SANDY CREEK SOLAR FARM

PEER REVIEW OF
SOLAR PHOTOVOLTAIC GLINT AND GLARE STUDY

Prepared For
Wagga Wagga City Council

November 2021

Prepared By Environmental Ethos
for Wagga Wagga City Counil

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1. INTRODUCTION

This peer review of the Sandy Creek Solar Farm Solar Photovoltaic Glint and Glare Study (the study) prepared by Pager Power Urban & Renewables (Pager Power), dated April 2021, has been prepared by Environmental Ethos at the request of NGH Consulting on behalf of Wagga Wagga City Council (council). The purpose of the peer review is to provide independent advice on the study to assist council's assessment of the Sandy Creek Solar Farm (the Project) planning application.

The Project consists of small-scale solar farm with photovoltaic (PV) arrays mounted on a single axis tracking system. The PV arrays consists of two PV panels in portrait resulting in an array of approximately 4.5 metres wide. The PV arrays are aligned north to south and will track the sun's movement east to west. The PV array, including the mounting structures, will be a maximum height of 2.15m to the axis, and 3.5m high at maximum rotation.

The Project covers an area of approximately 41 hectares and is located on rural land approximately 2 km to the north east of Uranquinty (near Wagga Wagga), NSW. The south eastern boundary of the Project site adjoins the Main South rail line and the Olympic Highway.

This peer review has been based on the following information:

- Sandy Creek Solar Farm Solar Photovoltaic Glint and Glare Study, prepared by Pager Power Urban & Renewables, April 2021 *(Appendix A)*
- Mitigation measures – information from the Statement of Environmental Effects provided by NRG Consulting *(Appendix B)*
- RFI responses and supporting documentation (ForgeSolar data results) provided by Pager Power *(Appendix C)*
- Sandy Creek Solar Farm Addendum – Consideration of Alternative Resting Angles (the addendum), prepared by Pager Power, dated August 2021 *(Appendix D)*
- Additional Assessment - Sandy Creek Solar Farm Solar Photovoltaic Glint and Glare Study, prepared by Pager Power Urban & Renewables, October 2021 *(Appendix E)*

Environmental Ethos is a specialist consultancy with expertise in glint and glare assessments throughout Australia (*refer to Appendix F*). Environmental Ethos is not affiliated with NGH Consulting or Pager Power.

2. RELEVANT PLANNING GUIDELINES

New South Wales currently has no policy or planning guidelines specifically addressing the assessment of glint and glare resulting from solar farms.

NSW Government, Large-Scale Solar Energy Guidelines For State Significant Developments

The NSW Government Large-Scale Solar Energy Guideline for State Significant Development, 2018[1] (the NSW Guideline), provides guidance to State significant solar energy projects. Sandy Creek Solar Farm is below the threshold of capital investment value and is therefore not considered State

[1] https://www.planning.nsw.gov.au/-/media/Files/DPE/Guidelines/large-scale-solar-energy-guideline-2018-12-11.pdf?la=en

significant. However, whilst not directly applicable, the Guideline provides assistance in highlighting some of the common key issues for consideration in the development of solar farms. These issues includes the consideration of potential impacts on landscape character and values, and the visual amenity of landholders and communities. The NSW Guidelines does not directly address the issue of potential glare hazard.

Victorian State Government, Solar Energy Facilities Design and Development Guidelines

The Victorian State Government, Solar Energy Facilities Design and Development Guidelines, 2019[2] (VIC Guidelines), provides guidance on glint and glare management. The VIC Guidelines state the following:

Any assessment of glint and glare should use an accepted methodology based on best practice and consider impacts on:

- *dwellings and roads within 1 km of the proposed facility, taking into consideration their height within the landscape*
- *aviation infrastructure including any air traffic control tower or runway approach path close to the proposed facility*
- *any other receptor to which a responsible authority considers solar reflection may be a hazard.*

The impacts of solar reflection vary for each type of receptor. The following criteria for glint and glare effects, should be used to guide an assessment.

- *No impact: a solar reflection is not geometrically possible, or it will not be visible from the assessed receptor. No mitigation is required.*
- *Low impact: a solar reflection is geometrically possible, but the intensity and duration of an impact is considered to be small and can be mitigated with screening or other measure.*
- *Moderate impact: a solar reflection is geometrically possible and visible, but the intensity and duration of an impact varies according to conditions. Mitigation measures (such as through design, orientation, landscaping or other screening method) to reduce impacts to an acceptable level will be required.*
- *Major impact: a solar reflection is geometrically possible and visible under a range of conditions that will produce impacts with significant intensity and duration. Significant mitigation measures are required if the proposed development is to proceed.*

The responsible authority will require a glint and glare assessment, and a proponent should agree a methodology for the assessment with the responsibility authority. Where a solar energy facility is proposed close to an airfield, airport or road network, the proponent should consultant the owner/operator of the facility and the relevant roads corporation.

Since NSW does not currently have policy or guidelines specifically addressing the impacts of glint and glare, the VIC Guidelines have been used as the most relevant planning guideline in Australia for assessing the study. It should be noted that the definition of glint and glare used in the VIC Guidelines differs from that used in the study (item 1.2). The VIC Guidelines identifies the difference between glint and glare as intensity:

[2] The State of Victoria Department of Environment, Land, Water and Planning 2019, Solar Energy Facilities Design and Development GuidelineS

"Glint can be caused by direct reflection of the sun from the surface of an object, whereas glare is a continuous source of brightness. Glare is much less intense than glint."(p23)

Pager Power use the term 'solar reflection' to cover both types of solar reflection (glint and glare).

3. REVIEW

The outcomes for the peer review are detailed in *Table 1*.

Table 1. Peer review outcomes

Item No.	Description	Comment/Recommendation
1.	Methodology: the study considers visibility of the panels from the location of a receptor, if there is line of sight to the solar farm a geometric analysis is undertaken. The significance of impact is determined based on the Pager Powers recommendations, the VIC Guidelines are included in Appendix D. Additional assessment (October 2021) (refer Appendix E) - assessment of local roads and the model airfield according to the VIC Guidelines.	a) The methodology for determining the visibility of panels is not detailed. b) Geometric analysis uses ForgeSolar's Solar Glare Hazard Analysis Tool (SGHAT) which is widely used for this type of assessment. c) Pager Power's impact significance definition and mitigation requirements differ from those contained in the VIC Guidelines notably the required extent of mitigation for moderate and major impacts. d) VIC Guidelines impact significance should prevail as the most relevant planning guideline within Australia.
2.	Extent of the study: • 1km for receptors (dwellings) • 500m for rail line • 1km National and Regional Roads • Local Roads -Additional Assessment (October 2021) • Aviation Infrastructure – not assessed • Other sensitive receptors – Model Airfield (October 2021)	VIC Guidelines requires a consideration of impacts within a 1km radius of a solar farm, and potentially further if the receptors are elevated. a) Railway line – not consistent with the 1km radius, however worst case section was assessed. b) Local Roads – additional assessment completed October 2021. c) Aviation Infrastructure – not assessed. Wagga RAAF Base is 17.2km to the east of the Project and not within the viewshed. The study could have included a statement as to why aviation infrastructure was not assessed. d) Other sensitive receptors may include recreational/public and commercial facilities. Additional assessment (October 2021) considered impacts to Connorton Model Airfield (Wagga Model Aero Club) located to the south east of the Project site.
3.	Impacts on Road Receptors: • 3.15km section of Olympic Highway was assessed • 1.5m eye height was used as typical eye level of a road users • The study found glare affecting the Olympic Highway is geometrically possible, occurring in late afternoon. • Additional assessment (October 2021) undertaken for local roads, glare potential was found to affect some roads.	a) The study did not consider the increased eye height of drivers in larger vehicles such as trucks, which is approximately 2m. The existing railway embankment was noted as providing partial screening, however this is less effective for drivers of larger vehicles. b) Further assessment provided by Pager Power (the addendum) considered alternative resting angles, adjustment of the glare modeling removed the geometric possibility of glare when the resting angle was set at 3 degrees. c) Additional assessment identified some glare impacts to local roads when the resting angle was set at 0 degrees, when this was changed to 5 degrees no local roads were affected.

4.	Impacts on Dwellings: • No dwelling receptors were taken forward for geometric and detailed modelling because the assessment found the dwellings are significantly screened.	a) The study did not clarify if visual screening was based on topography or vegetation. Review of aerial photography indicated the study was likely to be referring to vegetation screening. Vegetation screens occur on both private and public land, the value of this vegetation as a screen to potential glare hazard was not verified by the study since glare modelling was not undertaken.
5.	Impacts on Train Driver Receptors • 2.05km section of railway was assessed • Driver's eye level of 2.75m was used. • No railway signals were identified within 500m based on aerial imagery. • The study found glare affecting the railway line was geometrically possible	a) The study found glare affecting the railway line is geometrically possible, occurring in late afternoon. b) Further assessment provided by Pager Power (the addendum) considered alternative resting angles, adjustment of the glare modeling removed the geometric possibility of glare when the resting angle was set at 5 degrees.
6.	Impacts on other sensitive receptors • Additional assessment (October 2021) considered impacts to Connorton Model Airfield (Wagga Model Aero Club).	a) Additional assessment identified low impact on the model airfield when the resting angle was set at 0 degrees, when this was changed to 5 degrees the geometric analysis identified no glare.
7.	Adjustment of the resting angle in the glare modelling • The study used a resting angle of 0 degrees simulating a 'worst case' backtracking operation • The addendum considered alternative resting angles to remove the geometric possibility of glare occurring	a) Backtracking operations are a means of maximizing solar gain by reducing panel over shadowing when the sun is in a low position at the beginning and end of the day. Various algorithms are used to manage backtracking and these can be adjusted to specific site requirements. By setting the resting angle at 0 degrees (horizontal to the ground) in the study's glare model, solar reflection results due to the increase angle of incidence of the PV panel relative to the position of the sun. b) Further assessment of alternative resting angles demonstrated the geometric possibility of glare can be removed when the resting angle is set at 5 degrees for impacts on the railway line, highway, local roads, and model airfield. c) Restrictions on backtracking can be managed through the Project Construction Management Plan (CMP) and Environmental Management Plan (EMP) and conditioned as part of the approval process.
8.	Mitigation Measures • Tree planting was included in the site layout plan as a mitigation measure for visual and glare impacts • The study assumes the screen planting will be entirely opaque across its length and at sufficient height to eliminate views of the PV panels	a) No detail of the screen planting is provided in the study b) The Statement of Environmental Effects included under 'Safeguards and mitigation measures' (VA1) screening vegetation to a height of 3 to 4m within 8 years, and more than 1 row deep to block views. c) A landscape plan is to be provided prior to construction. d) The study did not address the glare hazard mitigation requirements prior to the vegetation screens becoming established sufficient to block glare (potentially an 8 year period). e) Mitigation of glare hazard could be managed in the short term through restrictions on the backtracking operation. f) In the long term visual screening of the Project will also screen glare and restrictions on backtracking would no longer be required.

4. CONSIDERATIONS

The following options are put forward to council for consideration in the Project approval process:

- Limitations on the backtracking operation of the solar farm can be managed through the Project CMP and EMP. A restriction on the resting angle of the PV panels to a minimum of 5 degrees during daylight hours could be implemented to reduce the geometric possibility of glare impacting the railway line, highway, local roads, and model airfield. This restriction could be reduced/removed at such time that the proponent can demonstrate the vegetation screening surrounding the Project is of sufficient maturity to block glare to surrounding sensitive receptors.
- The Project Landscape Plan is to include vegetation screens, it is recommended these screens should be at minimum 5 metres wide and include a variety of plant species to provide a dense screen sufficient to block glare, to a minimum height of 4 metres. The vegetation screens should extend the full length of the eastern, southern, and western boundaries of the solar farm.
- It is recommended the Project Environmental Management Plan includes a process for managing complaints and provides a rectification procedure that may include further adjustment to the backtracking operation and/or screening where appropriate.

APPENDIX A:

SOLAR PHOTOVOLTAIC GLINT AND GLARE STUDY

PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

NGH Consulting

Sandy Creek Solar Farm

April 2021





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ADMINISTRATION PAGE

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Issue	Date	Detail of Changes
1	March 2021	Initial issue
2	April 2021	Proposed screening considered in the analysis and other minor amendments

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from a proposed solar photovoltaic (PV) development located north-east of Uranquinty in Australia. This glint and glare assessment concerns the possible impact upon surrounding roads users, dwellings, and railway operations and infrastructure.

Pager Power

Pager Power has undertaken over 600 glint and glare assessments internationally. The company's own glint and glare guidance is based on industry experience and extensive consultation with industry stakeholders, including airports and aviation regulators.

Conclusions

All dwellings in the locality appear to be suitably screened and therefore no impact is predicted. Following the implementation of the tree planting as indicated by the developer in the site plan on page 13, no significant impact is predicted on roads or railways in the area because all predicted solar reflections will be screened. This is assuming that the screening will be entirely opaque along its length and at a sufficient height to eliminate views from the relevant receptors along the assessed sections of Olympic Highway and the railway line.

Guidance and Studies

Guidelines exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. However, a specific methodology for determining the impact upon road safety, residential amenity and railway operations has not been produced to date. Therefore, Pager Power has reviewed existing guidelines and the available studies (discussed below) in the process of defining its own glint and glare assessment guidance and methodology[1]. This methodology defines the process for determining the impact upon road safety, residential amenity, and railway operations.

Pager Power's approach is to undertake geometric reflection calculations and, where a solar reflection is predicted, consider the screening (existing and/or proposed) between the receptor and the reflecting solar panels. The scenario in which a solar reflection can occur for all receptors is then identified and discussed, and a comparison is made against the available solar panel reflection studies to determine the overall impact.

The available studies have measured the intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. The results show that the reflections

[1] Source: Solar Photovoltaic Development – Glint and Glare Guidance, Third Edition, December 2020. Pager Power.

produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel[2].

Assessment Results

Roads

The modelling has shown that solar reflections are geometrically possible towards 21 of the 32 assessed receptors along Olympic Highway.

For road receptors 12 – 14, views of the reflecting panels may be possible, despite partial screening in the form of the elevated railway embankment. The impact is moderate according to the guidance presented in Appendix D; however, no mitigation is required because the reflections occur outside of a road user's primary field of view in both directions of travel (50 degrees either side) and there is partial screening in the form of the elevated railway embankment. Furthermore, the developer has already proposed mitigation in the form of tree planting along the site boundary (see the site plan on page 13). Following the implementation of the tree planting, no impact is predicted because views of reflecting panels should not be possible.

For road receptors 15 – 25, views of the reflecting panels may be possible within a road user's primary field of view when travelling in the north-east to south-west direction, despite partial screening in the form of the elevated railway embankment. There does not appear to be any significant screening between the road and the proposed solar development location. The impact is moderate according to the guidance presented in Appendix D. However, the developer has already proposed mitigation in the form of tree planting along the site boundary. Following the implementation of the tree planting, no impact is predicted because views of reflecting panels should not be possible. No further mitigation is required.

For road receptors 26 – 32, solar reflections are not predicted to be experienced in practice as the reflecting solar panels are expected to be significantly screened by the elevated railway embankment and intervening vegetation. The proposed tree planting along the site boundary will provide further screening. No impact is predicted.

Railways

The modelling has shown that solar reflections are geometrically possible towards 16 of the 21 assessed receptors along the railway line.

For receptors 6 – 8, views of the reflecting panels may be possible. The impact is moderate according to the guidance presented in Appendix D; however, no mitigation is required because the reflections occur outside of a train driver's primary field of view in both directions of travel (30 degrees either side). Furthermore, the developer has already proposed mitigation in the form of tree planting along the site boundary (see the site plan on page 13). Following the implementation of the tree planting, no impact is predicted because views of reflecting panels should not be possible.

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[2] SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy, 2010).

For receptors 9 – 19, views of the reflecting panels may be possible within a train driver's primary field of view when travelling in the north-east to south-west direction. There does not appear to be any significant screening between the railway and the proposed solar development location. The impact is moderate according to the guidance presented in Appendix D. However, the developer has already proposed mitigation in the form of tree planting along the site boundary. Following the implementation of the tree planting, no impact is predicted because views of reflecting panels should not be possible. No further mitigation is required.

For receptors 20 – 21, solar reflections are not predicted to be experienced in practice as the reflecting solar panels are expected to be significantly screened by intervening terrain and vegetation. The proposed tree planting along the site boundary will provide further screening. No impact is predicted.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 49 countries within Europe, Africa, America, Asia and Australasia.

The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems.

Over the years, the company has expanded into numerous fields including:

- Renewable energy projects.
- Building developments.
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

1 INTRODUCTION

1.1 Overview

Pager Power has been retained to assess the possible effects of glint and glare from a proposed solar photovoltaic (PV) development located north-east of Uranquinty in Australia. This glint and glare assessment concerns the possible impact upon surrounding roads users, dwellings, and railway operations and infrastructure.

This report contains the following:

- Solar development details.
- Explanation of glint and glare.
- Overview of relevant guidance.
- Overview of relevant studies.
- Overview of Sun movement.
- Assessment methodology.
- Identification of receptors.
- Glint and glare assessment for identified receptors.
- Results discussion.
- High-Level Overview of Mitigation

Following this, a summary of findings and overall conclusions and recommendations from the desk-based analysis is presented. No site survey has taken place at this stage.

1.2 Pager Power's Experience

Pager Power has undertaken over 600 Glint and Glare assessments in the UK and internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Glint and Glare Definition

The definition of glint and glare can vary however, the definition used by Pager Power is as follows[3]:

- Glint – a momentary flash of bright light typically received by moving receptors or from moving reflectors.
- Glare – a continuous source of bright light typically received by static receptors or from large reflective surfaces.

The term 'solar reflection' is used in this report to refer to both reflection types.

[3] These definitions are aligned with those of the Federal Aviation Administration (FAA) in the United States of America.

2 PROPOSED SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Site Layout Plan

The layout of the proposed solar development is shown in Figure 1[4] below, received from NGH Consulting. The black lines represent the location of solar panels and the green lines represent proposed tree planting.

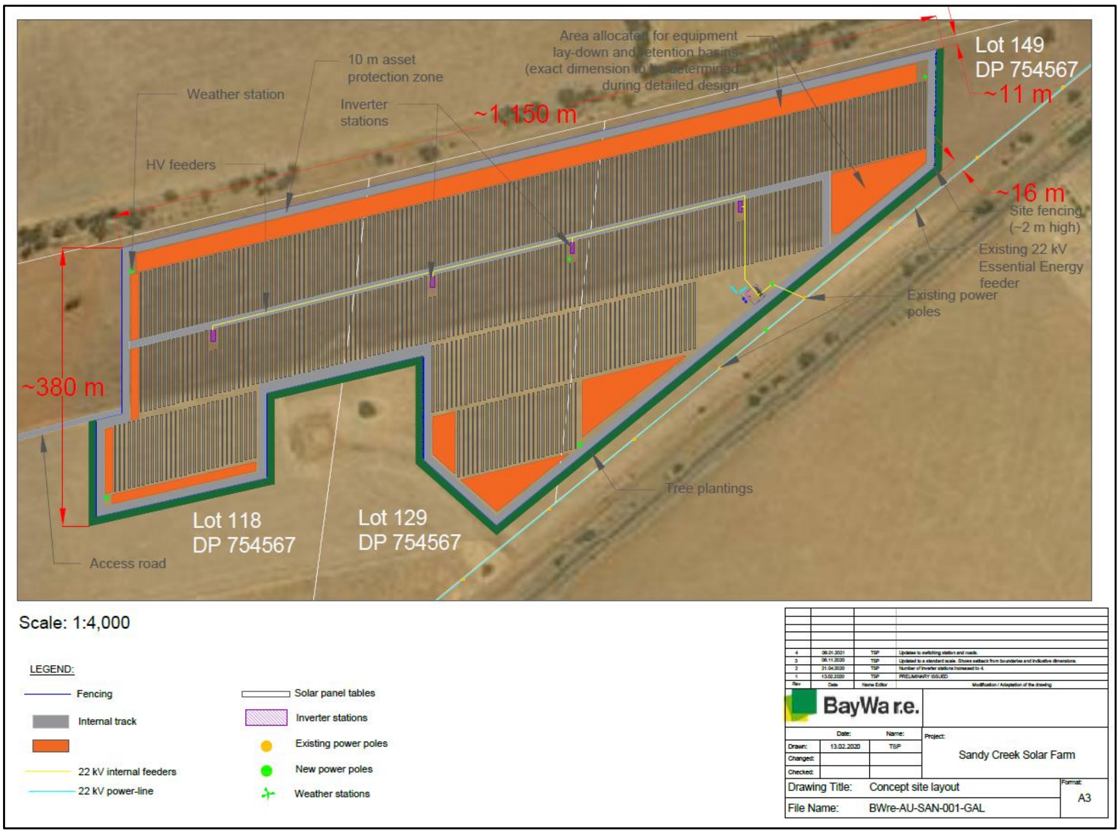

Figure 1 *Site layout plan*

[4] Source: 20210105 SAN site layout BWre-AU-SAN-001-GAL rev 4-2.pdf

2.2 Proposed Solar Development Location – Aerial Image

Figure 2[5] below shows the location of the proposed solar development. The red line represents the outer red line boundary, and the blue shaded area represents the assessed area of solar panels. Based on the information in Figure 1, panels may not actually be located in the whole of this blue area, however this is a conservative assessment and a worst-case scenario panel area has been considered.

Figure 2 *Proposed development location – aerial image*

[5] Copyright © 2021 Google.

2.3 Solar Panel Information

The design of the solar panel table is shown in Figure 3[6] below, received from NGH Consulting. The technical characteristics used for the modelling are presented in Table 1.

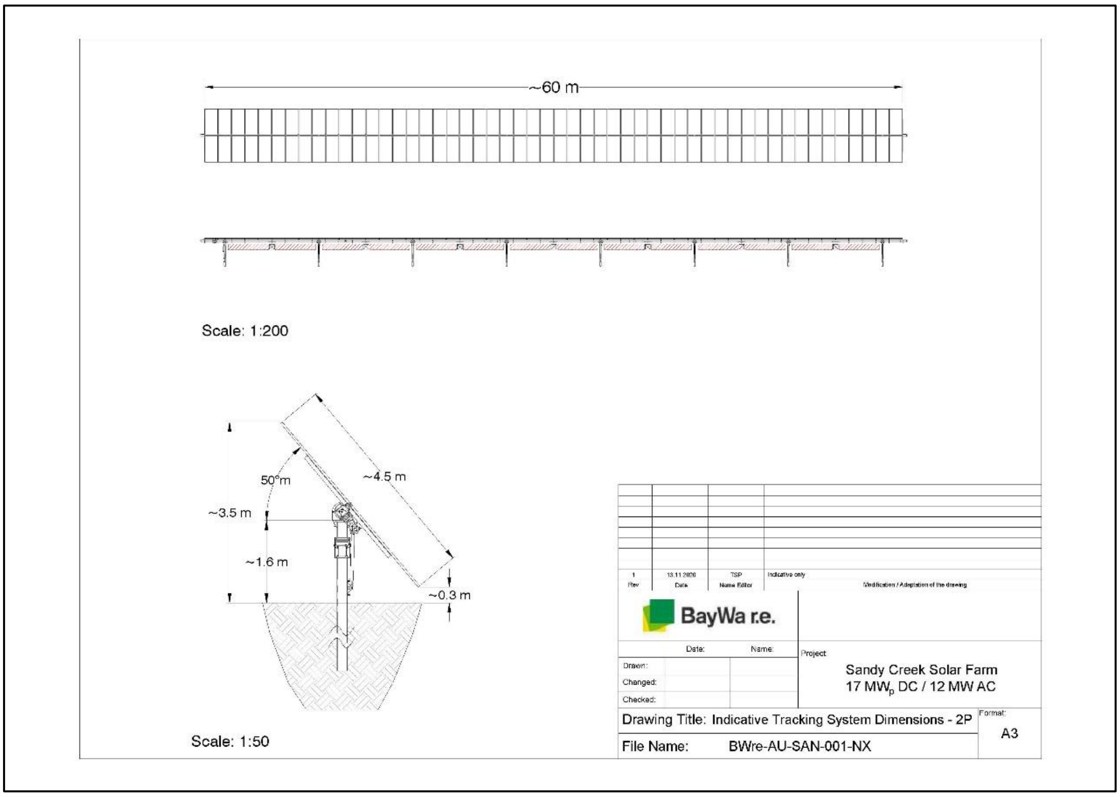

Figure 3 *Design of the solar panel table*

Solar Panel Technical Information	
Azimuth angle (°)	0
Axis height (m)	2.15 agl (above ground level)
Tracking	Horizontal Single Axis tracks Sun East to West
Tracker Range of Motion (°)	±60°
Resting angle (°)	0°

Table 1 *Solar panel technical information*

[6] Source: 2P Tracking System Drawing BWre-AU-SAN-001-NX-2P.pdf

2.3.1 Solar Panel Backtracking

Shading considerations dictate the panel tilt. This is affected by:

- The elevation angle of the Sun;
- The vertical tilt of the panels;
- The spacing between the panel rows.

This means that early in the morning and late in the evening, the panels will not be directed exactly towards the Sun, as the loss from shading of the panels (caused by facing the sun directly when the Sun is low in the horizon), would be greater than the loss from lowering the panels to a less direct angle in order to avoid the shading. Figure 4 below illustrates this.

Note the graphics in Figure 4 show two lines illustrating the paths of light from the Sun towards the solar panels. In reality, the lines from the Sun to each panel would be effectively parallel due to the large separation distance. The figure is for illustrative purposes only.

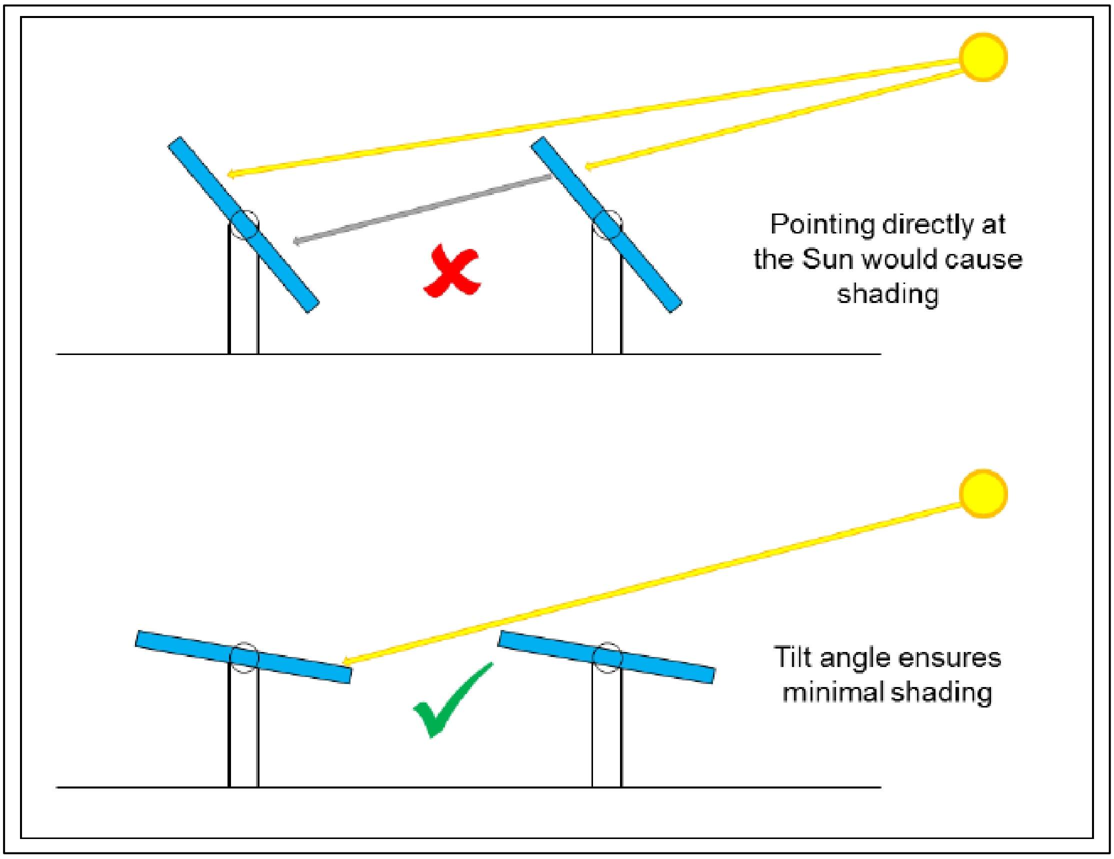

Figure 4 *Shading Considerations*

Later in the day, the panels can be directed towards the Sun without any shading issues. This is illustrated in Figure 5 on the next page.

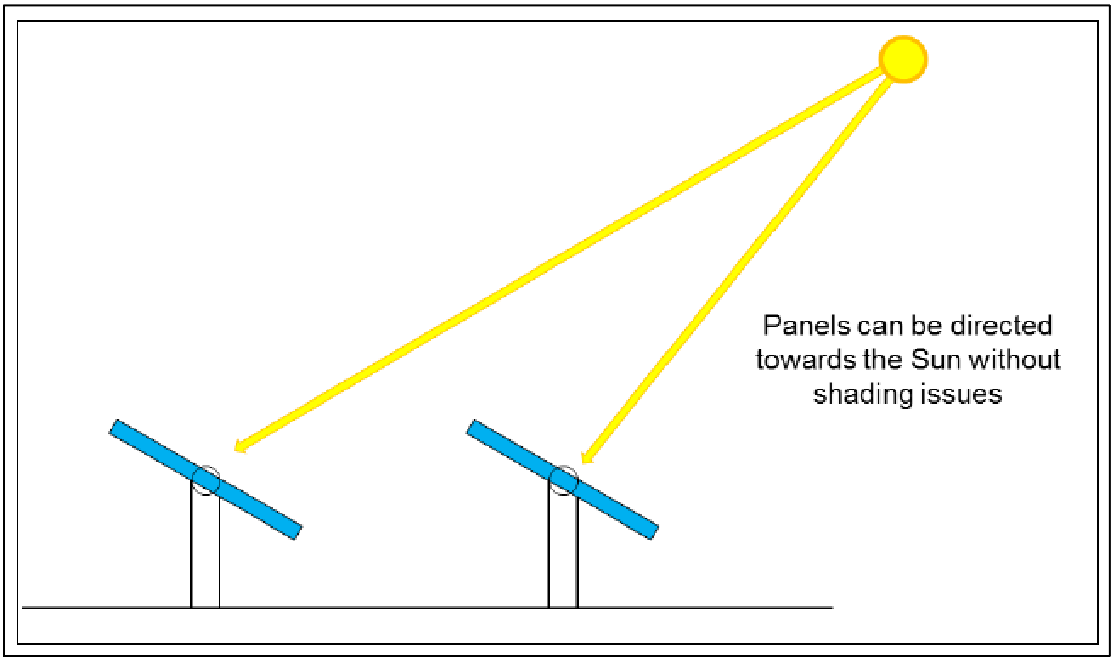

Figure 5 *Panel alignment at high solar angles*

Note that in reality, the lines from the Sun to each panel would be effectively parallel due to the large separation distance. The two previous figures are for illustrative purposes only.

The solar panels backtrack (where the panel angle gradually declines to prevent shading) by reverting to 0 degrees (flat) once the maximum elevation angle of the panels (60 degrees) becomes ineffective due to the low height of the Sun above the horizon and to avoid shading.

3 RAILWAYS AND GLINT AND GLARE

3.1 Overview

A railway stakeholder may request further information regarding the potential effects of glint and glare from reflective surfaces when a development is located adjacent to a railway line (typically 50-100m from its infrastructure). The request may depend on the scale, percentage of reflective surfaces and the complexity of the nearby railway, for example. The following section presents details regarding the most common concerns relating to glint and glare.

3.2 Common Concerns and Signal Overview

Typical reasons stated by a railway stakeholder for requesting a glint and glare assessment often relate to the following:

1. The development producing solar reflections towards train drivers;
2. The development producing solar reflections, which causes a train driver to take action; and
3. The development producing solar reflections that affect railway signals.

With respect to point 1, a reflective panel could produce solar reflections towards a train driver. If this reflection occurs where a railway signal, crossing etc., is present, or where the driver's workload is particularly high, the solar reflection may affect operations. This is deemed to be the most concern with respect to solar reflections.

Following from point 1, point 2 identifies whether a modelled solar reflection could be significant depending on the technical and operational context. Only where a solar reflection occurs under certain conditions may it cause a reaction from a train driver and thus potentially affect safe operations. Therefore, any predicted reflections are evaluated based on technical and operational considerations to determine whether they could potentially affect the safety of operations. Points 1 and 2 are completed in a 2-step approach.

With respect to all points, railway lines use light signals to manage trains on approach towards particular sections of track. If a signal is passed when not permitted, a SPAD (Signal Passed At Danger) is issued. The concerns will relate specifically to the possibility of the reflections appearing to illuminate signals that are not switched on (known as a phantom aspect illusion) or a distraction caused by the glare itself, both of which could lead to a SPAD. The definition is presented below:

'Light emitted from a Signal lens assembly that has originated from an external source (usually the sun) and has been internally reflected within the Signal Head in such a way that the lens assembly gives the appearance of being lit.[7]*'*

Details regarding the identified railway receptors are presented in Section 5 of this report.

[7] Source: Glossary of Signalling Terms, Railway Group Guidance Note GK/GN0802. Issue One. Date April 2004.

4 GLINT AND GLARE ASSESSMENT METHODOLOGY

4.1 Guidance and Studies

Appendices A and B present a review of relevant guidance and independent studies with regard to glint and glare issues from solar panels. The overall conclusions from the available studies are as follows:

- Specular reflections of the Sun from solar panels are possible.
- The measured intensity of a reflection from solar panels can vary from 2% to 30% depending on the angle of incidence.
- Published guidance shows that the intensity of solar reflections from solar panels are equal to or less than those from water. It also shows that reflections from solar panels are significantly less intense than many other reflective surfaces, which are common in an outdoor environment.

4.2 Background

Details of the Sun's movements and solar reflections are presented in Appendix C.

4.3 Pager Power's Methodology

The glint and glare assessment methodology has been derived from the information provided to Pager Power through consultation with stakeholders and by reviewing the available guidance and studies. The methodology for glint and glare assessments is as follows:

- Identify receptors in the area surrounding the solar development.
- Consider direct solar reflections from the solar development towards the identified receptors by undertaking geometric calculations.
- Consider the visibility of the panels from the receptor's location. If the panels are not visible from the receptor then no reflection can occur.
- Based on the results of the geometric calculations, determine whether a reflection can occur, and if so, at what time it will occur.
- Consider both the solar reflection from the solar development and the location of the direct sunlight with respect to the receptor's position.
- Consider the solar reflection with respect to the published studies and guidance.
- Determine whether a significant detrimental impact is expected in line with the process presented in Appendix D.

Within the Pager Power model, the solar development area is defined, as well as the relevant receptor locations. The result is a chart that states whether a reflection can occur, the duration and the panels that can produce the solar reflection towards the receptor.

4.4 Assessment Limitations

Further technical details regarding the methodology of the geometric calculations and limitations are presented in Appendix E and Appendix F.

5 IDENTIFICATION OF RECEPTORS

5.1 Receptors Overview

There is no formal guidance with regard to the maximum distance at which glint and glare should be assessed. From a technical perspective, there is no maximum distance for potential reflections. The significance of a reflection however decreases with distance because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases. Terrain and shielding by vegetation are also more likely to obstruct an observer's view at longer distances.

The above parameters and extensive experience over a significant number of glint and glare assessments undertaken show that a 1km buffer[8] (yellow lines on the proceeding figures) from the proposed development (blue areas), is considered appropriate for glint and glare effects on ground-based receptors, and a 500m buffer (white lines) for railway receptors.

Potential receptors are identified based on mapping and aerial photography of the region. The initial judgement is made based on a high-level consideration of aerial photography and mapping i.e. receptors are excluded if it is clear from the outset that no visibility would be possible. A more detailed assessment is made if the modelling reveals a reflection would be geometrically possible.

Terrain elevation heights are based on Forge SRTM data. An overview of the buffer zones is presented in Figure 6[5] on the following page and the receptors are further clarified in the following sections. Receptor details can be found in Appendix G.

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[8] Guidance from the Victoria State Government agrees with this. See Page 23 of Solar Energy Facilities Design and Development Guideline from August 2019.

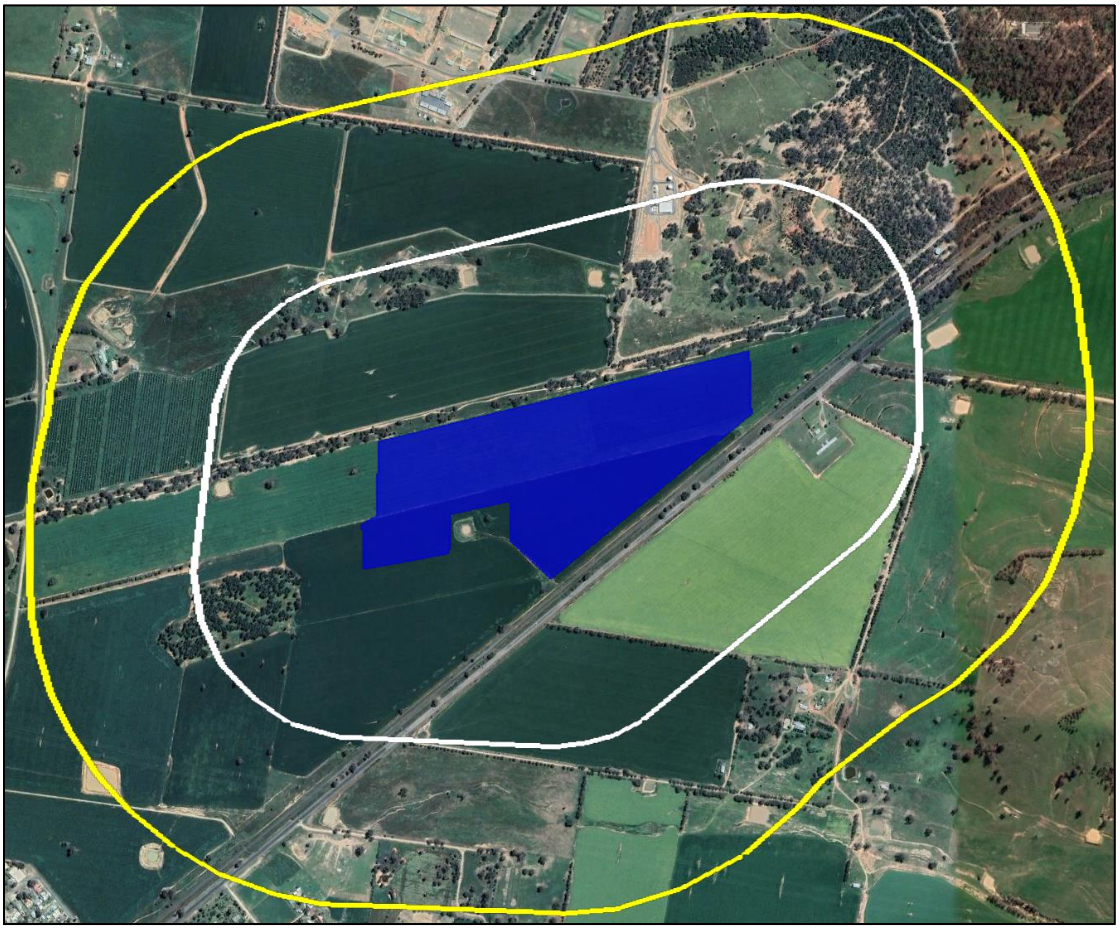

Figure 6 *Buffer zones overview– aerial image*

5.2 Road Receptors

Road types can generally be categorised as:

- Major National – Typically a road with a minimum of two carriageways with a maximum speed limit of up to 110kph. These roads typically have fast-moving vehicles with busy traffic.
- National – Typically a road with a one or more carriageways with a maximum speed limit of up to 100kph or 110kph. These roads typically have fast-moving vehicles with moderate to busy traffic density.
- Regional – Typically a single carriageway with a maximum speed limit of up to 100kph. The speed of vehicles will vary with a typical traffic density of low to moderate; and
- Local - Typically roads and lanes with the lowest traffic densities. Speed limits vary.

Assessment is not recommended for local roads, where traffic volumes and/or speeds are likely to be relatively low, as any solar reflections from the proposed development that are experienced by a road user would be considered 'low' impact in the worst case. The analysis has therefore considered any major national, national, and regional roads that:

- Are within, or close to one kilometre of the proposed development.
- Have a potential view of the panels.

A 3.15 km section of Olympic Highway was identified for assessment, running adjacent to the south boundary of the site, as shown by the orange line in Figure 7[5] below. 32 receptors were identified, distanced circa 100m apart. A height of 1.5 metres above ground level has been taken as typical eye level for a road user. This height has therefore been added to the ground height at each receptor location. Visibility and direction of travel is considered in the assessment of all receptors.

Figure 7 *Assessed road receptors – aerial image*

5.3 Dwellings

The analysis has considered dwellings that:

- Are within, or close to one kilometre of the proposed development.
- Have a potential view of the panels.

The surrounding area within 1km of the site has been reviewed based on the available aerial and street view imagery. Considering the results of this review, no dwelling receptors have been taken forward for geometric and detailed modelling because any dwellings within 1km of the site were found to be significantly screened. The identified dwellings and associated screening are shown in Figures 8 to 10 on the following pages.

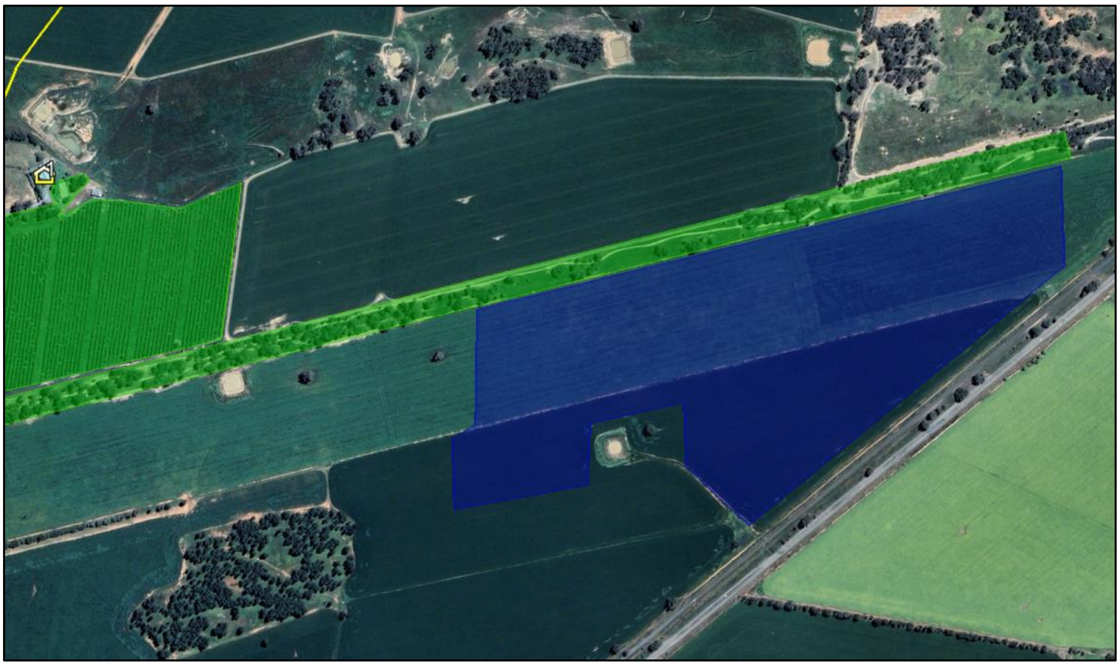

Figure 8 *Dwelling 1 with associated screening (green)– aerial image*

Figure 9 *Dwellings 2-3 with associated screening (green)– aerial image*

Figure 10 *Dwellings 2-3 with associated screening (green)– closeup aerial image*

5.4 Railway Signals

Following a conservative review of available imagery, no railway signals were identified within 500m of the proposed development. This report can be updated if railway signals are identified at a later date.

5.5 Train Driver Receptors

The impact of a solar reflection is assessed by identifying locations along the sections of railway line that could potentially receive a solar reflection from the reflective surfaces on the development. Railways have been considered out to a maximum of approximately 500m from the proposed development.

A 2.05 km section of railway running adjacent to the south boundary of the site was identified for assessment, as shown by the orange line in Figure 11[5] on the following page. 21 receptors were identified, distanced circa 100m apart. Based on previous consultation[9] the driver's eye level is assumed to be 2.75m above rail level[10]. This height has therefore been added to the ground height at each receptor location. Visibility and direction of travel is considered in the assessment of all receptors.

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[9] Consultation undertaken with Network Rail in the UK.

[10] This height may vary based on driver height however this figure is used as the industry standard in the UK. There does not appear to be an industry standard figure for Australia. It is a reasonable assumption that this height will be similar in Australia and any differences are not expected to change the results of the assessment.

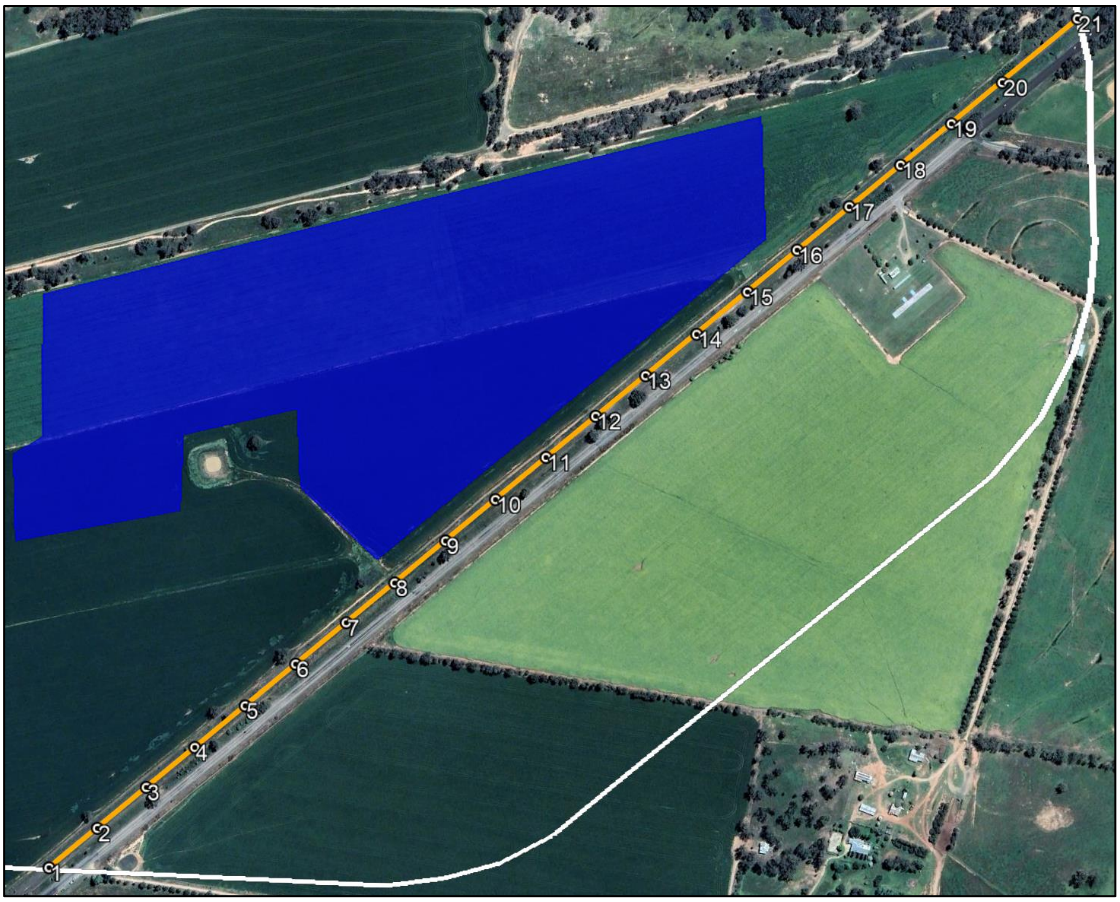

Figure 11 *Assessed train driver receptors – aerial image*

6 ASSESSED REFLECTOR AREA

6.1 Reflector Area

The bounding coordinates for the proposed solar farm development have been extrapolated from the site plans. The data can be found in Appendix G. Figure 12 below shows the assessed reflector area that has been used for modelling purposes.

Figure 12 *Assessed reflector area – aerial image*

7 GLINT AND GLARE ASSESSMENT – TECHNICAL RESULTS

7.1 Summary of Results

The tables in the following subsections summarise the results of the assessment. The predicted glare times are based solely on bare-earth terrain i.e. without consideration of screening from buildings and vegetation. The final column summarises the predicted impact considering the level of predicted screening based on a desk-based review of the available imagery. The significance of any predicted impact is discussed in the subsequent report sections. The modelling output showing the precise predicted times and the reflecting panel area is shown in Appendix H.

7.2 Geometric Calculation Results Overview – Road Receptors

Table 2 below presents the results of the roads analysis.

Receptor	Results		Comments
	Reflection possible towards the road user? (AEDT[11])		
	am	pm	
1 – 11.	No.	No.	Solar reflections are not geometrically possible. No impact predicted.
12 – 14.	No.	Yes.	Predicted solar reflections are predicted to occur outside of a road user's primary field of view, partially screened by the elevated railway embankment and significantly screened by the proposed tree planting along the site boundary. No impact predicted.
15 – 25.	No.	Yes.	Predicted solar reflections are predicted to be partially screened by the elevated railway embankment and significantly screened by the proposed tree planting along the site boundary. No impact predicted.

[11] Modelling was run in AEDT but conclusions for AEST would be the same; only the glare curves would shift one hour in accordance with sunset and sunrise times shifting by one hour.

Receptor	Results		Comments
	Reflection possible towards the road user? (AEDT[11])		
	am	pm	
26 – 32.	No.	Yes.	Predicted solar reflections are predicted to be significantly screened by the elevated railway embankment, existing vegetation and proposed tree planting along the site boundary. No impact predicted.

Table 2 *Geometric analysis results – road receptors*

7.3 Geometric Calculation Results Overview – Train Driver Receptors

Table 3 below presents the results of the train driver analysis.

Receptor	Results		Comments
	Reflection possible towards the train driver? (AEDT)		
	am	pm	
1 – 5.	No.	No.	Solar reflections are not geometrically possible. No impact predicted.
6 – 8.	No.	Yes.	Predicted solar reflections are predicted to occur outside of a train driver's primary field of view and significantly screened by proposed tree planting along the site boundary. No impact predicted.
9 – 19.	No.	Yes.	Predicted solar reflections are predicted to be significantly screened by proposed tree planting along the site boundary. No impact predicted.

Receptor	Results		Comments
	Reflection possible towards the train driver? (AEDT)		
	am	pm	
20 – 21.	No.	Yes.	Predicted solar reflections are predicted to be significantly screened by intervening terrain, existing vegetation and proposed tree planting along the site boundary. No impact predicted.

Table 3 *Geometric analysis results – train driver receptors*

8 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

8.1 Roads

The process for quantifying impact significance is defined in the report appendices. For road users, the key considerations are:

- Whether a reflection is predicted in practice.
- The type of road (and associated likely traffic levels/speeds).
- The location of the reflecting panels relative to a road user's direction of travel (a reflection directly in front of a driver is more hazardous than a reflection from a location off to one side).

The modelling has shown that solar reflections are geometrically possible towards 21 of the 32 assessed receptors along Olympic Highway (12 – 32).

For road receptors 12 – 14, marginal views of the reflecting panels may be possible, despite partial screening in the form of the elevated railway embankment. The impact is moderate according to the guidance presented in Appendix D; however, no mitigation is required because the reflections occur outside of a road user's primary field of view in both directions of travel (50 degrees either side). Furthermore, the developer has already proposed mitigation in the form of tree planting along the site boundary (see Figure 1 on page 13). Following the implementation of the tree planting, no impact is predicted because views of reflecting panels should not be possible.

For road receptors 15 – 25, views of the reflecting panels may be possible within a road user's primary field of view when travelling in the north-east to south-west direction, despite partial screening in the form of the elevated railway embankment. There does not appear to be any significant screening between the road and the proposed solar development location. The impact is moderate according to the guidance presented in Appendix D. However, the developer has already proposed mitigation in the form of tree planting along the site boundary. Following the implementation of the tree planting, no impact is predicted because views of reflecting panels should not be possible. No further mitigation is required.

For road receptors 26 – 32, solar reflections are not predicted to be experienced in practice as the reflecting solar panels are expected to be significantly screened by the elevated railway embankment and intervening vegetation, as shown in Figures 14 and 15[5] on the following pages. The proposed tree planting along the site boundary will provide further screening. No impact is predicted.

Figure 13[5] on the following page shows the section of road where solar reflections are geometrically possible (orange line) and the area of proposed tree planting (green line).

Figure 13 *Section of Olympic Highway where solar reflections are geometrically possible (orange) and proposed tree planting (green) – aerial image*

Figure 14 *Significant screening (green highlighted area) for road receptors 26 to 32 – closeup aerial image*

Figure 15 *Significant screening (green highlighted area) for road receptors 26 to 32 – aerial image*

8.2 Train Drivers

The process for quantifying impact significance is defined in the report appendices. For train driver receptors, the key considerations are:

- Whether a significant reflection is predicted in practice.
- Whether the reflection originates in front of the train driver.

The modelling has shown that solar reflections are geometrically possible towards 16 of the 21 assessed receptors along the railway line (6 – 21).

For receptors 6 – 8, views of the reflecting panels may be possible. The impact is moderate according to the guidance presented in Appendix D; however, no mitigation is required because the reflections occur outside of a train driver's primary field of view in both directions of travel (30 degrees either side). Furthermore, the developer has already proposed mitigation in the form of tree planting along the site boundary (see Figure 1 on page 13). Following the implementation of the tree planting, no impact is predicted because views of reflecting panels should not be possible.

For receptors 9 – 19, views of the reflecting panels may be possible within a train driver's primary field of view when travelling in the north-east to south-west direction. There does not appear to be any significant screening between the railway and the proposed solar development location. The impact is moderate according to the guidance presented in Appendix D. However, the developer has already proposed mitigation in the form of tree planting along the site boundary. Following the implementation of the tree planting, no impact is predicted because views of reflecting panels should not be possible. No further mitigation is required.

For receptors 20 – 21, solar reflections are not predicted to be experienced in practice as the reflecting solar panels are expected to be significantly screened by intervening terrain and vegetation, as shown in Figures 17 and 18[5] on the following page. The proposed tree planting along the site boundary will provide further screening. No impact is predicted.

Figure 16 below shows the section of road where solar reflections are geometrically possible (orange line) and the area of proposed tree planting (green line).

Figure 16 *Section of railway where solar reflections are geometrically possible (orange) and proposed tree planting (green) – aerial image*

Figure 17 *Significant screening (green highlighted area) for train driver receptors 20 and 21 – closeup aerial image*

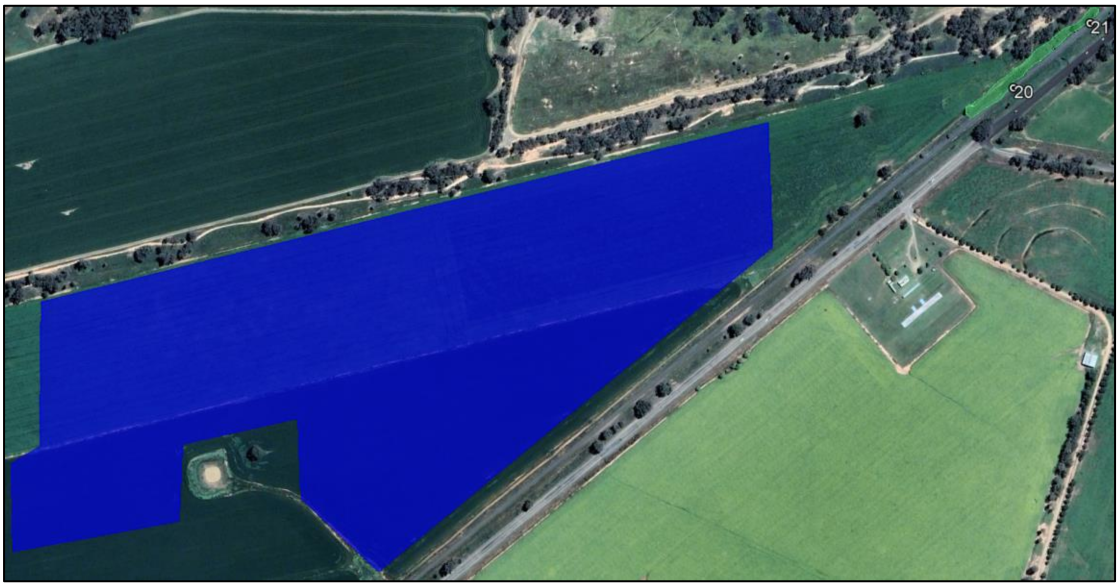

Figure 18 *Significant screening (green highlighted area) for train driver receptors 20 and 21 – aerial image*

8.3 High-Level Mitigation Recommendation

Mitigation in the form of tree planting has already been included in the site plan as shown in Figure 1 on page 13. The height of this planting should be managed such that views of the reflecting panels are sufficiently obstructed. The required height will depend on the relative elevation of the receptors, the base of the planting itself, and the reflecting panels. Consideration of this should inform the landscaping / LVIA aspect of the proposal. Further to the implementation of this tree planting, no impact is predicted (assuming that the screening will be entirely opaque along its length and at a sufficient height to eliminate views from the relevant receptors along the assessed sections of Olympic Highway and the railway line).

9 OVERALL CONCLUSIONS

All dwellings in the locality appear to be suitably screened and therefore no impact is predicted. Following the implementation of the tree planting as indicated by the developer in the site plan on page 13, no significant impact is predicted on roads or railways in the area because all predicted solar reflections will be screened. This is assuming that the screening will be entirely opaque along its length and at a sufficient height to eliminate views from the relevant receptors along the assessed sections of Olympic Highway and the railway line.

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

This section presents details regarding the relevant guidance and studies with respect to the considerations and effects of solar reflections from solar panels, known as 'Glint and Glare'.

This is not a comprehensive review of the data sources, rather it is intended to give an overview of the important parameters and considerations that have informed this assessment.

UK Planning Policy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[12] (specifically regarding the consideration of solar farms, paragraph 013) states:

'What are the particular planning considerations that relate to large scale ground-mounted solar photovoltaic Farms?

The deployment of large-scale solar farms can have a negative impact on the rural environment, particularly in undulating landscapes. However, the visual impact of a well-planned and well-screened solar farm can be properly addressed within the landscape if planned sensitively.

Particular factors a local planning authority will need to consider include:

…

- *the proposal's visual impact, the effect on landscape of glint and glare (see guidance on landscape assessment) and on **neighbouring uses and aircraft safety**;*
- *the extent to which there may be additional impacts if solar arrays follow the daily movement of the sun.*

…

The approach to assessing cumulative landscape and visual impact of large-scale solar farms is likely to be the same as assessing the impact of wind turbines. However, in the case of ground-mounted solar panels it should be noted that with effective screening and appropriate land topography the area of a zone of visual influence could be zero.'

Assessment Process – Ground-Based Receptors

No process for determining and contextualising the effects of glint and glare are, however, provided for assessing the impact of solar reflections upon surrounding roads and dwellings. Therefore, the Pager Power approach is to determine whether a reflection from the proposed solar development is geometrically possible and then to compare the results against the relevant guidance/studies to determine whether the reflection is significant. The Pager Power approach

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[12] Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 18 June 2015, accessed on: 17/06/2020

has been informed by the policy presented above, current studies (presented in Appendix B) and stakeholder consultation. Further information can be found in Pager Power's Glint and Glare Guidance document[13] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

Assessment Process – Railways

Railway operations is not mentioned specifically within this guidance however it is stated that a developer will need to consider *'the proposal's visual impact, the effect on landscape of glint and glare and on neighbouring uses…'*. In the UK, Network Rail is a statutory consultee when a development is located in close proximity to its infrastructure. In New South Wales, ARTC would be a consultee if a development impacts its infrastructure.

No process for determining and contextualising the effects of glint and glare are, however, provided. Therefore, the Pager Power approach is to determine whether a reflection from a development is geometrically possible and then to compare the results against the relevant guidance/studies to determine whether the reflection is significant.

Railway Assessment Guidelines

The following section provides an overview of the relevant railway guidance with respect to the siting of signals on railway lines. Network Rail is the stakeholder of the UK's railway infrastructure. Whilst the guidance is not strictly applicable in Australia, the general principles within the guidance is expected to apply.

A railway operator's concerns would likely to relate to the following:

1. The development producing solar glare that affects train drivers; and
2. The development producing solar reflections that affect railway signals and create a risk of a phantom aspect signal.

Railway guidelines are presented below. These relate specifically to the sighting distance for railway signals.

Reflections and Glare

The extract below and on the following page is taken from Section A5 – Reflections and glare (pages 64-65) of the 'Signal Sighting Assessment Requirements'[14] which details the requirement for assessing glare towards railway signals.

Reflections and glare

Rationale

Reflections can alter the appearance of a display so that it appears to be something else.

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[13] Solar Photovoltaic Development – Glint and Glare Guidance, Third Edition, December 2020. Pager Power.

[14] Source: Signal Sighting Assessment Requirements, June 2016. Railway Group Guidance Note. Last accessed 18.10.2016.

Guidance

A5 is present if direct glare or reflected light is directed into the eyes or into the lineside signalling asset that could make the asset appear to show a different aspect or indication to the one presented.

A5 is relevant to any lineside signalling asset that is capable of presenting a lit signal aspect or indication.

The extent to which excessive illumination could make an asset appear to show a different signal aspect or indication to the one being presented can be influenced by the product being used. Requirements for assessing the phantom display performance of signalling products are set out in GKRT0057 section 4.1.

Problems arising from reflection and glare occur when there is a very large range of luminance, that is, where there are some objects that are far brighter than others. The following types of glare are relevant:

a) *Disability glare, caused by scattering of light in the eye, can make it difficult to read a lit display.*
b) *Discomfort glare, which is often associated with disability glare. While being unpleasant, it does not affect the signal reading time directly, but may lead to distraction and fatigue.*

Examples of the adverse effect of disability glare include:

a) *When a colour light signal presenting a lit yellow aspect is viewed at night but the driver is unable to determine whether the aspect is a single yellow or a double yellow.*
b) *Where a colour light signal is positioned beneath a platform roof painted white and the light reflecting off the roof can make the signal difficult to read.*

Options for militating against A5 include:

a) *Using a product that is specified to achieve high light source: phantom ratio values.*
b) *Alteration to the features causing the glare or reflection.*
c) *Provision of screening.*

Glare is possible and should be assessed when the luminance is much brighter than other light sources. Glare may be unpleasant and therefore cause distraction and fatigue, or may make the signal difficult to read and increase the reading time.

Determining the Field of Focus

The extract on the following pages is taken from Appendix F - Guidance on Field of Vision (pages 98-101) of the 'Signal Sighting Assessment Requirements'[15] which details the visibility of signals, train drivers' field of vision and the implications with regard to signal positioning.

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[15] Source: Signal Sighting Assessment Requirements, June 2016. Railway Group Guidance Note. Last accessed 28.08.2020.

Asset visibility

The effectiveness of an observer's visual system in detecting the existence of a target asset will depend upon its:

a) Position in the observer's visual field.

b) Contrast with its background.

c) Luminance properties.

d) The observer's adaptation to the illumination level of the environment.

It is also influenced by the processes relating to colour vision, visual accommodation, and visual acuity. Each of these issues is described in the following sections.

Field of vision

The field of vision, or visual field, is the area of the visual environment that is registered by the eyes when both eyes and head are held still. The normal extent of the visual field is approximately 135o in the vertical plane and 200o in the horizontal plane.

The visual field is usually described in terms of central and peripheral regions: the central field being the area that provides detailed information. This extends from the central point (0^{o}) to approximately 30^{o} at each eye. The peripheral field extends from 30o out to the edge of the visual field.

F.6.3 Objects positioned towards the centre of the observer's field of vision are seen more quickly and identified more accurately because this is where our sensitivity to contrast is the highest. Peripheral vision is particularly sensitive to movement and light.

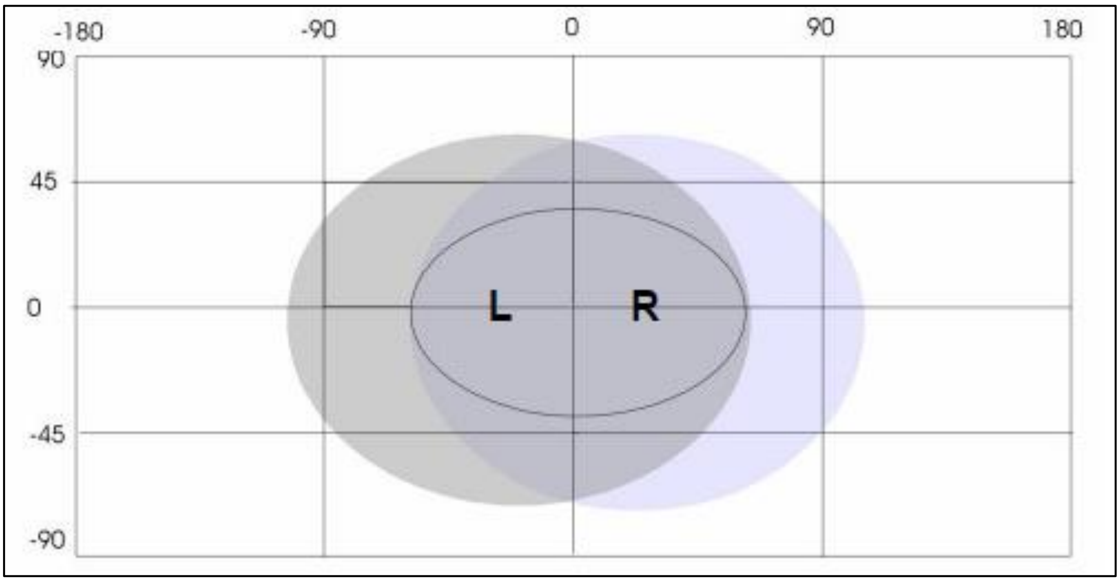


Figure G 21 - Field of view

In Figure G 21, the two shaded regions represent the view from the left eye (L) and the right eye (R) respectively. The darker shaded region represents the region of binocular overlap. The oval in the centre represents the central field of vision.

Research has shown that drivers search for signs or signals towards the centre of the field of vision.

Signals, indicators and signs should be positioned at a height and distance from the running line that permits them to be viewed towards the centre of the field of vision. This is because:

a) *As train speed increases, drivers become increasingly dependent on central vision for asset detection. At high speeds, drivers demonstrate a tunnel vision effect and focus only on objects in a field of + 8º from the direction of travel.*
b) *Sensitivity to movement in the peripheral field, even minor distractions can reduce the visibility of the asset if it is viewed towards the peripheral field of vision. The presence of clutter to the sides of the running line can be highly distracting (for example, fence posts, lamp-posts, traffic, or non-signal lights, such as house, compatibility factors or security lights).*

Figure G 22 and Table G 5 identify the radius of an 8o cone at a range of close-up viewing distances from the driver's eye. This shows that, depending on the lateral position of a stop signal, the optimal (normal) train stopping point could be as far as 25 m back from the signal to ensure that it is sufficiently prominent.

The dimensions quoted in Table G 5 assume that the driver is looking straight ahead. Where driver-only operation (DOO) applies, the drivers' line of sight at the time of starting the train is influenced by the location of DOO monitors and mirrors. In this case it may be appropriate to provide supplementary information alongside the monitors or mirrors using one of the following:

a) *A co-acting signal.*
b) *A miniature banner repeater indicator.*
c) *A right away indicator.*
d) *A sign to remind the driver to check the signal aspect.*

In order to prevent misreading by trains on adjacent lines, the co-acting signal or miniature banner repeater may be configured so that the aspect or indication is presented only when a train is at the platform to which it applies.

'Car stop' signs should be positioned so that the relevant platform starting signals and / or indicators can be seen in the driver's central field of vision.

If possible, clutter and non-signal lights in a driver's field of view should be screened off or removed so that they do not cause distraction.

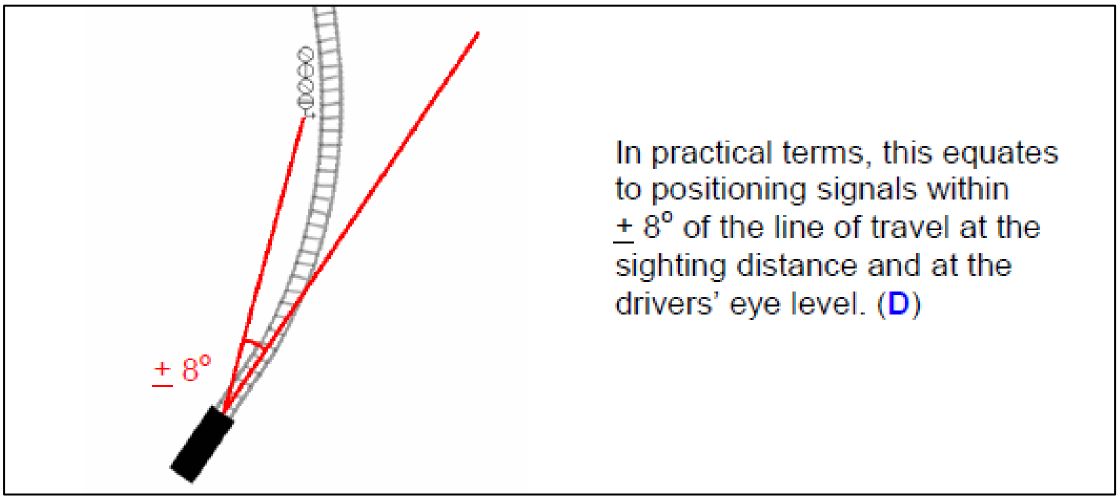


Figure G 22 - Signal positioning

'A' (m)	'B' (m)	Typical display positions
5	*0.70*	-
6	*0.84*	-
7	*0.98*	-
8	*1.12*	-
9	*1.26*	-
10	*1.41*	-
11	*1.55*	-
12	*1.69*	-
13	*1.83*	-
14	*1.97*	-
15	*2.11*	*A stop aspect positioned 3.3 m above rail level and 2.1 m from the left hand rail is within the 8° cone at 15.44 m in front of the driver*
16	*2.25*	-
17	*2.39*	-
18	*2.53*	*A stop aspect positioned 5.1 m above rail level and 0.9 m from the left hand rail is within the 8° cone at 17.93 m in front of the driver*
19	*2.67*	-
20	*2.81*	-
21	*2.95*	-
22	*3.09*	-
23	*3.23*	-
24	*3.37*	-
25	*3.51*	*A stop aspect positioned 3.3 m above rail level and 2.1 m from the right hand rail is within the 8° cone at 25.46 m in front of the driver*

Table G 5 – 8° cone angle co-ordinates for close-up viewing

The distance at which the 8° cone along the track is initiated is dependent on the minimum reading time and distance which is associated to the speed of trains along the track. This is discussed below.

Determining the Assessed Minimum Reading Time

The extract below is taken from section B5 (pages 8-9) of the 'Guidance on Signal Positioning and Visibility' which details the required minimum reading time for a train driver when approaching a signal.

'B5.2.2 Determining the assessed minimum reading time

GE/RT8037

The assessed minimum reading time shall be no less than eight seconds travelling time before the signal.

The assessed minimum reading time shall be greater than eight seconds where there is an increased likelihood of misread or failure to observe. Circumstances where this applies include, but are not necessarily limited to, the following:

a) the time taken to identify the signal is longer (for example, because the signal being viewed is one of a number of signals on a gantry, or because the signal is viewed against a complex background)
b) the time taken to interpret the information presented by the signal is longer (for example, because the signal is capable of presenting route information for a complex layout ahead)
c) there is a risk that the need to perform other duties could cause distraction from viewing the signal correctly (for example, the observance of lineside signs, a station stop between the caution and stop signals, or DOO (P) duties)
d) the control of the train speed is influenced by other factors (for example, anticipation of the signal aspect changing).

The assessed minimum reading time shall be determined using a structured format approved by the infrastructure controller.'

The distance at which a signal should be clearly viewable is determined by the maximum speed of the trains along the track. If there are multiple signals present at a location then an additional 0.2 seconds reading time is added to the overall viewing time.

Signal Design and Lighting System

Many railway signals are now LED lights and not filament (incandescent) bulbs. The benefits of an LED signal over a filament bulb signal with respect to possible phantom aspect illuminations are as follows:

- An LED railway signal produces a more intense light making them more visible to approaching trains when compared to the traditional filament bulb technology[16];

[16] Source: Wayside LED Signals – Why it's Harder than it Looks, Bill Petit.

- No reflective mirror is present within the LED signal itself unlike a filament bulb. The presence of the reflective surfaces greatly increases the likelihood of incoming light being reflecting out making the signal appear illuminated.

Many LED signal manufacturers[17,18,19] claim that LED signal lights significantly reduce or completely remove the likelihood of a phantom aspect illumination occurring.

[17] Source: http://www.unipartdorman.co.uk/assets/unipart_dorman_rail_brochure.pdf. (Last accessed 21.02.18).
[18] Source: http://www.vmstech.co.uk/downloads/Rail.pdf. (Last accessed 21.02.18).
[19] Source: Siemens, Sigmaguard LED Tri-Colour L Signal – LED Signal Technology at Incandescent Prices. Datasheet 1A-23. (Last accessed 22.02.18).

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

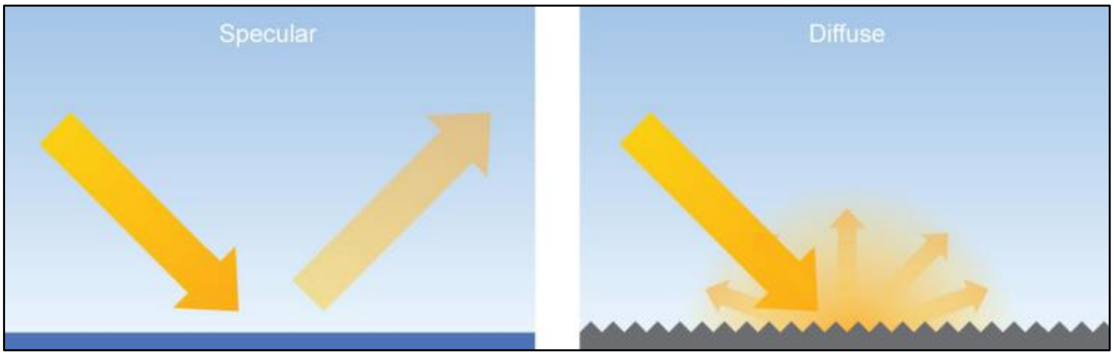
Overview

Studies have been undertaken assessing the type and intensity of solar reflections from various surfaces including solar panels and glass. An overview of these studies is presented below.

The guidelines presented are related to aviation safety. The results are applicable for the purpose of this analysis.

Reflection Type from Solar Panels

Based on the surface conditions reflections from light can be specular and diffuse. A specular reflection has a reflection characteristic similar to that of a mirror; a diffuse will reflect the incoming light and scatter it in many directions. The figure below, taken from the FAA guidance[20], illustrates the difference between the two types of reflections. Because solar panels are flat and have a smooth surface most of the light reflected is specular, which means that incident light from a specific direction is reradiated in a specific direction.



Specular and diffuse reflections

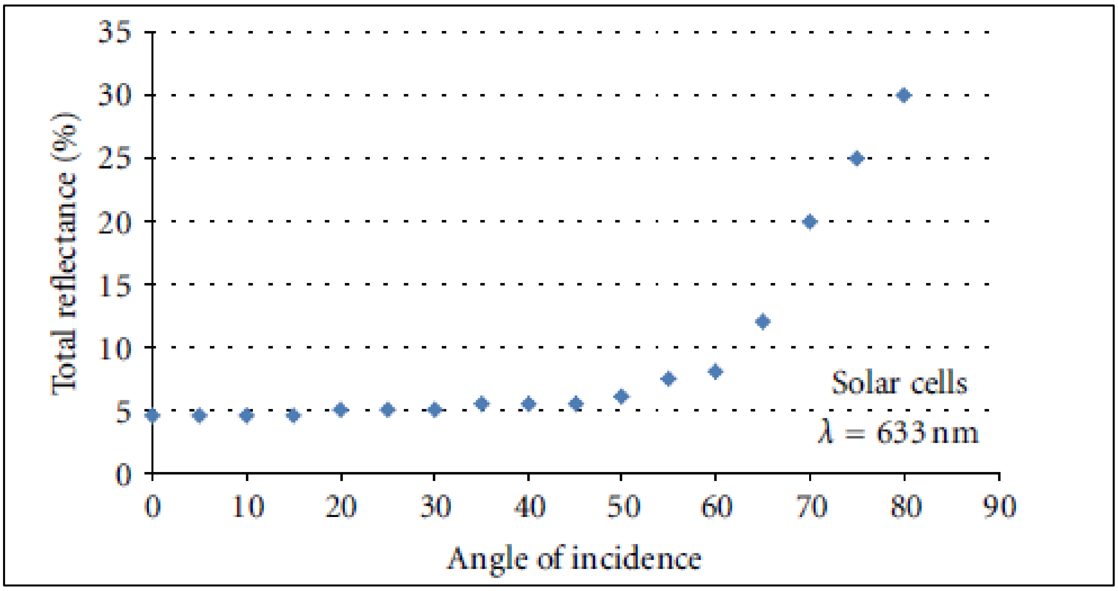
[20] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

Solar Reflection Studies

An overview of content from identified solar panel reflectivity studies is presented in the subsections below.

Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems"

Evan Riley and Scott Olson published in 2011 their study titled: *A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems*[21]". They researched the potential glare that a pilot could experience from a 25 degree fixed tilt PV system located outside of Las Vegas, Nevada. The theoretical glare was estimated using published ocular safety metrics which quantify the potential for a postflash glare after-image. This was then compared to the postflash glare after-image caused by smooth water. The study demonstrated that the reflectance of the solar cell varied with angle of incidence, with maximum values occurring at angles close to 90 degrees. The reflectance values varied from approximately 5% to 30%. This is shown on the figure below.



Total reflectance % when compared to angle of incidence

The conclusions of the research study were:

- The potential for hazardous glare from flat-plate PV systems is similar to that of smooth water;
- Portland white cement concrete (which is a common concrete for runways), snow, and structural glass all have a reflectivity greater than water and flat plate PV modules.

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[21] Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems," ISRN Renewable Energy, vol. 2011, Article ID 651857, 6 pages, 2011. doi:10.5402/2011/651857

FAA Guidance – "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[22]

The 2010 FAA Guidance included a diagram which illustrates the relative reflectance of solar panels compared to other surfaces. The figure shows the relative reflectance of solar panels compared to other surfaces. Surfaces in this figure produce reflections which are specular and diffuse. A specular reflection (those made by most solar panels) has a reflection characteristic similar to that of a mirror. A diffuse reflection will reflect the incoming light and scatter it in many directions. A table of reflectivity values, sourced from the figure within the FAA guidance, is presented below.

Surface	Approximate Percentage of Light Reflected[23]
Snow	80
White Concrete	77
Bare Aluminium	74
Vegetation	50
Bare Soil	30
Wood Shingle	17
Water	5
Solar Panels	5
Black Asphalt	2

Relative reflectivity of various surfaces

Note that the data above does not appear to consider the reflection type (specular or diffuse).

An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel.

The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

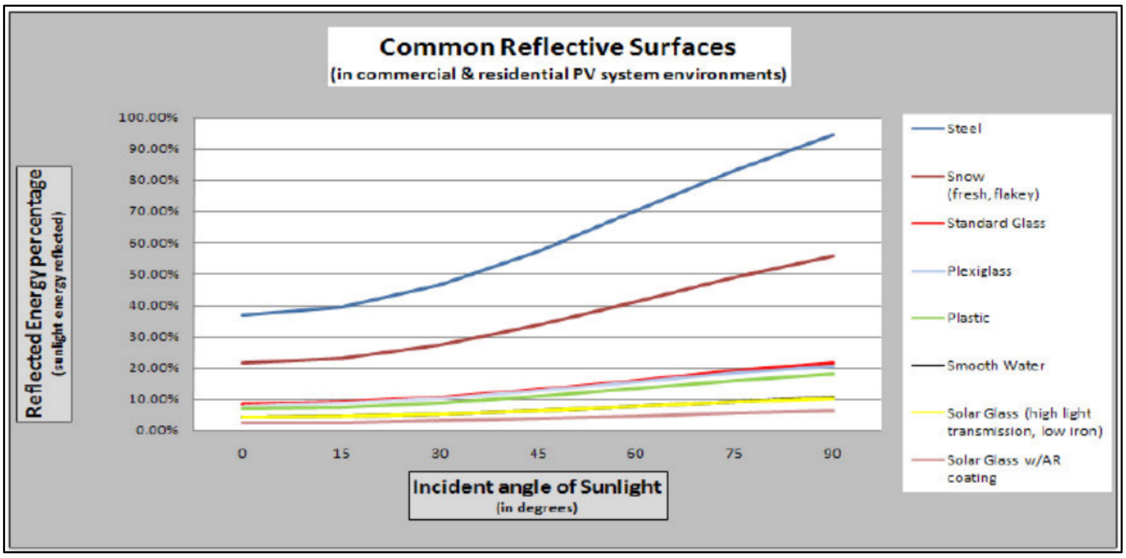
[22] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

[23] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification[24] to 'increase awareness concerning the possible glare and reflectance impact of PV Systems on their surrounding environment'.

The figure presented below shows the relative reflectivity of solar panels compared to other natural and manmade materials including smooth water, standard glass and steel.



Common reflective surfaces

The results, similarly to those from Riley and Olsen study (2011) and the FAA (2010), show that solar panels produce a reflection that is less intense than those of '*standard glass and other common reflective surfaces*'.

With respect to aviation and solar reflections observed from the air, SunPower has developed several large installations near airports or on Air Force bases. It is stated that these developments have all passed FAA or Air Force standards with all developments considered "No Hazard to Air Navigation". The note suggests that developers discuss any possible concerns with stakeholders near proposed solar farms.

[24] Source: Technical Support, 2009. SunPower Technical Notification – Solar Module Glare and Reflectance.

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

The Sun's position in the sky can be accurately described by its azimuth and elevation. Azimuth is a direction relative to true north (horizontal angle i.e. from left to right) and elevation describes the Sun's angle relative to the horizon (vertical angle i.e. up and down).

The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

- Time.
- Date.
- Latitude.
- Longitude.

The combination of the Sun's azimuth angle and vertical elevation will affect the direction and angle of the reflection from a reflector.

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

The significance of glint and glare will vary for different receptors. The following section presents a general overview of the significance criteria with respect to experiencing a solar reflection.

Impact Significance Definition

The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not required e.g. intervening screening will limit the view of the reflecting solar panels.	No mitigation required.
Moderate	A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case.	Whilst the impact may be acceptable, consultation and/or further analysis should be undertaken to determine the requirement for mitigation.
Major	A solar reflection is geometrically possible and visible under conditions that will produce a significant impact. Mitigation and consultation is recommended.	Mitigation will be required if the proposed solar development is to proceed.

Impact significance definition

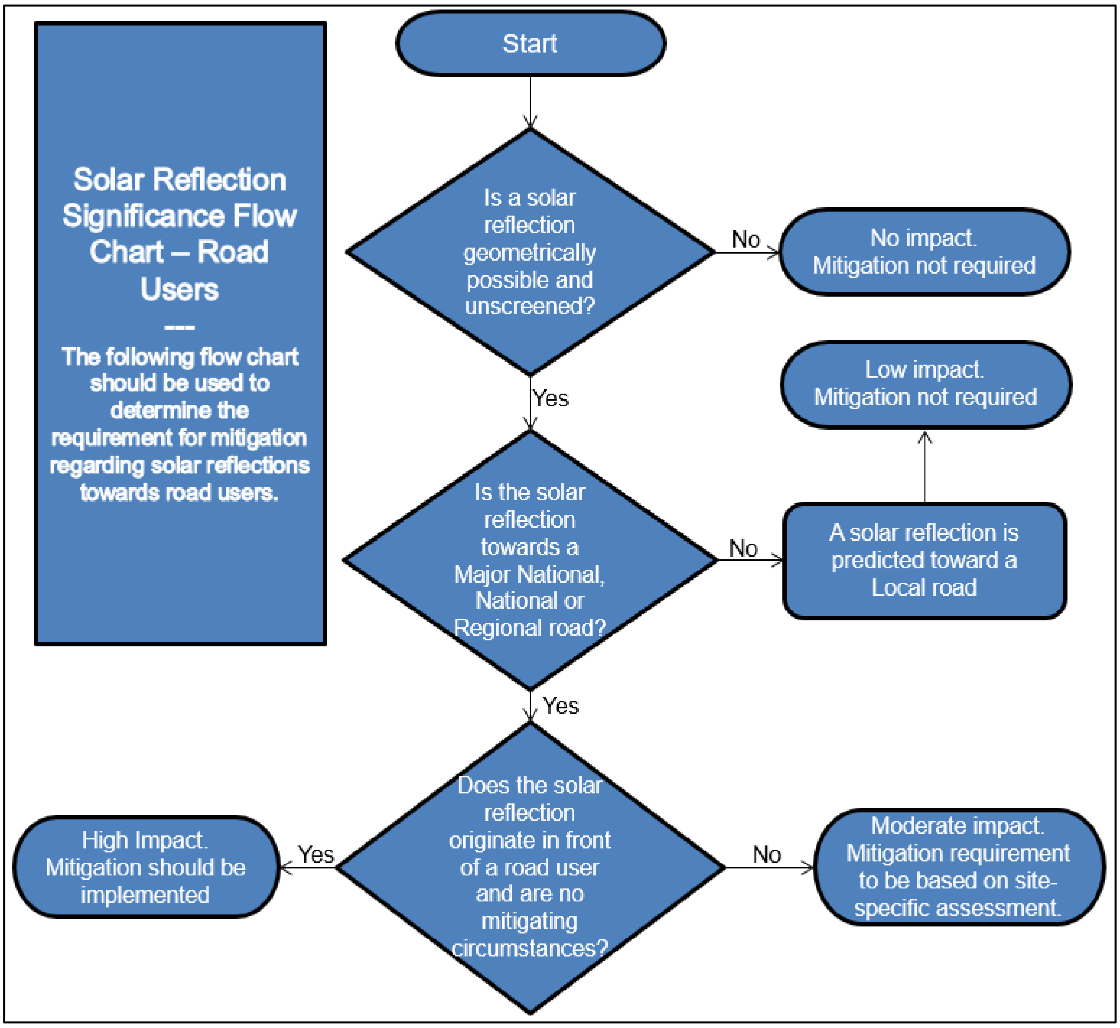
The following is an extract taken from Victoria State Government guidance for solar panel developments[8]. This agrees with Pager Power methodology.

The impacts of solar reflection vary for each type of receptor. The following criteria for glint and glare effects, should be used to guide an assessment.

- *No impact: a solar reflection is not geometrically possible, or it will not be visible from the assessed receptor. No mitigation is required.*
- *Low impact: a solar reflection is geometrically possible, but the intensity and duration of an impact is considered to be small and can be mitigated with screening or other measure.*
- *Moderate impact: a solar reflection is geometrically possible and visible, but the intensity and duration of an impact varies according to conditions. Mitigation measures (such as through design, orientation, landscaping or other screening method) to reduce impacts to an acceptable level will be required.*
- *Major impact: a solar reflection is geometrically possible and visible under a range of conditions that will produce impacts with significant intensity and duration. Significant mitigation measures are required if the proposed development is to proceed.*

Assessment Process for Road Receptors

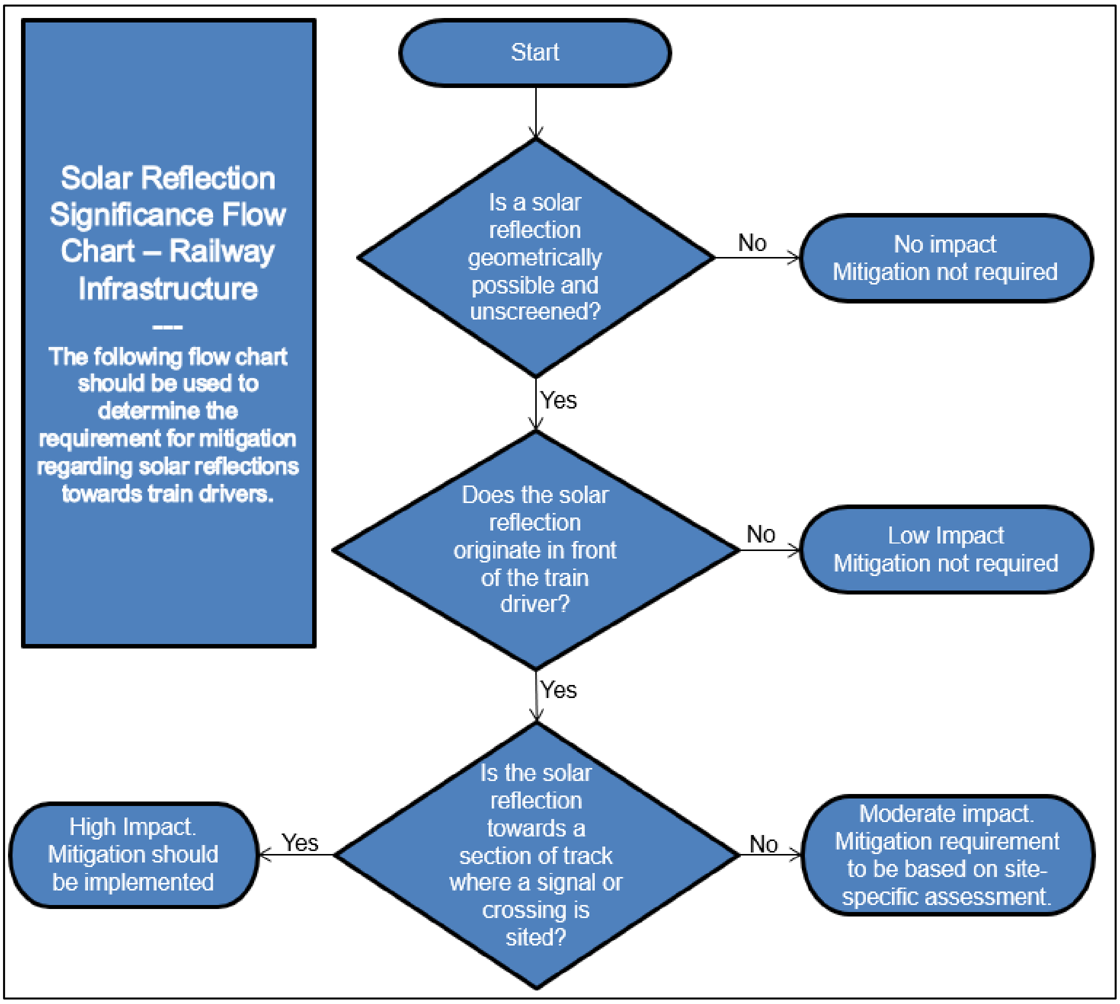
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road receptor mitigation requirement flow chart

Assessment Process for Railway Receptors

The flow chart presented below has been followed when determining the mitigation requirement for railway receptors.



Train driver impact significance flow chart

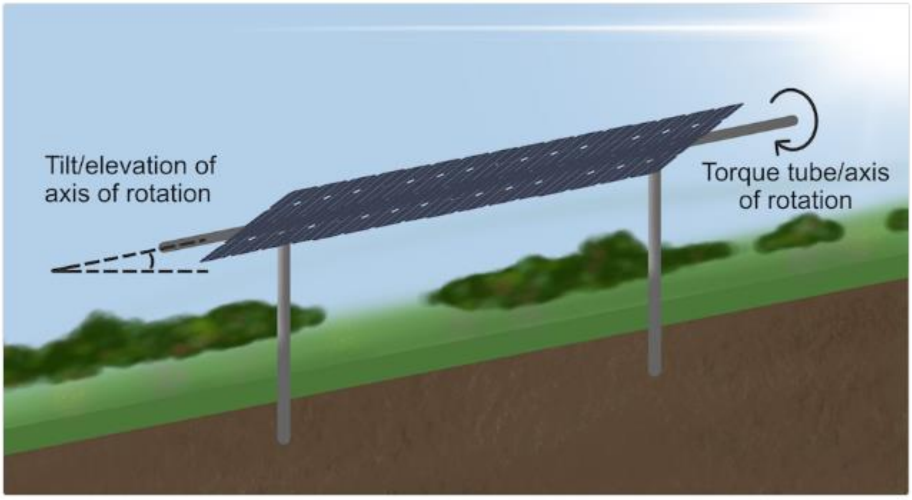
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Forge Reflection Calculations Methodology

Extracts taken from the Forge Solar Model.

Tracking System Parameters

Single-axis module tracking systems are described by a unique set of parameters. These angular inputs model the tracking axis, rotation range and backtracking behavior. Dual-axis module tracking systems are assumed to track the sun at all times.



Single-axis tracking system with torque tube tilted due to geography

Tilt of tracking axis (°)
Tilt above flat ground of axis over which panels rotate (e.g. torque tube). System on flat, level ground would have axis tilt of 0°.

Orientation of tracking axis (°)
Azimuthal angle of axis over which panels rotate. Angle represents the facing of the axis and system. For example, typical tracking system in northern hemisphere has tracking axis oriented north-south with an orientation of 180°, allowing panels to rotate east-west with potential south-facing tilt. Typical tracking system in southern hemisphere runs south-north with axis orientation of 0°, yielding east-west rotation with potential north-facing tilt.

Offset angle of module (°)
Additional tilt angle of PV module elevated above tracking axis/torque tube. Offset angle is measured from the torque tube.

Maximum tracking angle (°)
Maximum angle of rotation of tracking system in one direction. For example, a typical system with a 120° range of rotation has a *max tracking angle* of 60° (east/west).

Resting angle (°)
Angle of rotation of panels when sun is outside tracking range. Used to model backtracking. Panels will revert to the position described by this rotation angle at all times when the sun is outside the rotation range. Setting this equal to the *maximum tracking angle* implies the panels do not backtrack.

ForgeSolar utilizes a simplified model of backtracking which assumes panels instantaneously revert to the *resting angle* whenever the sun is outside the rotation range. For example, panels with *max tracking angle* of 60° and *resting angle* of 0° would lie flat from sunrise until the sun enters the rotation range, and immediately after the sun leaves the rotation range until sunset daily.

Tracking System Parameters

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Forge's Sandia National Laboratories' (SGHAT) Model[25]

Summary of assumptions and abstractions required by the SGHAT/ForgeSolar analysis methodology

1. Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
2. Result data files and plots are now retained for two years after analysis completion. Files should be downloaded and saved if additional persistence is required.
3. 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.
4. Several 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 analyses of path receptors.
5. 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.
6. 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.)
7. The algorithm assumes that the PV array is aligned with a plane defined by the total heights of the coordinates outlined in the Google map. For more accuracy, the user should perform runs using minimum and maximum values for the vertex heights to bound the height of the plane containing the solar array. Doing so will expand the range of observed solar glare when compared to results using a single height value.
8. 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.
9. 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.
10. 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.
11. 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.
12. 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.
13. Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
14. Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
15. PV array tracking assumes the modules move instantly when tracking the sun, and when reverting to the rest position.

[25] https://www.forgesolar.com/help/#assumptions

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Terrain Height

Terrain Height is calculated by Forge from SRTM data, based on the coordinates of the point of interest.

Road Receptor Data

The table below presents the coordinates for the assessed road receptors.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.25511	-35.18640	17	147.26870	-35.17725
2	147.25597	-35.18582	18	147.26957	-35.17666
3	147.25681	-35.18525	19	147.27042	-35.17609
4	147.25770	-35.18465	20	147.27128	-35.17551
5	147.25852	-35.18409	21	147.27210	-35.17495
6	147.25938	-35.18352	22	147.27297	-35.17436
7	147.26022	-35.18296	23	147.27384	-35.17379
8	147.26111	-35.18239	24	147.27470	-35.17319
9	147.26193	-35.18182	25	147.27555	-35.17262
10	147.26277	-35.18127	26	147.27643	-35.17203
11	147.26362	-35.18068	27	147.27729	-35.17145
12	147.26444	-35.18014	28	147.27817	-35.17085
13	147.26529	-35.17953	29	147.27902	-35.17024
14	147.26611	-35.17899	30	147.27984	-35.16968
15	147.26697	-35.17841	31	147.28074	-35.16916
16	147.26785	-35.17783	32	147.28206	-35.16851

Road Receptor Data

Train Driver Receptor Data

The table below presents the coordinates for the assessed train driver receptors.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.26016	-35.18262	12	147.26944	-35.17636
2	147.26098	-35.18207	13	147.27028	-35.17580
3	147.26182	-35.18150	14	147.27115	-35.17522
4	147.26264	-35.18095	15	147.27201	-35.17464
5	147.26350	-35.18037	16	147.27284	-35.17406
6	147.26436	-35.17979	17	147.27372	-35.17347
7	147.26521	-35.17921	18	147.27459	-35.17289
8	147.26604	-35.17866	19	147.27544	-35.17232
9	147.26690	-35.17808	20	147.27630	-35.17176
10	147.26775	-35.17751	21	147.27754	-35.17090
11	147.26860	-35.17692			

Train Driver Receptor Data

Panel Boundary Data

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.272229	-35.172240	7	147.262361	-35.177713
2	147.260027	-35.174684	8	147.262408	-35.176646
3	147.259986	-35.176672	9	147.264354	-35.176292
4	147.259613	-35.176805	10	147.264408	-35.177379
5	147.259489	-35.176907	11	147.265721	-35.178382
6	147.259561	-35.178130	12	147.272300	-35.173957

Panel Boundary Data

APPENDIX H – DETAILED MODELLING RESULTS

Overview

The following charts are taken from Forge and present relevant information for the potentially affected receptors for completeness. Each chart shows:

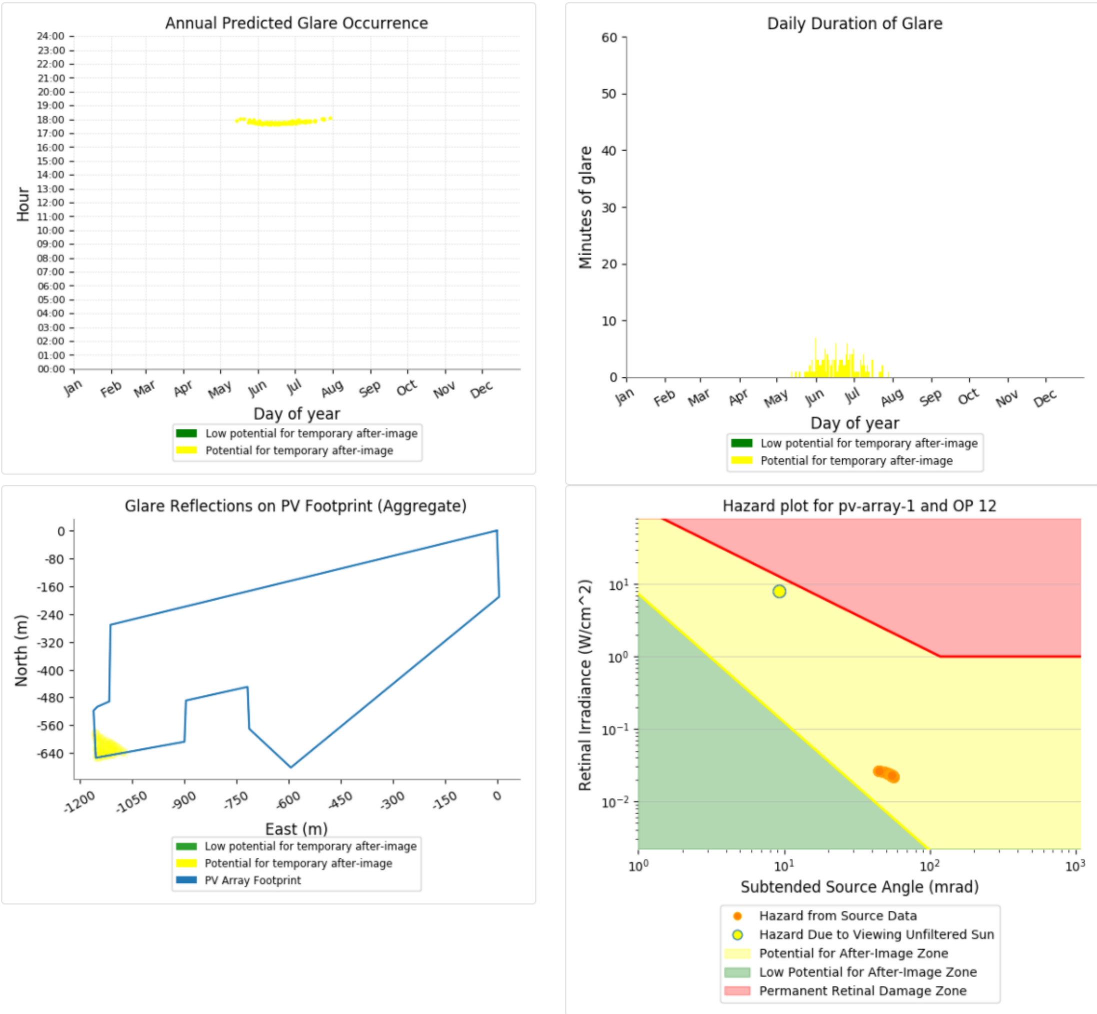
- The reflection date/time graph – top left graph. This relates to reflections from the yellow areas;
- The daily duration of glare – top right image.
- The reflecting panels – bottom left image. The reflecting area is shown in yellow. If the yellow panels are not visible from the observer location, no issues will occur in practice. Additional obstructions which may obscure the panels from view are considered separately within the analysis;

Road Receptors

PV array 1 - OP Receptor (OP 12)

PV array is expected to produce the following glare for receptors at this location:

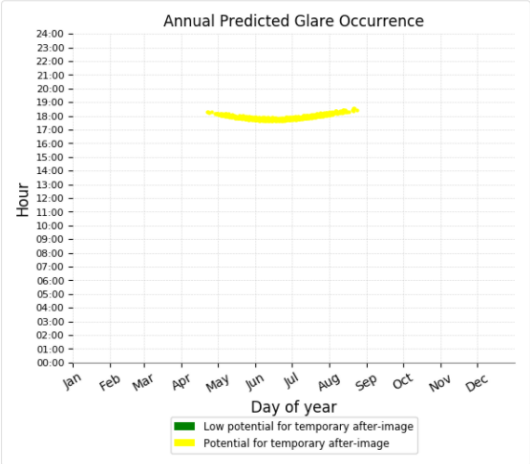
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 134 minutes of "yellow" glare with potential to cause temporary after-image.

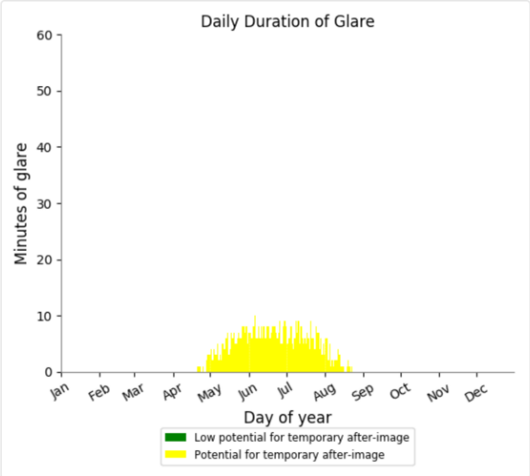


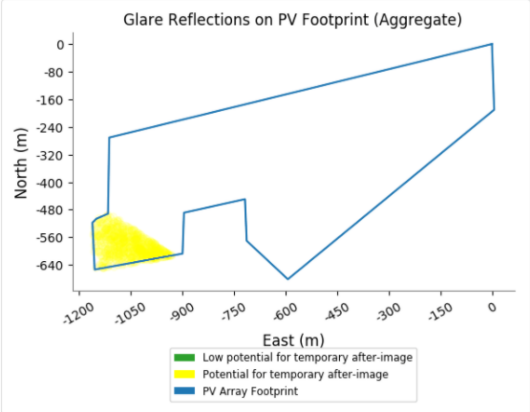
PV array 1 - OP Receptor (OP 13)

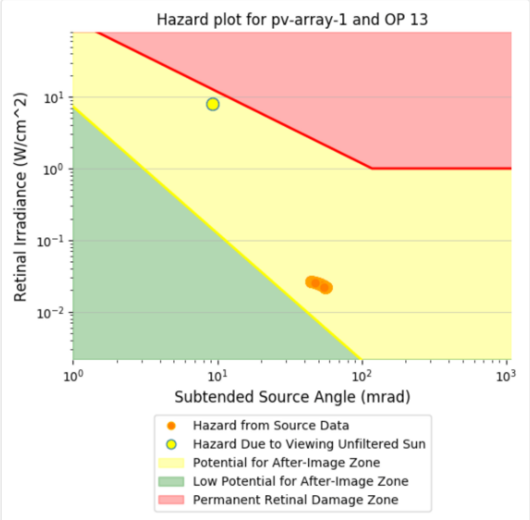
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 617 minutes of "yellow" glare with potential to cause temporary after-image.





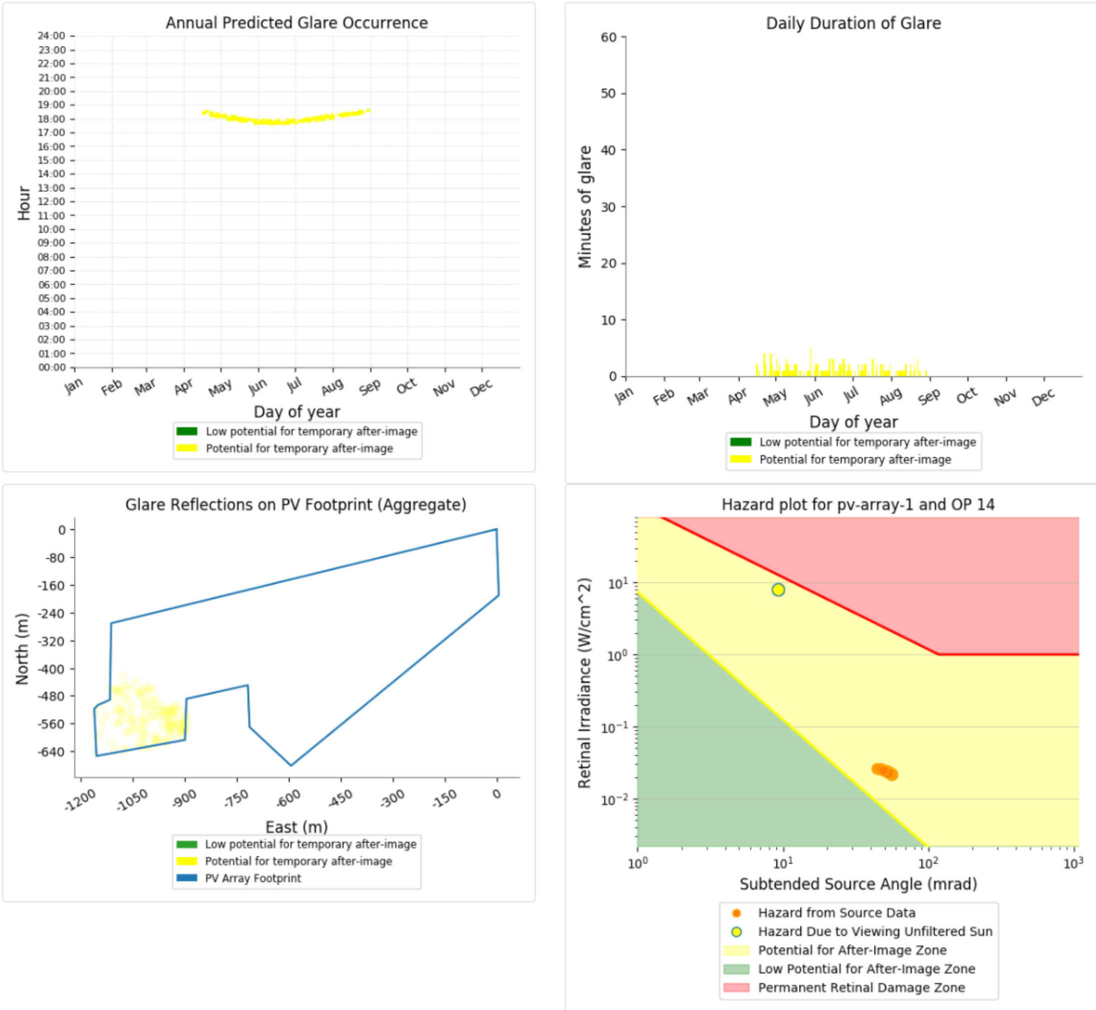




PV array 1 - OP Receptor (OP 14)

PV array is expected to produce the following glare for receptors at this location:

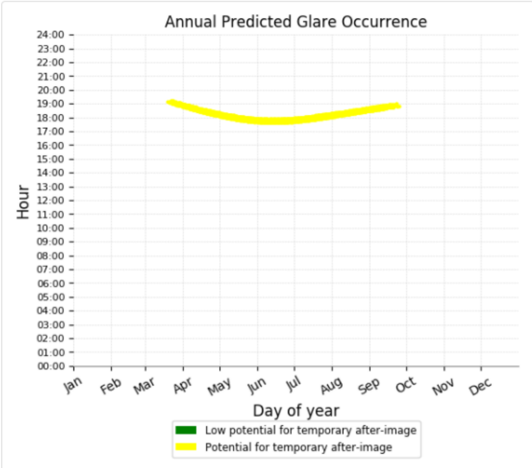
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 143 minutes of "yellow" glare with potential to cause temporary after-image.

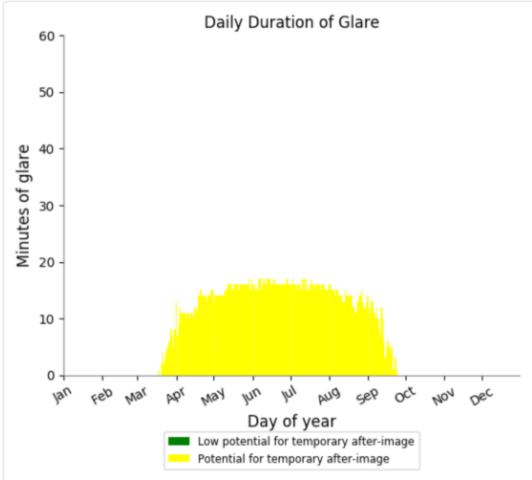


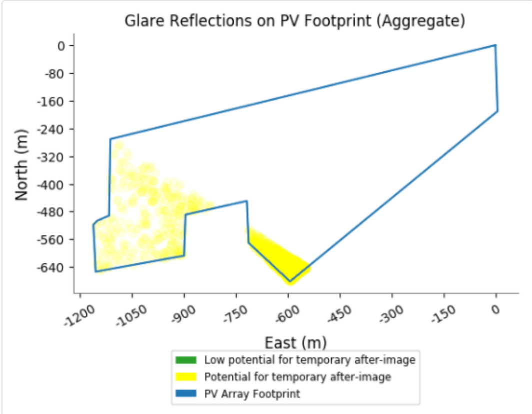
PV array 1 - OP Receptor (OP 15)

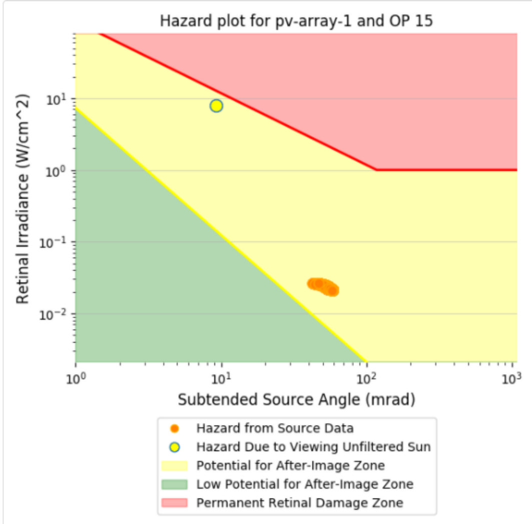
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,485 minutes of "yellow" glare with potential to cause temporary after-image.





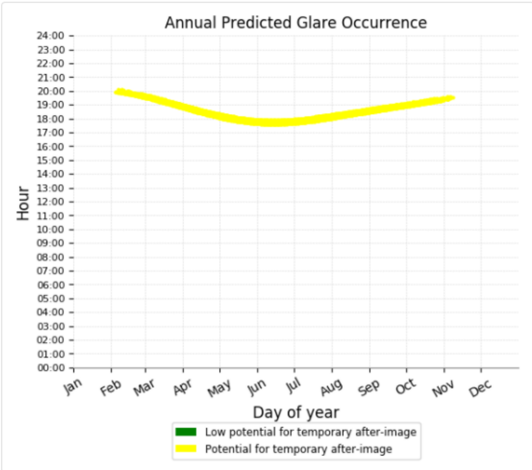


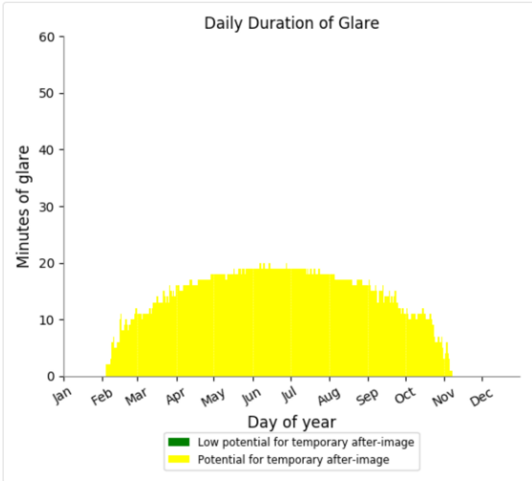


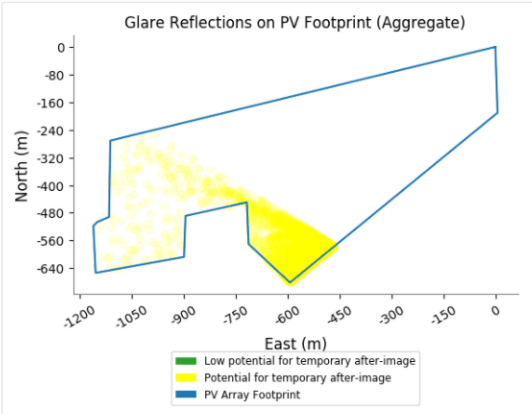
PV array 1 - OP Receptor (OP 16)

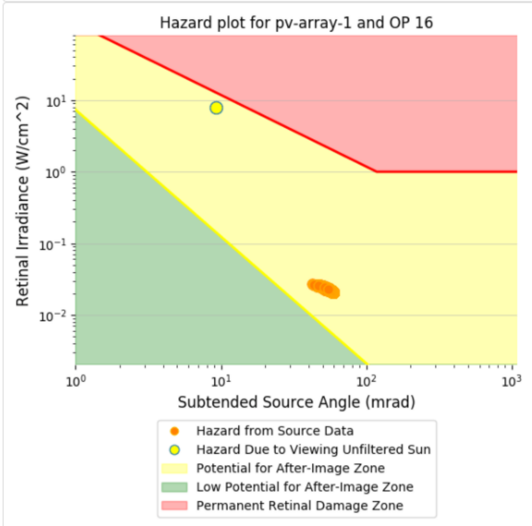
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,050 minutes of "yellow" glare with potential to cause temporary after-image.





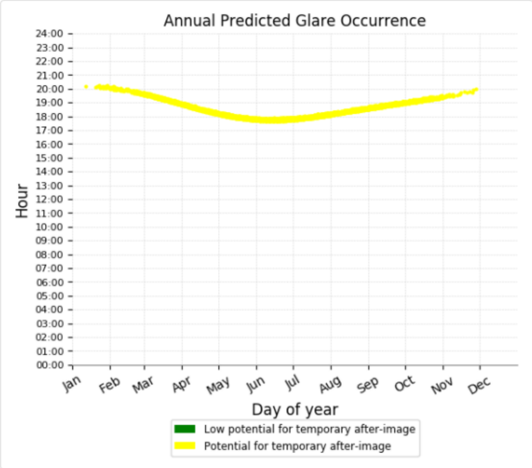


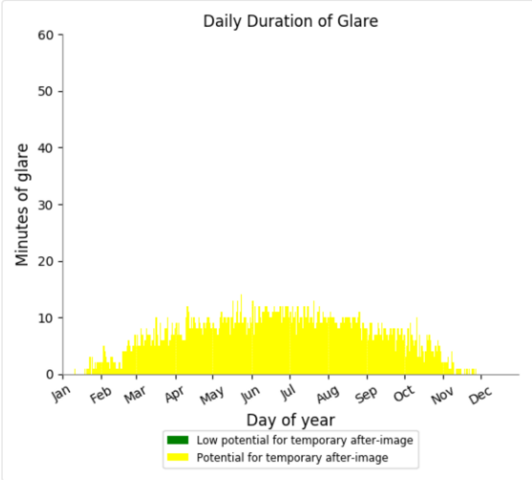


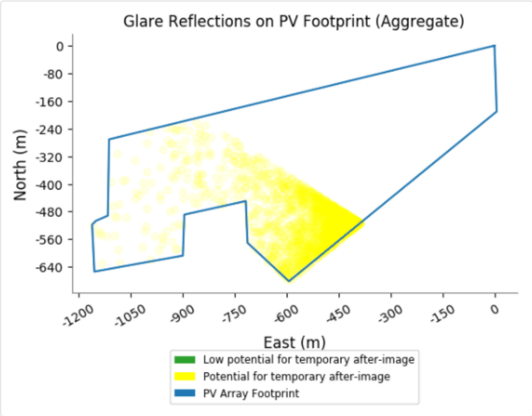
PV array 1 - OP Receptor (OP 17)

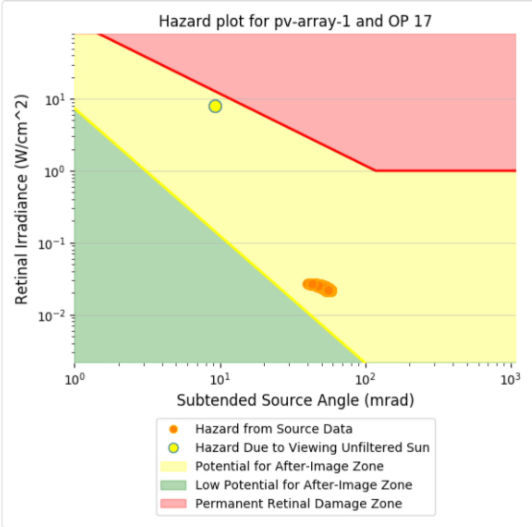
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,205 minutes of "yellow" glare with potential to cause temporary after-image.





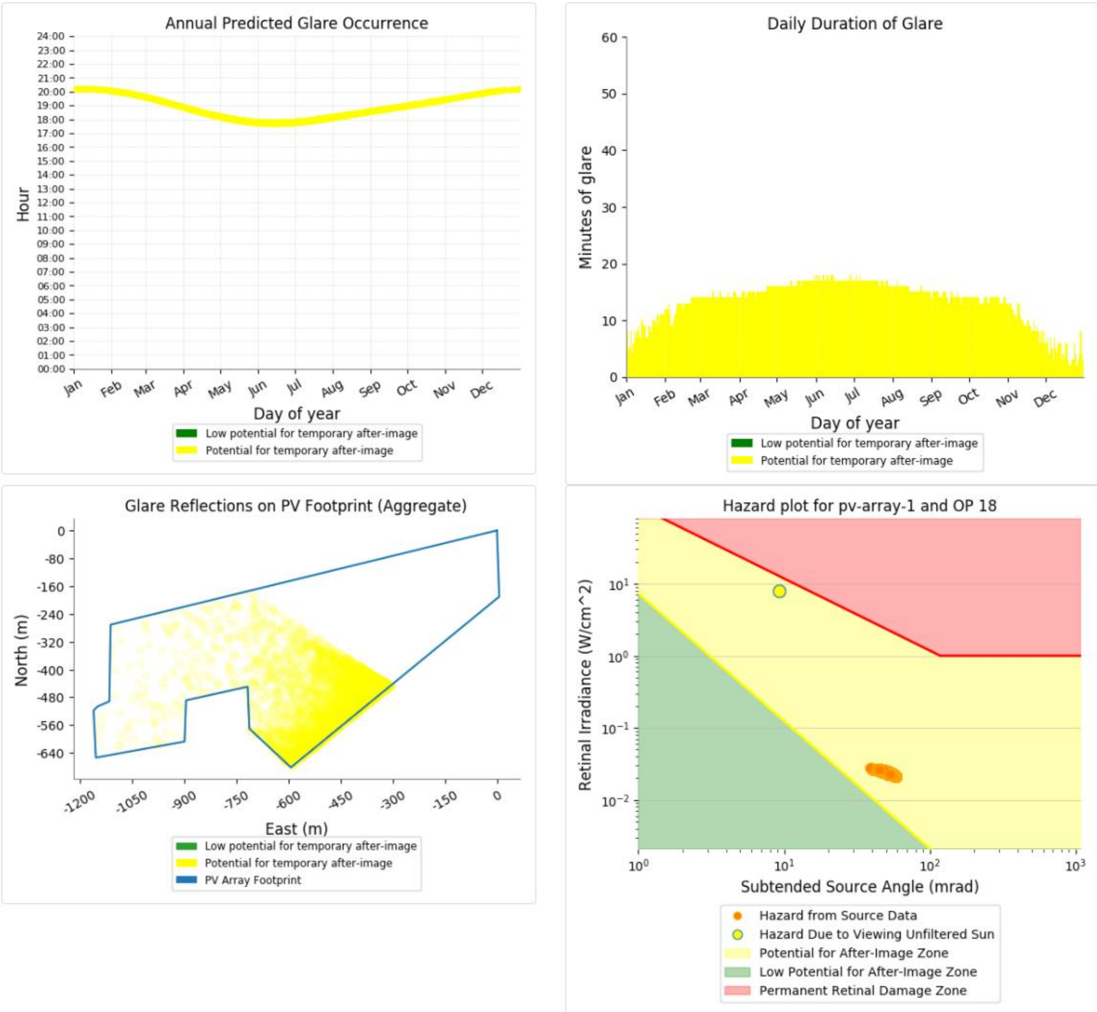




PV array 1 - OP Receptor (OP 18)

PV array is expected to produce the following glare for receptors at this location:

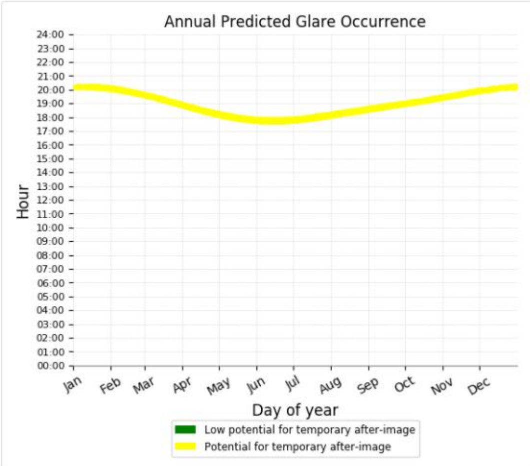
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,824 minutes of "yellow" glare with potential to cause temporary after-image.

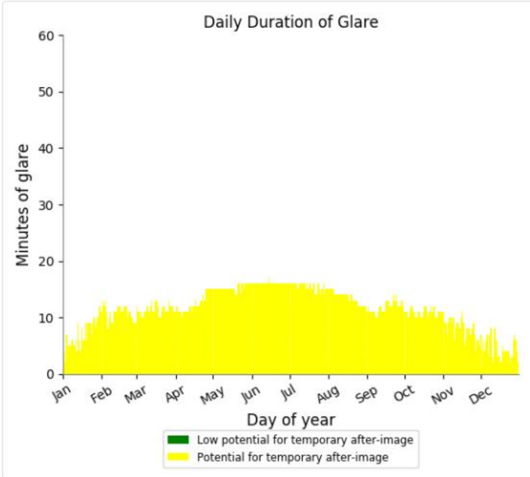


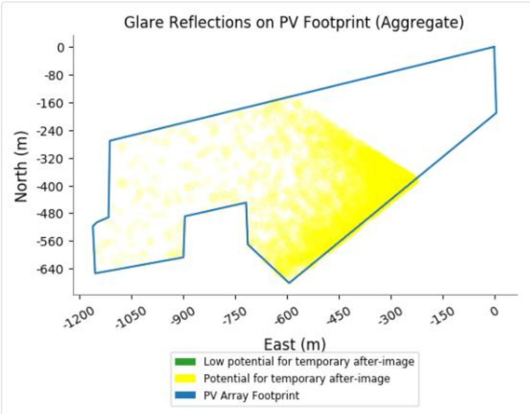
PV array 1 - OP Receptor (OP 19)

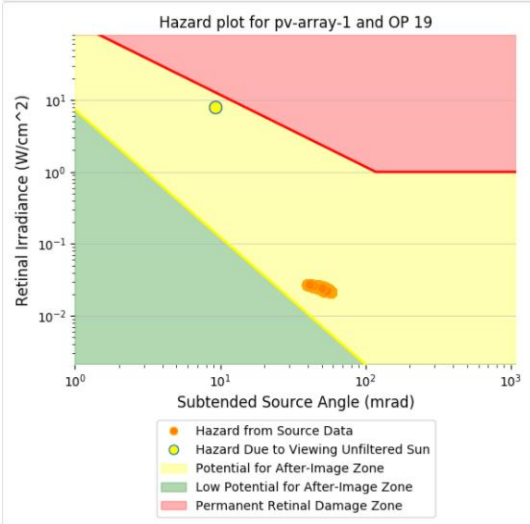
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,180 minutes of "yellow" glare with potential to cause temporary after-image.





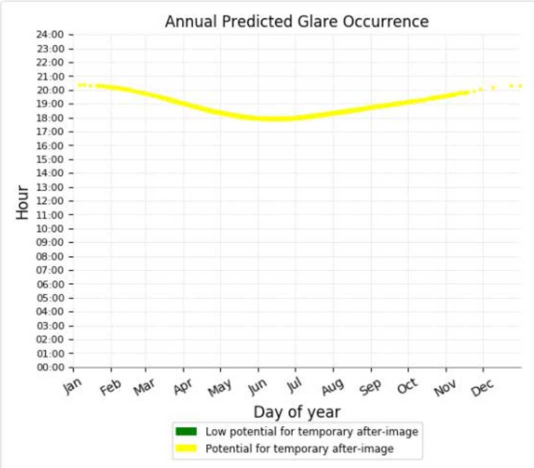


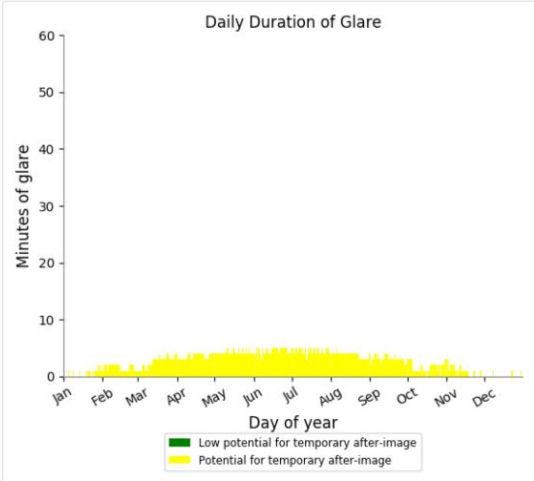


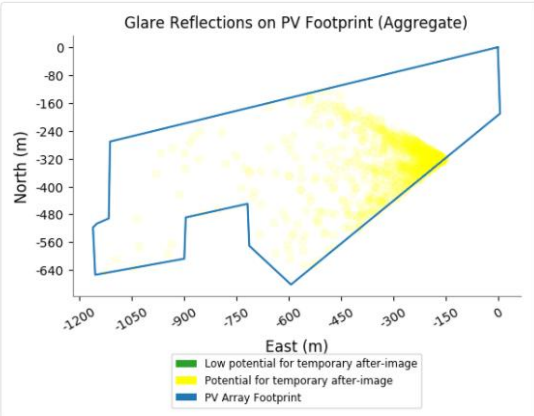
PV array 1 - OP Receptor (OP 20)

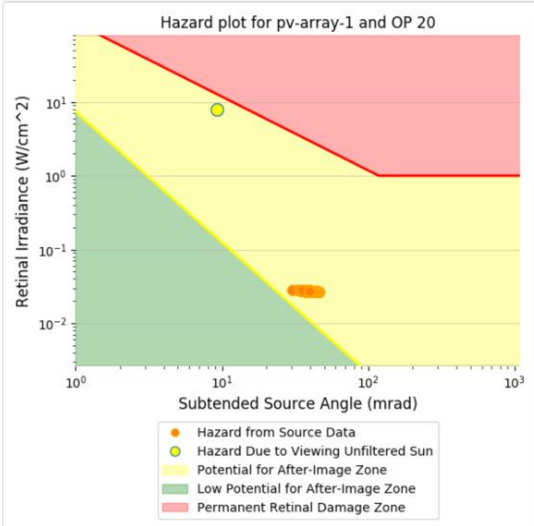
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 935 minutes of "yellow" glare with potential to cause temporary after-image.





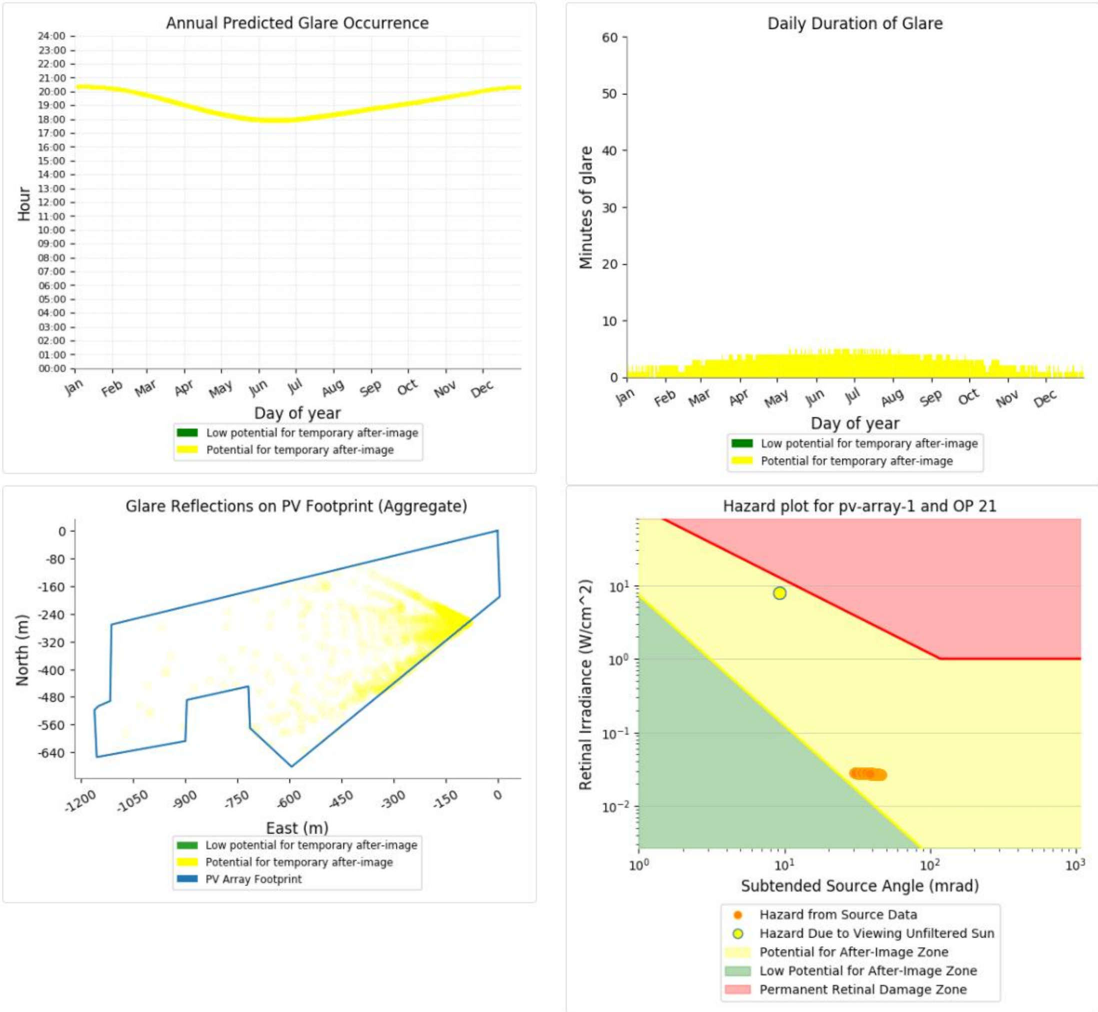




PV array 1 - OP Receptor (OP 21)

PV array is expected to produce the following glare for receptors at this location:

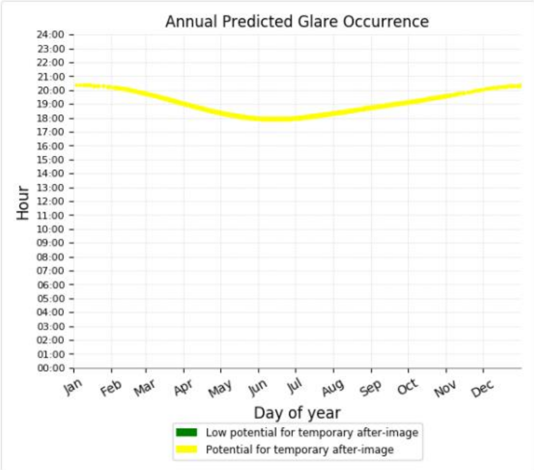
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,099 minutes of "yellow" glare with potential to cause temporary after-image.

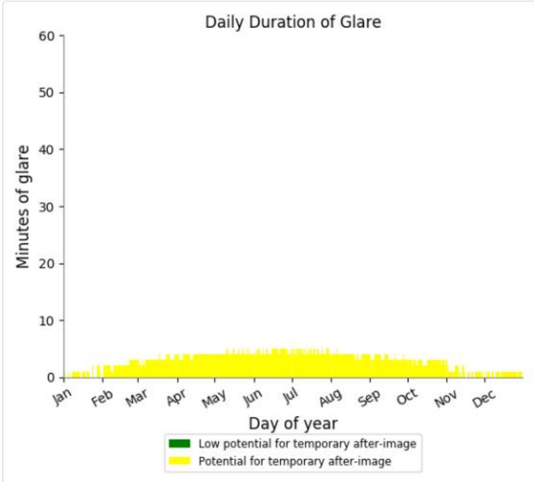


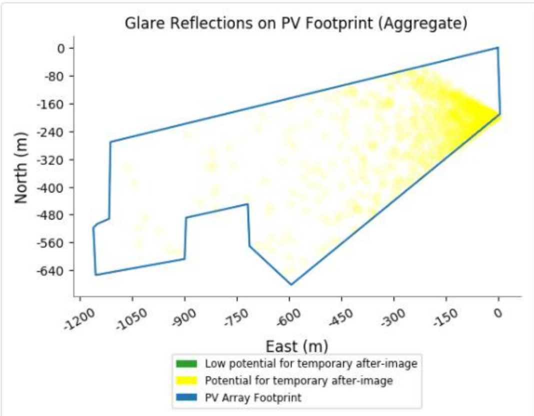
PV array 1 - OP Receptor (OP 22)

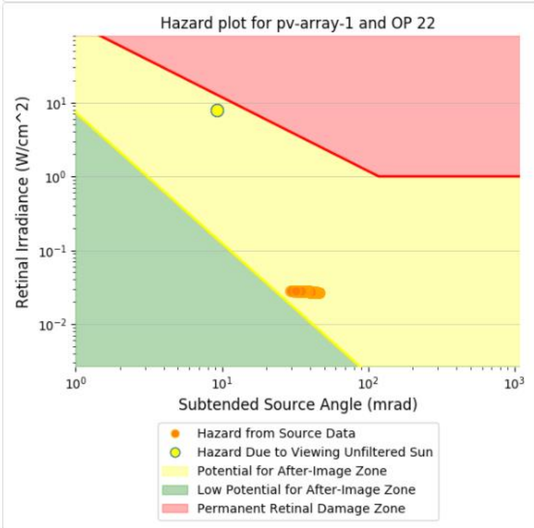
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,055 minutes of "yellow" glare with potential to cause temporary after-image.





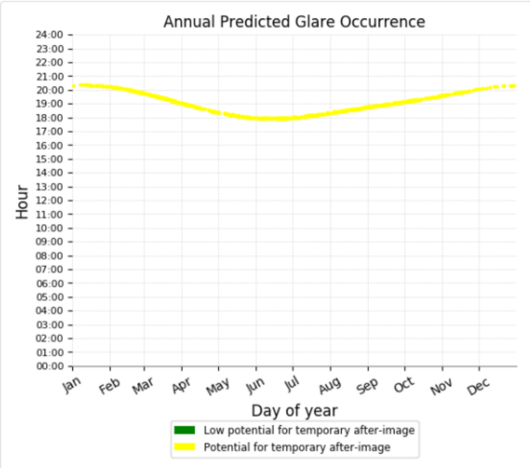


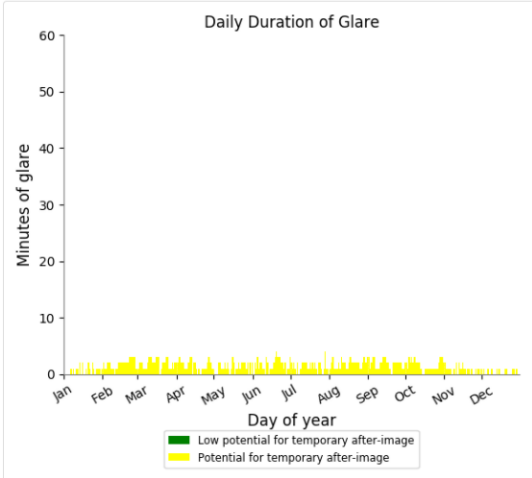


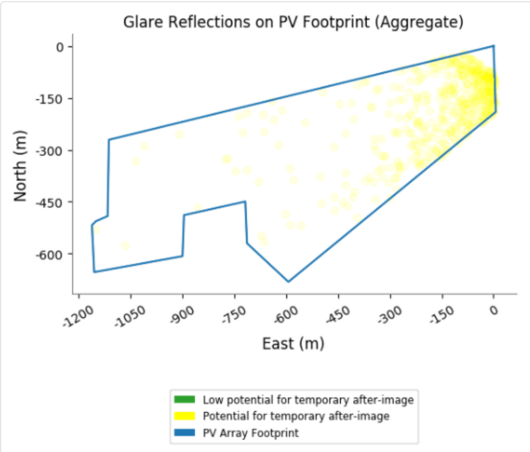
PV array 1 - OP Receptor (OP 23)

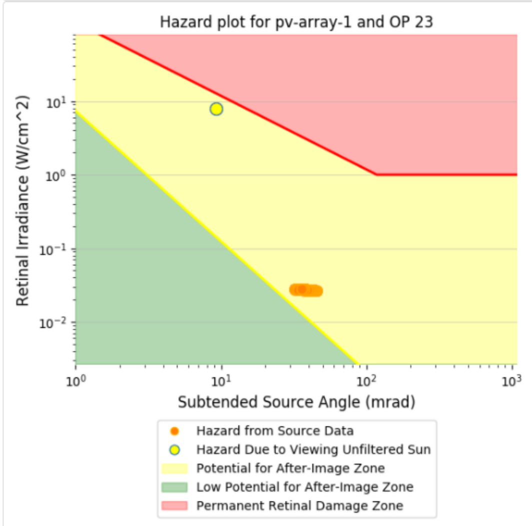
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 504 minutes of "yellow" glare with potential to cause temporary after-image.





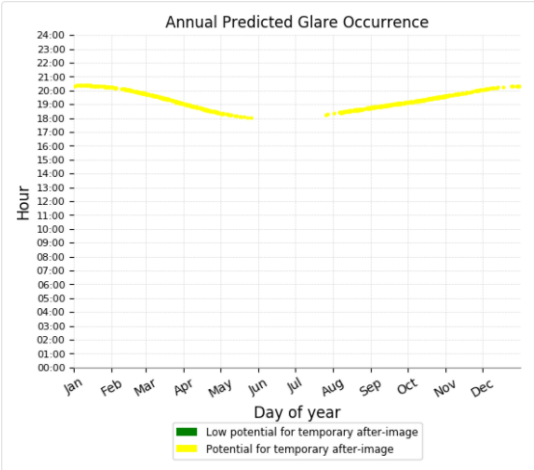


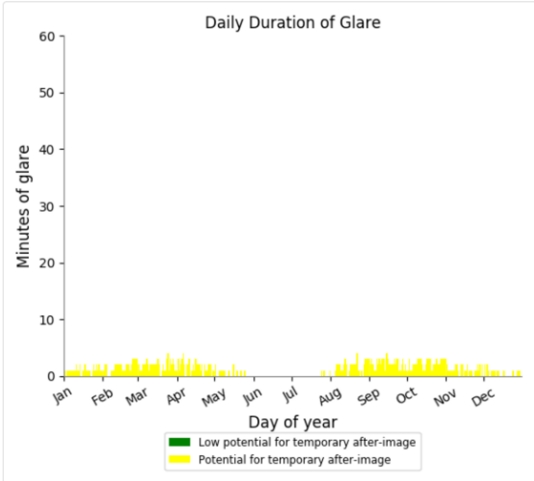


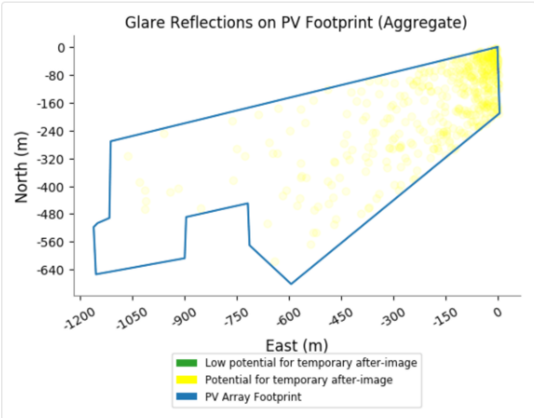
PV array 1 - OP Receptor (OP 24)

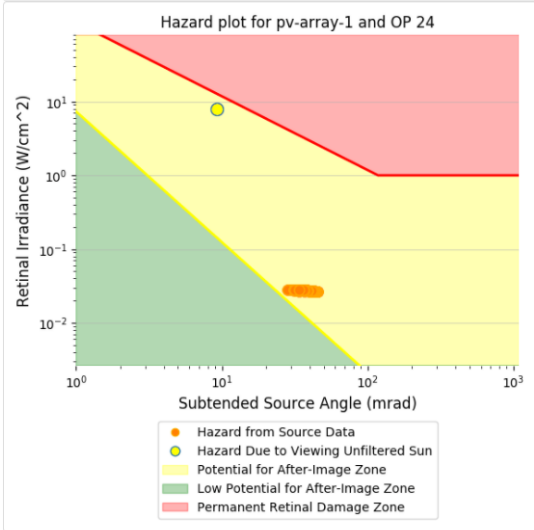
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 446 minutes of "yellow" glare with potential to cause temporary after-image.





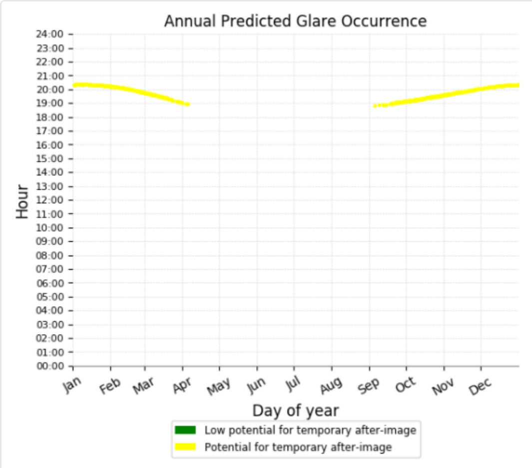


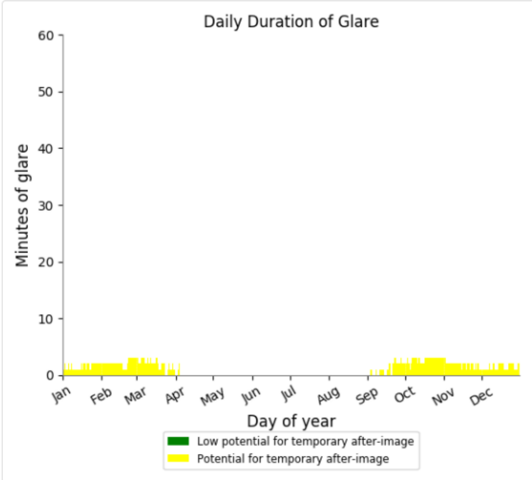


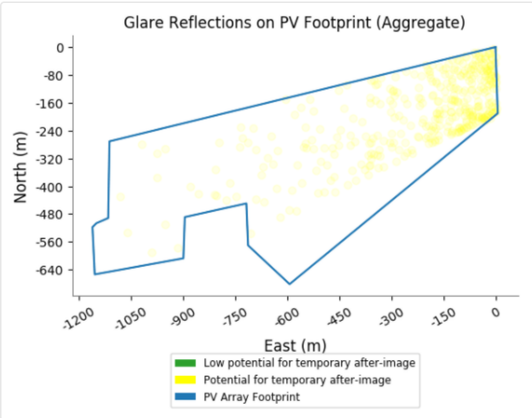
PV array 1 - OP Receptor (OP 25)

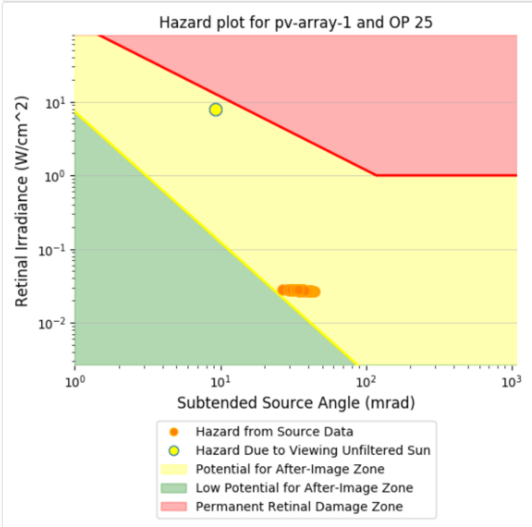
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 382 minutes of "yellow" glare with potential to cause temporary after-image.





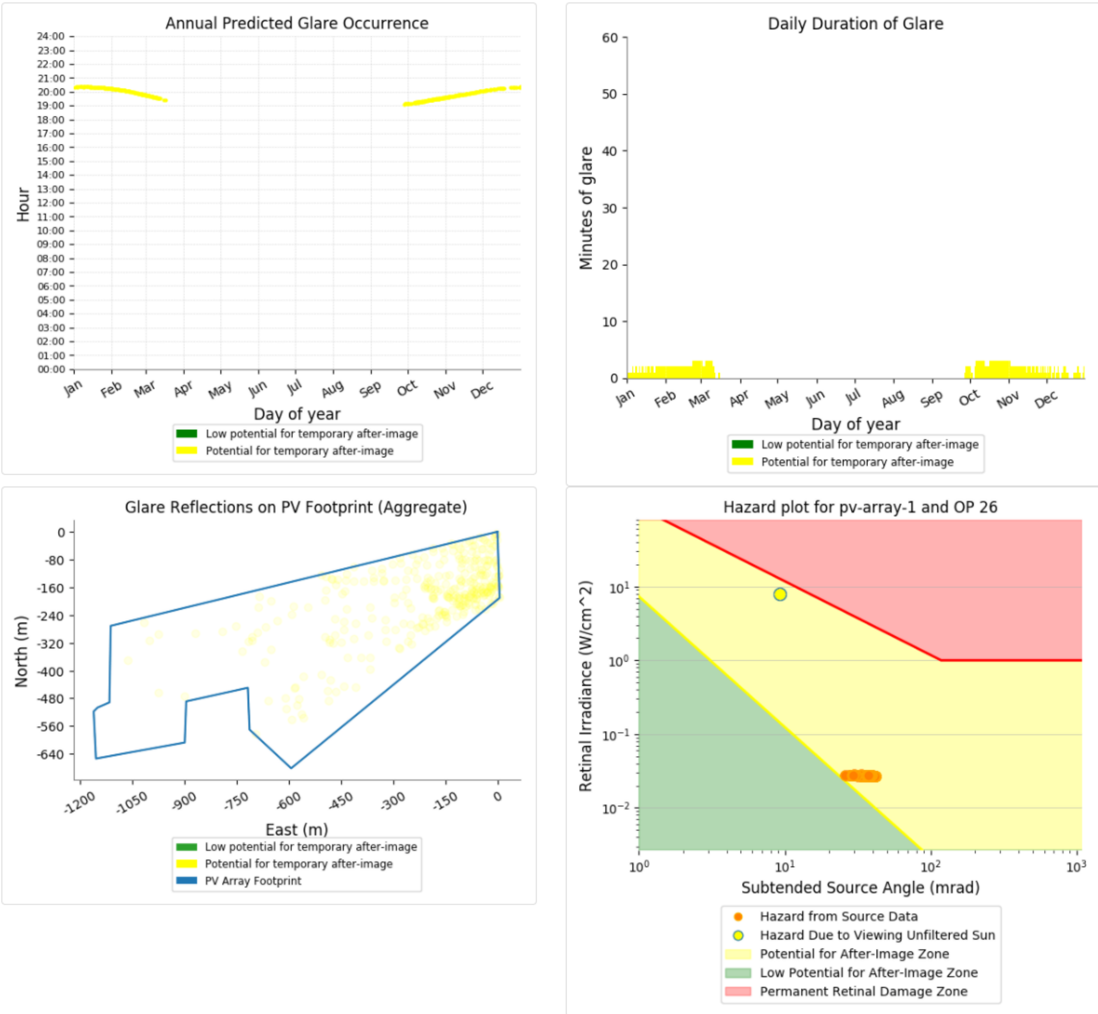




PV array 1 - OP Receptor (OP 26)

PV array is expected to produce the following glare for receptors at this location:

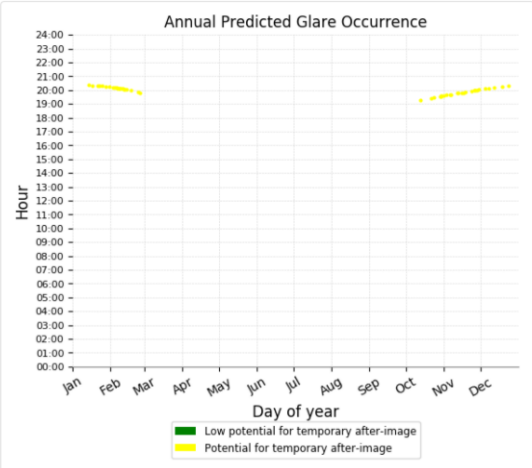
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 319 minutes of "yellow" glare with potential to cause temporary after-image.

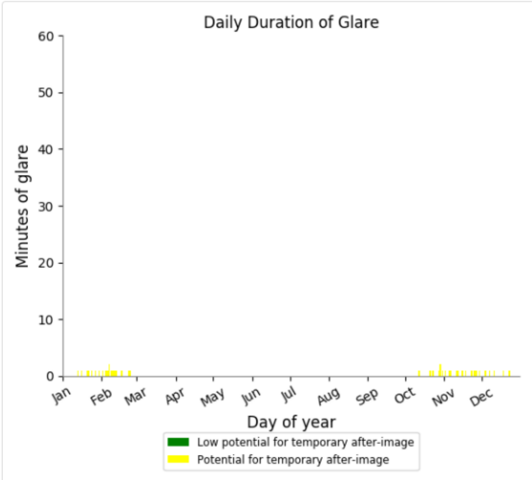


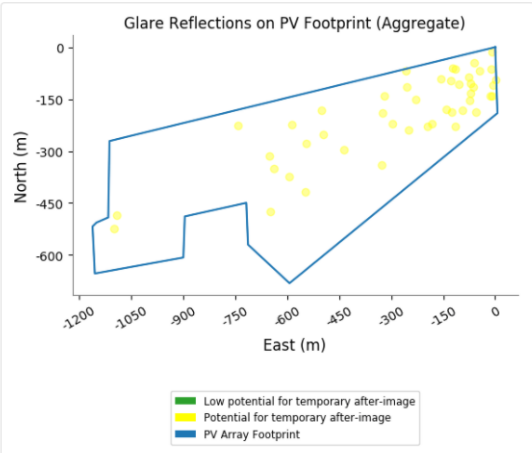
PV array 1 - OP Receptor (OP 27)

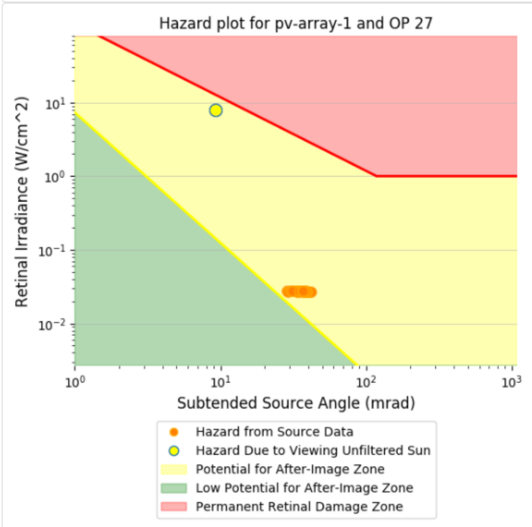
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 46 minutes of "yellow" glare with potential to cause temporary after-image.





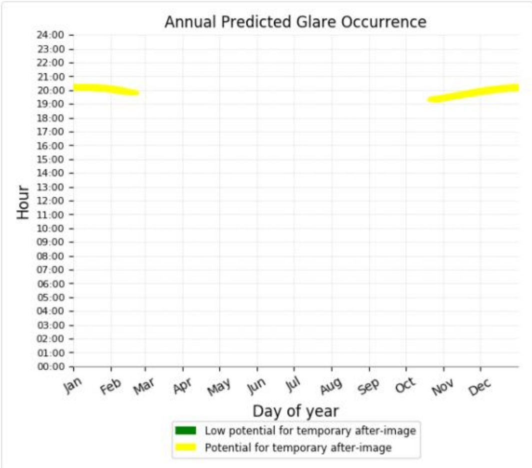


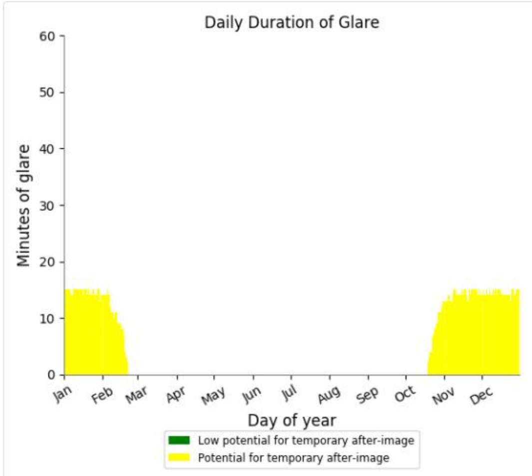


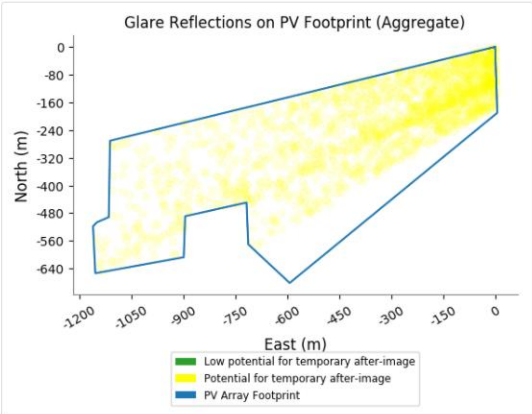
PV array 1 - OP Receptor (OP 28)

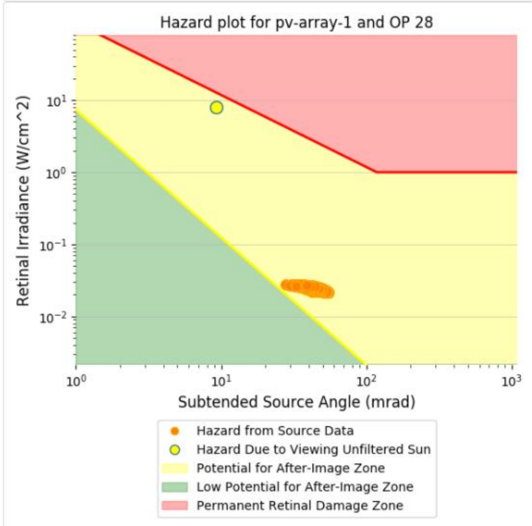
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,639 minutes of "yellow" glare with potential to cause temporary after-image.





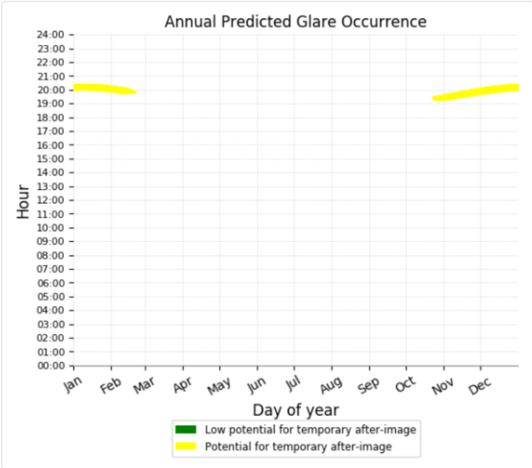


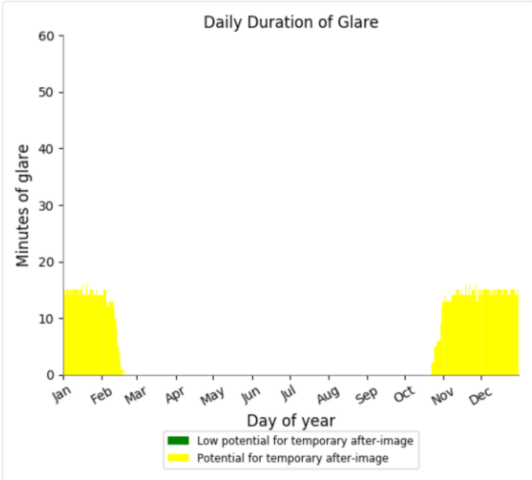


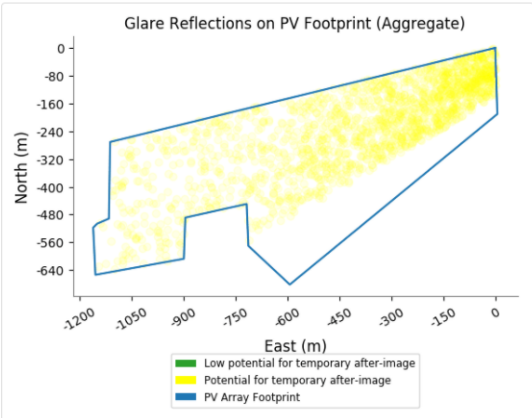
PV array 1 - OP Receptor (OP 29)

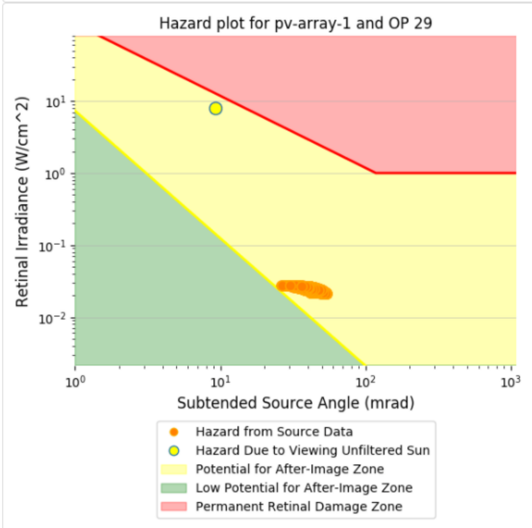
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,565 minutes of "yellow" glare with potential to cause temporary after-image.





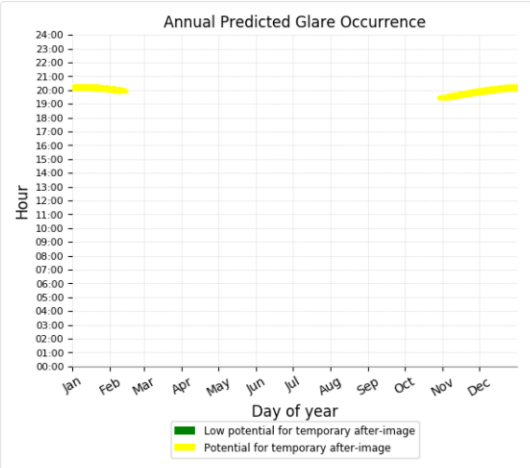


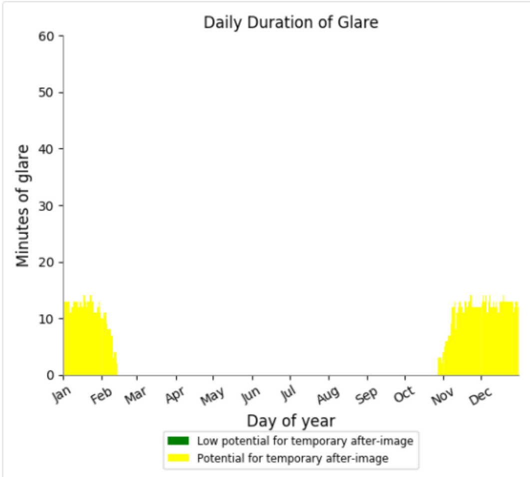


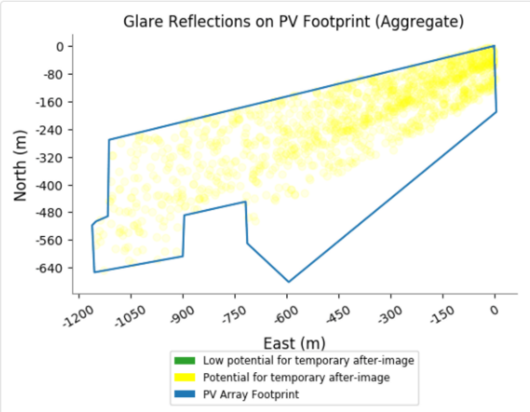
PV array 1 - OP Receptor (OP 30)

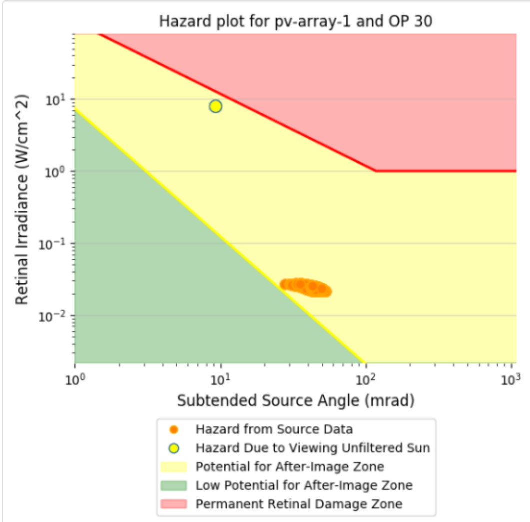
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,208 minutes of "yellow" glare with potential to cause temporary after-image.





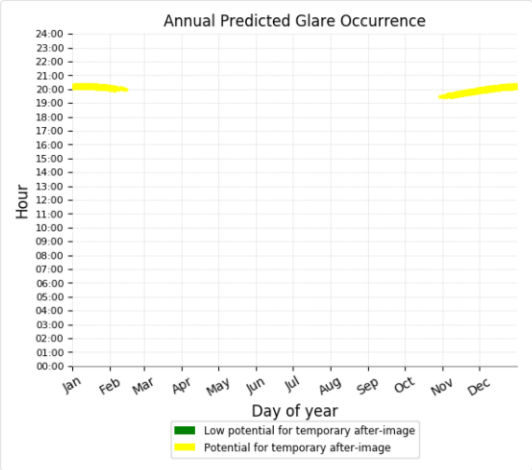


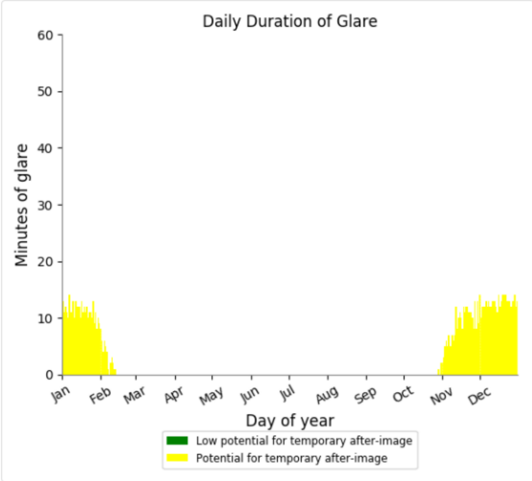


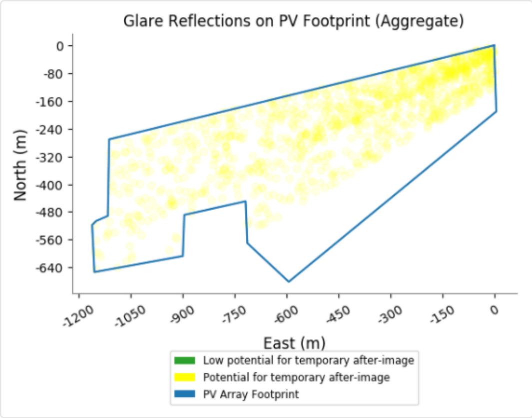
PV array 1 - OP Receptor (OP 31)

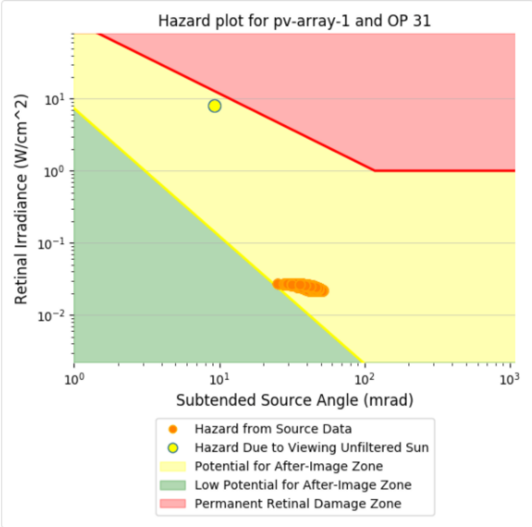
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,047 minutes of "yellow" glare with potential to cause temporary after-image.





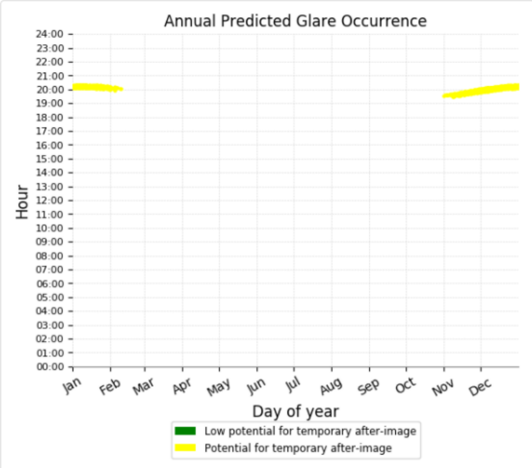


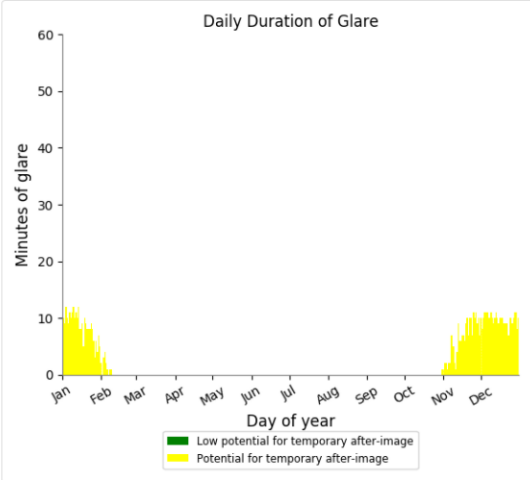


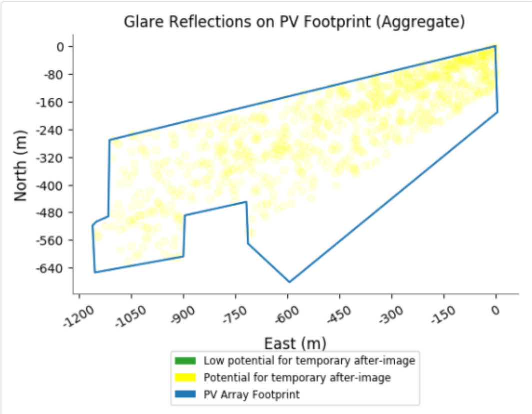
PV array 1 - OP Receptor (OP 32)

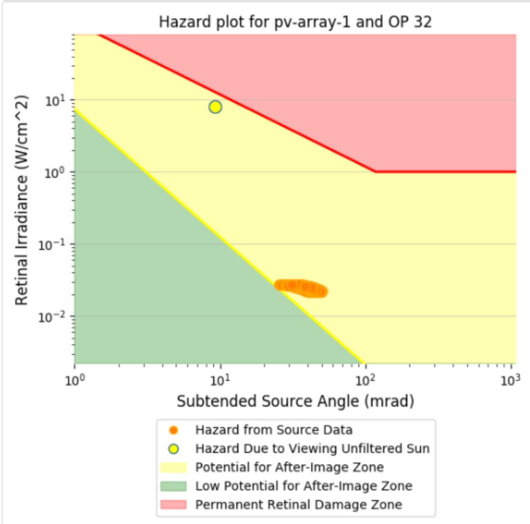
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 773 minutes of "yellow" glare with potential to cause temporary after-image.







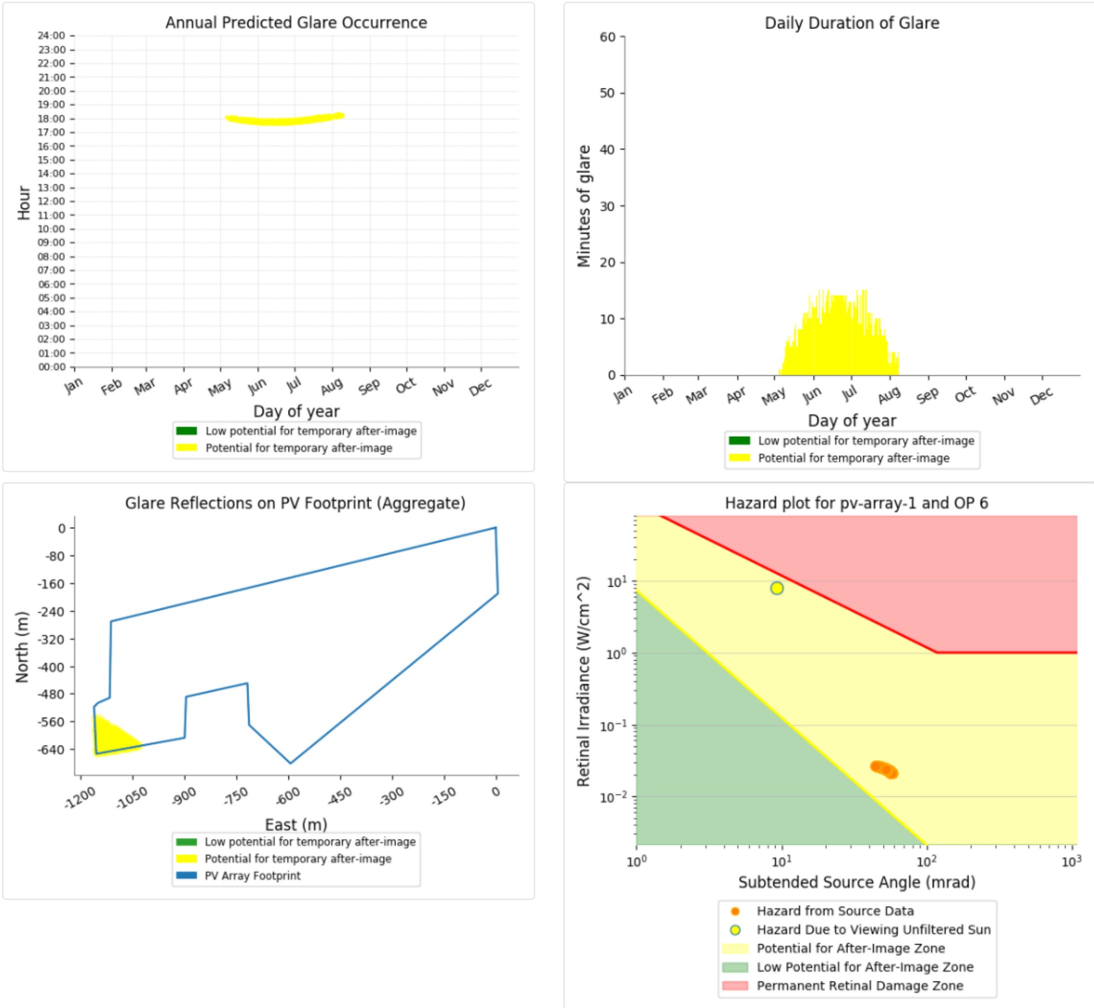


Train Driver Receptors

PV array 1 - OP Receptor (OP 6)

PV array is expected to produce the following glare for receptors at this location:

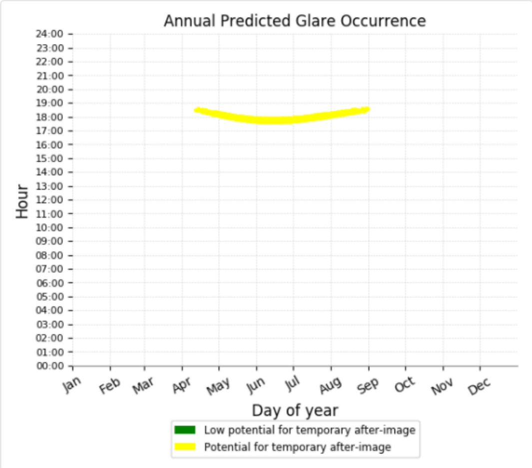
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 912 minutes of "yellow" glare with potential to cause temporary after-image.

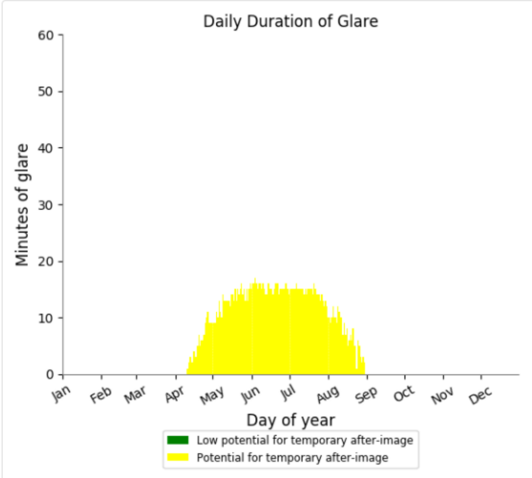


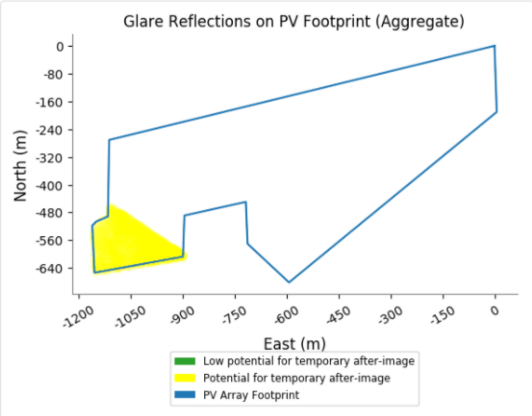
PV array 1 - OP Receptor (OP 7)

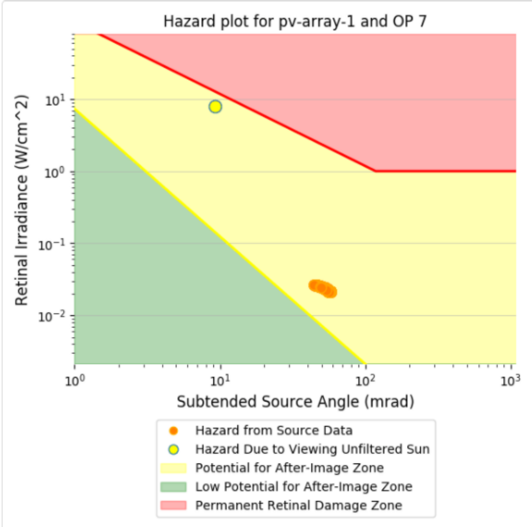
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,642 minutes of "yellow" glare with potential to cause temporary after-image.





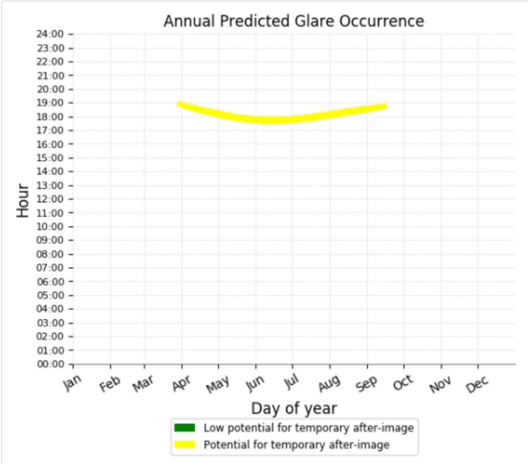


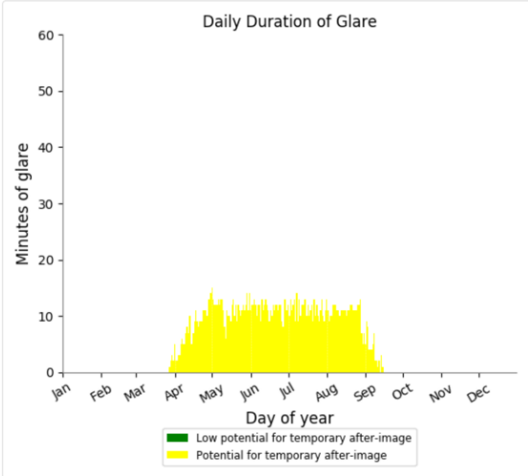


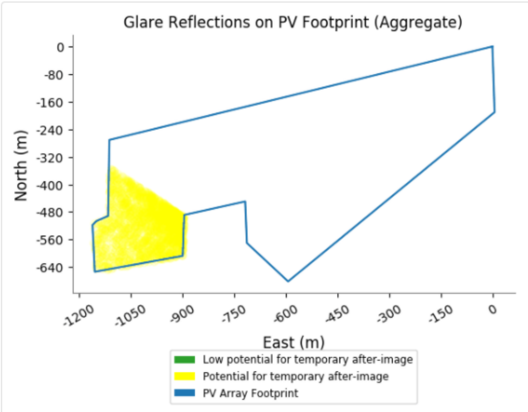
PV array 1 - OP Receptor (OP 8)

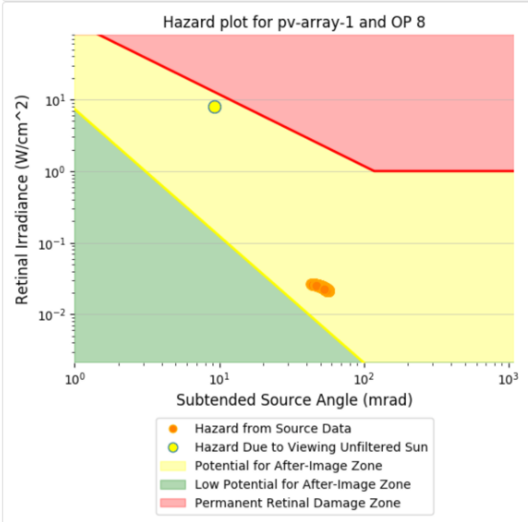
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,671 minutes of "yellow" glare with potential to cause temporary after-image.





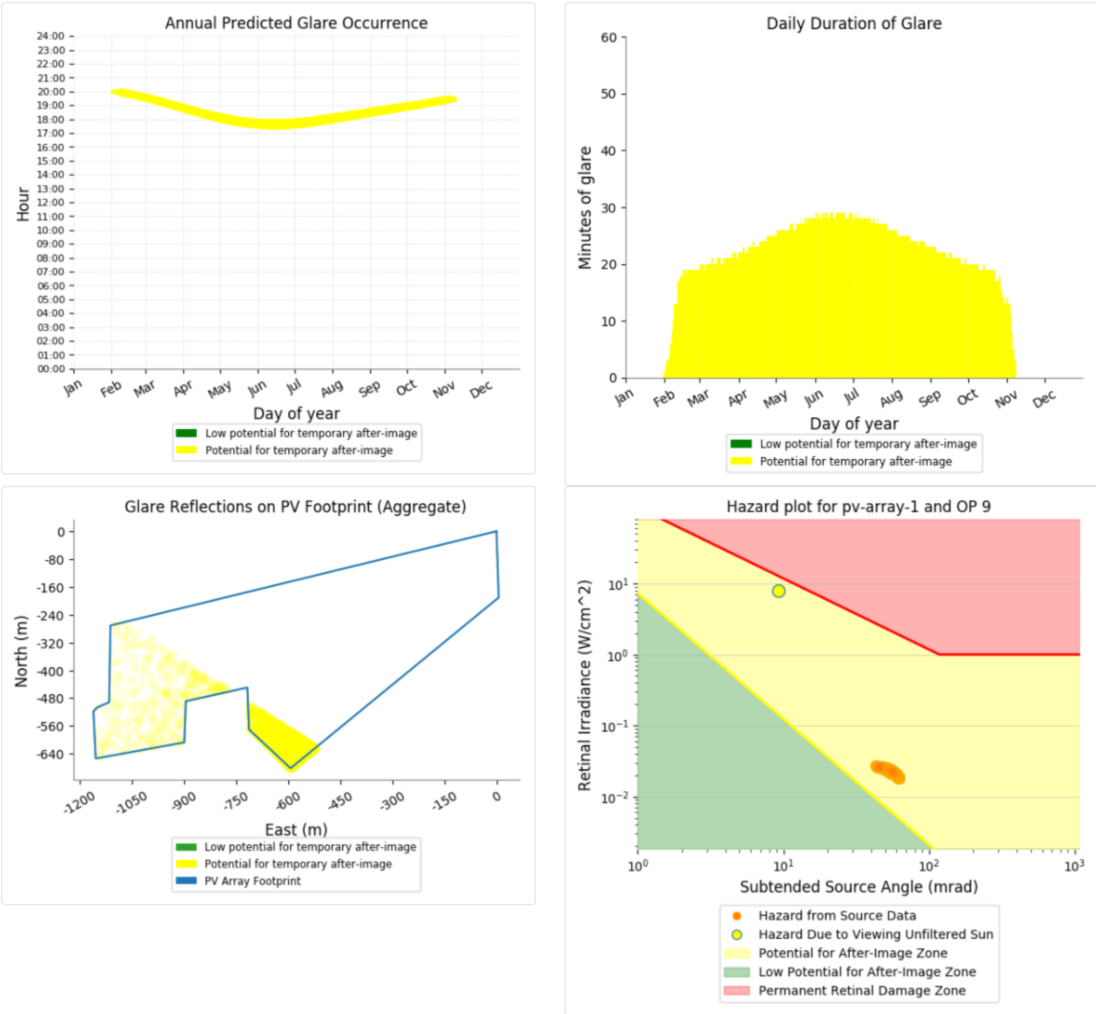




PV array 1 - OP Receptor (OP 9)

PV array is expected to produce the following glare for receptors at this location:

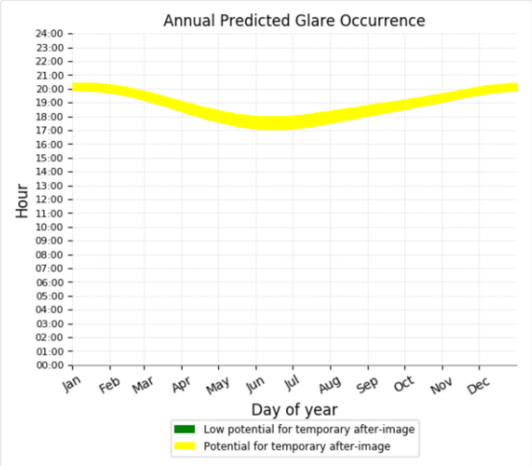
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,321 minutes of "yellow" glare with potential to cause temporary after-image.

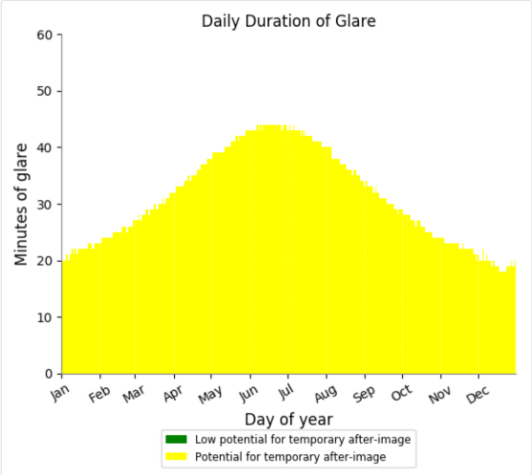


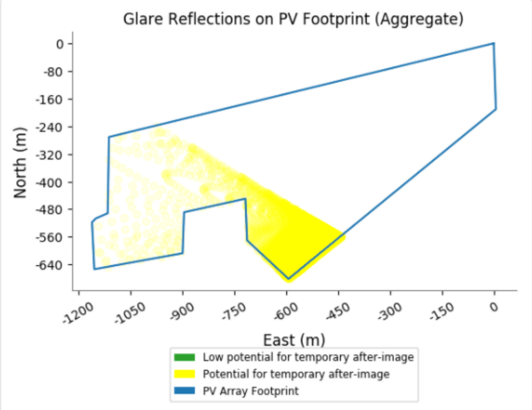
PV array 1 - OP Receptor (OP 10)

PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 11,356 minutes of "yellow" glare with potential to cause temporary after-image.



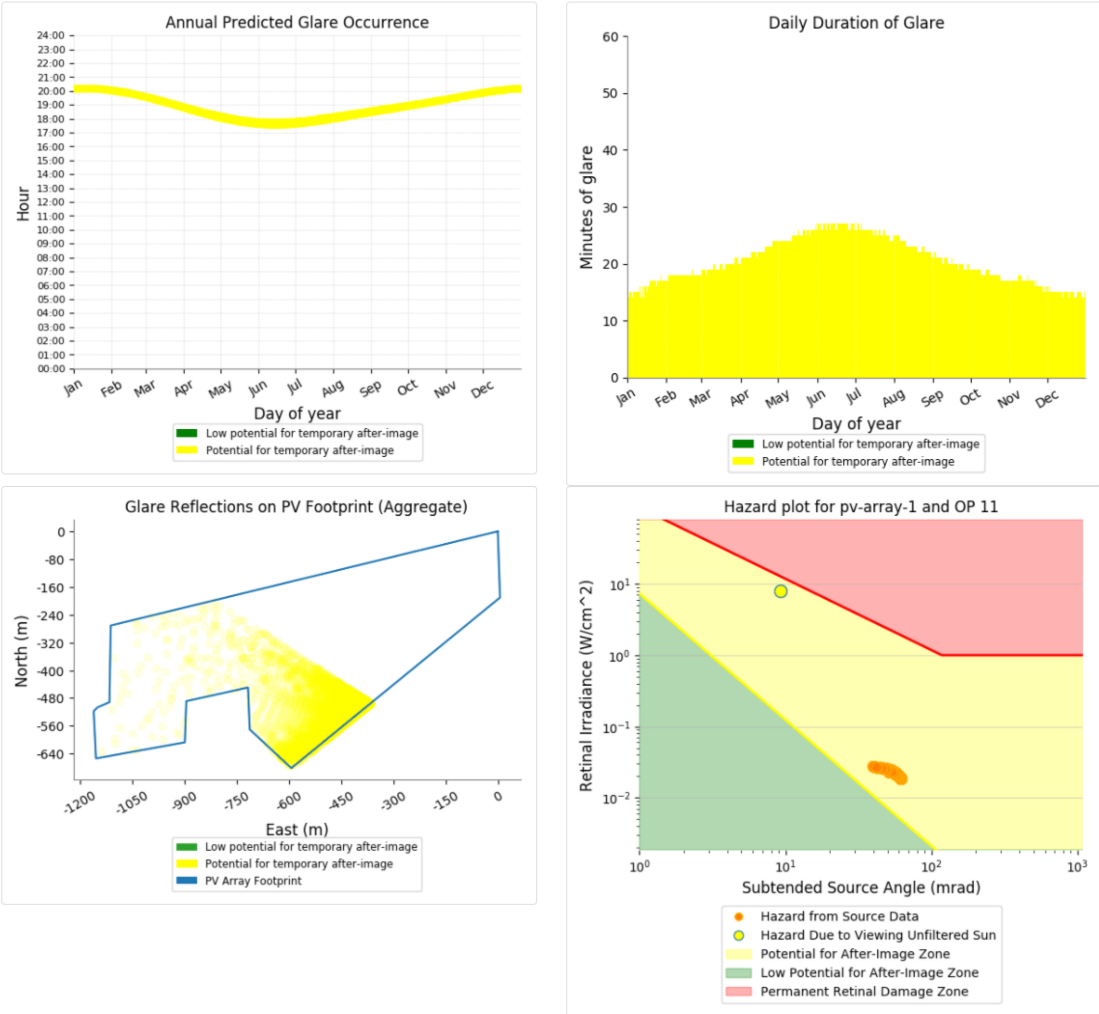




PV array 1 - OP Receptor (OP 11)

PV array is expected to produce the following glare for receptors at this location:

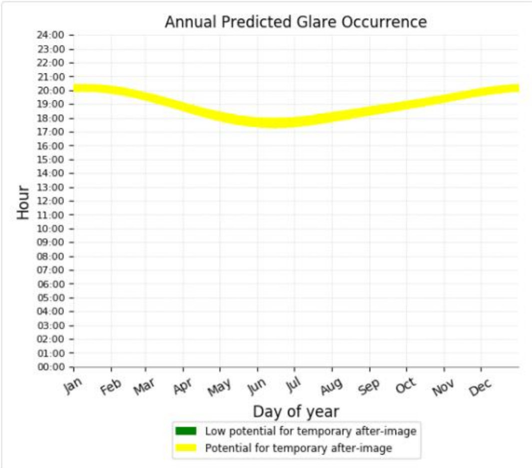
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 7,489 minutes of "yellow" glare with potential to cause temporary after-image.

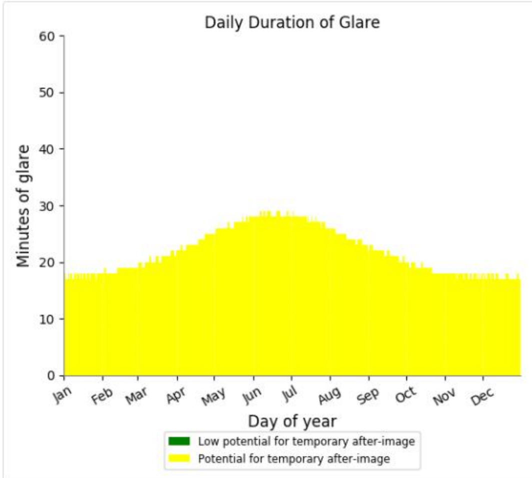


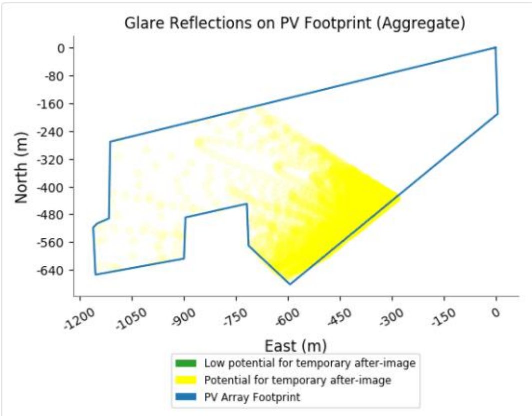
PV array 1 - OP Receptor (OP 12)

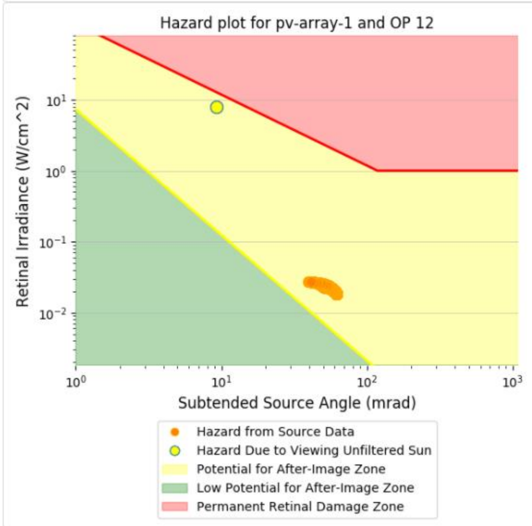
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 7,989 minutes of "yellow" glare with potential to cause temporary after-image.





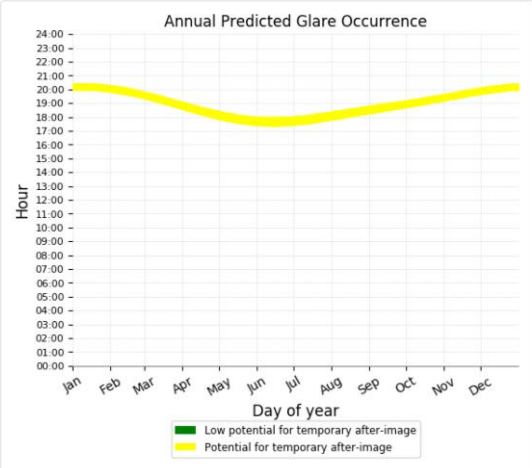


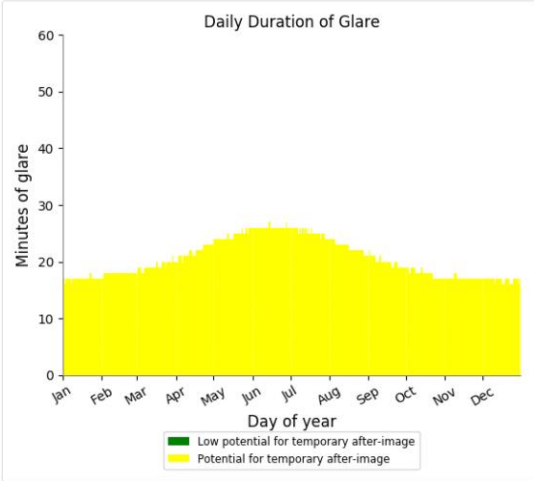


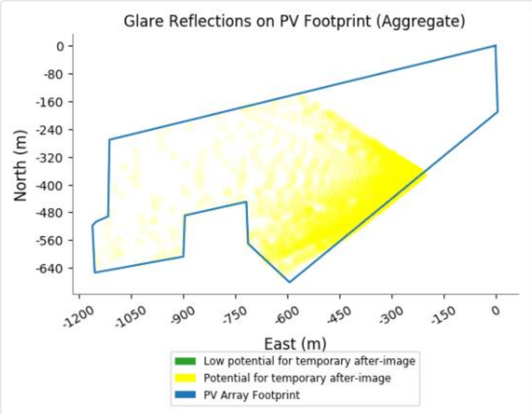
PV array 1 - OP Receptor (OP 13)

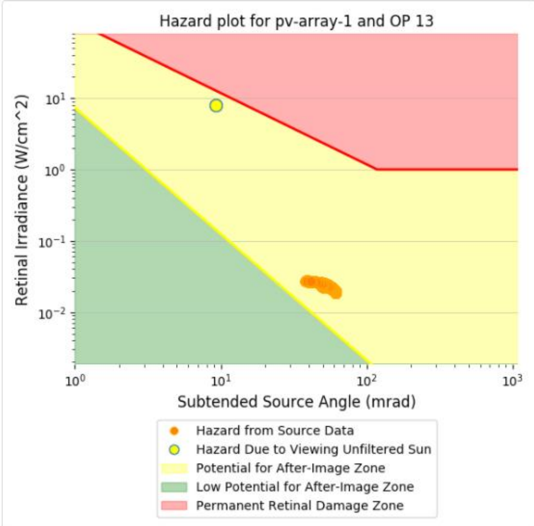
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 7,500 minutes of "yellow" glare with potential to cause temporary after-image.





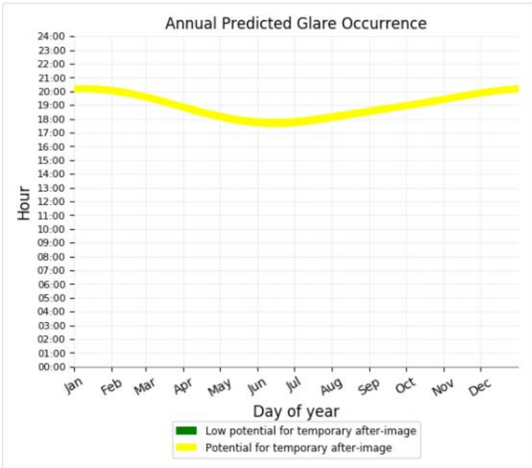


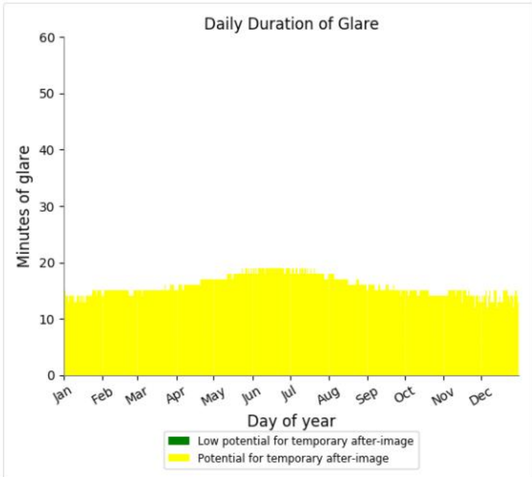


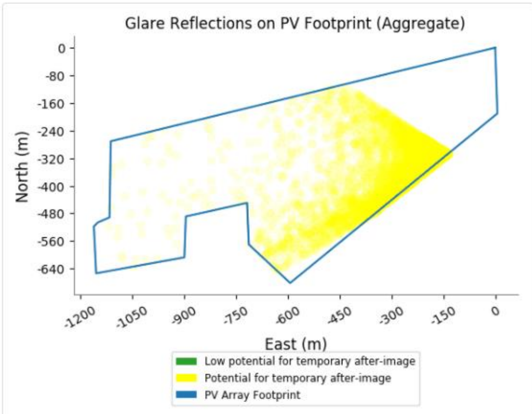
PV array 1 - OP Receptor (OP 14)

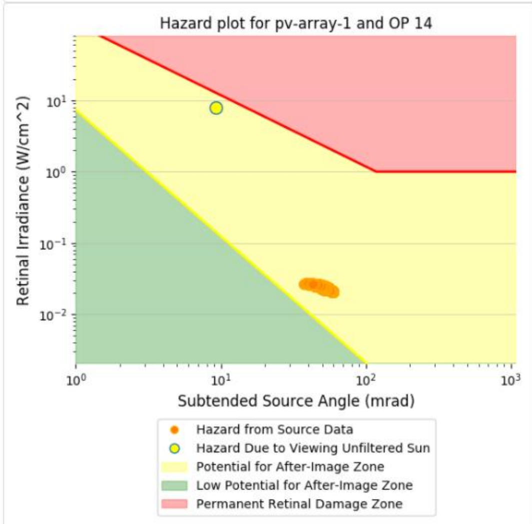
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 5,771 minutes of "yellow" glare with potential to cause temporary after-image.





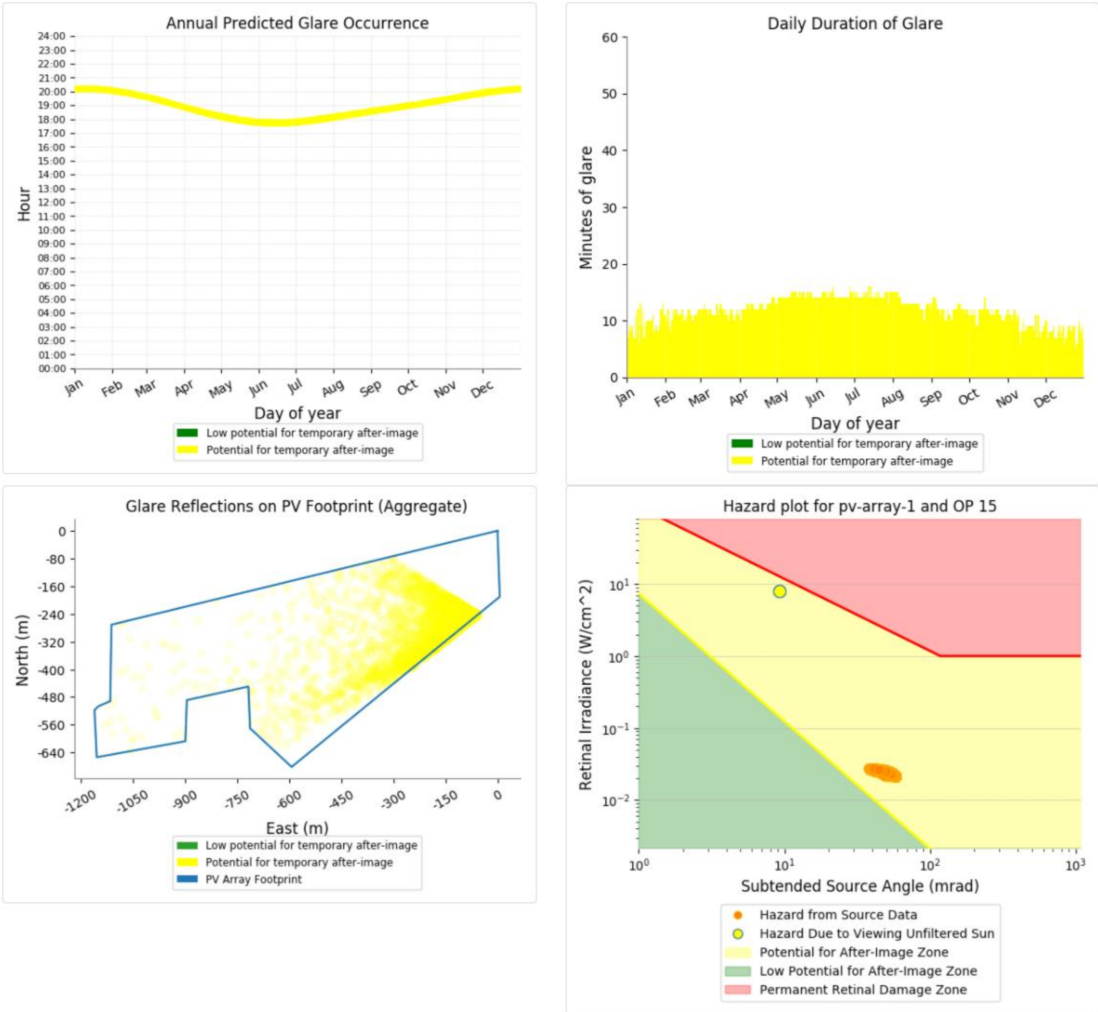




PV array 1 - OP Receptor (OP 15)

PV array is expected to produce the following glare for receptors at this location:

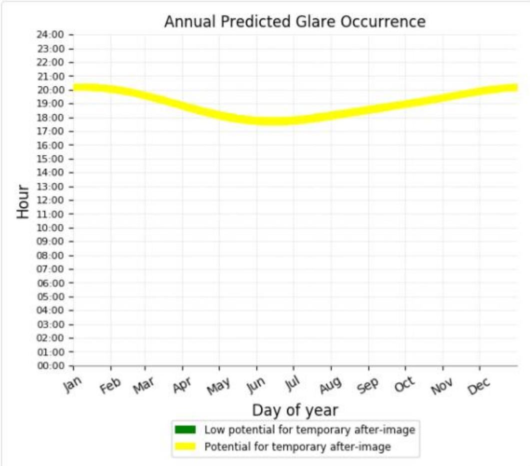
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,313 minutes of "yellow" glare with potential to cause temporary after-image.

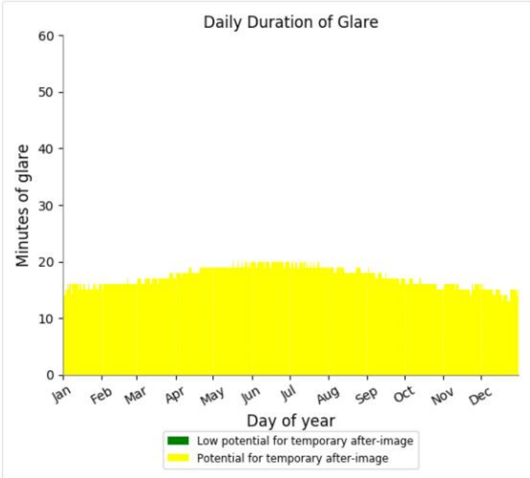


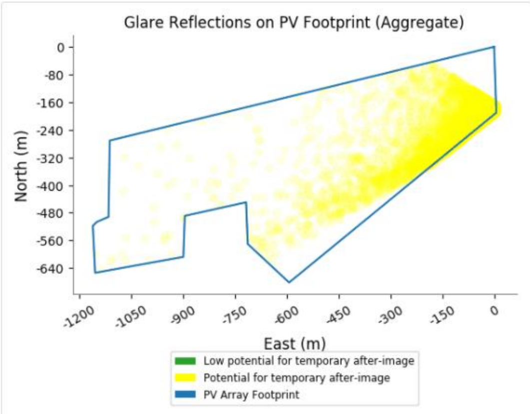
PV array 1 - OP Receptor (OP 16)

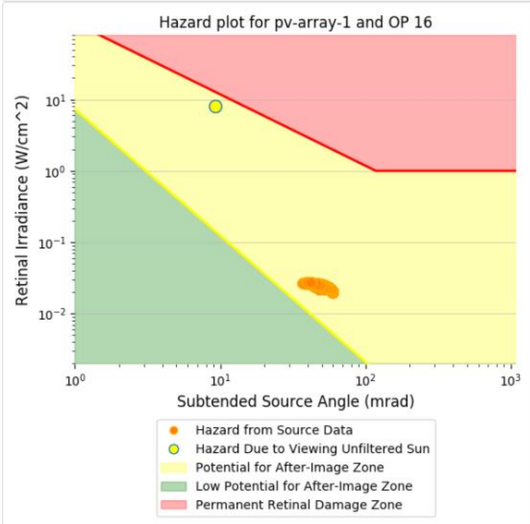
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,296 minutes of "yellow" glare with potential to cause temporary after-image.





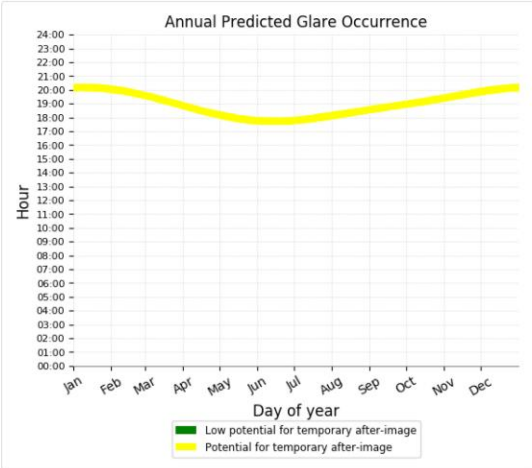


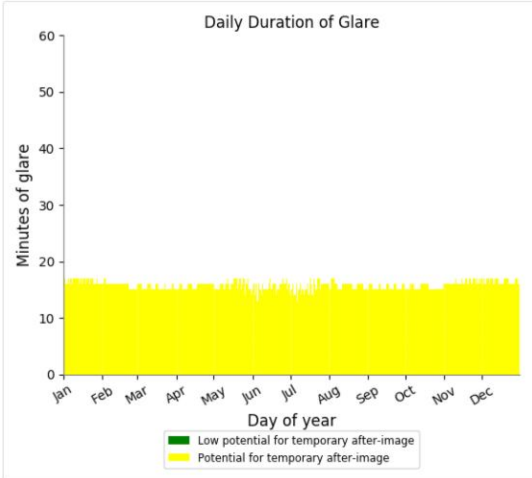


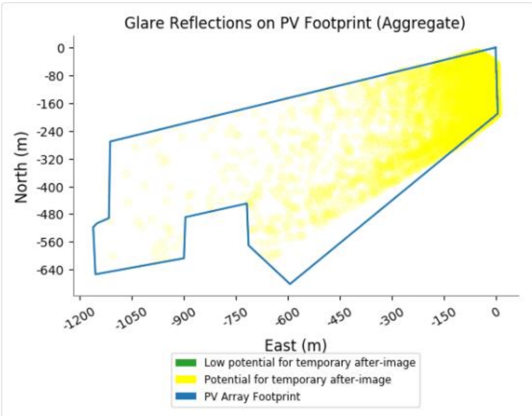
PV array 1 - OP Receptor (OP 17)

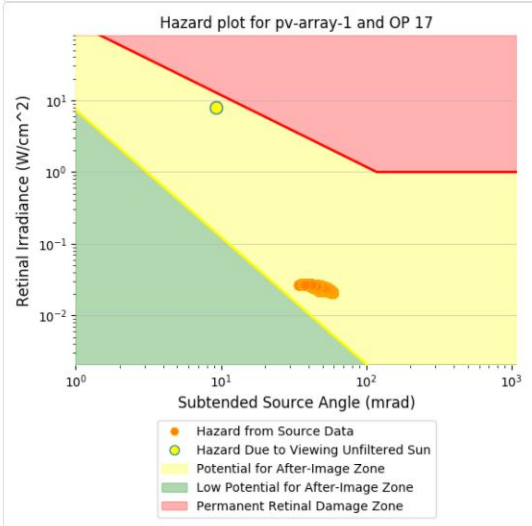
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 5,753 minutes of "yellow" glare with potential to cause temporary after-image.





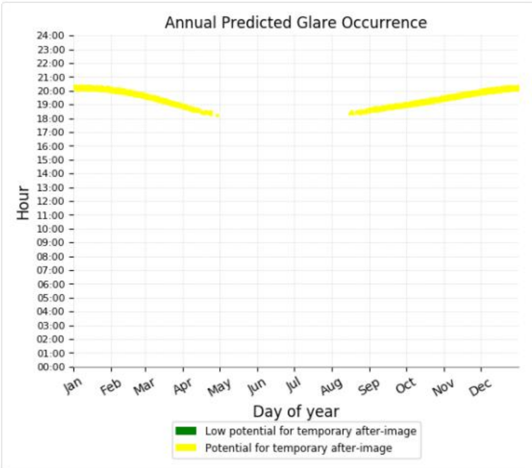


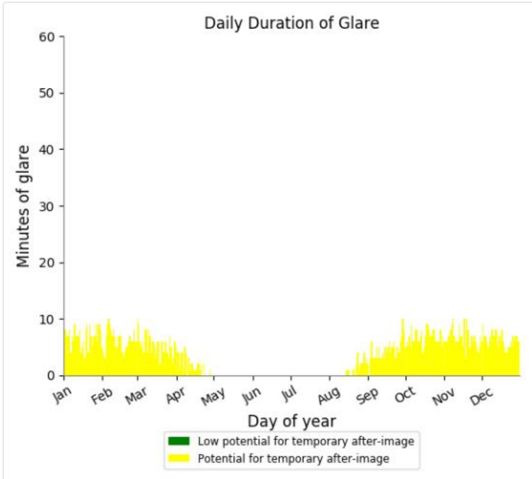


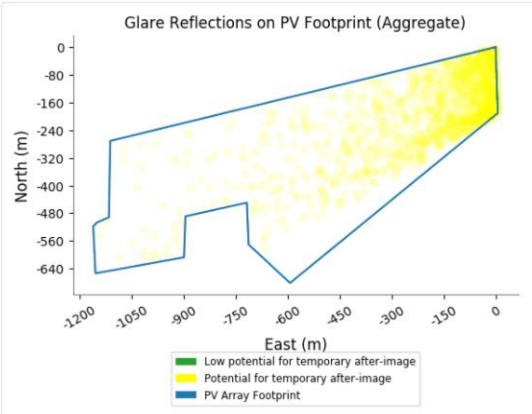
PV array 1 - OP Receptor (OP 18)

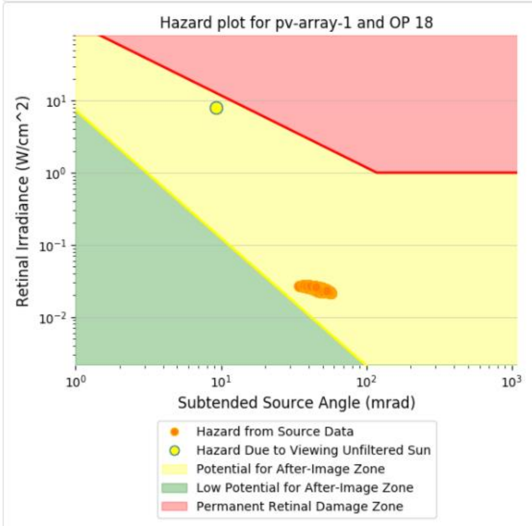
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,375 minutes of "yellow" glare with potential to cause temporary after-image.





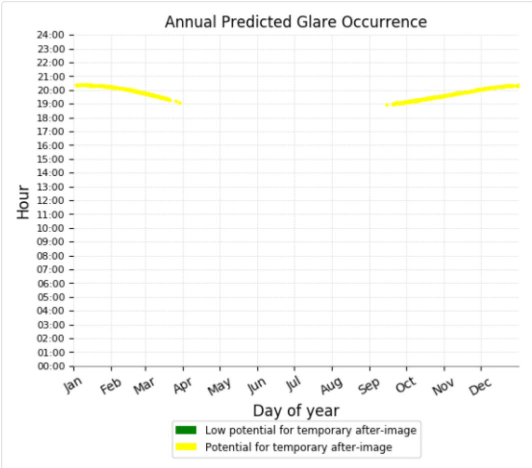


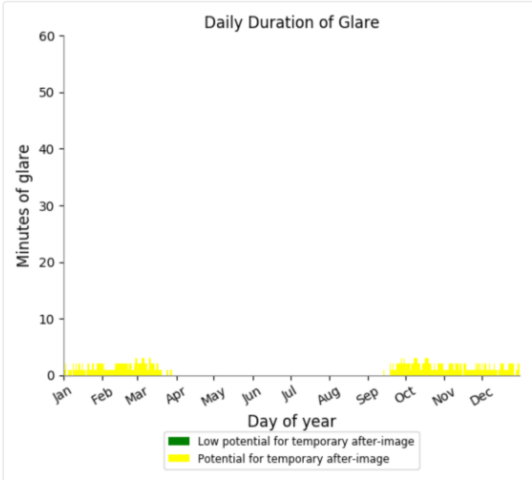


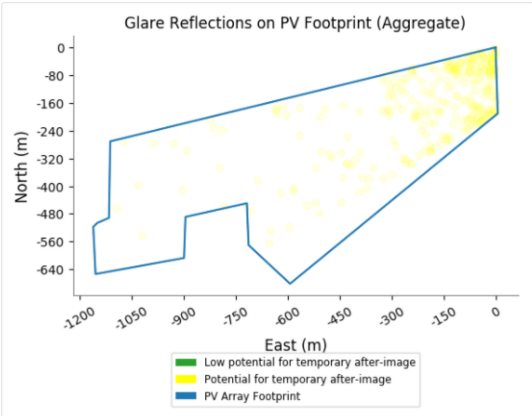
PV array 1 - OP Receptor (OP 19)

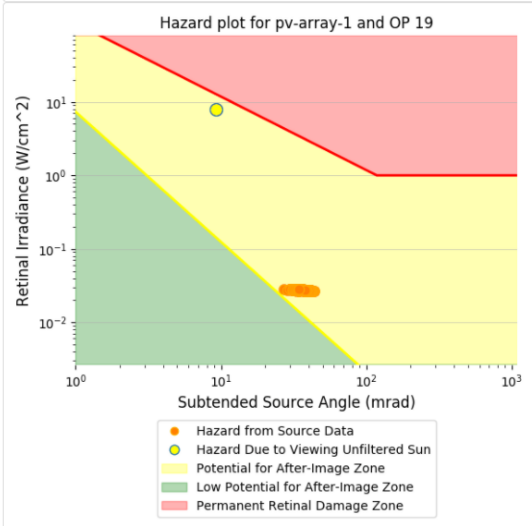
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 291 minutes of "yellow" glare with potential to cause temporary after-image.





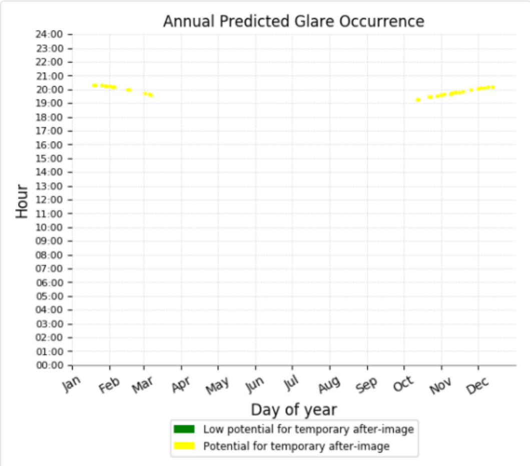


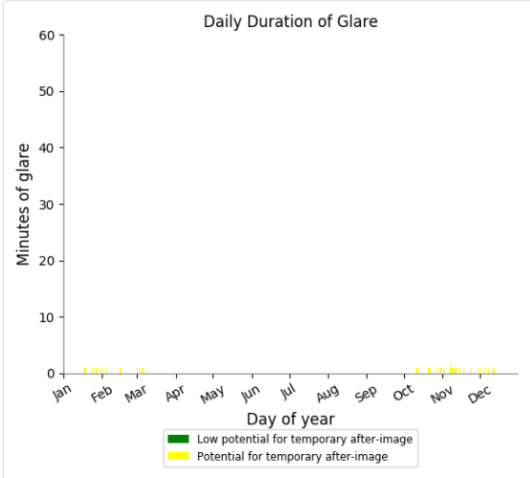


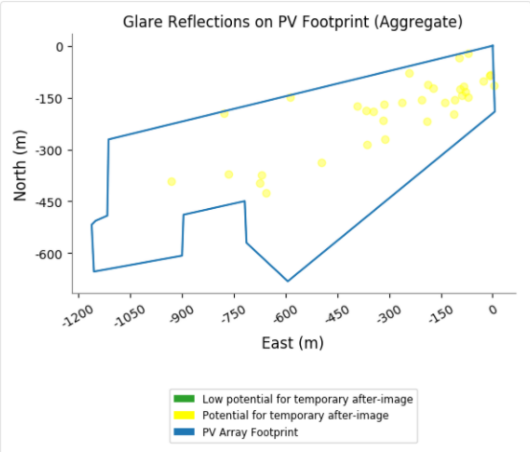
PV array 1 - OP Receptor (OP 20)

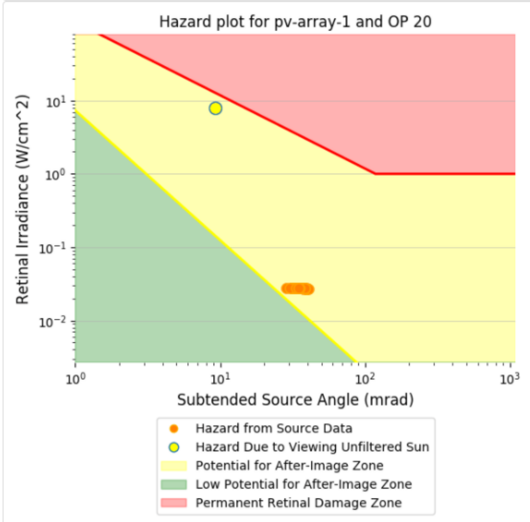
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 35 minutes of "yellow" glare with potential to cause temporary after-image.





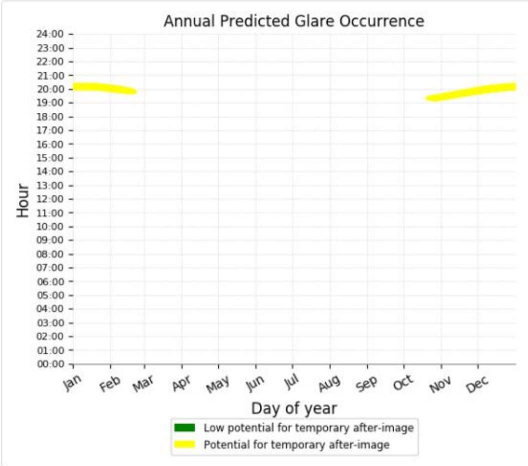


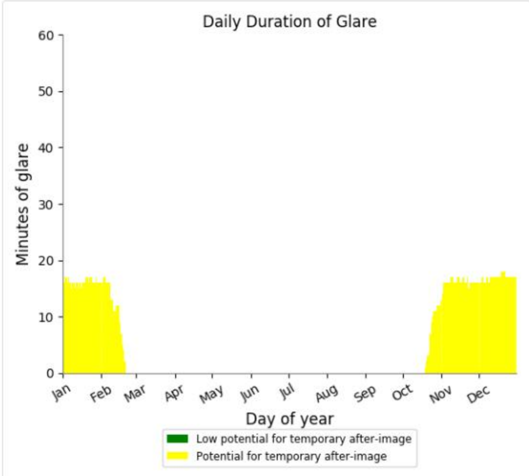


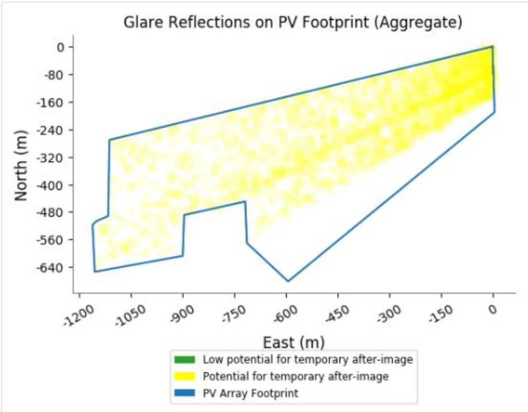
PV array 1 - OP Receptor (OP 21)

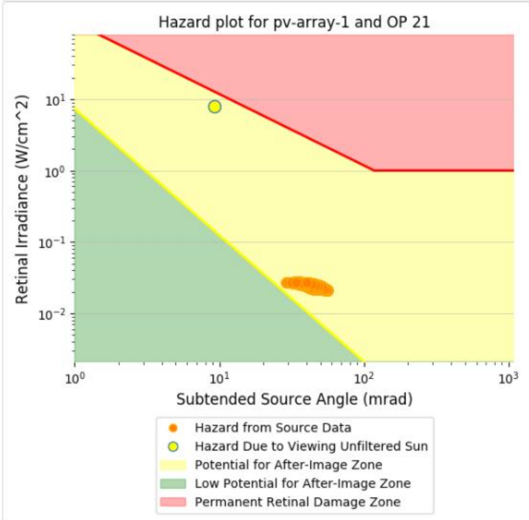
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,852 minutes of "yellow" glare with potential to cause temporary after-image.









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Sudbury
Suffolk
CO10 7GB

Tel: +44 1787 319001 **Email:** info@pagerpower.com **Web:** www.pagerpower.com

APPENDIX B:

EXTRACT FROM STATEMENT OF ENVIRONMENTAL EFFECTS

From: Johanna Duck
To: Sian Crawford
Subject: RE: 19-890 - Uranquinty (Sandy Creek) Solar Farm - Peer review of glint and glare study
Date: Tuesday, 20 July 2021 11:52:19 AM
Attachments: image001.png
image002.png
image006.png
608ed184-887d-44a8-920d-ba41120eac45.png
20210105 SAN site layout BWre-AU-SAN-001-GAL rev 4-2.pdf
20210105 SAN site layout BWre-AU-SAN-001-GAL rev 4-1.pdf

Hi Sian,

Thanks for the chat this morning. Attached are the two plans showing the planting area. I have also provided below the mitigation measures we included in the Statement of Environmental Effects

1.1.1. Mitigation measures

Design

The design of the solar farm included consideration of landscaping around the periphery of the infrastructure. The landscaping is proposed where the greatest number of people would have potential views of the solar farm.

A 5-metre screening buffer comprising native species would be planted following construction along the southern and eastern boundary of the development site, on the outside of the security fence to break up views of the proposal from residences and vehicles travelling along Churches Plain Road and Olympic Highway.

While fast growing species would be selected for planted screening vegetation, the proponent estimates a period of five years before the benefits of the screening in breaking up views of the proposal are noticeable. Proposed screening vegetation is shown in Figure 3-28 on the following page.

The materials and colour of onsite infrastructure would, where practical, be non-reflective and in keeping with the materials and colouring of existing infrastructure or of a colour that would blend with the landscape. Where practical:

- Buildings would be non-reflective and in eucalypt green, beige, or muted brown.
- Security fencing posts and wire would be non-reflective.
- Avoidance of unnecessary lighting, signage, and logos.
- Retain and protect existing boundary landscaping.

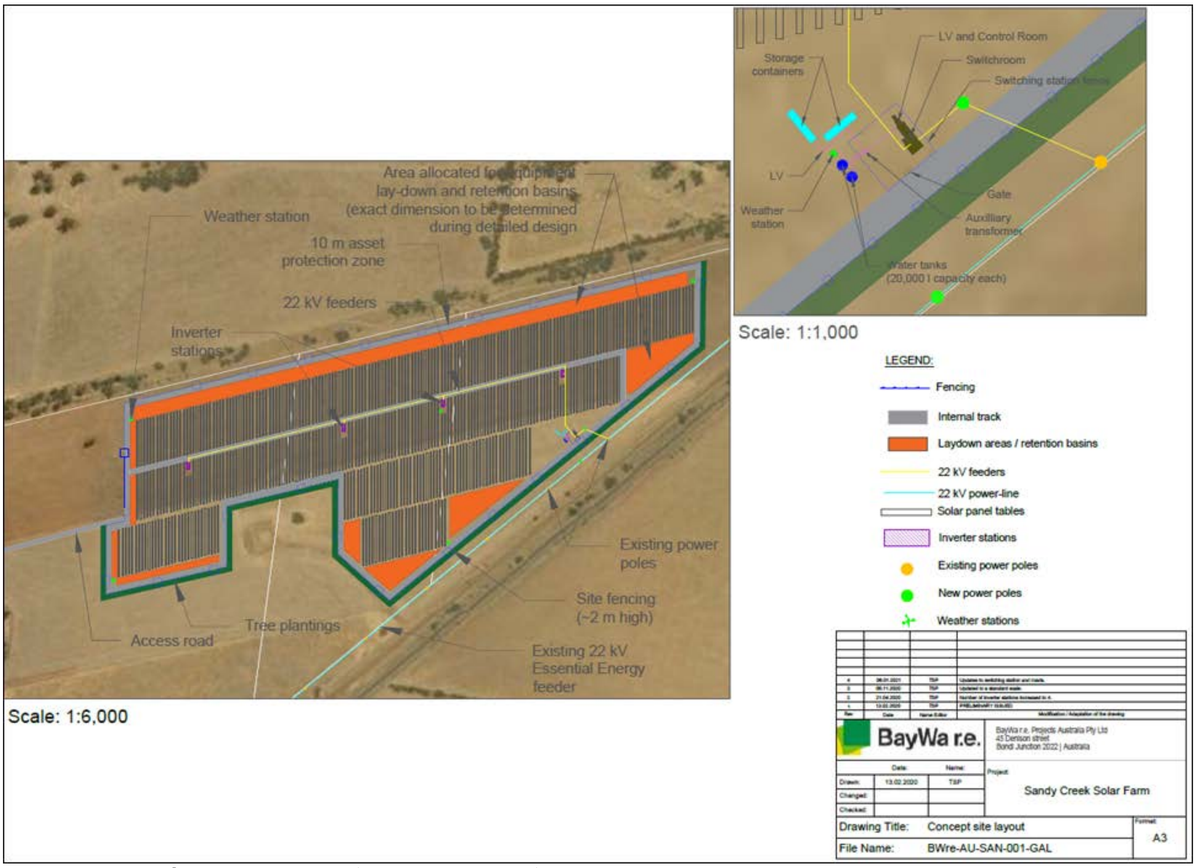


Figure 3-27 Proposed vegetation screening (Source: BayWa, 2020)

Construction

During construction, dust would be controlled in response to visual cues. Areas of soil disturbed by the project would be rehabilitated progressively or immediately post-construction, reducing views of bare soil.

Night lighting

Light spill is light that falls outside the area that is intended to be lit and can contribute to glare and wasted energy. Spill light above the horizontal plane also contributes to artificial skyglow. All light fittings would be located aimed or shielded to avoid spill. Measures to prevent spill include:

- Installing light fittings with an opaque cover and flat glass, mounted horizontally on both axis.
- Mounting lights under part of a building (including awnings, verandah, or roof) so light is blocked above the horizontal plane.
- Design buildings to internalise lights.

Operational light from the proposal must be directed downwards, or inwards towards the work area.

Where floodlights are required, wherever possible use fittings with asymmetric beams that permit horizontal glazing. These are to be kept at or near parallel to the surface being lit, usually the ground and should prevent light spill.

Safeguards and mitigation measures

No viewpoint specific mitigation measures were required due to the low, and moderate inherent visual impact ratings at Viewpoints 1 to 16. The general mitigation measures proposed as part of the design of the solar farm are listed below. It is considered that these measures reasonably address visual impacts of the development.

Table 3-22 Safeguards and mitigation measures for visual impacts

No.	***Safeguards and mitigation measures***	***C***	***O***	***D***
VA1	Screening vegetation would be planted along the boundary of the development footprint as indicated by the site plan: • Plantings would be more than one row deep to break up views of infrastructure including the fencing. • The plant species to be used in the screen would be native and derived from the naturally occurring vegetation community in the area. They should be fast growing and comprise a mixture of trees and shrubs capable of reaching a height of 3 to 4m within 8 years. • Planting would be within 2 months of the completion of construction, so actual views of infrastructure are known or during winter/spring to increase the chance of plant survival. • The screen would be maintained for the operational life of the solar farm. Dead plants would be replaced. Pruning and weeding would be undertaken as required to maintain the screen's visual amenity and effectiveness in breaking up views.		**O**	**D**
VA2	Prior to the commencement of construction, a detailed landscape plan would be prepared including: • Screening location. • Species type. • Planting density and spacing. • Method for planting. • Descriptive measures that would be implemented to ensure vegetative screening is successful (i.e. irrigation or other watering method). A program to manage, monitor and report on the effectiveness of implemented measures.	**Design stage**		
VA3	The materials and colour of onsite infrastructure would, where practical, be non-reflective and in keeping with the materials and colouring of existing infrastructure or of a colour that would blend with the landscape.	**Design stage**		
VA4	During construction, dust would be controlled in response to visual cues. Areas of soil disturbed by the project would be rehabilitated progressively or immediately post-construction, reducing views of bare soil.	**C**		
VA5	All construction vehicles would enter the development site via the western entrance on Churches Plan Road to minimise impact on residences.	**C**		

C: Construction; O: Operation; D: Decommissioning

Regards
Jo

JOHANNA DUCK

APPENDIX C:

RFI RESPONSE AND SUPPORTING DOCUMENTATION

REQUEST FOR ADDITIONAL INFORMATION:

1. Provide a complete set of glare modelling results including input parameters, analysis settings, and analysis results (Forgesolar data outputs).
2. Confirm whether a back tracking operation is to be utilised and if so provide glare modelling backtracking simulations such as alternative resting angle scenarios.
3. Explain why the resting angle of 0 degrees has been used in the glare model, is the intent that the PV arrays will be held at 0 degrees (flat) at sunrise and sunset, and is this operational procedure resulting in glare affecting the highway and rail line?
4. If the back tracking operational procedures are responsible for potential glare affecting the highway and rail line, why is this parameters of the backtracking system not been adjusted to remove the glare risk?
   - PP COMMENTS:
   - Full Forge results have been attached.
   - We can confirm that the modelling scenario considered included assessment of backtracking with a resting angle of 0°, as instructed by NGH Consulting. This generally gives the worst-case scenario for glint and glare.
   - The developer has already proposed vegetation screening to mitigate the glare risk, and therefore there was no requirement to undertake modelling of any alternative resting angles to remove the glare risk.

Assessment results: Roads

5. There is currently insufficient screening between the proposed solar farm and the Olympic Highway and potential glare has been identified in the modelling, the elevated railway embankment appears to provide limited screening. Provide evidence of the extent of screening provided by the railway embankment in relation to truck drivers with a typical eye height of 2m.
6. The assessment results state "reflecting panels may be possible within a road user's primary field of view" and "there does not appear to be any significant screening between the road and the proposed solar development location" however the impact is identified as 'moderate' in the report. Explain why the impact is not classified as 'high' in accordance with the flow chart in Appendix D.
7. Mitigation of the identified Moderate and High impact glare identified as potentially affecting the Olympic Highway is reliant on the proposed screen planting, the project Statement of Environmental Effect states screen planting is to occur after construction of the solar farm and will take up to 8 years to become established, during the 8 year period the highway will be exposed to unacceptable levels of glare which may present a risk to road users. Provide details on the proposed mitigation measures to reduce glare impacts on road users during the period of plant establishment.

- PP COMMENTS:
- Evidence of the extent of screening can be seen on Google Earth street view imagery taken from the assessed section of Olympic Highway. According to Google Earth, this is taken from somewhere between 2 and 3 metres above ground level. The railway embankment is expected to provide screening for typical road users at 1.5m eye height, and along some sections of the road may completely screen reflecting panels. See the image below which gives an indication that the railway line sits around the eye level of the SUV driver near road receptor 24. For elevated road users such as truck drivers, the screening provided by the embankment would be of lower significance.
- 

- The impact on the road section is classified as moderate because reflections would not occur from directly in front of the road user. This agrees with the flow chart in Appendix D.
- As the report states, until the planting has matured to the required height and thickness to screen solar reflections towards road users, a moderate impact is predicted. If this screening will take a significant period of time to mature to the required level, we recommend that some kind of intermediary mitigation is put in place.

Assessment results: Train Drivers

8. The assessment results state "The modelling has shown that solar reflections are geometrically possible" and that in some cases the impacts is within the primary field of view and there is no existing screening. Mitigation of the identified glare is reliant on the proposed screen planting and screen planting is to occur after construction of the solar farm and will take up to 8 years to become established, during the 8 year period the railway will be exposed to unacceptable levels of glare which may present a risk to train users. Provide details on the proposed mitigation measures to reduce glare impacts on train users during the period of plant establishment.

- PP COMMENTS:
- As the report states, until the planting has matured to the required height and thickness to screen solar reflections towards train drivers, a moderate impact is predicted. If this screening will take a significant period of time to mature to the required level, we recommend that some kind of intermediary mitigation is put in place.

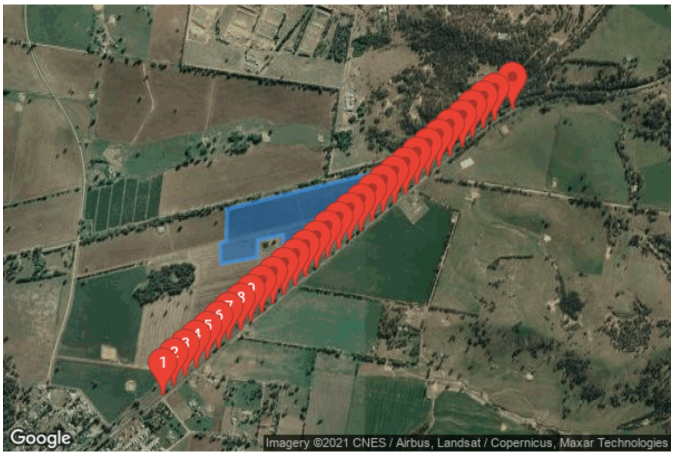
ForgeSolar

10333A - Sandy Creek Solar Farm

Roads

Created March 11, 2021
Updated March 26, 2021
Time-step 1 minute
Timezone offset UTC10
Site ID 50954.8862

Project type V1
Project status: active



Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:
- Observation point: **Version 1**
- 2-Mile Flight Path: **Version 1**
- Route: **Version 1**

Summary of Results

Glare with potential for temporary after-image predicted

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	SA tracking	SA tracking	0	30,141	-

Component Data

PV Array(s)

Total PV footprint area: 101.2 acres

Name: PV array 1
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 0.0 deg
Footprint area: 101.2 acres
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
1	-35.172240	147.272229	751.24	7.05	758.29
2	-35.174684	147.260027	706.79	7.05	713.84
3	-35.176672	147.259986	693.90	7.05	700.95
4	-35.176805	147.259613	694.43	7.05	701.49
5	-35.176907	147.259489	696.11	7.05	703.16
6	-35.178130	147.259561	708.02	7.05	715.07
7	-35.177713	147.262361	718.44	7.05	725.50
8	-35.176646	147.262408	711.59	7.05	718.64
9	-35.176292	147.264354	725.30	7.05	732.36
10	-35.177379	147.264408	724.95	7.05	732.00
11	-35.178382	147.265721	736.04	7.05	743.09
12	-35.173957	147.272300	758.19	7.05	765.24

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	ft	ft	ft
OP 1	-35.186403	147.255107	692.83	4.92	697.75
OP 2	-35.185823	147.255966	695.38	4.92	700.30
OP 3	-35.185250	147.256812	698.77	4.92	703.69
OP 4	-35.184650	147.257696	708.20	4.92	713.12
OP 5	-35.184094	147.258516	715.62	4.92	720.54
OP 6	-35.183517	147.259383	721.82	4.92	726.74
OP 7	-35.182957	147.260216	722.35	4.92	727.28
OP 8	-35.182386	147.261108	725.10	4.92	730.02
OP 9	-35.181822	147.261932	728.75	4.92	733.67
OP 10	-35.181266	147.262773	733.03	4.92	737.95
OP 11	-35.180682	147.263615	735.57	4.92	740.49
OP 12	-35.180138	147.264436	737.22	4.92	742.14
OP 13	-35.179531	147.265294	740.07	4.92	744.99
OP 14	-35.178992	147.266114	741.29	4.92	746.21
OP 15	-35.178407	147.266974	745.91	4.92	750.83
OP 16	-35.177826	147.267851	751.16	4.92	756.08
OP 17	-35.177253	147.268703	750.79	4.92	755.71
OP 18	-35.176656	147.269575	756.06	4.92	760.99
OP 19	-35.176090	147.270419	757.87	4.92	762.79
OP 20	-35.175506	147.271279	758.07	4.92	762.99
OP 21	-35.174954	147.272102	758.95	4.92	763.87
OP 22	-35.174362	147.272965	763.84	4.92	768.76
OP 23	-35.173790	147.273843	768.13	4.92	773.06
OP 24	-35.173189	147.274701	769.95	4.92	774.87
OP 25	-35.172615	147.275545	770.35	4.92	775.27
OP 26	-35.172029	147.276431	770.14	4.92	775.07
OP 27	-35.171446	147.277292	779.98	4.92	784.90
OP 28	-35.170852	147.278170	791.72	4.92	796.64
OP 29	-35.170240	147.279018	800.52	4.92	805.44
OP 30	-35.169677	147.279838	800.25	4.92	805.17
OP 31	-35.169161	147.280736	800.62	4.92	805.54
OP 32	-35.168506	147.282059	807.00	4.92	811.92

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	SA tracking	SA tracking	0	30,141	-	-

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	0	0	0	0	0	0	0	0	0	0	0	0
pv-array-1 (yellow)	472	446	549	604	685	682	694	639	556	504	459	473

PV & Receptor Analysis Results

Results for each PV array and receptor

PV array 1 potential temporary after-image

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	112
OP: OP 13	0	649
OP: OP 14	0	158
OP: OP 15	0	2586
OP: OP 16	0	4259
OP: OP 17	0	2335
OP: OP 18	0	4959
OP: OP 19	0	4297
OP: OP 20	0	984
OP: OP 21	0	1068
OP: OP 22	0	1042
OP: OP 23	0	455
OP: OP 24	0	540
OP: OP 25	0	351
OP: OP 26	0	262
OP: OP 27	0	65
OP: OP 28	0	1504
OP: OP 29	0	1636

OP: OP 30	0	1186
OP: OP 31	0	985
OP: OP 32	0	708

PV array 1 - OP Receptor (OP 1)
No glare found

PV array 1 - OP Receptor (OP 2)
No glare found

PV array 1 - OP Receptor (OP 3)
No glare found

PV array 1 - OP Receptor (OP 4)
No glare found

PV array 1 - OP Receptor (OP 5)
No glare found

PV array 1 - OP Receptor (OP 6)
No glare found

PV array 1 - OP Receptor (OP 7)
No glare found

PV array 1 - OP Receptor (OP 8)
No glare found

PV array 1 - OP Receptor (OP 9)
No glare found

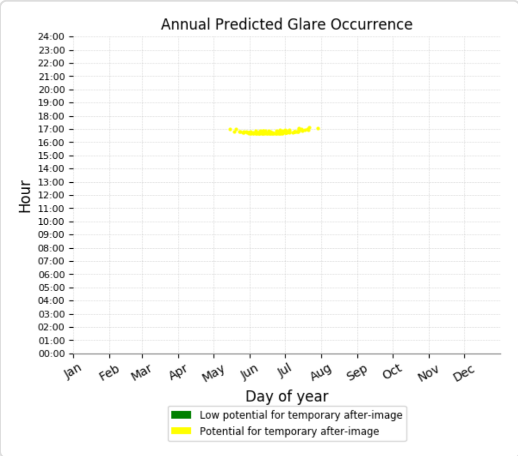
PV array 1 - OP Receptor (OP 10)
No glare found

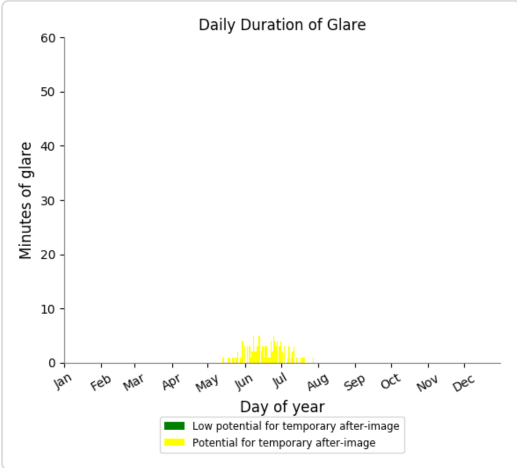
PV array 1 - OP Receptor (OP 11)
No glare found

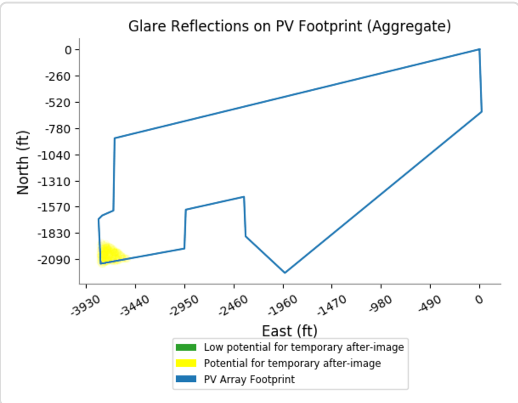
PV array 1 - OP Receptor (OP 12)

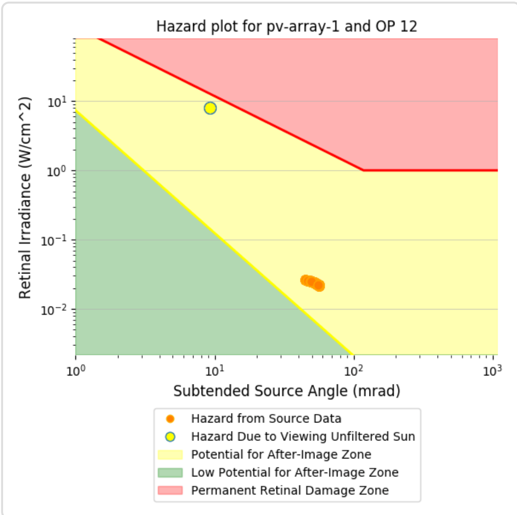
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 112 minutes of "yellow" glare with potential to cause temporary after-image.



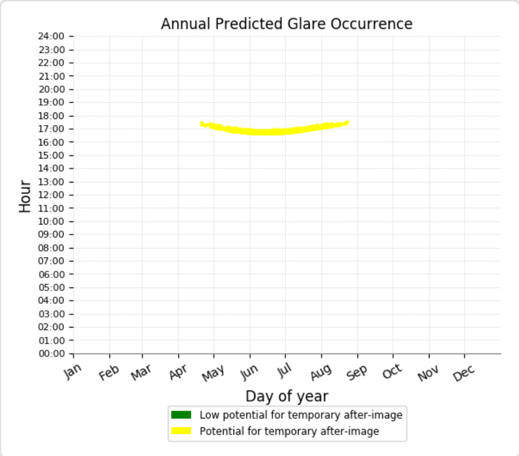


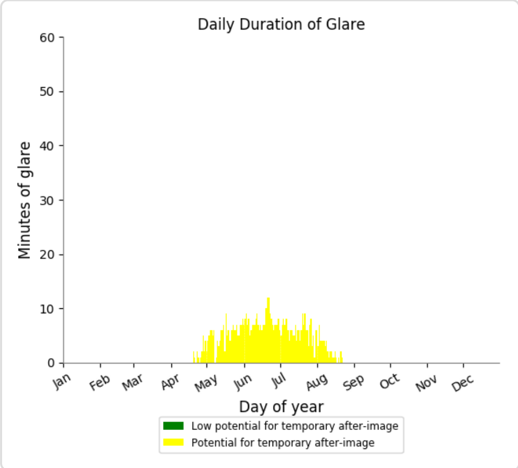


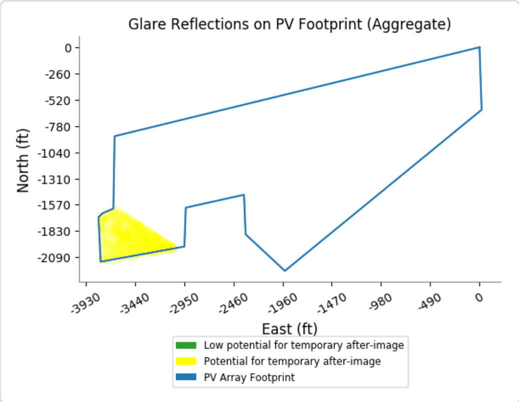


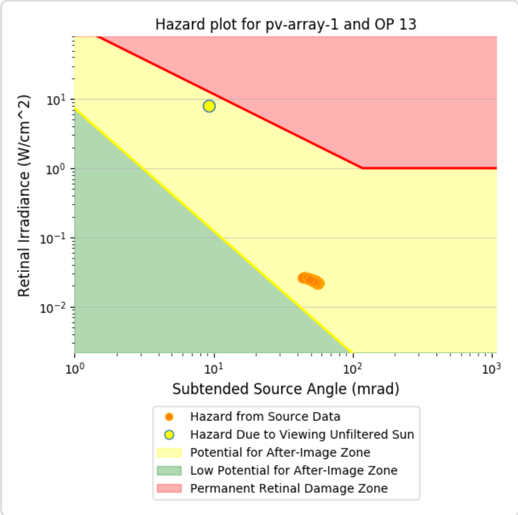
PV array 1 - OP Receptor (OP 13)

PV array is expected to produce the following glare for receptors at this location:
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 649 minutes of "yellow" glare with potential to cause temporary after-image.





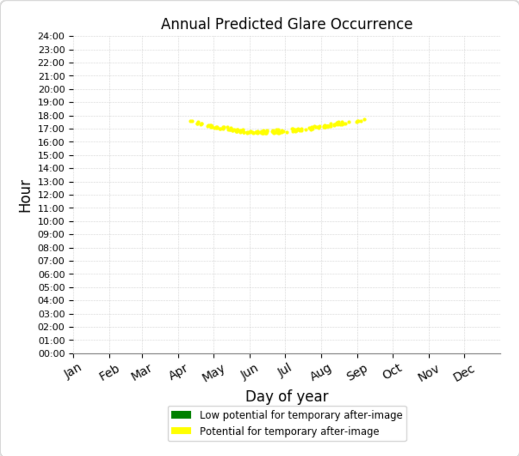


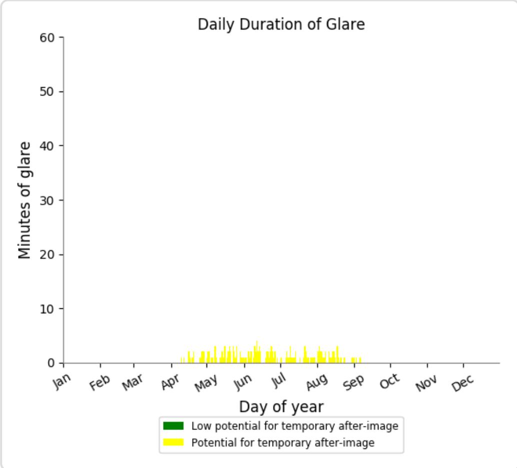


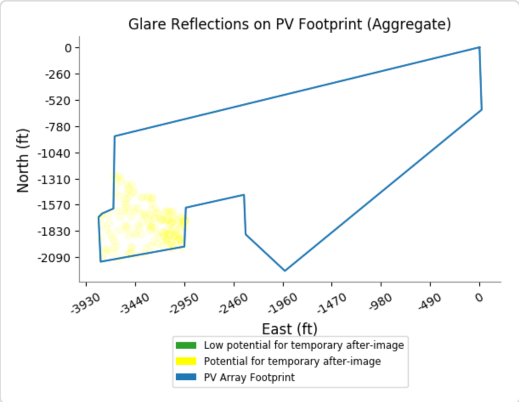
PV array 1 - OP Receptor (OP 14)

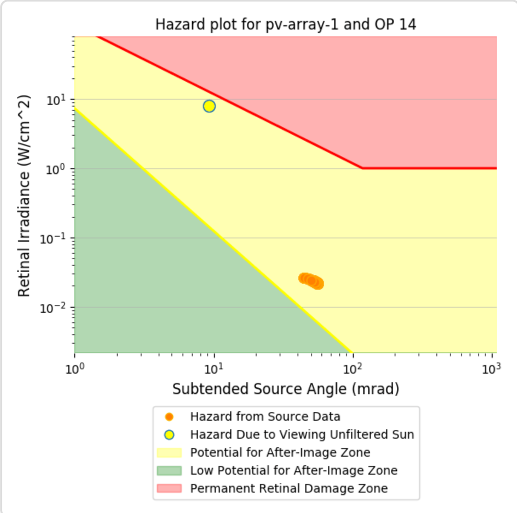
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 158 minutes of "yellow" glare with potential to cause temporary after-image.





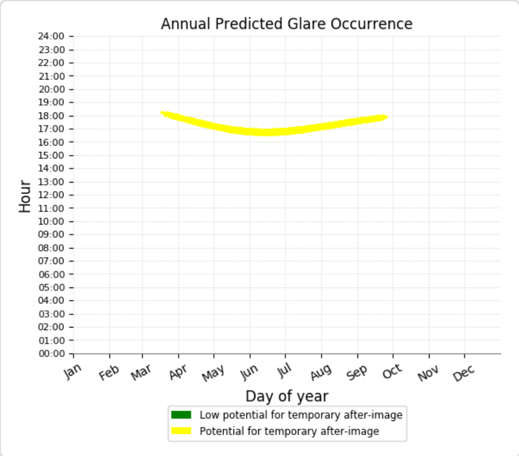


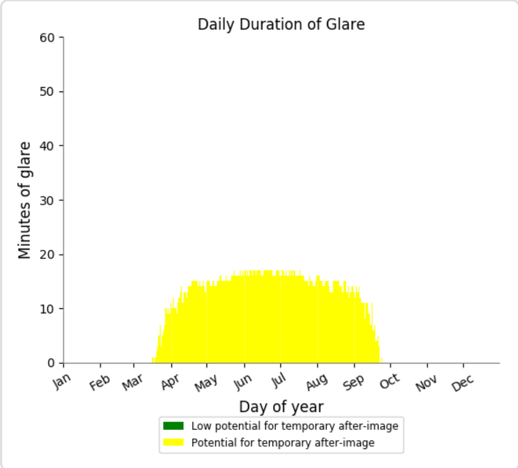


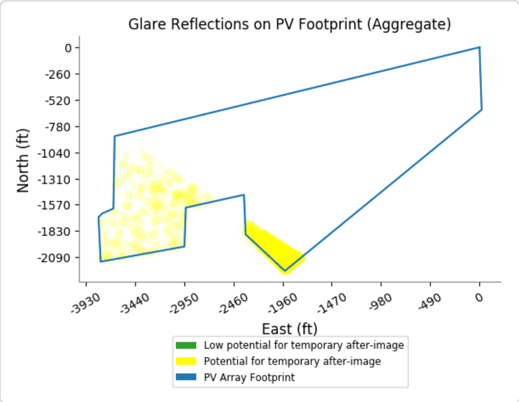
PV array 1 - OP Receptor (OP 15)

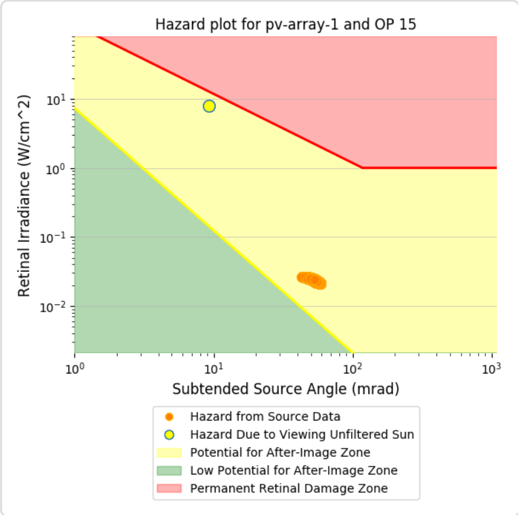
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,586 minutes of "yellow" glare with potential to cause temporary after-image.





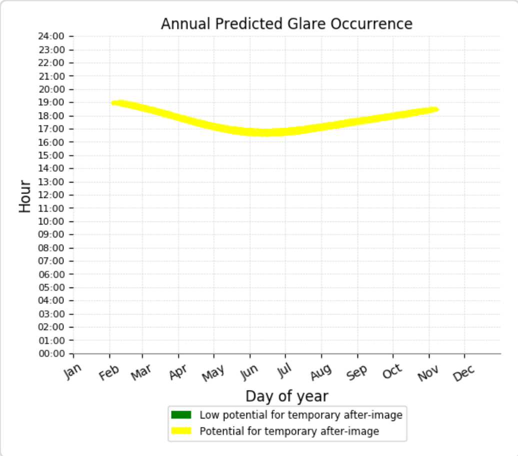


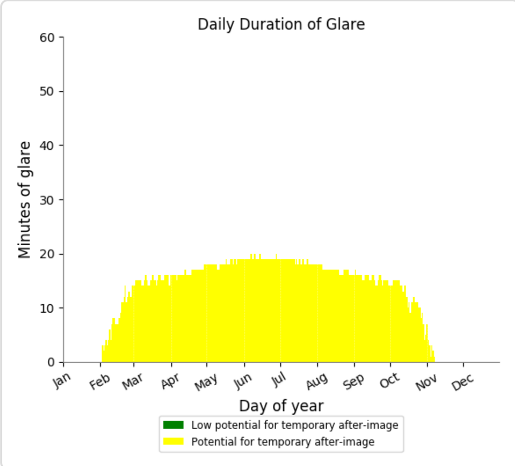


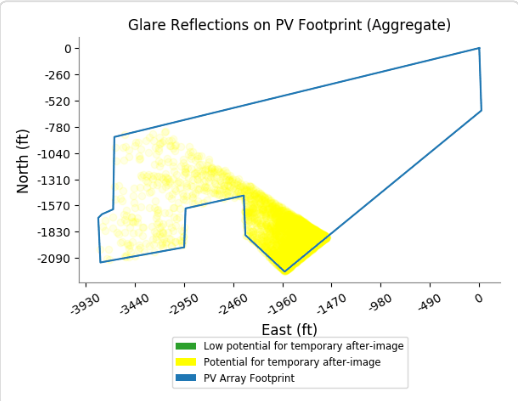
PV array 1 - OP Receptor (OP 16)

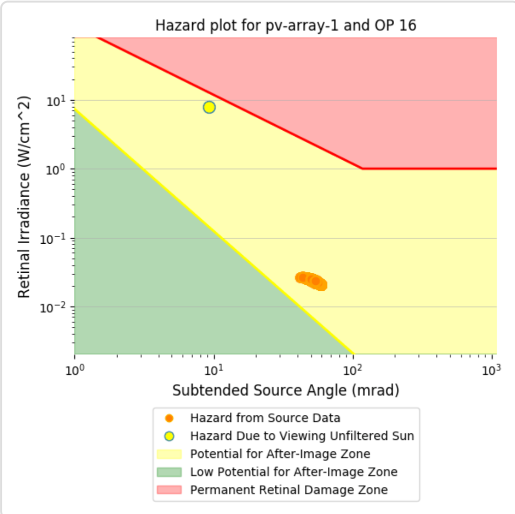
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,259 minutes of "yellow" glare with potential to cause temporary after-image.





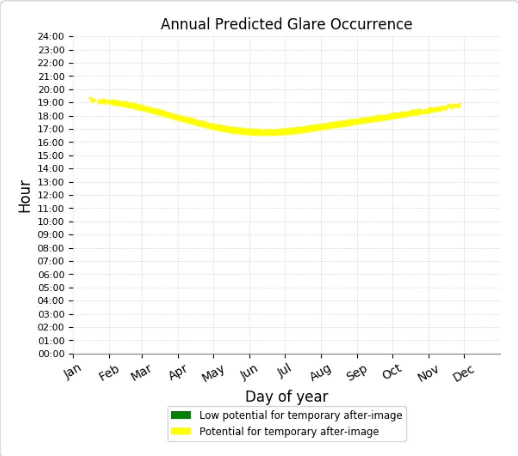


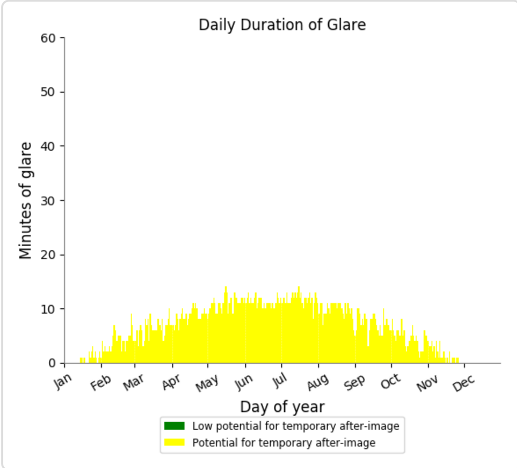


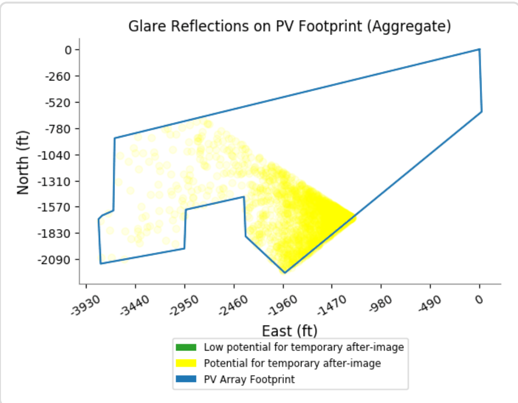
PV array 1 - OP Receptor (OP 17)

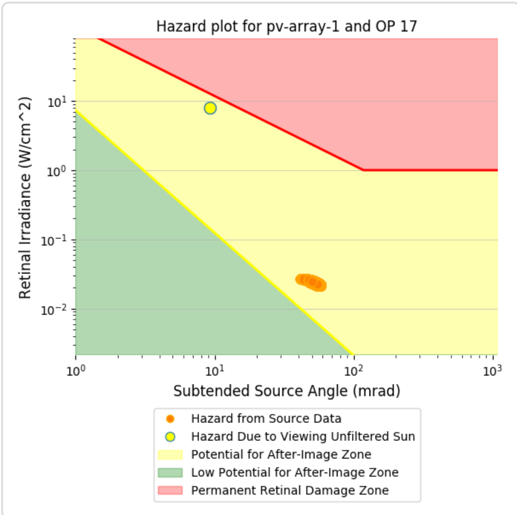
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,335 minutes of "yellow" glare with potential to cause temporary after-image.





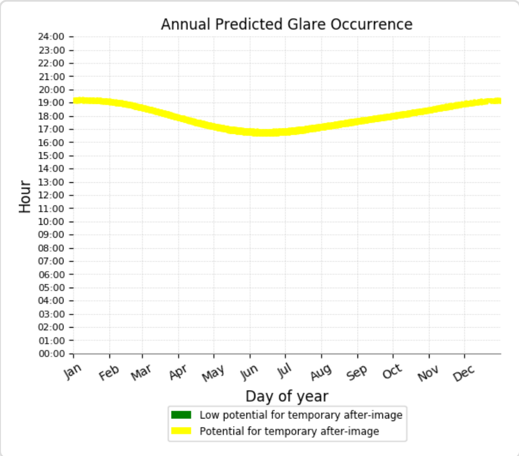


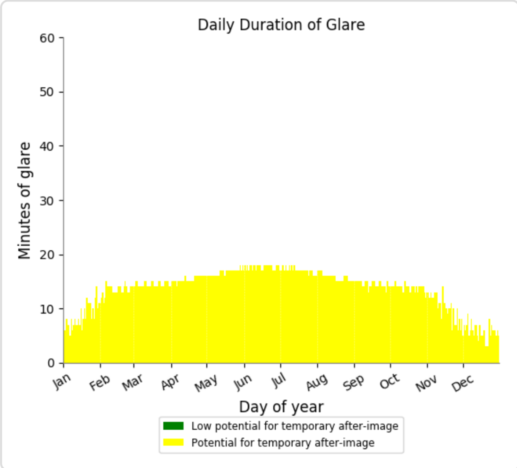


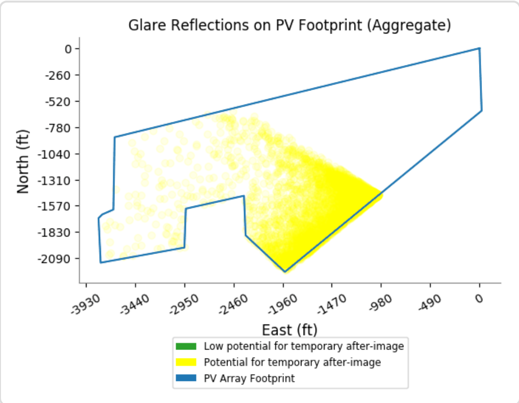
PV array 1 - OP Receptor (OP 18)

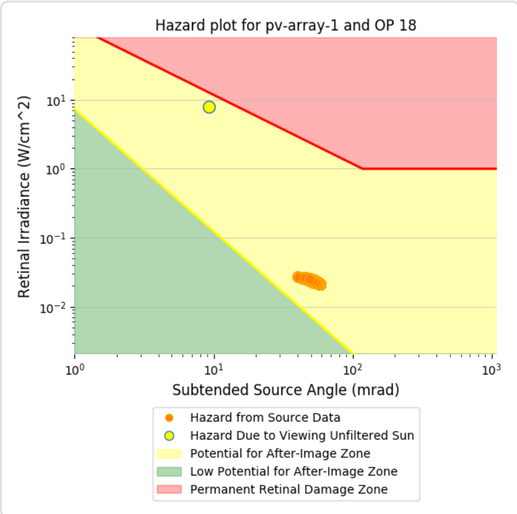
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,959 minutes of "yellow" glare with potential to cause temporary after-image.



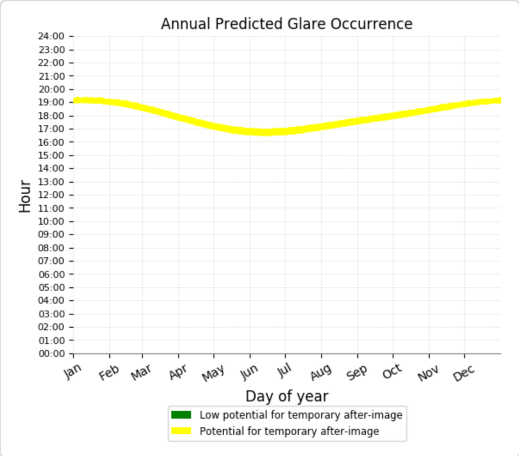


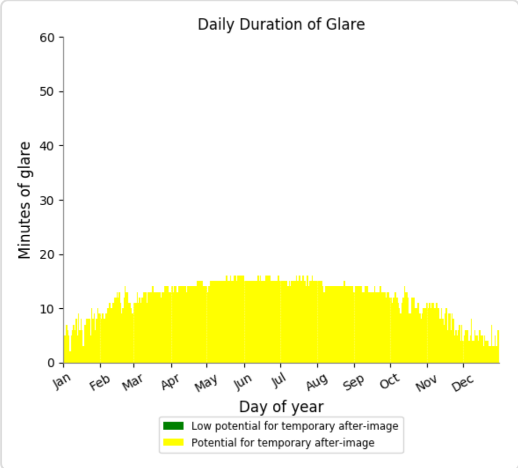


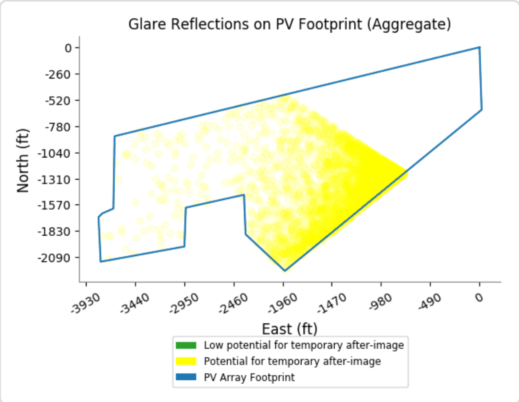


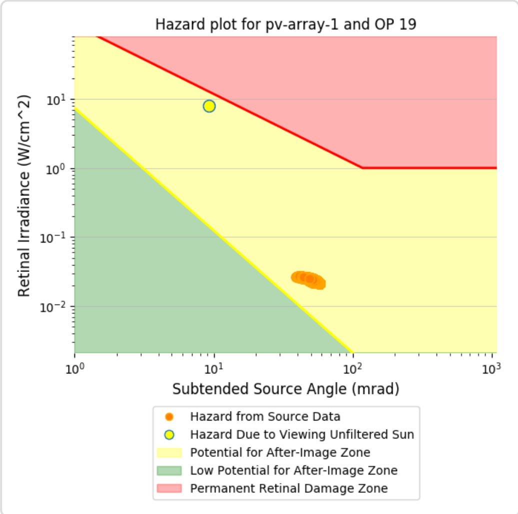
PV array 1 - OP Receptor (OP 19)

PV array is expected to produce the following glare for receptors at this location:
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,297 minutes of "yellow" glare with potential to cause temporary after-image.





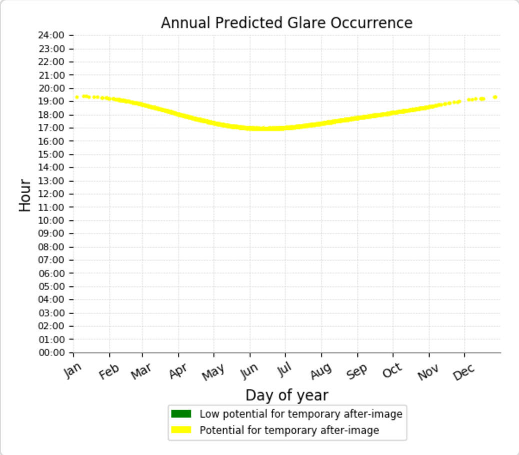


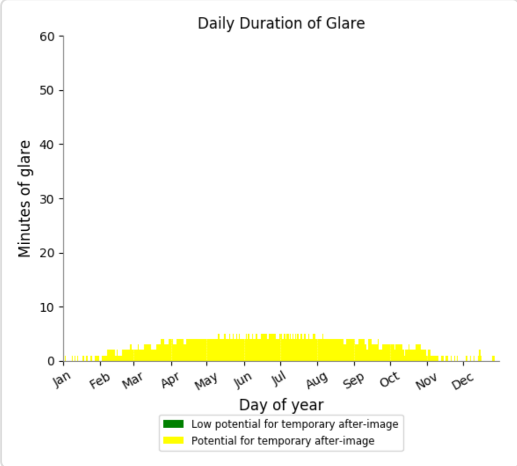


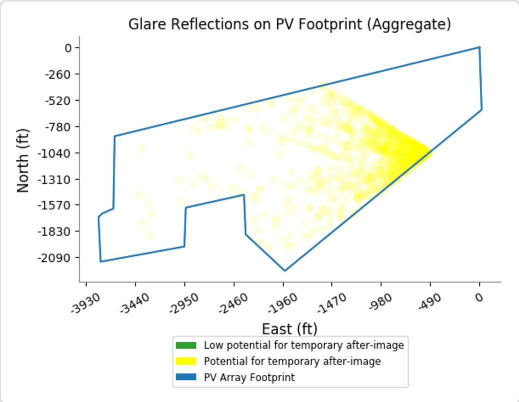
PV array 1 - OP Receptor (OP 20)

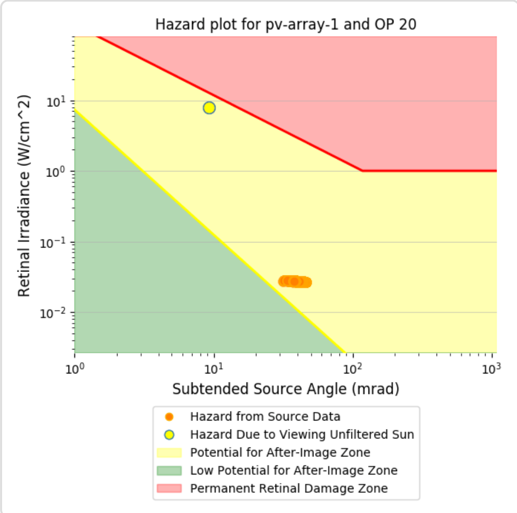
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 984 minutes of "yellow" glare with potential to cause temporary after-image.





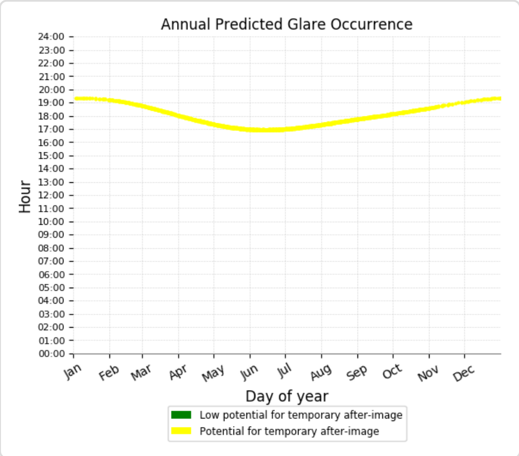


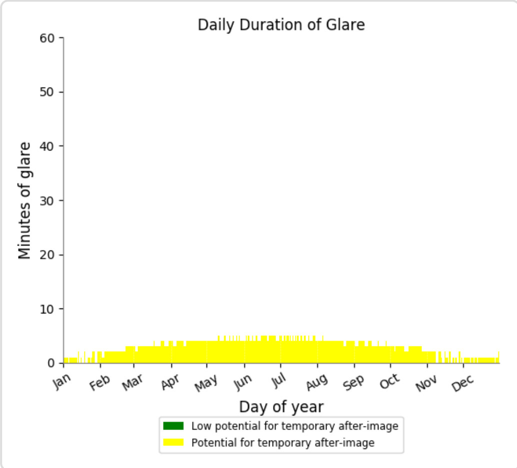


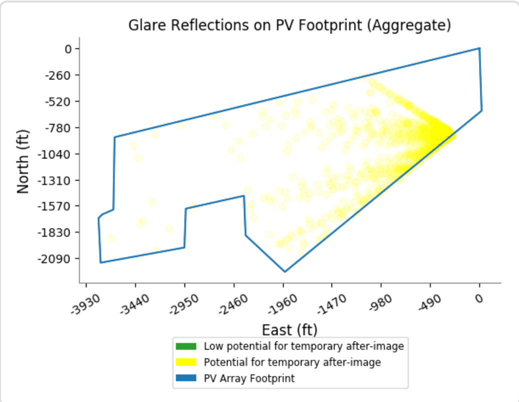
PV array 1 - OP Receptor (OP 21)

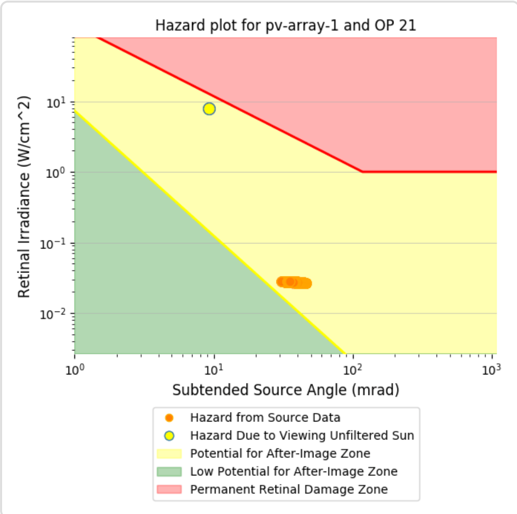
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,068 minutes of "yellow" glare with potential to cause temporary after-image.





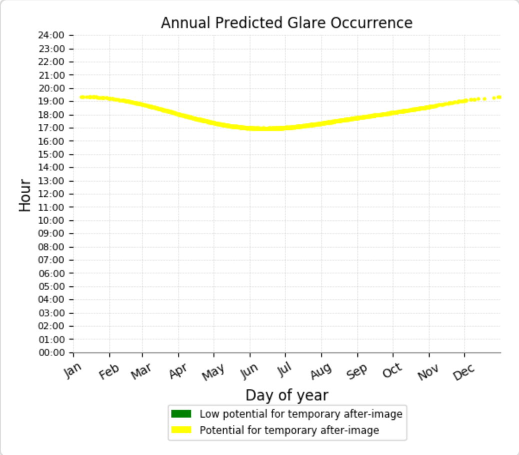


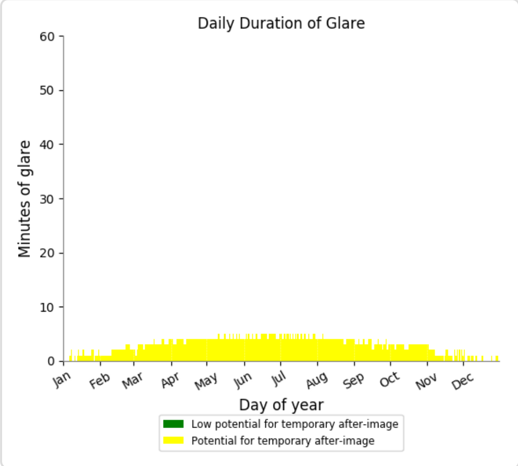


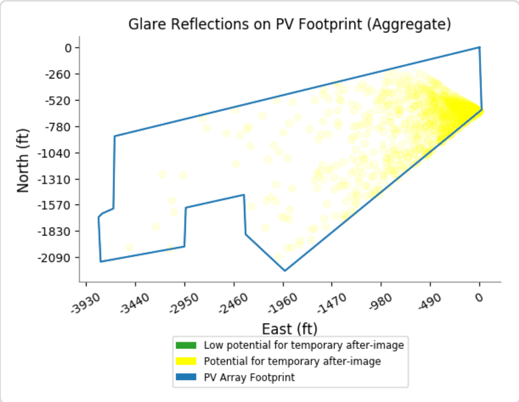
PV array 1 - OP Receptor (OP 22)

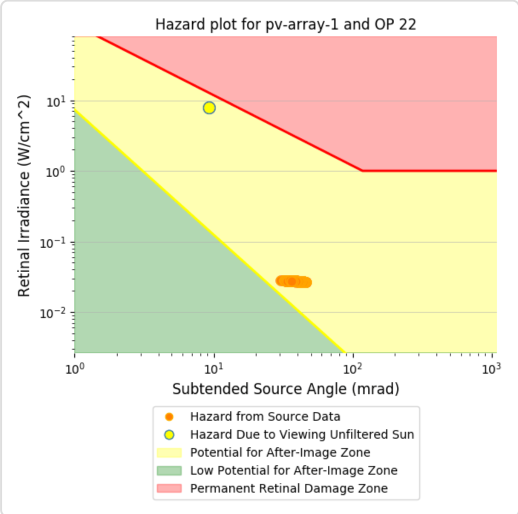
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,042 minutes of "yellow" glare with potential to cause temporary after-image.





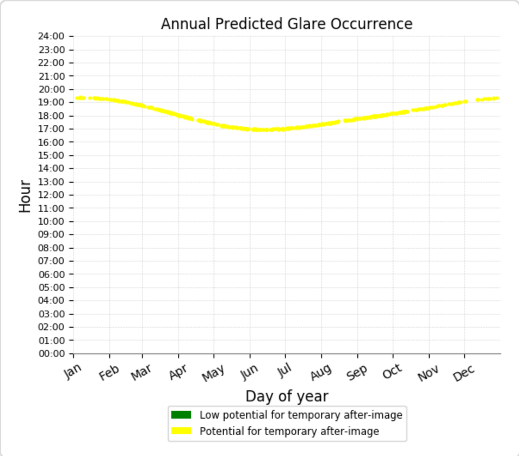


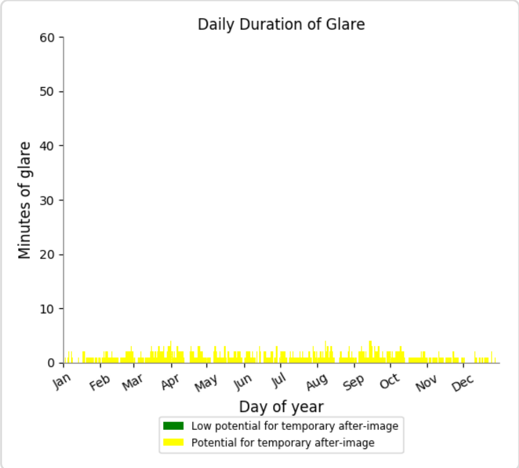


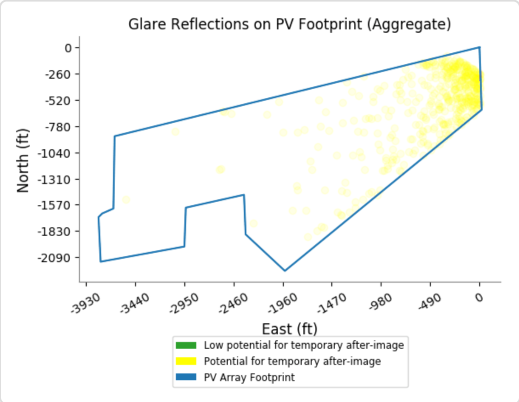
PV array 1 - OP Receptor (OP 23)

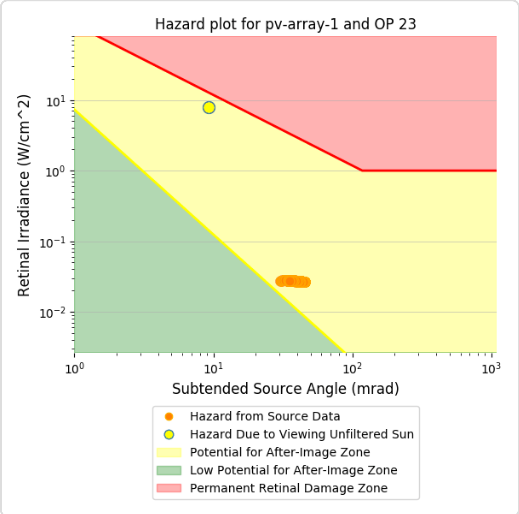
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 455 minutes of "yellow" glare with potential to cause temporary after-image.





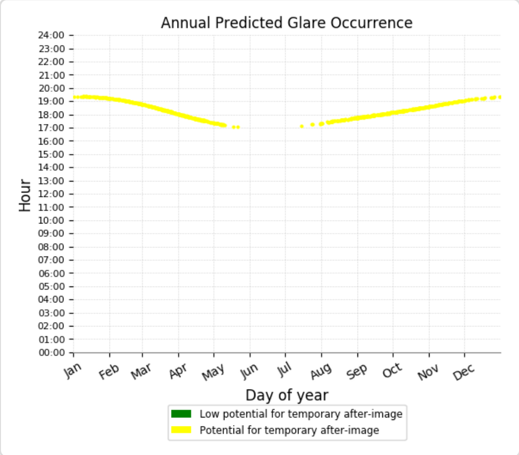


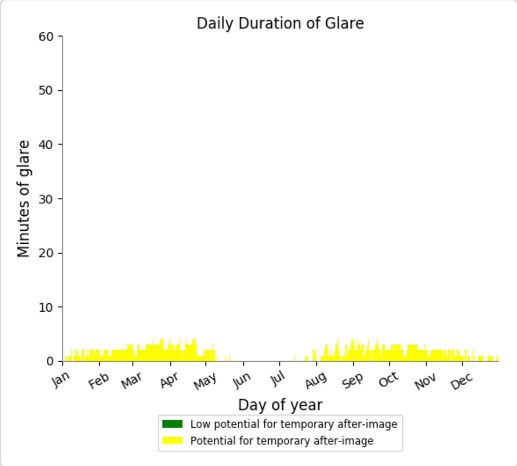


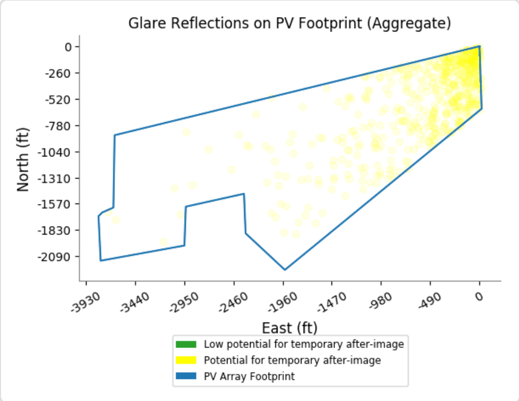
PV array 1 - OP Receptor (OP 24)

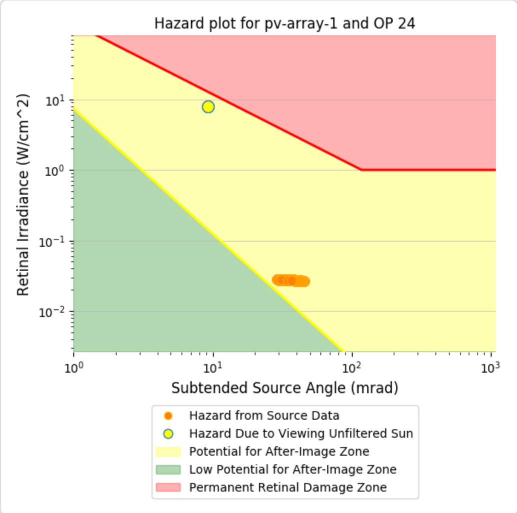
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 540 minutes of "yellow" glare with potential to cause temporary after-image.





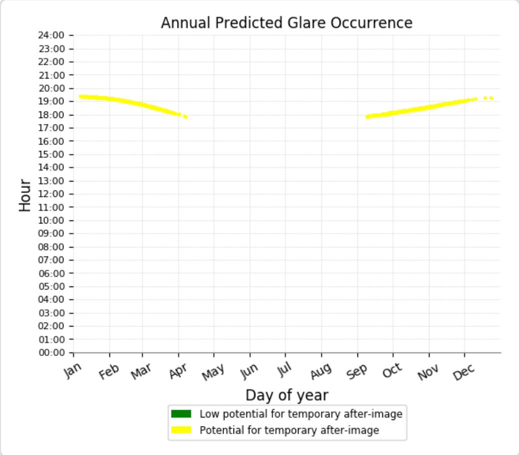


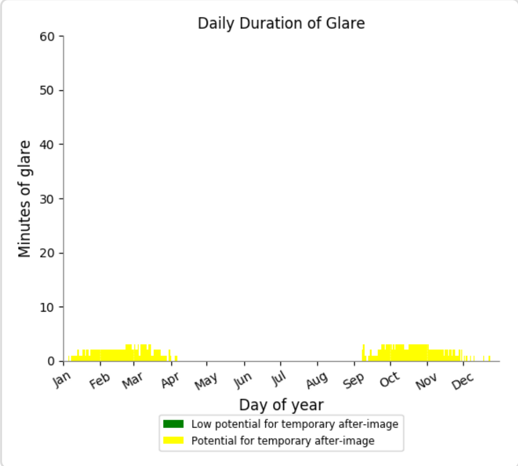


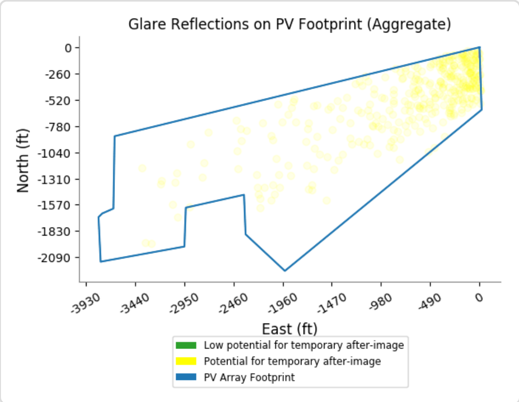
PV array 1 - OP Receptor (OP 25)

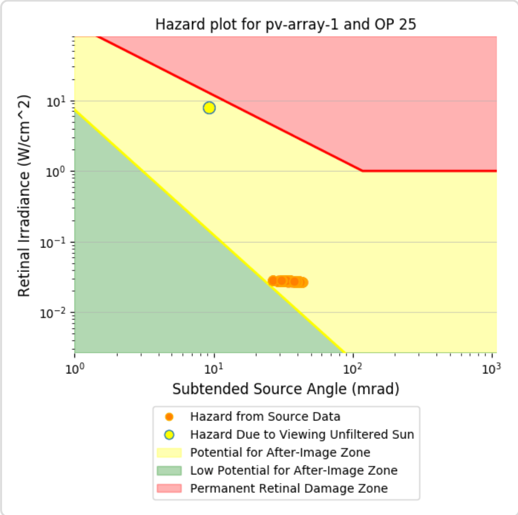
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 351 minutes of "yellow" glare with potential to cause temporary after-image.





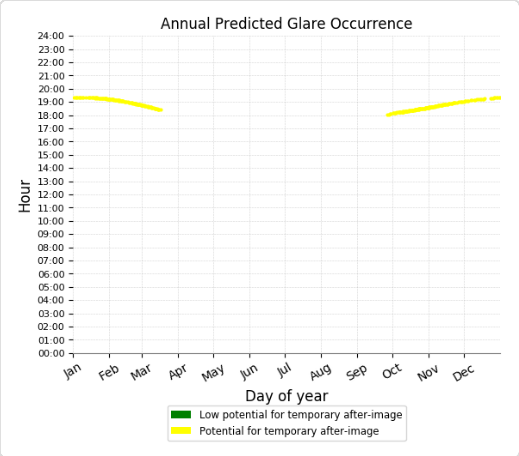


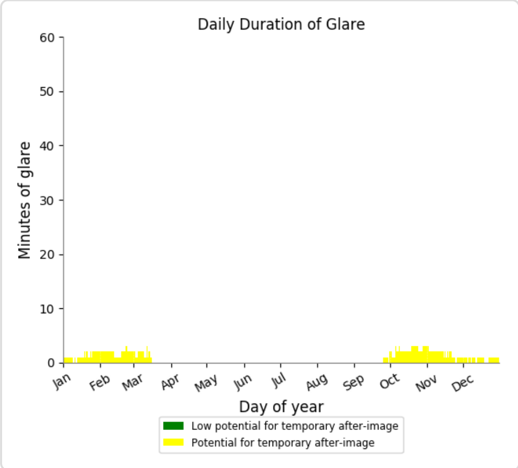


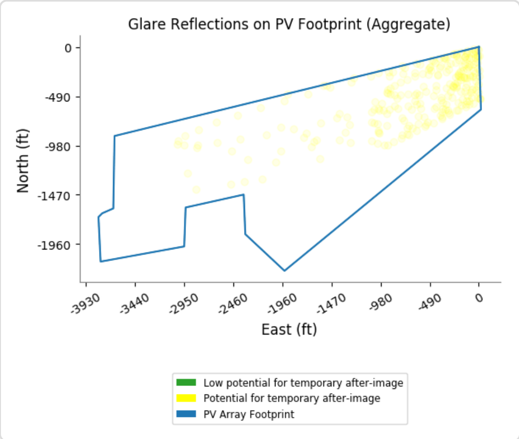
PV array 1 - OP Receptor (OP 26)

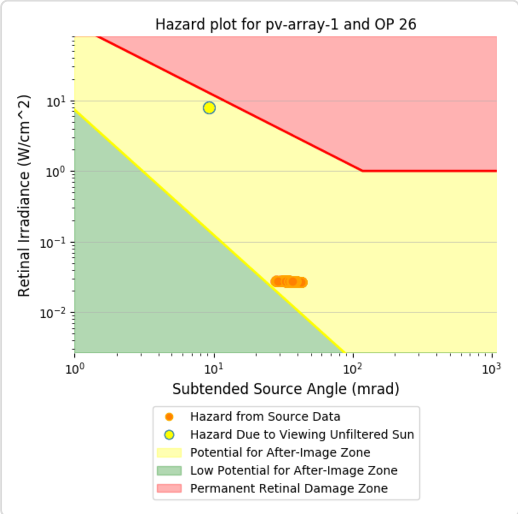
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 262 minutes of "yellow" glare with potential to cause temporary after-image.





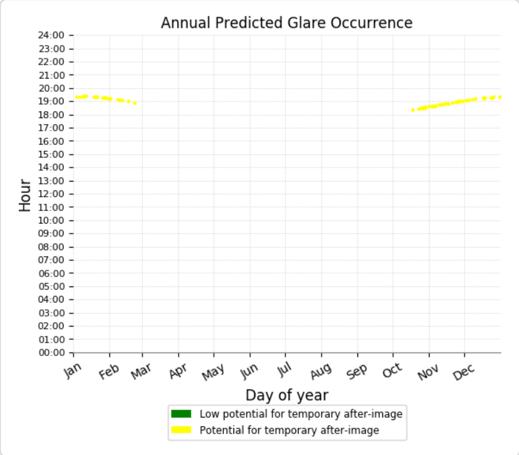


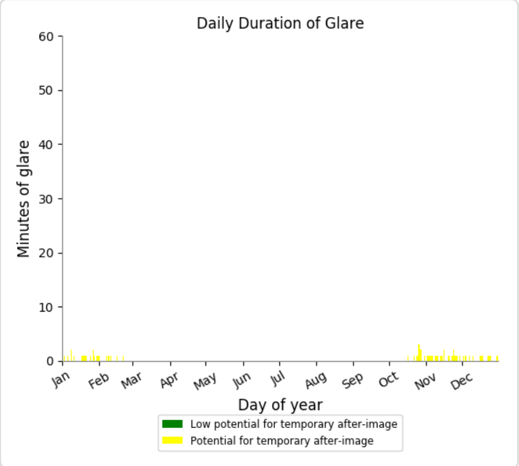


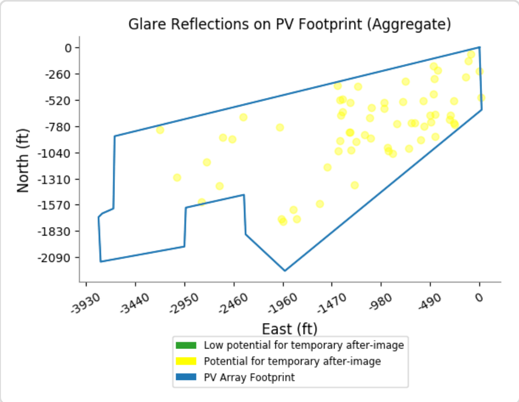
PV array 1 - OP Receptor (OP 27)

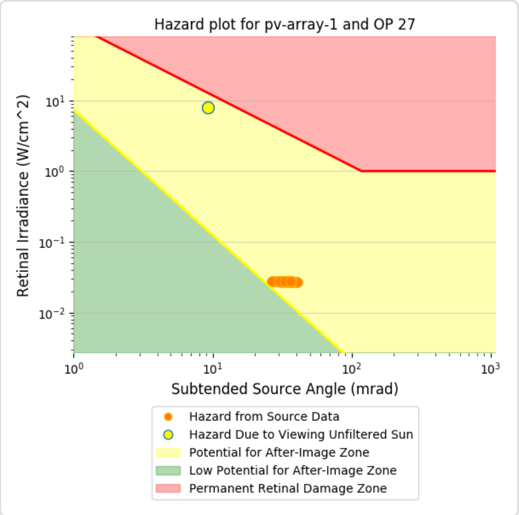
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 65 minutes of "yellow" glare with potential to cause temporary after-image.





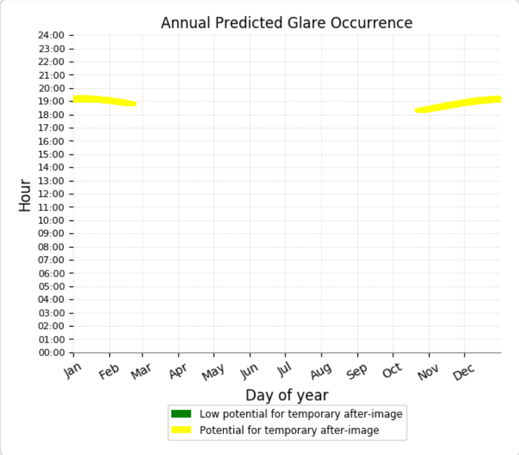


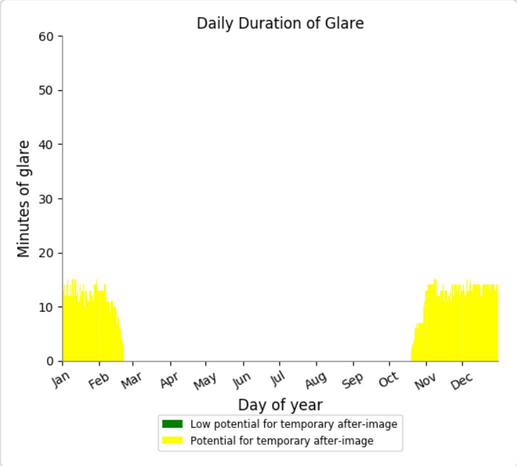


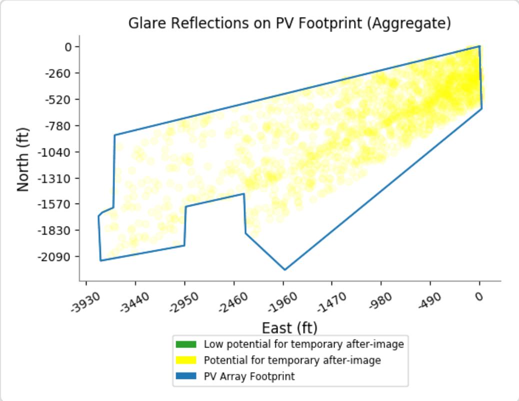
PV array 1 - OP Receptor (OP 28)

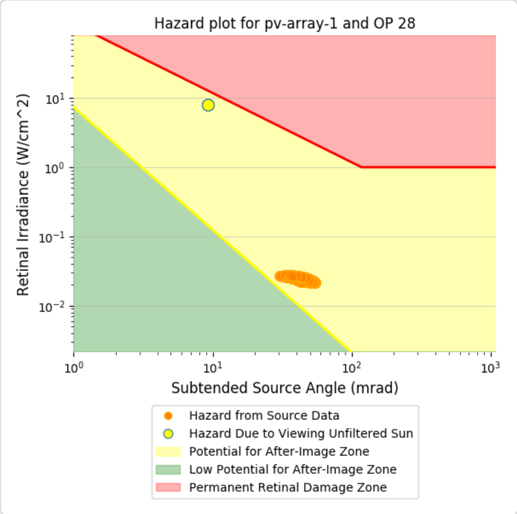
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,504 minutes of "yellow" glare with potential to cause temporary after-image.





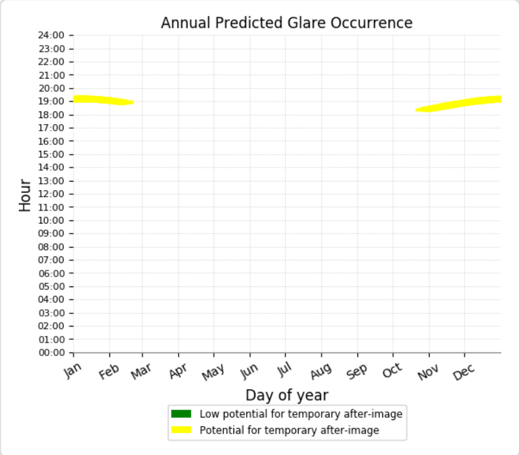


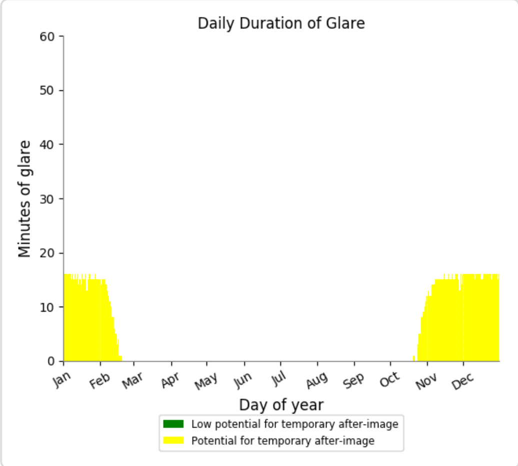


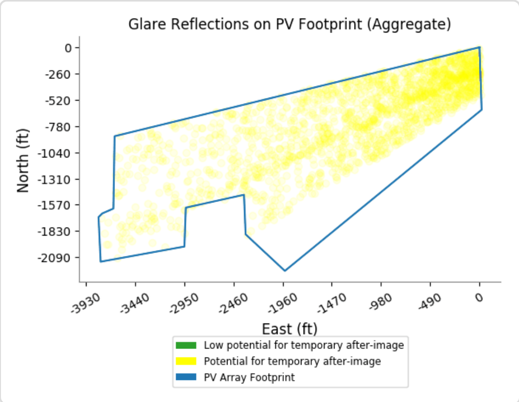
PV array 1 - OP Receptor (OP 29)

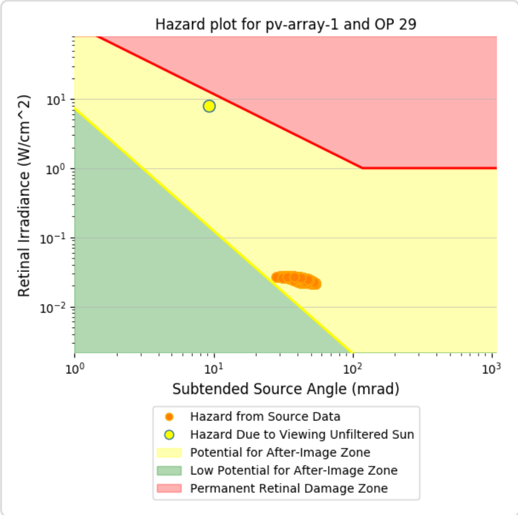
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,636 minutes of "yellow" glare with potential to cause temporary after-image.



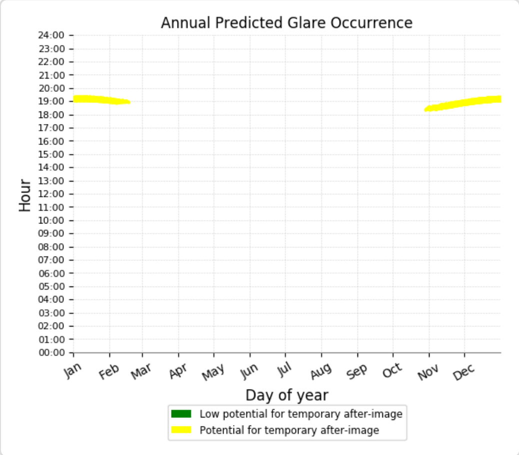


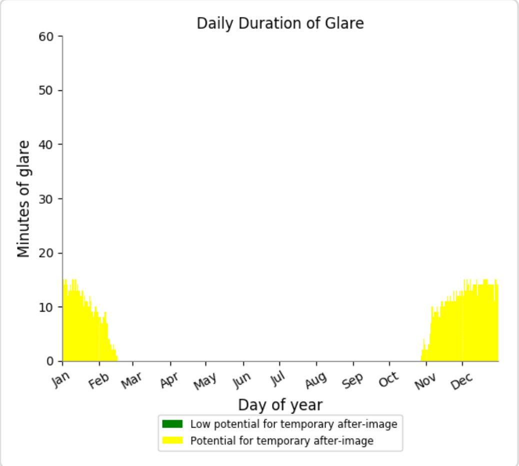


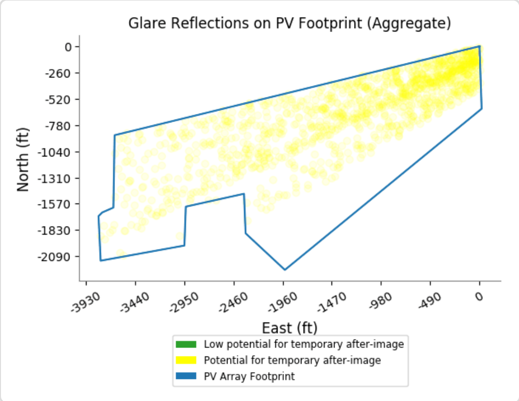


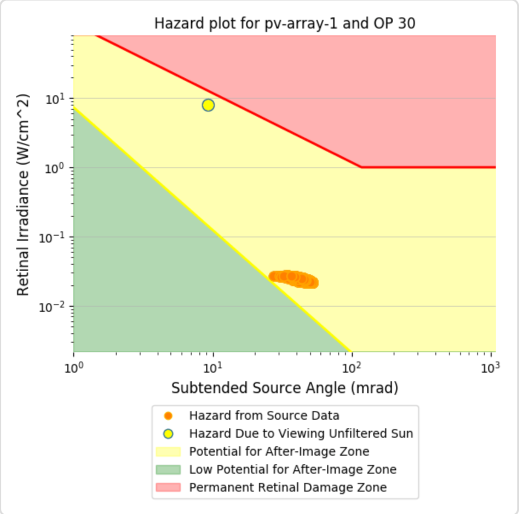
PV array 1 - OP Receptor (OP 30)

PV array is expected to produce the following glare for receptors at this location:
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,186 minutes of "yellow" glare with potential to cause temporary after-image.





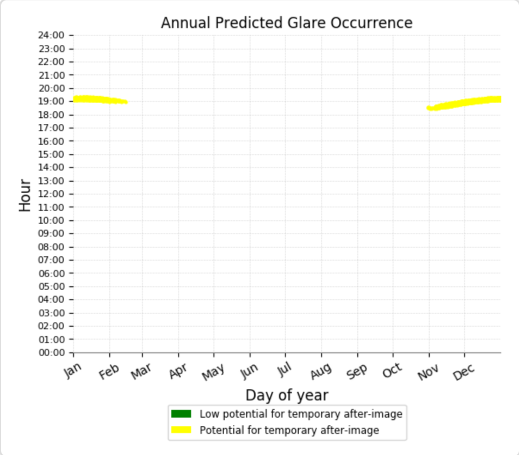


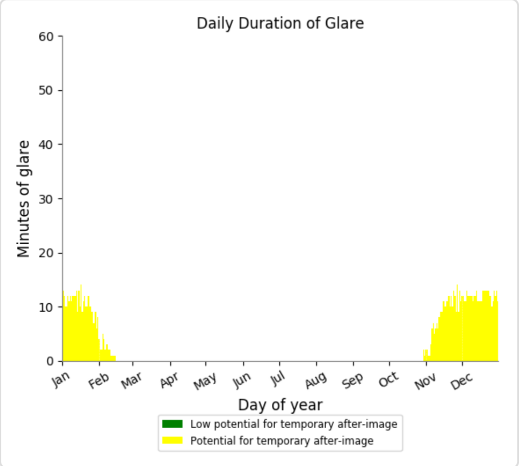


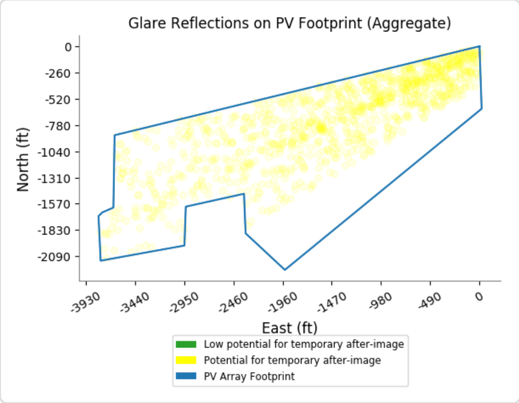
PV array 1 - OP Receptor (OP 31)

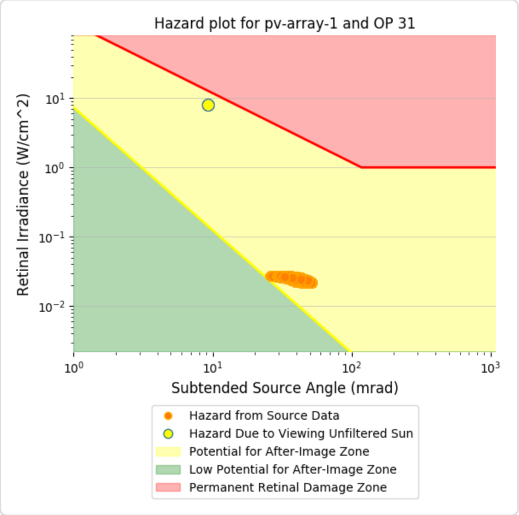
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 985 minutes of "yellow" glare with potential to cause temporary after-image.





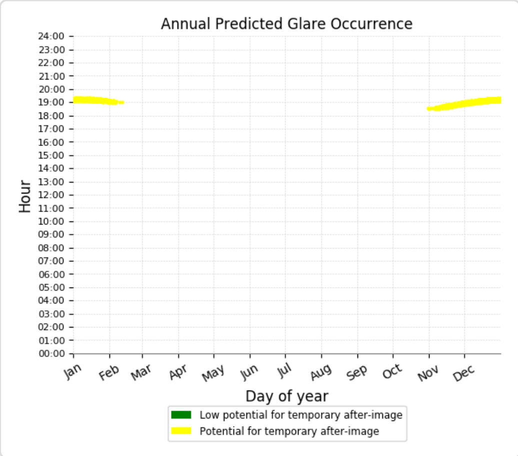


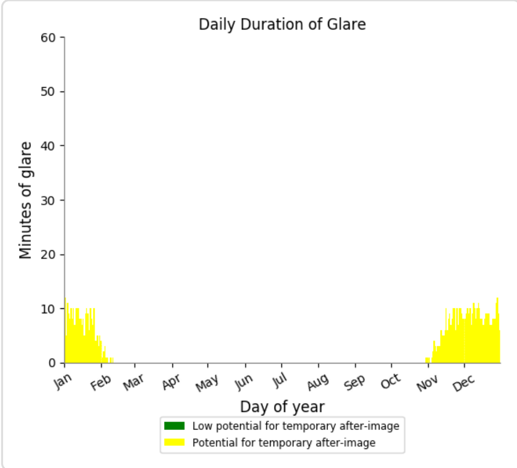


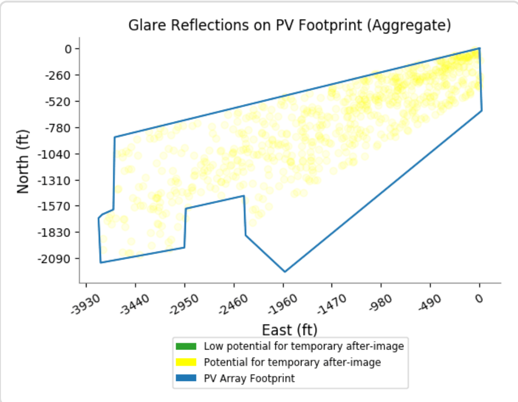
PV array 1 - OP Receptor (OP 32)

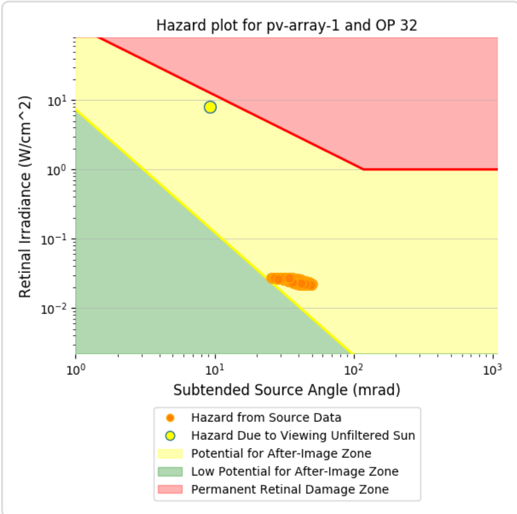
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 708 minutes of "yellow" glare with potential to cause temporary after-image.









Assumptions

- 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.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- 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.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results fc 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.)
- 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.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

ForgeSolar

10333A - Sandy Creek Solar Farm

Train Drivers

Created March 11, 2021
Updated March 11, 2021
Time-step 1 minute
Timezone offset UTC10
Site ID 50953.8862

Project type V1
Project status: active

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:
- Observation point: **Version 1**
- 2-Mile Flight Path: **Version 1**
- Route: **Version 1**

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

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh
PV array 1	SA tracking	SA tracking	0	70,566	-

Component Data

PV Array(s)

Total PV footprint area: 101.2 acres

Name: PV array 1
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 0.0 deg
Footprint area: 101.2 acres
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
1	-35.172240	147.272229	751.24	7.05	758.29
2	-35.174684	147.260027	706.79	7.05	713.84
3	-35.176672	147.259986	693.90	7.05	700.95
4	-35.176805	147.259613	694.43	7.05	701.49
5	-35.176907	147.259489	696.11	7.05	703.16
6	-35.178130	147.259561	708.02	7.05	715.07
7	-35.177713	147.262361	718.44	7.05	725.50
8	-35.176646	147.262408	711.59	7.05	718.64
9	-35.176292	147.264354	725.30	7.05	732.36
10	-35.177379	147.264408	724.95	7.05	732.00
11	-35.178382	147.265721	736.04	7.05	743.09
12	-35.173957	147.272300	758.19	7.05	765.24

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	ft	ft	ft
OP 1	-35.182622	147.260155	720.59	9.02	729.61
OP 2	-35.182071	147.260980	724.25	9.02	733.27
OP 3	-35.181500	147.261816	729.16	9.02	738.18
OP 4	-35.180945	147.262641	731.66	9.02	740.69
OP 5	-35.180366	147.263498	735.00	9.02	744.02
OP 6	-35.179787	147.264355	737.98	9.02	747.00
OP 7	-35.179213	147.265214	738.95	9.02	747.98
OP 8	-35.178663	147.266036	739.38	9.02	748.40
OP 9	-35.178080	147.266900	744.55	9.02	753.58
OP 10	-35.177508	147.267745	753.78	9.02	762.80
OP 11	-35.176924	147.268600	749.71	9.02	758.73
OP 12	-35.176355	147.269440	753.39	9.02	762.41
OP 13	-35.175795	147.270284	755.63	9.02	764.65
OP 14	-35.175223	147.271147	755.66	9.02	764.68
OP 15	-35.174639	147.272006	757.32	9.02	766.34
OP 16	-35.174062	147.272841	762.86	9.02	771.88
OP 17	-35.173466	147.273718	767.13	9.02	776.15
OP 18	-35.172892	147.274585	766.51	9.02	775.53
OP 19	-35.172322	147.275443	766.87	9.02	775.89
OP 20	-35.171757	147.276298	771.03	9.02	780.05
OP 21	-35.170897	147.277536	792.95	9.02	801.97

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh	Data File
PV array 1	SA tracking	SA tracking	0	70,566	-	-

PV & Receptor Analysis Results

Results for each PV array and receptor

PV array 1 potential temporary after-image

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	912
OP: OP 7	0	1642
OP: OP 8	0	1671
OP: OP 9	0	6321
OP: OP 10	0	11356
OP: OP 11	0	7489
OP: OP 12	0	7989
OP: OP 13	0	7500
OP: OP 14	0	5771
OP: OP 15	0	4313
OP: OP 16	0	6296
OP: OP 17	0	5753
OP: OP 18	0	1375
OP: OP 19	0	291
OP: OP 20	0	35
OP: OP 21	0	1852

PV array 1 - OP Receptor (OP 1)

No glare found

PV array 1 - OP Receptor (OP 2)

No glare found

PV array 1 - OP Receptor (OP 3)

No glare found

PV array 1 - OP Receptor (OP 4)

No glare found

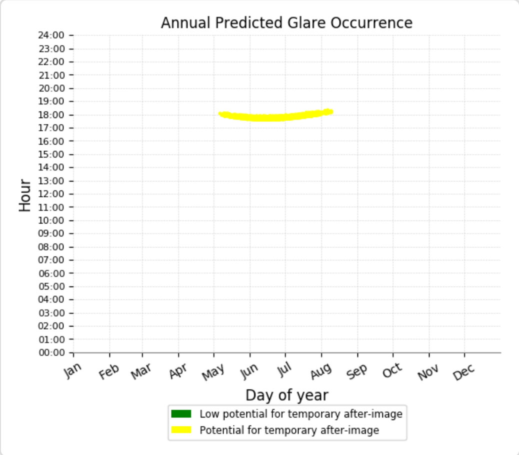
PV array 1 - OP Receptor (OP 5)

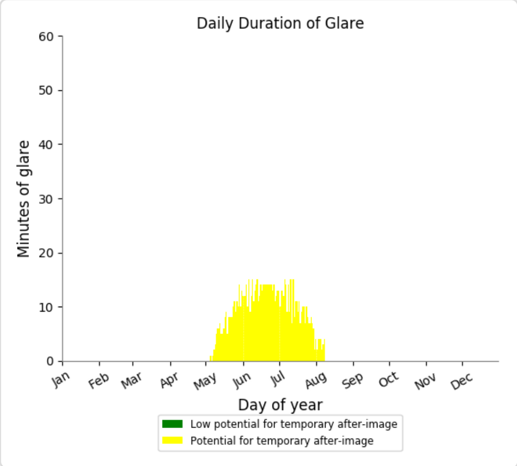
No glare found

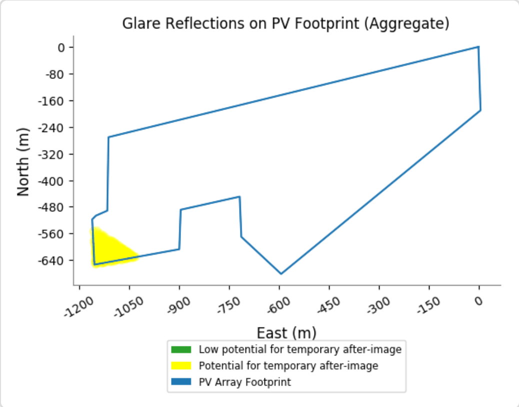
PV array 1 - OP Receptor (OP 6)

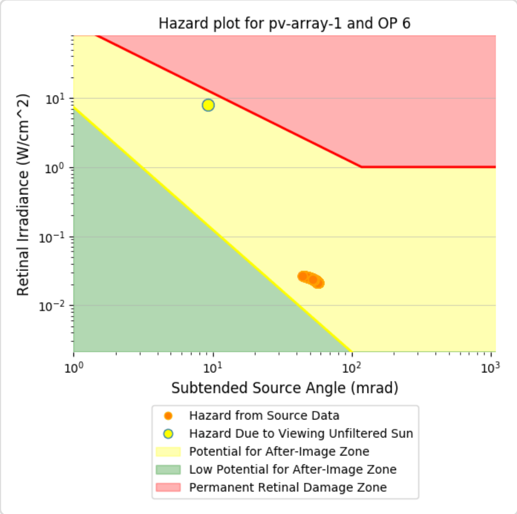
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 912 minutes of "yellow" glare with potential to cause temporary after-image.





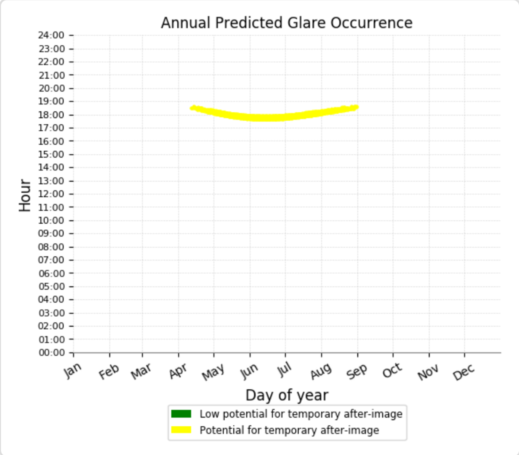


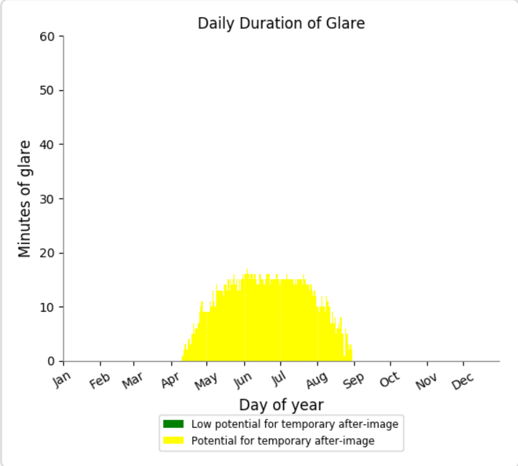


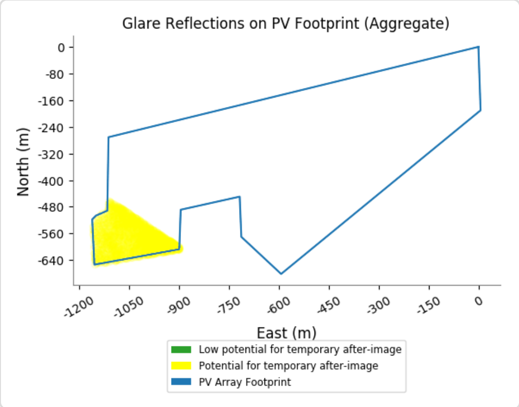
PV array 1 - OP Receptor (OP 7)

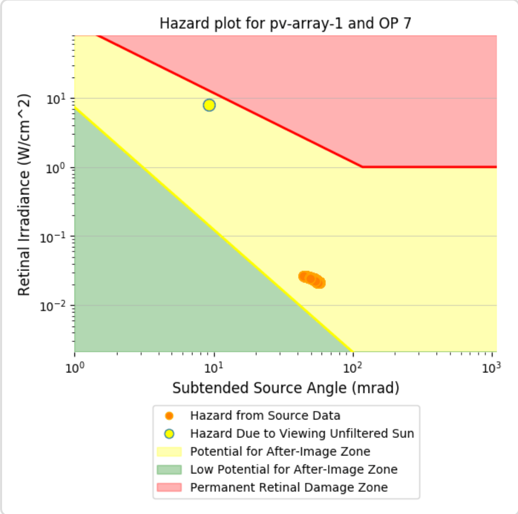
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,642 minutes of "yellow" glare with potential to cause temporary after-image.





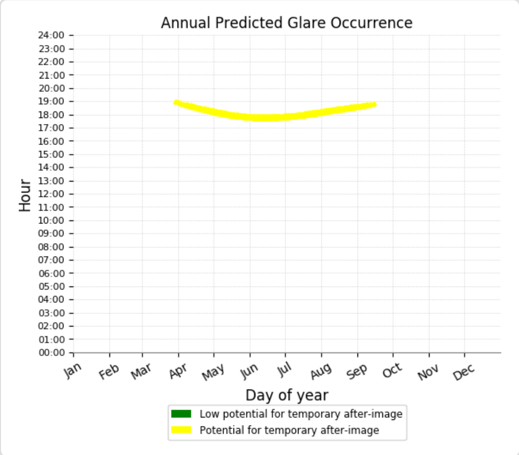


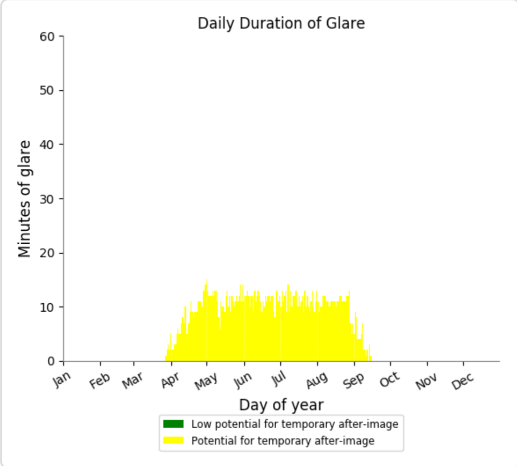


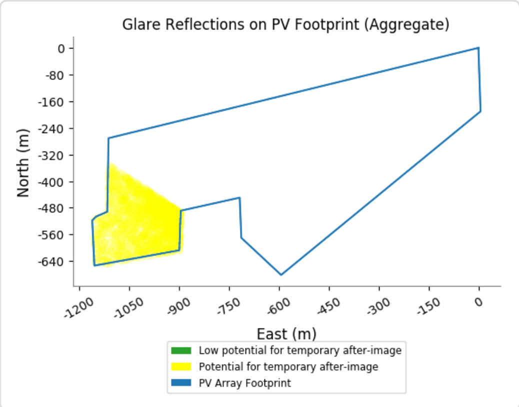
PV array 1 - OP Receptor (OP 8)

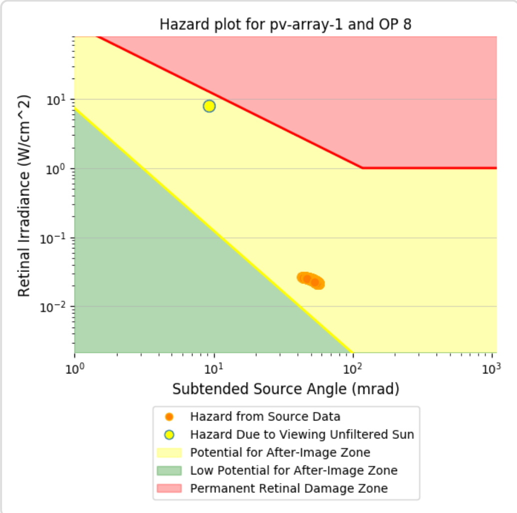
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,671 minutes of "yellow" glare with potential to cause temporary after-image.





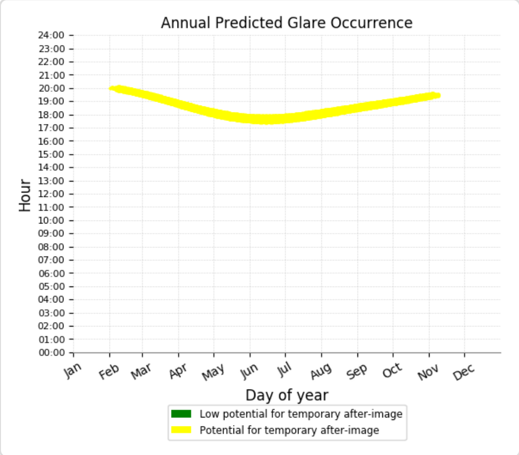


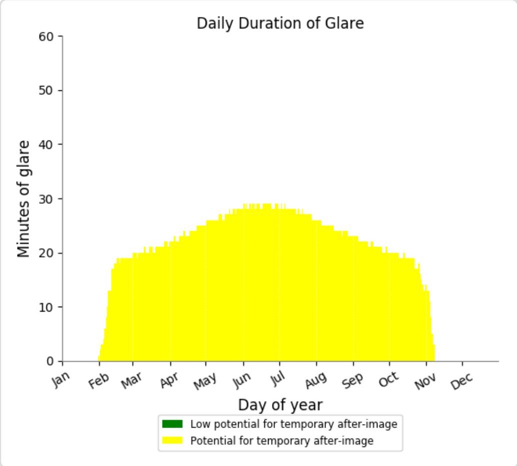


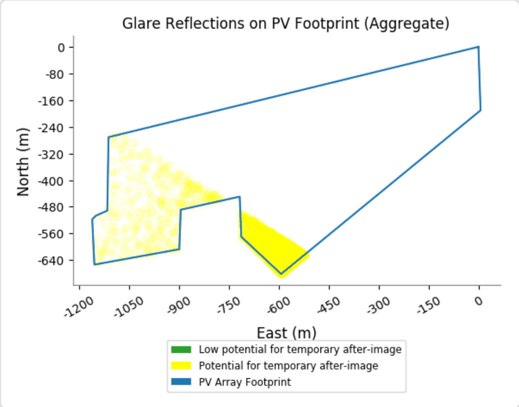
PV array 1 - OP Receptor (OP 9)

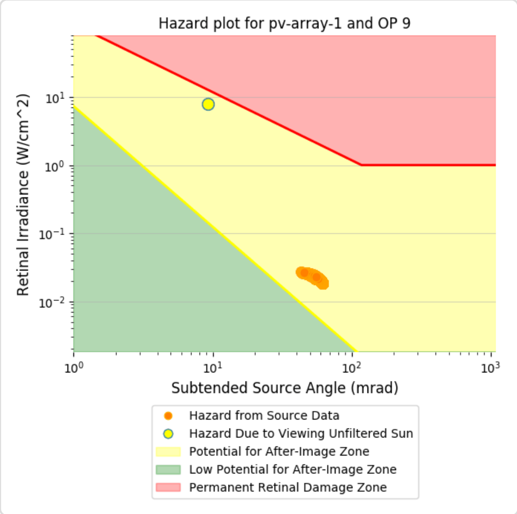
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,321 minutes of "yellow" glare with potential to cause temporary after-image.





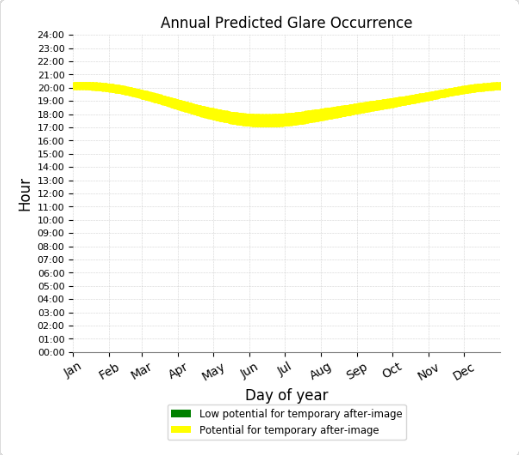


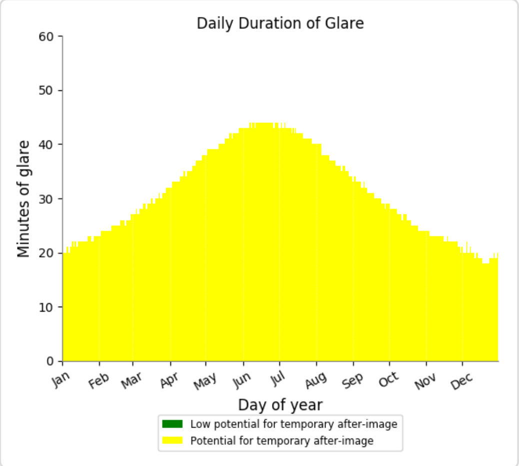


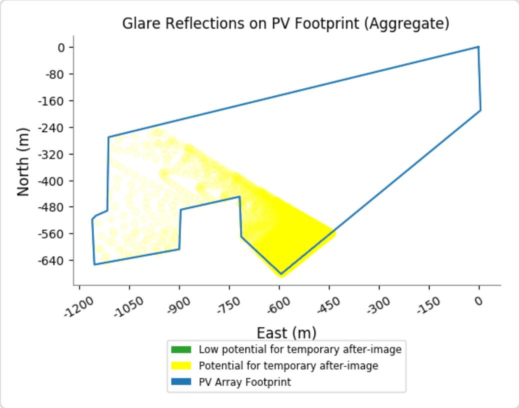
PV array 1 - OP Receptor (OP 10)

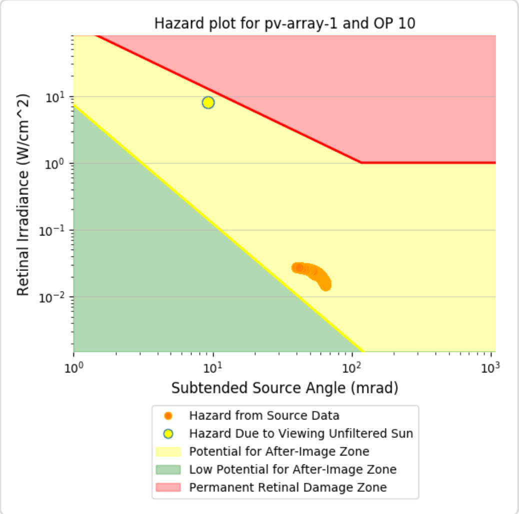
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 11,356 minutes of "yellow" glare with potential to cause temporary after-image.





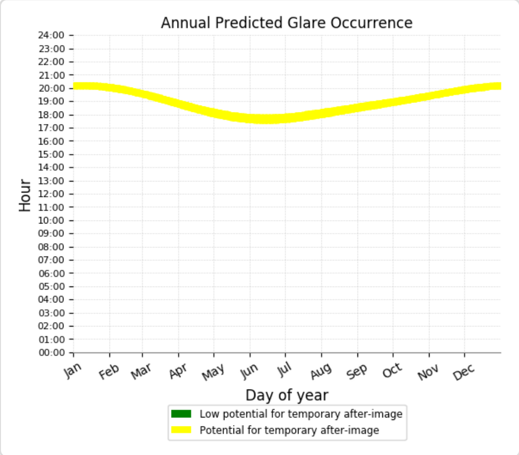


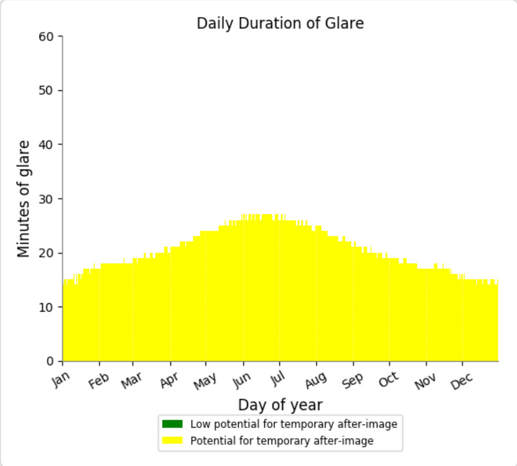


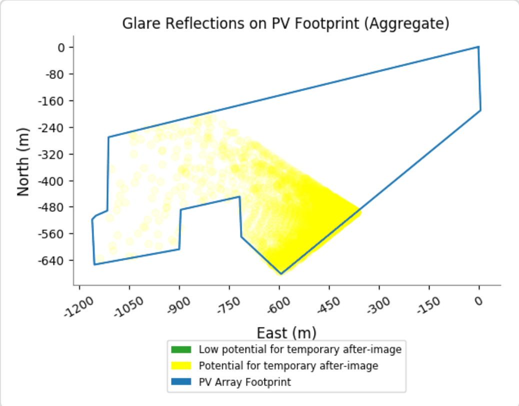
PV array 1 - OP Receptor (OP 11)

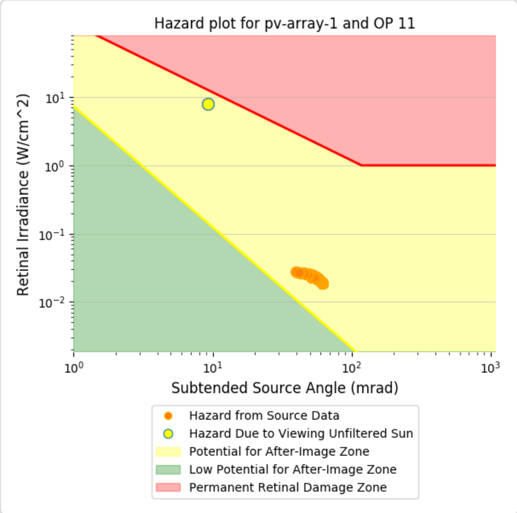
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 7,489 minutes of "yellow" glare with potential to cause temporary after-image.





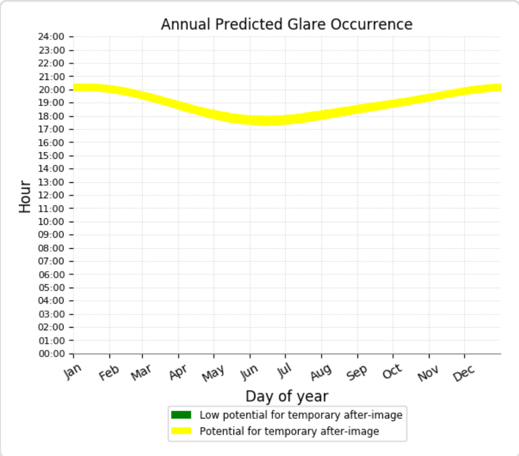


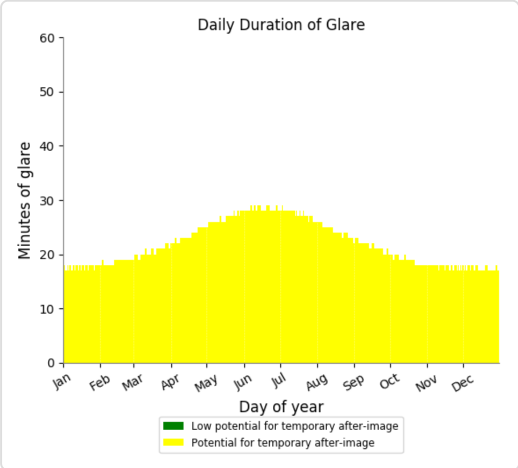


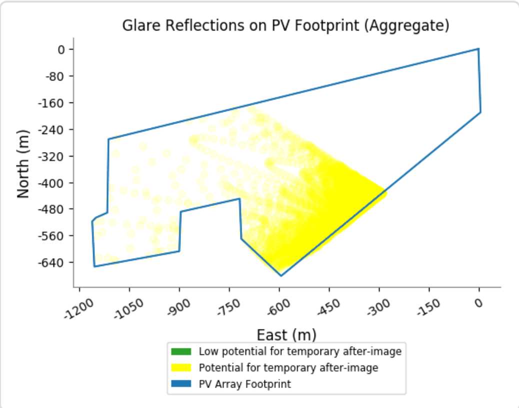
PV array 1 - OP Receptor (OP 12)

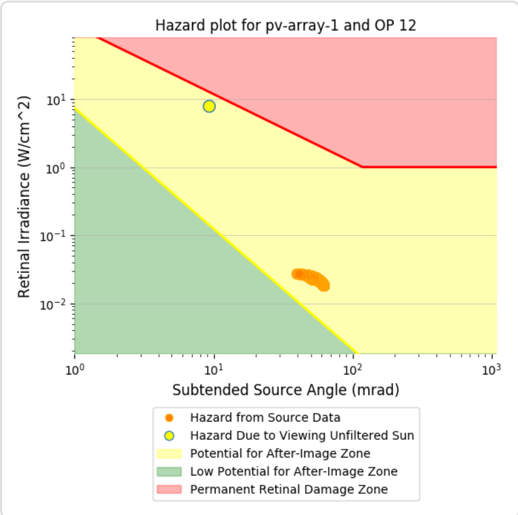
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 7,989 minutes of "yellow" glare with potential to cause temporary after-image.





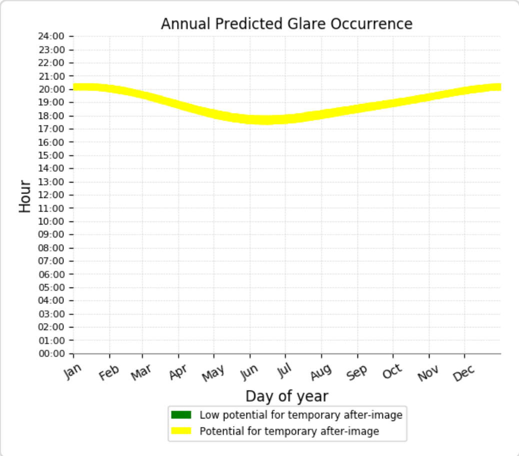


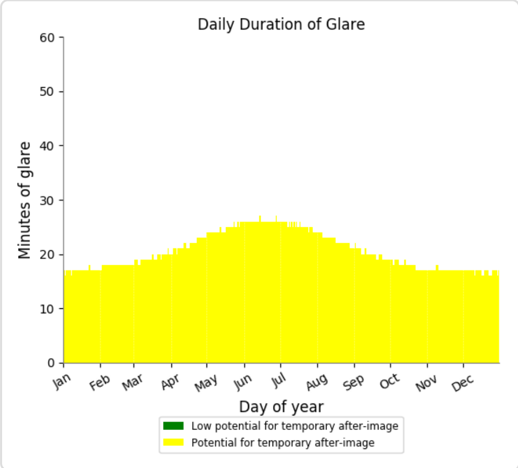


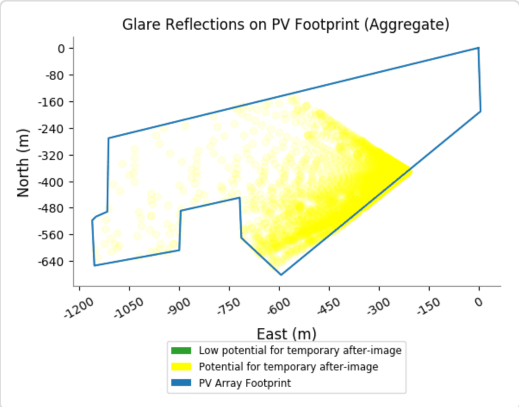
PV array 1 - OP Receptor (OP 13)

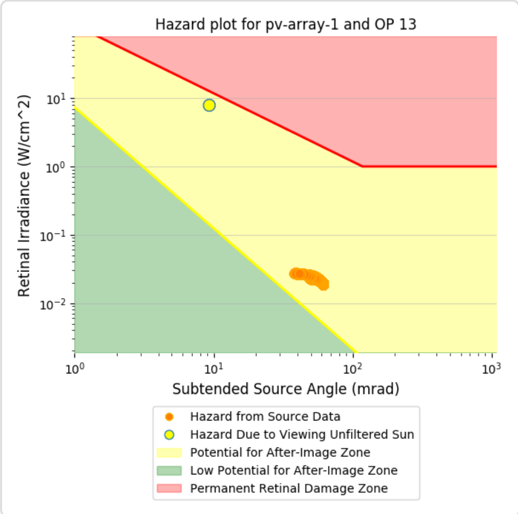
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 7,500 minutes of "yellow" glare with potential to cause temporary after-image.





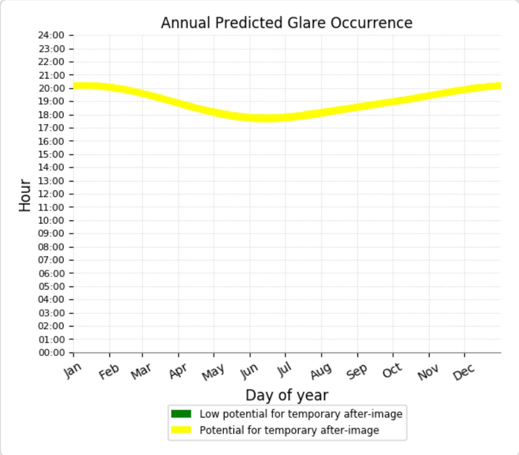


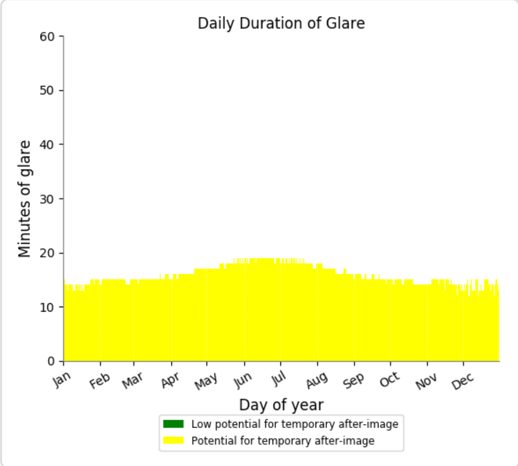


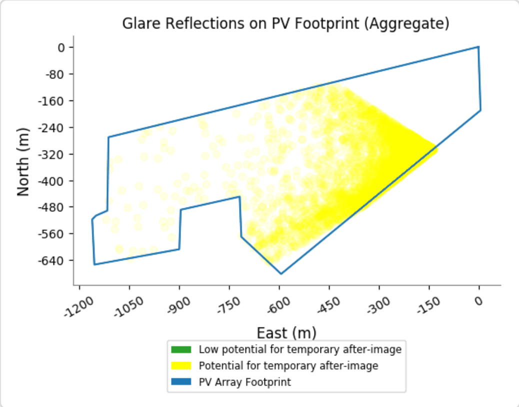
PV array 1 - OP Receptor (OP 14)

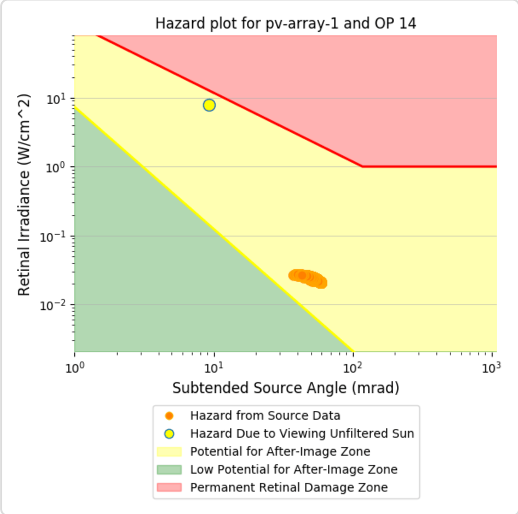
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 5,771 minutes of "yellow" glare with potential to cause temporary after-image.





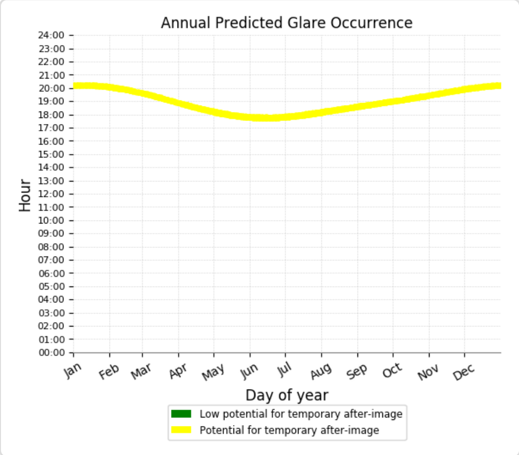


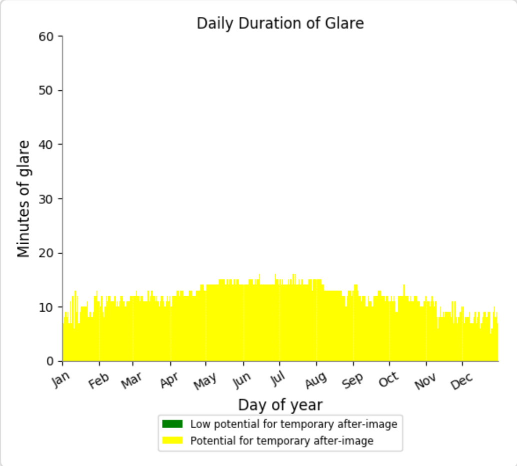


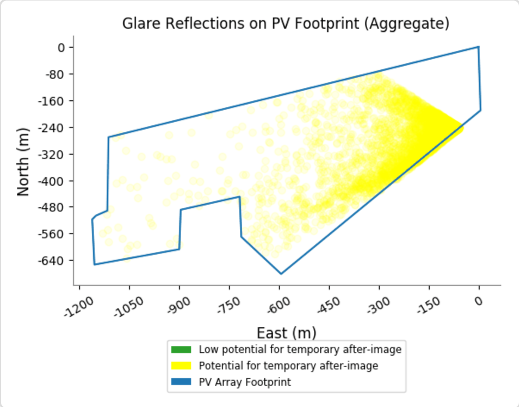
PV array 1 - OP Receptor (OP 15)

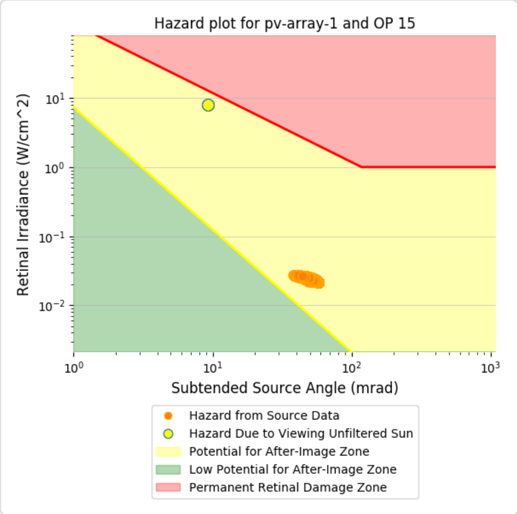
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,313 minutes of "yellow" glare with potential to cause temporary after-image.





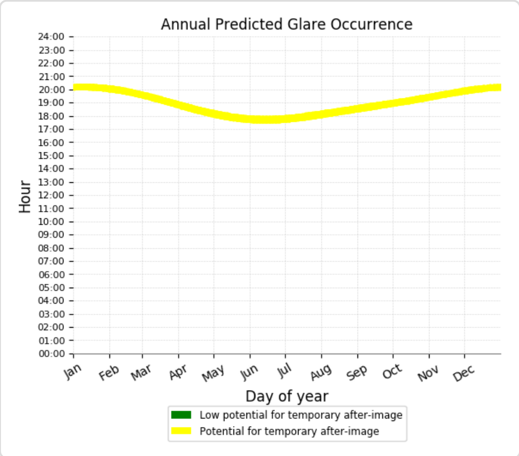


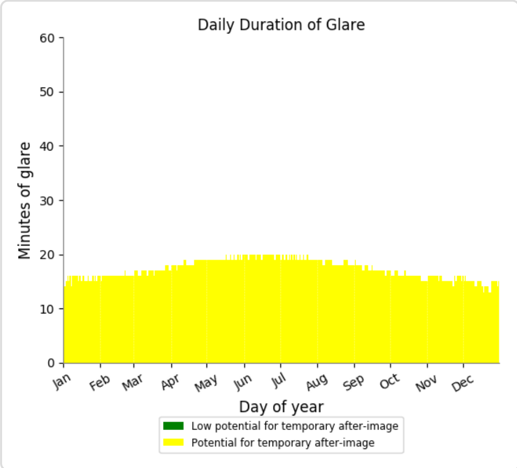


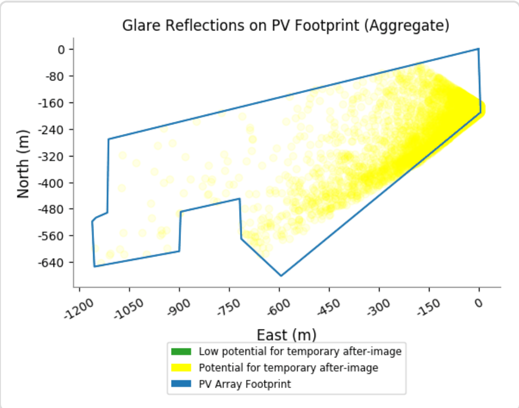
PV array 1 - OP Receptor (OP 16)

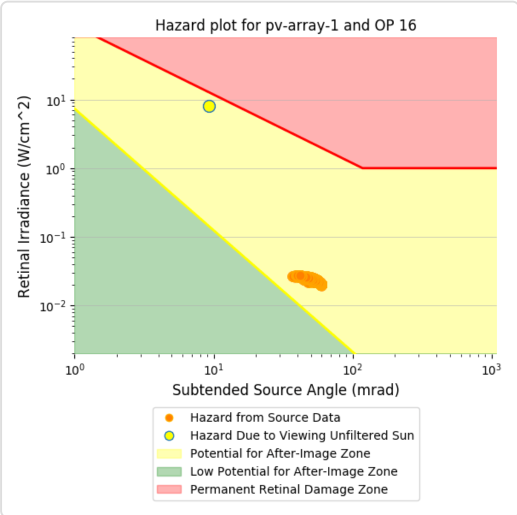
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,296 minutes of "yellow" glare with potential to cause temporary after-image.





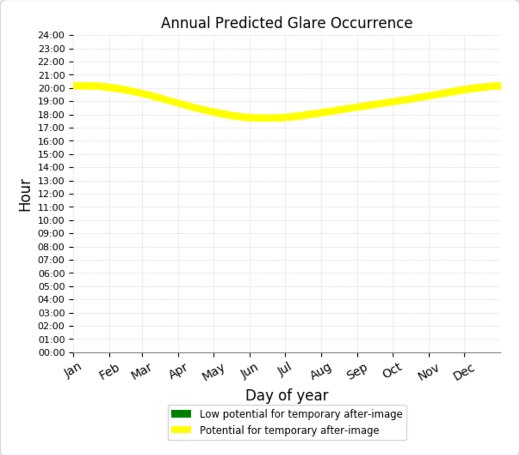


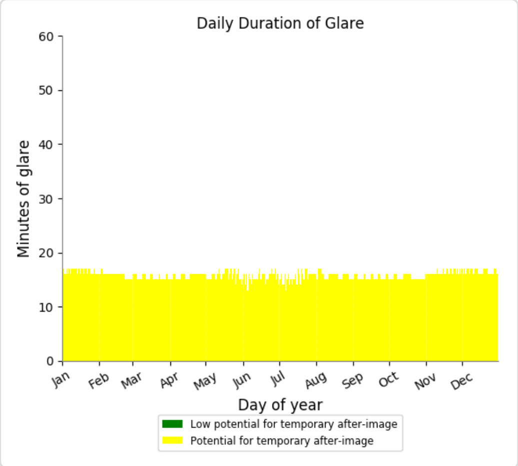


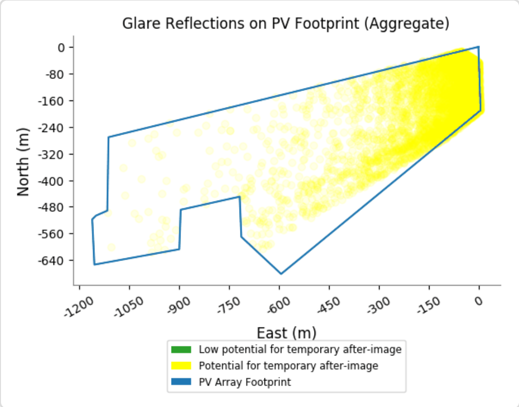
PV array 1 - OP Receptor (OP 17)

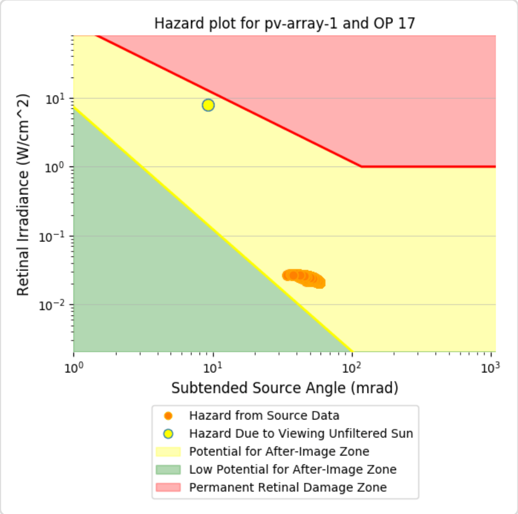
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 5,753 minutes of "yellow" glare with potential to cause temporary after-image.





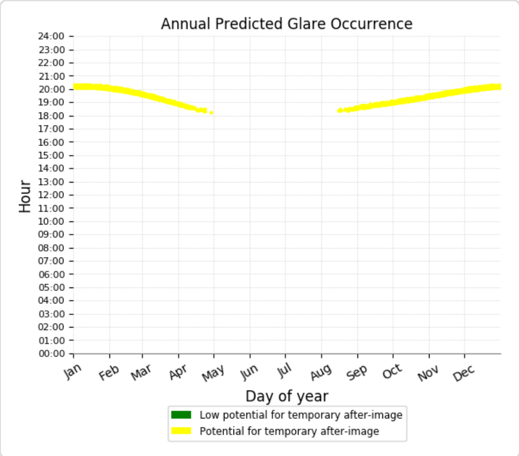


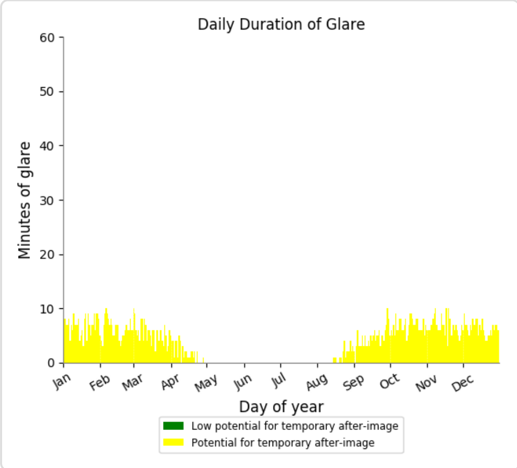


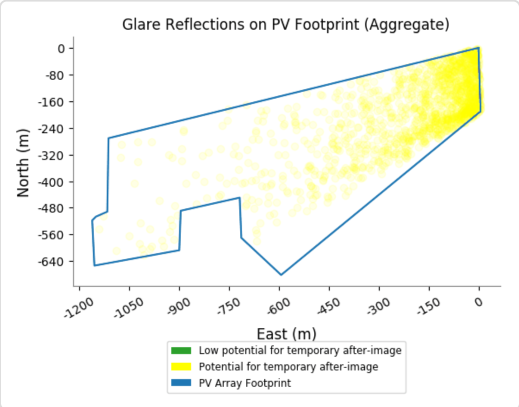
PV array 1 - OP Receptor (OP 18)

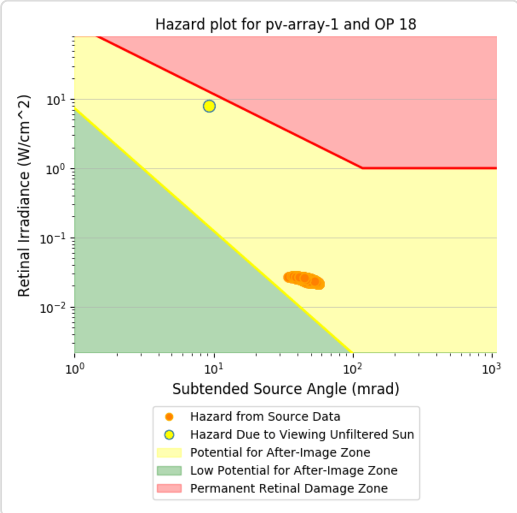
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,375 minutes of "yellow" glare with potential to cause temporary after-image.





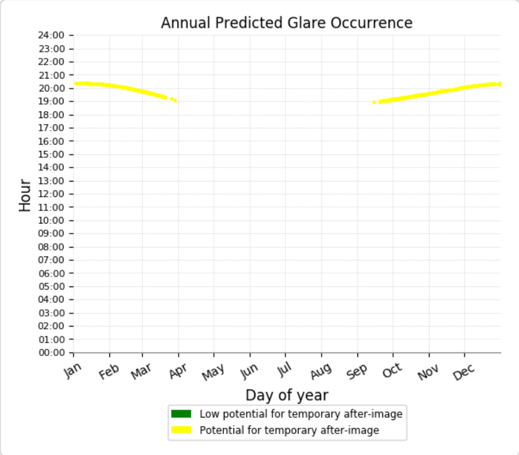


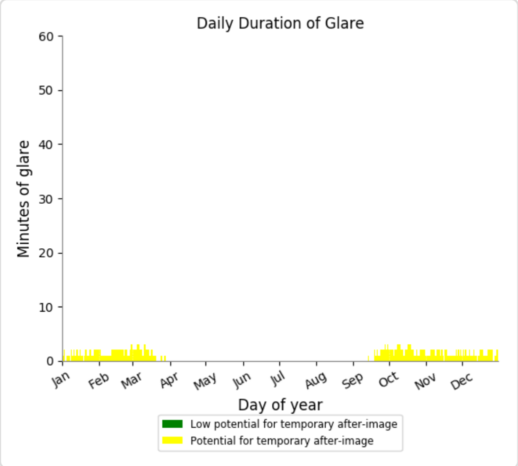


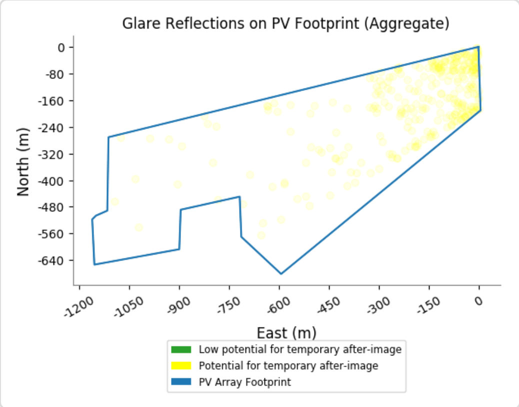
PV array 1 - OP Receptor (OP 19)

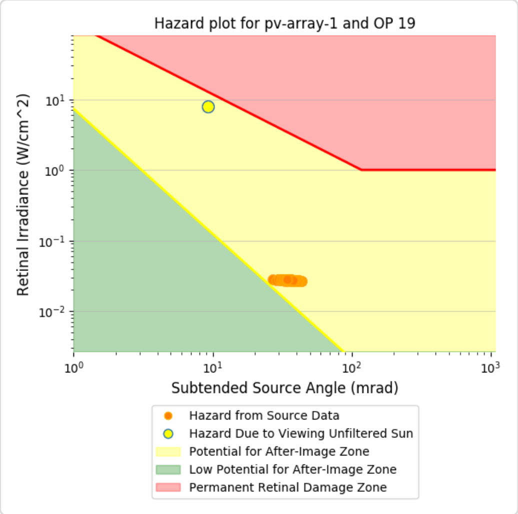
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 291 minutes of "yellow" glare with potential to cause temporary after-image.





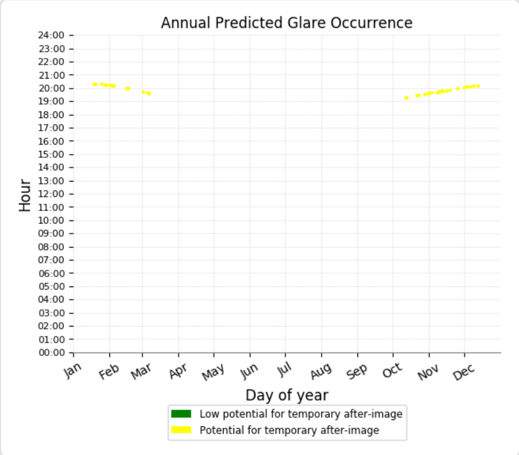


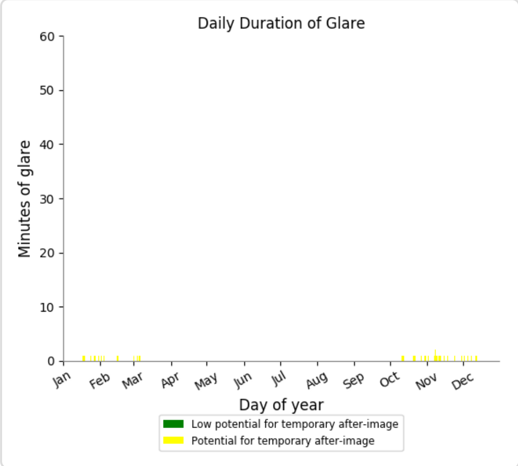


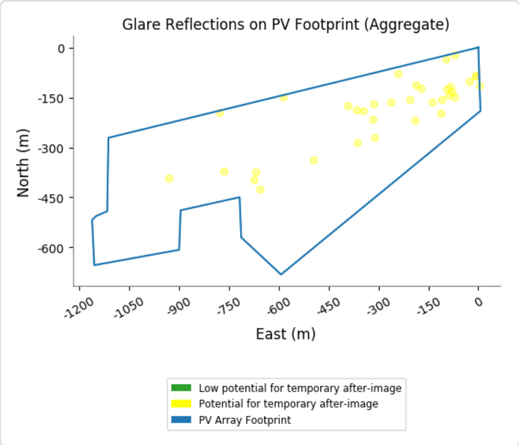
PV array 1 - OP Receptor (OP 20)

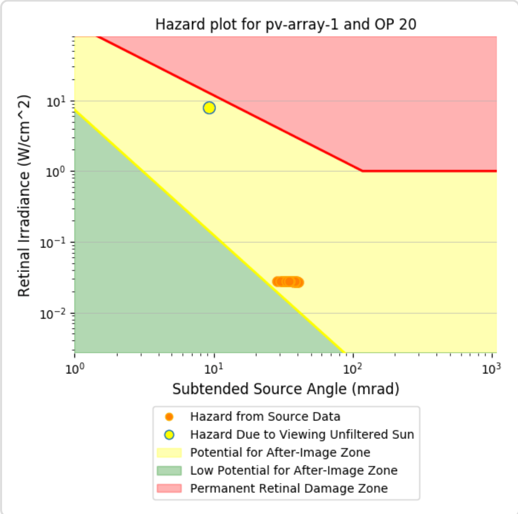
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 35 minutes of "yellow" glare with potential to cause temporary after-image.





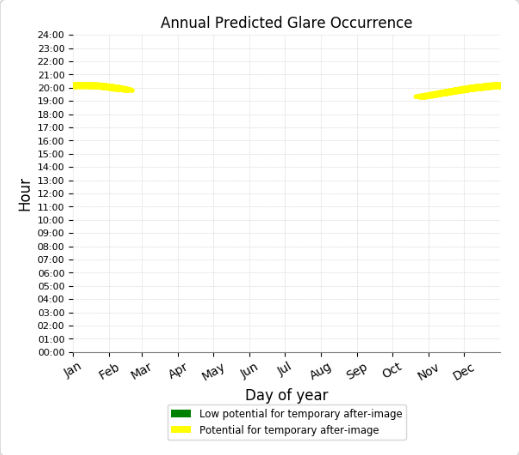


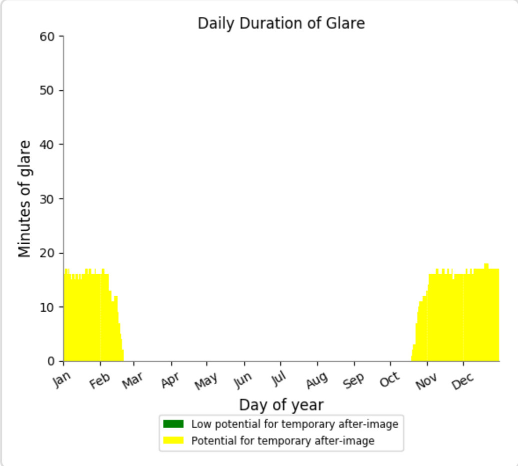


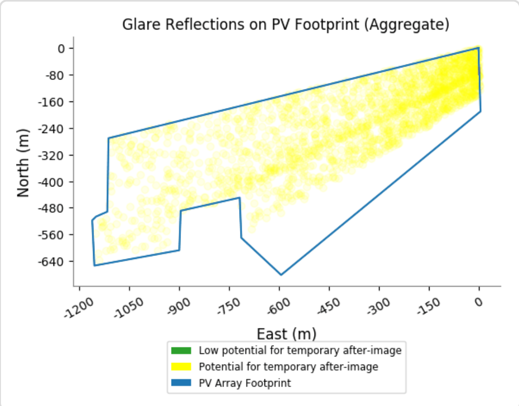
PV array 1 - OP Receptor (OP 21)

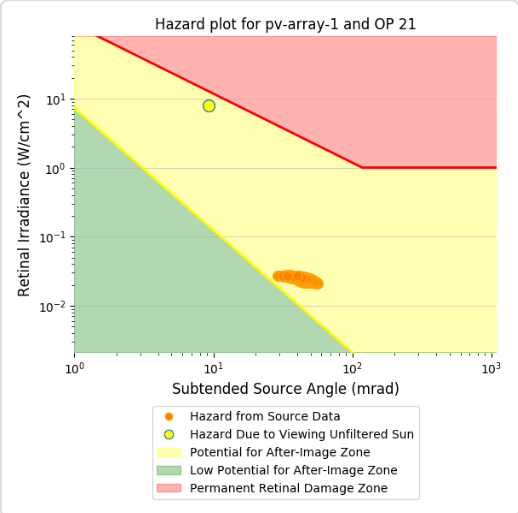
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,852 minutes of "yellow" glare with potential to cause temporary after-image.









Assumptions

- 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.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- 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.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results fc 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.)
- 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.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

APPENDIX D:

ADDENDUM – CONSIDERATION OF ALTERNATIVE RESTING ANGLES

PAGERPOWER

Urban & Renewables

Addendum – Consideration of Alternative Resting Angles

NGH Consulting

Sandy Creek Solar Farm

August 2021





ADMINISTRATION PAGE

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Date:	August 2021
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Issue	Date	Detail of Changes
1	August 2021	Initial issue

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ADDENDUM – CONSIDERATION OF ALTERNATIVE RESTING ANGLES

Purpose of this Addendum

Pager Power has been retained to assess the possible effects of glint and glare from a proposed solar photovoltaic (PV) development located north-east of Uranquinty in Australia. This document forms an addendum to the previously completed glint and glare assessment concerning the possible impact upon surrounding road users, dwellings, and railway operations and infrastructure. Additional modelling has been undertaken to investigate alternative resting angle scenarios using the previously modelled road and railway receptors.

Conclusions

Changing the resting angle to 5 degrees eliminates all possible glare towards the assessed road and railway sections[1]. In this scenario, no impacts are predicted and mitigation is not required.

Analysis

The resting angle of the solar panels when the sun is outside of the rotation range was previously modelled in the original study at 0° (sitting flat on the horizontal). This is generally considered to be the worst-scenario for glare in the early morning and late evening, when the sun is low in the sky beyond the reflecting panels. This was particularly significant in the original study because all solar reflections that were geometrically possible were in the evening.

In this study, further modelling has been undertaken, increasing the resting angle at intervals of 1°, until no glare was geometrically possible towards the receptors. The originally modelled road receptors and railway receptors were carried forward.

[1] Confirmed by both Pager Power and Forge models.

Geometric Calculation Results Overview

Table 1 below presents the results of the Pager Power and Forge analysis.

Resting angle (°)	Pager Power Results		Forge Results		Comments
	Reflection possible? (AEST[2])		Reflection possible? (AEST[2])		
	Road	Railway	Road	Railway	
0	Yes.	Yes.	Yes.	Yes.	Solar reflections are geometrically possible towards the assessed road and railway according to both models.
1	Yes.	Yes.	Yes.	Yes.	Solar reflections are geometrically possible towards the assessed road and railway according to both models.
2	No.	Yes.	Yes.	Yes.	Solar reflections are geometrically possible towards the assessed road according to Forge only. Solar reflections are geometrically possible towards the assessed railway according to both models.
3	No.	Yes.	No.	Yes.	Solar reflections are not geometrically possible towards the assessed road according to both models. Solar reflections are geometrically possible towards the assessed railway according to both models.
4	No.	Yes.	No.	Yes.	Solar reflections are not geometrically possible towards the assessed road according to both models. Solar reflections are geometrically possible towards the assessed railway according to both models.

[2] Modelling was run in AEST but conclusions for AEDT would be the same; only the glare curves would shift one hour in accordance with sunset and sunrise times shifting by one hour.

Resting angle (°)	Pager Power Results		Forge Results		Comments
	Reflection possible? (AEST[2])		Reflection possible? (AEST[2])		
	Road	Railway	Road	Railway	
5	**No.**	**No.**	**No.**	**No.**	**Solar reflections are not geometrically possible towards the** assessed **road and railway according to both models.**

Table 1 *Geometric analysis results – road and railway receptors*

Table 1 shows that 5° is the minimum resting angle that would eliminate all possible glare according to both models.

The small difference between the results of the two models could be due to:

- Forge accounts for the solar panel's diffusivity while the Pager Power model does not.
- Forge uses SRTM data to calculate terrain height while the Pager Power model uses OS Panorama 50m DTM.
- Differences in the geometric model of the Sun and glare produced by the solar panels.

Urban & Renewables

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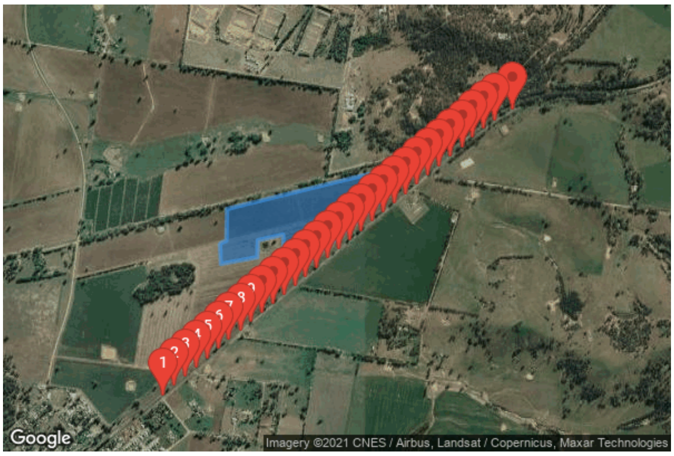
ForgeSolar

10333A - Sandy Creek Solar Farm

Roads 5 deg rest

Created Aug. 23, 2021
Updated Aug. 23, 2021
Time-step 1 minute
Timezone offset UTC10
Site ID 57742.8862

Project type V1
Project status: active



Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:
- Observation point: **Version 1**
- 2-Mile Flight Path: **Version 1**
- Route: **Version 1**

Summary of Results No glare predicted!

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	SA tracking	SA tracking	0	0	-

Component Data

PV Array(s)

Total PV footprint area: 409,350 m^2

Name: PV array 1
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 5.0 deg
Footprint area: 409,350 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-35.172240	147.272229	228.97	2.15	231.12
2	-35.174684	147.260027	215.42	2.15	217.57
3	-35.176672	147.259986	211.49	2.15	213.64
4	-35.176805	147.259613	211.65	2.15	213.80
5	-35.176907	147.259489	212.16	2.15	214.31
6	-35.178130	147.259561	215.79	2.15	217.94
7	-35.177713	147.262361	218.97	2.15	221.12
8	-35.176646	147.262408	216.88	2.15	219.03
9	-35.176292	147.264354	221.06	2.15	223.21
10	-35.177379	147.264408	220.95	2.15	223.10
11	-35.178382	147.265721	224.33	2.15	226.48
12	-35.173957	147.272300	231.08	2.15	233.23

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	-35.186403	147.255107	211.16	1.50	212.66
OP 2	-35.185823	147.255966	211.94	1.50	213.44
OP 3	-35.185250	147.256812	212.97	1.50	214.47
OP 4	-35.184650	147.257696	215.85	1.50	217.35
OP 5	-35.184094	147.258516	218.11	1.50	219.61
OP 6	-35.183517	147.259383	220.00	1.50	221.50
OP 7	-35.182957	147.260216	220.16	1.50	221.66
OP 8	-35.182386	147.261108	221.00	1.50	222.50
OP 9	-35.181822	147.261932	222.11	1.50	223.61
OP 10	-35.181266	147.262773	223.42	1.50	224.92
OP 11	-35.180682	147.263615	224.19	1.50	225.69
OP 12	-35.180138	147.264436	224.69	1.50	226.19
OP 13	-35.179531	147.265294	225.56	1.50	227.06
OP 14	-35.178992	147.266114	225.93	1.50	227.43
OP 15	-35.178407	147.266974	227.34	1.50	228.84
OP 16	-35.177826	147.267851	228.94	1.50	230.44
OP 17	-35.177253	147.268703	228.83	1.50	230.33
OP 18	-35.176656	147.269575	230.44	1.50	231.94
OP 19	-35.176090	147.270419	230.99	1.50	232.49
OP 20	-35.175506	147.271279	231.05	1.50	232.55
OP 21	-35.174954	147.272102	231.32	1.50	232.82
OP 22	-35.174362	147.272965	232.81	1.50	234.31
OP 23	-35.173790	147.273843	234.12	1.50	235.62
OP 24	-35.173189	147.274701	234.67	1.50	236.17
OP 25	-35.172615	147.275545	234.79	1.50	236.29
OP 26	-35.172029	147.276431	234.73	1.50	236.23
OP 27	-35.171446	147.277292	237.73	1.50	239.23
OP 28	-35.170852	147.278170	241.30	1.50	242.80
OP 29	-35.170240	147.279018	243.99	1.50	245.49
OP 30	-35.169677	147.279838	243.90	1.50	245.40
OP 31	-35.169161	147.280736	244.02	1.50	245.52
OP 32	-35.168506	147.282059	245.96	1.50	247.46

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	SA tracking	SA tracking	0	0	-	

PV & Receptor Analysis Results

Results for each PV array and receptor

PV array 1 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	0
OP: OP 15	0	0
OP: OP 16	0	0
OP: OP 17	0	0
OP: OP 18	0	0
OP: OP 19	0	0
OP: OP 20	0	0
OP: OP 21	0	0
OP: OP 22	0	0
OP: OP 23	0	0
OP: OP 24	0	0
OP: OP 25	0	0
OP: OP 26	0	0
OP: OP 27	0	0
OP: OP 28	0	0
OP: OP 29	0	0
OP: OP 30	0	0
OP: OP 31	0	0
OP: OP 32	0	0

No glare found

Assumptions

- 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.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- 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.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results fc 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.)
- 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.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

ForgeSolar

10333A - Sandy Creek Solar Farm

Train Drivers 5 deg rest

Created Aug. 23, 2021
Updated Aug. 25, 2021
Time-step 1 minute
Timezone offset UTC10
Site ID 57741.8862

Project type V1
Project status: active

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:
- Observation point: **Version 1**
- 2-Mile Flight Path: **Version 1**
- Route: **Version 1**

Summary of Results No glare predicted!

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	SA tracking	SA tracking	0	0	-

Component Data

PV Array(s)

Total PV footprint area: 409,350 m^2

Name: PV array 1
Axis tracking: Single-axis rotation
Tracking axis orientation: 0.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 5.0 deg
Footprint area: 409,350 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	-35.172240	147.272229	228.97	2.15	231.12
2	-35.174684	147.260027	215.42	2.15	217.57
3	-35.176672	147.259986	211.49	2.15	213.64
4	-35.176805	147.259613	211.65	2.15	213.80
5	-35.176907	147.259489	212.16	2.15	214.31
6	-35.178130	147.259561	215.79	2.15	217.94
7	-35.177713	147.262361	218.97	2.15	221.12
8	-35.176646	147.262408	216.88	2.15	219.03
9	-35.176292	147.264354	221.06	2.15	223.21
10	-35.177379	147.264408	220.95	2.15	223.10
11	-35.178382	147.265721	224.33	2.15	226.48
12	-35.173957	147.272300	231.08	2.15	233.23

Discrete Observation Receptors

Number	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total Elevation m
OP 1	-35.182622	147.260155	219.62	2.75	222.37
OP 2	-35.182071	147.260980	220.74	2.75	223.49
OP 3	-35.181500	147.261816	222.24	2.75	224.99
OP 4	-35.180945	147.262641	223.00	2.75	225.75
OP 5	-35.180366	147.263498	224.02	2.75	226.77
OP 6	-35.179787	147.264355	224.92	2.75	227.67
OP 7	-35.179213	147.265214	225.22	2.75	227.97
OP 8	-35.178663	147.266036	225.35	2.75	228.10
OP 9	-35.178080	147.266900	226.93	2.75	229.68
OP 10	-35.177508	147.267745	229.74	2.75	232.49
OP 11	-35.176924	147.268600	228.50	2.75	231.25
OP 12	-35.176355	147.269440	229.62	2.75	232.37
OP 13	-35.175795	147.270284	230.30	2.75	233.05
OP 14	-35.175223	147.271147	230.31	2.75	233.06
OP 15	-35.174639	147.272006	230.82	2.75	233.57
OP 16	-35.174062	147.272841	232.51	2.75	235.26
OP 17	-35.173466	147.273718	233.81	2.75	236.56
OP 18	-35.172892	147.274585	233.62	2.75	236.37
OP 19	-35.172322	147.275443	233.73	2.75	236.48
OP 20	-35.171757	147.276298	235.00	2.75	237.75
OP 21	-35.170897	147.277536	241.68	2.75	244.43

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	SA tracking	SA tracking	0	0	-	

PV & Receptor Analysis Results

Results for each PV array and receptor

PV array 1 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	0
OP: OP 15	0	0
OP: OP 16	0	0
OP: OP 17	0	0
OP: OP 18	0	0
OP: OP 19	0	0
OP: OP 20	0	0
OP: OP 21	0	0

No glare found

Assumptions

- 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.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- 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.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results fc 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.)
- 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.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

APPENDIX E:

ADDITIONAL ASSESSMENT - SOLAR PHOTOVOLTAIC GLINT AND GLARE STUDY (OCTOBER 2021)

Solar Photovoltaic Glint and Glare Study

NGH Consulting

Sandy Creek Solar Farm

October 2021

PAGERPOWER
Urban & Renewables

ADMINISTRATION PAGE

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Issue	Date	Detail of Changes
1	October 2021	Initial issue

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from a proposed solar photovoltaic (PV) development located north-east of Uranquinty in Australia. This glint and glare assessment concerns the possible impact upon surrounding local roads users, and activity at Connorton Model Airfield (Wagga Model Aero Club).

Pager Power

Pager Power has undertaken over 700 glint and glare assessments internationally. The company's own glint and glare guidance is based on industry experience and extensive consultation with industry stakeholders, including airports and aviation regulators.

Conclusions

Reflections are geometrically possible towards some of the local road receptors at certain times of the year. These reflections have been evaluated with reference to the Victoria State Government guidelines for solar developments, along with industry best-practice and experience. There are sufficient mitigating factors in place such that no further mitigation requirement has been identified.

Guidance and Studies

The Department of Environment, Land, Water and Planning in the Victoria State Government has created its own set of guidelines for the design and development of solar energy facilities, including a methodology for determining the impact upon road safety[1]. This set of guidelines was reviewed in the context of the proposed development.

Guidelines also exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. However, a specific methodology for determining the impact upon road safety and model aircraft activity has not been identified to date. Pager Power has consulted with relevant stakeholders and reviewed existing guidelines and the available studies (discussed below) in the process of defining its own glint and glare assessment guidance and methodology[2]. This methodology defines the process for determining the impact upon road safety.

Pager Power's approach is to undertake geometric reflection calculations and, where a solar reflection is predicted, consider the screening (existing and/or proposed) between the receptor and the reflecting solar panels. The scenario in which a solar reflection can occur for all

[1] Source: Solar Energy Facilities Design and Development Guideline, August 2019

[2] Source: Pager Power Glint and Glare Guidance, Third Edition (3.1), April 2021

receptors is then identified and discussed, and a comparison is made against the available solar panel reflection studies to determine the overall impact. The available studies have measured the intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. The results show that the reflections produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel[3].

The methodology for this assessment was formed with reference to the Victoria State Government guidelines for solar developments, along with industry best-practice and experience.

Assessment Results

Local Roads

Following a review of the available imagery and local topography, any solar reflections that are geometrically possible towards four of the 15 assessed road routes are predicted to be significantly screened under baseline conditions. No impacts are predicted, and no mitigation is required.

Any solar reflections that are geometrically possible towards three of the 15 assessed road routes are predicted to be significantly filtered under baseline conditions, such that only marginal views of reflecting panels may be possible. The intensity and duration of any impact is considered to be small. A low impact is predicted on these routes according to Pager Power's interpretation of the Victoria State Government guidelines for solar developments. Mitigation is not recommended due to sufficient mitigating factors already being in place.

Any solar reflections that are geometrically possible towards two of the 15 assessed road routes are predicted to be filtered under baseline conditions, however views of reflecting panels may be possible. The intensity and duration of any impact varies according to conditions. A moderate impact is predicted on these routes according to Pager Power's interpretation of the Victoria State Government guidelines for solar developments. Mitigation is not recommended due to sufficient mitigating factors already being in place.

Connorton Model Airfield

The modelling has shown that solar reflections are geometrically possible towards the assessed point at Connorton Model Airfield when the resting angle of the solar panels is set to zero degrees. The maximum daily duration of glare per day is four minutes. The intensity and duration of any impact is considered to be small. A low impact is therefore predicted. Mitigation is not recommended because:

- Reflections would only be possible in the evening when the Sun is low in the sky. Therefore, an observer will likely have a view of the Sun within the same viewpoint of the reflecting solar panels. The Sun is a far more significant source of light.

[3] Source: SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy, 2010).

- The tree belt proposed in the layout plan at the site boundary will significantly screen reflections once fully developed.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 51 countries within Europe, Africa, America, Asia and Australasia.

The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems.

Over the years, the company has expanded into numerous fields including:

- Renewable energy projects.
- Building developments.
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

1 INTRODUCTION

1.1 Overview

Pager Power has been retained to assess the possible effects of glint and glare from a proposed solar photovoltaic (PV) development located north-east of Uranquinty in Australia. This glint and glare assessment concerns the possible impact upon surrounding local roads users, and activity at Connorton Model Airfield (Wagga Model Aero Club).

This report contains the following:

- Solar development details.
- Explanation of glint and glare.
- Overview of relevant guidance.
- Overview of relevant studies.
- Overview of Sun movement.
- Assessment methodology.
- Identification of receptors.
- Glint and glare assessment for identified receptors.
- Results discussion.

Following this, a summary of findings and overall conclusions and recommendations from the desk-based analysis is presented. No site survey has taken place at this stage.

1.2 Pager Power's Experience

Pager Power has undertaken over 700 glint and glare assessments internationally. The company's own glint and glare guidance is based on industry experience and extensive consultation with industry stakeholders, including airports and aviation regulators.

1.3 Glint and Glare Definition

The definition of glint and glare can vary however, the definition used by Pager Power is as follows:

- Glint – a momentary flash of bright light typically received by moving receptors or from moving reflectors.
- Glare – a continuous source of bright light typically received by static receptors or from large reflective surfaces.

These definitions are aligned with those of the Federal Aviation Administration (FAA) in the United States of America. The term 'solar reflection' is used in this report to refer to both reflection types.

2 PROPOSED SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Site Layout Plan

The layout of the proposed solar development is shown in Figure 1[4] below, received from NGH Consulting. The black lines represent the location of solar panels and the green lines represent proposed tree planting.

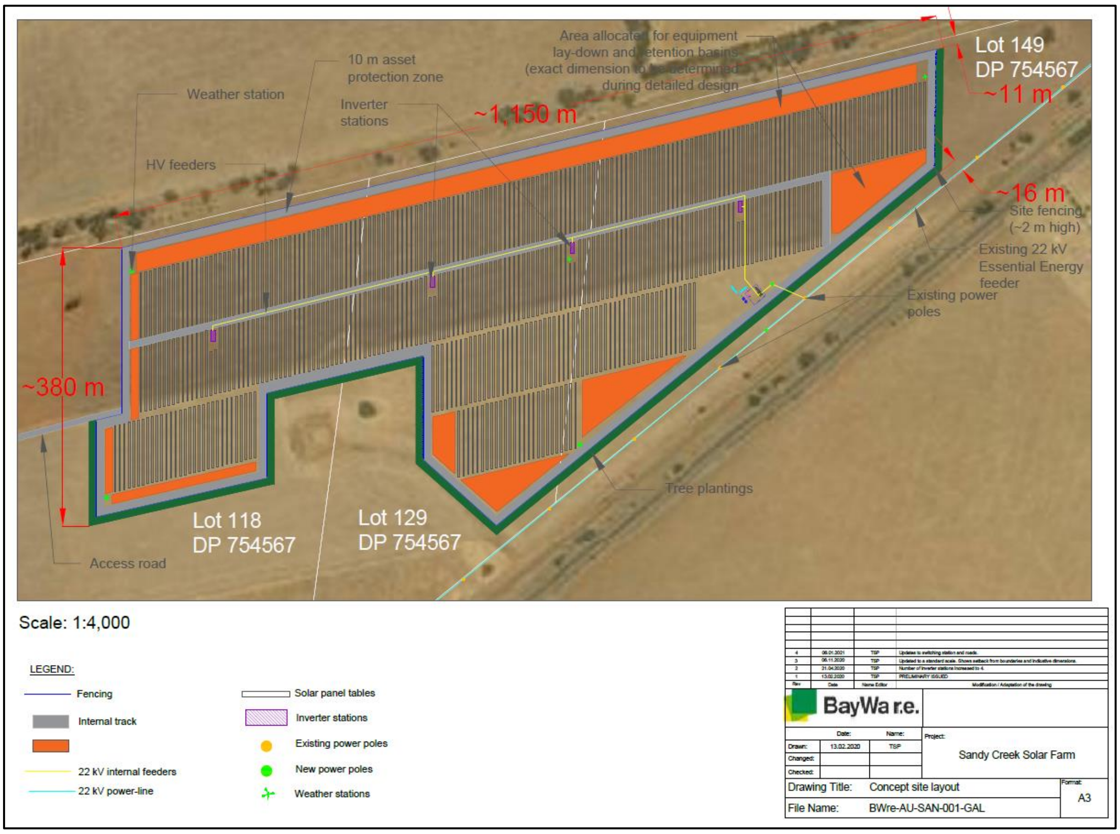

Figure 1 *Site layout plan*

[4] Source: 20210105 SAN site layout BWre-AU-SAN-001-GAL rev 4-2.pdf

2.2 Proposed Solar Development Location – Aerial Image

Figure 2[5] below shows the location of the proposed solar development. The red line represents the outer red line boundary, and the blue shaded area represents the assessed area of solar panels. Based on the information in Figure 1, panels may not actually be located in the whole of this blue area, however this is a conservative assessment and a worst-case scenario panel area has been considered.

Figure 2 *Proposed development location – aerial image*

[5] Copyright © 2021 Google.

2.3 Solar Panel Information

The design of the solar panel table is shown in Figure 3[6] below, received from NGH Consulting. The technical characteristics used for the modelling are presented in Table 1.

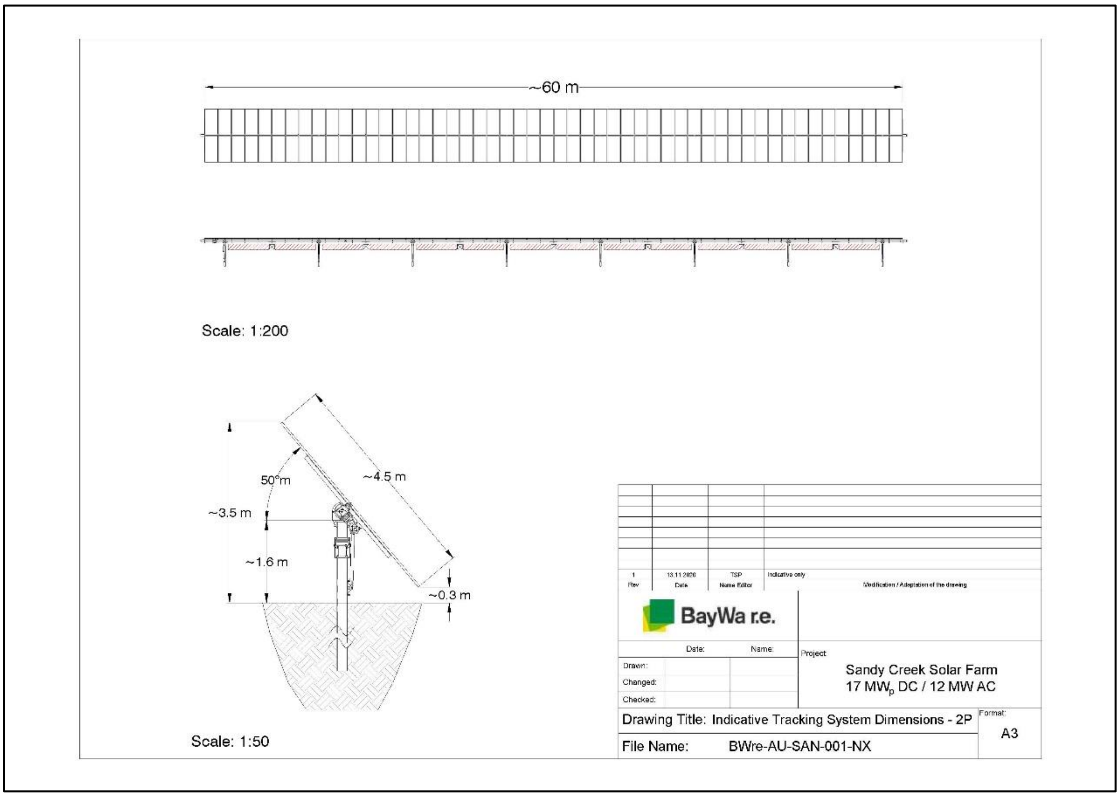

Figure 3 *Design of the solar panel table*

Solar Panel Technical Information	
Azimuth angle (°)	0
Axis height (m)	2.15 agl (above ground level)
Tracking	Horizontal Single Axis tracks Sun East to West
Tracker Range of Motion (°)	±60°
Resting angle (°)	0 or 5°

Table 1 *Solar panel technical information*

[6] Source: 2P Tracking System Drawing BWre-AU-SAN-001-NX-2P.pdf

2.3.1 Solar Panel Backtracking

Shading considerations dictate the panel tilt. This is affected by:

- The elevation angle of the Sun;
- The vertical tilt of the panels;
- The spacing between the panel rows.

This means that early in the morning and late in the evening, the panels will not be directed exactly towards the Sun, as the loss from shading of the panels (caused by facing the sun directly when the Sun is low in the horizon), would be greater than the loss from lowering the panels to a less direct angle in order to avoid the shading. Figure 4[7] below illustrates this.

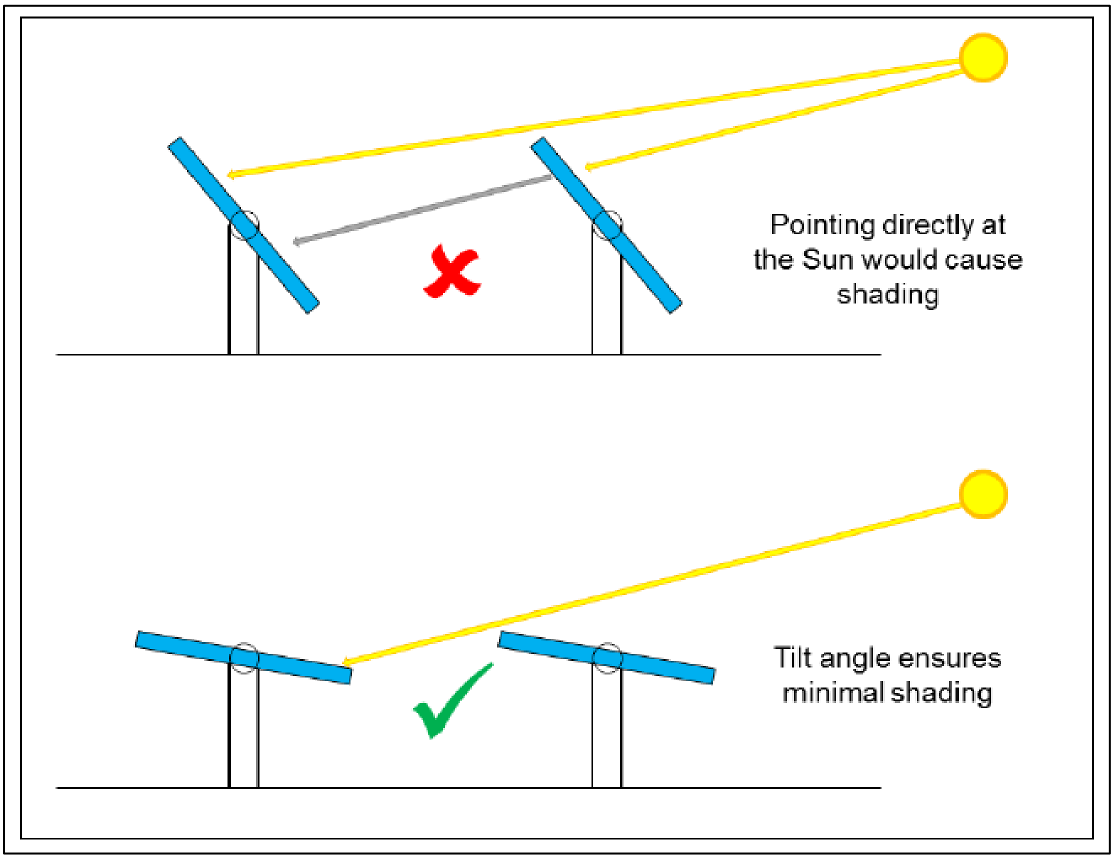

Figure 4 *Shading Considerations*

Later in the day, the panels can be directed towards the Sun without any shading issues. This is illustrated in Figure 5[7] on the following page.

[7] Note the graphics in Figure 4 and Figure 5 show two lines illustrating the paths of light from the Sun towards the solar panels. In reality, the lines from the Sun to each panel would be effectively parallel due to the large separation distance. The figure is for illustrative purposes only.

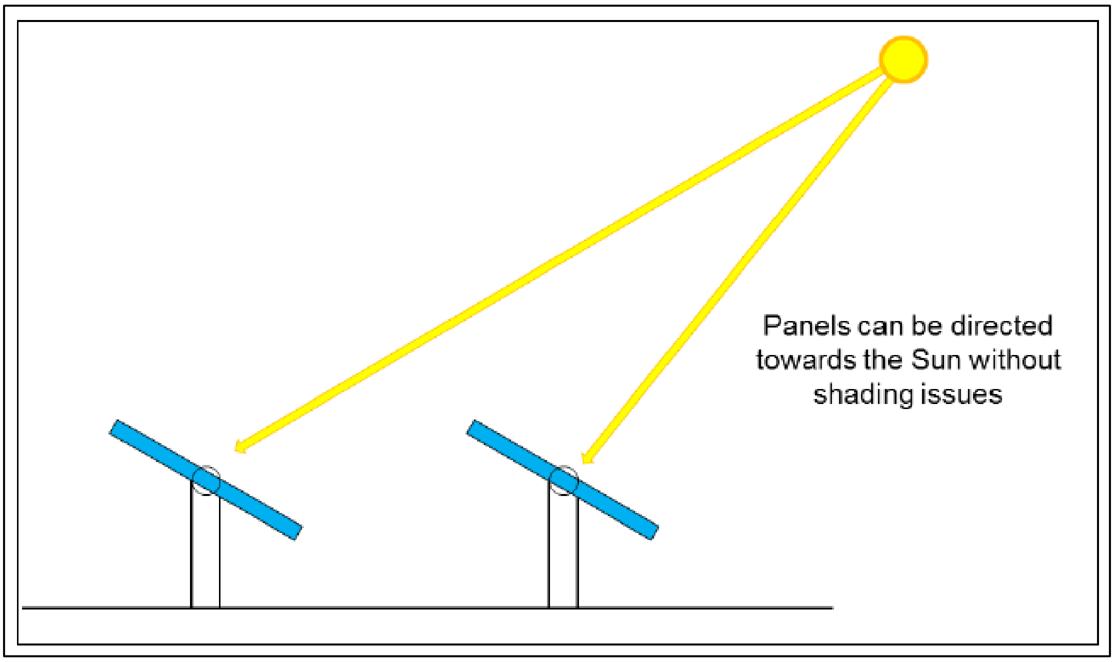

Figure 5 *Panel alignment at high solar angles*

The solar panels backtrack (where the panel angle gradually declines to prevent shading) by reverting to either 0 degrees (flat) or 5 degrees, once the maximum elevation angle of the panels (60 degrees) becomes ineffective due to the low height of the Sun above the horizon and to avoid shading.

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Guidance and Studies

Appendices A and B present a review of relevant guidance and independent studies with regard to glint and glare issues from solar panels. The overall conclusions from the available studies are as follows:

- Specular reflections of the Sun from solar panels are possible.
- The measured intensity of a reflection from solar panels can vary from 2% to 30% depending on the angle of incidence.
- Published guidance shows that the intensity of solar reflections from solar panels are equal to or less than those from water. It also shows that reflections from solar panels are significantly less intense than many other reflective surfaces, which are common in an outdoor environment.

3.2 Background

Details of the Sun's movements and solar reflections are presented in Appendix C.

3.3 Victoria State Government Guidelines

The Department of Environment, Land, Water and Planning in the Victoria State Government produced a set of guidelines for the design and development of solar energy facilities in 2019[8]. It states that any assessment of glint and glare should use an accepted methodology based on best practice.

The guidelines also state that any assessment should consider impacts on:

- dwellings and roads within 1 km of the proposed facility, taking into consideration their height within the landscape.
- aviation infrastructure including any air traffic control tower or runway approach path close to the proposed facility
- any other receptor to which a responsible authority considers solar reflection may be a hazard.

3.4 Methodology

The methodology for this assessment was formed with reference to the Victoria State Government guidelines, along with industry best-practice and experience and is as follows:

- Identify receptors within 1km of the solar development.
- Consider direct solar reflections from the solar development towards the identified receptors by undertaking geometric calculations.

[8] Solar Energy Facilities Design and Development Guideline

- Consider the visibility of the panels from the receptor's location. If the panels are not visible from the receptor then no reflection can occur.
- Based on the results of the geometric calculations, determine whether a reflection can occur, and if so, at what time it will occur.
- Consider both the solar reflection from the solar development and the location of the direct sunlight with respect to the receptor's position.
- Consider the solar reflection with respect to the published studies and guidance.
- Determine whether a significant detrimental impact is expected in line with the process stated in the Victoria State Government guidelines. This is presented in Appendix D.

In this assessment, Forge was exclusively used for the modelling. Within the model, the solar development area is defined, as well as the relevant receptor locations. The result is a chart that states whether a reflection can occur, the duration and the panels that can produce the solar reflection towards the receptor.

3.5 Assessment Limitations

Further technical details regarding the methodology of the geometric calculations and limitations are presented in Appendix E and Appendix F.

4 IDENTIFICATION OF RECEPTORS

4.1 Receptors Overview

The Victoria State Government guidelines for solar developments[8] state that any assessment should consider impacts on relevant receptors within 1 km of the proposed facility, taking into consideration their height within the landscape. Therefore, the assessment area has been designed accordingly as a 1km boundary from solar panels (white outlined areas on the proceeding figures).

Potential receptors are identified based on mapping and aerial photography of the region. The initial judgement is made based on a high-level consideration of aerial photography and mapping i.e. receptors are excluded if it is clear from the outset that no visibility would be possible. A more detailed assessment is made if the modelling reveals a reflection would be geometrically possible.

Terrain elevation heights are based on Forge SRTM data. An overview of the one-kilometre assessment area is presented in Figure 6[5] below and the receptors are further clarified in the following sections. Receptor details can be found in Appendix G.

Figure 6 *One-kilometre assessment area overview – aerial image*

4.2 Road Receptors

Road types can generally be categorised as:

- Major National – Typically a road with a minimum of two carriageways with a maximum speed limit of up to 110kph. These roads typically have fast-moving vehicles with busy traffic.
- National – Typically a road with a one or more carriageways with a maximum speed limit of up to 100kph or 110kph. These roads typically have fast-moving vehicles with moderate to busy traffic density.
- Regional – Typically a single carriageway with a maximum speed limit of up to 100kph. The speed of vehicles will vary with a typical traffic density of low to moderate; and
- Local - Typically roads and lanes with the lowest traffic densities. Speed limits vary.

In this assessment, the analysis has considered any local roads that are within one kilometre of the proposed development.

15 local road routes were identified for assessment, as shown by the blue lines in Figure 7[5] below and labelled. A height of 1.5 metres above ground level has been taken as typical eye level for a road user. This height has been added to the ground height at each receptor location. Visibility and direction of travel is considered in the assessment of all receptors.

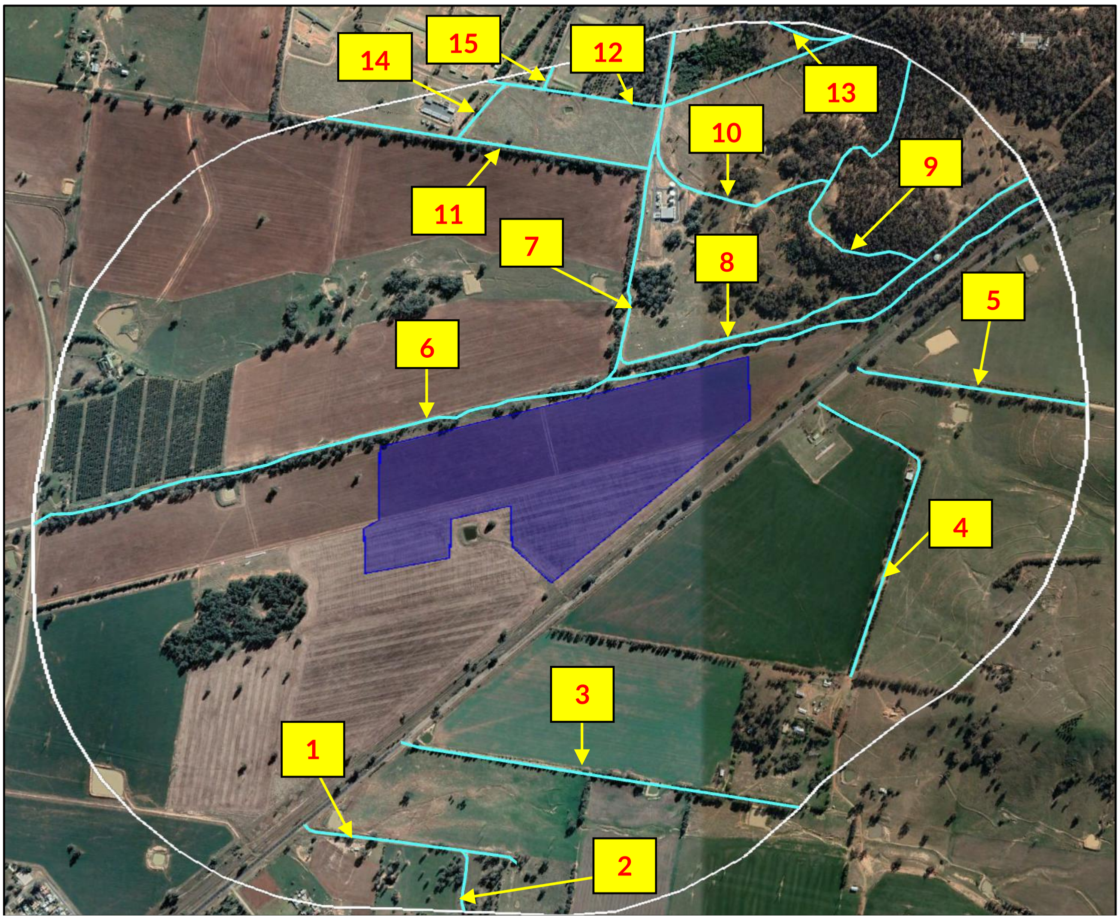

Figure 7 *Assessed road routes – aerial image*

4.3 Connorton Model Airfield

The analysis has considered Connorton Model Airfield, where activities related to model aircraft flight take place, following the criteria for a dwelling observer. A height of 1.8 metres above ground level has been taken as typical eye level for an observer standing on the ground.

An overview of the receptor location is shown in Figure 8[5] below.

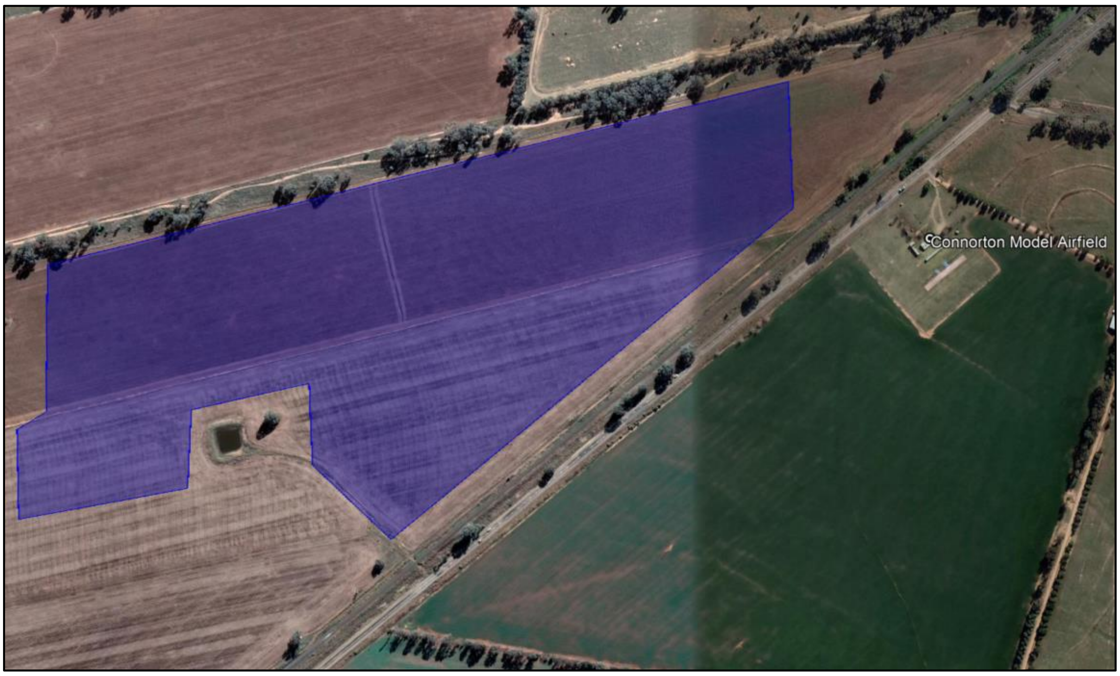

Figure 8 *Connorton Model Airfield Receptor*

5 ASSESSED REFLECTOR AREA

5.1 Reflector Area

The bounding coordinates for the proposed solar farm development have been extrapolated from the site plans. The data can be found in Appendix G. Figure 9 below shows the assessed reflector area that has been used for modelling purposes.

Figure 9 *Assessed reflector area – aerial image*

6 GLINT AND GLARE ASSESSMENT – GEOMETRIC CALCULATION RESULTS

6.1 Geometric Calculation Results Overview

The tables in the following subsections present the results of the geometric calculations for the ground-based receptors. The predicted glare times are based solely on bare-earth terrain i.e. without consideration of screening from buildings and vegetation.

Section 7 summarises the predicted impact considering the level of identified screening based on a desk-based review of the available imagery. The flowcharts setting out the impact characterisation and presented in Appendix D. The list of assumptions and limitations are presented in Appendix F. The significance of any predicted effects has been evaluated based on Pager Power's interpretation of the Victoria State Government guidance for solar developments**Error! Bookmark not defined.**. The modelling output for key receptors showing the precise predicted times and the reflecting panel area(s) can be provided on request.

When evaluating visibility in the context of glint and glare, it is only the *reflecting* panel area that must be considered. For example, if the western half of the development is visible, but reflections would only be possible from the eastern half, it can be concluded that the reflecting area is not visible and no impacts are predicted. This is why there can be instances where visibility of the development is predicted, but glint and glare issues are screened.

6.2 Road Routes

6.2.1 0-degree resting angle

The results of the geometric calculations towards the road routes for a 0-degree resting angle are presented in Table 2 below.

Route	Results: Reflection possible towards the road user? (AEDT[9]) am	Results: Reflection possible towards the road user? (AEDT[9]) pm	Comments
1 – 2.	No.	No.	Solar reflections are not geometrically possible. No impact is predicted.

[9] Modelling was run in AEDT but conclusions for AEST would be the same; only the glare curves would shift one hour in accordance with sunset and sunrise times shifting by one hour.

Route	Results		Comments
	Reflection possible towards the road user? (AEDT[9])		
	am	pm	
3	No.	Yes.	Solar reflections predicted to originate from south-western panel areas.
4 – 5.	No.	Yes.	Solar reflections predicted to originate from all panel areas.
6	Yes.	Yes.	Solar reflections predicted to originate from upper panel areas.
7	Yes.	Yes.	Solar reflections predicted to originate from north-eastern and north-western panel areas.
8	Yes.	Yes.	Solar reflections predicted to originate from upper panel areas.
9	No.	Yes.	Solar reflections predicted to originate from northern and north-western panel areas.
10	No.	Yes.	Solar reflections predicted to originate from north-western panel areas.
11	Yes.	No.	Solar reflections predicted to originate from north-eastern panel areas.
12 – 15.	No.	No.	Solar reflections are not geometrically possible. No impact is predicted.

Table 2 *Geometric analysis results for a 0-degree resting angle – road routes*

6.2.2 5-degree resting angle

The results of the geometric calculations towards the road routes for a 5-degree resting angle are presented in Table 3 below.

Route	Results		Comments
	Reflection possible towards the road user? (AEDT[9])		
	am	pm	
1 – 15.	No.	No.	Solar reflections are not geometrically possible. No impacts are predicted.

Table 3 *Geometric analysis results for a 5-degree resting angle – road routes*

6.3 Connorton Model Airfield

The results of the geometric calculations towards the Connorton Model Airfield receptor are presented in Table 4 below.

Resting angle	Results		Comments
	Reflection possible? (AEDT)		
	am	pm	
0	No.	Yes.	Solar reflections predicted to originate from panel areas around the site.
5	No.	No.	Solar reflections are not geometrically possible.

Table 4 Geometric analysis results – Connorton Model Airfield receptor

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Road Routes

The modelling has shown that solar reflections are geometrically possible towards:

- Route 3 originating from south-western panel areas;
- Routes 4 and 5 originating from all panel areas;
- Route 6 originating from upper panel areas;
- Route 7 originating from north-eastern and north-western panel areas;
- Route 8 originating from upper panel areas;
- Route 9 originating from northern and north-western panel areas;
- Route 10 originating from north-western panel areas; and
- Route 11 originating from north-eastern panel areas.

These sections of road are represented by the yellow lines in Figure 10[5] below. The reflections are only possible when the resting angle of the solar panels is set to 0 degrees. The modelling output for these receptors showing the precise predicted times and the reflecting panel area(s) can be provided on request.

Figure 10 *Sections of road where solar reflections are geometrically possible (yellow lines) – aerial image*

Table 5 below summarises the predicted impact significance and mitigation requirement for the road routes where solar reflections are geometrically possible. The impact significance was determined following the recommended definitions stated in Victoria State Government guidance for solar panel developments and outlined in Appendix D. The proposed screening from the developer has been considered where required.

Road Route	Analysis of Baseline Conditions	Impact Classification according to Victoria Guidelines	Relevant Factors	Further Mitigation Recommended?
3	Maximum daily duration of glare per day is 3 minutes. Existing vegetation and intervening terrain screening will significantly filter views. Marginal views within field of view may be possible.	Low impact predicted.	Tree Belt proposed in layout plan at site boundary will significantly screen reflections once fully developed. The reflecting area within the proposed development is more than a kilometre away from the section of the road route where reflections are possible.	No.
4	Maximum daily duration of glare per day is 16 minutes. Existing vegetation screening will filter views. Views within field of view may be possible.	Moderate impact predicted.	Tree Belt proposed in layout plan at site boundary will significantly screen reflections once fully developed. A large part of the reflecting area within the proposed development is more than a kilometre away from the section of the road route where reflections are possible.	No.

Road Route	Analysis of Baseline Conditions	Impact Classification according to Victoria Guidelines	Relevant Factors	Further Mitigation Recommended?
5	Maximum daily duration of glare per day is 19 minutes. Existing vegetation and intervening terrain screening will significantly filter views. Marginal views within field of view may be possible.	Low impact predicted.	Tree Belt proposed in layout plan at site boundary will significantly screen reflections once fully developed.	No.
6	Maximum daily duration of glare per day is 45 minutes. Existing vegetation screening will filter views. Views within field of view may be possible.	Moderate impact predicted.	The route appears to be a single lane track, with no markings, and is difficult to identify on aerial imagery. The level of traffic on this road is likely to be extremely low.	No.
7	Maximum daily duration of glare per day is 18 minutes. Existing vegetation screening will significantly filter views. Marginal views within field of view may be possible.	Low impact predicted.	The route appears to be a single lane track, with no markings. The level of traffic on this road is likely to be extremely low.	No.
8	Maximum daily duration of glare per day is 33 minutes. Existing vegetation screening will significantly filter views. Views are not expected to be possible.	No impact predicted.	The route appears to be an single lane track, with no markings. The level of traffic on this road is likely to be extremely low.	No.

Road Route	Analysis of Baseline Conditions	Impact Classification according to Victoria Guidelines	Relevant Factors	Further Mitigation Recommended?
9	Maximum daily duration of glare per day is 23 minutes. Existing vegetation screening will significantly filter views. Views are not expected to be possible.	No impact predicted.	The route appears to be a single lane track, with no markings, and is difficult to identify on aerial imagery. The level of traffic on this road is likely to be extremely low.	No.
10	Maximum daily duration of glare per day is 7 minutes. Existing vegetation screening will significantly filter views. Views are not expected to be possible.	No impact predicted.	The route appears to be a single lane track, with no markings. The level of traffic on this road is likely to be extremely low.	No.
11	Maximum daily duration of glare per day is 8 minutes. Existing vegetation screening and intervening terrain will significantly filter views. Views are not expected to be possible.	No impact predicted.	The route appears to be a single lane track, with no markings. The level of traffic on this road is likely to be extremely low.	No.

Table 5 *Assessment of mitigation requirement – dwelling receptors*

Following a review of the available imagery and local topography, any solar reflections that are geometrically possible towards road routes 8 – 11 are predicted to be significantly screened under baseline conditions. No impacts are predicted, and no mitigation is required.

Any solar reflections that are geometrically possible towards road routes 3, 5, and 7, are predicted to be significantly filtered under baseline conditions, such that only marginal views of reflecting panels may be possible. The intensity and duration of any impact is considered to be small. A low impact is predicted on these routes according to Pager Power's interpretation of the Victoria State Government Reflections are geometrically possible towards some of the local road receptors at certain times of the year. These reflections have been evaluated with reference to the Victoria State Government guidelines for solar developments, along with industry best-practice and experience. There are sufficient mitigating factors in place such that no further mitigation requirement has been identified.

for solar developments. Mitigation is not recommended due to sufficient mitigating factors already being in place, as per Table 5.

Any solar reflections that are geometrically possible towards road routes 4 and 6 are predicted to be filtered under baseline conditions, however views of reflecting panels may be possible. The intensity and duration of any impact varies according to conditions. A moderate impact is predicted on these routes according to Pager Power's interpretation of the Victoria State Government guidance for solar developments. Mitigation is not recommended due to sufficient mitigating factors already being in place, as per Table 5.

7.2 Connorton Model Airfield

The modelling has shown that solar reflections are geometrically possible towards the Connorton Model Airfield receptor when the resting angle of the solar panels is set to 0 degrees. The maximum daily duration of glare per day is 4 minutes. The intensity and duration of any impact is considered to be small. A low impact is therefore predicted. Mitigation is not recommended because:

- Reflections would only be possible in the evening when the Sun is low in the sky. Therefore, an observer will likely have a view of the Sun within the same viewpoint of the reflecting solar panels. The Sun is a far more significant source of light.
- The tree belt proposed in the layout plan at the site boundary will significantly screen reflections once fully developed.

7.3 Overall Conclusions

Reflections are geometrically possible towards some of the local road receptors at certain times of the year. These reflections have been evaluated with reference to the Victoria State Government guidelines for solar developments, along with industry best-practice and experience. There are sufficient mitigating factors in place such that no further mitigation requirement has been identified.

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

This section presents details regarding the relevant guidance and studies with respect to the considerations and effects of solar reflections from solar panels, known as 'Glint and Glare'.

This is not a comprehensive review of the data sources, rather it is intended to give an overview of the important parameters and considerations that have informed this assessment.

UK Planning Policy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[10] (specifically regarding the consideration of solar farms, paragraph 013) states:

'What are the particular planning considerations that relate to large scale ground-mounted solar photovoltaic Farms?

The deployment of large-scale solar farms can have a negative impact on the rural environment, particularly in undulating landscapes. However, the visual impact of a well-planned and well-screened solar farm can be properly addressed within the landscape if planned sensitively.

Particular factors a local planning authority will need to consider include:

…

- *the proposal's visual impact, the effect on landscape of glint and glare (see guidance on landscape assessment) and on **neighbouring uses and aircraft safety**;*
- *the extent to which there may be additional impacts if solar arrays follow the daily movement of the sun.*

…

The approach to assessing cumulative landscape and visual impact of large-scale solar farms is likely to be the same as assessing the impact of wind turbines. However, in the case of ground-mounted solar panels it should be noted that with effective screening and appropriate land topography the area of a zone of visual influence could be zero.'

Assessment Process – Ground-Based Receptors

No process for determining and contextualising the effects of glint and glare are, however, provided for assessing the impact of solar reflections on surrounding roads and dwellings. Therefore, the Pager Power approach is to determine whether a reflection from the proposed solar development is geometrically possible and then to compare the results against the

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[10] Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 18 June 2015, accessed on: 17/06/2020

relevant guidance/studies to determine whether the reflection is significant. The Pager Power approach has been informed by the policy presented above, current studies (presented in Appendix B) and stakeholder consultation. Further information can be found in Pager Power's Glint and Glare Guidance document[11] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

[11] Source: Pager Power Glint and Glare Guidance, Third Edition (3.1), April 2021

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

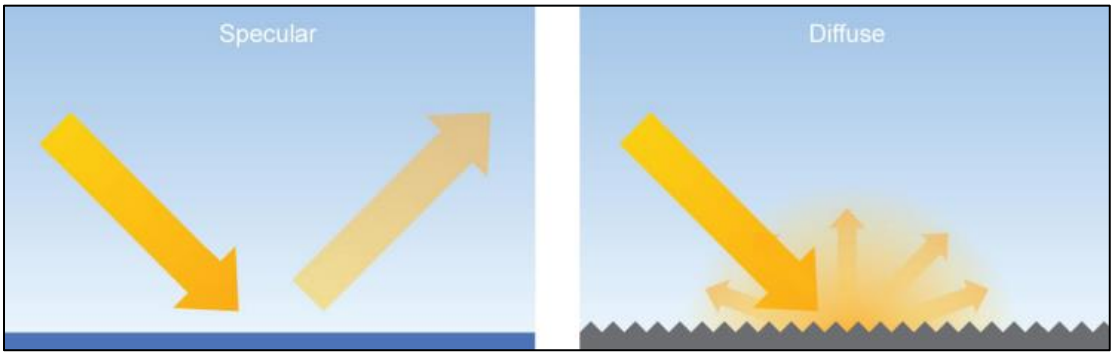
Overview

Studies have been undertaken assessing the type and intensity of solar reflections from various surfaces including solar panels and glass. An overview of these studies is presented below.

The guidelines presented are related to aviation safety. The results are applicable for the purpose of this analysis.

Reflection Type from Solar Panels

Based on the surface conditions reflections from light can be specular and diffuse. A specular reflection has a reflection characteristic similar to that of a mirror; a diffuse will reflect the incoming light and scatter it in many directions. The figure below, taken from the FAA guidance[12], illustrates the difference between the two types of reflections. Because solar panels are flat and have a smooth surface most of the light reflected is specular, which means that incident light from a specific direction is reradiated in a specific direction.



Specular and diffuse reflections

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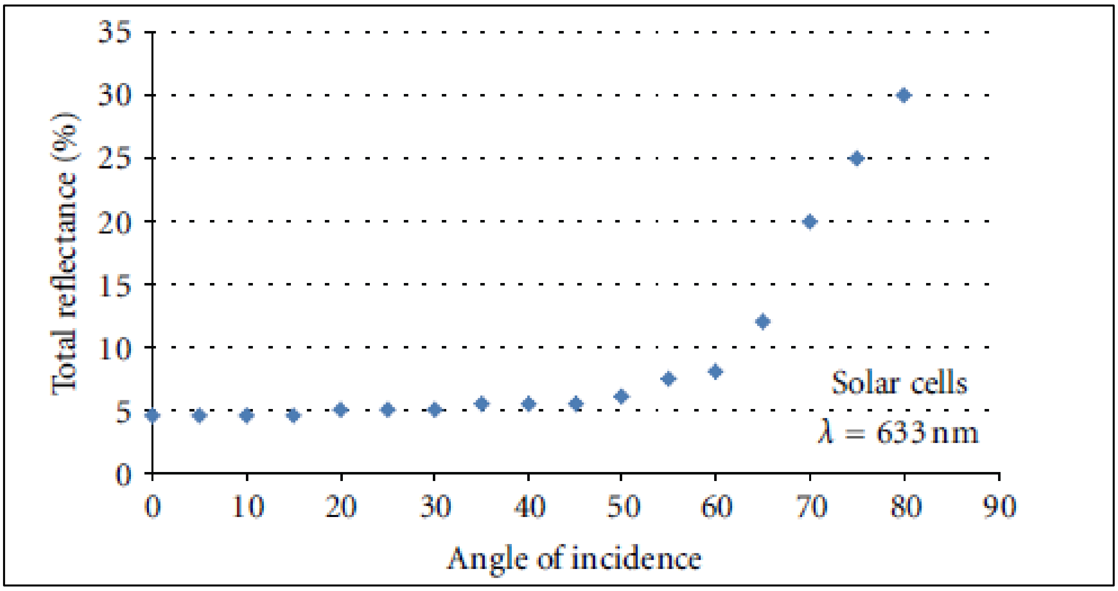
[12] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

Solar Reflection Studies

An overview of content from identified solar panel reflectivity studies is presented in the subsections below.

Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems"

Evan Riley and Scott Olson published in 2011 their study titled: *A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems*[13]". They researched the potential glare that a pilot could experience from a 25 degree fixed tilt PV system located outside of Las Vegas, Nevada. The theoretical glare was estimated using published ocular safety metrics which quantify the potential for a postflash glare after-image. This was then compared to the postflash glare after-image caused by smooth water. The study demonstrated that the reflectance of the solar cell varied with angle of incidence, with maximum values occurring at angles close to 90 degrees. The reflectance values varied from approximately 5% to 30%. This is shown on the figure below.



Total reflectance % when compared to angle of incidence

The conclusions of the research study were:

- The potential for hazardous glare from flat-plate PV systems is similar to that of smooth water;
- Portland white cement concrete (which is a common concrete for runways), snow, and structural glass all have a reflectivity greater than water and flat plate PV modules.

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[13] Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems," ISRN Renewable Energy, vol. 2011, Article ID 651857, 6 pages, 2011. doi:10.5402/2011/651857

FAA Guidance – "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[14]

The 2010 FAA Guidance included a diagram which illustrates the relative reflectance of solar panels compared to other surfaces. The figure shows the relative reflectance of solar panels compared to other surfaces. Surfaces in this figure produce reflections which are specular and diffuse. A specular reflection (those made by most solar panels) has a reflection characteristic similar to that of a mirror. A diffuse reflection will reflect the incoming light and scatter it in many directions. A table of reflectivity values, sourced from the figure within the FAA guidance, is presented below.

Surface	Approximate Percentage of Light Reflected[15]
Snow	80
White Concrete	77
Bare Aluminium	74
Vegetation	50
Bare Soil	30
Wood Shingle	17
Water	5
Solar Panels	5
Black Asphalt	2

Relative reflectivity of various surfaces

Note that the data above does not appear to consider the reflection type (specular or diffuse).

An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel.

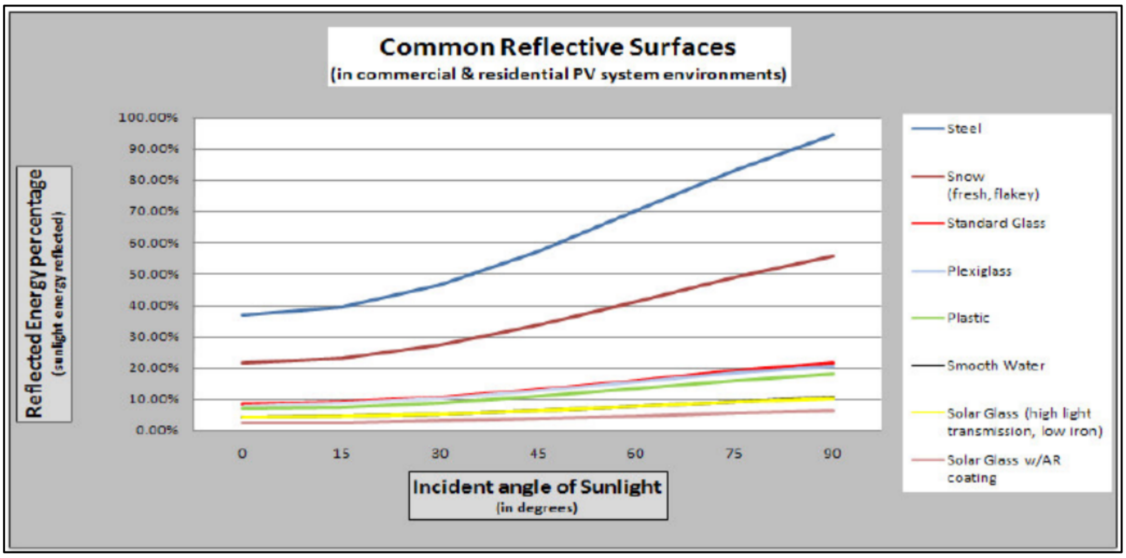
The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

[14] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.
[15] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification[16] to 'increase awareness concerning the possible glare and reflectance impact of PV Systems on their surrounding environment'.

The figure presented below shows the relative reflectivity of solar panels compared to other natural and manmade materials including smooth water, standard glass and steel.



Common reflective surfaces

The results, similarly to those from Riley and Olsen study (2011) and the FAA (2010), show that solar panels produce a reflection that is less intense than those of '*standard glass and other common reflective surfaces*'.

With respect to aviation and solar reflections observed from the air, SunPower has developed several large installations near airports or on Air Force bases. It is stated that these developments have all passed FAA or Air Force standards with all developments considered "No Hazard to Air Navigation". The note suggests that developers discuss any possible concerns with stakeholders near proposed solar farms.

[16] Source: Technical Support, 2009. SunPower Technical Notification – Solar Module Glare and Reflectance.

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

The Sun's position in the sky can be accurately described by its azimuth and elevation. Azimuth is a direction relative to true north (horizontal angle i.e. from left to right) and elevation describes the Sun's angle relative to the horizon (vertical angle i.e. up and down).

The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

- Time.
- Date.
- Latitude.
- Longitude.

The combination of the Sun's azimuth angle and vertical elevation will affect the direction and angle of the reflection from a reflector.

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

The significance of glint and glare will vary for different receptors. The following section presents a general overview of the significance criteria with respect to experiencing a solar reflection.

Impact Significance Definition

The table below presents the recommended definition of 'impact significance' in glint and glare terms according to Victoria State Government guidance for solar panel developments**Error! Bookmark not defined.**.

Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible, but the intensity and duration of an impact is considered to be small.	Can be mitigated with screening or other measure.
Moderate	A solar reflection is geometrically possible and visible, but the intensity and duration of an impact varies according to conditions.	Mitigation measures (such as through design, orientation, landscaping or other screening method) to reduce impacts to an acceptable level will be required.
Major	A solar reflection is geometrically possible and visible under a range of conditions that will produce impacts with significant intensity and duration.	Significant mitigation measures are required if the proposed development is to proceed.

Impact significance definition – Victoria State Government guidance

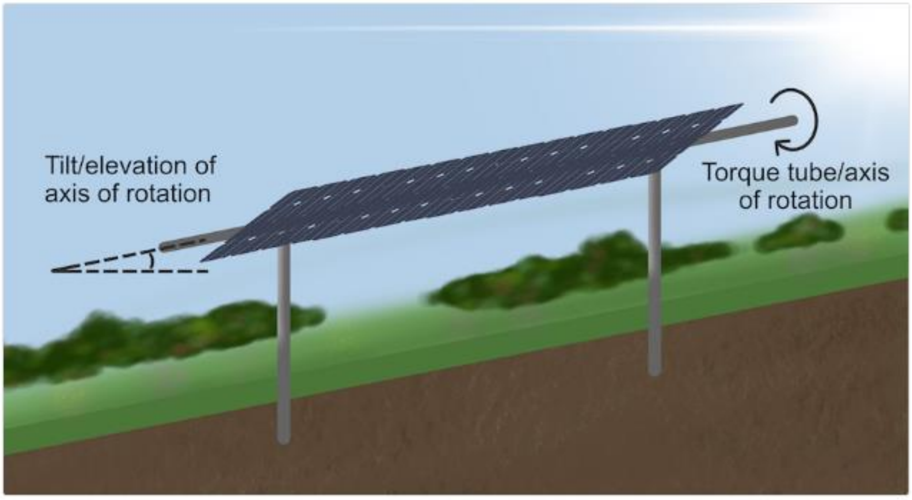
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Forge Reflection Calculations Methodology

Extracts taken from the Forge Solar Model.

Tracking System Parameters

Single-axis module tracking systems are described by a unique set of parameters. These angular inputs model the tracking axis, rotation range and backtracking behavior. Dual-axis module tracking systems are assumed to track the sun at all times.



Single-axis tracking system with torque tube tilted due to geography

Tilt of tracking axis (°)
Tilt above flat ground of axis over which panels rotate (e.g. torque tube). System on flat, level ground would have axis tilt of 0°.

Orientation of tracking axis (°)
Azimuthal angle of axis over which panels rotate. Angle represents the facing of the axis and system. For example, typical tracking system in northern hemisphere has tracking axis oriented north-south with an orientation of 180°, allowing panels to rotate east-west with potential south-facing tilt. Typical tracking system in southern hemisphere runs south-north with axis orientation of 0°, yielding east-west rotation with potential north-facing tilt.

Offset angle of module (°)
Additional tilt angle of PV module elevated above tracking axis/torque tube. Offset angle is measured from the torque tube.

Maximum tracking angle (°)
Maximum angle of rotation of tracking system in one direction. For example, a typical system with a 120° range of rotation has a *max tracking angle* of 60° (east/west).

Resting angle (°)
Angle of rotation of panels when sun is outside tracking range. Used to model backtracking. Panels will revert to the position described by this rotation angle at all times when the sun is outside the rotation range. Setting this equal to the *maximum tracking angle* implies the panels do not backtrack.

ForgeSolar utilizes a simplified model of backtracking which assumes panels instantaneously revert to the *resting angle* whenever the sun is outside the rotation range. For example, panels with *max tracking angle* of 60° and *resting angle* of 0° would lie flat from sunrise until the sun enters the rotation range, and immediately after the sun leaves the rotation range until sunset daily.

Tracking System Parameters

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Forge's Sandia National Laboratories' (SGHAT) Model[17]

Summary of assumptions and abstractions required by the SGHAT/ForgeSolar analysis methodology

1. Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
2. Result data files and plots are now retained for two years after analysis completion. Files should be downloaded and saved if additional persistence is required.
3. 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.
4. Several 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 analyses of path receptors.
5. 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.
6. 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.)
7. The algorithm assumes that the PV array is aligned with a plane defined by the total heights of the coordinates outlined in the Google map. For more accuracy, the user should perform runs using minimum and maximum values for the vertex heights to bound the height of the plane containing the solar array. Doing so will expand the range of observed solar glare when compared to results using a single height value.
8. 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.
9. 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.
10. 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.
11. 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.
12. 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.
13. Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
14. Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
15. PV array tracking assumes the modules move instantly when tracking the sun, and when reverting to the rest position.

[17] https://www.forgesolar.com/help/#assumptions

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Terrain Height

Terrain Height is calculated by Forge from SRTM data, based on the coordinates of the point of interest.

Road Route 1 Data

The table below presents the coordinates defining the vertices defining the assessed road route 1.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.257485	-35.184852	3	147.264319	-35.185738
2	147.25771	-35.185071	4	147.264566	-35.185948

Road Route 1

Road Route 2 Data

The table below presents the coordinates defining the vertices defining the assessed road route 2.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.262774	-35.185589	3	147.262742	-35.187027
2	147.262913	-35.185782	4	147.262913	-35.187334

Road Route 2

Road Route 3 Data

The table below presents the coordinates defining the vertices defining the assessed road route 3.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.260864	-35.182621	3	147.273961	-35.184357
2	147.261143	-35.182735			

Road Route 3

Road Route 4 Data

The table below presents the coordinates defining the vertices defining the assessed road route 4.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.274411	-35.173402	4	147.277801	-35.174971
2	147.275055	-35.173761	5	147.277844	-35.175182
3	147.277576	-35.174796	6	147.275559	-35.180803

Road Route 4

Road Route 5 Data

The table below presents the coordinates defining the vertices defining the assessed road route 5.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.275802	-35.172497	3	147.283291	-35.17355
2	147.276532	-35.172743			

Road Route 5

Road Route 6 Data

The table below presents the coordinates defining the vertices defining the assessed road route 6.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.248487	-35.176724	21	147.267438	-35.17291
2	147.249259	-35.176496	22	147.267604	-35.172823
3	147.249989	-35.176496	23	147.268028	-35.172818
4	147.250874	-35.176284	24	147.268929	-35.172665
5	147.251926	-35.176078	25	147.270147	-35.172463
6	147.25207	-35.175907	26	147.270753	-35.172336
7	147.253658	-35.175543	27	147.271498	-35.172025
8	147.254999	-35.175206	28	147.272019	-35.171911

9	147.256464	-35.174951	29	147.272453	-35.171919
10	147.257539	-35.174827	30	147.27292	-35.17177
11	147.25925	-35.174428	31	147.273612	-35.171726
12	147.260801	-35.174116	32	147.274063	-35.171525
13	147.261466	-35.173985	33	147.274604	-35.171384
14	147.261923	-35.173862	34	147.275667	-35.171248
15	147.26261	-35.173879	35	147.276407	-35.171051
16	147.263076	-35.173656	36	147.277727	-35.170345
17	147.263827	-35.173542	37	147.278644	-35.169784
18	147.264562	-35.173366	38	147.279577	-35.169104
19	147.265254	-35.173287	39	147.280725	-35.168477
20	147.266332	-35.173213	40	147.281728	-35.168039

Road Route 6

Road Route 7 Data

The table below presents the coordinates defining the vertices defining the assessed road route 7.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.267608	-35.172829	6	147.268809	-35.167848
2	147.267897	-35.172452	7	147.269077	-35.166804
3	147.268112	-35.171566	8	147.269314	-35.165822
4	147.26838	-35.170496	9	147.269485	-35.164971
5	147.268509	-35.169233	10	147.269786	-35.16341

Road Route 7

Road Route 8 Data

The table below presents the coordinates defining the vertices defining the assessed road route 8.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.267994	-35.172049	7	147.275171	-35.170724
2	147.268026	-35.172329	8	147.275654	-35.170698
3	147.268241	-35.172417	9	147.276513	-35.170488
4	147.270826	-35.171821	10	147.27942	-35.168541
5	147.273712	-35.171338	11	147.280965	-35.16762
6	147.274088	-35.171189	12	147.281353	-35.16746

Road Route 8

Road Route 9 Data

The table below presents the coordinates defining the vertices defining the assessed road route 9.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.277716	-35.169692	9	147.275431	-35.16678
2	147.277073	-35.169438	10	147.275796	-35.166544
3	147.276236	-35.16928	11	147.276225	-35.166491
4	147.275431	-35.169131	12	147.276622	-35.166719
5	147.274465	-35.16892	13	147.276901	-35.166333
6	147.27424	-35.168622	14	147.277083	-35.165684
7	147.274208	-35.168377	15	147.27733	-35.164281
8	147.274648	-35.167798			

Road Route 9

Road Route 10 Data

The table below presents the coordinates defining the vertices defining the assessed road route 10.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.269198	-35.166324	7	147.272845	-35.168035
2	147.269305	-35.16693	8	147.273167	-35.167807
3	147.269863	-35.167508	9	147.273886	-35.167684
4	147.27071	-35.167754	10	147.274251	-35.167614
5	147.27203	-35.16807	11	147.274691	-35.167693
6	147.272405	-35.168193			

Road Route 10

Road Route 11 Data

The table below presents the coordinates defining the vertices defining the assessed road route 11.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.268994	-35.167149	2	147.258222	-35.165772

Road Route 11

Road Route 12 Data

The table below presents the coordinates defining the vertices defining the assessed road route 12.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.263694	-35.164816	6	147.273704	-35.164237
2	147.264434	-35.16486	7	147.274755	-35.163939
3	147.267213	-35.165237	8	147.27498	-35.163842
4	147.269412	-35.165465	9	147.275141	-35.163527
5	147.271687	-35.164816			

Road Route 12

Road Route 13 Data

The table below presents the coordinates defining the vertices defining the assessed road route 13.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.272802	-35.163237	4	147.274991	-35.163851
2	147.273757	-35.163579	5	147.275764	-35.163667
3	147.27453	-35.163834			

Road Route 13

Road Route 14 Data

The table below presents the coordinates defining the vertices defining the assessed road route 14.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.262632	-35.166346	3	147.264316	-35.164855
2	147.26334	-35.165592			

Road Route 14

Road Route 15 Data

The table below presents the coordinates defining the vertices defining the assessed road route 15.

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.265453	-35.164987	2	147.265829	-35.164312

Road Route 15

Connorton Model Airfield Receptor Details

The table below presents the coordinates and overall altitude of the Connorton Model Airfield receptor.

Longitude (°)	Latitude (°)	Overall Assessed Altitude (m amsl)
147.274493	-35.174389	237.43

Connorton Model Airfield Receptor Details

Panel Boundary Data

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	147.272229	-35.172240	7	147.262361	-35.177713
2	147.260027	-35.174684	8	147.262408	-35.176646
3	147.259986	-35.176672	9	147.264354	-35.176292
4	147.259613	-35.176805	10	147.264408	-35.177379
5	147.259489	-35.176907	11	147.265721	-35.178382
6	147.259561	-35.178130	12	147.272300	-35.173957

Panel Boundary Data

PAGERPOWER
Urban & Renewables
Pager Power Limited
Stour Valley Business Centre
Sudbury
Suffolk
CO10 7GB

Tel: +44 1787 319001 **Email:** info@pagerpower.com **Web:** www.pagerpower.com

APPENDIX F:

PEER REVIEWER - SOLAR GLARE IMPACT EXPERTISE

SOLAR GLARE IMPACT ASSESSMENT

Sian Crawford (Director Environmental Ethos)
BA LArch (Hons) Heriot-Watt University 1987
MBEnv (Sustainable Development) UNSW, 2003

RELEVANT EXPERTISE

25 years of experience in the fields of landscape architecture and sustainable development, project management, landscape planning and rehabilitation, impact assessment, environmental and planning approvals, and community consultation. Expertises include:

- Solar Glare Impact Assessment
- Landscape and Visual Impact Assessment
- Environmental and Landscape Planning
- Community Consultation
- Climate Change Adaptation
- Landscape Rehabilitation
- Landscape master planning
- Project Management

PROFESSIONAL EXPERIENCE

SOLAR GLARE IMPACT ASSESSMENT

- ***Goornong Solar Farm:*** Solar Glare Impact Assessment for a 5MW solar farm in Victoria.
- ***Morwell Solar Energy Facility:*** Solar Glare Impact Aassessment for a 70MW solar farm in Victoria.
- ***Nhill Solar Farm:*** Solar Glare Impact Assessment for a 5MW solar farm in Victoria.
- ***Carisbrook Solar Farm:*** Solar Glare Impact Assessment for a 90MW solar farm in the Central Goldfields Shire, Victoria.
- ***Kilcoy Solar Farm:*** Solar Glare Impact Assessment for a 1,500MW solar farm in Queensland.
- ***Witmack Road Solar Farm:*** Visual and Solar Glare Impact Assessments for a 50MW solar farm in Toowoomba Region, Queensland.
- ***Chaff Mill Solar Farm:*** Solar Glare Impact Assessment for a 100MW solar farm in the Clare Valley, South Australia.
- ***Confidential Solar Farm:*** Solar Glare Impact Assessment for a 350MW solar farm in Central Queensland.
- ***Confidential Solar Farm:*** Solar Glare Impact Assessment for a 90MW solar farm in Issac Region, Queensland.
- ***Roche Road Solar Farm:*** Solar Glare Impact Assessment for a 40MW solar farm, for Maryrorough Solar.
- ***Clermont Solar Farm:*** Visual Impact Assessment and Solar Glare Impact Assessment for a 150MW solar farm, for Epuron.
- ***Yarranlea Solar Farm:*** Visual Impact Assessment and Solar Glare Impact Assessment for a 100MW solar farm, for Yarranlea Solar.
- ***Dalby Solar Farm:*** Solar Glare Impact Assessment for a 30MW solar farm, for FRV.

ENVIRONMENTAL ETHOS

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SOLAR GLARE IMPACT ASSESSMENT

Sian Crawford (Director Environmental Ethos)
BA LArch (Hons) Heriot-Watt University 1987
MBEnv (Sustainable Development) UNSW, 2003

PROFESSIONAL EXPERIENCE

PROJECT MANAGEMENT

- ***Baralaba, Clare and Lilyvale Solar Farms:*** Desktop assessment and preparation of technical reports for three large scale solar farms located in Queensland. The studies included viewshed and solar glare hazard analysis to identify potential risks of glare resulting from the projects, for FRV.
- ***Solar Dawn:*** Project Manager environmental planning approvals for proposed 250MW Solar Thermal Power Plant in Queensland. The project was being developed for the Commonwealth Government's Solar Flagships program and will be the largest of its kind in the world, for Solar Dawn Consortium.

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