ITP Renewables
Consulting | Engineering | Implementation

GLINT AND GLARE ASSESSMENT

Hay 2A Solar Farm

December 2019

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The staff at ITP have backgrounds in renewable energy and energy efficiency, research, development and implementation, managing and reviewing government incentive programs, high-level policy analysis and research, engineering design and project management.

Document Control Record

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Document Control

Document Title	Visual Impact Assessment of the Hay 2A Solar Farm			
ITP Project No.	Hay 2A			
Rev.	**Date**	**Status**	**Author/s**	**Reviewer**
1	11 December 2019	Draft	K Banks	S Dedman

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TABLE OF CONTENTS

TABLE OF FIGURES

LIST OF TABLES

LIST OF 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

1. INTRODUCTION

1.1. Overview

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

Table 1. Site information

Parameter	Description
Solar farm name	Hay 2A Solar Farm
Site reference	Hay 2A
Lot/DP(s)	110/1187931
Street address	Mid Western Highway, Hay, NSW 2711
Council	Hay Shire Council
AC capacity	5MW
DC capacity	Approx. 8MW
Project area	Approx. 6.2ha
Current land use	Unused

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.

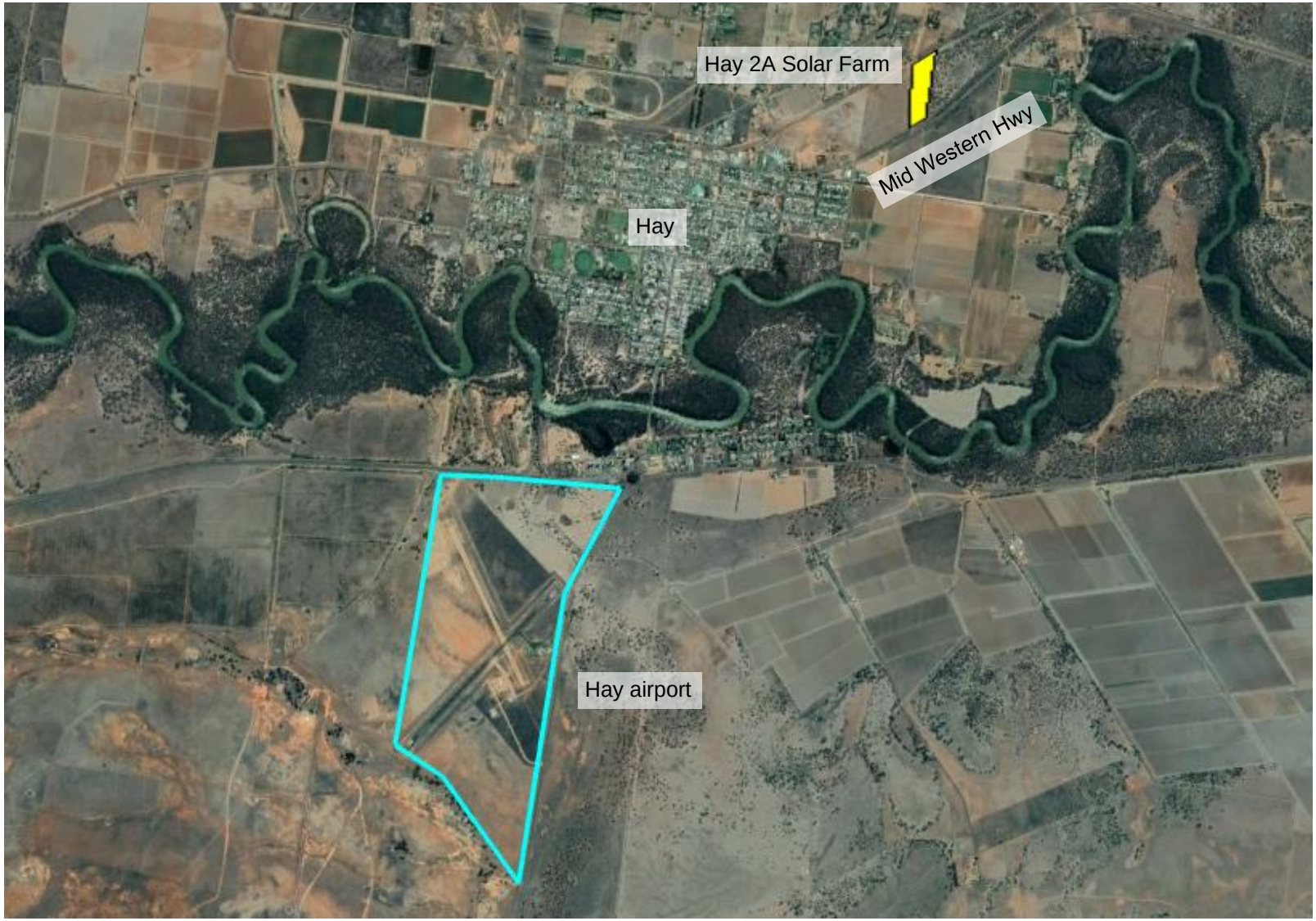

Figure 1. Proposed solar farm site and surrounding area

2. PROJECT DESCRIPTION

ITP Development is proposing to construct a solar farm with a DC capacity of approximately 8MWp and AC output of 5MW, on an approximately 6.2ha site that is currently unused.

There are to be approximately 18,500 solar modules installed in 26 blocks of modules. Each block comprises rows of alternate facing modules fixed at 8 degrees from the horizontal, as illustrated in Figure 2. The modules have a maximum height of 1.1m above the ground. The general arrangement of the solar farm is shown on drawing HAY2A-G-210, and the array mounting details on drawing HAY2A-E-341.

The solar farm will also comprise two 2.5MW inverter stations. These inverters are to be located within the array and are each mounted on a 20-foot skid. Each of these inverter stations incorporate the high voltage switchgear and transformers. The arrangement of the inverter station skid is shown in drawing HAY2A-E-430.

The module blocks are secured with 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 2.5 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 2. The PEG mounting structure comprises rows of alternate facing modules (photo courtesy of Belectric, n.d.)

3. ANALYSIS

3.1 Overview

In a north-facing 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. The Hay 2A Solar Farm PV array contains rows of alternating modules facing approximately northwest and southeast. The variation in the angle of incidence will therefore be largest around noon and smallest at sunrise or sunset, depending upon the season, because the modules will not be directly facing the sun around noon. Theoretically, a PV array in this configuration will have greater potential to cause glare than one that is tracking the sun throughout the day, although the glare would be similar to one with a fixed north-facing orientation.

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	None (fixed)
Module surface material	Smooth glass with ARC (anti-reflective coating)
Module tilt	8°
Module orientation	97° and 277°
Height of modules above ground	1.1m

3.2 Potential Receptors

A viewshed model considers the elevation of the site relative to the surrounding land to determine the viewpoints that have the potential to be impacted by glint and glare from the PV modules. For this project, visual receptors within 2 km of the site were considered including residences and road users. 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 (Scrivener et al., 2017).

Potential residential property and road user observation points were first identified using satellite imagery. Many of these were discounted based on large stands of trees or structures that will prevent direct observation of the proposed solar farm. The remaining potential receptors were then plotted on the viewshed model of the site to determine whether the solar farm would be visible at those locations. These receptors are shown on the viewshed model map in Figure 3. Receptors in the blue-shaded areas would have direct line of sight to the solar farm based solely on topography. Other visual obstructions such as vegetation or structures may impede the line of site, but where these could not be definitively established, a conservative approach was taken and they have been included in the study.

As shown in Figure 3, 47 residential observation points (indicated by the red circles) and four road routes (purple lines) were identified as potential visual receptors of the site. The potential for visual receptors increases as shading becomes darker, and there is no potential for visual receptors where there is no shading.

Many of the potential observation points will not be in direct line of sight of the solar farm, and thus would not be impacted by glint or glare. Where the topography does not prevent line of sight, these observation points may have some visual impact from the solar farm. This is discussed in more detail in Section 3.4.

The Hay airport was also considered in the GlareGauge analysis. The airport is approximately 4km southwest of the proposed solar farm, and planes approaching or leaving the airport are not expected to be impacted by glare from the solar farm. The runway locations are not shown on Figure 3 due to the relatively large distance between the airport and solar farm.

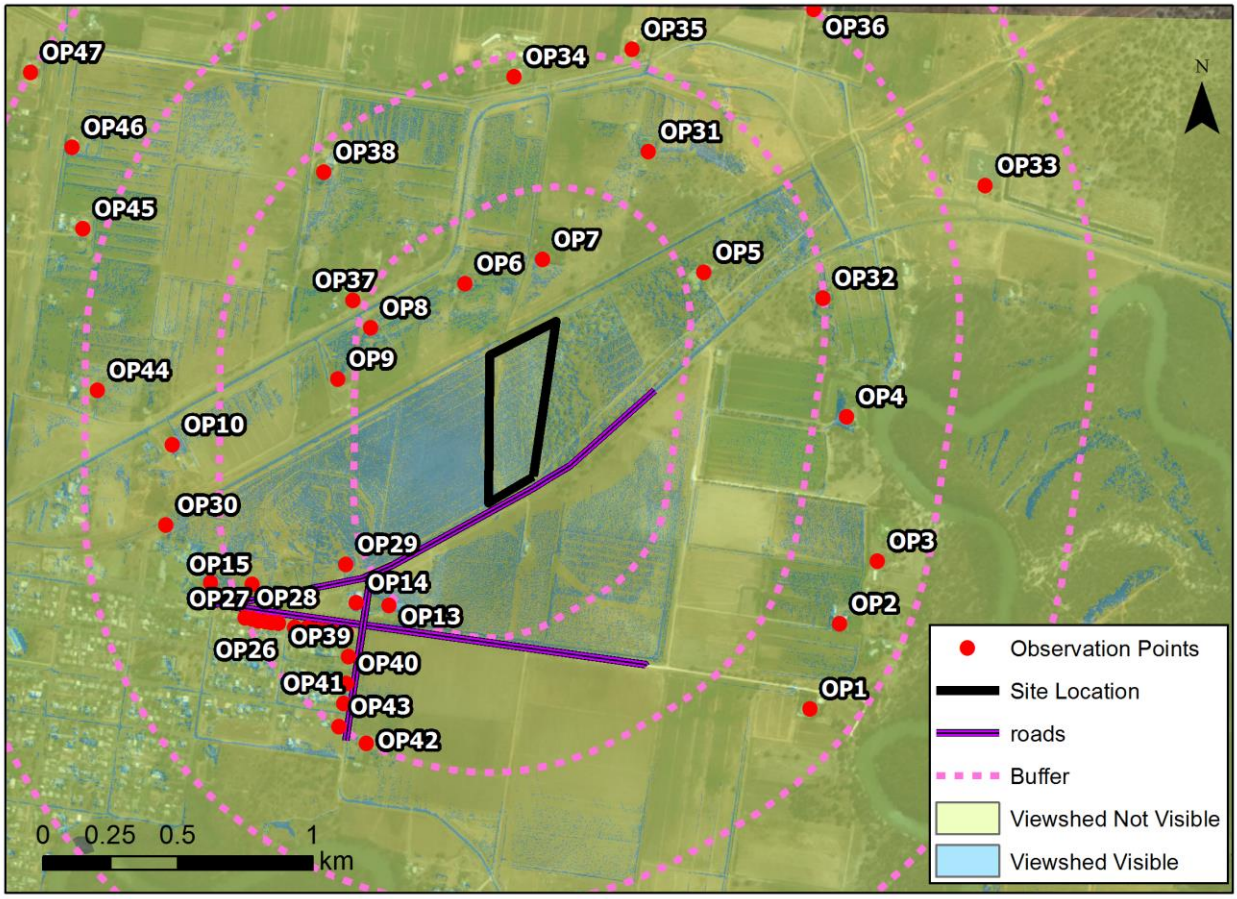

Figure 3. Viewshed model output based on existing elevation of the site area. 47 residential observation points were identified (shown by the red circles) and four roadways (purple lines). The model does not reference landscape features such as roadside trees or structures.

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 entirely cleared with no trees or buildings on the property.

Atmospheric conditions, such as cloud cover, will also influence light reflection and the resulting impact on visual receptors. Varying atmospheric conditions have not been accounted for in the GlareGauge analysis. The GlareGauge analysis assumes clear sky conditions, with a peak direct normal irradiance (DNI) of 1,000W/m^2 which varies throughout the day.

3.4 Results

The results of the GlareGauge analysis (Appendix A) at each of the observation points are outlined in Table 3 and illustrated in Figure 4. Observation points to the north and south of the solar farm are not expected to receive glare, which is not surprising given that the PV modules do not face north or south. Observation points to the east of the solar farm may receive glare in the late afternoon/evening. However, the land directly to the east and southeast of the solar farm is heavily vegetated, so it is unlikely that glare will actually be observed at these locations. Observations points to the west of the solar farm may receive glare in the early morning. It is expected that the solar farm to be constructed immediately to the west of the Hay 2A solar farm would obstruct any of this early morning glare, along with the vegetative screening planted along its southern boundary adjacent to the Mid Western Highway.

Mitigation measures are not necessitated since existing visual obstructions are considered to be sufficient. As discussed in Section 3.2, the topography of the land also prevents direct line of sight at many locations surrounding the solar farm. Nevertheless, if glint or glare are observed at any location outside the solar farm, screening should be implemented immediately. Vegetation along the property boundary is recommended for this.

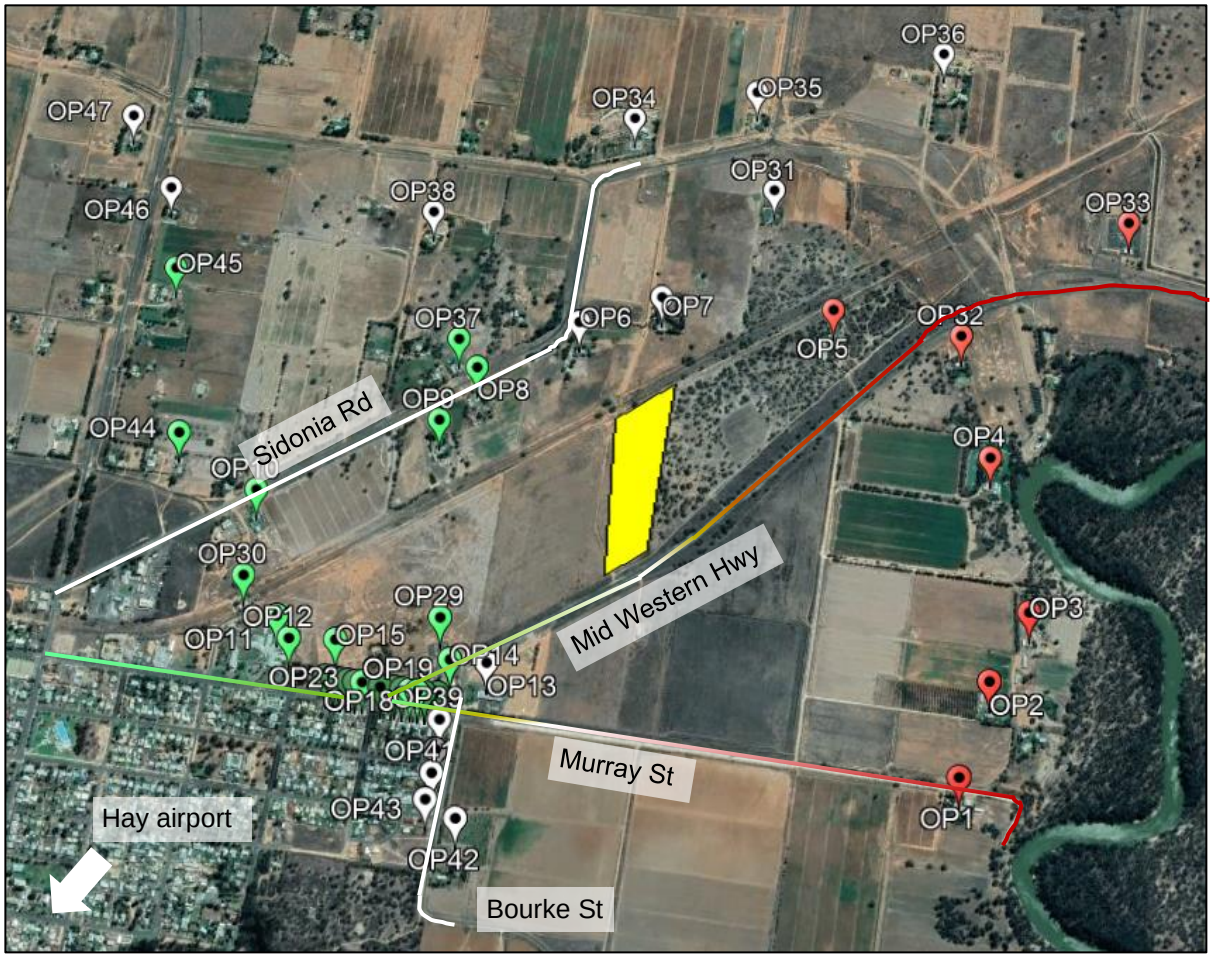

Figure 4. Map showing observation points potentially impacted by glare in the morning (green) and afternoon (red), and those not impacted (white). This glare may be obstructed by trees and buildings which are not shown here.

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	1.3km south east	0	216	Up to 5 minutes of glare around 3:30-4pm in May-Aug
OP2	Residential	1.2km south east	0	122	Up to 3 minutes of glare around 3:30-5pm in Apr-Sep
OP3	Residential	1.2km south east	0	139	Up to 5 minutes of glare around 4-5pm in Mar-May & Aug-Sep
OP4	Residential	1km east	0	212	Up to 5 minutes of glare around 4:30-6pm in Sep-Mar
OP5	Residential	700m north east	0	5	Up to 1 minute of glare around 6pm in Dec
OP6	Residential	400m north	0	0	No glare
OP7	Residential	500m north	0	0	No glare
OP8	Residential	500m north west	0	490	Up to 8 minutes of glare around 6:30-7:30am in Oct-Feb
OP9	Residential	500m north west	0	1127	Up to 10 minutes of glare around 6:30-8am in Sep-Mar
OP10	Residential	1.1km west	0	57	Up to 3 minutes of glare around 7-8am in Feb-Mar & Sep-Nov
OP11	Residential	1.1km south west	0	604	Up to 10 minutes of glare around 7:30-9am in Mar-Sep
OP12	Residential	1.1km south west	0	837	Up to 10 minutes of glare around 8-9am in Apr-Sep
OP13	Residential	700m south west	0	0	No glare

	Type of observation point	Location relative to solar farm	Green glare (minutes)	Yellow glare (minutes)	Glare potential
OP14	Residential	750m south west	0	49	Up to 2 minutes of glare around 8-8-8:30am in May-Jul
OP15	Residential	950m south west	0	561	Up to 8 minutes of glare around 8-9am in Apr-Sep
OP16	Residential	850m south west	0	3	Up to 1 minute of glare around 8:30am in Jun
OP17	Residential	850m south west	0	42	Up to 4 minutes of glare around 8:30-9am in Jun-Jul
OP18	Residential	900m south west	0	157	Up to 5 minutes of glare around 8:30-9am in May-Jul
OP19	Residential	900m south west	0	233	Up to 6 minutes of glare around 8-9am in May-Jul
OP20	Residential	900m south west	0	363	Up to 8 minutes of glare around 8-9am in May-Jul
OP21	Residential	900m south west	0	475	Up to 10 minutes of glare around 8-9am in May-Aug
OP22	Residential	950m south west	0	565	Up to 12 minutes of glare around 8-9am in May-Aug
OP23	Residential	950m south west	0	788	Up to 10 minutes of glare around 8-9am in Apr-Aug
OP24	Residential	1km south west	0	713	Up to 12 minutes of glare around 8-9am in Apr-Aug

	Type of observation point	Location relative to solar farm	Green glare (minutes)	Yellow glare (minutes)	Glare potential
OP25	Residential	1km south west	0	625	Up to 10 minutes of glare around 8-9am in Apr-Aug
OP26	Residential	1km south west	0	519	Up to 11 minutes of glare around 8-9am in Apr-Aug
OP27	Residential	1km south west	0	651	Up to 10 minutes of glare around 8-9am in Apr-Aug
OP28	Residential	1km south west	0	604	Up to 8 minutes of glare around 8-9am in Apr-Aug
OP29	Residential	700m south west	0	244	Up to 5 minutes of glare around 8-9am in Apr-Aug
OP30	Residential	1.1km west	0	214	Up to 5 minutes of glare around 7:30-8:30am in Mar-May & Aug-Oct
OP31	Residential	900m north east	0	0	No glare
OP32	Residential	1km east	0	476	Up to 10 minutes of glare around 5-6pm in Oct-Feb
OP33	Residential	1.6km north east	0	14	Up to 2 minutes of glare around 6pm in Dec-Jan
OP34	Residential	1km north	0	0	No glare
OP35	Residential	1.1km north	0	0	No glare
OP36	Residential	1.5km north east	0	0	No glare
OP37	Residential	600m north west	0	204	Up to 7 minutes of glare around 6:30-7:30am in Nov-Feb
OP38	Residential	950m north west	0	0	No glare

	Type of observation point	Location relative to solar farm	Green glare (minutes)	Yellow glare (minutes)	Glare potential
OP39	Residential	900m south west	0	0	No glare
OP40	Residential	1km south west	0	0	No glare
OP41	Residential	1km south west	0	0	No glare
OP42	Residential	1.1km south	0	0	No glare
OP43	Residential	1.1km south west	0	0	No glare
OP44	Residential	1.3km west	0	176	Up to 3 minutes of glare around 6:30-8am in Oct-Mar
OP45	Residential	1.4km north west	0	85	Up to 2 minutes of glare around 6-7am in Nov-Jan
OP46	Residential	1.6km north west	0	0	No glare
OP47	Residential	1.8km north west	0	0	No glare
OP48	Road user – Bourke St	South west	0	0	No glare
OP49	Road user – Mid Western Hwy	South west through to east	0	1432	Glare ranging between 3:30pm in winter to 6pm in summer, and 8-9am in May-Aug
OP50	Road user – Murray St	South west through to south west	0	96	Glare around 8-9am in May-Jun, and 4-4:30pm in May-Aug
OP51	Road user – Sidonia Rd	West through to north	0	0	No glare
OP52	Runway – Hay airport runway 04 (approach from southwest)	5.8km south west (threshold point)	0	0	No glare
OP53	Runway – Hay airport runway 15 (approach from northwest)	4.3km south west (threshold point)	0	0	No glare
OP54	Runway – Hay airport runway 22 (approach from northeast)	4.5km south west (threshold point)	0	0	No glare

	Type of observation point	Location relative to solar farm	Green glare (minutes)	Yellow glare (minutes)	Glare potential
OP55	Runway – Hay airport runway 33 (approach from southeast)	5km south west (threshold point)	0	0	No glare

4. SUMMARY

The results of the GlareGauge analysis indicated that some of the identified observation points may receive glare due to the proposed solar farm. The solar farm comprises alternating rows of modules facing 97° and 277°. As a result, observation points to the east of the solar farm may receive glare in the late afternoon/evening, while observation points to the west may receive glare in the early morning.

Visual obstructions such as vegetation, buildings, road verges, and the adjacent solar farm are expected to prevent these observation points from receiving glare. The viewshed analysis also demonstrates that many of these potential observation points will not have direct line of sight of the solar farm, so will not be impacted by glint or glare.

Vegetation screening could be considered around the perimeter of the solar farm to mitigate any impacts to visual amenity.

5. REFERENCES

Belectric (n.d.). *PEG solar power plant*. Retrieved from https://belectric.com/solarplants/peg/

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

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FORGESOLAR GLARE ANALYSIS

Project: **Hay 2A**
Hay 2A solar farm

Site configuration: **Hay 2A v1-0**
Analysis conducted by ITP Engineering (engineering@itpau.com.au) at 05:10 on 13 Dec, 2019.

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
Flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	N/A	No ATCT receptors designated

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

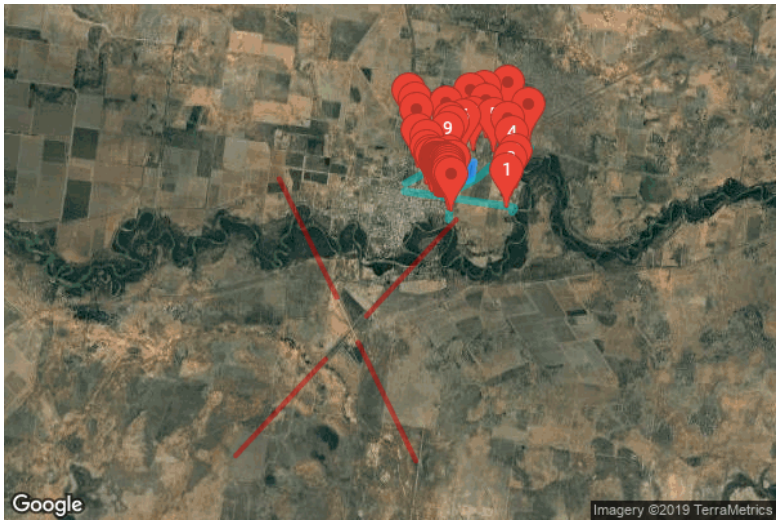
- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 34176.6213



PV Array(s)

Name: PV array 1 - SE
Axis tracking: Fixed (no rotation)
Tilt: 8.0°
Orientation: 97.0°
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	-34.494064	144.863958	91.38	1.10	92.48
2	-34.493817	144.863561	91.77	1.10	92.87
3	-34.494498	144.862091	91.81	1.10	92.91
4	-34.498539	144.861790	90.90	1.10	92.00
5	-34.497902	144.863228	91.29	1.10	92.39

Name: PV array 2 - NW
Axis tracking: Fixed (no rotation)
Tilt: 8.0°
Orientation: 277.0°
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	-34.494056	144.863947	91.38	1.10	92.48
2	-34.493808	144.863550	91.79	1.10	92.89
3	-34.494498	144.862080	91.81	1.10	92.91
4	-34.498521	144.861780	90.92	1.10	92.02
5	-34.497893	144.863217	91.29	1.10	92.39

Flight Path Receptor(s)

Name: Runway 04
Description:
Threshold height: 15 m
Direction: 43.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-34.537344	144.823984	89.29	15.24	104.53
Two-mile	-34.558489	144.800019	90.00	183.22	273.22

Name: Runway 15
Description:
Threshold height: 15 m
Direction: 154.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-34.523774	144.827007	89.57	15.24	104.81
Two-mile	-34.497787	144.811605	89.96	183.53	273.49

Name: Runway 22
Description:
Threshold height: 15 m
Direction: 223.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-34.527885	144.834869	89.00	15.24	104.24
Two-mile	-34.506740	144.858831	89.92	183.00	272.92

Name: Runway 33
Description:
Threshold height: 15 m
Direction: 334.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-34.533669	144.832693	90.62	15.24	105.86
Two-mile	-34.559656	144.848097	90.05	184.50	274.55

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-34.504166	144.872442	92.73	1.65
OP 2	2	-34.501831	144.873472	91.30	1.65
OP 3	3	-34.500155	144.874674	91.98	1.65
OP 4	4	-34.496176	144.873816	91.73	1.65
OP 5	5	-34.492176	144.868880	92.93	1.65
OP 6	6	-34.492547	144.860984	93.19	1.65
OP 7	7	-34.491964	144.863559	93.00	1.65
OP 8	8	-34.493820	144.857830	91.36	1.65
OP 9	9	-34.495218	144.856778	91.98	1.65
OP 10	10	-34.497039	144.851242	91.04	1.65
OP 11	11	-34.500205	144.852100	93.96	1.65
OP 12	12	-34.500806	144.852508	94.58	1.65
OP 13	13	-34.501372	144.858473	90.18	1.65
OP 14	14	-34.501336	144.857336	90.44	1.65
OP 15	15	-34.500881	144.853914	92.39	1.65
OP 16	16	-34.502190	144.857063	89.97	1.65
OP 17	17	-34.502176	144.856682	91.15	1.65
OP 18	18	-34.502128	144.856424	91.63	1.65
OP 19	19	-34.502110	144.856199	92.12	1.65
OP 20	20	-34.502092	144.855936	92.48	1.65
OP 21	21	-34.502070	144.855716	92.69	1.65
OP 22	22	-34.502039	144.855324	93.11	1.65
OP 23	23	-34.501911	144.854783	93.89	1.65
OP 24	24	-34.501911	144.854552	93.68	1.65
OP 25	25	-34.501893	144.854343	93.40	1.65
OP 26	26	-34.501858	144.854101	93.07	1.65
OP 27	27	-34.501809	144.853871	93.03	1.65
OP 28	28	-34.501774	144.853645	93.09	1.65
OP 29	29	-34.500313	144.856987	91.00	1.65
OP 30	30	-34.499181	144.851043	92.47	1.65
OP 31	31	-34.488875	144.867056	92.12	1.65
OP 32	32	-34.492943	144.872871	92.99	1.65
OP 33	33	-34.489852	144.878343	92.18	1.65
OP 34	34	-34.486846	144.862657	91.95	1.65
OP 35	35	-34.486129	144.866562	91.00	1.65
OP 36	36	-34.485086	144.872656	93.55	1.65
OP 37	37	-34.493009	144.857271	91.40	1.65
OP 38	38	-34.489516	144.856252	90.80	1.65
OP 39	39	-34.502859	144.857132	90.75	1.65
OP 40	40	-34.503540	144.857035	91.86	1.65
OP 41	41	-34.504150	144.856939	92.55	1.65
OP 42	42	-34.505247	144.857690	91.72	1.65
OP 43	43	-34.504756	144.856810	91.81	1.65
OP 44	44	-34.495525	144.848774	91.95	1.65
OP 45	45	-34.490989	144.848227	89.70	1.65
OP 46	46	-34.488767	144.847922	91.93	1.65
OP 47	47	-34.486734	144.846477	92.92	1.65

Route Receptor(s)

Name: Bourke St
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.506820	144.857170	90.80	1.50	92.30
2	-34.506714	144.856891	90.96	1.50	92.46
3	-34.506528	144.856794	91.22	1.50	92.72
4	-34.506051	144.856858	91.84	1.50	93.34
5	-34.500613	144.857824	91.35	1.50	92.85

Name: Mid Western Hwy
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.500505	144.845063	92.00	1.50	93.50
2	-34.501352	144.852240	94.77	1.50	96.27
3	-34.501378	144.852857	94.46	1.50	95.96
4	-34.501365	144.853296	93.84	1.50	95.34
5	-34.501334	144.853763	93.34	1.50	94.84
6	-34.501201	144.854691	92.09	1.50	93.59
7	-34.500834	144.856880	91.06	1.50	92.56
8	-34.500746	144.857298	91.47	1.50	92.97
9	-34.500534	144.858017	91.18	1.50	92.68
10	-34.500295	144.858709	90.94	1.50	92.44
11	-34.500070	144.859256	90.63	1.50	92.13
12	-34.499221	144.861096	90.67	1.50	92.17
13	-34.498566	144.862577	91.00	1.50	92.50
14	-34.498279	144.863210	91.08	1.50	92.58
15	-34.497890	144.863966	91.81	1.50	93.31
16	-34.497629	144.864449	92.16	1.50	93.66
17	-34.497258	144.865039	92.00	1.50	93.50
18	-34.496608	144.865935	90.86	1.50	92.36
19	-34.494875	144.868263	90.45	1.50	91.95
20	-34.493433	144.870205	91.00	1.50	92.50
21	-34.493053	144.870715	91.23	1.50	92.73
22	-34.492669	144.871305	92.48	1.50	93.98
23	-34.492310	144.871911	92.99	1.50	94.49
24	-34.492010	144.872496	92.08	1.50	93.58
25	-34.491691	144.873231	92.93	1.50	94.43
26	-34.491391	144.874078	91.35	1.50	92.85
27	-34.491099	144.875344	91.92	1.50	93.42
28	-34.490922	144.876524	93.01	1.50	94.51
29	-34.490843	144.877597	91.07	1.50	92.57
30	-34.490860	144.878552	91.07	1.50	92.57

Name: Murray St
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.505023	144.873795	94.34	1.50	95.84
2	-34.504307	144.874310	94.56	1.50	96.06
3	-34.504175	144.874342	94.44	1.50	95.94
4	-34.504086	144.874128	93.71	1.50	95.21
5	-34.503936	144.873398	91.37	1.50	92.87
6	-34.502468	144.861479	92.57	1.50	94.07
7	-34.501726	144.855095	93.06	1.50	94.56
8	-34.501133	144.855159	91.26	1.50	92.76

Name: Sidonia Rd
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.498774	144.845379	91.75	1.50	93.25
2	-34.494159	144.855861	91.96	1.50	93.46
3	-34.492523	144.859541	91.62	1.50	93.12
4	-34.492257	144.860066	92.77	1.50	94.27
5	-34.491930	144.860442	93.49	1.50	94.99
6	-34.491612	144.860656	93.39	1.50	94.89
7	-34.491267	144.860732	92.50	1.50	94.00
8	-34.488764	144.861128	91.35	1.50	92.85
9	-34.488260	144.861268	91.49	1.50	92.99
10	-34.487986	144.861461	90.76	1.50	92.26
11	-34.487712	144.861815	90.25	1.50	91.75
12	-34.487624	144.862126	90.83	1.50	92.33

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV array 1 - SE	8.0	97.0	0	2,656	-
PV array 2 - NW	8.0	277.0	0	10,442	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
Runway 04	0	0
Runway 15	0	0
Runway 22	0	0
Runway 33	0	0
OP 1	0	216
OP 2	0	122
OP 3	0	139
OP 4	0	212
OP 5	0	5
OP 6	0	0
OP 7	0	0
OP 8	0	490
OP 9	0	1127
OP 10	0	57
OP 11	0	604
OP 12	0	837
OP 13	0	0
OP 14	0	49
OP 15	0	561
OP 16	0	3
OP 17	0	42
OP 18	0	157
OP 19	0	233
OP 20	0	363
OP 21	0	475
OP 22	0	565
OP 23	0	788

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
OP 24	0	713
OP 25	0	625
OP 26	0	519
OP 27	0	651
OP 28	0	604
OP 29	0	244
OP 30	0	214
OP 31	0	0
OP 32	0	476
OP 33	0	14
OP 34	0	0
OP 35	0	0
OP 36	0	0
OP 37	0	204
OP 38	0	0
OP 39	0	0
OP 40	0	0
OP 41	0	0
OP 42	0	0
OP 43	0	0
OP 44	0	176
OP 45	0	85
OP 46	0	0
OP 47	0	0
Bourke St	0	0
Mid Western Hwy	0	1432
Murray St	0	96
Sidonia Rd	0	0

Results for: PV array 1 - SE

Receptor	Green Glare (min)	Yellow Glare (min)
Runway 04	0	0
Runway 15	0	0
Runway 22	0	0
Runway 33	0	0
OP 1	0	216
OP 2	0	122
OP 3	0	139
OP 4	0	212

Receptor	Green Glare (min)	Yellow Glare (min)
OP 5	0	5
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
OP 28	0	0
OP 29	0	0
OP 30	0	0
OP 31	0	0
OP 32	0	476
OP 33	0	14
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
OP 41	0	0
OP 42	0	0
OP 43	0	0
OP 44	0	0
OP 45	0	0
OP 46	0	0

Receptor	Green Glare (min)	Yellow Glare (min)
OP 47	0	0
Bourke St	0	0
Mid Western Hwy	0	1390
Murray St	0	82
Sidonia Rd	0	0

Flight Path: Runway 04

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Runway 15

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Runway 22

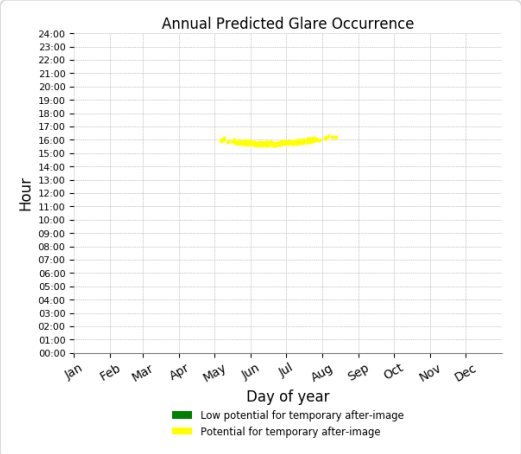
0 minutes of yellow glare
0 minutes of green glare

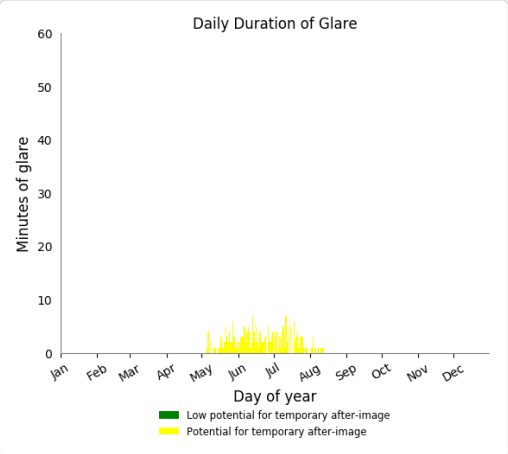
Flight Path: Runway 33

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 1

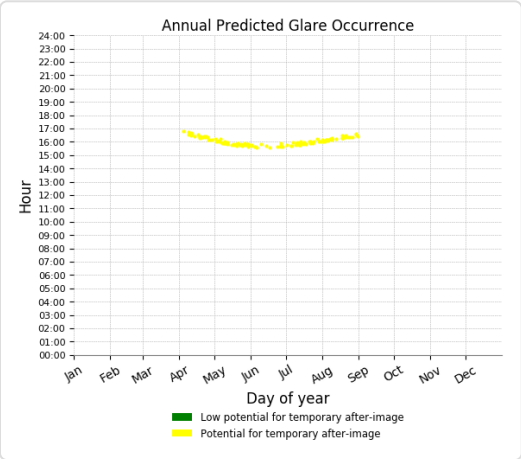
216 minutes of yellow glare
0 minutes of green glare

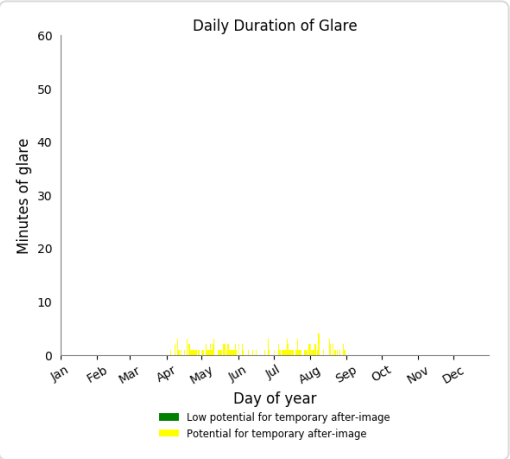




Point Receptor: OP 2

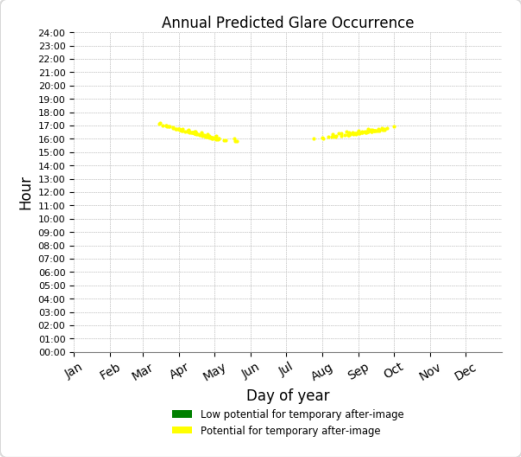
122 minutes of yellow glare
0 minutes of green glare

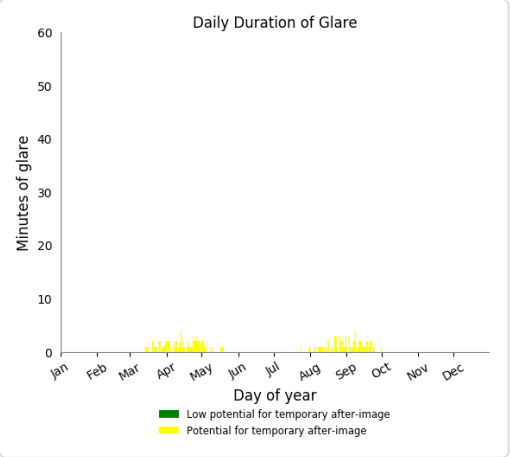




Point Receptor: OP 3

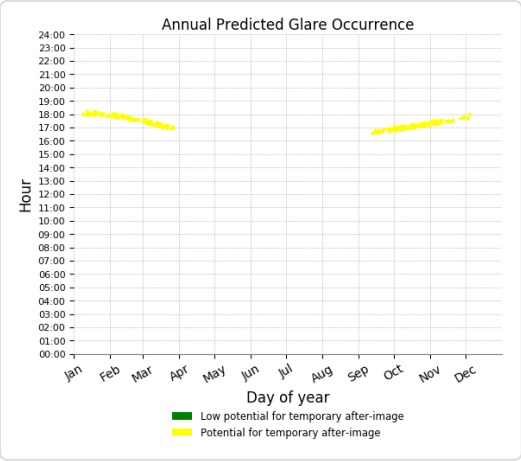
139 minutes of yellow glare
0 minutes of green glare

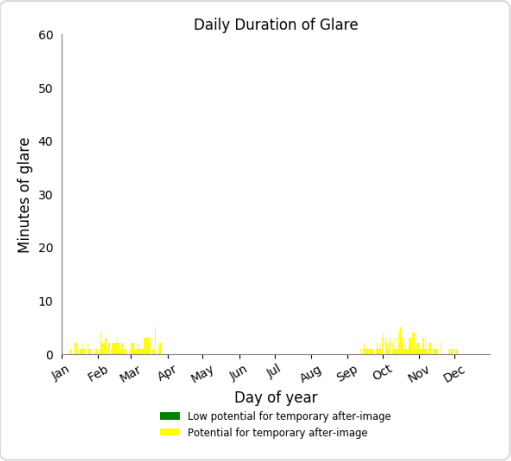




Point Receptor: OP 4

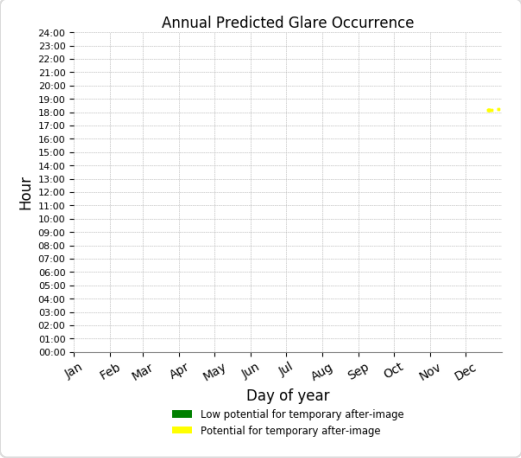
212 minutes of yellow glare
0 minutes of green glare

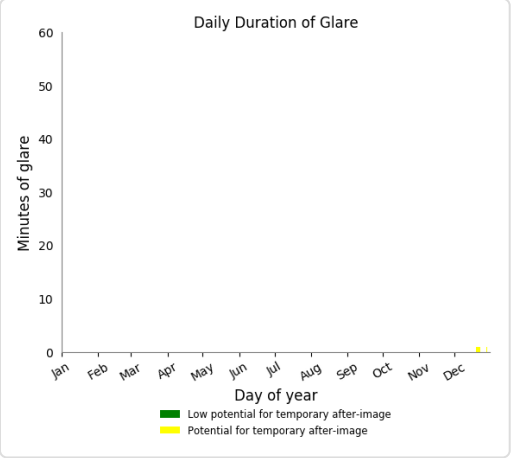




Point Receptor: OP 5

5 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

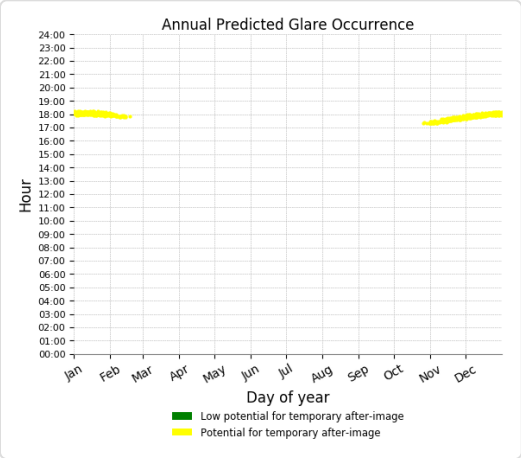
0 minutes of yellow glare
0 minutes of green glare

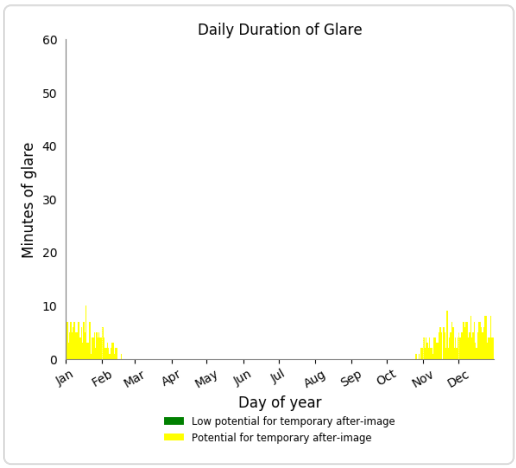
Point Receptor: OP 31

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 32

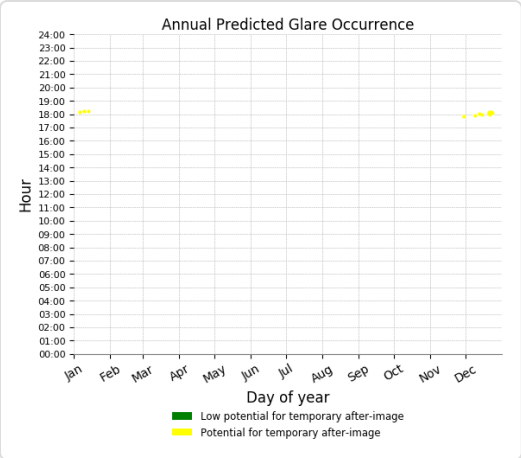
476 minutes of yellow glare
0 minutes of green glare

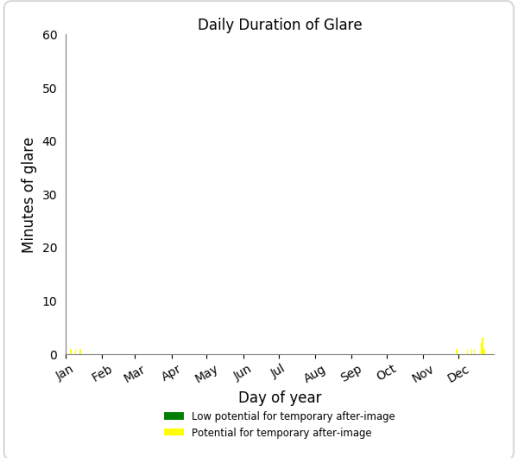




Point Receptor: OP 33

14 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

Point Receptor: OP 41

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 42

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 43

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 44

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 45

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 46

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 47

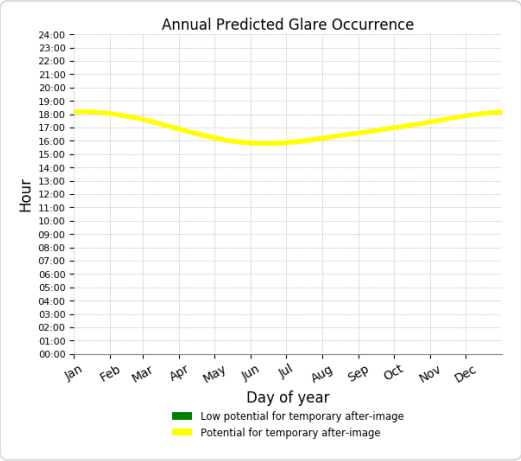
0 minutes of yellow glare
0 minutes of green glare

Route: Bourke St

0 minutes of yellow glare
0 minutes of green glare

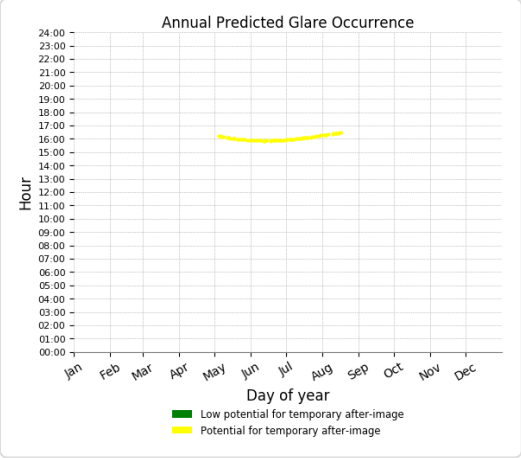
Route: Mid Western Hwy

1390 minutes of yellow glare
0 minutes of green glare



Route: Murray St

82 minutes of yellow glare
0 minutes of green glare



Route: Sidonia Rd

0 minutes of yellow glare
0 minutes of green glare

Results for: PV array 2 - NW

Receptor	Green Glare (min)	Yellow Glare (min)
Runway 04	0	0
Runway 15	0	0
Runway 22	0	0
Runway 33	0	0
OP 1	0	0

Receptor	Green Glare (min)	Yellow Glare (min)
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	490
OP 9	0	1127
OP 10	0	57
OP 11	0	604
OP 12	0	837
OP 13	0	0
OP 14	0	49
OP 15	0	561
OP 16	0	3
OP 17	0	42
OP 18	0	157
OP 19	0	233
OP 20	0	363
OP 21	0	475
OP 22	0	565
OP 23	0	788
OP 24	0	713
OP 25	0	625
OP 26	0	519
OP 27	0	651
OP 28	0	604
OP 29	0	244
OP 30	0	214
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	204
OP 38	0	0
OP 39	0	0
OP 40	0	0
OP 41	0	0
OP 42	0	0
OP 43	0	0

Receptor	Green Glare (min)	Yellow Glare (min)
OP 44	0	176
OP 45	0	85
OP 46	0	0
OP 47	0	0
Bourke St	0	0
Mid Western Hwy	0	42
Murray St	0	14
Sidonia Rd	0	0

Flight Path: Runway 04

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Runway 15

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Runway 22

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Runway 33

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 6

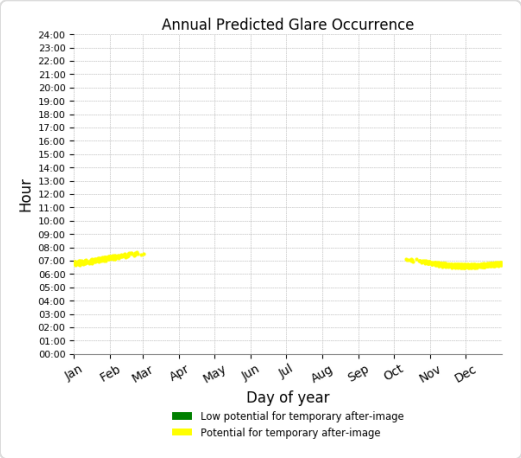
0 minutes of yellow glare
0 minutes of green glare

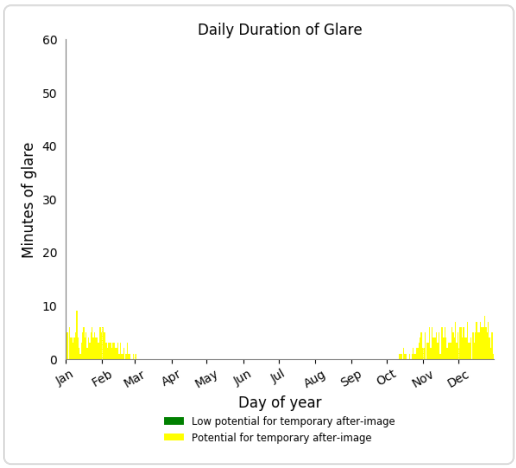
Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 8

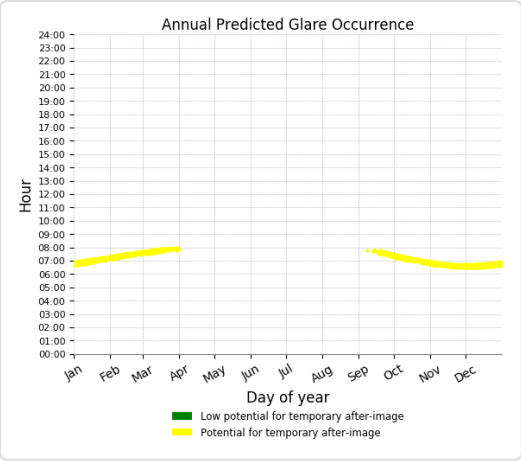
490 minutes of yellow glare
0 minutes of green glare

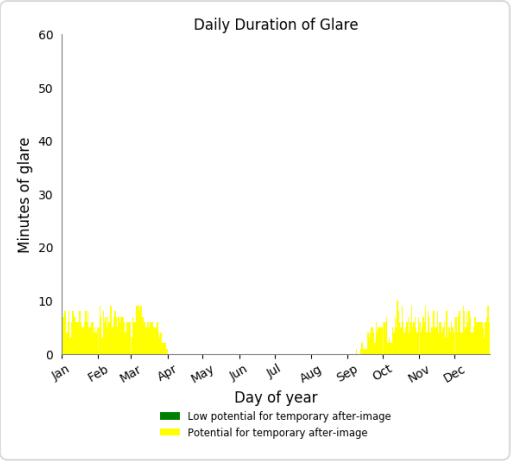




Point Receptor: OP 9

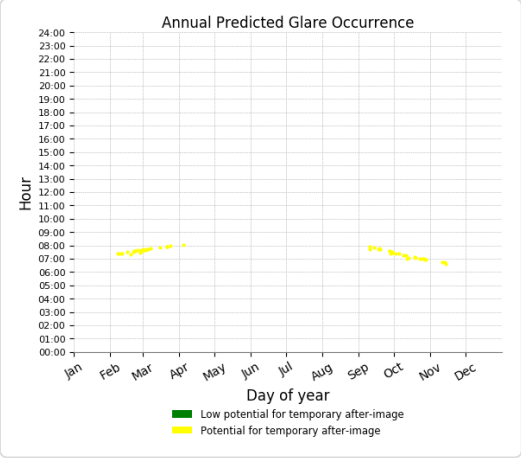
1127 minutes of yellow glare
0 minutes of green glare

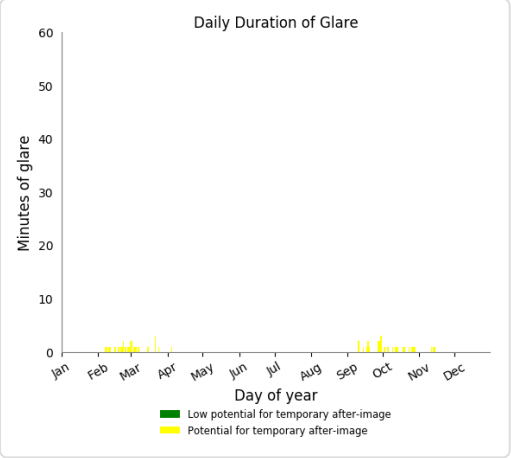




Point Receptor: OP 10

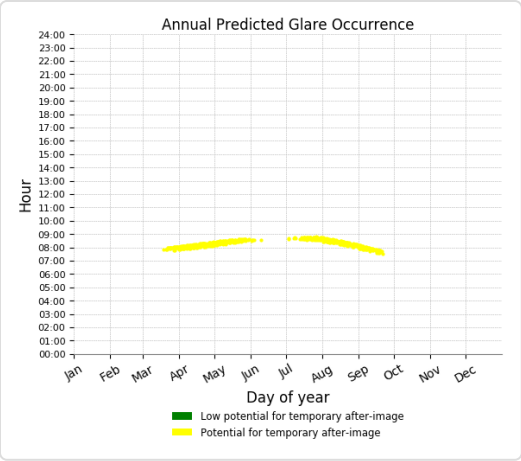
57 minutes of yellow glare
0 minutes of green glare

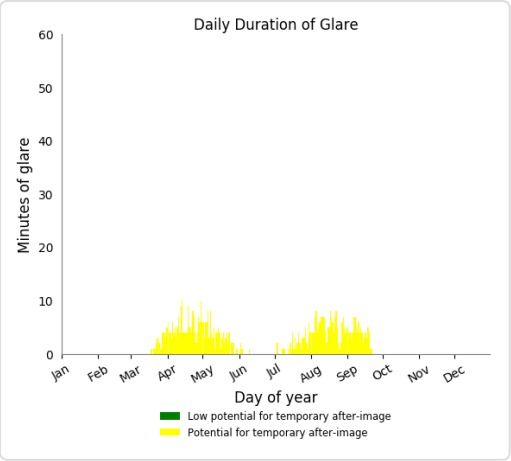




Point Receptor: OP 11

604 minutes of yellow glare
0 minutes of green glare

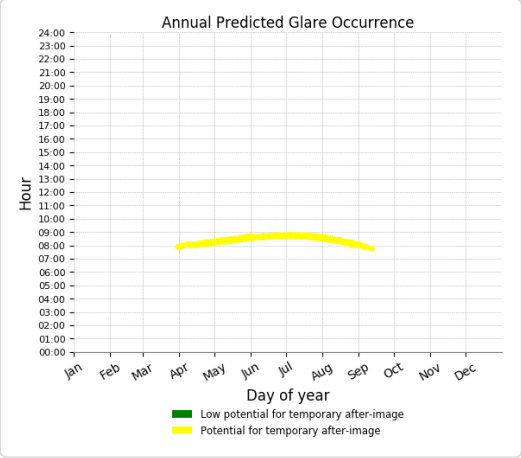


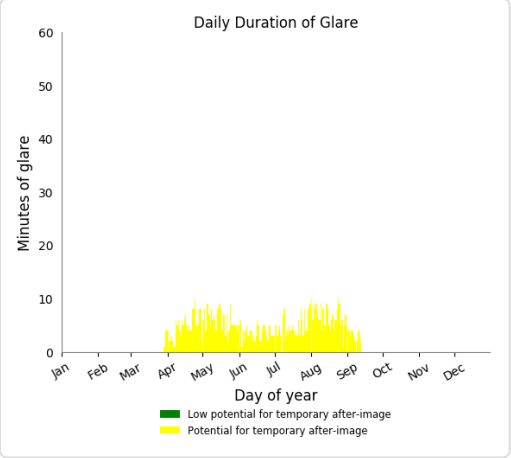


Point Receptor: OP 12

837 minutes of yellow glare

0 minutes of green glare





Point Receptor: OP 13

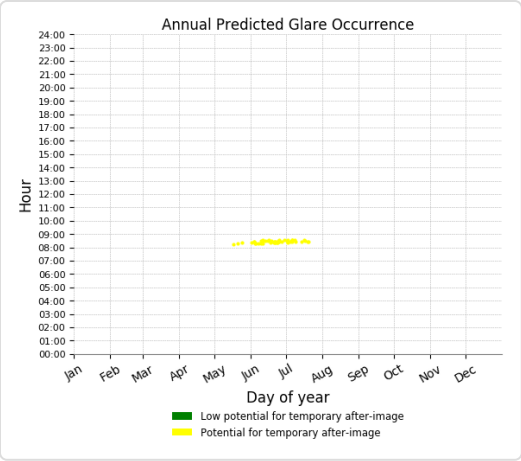
0 minutes of yellow glare

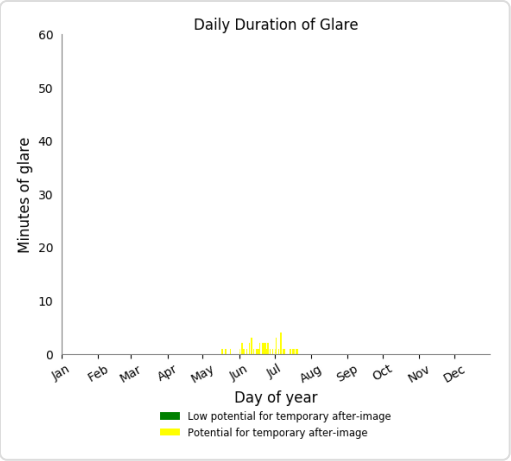
0 minutes of green glare

Point Receptor: OP 14

49 minutes of yellow glare

0 minutes of green glare

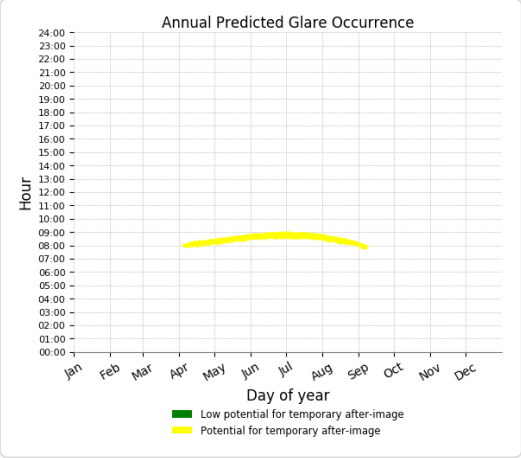


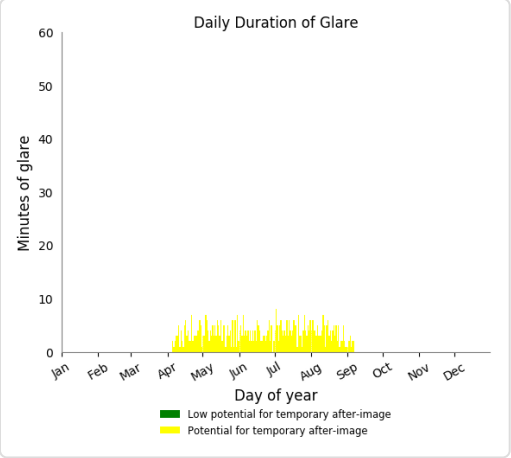


Point Receptor: OP 15

561 minutes of yellow glare

0 minutes of green glare

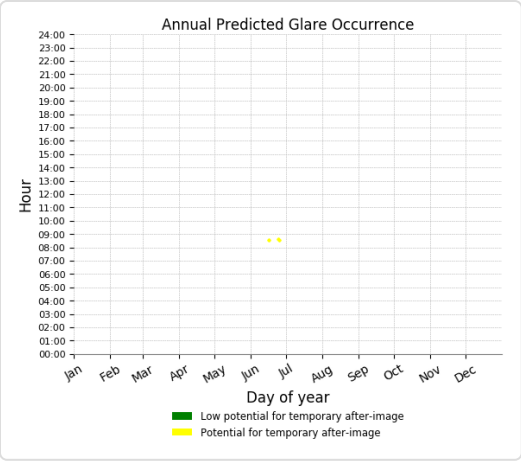


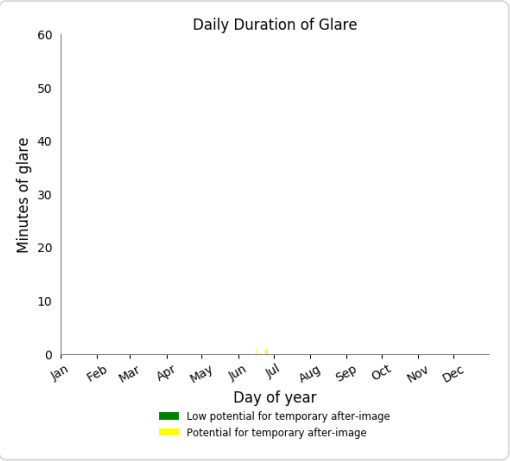


Point Receptor: OP 16

3 minutes of yellow glare

0 minutes of green glare

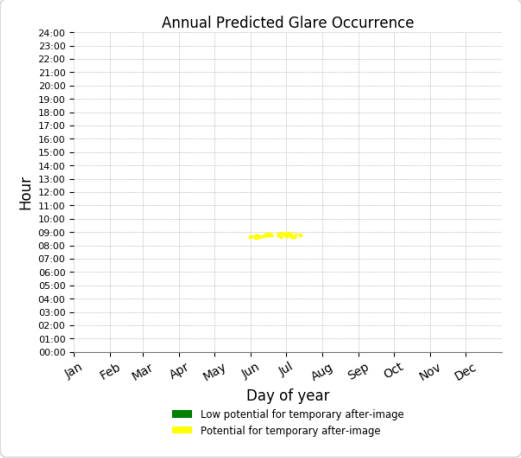


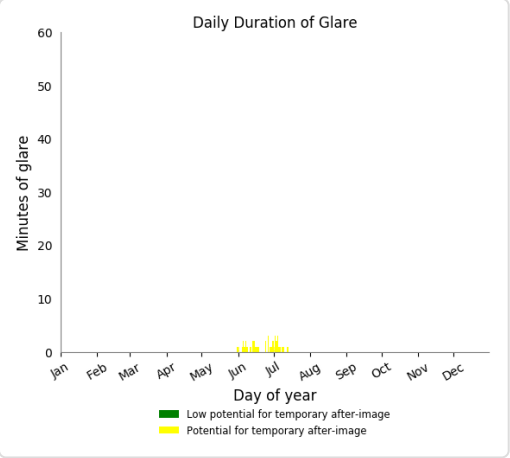


Point Receptor: OP 17

42 minutes of yellow glare

0 minutes of green glare

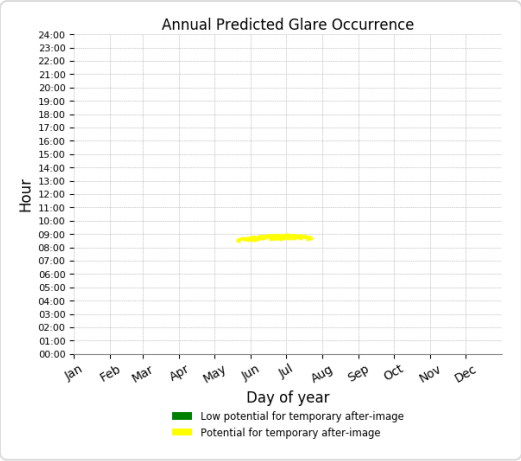


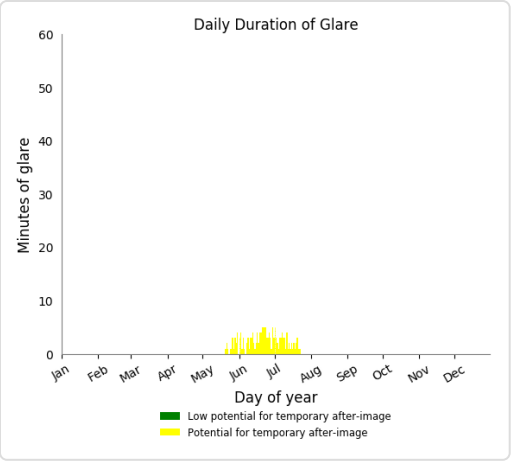


Point Receptor: OP 18

157 minutes of yellow glare

0 minutes of green glare

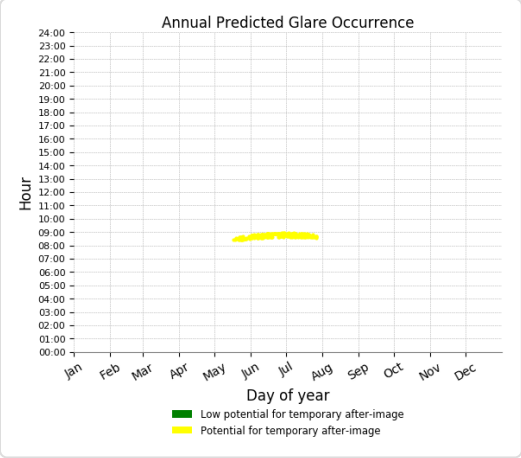


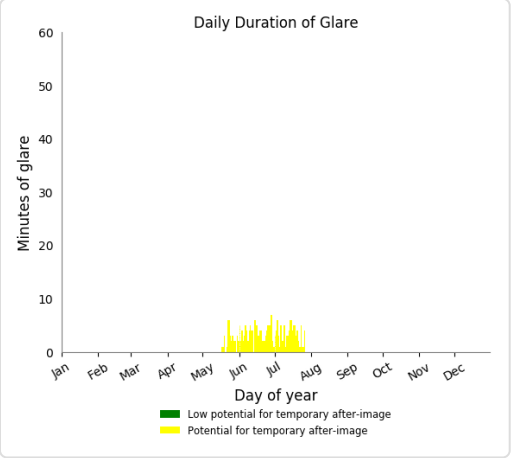


Point Receptor: OP 19

233 minutes of yellow glare

0 minutes of green glare

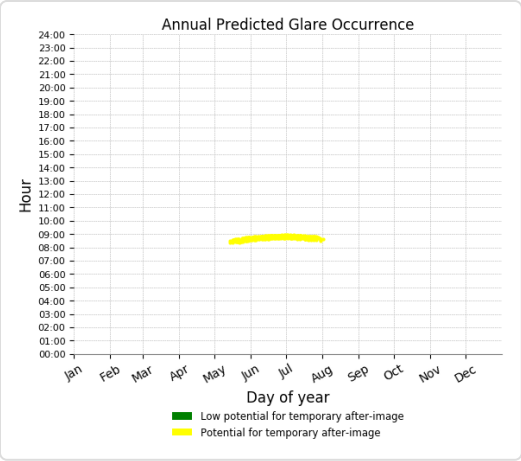


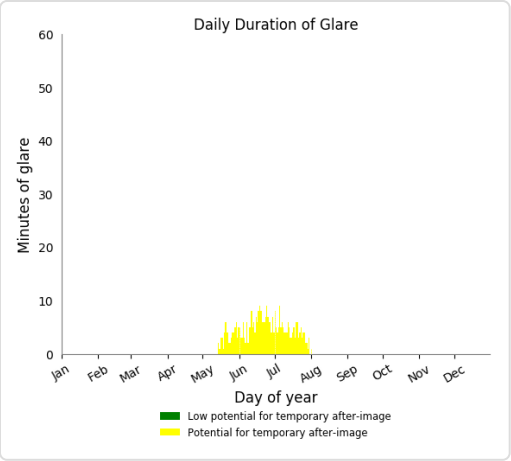


Point Receptor: OP 20

363 minutes of yellow glare

0 minutes of green glare

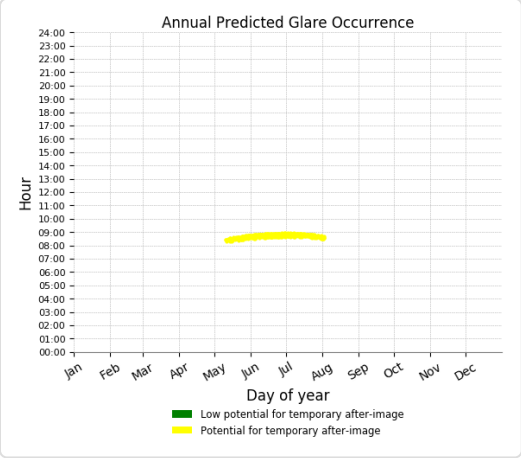


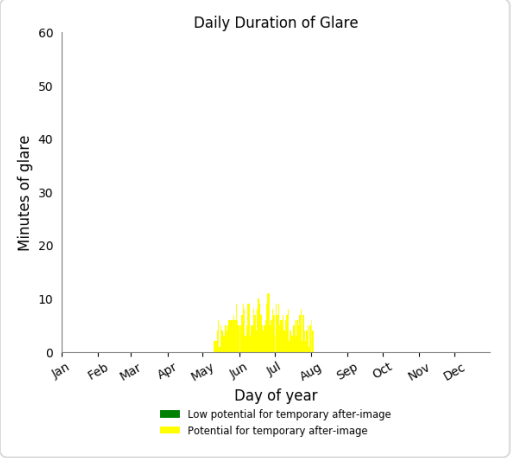


Point Receptor: OP 21

475 minutes of yellow glare

0 minutes of green glare

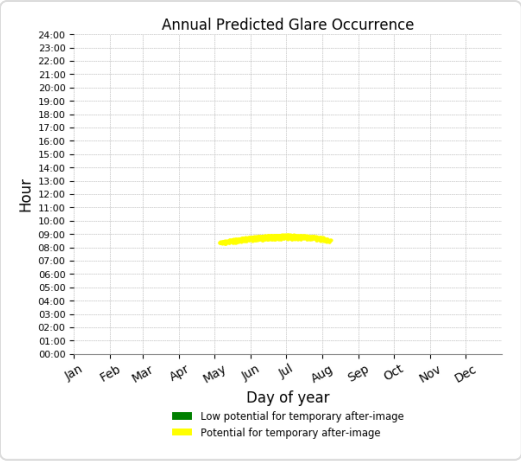


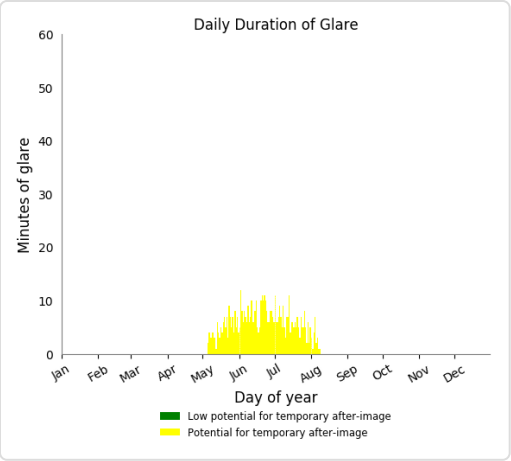


Point Receptor: OP 22

565 minutes of yellow glare

0 minutes of green glare

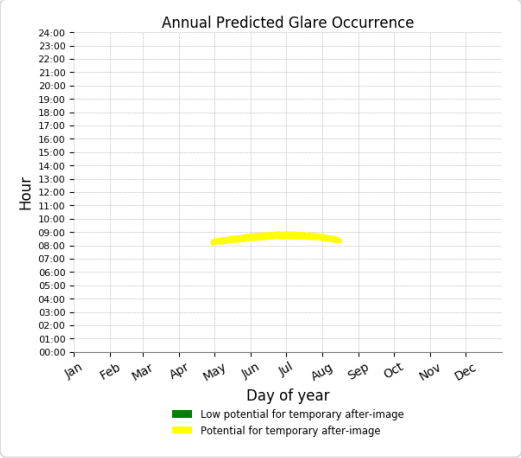


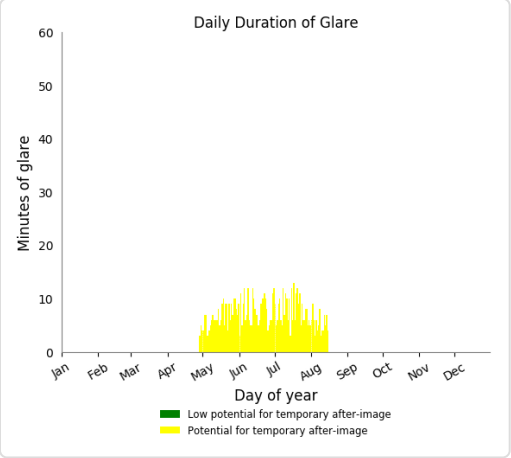


Point Receptor: OP 23

788 minutes of yellow glare

0 minutes of green glare

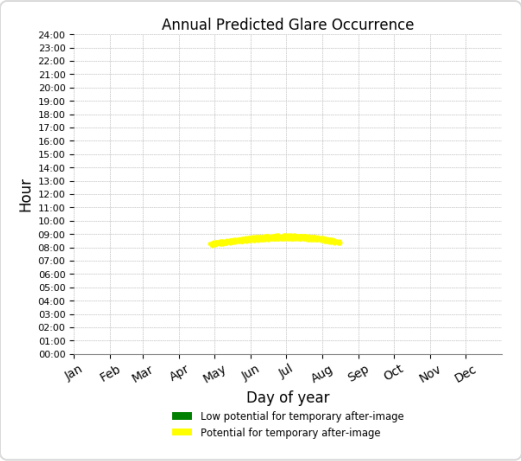


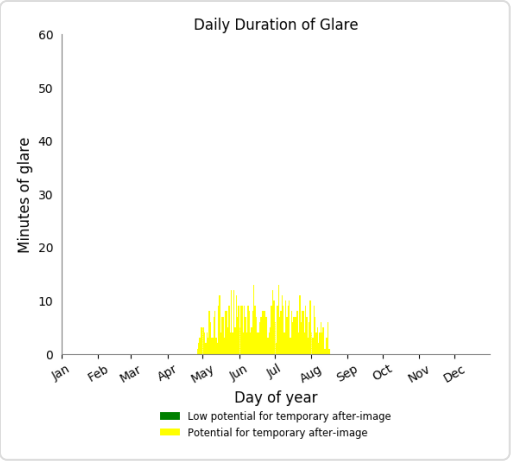


Point Receptor: OP 24

713 minutes of yellow glare

0 minutes of green glare

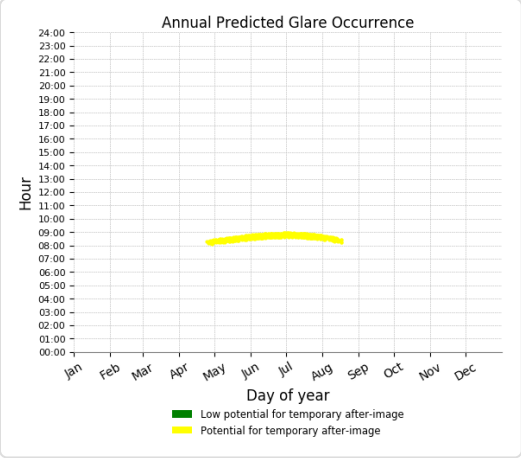


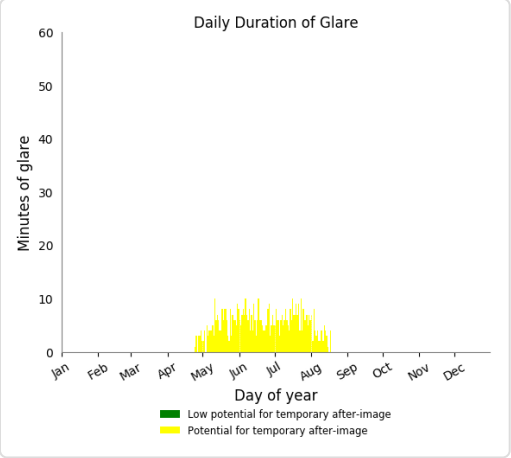


Point Receptor: OP 25

625 minutes of yellow glare

0 minutes of green glare

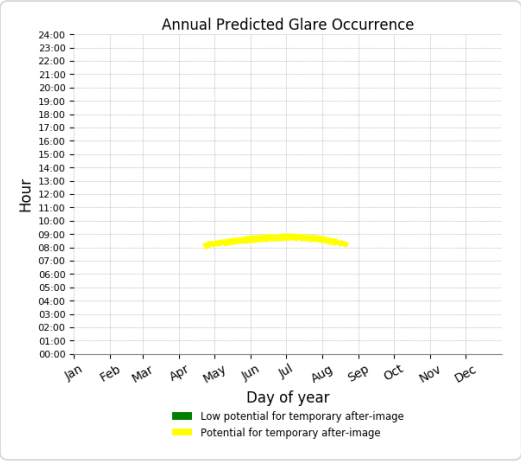


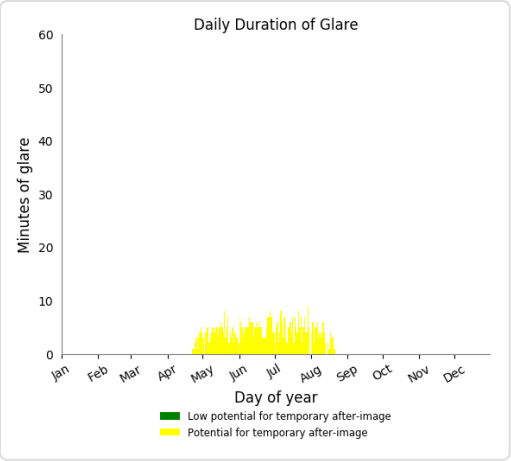


Point Receptor: OP 26

519 minutes of yellow glare

0 minutes of green glare

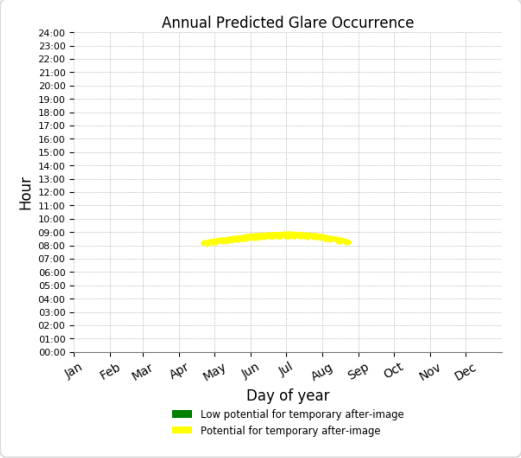


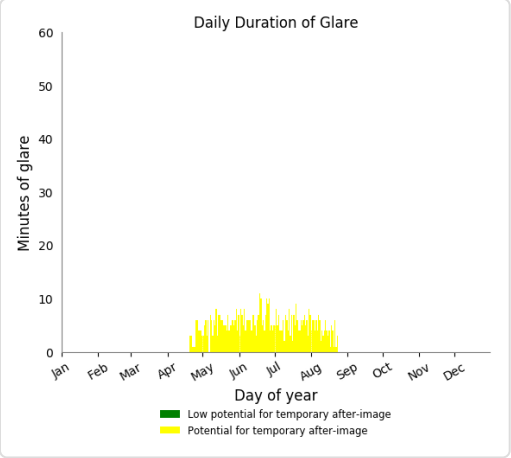


Point Receptor: OP 27

651 minutes of yellow glare

0 minutes of green glare

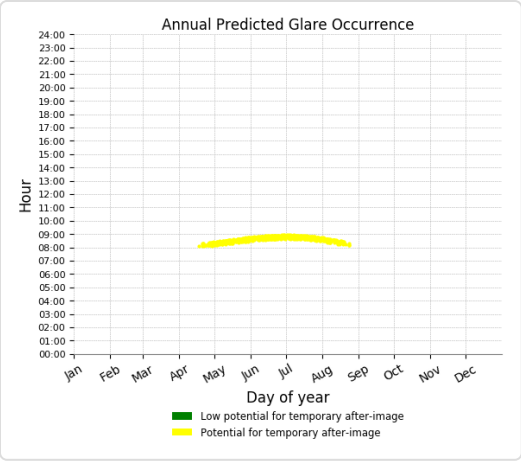


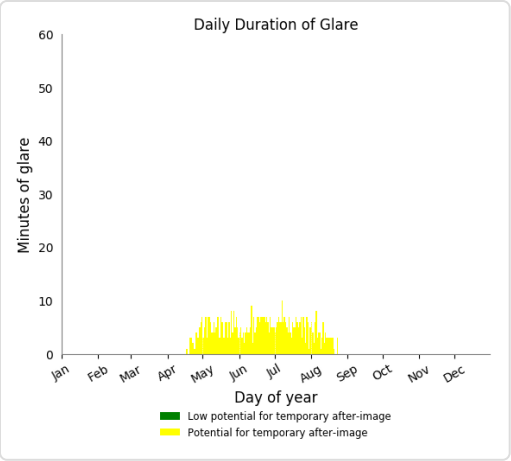


Point Receptor: OP 28

604 minutes of yellow glare

0 minutes of green glare

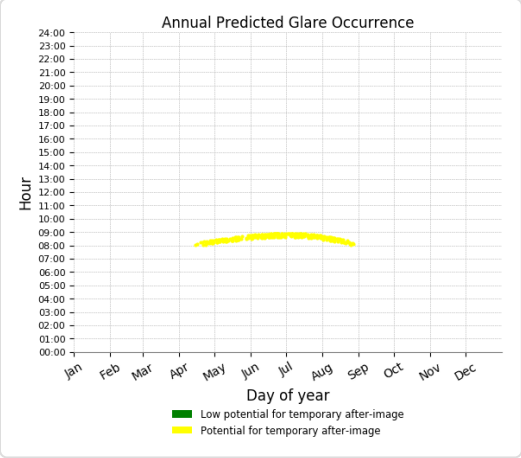


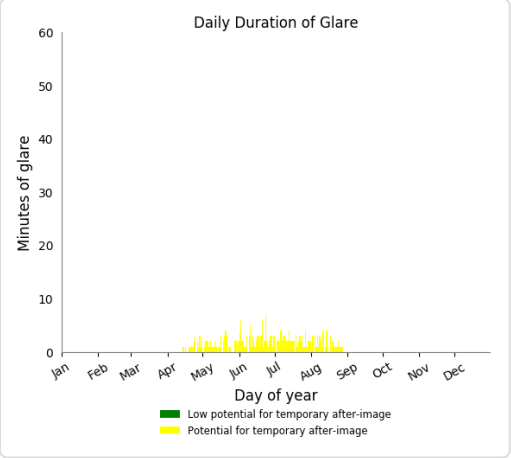


Point Receptor: OP 29

244 minutes of yellow glare

0 minutes of green glare

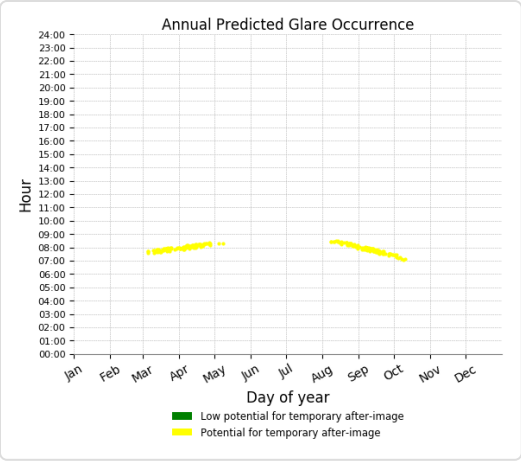


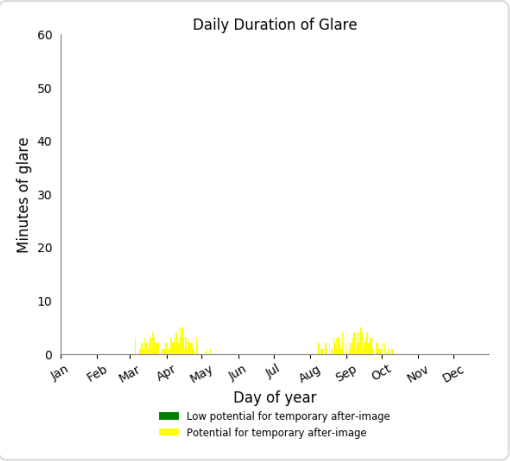


Point Receptor: OP 30

214 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

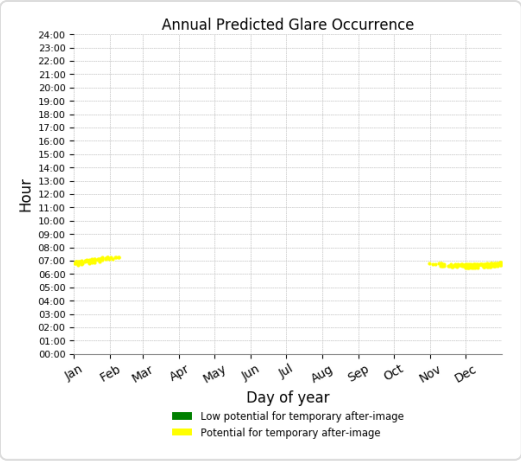
0 minutes of yellow glare
0 minutes of green glare

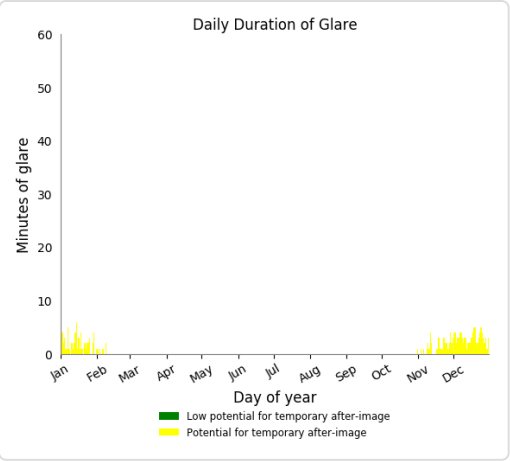
Point Receptor: OP 36

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 37

204 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

Point Receptor: OP 41

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 42

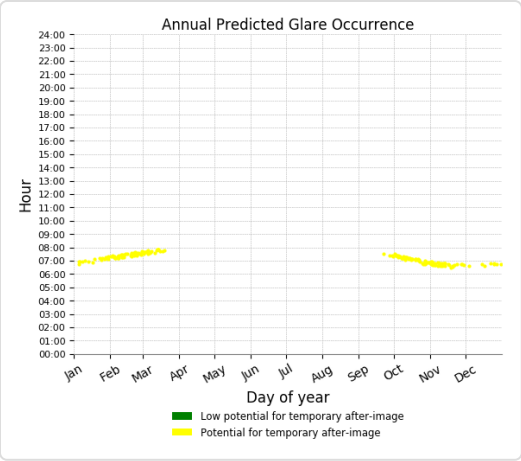
0 minutes of yellow glare
0 minutes of green glare

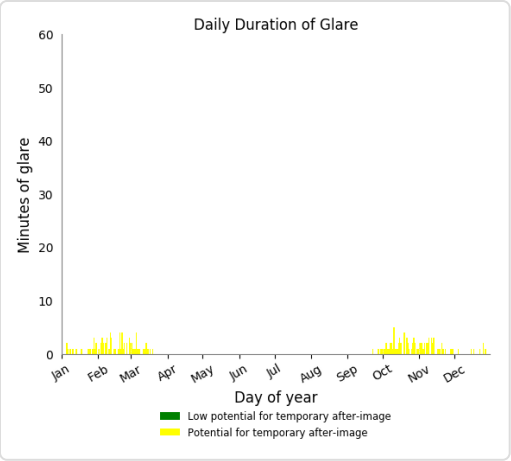
Point Receptor: OP 43

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 44

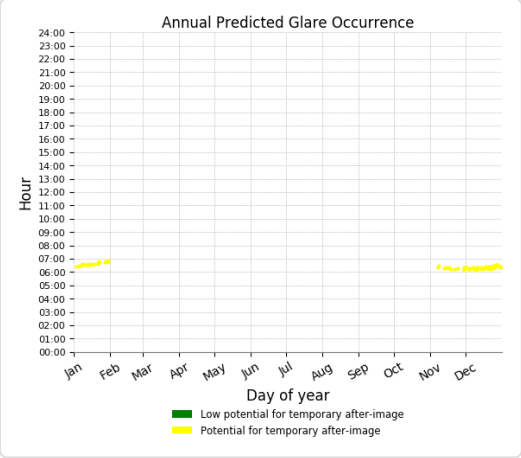
176 minutes of yellow glare
0 minutes of green glare

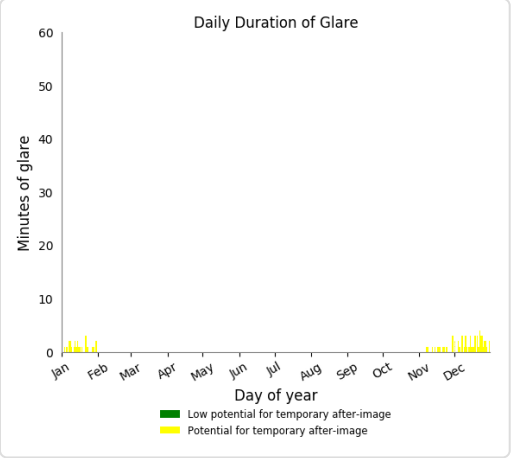




Point Receptor: OP 45

85 minutes of yellow glare
0 minutes of green glare





Point Receptor: OP 46

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 47

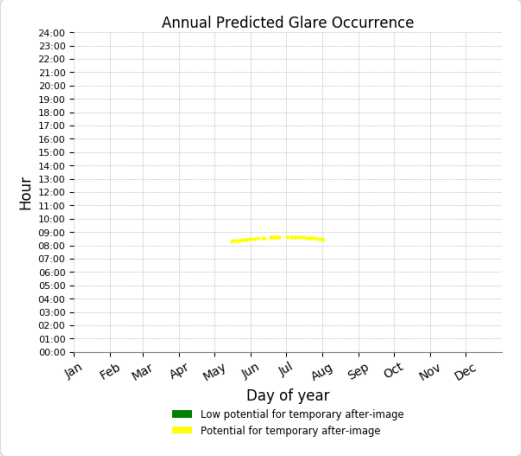
0 minutes of yellow glare
0 minutes of green glare

Route: Bourke St

0 minutes of yellow glare
0 minutes of green glare

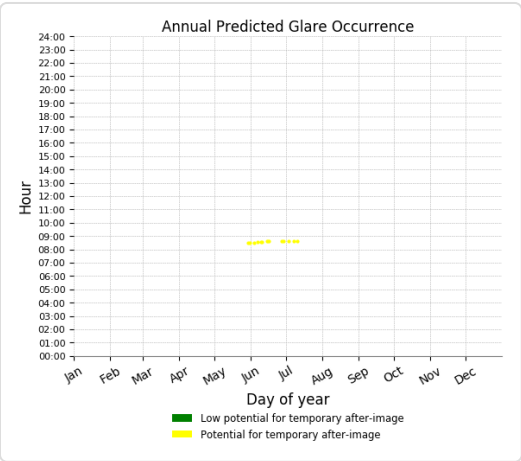
Route: Mid Western Hwy

42 minutes of yellow glare
0 minutes of green glare



Route: Murray St

14 minutes of yellow glare
0 minutes of green glare



Route: Sidonia Rd

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.