AVIATION GLINT AND GLARE ASSESSMENT

Proposed Elmfield Residential Development

Ninth Lock Road, Clondalkin, Dublin 22.

Prepared by Macro Works Ltd

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LVIA I TVIA I Landscape Design I Visibility Analysis I Glint and Glare I Verified Photomontages I CGI I Shadow Flicker Analysis

Registered Landscape Architect

macroworks
APEM Group

1. AVIATION GLINT AND GLARE ASSESSMENT

1.1 INTRODUCTION

This Glint and Glare Assessment was carried out by Macro Works Ltd to determine the potential for solar reflectance effects upon aviation receptors in respect of proposed roof-mounted solar PV installations on the roofs of several proposed residential buildings at Clondalkin, Dublin 22. The proposed buildings have a range of heights, the highest of which will be approximately 25m above the terrain. The proposed panels will remain in a fixed position throughout the day and year (i.e. they will not rotate to track the movement of the sun). Figure 1.1 and Figure 1.2 refer.

Figure 1.1 Aerial view indicating the location of the proposed PV panels

Figure 1.2 Extract from site layout drawing indicating the locations of the proposed panels (white polygons).

1.1.1 Statement of Authority

Macro Works' relevant experience includes twenty years of analysing the visual effects of a wide range of infrastructural and commercial development types. This experience includes numerous domestic and international wind and solar energy developments.

1.1.2 Guidance and Best Practice

The Irish Aviation Authority (IAA) has not published any specific guidance on solar PV developments. The IAA identifies the need to ensure safety in relation to potential reflectance effects emitting from solar developments and highlights the potential for an ocular assessment to be requested.[1] The European Union Aviation Safety Authority (EASA) requires an assessment of the luminance of proposed PV panels, rather than by ocular irradiance, so as not to dazzle air traffic controllers to the extent of a reduction in visual perception of airport operations.[2] EASA found that 20,000 cd/m2 was the maximum acceptable luminance value for solar PV arrays in the vicinity of an aviation receptor. As the IAA refer to the need for an ocular assessment, this analysis will focus on potential ocular effects.

The sequence of guidance developed by the United States Federal Aviation Administration (FAA) to address the potential hazards that solar developments may pose to aviation activities, is considered the most comprehensive for the purposes of assessment of solar developments near aerodromes. The initial guidance was prepared in 2010 (entitled 'Technical Guidance for Evaluating Selected Solar Technologies on Airports' (archived)), was subsequently updated in 2013[3] (entitled 'Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'). The most current version of the guidance (Version 1.1) 'Technical Guidance for Evaluating Selected Solar Technologies on Airports' was released in 2018.[4]

The SGHAT was developed in conjunction with the FAA in harmony with this guidance and is adopted as the standard for measuring the ocular impact of solar developments. Furthermore, it is commonly regarded as the accepted industry standard by aviation authorities internationally when considering the glint and glare effects upon aviation-related receptors.

By virtue of their efficiency, the intensity of reflected light from modern PV solar panels is deliberately low and currently equates with that of the reflection from still water. Recent studies generally agree, however, that there still exists the potential for hazard or nuisance upon surrounding receptors. Macro Works' glint and glare analysis methods and determination of effects are based on a combination of available studies and established best practice. This methodology has been successfully implemented on numerous previous solar farm projects that met with the approval of various Planning Authorities

Federal Aviation Authority

Within the FAA's interim policy, a 'Review of Solar Energy System Projects on Federally Obligated Airports'[5] it states:

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1 Irish Aviation Authority. (2025). IAA - National Aviation Safeguarding Framework, Consultation Document, p. 30.

2 European Union Aviation Safety Agency. (2025). Certification Specifications and Guidance Material for Aerodrome Design (CS-ADR-DSN). Issue 7. Page 161. https://www.easa.europa.eu/en/document-library/certification-specifications/group/cs-adr-dsn-aerodromes-design?utm_source=chatgpt.com#cs-adr-dsn-aerodromes-design.

3 Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports, Department of Transportation, Federal Aviation Administration, date: 10/2013

4 Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018

5 Federal Aviation Administration (FAA). (2013). Department of Transportation - Federal Aviation Administration. Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports. Vol 78 (No 205), 63276-63279. Available at: https://www.federalregister.gov/documents/2013/10/23/2013-24729/interim-policy-faa-review-of-solar-energy-system-projects-on-federally-obligated-airports

> *"To obtain FAA approval to revise an airport layout plan to depict a solar installation and/or a ''no objection'' to a Notice of Proposed Construction Form 7460–1, the airport sponsor will be required to demonstrate that the proposed solar energy system meets the following standards:*
>
> *No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, and*
>
> *No potential for glare or ''low potential for after-image'' (shown in green in Figure 1[Figure 1.3 refers]) along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath."*

An update of the policy in 2021[6] replaced this interim policy, with the key amendment of deprioritising runway approaches as critical aviation receptors, citing the following;

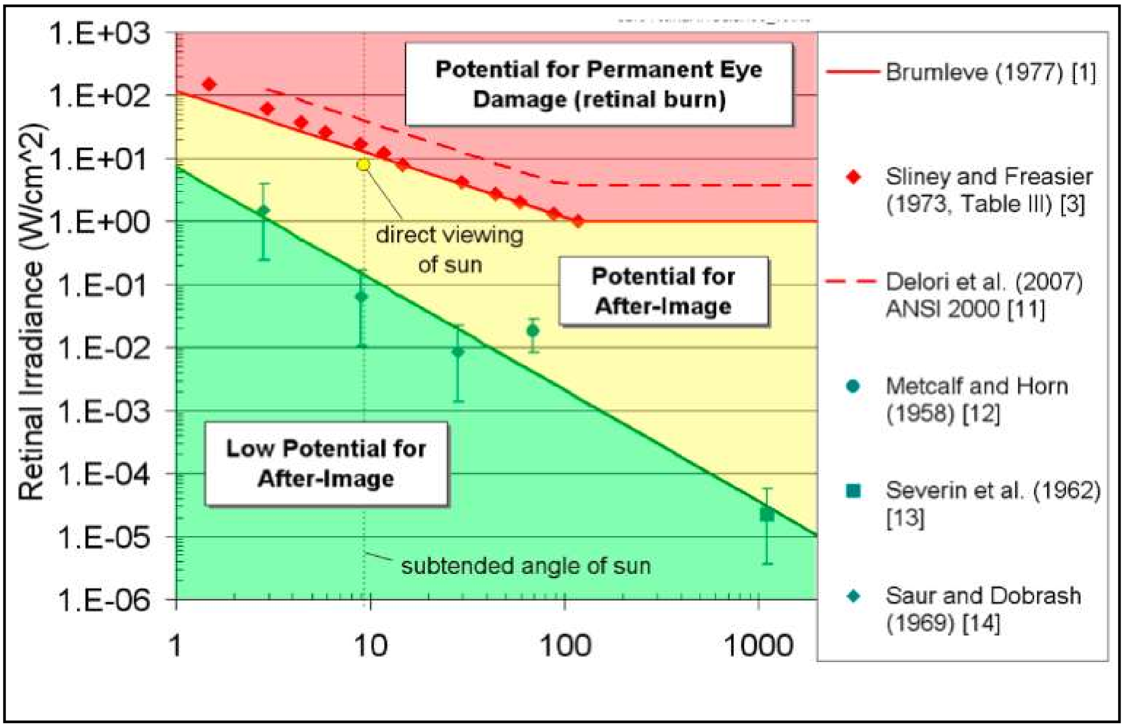
> *"Initially, FAA believed that solar energy systems could introduce a novel glint and glare effect to pilots on final approach. FAA has subsequently concluded that in most cases, the glint and glare from solar energy systems to pilots on final approach is similar to glint and glare pilots routinely experience from water bodies, glass-façade buildings, parking lots, and similar features. However, FAA has continued to receive reports of potential glint and glare from on-airport solar energy systems on personnel working in ATCT cabs. Therefore, FAA has determined the scope of agency policy should be focused on the impact of on-airport solar energy systems to federally-obligated towered airports, specifically the airport's ATCT" (Federal Aviation Administration 05/11/2021).*

<u>In summary, glare at an ATCT is not acceptable and while still relevant glare with a ''low potential for after-image'' is generally acceptable along final approach paths to runways in most instances.</u>

<u>Solar Glare Hazard Analysis Tool</u>

The SGHAT was designed to determine whether a proposed solar energy project would result in the potential for ocular impact as depicted on the Solar Glare Hazard Analysis Plot (Figure 1.3 refers). SGHAT analyses ocular impact over the entire calendar year in one minute intervals from when the sun rises above the horizon until the sun sets below the horizon. One of the principal outputs from the SGHAT report is a glare plot per receptor that indicates the time of day and days per year that glare has the potential to occur. SGHAT plot classifies the intensity of ocular impact as either Green Glare, Yellow Glare or Red Glare. These colour classifications are equivalent to the FAA's definitions regarding the level of ocular impact e.g. 'Green Glare' in the SGHAT is synonymous to the FAA's ''low potential for after-image',' and so forth. The various correlations are illustrated on the Solar Glare Hazard Analysis Plot.

6 Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports; date: 11/2021



Solar Glare Ocular Hazard Plot: The potential ocular hazard from solar glare is a function of retinal irradiance and the subtended angle (size/distance) of the glare source. It should be noted that the ratio of spectrally weighted solar illuminance to solar irradiance at the earth's surface yields a conversion factor of ~100 lumens/W. Plot adapted from Ho et al., 2011.

Chart References: Ho, C.K., C.M. Ghanbari, and R.B. Diver, 2011, Methodology to Assess Potential Glint and Glare Hazards from Concentrating Solar Power Plants: Analytical Models and Experimental Validation, J. Solar Energy Engineering, August 2011, Vol. 133, 031021-1 – 031021-9.

Figure 1.3 - Figure 1 from the FAA Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports

1.2 METHODOLOGY

The process for dealing with aviation receptors is as follows:

1. The Federal Aviation Administration (FAA) approved Solar Glare Hazard Analysis Tool (SGHAT) is used to determine if any of these aviation receptors has the potential to theoretically experience glint or glare. This tool also calculates the intensity of such reflectance and whether it is acceptable by FAA standards.
2. SGHAT does not account for terrain screening or screening provided by surface elements such as existing vegetation or buildings, therefore the results of the SGHAT may need to be considered, in conjunction with an assessment of existing intervening screening that may be present, to establish if reflectance can actually be experienced at the receptors.
3. Finally, if necessary, additional assessment is undertaken using Macro Works' bespoke model which would into account any screening provided by any proposed mitigation measures.

1.2.1 Identification of Relevant Receptors

The Planning and Development (Solar Safeguarding Zone) Regulations 2022 set out 43 Solar Safeguarding Zones (SSZs). A SSZ is an area around an airport, aerodrome or helipad in which there is a potential for glint or glare from solar panels to impact aviation safety. The proposed development lies within the Baldonnel (Casement Aerodrome) Solar Safeguarding Zone.

Runways & Air Traffic Control Towers

This SGHAT analysis was produced to assess the potential for impacts upon aviation receptors, resulting from the proposed solar installation. Casement Aerodrome is located approximately 3.9km southwest of the proposed development and comprises two runways and one Air Traffic Control Tower (ATCT).

Figure 1.4 Map showing the location of the proposed development relative to the identified aviation receptor.

1.3 RESULTS

1.3.1 Runway Approaches

The SGHAT results are contained in Appendix A and show that two of the four runway approaches analysed had potential for Green Glare to occur (Runway 04 and Runway 10).

None of the four runways showed any potential for Yellow Glare as a result of the proposed solar panels. The absence of Yellow Glare is regarded as a 'Pass' in this assessment as there would only be low potential for after-image.

1.3.2 Air Traffic Control Towers

The SGHAT results contained in Appendix A also show the theoretical potential for glare at 1-ATCT as a result of the proposed development. The results show that 1-ATCT would receive a total of 8,038 minutes of Green Glare over the course of the year.

There was no potential for Yellow Glare detected from any of the PV panels. As the potential for any glare on the ATCT constitutes a 'Fail' in this assessment, a viewshed analysis (see Section 1.3.3) was conducted for further investigation.

These results are not unexpected or uncommon as the SGHAT software does not account for screening as a result of intervening surface features on the terrain such as buildings or vegetation. Therefore, a 3D visibility analysis was undertaken from the Casement Aerodrome ATCT.

1.3.3 Visibility Analysis

A viewshed analysis was carried out for the Air Traffic Control Tower at Casement Aerodrome to identify what portions of the proposed development are theoretically visible. This analysis was undertaken with the aid of a high-resolution digital surface model (DSM) to produce a Zone of Theoretical Visibility (ZTV) map (Figure 1.5 refers). The ZTV identifies that the solar panel of the proposed development would not be visible from Casement Aerodrome ATCT due to the screening afforded by a combination of intervening terrain, vegetation, built development, and the parapet walls of the proposed development. Thus, there will be no potential for glint or glare to occur at Casement Aerodrome ATCT.

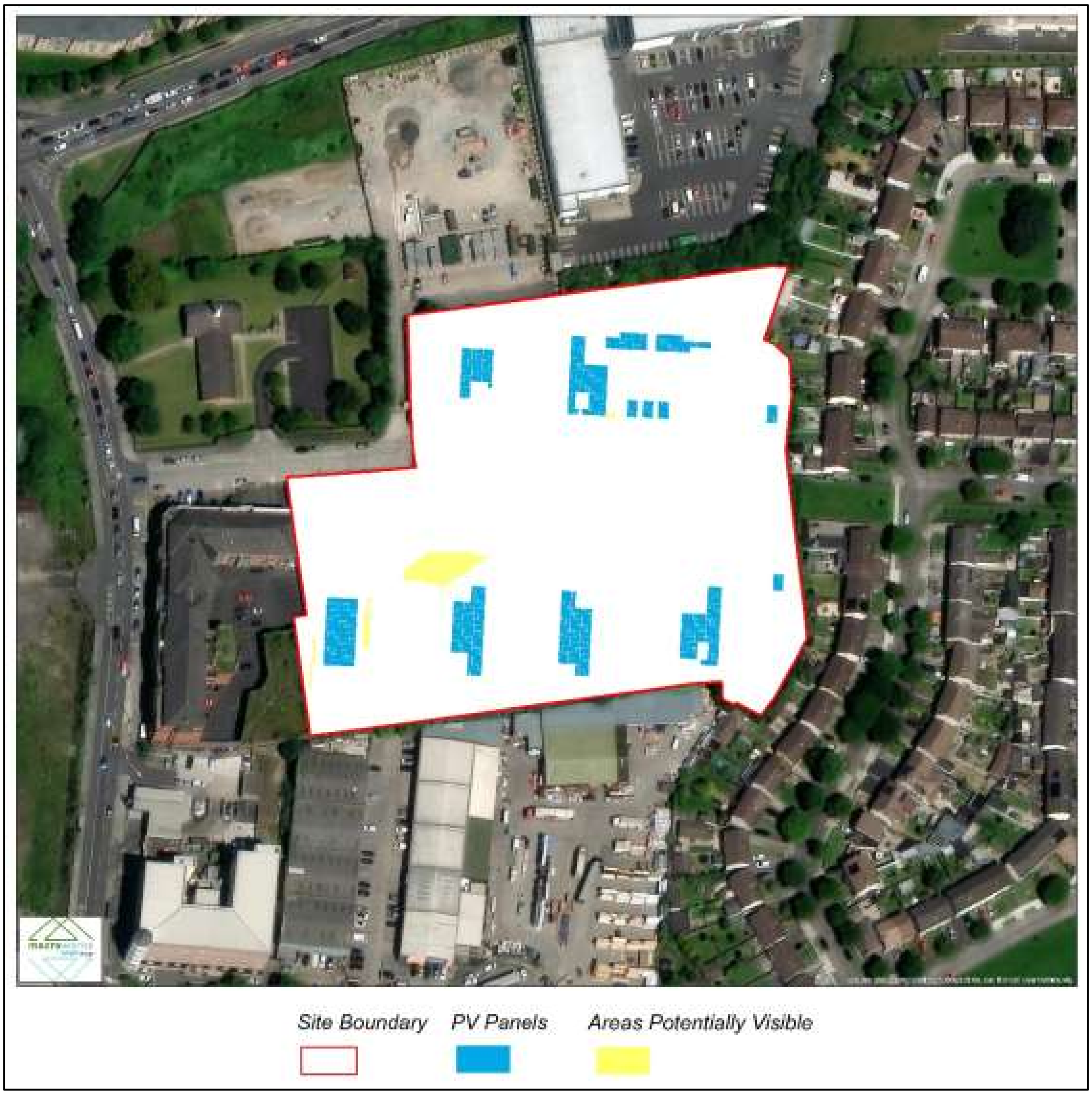


Figure 1.5 Map showing the Zone of Theoretical Visibility (ZTV) from Casement Aerodrome Air Traffic Control Tower

1.3.4 Ameliorating Factors

A key consideration for reflectance effects is the incidence (incoming) angle of the sun's rays when they strike the reflecting surface (solar panels in this instance). The most intense reflective rays occur when the receptor is at 90 degrees to the incidence rays. At decreasing angles, the reflectance becomes increasingly diffused across a wider portion of the reflecting surface, thereby diminishing the intensity of the reflected rays. The nature of the reflecting surface also plays a major part in the degree of diffusion / absorption of the incidence rays and modern PV solar panels have become very efficient at absorbing rather than reflecting light.

A technical note on solar module glare and reflectance prepared by SunPower Corporation[7] outlines the degree of material reflectivity for a range of sun incident angles. As per the table below (Table 1 Material Reflectivity at various sun incident angles (derived from Sunpower Corporation (September 2009), T09014 Solar Module Glare and Reflectance Technical Memo) below) the degree of reflectivity of solar panels below 7 degrees is < 2.64% and is likely to have no material consequence on surrounding receptors. It is also important to reiterate that, in terms of reflectance, photovoltaic solar panels are by no means a highly reflective surface. They are designed to absorb sunlight and not to reflect it. Furthermore, as technology has improved, the addition of an antireflective coating on panels has become an option. A June 2023 study by Loughborough University states "currently around 90% of commercial PV modules are supplied with an AR coating applied to the cover glass".[8]

Several studies have shown that even standard photovoltaic panels, without anti-reflective coatings have similar reflectance characteristics to water, which is much lower than the likes of glass, steel and snow by comparison (see Table 1). In the case of modern PV solar panels which include an anti-reflective coating, reflectance levels are even less than that emitted from standard window glass and still water. In the context of the proposed development, there are numerous structures in the surrounding area that emit similar levels of reflectance. It should also be considered that, while still within the SSZ for Baldonnel, the proposed site is a considerable distance (just under 4km) from the control tower. The level of reflectance experienced at this distance is unlikely to have a material effect in the context of continuous urban fabric incorporating a broad spectrum of reflecting surfaces.

Table 1 Material Reflectivity at various sun incident angles (derived from Sunpower Corporation (September 2009), T09014 Solar Module Glare and Reflectance Technical Memo)

Common Reflective Surfaces (in surrounding environments for PV systems)		Sun Incident angle in degrees						
		0	15	30	45	60	75	90
Material Reflectivity (percent of incident light reflected)	Steel	36.73%	39.22%	46.34%	57.11%	70.02%	83.15%	94.40%
	Snow	21.63%	23.09%	27.29%	33.63%	41.23%	48.96%	55.59%
	Standard Glass	8.44%	9.01%	10.65%	13.12%	16.09%	19.10%	21.69%
	Plexiglass	8.00%	8.54%	10.09%	12.44%	15.25%	18.11%	20.56%
	Plastic	6.99%	7.46%	8.82%	10.87%	13.33%	15.83%	17.97%
	Smooth Water	4.07%	4.35%	5.14%	6.33%	7.76%	9.22%	10.47%
	Solar Glass (high light transmission)	3.99%	4.26%	5.03%	6.20%	7.61%	9.03%	10.26%
	Solar Glass w/AR coating	2.47%	2.64%	3.12%	3.84%	4.71%	5.59%	6.35%

7 Sunpower Corporation (September 2009), T09014 Solar Module Glare and Reflectance Technical Memo.

8 "The performance and durability of Anti-reflection coatings for solar module cover glass – a review" Available at: https://www.sciencedirect.com/science/article/pii/S0038092X23004061.

1.4 OVERALL CONCLUSION

The SGHAT results indicate that the proposed solar PV panels on the roofs of the proposed buildings at Ninth Lock, Clondalkin, Dublin 22, resulted in a 'Pass' in respect of the flightpaths at Casement Aerodrome. However, the SGHAT results show that the proposed development resulted in a 'Fail' due to a potential for reflectance from some of the panels at the ATCT at Casement Aerodrome. A follow up Visibility Analysis, utilising Digital Surface Model (DSM) data, determined that there will be no visibility of the proposed panels from the ATCT. As such, there will be no potential for glint or glare to occur at Casement Aerodrome ATCT.

APPENDIX A: SGHAT RESULTS

FORGESOLAR GLARE ANALYSIS

Project: **Dublin Casement**
Site configuration: **Elmfield Clondalkin Residential Revised1**
Analysis conducted by Luis Dominguez (luis@macroworks.ie) at 15:26 on 20 Aug, 2026.
Calculated via ForgeSolar Radiometric Physics Engine v3.2.1

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)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	FAIL	Receptor(s) marked as ATCT receive green and/or yellow glare

ForgeSolar default analysis parameters and observer eye characteristics, listed for reference only. The values used for this analysis are given under Analysis Parameters in the Site Configuration section.

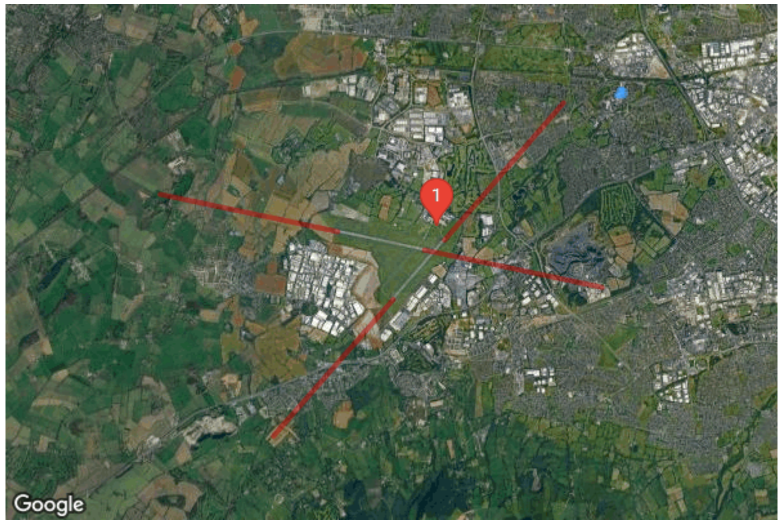
- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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
Min luminance threshold: 5,000 cd/m^2
Site Config ID: 186077.13297



PV Array(s)

Name: PA1
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 0.0°
Rated power: -
Panel material: Smooth glass without AR coating

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.327210	-6.393240	53.60	25.89	79.49
2	53.327210	-6.393030	53.60	25.89	79.49
3	53.327020	-6.393050	53.60	25.89	79.49
4	53.327030	-6.393270	53.60	25.89	79.49
5	53.327210	-6.393240	53.60	25.89	79.49

Name: PA10
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 0.0°
Rated power: -
Panel material: Smooth glass without AR coating

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.326470	-6.391600	54.60	8.41	63.01
2	53.326460	-6.391540	54.60	8.41	63.01
3	53.326410	-6.391550	54.60	8.41	63.01
4	53.326410	-6.391610	54.60	8.41	63.01
5	53.326470	-6.391600	54.60	8.41	63.01

Name: PA11
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 0.0°
Rated power: -
Panel material: Smooth glass without AR coating

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.327250	-6.392460	53.60	16.44	70.04
2	53.327240	-6.392230	53.60	16.44	70.04
3	53.327180	-6.392240	53.60	16.44	70.04
4	53.327190	-6.392470	53.60	16.44	70.04
5	53.327250	-6.392460	53.60	16.44	70.04

Name: PA2
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 0.0°
Rated power: -
Panel material: Smooth glass without AR coating

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.327250	-6.392650	53.60	16.44	70.04
2	53.327250	-6.392560	53.60	16.44	70.04
3	53.327150	-6.392560	53.60	16.44	70.04
4	53.327140	-6.392440	53.60	16.44	70.04
5	53.326960	-6.392450	53.60	16.44	70.04
6	53.326970	-6.392680	53.60	16.44	70.04
7	53.327250	-6.392650	53.60	16.44	70.04

Name: PA3
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 0.0°
Rated power: -
Panel material: Smooth glass without AR coating

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.327030	-6.392350	53.60	12.69	66.29
2	53.327020	-6.392120	53.60	12.69	66.29
3	53.326960	-6.392130	53.60	12.69	66.29
4	53.326970	-6.392360	53.60	12.69	66.29
5	53.327030	-6.392350	53.60	12.69	66.29

Name: PA4
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 0.0°
Rated power: -
Panel material: Smooth glass without AR coating

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.327240	-6.392190	53.54	16.50	70.04
2	53.327230	-6.392030	53.54	16.50	70.04
3	53.327210	-6.392040	53.54	16.50	70.04
4	53.327200	-6.391900	53.54	16.50	70.04
5	53.327160	-6.391900	53.54	16.50	70.04
6	53.327180	-6.392200	53.54	16.50	70.04
7	53.327240	-6.392190	53.54	16.50	70.04

Name: PA5
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 0.0°
Rated power: -
Panel material: Smooth glass without AR coating

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.327010	-6.391620	53.60	10.14	63.74
2	53.327000	-6.391550	53.60	10.14	63.74
3	53.326940	-6.391560	53.60	10.14	63.74
4	53.326940	-6.391620	53.60	10.14	63.74
5	53.327010	-6.391620	53.60	10.14	63.74

Name: PA6
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 0.0°
Rated power: -
Panel material: Smooth glass without AR coating

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.326430	-6.393980	54.50	13.32	67.82
2	53.326420	-6.393770	54.50	13.32	67.82
3	53.326190	-6.393800	54.50	13.32	67.82
4	53.326200	-6.394010	54.50	13.32	67.82
5	53.326430	-6.393980	54.50	13.32	67.82

Name: PA7
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 0.0°
Rated power: -
Panel material: Smooth glass without AR coating

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.326410	-6.393300	54.40	16.57	70.97
2	53.326400	-6.393210	54.40	16.57	70.97
3	53.326460	-6.393200	54.40	16.57	70.97
4	53.326450	-6.393110	54.40	16.57	70.97
5	53.326150	-6.393150	54.40	16.57	70.97
6	53.326160	-6.393240	54.40	16.57	70.97
7	53.326230	-6.393230	54.40	16.57	70.97
8	53.326240	-6.393320	54.40	16.57	70.97
9	53.326410	-6.393300	54.40	16.57	70.97

Name: PA8
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 0.0°
Rated power: -
Panel material: Smooth glass without AR coating

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.326430	-6.392720	54.40	16.57	70.97
2	53.326430	-6.392640	54.40	16.57	70.97
3	53.326380	-6.392650	54.40	16.57	70.97
4	53.326370	-6.392550	54.40	16.57	70.97
5	53.326150	-6.392570	54.40	16.57	70.97
6	53.326150	-6.392670	54.40	16.57	70.97
7	53.326190	-6.392660	54.40	16.57	70.97
8	53.326190	-6.392760	54.40	16.57	70.97
9	53.326430	-6.392720	54.40	16.57	70.97

Name: PA9
Axis tracking: Fixed (no rotation)
Tilt: 0.0°
Orientation: 0.0°
Rated power: -
Panel material: Smooth glass without AR coating

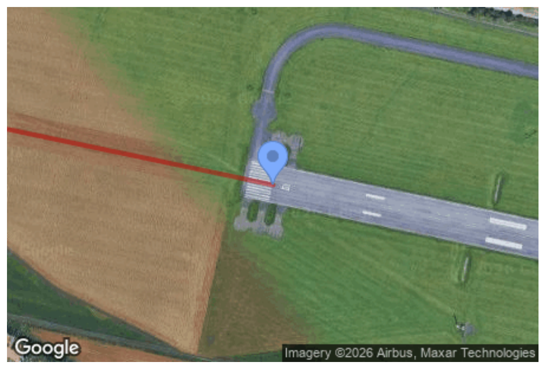
Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.326440	-6.391950	54.40	13.42	67.82
2	53.326430	-6.391860	54.40	13.42	67.82
3	53.326170	-6.391900	54.40	13.42	67.82
4	53.326180	-6.392000	54.40	13.42	67.82
5	53.326200	-6.392000	54.40	13.42	67.82
6	53.326200	-6.391960	54.40	13.42	67.82
7	53.326250	-6.391950	54.40	13.42	67.82
8	53.326250	-6.392000	54.40	13.42	67.82
9	53.326200	-6.392010	54.40	13.42	67.82
10	53.326200	-6.392110	54.40	13.42	67.82
11	53.326350	-6.392090	54.40	13.42	67.82
12	53.326350	-6.391960	54.40	13.42	67.82
13	53.326440	-6.391950	54.40	13.42	67.82

Flight Path Receptor(s)

Name: Casement 04 Runway
Description: None
Threshold height: 15 m
Direction: 41.3°
Glide slope: 4.3°
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	53.293830	-6.453465	98.30	15.20	113.50
Two-mile	53.272113	-6.485435	154.40	127.80	282.20

Name: Casement 10 Runway
Description: None
Threshold height: 15 m
Direction: 101.8°
Glide slope: 3.42°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

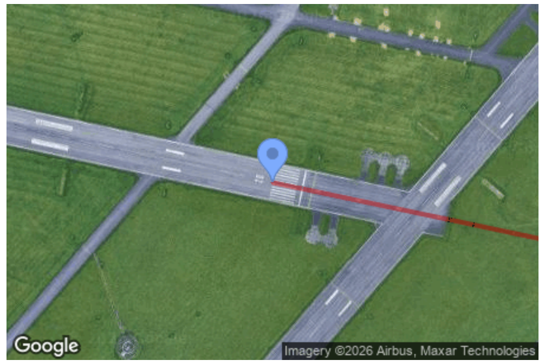


Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.304622	-6.468287	86.30	15.30	101.60
Two-mile	53.310549	-6.515700	73.60	196.60	270.20

Name: Casement 22 Runway
Description: None
Threshold height: 15 m
Direction: 220.9°
Glide slope: 4.3°
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	53.303267	-6.439788	93.40	15.20	108.60
Two-mile	53.325107	-6.408047	62.50	214.80	277.30

Name: Casement 28 Runway
Description: None
Threshold height: 15 m
Direction: 281.8°
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	53.301696	-6.445153	96.10	15.20	111.30
Two-mile	53.295759	-6.397747	106.20	173.80	280.00

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	53.305496	-6.441790	93.50	9.00

Map image of 1-ATCT

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt	Orient	"Green" Glare	"Yellow" Glare	Energy
	(°)	(°)	min	min	kWh
PA1	0.0	0.0	2,063	0	-
PA10	0.0	0.0	2,069	0	-
PA11	0.0	0.0	2,180	0	-
PA2	0.0	0.0	2,249	0	-
PA3	0.0	0.0	2,195	0	-
PA4	0.0	0.0	2,174	0	-
PA5	0.0	0.0	2,122	0	-
PA6	0.0	0.0	2,245	0	-
PA7	0.0	0.0	2,119	0	-
PA8	0.0	0.0	2,097	0	-
PA9	0.0	0.0	2,095	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
Casement 04 Runway	1501	0
Casement 10 Runway	14069	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	8038	0

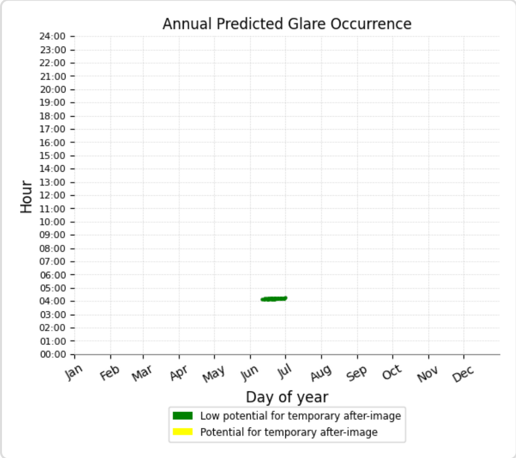
Results for: PA1

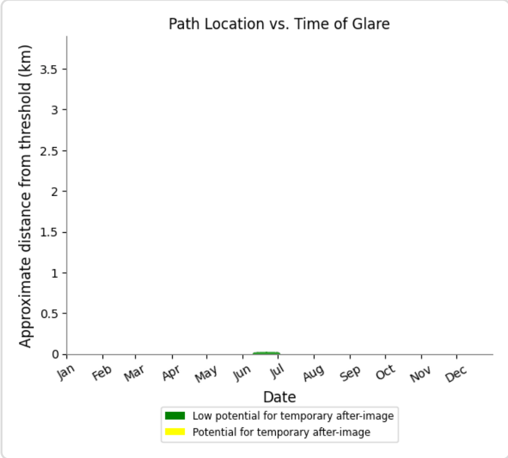
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	55	0
Casement 10 Runway	1253	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	755	0

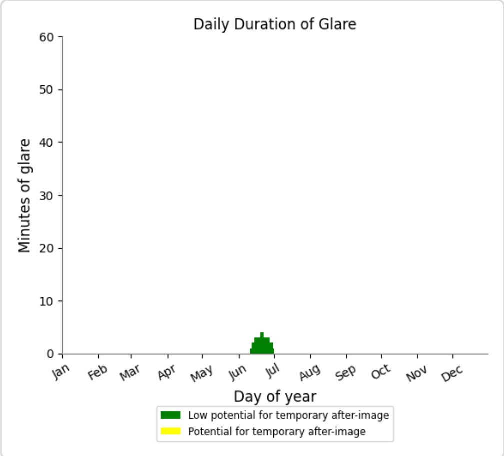
Flight Path: Casement 04 Runway

0 minutes of yellow glare

55 minutes of green glare

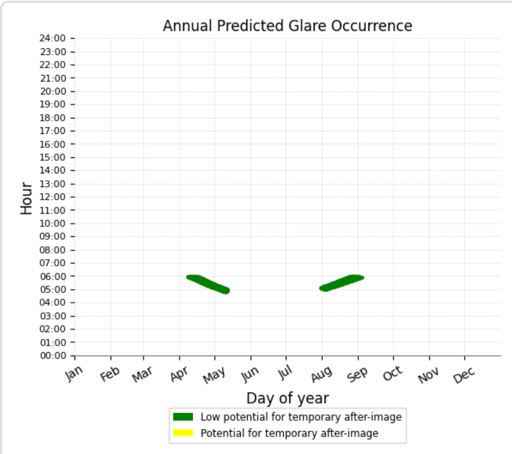


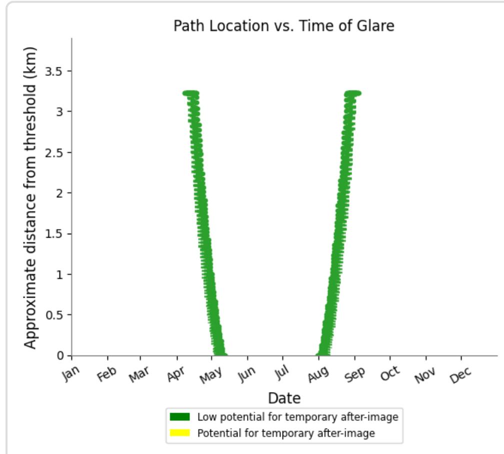


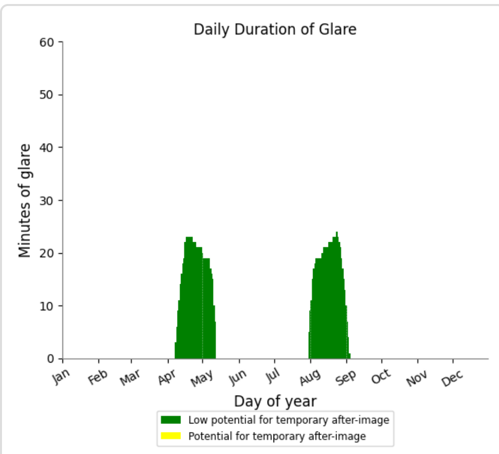


Flight Path: Casement 10 Runway

0 minutes of yellow glare
1253 minutes of green glare







Flight Path: Casement 22 Runway

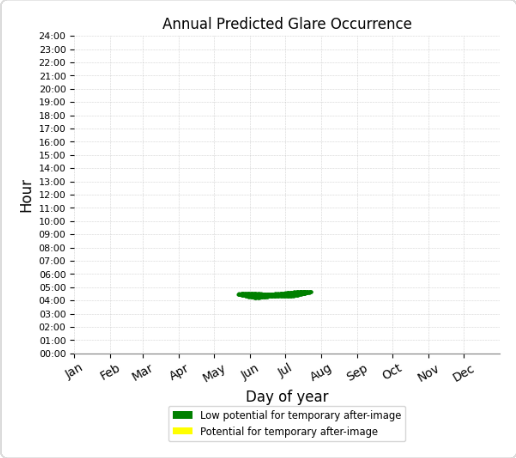
0 minutes of yellow glare
0 minutes of green glare

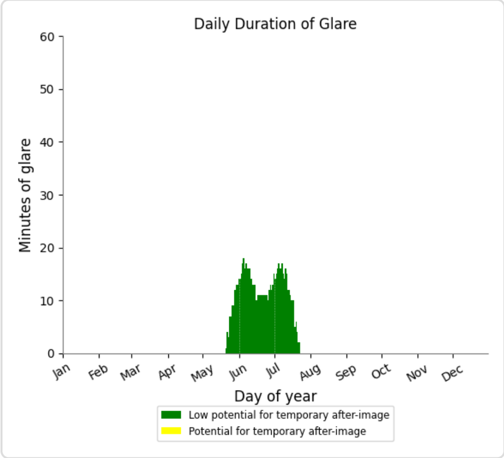
Flight Path: Casement 28 Runway

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare
755 minutes of green glare





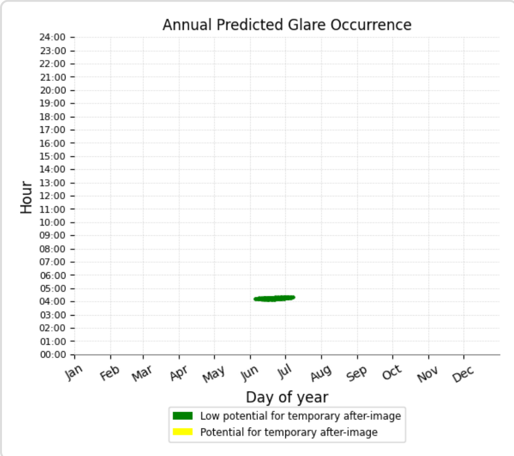
Results for: PA10

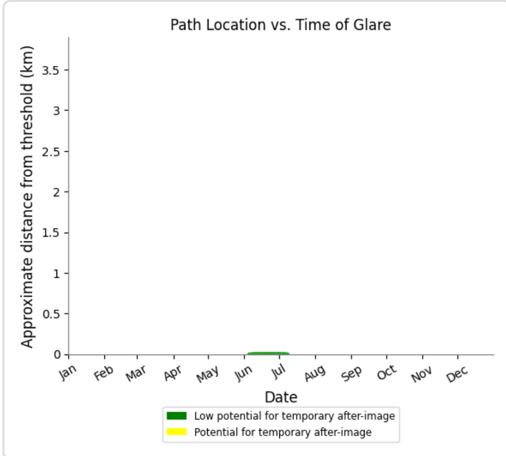
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	224	0
Casement 10 Runway	1261	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	584	0

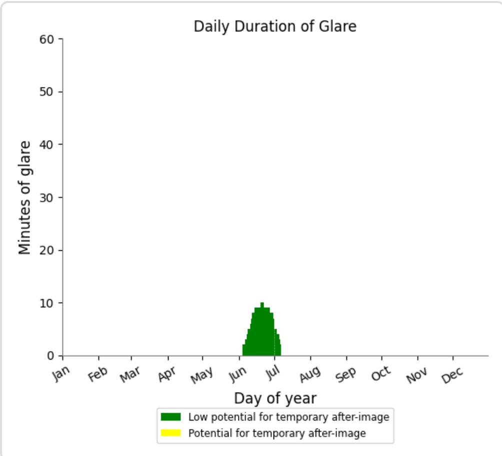
Flight Path: Casement 04 Runway

0 minutes of yellow glare

224 minutes of green glare

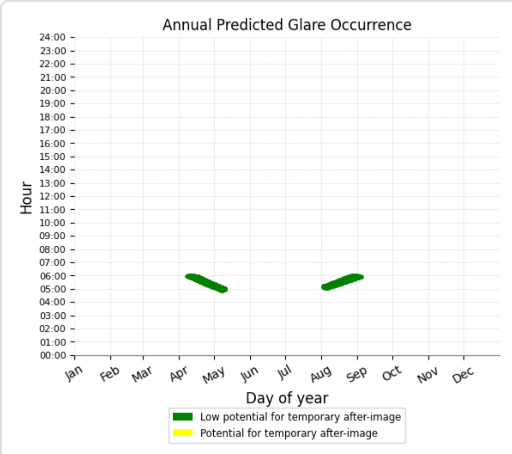


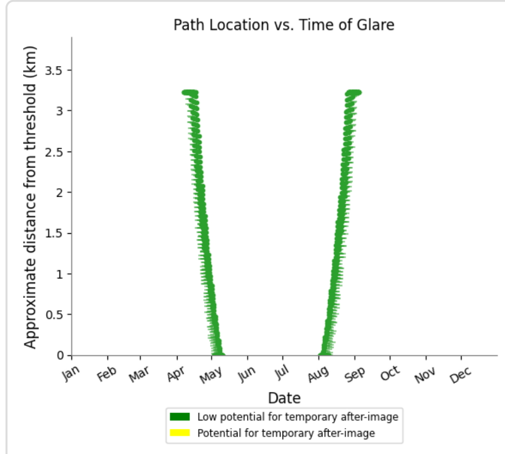


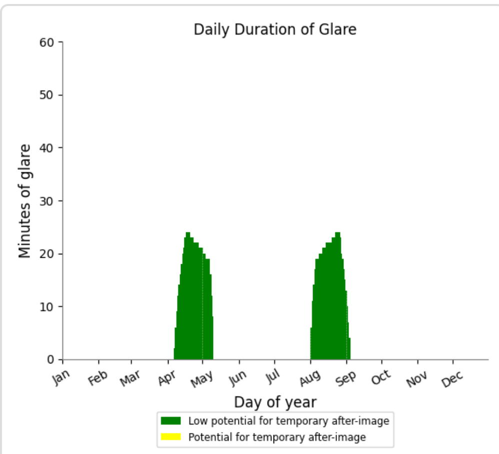


Flight Path: Casement 10 Runway

0 minutes of yellow glare
1261 minutes of green glare







Flight Path: Casement 22 Runway

0 minutes of yellow glare
0 minutes of green glare

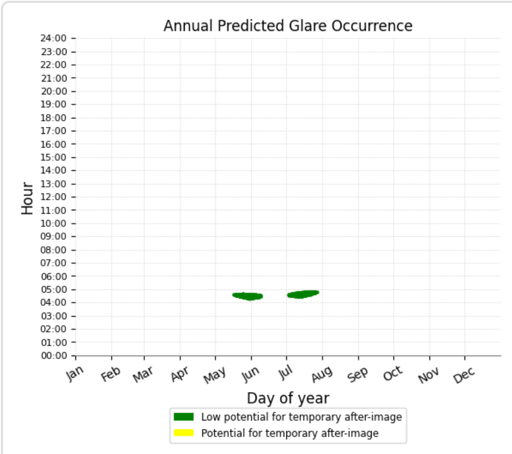
Flight Path: Casement 28 Runway

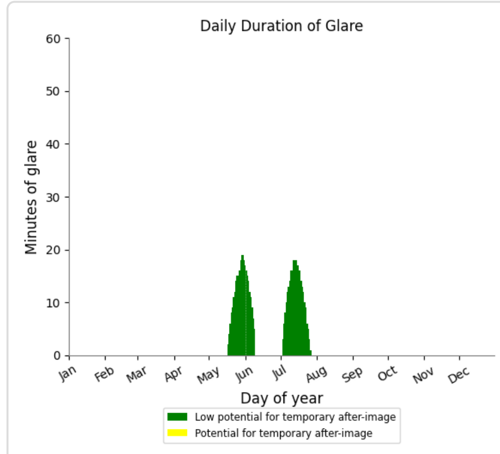
0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare

584 minutes of green glare





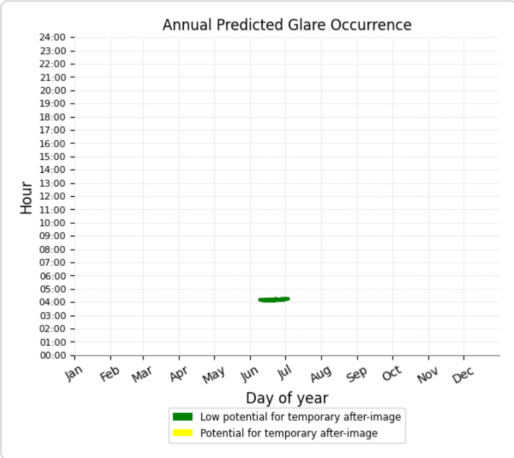
Results for: PA11

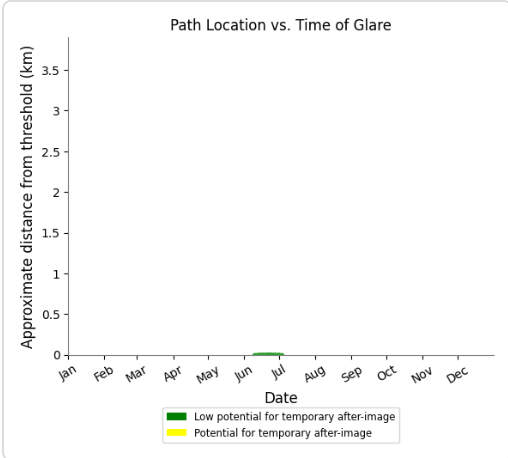
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	85	0
Casement 10 Runway	1283	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	812	0

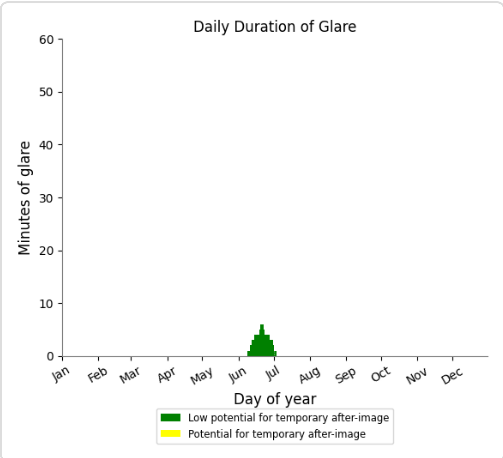
Flight Path: Casement 04 Runway

0 minutes of yellow glare

85 minutes of green glare

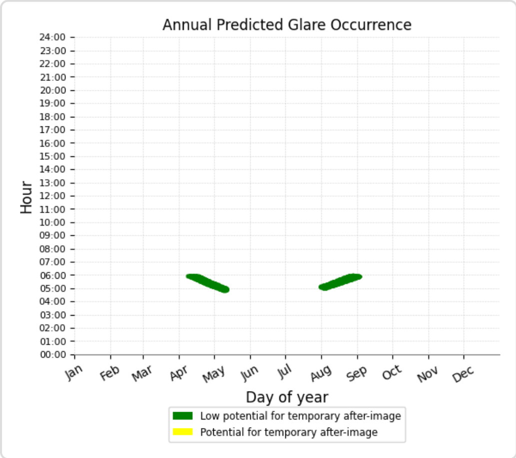


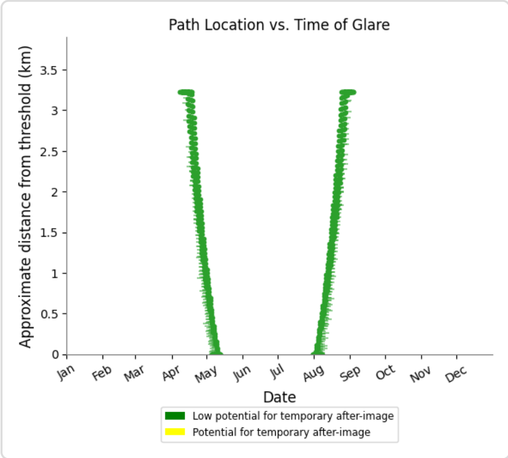


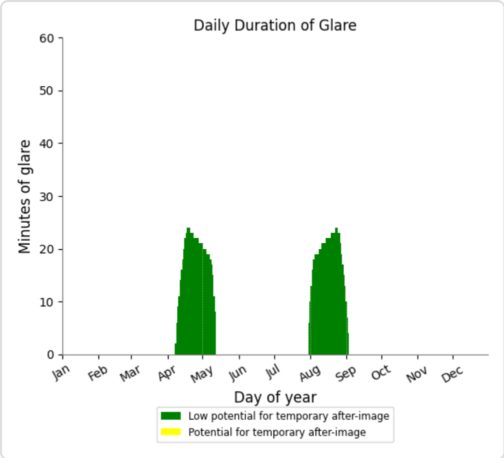


Flight Path: Casement 10 Runway

0 minutes of yellow glare
1283 minutes of green glare







Flight Path: Casement 22 Runway

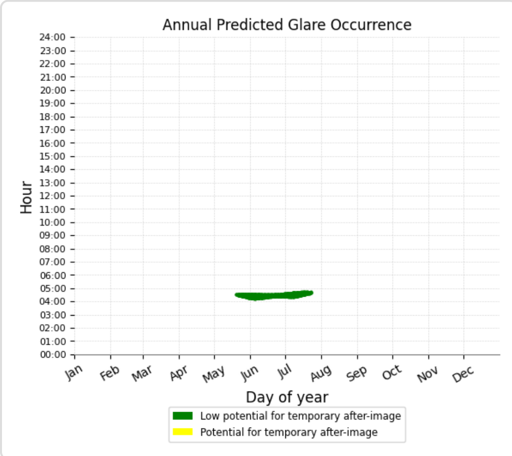
0 minutes of yellow glare
0 minutes of green glare

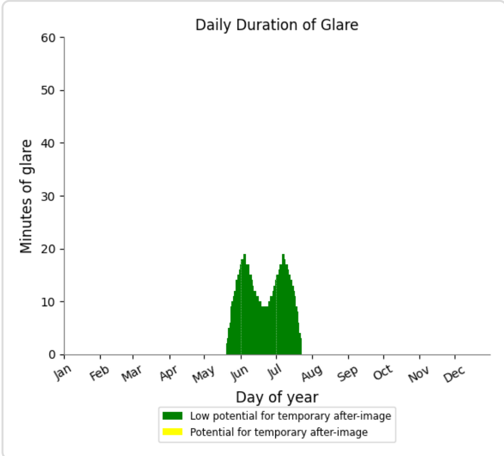
Flight Path: Casement 28 Runway

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare
812 minutes of green glare



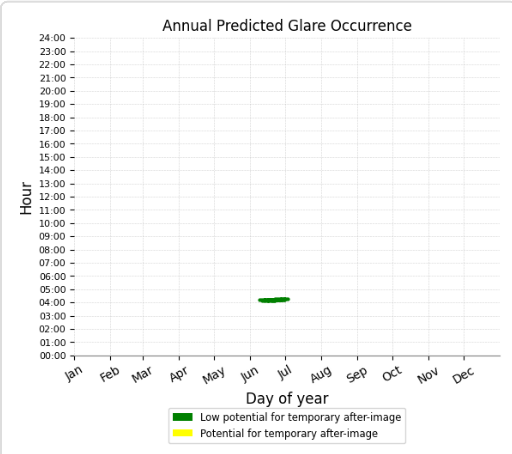


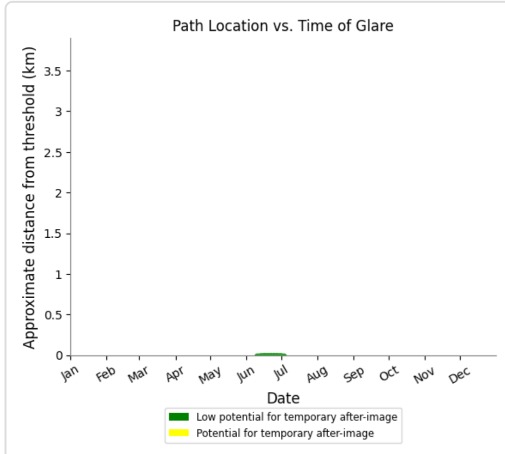
Results for: PA2

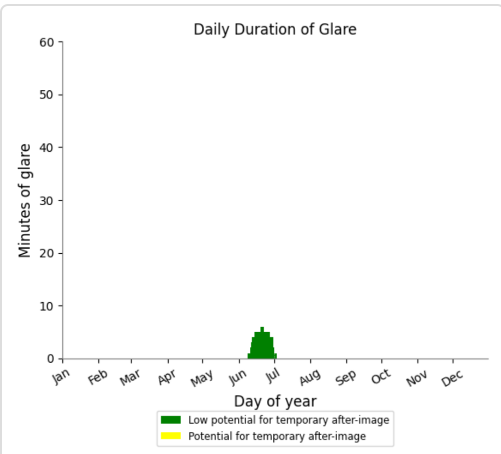
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	99	0
Casement 10 Runway	1296	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	854	0

Flight Path: Casement 04 Runway

0 minutes of yellow glare
99 minutes of green glare

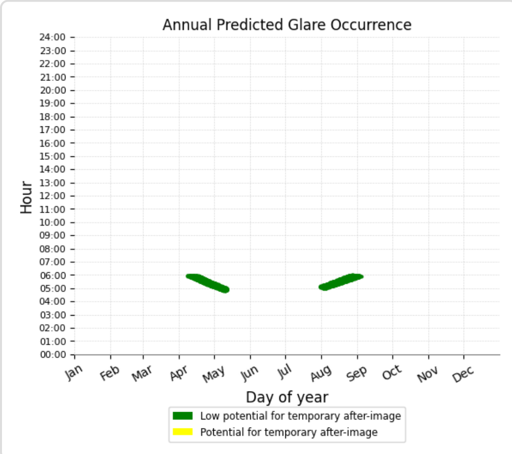


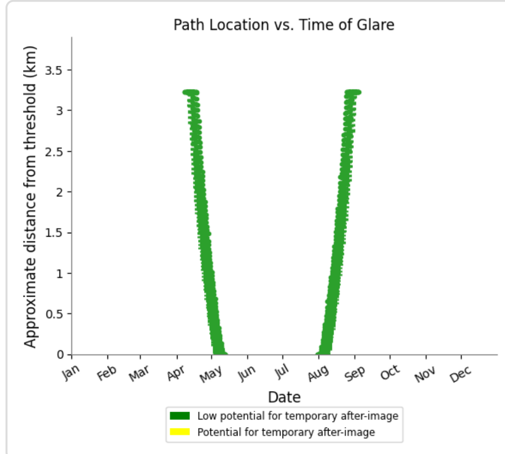


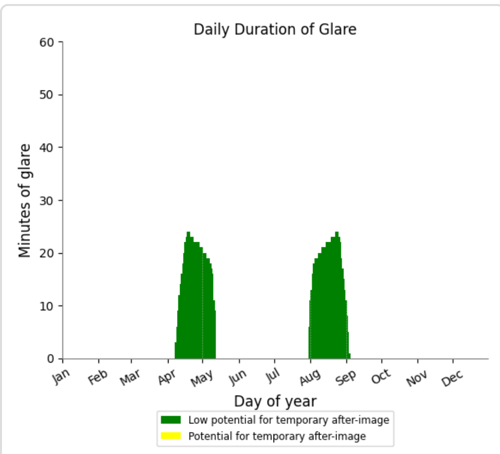


Flight Path: Casement 10 Runway

0 minutes of yellow glare
1296 minutes of green glare







Flight Path: Casement 22 Runway

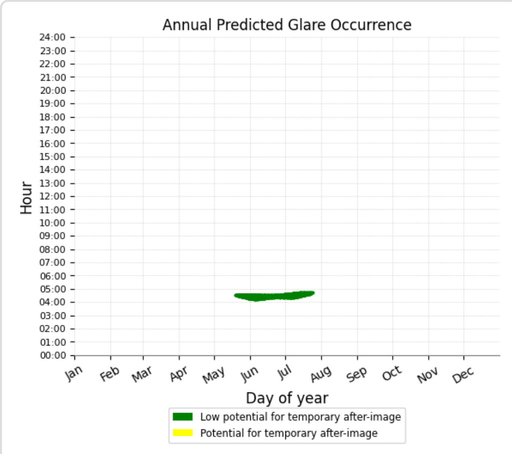
0 minutes of yellow glare
0 minutes of green glare

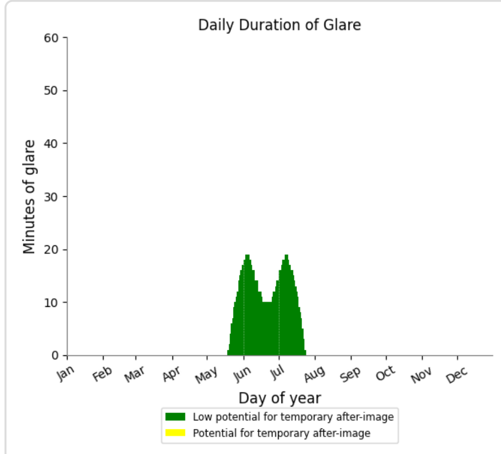
Flight Path: Casement 28 Runway

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare
854 minutes of green glare



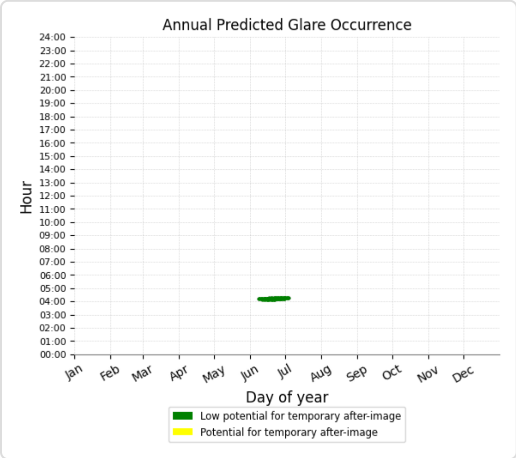


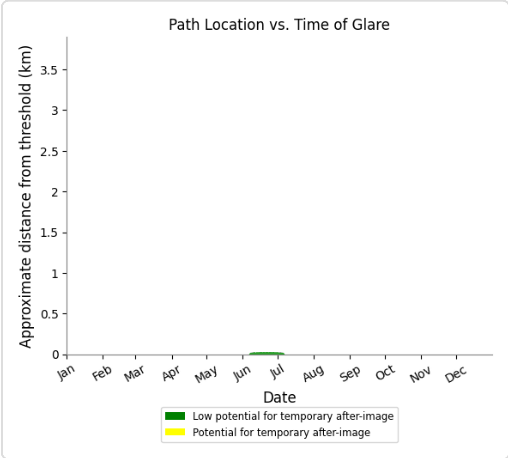
Results for: PA3

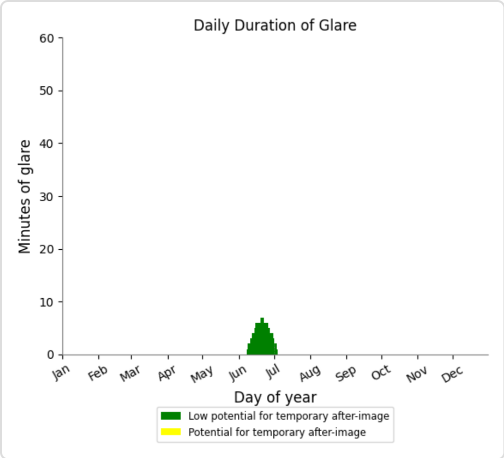
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	118	0
Casement 10 Runway	1291	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	786	0

Flight Path: Casement 04 Runway

0 minutes of yellow glare
118 minutes of green glare

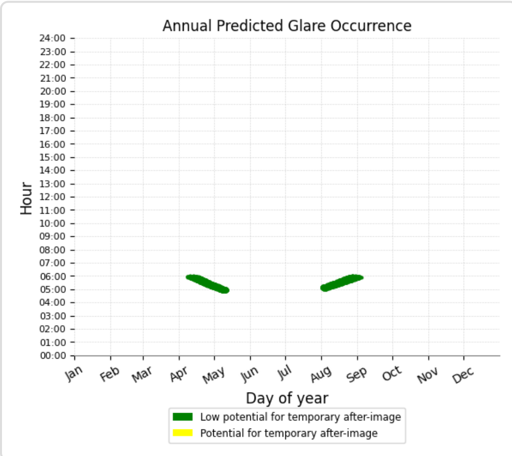


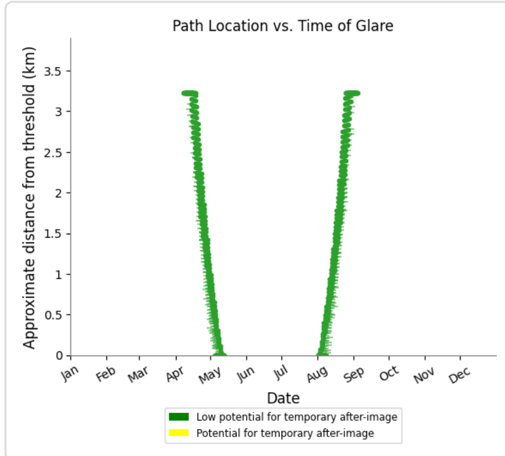


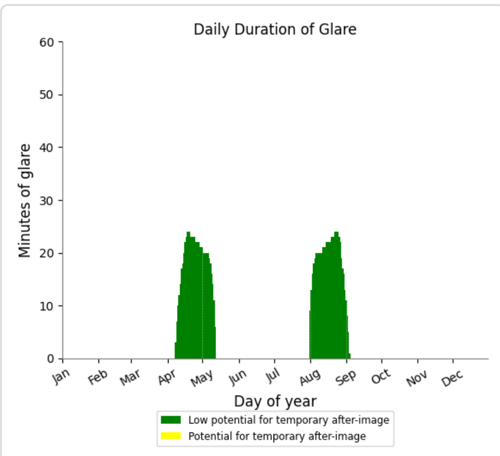


Flight Path: Casement 10 Runway

0 minutes of yellow glare
1291 minutes of green glare







Flight Path: Casement 22 Runway

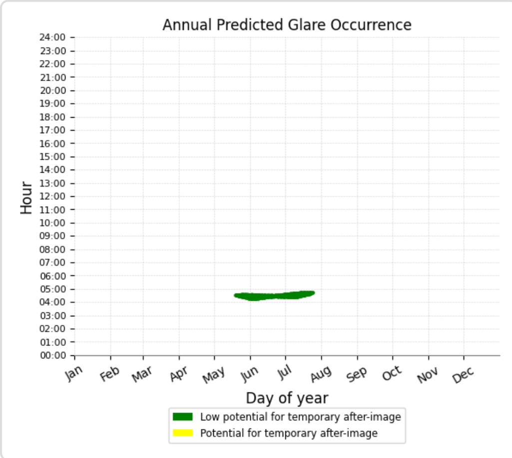
0 minutes of yellow glare
0 minutes of green glare

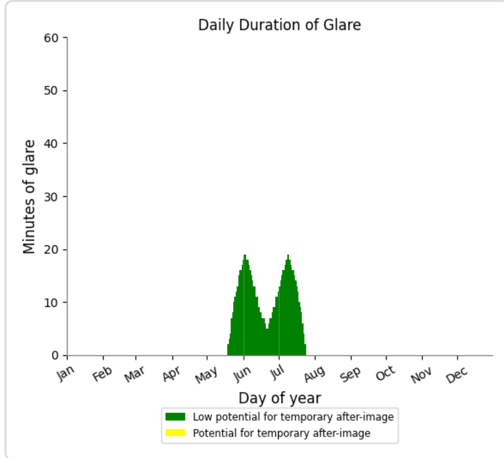
Flight Path: Casement 28 Runway

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare
786 minutes of green glare



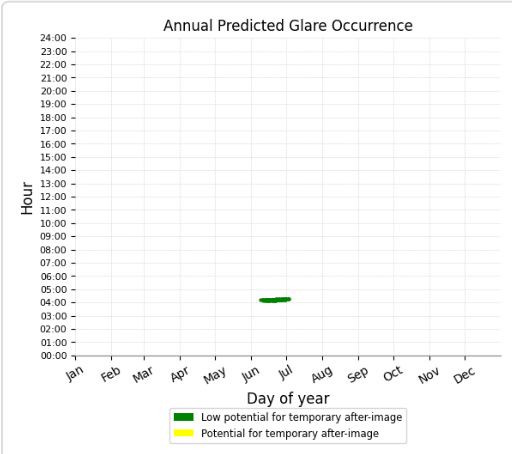


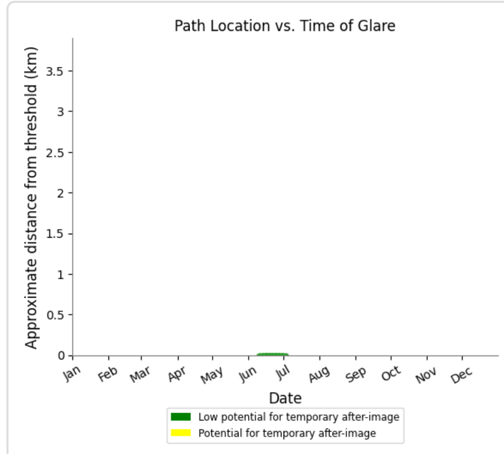
Results for: PA4

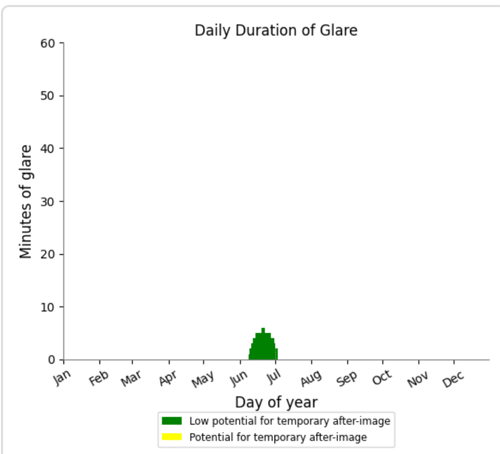
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	104	0
Casement 10 Runway	1282	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	788	0

Flight Path: Casement 04 Runway

0 minutes of yellow glare
104 minutes of green glare

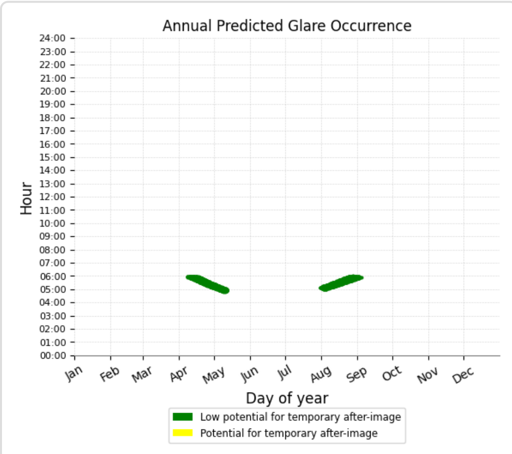


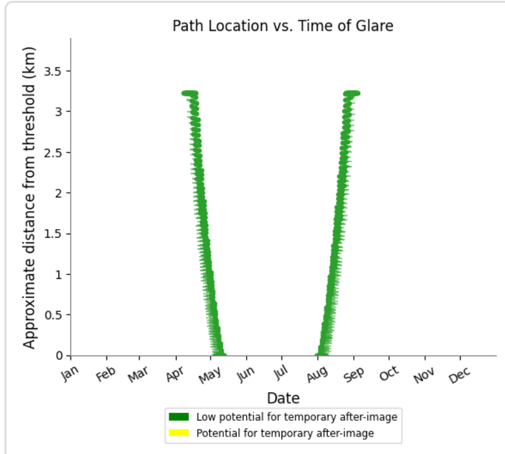


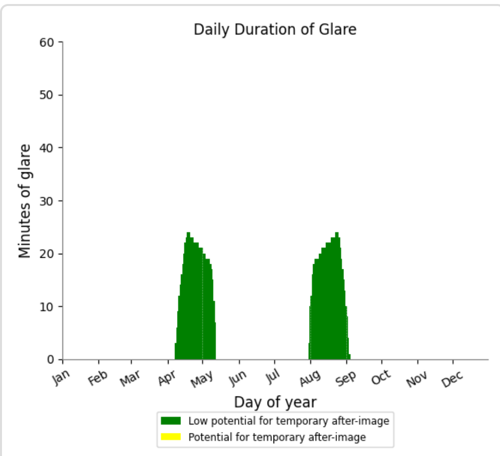


Flight Path: Casement 10 Runway

0 minutes of yellow glare
1282 minutes of green glare







Flight Path: Casement 22 Runway

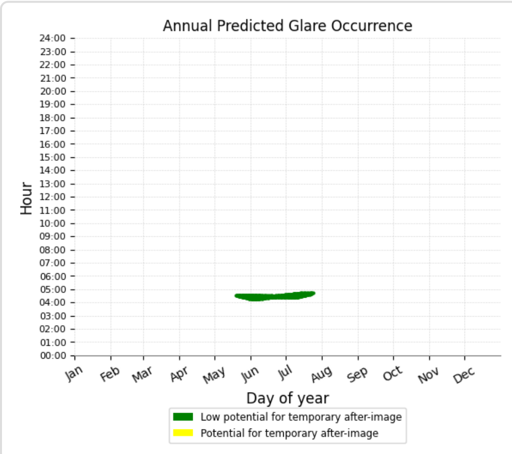
0 minutes of yellow glare
0 minutes of green glare

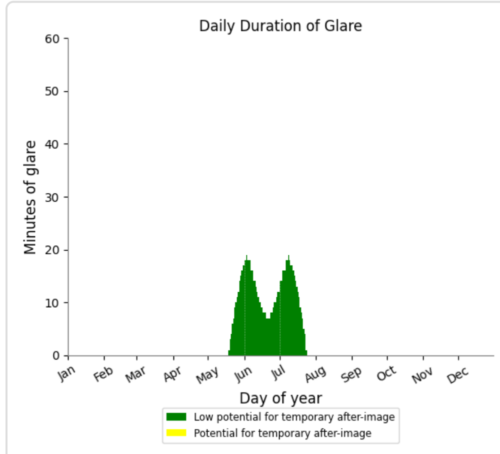
Flight Path: Casement 28 Runway

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare
788 minutes of green glare



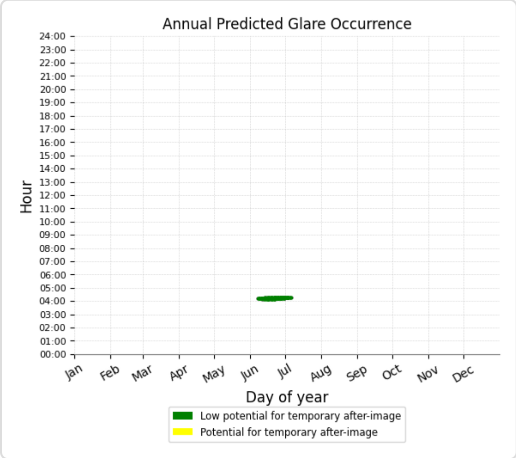


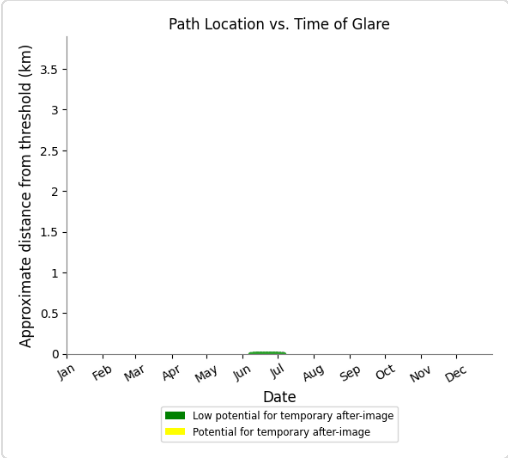
Results for: PA5

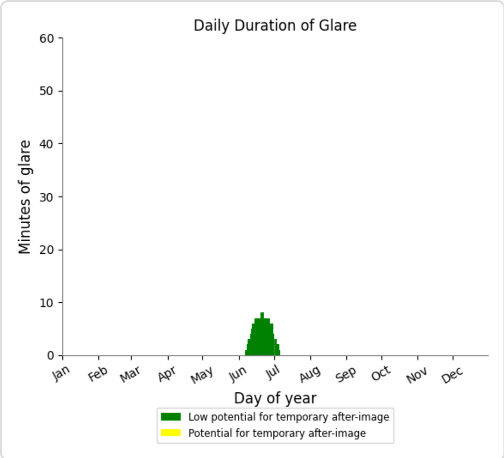
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	157	0
Casement 10 Runway	1290	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	675	0

Flight Path: Casement 04 Runway

0 minutes of yellow glare
157 minutes of green glare

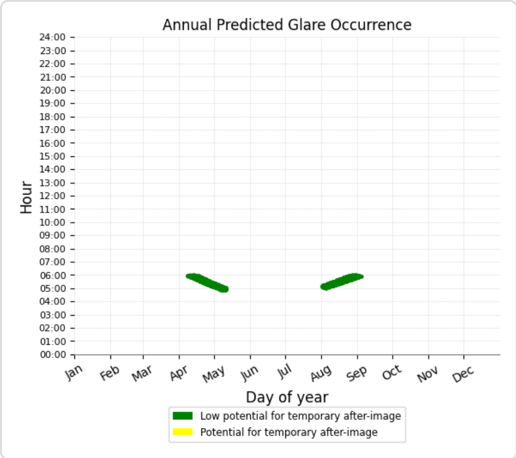


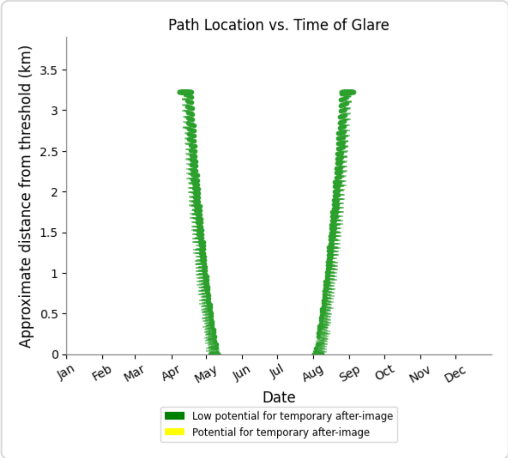


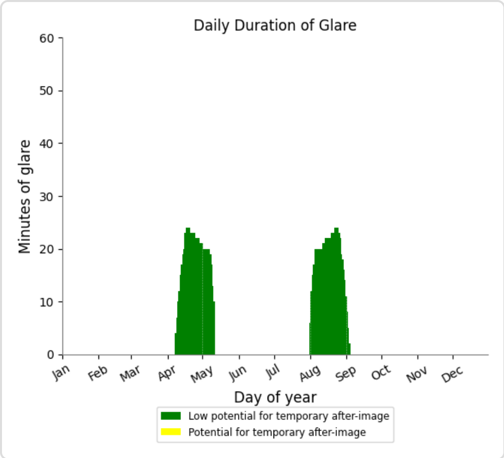


Flight Path: Casement 10 Runway

0 minutes of yellow glare
1290 minutes of green glare







Flight Path: Casement 22 Runway

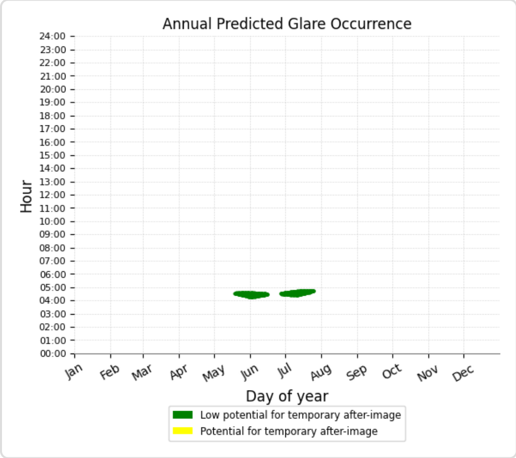
0 minutes of yellow glare
0 minutes of green glare

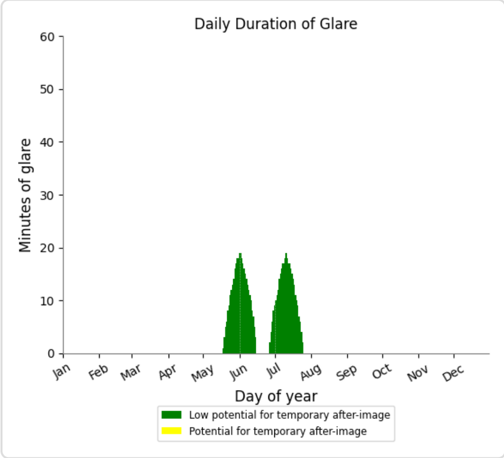
Flight Path: Casement 28 Runway

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare
675 minutes of green glare



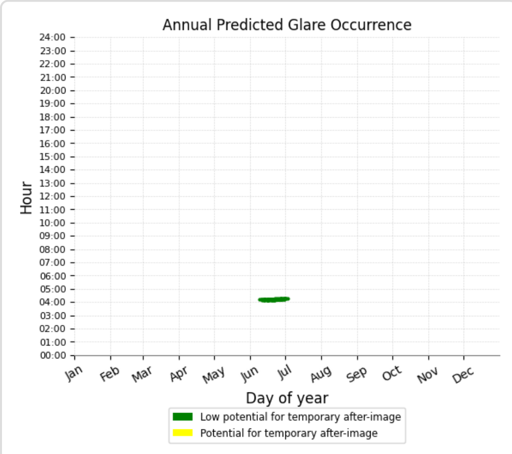


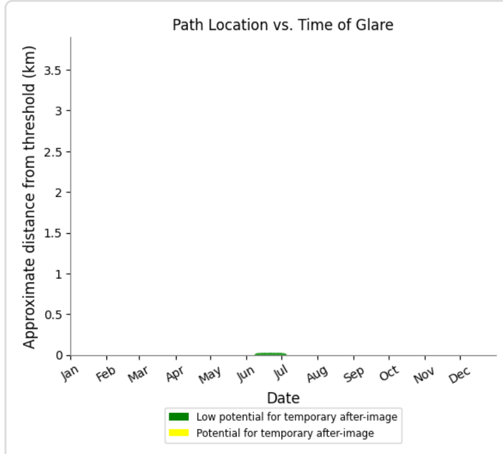
Results for: PA6

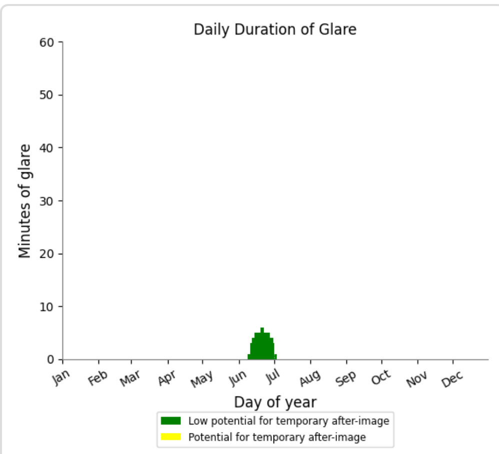
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	101	0
Casement 10 Runway	1309	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	835	0

Flight Path: Casement 04 Runway

0 minutes of yellow glare
101 minutes of green glare

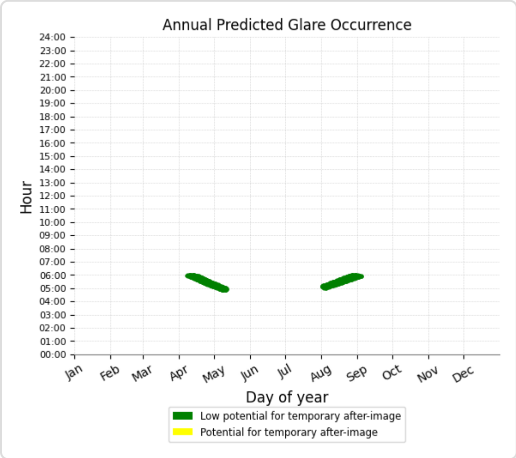


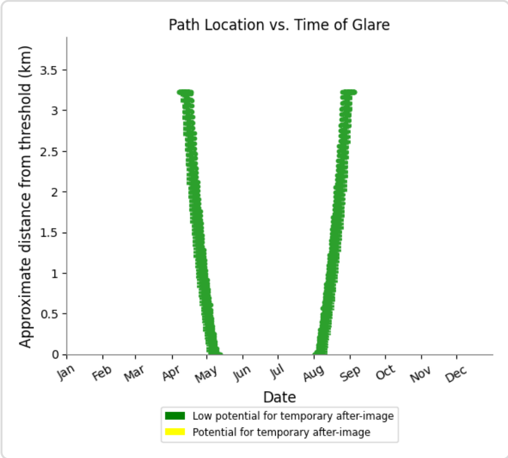


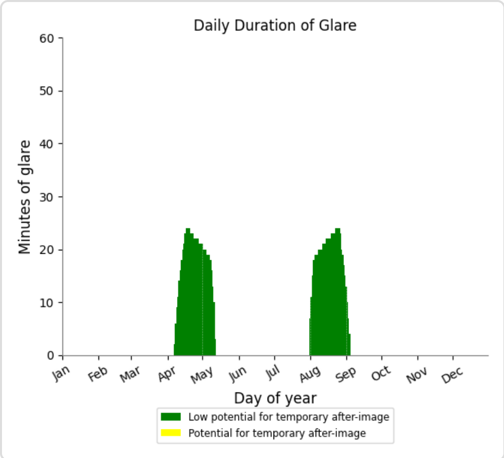


Flight Path: Casement 10 Runway

0 minutes of yellow glare
1309 minutes of green glare







Flight Path: Casement 22 Runway

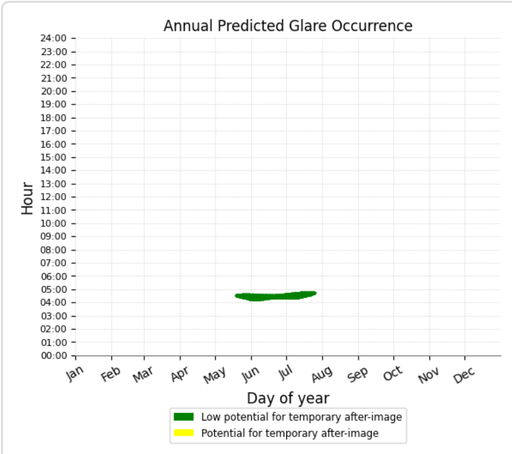
0 minutes of yellow glare
0 minutes of green glare

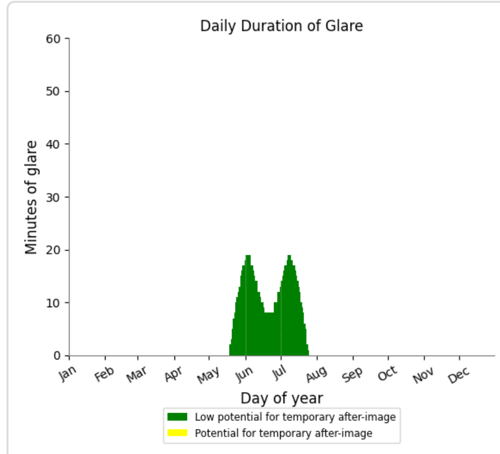
Flight Path: Casement 28 Runway

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare
835 minutes of green glare



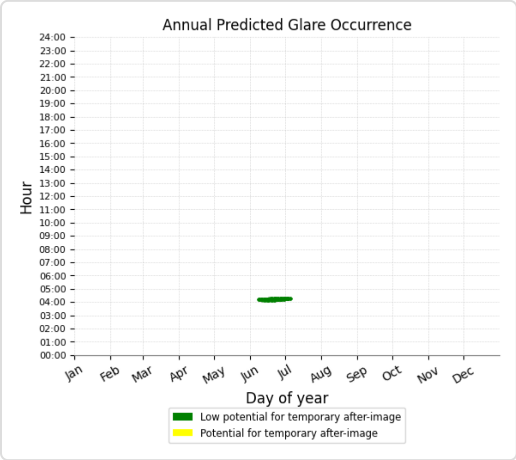


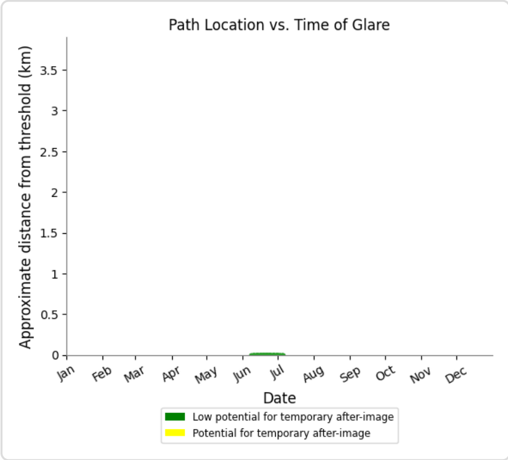
Results for: PA7

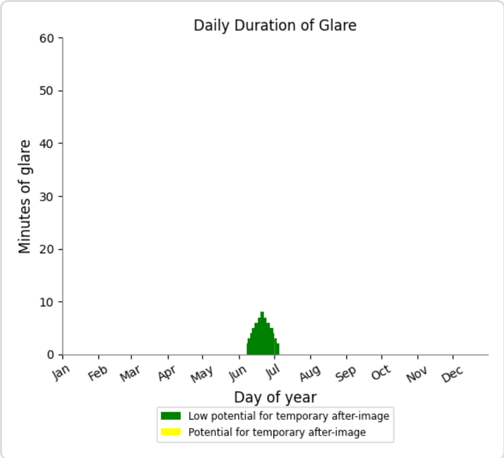
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	143	0
Casement 10 Runway	1278	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	698	0

Flight Path: Casement 04 Runway

0 minutes of yellow glare
143 minutes of green glare

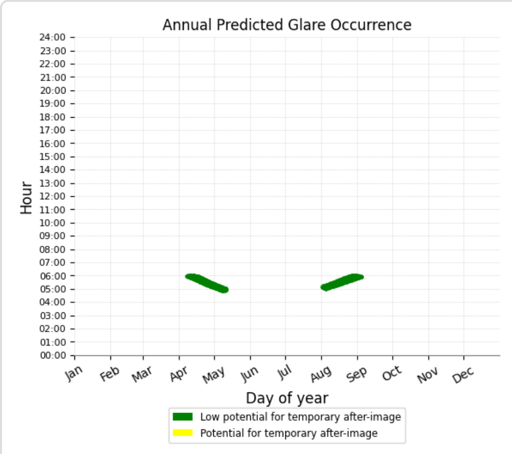


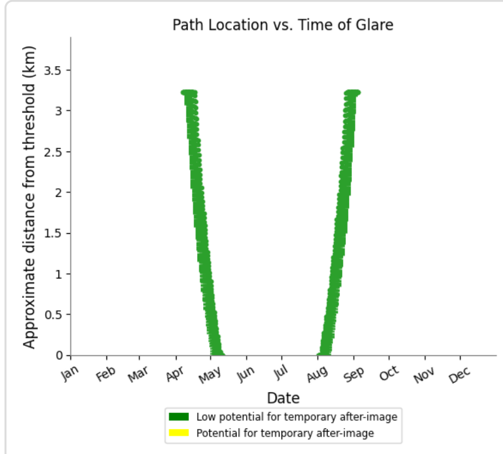


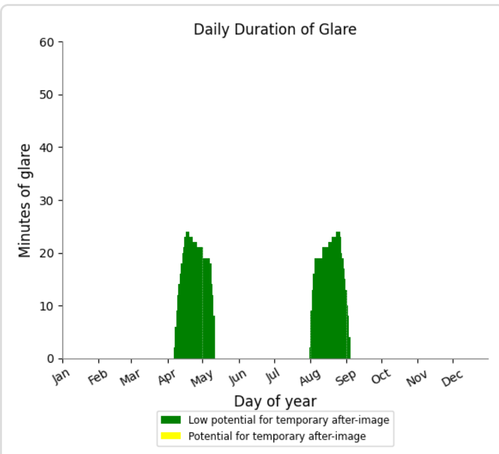


Flight Path: Casement 10 Runway

0 minutes of yellow glare
1278 minutes of green glare







Flight Path: Casement 22 Runway

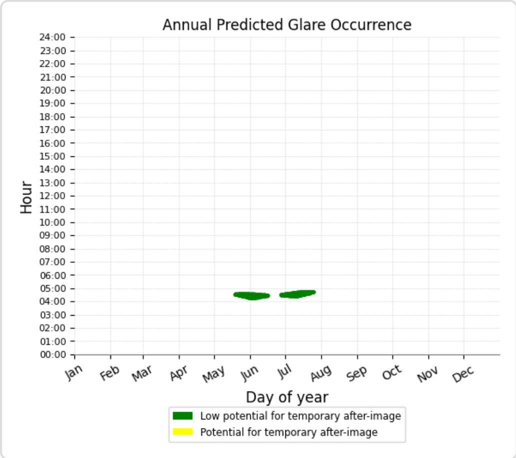
0 minutes of yellow glare
0 minutes of green glare

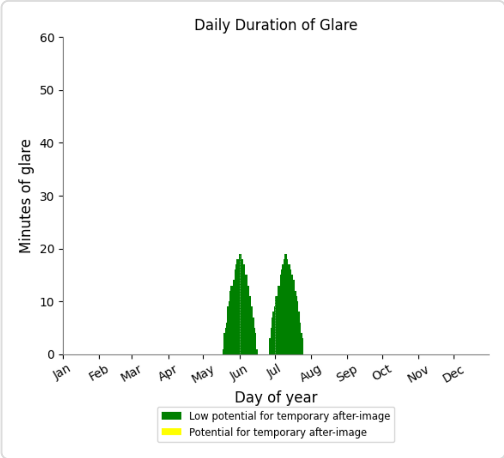
Flight Path: Casement 28 Runway

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare
698 minutes of green glare



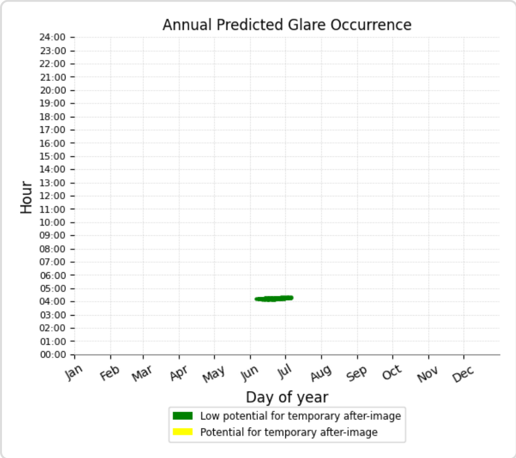


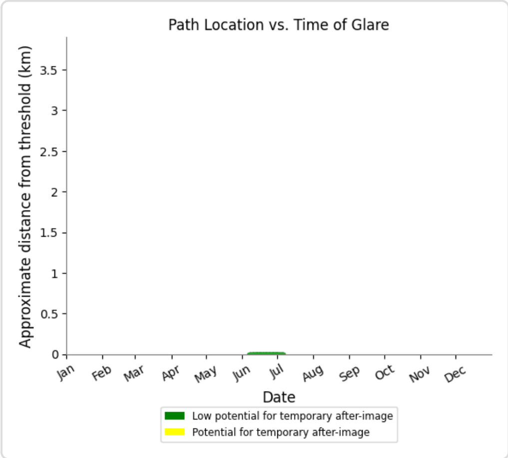
Results for: PA8

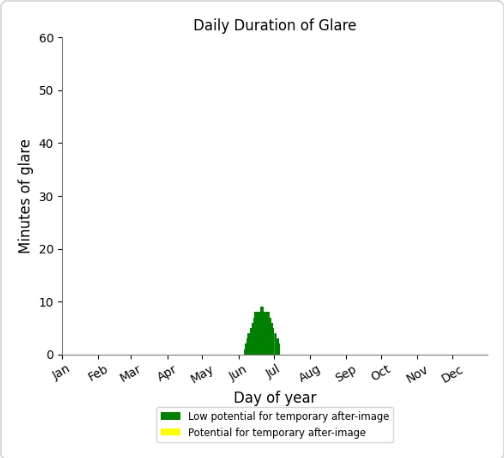
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	185	0
Casement 10 Runway	1267	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	645	0

Flight Path: Casement 04 Runway

0 minutes of yellow glare
185 minutes of green glare

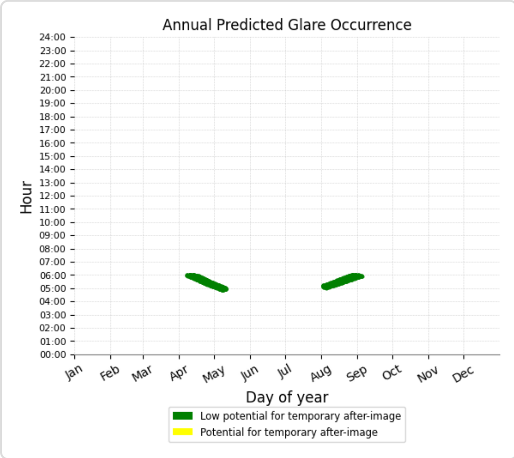


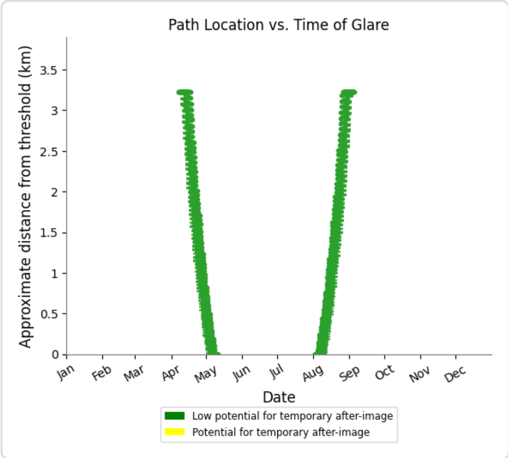


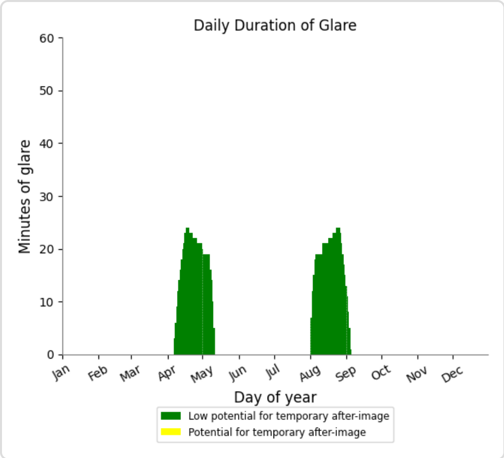


Flight Path: Casement 10 Runway

0 minutes of yellow glare
1267 minutes of green glare







Flight Path: Casement 22 Runway

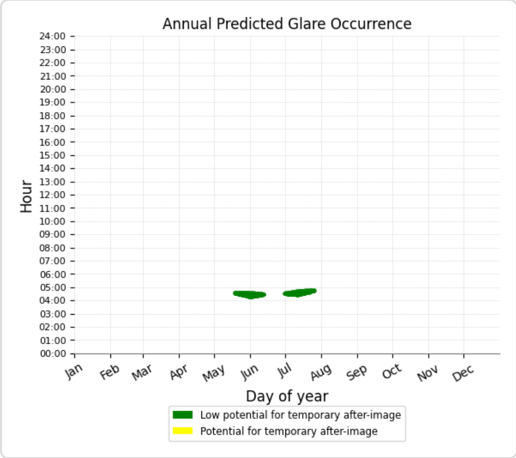
0 minutes of yellow glare
0 minutes of green glare

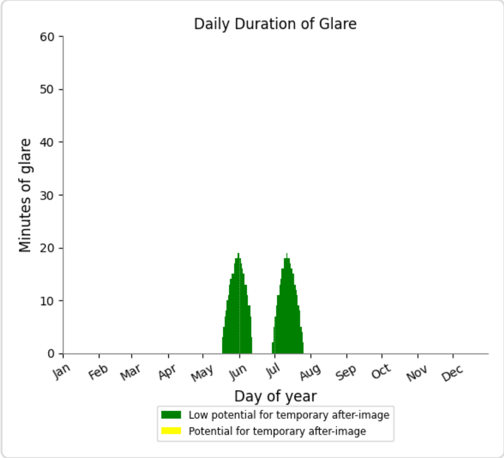
Flight Path: Casement 28 Runway

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare
645 minutes of green glare



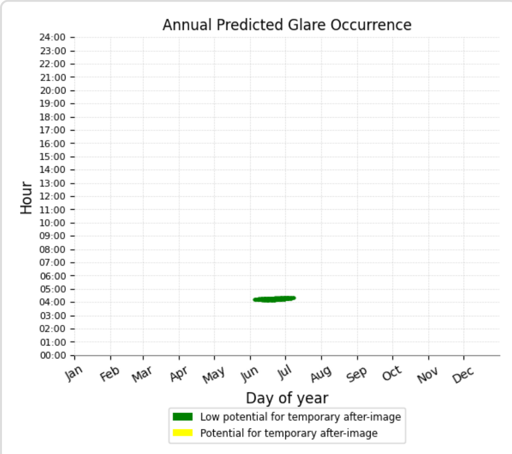


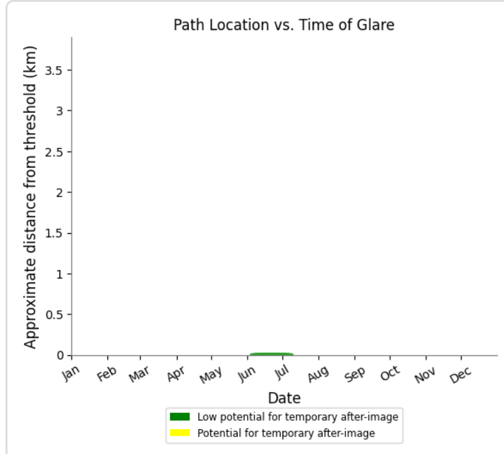
Results for: PA9

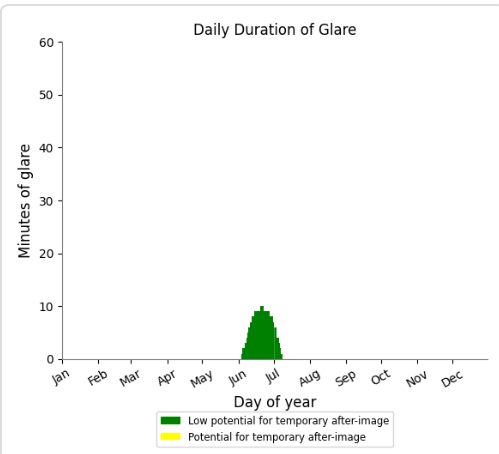
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	230	0
Casement 10 Runway	1259	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	606	0

Flight Path: Casement 04 Runway

0 minutes of yellow glare
230 minutes of green glare

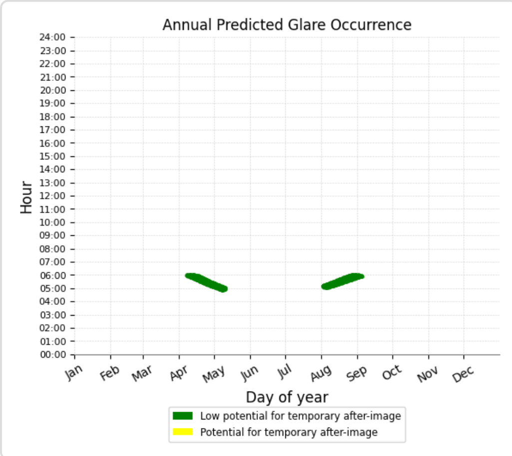


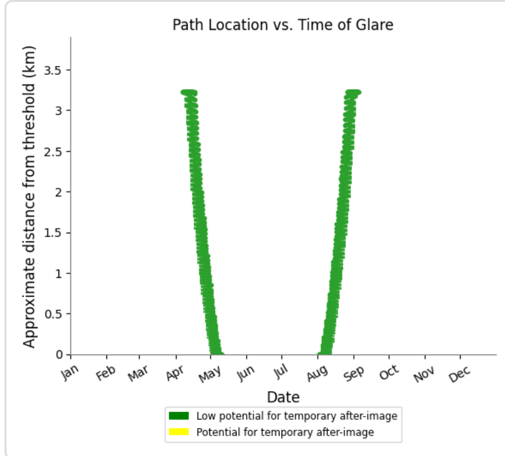


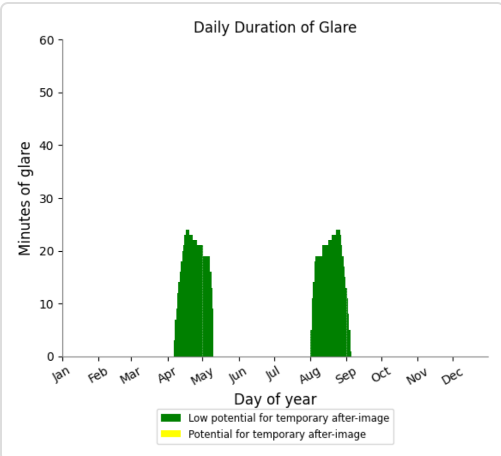


Flight Path: Casement 10 Runway

0 minutes of yellow glare
1259 minutes of green glare







Flight Path: Casement 22 Runway

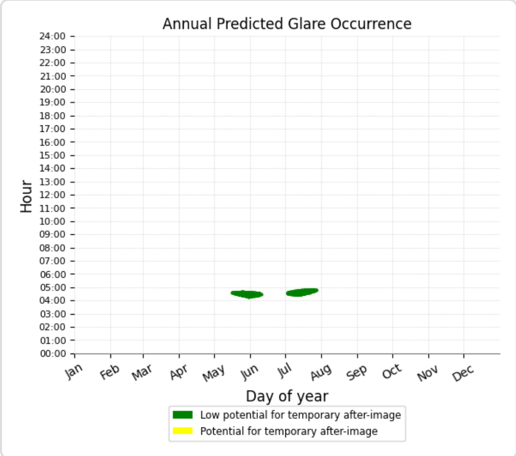
0 minutes of yellow glare
0 minutes of green glare

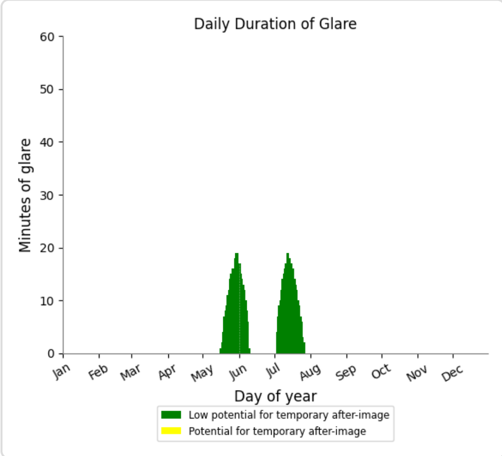
Flight Path: Casement 28 Runway

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare
606 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.
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.

This analysis was conducted using the best available radiometric modeling at the time of generation. Future updates to the modeling methodology may yield different results.