Glint and Glare Assessment

Narrabri 3A Solar Farm

March 2021

ENGINEERING | STRATEGY | ANALYTICS | CONSTRUCTION

DOCUMENT CONTROL

Report Title		Glint and Glare Assessment – Narrabri 3A Solar Farm			
ITP Project Number		Narrabri 3A			
Rev	Date	Status	Author/s	Reviewed By	Approved
1	23/09/2020	First issue	I Berwick	S Dedman	Approved
2	24/03/2021	Second issue	I Chawla	S Dedman	Approved

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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

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1 INTRODUCTION

1.1 Overview

ITP Development is proposing to develop a solar farm as described in Table 1. It will be located approximately 3.5 km southwest of the town of Narrabri, NSW (see Figure 1).

Table 1. Site Information

Parameter	Description
Solar farm name	Narrabri 3A Solar Farm
Site reference	Narrabri 3A
Lot/DP(s)	102/579423
Street address	11498 Newell Hwy, Narrabri, NSW 2390
Council	Narrabri Shire Council
AC capacity	5 MW
DC capacity	6.4 MW
Project area	Approx. 11.32 ha
Current land use	Grazing, recently destocked

This report provides a desktop glint and glare assessment to support the Development Application for the project. It provides:

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

1.2 Glint and Glare

Glint is defined as a momentary flash of bright light, while glare is a continuous source of excessive brightness relative to ambient lighting (Federal Aviation Administration [FAA], 2018). The GlareGauge analysis used to assess the glint and glare hazard (see Section 3) was run with a simulation interval of one minute, as sunlight reflection from PV modules typically lasts for at least one minute. Glint, which lasts for less than one minute, is unlikely to occur from the sun based on how slowly the sun and modules move, so has not been considered further in this assessment.

Solar photovoltaic (PV) modules are designed to absorb as much light as possible to maximise efficiency (generally around 98% of the light received). To limit reflection, the modules are constructed from dark, light-absorbing material and the glass is treated with an anti-reflective coating. As a result, the glare generated from PV modules is lower than from many other surfaces, including cropping/grassland and concrete (an albedo of 20% is typically assumed for PV modules, compared to 25-30% for grass and up to 25% for concrete; Ramírez & Muňoz, 2012).

However, the glass modules still have the potential to generate glare. This needs to be assessed to ensure that visual receptors—such as road users, nearby buildings, air traffic control towers and aircraft pilots—are not impacted by the development of solar farms.

2 PROJECT DESCRIPTION

ITP Development is proposing to construct a solar farm with a DC capacity of 6.4 MW_p and AC output of 5 MW, on an approximately 11.32 ha site that is currently used for grazing and has recently been destocked.

There are to be approximately 12,100 solar modules installed on around 140 mounting structures running north to south. Each row of solar photovoltaic (PV) modules will rotate to track the sun across the sky from east to west each day. The hub height of each tracker will be around 1.5 m, with the peak of the modules reaching a height of approximately 2.75 m when the array is fully tilted to 60 degrees from horizontal. The general arrangement of the solar farm is shown on drawing NAR3A-G-210, and the array tracker details on drawing NAR3A -E-341.

The solar farm will also comprise two 3 MW inverter stations. These inverters are to be located within the array and are both mounted on a 12.19 m skid. Each of these inverter stations incorporate the high voltage switchgear and transformers. The arrangement of the inverter station skid is shown in drawing NAR3A -E-430.

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 7am – 4pm, 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.

Figure 1 - Proposed 62 ha solar farm site and surrounding farm area (note the project will comprise 11.24 ha within this area)

3 ANALYSIS

3.1 Overview

In a fixed-tilt PV array, the angle of incidence at which direct sunlight hits the PV modules varies as the sun moves across the sky. It will be smallest around noon when the sun is overhead and largest in the early morning and late afternoon when the sun is near the horizon. If the PV array is mounted on a single-axis tracking system as proposed in this project, the variation in the angle of incidence will be much smaller since the modules rotate to follow the sun. The main variation will be seasonal, i.e. because the sun is higher in the sky during summer and lower during winter. A PV array that is mounted on a tracking system therefore has less potential to cause glare.

The 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 analysis uses SGHAT to provide an indication of the type of glare that can be expected at each potential receptor. Glare is indicated by three colours according to severity:

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

The parameters used in the SGHAT model for the project are detailed in Table 2. GlareGauge default settings were adopted for the analysis time interval, direct normal irradiance, observer eye characteristics and slope error. The heights of the observation points were assumed to be 1.5m for a road user (i.e. sitting in a car) and 1.65m for a person (i.e. standing).

Table 2. 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

For this project, visual receptors within 2 km of the site were considered including residences and road users There is no formal guidance on the maximum distance at which glint and glare should be assessed; however, the significance of a reflection decreases with distance. This is due to the proportion of the observer's field of vision taken up by the reflective area decreasing as distance increases. In addition, as the separation distance increases, terrain and shielding by vegetation and other structures are more likely to obstruct the view of the reflective area. A 2-km radius from the site was considered appropriate based on it being highly unlikely for glint and glare impacts at distances greater than this. This is a conservative distance based on existing studies and assessment experience.

As shown in Figure 2, 4 commercial points and 18 residential observation points were identified as potential visual receptors of the site. The potential for glare was also assessed along 19 different road routes.

While there was a greater number of residential/commercial properties considered, some were discounted based on large stands of trees and other structures acting as visual barriers.

The Narrabri Airport is located approximately 8 km north-east of the site so was not considered a potential visual receptor.

Figure 2. Map showing potential visual receptors within 2km of the site

3.3 Assumptions

The visual impact of solar farm development 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. It is noted that the site is mostly cleared with only a few trees within the property.

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/m2 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 3. None of the residences, commercial properties or road users are expected to experience any glare from the solar farm. Many residences will also not have direct view of the solar farm due to visual obstructions from trees and other structures. The distances in the table below are provided as indication of the location of the receptor relative to the solar array, but are not direct inputs to the GlareGauge analysis, which utilises the PV array centroid for its calculations.

Table 3. Glare potential at observation points

	Type of Observation Point	Location relative to solar farm	Green glare (minutes)	Yellow glare (minutes)	Glare potential
OP1	Residential	0.14 km north-east	0	0	No glare
OP2	Residential	0.18 km north-east	0	0	No glare
OP3	Residential	0.49 km north-east	0	0	No glare
OP4	Residential	0.59 km north-east	0	0	No glare
OP5	Residential	0.63 km north-east	0	0	No glare
OP6	Residential	0.64 km south-west	0	0	No glare
OP7	Residential	0.97 km south-west	0	0	No glare
OP8	Residential	1.73 km south-west	0	0	No glare
OP9	Residential	1.54 km south-east	0	0	No glare
OP10	Residential	1.55 km south-east	0	0	No glare
OP11	Residential	1.53 km south-east	0	0	No glare
OP12	Commercial	1.83 km south-east	0	0	No glare
OP13	Residential	1.41 km east	0	0	No glare

OP14	Residential	1.38 km east	0	0	No glare
OP15	Commercial	1.04 km north-east	0	0	No glare
OP16	Commercial	1.19 km north-east	0	0	No glare
OP17	Commercial	0.72 km north-east	0	0	No glare
OP18	Residential	1.55 km north-east	0	0	No glare
OP19	Residential	1.51 km north-east	0	0	No glare
OP20	Residential	1.48 km north-east	0	0	No glare
OP21	Residential	1.39 km north	0	0	No glare
OP22	Residential	1.40 km north-east	0	0	No glare
Avon Street	Road Route	North-east	0	0	No glare
Boheena Street	Road Route	North	0	0	No glare
Boundary Street	Road Route	West	0	0	No glare
Burigal Street	Road Route	North	0	0	No glare
Burt Street	Road Route	North	0	0	No glare
Fraser Street	Road Route	North-east	0	0	No glare
Goobar Street	Road Route	North	0	0	No glare
Gould Street	Road Route	North	0	0	No glare
Kamilaroi Highway	Road Route	West	0	0	No glare
Kelvin Vickery Avenue	Road Route	North	0	0	No glare
Mooloobar Street	Road Route	North	0	0	No glare
Newell Highway	Road Route	North-west	0	0	No glare

Old Turrawan Road	Road Route	North-east	0	0	No glare
Railway Street North	Road Route	North-west	0	0	No glare
Railway Street South	Road Route	North	0	0	No glare
Sarnia Street	Road Route	North	0	0	No glare
Unnamed Road	Road Route	West	0	0	No glare
Wukawa Street	Road Route	North	0	0	No glare
Zimmerman Street	Road Route	North	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 on the major road to the west of the site (Newell Highway), further minimising the visual impact of the project. Road users approaching the solar farm along the other roads surrounding the site are also not expected to experience any glare.

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/

Ramírez, A. Z., & Muňoz, C. B (2012). Albedo effect and energy efficiency of cities. Sustainable Development – Energy, Engineering and Technologies – Manufacturing and Environment. Retrieved from https://www.intechopen.com/books/sustainable-development-energy-engineering-and-technologies-manufacturing-and-environment/albedo-effect-and-energy-efficiency-of-cities

APPENDIX A. FORGESOLAR GLARE ANALYSIS

FORGESOLAR GLARE ANALYSIS

Project: **NAR3A**
Site configuration: **NAR3A**
Analysis conducted by ITP Engineering (engineering@itpau.com.au) at 03:34 on 23 Sep, 2020.

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: 43262.7843

PV Array(s)

Name: PV array NAR3A - KMZ
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: -
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	-30.354030	149.754500	216.78	1.78	218.56
2	-30.355010	149.754500	216.86	1.78	218.64
3	-30.355130	149.755400	216.00	1.78	217.78
4	-30.356210	149.755400	216.43	1.78	218.21
5	-30.355310	149.748900	216.39	1.78	218.17
6	-30.354240	149.748800	216.99	1.78	218.77
7	-30.354520	149.750900	215.53	1.78	217.31
8	-30.353540	149.750900	215.95	1.78	217.73

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-30.353173	149.753079	218.72	1.65
OP 2	2	-30.353247	149.753722	218.21	1.65
OP 3	3	-30.352532	149.757019	215.94	1.65
OP 4	4	-30.352074	149.757974	216.06	1.65
OP 5	5	-30.351148	149.757765	216.42	1.65
OP 6	6	-30.356492	149.746138	217.96	1.65
OP 7	7	-30.358253	149.743475	220.29	1.65
OP 8	8	-30.365571	149.740265	221.00	1.65
OP 9	9	-30.363083	149.764647	218.09	1.65
OP 10	10	-30.362759	149.765108	219.23	1.65
OP 11	11	-30.361944	149.765527	219.31	1.65
OP 12	12	-30.360056	149.770269	219.24	1.65
OP 13	13	-30.353969	149.767152	216.05	1.65
OP 14	14	-30.352941	149.766685	215.92	1.65
OP 15	15	-30.348599	149.760967	215.73	1.65
OP 16	16	-30.348729	149.763166	215.26	1.65
OP 17	17	-30.348821	149.756643	216.73	1.65
OP 18	18	-30.350312	149.768036	214.95	1.65
OP 19	19	-30.349155	149.767178	214.00	1.65
OP 20	20	-30.343240	149.761269	213.06	1.65
OP 21	21	-30.343531	149.760282	214.52	1.65
OP 22	22	-30.345022	149.762411	214.00	1.65

Route Receptor(s)

Name: Avon Street
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	-30.348099	149.767619	212.25	1.50	213.75
2	-30.348913	149.768080	213.34	1.50	214.84
3	-30.349330	149.769765	215.58	1.50	217.08

Name: Boheena Street
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	-30.339753	149.762667	214.09	1.50	215.59
2	-30.341179	149.764791	214.79	1.50	216.29

Name: Boundary Street
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	-30.338211	149.747813	217.78	1.50	219.28
2	-30.341035	149.745973	216.62	1.50	218.12
3	-30.342880	149.743677	219.06	1.50	220.56
4	-30.343674	149.743409	219.47	1.50	220.97
5	-30.346072	149.742961	218.67	1.50	220.17
6	-30.346632	149.743135	219.00	1.50	220.50
7	-30.347803	149.745438	215.28	1.50	216.78
8	-30.348233	149.745580	215.77	1.50	217.27
9	-30.357885	149.738434	218.73	1.50	220.23

Name: Burigal Street
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	-30.339144	149.752741	213.85	1.50	215.35
2	-30.337200	149.754007	215.75	1.50	217.25

Name: Burt St
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	-30.339340	149.750317	215.19	1.50	216.69
2	-30.339877	149.750918	214.69	1.50	216.19
3	-30.340211	149.750896	214.83	1.50	216.33
4	-30.341100	149.750253	213.54	1.50	215.04

Name: Fraser Street
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	-30.348099	149.767587	212.25	1.50	213.75
2	-30.345136	149.769239	214.22	1.50	215.72
3	-30.340654	149.770076	214.23	1.50	215.73

Name: Goobar Street
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	-30.339181	149.755487	215.37	1.50	216.87
2	-30.337218	149.751604	214.00	1.50	215.50
3	-30.334848	149.748771	214.30	1.50	215.80

Name: Gould St
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	-30.339525	149.746948	216.80	1.50	218.30
2	-30.342600	149.753107	214.75	1.50	216.25

Name: Kamilaroi Highway
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	-30.348165	149.760094	217.41	1.50	218.91
2	-30.350728	149.762307	214.28	1.50	215.78
3	-30.363564	149.767006	221.05	1.50	222.55
4	-30.364619	149.768014	226.10	1.50	227.60
5	-30.365285	149.769259	227.12	1.50	228.62

Name: Kelvin Vickery Avenue
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	-30.347933	149.759758	216.55	1.50	218.05
2	-30.346988	149.758235	216.00	1.50	217.50
3	-30.344100	149.752227	213.79	1.50	215.29

Name: Mooloobar Street
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	-30.344266	149.762441	214.34	1.50	215.84
2	-30.338507	149.751390	214.27	1.50	215.77
3	-30.338711	149.750703	214.00	1.50	215.50
4	-30.339285	149.750296	215.17	1.50	216.67

Name: Newell Highway
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	-30.367516	149.733479	224.17	1.50	225.67
2	-30.354518	149.746632	219.68	1.50	221.18
3	-30.348222	149.759765	217.17	1.50	218.67
4	-30.344889	149.761524	214.93	1.50	216.43
5	-30.339945	149.765987	213.86	1.50	215.36

Name: Old Turrawan 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	-30.362708	149.771946	222.80	1.50	224.30
2	-30.360153	149.768492	218.06	1.50	219.56
3	-30.344377	149.762548	214.41	1.50	215.91

Name: Railway Street North
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	-30.339340	149.750317	215.19	1.50	216.69
2	-30.337562	149.746154	216.36	1.50	217.86

Name: Railway Street South
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	-30.341674	149.753879	214.15	1.50	215.65
2	-30.344581	149.759651	215.20	1.50	216.70

Name: Sarnia Street
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	-30.344637	149.759673	215.09	1.50	216.59
2	-30.345062	149.759673	214.74	1.50	216.24
3	-30.346933	149.758321	216.00	1.50	217.50

Name: Unnamed 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	-30.357634	149.738497	218.01	1.50	219.51
2	-30.357578	149.738347	217.86	1.50	219.36
3	-30.357838	149.732017	220.76	1.50	222.26

Name: Wukawa Street
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	-30.342124	149.760521	212.55	1.50	214.05
2	-30.338587	149.763568	213.01	1.50	214.51

Name: Zimmerman Street
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	-30.344062	149.752291	213.99	1.50	215.49
2	-30.341711	149.753793	214.08	1.50	215.58

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV array NAR3A - KMZ	SA tracking	SA tracking	0	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

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
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
Avon Street	0	0
Boheena Street	0	0
Boundary Street	0	0
Burigal Street	0	0
Burt St	0	0
Fraser Street	0	0
Goobar Street	0	0
Gould St	0	0
Kamilaroi Highway	0	0
Kelvin Vickery Avenue	0	0
Mooloobar Street	0	0
Newell Highway	0	0
Old Turrawan Road	0	0
Railway Street North	0	0
Railway Street South	0	0
Sarnia Street	0	0
Unnamed Road	0	0
Wukawa Street	0	0
Zimmerman Street	0	0

Results for: PV array NAR3A - KMZ

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

Receptor	Green Glare (min)	Yellow Glare (min)
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
Avon Street	0	0
Boheena Street	0	0
Boundary Street	0	0
Burigal Street	0	0
Burt St	0	0
Fraser Street	0	0
Goobar Street	0	0
Gould St	0	0
Kamilaroi Highway	0	0
Kelvin Vickery Avenue	0	0
Mooloobar Street	0	0
Newell Highway	0	0
Old Turrawan Road	0	0
Railway Street North	0	0
Railway Street South	0	0
Sarnia Street	0	0
Unnamed Road	0	0
Wukawa Street	0	0
Zimmerman Street	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

Route: Avon Street

0 minutes of yellow glare
0 minutes of green glare

Route: Boheena Street

0 minutes of yellow glare
0 minutes of green glare

Route: Boundary Street

0 minutes of yellow glare
0 minutes of green glare

Route: Burigal Street

0 minutes of yellow glare
0 minutes of green glare

Route: Burt St

0 minutes of yellow glare
0 minutes of green glare

Route: Fraser Street

0 minutes of yellow glare
0 minutes of green glare

Route: Goobar Street

0 minutes of yellow glare
0 minutes of green glare

Route: Gould St

0 minutes of yellow glare
0 minutes of green glare

Route: Kamilaroi Highway

0 minutes of yellow glare

0 minutes of green glare

Route: Kelvin Vickery Avenue

0 minutes of yellow glare
0 minutes of green glare

Route: Mooloobar Street

0 minutes of yellow glare
0 minutes of green glare

Route: Newell Highway

0 minutes of yellow glare
0 minutes of green glare

Route: Old Turrawan Road

0 minutes of yellow glare
0 minutes of green glare

Route: Railway Street North

0 minutes of yellow glare
0 minutes of green glare

Route: Railway Street South

0 minutes of yellow glare
0 minutes of green glare

Route: Sarnia Street

0 minutes of yellow glare
0 minutes of green glare

Route: Unnamed Road

0 minutes of yellow glare
0 minutes of green glare

Route: Wukawa Street

0 minutes of yellow glare
0 minutes of green glare

Route: Zimmerman Street

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 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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