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Goulburn Valley Water Solar Farm – Seymour

Glare Assessment Report

Goulburn Valley Water

26 March 2024

→ The Power of Commitment

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The Power of Commitment

Executive Summary

This report is subject to, and must be read in conjunction with, the limitations set out in sections 1.3 and 1.4 and the assumptions and qualifications contained throughout the Report.

Goulburn Valley Water (GVW) is seeking to install large-scale photovoltaic (PV) solar facilities within its Tatura and Seymour waste management facilities, both situated on GVW-owned land. The aim is to maximise energy yield in order to offset GVW's carbon footprint, as well as to generate revenue by selling exported electricity generated on-site to the electricity market. GHD anticipates the potential PV system sizes to meet the targeted annual electricity generation to be approximately 3 to 15 MW.

This report details the results of a comprehensive glare impact assessment conducted by GHD on the Seymour site, specific to the chosen PV solution. This assessment focuses on potential repercussions on aviation operations related to Puckapunyal Airport, located approximately 10 kilometres aerial distance from the proposed PV site, encompassing an examination of runway approach trajectories. Furthermore, it extends to analysing potential effects on adjacent receptors, such as road users and the local community.

Key Findings

The table below summarises the predicted annual glare at the various route receptors, observer points and flight paths in the vicinity of the proposed solar facility at Seymour.

	Red Glare	Yellow Glare	Green Glare
Flight Paths	0	0	0
Route Receptors	0	218 minutes (3.6 hours)	2,408 minutes (40.1 hours)
Observer Points	0	114 minutes (1.9 hours)	3,768 minutes (62.8 hours)
Red Glare – Potential for permanent eye damage (retinal burn) Yellow Glare – Potential for after-image Green Glare – Low potential for after-image			

No red glare is predicted to occur at any point within the vicinity of the proposed Seymour solar facility.

A small amount of yellow glare is expected to occur between 7:00 am and 8:00 am at the intersection of Avenel and Tarcombe Road, as well as at property located approximately 600 meters away from the south-west corner of the proposed PV installation. The level of irradiance of the predicted glare relative to the subtended source angle at the above-mentioned locations is relatively low and borderline classified as 'yellow glare'. Mitigation measures have been suggested to reduce the impact of the glare on road users and property owners, however the risk of developing after-image due to the glare is relatively low.

A large amount of green glare is predicted to occur across various route receptors and observer points predominantly between 7:00 am and 8:00 am, however there is low potential for after-image developing, and thus green glare is not perceived as a risk requiring any mitigation strategies.

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Abbreviations

Abbreviation	Definition
ARC	Anti-reflective Coating
ATCT	Air Traffic Control Tower
CASA	Civil Aviation Safety Authority
DNI	Direct Normal Irradiance
FAA	American Federal Aviation Administration
hrs	Hours
HV	Heavy Vehicle
km	Kilometre
LV	Light Vehicle
MW	Mega Watt
MWp	Mega Watts Peak
min	Minutes
OP	Observation Point
PV	Photovoltaic
SAT	Single Axis Tracking
SGHAT	Solar Glare Hazard Analysis Tool
W/cm^2	Watts per square centimetre
W/m^2	Watts per square metre

1. Introduction

1.1 Project overview

Goulburn Valley Water (GVW) is seeking to install large-scale solar facilities within its Waste Management Facility (WMF) sites. The proposed solar site at the Seymour WMF is located at the intersection of Back Mountain Road and Dead Horse Lane in Seymour, in the Goulburn Valley region of Victoria, shown in Figure 1.

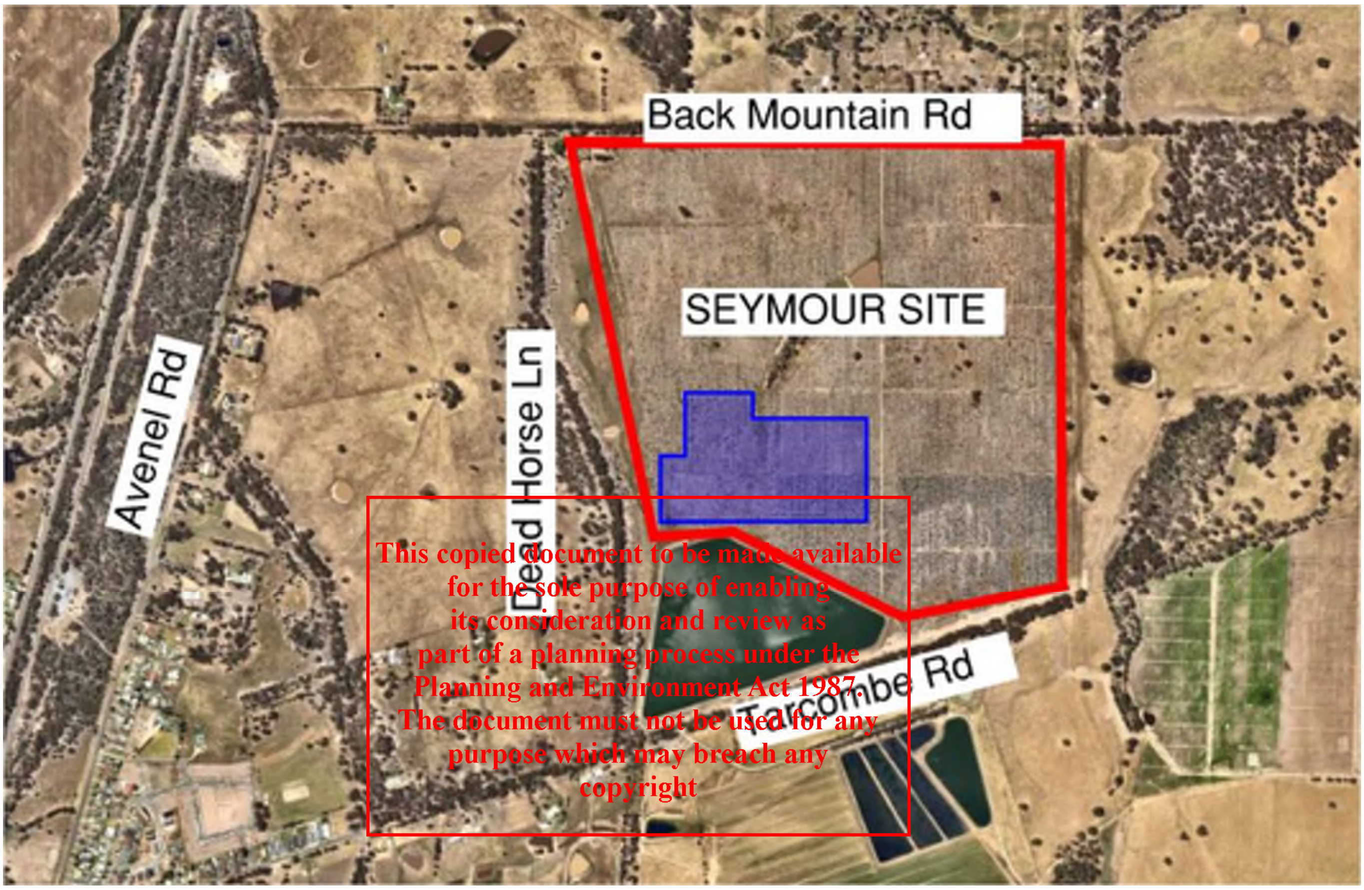


Figure 1 Project location

GHD have been engaged by GVW to undertake a solar glare assessment for the proposed 5.23 MWp solar farm with single-axis trackers (SAT).

1.2 Purpose

This report provides the methodology of the glare study conducted with the Solar Glare Hazard Analysis Tool (SGHAT), and lists the assumptions and parameters used and details the results and conclusions made.

1.3 Scope and limitations

This report: has been prepared by GHD for Goulburn Valley Water and may only be used and relied on by Goulburn Valley Water for the purpose agreed between GHD and Goulburn Valley Water as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Goulburn Valley Water arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.2 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

Accessibility of documents

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

1.4 Assumptions

The glare assessment was conducted with the following assumptions:

- Glare is assessed by a desktop study using industry leading software named ForgeSolar.
- The design parameters and location details were extracted from the concept designs for the Goulburn Valley Water Solar Farm project.
- The preliminary receptors were selected based on the site proximity to the receptors and were based on aerial observation of surrounding area.
- Publicly available information is used for the modelling of runway flight paths.
- Assessment was conducted considering single-axis tracking modules with tracking-axis along north to south, and maximum tracking angle of 60°.
- A maximum panel height of 1.6 m above ground is considered for assessing worst case glare effect scenario.
- A viewing height of 1.76 m was used, which is within the average typical viewing level range of an adult in Australia.
- The modelling only considered the landform and did not include land cover factors such as presence of buildings, trees, or screening. However, this represents the worst-case scenario for the potential glare.
- Times are given in standard time and unadjusted for daylight savings.

1.5 ForgeSolar SGHAT software overview

NOTE: While there are more sophisticated methods for calculating glare more accurately, ForgeSolar SGHAT is the only platform specifically intended for evaluating the impact of hazardous solar glare, reflected by solar panels, on the aviation industry.

Licensed from Sandia National Laboratories and provided by ForgeSolar, SGHAT is an industry-standard technical modelling tool. SGHAT can also be used to determine the impact of glare on aeroplane pilots, air-traffic controllers, pedestrians, motorists, and train drivers. SGHAT calculates the sun position and sunlight intensity at 1-minute intervals specific to location data, time of day, and time of year to determine the direction and intensity of the glare.

1.5.1 Glare assessment parameters

The ForgeSolar SGHAT can account for the following factors:

- The tilt, orientation, optical properties, and elevation of the solar panels in the solar farm
- The sun position with respect to geographic location, elevation, time of year and time of day
- The location of sensitive receptors (viewers) and their elevation

ForgeSolar SGHAT uses the following assumptions for evaluation:

- Clear atmospheric conditions are assumed as this will present the strongest conditions for glare, therefore the effect of clouds and dust will not be included.
- There is no shading by native vegetation.
- The Google Earth topography database, which is used to determine elevation specific to location data, is accurate.

1.5.2 Limitations

ForgeSolar SGHAT is limited by the following:

- The algorithm does not rigorously represent the detailed geometry of a system; including features such as gaps between modules, variable height of the PV array, and support structures which may impact actual glare results.
- It is only capable of assessing the glare of an array in a single orientation.
- Random number computations are utilised by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result.
- The algorithm assumes that the PV array is aligned with a plane defined by the approximate total heights of the PV vertices.
- The algorithm does not 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 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 normalised 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.
- 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 modelling methods.
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- The program does not consider glint (momentary flashes of bright light, often caused by a moving source).

2. Glare principles

2.1 Angle of incidence and reflection

Solar panels aim to maximise the conversion of sunlight energy to electrical energy by, in parts, minimising energy loss through reflection of sunlight. Some manufacturers of solar panels provide Anti-Reflective Coatings (ARC) to reduce surface reflectivity. ARC is most effective with small angles of incidence (the angle between panel perpendicular and sun) and is not as effective as angle of incidence increases, demonstrated by Yellowhair, 2015, Figure 2. The SGHAT model explains this as the greater surface texturing can increase the size of the subtended source angle (i.e., glare spot) increasing reflection. SGHAT can account for ARC.

Figure 2 also demonstrates that reflected light is fairly insignificant at low angles of incidence, however, increases exponentially as angle of incidence exceeds 60°.

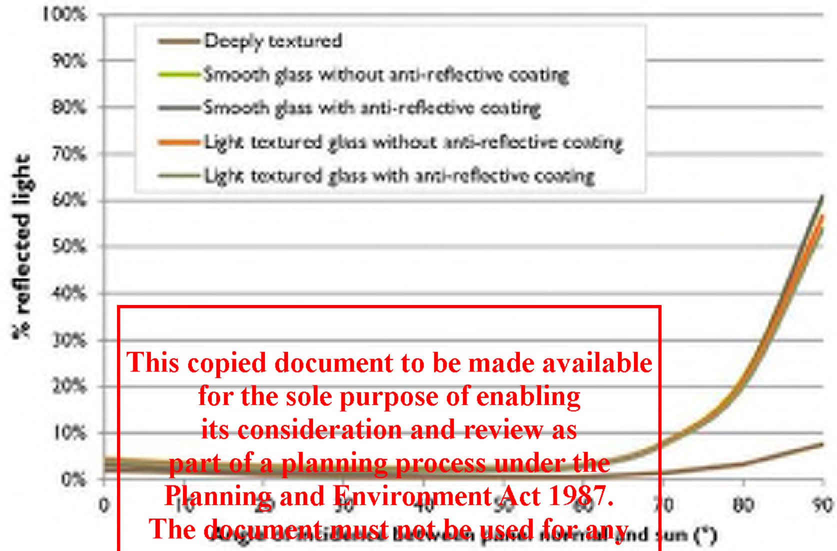


Figure 2 Angle of incidence and panel reflectance (Yellowhair, 2015)

Glare intensity depends on the surface of solar panels. Clean solar panels with smooth glass create specular reflection, whereas solar panels with ARC or dust can result in diffuse reflection as shown in Figure 3, below. Specular reflection has a direction symmetrical to the angle of incidence with reference to the panel's normal direction. This results in more intense reflections.

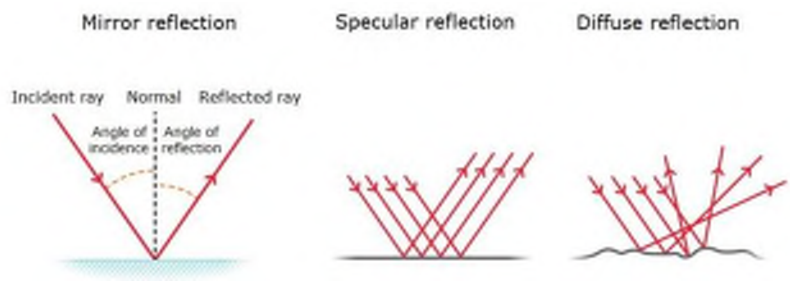


Figure 3 Specular and diffuse reflection

Diffuse reflections result from a beam of light being scattered in multiple angles due to a rough surface. Such reflections may occur on a solar farm due to any slight roughness of the panel surface type, or by dust and contaminants. Diffuse reflection lowers the intensity of the overall specular reflection and therefore it can be considered to lower the likelihood of hazardous glare.

2.2 Direct normal irradiance

Direct normal irradiance (DNI) is the measurement of power that a given surface area may absorb when it is exposed to sunlight, measured in watts per square meter (W/m^2). The maximum irradiance occurs at midday when the sun is directly overhead; however, this irradiance will decrease as the sun angle decreases as the sunlight passes through more of the atmosphere and less energy will reach the solar panel surface. SGHAT accounts for the variation in sunlight intensity by applying a subtractive function depending on the sun angle.

2.3 Glare ocular impact categories

Ocular impact is a measure of the potential for after-image and damage that may occur to the human eye when exposed to glare. Ocular impact is a function of both the magnitude of the reflected sunlight received by the observer "retinal irradiance" (W/cm^2) and the size of the glare source perceived by the observer, measured by the subtended angle of the reflected glare (milliradians). Glare is classified by SGHAT as:

- Low potential for after-image, also referred to as green glare
- Potential for after-image, also referred to as yellow glare
- Potential for permanent eye damage, also referred to as red glare

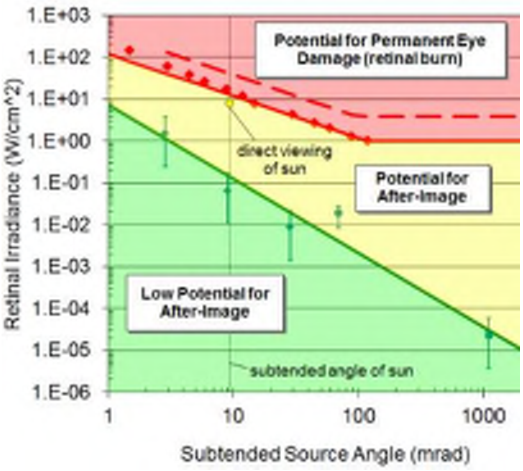


Figure 4 Ocular impact categories (Ho, 2011)

2.4 Scale of glare effects

Glare hazard is the human impact caused by exposure to the reflected light. Factors that contribute to glare hazard for a solar farm include:

- Reflectivity of surfaces
- Angle of incidence
- Strength of the light source
- Receptors
- Distance

Photovoltaic efficiency describes the efficiency or percentage of radiation (sun) energy that can be converted into electrical energy. The more light that can be absorbed by a solar panel, the more efficient the process.

For these reasons, photovoltaic panel surfaces are designed to absorb as much light as possible and limit reflection. However, glare or reflection can still occur at various times throughout the day.

2.5 Intensity

Glare effect can be described as the presence of light within the human field of vision that will result in visual discomfort or impairment. This can be experienced when looking at a reflection of the sun from a surface such as glass, water, or metal. The assessment of the effect of glare varies depending on the intensity of the incoming light, relativity to the field of human vision, duration of exposure, size of the glare and distance of the receiver from the glare source.

Glare is defined as either discomfort, or disability glare. Discomfort glare creates difficulty in seeing the object(s) being focused upon whereas disability glare can impair vision for a short or sustained period. Disability glare is a primary and common cause of concern in relation to traffic safety.

The assessment of glare effects and associated scale of effects are primarily based on the assessment distance to the Project, viewer numbers based on location, and potential for afterimage.

- **Distance:** Refers to the distance of the viewer from the Project. The level of impact decreases as distance increases.
- **Number of viewers:** The level of impact is less likely to occur where there are fewer people able to experience afterimage.

Visibility in terms of line of sight towards the Project also plays a factor in the potential for afterimage effect because if the Project is not visible from a specific location, then there is no chance for afterimage.

3. Methodology

3.1 Aviation impact assessment

In the event of absence of particular guidelines, GHD has used guidance from the American Federal Aviation Administration (FAA), on solar glare hazard analysis. According to the interim FAA policy, effective October 2013, SGHAT was required to "demonstrate that the proposed solar energy system meets the following standards:

- No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, and
- No potential for glare or "low potential for after-image" (shown in green in Figure 4) "along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3°) glidepath."

This advice has been reduced in the final policy, effective May 2021 that the FAA "will rely on the airport sponsor to include a statement that the proposed solar project will not result in ocular (i.e., glint or glare) impacts to the airport's ATCT cab".

3.2 Road users impact assessment

The SGHAT route receptor function can assess glare impact for vehicle operators traveling along continuous paths such as roads or railways. For a standard approach, glare for roads is assessed for a height representing the driver's position in a light vehicle (LV).

The SGHAT algorithm does not consider obstacles (either man-made or natural) between the observation points and the solar farm that may obstruct observed glare, such as trees, hills, buildings, etc.

3.3 Community users impact assessment

In SGHAT, an Observation Point (OP) receptor allows the simulation of an observer at a single, location, defined by a latitude, longitude, elevation, and a height above ground. OP receptors were used to assess the potential glare for a pedestrian, 1.76 m was used for average viewing height of an adult in Australia.

3.4 Hierarchy of controls

GHD approaches solar glare mitigation with the Hierarchy of Controls, as depicted in Figure 5:

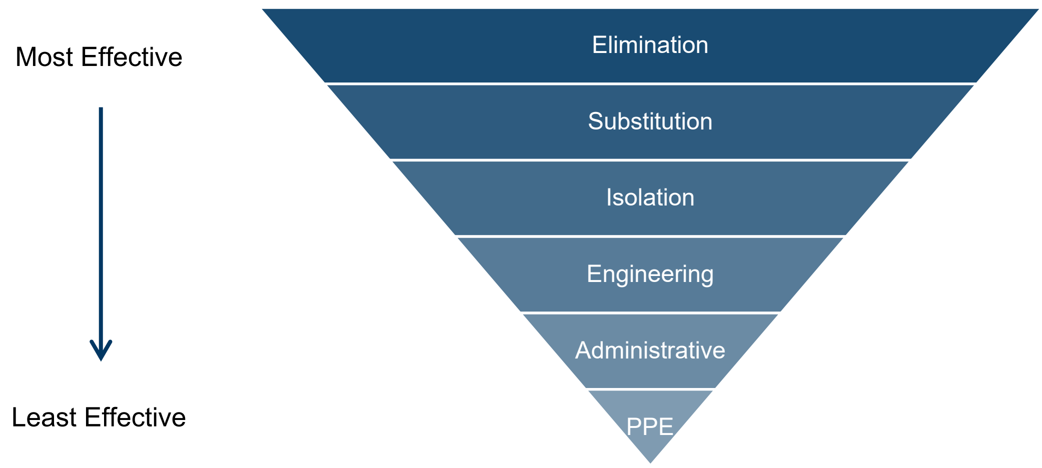


Figure 5 The Hierarchy of Controls

The highest control in the hierarchy that can possibly be used, should be implemented to minimise risk.

With regard to the impact of glare due to solar arrays, the possible mitigation strategies are:

– **Elimination**: Moving the solar array to a location where it does not have the potential to produce glare that affects sensitive receptors. This involves moving the array to a location that is isolated from any public roads, airports, residences, and culturally significant areas.
– **Substitution**: Altering the orientation and/or tilt angle of the panels. Fixed 35 degrees towards east arrays with a tilt angle of 10° have been considered for the assessment.
– **Isolation**: Obstructing glare with barriers or vegetation. This approach is appropriate for stationary observers and roads; however, it is not practical for obstructing glare in the case of approaching aircraft as barriers would need to be a considerable height.
– **Engineering**: The selection of solar panels with ARC slightly reduces glare intensity and improves energy generation However, it is not very effective at low sun angles (high angle of incidence). The Trina 600 Wp panels that have proposed feature an ARC. Additionally, proposal of bifacial panel will reduce the glare effect.
– **Administration**: Advising road users and visitors of the glare hazard times.
– **PPE**: Using personal protective equipment such as sunglasses.

4. Modelling

4.1 Design parameters

The glare study used the assumptions and considerations set out in the feasibility study report. The assessment considered the solar farm layout as shown in Figure 6 below. The concept design for the Seymour Site proposes 264 single-axis tracker modules covering a total area of approximately 21.5 ha.

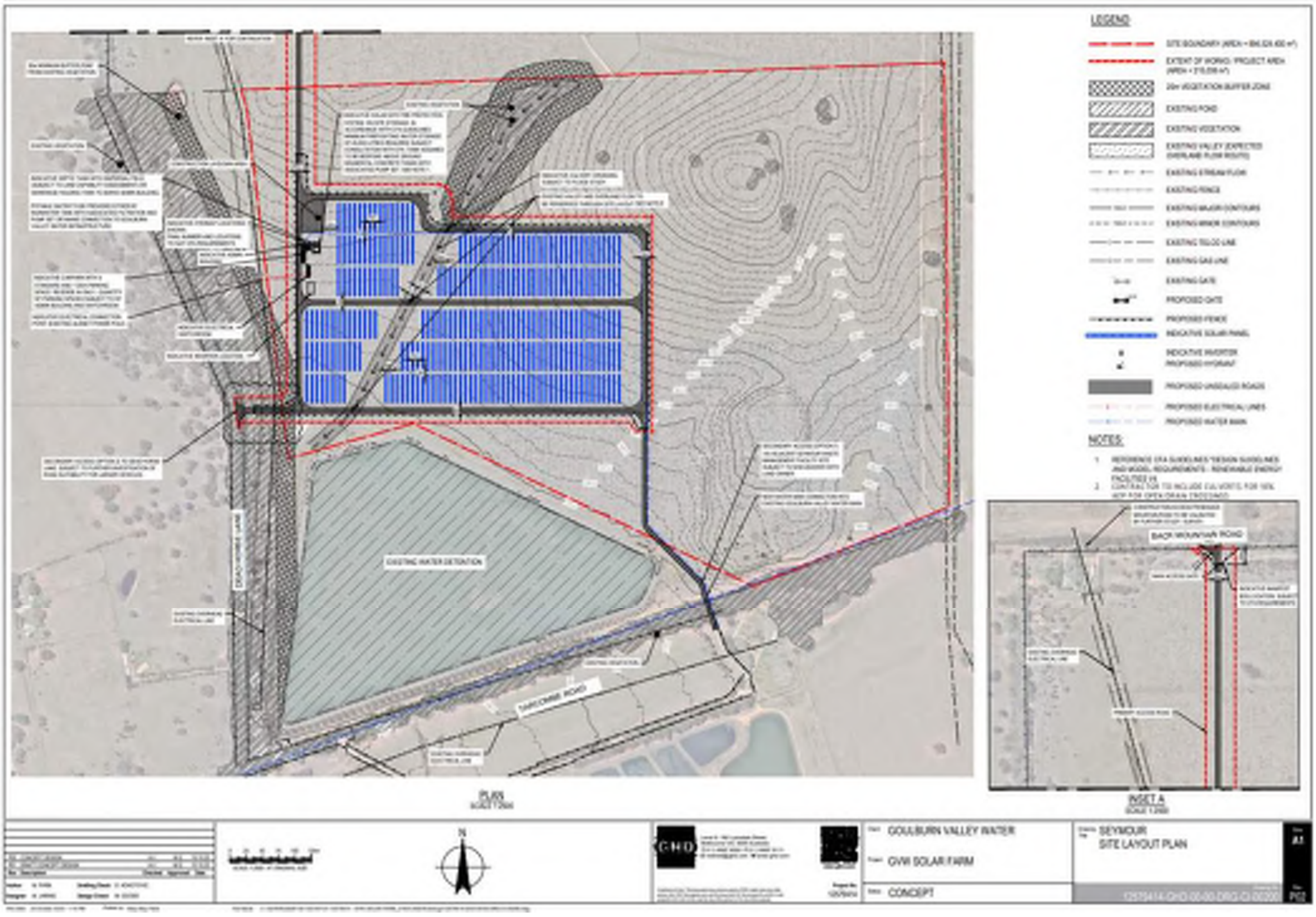


Figure 6 Concept site layout

The parameters considered for this assessment are outlined in Table 1 below.

Table 1 Seymour site solar farm parameters

Parameter/Information	Value/Comments
Solar farm size	5.23 MWp
Maximum tracking angle	60°
Tracking axis orientation	North-south (0°)
Coordinates of solar farm	-37.008039, 145.167990
Module type	Monocrystalline split-cell panel with anti-reflective coating
Layout	Based on concept drawing (12579414-GHD-00-00-DRG-CI-00200)

The proposed panels are single-axis trackers orientated north to south with a maximum tracking angle of 60°, mounted at 1.59 m from the ground, shown in Figure 7.

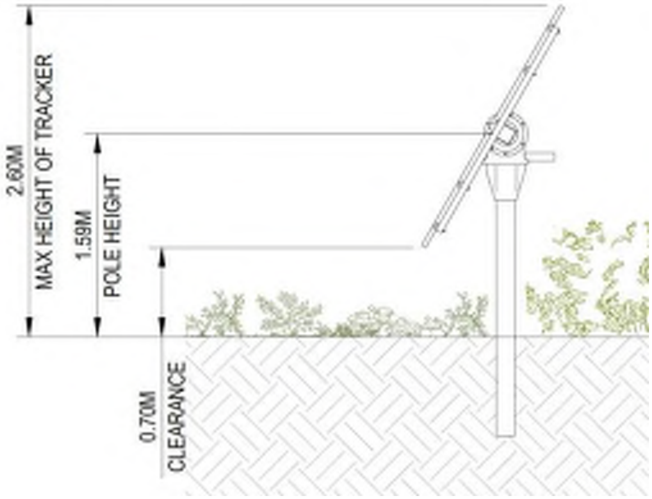


Figure 7 Indicative cross-section of single-axis solar tracker mounting structure

The following polygon vertex parameters were used in the SGHAT simulation to model the PV array area.

Table 2 Seymour site boundary parameters

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.008039	145.167990	157.40	1.6	159.00
2	-37.006600	145.168011	159.46	1.6	161.06
3	-37.006591	145.168590	159.37	1.6	160.97
4	-37.005092	145.168623	165.40	1.6	167.00
5	-37.005118	145.170296	162.53	1.6	164.13
6	-37.005580	145.170275	161.21	1.6	162.81
7	-37.005606	145.173472	172.37	1.6	173.97
8	-37.008082	145.173494	160.53	1.6	162.13
9	-37.008063	145.172123	160.35	1.6	161.95
10	-37.008095	145.170731	157.25	1.6	158.85

4.2 Flight path receptors

Puckapunyal Airport is located approximately 10 kilometres to the west of the site, as seen in Figure 8. Two 2-mile flight path receptors were modelled to simulate an aircraft's straight-line approach towards Runways 03 and 21 as depicted in Figure 9 and Figure 10. The input parameters for this model are provided in Table 3 and Table 4 below. Puckapunyal Airport does not have an Airport Traffic Control Tower (ATCT) and therefore no ACTC receptor was modelled.

Figure 8 Puckapunyal Airport location

Figure 9 Aerial view of Puckapunyal Airport

Figure 10 Puckapunyal Airport two-mile runway and flight path

Table 3 Flight path details

Flight path ID	Flight path name	Direction (° bearing)	Glide slope (°)	Threshold crossing height (m)	Azimuthal viewing angle (°)
FP1	Runway 21	221	3	15	50
FP2	Runway 03	43	3	15	50

Table 4 Flight path receptors parameters

ID	Point type	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
FP 1	Threshold	-36.995416	145.067056	171.54	15.24	186.78
	Two-mile	-36.973585	145.090819	167.73	187.73	355.46
FP2	Threshold	-37.000257	145.061663	162.95	15.24	178.19
	Two-mile	-37.021395	145.036934	176.29	170.58	346.87

4.3 Route receptors

The SGHAT route receptor function can simulate observers traveling along continuous paths such as roads or railways. This function was used to represent both light vehicles (LVs) and heavy vehicles (HVs) travelling along the nearby roads. SGHAT nominates a default observer viewing angle of 50° left and right of the visual center line (total field of view 100°).

Glare impact was assessed on four of the nearest roads to the proposed PV plant location, as well as the rail corridor running adjacent to Avenel Rd. These route receptors, ranging between 2 km to 3 km, are depicted in Figure 11. To simulate the impact for day-to-day users of the highway, a receptor height of 2 m was selected for this assessment. For the rail corridor, a receptor height of 2.5 m was selected to consider the additional height of a train. The route receptor parameters for the roads and rail corridor are provided in Table 5 below.

Figure 11 Route receptors and observation points

Table 5 Route receptors parameters

ID	Vertex	Latitude (deg)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Route 1 (Black Mountain Road)	1	-36.999681	145.157094	165.17	2	167.17
	2	-36.999818	145.180182	192.54	2	194.54
Route 2 (Avenel Rd)	1	-37.017124	145.151214	152.79	2	154.79
	2	-36.999715	145.157137	165.51	2	167.51
Route 3 (Tarcombe Rd)	1	-37.017912	145.148108	150.11	2	152.11
	2	-37.012601	145.168337	152.99	2	154.99

ID	Vertex	Latitude (deg)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
	3	-37.013458	145.170097	150.31	2	152.31
	4	-37.012190	145.175247	156.78	2	158.78
	5	-37.011539	145.175805	158.36	2	160.36
Route 4 (Dead Horse Ln)	1	-37.012944	145.166835	153.46	2	155.46
	2	-37.008112	145.167007	162.88	2	164.88
	3	-37.003759	145.164733	173.51	2	175.51
	4	-36.999852	145.164818	172.01	2	174.01
Route 5 (Rail)	1	-37.019141	145.146426	141.86	2.5	144.36
	2	-37.016691	145.148271	150.19	2.5	152.69
	3	-37.015594	145.148786	147.47	2.5	149.97
	4	-37.003480	145.152970	152.23	2.5	154.73
	5	-36.996718	145.155256	166.62	2.5	169.12

4.4 Observer points

In ForgeSolar, an Observation Point (OP) receptor enables the simulation of an observer at a specific, defined location, characterised by latitude, longitude, elevation, and height above the ground. OP receptors were employed to evaluate viewpoints (VP) identified as sensitive visual receptors in relation to the solar farm's location. The selection of OPs was guided by satellite imagery, considering the presence of dwellings and human activities. The parameters and descriptions for the OPs are provided in Table 6 below, and their locations are depicted in Figure 12 below.

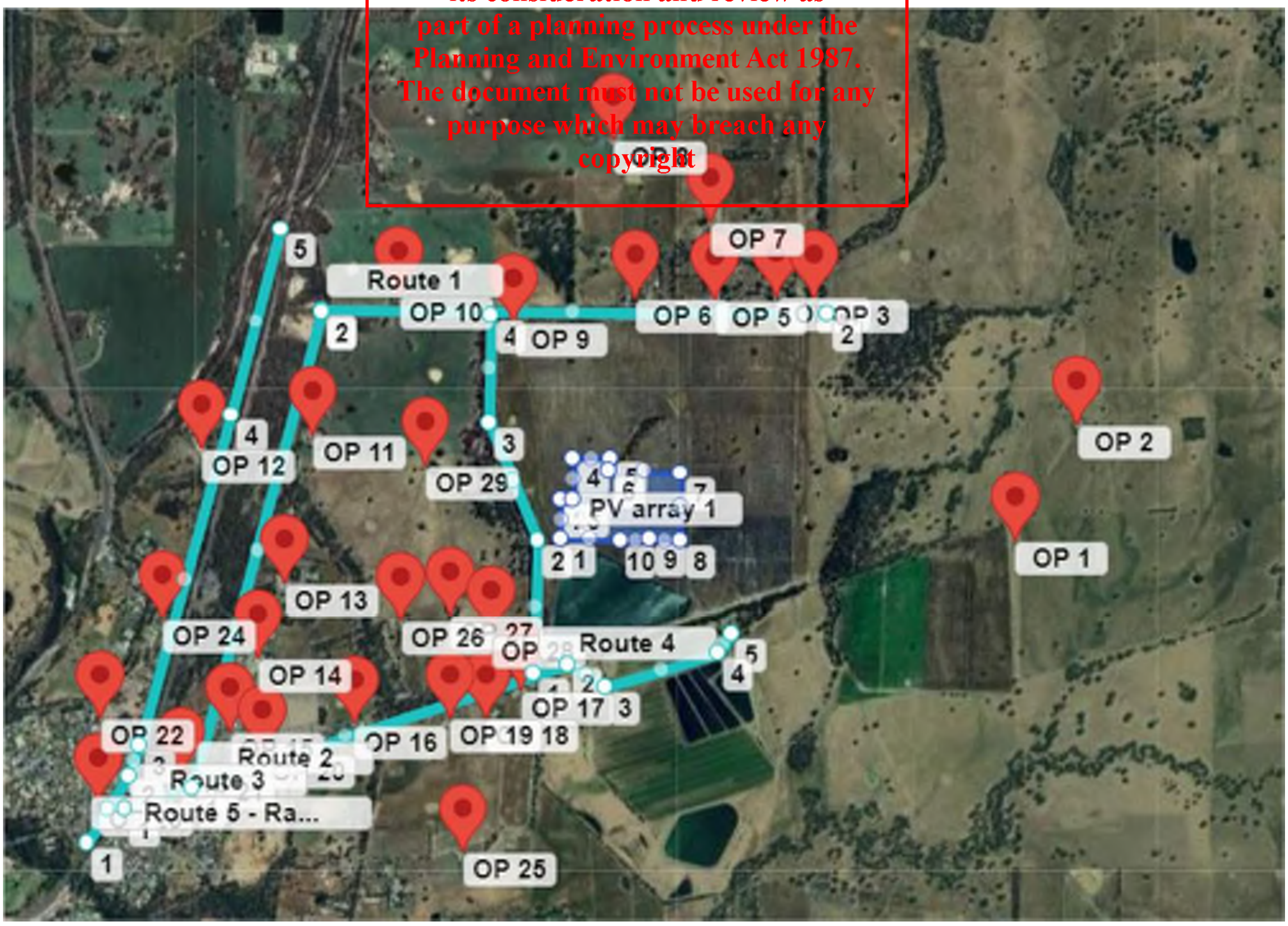


Figure 12 Observer Points

Table 6 *Discrete observation point receptors*

ID	Latitude (°)	Longitude (°)	Ground Elevation (m)	Height above ground (m)	Total elevation (m)	Comments
OP 1	-37.008078	145.188766	174.04	1.76	175.80	Building located approx. 1.3 km east of south-east corner or proposed array
OP 2	-37.003848	145.191661	192.55	1.76	194.31	Building located approx. 1.5 km east of north-east corner or proposed array
OP 3	-36.999235	145.179613	189.15	1.76	190.91	Building located approx. 860 m north-east of north-east corner of proposed array
OP 4	-36.999218	145.177918	185.74	1.76	187.5	Building located approx. 850 m north-east of north-east corner of proposed array
OP 5	-36.999321	145.175021	182.21	1.76	183.97	Building located approx. 720 m north of north-east corner of proposed array
OP 6	-36.999287	145.171416	174.81	1.76	176.57	Building located approx. 700 m north of proposed array
OP 7	-36.996476	145.174914	174.62	1.76	176.38	Building located approx. 1 km north of north-east corner of proposed array
OP 8	-36.993528	145.170386	186.85	1.76	188.61	Building located approx. 1.3 km north of proposed array
OP 9	-37.000143	145.165847	173.31	1.76	175.07	Building located approx. 600 m north of north-west corner of proposed array
OP 10	-36.999100	145.160647	170.05	1.76	171.81	Building located approx. 830 m north-west of north-west corner of proposed array
OP 11	-37.004299	145.156704	159.05	1.76	160.81	Building located approx. 1 km west of north-west corner of proposed array
OP 12	-37.004751	145.151612	148.63	1.76	150.39	Building located approx. 1.4 km west of north-west corner of proposed array
OP 13	-37.009700	145.155367	158.19	1.76	159.95	Building located approx. 1.1 km west of south-west corner of proposed array

ID	Latitude (°)	Longitude (°)	Ground Elevation (m)	Height above ground (m)	Total elevation (m)	Comments
OP 14	-37.012407	145.154208	157.71	1.76	159.47	Building located approx. 1.4 km south-west of south-west corner of proposed array
OP 15	-37.015080	145.152920	150.06	1.76	151.82	Building located approx. 1.6 km south-west of south-west corner of proposed array
OP 16	-37.014792	145.158585	158.71	1.76	160.47	Building located approx. 1.2 km south-west of south-west corner of proposed array
OP 17	-37.013593	145.166181	150.62	1.76	152.38	Building located approx. 750 m south of south-west corner of proposed array
OP 18	-37.014586	145.164550	150.34	1.76	152.1	Building located approx. 780 m south of south-west corner of proposed array
OP 19	-37.014586	145.162920	152.91	1.76	154.67	Building located approx. 800 m south of south-west corner of proposed array
OP 20	-37.015923	145.154379	152.40	1.76	154.16	Building located approx. 1.5 km south-west of south-west corner of proposed array
OP 21	-37.016642	145.150689	149.80	1.76	151.56	Building located approx. 1.8 km south-west of south-west corner of proposed array
OP 22	-37.014586	145.146998	145.36	1.76	147.12	Building located approx. 2.1 km south-west of south-west corner of proposed array
OP 23	-37.017636	145.146912	150.15	1.76	151.91	Building located approx. 2.3 km south-west of south-west corner of proposed array
OP 24	-37.010954	145.149788	147.34	1.76	149.1	Building located approx. 1.6 km west of south-west corner of proposed array
OP 25	-37.019452	145.163563	147.93	1.76	149.69	Building located approx. 1.3 km south of south-west corner of proposed array

ID	Latitude (°)	Longitude (°)	Ground Elevation (m)	Height above ground (m)	Total elevation (m)	Comments
OP 26	-37.011022	145.160688	165.01	1.76	166.77	Building located approx. 780 m south-west of south-west corner of proposed array
OP 27	-37.010817	145.162963	166.82	1.76	168.58	Building located approx. 600 m south-west of south-west corner of proposed array
OP 28	-37.011502	145.164851	160.60	1.76	162.36	Building located approx. 580 m south-west of south-west corner of proposed array
OP 29	-37.005394	145.161873	180.28	1.76	182.04	Building located approx. 430 m west of proposed array

5. Results

5.1 Summary

Glare simulations were completed using ForgeSolar and the results are summarised in Table 7 below. Potential for glare is expressed in total annual hours of either green, yellow, or red glare as specified in section 2.3.

Table 7 Potential total annual glare duration

Observers	Receptor Type	Receptor ID	Total annual glare predicted (hrs)		
			Green	Yellow	Red
Puckapunyal Airport	Flight Path	FP 1	0	0	0
		FP 2	0	0	0
Drivers Commuters Pedestrians	Route Receptor	Route 1	0	0	0
		Route 2	10.1	3.3	0
		Route 3	16.1	0.3	0
		Route 4	0	0	0
		Route 5 - Rail	13.9	0	0
People	Observation Point	OP 1	0	0	0
		OP 2	0	0	0
		OP 3	0	0	0
		OP 4	0	0	0
		OP 5	0	0	0
		OP 6	0	0	0
		OP 7	0	0	0
		OP 8	0	0	0
		OP 9	0	0	0
		OP 10	0	0	0
		OP 11	0	0	0
		OP 12	0	0	0
		OP 13	0.4	0	0
		OP 14	6.7	0	0
		OP 15	6.8	0	0
		OP 16	6.1	0	0
		OP 17	0	0	0
		OP 18	0	0	0
		OP 19	0	0	0
		OP 20	6.5	0	0
		OP 21	6.9	0	0
		OP 22	3.9	0	0
		OP 23	7.0	0	0
		OP 24	0	0	0
		OP 25	0	0	0

		OP 26	7.2	0	0
		OP 27	5.3	1.9	0
		OP 28	6.0	0	0
		OP 29	0	0	0

5.2 Puckapunyal Airport receptors

No green or yellow glare was forecasted for either flight path FP1 or FP2 at Puckapunyal Airport.

5.3 Route receptors

Green and yellow glare have been forecasted for both routes 2 and 3 receptors along Avenel Road and Tarcombe Road respectively, as well as along the rail corridor route 5. Refer to Figure 11 above which depicts the location of each of the impacted routes in relation to the proposed PV array location.

5.3.1 Route 2

Potential green and yellow glare is expected between May and early August each year during the morning hours between 7:00 am to 8:00 am.

The annual predicted glare occurrence and daily duration of glare along Route 2 is provided below in Figure 13.

Annually it is predicted that 10.1 hours of green glare and 3.3 hours of yellow glare will occur each year along Avenel Road. It is noted that existing vegetation in between these observation points will reduce the impact of glare received at the routes. Hence the glare impact can be considered as relatively low for the whole year.

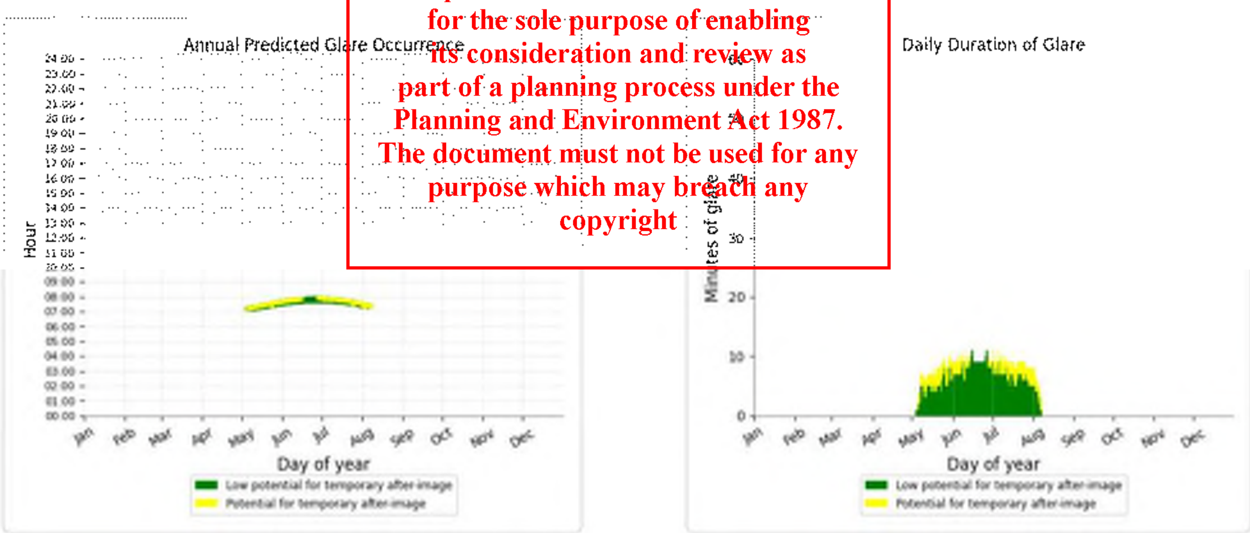


Figure 13 Predicted glare for Route 2 along Avenel Road

5.3.2 Route 3

Along route 3, potential green glare is expected between early May and early August each year during the morning hours between 7:00 am to 8:00 am, as well as some green glare between late May and Mid July during the late afternoon hours between 4:00 pm to 5:00 pm.

The annual predicted glare occurrence and daily duration of glare along route 2 is provided below in Figure 14.

Annually it is predicted that 16.1 hours of green glare and 20 minutes of yellow glare will occur each year along Tarcombe Road. It is noted that existing vegetation in between these observation points will reduce the impact of glare received at the routes. Hence the glare impact can be considered as relatively low for the whole year.

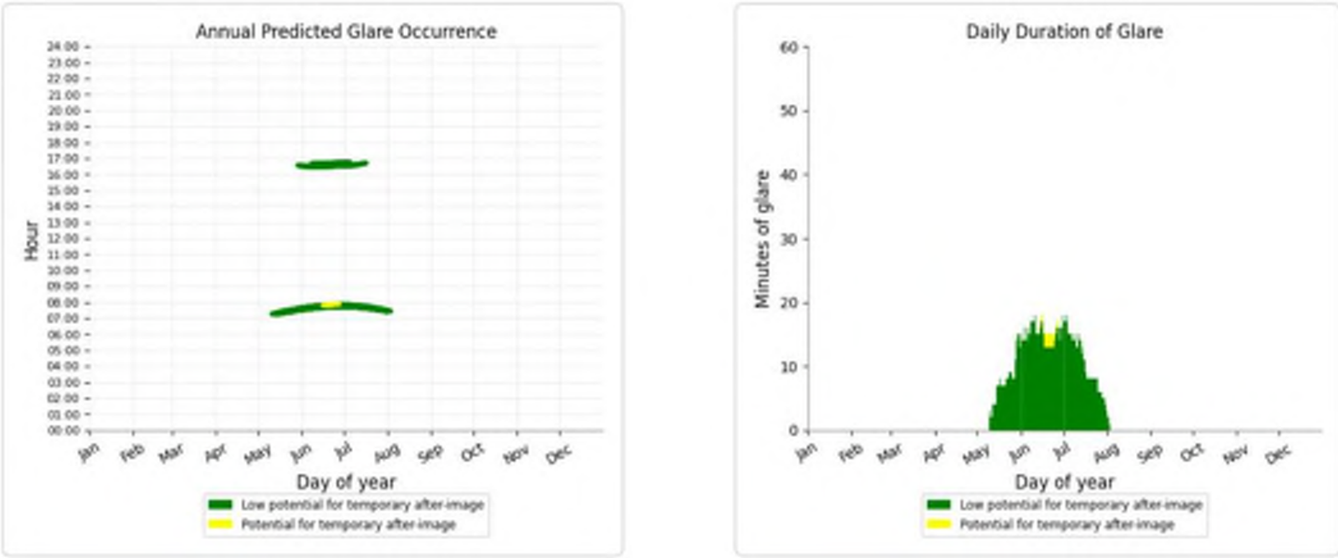


Figure 14 Predicted glare for Route 3 along Tarcombe Road

5.3.3 Route 5

Along the rail corridor (Route 5), potential green glare is expected between late April and mid-August each year during the morning hours between 7:00 am to just after 8:00 am.

The annual predicted glare occurrence and daily duration of glare along Route 5 is provided below in Figure 15.

Annually it is predicted that 13.9 hours of green glare will occur each year along the rail corridor.

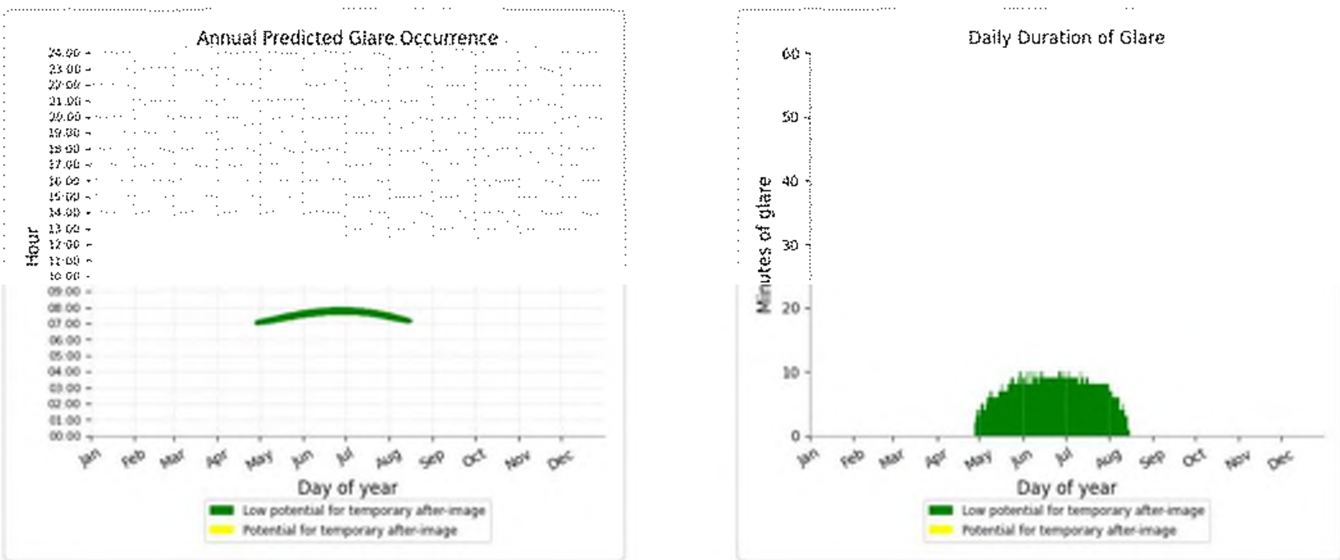


Figure 15 Predicted glare for Route 5 along the rail corridor

5.4 Observer point receptors

5.4.1 OP 13

OP 13, located approx. 1.1 km west of south-west corner of proposed array, is predicted to experience green glare during the second half of July between the morning hours of 7:00 am to 8:00 am. No yellow glare is predicted.

Figure 16 below depicts annual predicted glare occurrence and daily duration of glare.

Annually, it is predicted that 24 minutes of green glare will occur at this observation point.

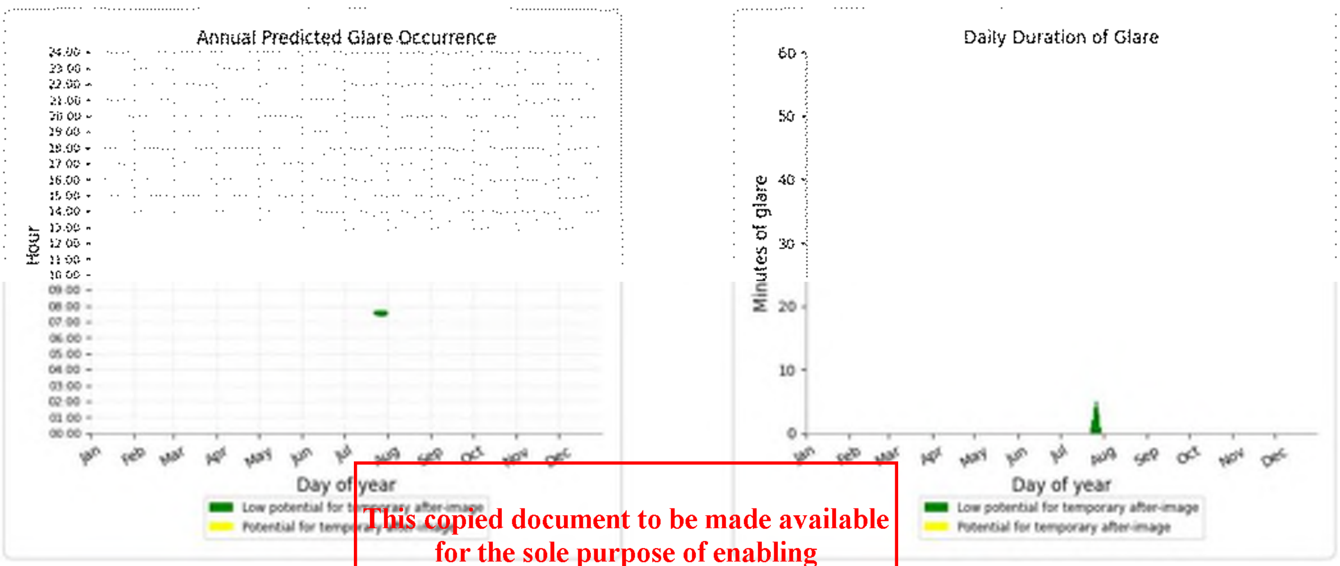


Figure 16 Predicted glare for OP 13 (Observer Point 13)

5.4.2 OP 14

OP 14, located approximately 1.4 km south-west of south-west corner of proposed array, is predicted to experience green glare from early June to early August between the morning hours of 7:00 am to 8:00 am. No yellow glare is predicted.

Figure 17 below depicts annual predicted glare occurrence and daily duration of glare.

Annually it is predicted that 6.7 hours of green glare will occur at this observation point.

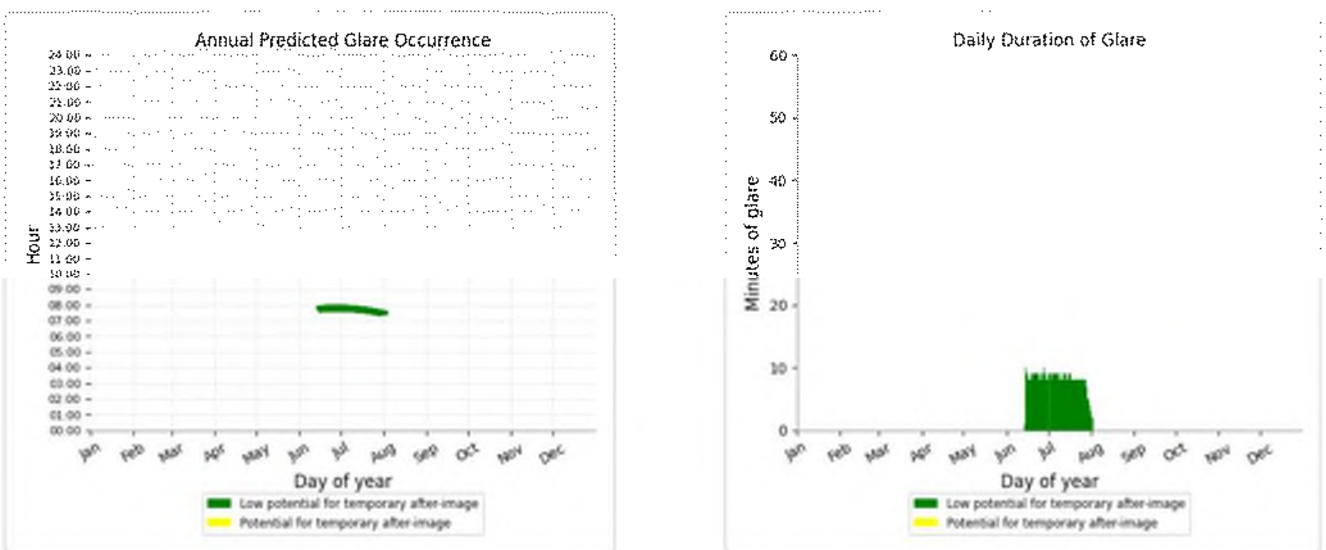


Figure 17 Predicted glare for OP 14 (Observer Point 14)

5.4.3 OP 15

OP 15, located approximately 1.6 km south-west of south-west corner of proposed array, is predicted to experience green glare from early June to early August between the morning hours of 7:00 am to 8:00 am. No yellow glare is predicted.

Figure 18 below depicts annual predicted glare occurrence and daily duration of glare.

Annually it is predicted that 6.8 hours of green glare will occur at this observation point.

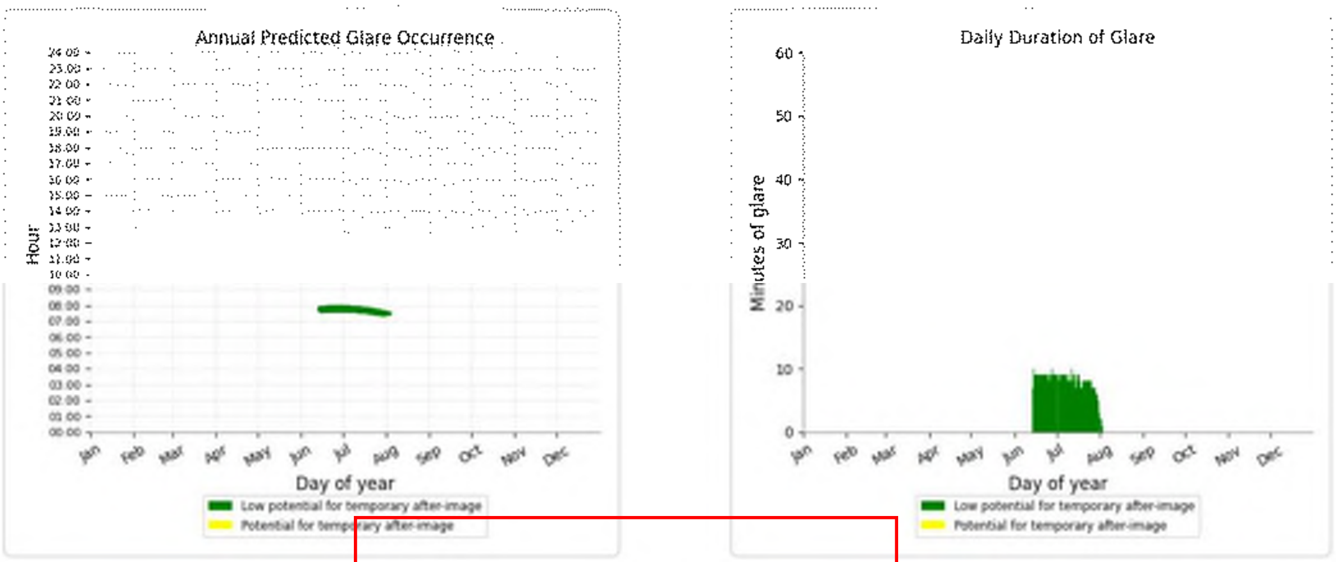


Figure 18 Predicted glare for OP 15 (Observer Point 15)

5.4.4 OP 16

OP 16, located approximately 1.2 km south-west of south-west corner of proposed array, is predicted to experience green glare from early June to mid-July between the morning hours of 7:00 am to 8:00 am. No yellow glare is predicted.

Figure 19 below depicts annual predicted glare occurrence and daily duration of glare.

Annually it is predicted that 6.1 hours of green glare will occur at this observation point.

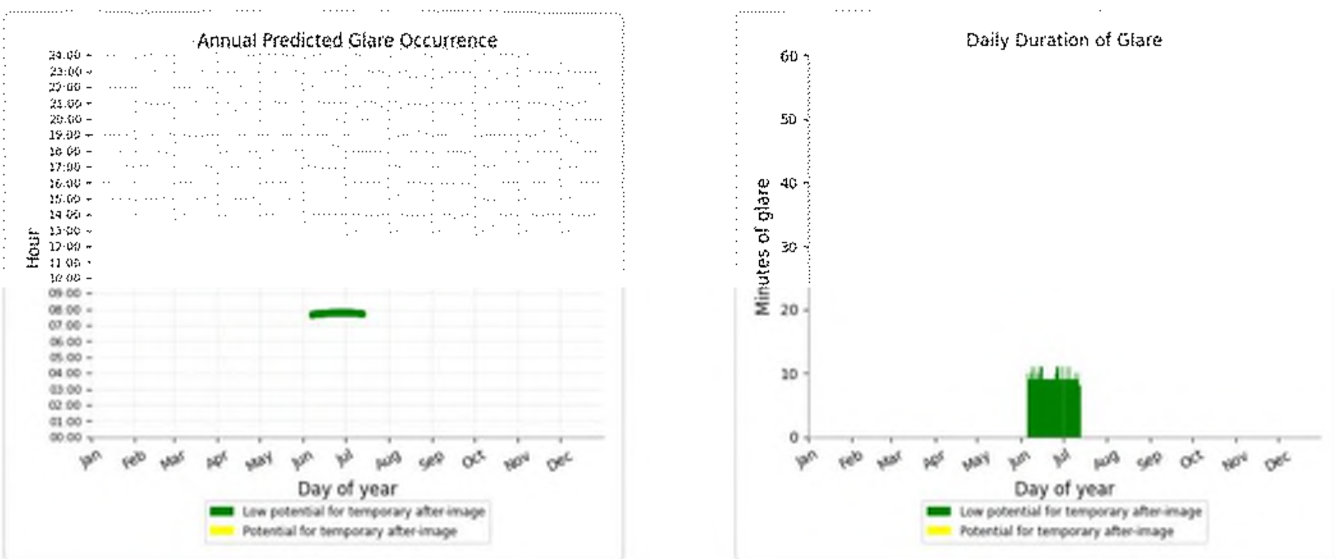


Figure 19 Predicted glare for OP 16 (Observer Point 16)

5.4.5 OP 20

OP 20, located approximately 1.5 km south-west of south-west corner of proposed array, is predicted to experience green glare from early June to late-July between the morning hours of 7:00 am to 8:00 am. No yellow glare is predicted.

Figure 20 below depicts annual predicted glare occurrence and daily duration of glare.

Annually it is predicted that 6.5 hours of green glare will occur at this observation point.

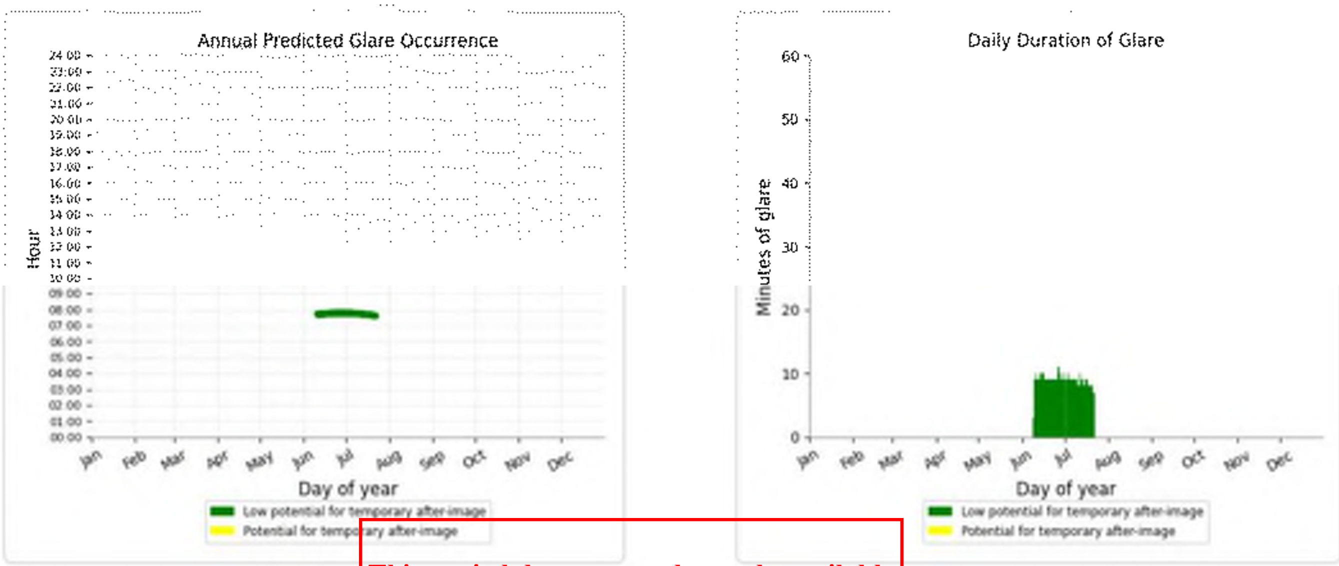


Figure 20 Predicted glare for OP 20 (Observer Point 20)

5.4.6 OP 21

OP 21, located approximately 1.8 km south-west of south-west corner of proposed array, is predicted to experience green glare from early June to late-July between the morning hours of 7:00 am to 8:00 am. No yellow glare is predicted.

Figure 21 below depicts annual predicted glare occurrence and daily duration of glare.

Annually it is predicted that 6.9 hours of green glare will occur at this observation point.

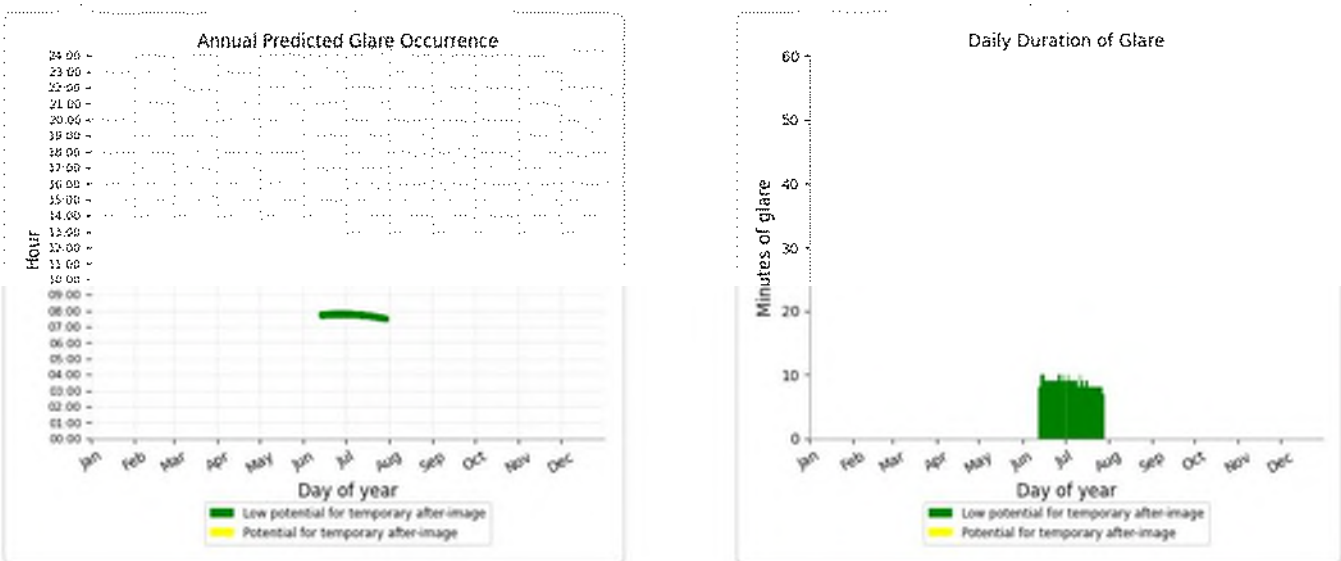


Figure 21 Predicted glare for OP 21 (Observer Point 21)

5.4.7 OP 22

OP 22, located approximately 2.1 km south-west of south-west corner of proposed array, is predicted to experience green glare from mid-June to late-July between the morning hours of 7:00 am to 8:00 am. No yellow glare is predicted.

Figure 22 below depicts annual predicted glare occurrence and daily duration of glare.

Annually it is predicted that 3.9 hours of green glare will occur at this observation point.

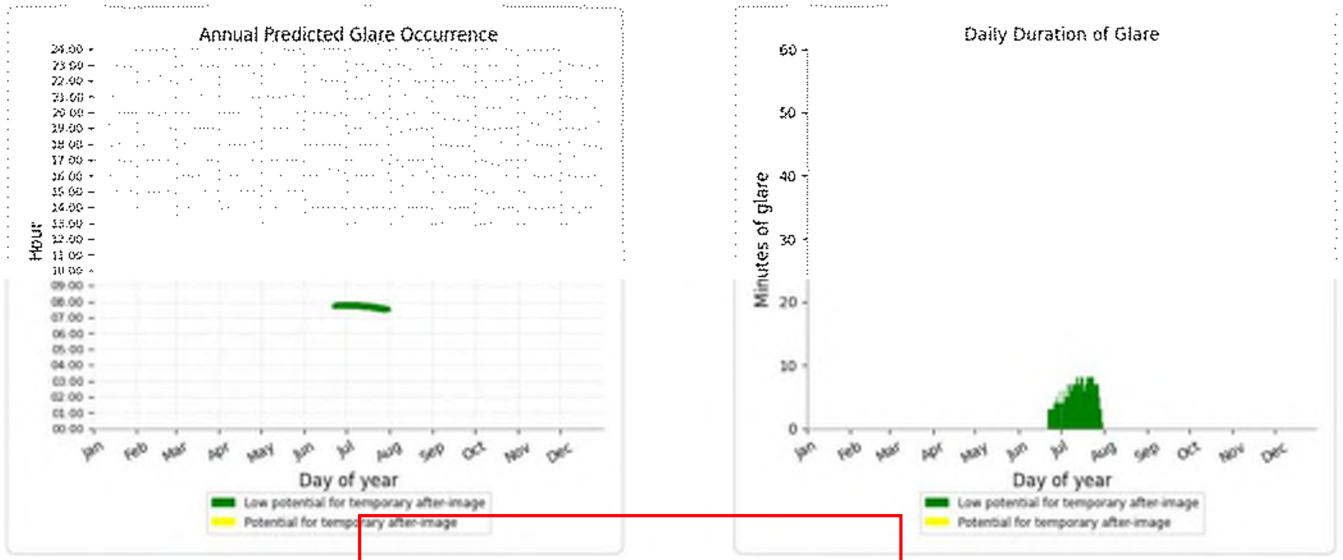


Figure 22 Predicted glare for OP 22 (Observer Point 22)

5.4.8 OP 23

OP 23, located approximately 2.3 km south-west of south-west corner of proposed array, is predicted to experience green glare from mid-June to early August between the morning hours of 7:00 am to 8:00 am. No yellow glare is predicted.

Figure 23 below depicts annual predicted glare occurrence and daily duration of glare.

Annually it is predicted that 7 hours of green glare will occur at this observation point.

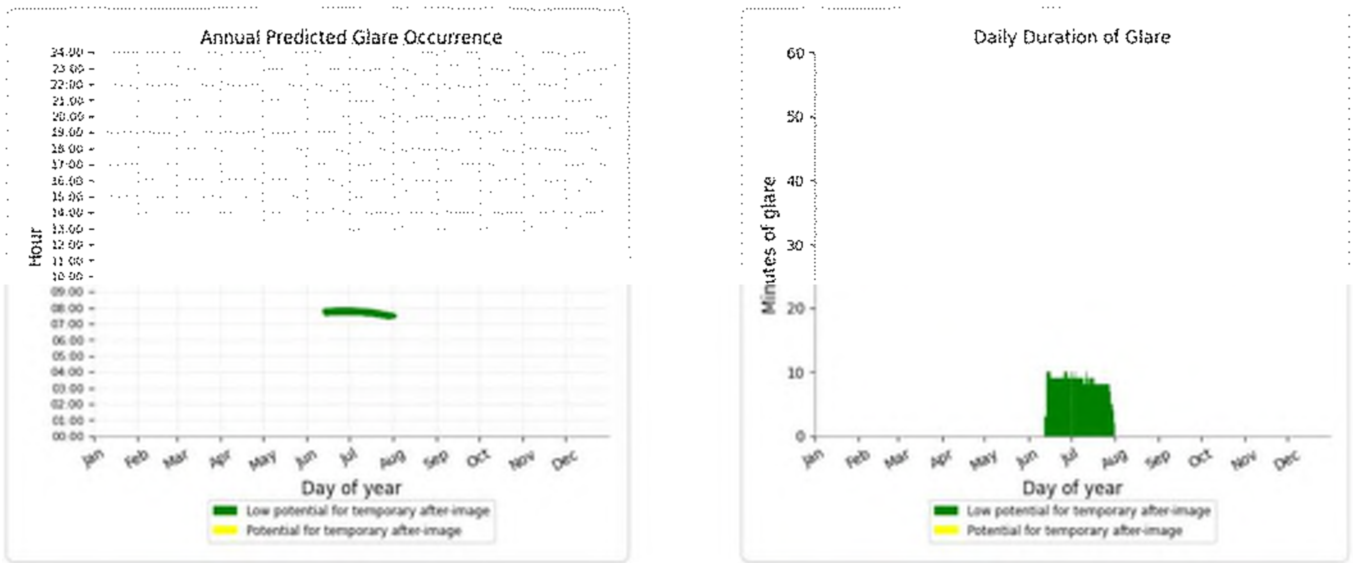


Figure 23 Predicted glare for OP 23 (Observer Point 23)

5.4.9 OP 26

OP 26, located approximately 780 m south-west of south-west corner of proposed array, is predicted to experience green glare from early June to mid-July between the morning hours of 7:00 am to 8:00 am. No yellow glare is predicted.

Figure 24 below depicts annual predicted glare occurrence and daily duration of glare.

Annually it is predicted that 7.2 hours of green glare will occur at this observation point.

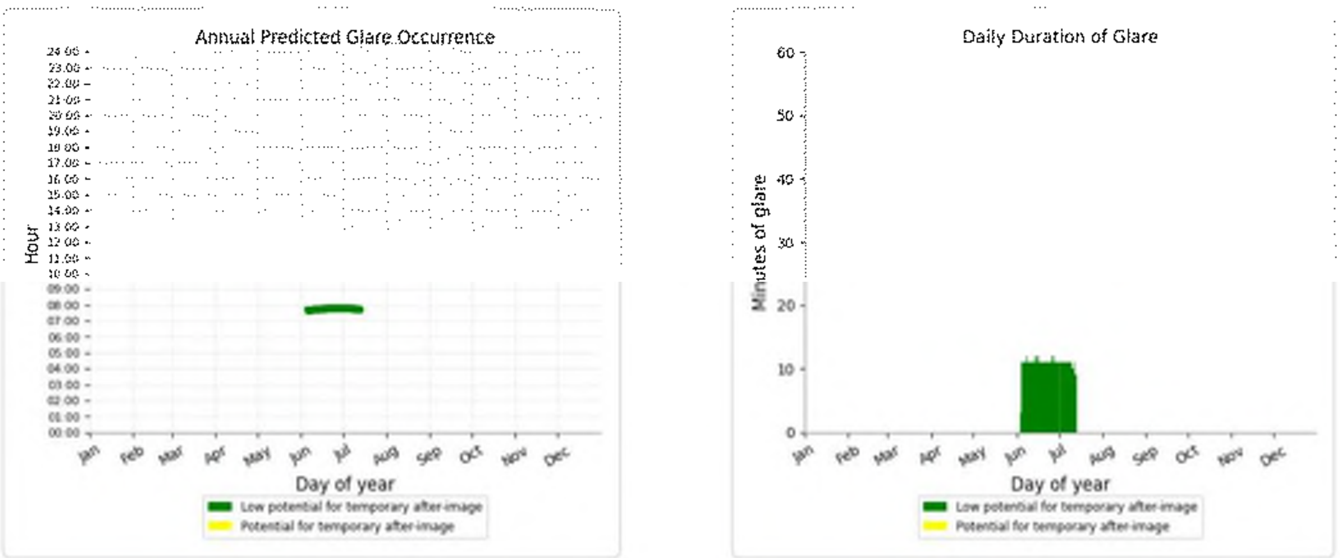


Figure 24 Predicted glare for OP 26 (Observer Point 26)

5.4.10 OP 27

OP 27 is the only observation point predicted to experience both yellow and green glare. OP 27 is located approximately 600 m south-west of south-west corner of proposed array and is predicted to experience green glare from late May throughout June and at the start of August between the morning hours of 7:00 am to 8:00 am.

Yellow glare is predicted from late May throughout June between the morning hours of 7:00 am to 8:00 am.

Figure 25 below depicts annual predicted glare occurrence and daily duration of glare.

Annually it is predicted that 5.2 hours of green glare and 1.9 hours of yellow glare will occur at this observation point. It is noted that existing vegetation in between these observer point will reduce the impact of glare received at OP27. Hence the glare impact can be considered as relatively low for the whole year.

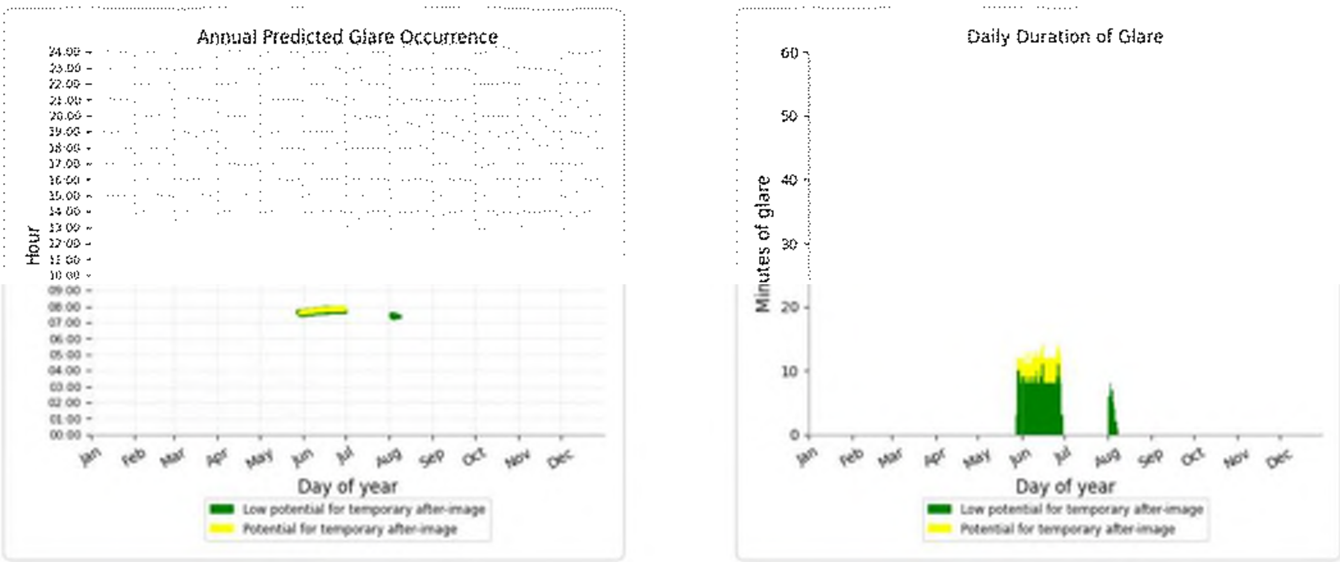


Figure 25 ***Predicted glare for OP 27 (Observer Point 27)***

5.4.11 OP 28

OP 28, located approximately 580 m south-west of south-west corner of proposed array, is predicted to experience green glare from early June to mid-July between the morning hours of 7:00 am to 8:00 am. No yellow glare is predicted.

Figure 26 below depicts annual predicted glare occurrence and daily duration of glare.

Annually it is predicted that 6 hours of green glare will occur at this observation point.

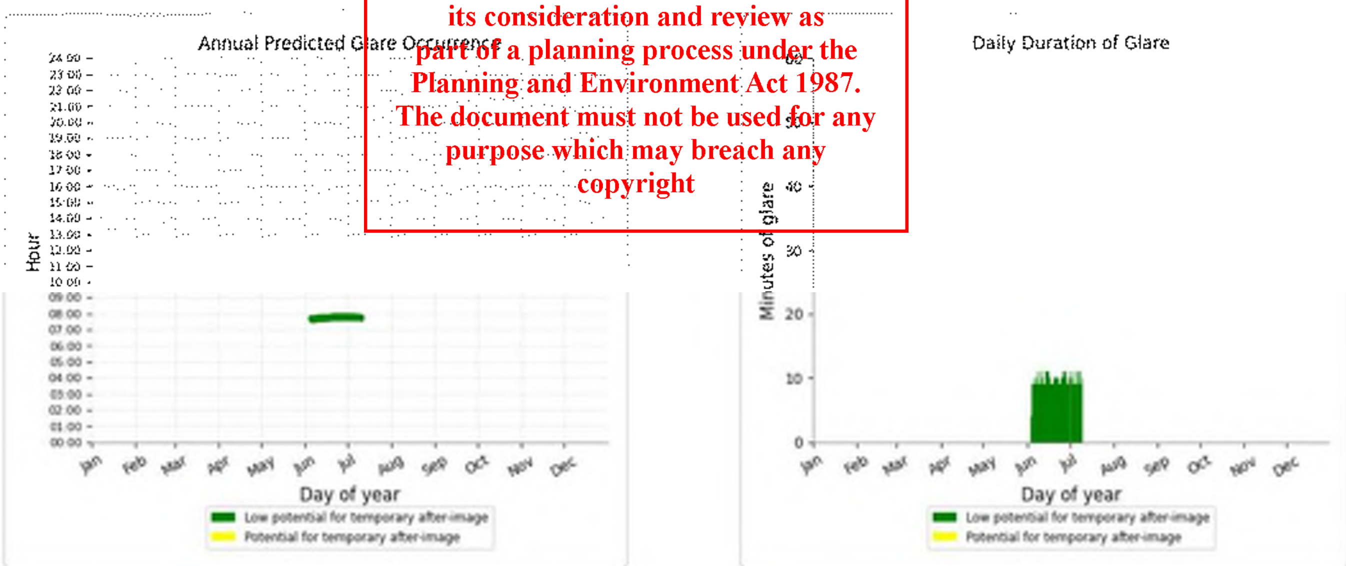


Figure 26 ***Predicted glare for OP 28 (Observer Point 28)***

For details on the hazard plot, predicted PV glare luminance, and for validation, three reports have been exported from the ForgeSolar tool and are attached as Appendices to this report as per Table 8.

Table 8 ***ForgeSolar Results***

Appendix	Description
Appendix A	ForgeSolar Aviation Report (FAA 2021)
Appendix B	ForgeSolar Aviation Report (FAA 2013)
Appendix C	ForgeSolar Complete Analysis Report

6. Conclusion and recommendations

From the results, it is concluded that between the autumn and spring months, when the sun angle is low in the morning and evening, (predominantly during 6:00 am to 8:00 am and 4:45 pm to 6:15 pm), there is potential for both green and yellow glare for route receptors and observer points located to the west and south-west of the PV array.

Table 9 below summarises the number of flight paths, route receptors and observer points out of the data sample which have been predicted to be impacted by green, yellow and red glare.

Table 9 Summary of receptors and observer points impacted by glare

	Green Glare	Yellow Glare	Red Glare
Flight Paths	0	0	0
Route Receptors	3	2	0
Observer Points	11	1	0

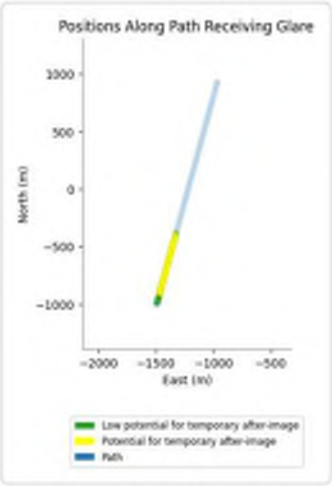
A total of 102.9 hours of green glare has been predicted amongst the various route receptors and observer points. Green glare has a low potential for after-image and poses little to no threat of damage to the observer during the impacted times.

A total of 5.5 hours of yellow glare has been predicted across the one observer point and the route receptors. Whilst yellow glare typically has the potential to cause after-image, in the scenarios where yellow glare has been predicted, the retinal irradiance relative to the subtended source angle is relatively small, and thus is borderline 'green glare' and unlikely to pose any threat or damage to an observer. It is also noted that there is sufficient natural vegetation screening between the solar array and the routes, OPs especially along dead horse lane which is not accounted by the software. This will reduce the impact of yellow glare, and in practical terms, no yellow glare is expected to be observed.

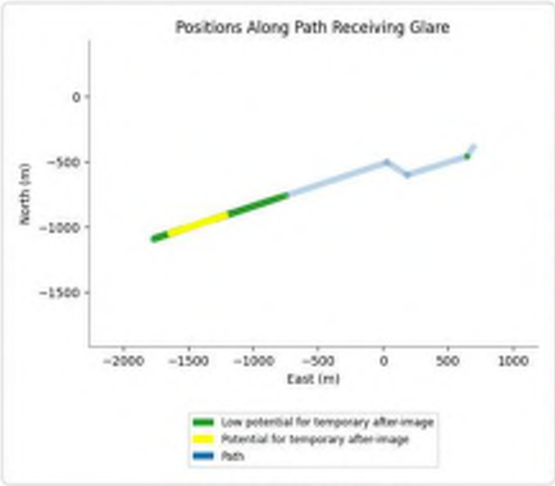
No red glare is predicted within the vicinity and surrounds of the proposed PV system, thus at any position relative to the proposed array there is no threat of permanent retinal damage to an observer.

For the route receptors and observer point where yellow glare is predicted as summarised in Figure 27 below, GHD recommend the following as mitigation measures if necessary:

– Project owners should consult with the community and ensure that community members and visitors are made aware of the potential glare intensity, duration, and occurrence times.
– As a mitigation plan, consider planting vegetation screening or installing glare screening of sufficient height along the sections of Avenel Road and Tarcombe Road where the SGHAT model indicates potential glare impact.
– Consider installing glare screening or planting vegetation around the buildings in proximity to Observer Point 27. Alternatively, screening can be installed at the border of the proposed PV array to mitigate the potential for yellow glare to be observed at Observer Point 27.



Route 2 – Avenel Road



Route 3 – Tarcombe Road

Observation Point 27 (Building)

Figure 27 *Areas impacted by yellow glare*

Appendices

Appendix A

ForgeSolar Aviation Report (FAA 2021)

FORGESOLAR GLARE ANALYSIS

Project: **GVW-Seymour Site**

Proposed 5.23 MWp solar farm with SAT

Site configuration: **GVW-Seymour Site**

Client: Goulburn Valley Water

Site description: SAT system based on concept design

Created 17 Dec, 2023
Updated 21 Dec, 2023
Time-step 1 minute
Timezone offset UTC10
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Site ID 108449.18756

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

Glare Policy Adherence

The following table estimates the policy adherence of this glare analysis according to the **2021** U.S. Federal Aviation Administration Policy:

Review of Solar Energy System Projects on Federally-Obligated Airports

This policy may require the following criteria be met for solar energy systems on airport property:

- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics, including 1-minute time step.

ForgeSolar is not affiliated with the U.S. FAA and does not represent or speak officially for the U.S. FAA. ForgeSolar cannot approve or deny projects - results are informational only. Contact the relevant airport and FAA district office for information on policy and requirements.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
ATCT(s)	N/A	No ATCT receptors assessed

The referenced policy can be read at https://www.federalregister.gov/d/2021-09862

Component Data

This report includes results for PV arrays and Observation Point ("OP") receptors marked as ATCTs. Components that are not pertinent to the policy, such as routes, flight paths, and vertical surfaces, are excluded.

PV Arrays

Name: PV array 1
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.4
Rated power: 5227.0 kW
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	-37.008039	145.167990	157.40	1.60	159.00
2	-37.006600	145.168011	159.46	1.60	161.06
3	-37.006591	145.168590	159.37	1.60	160.97
4	-37.005092	145.168623	165.40	1.60	167.00
5	-37.005118	145.170296	162.53	1.60	164.13
6	-37.005580	145.170275	161.21	1.60	162.81
7	-37.005606	145.173472	172.37	1.60	173.97
8	-37.008082	145.173494	160.53	1.60	162.13
9	-37.008063	145.172123	160.35	1.60	161.95
10	-37.008095	145.170731	157.25	1.60	158.85

Observation Point ATCT Receptors

No ATCT receptors were included in the analysis.

Glare Analysis Results

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	0	0.0	0	0.0	13,860,000.0

No ATCT receptors were included in the analysis.

PV: PV array 1

No ATCT receptors assessed.

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

Appendix B

ForgeSolar Aviation Report (FAA 2013)

FORGESOLAR GLARE ANALYSIS

Project: **GVW-Seymour Site**
Proposed 5.23 MWp solar farm with SAT

Site configuration: **GVW-Seymour Site**
Analysis conducted by Anto Jose (anto.jose@ghd.com) at 00:34 on 21 Dec, 2023.

U.S. FAA 2013 Policy Adherence

The following table summarizes the policy adherence of the glare analysis based on the 2013 U.S. Federal Aviation Administration Interim Policy 78 FR 63276. This policy requires the following criteria be met for solar energy systems on airport property:

- No "yellow" glare (potential for after-image) for any flight path from threshold to 2 miles
- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics (see list below)

ForgeSolar does not represent or speak officially for the FAA and cannot approve or deny projects. Results are informational only.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
2-mile flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	N/A	No ATCT receptors designated

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

FAA Policy 78 FR 63276 can be read at https://www.federalregister.gov/d/2013-24729

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 108449.18756
Methodology: V2

PV Array(s)

Name: PV array 1
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.4
Rated power: 5227.0 kW
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	-37.008039	145.167990	157.40	1.60	159.00
2	-37.006600	145.168011	159.46	1.60	161.06
3	-37.006591	145.168590	159.37	1.60	160.97
4	-37.005092	145.168623	165.40	1.60	167.00
5	-37.005118	145.170296	162.53	1.60	164.13
6	-37.005580	145.170275	161.21	1.60	162.81
7	-37.005606	145.173472	172.37	1.60	173.97
8	-37.008082	145.173494	160.53	1.60	162.13
9	-37.008063	145.172123	160.35	1.60	161.95
10	-37.008095	145.170731	157.25	1.60	158.85

Flight Path Receptor(s)

Name: FP 1
Description:
Threshold height: 15 m
Direction: 221.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-36.995416	145.067056	171.54	15.24	186.78
Two-mile	-36.973585	145.090819	167.73	187.73	355.46

Name: FP 2
Description:
Threshold height: 15 m
Direction: 43.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-37.000257	145.061663	162.95	15.24	178.19
Two-mile	-37.021395	145.036934	176.29	170.58	346.87

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-37.008078	145.188766	174.04	1.76
OP 2	2	-37.003848	145.191661	192.55	1.76
OP 3	3	-36.999235	145.179613	189.15	1.76
OP 4	4	-36.999218	145.177918	185.74	1.76
OP 5	5	-36.999321	145.175021	182.21	1.76
OP 6	6	-36.999287	145.171416	174.81	1.76
OP 7	7	-36.996476	145.174914	174.62	1.76
OP 8	8	-36.993528	145.170386	186.85	1.76
OP 9	9	-37.000143	145.165847	173.31	1.76
OP 10	10	-36.999100	145.160647	170.05	1.76
OP 11	11	-37.004299	145.156704	159.05	1.76
OP 12	12	-37.004751	145.151612	148.63	1.76
OP 13	13	-37.009700	145.155367	158.19	1.76
OP 14	14	-37.012407	145.154208	157.71	1.76
OP 15	15	-37.015080	145.152920	150.06	1.76
OP 16	16	-37.014792	145.158585	158.71	1.76
OP 17	17	-37.013593	145.166181	150.62	1.76
OP 18	18	-37.014586	145.164550	150.34	1.76
OP 19	19	-37.014586	145.162920	152.91	1.76
OP 20	20	-37.015923	145.154379	152.40	1.76
OP 21	21	-37.016642	145.150689	149.80	1.76
OP 22	22	-37.014586	145.146998	145.36	1.76
OP 23	23	-37.017636	145.146912	150.15	1.76
OP 24	24	-37.010954	145.149788	147.34	1.76
OP 25	25	-37.019452	145.163563	147.93	1.76
OP 26	26	-37.011022	145.160688	165.01	1.76
OP 27	27	-37.010817	145.162963	166.82	1.76
OP 28	28	-37.011502	145.154851	160.60	1.76
OP 29	29	-37.005394	145.161873	180.28	1.76

Route Receptor(s)

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

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-36.999681	145.157094	165.17	2.00	167.17
2	-36.999818	145.180182	192.54	2.00	194.54

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

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.017124	145.151214	152.79	2.00	154.79
2	-36.999715	145.157137	165.51	2.00	167.51

Name: Route 3
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.017912	145.148108	150.11	2.00	152.11
2	-37.012601	145.168337	152.99	2.00	154.99
3	-37.013458	145.170097	150.31	2.00	152.31
4	-37.012190	145.175247	156.78	2.00	158.78
5	-37.011539	145.175805	158.36	2.00	160.36

Name: Route 4
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.012944	145.166835	153.46	2.00	155.46
2	-37.008112	145.167007	162.88	2.00	164.88
3	-37.003759	145.164733	173.51	2.00	175.51
4	-36.999852	145.164818	172.01	2.00	174.01

Name: Route 5 - Rail
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.019141	145.146426	141.86	2.50	144.36
2	-37.016691	145.148271	150.19	2.50	152.69
3	-37.015594	145.148786	147.47	2.50	149.97
4	-37.003480	145.152970	152.23	2.50	154.73
5	-36.996718	145.155256	166.62	2.50	169.12

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV array 1	SA tracking	SA tracking	6,176	332	13,860,000.0

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
FP 1	0	0
FP 2	0	0
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	24	0
OP 14	399	0
OP 15	409	0
OP 16	366	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	391	0
OP 21	413	0
OP 22	231	0
OP 23	421	0
OP 24	0	0
OP 25	0	0
OP 26	433	0
OP 27	318	114
OP 28	363	0

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
OP 29	0	0
Route 1	0	0
Route 2	608	198
Route 3	965	20
Route 4	0	0
Route 5 - Rail	835	0

Results for: PV array 1

Receptor	Green Glare (min)	Yellow Glare (min)
FP 1	0	0
FP 2	0	0
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	24	0
OP 14	399	0
OP 15	409	0
OP 16	366	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	391	0
OP 21	413	0
OP 22	231	0
OP 23	421	0
OP 24	0	0
OP 25	0	0
OP 26	433	0
OP 27	318	114
OP 28	363	0
OP 29	0	0
Route 1	0	0
Route 2	608	198
Route 3	965	20
Route 4	0	0
Route 5 - Rail	835	0

Flight Path: FP 1

0 minutes of yellow glare
0 minutes of green glare

Flight Path: FP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 11

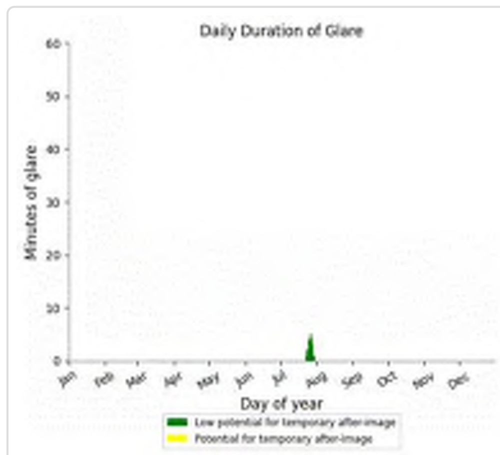
0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

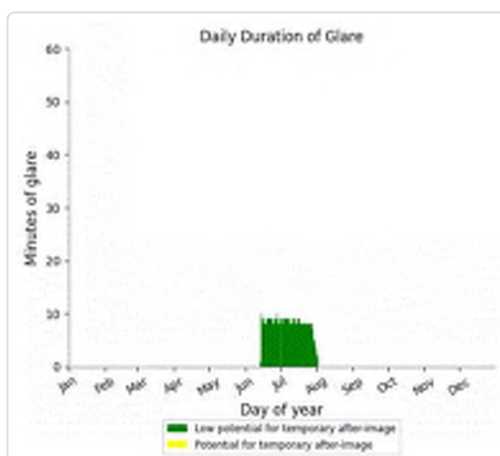
Point Receptor: OP 13

0 minutes of yellow glare
24 minutes of green glare



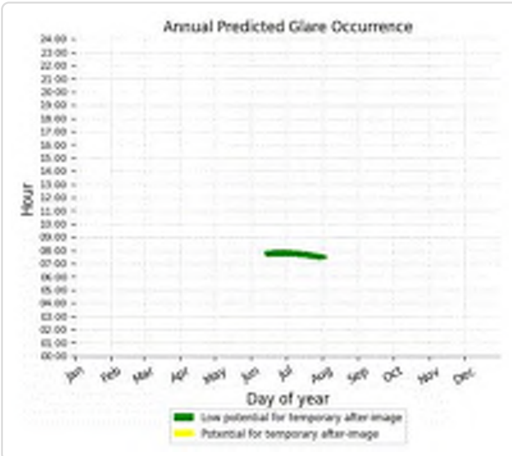
Point Receptor: OP 14

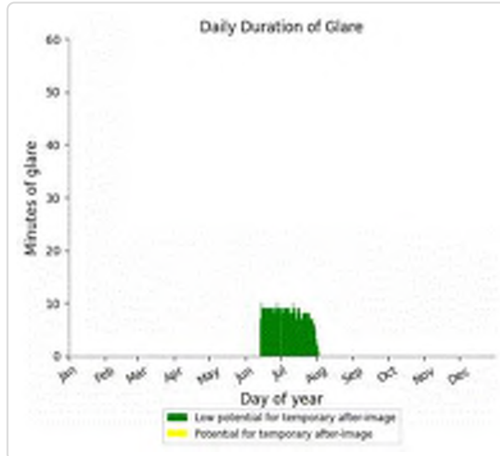
0 minutes of yellow glare
399 minutes of green glare



Point Receptor: OP 15

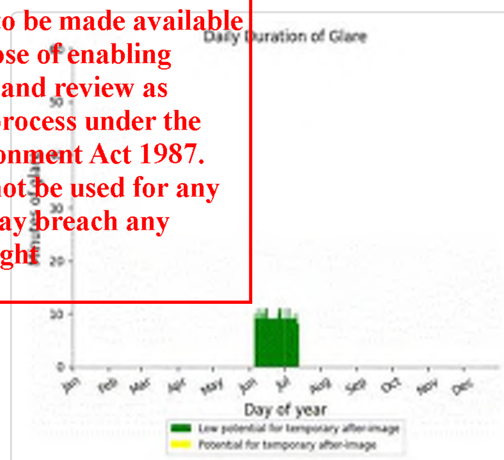
0 minutes of yellow glare
409 minutes of green glare





Point Receptor: OP 16

0 minutes of yellow glare
366 minutes of green glare



Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 18

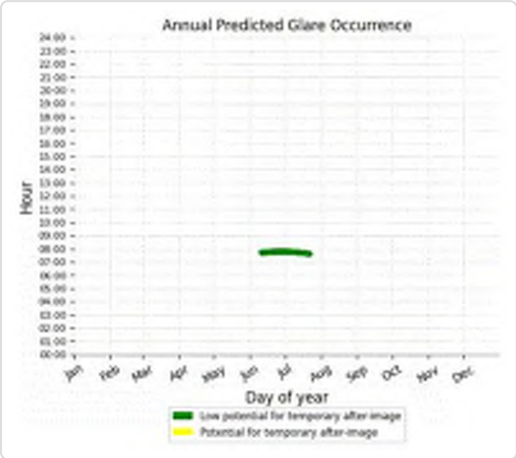
0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

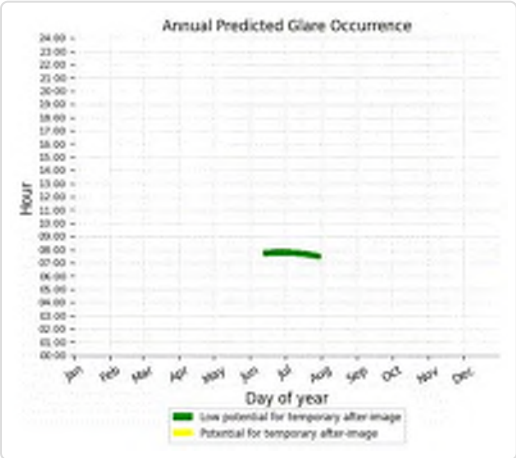
Point Receptor: OP 20

0 minutes of yellow glare
391 minutes of green glare



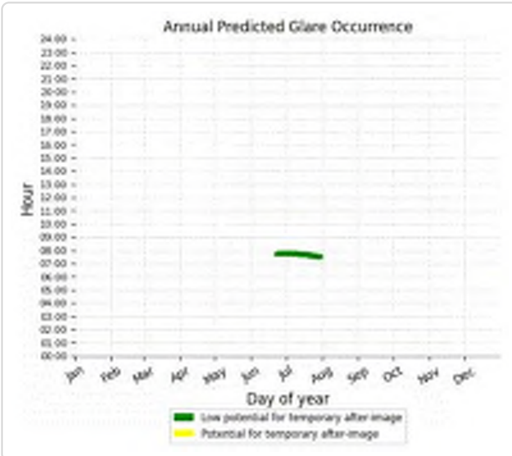
Point Receptor: OP 21

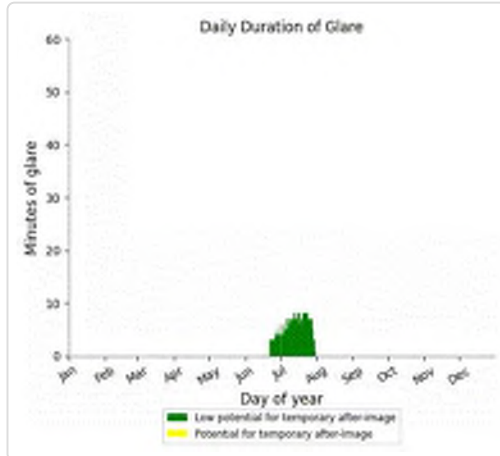
0 minutes of yellow glare
413 minutes of green glare



Point Receptor: OP 22

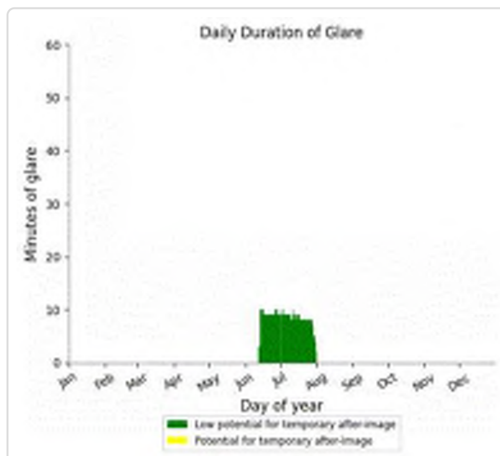
0 minutes of yellow glare
231 minutes of green glare





Point Receptor: OP 23

0 minutes of yellow glare
421 minutes of green glare



Point Receptor: OP 24

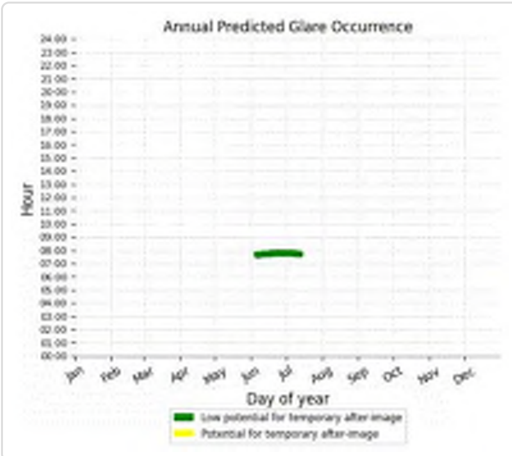
0 minutes of yellow glare
0 minutes of green glare

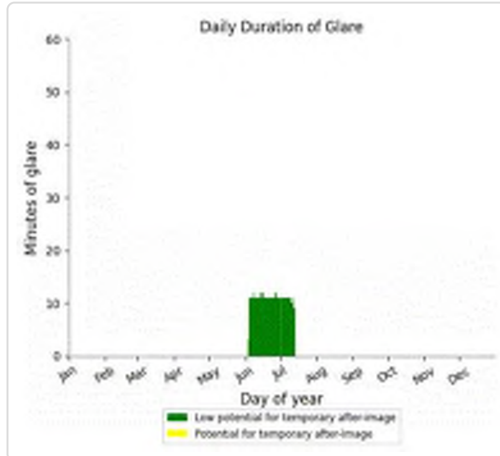
Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 26

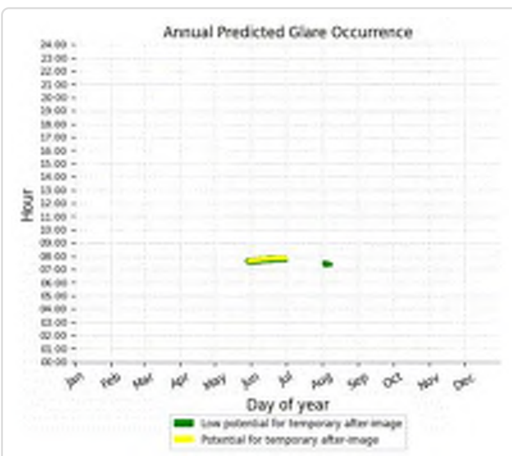
0 minutes of yellow glare
433 minutes of green glare

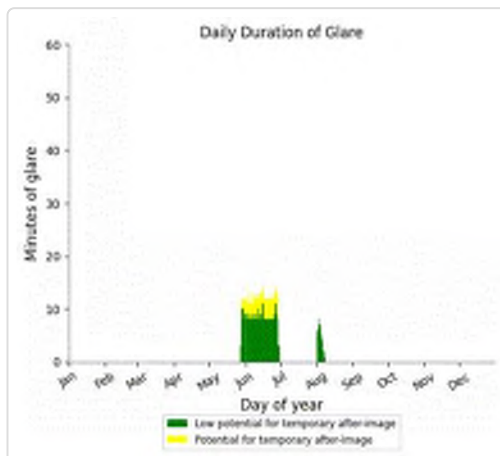




Point Receptor: OP 27

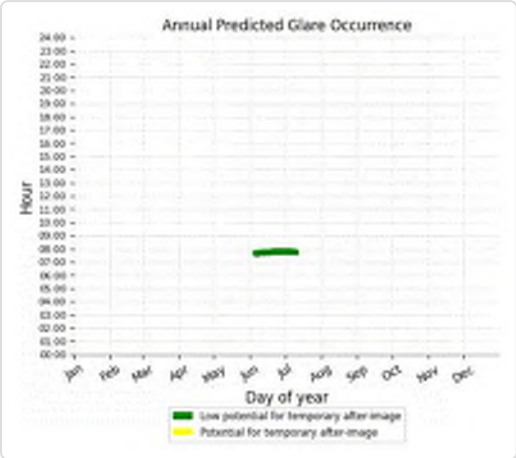
114 minutes of yellow glare
318 minutes of green glare





Point Receptor: OP 28

0 minutes of yellow glare
363 minutes of green glare



Point Receptor: OP 29

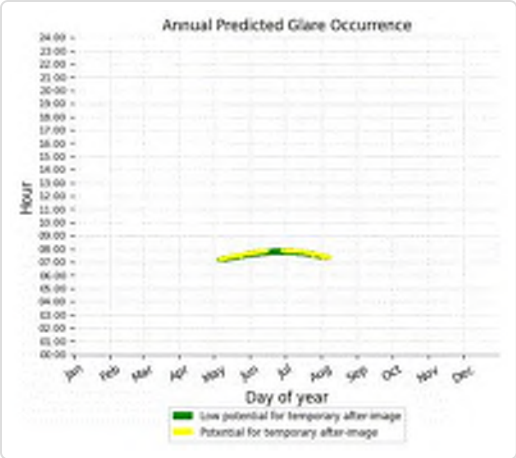
0 minutes of yellow glare
0 minutes of green glare

Route: Route 1

0 minutes of yellow glare
0 minutes of green glare

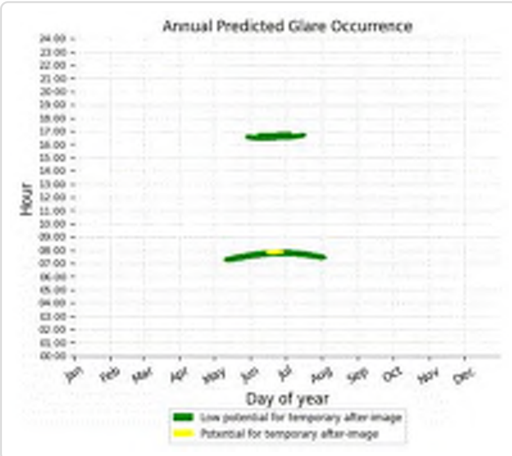
Route: Route 2

198 minutes of yellow glare
608 minutes of green glare



Route: Route 3

20 minutes of yellow glare
965 minutes of green glare

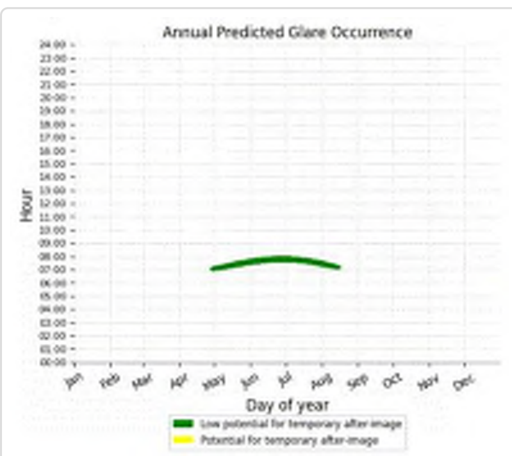


Route: Route 4

0 minutes of yellow glare
0 minutes of green glare

Route: Route 5 - Rail

0 minutes of yellow glare
835 minutes of green glare



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.
Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to V1 algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
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.)
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence may differ.
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.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

Appendix C

ForgeSolar Complete Analysis Report

FORGESOLAR GLARE ANALYSIS

Project: **GVW-Seymour Site**
Proposed 5.23 MWp solar farm with SAT

Site configuration: **GVW-Seymour Site**

Client: Goulburn Valley Water

Site description: SAT system based on concept design

Created 17 Dec, 2023
Updated 21 Dec, 2023
Time-step 1 minute
Timezone offset UTC10
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 5 MW to 10 MW
Site ID 108449.18756

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	SA tracking	SA tracking	6,176	102.9	332	5.5	13,860,000.0

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
Route 1	0	0.0	0	0.0
Route 2	608	10.1	198	3.3
Route 3	965	16.1	20	0.3
Route 4	0	0.0	0	0.0
Route 5 - Rail	835	13.9	0	0.0
FP 1	0	0.0	0	0.0
FP 2	0	0.0	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

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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	24	0.4	0	0.0
OP 14	399	6.7	0	0.0
OP 15	409	6.8	0	0.0
OP 16	366	6.1	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	391	6.5	0	0.0
OP 21	413	6.9	0	0.0
OP 22	231	3.9	0	0.0
OP 23	421	7.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	433	7.2	0	0.0
OP 27	318	5.3	114	1.9
OP 28	363	6.0	0	0.0
OP 29	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array 1
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.4
Rated power: 5227.0 kW
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	-37.008039	145.167990	157.40	1.60	159.00
2	-37.006600	145.168011	159.46	1.60	161.06
3	-37.006591	145.168590	159.37	1.60	160.97
4	-37.005092	145.168623	165.40	1.60	167.00
5	-37.005118	145.170296	162.53	1.60	164.13
6	-37.005580	145.170275	161.21	1.60	162.81
7	-37.005606	145.173472	172.37	1.60	173.97
8	-37.008082	145.173494	160.53	1.60	162.13
9	-37.008063	145.172123	160.35	1.60	161.95
10	-37.008095	145.170731	157.25	1.60	158.85

Route Receptors

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	-36.999681	145.157094	165.17	2.00	167.17
2	-36.999818	145.180182	192.54	2.00	194.54

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	-37.017124	145.151214	152.79	2.00	154.79
2	-36.999715	145.157137	165.51	2.00	167.51

Name: Route 3
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.017912	145.148108	150.11	2.00	152.11
2	-37.012601	145.168337	152.99	2.00	154.99
3	-37.013458	145.170097	150.31	2.00	152.31
4	-37.012190	145.175247	156.78	2.00	158.78
5	-37.011539	145.175805	158.36	2.00	160.36

Name: Route 4
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.012944	145.166835	153.46	2.00	155.46
2	-37.008112	145.167007	162.88	2.00	164.88
3	-37.003759	145.164733	173.51	2.00	175.51
4	-36.999852	145.164818	172.01	2.00	174.01

Name: Route 5 - Rail
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.019141	145.146426	141.86	2.50	144.36
2	-37.016691	145.148271	150.19	2.50	152.69
3	-37.015594	145.148786	147.47	2.50	149.97
4	-37.003480	145.152970	152.23	2.50	154.73
5	-36.996718	145.155256	166.62	2.50	169.12

Flight Path Receptors

Name: FP 1
Description:
Threshold height: 15 m
Direction: 221.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-36.995416	145.067056	171.54	15.24	186.78
Two-mile	-36.973585	145.090819	167.73	187.73	355.46

Name: FP 2
Description:
Threshold height: 15 m
Direction: 43.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-37.000257	145.061663	162.95	15.24	178.19
Two-mile	-37.021395	145.036934	176.29	170.58	346.87

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-37.008078	145.188766	174.04	1.76
OP 2	2	-37.003848	145.191661	192.55	1.76
OP 3	3	-36.999235	145.179613	189.15	1.76
OP 4	4	-36.999218	145.177918	185.74	1.76
OP 5	5	-36.999321	145.175021	182.21	1.76
OP 6	6	-36.999287	145.171416	174.81	1.76
OP 7	7	-36.996476	145.174914	174.62	1.76
OP 8	8	-36.993528	145.170386	186.85	1.76
OP 9	9	-37.000143	145.165847	173.31	1.76
OP 10	10	-36.999100	145.160647	170.05	1.76
OP 11	11	-37.004299	145.156704	159.05	1.76
OP 12	12	-37.004751	145.151612	148.63	1.76
OP 13	13	-37.009700	145.155367	158.19	1.76
OP 14	14	-37.012407	145.154208	157.71	1.76
OP 15	15	-37.015080	145.152920	150.06	1.76
OP 16	16	-37.014792	145.158585	158.71	1.76
OP 17	17	-37.013593	145.166181	150.62	1.76
OP 18	18	-37.014586	145.164550	150.34	1.76
OP 19	19	-37.014586	145.162920	152.91	1.76
OP 20	20	-37.015923	145.154379	152.40	1.76
OP 21	21	-37.016642	145.150689	149.80	1.76
OP 22	22	-37.014586	145.146998	145.36	1.76
OP 23	23	-37.017636	145.146912	150.15	1.76
OP 24	24	-37.010954	145.149788	147.34	1.76
OP 25	25	-37.019452	145.163563	147.93	1.76
OP 26	26	-37.011022	145.160688	165.01	1.76
OP 27	27	-37.010817	145.162963	166.82	1.76
OP 28	28	-37.011502	145.164851	160.60	1.76
OP 29	29	-37.005394	145.161873	180.28	1.76

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	SA tracking	SA tracking	6,176	102.9	332	5.5	13,860,000.0

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
Route 1	0	0.0	0	0.0
Route 2	608	10.1	198	3.3
Route 3	965	16.1	20	0.3
Route 4	0	0.0	0	0.0
Route 5 - Rail	835	13.9	0	0.0
FP 1	0	0.0	0	0.0
FP 2	0	0.0	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 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	24	0.4	0	0.0
OP 14	399	6.7	0	0.0
OP 15	409	6.8	0	0.0
OP 16	366	6.1	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	391	6.5	0	0.0
OP 21	413	6.9	0	0.0
OP 22	231	3.9	0	0.0
OP 23	421	7.0	0	0.0
OP 24	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	**hr**	**min**	**hr**
OP 25	0	0.0	0	0.0
OP 26	433	7.2	0	0.0
OP 27	318	5.3	114	1.9
OP 28	363	6.0	0	0.0
OP 29	0	0.0	0	0.0

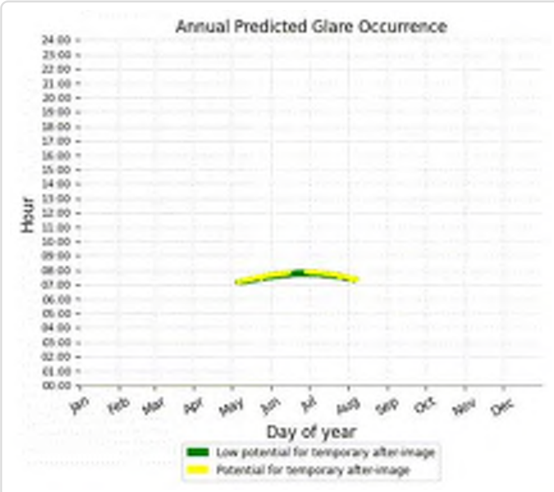
PV: PV array 1 potential temporary after-image

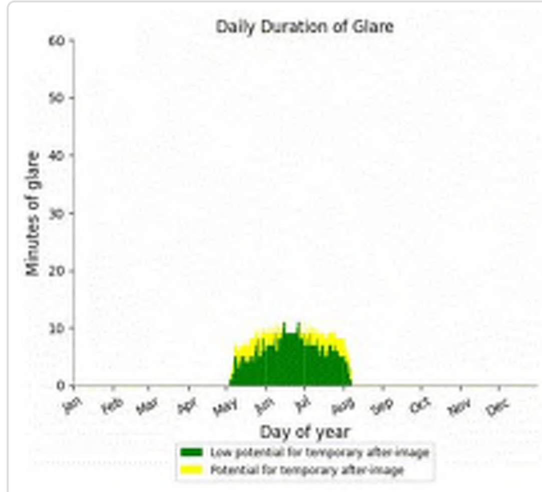
Receptor results ordered by category of glare

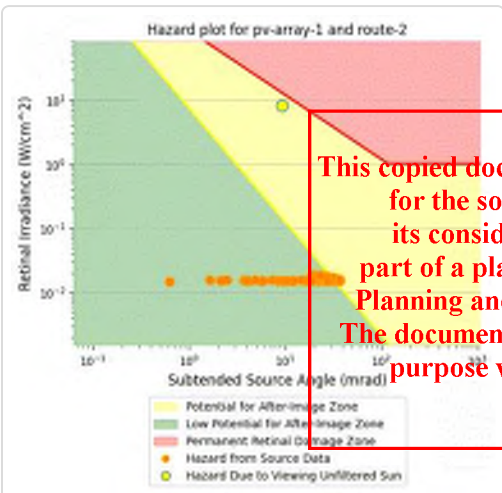
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Route 2	608	10.1	198	3.3
Route 3	965	16.1	20	0.3
Route 5 - Rail	835	13.9	0	0.0
Route 1	0	0.0	0	0.0
Route 4	0	0.0	0	0.0
FP 1	0	0.0	0	0.0
FP 2	0	0.0	0	0.0
OP 27	318	5.3	114	1.9
OP 13	24	0.4	0	0.0
OP 14	399	6.7	0	0.0
OP 15	409	6.8	0	0.0
OP 16	366	6.1	0	0.0
OP 20	391	6.5	0	0.0
OP 21	413	6.9	0	0.0
OP 22	231	3.9	0	0.0
OP 23	421	7.0	0	0.0
OP 26	433	7.2	0	0.0
OP 28	363	6.0	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 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 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 29	0	0.0	0	0.0

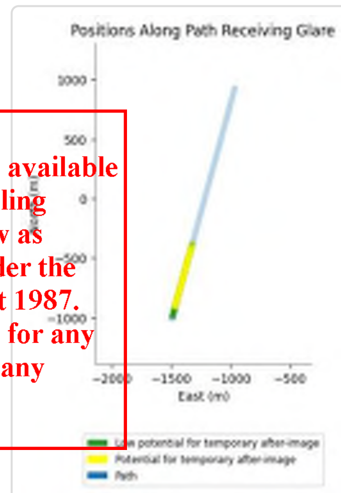
PV array 1 and Route: Route 2

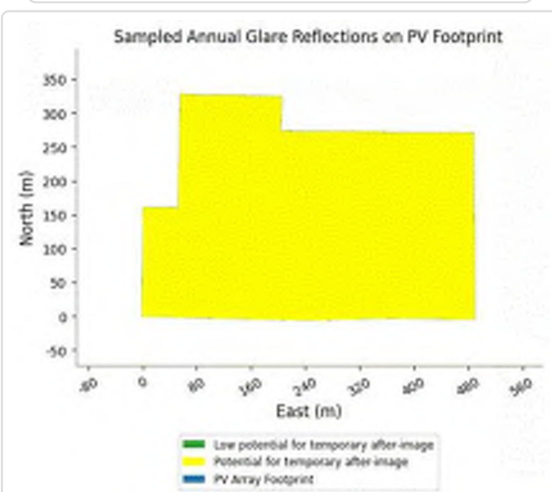
Yellow glare: 198 min.
Green glare: 608 min.





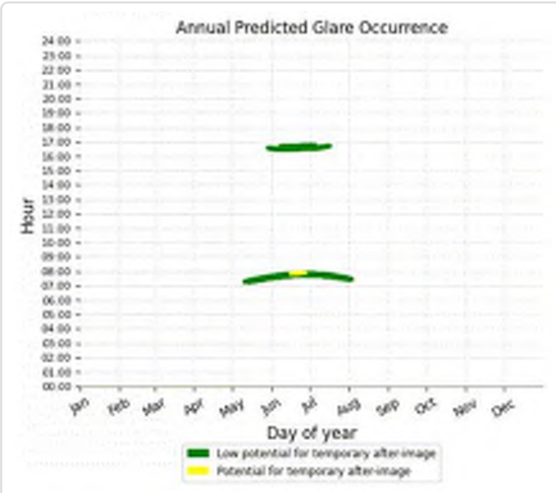


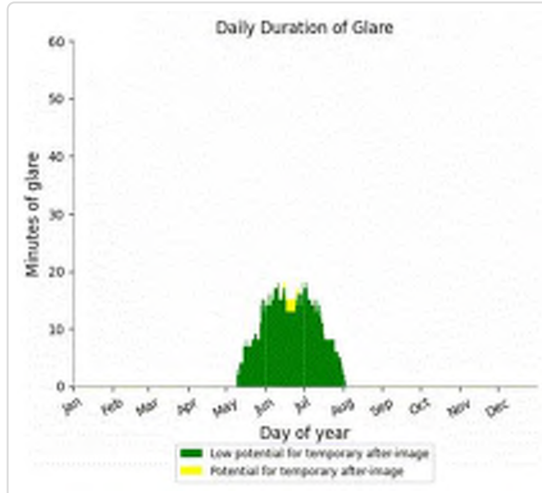


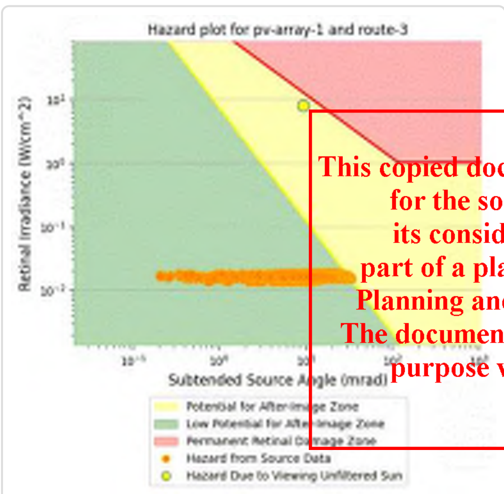


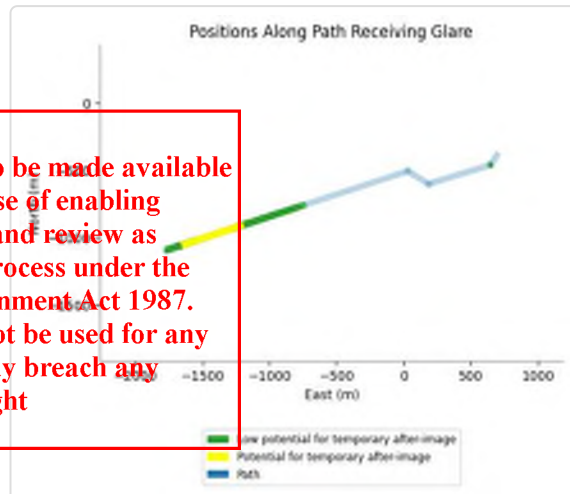
PV array 1 and Route: Route 3

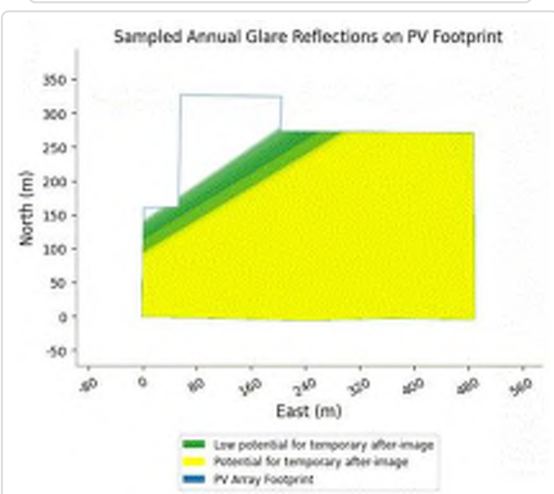
Yellow glare: 20 min.
Green glare: 965 min.





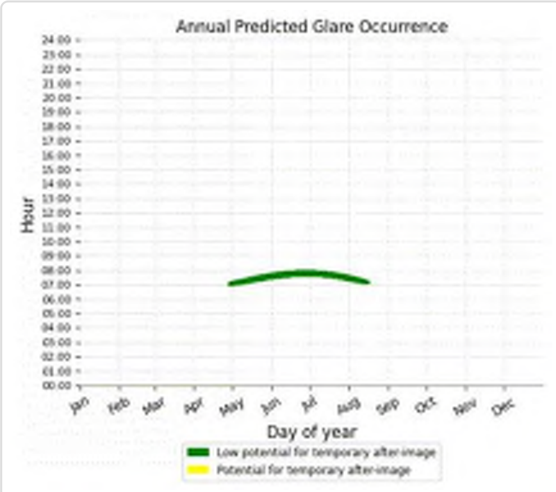


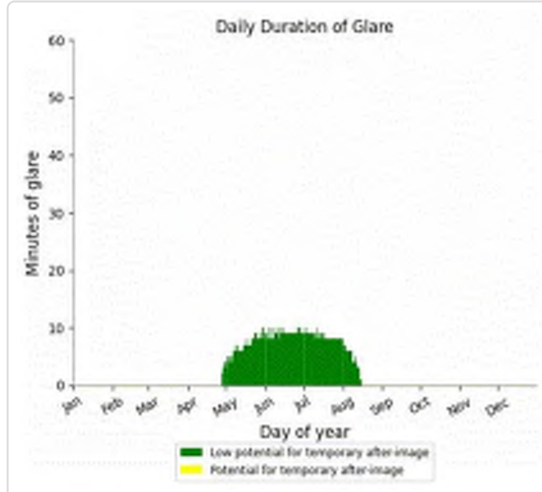


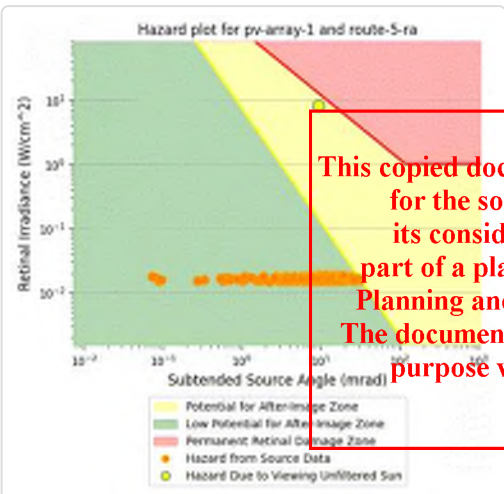


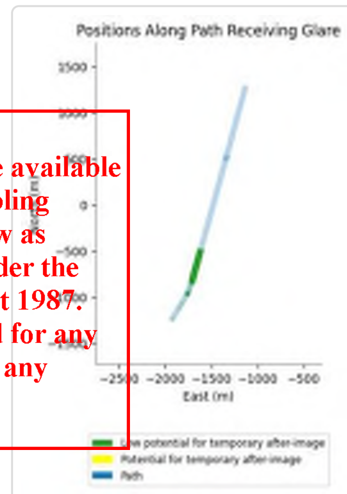
PV array 1 and Route: Route 5 - Rail

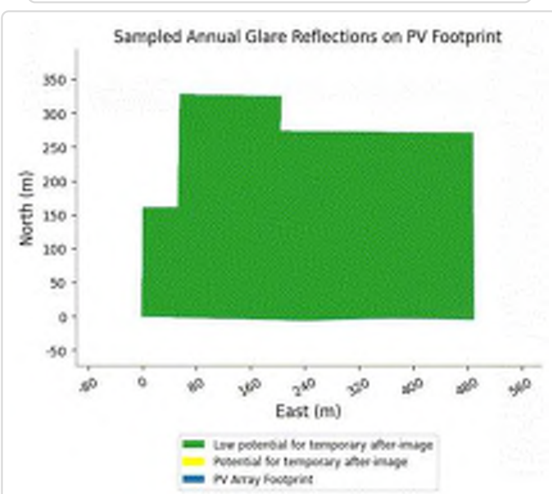
Yellow glare: none
Green glare: 835 min.











PV array 1 and Route: Route 1

No glare found

PV array 1 and Route: Route 4

No glare found

PV array 1 and FP: FP 1

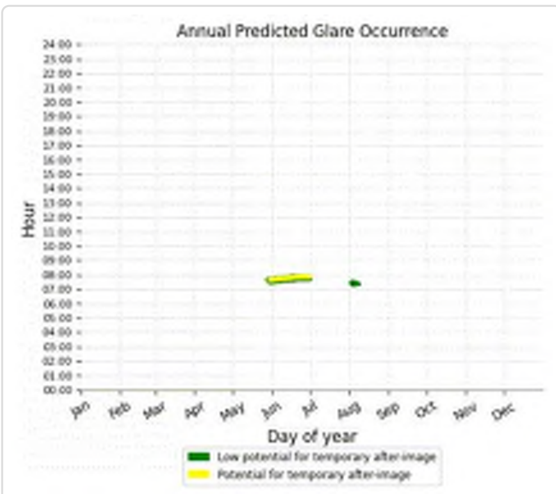
No glare found

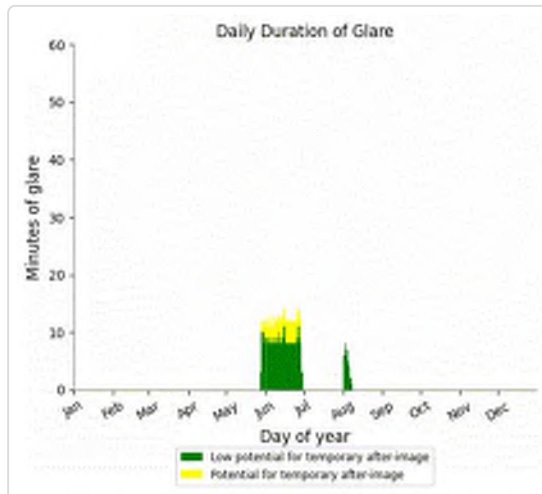
PV array 1 and FP: FP 2

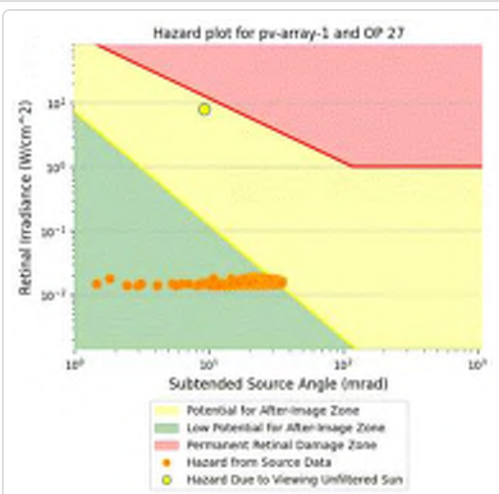
No glare found

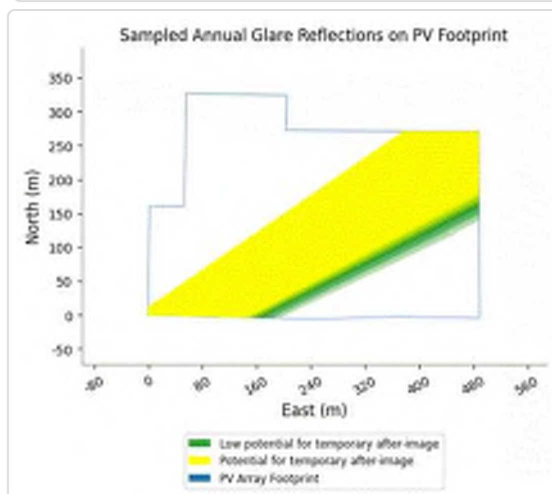
PV array 1 and OP 27

Yellow glare: 114 min.
Green glare: 318 min.



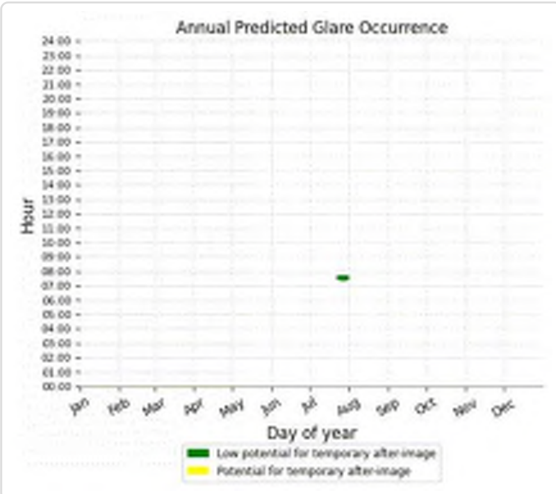


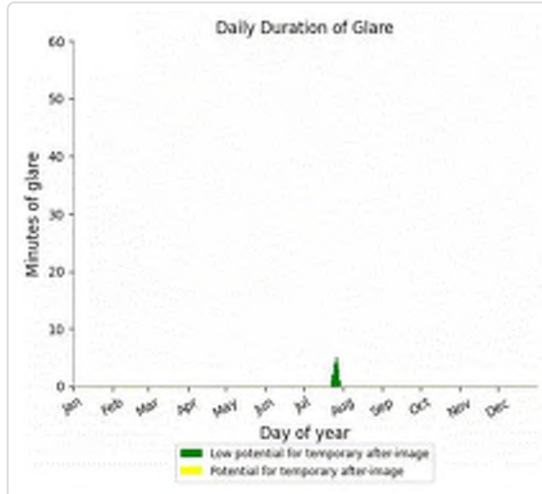


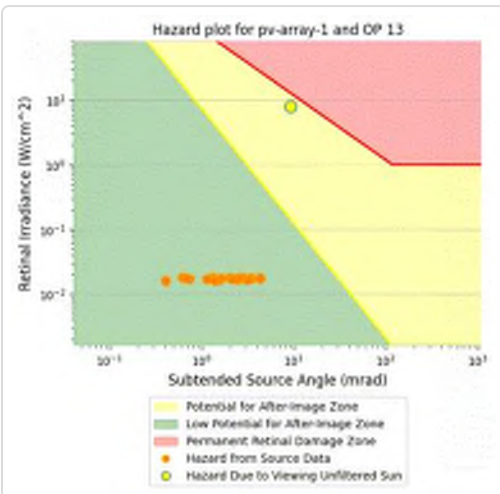


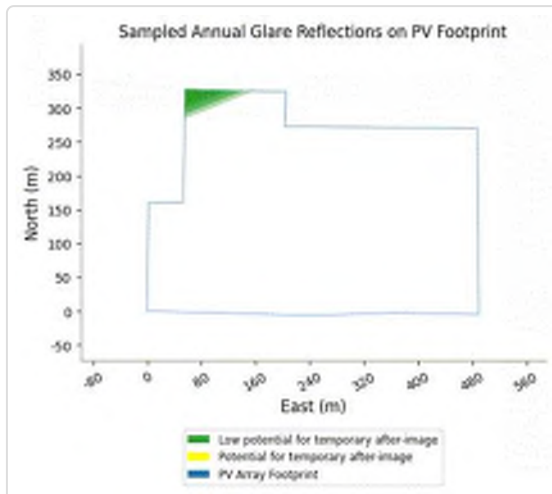
PV array 1 and OP 13

Yellow glare: none
Green glare: 24 min.





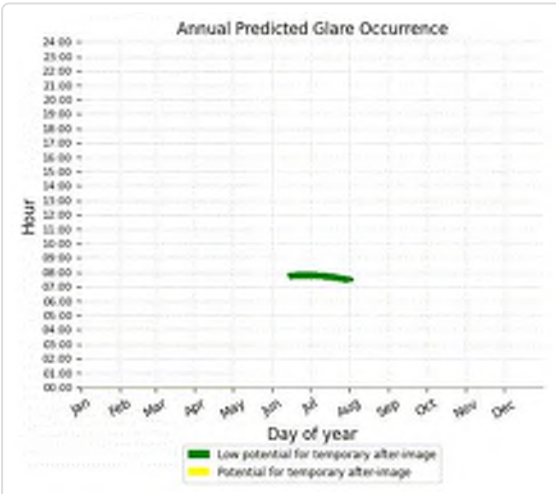


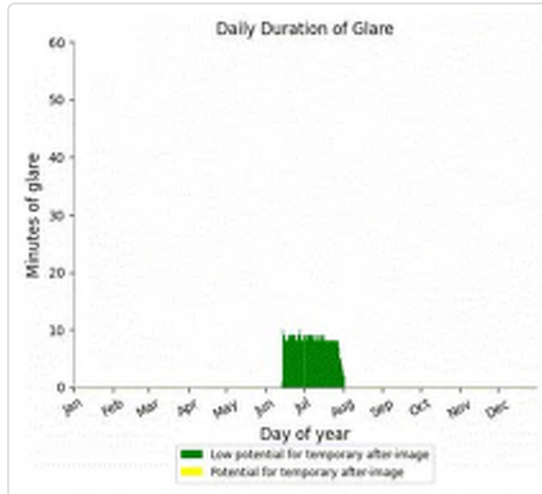


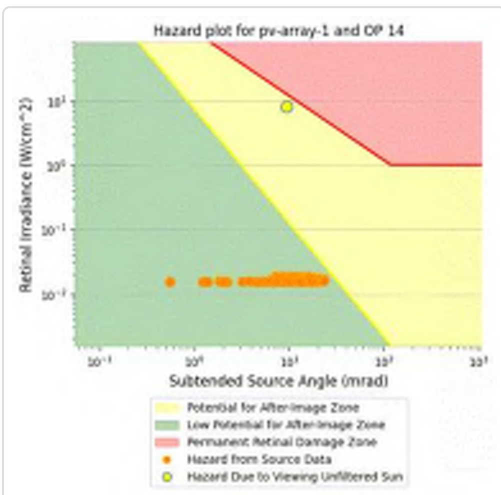
PV array 1 and OP 14

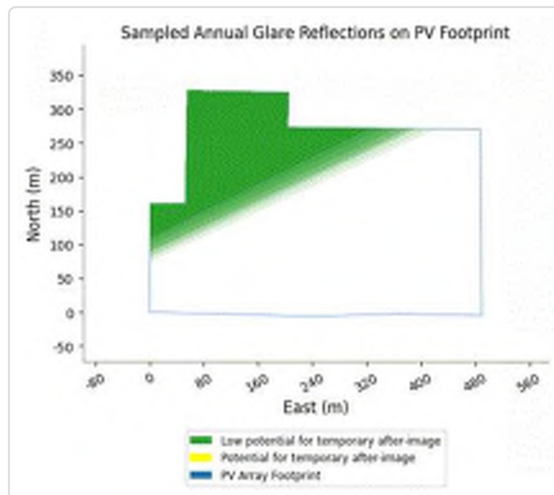
Yellow glare: none

Green glare: 399 min.



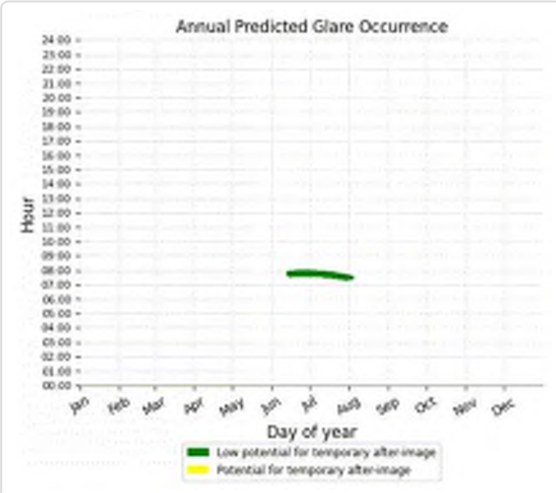


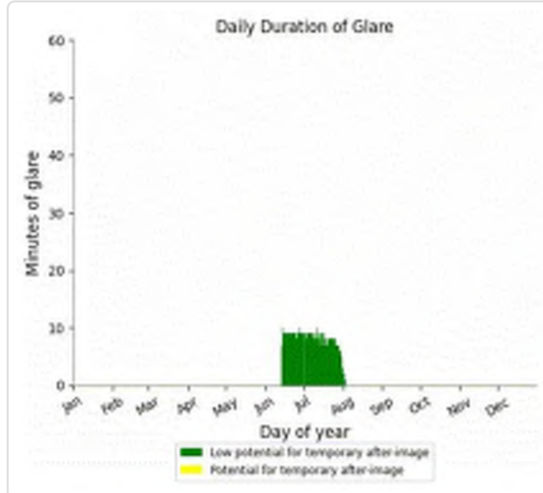


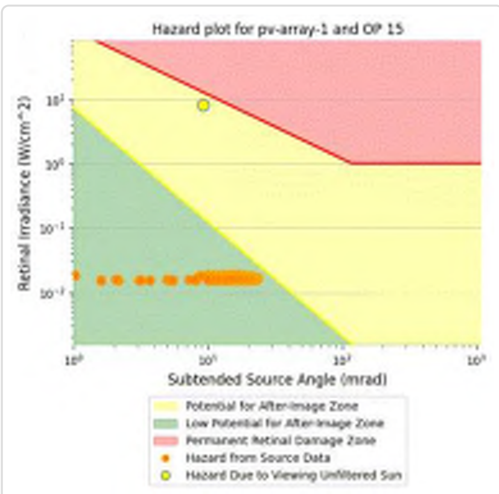


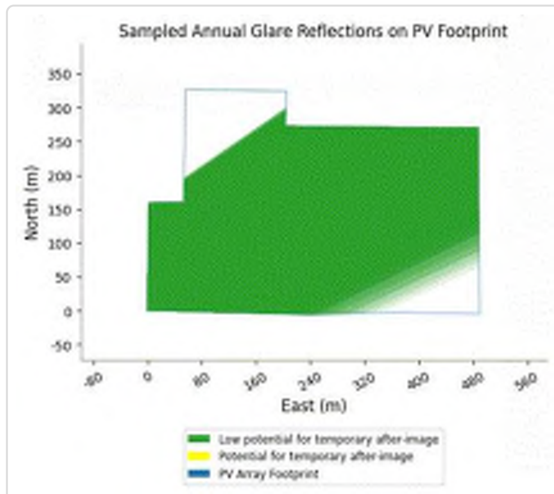
PV array 1 and OP 15

Yellow glare: none
Green glare: 409 min.



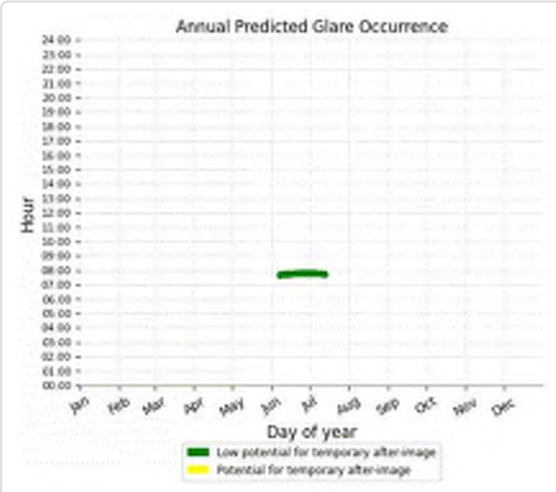


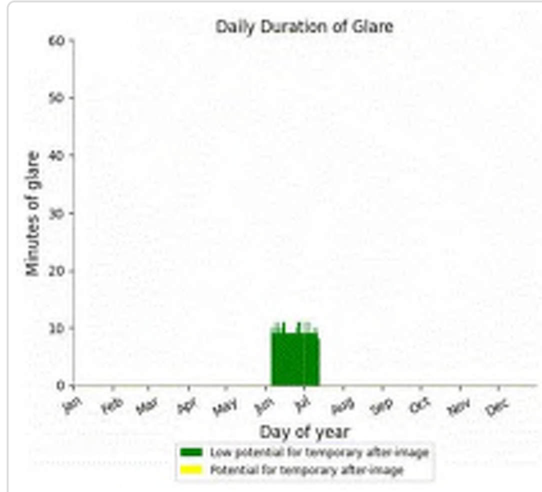


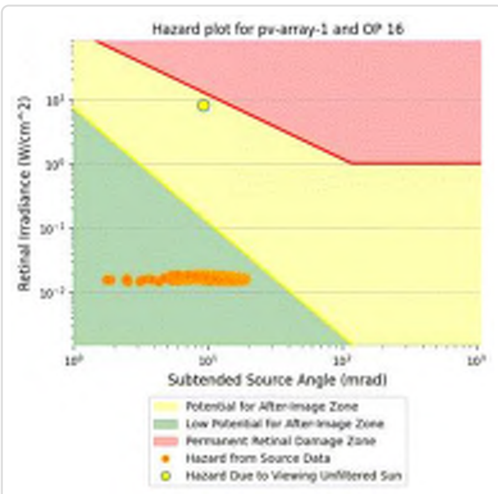


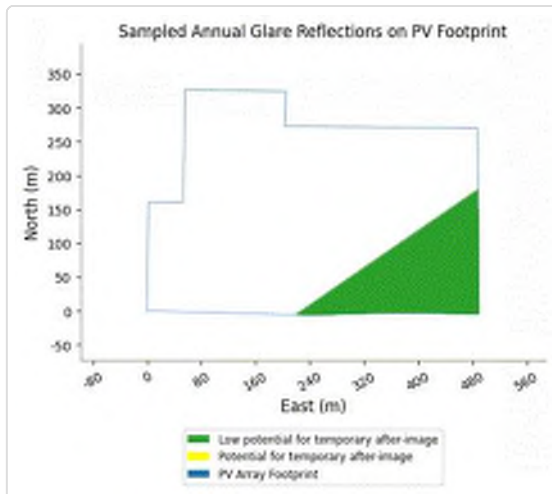
PV array 1 and OP 16

Yellow glare: none
Green glare: 366 min.



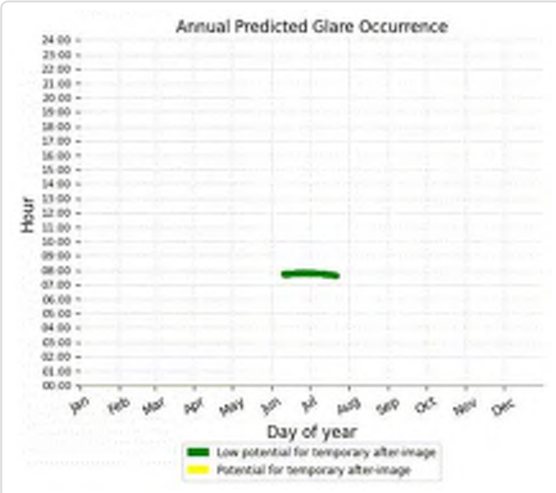


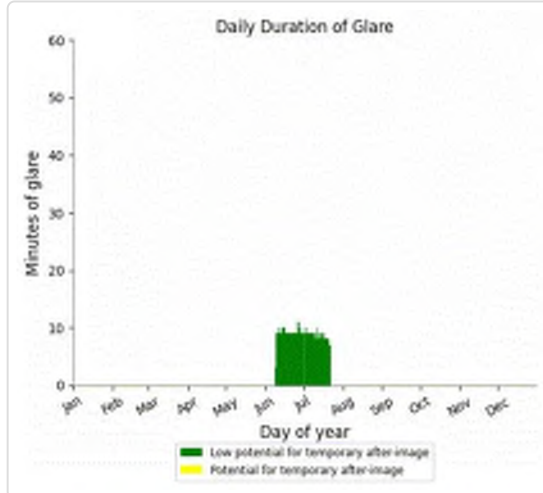


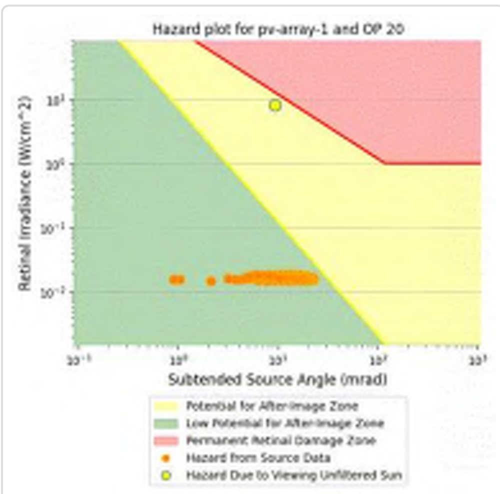


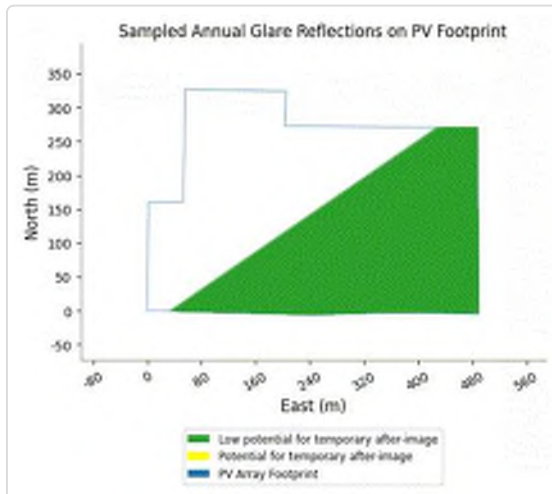
PV array 1 and OP 20

Yellow glare: none
Green glare: 391 min.



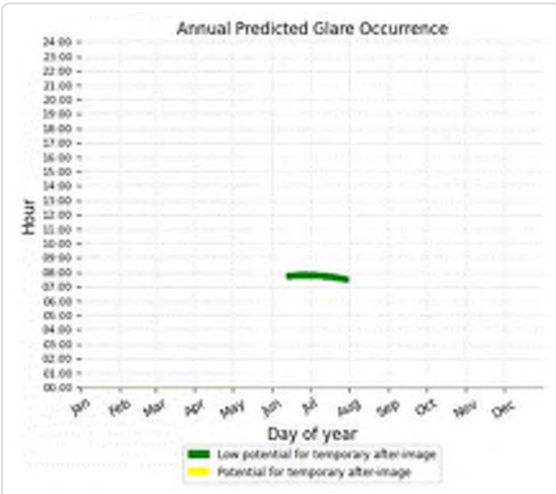


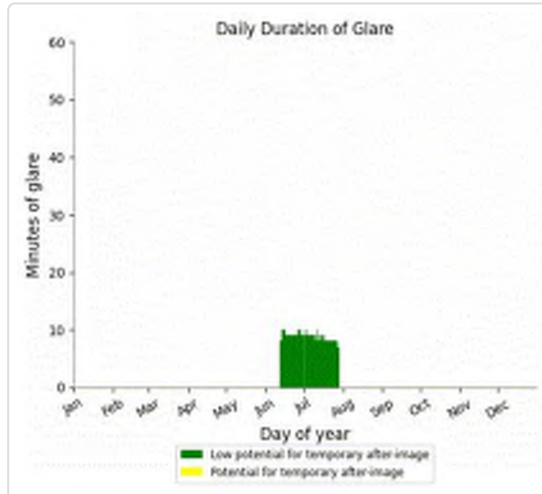


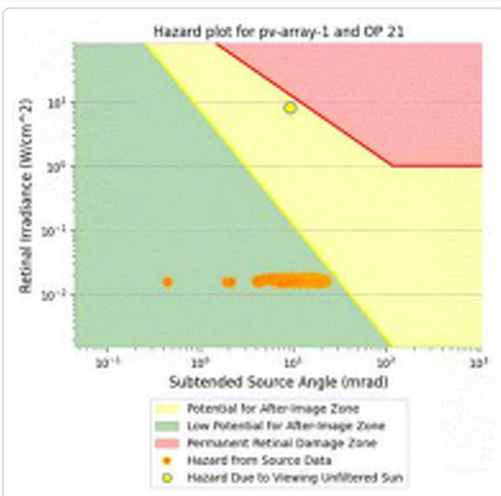


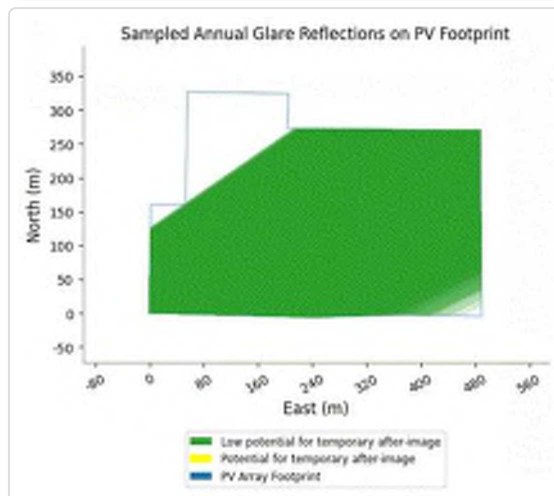
PV array 1 and OP 21

Yellow glare: none
Green glare: 413 min.



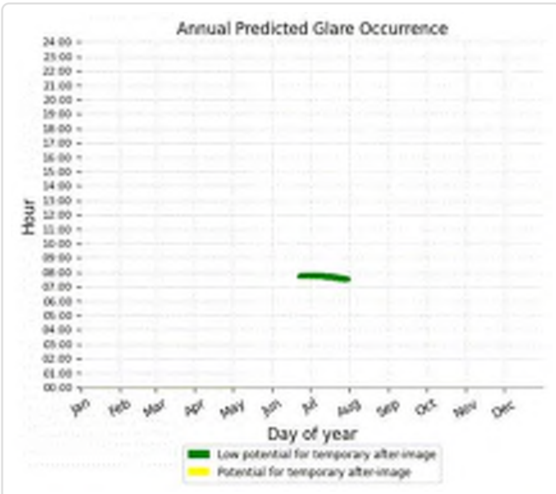


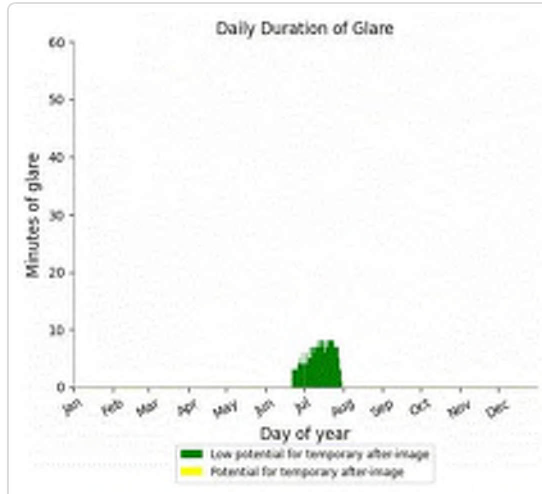


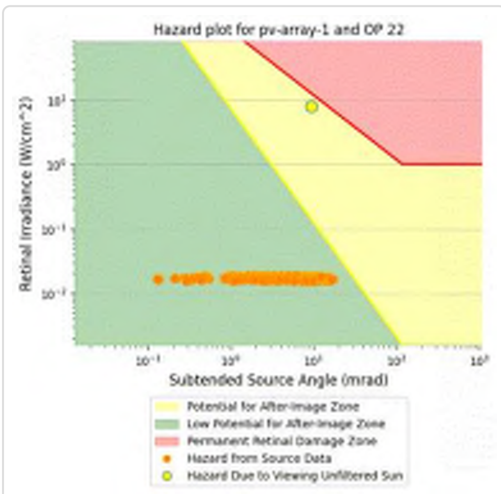


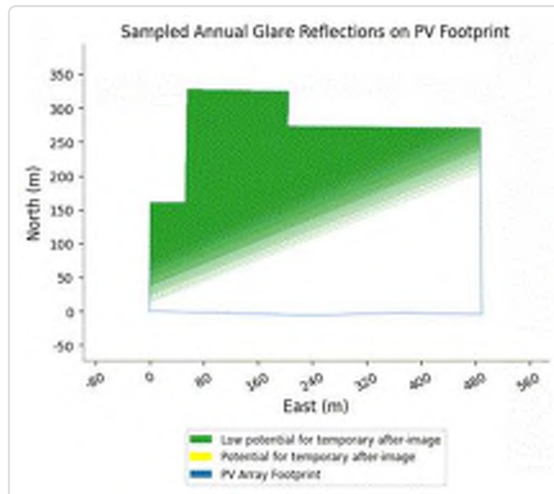
PV array 1 and OP 22

Yellow glare: none
Green glare: 231 min.



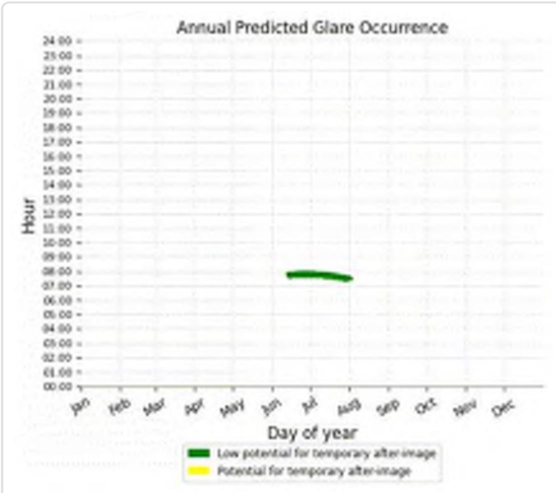


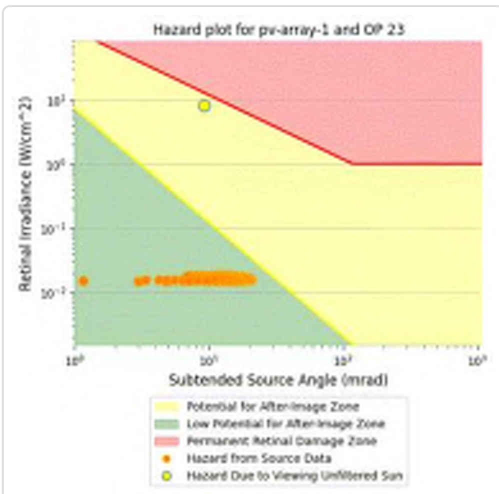


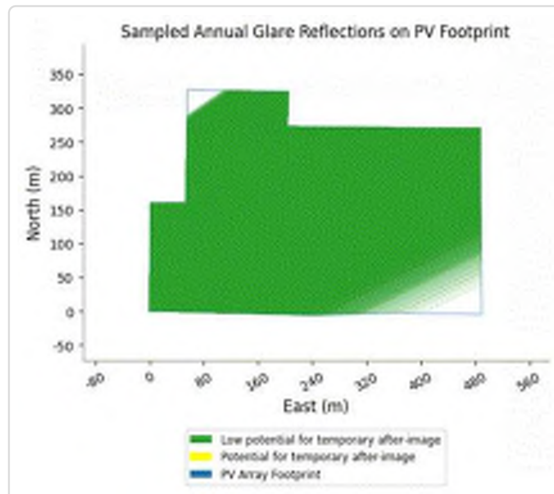


PV array 1 and OP 23

Yellow glare: none
Green glare: 421 min.

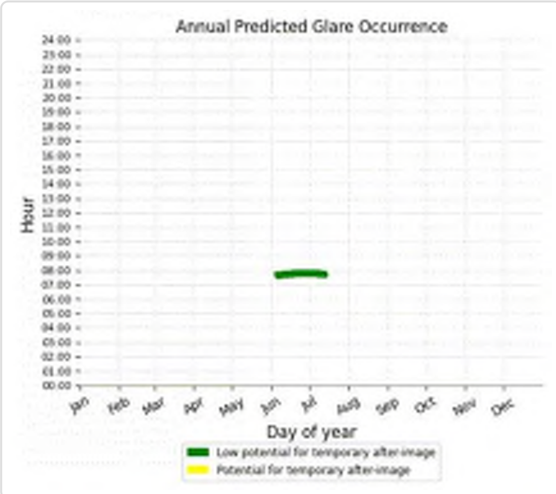


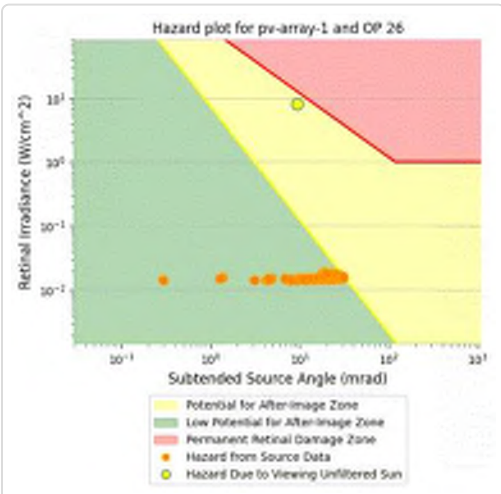


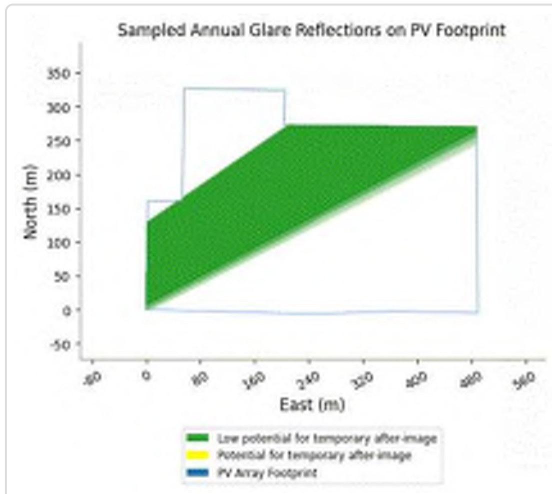


PV array 1 and OP 26

Yellow glare: none
Green glare: 433 min.

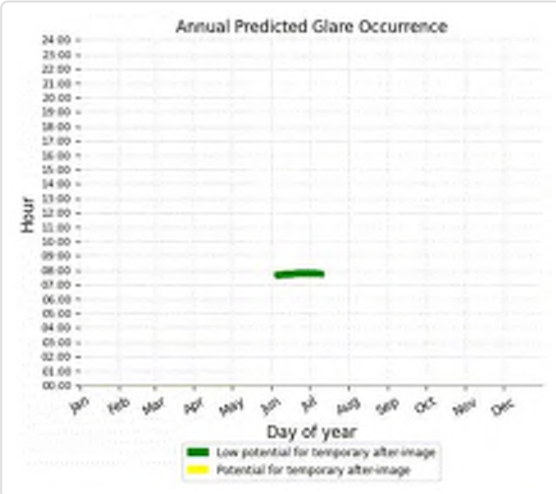


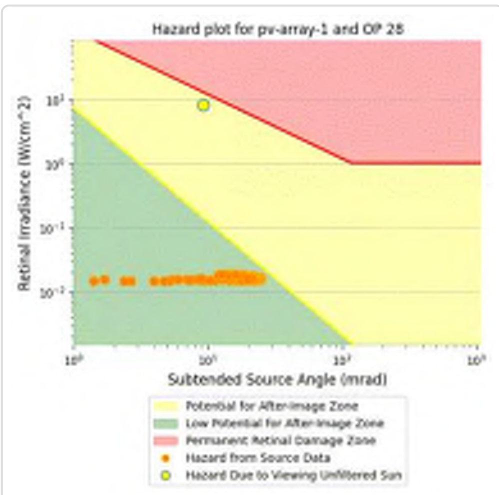


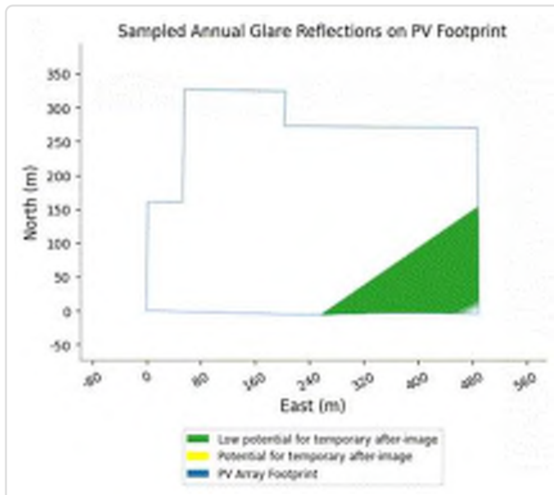


PV array 1 and OP 28

Yellow glare: none
Green glare: 363 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 17

No glare found

PV array 1 and OP 18

No glare found

PV array 1 and OP 19

No glare found

PV array 1 and OP 24

No glare found

PV array 1 and OP 25

No glare found

PV array 1 and OP 29

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