Glint and Glare Assessment

Gilgandra 1A Solar Farm

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ABBREVIATIONS

AC	Alternating current
CASA	Civil Aviation Safety Authority
DC	Direct current
FAA	Federal Aviation Administration (United States)
ha	Hectare
ITP	ITP Renewables
MW	Megawatt, unit of power (1 million Watts)
MWp	Megawatt-peak, unit of power at standard test conditions; used to indicate PV system capacity
NSW	New South Wales
OP	Observation point
PV	Photovoltaic
SGHAT	Solar Glare Hazard Analysis Tool

TABLES

FIGURES

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Overview

ITP Development has requested a glint and glare assessment for a proposed solar photovoltaic (PV) installation near Gilgandra, NSW. This assessment is to form part of the Development Application for the project. It includes:

- Identification of potential receptors of glint and glare from the proposed solar farm
- Assessment of the glint and glare hazard using the Solar Glare Hazard Analysis Tool (SGHAT) GlareGauge analysis

1.2 Glint and Glare

Glint is a momentary flash of bright light, while **glare** is a continuous source of excessive brightness relative to ambient lighting (Federal Aviation Administration [FAA], 2018). This can occur when light reflected off a surface (reflector) is viewed by a person (receptor). Typically, glint may be experienced in instances when either the receptor or the reflector is moving; while glare may occur when the reflector and receptor are completely or close to stationary, or from large reflective surfaces.

For a transparent material (e.g. glass, water) the quantity of light reflected depends on the surface itself (i.e. material and texture), and the angle at which the light intercepts it (angle of incidence). A higher angle of incidence will result in a higher proportion of light being reflected, as shown in Figure 1.

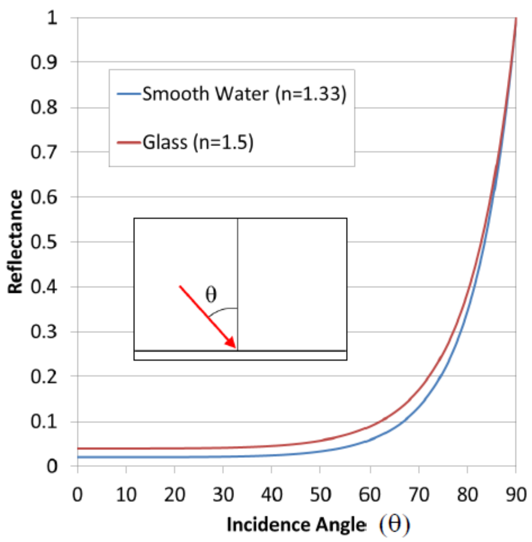


Figure 1: Angles of incidence and increased levels of reflected light

Potential visual impacts from glint and glare include distraction and temporary after-image; at its worst, it can cause retinal burn. The ocular hazard caused by glint or glare is a function of:

1. The intensity of the glare upon the eye (retinal irradiance)
2. The subtended angle of the glare source (i.e. the extent to which the glare occupies the receptor's field of vision; dependent on size and distance of the reflector).

The severity of the ocular hazard can be divided into three levels, as shown in Figure 2:

- 'Green' glare: Low potential for temporary after-image
- 'Yellow' glare: Potential for temporary after-image
- 'Red' glare: Retinal burn, not expected for PV

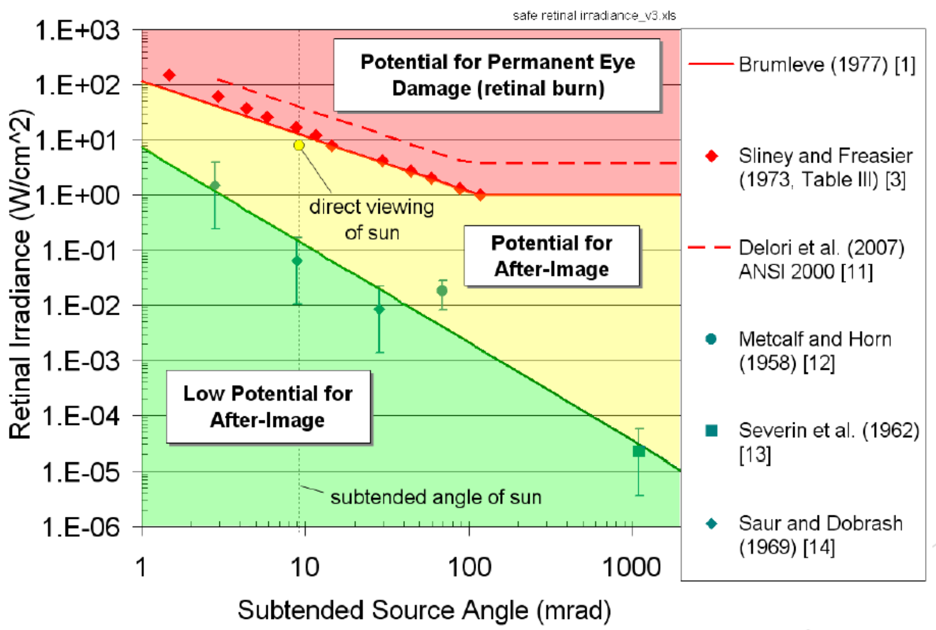


Figure 2: Classification of glare based on severity of ocular effects

1.3 Glare from Solar PV

Solar photovoltaic (PV) cells are designed to absorb as much light as possible to maximise efficiency (generally around 98% of the light received). To limit reflection, solar cells are constructed from dark, light-absorbing material and are treated with an anti-reflective coating. PV modules generate less glare than many other surfaces, as shown in Figure 3.

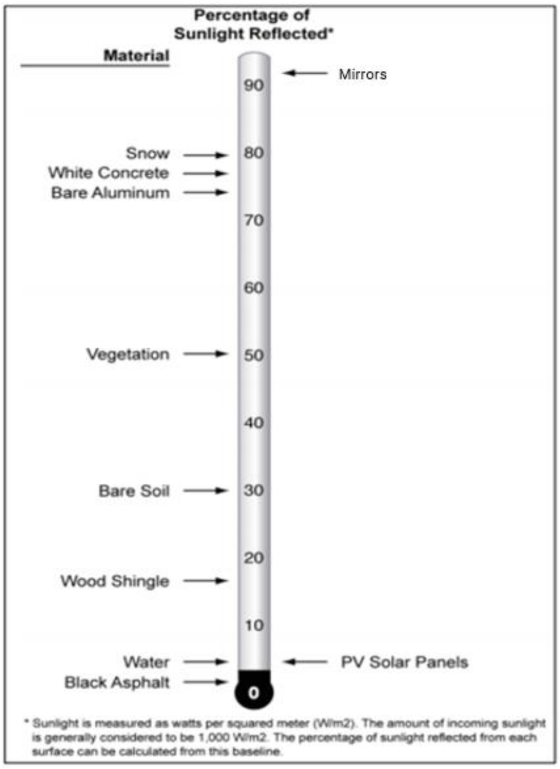


Figure 3: Typical percentage of sunlight reflected from different surfaces (Source: Adapted from Journal of Airport Management, 2014)

The small percentage of light reflected from PV modules varies depending on the angle of incidence. Figure 4 shows an example of this with a solar module. A larger angle of incidence will result in a higher percentage of reflected light.

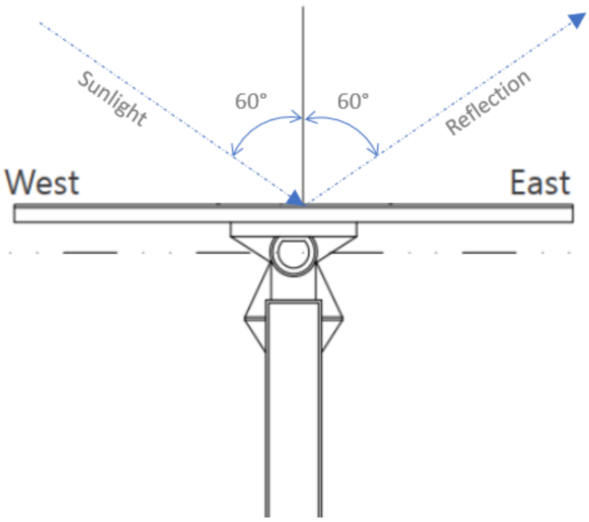


Figure 4: Typical sunlight reflection off the surface of a solar module

The two most common PV mounting structures are fixed-tilt and single axis tracking. Fixed-tilt arrays are stationary, while single-axis tracking arrays rotate the receiving surface of the modules from east to west throughout the day as the sun moves across the sky.

In a fixed-tilt PV array, since the sun is moving but the modules are stationary, the angle of incidence varies as the sun moves across the sky. It is smallest around noon when the sun is overhead and largest in the early morning and late afternoon when the sun is near the horizon. There is therefore a higher potential for glare at these times.

The angle of incidence for a single axis tracking system varies less as the reflective surface of the modules rotates on a horizontal axis to follow the sun. Single axis tracking arrays therefore generate less glare than fixed tilt arrays. The tracking varies throughout the year to match seasonal changes in the sun's path (see Figure 5).

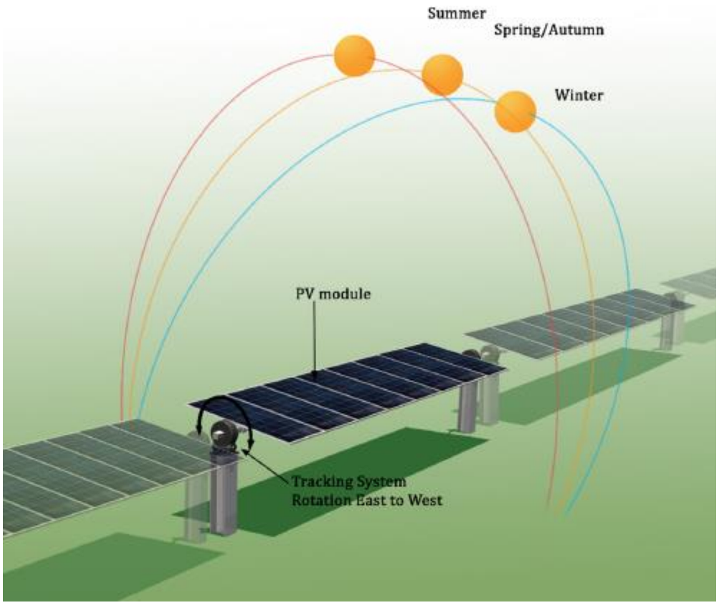


Figure 5: Sun position relative to PV module mounted on a horizontal single axis tracking system

2 PROJECT DESCRIPTION

2.1 Site Overview

ITP Development is proposing a solar farm at the location described in Table 1. The site is located on the Oxley Highway to the west of the Gilganda township, within the Gilgandra Shire Council area, NSW (see Figure *6*).

Table 1. Site Information

Parameter	Description
Lot/DP(s)	1 & 2/1070081
Street address	361 Oxley Highway, Gilgandra NSW 2827
Council	Gilganda Shire Council
Project area	Approx. 11.3 ha
Current land use	Agriculture

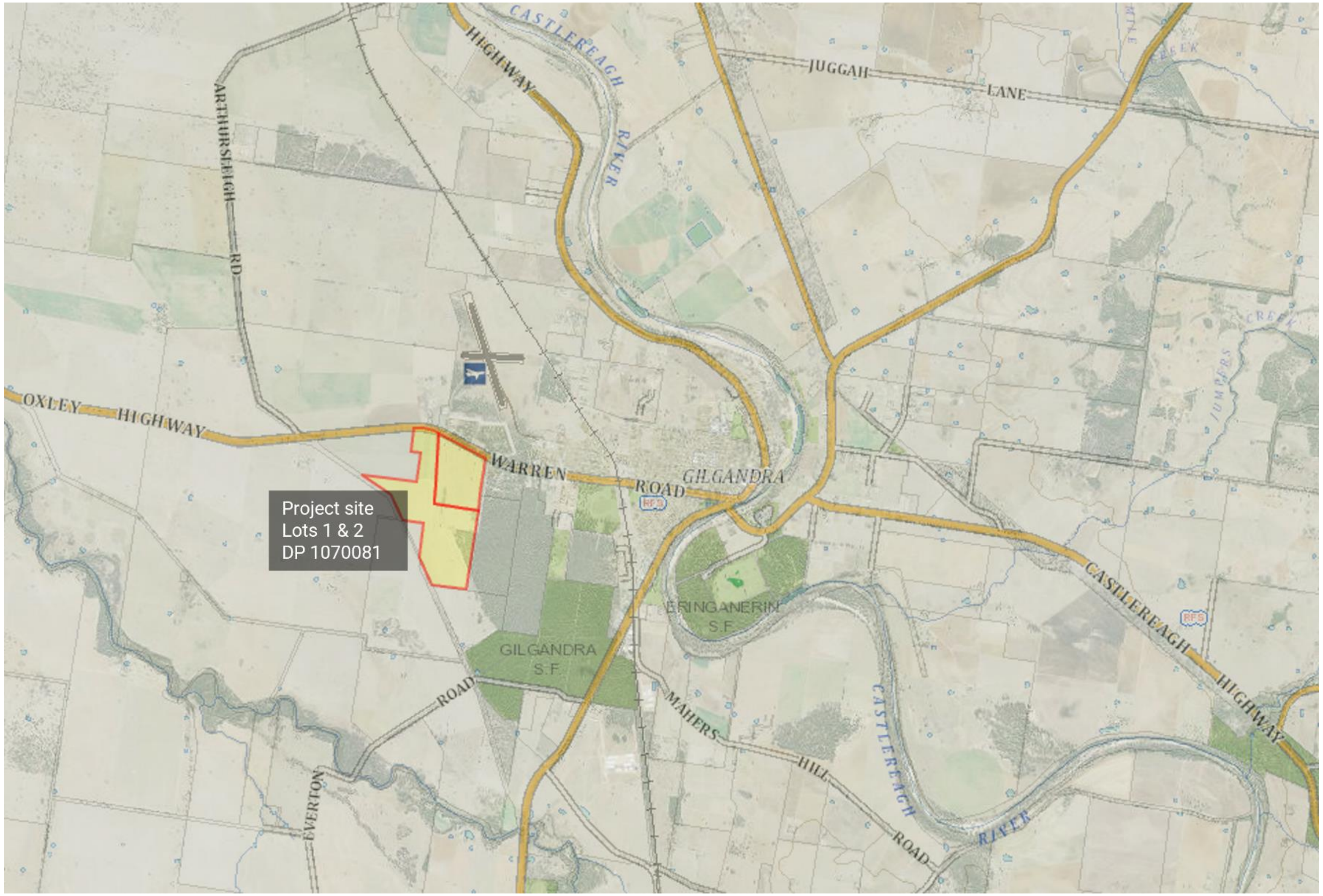


Figure 6. Proposed 133.2 ha solar farm site and surrounding area (note the project will comprise 11.3 ha within this area)

2.2 Solar Farm Details

Table 2 summarises the details of the proposed solar farm.

Table 2. Solar farm information

Parameter	Description
Solar farm name	Gilgandra Solar Farm
Site reference	GID1A
AC capacity	5 MW
DC capacity	6.4 MW
Mounting system	Single-axis tracking

ITPD is proposing to construct a solar farm with a DC capacity of 6.4 MWp and AC output of 5.0 MW on an approximately 11.3 ha site that is currently used for crops.

There are to be approximately 12,000 solar modules installed in138 rows (each row being approximately 105 m long and 2.2 m wide) running east to west. Each row of solar photovoltaic (PV) modules will rotate to track the sun across the sky from east to west each day. There is approximately 6.25 m spacing between each row. The maximum height of each module is 2.75 m.

The solar farm will also consist of an inverter station. The inverter station incorporates the high/medium voltage switchgear and transformers and two 3.4 MW inverters. The inverter station is ground mounted and incorporated on a 12.19 m skid. Allowance is made for a 2.9 m high battery energy storage facility (BESS) alongside the inverter stations.

The mounting system is constructed on piles that are driven into the ground. During construction there is expected to be 50 personnel on site working from 7 am – 4 pm Monday to Friday. The construction is expected to take approximately 3 months. Once operational the site will be unmanned. Maintenance is expected to be carried out quarterly by a crew of 2 – 3 people.

Solar panels and related infrastructure will be decommissioned and removed upon cessation of operations. This is likely to occur within two years of the end of the project. The site will be returned to the pre-development land use of agriculture.

3 ANALYSIS

3.1 Overview

The Solar Glare Hazard Analysis Tool (SGHAT) was developed by Sandia National Laboratories to evaluate glare resulting from solar farms at different viewpoints, based on the location, orientation, and specifications of the PV modules. This tool is required by the United States FAA for glare hazard analysis near airports and is also recognised by the Australian Government Civil Aviation Safety Authority (CASA).

The GlareGauge software uses SGHAT to provide an indication of the type of glare expected at each potential receptor. It runs with a simulation timestep of one minute. Glint lasting for less than one minute is unlikely to occur from the sun on PV modules due to their slow movement and is not considered further in this assessment.

Table 3 details the parameters used in the SGHAT model. GlareGauge default settings were adopted for the analysis time interval, direct normal irradiance, observer eye characteristics and slope error. The height of the observation points was assumed to be 1.5 m for a road user (i.e. sitting in a car) and 1.65 m for a person (i.e. standing).

Table 3. SGHAT specification inputs

Parameters	Input
Time zone	UTC+10:00
Module tracking	Single axis
Module surface material	Smooth glass with ARC (anti-reflective coating)
Tracking axis tilt	0°
Tracking axis orientation	0°
Module offset angle (angle between module and tracking axis)	0°
Maximum tracking angle	60°
Resting angle	30°
Height of modules above ground	1.78m (height from the ground to the PV panel centroid)

3.2 Potential Receptors

This assessment considers potential visual receptors (e.g., residences and road users) within 2 km of the site. There is no formal guidance on the maximum distance for glint and glare assessments; however, the significance of a reflection decreases with distance for two main reasons:

1. The solar farm appears smaller (smaller subtended angle) and hence glare has less impact
2. Visual obstructions (e.g. terrain, vegetation) may block the view of the solar farm

Glint and glare impacts beyond 2 km are highly unlikely. This choice of distance is conservative and is based on existing studies and assessment experience.

Forty observation points and six different road routes were identified as potential visual receptors, as shown in Figure 7.

While a greater number of observation points were considered, some were discounted based on large stands of trees and other structures acting as visual barriers.

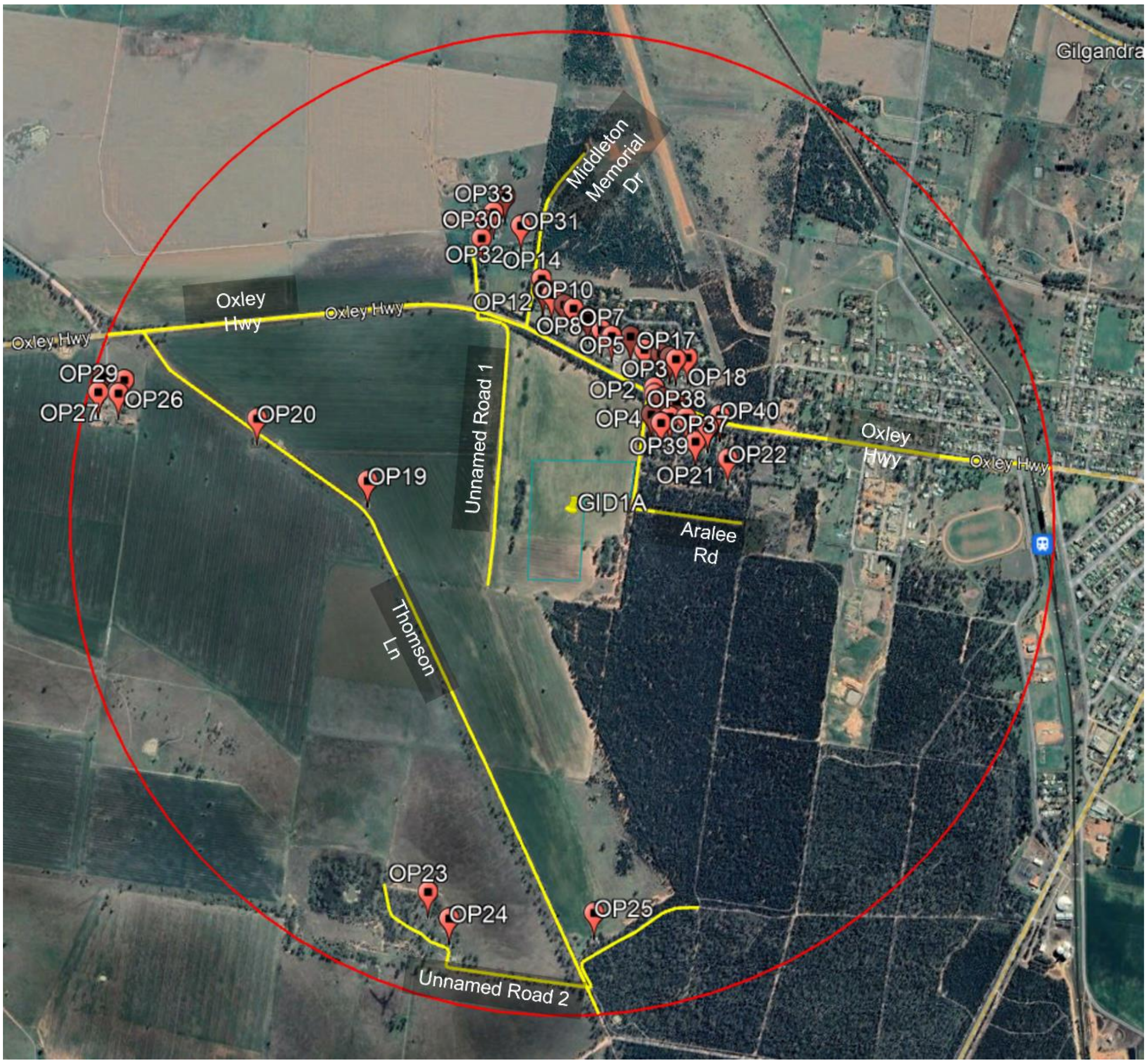


Figure 7. Potential visual receptors within 2 km of the site

3.3 Assumptions

The visual impact of solar farms 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. Some potential viewpoints were discounted because of significant existing features (such as trees or buildings), however, minor screening—such as roadside vegetation—was not assessed in detail. The GlareGauge analysis results are therefore considered conservative as the model assumes there is no screening.

Atmospheric conditions such as cloud cover will also influence light reflection and the resulting impact on visual receptors. The same is true of varying tilt angles of the modules. Varying atmospheric conditions have not been accounted for in the GlareGauge analysis, nor have the complexities of backtracking (due to the software's limitations). The GlareGauge analysis assumes clear sky conditions, with a peak direct normal irradiance (DNI) of 1,000 W/m^2 which varies throughout the day.

3.4 Results

The results of the GlareGauge analysis (attached in Appendix A) at each of the observation points are summarised in Table 4. No glare was identified.

Table 4. Glare potential at observation points

Observation Points	Location/Coordinates	'Green' glare (minutes)	'Yellow' glare (minutes)	Glare potential
OP1	-31.7095, 148.6367	0	0	No glare
OP2	-31.7087, 148.6368	0	0	No glare
OP3	-31.7085, 148.6368	0	0	No glare
OP4	-31.7098, 148.6371	0	0	No glare
OP5	-31.7071, 148.6364	0	0	No glare
OP6	-31.7066, 148.6358	0	0	No glare
OP7	-31.7066, 148.6350	0	0	No glare
OP8	-31.7064, 148.6345	0	0	No glare
OP9	-31.7059, 148.6339	0	0	No glare
OP10	-31.7056, 148.6333	0	0	No glare
OP11	-31.7055, 148.6329	0	0	No glare
OP12	-31.7051, 148.6324	0	0	No glare
OP13	-31.7049, 148.6320	0	0	No glare
OP14	-31.7045, 148.6320	0	0	No glare
OP15	-31.7073, 148.6371	0	0	No glare
OP16	-31.7074, 148.6375	0	0	No glare
OP17	-31.7075, 148.6377	0	0	No glare
OP18	-31.7074, 148.6382	0	0	No glare
OP19	-31.7119, 148.6245	0	0	No glare
OP20	-31.7096, 148.6198	0	0	No glare
OP21	-31.7105, 148.6386	0	0	No glare

Observation Points	Location/Coordinates	'Green' glare (minutes)	'Yellow' glare (minutes)	Glare potential
OP22	-31.7111, 148.6399	0	0	No glare
OP23	-31.7269, 148.6271	0	0	No glare
OP24	-31.7279, 148.6280	0	0	No glare
OP25	-31.7277, 148.6342	0	0	No glare
OP26	-31.7082, 148.6141	0	0	No glare
OP27	-31.7087, 148.6138	0	0	No glare
OP28	-31.7081, 148.6131	0	0	No glare
OP29	-31.7086, 148.6129	0	0	No glare
OP30	-31.7030, 148.6294	0	0	No glare
OP31	-31.7026, 148.6311	0	0	No glare
OP32	-31.7024, 148.6295	0	0	No glare
OP33	-31.7021, 148.6299	0	0	No glare
OP34	-31.7015, 148.6304	0	0	No glare
OP35	-31.7089, 148.6372	0	0	No glare
OP36	-31.7090, 148.6377	0	0	No glare
OP37	-31.7096, 148.6375	0	0	No glare
OP38	-31.7096, 148.6382	0	0	No glare
OP39	-31.7099, 148.6391	0	0	No glare
OP40	-31.7095, 148.6396	0	0	No glare
Aralee Rd	East, adjacent	0	0	No glare
Middleton Memorial Dr	North	0	0	No glare
Oxley Hwy	North, adjacent	0	0	No glare
Thomson Ln	West	0	0	No glare
Unnamed Rd 1	North-west, adjacent	0	0	No glare
Unnamed Rd 2	South	0	0	No glare

4 SUMMARY

The results of the GlareGauge analysis indicated that the selected observation points are unlikely to receive glare due to the proposed solar farm.

Existing roadside vegetation and structures are expected to provide a physical obstruction between the solar farm and road users, further minimising the visual impact of the project.

5 REFERENCES

Federal Aviation Administration (FAA), 2018. Solar Guide: Technical Guidance for Evaluating Selected Solar Technologies on Airports. Retrieved from the FAA website: https://www.faa.gov/airports/environmental/

Thompson, R., Ave, I., Anne, D., Jan, M., David, S. and Robert, C., 2013. Interim policy, FAA review of solar energy system projects on federally obligated airports.

Barrett, S., Devita, P., Ho, C. and Miller, B., 2014. Energy technologies' compatibility with airports and airspace: Guidance for aviation and energy planners. Journal of Airport Management, 8(4), pp.318-326.

APPENDIX A. FORGESOLAR GLARE ANALYSIS

FORGESOLAR GLARE ANALYSIS

Project: **GIL1A Gilgandra 1A**
5 MW solar farm proposed near Gilgandra NSW

Site configuration: **All Receptors_GIL1A_v2**
Analysis conducted by ITP Engineering (engineering@itpau.com.au) at 04:11 on 13 Oct, 2021.

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):

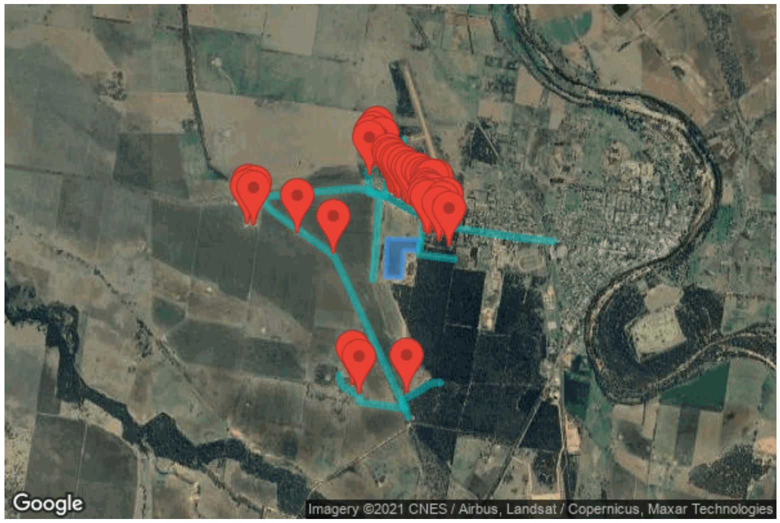
- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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: 59771.10627



PV Array(s)

Name: PV1
Axis tracking: Single-axis rotation
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 60.0°
Resting angle: 30.0°
Rated power: 6400.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-31.711550	148.635764	290.99	1.78	292.77
2	-31.711513	148.633822	288.85	1.78	290.63
3	-31.714576	148.633606	288.45	1.78	290.23
4	-31.714533	148.631370	287.00	1.78	288.78
5	-31.710161	148.631576	287.00	1.78	288.78
6	-31.710246	148.635989	291.64	1.78	293.42
7	-31.711550	148.635764	290.99	1.78	292.77

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-31.709481	148.636665	293.19	1.65
OP 2	2	-31.708740	148.636805	293.04	1.65
OP 3	3	-31.708502	148.636792	293.01	1.65
OP 4	4	-31.709791	148.637082	294.26	1.65
OP 5	5	-31.707117	148.636373	293.24	1.65
OP 6	6	-31.706638	148.635775	292.07	1.65
OP 7	7	-31.706620	148.634972	292.56	1.65
OP 8	8	-31.706409	148.634536	292.52	1.65
OP 9	9	-31.705945	148.633938	292.10	1.65
OP 10	10	-31.705616	148.633332	290.96	1.65
OP 11	11	-31.705478	148.632936	290.41	1.65
OP 12	12	-31.705104	148.632395	289.15	1.65
OP 13	13	-31.704933	148.632021	288.11	1.65
OP 14	14	-31.704526	148.631965	287.99	1.65
OP 15	15	-31.707280	148.637071	293.53	1.65
OP 16	16	-31.707383	148.637458	293.01	1.65
OP 17	17	-31.707463	148.637719	292.75	1.65
OP 18	18	-31.707410	148.638225	292.40	1.65
OP 19	19	-31.711891	148.624498	282.70	1.65
OP 20	20	-31.709618	148.619754	280.42	1.65
OP 21	21	-31.710470	148.638557	293.98	1.65
OP 22	22	-31.711098	148.639943	295.64	1.65
OP 23	23	-31.726896	148.627090	285.50	1.65
OP 24	24	-31.727867	148.627997	284.01	1.65
OP 25	25	-31.727661	148.634213	286.96	1.65
OP 26	26	-31.708207	148.614050	279.04	1.65
OP 27	27	-31.708693	148.613802	279.59	1.65
OP 28	28	-31.708081	148.613115	279.60	1.65
OP 29	29	-31.708647	148.612936	280.02	1.65
OP 30	30	-31.703042	148.629388	284.74	1.65
OP 31	31	-31.702580	148.631076	284.70	1.65
OP 32	32	-31.702402	148.629508	284.16	1.65
OP 33	33	-31.702089	148.629898	283.03	1.65
OP 34	34	-31.701514	148.630398	283.80	1.65
OP 35	35	-31.708878	148.637165	293.57	1.65
OP 36	36	-31.709013	148.637732	293.93	1.65
OP 37	37	-31.709565	148.637454	294.00	1.65
OP 38	38	-31.709597	148.638157	293.00	1.65
OP 39	39	-31.709923	148.639087	292.45	1.65
OP 40	40	-31.709511	148.639605	293.84	1.65

Route Receptor(s)

Name: Aralee Rd
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	-31.707667	148.636539	293.01	1.50	294.51
2	-31.711943	148.635876	292.52	1.50	294.02
3	-31.712479	148.640548	296.00	1.50	297.50

Name: Middleton Memorial Dr
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	-31.705331	148.631316	286.11	1.50	287.61
2	-31.704239	148.631534	287.00	1.50	288.50
3	-31.702629	148.631805	286.27	1.50	287.77
4	-31.701523	148.631979	287.71	1.50	289.21
5	-31.700733	148.632210	288.16	1.50	289.66
6	-31.700095	148.632685	290.69	1.50	292.19
7	-31.698980	148.633821	288.63	1.50	290.13

Name: Oxley Hwy
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	-31.705576	148.613345	280.50	1.50	282.00
2	-31.704497	148.626298	282.25	1.50	283.75
3	-31.704472	148.627125	281.07	1.50	282.57
4	-31.704566	148.628230	281.61	1.50	283.11
5	-31.704734	148.629336	283.70	1.50	285.20
6	-31.705380	148.631439	286.52	1.50	288.02
7	-31.706641	148.634189	292.75	1.50	294.25
8	-31.707967	148.637193	293.05	1.50	294.55
9	-31.708701	148.639249	295.66	1.50	297.16
10	-31.708975	148.640627	294.28	1.50	295.78
11	-31.709093	148.641804	293.29	1.50	294.79
12	-31.710108	148.649733	290.53	1.50	292.03
13	-31.710306	148.652448	287.02	1.50	288.52
14	-31.710463	148.653790	287.36	1.50	288.86

Name: Thomson Ln
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	-31.705399	148.614811	281.33	1.50	282.83
2	-31.706862	148.615995	279.00	1.50	280.50
3	-31.708694	148.618983	281.92	1.50	283.42
4	-31.711690	148.623936	282.15	1.50	283.65
5	-31.712015	148.624358	282.89	1.50	284.39
6	-31.712384	148.624686	282.50	1.50	284.00
7	-31.713229	148.625135	282.99	1.50	284.49
8	-31.714886	148.626064	283.19	1.50	284.69
9	-31.717870	148.627702	283.50	1.50	285.00
10	-31.719627	148.628669	285.14	1.50	286.64
11	-31.721275	148.629583	284.28	1.50	285.78
12	-31.730376	148.634427	289.46	1.50	290.96

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

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-31.702140	148.629338	284.33	1.50	285.83
2	-31.702376	148.629038	284.68	1.50	286.18
3	-31.702714	148.629022	284.57	1.50	286.07
4	-31.703097	148.629131	284.72	1.50	286.22
5	-31.704159	148.629213	284.41	1.50	285.91
6	-31.704680	148.629225	283.71	1.50	285.21
7	-31.705002	148.629229	283.25	1.50	284.75
8	-31.705031	148.629707	283.76	1.50	285.26
9	-31.705169	148.630264	284.50	1.50	286.00
10	-31.705294	148.630446	284.61	1.50	286.11
11	-31.705408	148.630511	284.52	1.50	286.02
12	-31.705590	148.630529	284.29	1.50	285.79
13	-31.705994	148.630511	283.87	1.50	285.37
14	-31.707938	148.630343	283.03	1.50	284.53
15	-31.710068	148.630170	285.24	1.50	286.74
16	-31.711287	148.630039	285.27	1.50	286.77
17	-31.712889	148.629935	286.04	1.50	287.54
18	-31.714749	148.629667	285.00	1.50	286.50

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

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-31.725630	148.625213	284.41	1.50	285.91
2	-31.726591	148.625447	287.30	1.50	288.80
3	-31.726813	148.625564	287.47	1.50	288.97
4	-31.727220	148.626283	287.44	1.50	288.94
5	-31.727459	148.626813	285.58	1.50	287.08
6	-31.727745	148.627201	284.11	1.50	285.61
7	-31.727962	148.627867	284.00	1.50	285.50
8	-31.728091	148.628001	284.08	1.50	285.58
9	-31.728544	148.627885	283.95	1.50	285.45
10	-31.728654	148.627871	283.44	1.50	284.94
11	-31.728699	148.628044	283.47	1.50	284.97
12	-31.729200	148.632085	283.34	1.50	284.84
13	-31.729405	148.634058	288.76	1.50	290.26
14	-31.729347	148.634100	288.90	1.50	290.40
15	-31.728686	148.633699	288.51	1.50	290.01
16	-31.728472	148.633713	288.43	1.50	289.93
17	-31.728339	148.633999	288.45	1.50	289.95
18	-31.727773	148.635129	289.99	1.50	291.49
19	-31.727398	148.635968	291.39	1.50	292.89
20	-31.726987	148.636655	292.39	1.50	293.89
21	-31.726672	148.637186	292.72	1.50	294.22
22	-31.726507	148.637745	293.41	1.50	294.91
23	-31.726482	148.638457	294.45	1.50	295.95
24	-31.726486	148.638723	294.83	1.50	296.33

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV1	SA tracking	SA tracking	0	0	18,950,000.0

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	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0
OP 26	0	0
OP 27	0	0

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
OP 28	0	0
OP 29	0	0
OP 30	0	0
OP 31	0	0
OP 32	0	0
OP 33	0	0
OP 34	0	0
OP 35	0	0
OP 36	0	0
OP 37	0	0
OP 38	0	0
OP 39	0	0
OP 40	0	0
Aralee Rd	0	0
Middleton Memorial Dr	0	0
Oxley Hwy	0	0
Thomson Ln	0	0
Unnamed road 1	0	0
Unnamed road 2	0	0

Results for: PV1

Receptor	Green Glare (min)	Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0

Receptor	Green Glare (min)	Yellow Glare (min)
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0
OP 26	0	0
OP 27	0	0
OP 28	0	0
OP 29	0	0
OP 30	0	0
OP 31	0	0
OP 32	0	0
OP 33	0	0
OP 34	0	0
OP 35	0	0
OP 36	0	0
OP 37	0	0
OP 38	0	0
OP 39	0	0
OP 40	0	0
Aralee Rd	0	0
Middleton Memorial Dr	0	0
Oxley Hwy	0	0
Thomson Ln	0	0
Unnamed road 1	0	0
Unnamed road 2	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

Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 13

0 minutes of yellow glare

0 minutes of green glare

Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 15

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 20

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 26

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 27

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 28

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 29

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 30

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 31

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 32

0 minutes of yellow glare

0 minutes of green glare

Point Receptor: OP 33

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 34

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 35

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 36

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 37

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 38

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 39

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 40

0 minutes of yellow glare
0 minutes of green glare

Route: Aralee Rd

0 minutes of yellow glare
0 minutes of green glare

Route: Middleton Memorial Dr

0 minutes of yellow glare
0 minutes of green glare

Route: Oxley Hwy

0 minutes of yellow glare
0 minutes of green glare

Route: Thomson Ln

0 minutes of yellow glare
0 minutes of green glare

Route: Unnamed road 1

0 minutes of yellow glare
0 minutes of green glare

Route: Unnamed road 2

0 minutes of yellow glare
0 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.

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