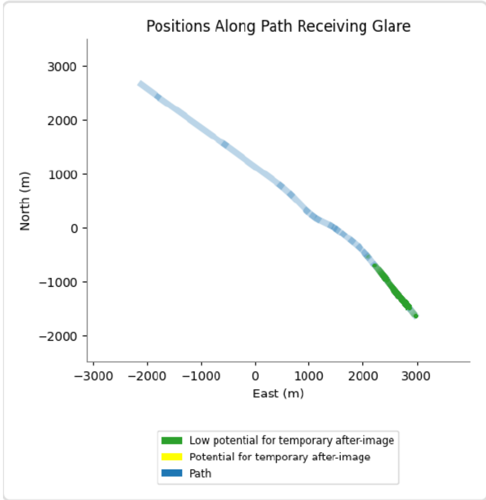
Figure 5-12: Annual Predicted Glare Occurrence at the Trainline from PV Arrays

Figure 5-13 and Figure 5-14 illustrate where the G&G emanates from, and which part of the route is affected by it.

PV Array 1



PV Array 2



PV Array 3

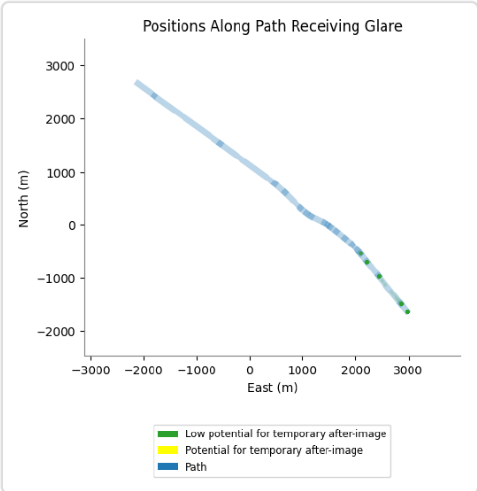
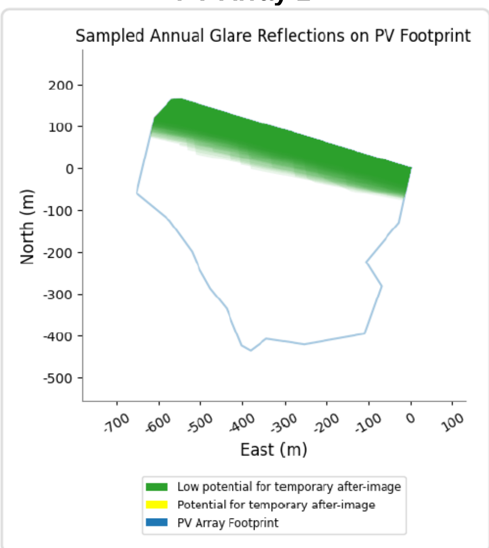
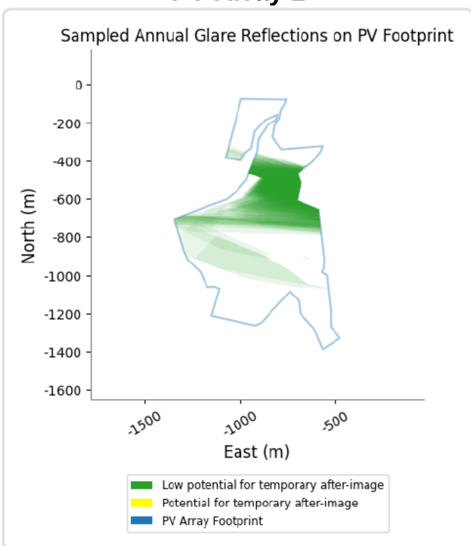


Figure 5-13: Positions Along the Trainline Receiving Glare from PV Arrays

PV Array 1



PV Array 2



PV Array 3

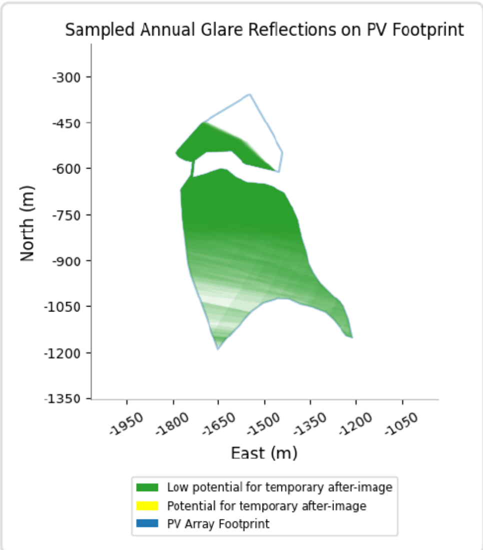


Figure 5-14: Area of PV Arrays where the glare emanates from

While existing hedgerows and trees have been included in the simulation to a limit of 10 screenings, additionally, there are other existing screenings such as trees, hedgerows and buildings as shown in the white polygon in Figure 5-15 that would partially obstruct the glare under real-life conditions. However, these obstructions could not be included in the assessment due to software limitations.

Figure 5-15: Existing screenings (white) along the trainline but not included in the simulation

(Source: Google Earth Pro)

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.

Given the short duration of low intensity glare, no occurrence of yellow glare, transient nature of G&G effects as train approach or move away from the PV arrays, combined with the mitigating effect of hedgerows, trees and buildings and large distance of impact point from the solar farm, the overall impact is assessed to be **minimal to none** and is unlikely to pose a risk to health or safety.

5.4.2 Fixed Ground Receptors

Out of the 40 fixed ground receptors, or Observation Points (OPs), included in the modelling, 18 of them are impacted by G&G as indicated in Table 5-4.

- Observation points OP6, OP14, OP15, OP16, and OP37 is predominately affected by yellow glare from March to September in the early evening (for OP6) due to the sun's angle moving from west and causing reflections eastward and in the early morning hours (OP14, OP15, OP16, and OP37) due to the sun's angle moving from east and causing reflections westward.
- The remaining thirteen observation points (OP1, OP13, OP17, OP23, OP24, OP25, OP29, OP30, OP31, OP32, OP33, OP34, and OP35) are predominately affected by

green glare with no yellow glare. Observation points OP1, OP13, OP17, OP34 experience green glare in the early morning hours between March and Mid-October. Whereas OP23, OP24, OP25, OP29, OP30, OP31, OP32, OP33, and OP35 experience glare in the early evening hours between April and Mid-September.

- Some receptors located closer to the PV areas have not been included in the modelling due to being surrounded by vegetation. These locations have limited or no visibility of the PV panels, and therefore the potential for glare is expected to be minimal to none.

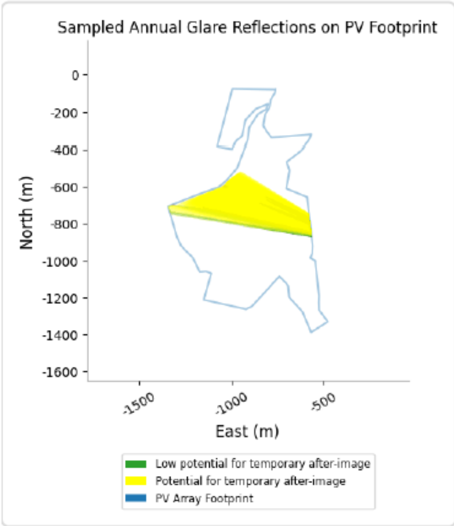
Figure 5-16 below illustrates the location of the fixed receptors affected mostly by yellow glare, as well as examples of how the reflections occur in the morning for these receptors.

Figure 5-16: Demonstration of reflectance across the Proposed Development, showing westward (green arrows) and eastward reflection (orange arrows)

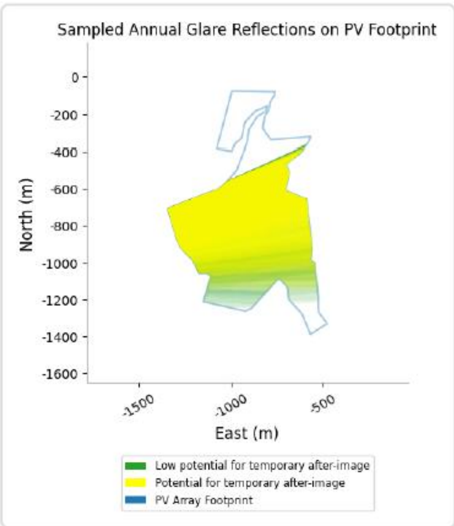
(Source: Google Earth Pro, 2025)

In addition, Figure 5-17 illustrates the areas of the Proposed Development from which the yellow glare affecting OP6, OP14, OP15, OP16, and OP37 emanates.

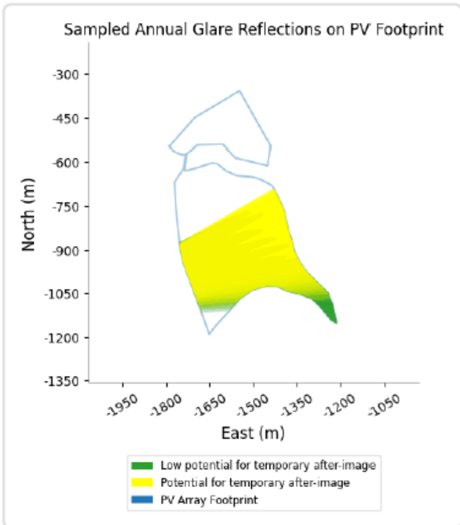
PV Array 2 to OP6



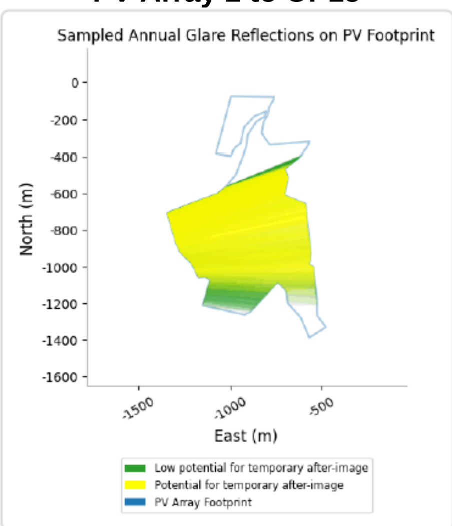
PV Array 2 to OP14



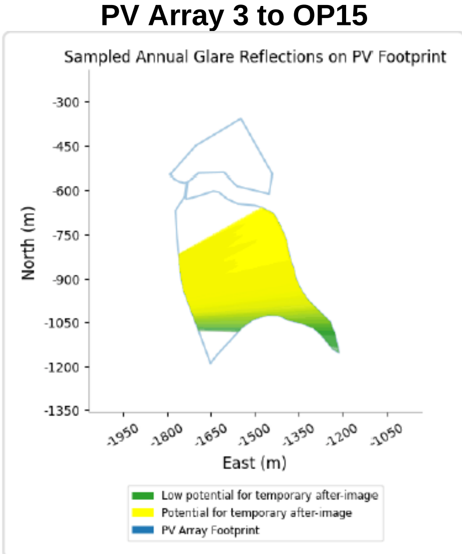
PV Array 3 to OP14



PV Array 2 to OP15



PV Array 3 to OP15



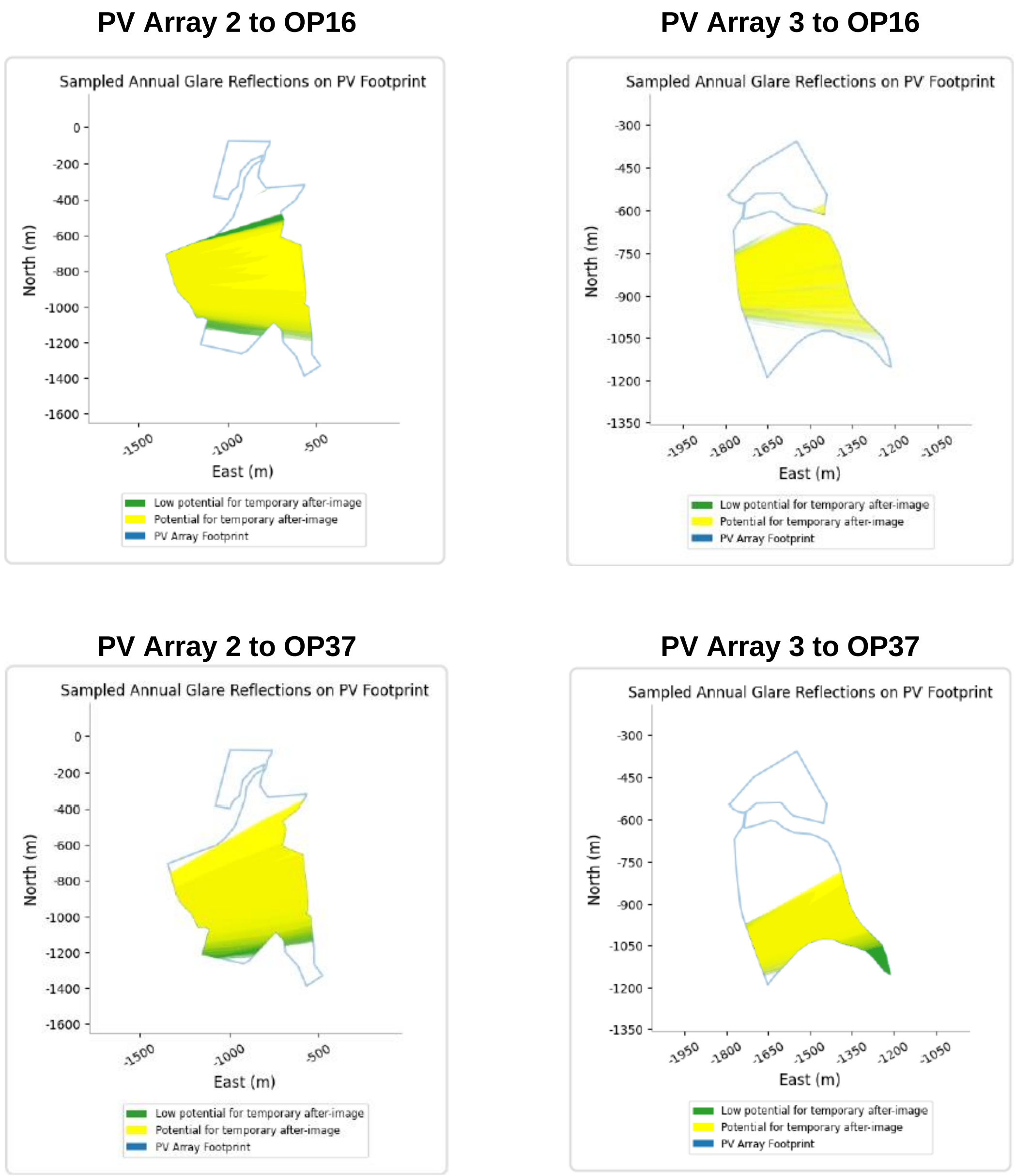


Figure 5-17: Areas of PV Arrays affecting fixed receptors affected by yellow glare

(Source: Appendix 1, ForgeSolar 2024)

Existing screening measures, such as trees, scrub planting and hedgerows and other obstructions, have been included in the simulation where applicable to provide a realistic assessment of G&G effects. However, certain screenings such as those illustrated in white in Figure 5-18 have not been included in the simulation, which will obstruct the reflections in the real-life conditions. In addition, the proposed Landscape Management Plan will further enhance screening around the PV arrays, supporting the reduction of potential impacts over time.

Figure 5-18: Existing screening (white) in between PV arrays 2 & 3 not included in simulation

(Source: Google Earth Pro, 2025)

The overall impact on receptors (OP6, OP14, OP15, OP16, and OP37) is considered negligible due to the short duration of yellow glare (38 to 88 hours in a whole year, presence of screening (fencing around PV arrays and trees/ hedgerows in between PV arrays) that will restrict the reflections. The residual effects after the implementation of the screening measures could be reduced to **minimal**.

The overall impact on rest of the 13 receptors identified above is deemed minimal due to the short duration (1 to 31 hours in the whole year) and low intensity of the glare. Even in the worst-case scenario, glare lasts only up to 35 minutes per day for OP1 and 2 to 31 minutes per day for the remaining affected receptors, with no occurrence outside of the April 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 Temporary Shading Netting

The Proposed Development includes a Landscape Mitigation Proposal, which proposes planting native scrub and trees to provide screening where potential G&G effects have been identified. In locations where new planting is proposed, temporary measures such as shade netting may be used while the planting establishes to an appropriate height.

These temporary shading nets, typically constructed from UV-stabilised material with a 50–80% shading factor, can be rapidly deployed at targeted locations identified through modelling. They offer a cost-effective and low-impact interim solution, and their flexible nature allows for adjustment or removal as planting matures.

The benefits of this approach include rapid deployment (within 1–2 weeks), low visual and physical impact, cost-efficiency, and adaptability. Shade nets can be adjusted or removed as necessary, offering flexibility in response to real-world observations and evolving landscape conditions.

Where feasible, existing fencing may be used to support the shade netting, provided it is structurally capable and located appropriately to intercept the reflected glare. Standard agricultural fencing may require reinforcement or additional posts to meet the typical installation height of 2–3 m and ensure effective performance under local wind conditions. This hybrid approach can reduce cost and visual impact while maintaining mitigation effectiveness. Design and placement will follow the glint and glare analysis to ensure effectiveness and compliance with planning requirements.

Taking into account the Landscape Mitigation Proposal, the availability of temporary screening options such as shade netting, and the conservative nature of the modelling assumptions, the impact from the PV modules on all receptors is considered to be minimal. No additional, specific mitigation beyond implementation of the Landscape Mitigation Proposal is considered necessary.

7.0 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 trainline and roads. Other less sensitive receptors include nearby residential and commercial buildings (a total of 40 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 trunk of tree 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.

The G&G assessment has identified varying levels of potential glare across different receptor types, with more noticeable effects along Routes 1 and 2, and limited, low-intensity green glare observed along the A1, the trainline, and several fixed ground receptors.

- The A1 and trainline are affected only by low-intensity green glare, occurring during limited periods of the year. Importantly, no yellow glare is predicted. In both cases, the transient nature of vehicle and train movement, the distance from the PV arrays, and the presence of natural screening substantially reduce the potential for visual discomfort. Although not all screening features could be modelled due to software constraints, real-life conditions include additional obstructions, such as trees, hedgerows, and buildings, that would further mitigate glare. These will be reinforced through the proposed Landscape Management Plan, which includes new native planting, enhancement of existing hedgerows, and the introduction of a woodland block. Temporary shade netting will provide effective mitigation during the establishment phase of this planting.
- Routes 1 and 2 are closest to the PV arrays and are predicted to experience the most prolonged potential exposure to yellow glare. However, this effect is significantly reduced in practice. As vehicles travel along these rural roads, glare is encountered as brief, intermittent flashes rather than continuous exposure. Existing hedgerows already provide partial screening, and further mitigation through the Landscape Management Plan, combined with temporary netting, will substantially reduce visibility of the panels and, by extension, the potential for glare.
- Other rural lanes, while not modelled due to their low traffic volumes, were considered qualitatively. These routes are infrequently used, meaning the risk of visual impact is inherently low. Once the proposed mitigation is implemented, including optional shade netting, any residual effects are expected to be minimal.
- Among the fixed ground receptors, five observation points are primarily affected by yellow glare between March and September. The overall impact is assessed as negligible, due to the short duration of exposure, presence of existing screening, and proposed enhancements to hedgerows and vegetation around the PV areas. The remaining receptors are only affected by green glare, with limited exposure durations, resulting in minimal overall impact.

In all cases, any potential glare would be no more disruptive than sunlight reflecting off a window or still water. In fact, solar panels have lower reflectivity than such surfaces. Moreover, drivers and train operators are regularly exposed to much more intense sunlight, particularly when the sun is low on the horizon. This context, combined with the low traffic volumes on affected rural roads, further reduces the likelihood of any significant visual impact.

Taking into account the conservative modelling assumptions, the effectiveness of both existing and proposed mitigation, and the contextual factors such as traffic patterns and receptor characteristics, the overall conclusion is that the glint and glare effects from the Proposed Development are expected to be **minimal and pose no material risk to safety**.

Appendix A ForgeSolar Report

Springfield Solar

Glint & Glare Assessment

Voltalia UK Ltd

SLR Project No.: 405.065783.00001

27 May 2025

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

FORGESOLAR GLARE ANALYSIS

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

Client: Voltalia

Created 05 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 125941.21523

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	78,310	1,305.2	38,406	640.1	-
PV array 2	12.0	180.0	114,627	1,910.5	91,578	1,526.3	-
PV array 3	12.0	180.0	14,926	248.8	26,913	448.6	-

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	705	11.8	0	0.0
Route 1	165,152	2,752.5	115,199	1,920.0
Route 2	10,564	176.1	22,694	378.2
Trainline	2,064	34.4	0	0.0
OP 1	1,770	29.5	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	875	14.6	2,265	37.8
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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	1,837	30.6	0	0.0
OP 14	5,076	84.6	4,715	78.6
OP 15	5,255	87.6	4,324	72.1
OP 16	3,597	60.0	2,446	40.8
OP 17	135	2.2	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	87	1.4	0	0.0
OP 24	65	1.1	0	0.0
OP 25	84	1.4	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	485	8.1	0	0.0
OP 30	670	11.2	0	0.0
OP 31	910	15.2	0	0.0
OP 32	808	13.5	0	0.0
OP 33	836	13.9	0	0.0
OP 34	980	16.3	0	0.0
OP 35	450	7.5	0	0.0
OP 36	0	0.0	0	0.0
OP 37	5,458	91.0	5,254	87.6
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	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	55.942685	-2.394388	81.82	2.33	84.15
2	55.941520	-2.394839	89.73	2.33	92.06
3	55.940679	-2.396083	95.33	2.33	97.66
4	55.940162	-2.395504	100.68	2.33	103.01
5	55.939140	-2.396148	99.09	2.33	101.42
6	55.938912	-2.398444	102.15	2.33	104.48
7	55.939032	-2.399860	101.90	2.33	104.23
8	55.938780	-2.400461	106.50	2.33	108.83
9	55.938888	-2.400804	106.86	2.33	109.19
10	55.939681	-2.401384	101.81	2.33	104.14
11	55.940114	-2.402006	99.81	2.33	102.14
12	55.940510	-2.402403	98.59	2.33	100.92
13	55.940901	-2.402703	98.50	2.33	100.83
14	55.941562	-2.403551	100.37	2.33	102.70
15	55.942145	-2.404817	104.50	2.33	106.83
16	55.943767	-2.404130	106.50	2.33	108.83
17	55.944151	-2.403476	103.11	2.33	105.44
18	55.944157	-2.403089	101.74	2.33	104.07

Name: PV array 2
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	55.941972	-2.406542	103.99	2.33	106.32
2	55.942008	-2.410308	108.47	2.33	110.80
3	55.939226	-2.411617	129.20	2.33	131.53
4	55.939112	-2.410330	124.19	2.33	126.52
5	55.939461	-2.410008	121.64	2.33	123.97
6	55.939707	-2.409471	119.62	2.33	121.95
7	55.940488	-2.409182	114.89	2.33	117.22
8	55.941029	-2.408280	111.13	2.33	113.46
9	55.941275	-2.407229	106.60	2.33	108.93
10	55.941017	-2.407379	108.93	2.33	111.26
11	55.940776	-2.408098	112.05	2.33	114.38
12	55.940122	-2.408860	116.34	2.33	118.67
13	55.939533	-2.408978	120.05	2.33	122.38
14	55.938944	-2.409385	124.06	2.33	126.39
15	55.938511	-2.409686	126.79	2.33	129.12
16	55.938213	-2.409880	128.87	2.33	131.20
17	55.937588	-2.410841	132.98	2.33	135.31
18	55.937282	-2.411506	134.45	2.33	136.78
19	55.936927	-2.413255	138.37	2.33	140.70
20	55.936352	-2.415895	149.33	2.33	151.66
21	55.934874	-2.415133	158.22	2.33	160.55
22	55.934435	-2.414768	160.13	2.33	162.46
23	55.934243	-2.414425	160.06	2.33	162.39
24	55.933870	-2.413738	159.63	2.33	161.96
25	55.933155	-2.413137	163.41	2.33	165.74
26	55.933179	-2.412580	160.29	2.33	162.62
27	55.933083	-2.412129	159.14	2.33	161.47
28	55.931803	-2.412783	172.84	2.33	175.17
29	55.931346	-2.409136	168.22	2.33	170.55
30	55.931472	-2.408642	164.60	2.33	166.93
31	55.932939	-2.406217	136.63	2.33	138.96
32	55.932626	-2.405659	136.61	2.33	138.94
33	55.932482	-2.405466	136.86	2.33	139.19
34	55.931917	-2.405359	140.20	2.33	142.53
35	55.931220	-2.404222	138.61	2.33	140.94
36	55.930222	-2.403471	135.27	2.33	137.60
37	55.930739	-2.402033	131.54	2.33	133.87
38	55.931304	-2.402784	132.89	2.33	135.22
39	55.931677	-2.402806	131.45	2.33	133.78
40	55.931989	-2.402784	130.01	2.33	132.34
41	55.933624	-2.403106	127.97	2.33	130.30
42	55.933702	-2.403095	128.04	2.33	130.37
43	55.933846	-2.403535	128.98	2.33	131.31
44	55.934051	-2.403374	129.03	2.33	131.36
45	55.934435	-2.403342	128.30	2.33	130.63
46	55.936797	-2.403814	127.24	2.33	129.57
47	55.937212	-2.405617	127.04	2.33	129.37
48	55.938089	-2.405338	124.28	2.33	126.61
49	55.938498	-2.405595	122.27	2.33	124.60
50	55.939051	-2.404308	112.89	2.33	115.22
51	55.939555	-2.403621	104.99	2.33	107.32
52	55.939796	-2.403471	102.26	2.33	104.59
53	55.939639	-2.406915	114.61	2.33	116.94
54	55.939928	-2.407322	114.08	2.33	116.41
55	55.940222	-2.407644	113.36	2.33	115.69
56	55.940781	-2.407462	110.24	2.33	112.57
57	55.941112	-2.407086	107.43	2.33	109.76
58	55.941466	-2.406979	104.48	2.33	106.81
59	55.941833	-2.406582	102.97	2.33	105.30

Name: PV array 3
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	55.937758	-2.423014	173.89	2.33	176.22
2	55.938648	-2.421597	171.51	2.33	173.84
3	55.939471	-2.419130	162.43	2.33	164.76
4	55.937776	-2.417424	151.65	2.33	153.98
5	55.937193	-2.417595	152.28	2.33	154.61
6	55.937428	-2.419344	158.59	2.33	160.92
7	55.937824	-2.420074	162.38	2.33	164.71
8	55.937800	-2.421447	167.29	2.33	169.62
9	55.937554	-2.422048	169.16	2.33	171.49
10	55.937025	-2.422145	170.69	2.33	173.02
11	55.937115	-2.421544	168.20	2.33	170.53
12	55.937277	-2.420653	163.84	2.33	166.17
13	55.937247	-2.420353	162.68	2.33	165.01
14	55.937031	-2.419881	161.37	2.33	163.70
15	55.936887	-2.419280	159.66	2.33	161.99
16	55.936839	-2.418357	155.20	2.33	157.53
17	55.936767	-2.417971	154.37	2.33	156.70
18	55.936581	-2.417339	153.37	2.33	155.70
19	55.936208	-2.416985	153.93	2.33	156.26
20	55.935782	-2.416652	155.77	2.33	158.10
21	55.935241	-2.416448	158.82	2.33	161.15
22	55.934922	-2.416255	160.39	2.33	162.72
23	55.934538	-2.416084	162.78	2.33	165.11
24	55.934225	-2.415805	164.63	2.33	166.96
25	55.933937	-2.415461	166.02	2.33	168.35
26	55.933624	-2.414903	166.67	2.33	169.00
27	55.933276	-2.414260	166.86	2.33	169.19
28	55.932879	-2.413981	169.78	2.33	172.11
29	55.932326	-2.413766	173.76	2.33	176.09
30	55.932422	-2.414088	174.38	2.33	176.71
31	55.932879	-2.414753	173.08	2.33	175.41
32	55.933083	-2.415161	172.50	2.33	174.83
33	55.933239	-2.415869	173.05	2.33	175.38
34	55.933312	-2.416470	174.13	2.33	176.46
35	55.933468	-2.417092	174.00	2.33	176.33
36	55.933480	-2.417650	174.68	2.33	177.01
37	55.933348	-2.418444	175.71	2.33	178.04
38	55.933095	-2.419066	176.10	2.33	178.43
39	55.932855	-2.419452	177.79	2.33	180.12
40	55.932566	-2.419946	177.88	2.33	180.21
41	55.932266	-2.420439	176.65	2.33	178.98
42	55.932001	-2.420804	174.32	2.33	176.65
43	55.934160	-2.422217	177.84	2.33	180.17
44	55.934502	-2.422367	178.50	2.33	180.83
45	55.935230	-2.422517	178.57	2.33	180.90
46	55.935855	-2.422646	177.63	2.33	179.96
47	55.936684	-2.422732	174.18	2.33	176.51
48	55.937105	-2.422206	170.77	2.33	173.10
49	55.937534	-2.422120	169.51	2.33	171.84
50	55.937525	-2.422233	169.98	2.33	172.31
51	55.937561	-2.422512	171.13	2.33	173.46
52	55.937636	-2.422780	172.53	2.33	174.86

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	55.966165	-2.427219	30.36	1.50	31.86
2	55.966003	-2.422765	30.16	1.50	31.66
3	55.965391	-2.418409	24.11	1.50	25.61
4	55.964716	-2.415442	23.88	1.50	25.38
5	55.963425	-2.411864	21.70	1.50	23.20
6	55.961893	-2.407626	19.77	1.50	21.27
7	55.958872	-2.401404	17.96	1.50	19.46
8	55.954764	-2.393631	27.85	1.50	29.35
9	55.954553	-2.393279	28.48	1.50	29.98
10	55.950889	-2.388516	35.98	1.50	37.48
11	55.948753	-2.383874	40.74	1.50	42.24
12	55.946518	-2.379883	38.93	1.50	40.43
13	55.944986	-2.376961	38.35	1.50	39.85
14	55.944326	-2.375062	37.59	1.50	39.09
15	55.942433	-2.367863	36.34	1.50	37.84
16	55.941428	-2.364764	42.33	1.50	43.83
17	55.939253	-2.360773	49.81	1.50	51.31
18	55.937237	-2.357485	58.29	1.50	59.79
19	55.936522	-2.356863	62.35	1.50	63.85
20	55.935861	-2.356378	64.50	1.50	66.00
21	55.933962	-2.356056	64.65	1.50	66.15
22	55.931786	-2.355588	68.98	1.50	70.48
23	55.927892	-2.354065	86.55	1.50	88.05
24	55.926716	-2.353326	85.68	1.50	87.18

Name: Route 1
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	55.949622	-2.400774	64.40	1.50	65.90
2	55.948721	-2.401793	69.20	1.50	70.70
3	55.948090	-2.402260	72.90	1.50	74.40
4	55.947066	-2.402600	78.30	1.50	79.80
5	55.945393	-2.403842	94.70	1.50	96.20
6	55.944515	-2.402941	99.40	1.50	100.90
7	55.944263	-2.403070	101.20	1.50	102.70
8	55.944323	-2.403585	102.90	1.50	104.40
9	55.943879	-2.404379	107.00	1.50	108.50
10	55.942328	-2.405065	106.30	1.50	107.80
11	55.942172	-2.406031	105.50	1.50	107.00
12	55.940682	-2.407383	110.40	1.50	111.90
13	55.940078	-2.407473	113.70	1.50	115.20
14	55.939231	-2.407452	119.70	1.50	121.20
15	55.937596	-2.408342	129.40	1.50	130.90
16	55.935721	-2.409844	140.70	1.50	142.20
17	55.934904	-2.410917	144.10	1.50	145.60
18	55.934159	-2.411561	147.20	1.50	148.70
19	55.933810	-2.412119	152.10	1.50	153.60
20	55.932344	-2.412805	170.20	1.50	171.70
21	55.931719	-2.413192	173.90	1.50	175.40
22	55.931154	-2.413406	171.70	1.50	173.20
23	55.930541	-2.414222	168.60	1.50	170.10
24	55.930315	-2.414263	166.00	1.50	167.50
25	55.929864	-2.413909	159.10	1.50	160.60
26	55.927701	-2.413426	143.30	1.50	144.80
27	55.927286	-2.413620	139.20	1.50	140.70

Name: Route 2
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	55.940519	-2.419270	156.80	1.50	158.30
2	55.940003	-2.421866	173.80	1.50	175.30
3	55.939318	-2.421459	173.10	1.50	174.60
4	55.938739	-2.421733	172.50	1.50	174.00
5	55.937781	-2.423239	175.00	1.50	176.50
6	55.937600	-2.423293	174.80	1.50	176.30
7	55.937072	-2.423164	174.70	1.50	176.20
8	55.936750	-2.423282	176.10	1.50	177.60
9	55.935973	-2.424715	184.80	1.50	186.30
10	55.934453	-2.425230	188.30	1.50	189.80
11	55.934248	-2.425573	189.00	1.50	190.50
12	55.933852	-2.427559	195.80	1.50	197.30
13	55.933088	-2.429072	196.10	1.50	197.60
14	55.932487	-2.429147	189.60	1.50	191.10
15	55.931947	-2.429969	189.40	1.50	190.90
16	55.931560	-2.430082	184.50	1.50	186.00
17	55.930929	-2.430085	174.00	1.50	175.50
18	55.930727	-2.430264	171.00	1.50	172.50
19	55.930575	-2.430570	170.00	1.50	171.50
20	55.930496	-2.430940	170.50	1.50	172.00
21	55.930622	-2.431922	175.80	1.50	177.30

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	55.966502	-2.428107	30.10	1.50	31.60
2	55.964485	-2.423203	29.86	1.50	31.36
3	55.956468	-2.403259	32.91	1.50	34.41
4	55.949667	-2.386708	39.55	1.50	41.05
5	55.948192	-2.383729	42.64	1.50	44.14
6	55.945471	-2.378995	41.34	1.50	42.84
7	55.944604	-2.377138	41.75	1.50	43.25
8	55.944084	-2.375780	40.56	1.50	42.06
9	55.943015	-2.371852	42.60	1.50	44.10
10	55.942688	-2.370778	42.77	1.50	44.27
11	55.942378	-2.369986	42.65	1.50	44.15
12	55.941596	-2.368179	42.29	1.50	43.79
13	55.940436	-2.365658	50.12	1.50	51.62
14	55.939386	-2.363434	53.07	1.50	54.57
15	55.938484	-2.361831	56.08	1.50	57.58
16	55.937874	-2.360844	59.78	1.50	61.28
17	55.936519	-2.358954	62.79	1.50	64.29
18	55.934068	-2.355524	63.58	1.50	65.08
19	55.929326	-2.348738	79.62	1.50	81.12
20	55.928100	-2.346978	81.80	1.50	83.30

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	55.927544	-2.413385	141.70	4.00
OP 2	2	55.927460	-2.414098	141.70	4.00
OP 3	3	55.927782	-2.414549	145.50	4.00
OP 4	4	55.927707	-2.416802	144.20	4.00
OP 5	5	55.928296	-2.419216	149.30	4.00
OP 6	6	55.934625	-2.399547	121.90	4.00
OP 7	7	55.920995	-2.405330	159.20	4.00
OP 8	8	55.921115	-2.405024	157.60	4.00
OP 9	9	55.918987	-2.398356	158.50	4.00
OP 10	10	55.919513	-2.398212	154.50	4.00
OP 11	11	55.923417	-2.416779	179.60	4.00
OP 12	12	55.923183	-2.415279	175.90	4.00
OP 13	13	55.926039	-2.433149	154.10	4.00
OP 14	14	55.932445	-2.429632	193.00	4.00
OP 15	15	55.933182	-2.429190	197.70	4.00
OP 16	16	55.934422	-2.428155	204.30	4.00
OP 17	17	55.944982	-2.421313	132.30	4.00
OP 18	18	55.949503	-2.397773	60.20	4.00
OP 19	19	55.944493	-2.394059	79.40	4.00
OP 20	20	55.944311	-2.393023	77.90	4.00
OP 21	21	55.943340	-2.392672	76.00	4.00
OP 22	22	55.944010	-2.391772	74.20	4.00
OP 23	23	55.941678	-2.382931	70.40	4.00
OP 24	24	55.941902	-2.380681	66.50	4.00
OP 25	25	55.942040	-2.379844	64.40	4.00
OP 26	26	55.938986	-2.375755	68.10	4.00
OP 27	27	55.938538	-2.375358	65.10	4.00
OP 28	28	55.939557	-2.375336	69.50	4.00
OP 29	29	55.929829	-2.368892	98.60	4.00
OP 30	30	55.930123	-2.367262	93.90	4.00
OP 31	31	55.932278	-2.365556	83.00	4.00
OP 32	32	55.932819	-2.364901	78.80	4.00
OP 33	33	55.928960	-2.372452	104.90	4.00
OP 34	34	55.937007	-2.416350	147.80	4.00
OP 35	35	55.929599	-2.368131	95.50	4.00
OP 36	36	55.945904	-2.411341	111.10	4.00
OP 37	37	55.931018	-2.430310	176.20	4.00
OP 38	38	55.921999	-2.403639	148.80	4.00
OP 39	39	55.921830	-2.404141	151.50	4.00
OP 40	40	55.922141	-2.403314	147.10	4.00

Obstruction Components

Name: Obstruction 1
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.931496	-2.413603	175.20
2	55.930793	-2.408936	166.90
3	55.929795	-2.408464	150.80
4	55.930264	-2.411404	158.90
5	55.931333	-2.413872	175.60
6	55.931496	-2.413603	175.20

Name: Obstruction 10
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.936950	-2.417094	151.10
2	55.936899	-2.415394	144.00
3	55.937185	-2.413758	138.10
4	55.938585	-2.410367	127.40
5	55.938435	-2.409810	127.40
6	55.937449	-2.411644	134.30
7	55.936704	-2.415088	143.80
8	55.936566	-2.416880	152.00
9	55.936950	-2.417094	151.10

Name: Obstruction 2
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.927421	-2.422530	140.60
2	55.925714	-2.414526	131.00
3	55.925942	-2.407059	113.80
4	55.927589	-2.396394	100.30
5	55.926892	-2.394484	125.30
6	55.925690	-2.402939	121.60
7	55.924511	-2.411693	143.20
8	55.926868	-2.422723	149.30
9	55.927421	-2.422530	140.60

Name: Obstruction 3
Top height: 15.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.941457	-2.394050	89.70
2	55.938681	-2.395552	100.00
3	55.936986	-2.394543	110.00
4	55.938092	-2.388063	95.20
5	55.940832	-2.383536	73.10
6	55.941457	-2.394050	89.70

Name: Obstruction 4
Top height: 7.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.928296	-2.417675	150.40
2	55.927978	-2.417728	147.10
3	55.927533	-2.413673	141.70
4	55.927899	-2.413641	145.50
5	55.928296	-2.417675	150.40

Name: Obstruction 5
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.939920	-2.421634	173.00
2	55.938826	-2.421430	171.80
3	55.939649	-2.419038	161.80
4	55.937811	-2.417214	150.70
5	55.937041	-2.417429	152.00
6	55.937017	-2.416828	149.90
7	55.937835	-2.416678	148.40
8	55.940370	-2.419167	158.10
9	55.939920	-2.421634	173.00

Name: Obstruction 6
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.934082	-2.402295	126.20
2	55.932675	-2.401544	126.10
3	55.932387	-2.400235	125.80
4	55.932760	-2.399849	126.00
5	55.933000	-2.400900	126.00
6	55.934094	-2.401587	124.70
7	55.934082	-2.402295	126.20

Name: Obstruction 7
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.934378	-2.394528	117.30
2	55.931962	-2.395901	116.70
3	55.930808	-2.396116	115.30
4	55.930496	-2.394421	98.70
5	55.931974	-2.388627	105.80
6	55.932707	-2.382919	97.10
7	55.933801	-2.384507	85.10
8	55.933465	-2.387833	82.90
9	55.934871	-2.389013	104.60
10	55.934378	-2.394528	117.30

Name: Obstruction 8
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.945101	-2.424426	135.40
2	55.942313	-2.429705	183.30
3	55.941328	-2.421980	164.70
4	55.941328	-2.413611	121.40
5	55.942049	-2.412968	115.20
6	55.943899	-2.422280	139.00
7	55.944885	-2.422409	136.90
8	55.945101	-2.424426	135.40

Name: Obstruction 9
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	55.930714	-2.421451	156.60
2	55.930579	-2.421344	156.20
3	55.930639	-2.420856	161.80
4	55.930369	-2.420427	163.50
5	55.930089	-2.420749	156.90
6	55.930023	-2.420679	157.00
7	55.930378	-2.420234	165.60
8	55.930762	-2.420894	162.80
9	55.930714	-2.421451	156.60

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	78,310	1,305.2	38,406	640.1	-
PV array 2	12.0	180.0	114,627	1,910.5	91,578	1,526.3	-
PV array 3	12.0	180.0	14,926	248.8	26,913	448.6	-

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	705	11.8	0	0.0
Route 1	165,152	2,752.5	115,199	1,920.0
Route 2	10,564	176.1	22,694	378.2
Trainline	2,064	34.4	0	0.0
OP 1	1,770	29.5	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	875	14.6	2,265	37.8
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	1,837	30.6	0	0.0
OP 14	5,076	84.6	4,715	78.6
OP 15	5,255	87.6	4,324	72.1
OP 16	3,597	60.0	2,446	40.8
OP 17	135	2.2	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	87	1.4	0	0.0
OP 24	65	1.1	0	0.0
OP 25	84	1.4	0	0.0
OP 26	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	485	8.1	0	0.0
OP 30	670	11.2	0	0.0
OP 31	910	15.2	0	0.0
OP 32	808	13.5	0	0.0
OP 33	836	13.9	0	0.0
OP 34	980	16.3	0	0.0
OP 35	450	7.5	0	0.0
OP 36	0	0.0	0	0.0
OP 37	5,458	91.0	5,254	87.6
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

PV: PV array 1 potential temporary after-image

Receptor results ordered by category of glare

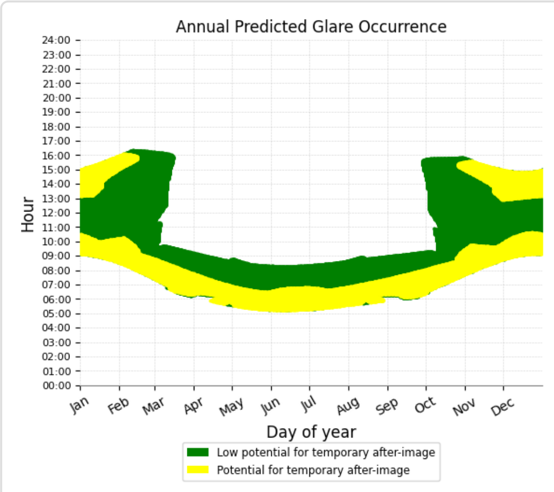
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Route 1	66,398	1,106.6	38,406	640.1
A1	152	2.5	0	0.0
Route 2	3,133	52.2	0	0.0
Trainline	143	2.4	0	0.0
OP 14	2,255	37.6	0	0.0
OP 15	2,400	40.0	0	0.0
OP 16	967	16.1	0	0.0
OP 17	135	2.2	0	0.0
OP 23	87	1.4	0	0.0
OP 24	65	1.1	0	0.0
OP 25	84	1.4	0	0.0
OP 34	980	16.3	0	0.0
OP 37	1,511	25.2	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	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 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 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

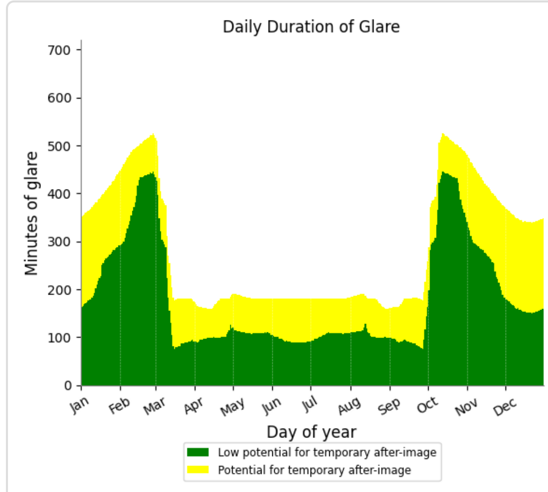
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

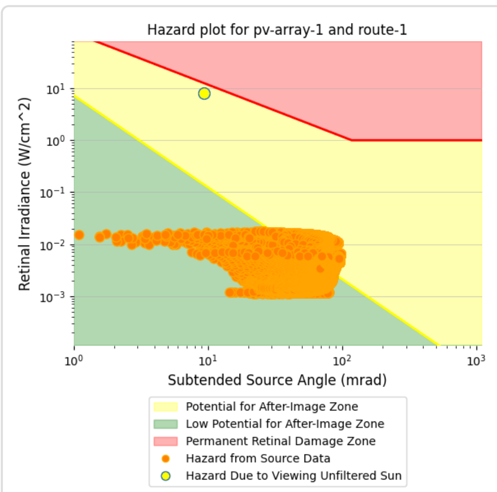
PV array 1 and Route: Route 1

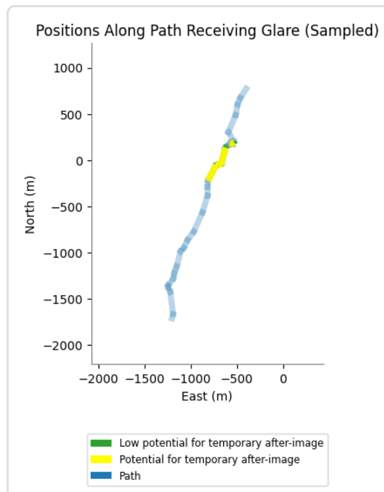
Yellow glare: 38,406 min.

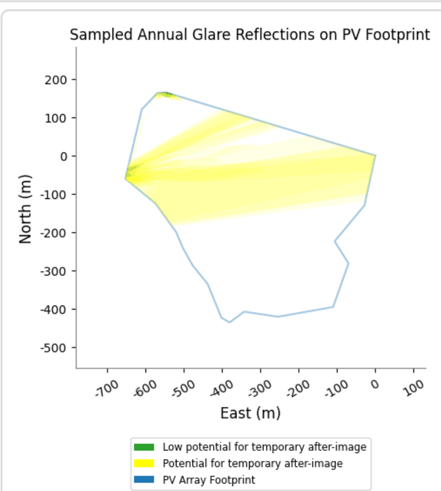
Green glare: 66,398 min.







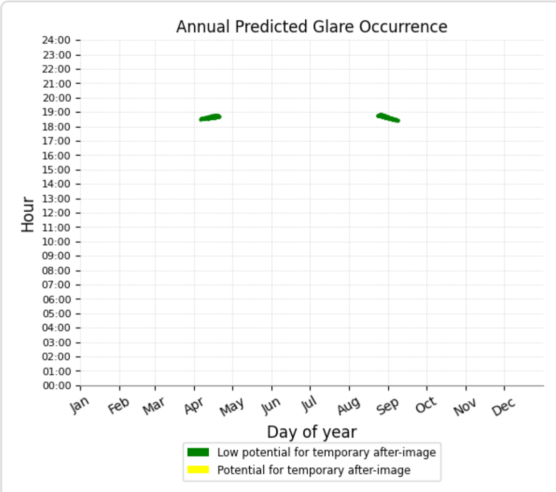


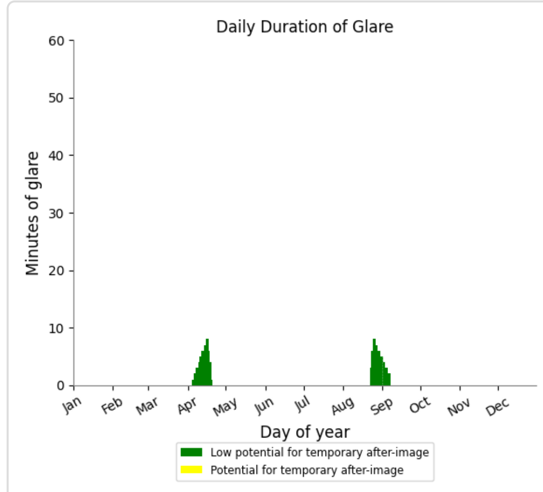


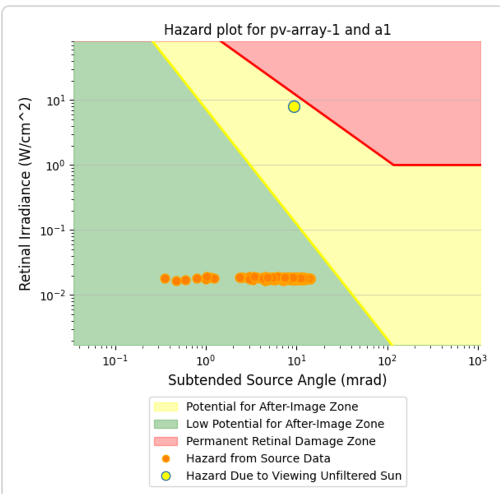
PV array 1 and Route: A1

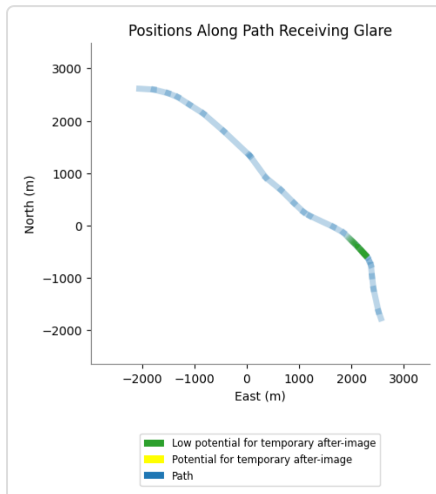
Yellow glare: none

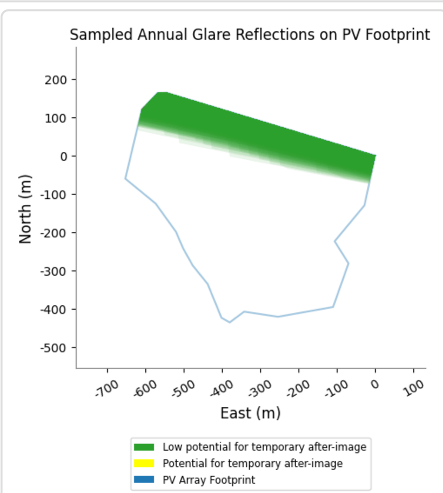
Green glare: 152 min.







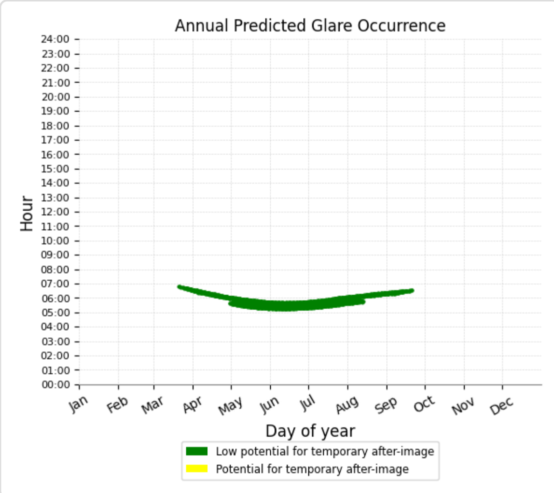


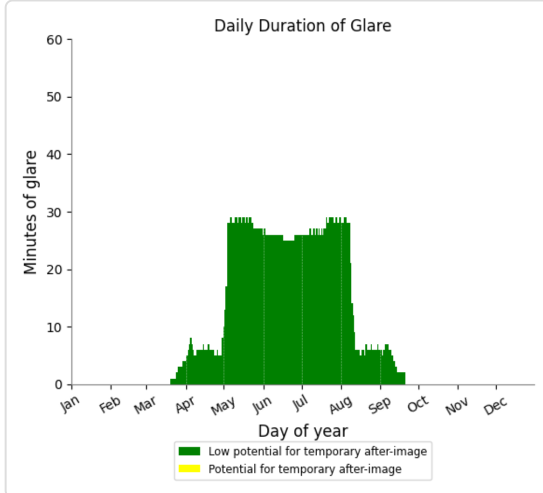


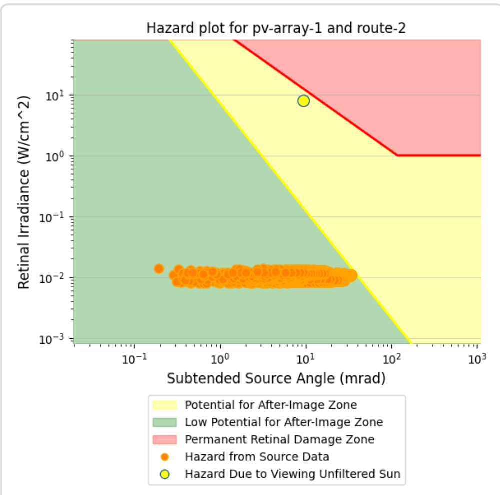
PV array 1 and Route: Route 2

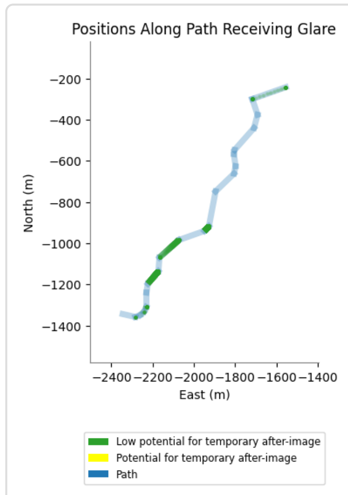
Yellow glare: none

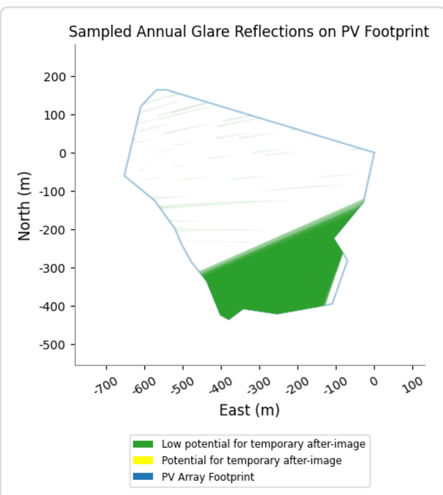
Green glare: 3,133 min.







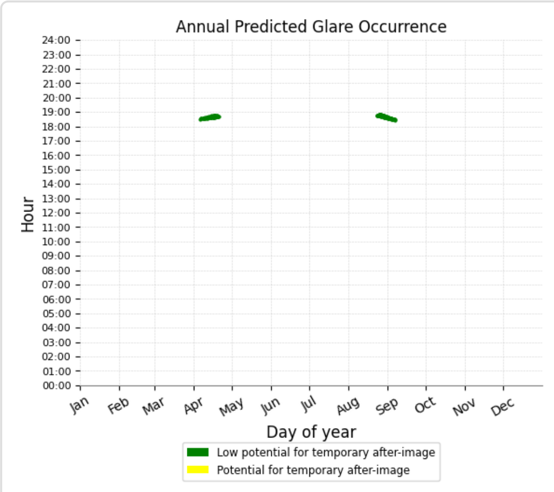


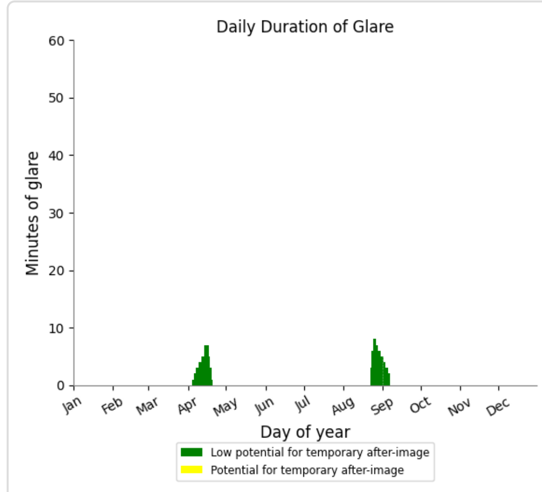


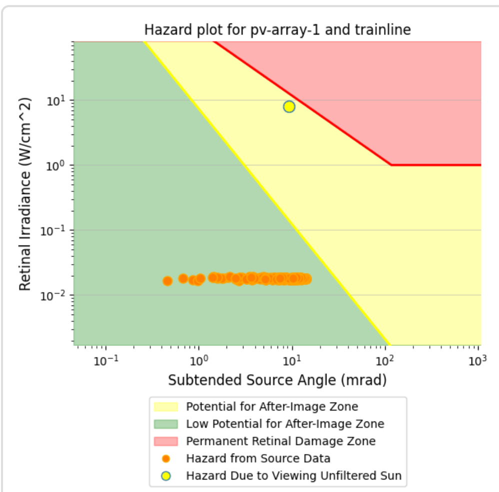
PV array 1 and Route: Trainline

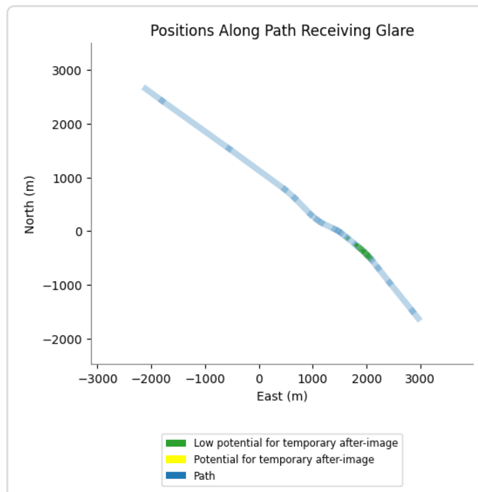
Yellow glare: none

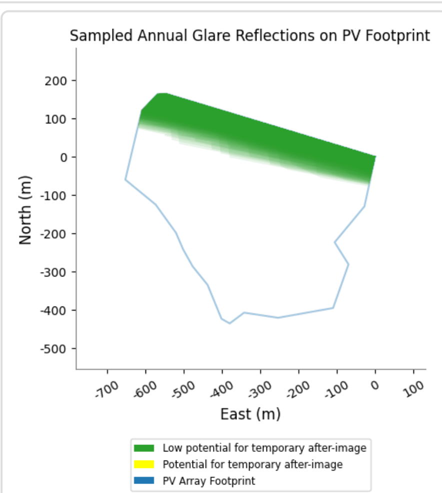
Green glare: 143 min.







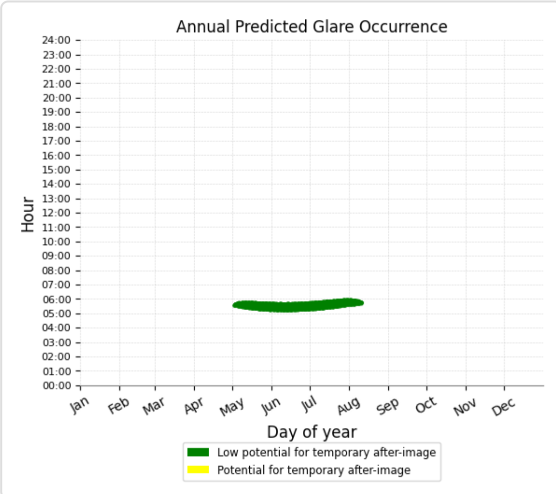


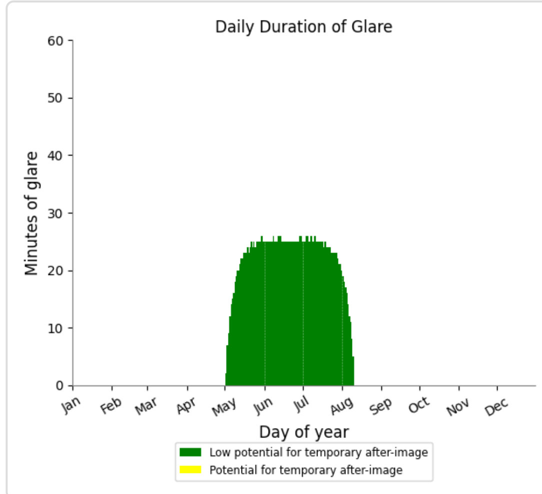


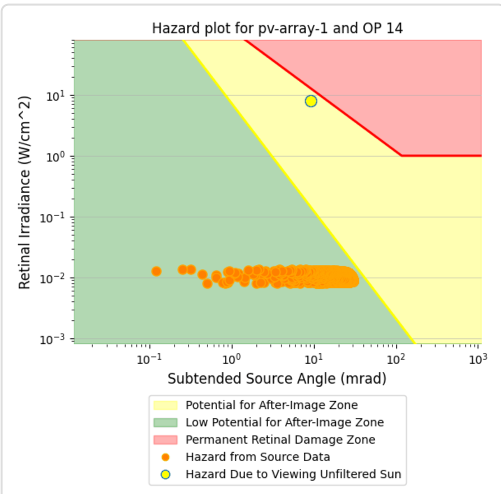
PV array 1 and OP 14

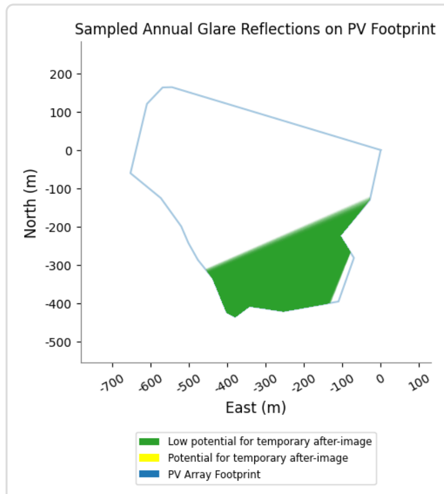
Yellow glare: none

Green glare: 2,255 min.





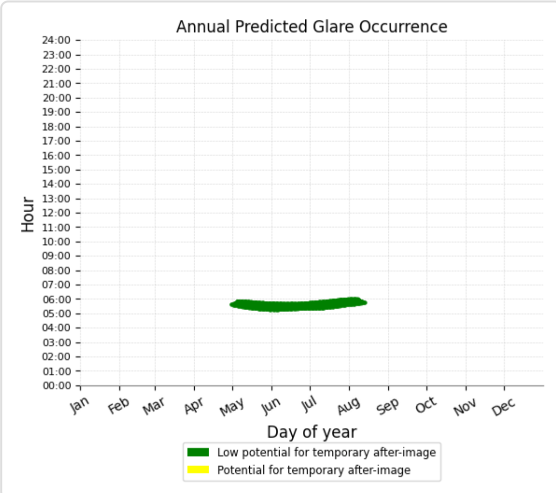


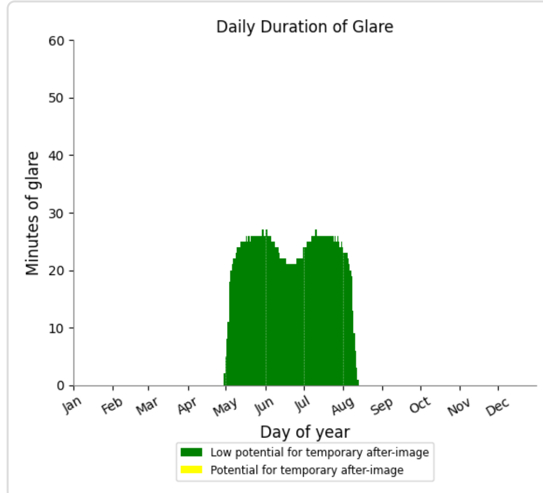


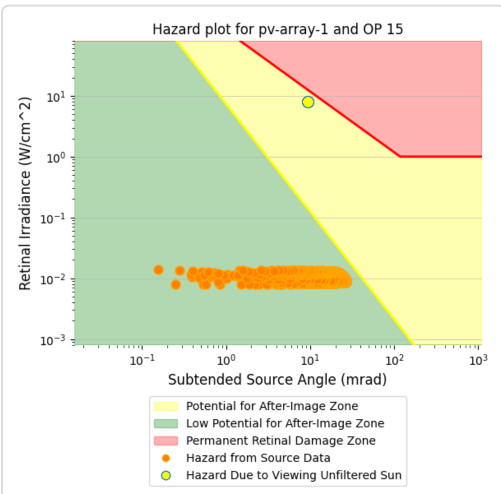
PV array 1 and OP 15

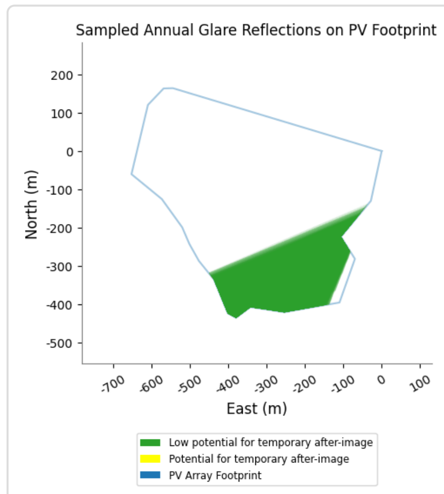
Yellow glare: none

Green glare: 2,400 min.



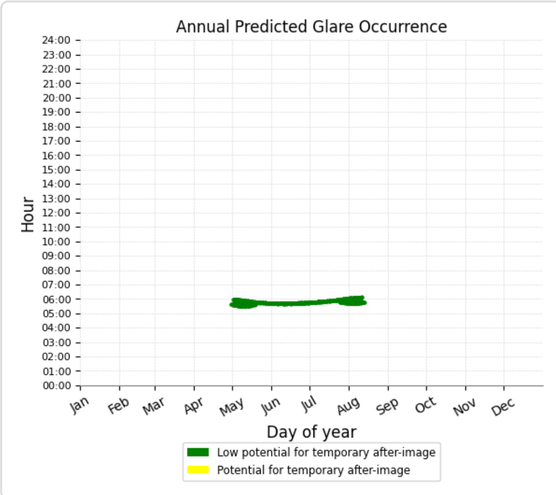


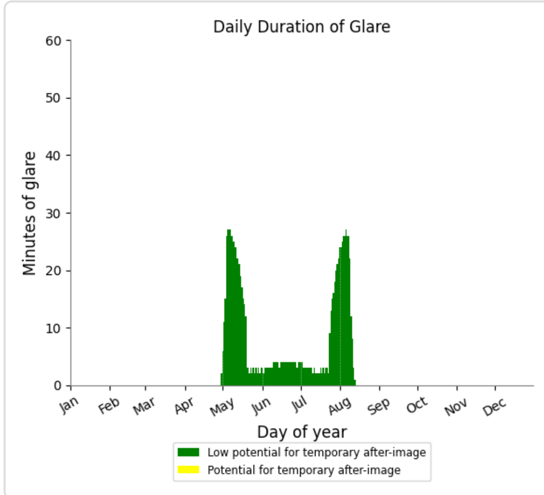


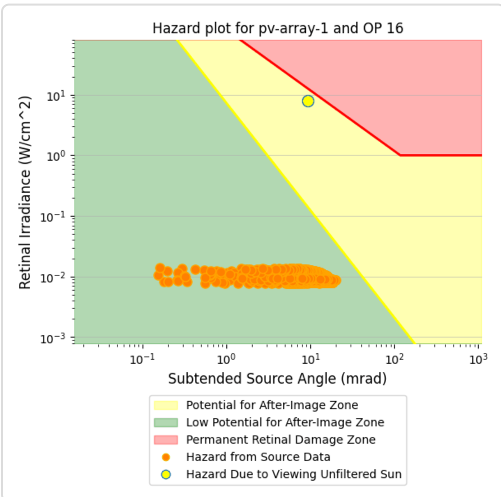


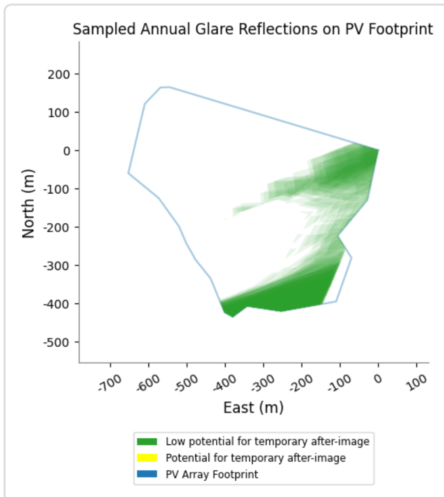
PV array 1 and OP 16

Yellow glare: none
Green glare: 967 min.





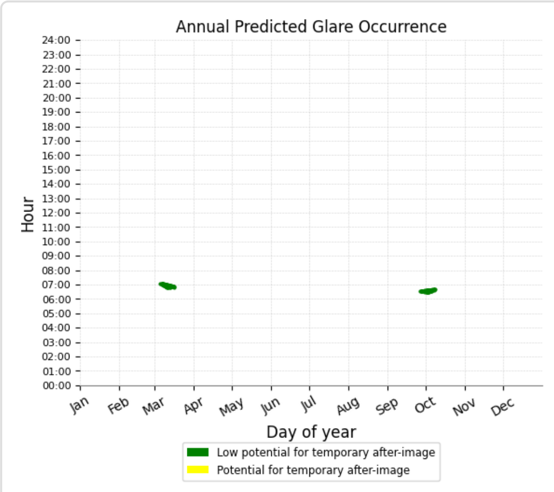


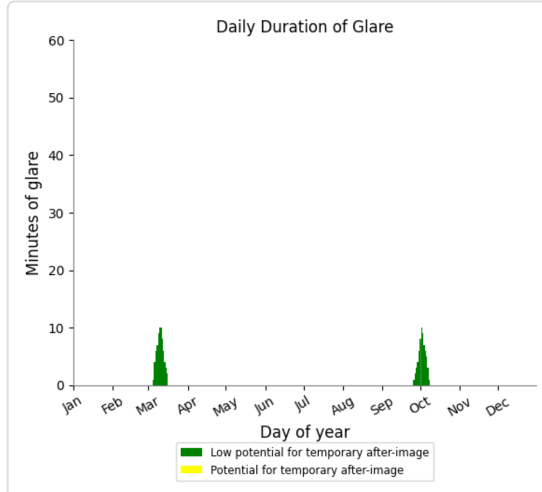


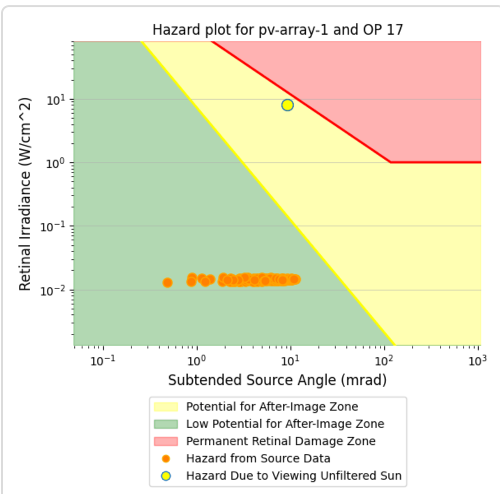
PV array 1 and OP 17

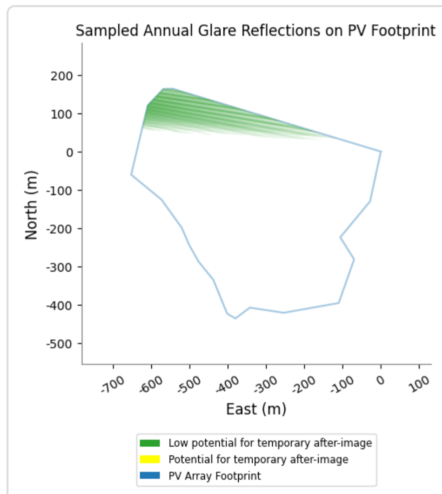
Yellow glare: none

Green glare: 135 min.





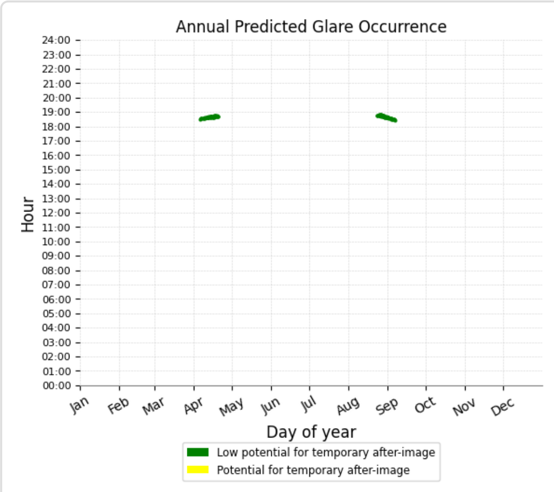


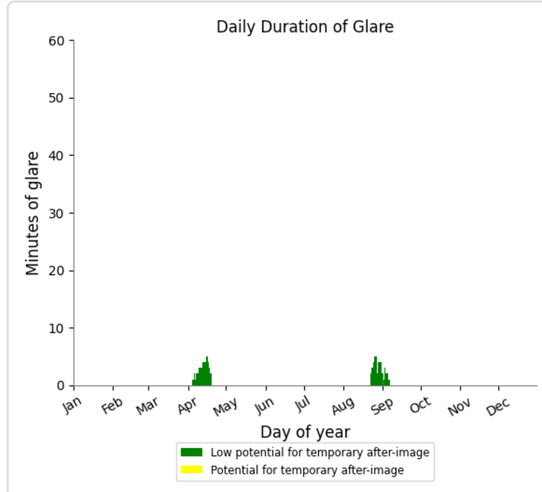


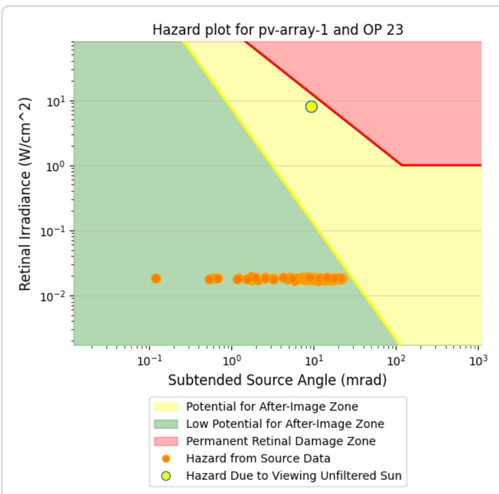
PV array 1 and OP 23

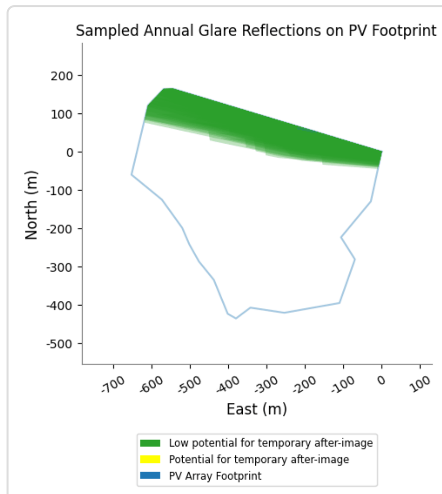
Yellow glare: none

Green glare: 87 min.





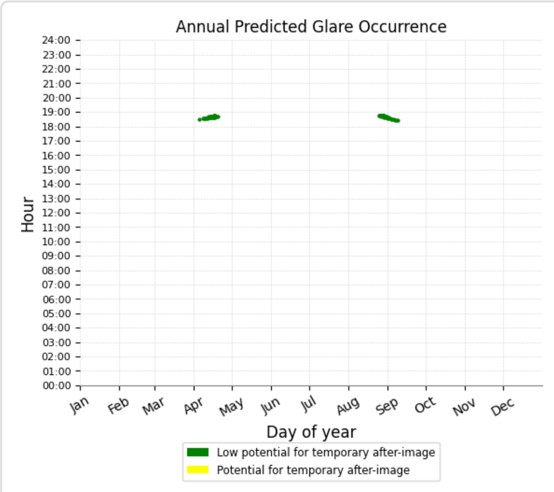


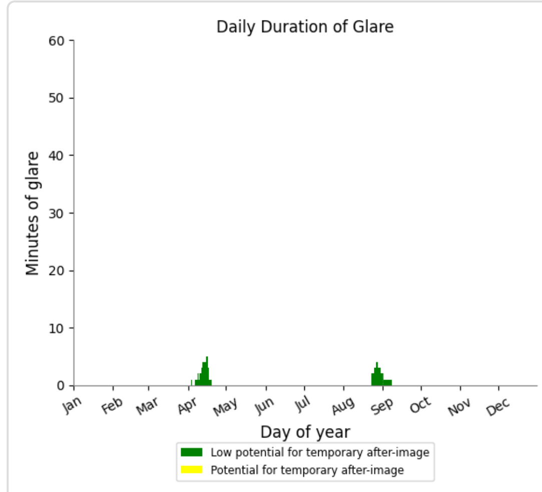


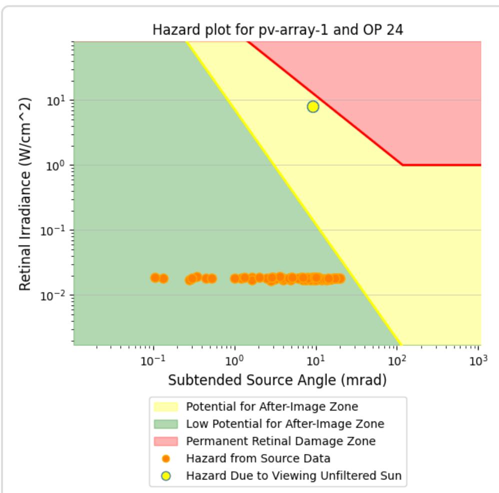
PV array 1 and OP 24

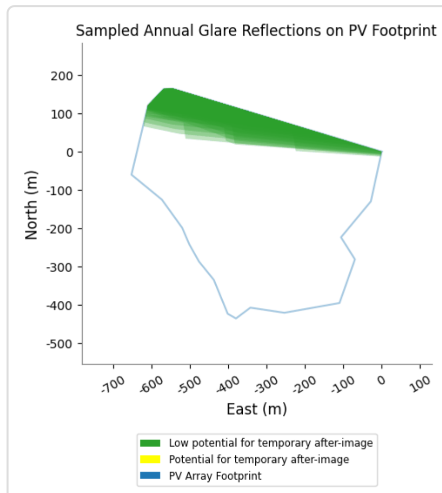
Yellow glare: none

Green glare: 65 min.





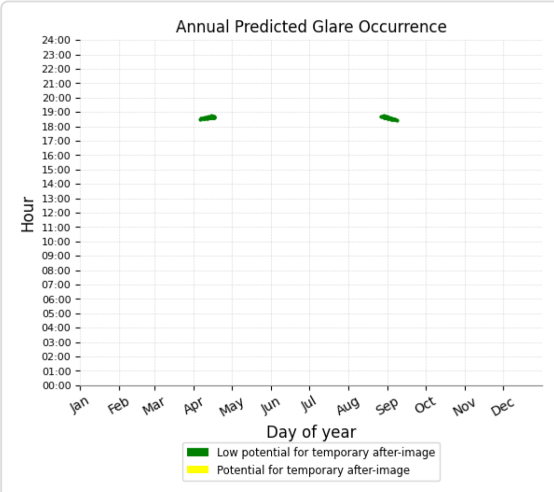


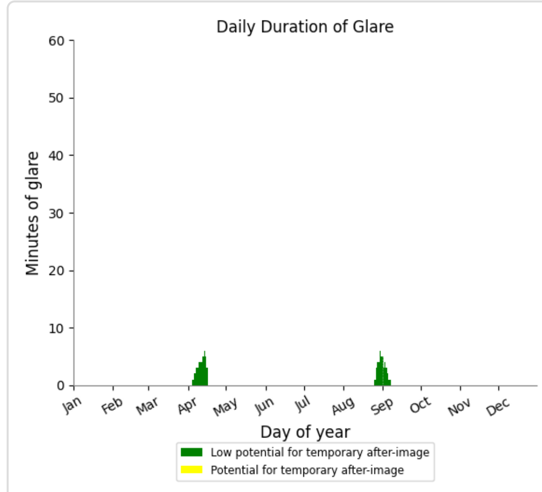


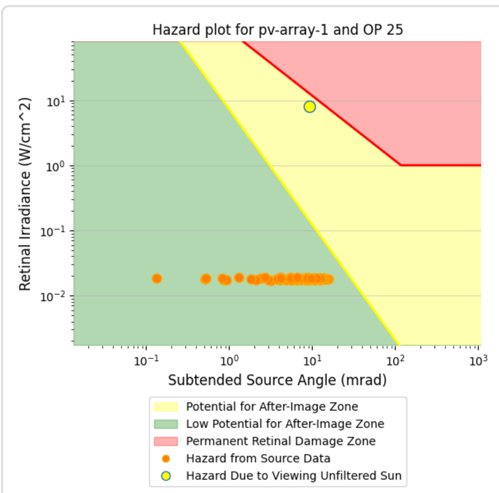
PV array 1 and OP 25

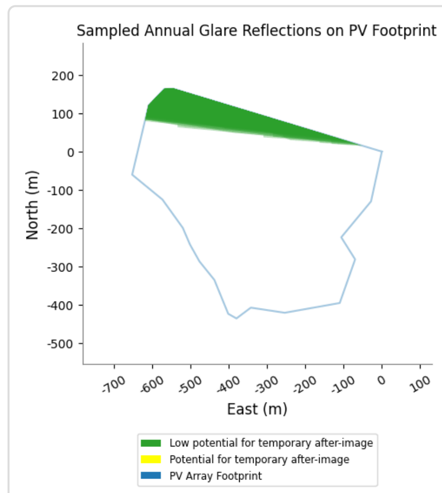
Yellow glare: none

Green glare: 84 min.



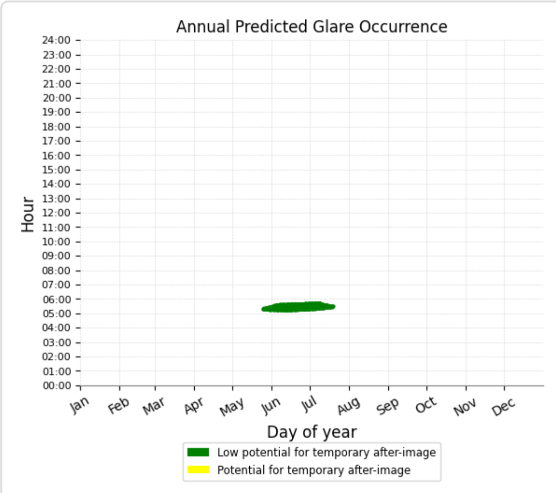


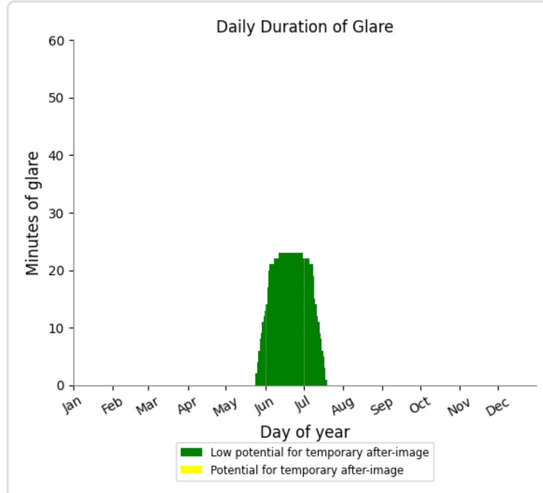


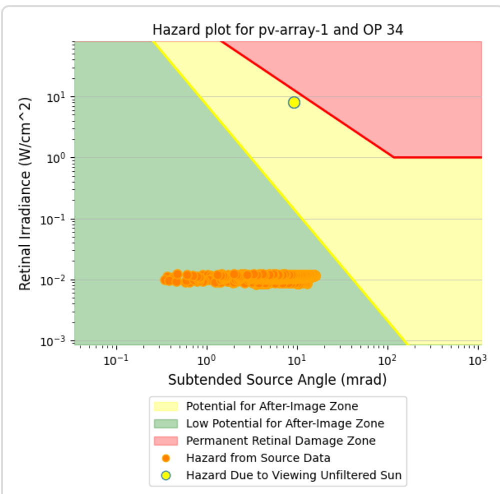


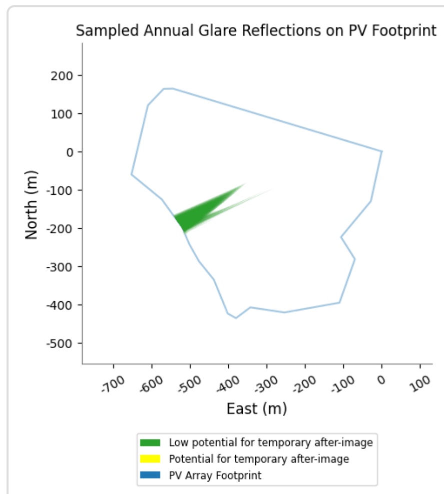
PV array 1 and OP 34

Yellow glare: none
Green glare: 980 min.



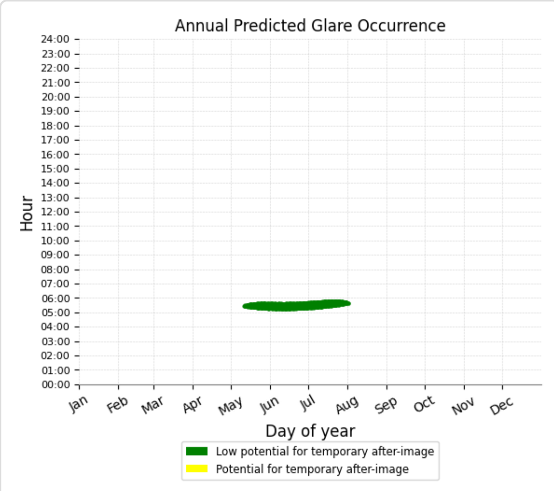


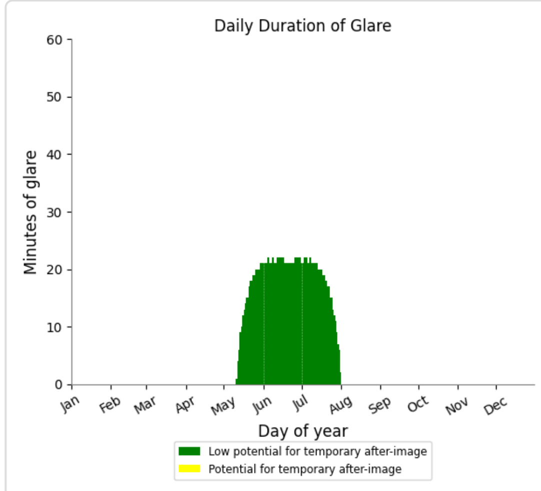


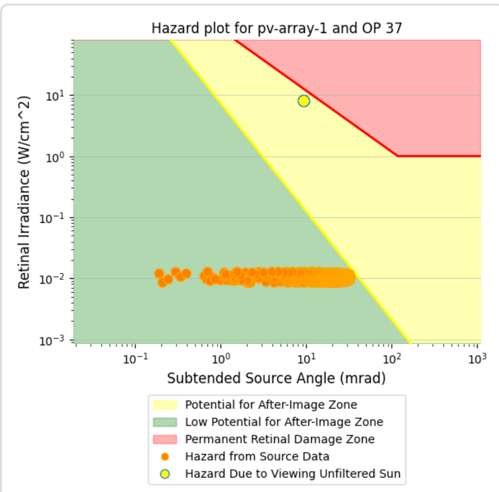


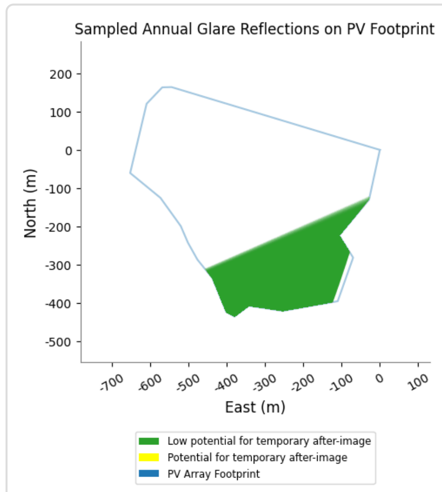
PV array 1 and OP 37

Yellow glare: none
Green glare: 1,511 min.









PV array 1 and OP 1

No glare found

PV array 1 and OP 2

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 5

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 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 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 35

No glare found

PV array 1 and OP 36

No glare found

PV array 1 and OP 38

No glare found

PV array 1 and OP 39

No glare found

PV array 1 and OP 40

No glare found

PV: PV array 2 potential temporary after-image

Receptor results ordered by category of glare

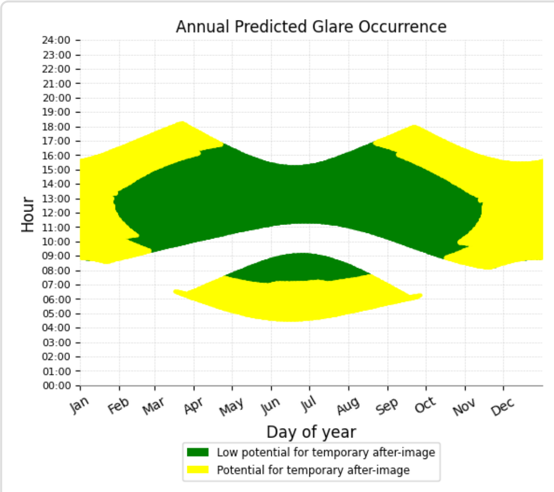
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Route 1	96,976	1,616.3	76,793	1,279.9
Route 2	2,899	48.3	5,522	92.0
A1	480	8.0	0	0.0
Trainline	1,440	24.0	0	0.0
OP 6	655	10.9	2,265	37.8
OP 14	1,359	22.6	1,416	23.6
OP 15	1,851	30.9	1,164	19.4
OP 16	1,004	16.7	1,808	30.1
OP 37	1,138	19.0	2,610	43.5
OP 1	1,770	29.5	0	0.0
OP 13	1,837	30.6	0	0.0
OP 29	292	4.9	0	0.0
OP 30	524	8.7	0	0.0
OP 31	867	14.4	0	0.0
OP 32	759	12.7	0	0.0
OP 33	508	8.5	0	0.0
OP 35	268	4.5	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	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 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	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

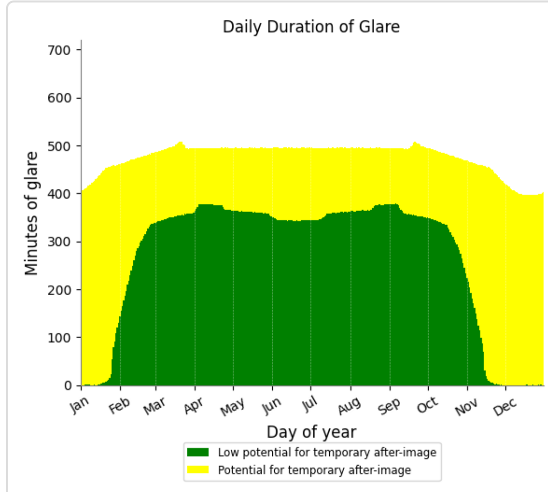
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 34	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

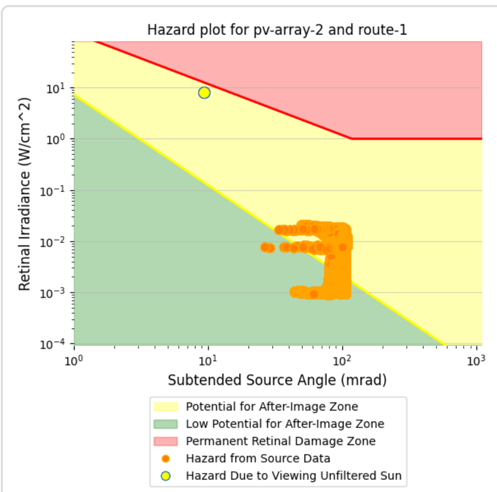
PV array 2 and Route: Route 1

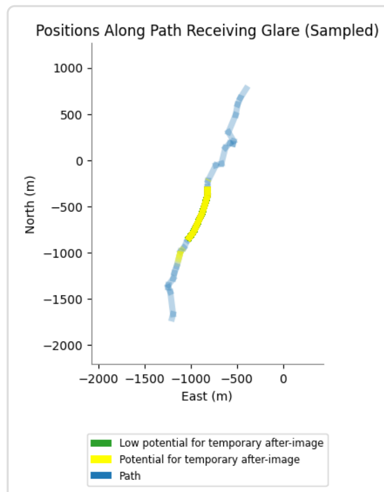
Yellow glare: 76,793 min.

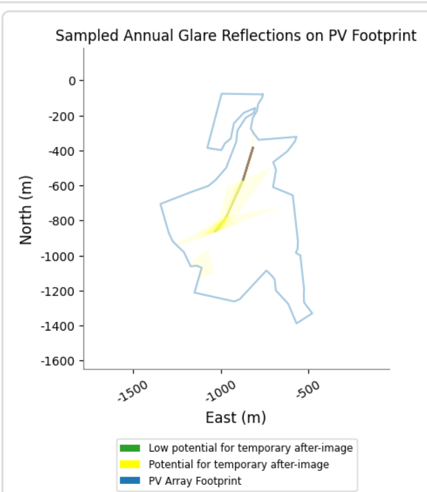
Green glare: 96,976 min.







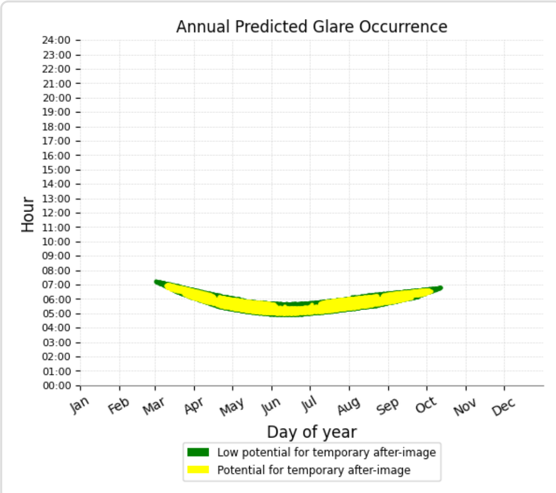


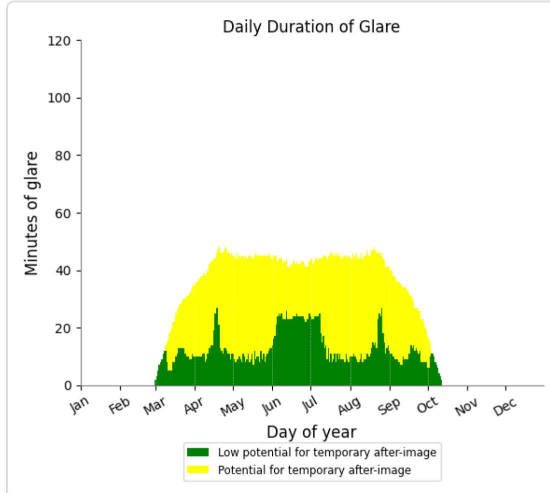


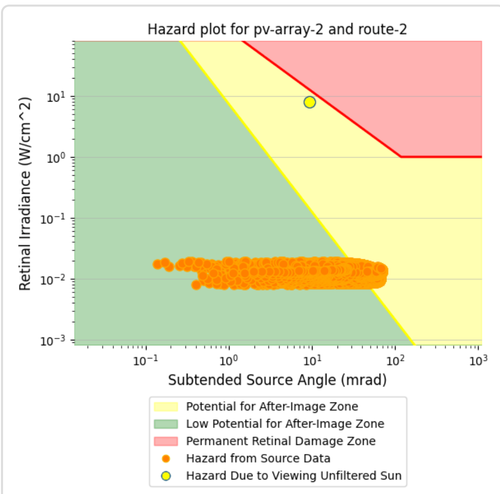
PV array 2 and Route: Route 2

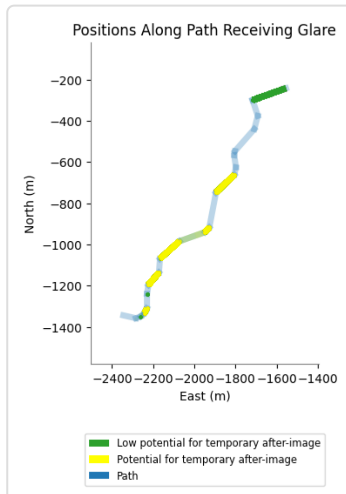
Yellow glare: 5,522 min.

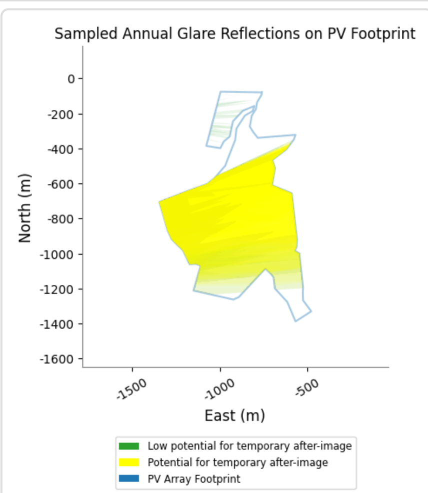
Green glare: 2,899 min.





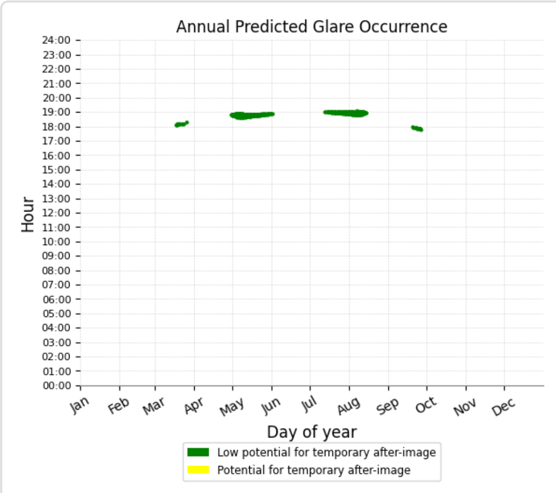


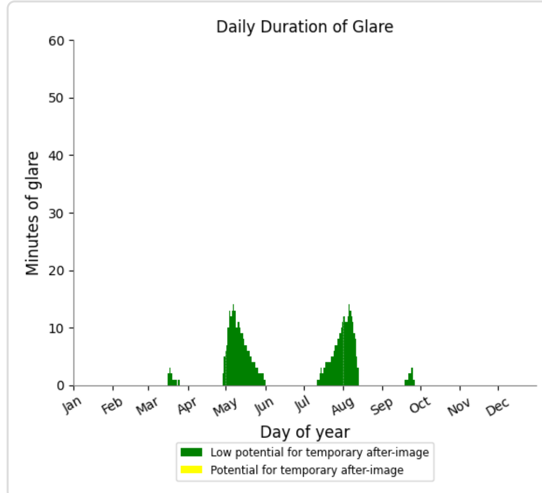


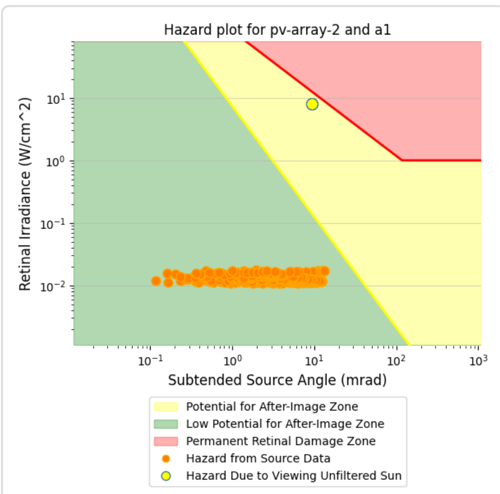


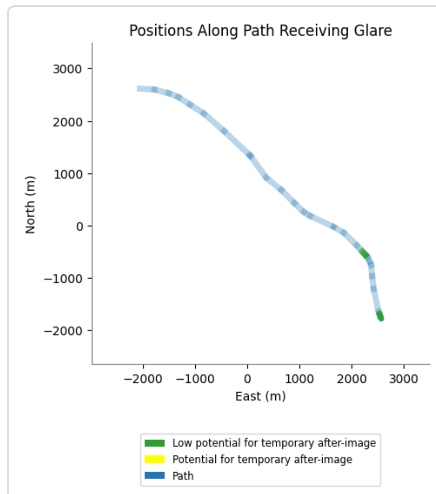
PV array 2 and Route: A1

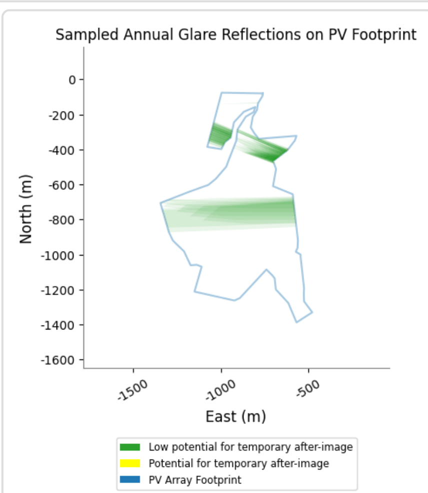
Yellow glare: none
Green glare: 480 min.





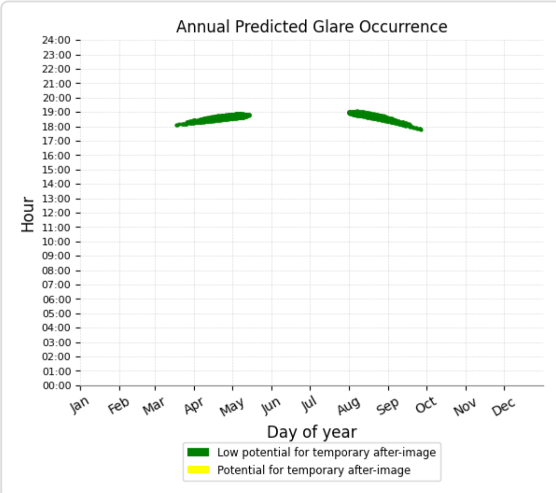


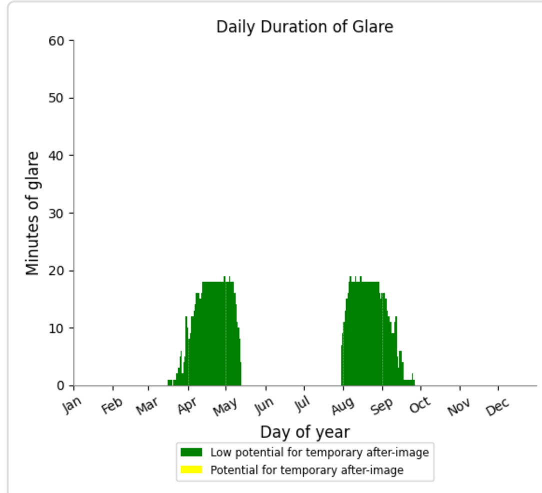


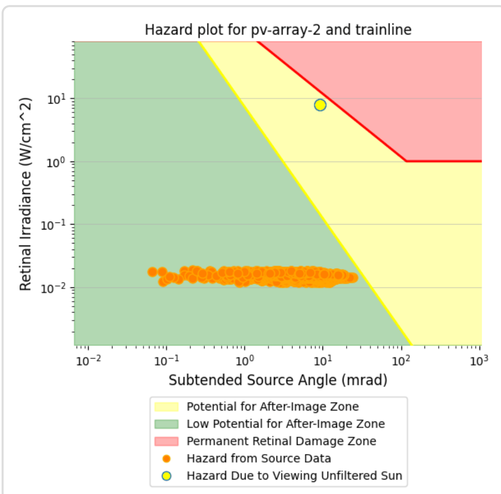


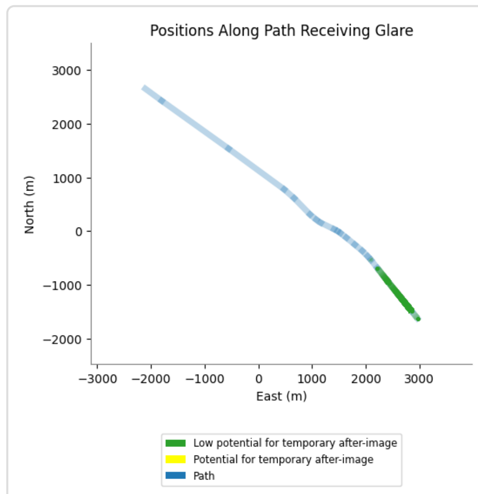
PV array 2 and Route: Trainline

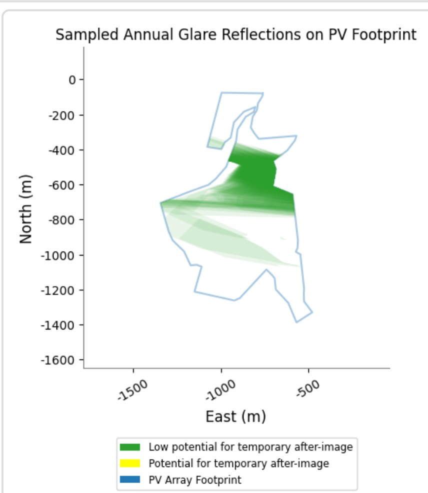
Yellow glare: none
Green glare: 1,440 min.





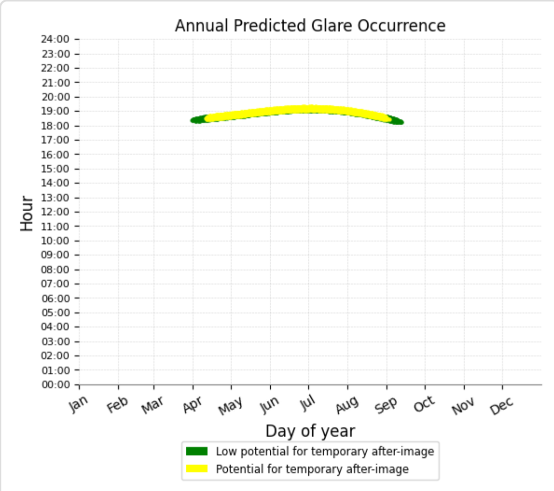


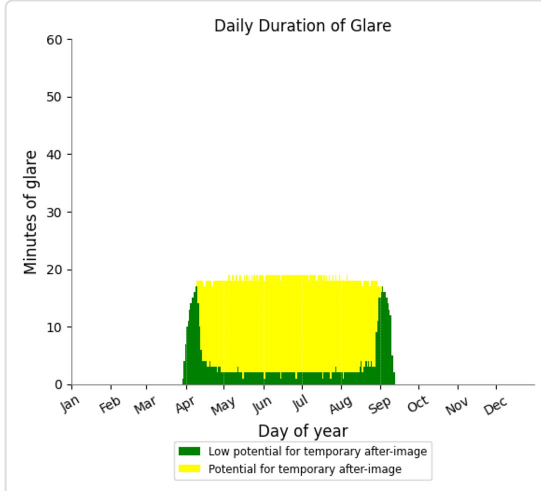


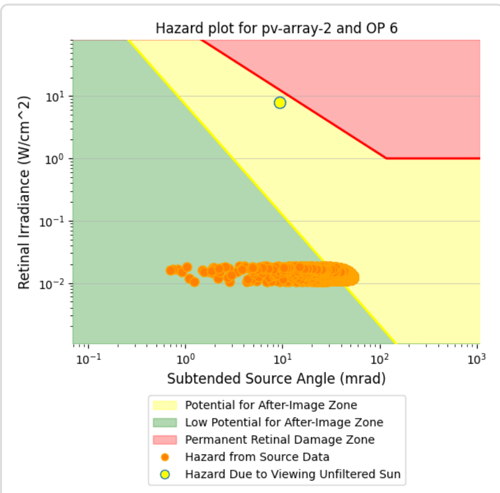


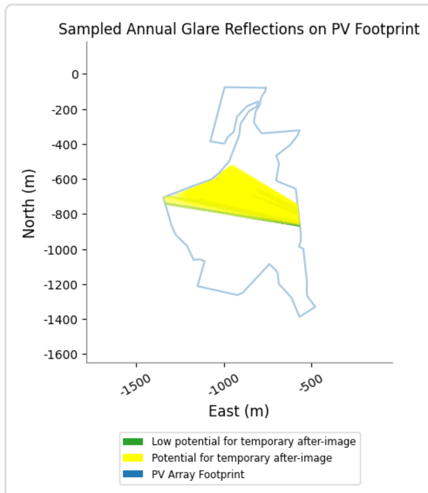
PV array 2 and OP 6

Yellow glare: 2,265 min.
Green glare: 655 min.





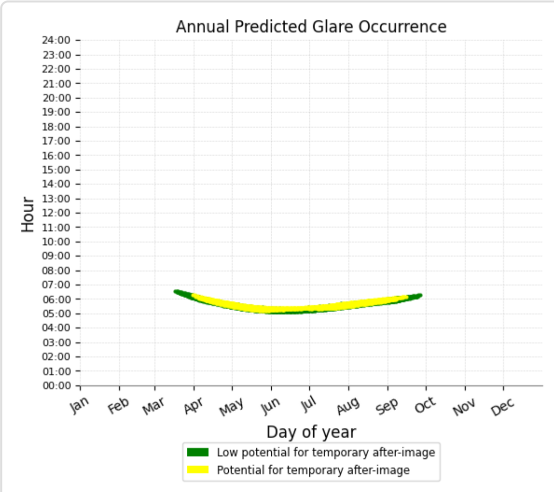


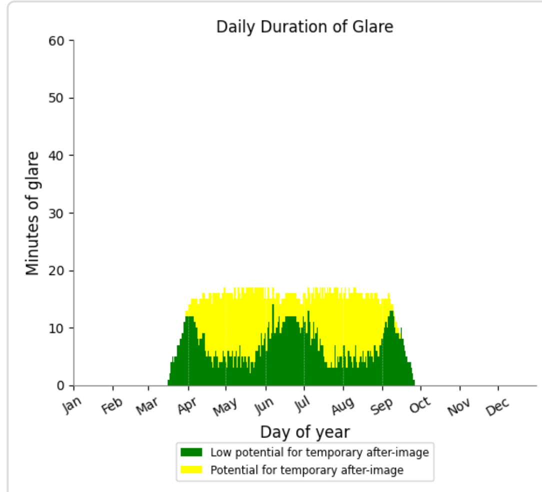


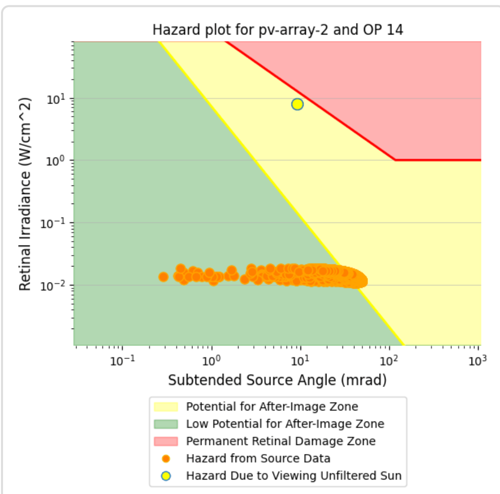
PV array 2 and OP 14

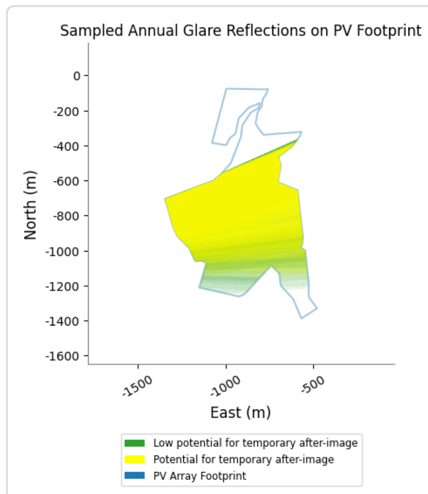
Yellow glare: 1,416 min.

Green glare: 1,359 min.





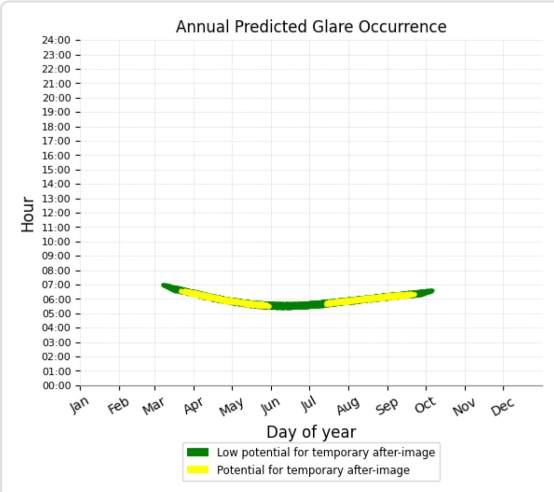


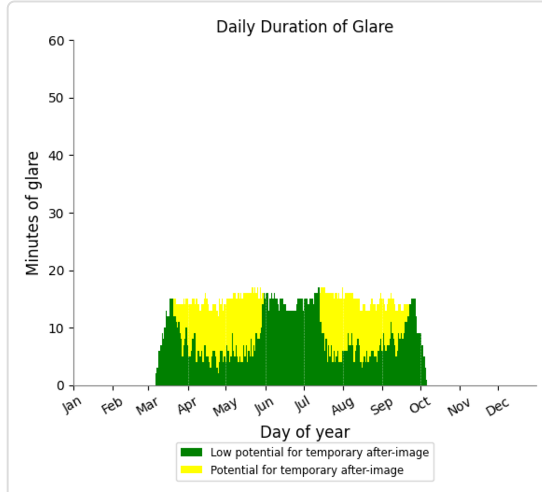


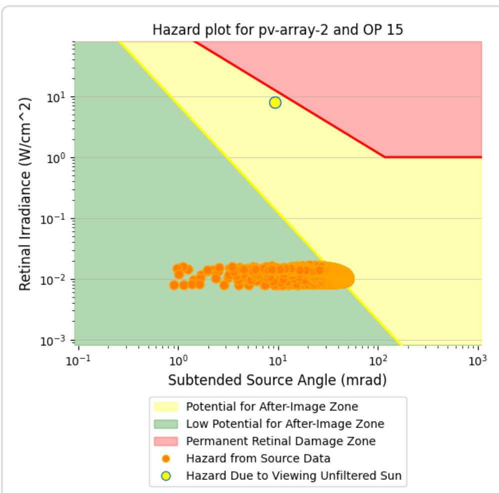
PV array 2 and OP 15

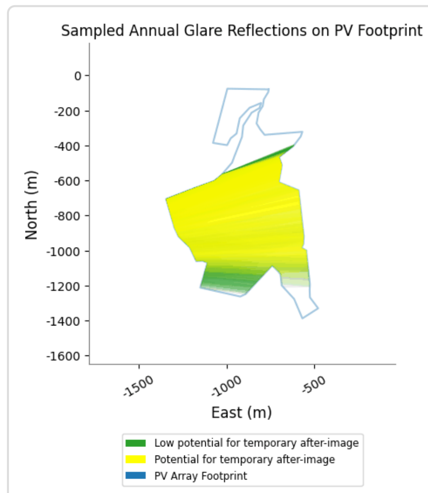
Yellow glare: 1,164 min.

Green glare: 1,851 min.





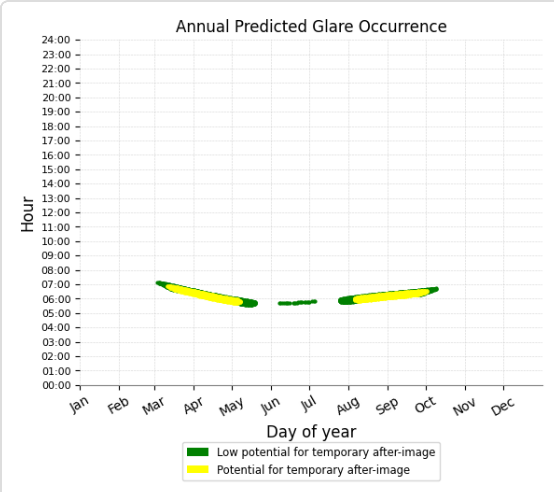


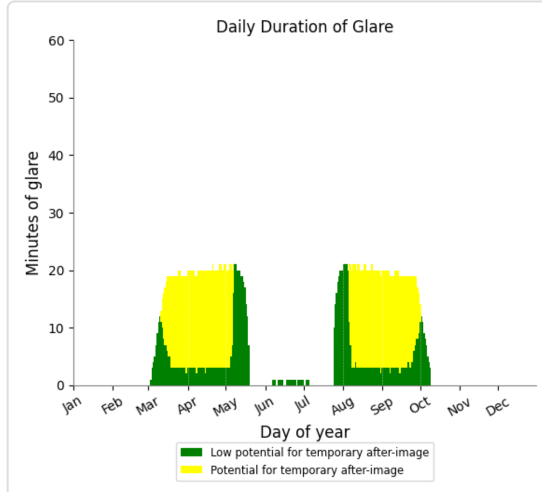


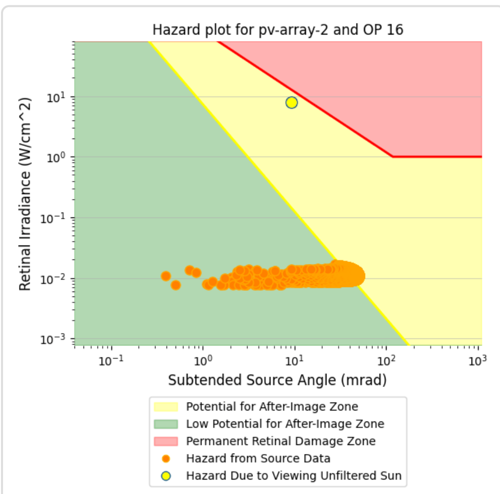
PV array 2 and OP 16

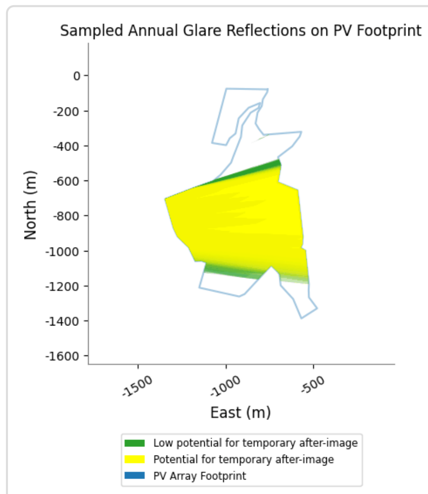
Yellow glare: 1,808 min.

Green glare: 1,004 min.





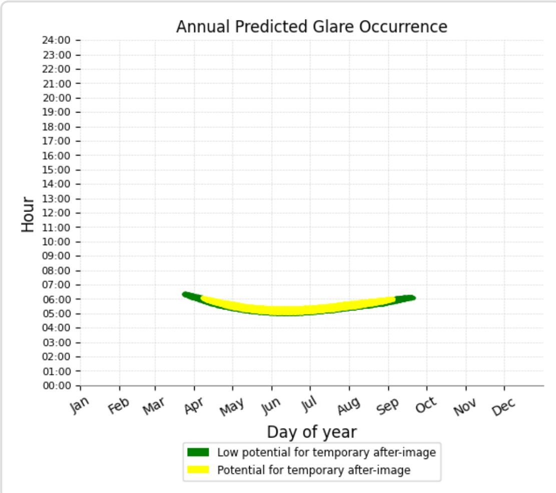


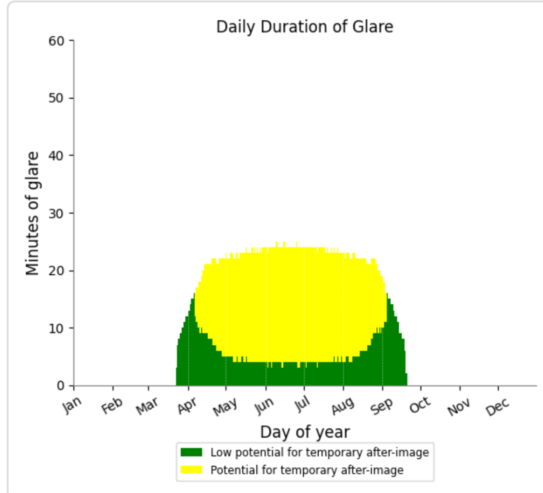


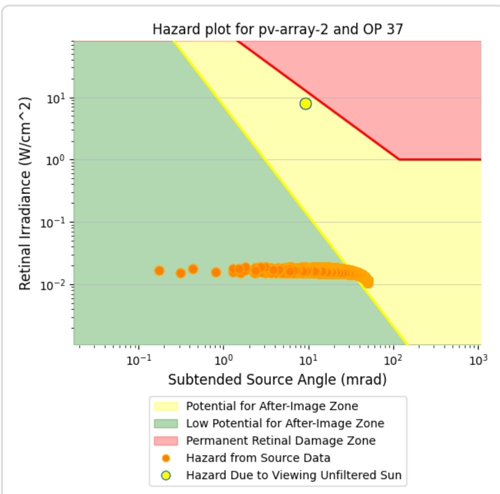
PV array 2 and OP 37

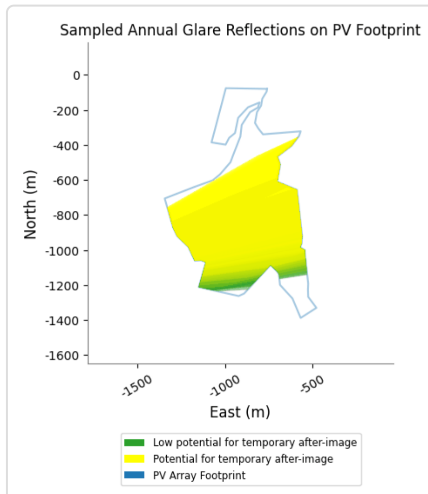
Yellow glare: 2,610 min.

Green glare: 1,138 min.





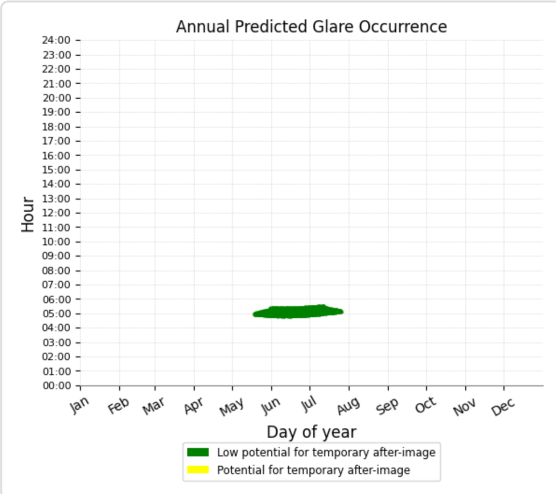


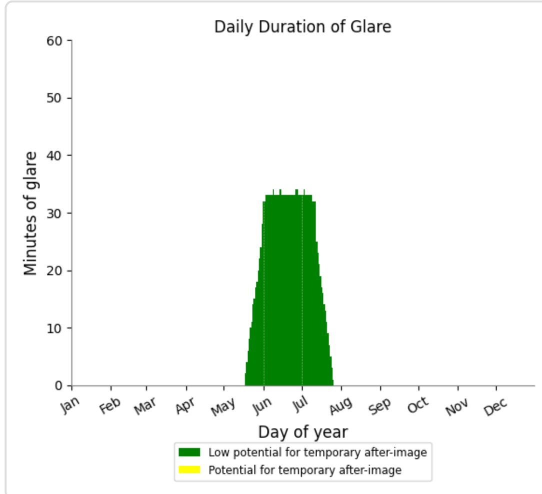


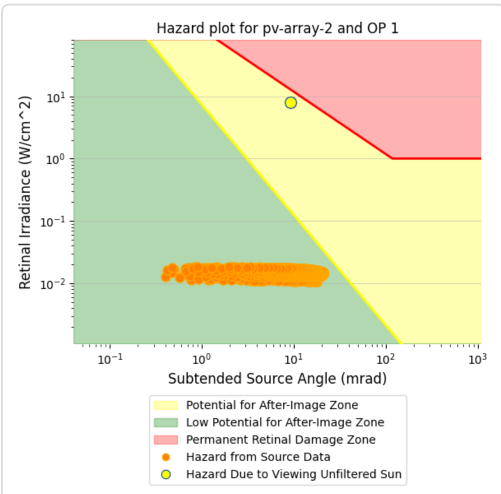
PV array 2 and OP 1

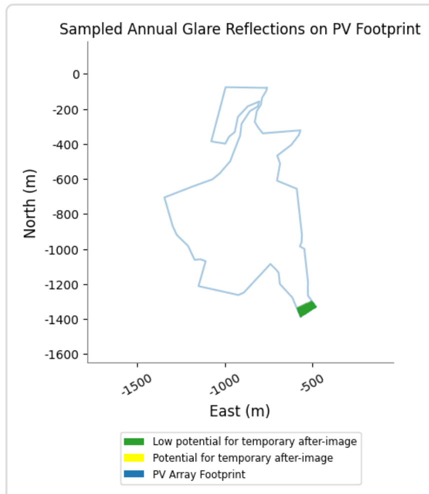
Yellow glare: none

Green glare: 1,770 min.





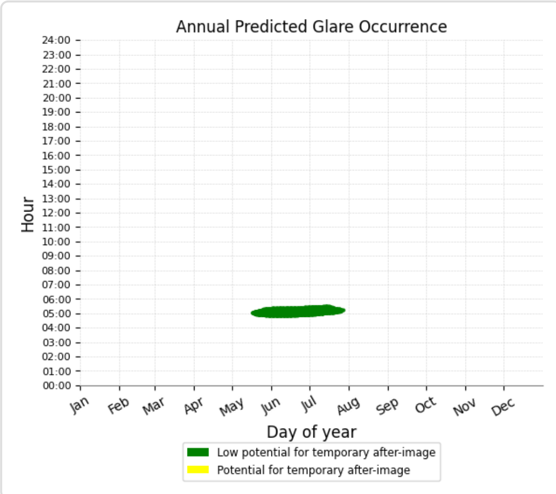


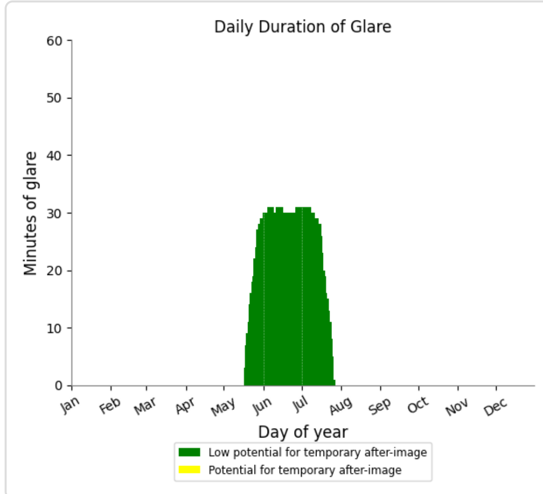


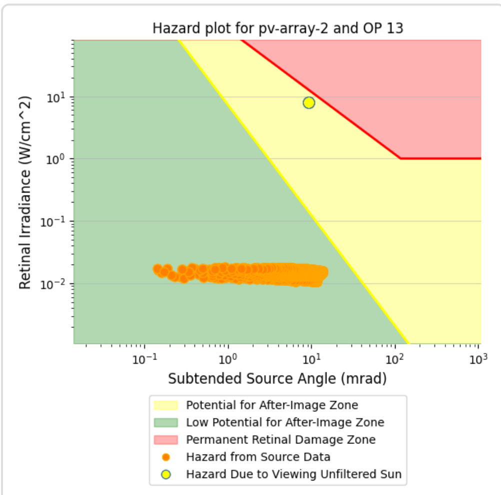
PV array 2 and OP 13

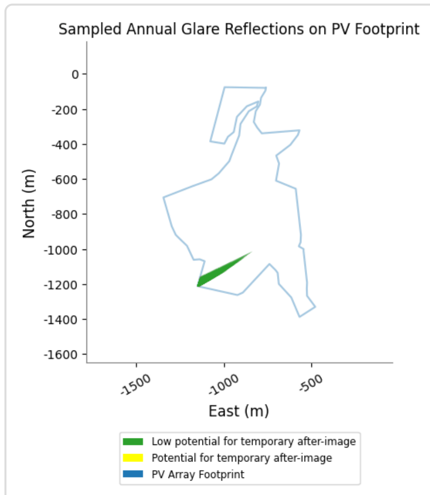
Yellow glare: none

Green glare: 1,837 min.



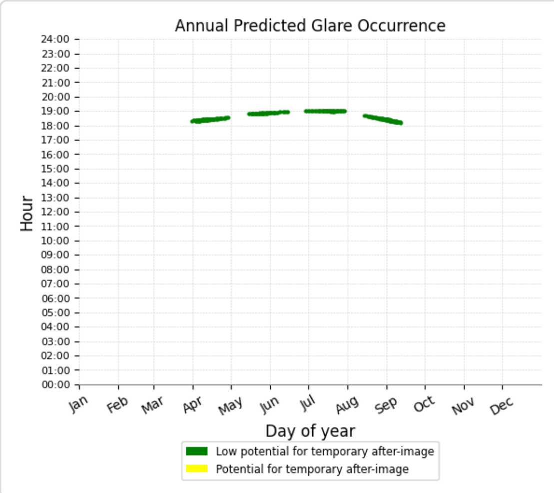


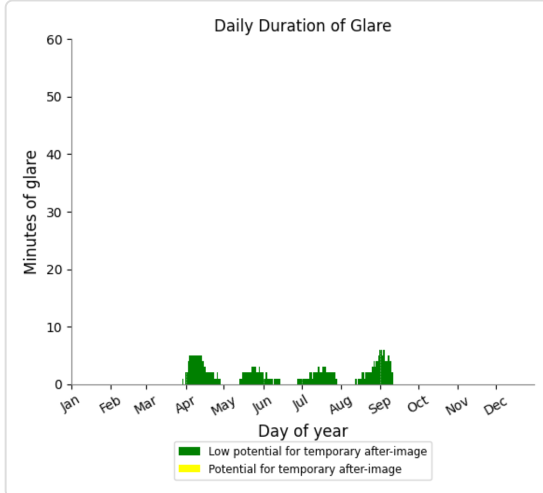


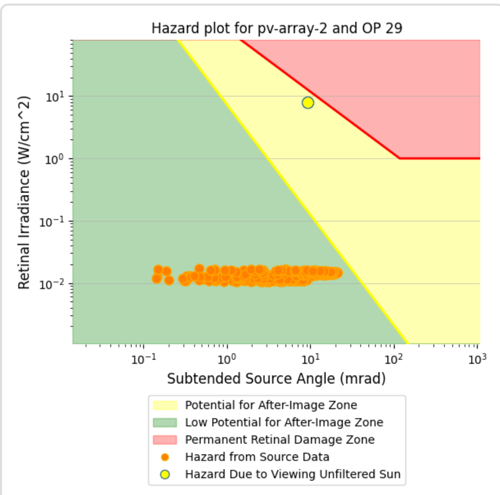


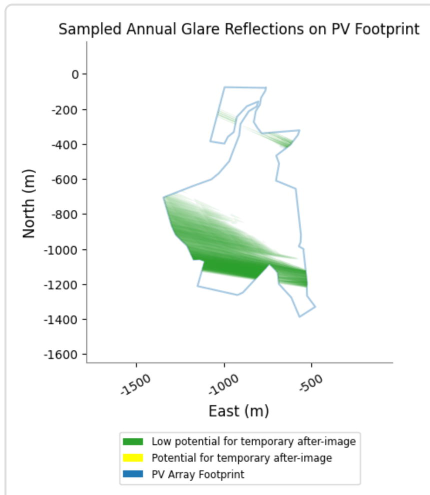
PV array 2 and OP 29

Yellow glare: none
Green glare: 292 min.





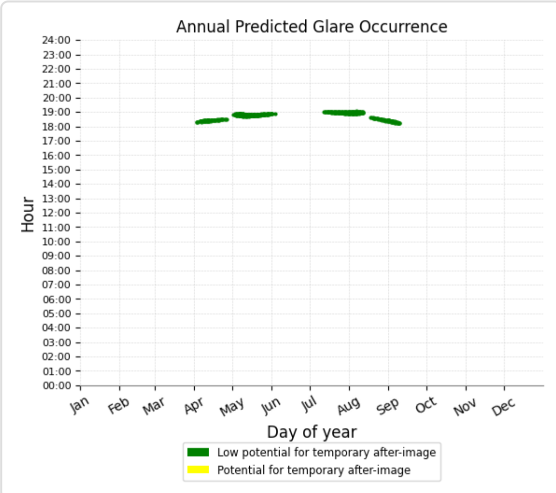


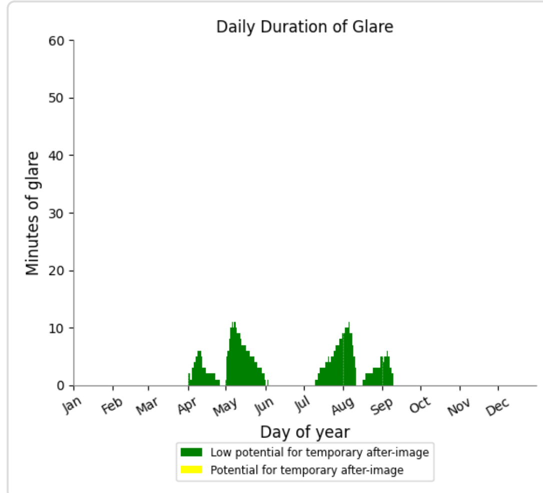


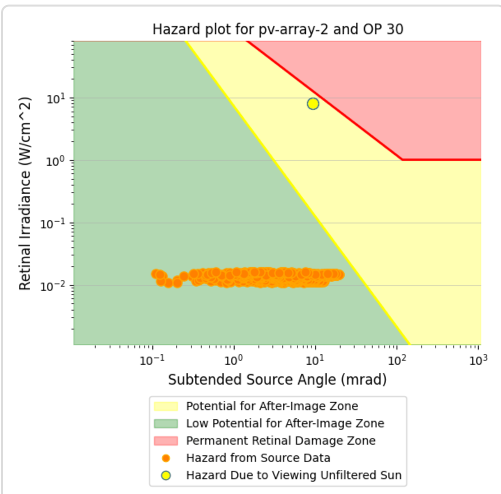
PV array 2 and OP 30

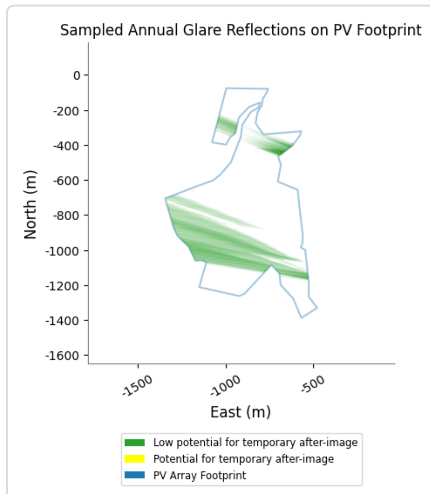
Yellow glare: none

Green glare: 524 min.





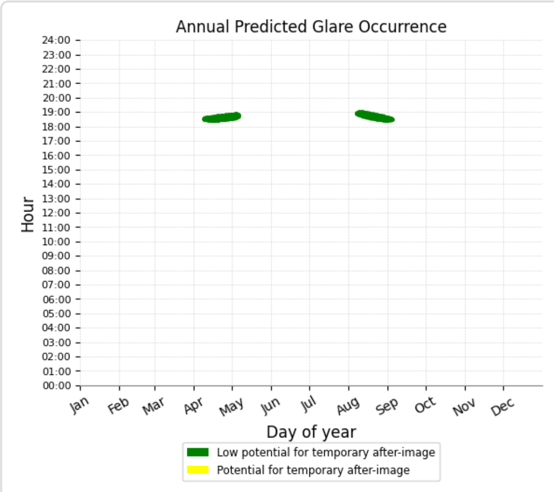


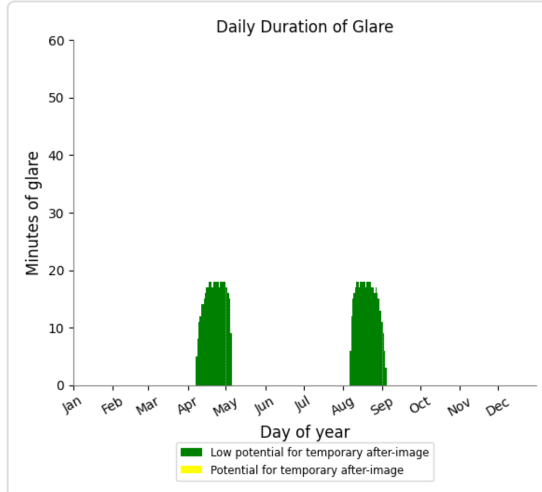


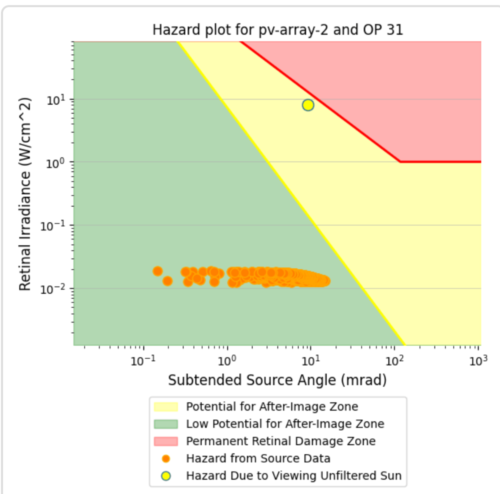
PV array 2 and OP 31

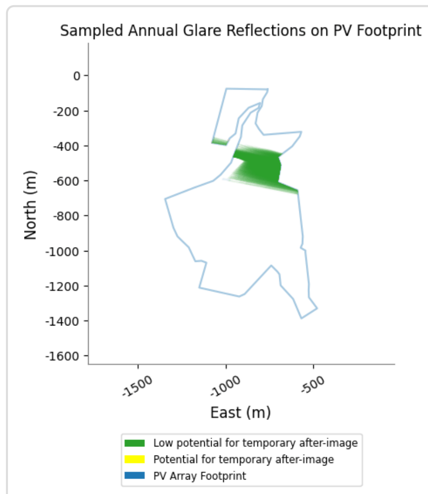
Yellow glare: none

Green glare: 867 min.



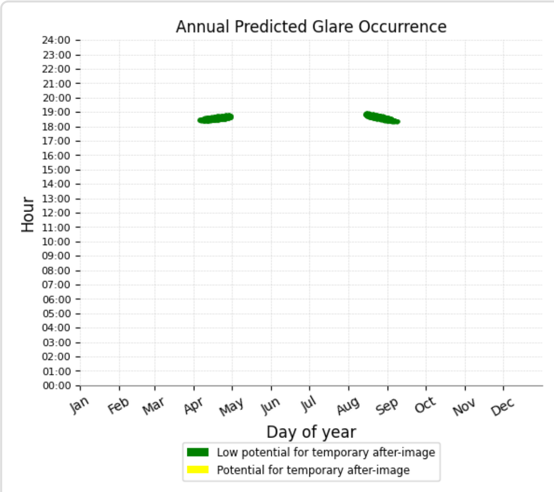


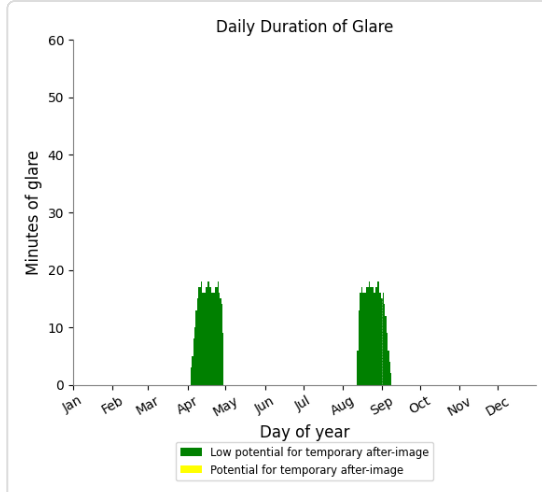


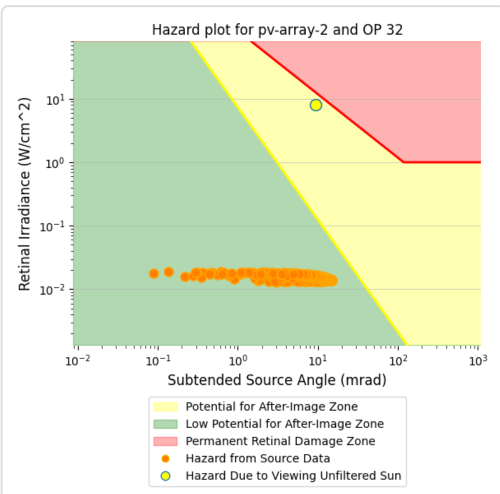


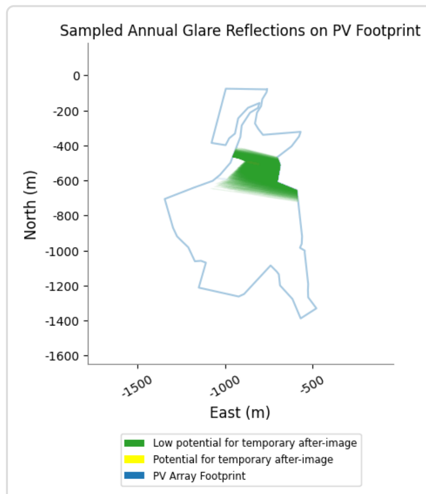
PV array 2 and OP 32

Yellow glare: none
Green glare: 759 min.





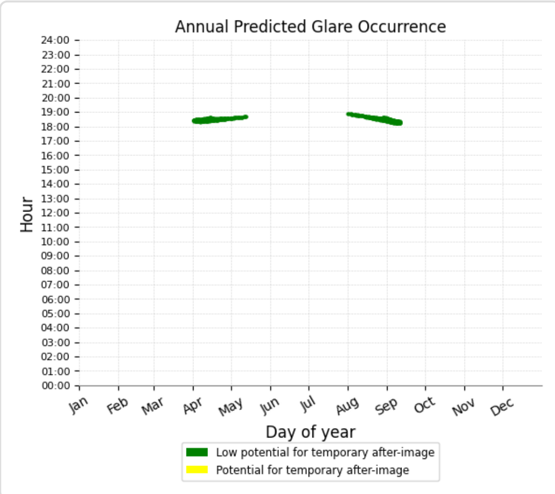


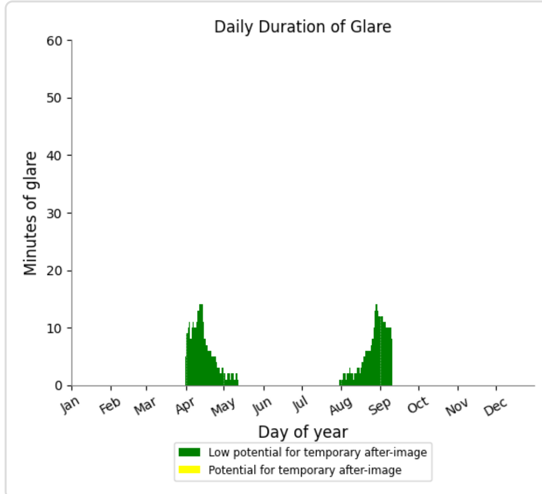


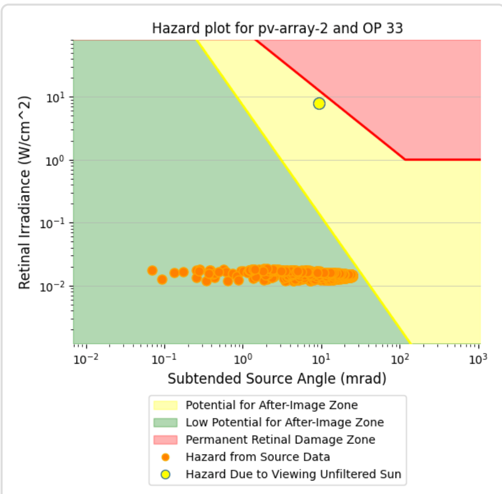
PV array 2 and OP 33

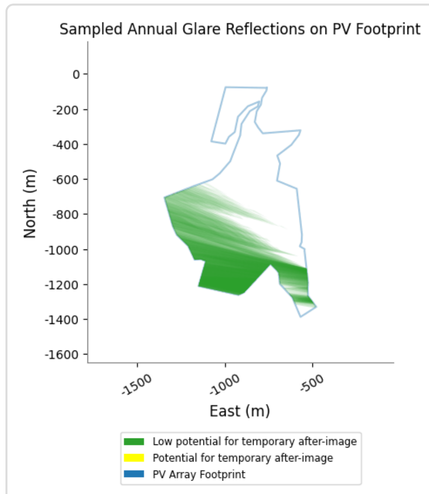
Yellow glare: none

Green glare: 508 min.



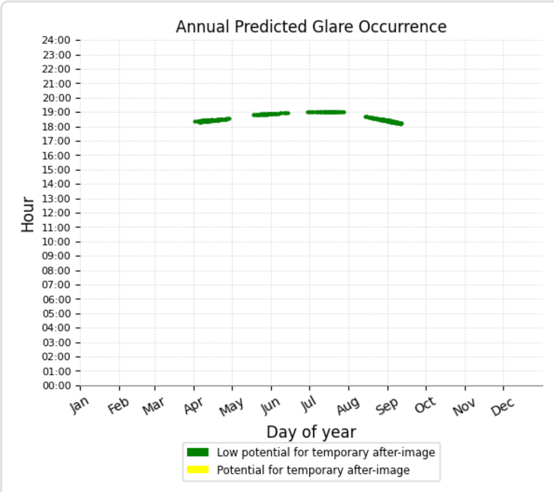


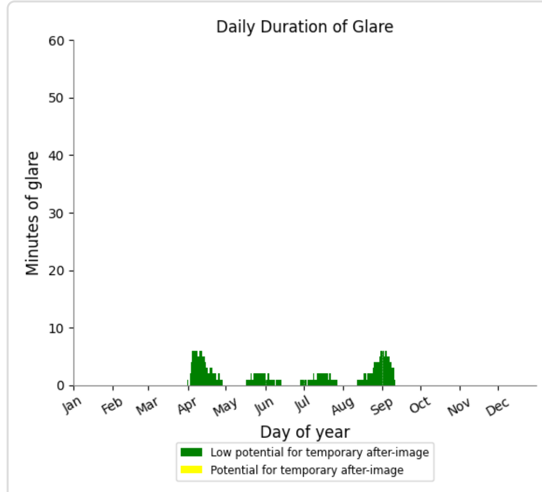


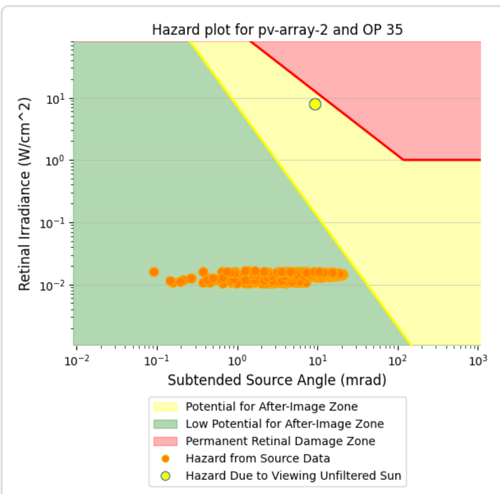


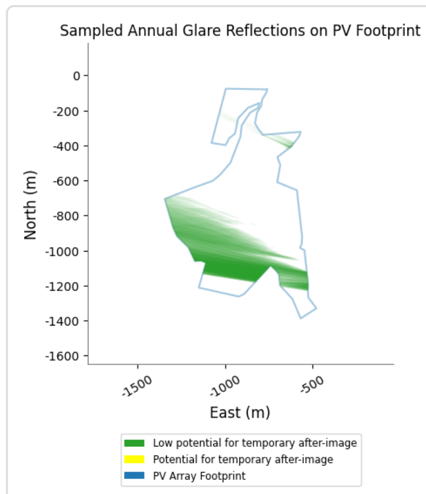
PV array 2 and OP 35

Yellow glare: none
Green glare: 268 min.









PV array 2 and OP 2

No glare found

PV array 2 and OP 3

No glare found

PV array 2 and OP 4

No glare found

PV array 2 and OP 5

No glare found

PV array 2 and OP 7

No glare found

PV array 2 and OP 8

No glare found

PV array 2 and OP 9

No glare found

PV array 2 and OP 10

No glare found

PV array 2 and OP 11

No glare found

PV array 2 and OP 12

No glare found

PV array 2 and OP 17

No glare found

PV array 2 and OP 18

No glare found

PV array 2 and OP 19

No glare found

PV array 2 and OP 20

No glare found

PV array 2 and OP 21

No glare found

PV array 2 and OP 22

No glare found

PV array 2 and OP 23

No glare found

PV array 2 and OP 24

No glare found

PV array 2 and OP 25

No glare found

PV array 2 and OP 26

No glare found

PV array 2 and OP 27

No glare found

PV array 2 and OP 28

No glare found

PV array 2 and OP 34

No glare found

PV array 2 and OP 36

No glare found

PV array 2 and OP 38

No glare found

PV array 2 and OP 39

No glare found

PV array 2 and OP 40

No glare found

PV: PV array 3 potential temporary after-image

Receptor results ordered by category of glare

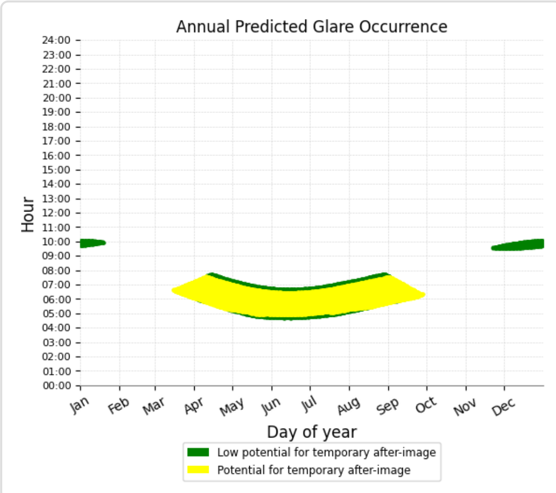
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Route 2	4,532	75.5	17,172	286.2
A1	73	1.2	0	0.0
Route 1	1,778	29.6	0	0.0
Trainline	481	8.0	0	0.0
OP 14	1,462	24.4	3,299	55.0
OP 15	1,004	16.7	3,160	52.7
OP 16	1,626	27.1	638	10.6
OP 37	2,809	46.8	2,644	44.1
OP 6	220	3.7	0	0.0
OP 29	193	3.2	0	0.0
OP 30	146	2.4	0	0.0
OP 31	43	0.7	0	0.0
OP 32	49	0.8	0	0.0
OP 33	328	5.5	0	0.0
OP 35	182	3.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	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 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	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

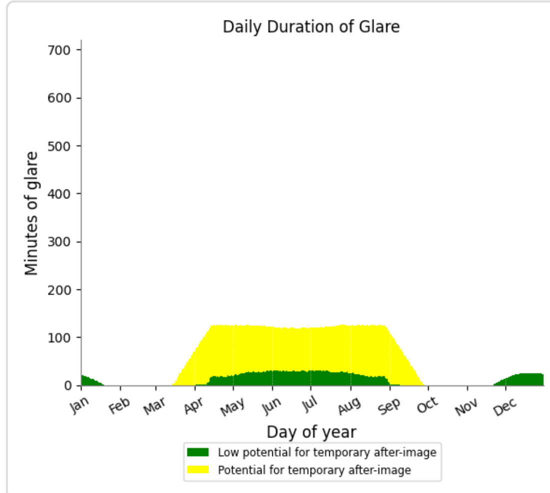
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 34	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

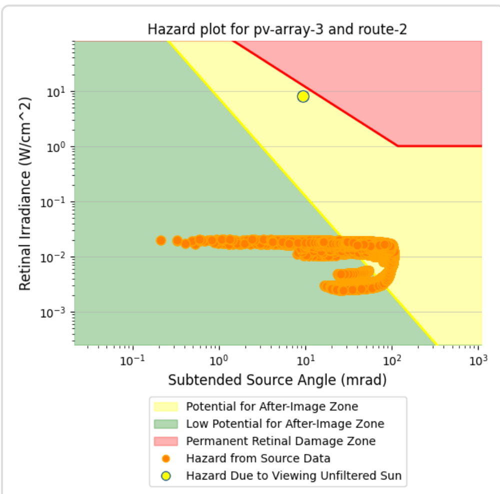
PV array 3 and Route: Route 2

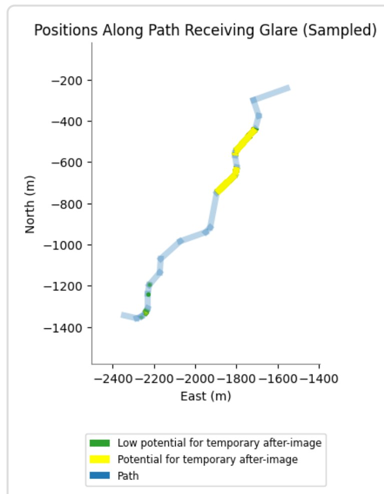
Yellow glare: 17,172 min.

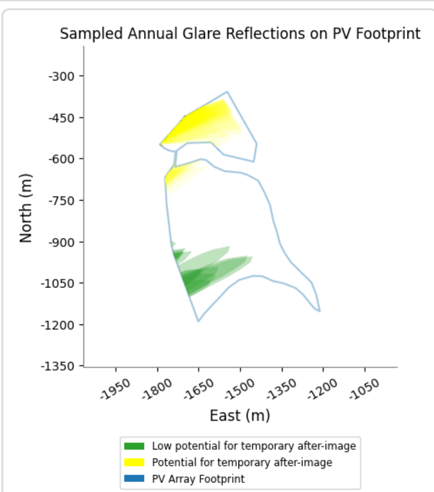
Green glare: 4,532 min.







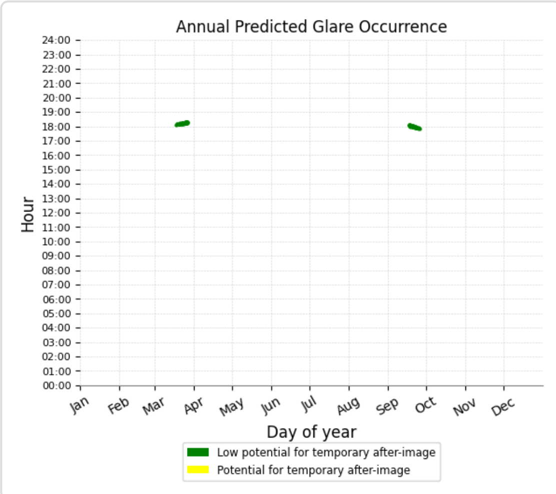


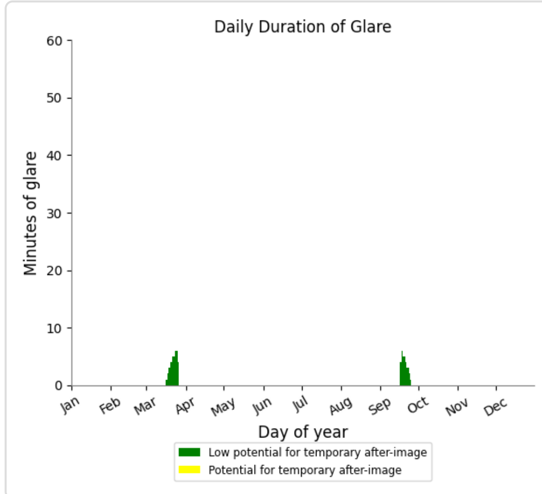


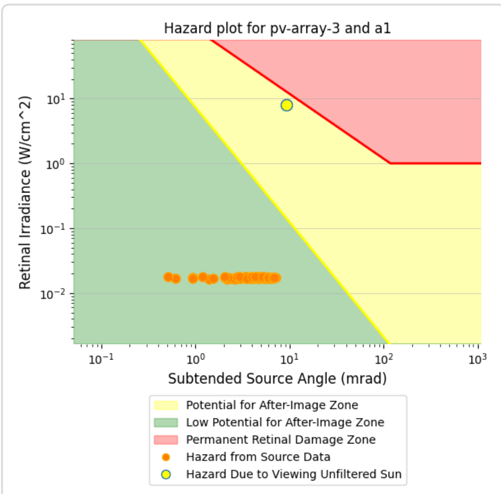
PV array 3 and Route: A1

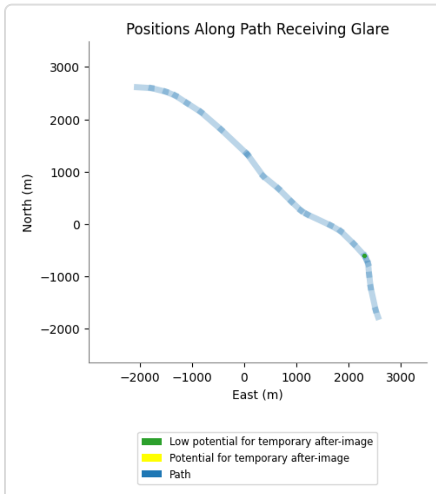
Yellow glare: none

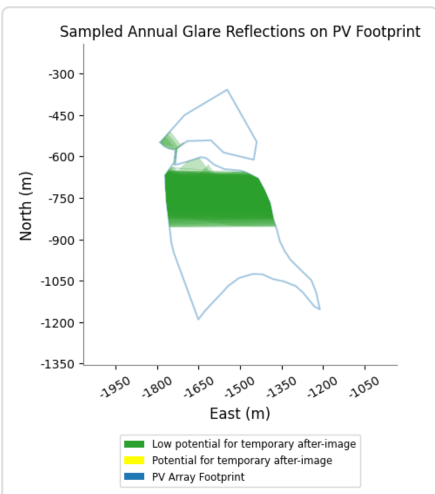
Green glare: 73 min.





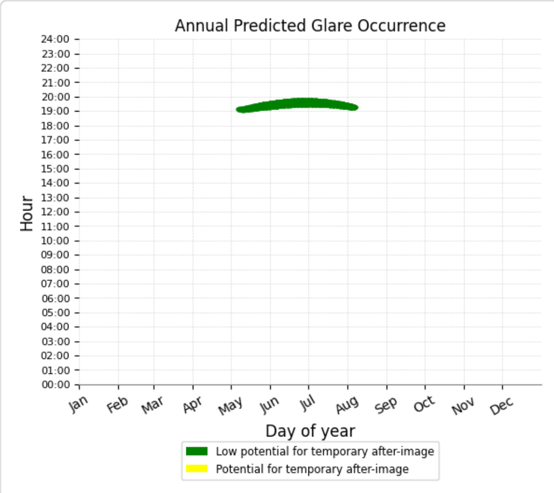


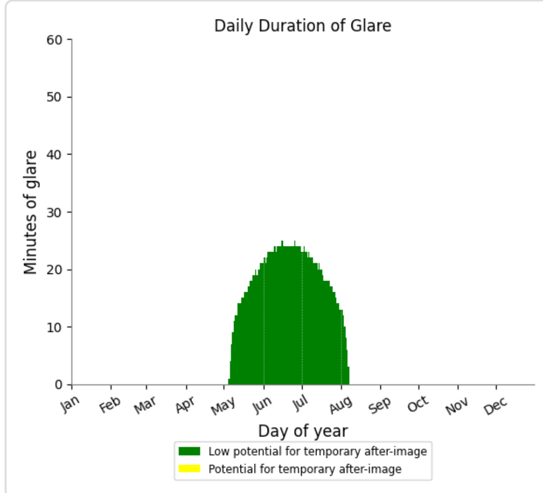


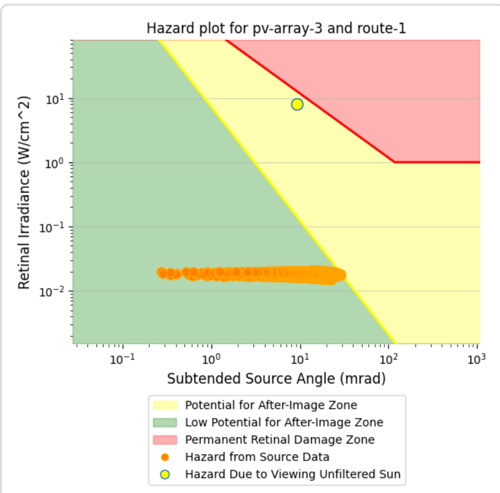


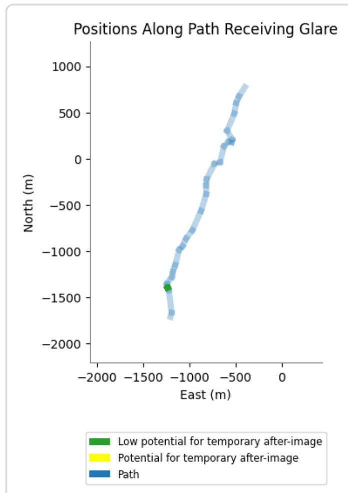
PV array 3 and Route: Route 1

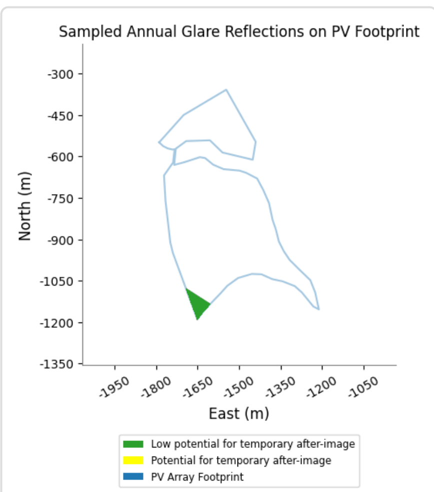
Yellow glare: none
Green glare: 1,778 min.







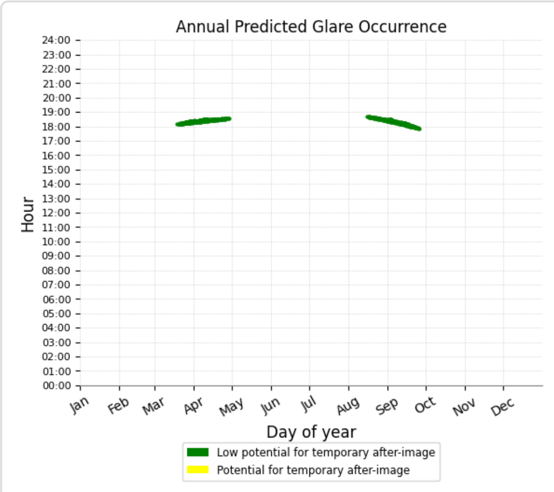


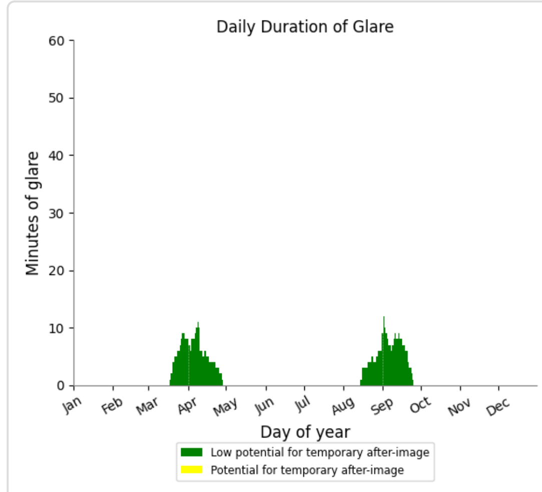


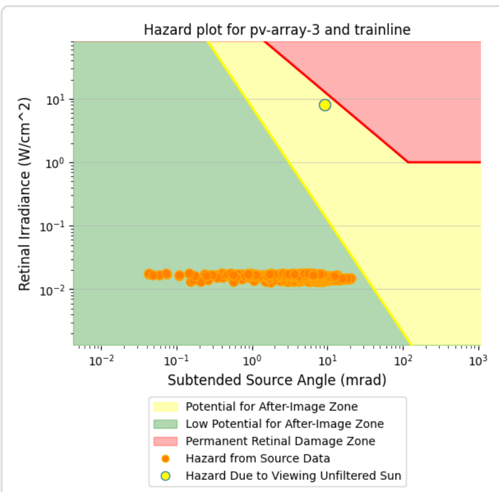
PV array 3 and Route: Trainline

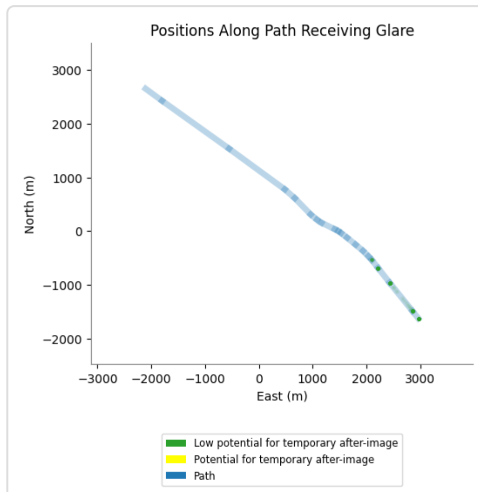
Yellow glare: none

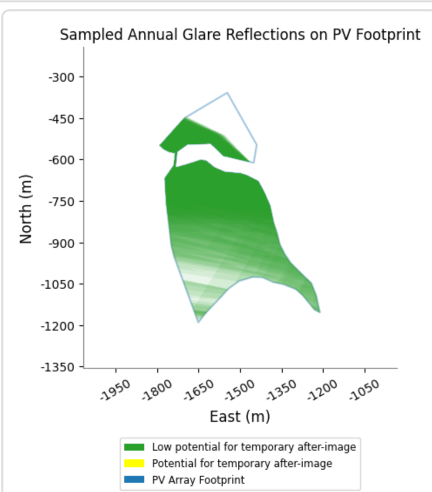
Green glare: 481 min.







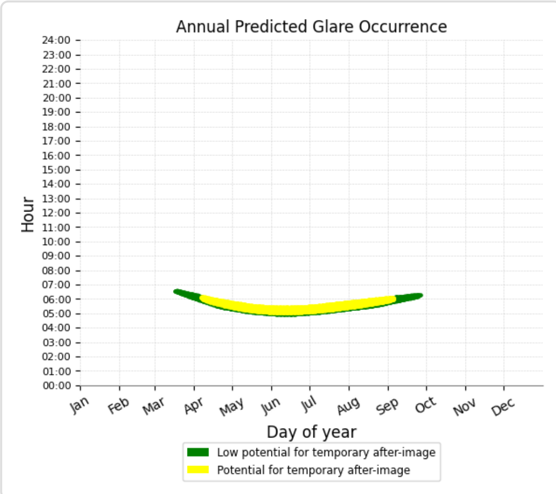


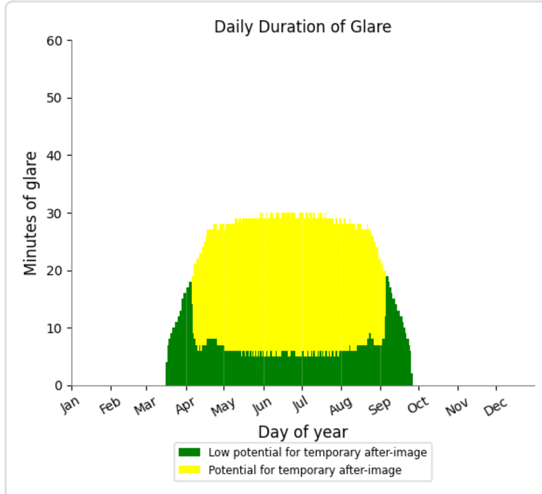


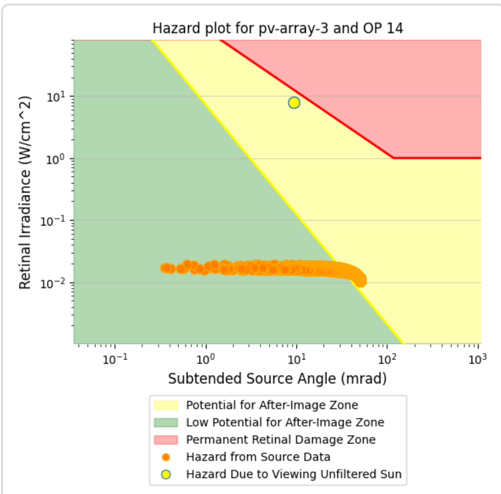
PV array 3 and OP 14

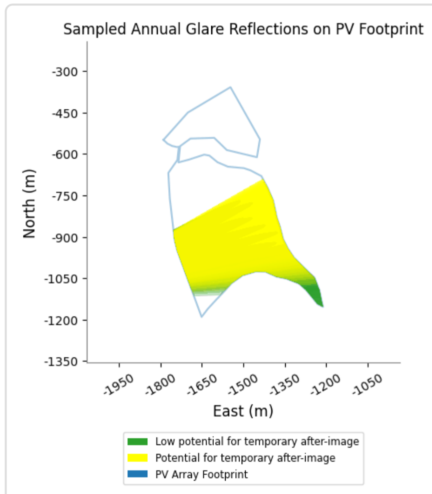
Yellow glare: 3,299 min.

Green glare: 1,462 min.



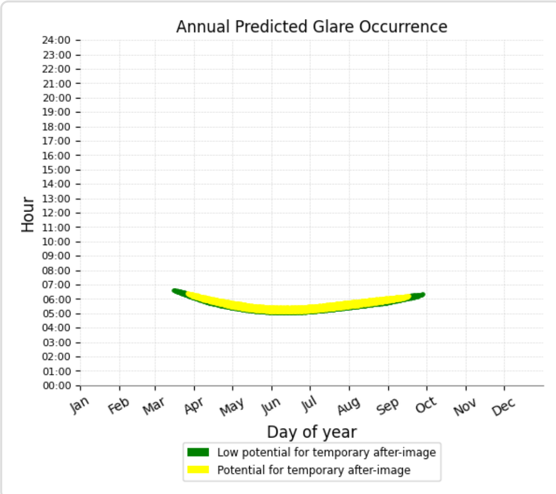


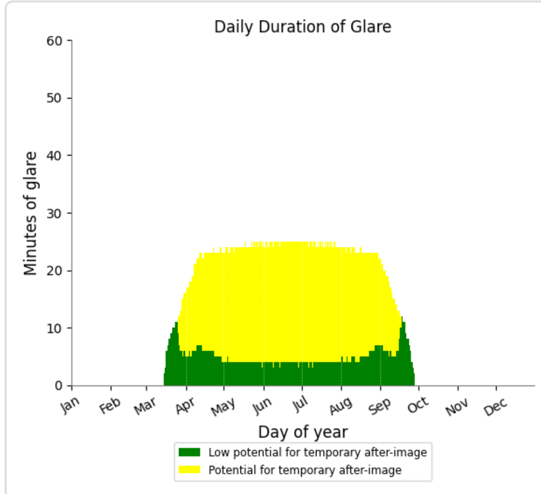


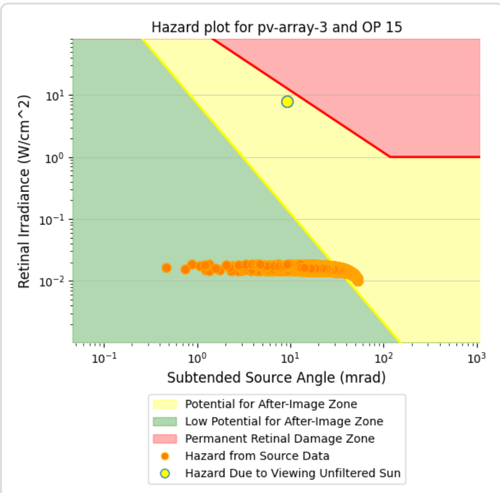


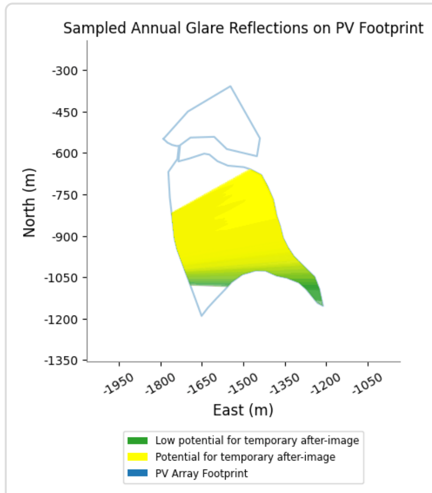
PV array 3 and OP 15

Yellow glare: 3,160 min.
Green glare: 1,004 min.



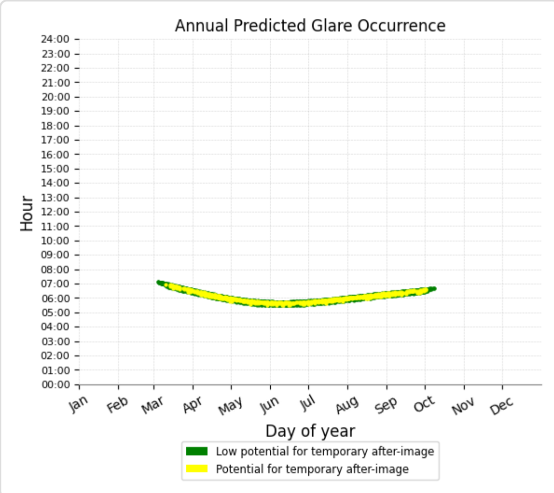


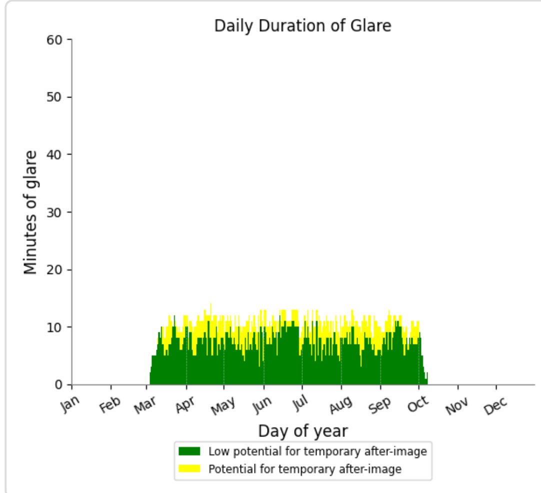


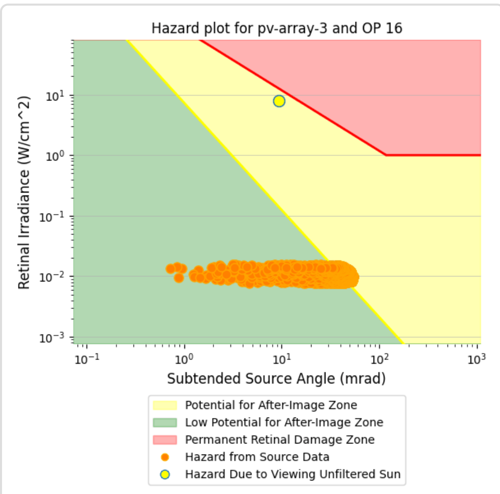


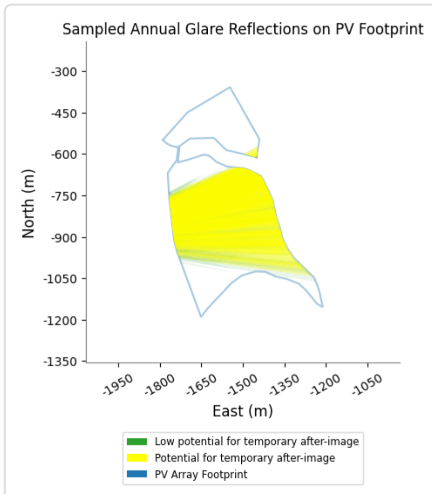
PV array 3 and OP 16

Yellow glare: 638 min.
Green glare: 1,626 min.





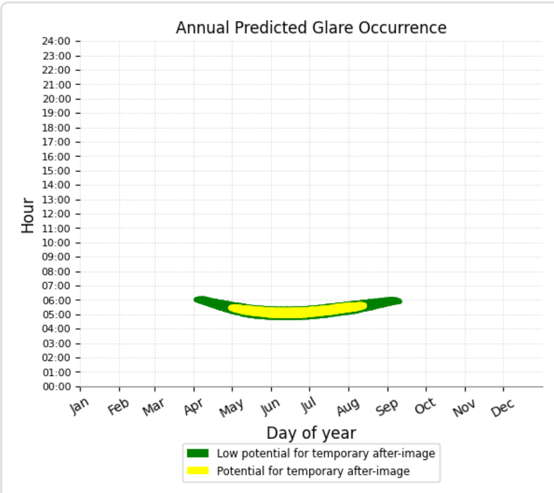


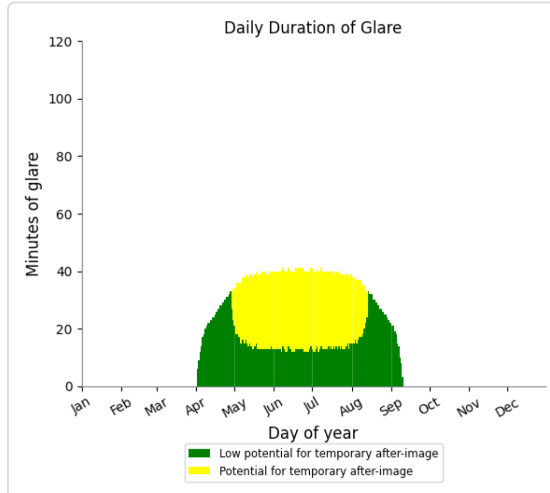


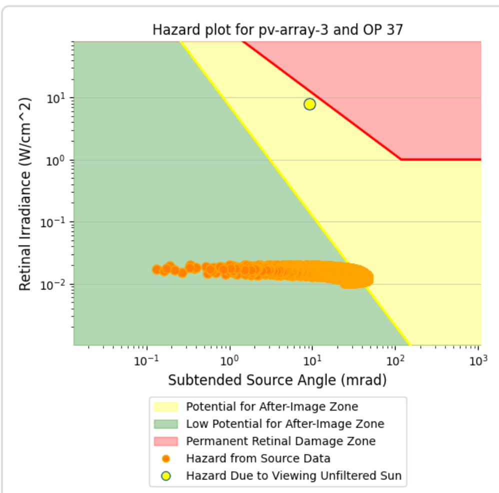
PV array 3 and OP 37

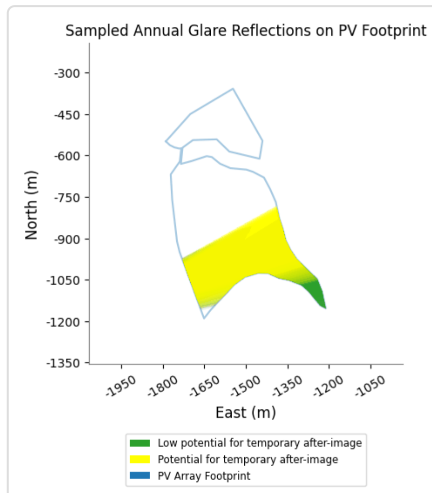
Yellow glare: 2,644 min.

Green glare: 2,809 min.





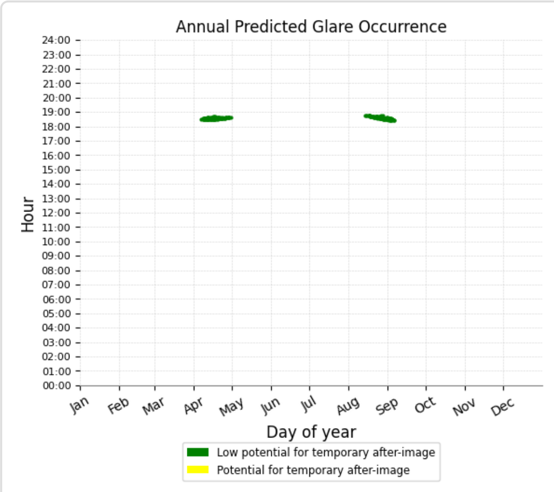


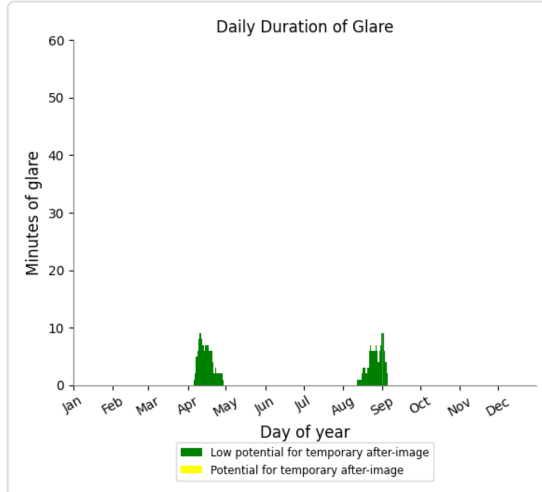


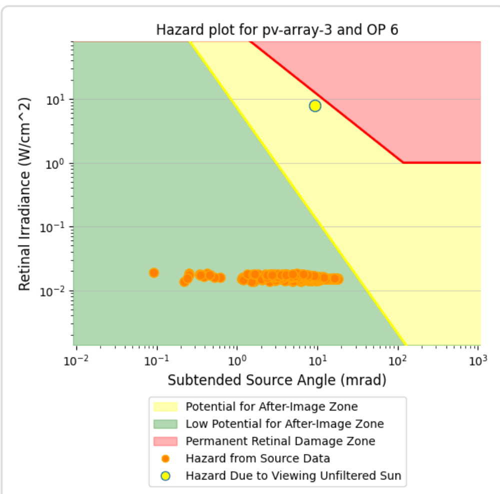
PV array 3 and OP 6

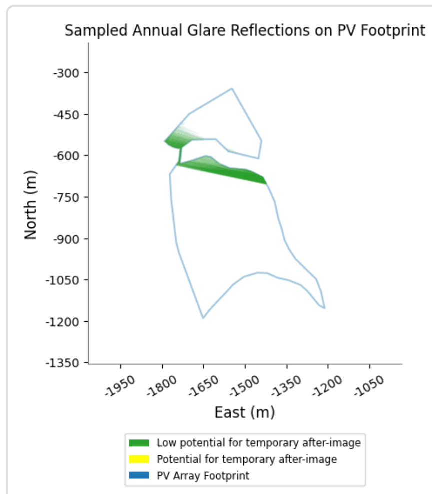
Yellow glare: none

Green glare: 220 min.



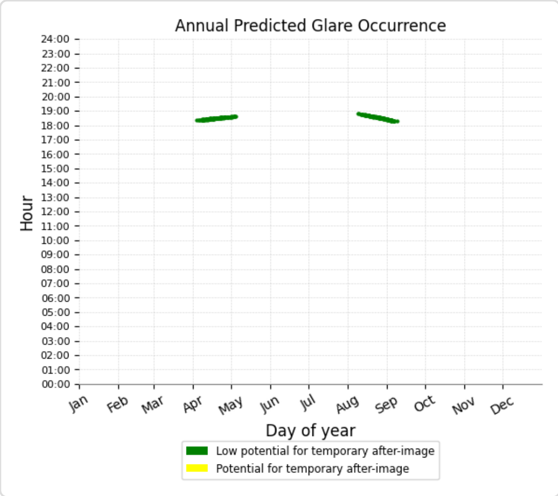


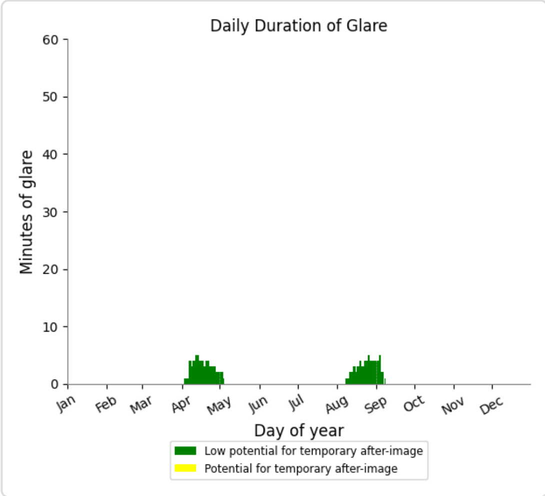


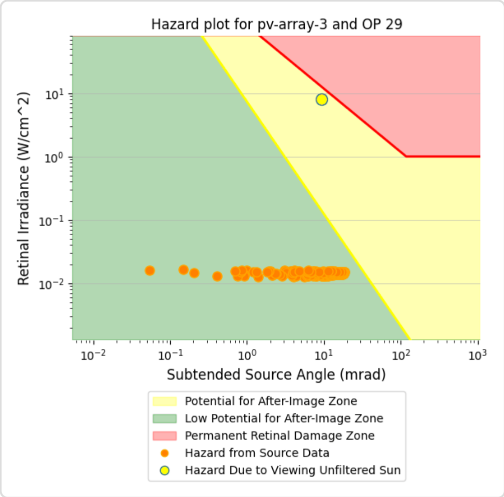


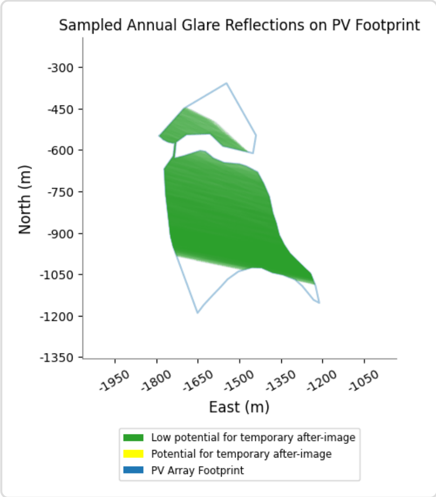
PV array 3 and OP 29

Yellow glare: none
Green glare: 193 min.





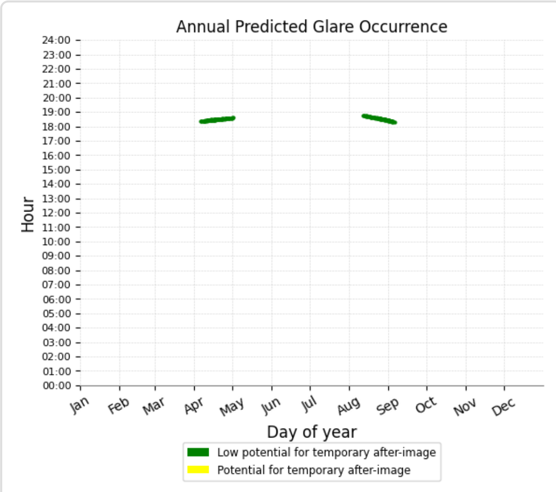


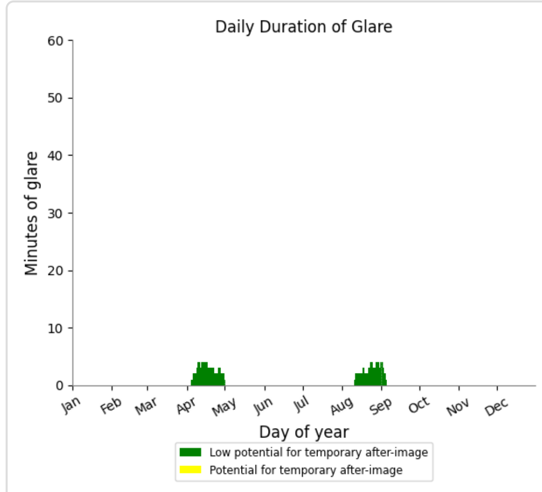


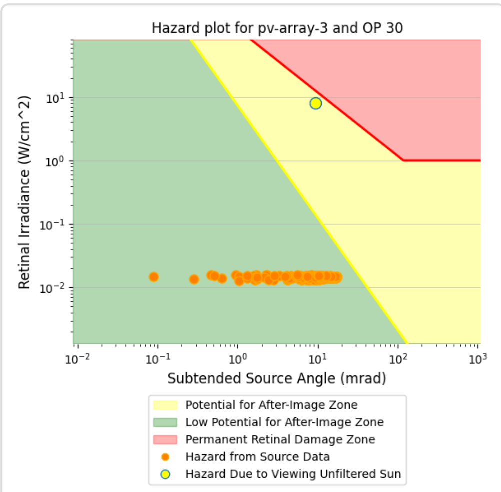
PV array 3 and OP 30

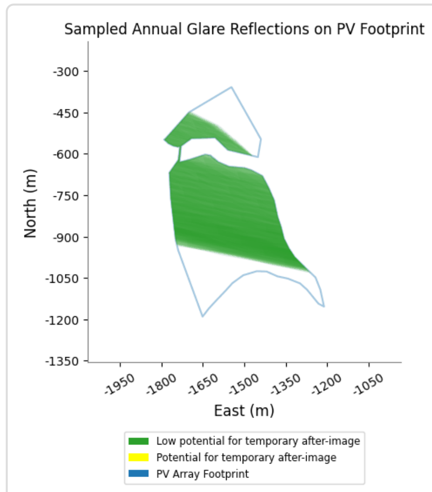
Yellow glare: none

Green glare: 146 min.





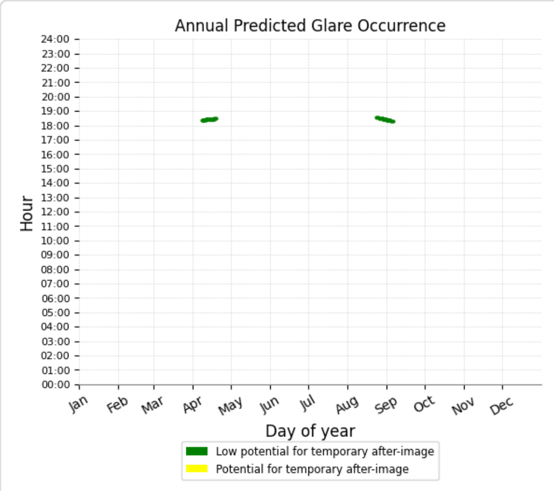


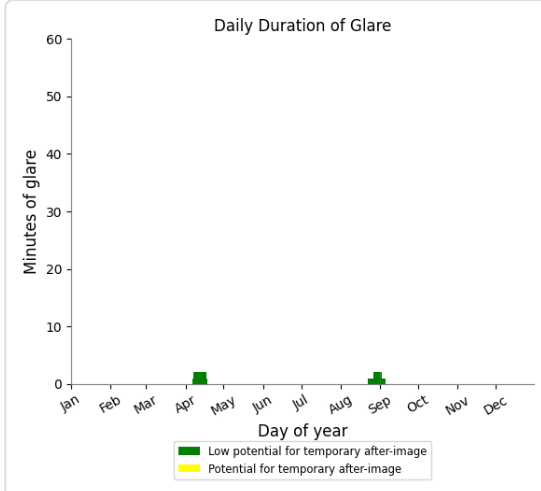


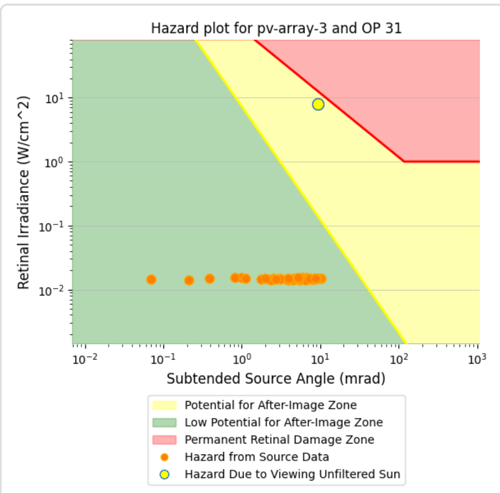
PV array 3 and OP 31

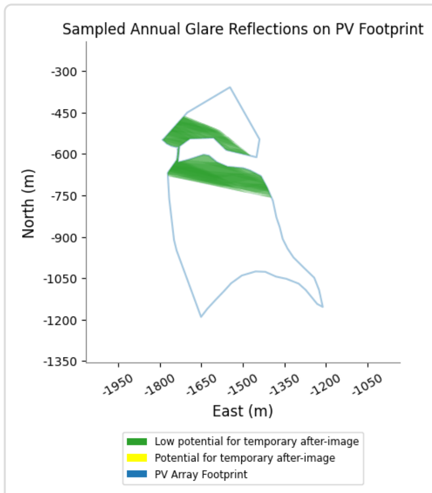
Yellow glare: none

Green glare: 43 min.



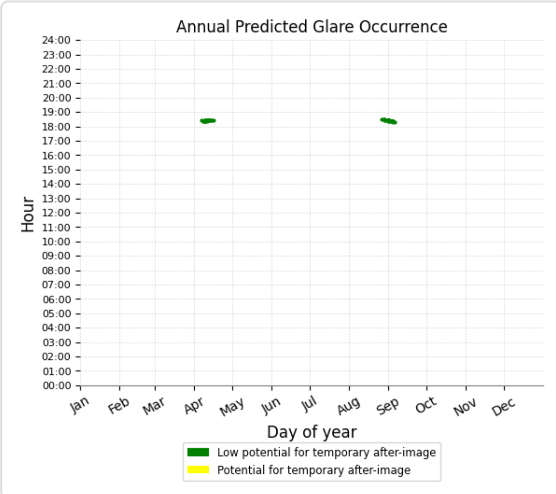


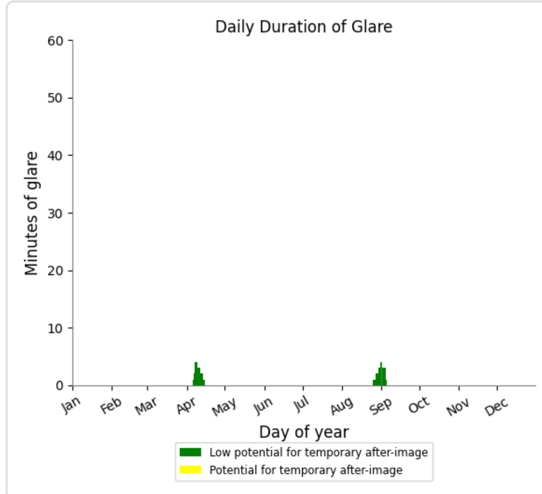


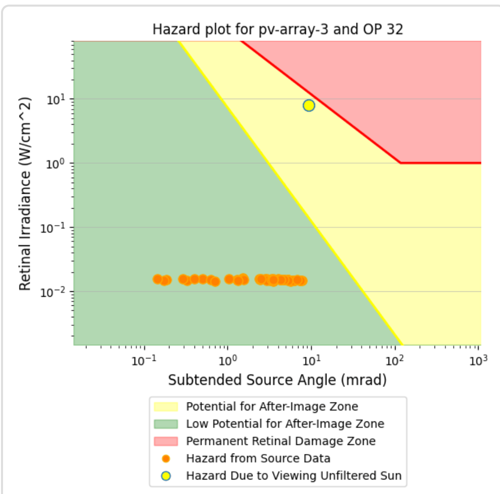


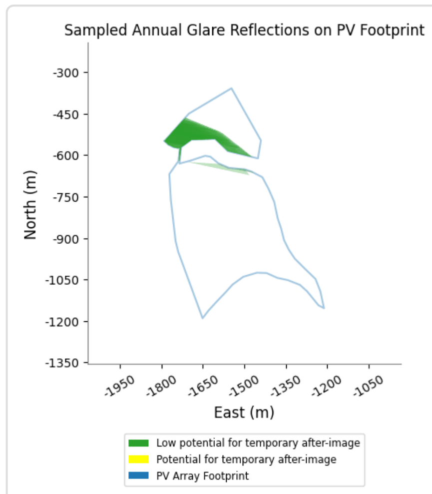
PV array 3 and OP 32

Yellow glare: none
Green glare: 49 min.





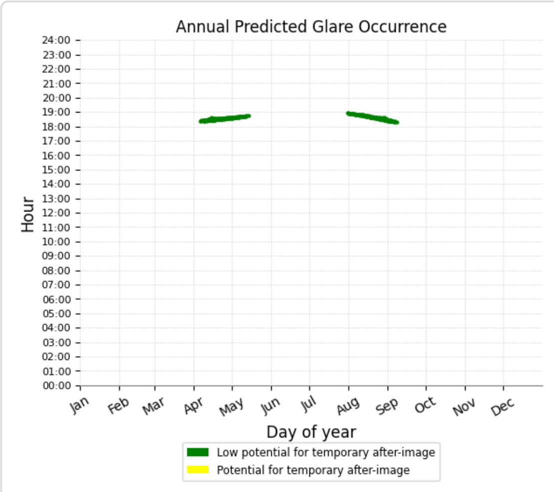


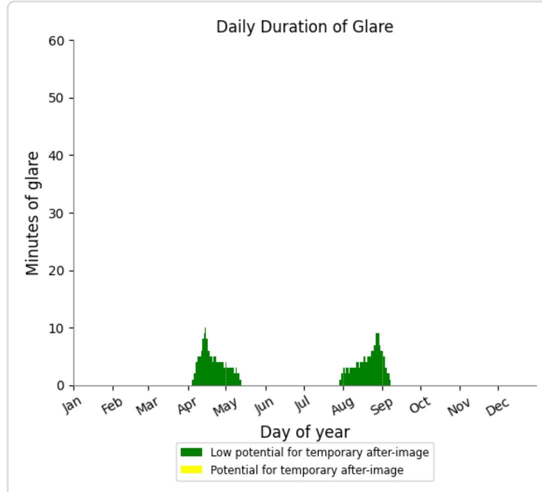


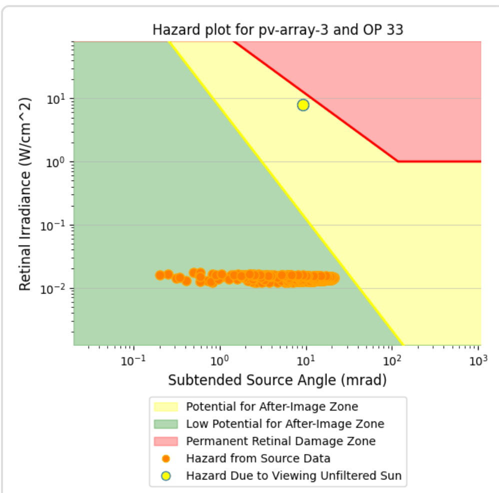
PV array 3 and OP 33

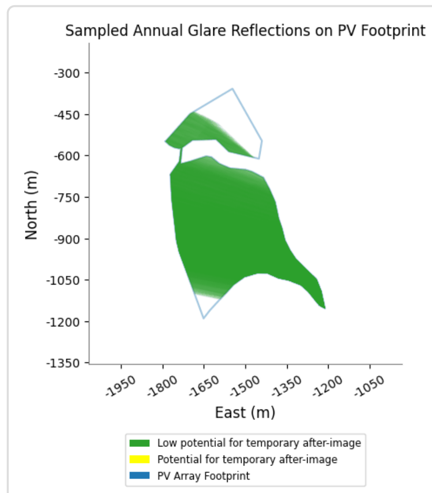
Yellow glare: none

Green glare: 328 min.



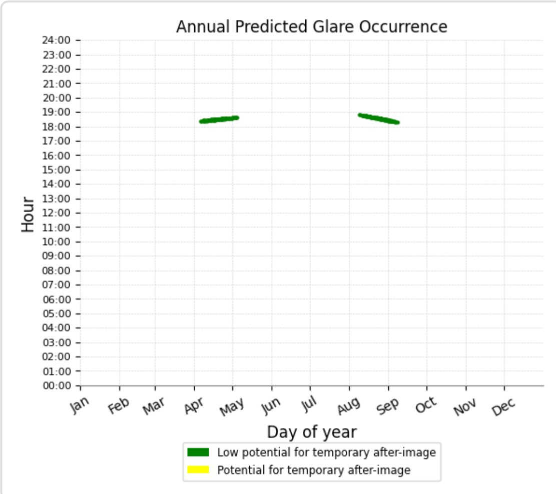


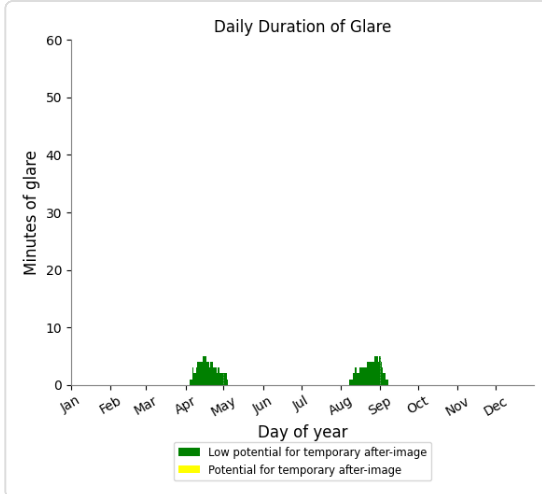


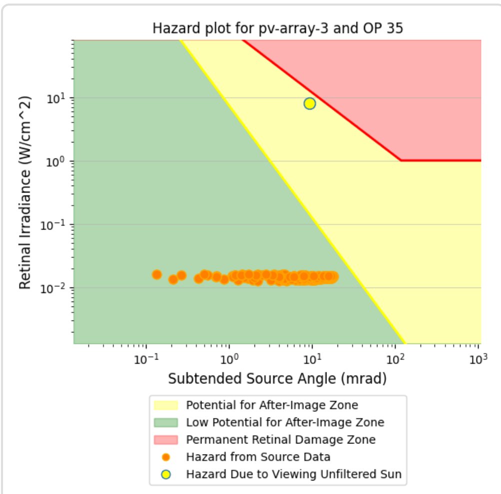


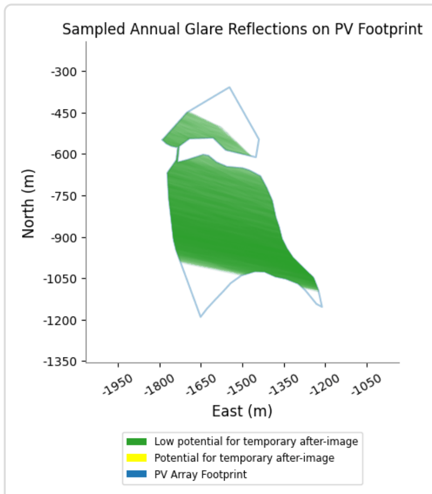
PV array 3 and OP 35

Yellow glare: none
Green glare: 182 min.









PV array 3 and OP 1

No glare found

PV array 3 and OP 2

No glare found

PV array 3 and OP 3

No glare found

PV array 3 and OP 4

No glare found

PV array 3 and OP 5

No glare found

PV array 3 and OP 7

No glare found

PV array 3 and OP 8

No glare found

PV array 3 and OP 9

No glare found

PV array 3 and OP 10

No glare found

PV array 3 and OP 11

No glare found

PV array 3 and OP 12

No glare found

PV array 3 and OP 13

No glare found

PV array 3 and OP 17

No glare found

PV array 3 and OP 18

No glare found

PV array 3 and OP 19

No glare found

PV array 3 and OP 20

No glare found

PV array 3 and OP 21

No glare found

PV array 3 and OP 22

No glare found

PV array 3 and OP 23

No glare found

PV array 3 and OP 24

No glare found

PV array 3 and OP 25

No glare found

PV array 3 and OP 26

No glare found

PV array 3 and OP 27

No glare found

PV array 3 and OP 28

No glare found

PV array 3 and OP 34

No glare found

PV array 3 and OP 36

No glare found

PV array 3 and OP 38

No glare found

PV array 3 and OP 39

No glare found

PV array 3 and OP 40

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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