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Goulburn River Solar Farm

Glint and Glare Assessment

Goulburn River Solar Farm

Glint and Glare Assessment

Prepared for
Umwelt Pty Limited

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A	28.02.2023	RR	SW	WIP for review
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Executive Summary

Moir Landscape Architecture (Moir LA) have been engaged by Umwelt Pty Limited to provide a glint and glare assessment for the proposed Goulburn River Solar Farm (the Project). The report will accompany the Environmental Impact Statement (EIS) prepared for the Project.

This Project is located within the Upper Hunter Local Government Area (LGA), approximately 28 kilometres (km) south of Merriwa (NSW).

The Glint and Glare Assessment has been prepared in accordance with the Department of Planning and Environment (DPE) *Large-Scale Solar Energy Guideline (August 2022)*.

In accordance with the Guideline, the following has been assessed:

- Assessment of residential dwellings within 3 km of the proposed solar array that have a line of sight.
- All roads and rail lines within 1 km of the proposed solar array
- Aviation receptors within 5km of the proposed solar array.

Moir LA have undertaken this glint and glare assessment utilising the Solar Glare Hazard Analysis Tool (SGHAT). The SGHAT is used to evaluate glare resulting from solar farms at different receptors, based on proximity, orientation and specifications of the PV modules.

A total of four (4) free standing Observation point (OP) were identified within 5km of the Project. Based on the desktop assessment no potential “Yellow” glare was investigated for residential receptors.

One (1) Road Receptors was identified as part of the assessment. Based on glare assessment Wollara Road has the potential to experience glare (<30 hrs per year) from the Project.

It is important to reiterate the assessment is based on a worst-case scenario and does not take into account weather conditions, intervening elements such as vegetation and built structures.

Principles for mitigation, to reduce potential glare have been discussed in this report in accordance with the *Large-Scale Solar Energy Guideline Technical Supplement - Landscape and Visual Impact Assessment*.

1.0 Introduction

1.1 The purpose of this report

Moir Landscape Architecture (Moir LA) have been engaged by Umwelt Pty Limited to provide a glint and glare assessment of the Project. The report will accompany the EIS prepared for the Project.

The Glint and Glare Assessment has been prepared in accordance with the Large-Scale Solar Energy Guideline Technical Supplement - Landscape and Visual Impact Assessment, 2022.

Glint is generally defined as a momentary flash of bright light while glare can be defined as continuous source of excessive brightness proportionates to ambient lighting (FAA, 2021).

While glint and glare impacts can be relatively uncommon, it is important to model and assess these impacts to ensure any potential significant impact is avoided or mitigated appropriately (DPE, 2022). Assessment needs to be undertaken to ensure that sensitive visual receptors such as road users, surrounding rail network, nearby buildings, air traffic controllers and pilots are not impacted by the proposed development (ForgeSolar, 2022).

1.2 Glint and glare key principles

The key principles for ensuring the Project can be undertaken whilst maintaining an acceptable level of amenity are outlined in the Guideline as follows:

1. **Solar panels should be sited to reduce the likely impacts of glint and glare.**

2. **Solar panels and other infrastructure should be constructed of materials and / or treated to minimise glint and glare.**

3. **If large scale solar energy development is likely to exceed the relevant criteria for glare and standards for glint, mitigation strategies should be adopted.**

1.3 Assessment requirements

Table 1 provides an outline of the assessment requirements for the glint and glare report (in accordance with the Guidelines, DPE 2022) and where these have been addressed in the report. The objective of the assessment as stated in the Guideline is to *"demonstrate that glint and glare would not pose a significant risk to motorists or pilots and that nuisance from glare is minimised for residential locations in accordance with the objectives outlines in [the Guideline]".*

Report Structure	
Requirements for Glint and Glare Assessment:	**Addressed in report:**
A description of the proposed PV panels indicating: *- the axis of rotation and maximum tilt angle* *- the light absorption efficiency and / or refractive index values at different angles.* *- whether any backtracking is proposed and the time and duration of these operations.*	**Refer to:** **Section 3.0: Project Overview**
A justification for excluding any modelled glare results because they would be insignificant due to the size, position and luminance of the glare source or high ambient luminence.	**Refer to:** **Section 2**
Results of the glint and glare analysis for each assessable receiver	**Refer to:** **Section 4.0: Residential Receptors** (Asses all residential dwellings within 3 km of the proposed solar array that have a line of sight.) **Section 5.0: Road and Rail Receptors** (Asses all roads and rail lines within 1 km of the proposed solar array.) **Section 6.0: Aviation Receptors** (Assess all air traffic control towers and take off / landing approaches to any runway or landing strip within 5 km of the proposed solar array.)
Identification of existing vegetation or built structures and a quantitative assessment of whether these features would eliminate or reduce the modelled impacts.	**Refer to Summary Tables**
Details of strategies to either avoid or mitigate impacts including re-siting or sizing the project, altering the tracking patterns, implementing vegetation screening, or entering neighbour agreements with landowners if all other measures have been exhausted.	**Refer to:** **Section 8.0: Mitigation Recommendations**

Table 1 Overview of Assessment Requirements

2.0 Study Method

2.1 Assessment Methodology

Moir LA have undertaken this glint and glare assessment utilising Solar Glare Hazard Analysis Tool (SGHAT) developed by Sandia National Laboratories. The SGHAT is used to evaluate glare resulting from solar farms at different receptors, based on proximity, orientation and specifications of the PV modules. This tool is recognised by the Australian Government Civil Aviation Safety Authority (CASA).

SGHAT is used to indicate the nature of glare that can be expected at each potential receptor. Glare can be broadly classified into three categories and presented by the following three colours:

- **Green Glare:** Low potential for temporary after-image
- **Yellow Glare:** Potential for temporary after-image
- **Red Glare:** Retinal burn, not expected for PV.

Note: The main focus of this assessment is the yellow glare. Red glare is not expected for PV and green glare is low potential to cause after image and deemed negligible. (HO,2011)

The glare analysis tool used to assess the glint and glare hazard was run at a simulation interval of one minute, based on the reflectivity of solar rays off PV modules which typically lasts for at least one minute.

Modelling for the solar farms in the SGHAT tool is based on the following factors:

- Position of the sun over time with respect to the location of the proposed solar farm.
- Assessment is based on a worst-case scenario assuming clear weather all year round, (ie. no consideration of cloud coverage).
- Tracking axis tilt, tracking axis orientation and properties of the PV modules.
- Potential to screen the impact by surrounding topography (does not take into account intervening elements such as vegetation and built structures).

2.2 Modelling Assumptions

The glare and glint impact is calculated utilising the geographic location, elevation, position of the sun and other vector calculations including module orientation, reflective environment and visual factors. Sun position is determined at every one (1) minute interval throughout the year.

Although the SGHAT is an extensive tool to understand the impacts of potential glare, it does not consider weather conditions, separation between PV modules and existing surrounding vegetation (if present) between the Project and a sensitive receiver.

Single axis tracking PV panels capable of rotating to a maximum of 60° have been considered to indicate a full rotational range of 120° for this analysis. The trackers are oriented north south with a maximum pitch distance of 5.3 m. Glare modelling has been conducted to correspond to maximum tracker height to provide a wider range of observed solar glare based on the extremities.

The glint and glare effects of PV panels depends on the scale and type of infrastructure, the prominence and topography of the site relative to the surrounding environment, and any proposed screening measures to reduce visibility of the site.

Glare modelling has been conducted using the Shade-slope backtracking function within the SGHAT tool. Ground Coverage Ratio (GCR) calculations are used within the SGHAT tool for 'Shade-Slope' backtracking analysis. GCR is defined as the ratio of the array length (L) to proposed pitch distance (R) (Doubleday et al. 2016).

$$\mathrm{GCR} = \frac{L}{R} \ .$$

For this assessment GCR is calculated considering L = 2.40 m and R = 5.3m. The resulting GCR = 0.43

Section 3.0 provides an overview of the PV panel parameters used for the assessment.

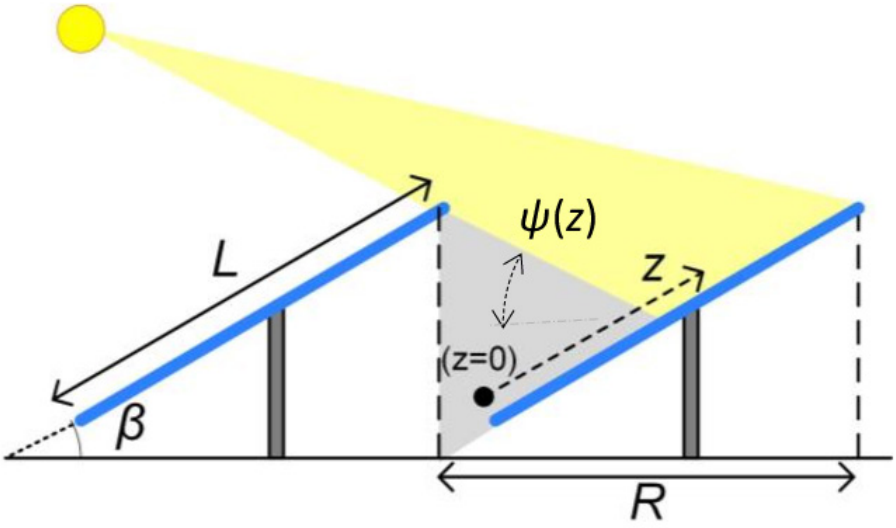


Image 01 Ground Coverage Ratio Calculations (Doubleday et al. 2016)

2.3 Backtracking Operations

A single axis horizontal tracking system can be configured to do a 'backtracking' technique, which implies that when the sun is low in the sky in the morning or evening, the tracking system can adjust the panels to maximise solar capture while minimising overshadowing.

ForgeSolar uses a simplified model of backtracking. Single-axis trackers follow the movement of the sun as it moves east to west throughout the day. Yields are maximized, and light reflection is minimised when panels are directly facing the sun. In times when the sun is not in the tracking range, we assume that the panels instantaneously revert to their resting angle of 0°. Due to this, glare from the backtracking mechanism will be more conservatively simulated and at times of sunset and sunrise, when the sun is at a lower angle relative to the array, glare impacts will be more noticeable.

Variable angles of incidence of the sun relative to the panels may occur when the tracking system is performing a backtracking operation, and this variation is somewhat represented by SGHAT software in its recent update of 2022.

Shade-slope backtracking function within the SGHAT tool considers the lowest possible panel rotation angle during backtracking. Therefore, using 0° resting angle option is modelled to determine backtracking operations. This function simulates the impression of the panels returning to a predefined angle after the maximum tilt angle has been attained.

It is important to note that this backtracking modelling is not a realistic representation of how a backtracking technique would work in actuality but on the other hand, gives some idea of the potential glare consequences of shifting the PV panels away from the sun after the maximum tilt is reached.

The following parameters have been considered to simulate a typical backtracking process for the proposed development:

- A maximum tracking angle of 60° is considered to indicate a full rotational range of 120°.
- To simulate 'backtracking', 'resting angle' determined as 0°, assuming the PV modules move directly to 0° once maximum tilt of 60° is reached and represents a worst-case scenario.
- To simulate glare experienced mid tracking an angle of 45° and 22° is considered assuming the PV modules move from the resting angle prior to arriving at the stowing angle.
- Night time angle (stowing angle after dark) of 5° is considered assuming the PV modules move directly to 5° once maximum tilt of 60° is reached and represents a worst-case scenario.

3.0 Project Overview

3.1 Site Context

The Project is located, approximately 28 kilometres (km) south of Merriwa (NSW) within the Upper Hunter Local Government Area (LGA). (Refer to Figure 1).

The Project covers an area of approximately 2,000 ha with a development footprint of approximately 799.5 ha. The Project Area encompasses two freehold properties and sections of Crown Land located along Wollara Road.

The Project includes PV arrays to generate approximately 550 megawatt peak (MWp) with a Battery Energy Storage System (BESS) to store up to 280 MWp/570 megawatt hour (MWh) capacity. The Project will also include supporting infrastructure, such as a substation and connection to an existing 500 kV transmission line via a proposed substation to be located in the south-eastern section of the Project Area, road repairs and upgrades to Ringwood Road, temporary construction facilities, operation and maintenance buildings, internal access roads, civil works and electrical infrastructure to connect the Project to the existing transmission line.

Figure 1 Project Site Context (Map Source: Google Earth, 2022)

3.2 Solar Panel Specifications

Each module consists of P type Mono-crystalline cell type with a 2.0 mm, anti-reflection coated semi-tempered glass set in an anodised aluminium alloy frame (Suzhou Talesun Solar Technologies Co., Ltd. 2021).

To attain optimum solar energy collection, the project modelling has utilised a maximum rotational range of 120°. The panels are fixed on a tubular frame with a single axis tracking procedure. For accuracy, Glare analysis has been performed using maximum tracker height not exceeding 1.80m when facing at the highest angle.

Refer to **Figure 2** for typical panel dimensions utilised for this assessment.

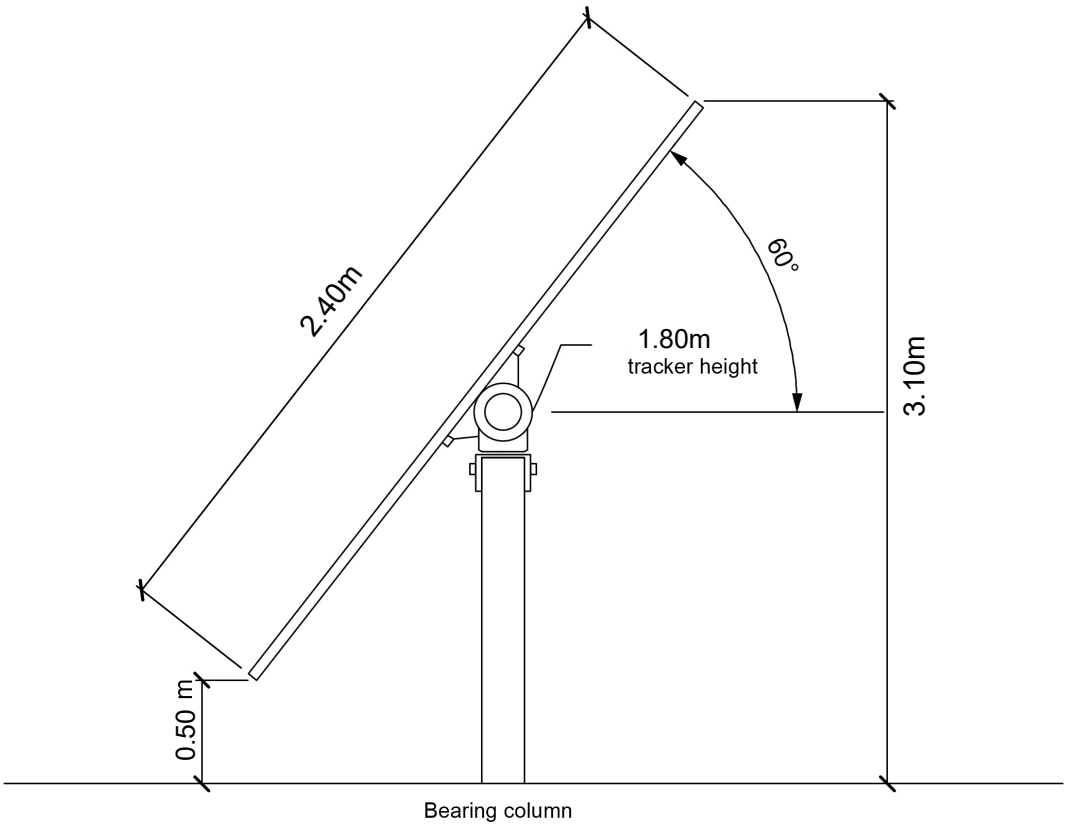


Figure 2 PV Parameters utilised for this assessment (provided by Lightsource bp)

General Solar PV system inputs:			
Input Data	**Units**	**Value**	**Comments**
Time Zone	UTC	+11	NSW time Zone
Orientation of Array	Degrees	0	Rows aligned in north-south directions
PV Surface materials	-	Smooth Glass with Anti-Reflective Coating	Provided by the Lightsource bp.
Mounting Type	-	Single Axis Tracking	As per tracker data sheet
Single Axis Tracking Parameters			
Axis Orientation	Degrees	0	Panels orientated north south
Module Offset angle	Degrees	0	Facing upwards Panels rotate during operation
Max tracking angle	Degrees	±60° (Range of 120°)	Panels following the Sun
Resting angle	Degrees	0°, 5°, 22° and 45°	Panels following the Sun, to represent backtracking and after dark stowing angles
Maximum Tracker Height	Metres	1.80m	Provided by the Lightsource bp.
Backtracking	-	Shade-Slope	Provided by the Lightsource bp.
Ground Coverage Ration	-	0.43	Ratio of the Array length to the pitch distance as provided by the Lightsource bp.

Table 2. Summary of modelling parameters

3.3 Array layout

A single axis tracking system follows the sun's trajectory and rotates the panels across east to west. There will be an estimated one million modules mounted on a north/south axis to slowly track movement of the sun. The rows of modules will be spaced approximately 5.3m apart to ensure no shading occurs and allows for ease of access for maintenance purposes. (Refer to **Table 2**)

For the purpose of this report, the Project has been divided into five (5) separate areas for assessment regarding to the software limitation which does not take any effects on the overall result.
Refer to **Figure 3** for PV array areas.

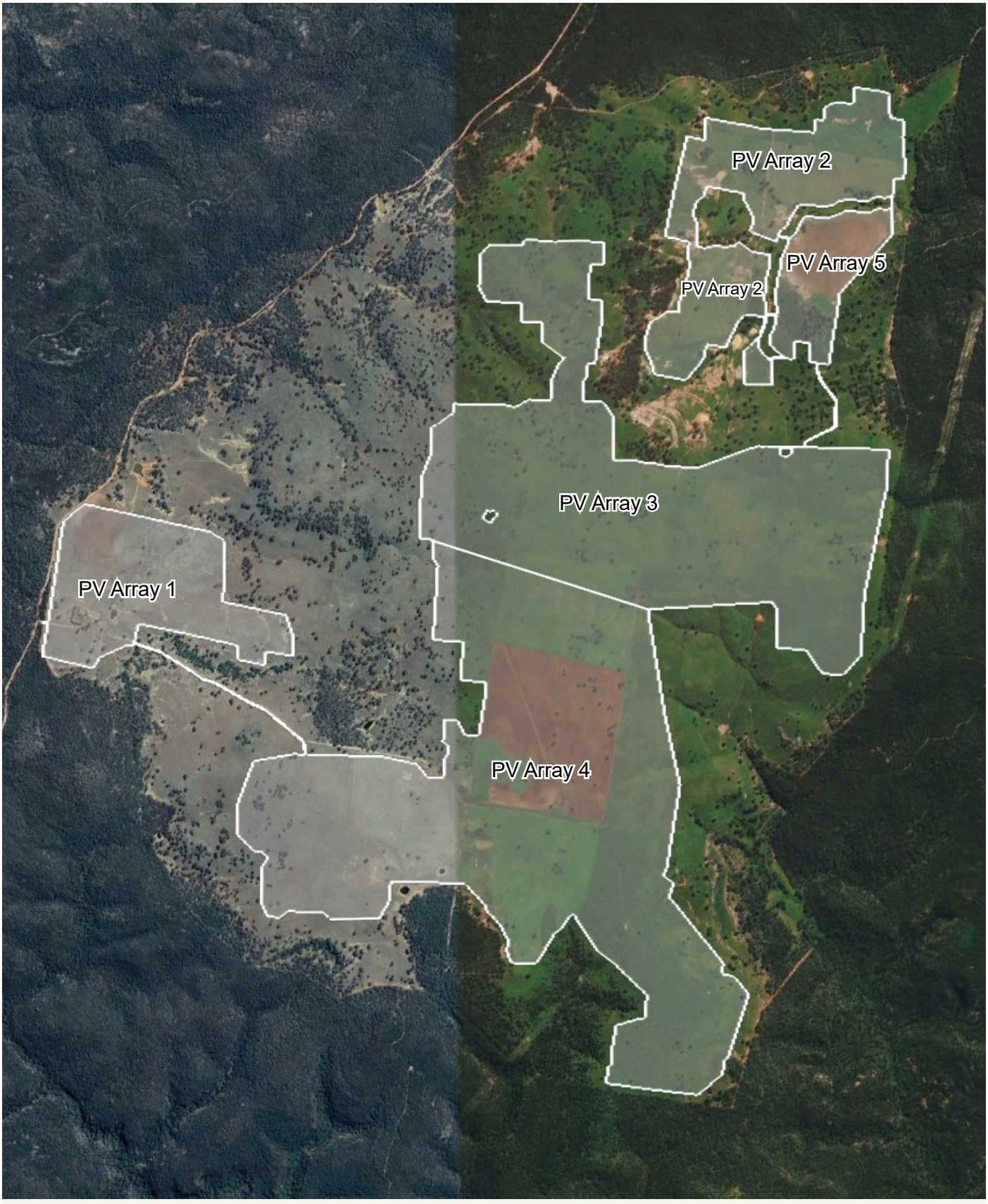


Figure 3 PV Array Areas (Map Source: Google Maps, 2022)

4.0 Residential Receptors

4.1 Overview of methodology

Table 4 provides an overview of the scope, methodology and performance objectives for assessment of glint and glare on residential receptors

Glint and Glare Requirements - Residential Receivers		
Scope	**Methodology**	**Performance Objective**
All residential viewpoints within 3km of the proposed solar array that have a line of sight. Representative viewpoints may be used for residential receivers that are clustered together.	**Analysis of the daily and yearly glare impacts in minutes.** **All residential receivers must be assessed at a height of 1.5 m above ground level.**	**Refer to Table 5.**
Note: Modeling for residential receptors is calculated on a receptor height of 1.5 m AGL.		

Table 4. Residential Receptors Assessment Requirements (Source: DPE, 2022)

Impact rating and performance objectives for glare impacts to residential dwellings		
High Glare Impact	**Moderate Glare Impact**	**Low Glare Impact**
> 30 minutes per day **> 30 hours per year** *Significant amount of glare that should be avoided*	**< 30 minutes per day** **< 30 hours per year** *Implement mitigation measures to reduce impacts as far as practicable*	**< 10 minutes per day** **< 10 hours per year** *No mitigation required*

Table 5. Residential receptor impact rating and performance objectives (Source: DPE, 2022)

4.2 Residential Receptors

A desktop assessment identified one (1) non associated Private Residential Receptors with a line of sight to the Project within 3 km of the Project.
Additionally three (3) key Public Residential Receptor locations within 5 km have been identified along the Goulburn River. These include Spring Gully Campground, Big River Campground, and Goulburn River National Park. (Refer to Figure 4)

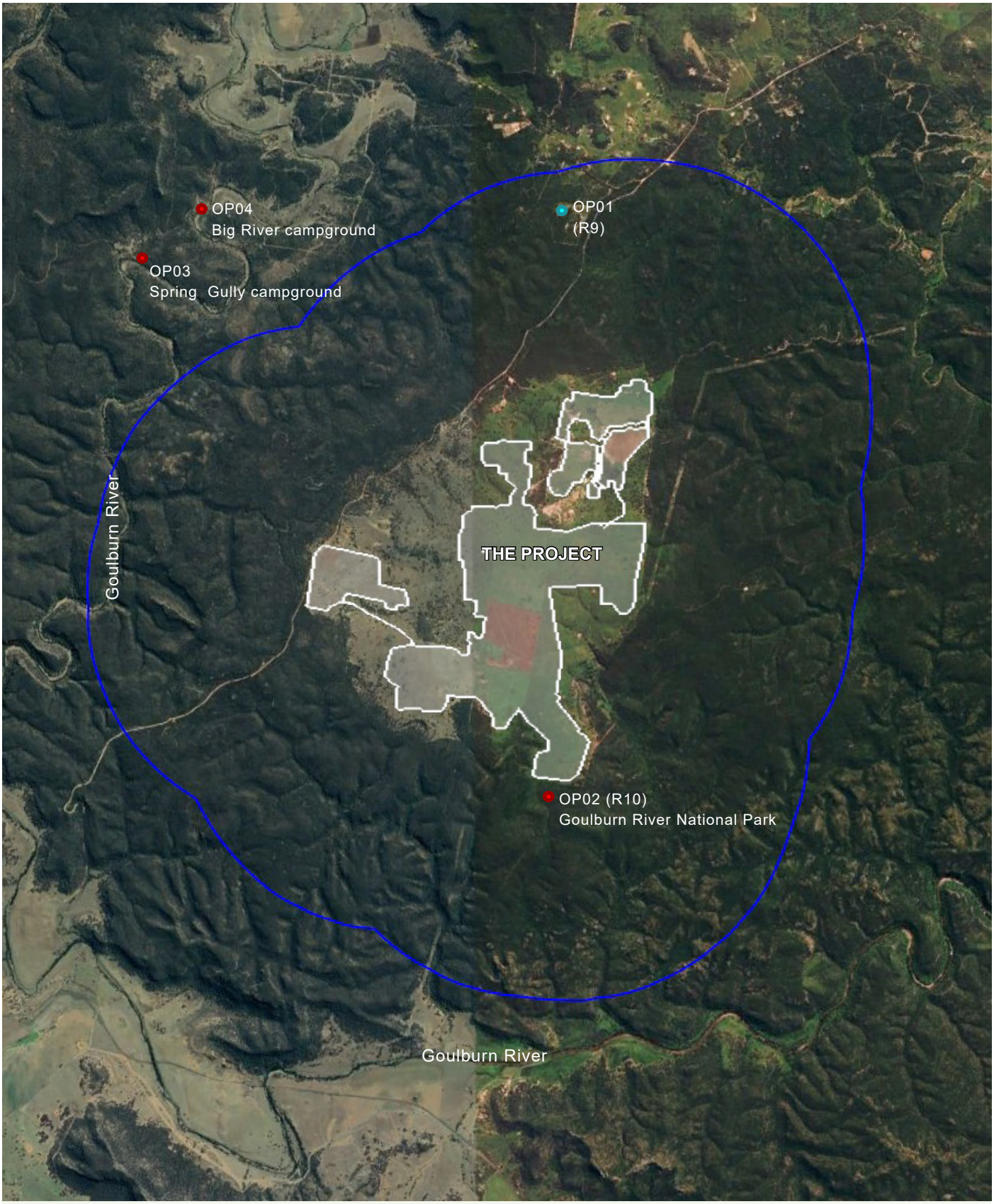


Figure 4 Residential Receptors (Map Source: Google Maps, 2022)

Residential Receptor	Location	Elevation	Distance to the nearest solar panel	Green Glare (Hours Per Year):	Yellow Glare (Hours Per Year):	Recommended Mitigation Measures
OP 01 (R9)	2076 WOLLARA ROAD MERRIWA	332.78m	2.49km	0	0	Not Required.
OP 02 (R10)	GOULBURN RIVER NATIONAL PARK	413.17m	0.23km	0	0	Not Required.
OP 03	SPRING GULLY CAMPGROUND	262.17m	4.58km	22.1	0	Not Required.
OP 04	BIG RIVER CAMPGROUND	265.23m	4.86km	8	0	Not Required.

Table 6. Residential receptor assessment results

Based on the desktop assessment no potential “Yellow” glare has been identified for Residential Receptors. It is important to reiterate the assessment is based on a worst-case scenario and does not take into account weather conditions, intervening elements such as vegetation and built structures.

Assessment indicates a low to moderate potential “Green” glare for OP03, and OP04.
“Green” glare has been recognised as having a low potential for an after image and considered negligible.

Additionally, desktop analysis of the receptors using aerial imagery indicates existing vegetation surrounding the Project will likely filter potential glare experienced at these receptors.

Therefore, no mitigation measures have been recommended for Residential Receptors surrounding the Project. The time of day glare is likely to be experienced is provided for each Residential Receptor in **Appendix A**.

5.0 Road and Rail Receptors

5.1 Overview of Methodology

Table 7 provides an overview of the scope, methodology and performance objectives for assessment of glint and glare on road and railway line receptors.

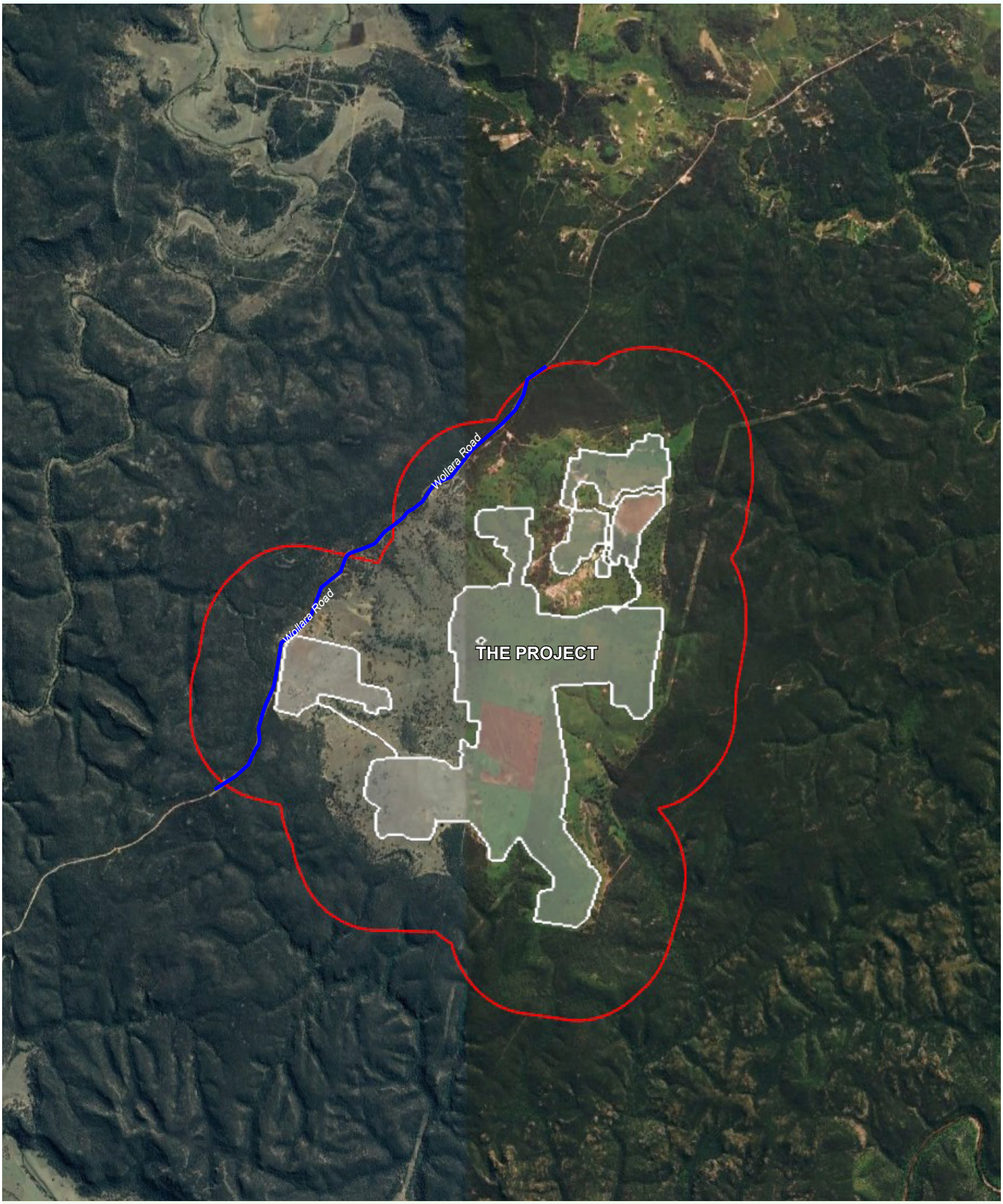
Glint and Glare Requirements - Road & Rail		
Scope	**Methodology**	**Performance Objective**
All roads and rail lines within 1 km of the proposed solar array.	**Solar glare analysis to identify whether glint and glare are geometrically possible within the forward looking eyeline of motorists and rail operators.**	**If glare is geometrically possible then measures should be taken to eliminate the occurrence of glare. Alternatively, the applicant must demonstrate that glare would not significantly impede the safe operation of vehicles or the interpretation of signals and signage.**
Note: Modeling for road receptors is calculated on a maximum height of 2.4 m AGL - representative of the eye level for truck drivers (Source: Austroads Ltd. 2021).		
Modeling for rail lines is based a representative eye height of 3 m AGL to represent the eye level of train drivers (Source: Transport Asset Standards Authority 2020).		

Table 7. Road and Rail Receptor Assessment Requirements (Source: DPE, 2022)

5.2 Road and Rail Receptors

A desktop assessment identified no Rail Receptor is located within 1 km of the Project. Wollara Road is the only Road Receptor within 1km of the Project.

Figure 5 illustrates Road Receptors identified within 1km of the Project.



LEGEND

Development Footprint

1 km from nearest panel

Road Receptor

N

Figure 5 Rail and Road Receptors (Map Source: Google Maps, 2022)

5.3 Results of Glint and Glare Assessment - Road and Rail

One (1) road receptor was considered as part of the assessment.
Table 8 provides an overview of the annual glare experienced along the Wollara Road.

Road / Rail Receptor:	Approximate Distance to the Project:	Elevation:	Yellow Glare (Hours Per Year):	Existing screening factors:	Mitigation Recommendations:
Wollara Road	0.1km	326-394m	11	Existing vegetation and topography will likely obscure potential glare from the Project.	Existing vegetation will likely obscure potential glare from the Project. Additional screening vegetation along areas of Wollara Road will likely mitigate further potential glare from the Project.

Table 8. Road & Rail receptor assessment results

Based on glare assessment Wollara Road will experience 11 hours of 'Yellow' glare per year from the Project which is recognised as having a moderate potential for an after image.
It is important to reiterate the assessment is based on a worst-case scenario and does not take into account weather conditions, intervening elements such as vegetation and built structures.

Detailed glare impact output for Wollara Road are provided in **Appendix A**.

6.0 Aviation Receptors

6.1 Overview of Methodology

Table 9 provides an overview of the scope, methodology and performance objectives for assessment of glint and glare on aviation receptors.

Glint and Glare Requirements - Aviation Receptors		
Scope	**Methodology**	**Performance Objective**
All air traffic control towers and take off / landing approaches to any runway or landing strip within 5km of the proposed solar array.	**Solar glare analysis that is worst case in all scenarios accounting for all aircraft using the airport (e.g. gliders, helicopters etc).**	**Any glint and glare should be avoided unless the aerodrome operator agrees that the impact would not be material (e.g. occurs at times when there are no flights or would not pose a safety risk to airport operations).**

Note: Modeling for Flight Path receptors is calculated on a threshold crossing height of 50ft (15m) in 2 mile (3.21km) point ground elevation and the ±50 degree azimuthal and 30 degree vertical viewing angle representative of the pilot field view from cockpit. (Source: Rogers, 2015)

Table 9. Aviation Receptor Assessment Requirements (Source: DPE, 2022)

6.2 Aviation Receptors

A desktop assessment identified no landing strips within 5 km of the development footprint and therefore no further assessment was undertaken.

7.0 Performance Objectives

7.1 Summary of assessment results

7.1.1 Residence Receptors

Table 5 provides an overview of the scope, methodology and performance objectives for assessment of glint and glare on residence receptors. The assessment undertaken by Moir LA has been summarised below:

No dwellings have been assessed as having a potential 'Yellow' glare

It is important to reiterate the assessment is based on a worst-case scenario and does not take into account weather conditions, intervening elements such as vegetation and built structures.

Assessment indicates "Green" glare' OP04 is less than 10 hours per year which is within the acceptable level.

Additionally, assessment indicates approximately 22.1 hours of potential 'Green Glare' per year for OP03. "Green" glare as per the methodology is considered negligible as the potential impact for an after image is low.

Furthermore, detailed assessment of aerial imagery indicates existing vegetation surrounding the Project will likely obscure potential glare from the Project. As such no mitigation measures are deemed necessary.

The time of day glare is likely to be experienced is provided for each Residential Receptor in **Appendix A**.

7.1.2 Road and Rail Receptors

Table 7 provides an overview of the scope, methodology and performance objectives for assessment of glint and glare on Road receptors. The assessment undertaken by Moir LA has been summarised below:

One (1) Road Receptor has been assessed as having a moderate glare rating (< 30 hours per year)

The assessment indicates approximately 11 hours per year potential "Yellow" glare for Wollara Road.

The assessment is based on a worst-case scenario and does not take into account weather conditions, intervening elements such as vegetation and built structures, when considering intervening vegetation and built structures, the potential experienced glare will likely be reduced. Moreover, additional screening vegetation along the Wollara Road is recommended to fragment any potential glare impacts from the Project. (Refer to **Section 8**)

Assessment of the outputs indicates the Wollara Road would experience minor "Yellow" glare in

very early March and very early October between 6:30 am - 7:10 am from PV Array 1 and from November to early February between 6:00 am - 7:00 am from PV Array 3. **(Refer to Appendix A)**

Assessment based on the aerial imagery indicates existing and proposed vegetation will likely obscure the potential glare experiencing from the Project.

8.0 Mitigation Measures

Mitigation measures were investigated to reduce the potential Impacts. An overview of these investigations has been provided in the assessment tables in Sections 4.0 - 6.0.

Detailed assessment of outputs indicates approximately 11 hours per year of “Yellow” glare from the Project, limited to Wollara Road.

An effective method for reducing the potential glare impact at residential receptors, road and rail receptors is to implement screen planting along the Project boundary or as applicable at affected viewpoints.

Mitigation principles have been recommended in accordance with DPE’s Technical Guidelines.

The Technical Supplement states: *Vegetation screening, or the planting of trees and shrubs, to visually screen solar energy projects or other potential visual impacts (such as glint and glare) from view may be a useful mitigation option for selected viewpoints. On-site screening, such as perimeter planting, should be considered in the first instance. If this is unlikely to be effective, screening can be considered at affected viewpoints.*

As detailed in the Project’s Visual Impact Assessment (VIA) Landscape Plan (Envisage, 2023), screening vegetation is proposed on-site on the north eastern boundary of PV Array 1 along Wollara Road will likely screen fragment potential glare impacts from the Project.
Details of the proposed landscaping including species has been included in the VIA.

Moreover, analysis of aerial imagery revealed existing vegetation associated with Goulburn River National Park around the Project will likely filter the potential glare impacts on surrounding receptors. Therefore no additional mitigation measures have been recommended.

The extent of existing and proposed screening vegetation has been illustrated in **Figure 6**.

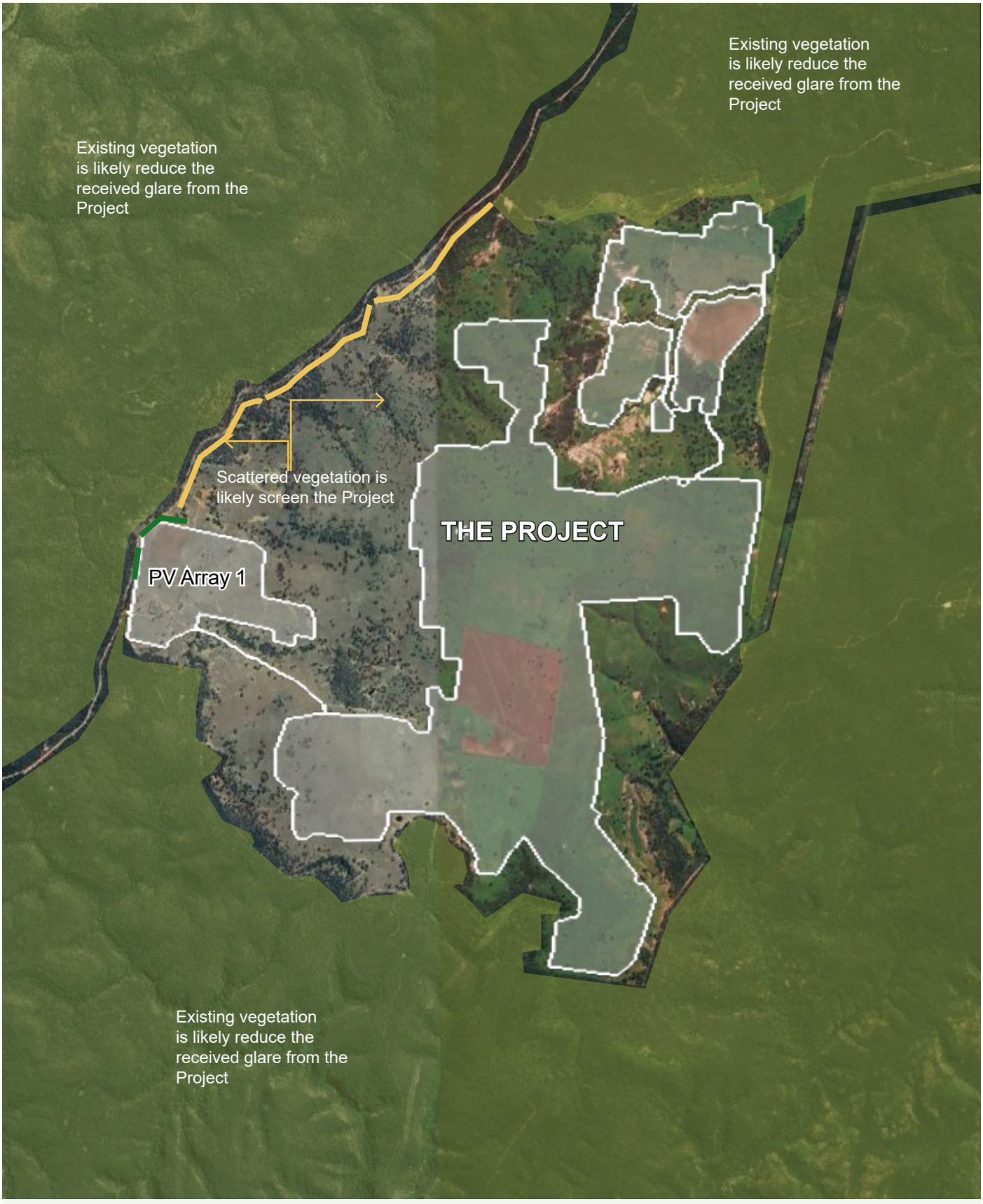


Figure 6 Mitigation Principles (Map Source: Google Maps, 2022)

9.0 Conclusion

The purpose of this report is to identify potential glint and glare impacts from the Project on the surrounding residential receptors (within 3 km of the Project), road and rail Receptors (within 1 km of the Project) and aviation receptors (within 5 km of the Project).

Based on the assumptions and aforementioned parameters in this report, potential to experience glare has been assessed for one (1) Private Residential receptor and three (3) Public sensitive receptor and one (1) Road Receptors.

Detailed assessment revealed moderate potential to experience “Yellow” glare along Wollara Road.

No aviation receptors were identified within 5km of the Project. Detailed assessment indicate Wollara Road will likely experience less than 30 hours per year of Potential “Yellow” glare.

Desktop analysis of aerial imagery indicates existing vegetation surrounding the Project and proposed on-site screening vegetation will likely fragment potential glare impacts from the Project. Therefore no additional mitigation measures have been recommended.

References

Austroads Ltd. 2021, Guide to Road Design Part 3: Geometric Design, AGRD03-16, Austroads Ltd., Sydney, NSW.

Australian Rail Track Corporation Limited 2010, Signal Sighting and Position, ESC-04-01, Australian Rail Track Corporation Limited, Sydney.

ForgeSolar n.d., www.forgesolar.com, viewed 21 February 2023, <https://www.forgesolar.com/help/#glare>.

Federal Aviation Administration (2021). Final Policy, Review of Solar Energy System Projects on Federally Obligated Airports. Document Number 2021-09862.

Goulburn River Solar Farm, Scoping Report, December 2021, UMWELT (Australia) Pty Limited.

Google Earth, Imigary date 26 March 2021.

Ho, C. K., Ghanbari, C. M., and Diver, R. B., 2011, “Methodology to Assess Potential Glint and Glare Hazards From Concentrating Solar Power Plants: Analytical Models and Experimental Validation”, ASME J. Sol. Energy Eng., 133.

New South Wales Department of Planning and Environment, Large-Scale Solar Energy Guideline, August 2022

New South Wales Department of Planning and Environment, Large-Scale Solar Energy Guideline-Technical Supplement - Landscape and Visual Impact Assessment, August 2022

Rogers, J. A., et al. (2015). “Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach”, Federal Aviation Administration (link)

Transport Asset Standards Authority 2020, Minimum Operating Standards for Rolling Stock – General Interface Requirements, T HR RS 00100 ST, Transport NSW, Sydney.

Appendix A

FORGESOLAR GLARE ANALYSIS

Project: **2290_GoulburnRiverSolarFarm**
Site configuration: **2290 Goulburn River SF_20230313**
Analysis conducted by David Moir (itsupport@moirla.com.au) at 04:45 on 15 Mar, 2023.

U.S. FAA 2013 Policy Adherence

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

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

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

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
2-mile flight path(s)	N/A	No flight paths analyzed
ATCT(s)	N/A	No ATCT receptors designated

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

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

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

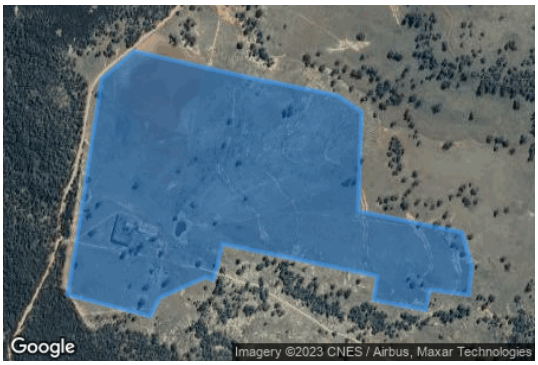
SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 86192.14902
Methodology: V2

PV Array(s)

Name: PV array 1
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.284940	150.071892	325.68	1.65	327.33
2	-32.286361	150.071592	335.58	1.65	337.23
3	-32.287019	150.074617	345.42	1.65	347.07
4	-32.286450	150.074961	340.65	1.65	342.30
5	-32.285826	150.076618	339.30	1.65	340.95
6	-32.285910	150.076892	341.14	1.65	342.79
7	-32.285467	150.077058	336.56	1.65	338.21
8	-32.284813	150.077232	333.29	1.65	334.94
9	-32.285083	150.078792	341.42	1.65	343.07
10	-32.285789	150.082849	359.58	1.65	361.23
11	-32.286525	150.082714	361.09	1.65	362.74
12	-32.286831	150.084619	368.70	1.65	370.35
13	-32.286207	150.084743	369.63	1.65	371.28
14	-32.286363	150.086186	376.29	1.65	377.94
15	-32.285477	150.086294	378.73	1.65	380.38
16	-32.284448	150.085935	380.39	1.65	382.04
17	-32.283800	150.082164	357.26	1.65	358.91
18	-32.280771	150.082293	357.96	1.65	359.61
19	-32.280275	150.081422	351.78	1.65	353.43
20	-32.280110	150.080523	348.10	1.65	349.75
21	-32.279736	150.078311	339.59	1.65	341.24
22	-32.279438	150.076745	336.09	1.65	337.74
23	-32.278904	150.074034	334.30	1.65	335.95
24	-32.279770	150.072840	334.41	1.65	336.06

Name: PV array 2
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.270193	150.106852	399.71	1.65	401.36
2	-32.270833	150.106665	405.61	1.65	407.26
3	-32.271498	150.106603	412.74	1.65	414.39
4	-32.272635	150.107121	415.96	1.65	417.61
5	-32.272870	150.108902	392.29	1.65	393.94
6	-32.272823	150.109106	391.22	1.65	392.87
7	-32.271933	150.109922	386.68	1.65	388.33
8	-32.271258	150.110137	385.32	1.65	386.97
9	-32.271268	150.111318	377.99	1.65	379.64
10	-32.269893	150.112092	376.51	1.65	378.16
11	-32.269681	150.112440	374.50	1.65	376.15
12	-32.269775	150.113563	366.93	1.65	368.58
13	-32.269235	150.113614	366.63	1.65	368.28
14	-32.268540	150.113514	366.38	1.65	368.03
15	-32.267375	150.113824	359.71	1.65	361.36
16	-32.266696	150.113885	358.85	1.65	360.50
17	-32.266626	150.112763	364.54	1.65	366.19
18	-32.266106	150.111956	364.69	1.65	366.34
19	-32.266317	150.111598	365.91	1.65	367.56
20	-32.266304	150.110678	370.05	1.65	371.70
21	-32.266423	150.110126	372.76	1.65	374.41
22	-32.266389	150.109611	374.45	1.65	376.10
23	-32.265215	150.109645	376.11	1.65	377.76
24	-32.264934	150.109565	377.84	1.65	379.49
25	-32.264599	150.109614	379.01	1.65	380.66
26	-32.264137	150.109801	379.63	1.65	381.28
27	-32.263922	150.110110	377.60	1.65	379.25
28	-32.263547	150.110169	377.00	1.65	378.65
29	-32.263783	150.112244	361.95	1.65	363.60
30	-32.264083	150.112151	362.99	1.65	364.64
31	-32.264956	150.112910	357.57	1.65	359.22
32	-32.265612	150.112625	360.73	1.65	362.38
33	-32.266055	150.114059	355.74	1.65	357.39
34	-32.265682	150.114334	353.82	1.65	355.47
35	-32.265461	150.114735	352.13	1.65	353.78
36	-32.264149	150.115515	349.78	1.65	351.43
37	-32.264188	150.117068	343.49	1.65	345.14
38	-32.264063	150.117902	341.34	1.65	342.99
39	-32.263912	150.118745	342.48	1.65	344.13
40	-32.263975	150.119550	342.14	1.65	343.79
41	-32.263791	150.120023	340.85	1.65	342.50
42	-32.263859	150.120455	338.04	1.65	339.69
43	-32.263704	150.121103	335.65	1.65	337.30
44	-32.262959	150.121198	340.32	1.65	341.97
45	-32.262958	150.121712	342.50	1.65	344.15
46	-32.262358	150.121753	346.90	1.65	348.55
47	-32.260113	150.121583	359.37	1.65	361.02
48	-32.260075	150.120918	363.27	1.65	364.92
49	-32.258920	150.120928	362.50	1.65	364.15
50	-32.258710	150.120541	361.93	1.65	363.58
51	-32.258658	150.118264	361.79	1.65	363.44
52	-32.259003	150.118278	363.94	1.65	365.59
53	-32.259667	150.116486	368.09	1.65	369.74
54	-32.260767	150.116600	370.65	1.65	372.30
55	-32.260578	150.113186	373.80	1.65	375.45
56	-32.260056	150.111978	376.95	1.65	378.60
57	-32.260100	150.110119	391.35	1.65	393.00
58	-32.261145	150.110084	386.83	1.65	388.48
59	-32.260927	150.109026	398.82	1.65	400.47

Name: PV array 3
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.266877	150.097035	417.50	1.65	419.15
2	-32.266317	150.097593	418.78	1.65	420.43
3	-32.266374	150.099459	418.01	1.65	419.66
4	-32.266197	150.099484	418.92	1.65	420.57
5	-32.266065	150.099685	417.92	1.65	419.57
6	-32.266116	150.101289	410.61	1.65	412.26
7	-32.266233	150.101425	411.45	1.65	413.10
8	-32.266074	150.101677	412.61	1.65	414.26
9	-32.266117	150.103903	421.63	1.65	423.28
10	-32.266120	150.104339	420.36	1.65	422.01
11	-32.266599	150.104330	418.52	1.65	420.17
12	-32.266904	150.104297	417.25	1.65	418.90
13	-32.267518	150.104197	414.63	1.65	416.28
14	-32.267472	150.103434	418.26	1.65	419.91
15	-32.268977	150.103367	409.45	1.65	411.10
16	-32.269073	150.104115	406.80	1.65	408.45
17	-32.270064	150.104238	412.12	1.65	413.77
18	-32.272206	150.103696	429.44	1.65	431.09
19	-32.272225	150.103229	428.32	1.65	429.97
20	-32.272837	150.103217	430.19	1.65	431.84
21	-32.272883	150.103077	429.51	1.65	431.16
22	-32.273139	150.102977	429.57	1.65	431.22
23	-32.273924	150.103021	431.96	1.65	433.61
24	-32.273951	150.104067	438.17	1.65	439.82
25	-32.274783	150.104803	436.40	1.65	438.05
26	-32.276647	150.104778	437.67	1.65	439.32
27	-32.277249	150.109665	423.94	1.65	425.59
28	-32.276054	150.113006	417.60	1.65	419.25
29	-32.276351	150.120590	413.33	1.65	414.98
30	-32.278255	150.120524	403.22	1.65	404.87
31	-32.283355	150.119382	416.09	1.65	417.74
32	-32.286489	150.119009	414.58	1.65	416.23
33	-32.287243	150.118026	407.98	1.65	409.63
34	-32.287208	150.116941	408.87	1.65	410.52
35	-32.286160	150.115929	418.36	1.65	420.01
36	-32.286131	150.114805	416.02	1.65	417.67
37	-32.284313	150.114833	417.40	1.65	419.05
38	-32.283726	150.113988	412.53	1.65	414.18
39	-32.284111	150.106761	422.52	1.65	424.17
40	-32.281989	150.094658	417.80	1.65	419.45
41	-32.281621	150.094451	418.11	1.65	419.76
42	-32.280782	150.094416	422.20	1.65	423.85
43	-32.280763	150.093617	417.98	1.65	419.63
44	-32.277814	150.093705	435.83	1.65	437.48
45	-32.276567	150.094209	434.87	1.65	436.52
46	-32.275164	150.094283	426.73	1.65	428.38
47	-32.275130	150.094508	426.22	1.65	427.87
48	-32.274702	150.095495	426.89	1.65	428.54
49	-32.274209	150.095507	425.62	1.65	427.27
50	-32.274225	150.098494	430.91	1.65	432.56
51	-32.274295	150.098991	430.11	1.65	431.76
52	-32.273793	150.099879	425.05	1.65	426.70
53	-32.273832	150.101158	424.12	1.65	425.77
54	-32.272951	150.101176	423.63	1.65	425.28
55	-32.272323	150.101688	425.97	1.65	427.62
56	-32.272053	150.101955	425.58	1.65	427.23
57	-32.271416	150.100731	421.38	1.65	423.03
58	-32.270031	150.100752	411.71	1.65	413.36
59	-32.270041	150.099511	409.54	1.65	411.19

Name: PV array 4
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.281997	150.094664	417.81	1.65	419.46
2	-32.284111	150.106758	422.52	1.65	424.17
3	-32.292557	150.108663	424.83	1.65	426.48
4	-32.297069	150.107708	419.38	1.65	421.03
5	-32.297483	150.108269	412.27	1.65	413.92
6	-32.298094	150.107989	415.27	1.65	416.92
7	-32.301386	150.111156	413.47	1.65	415.12
8	-32.301643	150.111090	417.81	1.65	419.46
9	-32.301889	150.111259	419.24	1.65	420.89
10	-32.301904	150.111718	413.67	1.65	415.32
11	-32.302881	150.112594	401.22	1.65	402.87
12	-32.306731	150.111069	421.63	1.65	423.28
13	-32.307742	150.109672	419.48	1.65	421.13
14	-32.307131	150.104325	431.29	1.65	432.94
15	-32.304328	150.104947	427.13	1.65	428.78
16	-32.303878	150.106575	433.66	1.65	435.31
17	-32.302867	150.106700	433.05	1.65	434.70
18	-32.300722	150.103847	418.69	1.65	420.34
19	-32.298883	150.102436	416.87	1.65	418.52
20	-32.301321	150.100390	419.58	1.65	421.23
21	-32.301295	150.098852	425.46	1.65	427.11
22	-32.300700	150.098617	425.32	1.65	426.97
23	-32.300308	150.098756	424.90	1.65	426.55
24	-32.299250	150.097989	431.11	1.65	432.76
25	-32.297117	150.095631	412.70	1.65	414.35
26	-32.297349	150.091975	409.17	1.65	410.82
27	-32.298231	150.091993	405.19	1.65	406.84
28	-32.299203	150.091344	409.68	1.65	411.33
29	-32.299212	150.088565	439.17	1.65	440.82
30	-32.298828	150.088161	442.65	1.65	444.30
31	-32.298839	150.086019	445.23	1.65	446.88
32	-32.299127	150.085506	445.82	1.65	447.47
33	-32.299127	150.084946	445.05	1.65	446.70
34	-32.298390	150.084454	440.01	1.65	441.66
35	-32.296598	150.084633	435.09	1.65	436.74
36	-32.296172	150.084897	438.16	1.65	439.81
37	-32.295847	150.084514	435.97	1.65	437.62
38	-32.295864	150.084108	434.06	1.65	435.71
39	-32.295024	150.083025	435.23	1.65	436.88
40	-32.293426	150.083144	433.99	1.65	435.64
41	-32.291513	150.084033	432.65	1.65	434.30
42	-32.291164	150.086417	416.56	1.65	418.21
43	-32.291155	150.087133	413.99	1.65	415.64
44	-32.291275	150.091747	418.49	1.65	420.14
45	-32.291498	150.093423	425.79	1.65	427.44
46	-32.292219	150.094025	429.48	1.65	431.13
47	-32.292247	150.094957	432.26	1.65	433.91
48	-32.291315	150.094969	433.09	1.65	434.74
49	-32.291206	150.095121	433.86	1.65	435.51
50	-32.290858	150.095185	433.80	1.65	435.45
51	-32.290603	150.094963	432.95	1.65	434.60
52	-32.289754	150.094990	435.65	1.65	437.30
53	-32.289789	150.095889	440.69	1.65	442.34
54	-32.290186	150.096363	441.01	1.65	442.66
55	-32.290220	150.097024	442.05	1.65	443.70
56	-32.287592	150.097462	438.48	1.65	440.13
57	-32.287423	150.095917	439.07	1.65	440.72
58	-32.285657	150.096016	436.64	1.65	438.29
59	-32.285642	150.094303	433.16	1.65	434.81

Name: PV array 5
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.273081	150.113903	384.75	1.65	386.40
2	-32.273093	150.112208	385.39	1.65	387.04
3	-32.271484	150.112305	373.03	1.65	374.68
4	-32.270828	150.113196	368.89	1.65	370.54
5	-32.270861	150.113391	368.47	1.65	370.12
6	-32.272172	150.113880	376.34	1.65	377.99
7	-32.271962	150.113904	375.10	1.65	376.75
8	-32.271869	150.114529	375.85	1.65	377.50
9	-32.271044	150.113875	368.89	1.65	370.54
10	-32.269892	150.114315	366.00	1.65	367.65
11	-32.269261	150.114342	366.00	1.65	367.65
12	-32.268375	150.114283	363.25	1.65	364.90
13	-32.267510	150.114508	357.19	1.65	358.84
14	-32.267087	150.114594	356.87	1.65	358.52
15	-32.266023	150.115023	352.91	1.65	354.56
16	-32.264857	150.115880	347.94	1.65	349.59
17	-32.264810	150.117145	343.22	1.65	344.87
18	-32.264518	150.118752	341.83	1.65	343.48
19	-32.264606	150.119553	340.93	1.65	342.58
20	-32.264520	150.119854	339.75	1.65	341.40
21	-32.264471	150.120155	338.68	1.65	340.33
22	-32.264439	150.120739	336.64	1.65	338.29
23	-32.264265	150.121133	334.64	1.65	336.29
24	-32.265697	150.120943	347.53	1.65	349.18
25	-32.268689	150.117921	367.78	1.65	369.43
26	-32.272132	150.117219	378.81	1.65	380.46
27	-32.271903	150.116153	379.64	1.65	381.29
28	-32.271162	150.116123	379.46	1.65	381.11
29	-32.271170	150.115187	374.42	1.65	376.07
30	-32.271956	150.115181	378.44	1.65	380.09
31	-32.272037	150.114074	375.98	1.65	377.63
32	-32.272139	150.114022	376.50	1.65	378.15

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-32.237750	150.108297	332.78	1.50
OP 2	2	-32.309558	150.106650	413.17	1.50
OP 3	3	-32.243961	150.047733	262.17	1.50
OP 4	4	-32.237611	150.056033	265.23	1.50

Route Receptor(s)

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

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.246039	150.110944	323.76	2.40	326.16
2	-32.250866	150.106824	339.28	2.40	341.68
3	-32.252681	150.103391	345.91	2.40	348.31
4	-32.254459	150.102876	348.64	2.40	351.04
5	-32.257798	150.100301	361.91	2.40	364.31
6	-32.260048	150.096524	380.42	2.40	382.82
7	-32.262008	150.094894	390.89	2.40	393.29
8	-32.263786	150.092705	392.49	2.40	394.89
9	-32.264040	150.090860	385.92	2.40	388.32
10	-32.266109	150.089572	375.28	2.40	377.68
11	-32.266435	150.088370	367.31	2.40	369.71
12	-32.270318	150.082963	352.60	2.40	355.00
13	-32.270499	150.080646	343.55	2.40	345.95
14	-32.273366	150.079315	336.56	2.40	338.96
15	-32.273765	150.077384	330.34	2.40	332.74
16	-32.277575	150.075625	329.07	2.40	331.47
17	-32.279933	150.072449	333.76	2.40	336.16
18	-32.287915	150.069616	344.39	2.40	346.79
19	-32.291870	150.068372	353.99	2.40	356.39
20	-32.294989	150.063522	377.90	2.40	380.30
21	-32.295886	150.059531	388.23	2.40	390.63
22	-32.299368	150.054982	413.79	2.40	416.19

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV array 1	SA tracking	SA tracking	5,079	0	-
PV array 2	SA tracking	SA tracking	0	0	-
PV array 3	SA tracking	SA tracking	954	660	-
PV array 4	SA tracking	SA tracking	0	0	-
PV array 5	SA tracking	SA tracking	2,665	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	1325	0
OP 4	478	0
Wollara Road	6895	660

Results for: PV array 1

Receptor	Green Glare (min)	Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
Wollara Road	5079	0

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

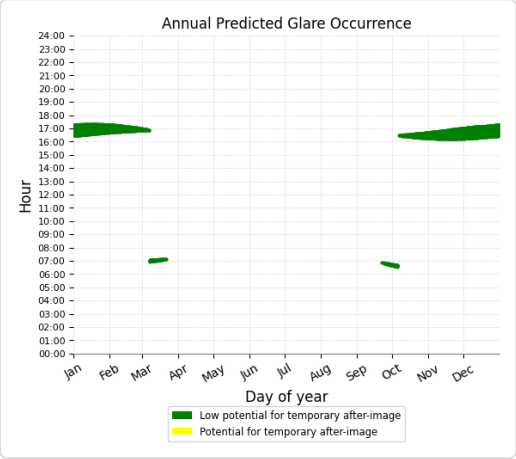
0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Route: Wollara Road

0 minutes of yellow glare
5079 minutes of green glare



Results for: PV array 2

Receptor	Green Glare (min)	Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
Wollara Road	0	0

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Route: Wollara Road

0 minutes of yellow glare
0 minutes of green glare

Results for: PV array 3

Receptor	Green Glare (min)	Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	537	0
OP 4	0	0
Wollara Road	417	660

Point Receptor: OP 1

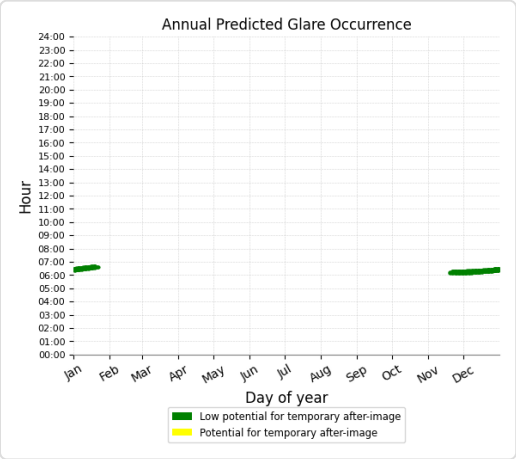
0 minutes of yellow glare
0 minutes of green glare

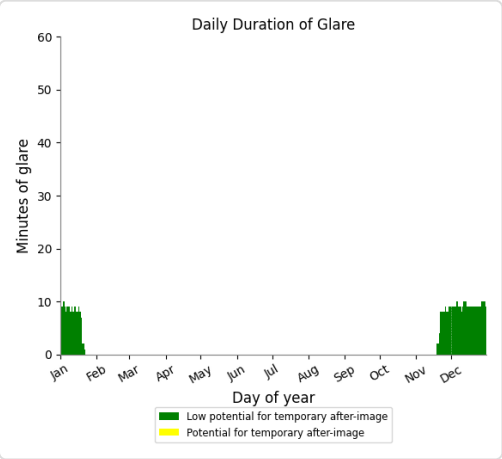
Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
537 minutes of green glare



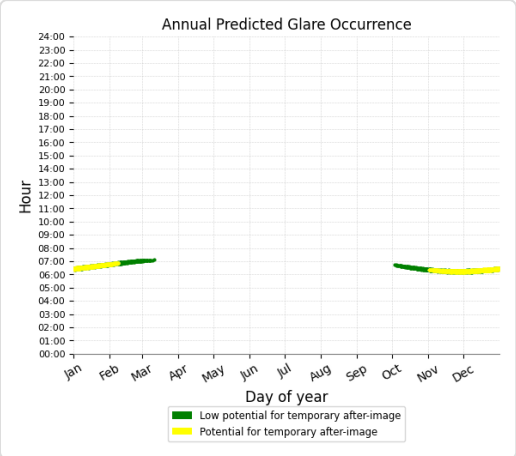


Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Route: Wollara Road

660 minutes of yellow glare
417 minutes of green glare



Results for: PV array 4

Receptor	Green Glare (min)	Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
Wollara Road	0	0

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Route: Wollara Road

0 minutes of yellow glare
0 minutes of green glare

Results for: PV array 5

Receptor	Green Glare (min)	Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	788	0
OP 4	478	0
Wollara Road	1399	0

Point Receptor: OP 1

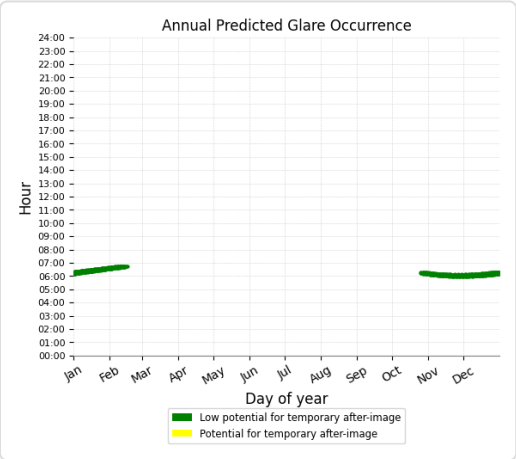
0 minutes of yellow glare
0 minutes of green glare

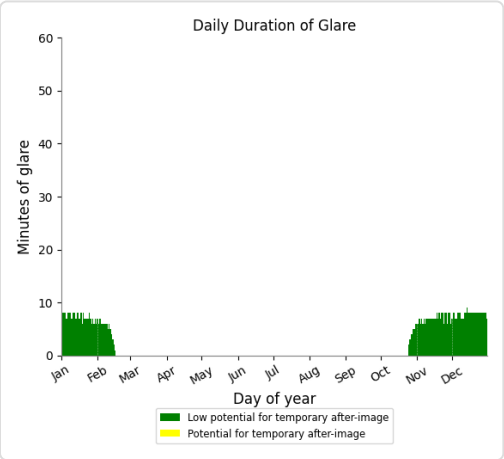
Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

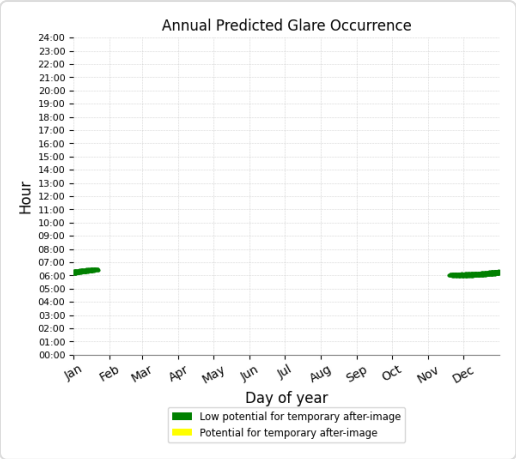
0 minutes of yellow glare
788 minutes of green glare

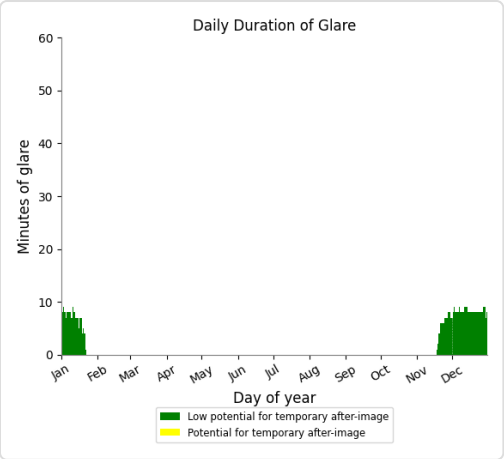




Point Receptor: OP 4

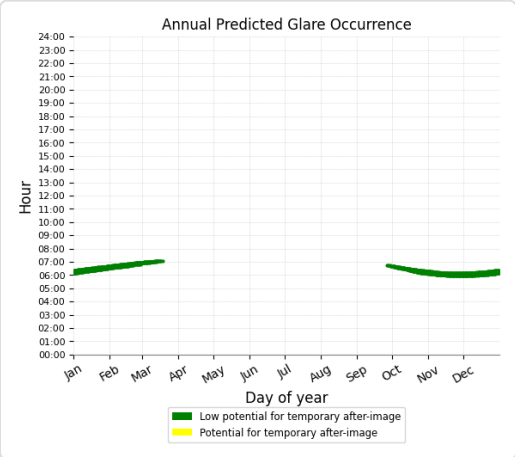
0 minutes of yellow glare
478 minutes of green glare





Route: Wollara Road

0 minutes of yellow glare
1399 minutes of green glare



Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to V1 algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence may differ.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

FORGESOLAR GLARE ANALYSIS

Project: **2290_GoulburnRiverSolarFarm**
Site configuration: **2290 Goulburn River SF_20230313_Backtracking5d**

Client: UMWELT

Created 14 Mar, 2023
Updated 15 Mar, 2023
Time-step 1 minute
Timezone offset UTC11
Site ID 86188.14902
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
PV analysis methodology V2

Summary of Results

Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	5,085	84.8	0	0.0	-
PV array 2	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 3	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 4	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 5	SA tracking	SA tracking	32	0.5	0	0.0	-

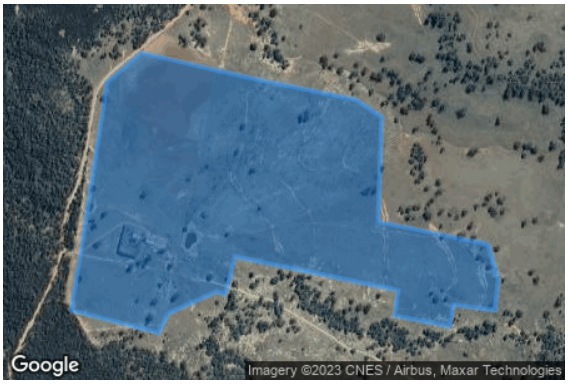
Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	5,117	85.3	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array 1
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 5.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.284940	150.071892	325.68	1.65	327.33
2	-32.286361	150.071592	335.58	1.65	337.23
3	-32.287019	150.074617	345.42	1.65	347.07
4	-32.286450	150.074961	340.65	1.65	342.30
5	-32.285826	150.076618	339.30	1.65	340.95
6	-32.285910	150.076892	341.14	1.65	342.79
7	-32.285467	150.077058	336.56	1.65	338.21
8	-32.284813	150.077232	333.29	1.65	334.94
9	-32.285083	150.078792	341.42	1.65	343.07
10	-32.285789	150.082849	359.58	1.65	361.23
11	-32.286525	150.082714	361.09	1.65	362.74
12	-32.286831	150.084619	368.70	1.65	370.35
13	-32.286207	150.084743	369.63	1.65	371.28
14	-32.286363	150.086186	376.29	1.65	377.94
15	-32.285477	150.086294	378.73	1.65	380.38
16	-32.284448	150.085935	380.39	1.65	382.04
17	-32.283800	150.082164	357.26	1.65	358.91
18	-32.280771	150.082293	357.96	1.65	359.61
19	-32.280275	150.081422	351.78	1.65	353.43
20	-32.280110	150.080523	348.10	1.65	349.75
21	-32.279736	150.078311	339.59	1.65	341.24
22	-32.279438	150.076745	336.09	1.65	337.74
23	-32.278904	150.074034	334.30	1.65	335.95
24	-32.279770	150.072840	334.41	1.65	336.06

Name: PV array 2
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 5.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.270193	150.106852	399.71	1.65	401.36
2	-32.270833	150.106665	405.61	1.65	407.26
3	-32.271498	150.106603	412.74	1.65	414.39
4	-32.272635	150.107121	415.96	1.65	417.61
5	-32.272870	150.108902	392.29	1.65	393.94
6	-32.272823	150.109106	391.22	1.65	392.87
7	-32.271933	150.109922	386.68	1.65	388.33
8	-32.271258	150.110137	385.32	1.65	386.97
9	-32.271268	150.111318	377.99	1.65	379.64
10	-32.269893	150.112092	376.51	1.65	378.16
11	-32.269681	150.112440	374.50	1.65	376.15
12	-32.269775	150.113563	366.93	1.65	368.58
13	-32.269235	150.113614	366.63	1.65	368.28
14	-32.268540	150.113514	366.38	1.65	368.03
15	-32.267375	150.113824	359.71	1.65	361.36
16	-32.266696	150.113885	358.85	1.65	360.50
17	-32.266626	150.112763	364.54	1.65	366.19
18	-32.266106	150.111956	364.69	1.65	366.34
19	-32.266317	150.111598	365.91	1.65	367.56
20	-32.266304	150.110678	370.05	1.65	371.70
21	-32.266423	150.110126	372.76	1.65	374.41
22	-32.266389	150.109611	374.45	1.65	376.10
23	-32.265215	150.109645	376.11	1.65	377.76
24	-32.264934	150.109565	377.84	1.65	379.49
25	-32.264599	150.109614	379.01	1.65	380.66
26	-32.264137	150.109801	379.63	1.65	381.28
27	-32.263922	150.110110	377.60	1.65	379.25
28	-32.263547	150.110169	377.00	1.65	378.65
29	-32.263783	150.112244	361.95	1.65	363.60
30	-32.264083	150.112151	362.99	1.65	364.64
31	-32.264956	150.112910	357.57	1.65	359.22
32	-32.265612	150.112625	360.73	1.65	362.38
33	-32.266055	150.114059	355.74	1.65	357.39
34	-32.265682	150.114334	353.82	1.65	355.47
35	-32.265461	150.114735	352.13	1.65	353.78
36	-32.264149	150.115515	349.78	1.65	351.43
37	-32.264188	150.117068	343.49	1.65	345.14
38	-32.264063	150.117902	341.34	1.65	342.99
39	-32.263912	150.118745	342.48	1.65	344.13
40	-32.263975	150.119550	342.14	1.65	343.79
41	-32.263791	150.120023	340.85	1.65	342.50
42	-32.263859	150.120455	338.04	1.65	339.69
43	-32.263704	150.121103	335.65	1.65	337.30
44	-32.262959	150.121198	340.32	1.65	341.97
45	-32.262958	150.121712	342.50	1.65	344.15
46	-32.262358	150.121753	346.90	1.65	348.55
47	-32.260113	150.121583	359.37	1.65	361.02
48	-32.260075	150.120918	363.27	1.65	364.92
49	-32.258920	150.120928	362.50	1.65	364.15
50	-32.258710	150.120541	361.93	1.65	363.58
51	-32.258658	150.118264	361.79	1.65	363.44
52	-32.259003	150.118278	363.94	1.65	365.59
53	-32.259667	150.116486	368.09	1.65	369.74
54	-32.260767	150.116600	370.65	1.65	372.30
55	-32.260578	150.113186	373.80	1.65	375.45
56	-32.260056	150.111978	376.95	1.65	378.60
57	-32.260100	150.110119	391.35	1.65	393.00
58	-32.261145	150.110084	386.83	1.65	388.48
59	-32.260927	150.109026	398.82	1.65	400.47

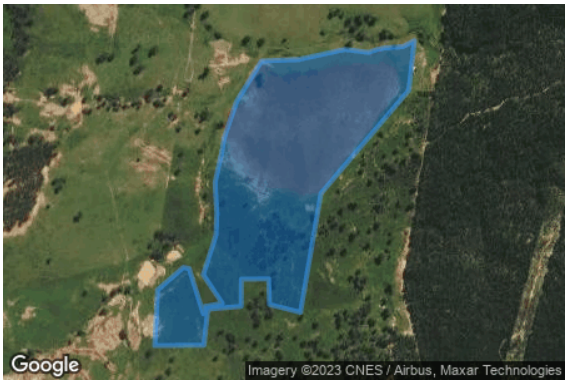
Name: PV array 3
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 5.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.266877	150.097035	417.50	1.65	419.15
2	-32.266317	150.097593	418.78	1.65	420.43
3	-32.266374	150.099459	418.01	1.65	419.66
4	-32.266197	150.099484	418.92	1.65	420.57
5	-32.266065	150.099685	417.92	1.65	419.57
6	-32.266116	150.101289	410.61	1.65	412.26
7	-32.266233	150.101425	411.45	1.65	413.10
8	-32.266074	150.101677	412.61	1.65	414.26
9	-32.266117	150.103903	421.63	1.65	423.28
10	-32.266120	150.104339	420.36	1.65	422.01
11	-32.266599	150.104330	418.52	1.65	420.17
12	-32.266904	150.104297	417.25	1.65	418.90
13	-32.267518	150.104197	414.63	1.65	416.28
14	-32.267472	150.103434	418.26	1.65	419.91
15	-32.268977	150.103367	409.45	1.65	411.10
16	-32.269073	150.104115	406.80	1.65	408.45
17	-32.270064	150.104238	412.12	1.65	413.77
18	-32.272206	150.103696	429.44	1.65	431.09
19	-32.272225	150.103229	428.32	1.65	429.97
20	-32.272837	150.103217	430.19	1.65	431.84
21	-32.272883	150.103077	429.51	1.65	431.16
22	-32.273139	150.102977	429.57	1.65	431.22
23	-32.273924	150.103021	431.96	1.65	433.61
24	-32.273951	150.104067	438.17	1.65	439.82
25	-32.274783	150.104803	436.40	1.65	438.05
26	-32.276647	150.104778	437.67	1.65	439.32
27	-32.277249	150.109665	423.94	1.65	425.59
28	-32.276054	150.113006	417.60	1.65	419.25
29	-32.276351	150.120590	413.33	1.65	414.98
30	-32.278255	150.120524	403.22	1.65	404.87
31	-32.283355	150.119382	416.09	1.65	417.74
32	-32.286489	150.119009	414.58	1.65	416.23
33	-32.287243	150.118026	407.98	1.65	409.63
34	-32.287208	150.116941	408.87	1.65	410.52
35	-32.286160	150.115929	418.36	1.65	420.01
36	-32.286131	150.114805	416.02	1.65	417.67
37	-32.284313	150.114833	417.40	1.65	419.05
38	-32.283726	150.113988	412.53	1.65	414.18
39	-32.284111	150.106761	422.52	1.65	424.17
40	-32.281989	150.094658	417.80	1.65	419.45
41	-32.281621	150.094451	418.11	1.65	419.76
42	-32.280782	150.094416	422.20	1.65	423.85
43	-32.280763	150.093617	417.98	1.65	419.63
44	-32.277814	150.093705	435.83	1.65	437.48
45	-32.276567	150.094209	434.87	1.65	436.52
46	-32.275164	150.094283	426.73	1.65	428.38
47	-32.275130	150.094508	426.22	1.65	427.87
48	-32.274702	150.095495	426.89	1.65	428.54
49	-32.274209	150.095507	425.62	1.65	427.27
50	-32.274225	150.098494	430.91	1.65	432.56
51	-32.274295	150.098991	430.11	1.65	431.76
52	-32.273793	150.099879	425.05	1.65	426.70
53	-32.273832	150.101158	424.12	1.65	425.77
54	-32.272951	150.101176	423.63	1.65	425.28
55	-32.272323	150.101688	425.97	1.65	427.62
56	-32.272053	150.101955	425.58	1.65	427.23
57	-32.271416	150.100731	421.38	1.65	423.03
58	-32.270031	150.100752	411.71	1.65	413.36
59	-32.270041	150.099511	409.54	1.65	411.19

Name: PV array 4
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 5.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.281997	150.094664	417.81	1.65	419.46
2	-32.284111	150.106758	422.52	1.65	424.17
3	-32.292557	150.108663	424.83	1.65	426.48
4	-32.297069	150.107708	419.38	1.65	421.03
5	-32.297483	150.108269	412.27	1.65	413.92
6	-32.298094	150.107989	415.27	1.65	416.92
7	-32.301386	150.111156	413.47	1.65	415.12
8	-32.301643	150.111090	417.81	1.65	419.46
9	-32.301889	150.111259	419.24	1.65	420.89
10	-32.301904	150.111718	413.67	1.65	415.32
11	-32.302881	150.112594	401.22	1.65	402.87
12	-32.306731	150.111069	421.63	1.65	423.28
13	-32.307742	150.109672	419.48	1.65	421.13
14	-32.307131	150.104325	431.29	1.65	432.94
15	-32.304328	150.104947	427.13	1.65	428.78
16	-32.303878	150.106575	433.66	1.65	435.31
17	-32.302867	150.106700	433.05	1.65	434.70
18	-32.300722	150.103847	418.69	1.65	420.34
19	-32.298883	150.102436	416.87	1.65	418.52
20	-32.301321	150.100390	419.58	1.65	421.23
21	-32.301295	150.098852	425.46	1.65	427.11
22	-32.300700	150.098617	425.32	1.65	426.97
23	-32.300308	150.098756	424.90	1.65	426.55
24	-32.299250	150.097989	431.11	1.65	432.76
25	-32.297117	150.095631	412.70	1.65	414.35
26	-32.297349	150.091975	409.17	1.65	410.82
27	-32.298231	150.091993	405.19	1.65	406.84
28	-32.299203	150.091344	409.68	1.65	411.33
29	-32.299212	150.088565	439.17	1.65	440.82
30	-32.298828	150.088161	442.65	1.65	444.30
31	-32.298839	150.086019	445.23	1.65	446.88
32	-32.299127	150.085506	445.82	1.65	447.47
33	-32.299127	150.084946	445.05	1.65	446.70
34	-32.298390	150.084454	440.01	1.65	441.66
35	-32.296598	150.084633	435.09	1.65	436.74
36	-32.296172	150.084897	438.16	1.65	439.81
37	-32.295847	150.084514	435.97	1.65	437.62
38	-32.295864	150.084108	434.06	1.65	435.71
39	-32.295024	150.083025	435.23	1.65	436.88
40	-32.293426	150.083144	433.99	1.65	435.64
41	-32.291513	150.084033	432.65	1.65	434.30
42	-32.291164	150.086417	416.56	1.65	418.21
43	-32.291155	150.087133	413.99	1.65	415.64
44	-32.291275	150.091747	418.49	1.65	420.14
45	-32.291498	150.093423	425.79	1.65	427.44
46	-32.292219	150.094025	429.48	1.65	431.13
47	-32.292247	150.094957	432.26	1.65	433.91
48	-32.291315	150.094969	433.09	1.65	434.74
49	-32.291206	150.095121	433.86	1.65	435.51
50	-32.290858	150.095185	433.80	1.65	435.45
51	-32.290603	150.094963	432.95	1.65	434.60
52	-32.289754	150.094990	435.65	1.65	437.30
53	-32.289789	150.095889	440.69	1.65	442.34
54	-32.290186	150.096363	441.01	1.65	442.66
55	-32.290220	150.097024	442.05	1.65	443.70
56	-32.287592	150.097462	438.48	1.65	440.13
57	-32.287423	150.095917	439.07	1.65	440.72
58	-32.285657	150.096016	436.64	1.65	438.29
59	-32.285642	150.094303	433.16	1.65	434.81

Name: PV array 5
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 5.0°
Ground Coverage Ratio: 0.36
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.273081	150.113903	384.75	1.65	386.40
2	-32.273093	150.112208	385.39	1.65	387.04
3	-32.271484	150.112305	373.03	1.65	374.68
4	-32.270828	150.113196	368.89	1.65	370.54
5	-32.270861	150.113391	368.47	1.65	370.12
6	-32.272172	150.113880	376.34	1.65	377.99
7	-32.271962	150.113904	375.10	1.65	376.75
8	-32.271869	150.114529	375.85	1.65	377.50
9	-32.271044	150.113875	368.89	1.65	370.54
10	-32.269892	150.114315	366.00	1.65	367.65
11	-32.269261	150.114342	366.00	1.65	367.65
12	-32.268375	150.114283	363.25	1.65	364.90
13	-32.267510	150.114508	357.19	1.65	358.84
14	-32.267087	150.114594	356.87	1.65	358.52
15	-32.266023	150.115023	352.91	1.65	354.56
16	-32.264857	150.115880	347.94	1.65	349.59
17	-32.264810	150.117145	343.22	1.65	344.87
18	-32.264518	150.118752	341.83	1.65	343.48
19	-32.264606	150.119553	340.93	1.65	342.58
20	-32.264520	150.119854	339.75	1.65	341.40
21	-32.264471	150.120155	338.68	1.65	340.33
22	-32.264439	150.120739	336.64	1.65	338.29
23	-32.264265	150.121133	334.64	1.65	336.29
24	-32.265697	150.120943	347.53	1.65	349.18
25	-32.268689	150.117921	367.78	1.65	369.43
26	-32.272132	150.117219	378.81	1.65	380.46
27	-32.271903	150.116153	379.64	1.65	381.29
28	-32.271162	150.116123	379.46	1.65	381.11
29	-32.271170	150.115187	374.42	1.65	376.07
30	-32.271956	150.115181	378.44	1.65	380.09
31	-32.272037	150.114074	375.98	1.65	377.63
32	-32.272139	150.114022	376.50	1.65	378.15

Route Receptors

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.246039	150.110944	323.76	2.40	326.16
2	-32.250866	150.106824	339.28	2.40	341.68
3	-32.252681	150.103391	345.91	2.40	348.31
4	-32.254459	150.102876	348.64	2.40	351.04
5	-32.257798	150.100301	361.91	2.40	364.31
6	-32.260048	150.096524	380.42	2.40	382.82
7	-32.262008	150.094894	390.89	2.40	393.29
8	-32.263786	150.092705	392.49	2.40	394.89
9	-32.264040	150.090860	385.92	2.40	388.32
10	-32.266109	150.089572	375.28	2.40	377.68
11	-32.266435	150.088370	367.31	2.40	369.71
12	-32.270318	150.082963	352.60	2.40	355.00
13	-32.270499	150.080646	343.55	2.40	345.95
14	-32.273366	150.079315	336.56	2.40	338.96
15	-32.273765	150.077384	330.34	2.40	332.74
16	-32.277575	150.075625	329.07	2.40	331.47
17	-32.279933	150.072449	333.76	2.40	336.16
18	-32.287915	150.069616	344.39	2.40	346.79
19	-32.291870	150.068372	353.99	2.40	356.39
20	-32.294989	150.063522	377.90	2.40	380.30
21	-32.295886	150.059531	388.23	2.40	390.63
22	-32.299368	150.054982	413.79	2.40	416.19

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-32.237750	150.108297	332.78	1.50
OP 2	2	-32.309558	150.106650	413.17	1.50
OP 3	3	-32.243961	150.047733	262.17	1.50
OP 4	4	-32.237611	150.056033	265.23	1.50

Glare Analysis Results

Summary of Results

Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	5,085	84.8	0	0.0	-
PV array 2	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 3	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 4	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 5	SA tracking	SA tracking	32	0.5	0	0.0	-

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

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	5,117	85.3	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

PV: PV array 1

low potential for temporary after-image

Receptor results ordered by category of glare

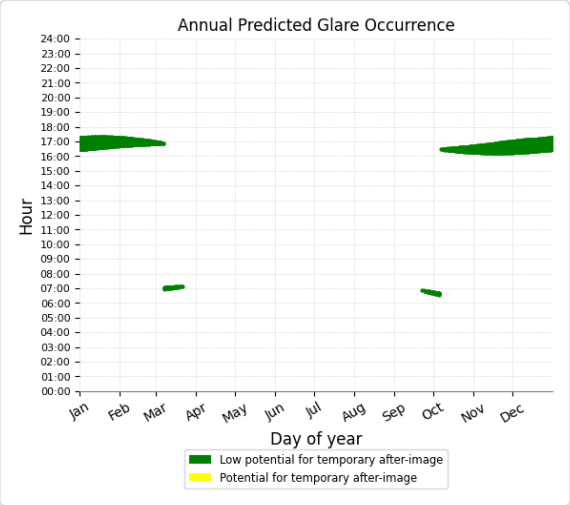
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	5,085	84.8	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

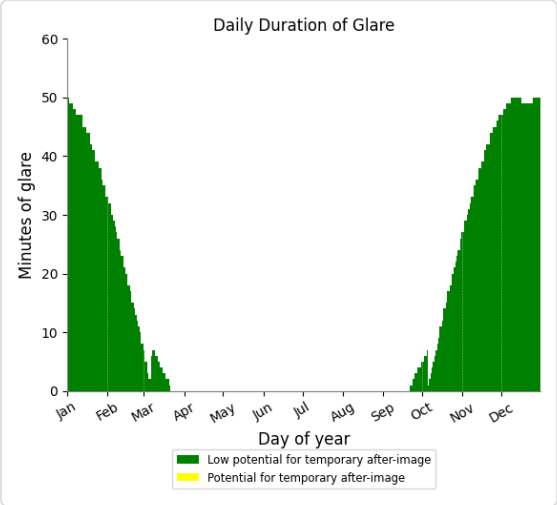
PV array 1 and Wollara Road

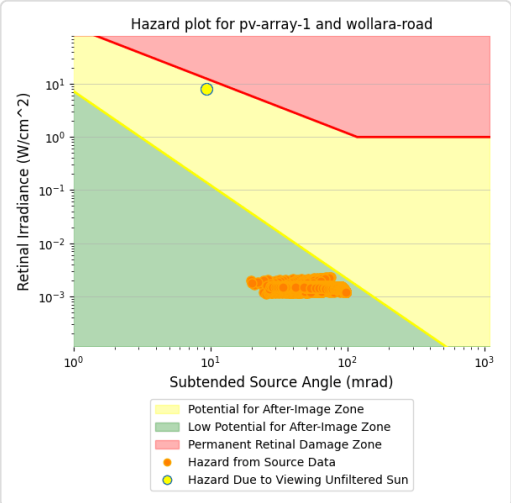
Receptor type: Route

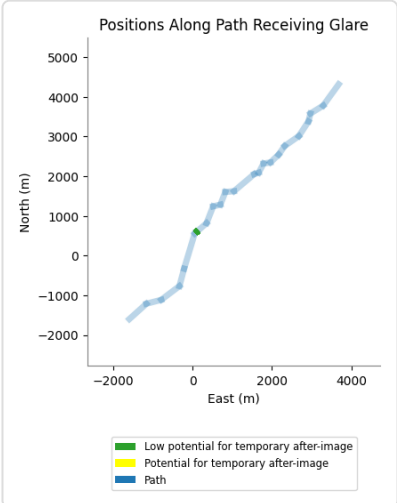
0 minutes of yellow glare

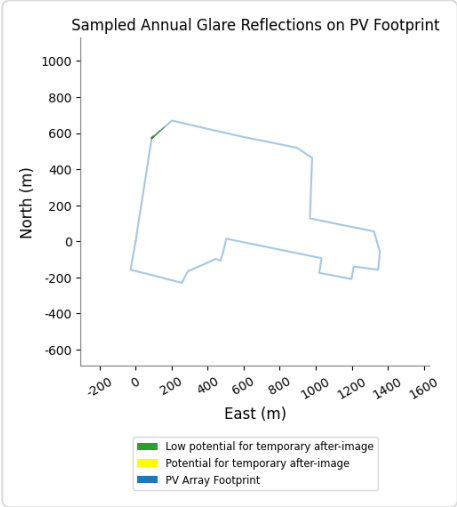
5,085 minutes of green glare











PV array 1 and OP 1

Receptor type: Observation Point
No glare found

PV array 1 and OP 2

Receptor type: Observation Point
No glare found

PV array 1 and OP 3

Receptor type: Observation Point
No glare found

PV array 1 and OP 4

Receptor type: Observation Point
No glare found

PV: PV array 2 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

PV array 2 and Wollara Road

Receptor type: Route
No glare found

PV array 2 and OP 1

Receptor type: Observation Point
No glare found

PV array 2 and OP 2

Receptor type: Observation Point
No glare found

PV array 2 and OP 3

Receptor type: Observation Point
No glare found

PV array 2 and OP 4

Receptor type: Observation Point
No glare found

PV: PV array 3 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

PV array 3 and Wollara Road

Receptor type: Route
No glare found

PV array 3 and OP 1

Receptor type: Observation Point
No glare found

PV array 3 and OP 2

Receptor type: Observation Point
No glare found

PV array 3 and OP 3

Receptor type: Observation Point
No glare found

PV array 3 and OP 4

Receptor type: Observation Point
No glare found

PV: PV array 4 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

PV array 4 and Wollara Road

Receptor type: Route
No glare found

PV array 4 and OP 1

Receptor type: Observation Point
No glare found

PV array 4 and OP 2

Receptor type: Observation Point
No glare found

PV array 4 and OP 3

Receptor type: Observation Point
No glare found

PV array 4 and OP 4

Receptor type: Observation Point
No glare found

PV: PV array 5 low potential for temporary after-image

Receptor results ordered by category of glare

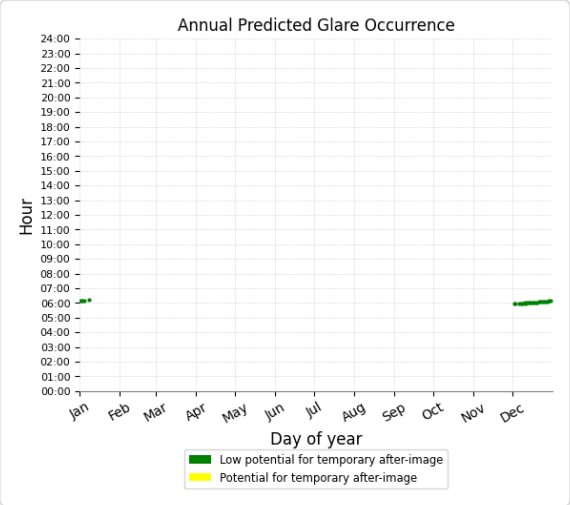
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	32	0.5	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

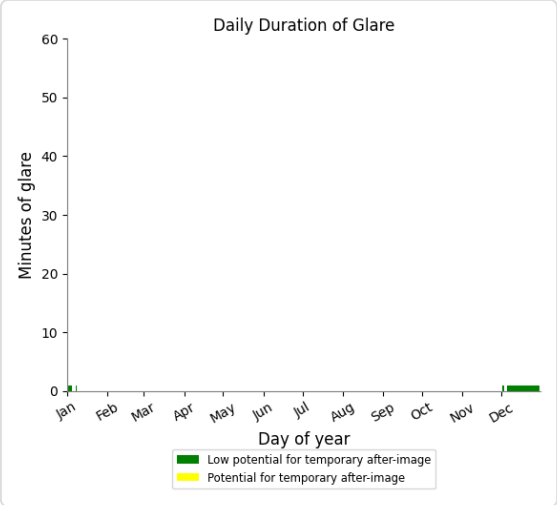
PV array 5 and Wollara Road

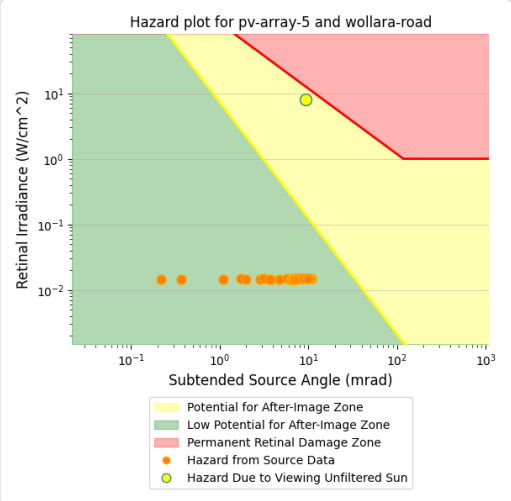
Receptor type: Route

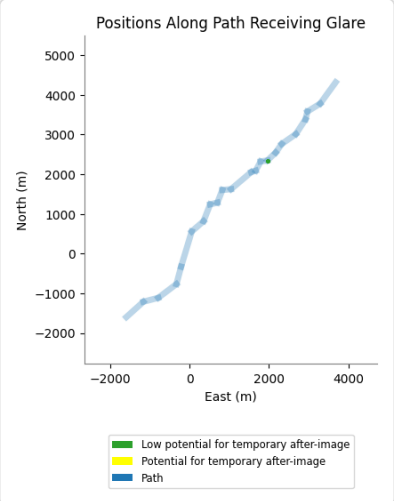
0 minutes of yellow glare

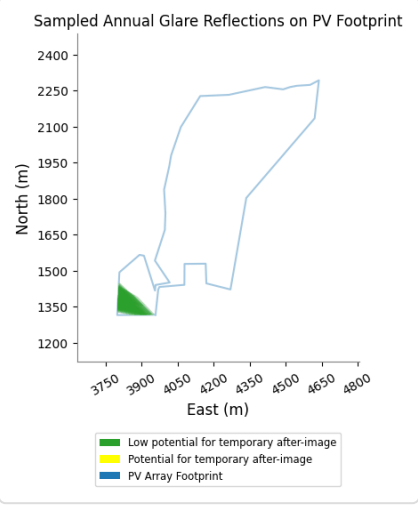
32 minutes of green glare











PV array 5 and OP 1

Receptor type: Observation Point
No glare found

PV array 5 and OP 2

Receptor type: Observation Point
No glare found

PV array 5 and OP 3

Receptor type: Observation Point
No glare found

PV array 5 and OP 4

Receptor type: Observation Point
No glare found

Assumptions

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

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

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

FORGESOLAR GLARE ANALYSIS

Project: **2290_GoulburnRiverSolarFarm**
Site configuration: **2290 Goulburn River SF_20230313_Backtracking22d**

Client: UMWELT

Created 14 Mar, 2023
Updated 15 Mar, 2023
Time-step 1 minute
Timezone offset UTC11
Site ID 86189.14902
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
PV analysis methodology V2

Summary of Results

Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	5,442	90.7	0	0.0	-
PV array 2	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 3	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 4	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 5	SA tracking	SA tracking	0	0.0	0	0.0	-

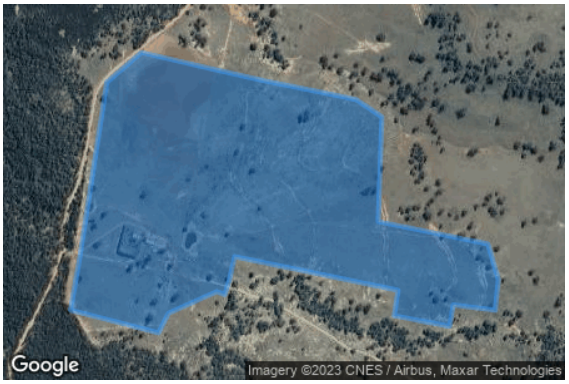
Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	5,442	90.7	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array 1
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 22.0°
Ground Coverage Ratio: 0.42
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.284940	150.071892	325.68	1.65	327.33
2	-32.286361	150.071592	335.58	1.65	337.23
3	-32.287019	150.074617	345.42	1.65	347.07
4	-32.286450	150.074961	340.65	1.65	342.30
5	-32.285826	150.076618	339.30	1.65	340.95
6	-32.285910	150.076892	341.14	1.65	342.79
7	-32.285467	150.077058	336.56	1.65	338.21
8	-32.284813	150.077232	333.29	1.65	334.94
9	-32.285083	150.078792	341.42	1.65	343.07
10	-32.285789	150.082849	359.58	1.65	361.23
11	-32.286525	150.082714	361.09	1.65	362.74
12	-32.286831	150.084619	368.70	1.65	370.35
13	-32.286207	150.084743	369.63	1.65	371.28
14	-32.286363	150.086186	376.29	1.65	377.94
15	-32.285477	150.086294	378.73	1.65	380.38
16	-32.284448	150.085935	380.39	1.65	382.04
17	-32.283800	150.082164	357.26	1.65	358.91
18	-32.280771	150.082293	357.96	1.65	359.61
19	-32.280275	150.081422	351.78	1.65	353.43
20	-32.280110	150.080523	348.10	1.65	349.75
21	-32.279736	150.078311	339.59	1.65	341.24
22	-32.279438	150.076745	336.09	1.65	337.74
23	-32.278904	150.074034	334.30	1.65	335.95
24	-32.279770	150.072840	334.41	1.65	336.06

Name: PV array 2
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 22.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.270193	150.106852	399.71	1.65	401.36
2	-32.270833	150.106665	405.61	1.65	407.26
3	-32.271498	150.106603	412.74	1.65	414.39
4	-32.272635	150.107121	415.96	1.65	417.61
5	-32.272870	150.108902	392.29	1.65	393.94
6	-32.272823	150.109106	391.22	1.65	392.87
7	-32.271933	150.109922	386.68	1.65	388.33
8	-32.271258	150.110137	385.32	1.65	386.97
9	-32.271268	150.111318	377.99	1.65	379.64
10	-32.269893	150.112092	376.51	1.65	378.16
11	-32.269681	150.112440	374.50	1.65	376.15
12	-32.269775	150.113563	366.93	1.65	368.58
13	-32.269235	150.113614	366.63	1.65	368.28
14	-32.268540	150.113514	366.38	1.65	368.03
15	-32.267375	150.113824	359.71	1.65	361.36
16	-32.266696	150.113885	358.85	1.65	360.50
17	-32.266626	150.112763	364.54	1.65	366.19
18	-32.266106	150.111956	364.69	1.65	366.34
19	-32.266317	150.111598	365.91	1.65	367.56
20	-32.266304	150.110678	370.05	1.65	371.70
21	-32.266423	150.110126	372.76	1.65	374.41
22	-32.266389	150.109611	374.45	1.65	376.10
23	-32.265215	150.109645	376.11	1.65	377.76
24	-32.264934	150.109565	377.84	1.65	379.49
25	-32.264599	150.109614	379.01	1.65	380.66
26	-32.264137	150.109801	379.63	1.65	381.28
27	-32.263922	150.110110	377.60	1.65	379.25
28	-32.263547	150.110169	377.00	1.65	378.65
29	-32.263783	150.112244	361.95	1.65	363.60
30	-32.264083	150.112151	362.99	1.65	364.64
31	-32.264956	150.112910	357.57	1.65	359.22
32	-32.265612	150.112625	360.73	1.65	362.38
33	-32.266055	150.114059	355.74	1.65	357.39
34	-32.265682	150.114334	353.82	1.65	355.47
35	-32.265461	150.114735	352.13	1.65	353.78
36	-32.264149	150.115515	349.78	1.65	351.43
37	-32.264188	150.117068	343.49	1.65	345.14
38	-32.264063	150.117902	341.34	1.65	342.99
39	-32.263912	150.118745	342.48	1.65	344.13
40	-32.263975	150.119550	342.14	1.65	343.79
41	-32.263791	150.120023	340.85	1.65	342.50
42	-32.263859	150.120455	338.04	1.65	339.69
43	-32.263704	150.121103	335.65	1.65	337.30
44	-32.262959	150.121198	340.32	1.65	341.97
45	-32.262958	150.121712	342.50	1.65	344.15
46	-32.262358	150.121753	346.90	1.65	348.55
47	-32.260113	150.121583	359.37	1.65	361.02
48	-32.260075	150.120918	363.27	1.65	364.92
49	-32.258920	150.120928	362.50	1.65	364.15
50	-32.258710	150.120541	361.93	1.65	363.58
51	-32.258658	150.118264	361.79	1.65	363.44
52	-32.259003	150.118278	363.94	1.65	365.59
53	-32.259667	150.116486	368.09	1.65	369.74
54	-32.260767	150.116600	370.65	1.65	372.30
55	-32.260578	150.113186	373.80	1.65	375.45
56	-32.260056	150.111978	376.95	1.65	378.60
57	-32.260100	150.110119	391.35	1.65	393.00
58	-32.261145	150.110084	386.83	1.65	388.48
59	-32.260927	150.109026	398.82	1.65	400.47

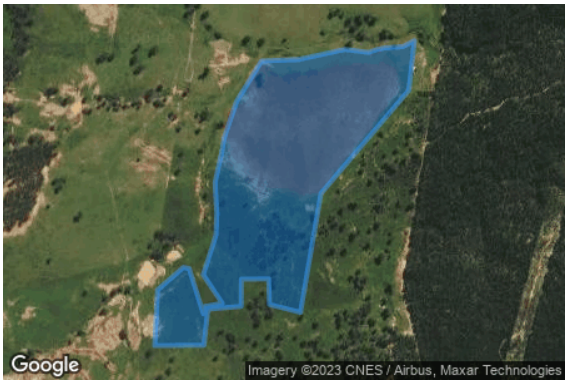
Name: PV array 3
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 22.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.266877	150.097035	417.50	1.65	419.15
2	-32.266317	150.097593	418.78	1.65	420.43
3	-32.266374	150.099459	418.01	1.65	419.66
4	-32.266197	150.099484	418.92	1.65	420.57
5	-32.266065	150.099685	417.92	1.65	419.57
6	-32.266116	150.101289	410.61	1.65	412.26
7	-32.266233	150.101425	411.45	1.65	413.10
8	-32.266074	150.101677	412.61	1.65	414.26
9	-32.266117	150.103903	421.63	1.65	423.28
10	-32.266120	150.104339	420.36	1.65	422.01
11	-32.266599	150.104330	418.52	1.65	420.17
12	-32.266904	150.104297	417.25	1.65	418.90
13	-32.267518	150.104197	414.63	1.65	416.28
14	-32.267472	150.103434	418.26	1.65	419.91
15	-32.268977	150.103367	409.45	1.65	411.10
16	-32.269073	150.104115	406.80	1.65	408.45
17	-32.270064	150.104238	412.12	1.65	413.77
18	-32.272206	150.103696	429.44	1.65	431.09
19	-32.272225	150.103229	428.32	1.65	429.97
20	-32.272837	150.103217	430.19	1.65	431.84
21	-32.272883	150.103077	429.51	1.65	431.16
22	-32.273139	150.102977	429.57	1.65	431.22
23	-32.273924	150.103021	431.96	1.65	433.61
24	-32.273951	150.104067	438.17	1.65	439.82
25	-32.274783	150.104803	436.40	1.65	438.05
26	-32.276647	150.104778	437.67	1.65	439.32
27	-32.277249	150.109665	423.94	1.65	425.59
28	-32.276054	150.113006	417.60	1.65	419.25
29	-32.276351	150.120590	413.33	1.65	414.98
30	-32.278255	150.120524	403.22	1.65	404.87
31	-32.283355	150.119382	416.09	1.65	417.74
32	-32.286489	150.119009	414.58	1.65	416.23
33	-32.287243	150.118026	407.98	1.65	409.63
34	-32.287208	150.116941	408.87	1.65	410.52
35	-32.286160	150.115929	418.36	1.65	420.01
36	-32.286131	150.114805	416.02	1.65	417.67
37	-32.284313	150.114833	417.40	1.65	419.05
38	-32.283726	150.113988	412.53	1.65	414.18
39	-32.284111	150.106761	422.52	1.65	424.17
40	-32.281989	150.094658	417.80	1.65	419.45
41	-32.281621	150.094451	418.11	1.65	419.76
42	-32.280782	150.094416	422.20	1.65	423.85
43	-32.280763	150.093617	417.98	1.65	419.63
44	-32.277814	150.093705	435.83	1.65	437.48
45	-32.276567	150.094209	434.87	1.65	436.52
46	-32.275164	150.094283	426.73	1.65	428.38
47	-32.275130	150.094508	426.22	1.65	427.87
48	-32.274702	150.095495	426.89	1.65	428.54
49	-32.274209	150.095507	425.62	1.65	427.27
50	-32.274225	150.098494	430.91	1.65	432.56
51	-32.274295	150.098991	430.11	1.65	431.76
52	-32.273793	150.099879	425.05	1.65	426.70
53	-32.273832	150.101158	424.12	1.65	425.77
54	-32.272951	150.101176	423.63	1.65	425.28
55	-32.272323	150.101688	425.97	1.65	427.62
56	-32.272053	150.101955	425.58	1.65	427.23
57	-32.271416	150.100731	421.38	1.65	423.03
58	-32.270031	150.100752	411.71	1.65	413.36
59	-32.270041	150.099511	409.54	1.65	411.19

Name: PV array 4
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 22.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.281997	150.094664	417.81	1.65	419.46
2	-32.284111	150.106758	422.52	1.65	424.17
3	-32.292557	150.108663	424.83	1.65	426.48
4	-32.297069	150.107708	419.38	1.65	421.03
5	-32.297483	150.108269	412.27	1.65	413.92
6	-32.298094	150.107989	415.27	1.65	416.92
7	-32.301386	150.111156	413.47	1.65	415.12
8	-32.301643	150.111090	417.81	1.65	419.46
9	-32.301889	150.111259	419.24	1.65	420.89
10	-32.301904	150.111718	413.67	1.65	415.32
11	-32.302881	150.112594	401.22	1.65	402.87
12	-32.306731	150.111069	421.63	1.65	423.28
13	-32.307742	150.109672	419.48	1.65	421.13
14	-32.307131	150.104325	431.29	1.65	432.94
15	-32.304328	150.104947	427.13	1.65	428.78
16	-32.303878	150.106575	433.66	1.65	435.31
17	-32.302867	150.106700	433.05	1.65	434.70
18	-32.300722	150.103847	418.69	1.65	420.34
19	-32.298883	150.102436	416.87	1.65	418.52
20	-32.301321	150.100390	419.58	1.65	421.23
21	-32.301295	150.098852	425.46	1.65	427.11
22	-32.300700	150.098617	425.32	1.65	426.97
23	-32.300308	150.098756	424.90	1.65	426.55
24	-32.299250	150.097989	431.11	1.65	432.76
25	-32.297117	150.095631	412.70	1.65	414.35
26	-32.297349	150.091975	409.17	1.65	410.82
27	-32.298231	150.091993	405.19	1.65	406.84
28	-32.299203	150.091344	409.68	1.65	411.33
29	-32.299212	150.088565	439.17	1.65	440.82
30	-32.298828	150.088161	442.65	1.65	444.30
31	-32.298839	150.086019	445.23	1.65	446.88
32	-32.299127	150.085506	445.82	1.65	447.47
33	-32.299127	150.084946	445.05	1.65	446.70
34	-32.298390	150.084454	440.01	1.65	441.66
35	-32.296598	150.084633	435.09	1.65	436.74
36	-32.296172	150.084897	438.16	1.65	439.81
37	-32.295847	150.084514	435.97	1.65	437.62
38	-32.295864	150.084108	434.06	1.65	435.71
39	-32.295024	150.083025	435.23	1.65	436.88
40	-32.293426	150.083144	433.99	1.65	435.64
41	-32.291513	150.084033	432.65	1.65	434.30
42	-32.291164	150.086417	416.56	1.65	418.21
43	-32.291155	150.087133	413.99	1.65	415.64
44	-32.291275	150.091747	418.49	1.65	420.14
45	-32.291498	150.093423	425.79	1.65	427.44
46	-32.292219	150.094025	429.48	1.65	431.13
47	-32.292247	150.094957	432.26	1.65	433.91
48	-32.291315	150.094969	433.09	1.65	434.74
49	-32.291206	150.095121	433.86	1.65	435.51
50	-32.290858	150.095185	433.80	1.65	435.45
51	-32.290603	150.094963	432.95	1.65	434.60
52	-32.289754	150.094990	435.65	1.65	437.30
53	-32.289789	150.095889	440.69	1.65	442.34
54	-32.290186	150.096363	441.01	1.65	442.66
55	-32.290220	150.097024	442.05	1.65	443.70
56	-32.287592	150.097462	438.48	1.65	440.13
57	-32.287423	150.095917	439.07	1.65	440.72
58	-32.285657	150.096016	436.64	1.65	438.29
59	-32.285642	150.094303	433.16	1.65	434.81

Name: PV array 5
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 22.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.273081	150.113903	384.75	1.65	386.40
2	-32.273093	150.112208	385.39	1.65	387.04
3	-32.271484	150.112305	373.03	1.65	374.68
4	-32.270828	150.113196	368.89	1.65	370.54
5	-32.270861	150.113391	368.47	1.65	370.12
6	-32.272172	150.113880	376.34	1.65	377.99
7	-32.271962	150.113904	375.10	1.65	376.75
8	-32.271869	150.114529	375.85	1.65	377.50
9	-32.271044	150.113875	368.89	1.65	370.54
10	-32.269892	150.114315	366.00	1.65	367.65
11	-32.269261	150.114342	366.00	1.65	367.65
12	-32.268375	150.114283	363.25	1.65	364.90
13	-32.267510	150.114508	357.19	1.65	358.84
14	-32.267087	150.114594	356.87	1.65	358.52
15	-32.266023	150.115023	352.91	1.65	354.56
16	-32.264857	150.115880	347.94	1.65	349.59
17	-32.264810	150.117145	343.22	1.65	344.87
18	-32.264518	150.118752	341.83	1.65	343.48
19	-32.264606	150.119553	340.93	1.65	342.58
20	-32.264520	150.119854	339.75	1.65	341.40
21	-32.264471	150.120155	338.68	1.65	340.33
22	-32.264439	150.120739	336.64	1.65	338.29
23	-32.264265	150.121133	334.64	1.65	336.29
24	-32.265697	150.120943	347.53	1.65	349.18
25	-32.268689	150.117921	367.78	1.65	369.43
26	-32.272132	150.117219	378.81	1.65	380.46
27	-32.271903	150.116153	379.64	1.65	381.29
28	-32.271162	150.116123	379.46	1.65	381.11
29	-32.271170	150.115187	374.42	1.65	376.07
30	-32.271956	150.115181	378.44	1.65	380.09
31	-32.272037	150.114074	375.98	1.65	377.63
32	-32.272139	150.114022	376.50	1.65	378.15

Route Receptors

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.246039	150.110944	323.76	2.40	326.16
2	-32.250866	150.106824	339.28	2.40	341.68
3	-32.252681	150.103391	345.91	2.40	348.31
4	-32.254459	150.102876	348.64	2.40	351.04
5	-32.257798	150.100301	361.91	2.40	364.31
6	-32.260048	150.096524	380.42	2.40	382.82
7	-32.262008	150.094894	390.89	2.40	393.29
8	-32.263786	150.092705	392.49	2.40	394.89
9	-32.264040	150.090860	385.92	2.40	388.32
10	-32.266109	150.089572	375.28	2.40	377.68
11	-32.266435	150.088370	367.31	2.40	369.71
12	-32.270318	150.082963	352.60	2.40	355.00
13	-32.270499	150.080646	343.55	2.40	345.95
14	-32.273366	150.079315	336.56	2.40	338.96
15	-32.273765	150.077384	330.34	2.40	332.74
16	-32.277575	150.075625	329.07	2.40	331.47
17	-32.279933	150.072449	333.76	2.40	336.16
18	-32.287915	150.069616	344.39	2.40	346.79
19	-32.291870	150.068372	353.99	2.40	356.39
20	-32.294989	150.063522	377.90	2.40	380.30
21	-32.295886	150.059531	388.23	2.40	390.63
22	-32.299368	150.054982	413.79	2.40	416.19

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-32.237750	150.108297	332.78	1.50
OP 2	2	-32.309558	150.106650	413.17	1.50
OP 3	3	-32.243961	150.047733	262.17	1.50
OP 4	4	-32.237611	150.056033	265.23	1.50

Glare Analysis Results

Summary of Results

Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	5,442	90.7	0	0.0	-
PV array 2	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 3	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 4	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 5	SA tracking	SA tracking	0	0.0	0	0.0	-

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

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	5,442	90.7	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

PV: PV array 1

low potential for temporary after-image

Receptor results ordered by category of glare

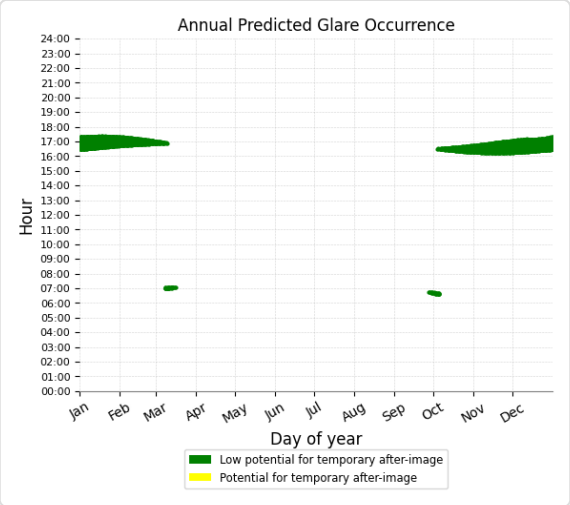
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	5,442	90.7	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

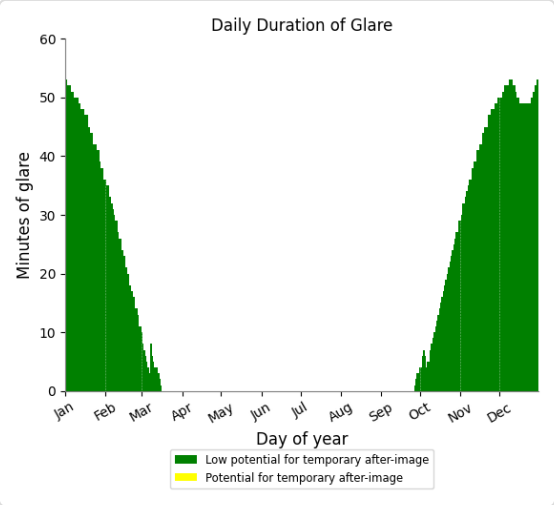
PV array 1 and Wollara Road

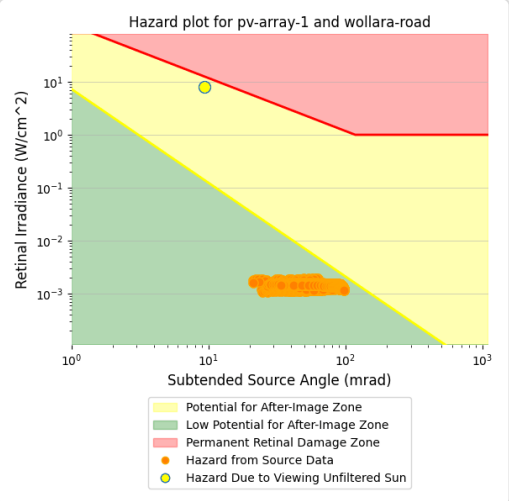
Receptor type: Route

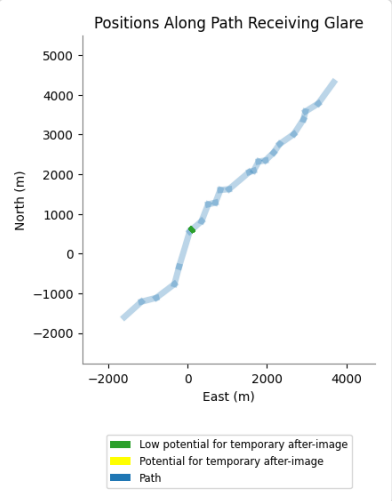
0 minutes of yellow glare

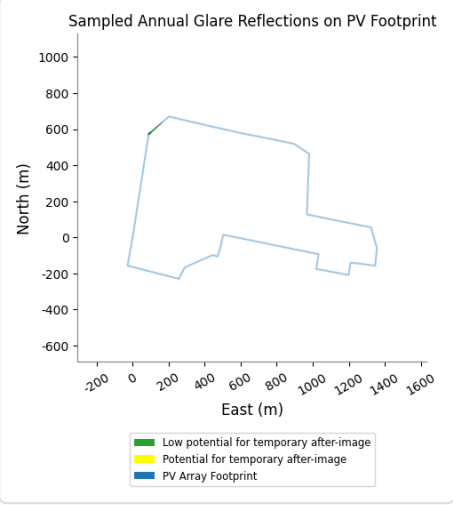
5,442 minutes of green glare











PV array 1 and OP 1

Receptor type: Observation Point
No glare found

PV array 1 and OP 2

Receptor type: Observation Point
No glare found

PV array 1 and OP 3

Receptor type: Observation Point
No glare found

PV array 1 and OP 4

Receptor type: Observation Point
No glare found

PV: PV array 2 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

PV array 2 and Wollara Road

Receptor type: Route
No glare found

PV array 2 and OP 1

Receptor type: Observation Point
No glare found

PV array 2 and OP 2

Receptor type: Observation Point
No glare found

PV array 2 and OP 3

Receptor type: Observation Point
No glare found

PV array 2 and OP 4

Receptor type: Observation Point
No glare found

PV: PV array 3 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

PV array 3 and Wollara Road

Receptor type: Route
No glare found

PV array 3 and OP 1

Receptor type: Observation Point
No glare found

PV array 3 and OP 2

Receptor type: Observation Point
No glare found

PV array 3 and OP 3

Receptor type: Observation Point
No glare found

PV array 3 and OP 4

Receptor type: Observation Point
No glare found

PV: PV array 4 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

PV array 4 and Wollara Road

Receptor type: Route
No glare found

PV array 4 and OP 1

Receptor type: Observation Point
No glare found

PV array 4 and OP 2

Receptor type: Observation Point
No glare found

PV array 4 and OP 3

Receptor type: Observation Point
No glare found

PV array 4 and OP 4

Receptor type: Observation Point
No glare found

PV: PV array 5 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

PV array 5 and Wollara Road

Receptor type: Route
No glare found

PV array 5 and OP 1

Receptor type: Observation Point
No glare found

PV array 5 and OP 2

Receptor type: Observation Point
No glare found

PV array 5 and OP 3

Receptor type: Observation Point
No glare found

PV array 5 and OP 4

Receptor type: Observation Point
No glare found

Assumptions

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

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

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

FORGESOLAR GLARE ANALYSIS

Project: **2290_GoulburnRiverSolarFarm**
Site configuration: **2290 Goulburn River SF_20230313_Backtracking45d**

Client: UMWELT

Created 14 Mar, 2023
Updated 15 Mar, 2023
Time-step 1 minute
Timezone offset UTC11
Site ID 86191.14902
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
PV analysis methodology V2

Summary of Results

Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	4,969	82.8	0	0.0	-
PV array 2	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 3	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 4	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 5	SA tracking	SA tracking	0	0.0	0	0.0	-

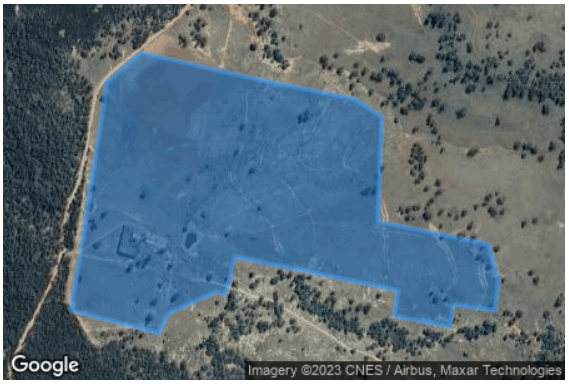
Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	4,969	82.8	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array 1
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 45.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.284940	150.071892	325.68	1.65	327.33
2	-32.286361	150.071592	335.58	1.65	337.23
3	-32.287019	150.074617	345.42	1.65	347.07
4	-32.286450	150.074961	340.65	1.65	342.30
5	-32.285826	150.076618	339.30	1.65	340.95
6	-32.285910	150.076892	341.14	1.65	342.79
7	-32.285467	150.077058	336.56	1.65	338.21
8	-32.284813	150.077232	333.29	1.65	334.94
9	-32.285083	150.078792	341.42	1.65	343.07
10	-32.285789	150.082849	359.58	1.65	361.23
11	-32.286525	150.082714	361.09	1.65	362.74
12	-32.286831	150.084619	368.70	1.65	370.35
13	-32.286207	150.084743	369.63	1.65	371.28
14	-32.286363	150.086186	376.29	1.65	377.94
15	-32.285477	150.086294	378.73	1.65	380.38
16	-32.284448	150.085935	380.39	1.65	382.04
17	-32.283800	150.082164	357.26	1.65	358.91
18	-32.280771	150.082293	357.96	1.65	359.61
19	-32.280275	150.081422	351.78	1.65	353.43
20	-32.280110	150.080523	348.10	1.65	349.75
21	-32.279736	150.078311	339.59	1.65	341.24
22	-32.279438	150.076745	336.09	1.65	337.74
23	-32.278904	150.074034	334.30	1.65	335.95
24	-32.279770	150.072840	334.41	1.65	336.06

Name: PV array 2
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 45.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.270193	150.106852	399.71	1.65	401.36
2	-32.270833	150.106665	405.61	1.65	407.26
3	-32.271498	150.106603	412.74	1.65	414.39
4	-32.272635	150.107121	415.96	1.65	417.61
5	-32.272870	150.108902	392.29	1.65	393.94
6	-32.272823	150.109106	391.22	1.65	392.87
7	-32.271933	150.109922	386.68	1.65	388.33
8	-32.271258	150.110137	385.32	1.65	386.97
9	-32.271268	150.111318	377.99	1.65	379.64
10	-32.269893	150.112092	376.51	1.65	378.16
11	-32.269681	150.112440	374.50	1.65	376.15
12	-32.269775	150.113563	366.93	1.65	368.58
13	-32.269235	150.113614	366.63	1.65	368.28
14	-32.268540	150.113514	366.38	1.65	368.03
15	-32.267375	150.113824	359.71	1.65	361.36
16	-32.266696	150.113885	358.85	1.65	360.50
17	-32.266626	150.112763	364.54	1.65	366.19
18	-32.266106	150.111956	364.69	1.65	366.34
19	-32.266317	150.111598	365.91	1.65	367.56
20	-32.266304	150.110678	370.05	1.65	371.70
21	-32.266423	150.110126	372.76	1.65	374.41
22	-32.266389	150.109611	374.45	1.65	376.10
23	-32.265215	150.109645	376.11	1.65	377.76
24	-32.264934	150.109565	377.84	1.65	379.49
25	-32.264599	150.109614	379.01	1.65	380.66
26	-32.264137	150.109801	379.63	1.65	381.28
27	-32.263922	150.110110	377.60	1.65	379.25
28	-32.263547	150.110169	377.00	1.65	378.65
29	-32.263783	150.112244	361.95	1.65	363.60
30	-32.264083	150.112151	362.99	1.65	364.64
31	-32.264956	150.112910	357.57	1.65	359.22
32	-32.265612	150.112625	360.73	1.65	362.38
33	-32.266055	150.114059	355.74	1.65	357.39
34	-32.265682	150.114334	353.82	1.65	355.47
35	-32.265461	150.114735	352.13	1.65	353.78
36	-32.264149	150.115515	349.78	1.65	351.43
37	-32.264188	150.117068	343.49	1.65	345.14
38	-32.264063	150.117902	341.34	1.65	342.99
39	-32.263912	150.118745	342.48	1.65	344.13
40	-32.263975	150.119550	342.14	1.65	343.79
41	-32.263791	150.120023	340.85	1.65	342.50
42	-32.263859	150.120455	338.04	1.65	339.69
43	-32.263704	150.121103	335.65	1.65	337.30
44	-32.262959	150.121198	340.32	1.65	341.97
45	-32.262958	150.121712	342.50	1.65	344.15
46	-32.262358	150.121753	346.90	1.65	348.55
47	-32.260113	150.121583	359.37	1.65	361.02
48	-32.260075	150.120918	363.27	1.65	364.92
49	-32.258920	150.120928	362.50	1.65	364.15
50	-32.258710	150.120541	361.93	1.65	363.58
51	-32.258658	150.118264	361.79	1.65	363.44
52	-32.259003	150.118278	363.94	1.65	365.59
53	-32.259667	150.116486	368.09	1.65	369.74
54	-32.260767	150.116600	370.65	1.65	372.30
55	-32.260578	150.113186	373.80	1.65	375.45
56	-32.260056	150.111978	376.95	1.65	378.60
57	-32.260100	150.110119	391.35	1.65	393.00
58	-32.261145	150.110084	386.83	1.65	388.48
59	-32.260927	150.109026	398.82	1.65	400.47

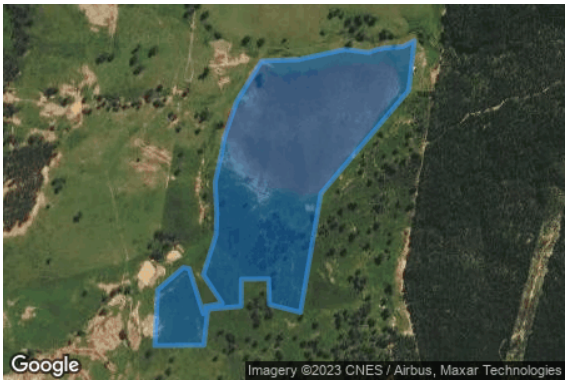
Name: PV array 3
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 45.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.266877	150.097035	417.50	1.65	419.15
2	-32.266317	150.097593	418.78	1.65	420.43
3	-32.266374	150.099459	418.01	1.65	419.66
4	-32.266197	150.099484	418.92	1.65	420.57
5	-32.266065	150.099685	417.92	1.65	419.57
6	-32.266116	150.101289	410.61	1.65	412.26
7	-32.266233	150.101425	411.45	1.65	413.10
8	-32.266074	150.101677	412.61	1.65	414.26
9	-32.266117	150.103903	421.63	1.65	423.28
10	-32.266120	150.104339	420.36	1.65	422.01
11	-32.266599	150.104330	418.52	1.65	420.17
12	-32.266904	150.104297	417.25	1.65	418.90
13	-32.267518	150.104197	414.63	1.65	416.28
14	-32.267472	150.103434	418.26	1.65	419.91
15	-32.268977	150.103367	409.45	1.65	411.10
16	-32.269073	150.104115	406.80	1.65	408.45
17	-32.270064	150.104238	412.12	1.65	413.77
18	-32.272206	150.103696	429.44	1.65	431.09
19	-32.272225	150.103229	428.32	1.65	429.97
20	-32.272837	150.103217	430.19	1.65	431.84
21	-32.272883	150.103077	429.51	1.65	431.16
22	-32.273139	150.102977	429.57	1.65	431.22
23	-32.273924	150.103021	431.96	1.65	433.61
24	-32.273951	150.104067	438.17	1.65	439.82
25	-32.274783	150.104803	436.40	1.65	438.05
26	-32.276647	150.104778	437.67	1.65	439.32
27	-32.277249	150.109665	423.94	1.65	425.59
28	-32.276054	150.113006	417.60	1.65	419.25
29	-32.276351	150.120590	413.33	1.65	414.98
30	-32.278255	150.120524	403.22	1.65	404.87
31	-32.283355	150.119382	416.09	1.65	417.74
32	-32.286489	150.119009	414.58	1.65	416.23
33	-32.287243	150.118026	407.98	1.65	409.63
34	-32.287208	150.116941	408.87	1.65	410.52
35	-32.286160	150.115929	418.36	1.65	420.01
36	-32.286131	150.114805	416.02	1.65	417.67
37	-32.284313	150.114833	417.40	1.65	419.05
38	-32.283726	150.113988	412.53	1.65	414.18
39	-32.284111	150.106761	422.52	1.65	424.17
40	-32.281989	150.094658	417.80	1.65	419.45
41	-32.281621	150.094451	418.11	1.65	419.76
42	-32.280782	150.094416	422.20	1.65	423.85
43	-32.280763	150.093617	417.98	1.65	419.63
44	-32.277814	150.093705	435.83	1.65	437.48
45	-32.276567	150.094209	434.87	1.65	436.52
46	-32.275164	150.094283	426.73	1.65	428.38
47	-32.275130	150.094508	426.22	1.65	427.87
48	-32.274702	150.095495	426.89	1.65	428.54
49	-32.274209	150.095507	425.62	1.65	427.27
50	-32.274225	150.098494	430.91	1.65	432.56
51	-32.274295	150.098991	430.11	1.65	431.76
52	-32.273793	150.099879	425.05	1.65	426.70
53	-32.273832	150.101158	424.12	1.65	425.77
54	-32.272951	150.101176	423.63	1.65	425.28
55	-32.272323	150.101688	425.97	1.65	427.62
56	-32.272053	150.101955	425.58	1.65	427.23
57	-32.271416	150.100731	421.38	1.65	423.03
58	-32.270031	150.100752	411.71	1.65	413.36
59	-32.270041	150.099511	409.54	1.65	411.19

Name: PV array 4
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 45.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.281997	150.094664	417.81	1.65	419.46
2	-32.284111	150.106758	422.52	1.65	424.17
3	-32.292557	150.108663	424.83	1.65	426.48
4	-32.297069	150.107708	419.38	1.65	421.03
5	-32.297483	150.108269	412.27	1.65	413.92
6	-32.298094	150.107989	415.27	1.65	416.92
7	-32.301386	150.111156	413.47	1.65	415.12
8	-32.301643	150.111090	417.81	1.65	419.46
9	-32.301889	150.111259	419.24	1.65	420.89
10	-32.301904	150.111718	413.67	1.65	415.32
11	-32.302881	150.112594	401.22	1.65	402.87
12	-32.306731	150.111069	421.63	1.65	423.28
13	-32.307742	150.109672	419.48	1.65	421.13
14	-32.307131	150.104325	431.29	1.65	432.94
15	-32.304328	150.104947	427.13	1.65	428.78
16	-32.303878	150.106575	433.66	1.65	435.31
17	-32.302867	150.106700	433.05	1.65	434.70
18	-32.300722	150.103847	418.69	1.65	420.34
19	-32.298883	150.102436	416.87	1.65	418.52
20	-32.301321	150.100390	419.58	1.65	421.23
21	-32.301295	150.098852	425.46	1.65	427.11
22	-32.300700	150.098617	425.32	1.65	426.97
23	-32.300308	150.098756	424.90	1.65	426.55
24	-32.299250	150.097989	431.11	1.65	432.76
25	-32.297117	150.095631	412.70	1.65	414.35
26	-32.297349	150.091975	409.17	1.65	410.82
27	-32.298231	150.091993	405.19	1.65	406.84
28	-32.299203	150.091344	409.68	1.65	411.33
29	-32.299212	150.088565	439.17	1.65	440.82
30	-32.298828	150.088161	442.65	1.65	444.30
31	-32.298839	150.086019	445.23	1.65	446.88
32	-32.299127	150.085506	445.82	1.65	447.47
33	-32.299127	150.084946	445.05	1.65	446.70
34	-32.298390	150.084454	440.01	1.65	441.66
35	-32.296598	150.084633	435.09	1.65	436.74
36	-32.296172	150.084897	438.16	1.65	439.81
37	-32.295847	150.084514	435.97	1.65	437.62
38	-32.295864	150.084108	434.06	1.65	435.71
39	-32.295024	150.083025	435.23	1.65	436.88
40	-32.293426	150.083144	433.99	1.65	435.64
41	-32.291513	150.084033	432.65	1.65	434.30
42	-32.291164	150.086417	416.56	1.65	418.21
43	-32.291155	150.087133	413.99	1.65	415.64
44	-32.291275	150.091747	418.49	1.65	420.14
45	-32.291498	150.093423	425.79	1.65	427.44
46	-32.292219	150.094025	429.48	1.65	431.13
47	-32.292247	150.094957	432.26	1.65	433.91
48	-32.291315	150.094969	433.09	1.65	434.74
49	-32.291206	150.095121	433.86	1.65	435.51
50	-32.290858	150.095185	433.80	1.65	435.45
51	-32.290603	150.094963	432.95	1.65	434.60
52	-32.289754	150.094990	435.65	1.65	437.30
53	-32.289789	150.095889	440.69	1.65	442.34
54	-32.290186	150.096363	441.01	1.65	442.66
55	-32.290220	150.097024	442.05	1.65	443.70
56	-32.287592	150.097462	438.48	1.65	440.13
57	-32.287423	150.095917	439.07	1.65	440.72
58	-32.285657	150.096016	436.64	1.65	438.29
59	-32.285642	150.094303	433.16	1.65	434.81

Name: PV array 5
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 45.0°
Ground Coverage Ratio: 0.43
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.273081	150.113903	384.75	1.65	386.40
2	-32.273093	150.112208	385.39	1.65	387.04
3	-32.271484	150.112305	373.03	1.65	374.68
4	-32.270828	150.113196	368.89	1.65	370.54
5	-32.270861	150.113391	368.47	1.65	370.12
6	-32.272172	150.113880	376.34	1.65	377.99
7	-32.271962	150.113904	375.10	1.65	376.75
8	-32.271869	150.114529	375.85	1.65	377.50
9	-32.271044	150.113875	368.89	1.65	370.54
10	-32.269892	150.114315	366.00	1.65	367.65
11	-32.269261	150.114342	366.00	1.65	367.65
12	-32.268375	150.114283	363.25	1.65	364.90
13	-32.267510	150.114508	357.19	1.65	358.84
14	-32.267087	150.114594	356.87	1.65	358.52
15	-32.266023	150.115023	352.91	1.65	354.56
16	-32.264857	150.115880	347.94	1.65	349.59
17	-32.264810	150.117145	343.22	1.65	344.87
18	-32.264518	150.118752	341.83	1.65	343.48
19	-32.264606	150.119553	340.93	1.65	342.58
20	-32.264520	150.119854	339.75	1.65	341.40
21	-32.264471	150.120155	338.68	1.65	340.33
22	-32.264439	150.120739	336.64	1.65	338.29
23	-32.264265	150.121133	334.64	1.65	336.29
24	-32.265697	150.120943	347.53	1.65	349.18
25	-32.268689	150.117921	367.78	1.65	369.43
26	-32.272132	150.117219	378.81	1.65	380.46
27	-32.271903	150.116153	379.64	1.65	381.29
28	-32.271162	150.116123	379.46	1.65	381.11
29	-32.271170	150.115187	374.42	1.65	376.07
30	-32.271956	150.115181	378.44	1.65	380.09
31	-32.272037	150.114074	375.98	1.65	377.63
32	-32.272139	150.114022	376.50	1.65	378.15

Route Receptors

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-32.246039	150.110944	323.76	2.40	326.16
2	-32.250866	150.106824	339.28	2.40	341.68
3	-32.252681	150.103391	345.91	2.40	348.31
4	-32.254459	150.102876	348.64	2.40	351.04
5	-32.257798	150.100301	361.91	2.40	364.31
6	-32.260048	150.096524	380.42	2.40	382.82
7	-32.262008	150.094894	390.89	2.40	393.29
8	-32.263786	150.092705	392.49	2.40	394.89
9	-32.264040	150.090860	385.92	2.40	388.32
10	-32.266109	150.089572	375.28	2.40	377.68
11	-32.266435	150.088370	367.31	2.40	369.71
12	-32.270318	150.082963	352.60	2.40	355.00
13	-32.270499	150.080646	343.55	2.40	345.95
14	-32.273366	150.079315	336.56	2.40	338.96
15	-32.273765	150.077384	330.34	2.40	332.74
16	-32.277575	150.075625	329.07	2.40	331.47
17	-32.279933	150.072449	333.76	2.40	336.16
18	-32.287915	150.069616	344.39	2.40	346.79
19	-32.291870	150.068372	353.99	2.40	356.39
20	-32.294989	150.063522	377.90	2.40	380.30
21	-32.295886	150.059531	388.23	2.40	390.63
22	-32.299368	150.054982	413.79	2.40	416.19

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-32.237750	150.108297	332.78	1.50
OP 2	2	-32.309558	150.106650	413.17	1.50
OP 3	3	-32.243961	150.047733	262.17	1.50
OP 4	4	-32.237611	150.056033	265.23	1.50

Glare Analysis Results

Summary of Results

Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	4,969	82.8	0	0.0	-
PV array 2	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 3	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 4	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 5	SA tracking	SA tracking	0	0.0	0	0.0	-

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

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	4,969	82.8	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

PV: PV array 1

low potential for temporary after-image

Receptor results ordered by category of glare

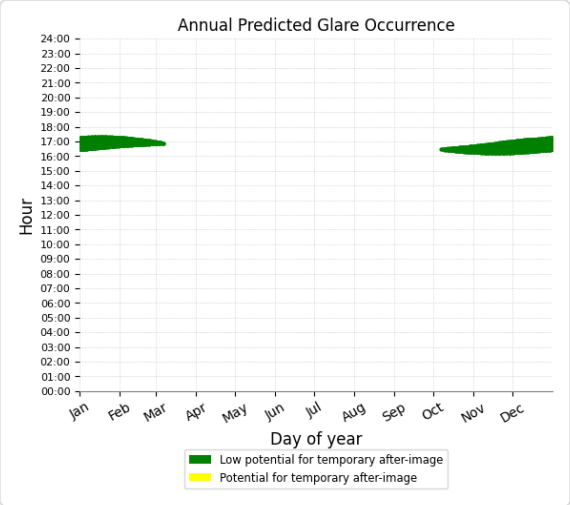
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	4,969	82.8	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

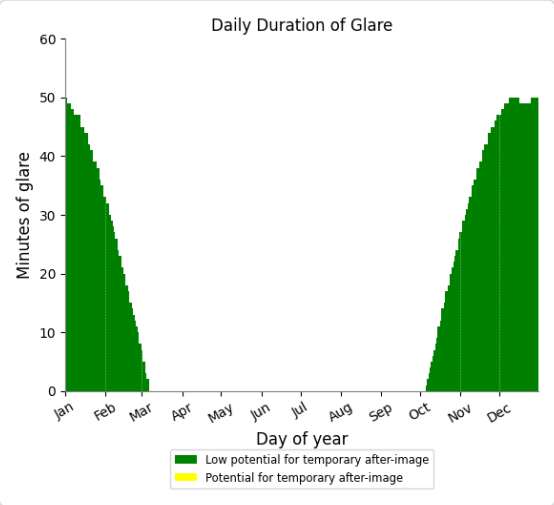
PV array 1 and Wollara Road

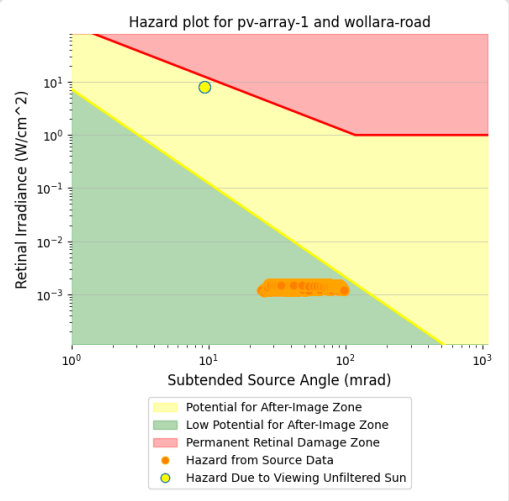
Receptor type: Route

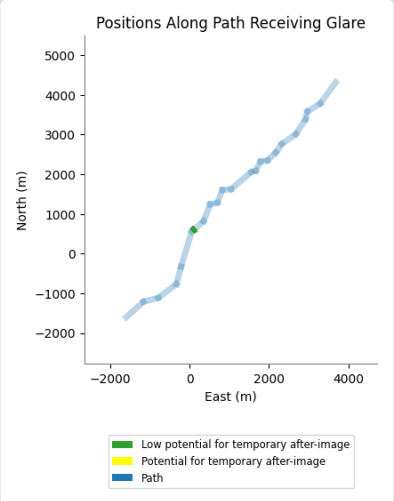
0 minutes of yellow glare

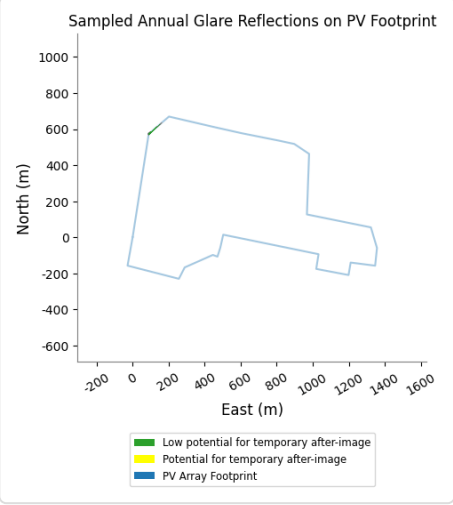
4,969 minutes of green glare











PV array 1 and OP 1

Receptor type: Observation Point
No glare found

PV array 1 and OP 2

Receptor type: Observation Point
No glare found

PV array 1 and OP 3

Receptor type: Observation Point
No glare found

PV array 1 and OP 4

Receptor type: Observation Point
No glare found

PV: PV array 2 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

PV array 2 and Wollara Road

Receptor type: Route
No glare found

PV array 2 and OP 1

Receptor type: Observation Point
No glare found

PV array 2 and OP 2

Receptor type: Observation Point
No glare found

PV array 2 and OP 3

Receptor type: Observation Point
No glare found

PV array 2 and OP 4

Receptor type: Observation Point
No glare found

PV: PV array 3 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

PV array 3 and Wollara Road

Receptor type: Route
No glare found

PV array 3 and OP 1

Receptor type: Observation Point
No glare found

PV array 3 and OP 2

Receptor type: Observation Point
No glare found

PV array 3 and OP 3

Receptor type: Observation Point
No glare found

PV array 3 and OP 4

Receptor type: Observation Point
No glare found

PV: PV array 4 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

PV array 4 and Wollara Road

Receptor type: Route
No glare found

PV array 4 and OP 1

Receptor type: Observation Point
No glare found

PV array 4 and OP 2

Receptor type: Observation Point
No glare found

PV array 4 and OP 3

Receptor type: Observation Point
No glare found

PV array 4 and OP 4

Receptor type: Observation Point
No glare found

PV: PV array 5 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Wollara Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0

PV array 5 and Wollara Road

Receptor type: Route
No glare found

PV array 5 and OP 1

Receptor type: Observation Point
No glare found

PV array 5 and OP 2

Receptor type: Observation Point
No glare found

PV array 5 and OP 3

Receptor type: Observation Point
No glare found

PV array 5 and OP 4

Receptor type: Observation Point
No glare found

Assumptions

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

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

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