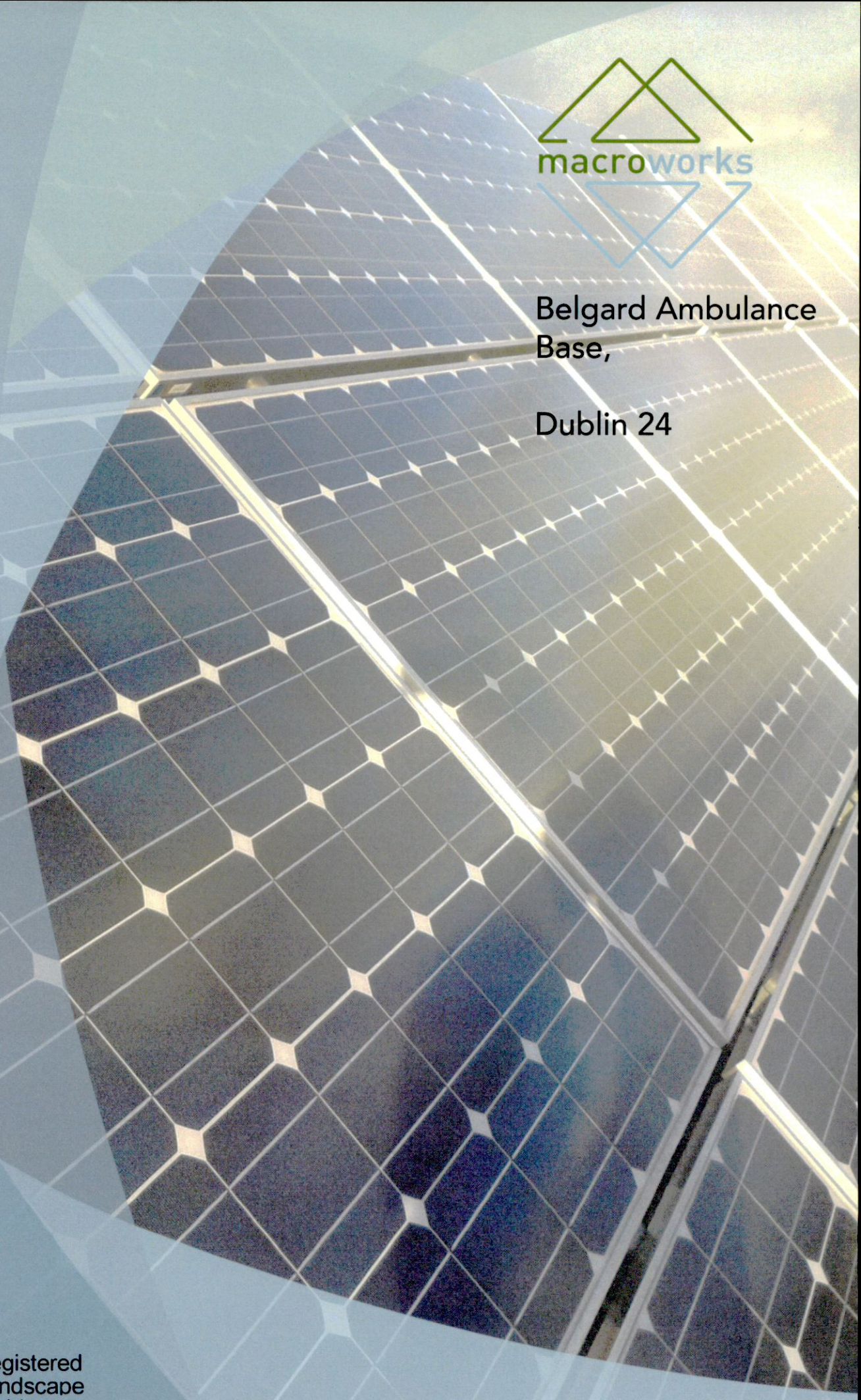
GLINT AND GLARE ASSESSMENT



macroworks

Belgard Ambulance Base,

Dublin 24

Registered Landscape Architect

October 2022

1 INTRODUCTION

Macro Works Ltd. were commissioned to undertake a glint and glare assessment for a proposed roof-mounted photovoltaic (PV) panel installation on the roof of the proposed HSE Belgard Ambulance Base building and covered parking bay at Glen Abbey, Tallaght, Dublin 24 (Figure 1 refers). The PV 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).

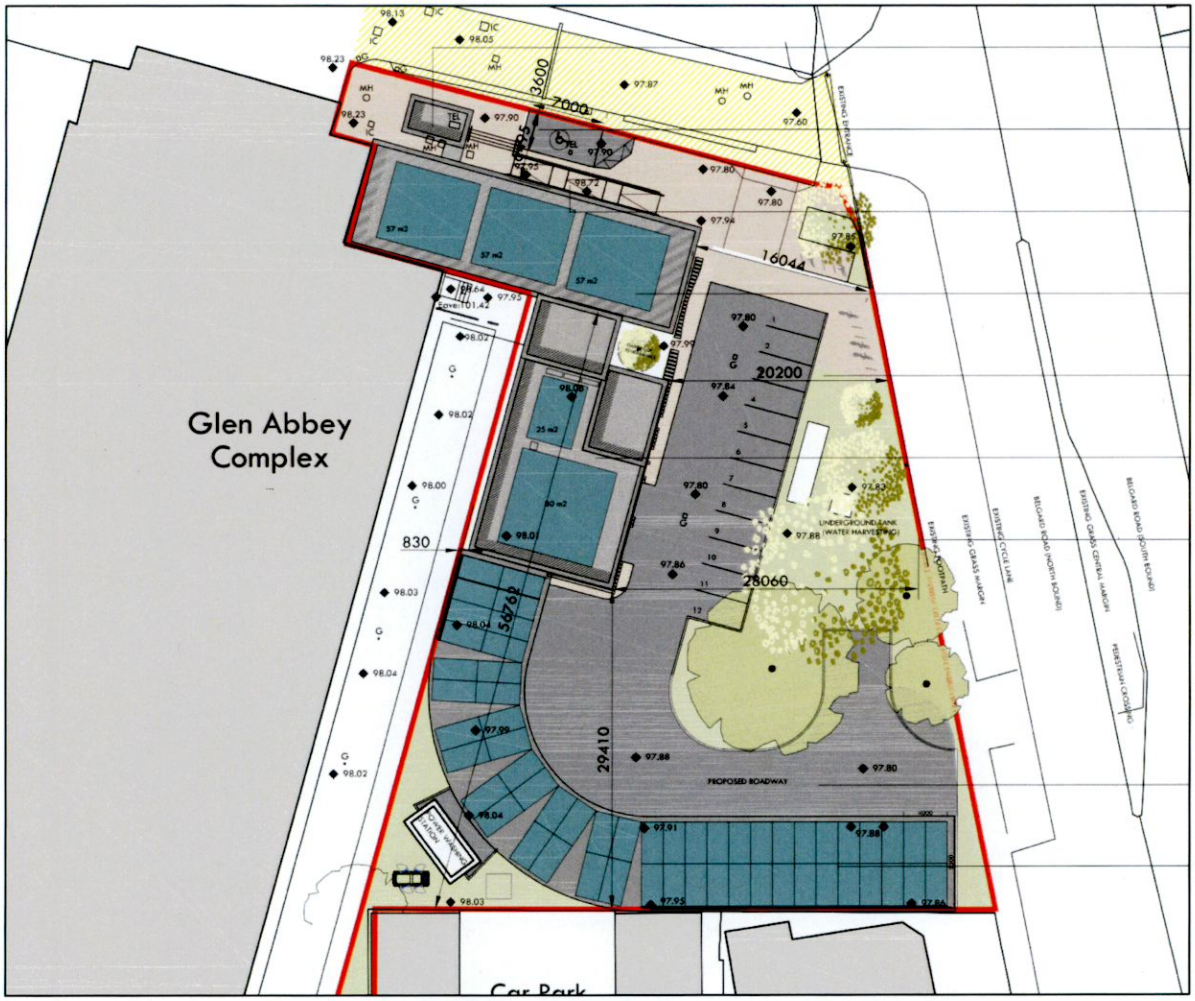


Figure 1: Extract from Drawing P(01)09 showing a plan view of the PV panel layout for analysis by SGHAT (shown in blue). The layout includes both horizontally and vertically mounted PV panels.

2 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. Macro Works has assessed the effects of glint and glare for many solar development sites throughout Ireland to date.

3 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.

4 GUIDANCE

Guidance has been prepared by the Federal Aviation Authority[1] to address the potential hazards that solar developments may pose to aviation activities, and this has been adopted for use by the Irish Aviation Authority. SGHAT was developed in conjunction with the FAA in harmony with this guidance and is commonly regarded as the accepted industry standard by aviation authorities internationally when considering the glint and glare effects upon aviation related receptors.

4.1 FEDERAL AVIATION AUTHORITY

Within the FAA's interim policy, a 'Review of Solar Energy System Projects on Federally Obligated Airports'[2] it states:

"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 2 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*

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[1] Harris, Miller, Miller & Hanson Inc.. (November 2010). Technical Guidance for Evaluating Selected Solar Technologies on Airports; 3.1.2 Reflectivity. *Technical Guidance for Evaluating Selected Solar Technologies on Airports*. Available at: https://www.faa.gov/airports/environmental/policy_guidance/media/airport-solar-guide.pdf

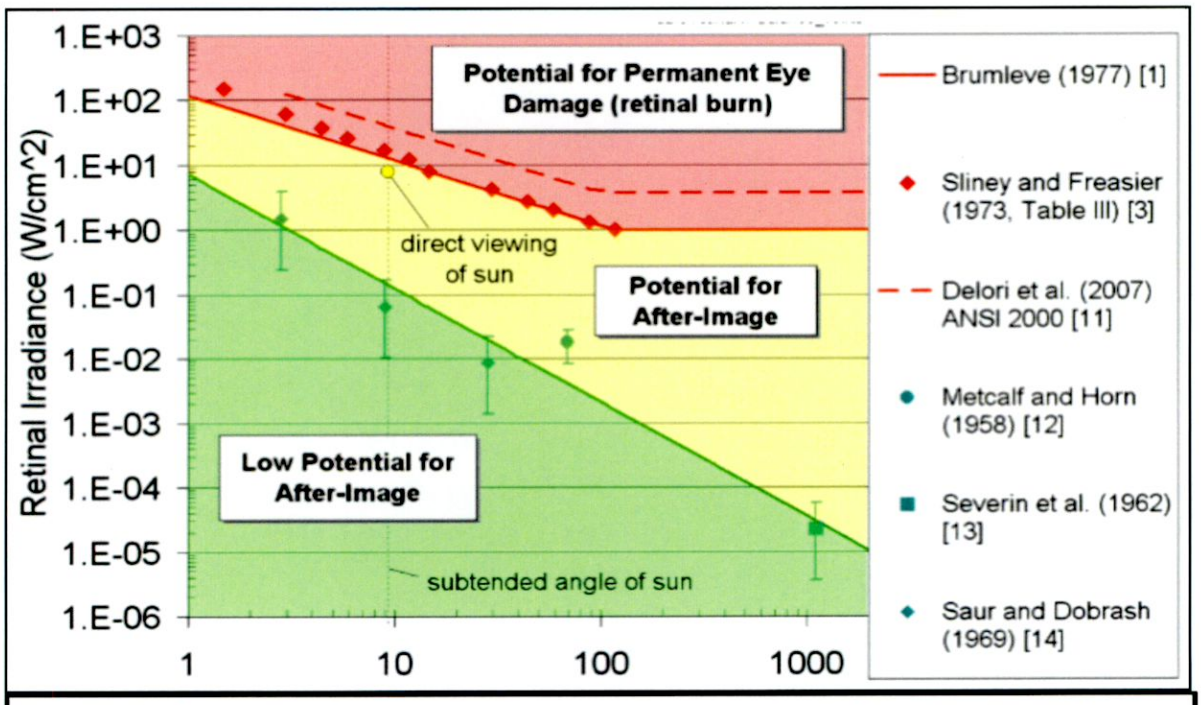
[2] Federal Aviation Administration (FAA). (2013). Department of Transportation - Federal Aviation Administration. *Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports*. Vol 78 (No 205), 63276-63279.

final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath."

In summary, glare at an ATCT is not acceptable but glare with a *"low potential for after-image"* is acceptable along final approach paths to runways.

4.2 SOLAR GLARE HAZARD ANALYSIS TOOL

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 2 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 with the FAA's *"low potential for after-image','* and so forth. The various correlations are illustrated on the Solar Glare Hazard Analysis Plot.



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 2: Figure 1 from the FAA Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports.

5 IDENTIFICATION OF RELEVANT RECEPTORS

5.1 RUNWAYS

Casement Aerodrome, also known as Baldonnel Aerodrome is a military airbase to the southwest of Dublin, situated off the N7 main road route to the south and south west. It is the headquarters and the sole airfield of the Irish Air Corps, and is also used for other government purposes. Casement Aerodrome currently hosts 2 operational runways 04/22 and 10/28 (Figure 3 refers).

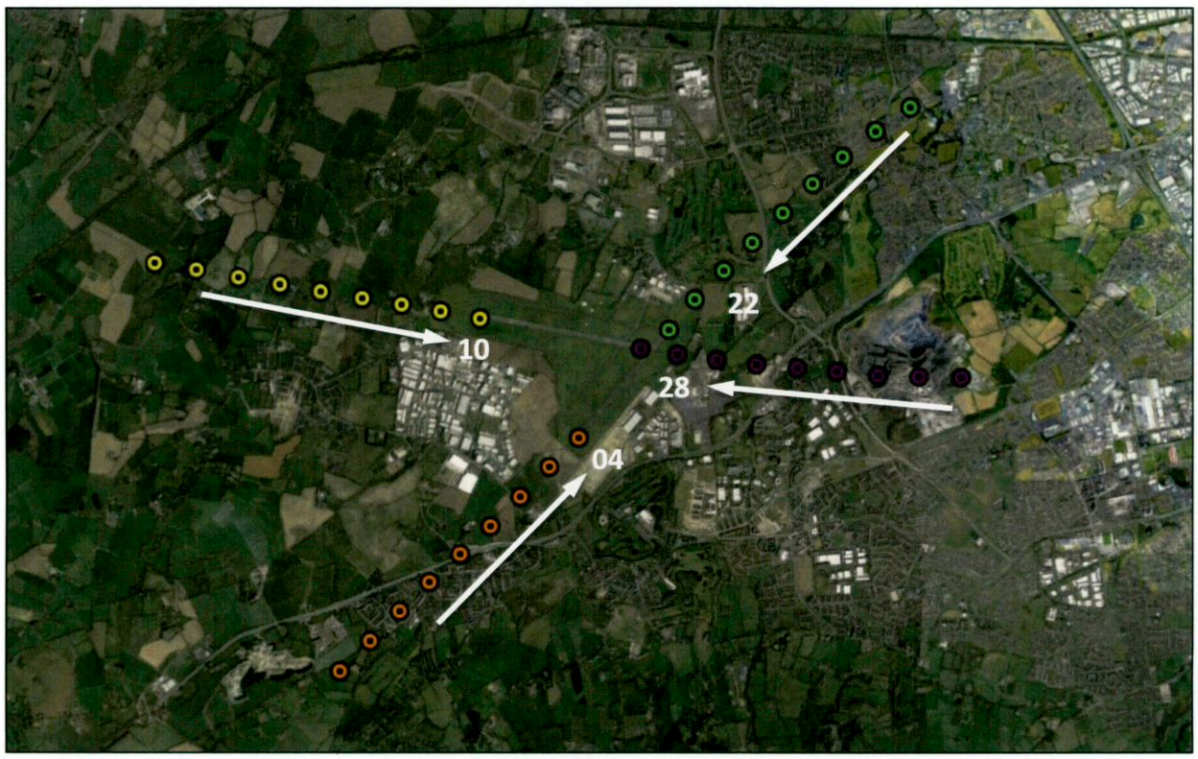


Figure 3: Aerial view (Google Earth Pro) showing 2 mile approach lines to runways at Casement Aerodrome (at ¼ mile intervals) as assessed by SGHAT.

5.2 AIR TRAFFIC CONTROL TOWERS

Casement Aerodrome has one Air Traffic Control Tower (ATCT) (Ref: '1-ATCT' in SGHAT) located to the east of the main terminal buildings, with a viewing height of 9m Above Ground Level (AGL) (Figure 4 refers).

Figure 4: Location of the Air Traffic Control Tower at Casement Aerodrome (red centre icon).

5.3 HELICOPTER RECEPTORS

The site falls within the Tallaght University Hospital Solar Safeguarding Zone, relating to a helipad at Tallaght University Hospital. The helipad is situated approximately 0.7km to the southwest (heading 220 degrees) of the proposed PV panels (Figure 5 refers). There is no category for helipads within the FAA guidance and only recently have these been included as a standard aviation receptor in Ireland.

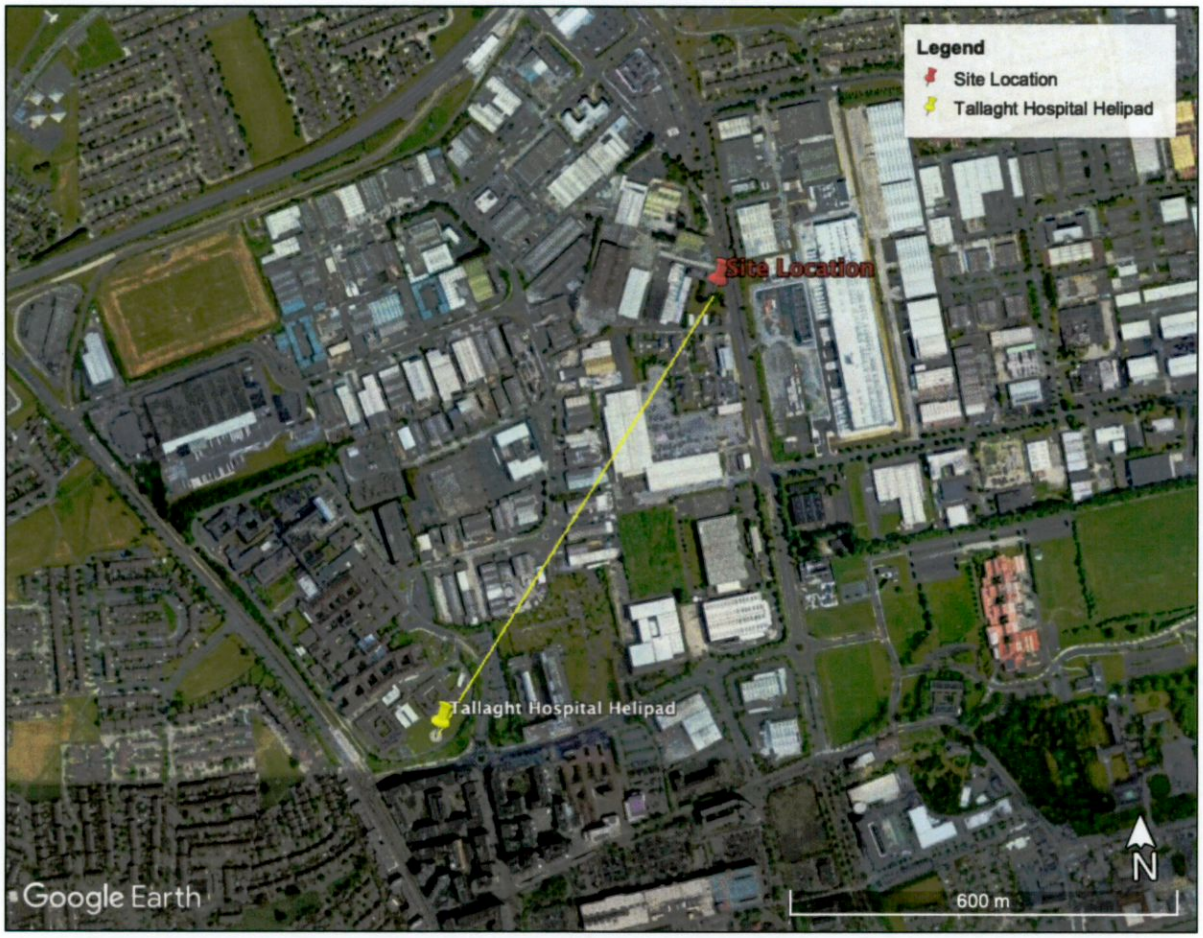


Figure 5: Aerial view (Google Earth Pro) showing the approximate location of the proposed development (red pin) relative to the identified aviation receptor (yellow pin).

6 RESULTS

6.1 RUNWAY APPROACHES

The SGHAT results for runway approaches are contained in Appendix A (building mounted installation only) and Appendix B (parking bay mounted installation only) and show that, of the four runway approaches analysed, two runway approaches – 04 and 10 at Casement Aerodrome the theoretical potential to receive glare from both the photovoltaic (PV) panel installation on the roof of the proposed HSE Belgard Ambulance Base building and the covered parking bays at Glen Abbey. In this instance, SGHAT calculated the potential glare to be *'Green Glare'*. SGHATs *'Green Glare'* classification regarding the intensity of the potential glare is synonymous with FAA's *'low potential for temporary after image'*. *'Green Glare'* / glare with a *'low potential for temporary after image,'* regardless of the number of minutes per year, is considered by the FAA to be an **acceptable level of reflectance effect for runway approaches**.

6.2 AIR TRAFFIC CONTROL TOWERS

The SGHAT results contained in Appendix A (building mounted installation only) and Appendix B (parking bay mounted installation only) also show the theoretical potential at the ATCT in Casement Aerodrome (1-ATCT). As shown in Appendix B (parking bay mounted installation only) SGHAT calculated this potential glare to be '*Green Glare*'. SGHATs '*Green Glare*' classification regarding the intensity of the potential glare is synonymous with FAA's *'low potential for temporary after image'*. *'Green Glare'* / glare with a *'low potential for temporary after image,'* regardless of the number of minutes per year, is considered by the FAA to be an unacceptable intensity of reflectance effect for an ATCT.

These results are not unexpected or uncommon as the SGHAT software does not account for screening as a result of intervening terrain, buildings or vegetation, therefore a 3D visibility analysis was undertaken from each of these ATCTs.

6.3 VISIBILITY ANALYSIS

6.3.1 Air Traffic Control Tower at Casement

A viewshed analysis was carried out for the Air Traffic Control Tower at Casement Aerodrome (1-ATCT) to identify what portions of the proposed development are theoretically visible. This was undertaken with the aid of a highly detailed digital surface model (DSM) to produce a Zone of Theoretical Visibility (ZTV) map with an accuracy of c.25cm (Figure 6 refers). The results of this analysis shows that there is no direct line of sight between the Air Traffic Control Tower and the surface of the proposed roof mounted PV panels hence it is not geometrically possible for any glint and glare to occur at the ATCT because of the proposed PV panels.

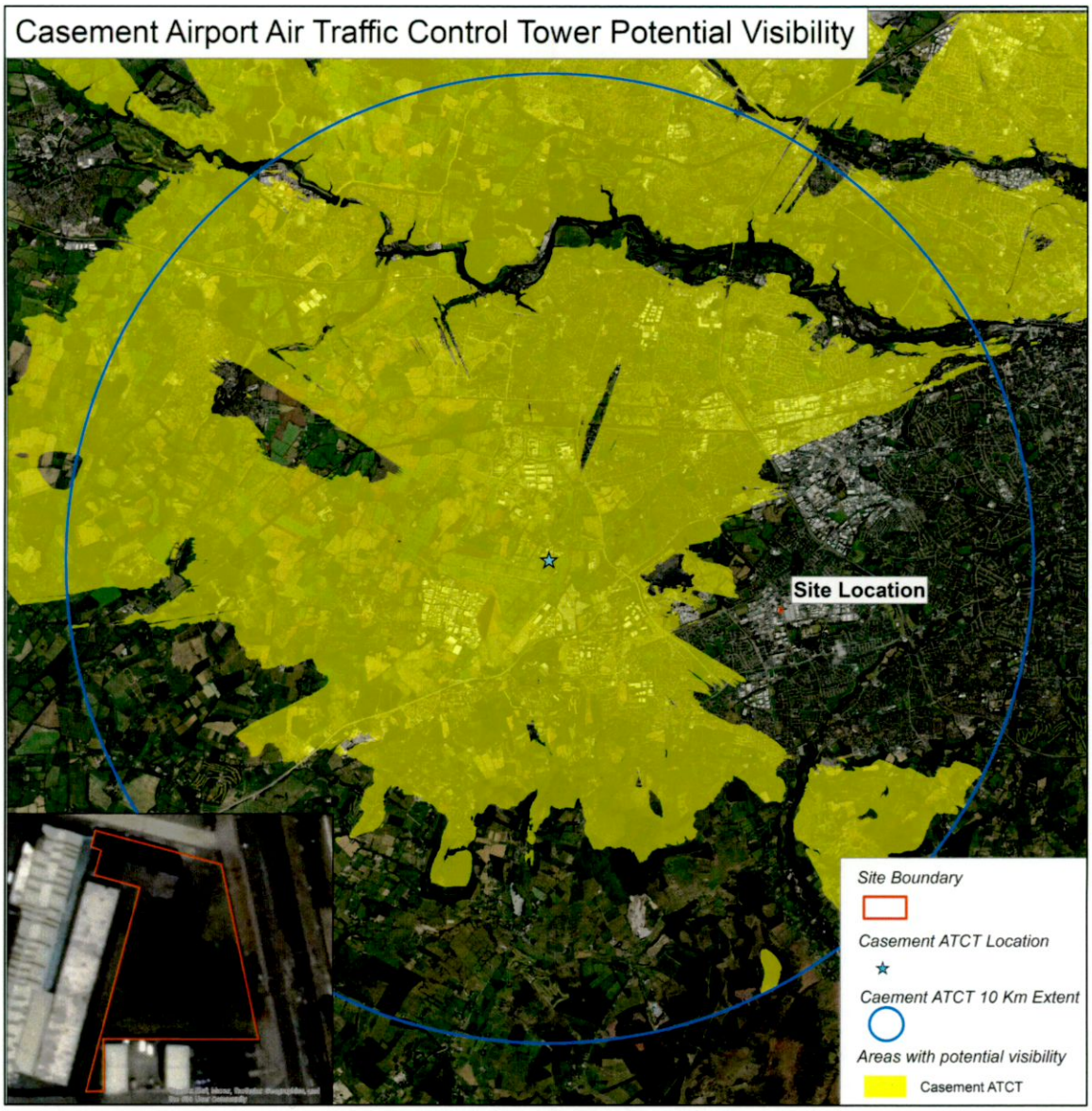


Figure 6: Viewshed / Zone of Theoretical Visibility (ZTV) map, based on a digital surface model (DSM), showing that no areas within the site are potentially visible (yellow pattern) from the air traffic control tower (2-ATCT) in Casement Aerodrome.

7 HELICOPTER RECEPTORS

In the absence of specific flight path information for the helicopters that land and take off within the Tallaght University Hospital Solar Safeguarding Zone, and given the potential random trajectory of helicopter destination and arrival flights, it was deemed appropriate to analyse receptor points at multiple height intervals above the helipad location. It is intended that these will serve for the evaluation of a wide variety of flight scenarios to and from the Tallaght Hospital Helipad.

The SGHAT software was utilised to undertake this analysis. Using the SGHAT software, Observation Points (OP) were placed at a representative selection of four different heights (OP1, OP3, OP3 and

OP4), starting at 0m then increasing at 100m intervals above the helipad surface; 0m, 100m, 200m, 300m.

While the use of Observation Points for assessing a helipad are not included for in the FAA guidance, for the purpose of this assessment, it was assumed, as a worst-case scenario, that a similar hazard intensity classification would apply to helicopters at these Observation Points as would apply to passenger aircraft approaching a runway.

7.1 HELICOPTER ANALYSIS RESULTS

The SGHAT results for the Observation Points above the helipad at Tallaght University Hospital are contained in Appendix C (building mounted installation only) and Appendix D (parking bay mounted installation only) and show that **none** of the four Observation Points (OP1, OP3, OP3 and OP4) have the theoretical potential to receive glare from any of the proposed PV panel installations. **For this reason, it is deemed highly unlikely for there to be any potential for hazardous impacts on helicopters approaching the helipad at Tallaght University Hospital**.

8 OVERALL CONCLUSION

From the analysis and discussions contained herein, it is considered that there will not be any hazardous glint and glare effects upon the identified aviation receptors - Casement Aerodrome nor Tallaght University Hospital Helipad, as a result of the proposed roof-mounted solar PV panels.

APPENDIX A:

RUNWAYS APPROACHES AND AIR TRAFFIC CONTROL TOWERS (ATCT) - BUILDING MOUNTED PV INSTALLMENT ONLY

The SGHAT results contained within this Appendix assess the potential for glint and glare from the proposed roof-mounted photovoltaic (PV) panel installation on the roof of the proposed HSE Belgard Ambulance Base building only at Casement Aerodrome Runway Approaches and Casement ATCT.

FORGESOLAR GLARE ANALYSIS

Project: **SGHAT**
Site configuration: **Glen Abbey HSE**
Analysis conducted by Luis Dominguez (luis@macroworks.ie) at 15:58 on 25 Jun, 2021.

U.S. FAA 2013 Policy Adherence

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

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

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

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
2-mile flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	PASS	Receptor(s) marked as ATCT do not receive glare

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

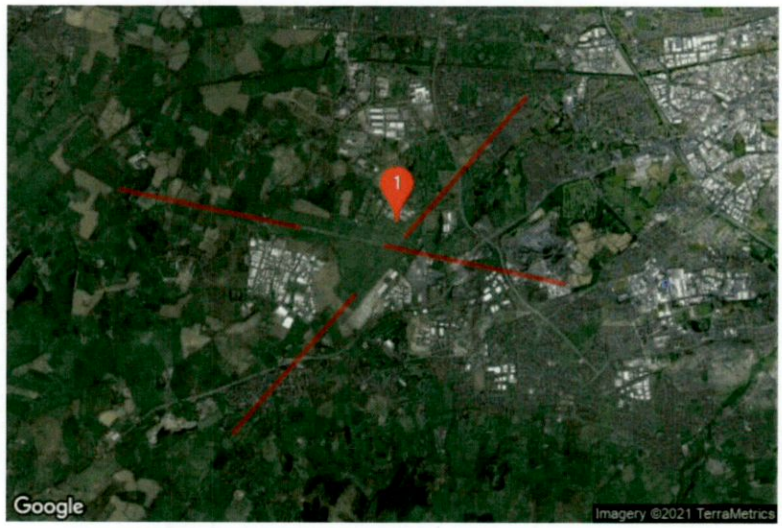
- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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: 55545.9717



PV Array(s)

Name: Area 1 NW
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 285.0°
Rated power: -
Panel material: Smooth glass without 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	53.295870	-6.370676	98.00	11.48	109.48
2	53.295850	-6.370561	98.00	11.48	109.48
3	53.295788	-6.370591	98.00	11.48	109.48
4	53.295808	-6.370706	98.00	11.48	109.48
5	53.295870	-6.370676	98.00	11.48	109.48

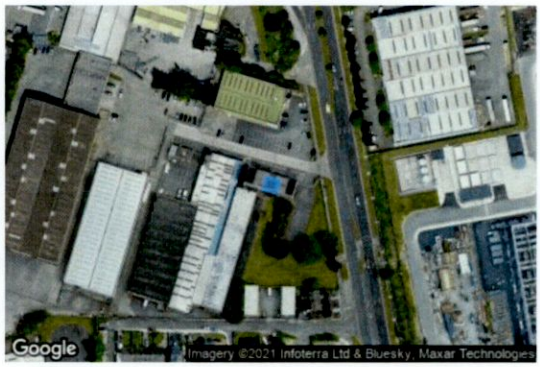
Name: Area 1 SE
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 105.0°
Rated power: -
Panel material: Smooth glass without AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.295870	-6.370676	98.00	11.48	109.48
2	53.295850	-6.370561	98.00	11.48	109.48
3	53.295788	-6.370591	98.00	11.48	109.48
4	53.295808	-6.370706	98.00	11.48	109.48
5	53.295870	-6.370676	98.00	11.48	109.48

Name: Area 2 NW
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 285.0°
Rated power: -
Panel material: Smooth glass without 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	53.295847	-6.370546	98.00	11.48	109.48
2	53.295827	-6.370431	98.00	11.48	109.48
3	53.295765	-6.370458	98.00	11.48	109.48
4	53.295785	-6.370576	98.00	11.48	109.48
5	53.295847	-6.370546	98.00	11.48	109.48

Name: Area 2 SE
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 105.0°
Rated power: -
Panel material: Smooth glass without 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	53.295847	-6.370546	98.00	11.48	109.48
2	53.295827	-6.370431	98.00	11.48	109.48
3	53.295765	-6.370458	98.00	11.48	109.48
4	53.295785	-6.370576	98.00	11.48	109.48
5	53.295847	-6.370546	98.00	11.48	109.48

Name: Area 3 NW
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 285.0°
Rated power: -
Panel material: Smooth glass without 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	53.295825	-6.370416	98.00	11.48	109.48
2	53.295804	-6.370300	98.00	11.48	109.48
3	53.295742	-6.370331	98.00	11.48	109.48
4	53.295763	-6.370446	98.00	11.48	109.48
5	53.295825	-6.370416	98.00	11.48	109.48

Name: Area 3 SE
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 105.0°
Rated power: -
Panel material: Smooth glass without 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	53.295825	-6.370416	98.00	11.48	109.48
2	53.295804	-6.370300	98.00	11.48	109.48
3	53.295742	-6.370331	98.00	11.48	109.48
4	53.295763	-6.370446	98.00	11.48	109.48
5	53.295825	-6.370416	98.00	11.48	109.48

Name: Area 4 NW
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 285.0°
Rated power: -
Panel material: Smooth glass without 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	53.295870	-6.370676	98.00	11.48	109.48
2	53.295850	-6.370561	98.00	11.48	109.48
3	53.295788	-6.370591	98.00	11.48	109.48
4	53.295808	-6.370706	98.00	11.48	109.48
5	53.295870	-6.370676	98.00	11.48	109.48

Name: Area 4 SE
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 105.0°
Rated power: -
Panel material: Smooth glass without 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	53.295715	-6.370483	98.00	14.20	112.20
2	53.295739	-6.370471	98.00	14.20	112.20
3	53.295727	-6.370397	98.00	14.20	112.20
4	53.295702	-6.370409	98.00	14.20	112.20
5	53.295715	-6.370483	98.00	14.20	112.20

Name: Area 5 NW
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 285.0°
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	53.295641	-6.370504	98.00	5.14	103.14
2	53.295692	-6.370479	98.00	5.14	103.14
3	53.295681	-6.370417	98.00	5.14	103.14
4	53.295630	-6.370442	98.00	5.14	103.14
5	53.295641	-6.370504	98.00	5.14	103.14

Name: Area 5 SE
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 105.0°
Rated power: -
Panel material: Smooth glass without 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	53.295641	-6.370504	98.00	5.14	103.14
2	53.295692	-6.370479	98.00	5.14	103.14
3	53.295681	-6.370417	98.00	5.14	103.14
4	53.295630	-6.370442	98.00	5.14	103.14
5	53.295641	-6.370504	98.00	5.14	103.14

Name: Area 6 NW
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 285.0°
Rated power: -
Panel material: Smooth glass without 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	53.295660	-6.370389	98.00	6.81	104.81
2	53.295652	-6.370345	98.00	6.81	104.81
3	53.295629	-6.370356	98.00	6.81	104.81
4	53.295636	-6.370400	98.00	6.81	104.81
5	53.295660	-6.370389	98.00	6.81	104.81

Name: Area 6 SE
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 105.0°
Rated power: -
Panel material: Smooth glass without 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	53.295660	-6.370389	98.00	6.81	104.81
2	53.295652	-6.370345	98.00	6.81	104.81
3	53.295629	-6.370356	98.00	6.81	104.81
4	53.295636	-6.370400	98.00	6.81	104.81
5	53.295660	-6.370389	98.00	6.81	104.81

Name: Area 7 NW
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 285.0°
Rated power: -
Panel material: Smooth glass without 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	53.295632	-6.370509	98.00	5.14	103.14
2	53.295610	-6.370379	98.00	5.14	103.14
3	53.295533	-6.370417	98.00	5.14	103.14
4	53.295555	-6.370547	98.00	5.14	103.14
5	53.295632	-6.370509	98.00	5.14	103.14

Name: Area 7 SE
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 105.0°
Rated power: -
Panel material: Smooth glass without 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	53.295632	-6.370509	98.00	5.14	103.14
2	53.295610	-6.370379	98.00	5.14	103.14
3	53.295533	-6.370417	98.00	5.14	103.14
4	53.295555	-6.370547	98.00	5.14	103.14
5	53.295632	-6.370509	98.00	5.14	103.14

Vertical Surface(s)

Name: Staircore Facade PV Array
Use default smooth glass reflectivity profile?: Yes
Slope error: 10.0 mrad
Bottom height above ground of surface: 103 m
Top height above ground of surface: 109 m
Treat both sides of surface as reflective?: No

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.295712	-6.370498	98.94	0.00	98.94
2	53.295694	-6.370397	98.90	0.00	98.90

Flight Path Receptor(s)

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

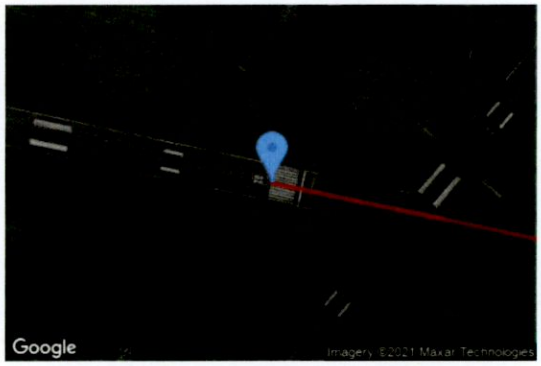
Name: Casement 10 Runway
Description: None
Threshold height: 15 m
Direction: 101.8°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.304622	-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: 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	53.303267	-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
Area 1 NW	7.0	285.0	3,015	0	-
Area 1 SE	7.0	105.0	0	0	-
Area 2 NW	7.0	285.0	2,964	0	-
Area 2 SE	7.0	105.0	0	0	-
Area 3 NW	7.0	285.0	2,971	0	-
Area 3 SE	7.0	105.0	0	0	-
Area 4 NW	7.0	285.0	2,836	0	-
Area 4 SE	7.0	105.0	0	0	-
Area 5 NW	7.0	285.0	3,783	0	-
Area 5 SE	7.0	105.0	0	0	-
Area 6 NW	7.0	285.0	2,997	0	-
Area 6 SE	7.0	105.0	0	0	-
Area 7 NW	7.0	285.0	3,104	0	-
Area 7 SE	7.0	105.0	0	0	-

Total minutes of glare produced by each vertical surface

Vertical Surface	Annual Green Glare (min)	Annual Yellow Glare (min)
Staircore Facade PV Array	0	0

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
Casement 04 Runway	19248	0
Casement 10 Runway	2422	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	0	0

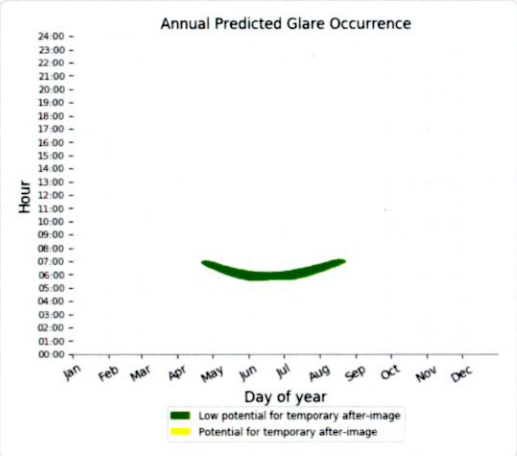
Results for: Area 1 NW

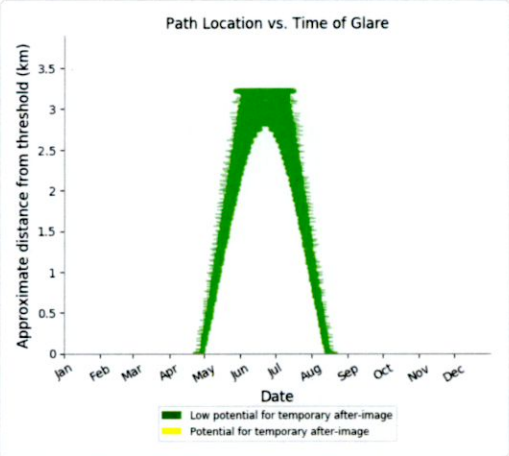
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	2688	0
Casement 10 Runway	327	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	0	0

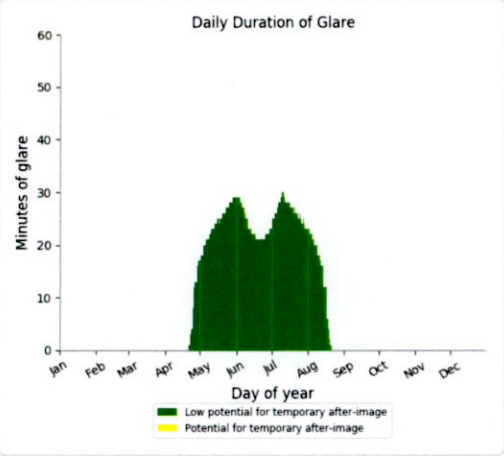
Flight Path: Casement 04 Runway

0 minutes of yellow glare

2688 minutes of green glare



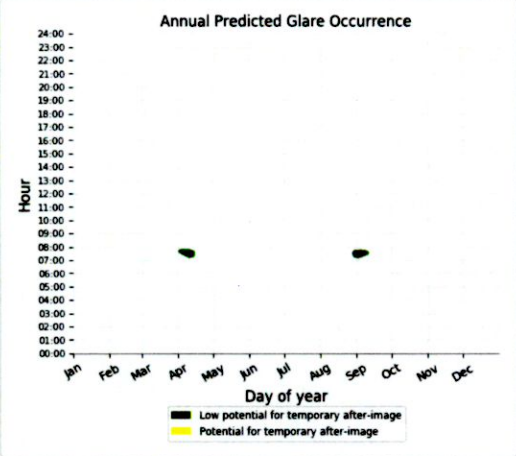


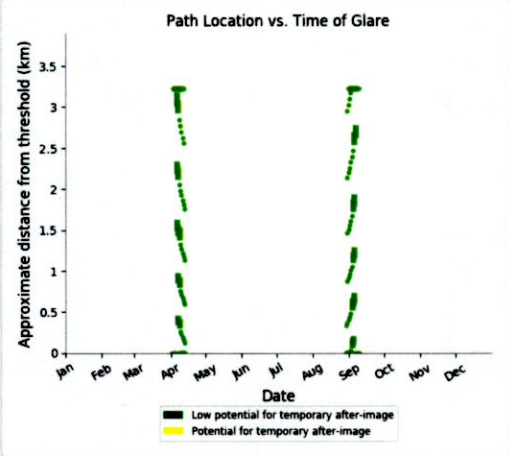


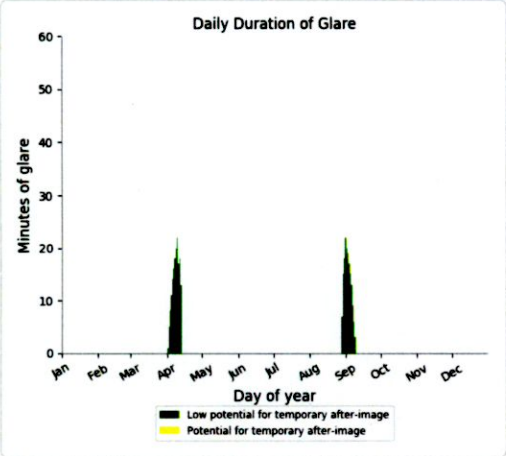
Flight Path: Casement 10 Runway

0 minutes of yellow glare

327 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

0 minutes of green glare

Results for: Area 1 SE

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

Flight Path: Casement 04 Runway

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare
0 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
0 minutes of green glare

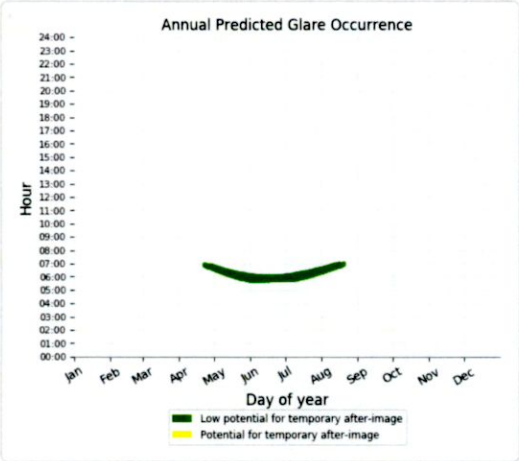
Results for: Area 2 NW

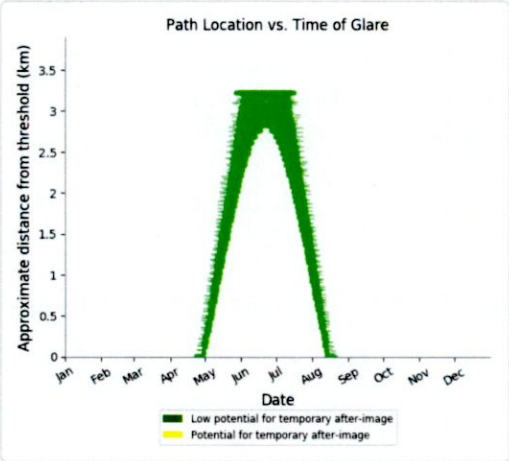
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	2634	0
Casement 10 Runway	330	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	0	0

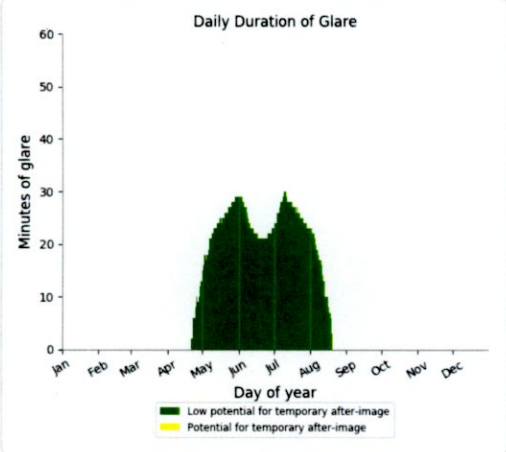
Flight Path: Casement 04 Runway

0 minutes of yellow glare

2634 minutes of green glare



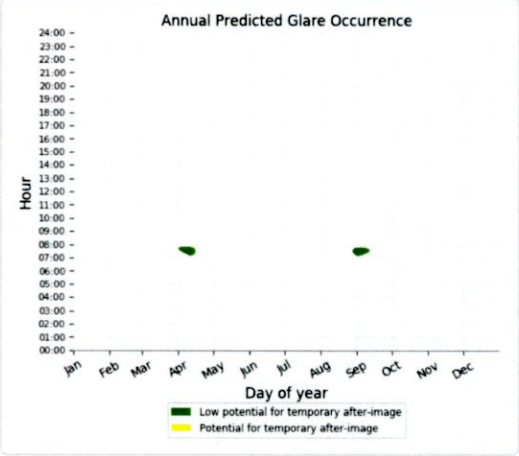


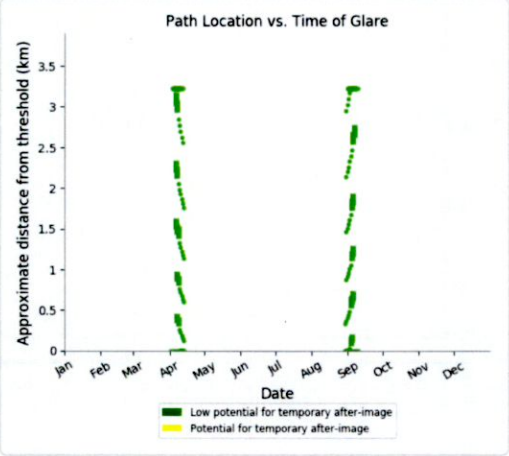


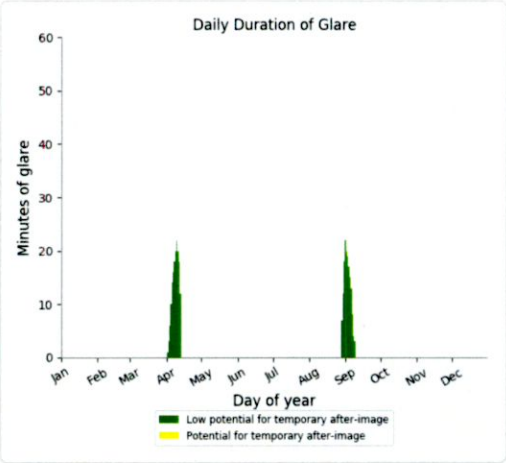
Flight Path: Casement 10 Runway

0 minutes of yellow glare

330 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
0 minutes of green glare

Results for: Area 2 SE

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

Flight Path: Casement 04 Runway

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare

0 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

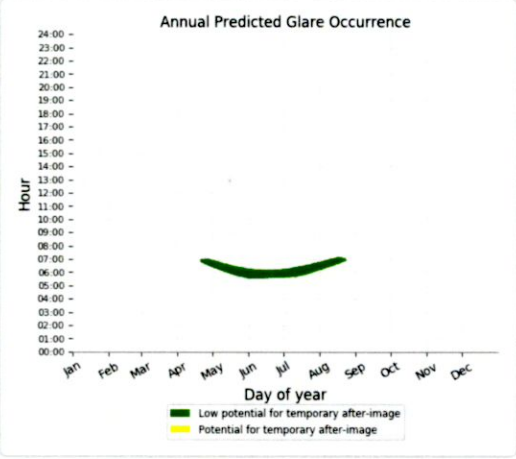
0 minutes of yellow glare
0 minutes of green glare

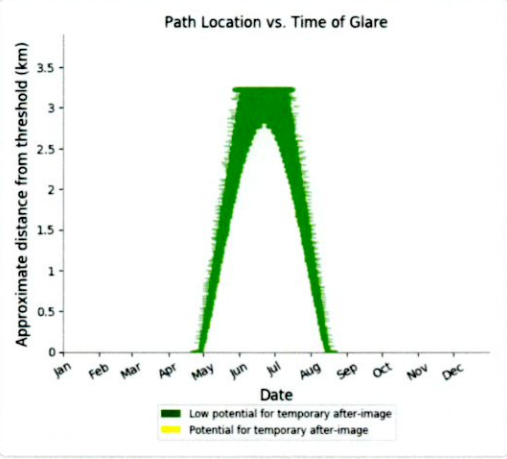
Results for: Area 3 NW

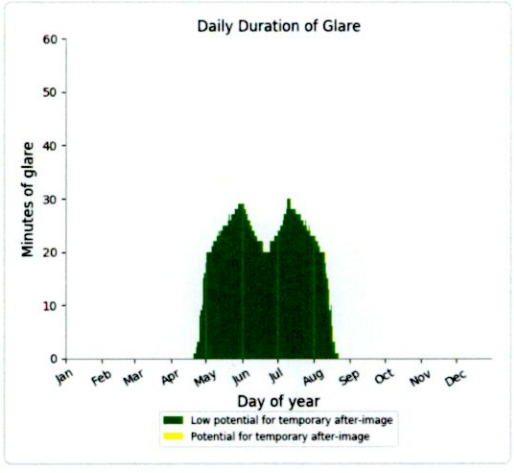
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	2645	0
Casement 10 Runway	326	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	0	0

Flight Path: Casement 04 Runway

0 minutes of yellow glare
2645 minutes of green glare



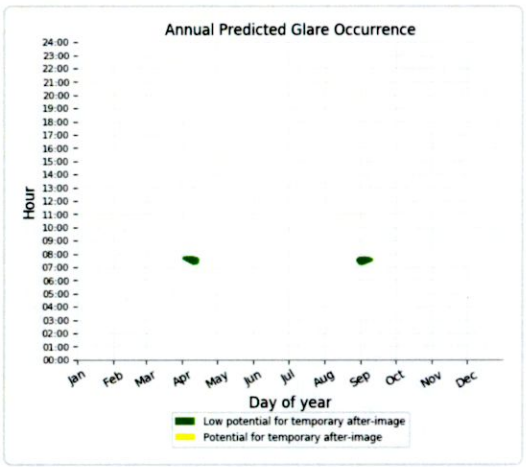


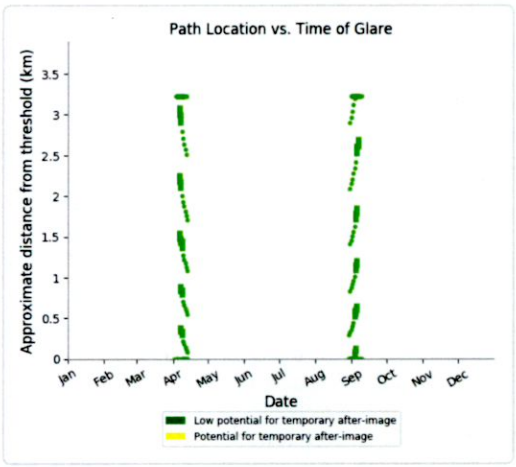


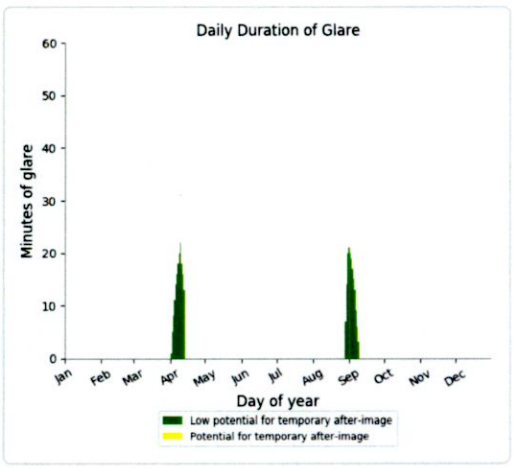
Flight Path: Casement 10 Runway

0 minutes of yellow glare

326 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
0 minutes of green glare

Results for: Area 3 SE

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

Flight Path: Casement 04 Runway

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare
0 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
0 minutes of green glare

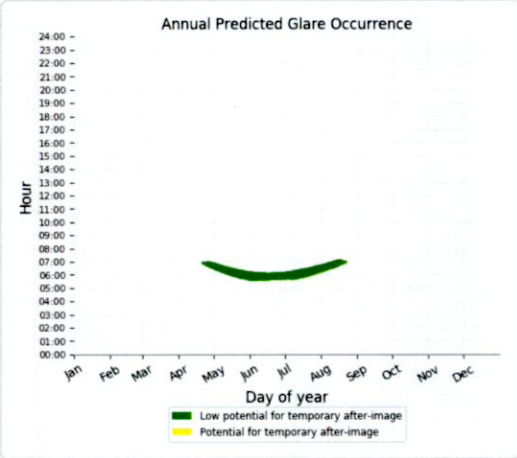
Results for: Area 4 NW

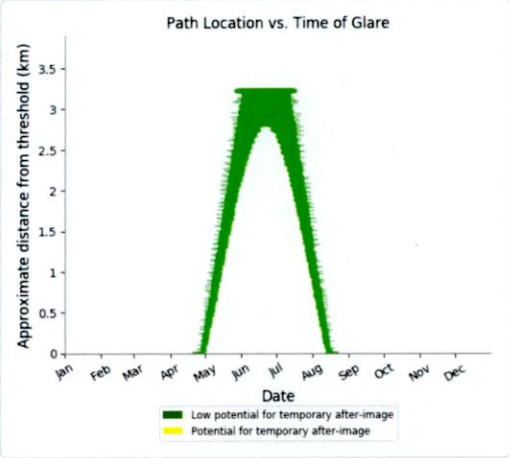
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	2518	0
Casement 10 Runway	318	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	0	0

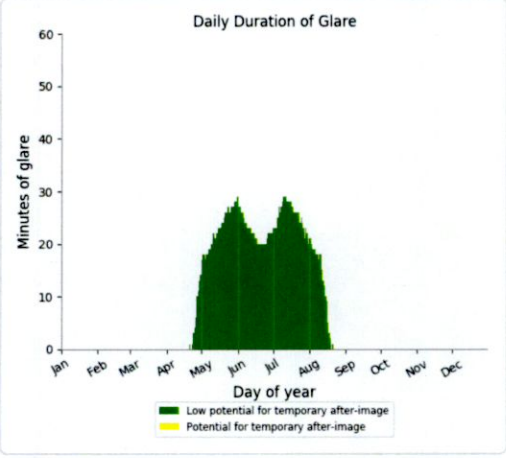
Flight Path: Casement 04 Runway

0 minutes of yellow glare

2518 minutes of green glare



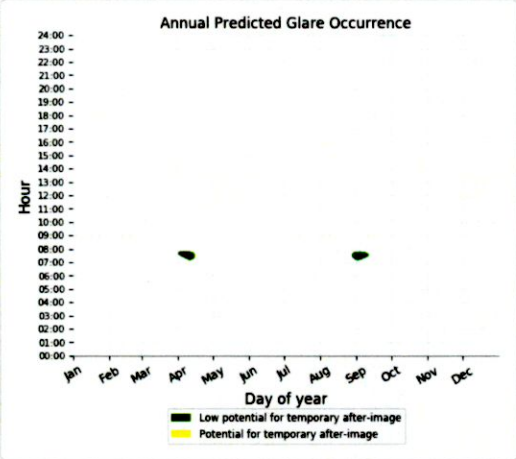


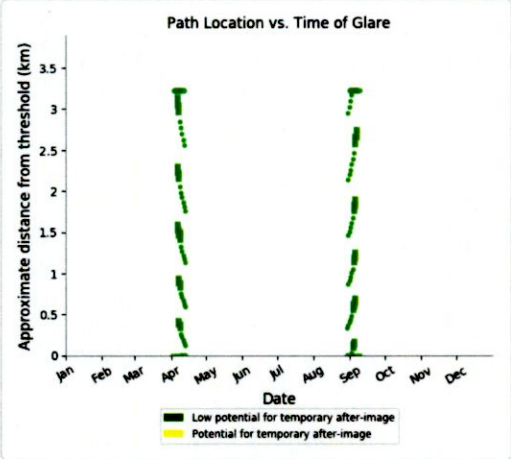


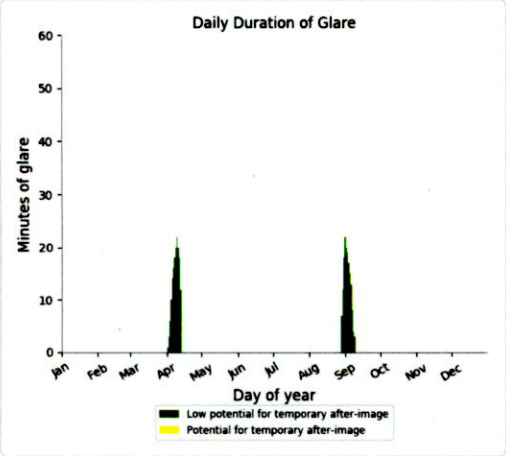
Flight Path: Casement 10 Runway

0 minutes of yellow glare

318 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
0 minutes of green glare

Results for: Area 4 SE

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

Flight Path: Casement 04 Runway

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare
0 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
0 minutes of green glare

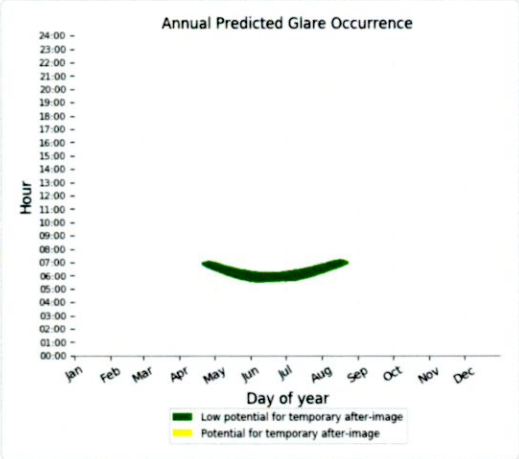
Results for: Area 5 NW

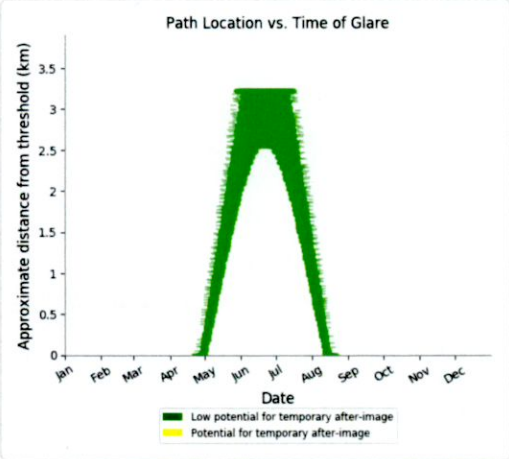
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	3310	0
Casement 10 Runway	473	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	0	0

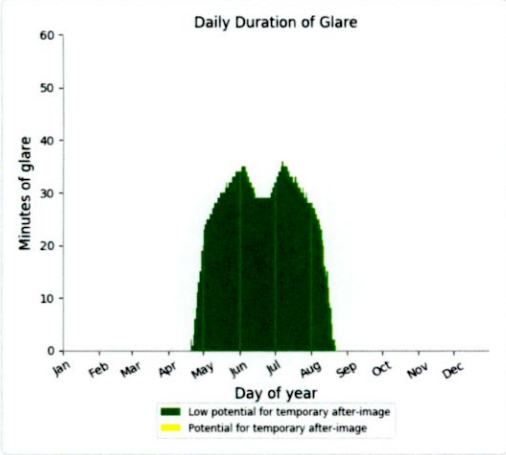
Flight Path: Casement 04 Runway

0 minutes of yellow glare

3310 minutes of green glare



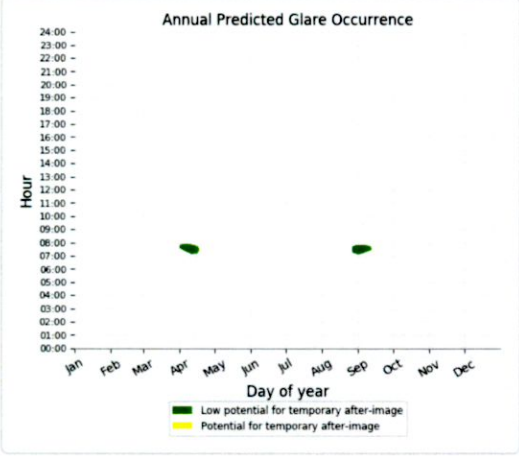


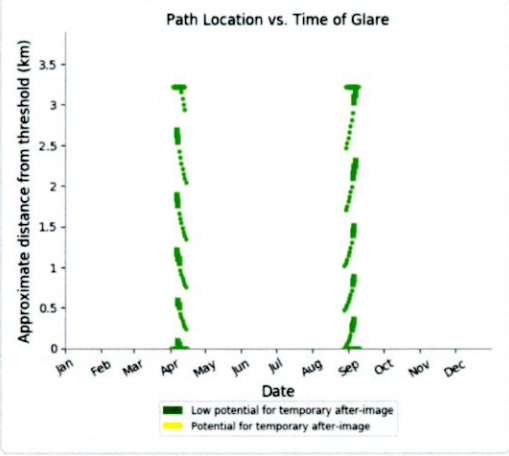


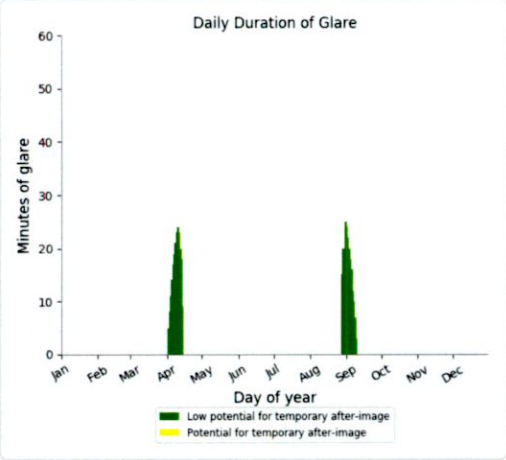
Flight Path: Casement 10 Runway

0 minutes of yellow glare

473 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
0 minutes of green glare

Results for: Area 5 SE

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

Flight Path: Casement 04 Runway

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare

0 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

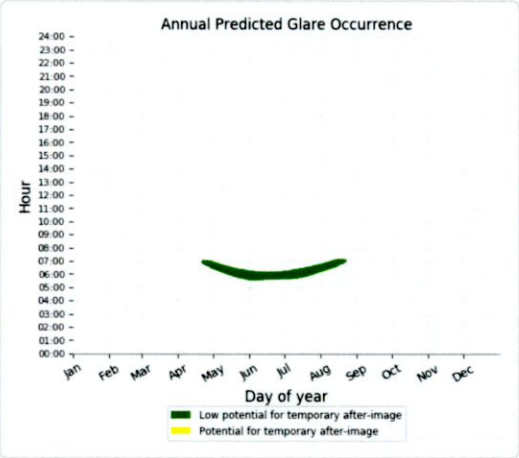
0 minutes of yellow glare
0 minutes of green glare

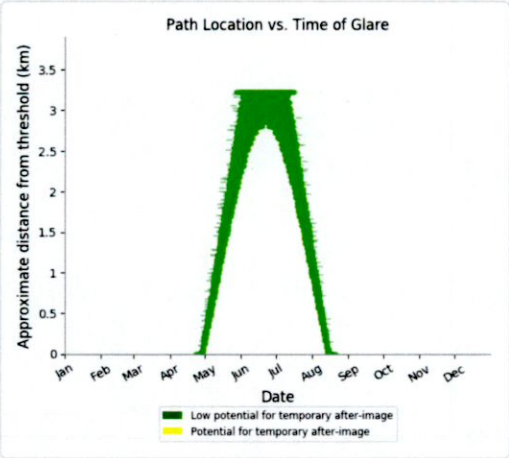
Results for: Area 6 NW

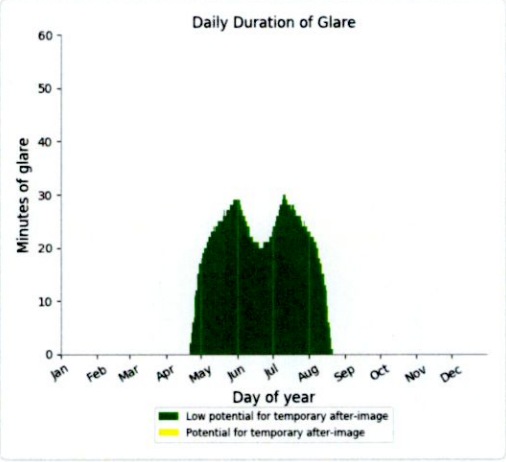
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	2677	0
Casement 10 Runway	320	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	0	0

Flight Path: Casement 04 Runway

0 minutes of yellow glare
2677 minutes of green glare



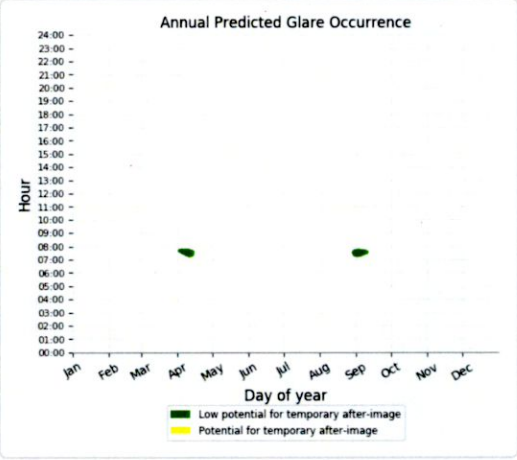


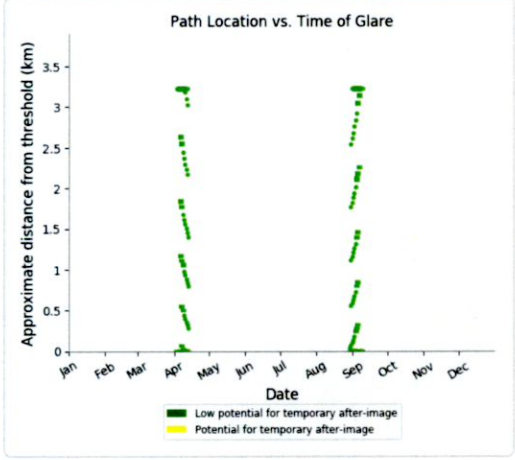


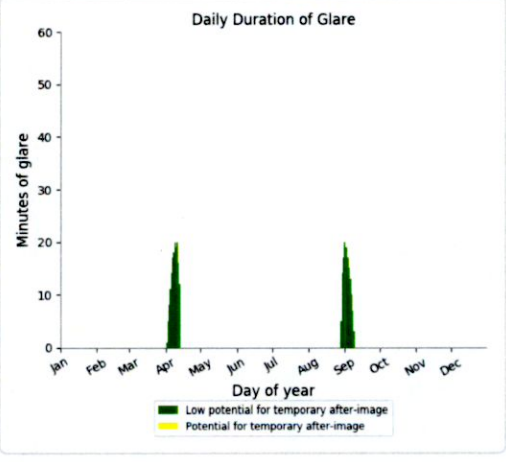
Flight Path: Casement 10 Runway

0 minutes of yellow glare

320 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
0 minutes of green glare

Results for: Area 6 SE

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

Flight Path: Casement 04 Runway

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare
0 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
0 minutes of green glare

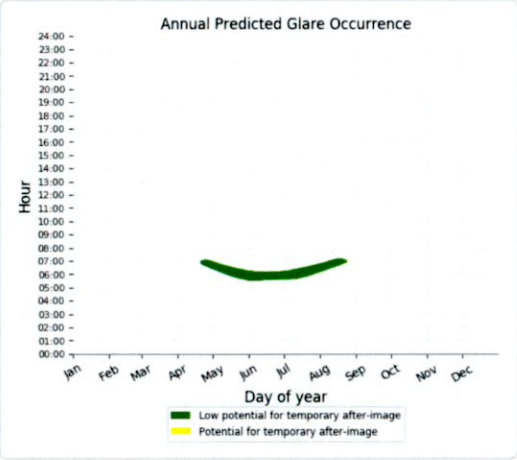
Results for: Area 7 NW

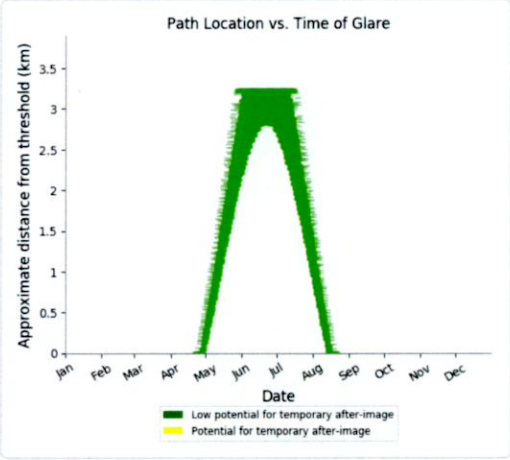
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	2776	0
Casement 10 Runway	328	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	0	0

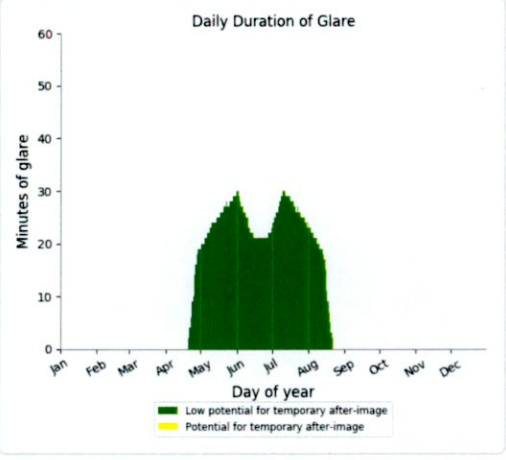
Flight Path: Casement 04 Runway

0 minutes of yellow glare

2776 minutes of green glare



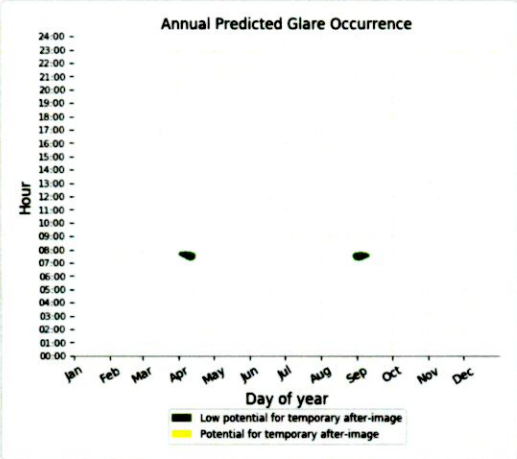


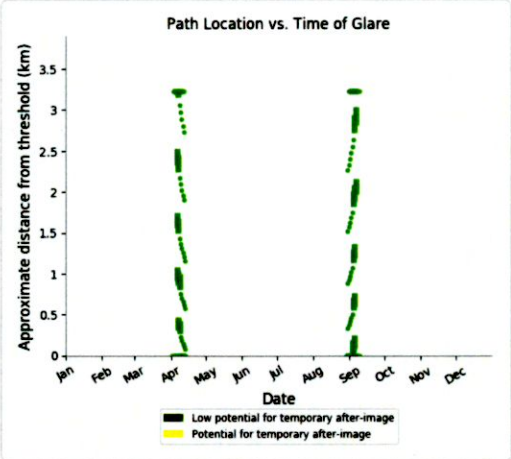


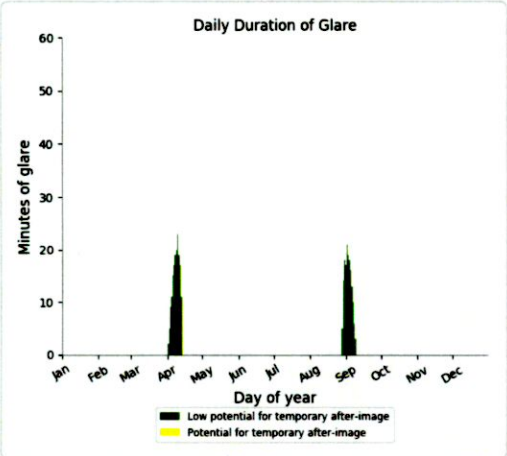
Flight Path: Casement 10 Runway

0 minutes of yellow glare

328 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
0 minutes of green glare

Results for: Area 7 SE

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

Flight Path: Casement 04 Runway

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare
0 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
0 minutes of green glare

Results for: Staircore Facade PV Array

Face 1-2

Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	0	0
Casement 10 Runway	0	0
Casement 22 Runway	0	0

Receptor	Green Glare (min)	Yellow Glare (min)
Casement 28 Runway	0	0
1-ATCT	0	0

Flight Path: Casement 04 Runway

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare
0 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
0 minutes of green glare

Assumptions

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

APPENDIX B:

RUNWAYS APPROACHES AND AIR TRAFFIC CONTROL TOWERS (ATCT) - COVERED PARKING BAY MOUNTED PV INSTALLMENT ONLY

The SGHAT results contained within this Appendix assess the potential for glint and glare from the proposed roof-mounted photovoltaic (PV) panel installation on only the covered parking bay at Casement Aerodrome Runway Approaches and Casement ATCT.

FORGESOLAR GLARE ANALYSIS

Project: **Tallagh Hospital - Helipad**
Site configuration: **Glen Abbey HSE 2**
Analysis conducted by Luis Dominguez (luis@macroworks.ie) at 14:50 on 05 Oct, 2022.

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

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

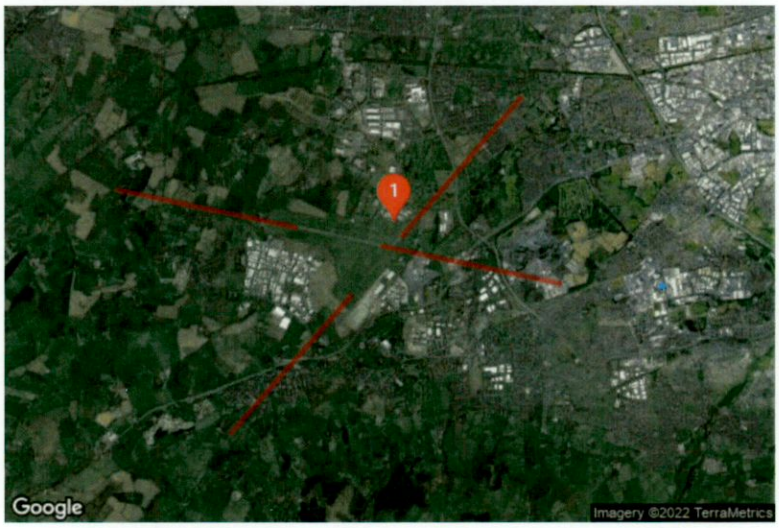
- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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: 77093.9959
Methodology: V2



PV Array(s)

Name: Canopy 1
Axis tracking: Fixed (no rotation)
Tilt: 5.0°
Orientation: 180.0°
Rated power: -
Panel material: Smooth glass without 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	53.295307	-6.369949	98.00	4.19	102.19
2	53.295238	-6.369950	98.00	3.48	101.48
3	53.295245	-6.370363	98.00	3.48	101.48
4	53.295314	-6.370362	98.00	4.19	102.19
5	53.295307	-6.369949	98.00	4.19	102.19

Name: Canopy 2
Axis tracking: Fixed (no rotation)
Tilt: 5.0°
Orientation: 104.0°
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	53.295322	-6.370423	98.00	4.19	102.19
2	53.295314	-6.370362	98.00	4.19	102.19
3	53.295246	-6.370391	98.00	3.48	101.48
4	53.295255	-6.370453	98.00	3.48	101.48
5	53.295322	-6.370423	98.00	4.19	102.19

Name: Canopy 3
Axis tracking: Fixed (no rotation)
Tilt: 5.0°
Orientation: 230.0°
Rated power: -
Panel material: Smooth glass without 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	53.295344	-6.370474	98.00	4.19	102.19
2	53.295322	-6.370423	98.00	4.19	102.19
3	53.295265	-6.370491	98.00	3.48	101.48
4	53.295287	-6.370541	98.00	3.48	101.48
5	53.295344	-6.370474	98.00	4.19	102.19

Name: Canopy 4
Axis tracking: Fixed (no rotation)
Tilt: 5.0°
Orientation: 248.0°
Rated power: -
Panel material: Smooth glass without 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	53.295374	-6.370510	98.00	4.19	102.19
2	53.295344	-6.370474	98.00	4.19	102.19
3	53.295304	-6.370571	98.00	3.48	101.48
4	53.295334	-6.370607	98.00	3.48	101.48
5	53.295374	-6.370510	98.00	4.19	102.19

Name: Canopy 5
Axis tracking: Fixed (no rotation)
Tilt: 5.0°
Orientation: 262.0°
Rated power: -
Panel material: Smooth glass without 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	53.295410	-6.370526	98.00	4.19	102.19
2	53.295374	-6.370510	98.00	4.19	102.19
3	53.295357	-6.370624	98.00	3.48	101.48
4	53.295392	-6.370640	98.00	3.48	101.48
5	53.295410	-6.370526	98.00	4.19	102.19

Name: Canopy 6
Axis tracking: Fixed (no rotation)
Tilt: 5.0°
Orientation: 273.0°
Rated power: -
Panel material: Smooth glass without 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	53.295444	-6.370522	98.00	4.19	102.19
2	53.295410	-6.370526	98.00	4.19	102.19
3	53.295415	-6.370644	98.00	3.48	101.48
4	53.295450	-6.370641	98.00	3.48	101.48
5	53.295444	-6.370522	98.00	4.19	102.19

Name: Canopy 7
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 280.0°
Rated power: -
Panel material: Smooth glass without 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	53.295512	-6.370490	98.00	4.19	102.19
2	53.295444	-6.370522	98.00	4.19	102.19
3	53.295463	-6.370633	98.00	3.48	101.48
4	53.295532	-6.370601	98.00	3.48	101.48
5	53.295512	-6.370490	98.00	4.19	102.19

Flight Path Receptor(s)

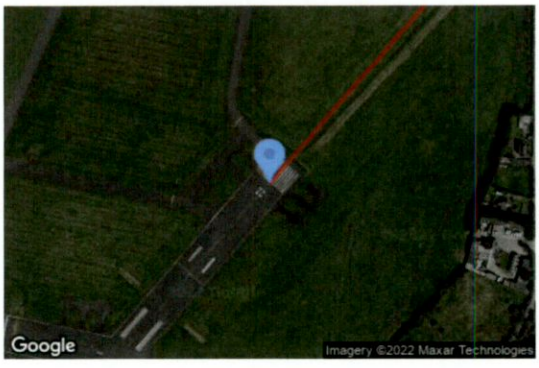
Name: Casement 04 Runway
Description: None
Threshold height: 15 m
Direction: 41.3°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.293830	-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: 3.0°
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	53.304622	-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: 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	53.303267	-6.439788	93.40	15.20	108.60
Two-mile	53.325107	-6.408047	62.50	214.80	277.30

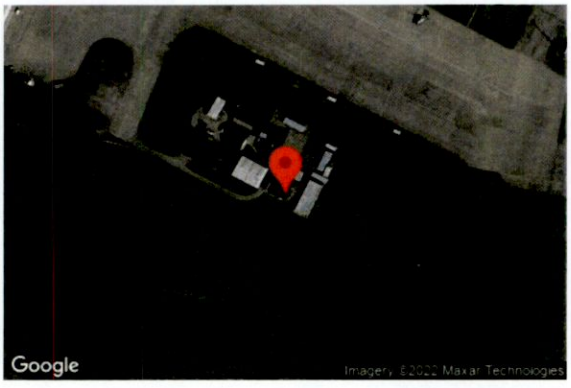
Name: Casement 28 Runway
Description: None
Threshold height: 15 m
Direction: 281.8°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

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 min	"Yellow" Glare min	Energy kWh
Canopy 1	5.0	180.0	1,809	0	-
Canopy 2	5.0	104.0	0	0	-
Canopy 3	5.0	230.0	3,695	0	-
Canopy 4	5.0	248.0	3,945	0	-
Canopy 5	5.0	262.0	3,992	0	-
Canopy 6	5.0	273.0	3,956	0	-
Canopy 7	7.0	280.0	4,967	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
Casement 04 Runway	17600	0
Casement 10 Runway	2787	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	1977	0

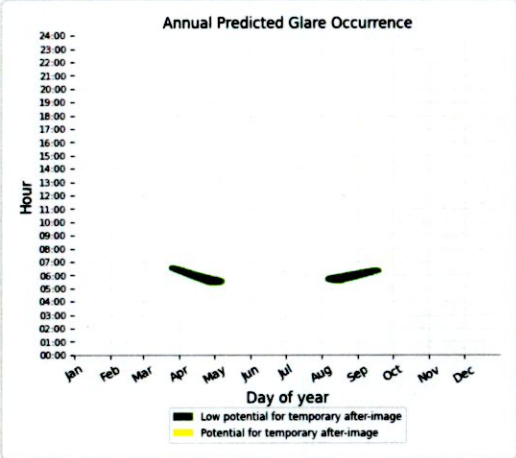
Results for: Canopy 1

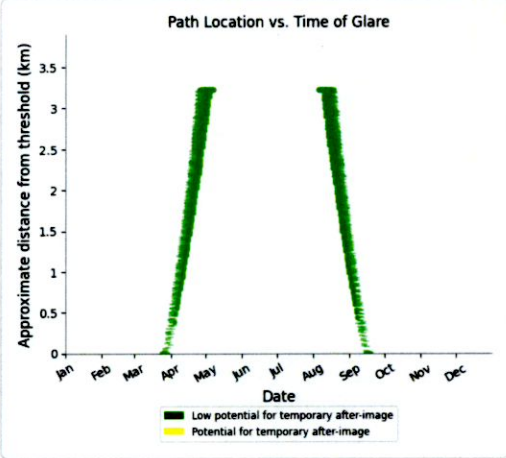
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	1700	0
Casement 10 Runway	109	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	0	0

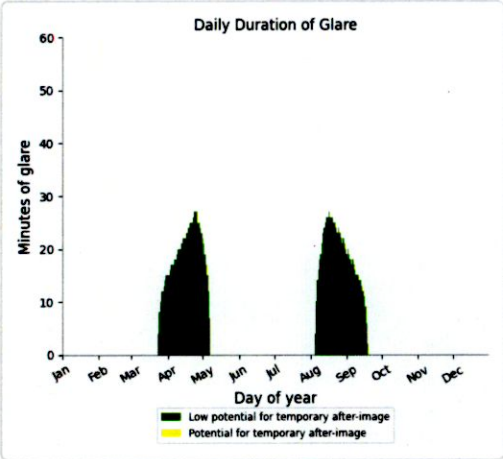
Flight Path: Casement 04 Runway

0 minutes of yellow glare

1700 minutes of green glare



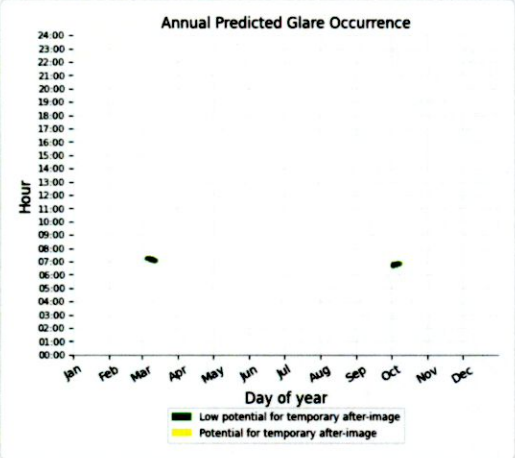


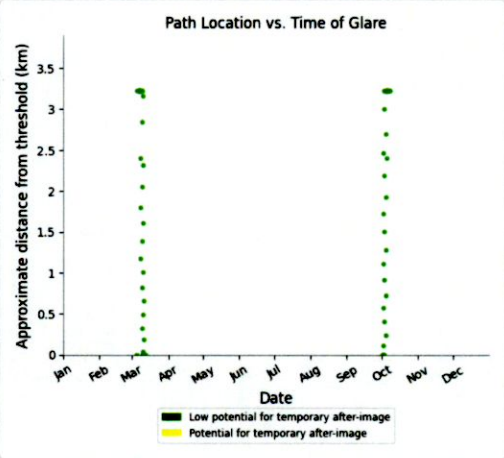


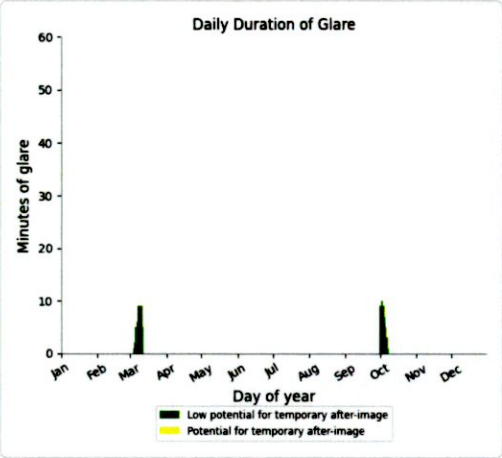
Flight Path: Casement 10 Runway

0 minutes of yellow glare

109 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

0 minutes of green glare

Results for: Canopy 2

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

Flight Path: Casement 04 Runway

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare
0 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
0 minutes of green glare

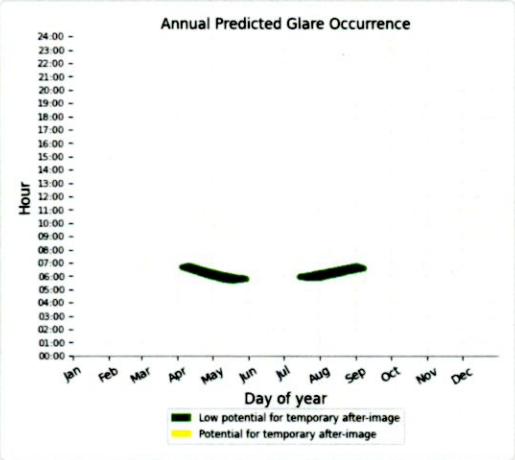
Results for: Canopy 3

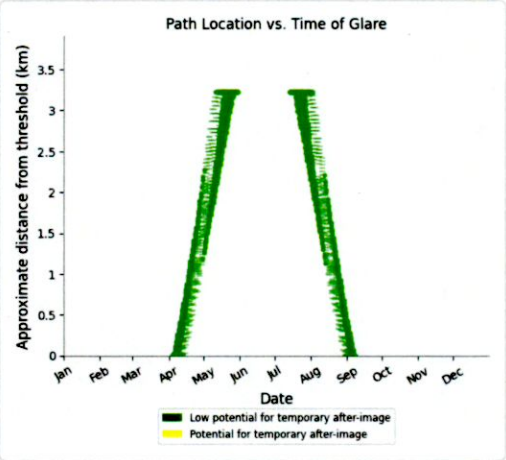
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	2803	0
Casement 10 Runway	524	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	368	0

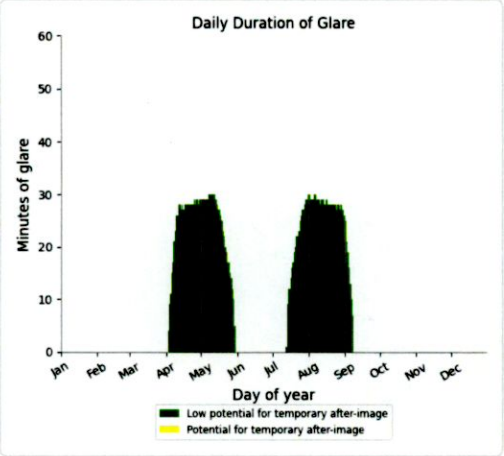
Flight Path: Casement 04 Runway

0 minutes of yellow glare

2803 minutes of green glare



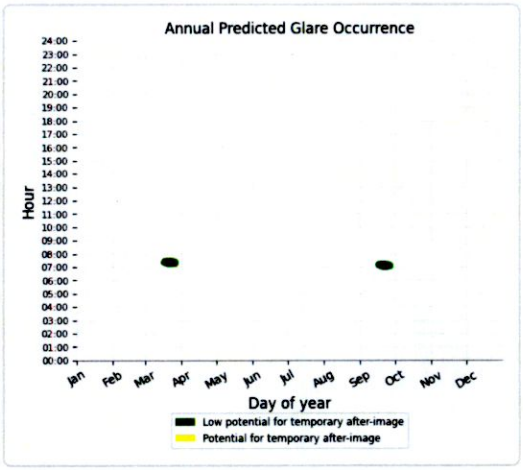


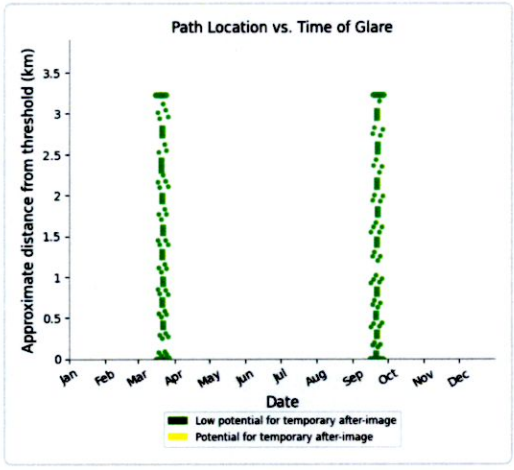


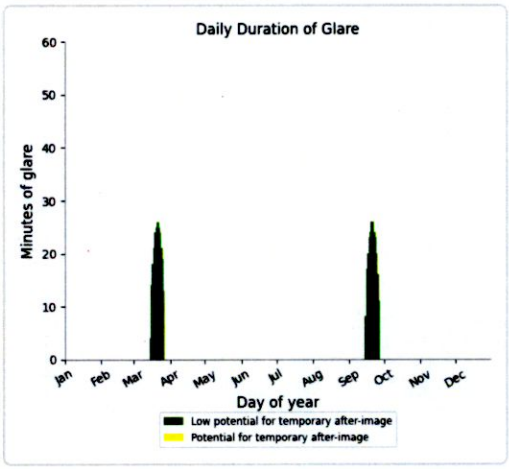
Flight Path: Casement 10 Runway

0 minutes of yellow glare

524 minutes of green glare







Flight Path: Casement 22 Runway

0 minutes of yellow glare

0 minutes of green glare

Flight Path: Casement 28 Runway

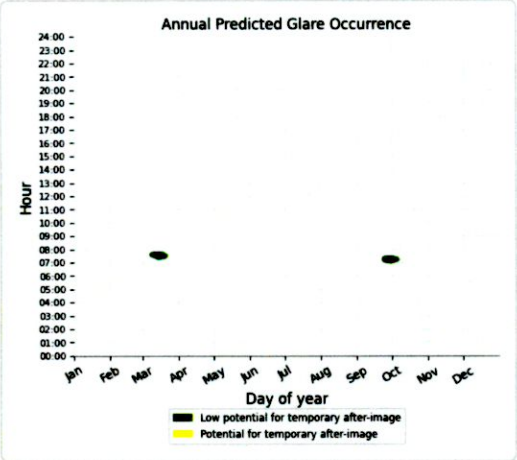
0 minutes of yellow glare

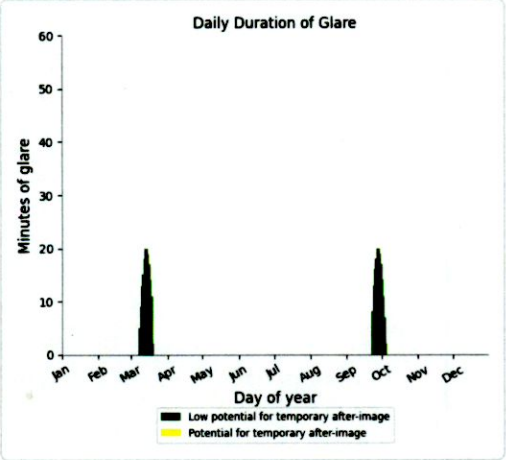
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare

368 minutes of green glare





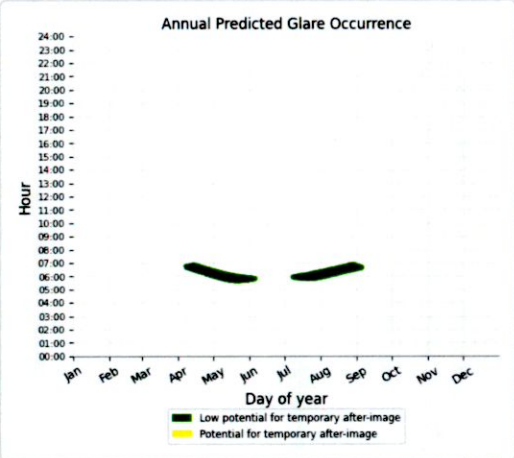
Results for: Canopy 4

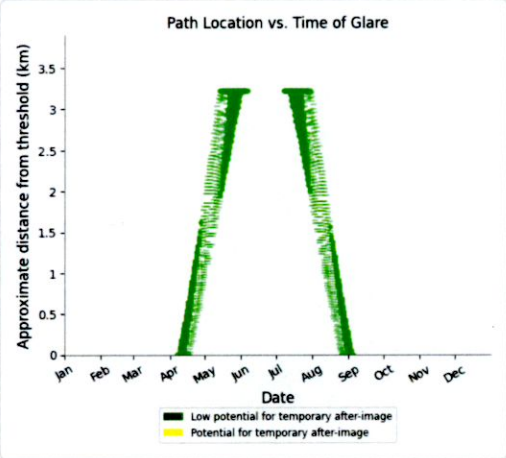
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	3015	0
Casement 10 Runway	528	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	402	0

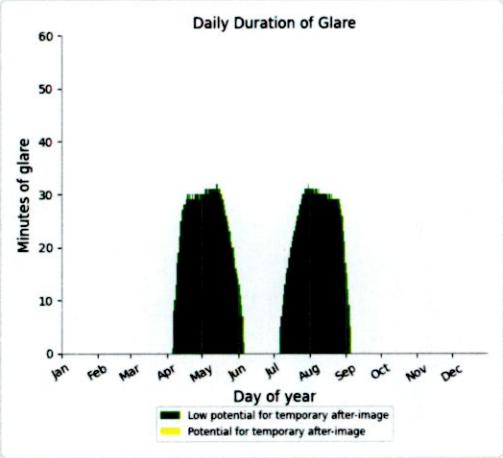
Flight Path: Casement 04 Runway

0 minutes of yellow glare

3015 minutes of green glare



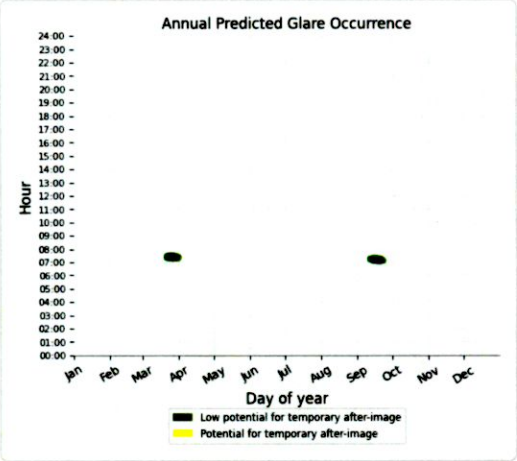


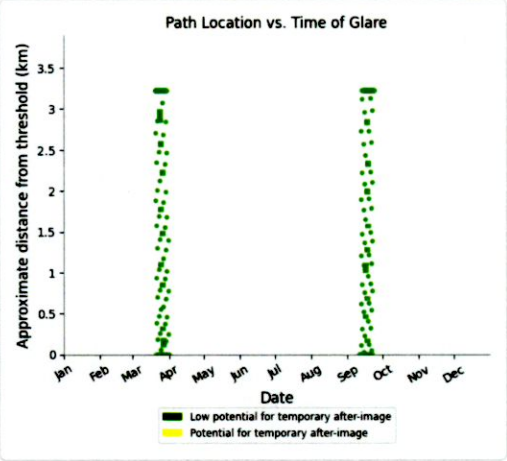


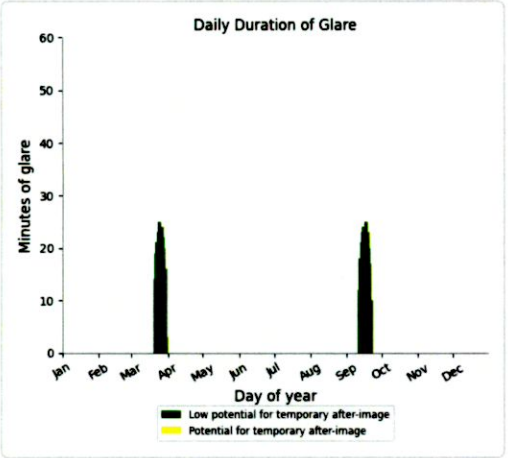
Flight Path: Casement 10 Runway

0 minutes of yellow glare

528 minutes of green glare







Flight Path: Casement 22 Runway

0 minutes of yellow glare

0 minutes of green glare

Flight Path: Casement 28 Runway

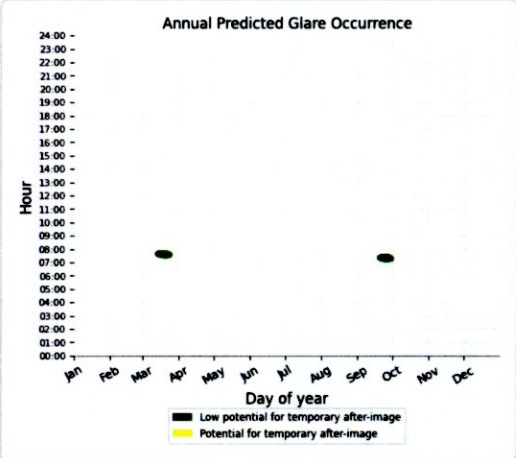
0 minutes of yellow glare

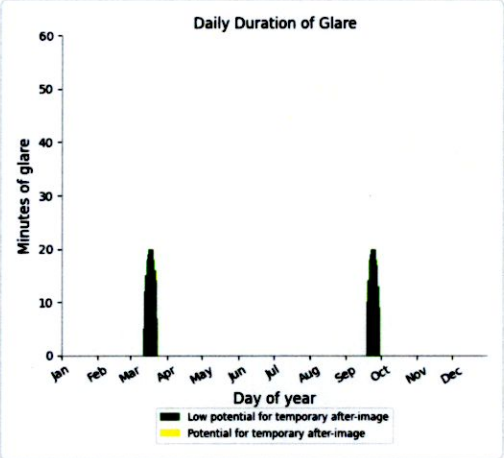
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare

402 minutes of green glare





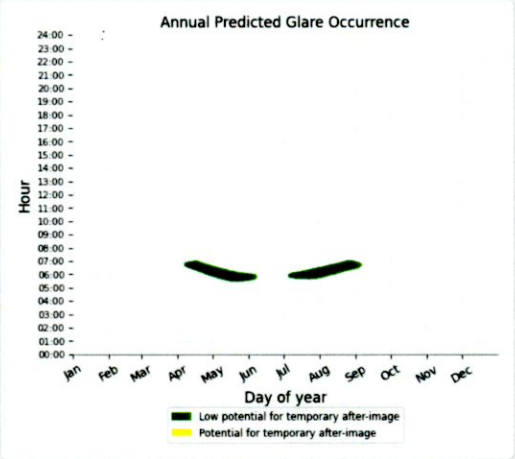
Results for: Canopy 5

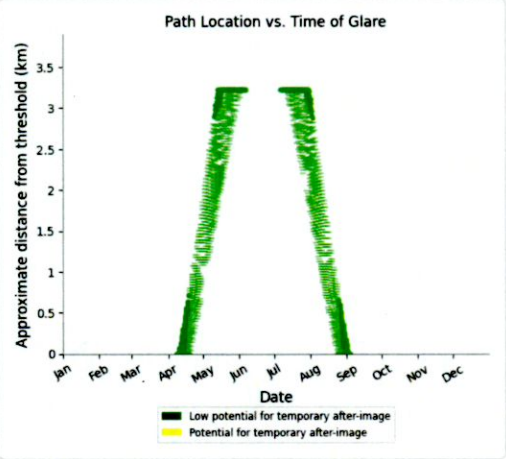
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	3061	0
Casement 10 Runway	532	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	399	0

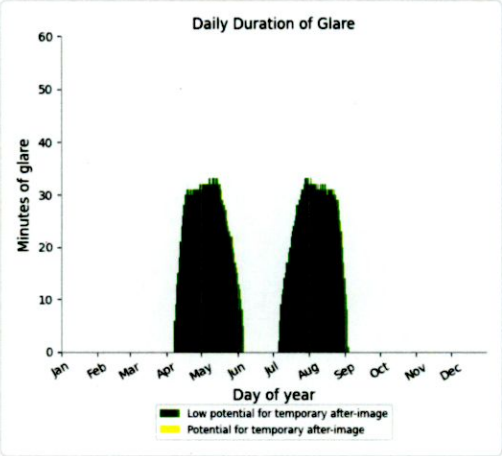
Flight Path: Casement 04 Runway

0 minutes of yellow glare

3061 minutes of green glare



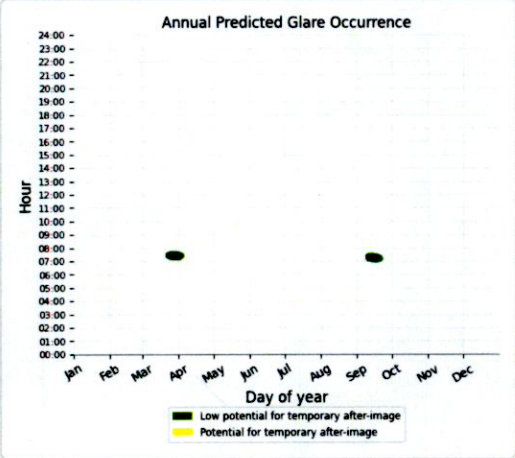


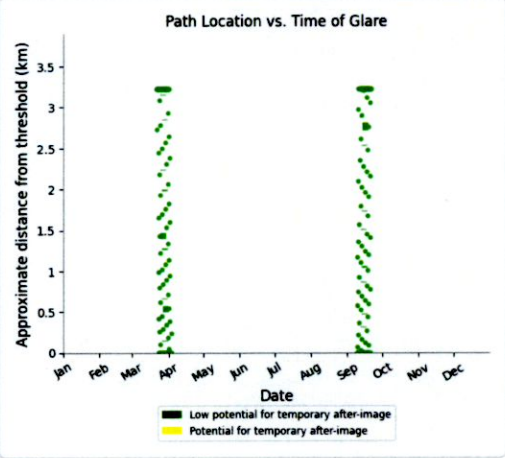


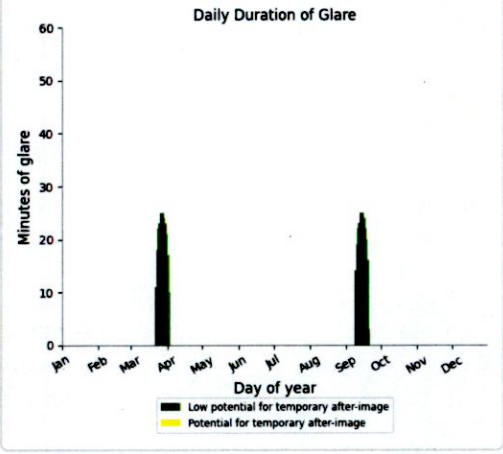
Flight Path: Casement 10 Runway

0 minutes of yellow glare

532 minutes of green glare







Flight Path: Casement 22 Runway

0 minutes of yellow glare

0 minutes of green glare

Flight Path: Casement 28 Runway

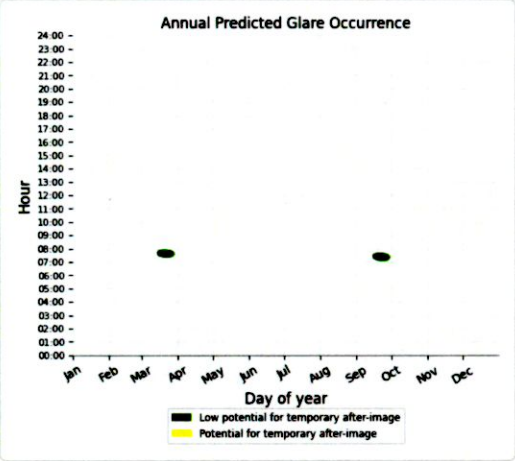
0 minutes of yellow glare

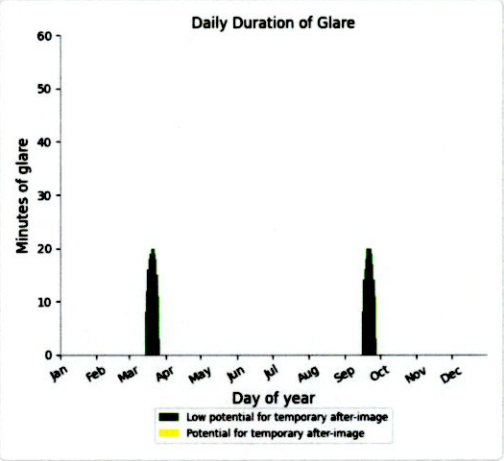
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare

399 minutes of green glare





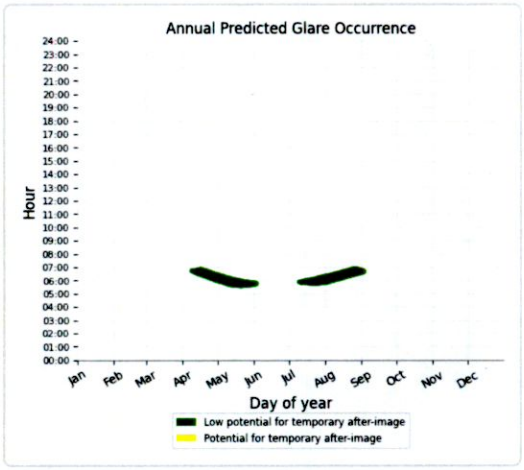
Results for: Canopy 6

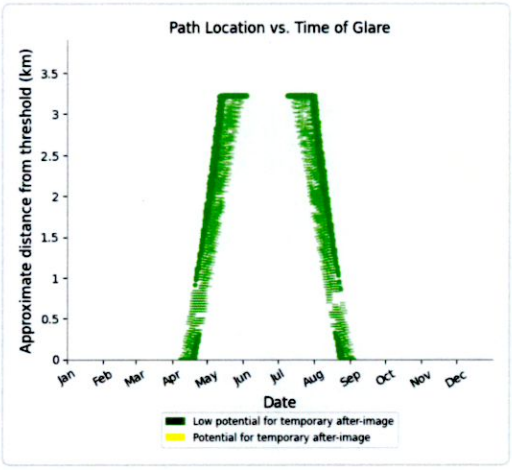
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	3023	0
Casement 10 Runway	534	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	399	0

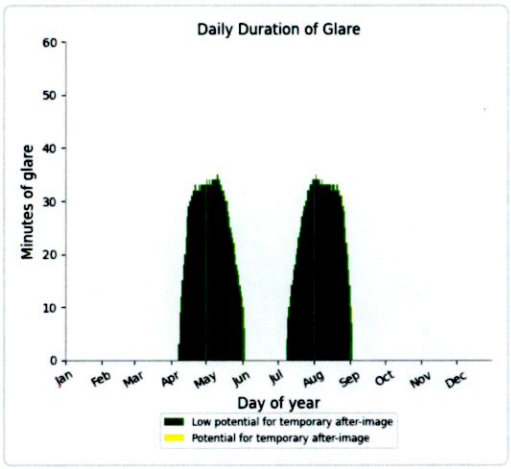
Flight Path: Casement 04 Runway

0 minutes of yellow glare

3023 minutes of green glare



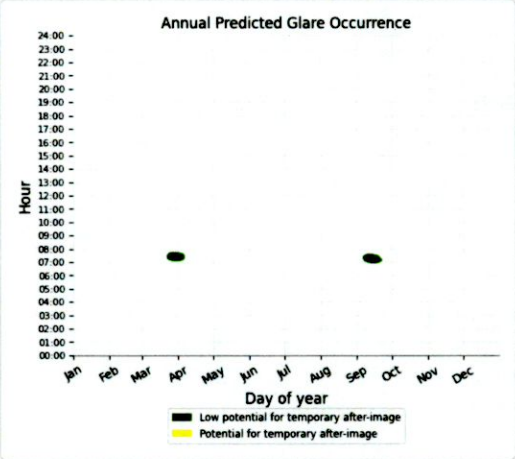


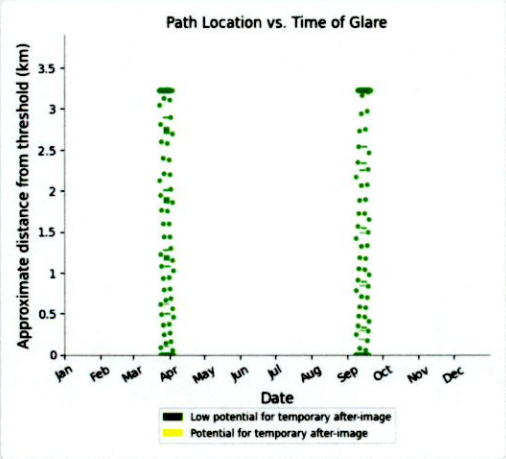


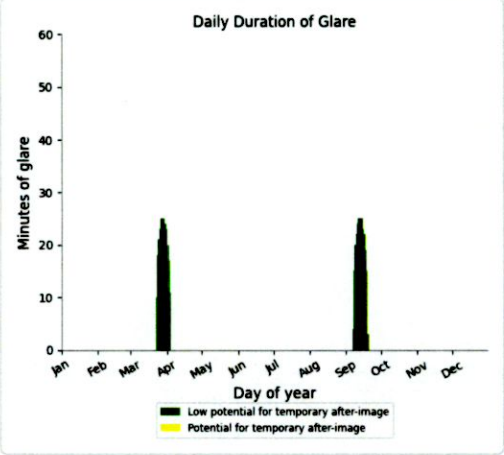
Flight Path: Casement 10 Runway

0 minutes of yellow glare

534 minutes of green glare







Flight Path: Casement 22 Runway

0 minutes of yellow glare

0 minutes of green glare

Flight Path: Casement 28 Runway

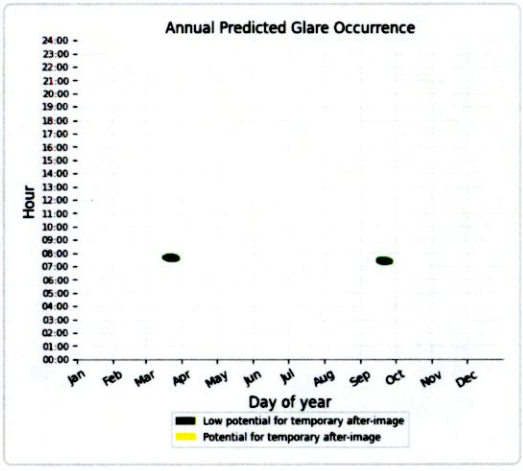
0 minutes of yellow glare

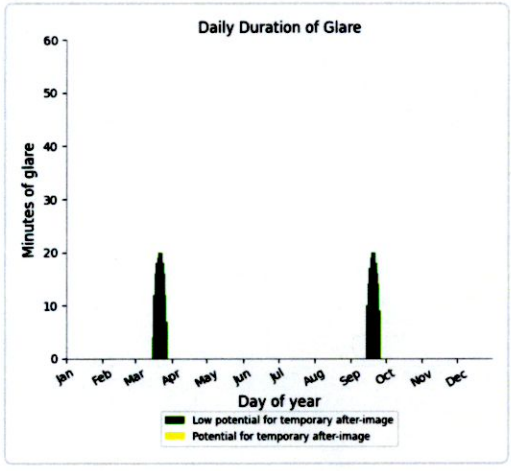
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare

399 minutes of green glare





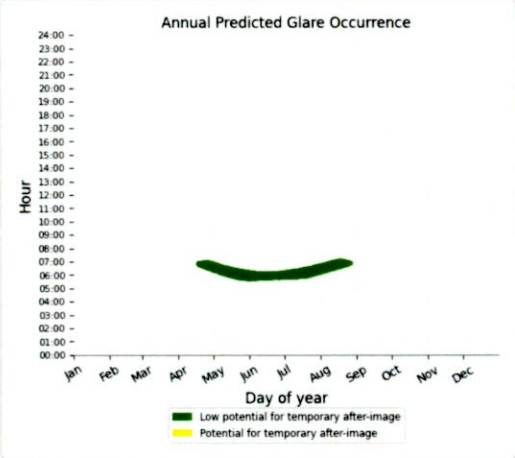
Results for: Canopy 7

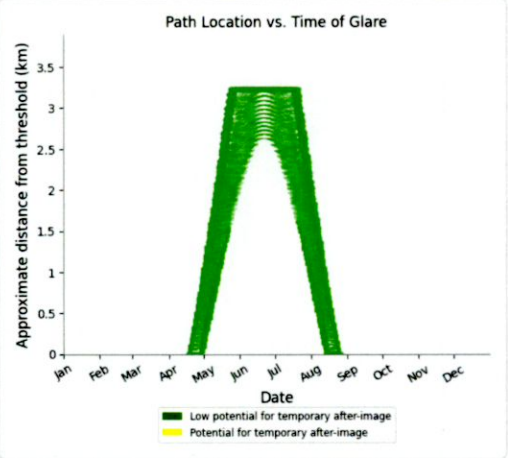
Receptor	Green Glare (min)	Yellow Glare (min)
Casement 04 Runway	3998	0
Casement 10 Runway	560	0
Casement 22 Runway	0	0
Casement 28 Runway	0	0
1-ATCT	409	0

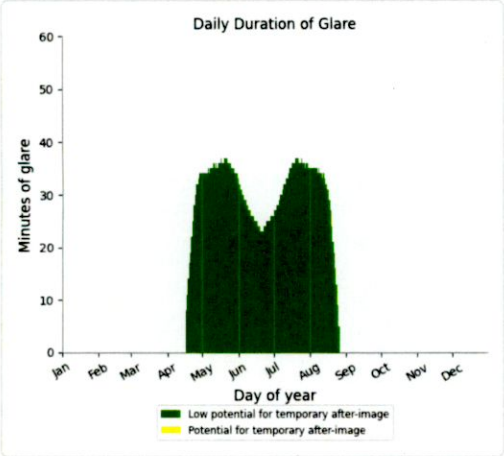
Flight Path: Casement 04 Runway

0 minutes of yellow glare

3998 minutes of green glare



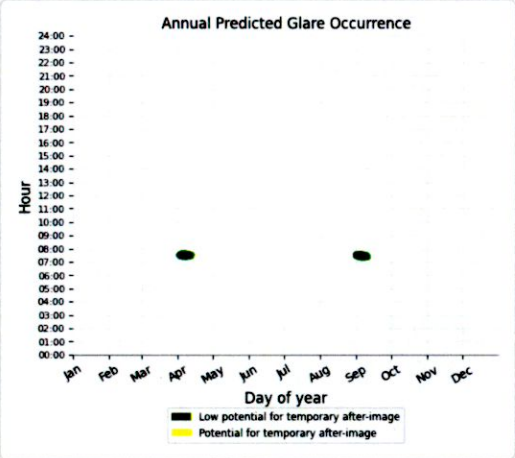


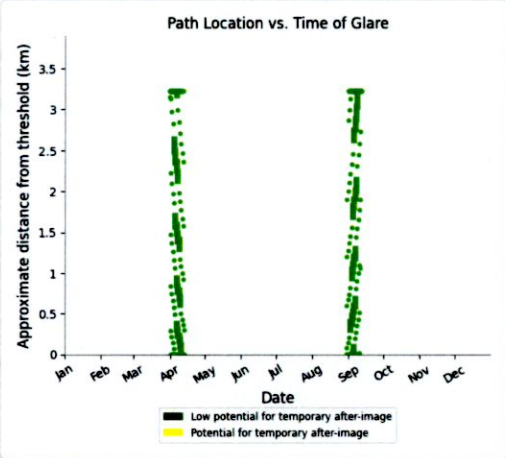


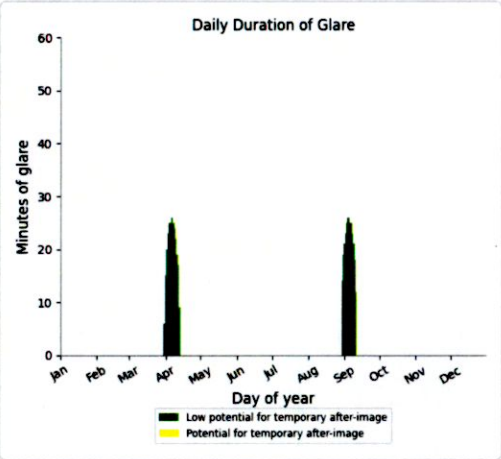
Flight Path: Casement 10 Runway

0 minutes of yellow glare

560 minutes of green glare







Flight Path: Casement 22 Runway

0 minutes of yellow glare

0 minutes of green glare

Flight Path: Casement 28 Runway

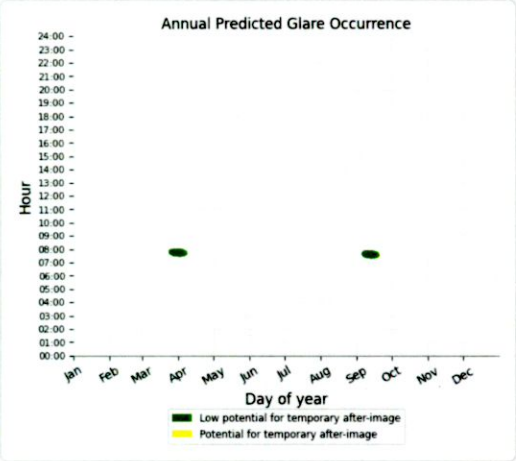
0 minutes of yellow glare

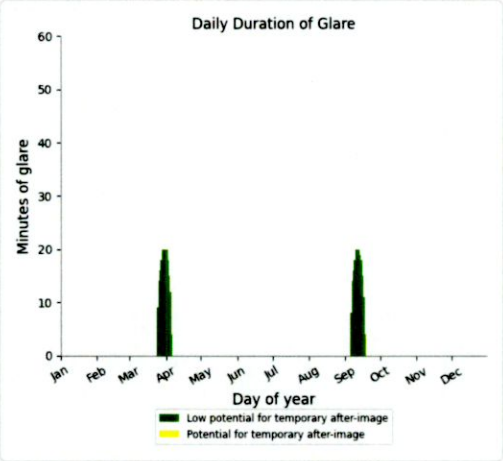
0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare

409 minutes of green glare





Assumptions

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

APPENDIX C:

HELICOPTER RECEPTORS - BUILDING MOUNTED PV INSTALLMENT ONLY

The results contained within this Appendix assess the potential for glint and glare from the proposed roof-mounted photovoltaic (PV) panel installation on the roof of the proposed HSE Belgard Ambulance Base building only at Tallaght University Hospital Helipad.

FORGESOLAR GLARE ANALYSIS

Project: **Tallagh Hospital - Helipad**
Site configuration: **Glen Abbey HSE**
Analysis conducted by Luis Dominguez (luis@macroworks.ie) at 17:06 on 25 Jun, 2021.

U.S. FAA 2013 Policy Adherence

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

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

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

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

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

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

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

SITE CONFIGURATION

Analysis Parameters

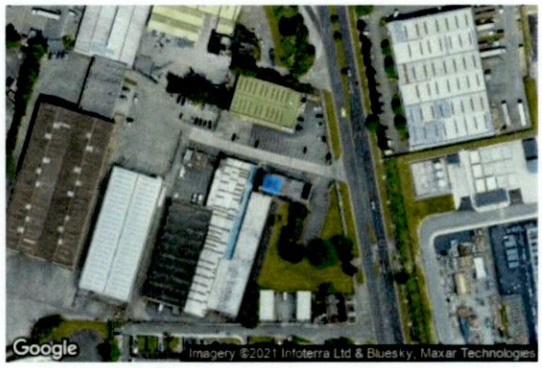
DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 55646.9959

PV Array(s)

Name: Area 1 NW
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 285.0°
Rated power: -
Panel material: Smooth glass without 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	53.295870	-6.370676	98.00	11.48	109.48
2	53.295850	-6.370561	98.00	11.48	109.48
3	53.295788	-6.370591	98.00	11.48	109.48
4	53.295808	-6.370706	98.00	11.48	109.48
5	53.295870	-6.370676	98.00	11.48	109.48

Name: Area 1 SE
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 105.0°
Rated power: -
Panel material: Smooth glass without 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	53.295870	-6.370676	98.00	11.48	109.48
2	53.295850	-6.370561	98.00	11.48	109.48
3	53.295788	-6.370591	98.00	11.48	109.48
4	53.295808	-6.370706	98.00	11.48	109.48
5	53.295870	-6.370676	98.00	11.48	109.48

Name: Area 2 NW
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 285.0°
Rated power: -
Panel material: Smooth glass without 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	53.295847	-6.370546	98.00	11.48	109.48
2	53.295827	-6.370431	98.00	11.48	109.48
3	53.295765	-6.370458	98.00	11.48	109.48
4	53.295785	-6.370576	98.00	11.48	109.48
5	53.295847	-6.370546	98.00	11.48	109.48

Name: Area 2 SE
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 105.0°
Rated power: -
Panel material: Smooth glass without 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	53.295847	-6.370546	98.00	11.48	109.48
2	53.295827	-6.370431	98.00	11.48	109.48
3	53.295765	-6.370458	98.00	11.48	109.48
4	53.295785	-6.370576	98.00	11.48	109.48
5	53.295847	-6.370546	98.00	11.48	109.48

Name: Area 3 NW
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 285.0°
Rated power: -
Panel material: Smooth glass without 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	53.295825	-6.370416	98.00	11.48	109.48
2	53.295804	-6.370300	98.00	11.48	109.48
3	53.295742	-6.370331	98.00	11.48	109.48
4	53.295763	-6.370446	98.00	11.48	109.48
5	53.295825	-6.370416	98.00	11.48	109.48

Name: Area 3 SE
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 105.0°
Rated power: -
Panel material: Smooth glass without 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	53.295825	-6.370416	98.00	11.48	109.48
2	53.295804	-6.370300	98.00	11.48	109.48
3	53.295742	-6.370331	98.00	11.48	109.48
4	53.295763	-6.370446	98.00	11.48	109.48
5	53.295825	-6.370416	98.00	11.48	109.48

Name: Area 4 NW
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 285.0°
Rated power: -
Panel material: Smooth glass without 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	53.295870	-6.370676	98.00	11.48	109.48
2	53.295850	-6.370561	98.00	11.48	109.48
3	53.295788	-6.370591	98.00	11.48	109.48
4	53.295808	-6.370706	98.00	11.48	109.48
5	53.295870	-6.370676	98.00	11.48	109.48

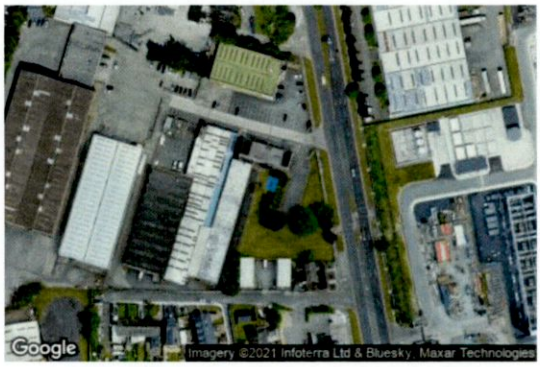
Name: Area 4 SE
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 105.0°
Rated power: -
Panel material: Smooth glass without AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.295715	-6.370483	98.00	14.20	112.20
2	53.295739	-6.370471	98.00	14.20	112.20
3	53.295727	-6.370397	98.00	14.20	112.20
4	53.295702	-6.370409	98.00	14.20	112.20
5	53.295715	-6.370483	98.00	14.20	112.20

Name: Area 5 NW
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 285.0°
Rated power: -
Panel material: Smooth glass without 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	53.295641	-6.370504	98.00	5.14	103.14
2	53.295692	-6.370479	98.00	5.14	103.14
3	53.295681	-6.370417	98.00	5.14	103.14
4	53.295630	-6.370442	98.00	5.14	103.14
5	53.295641	-6.370504	98.00	5.14	103.14

Name: Area 5 SE
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 105.0°
Rated power: -
Panel material: Smooth glass without 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	53.295641	-6.370504	98.00	5.14	103.14
2	53.295692	-6.370479	98.00	5.14	103.14
3	53.295681	-6.370417	98.00	5.14	103.14
4	53.295630	-6.370442	98.00	5.14	103.14
5	53.295641	-6.370504	98.00	5.14	103.14

Name: Area 6 NW
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 285.0°
Rated power: -
Panel material: Smooth glass without 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	53.295660	-6.370389	98.00	6.81	104.81
2	53.295652	-6.370345	98.00	6.81	104.81
3	53.295629	-6.370356	98.00	6.81	104.81
4	53.295636	-6.370400	98.00	6.81	104.81
5	53.295660	-6.370389	98.00	6.81	104.81

Name: Area 6 SE
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 105.0°
Rated power: -
Panel material: Smooth glass without 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	53.295660	-6.370389	98.00	6.81	104.81
2	53.295652	-6.370345	98.00	6.81	104.81
3	53.295629	-6.370356	98.00	6.81	104.81
4	53.295636	-6.370400	98.00	6.81	104.81
5	53.295660	-6.370389	98.00	6.81	104.81

Name: Area 7 NW
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 285.0°
Rated power: -
Panel material: Smooth glass without 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	53.295632	-6.370509	98.00	5.14	103.14
2	53.295610	-6.370379	98.00	5.14	103.14
3	53.295533	-6.370417	98.00	5.14	103.14
4	53.295555	-6.370547	98.00	5.14	103.14
5	53.295632	-6.370509	98.00	5.14	103.14

Name: Area 7 SE
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 105.0°
Rated power: -
Panel material: Smooth glass without 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	53.295632	-6.370509	98.00	5.14	103.14
2	53.295610	-6.370379	98.00	5.14	103.14
3	53.295533	-6.370417	98.00	5.14	103.14
4	53.295555	-6.370547	98.00	5.14	103.14
5	53.295632	-6.370509	98.00	5.14	103.14

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	53.289501	-6.376776	104.60	0.00
OP 2	2	53.289501	-6.376776	104.60	100.00
OP 3	3	53.289501	-6.376776	104.60	200.00
OP 4	4	53.289501	-6.376776	104.60	300.00

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt	Orient	"Green" Glare	"Yellow" Glare	Energy
	(°)	(°)	min	min	kWh
Area 1 NW	7.0	285.0	0	0	-
Area 1 SE	7.0	105.0	0	0	-
Area 2 NW	7.0	285.0	0	0	-
Area 2 SE	7.0	105.0	0	0	-
Area 3 NW	7.0	285.0	0	0	-
Area 3 SE	7.0	105.0	0	0	-
Area 4 NW	7.0	285.0	0	0	-
Area 4 SE	7.0	105.0	0	0	-
Area 5 NW	7.0	285.0	0	0	-
Area 5 SE	7.0	105.0	0	0	-
Area 6 NW	7.0	285.0	0	0	-
Area 6 SE	7.0	105.0	0	0	-
Area 7 NW	7.0	285.0	0	0	-
Area 7 SE	7.0	105.0	0	0	-

Total annual glare received by each receptor

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

Results for: Area 1 NW

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Area 1 SE

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Area 2 NW

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Area 2 SE

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Area 3 NW

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Area 3 SE

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Area 4 NW

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Area 4 SE

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Area 5 NW

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Area 5 SE

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Area 6 NW

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Area 6 SE

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Area 7 NW

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Area 7 SE

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Assumptions

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

APPENDIX D:

HELICOPTER RECEPTORS - COVERED PARKING BAY MOUNTED PV INSTALLMENT ONLY

The results contained within this Appendix assess the potential for glint and glare from the proposed roof-mounted photovoltaic (PV) panel installation on only the covered parking bay at Tallaght University Hospital Helipad.

FORGESOLAR GLARE ANALYSIS

Project: **Tallagh Hospital - Helipad**
Site configuration: **Glen Abbey HSE 2 TH**
Analysis conducted by Luis Dominguez (luis@macroworks.ie) at 15:39 on 05 Oct, 2022.

U.S. FAA 2013 Policy Adherence

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

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

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

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

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

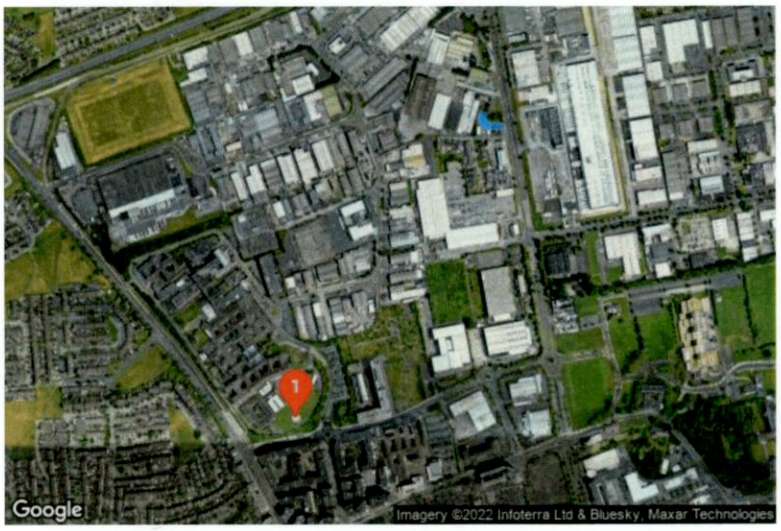
- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 77094.9959
Methodology: V2



PV Array(s)

Name: Canopy 1
Axis tracking: Fixed (no rotation)
Tilt: 5.0°
Orientation: 180.0°
Rated power: -
Panel material: Smooth glass without 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	53.295307	-6.369949	98.00	4.19	102.19
2	53.295238	-6.369950	98.00	3.48	101.48
3	53.295245	-6.370363	98.00	3.48	101.48
4	53.295314	-6.370362	98.00	4.19	102.19
5	53.295307	-6.369949	98.00	4.19	102.19

Name: Canopy 2
Axis tracking: Fixed (no rotation)
Tilt: 5.0°
Orientation: 104.0°
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	53.295322	-6.370423	98.00	4.19	102.19
2	53.295314	-6.370362	98.00	4.19	102.19
3	53.295246	-6.370391	98.00	3.48	101.48
4	53.295255	-6.370453	98.00	3.48	101.48
5	53.295322	-6.370423	98.00	4.19	102.19

Name: Canopy 3
Axis tracking: Fixed (no rotation)
Tilt: 5.0°
Orientation: 230.0°
Rated power: -
Panel material: Smooth glass without 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	53.295344	-6.370474	98.00	4.19	102.19
2	53.295322	-6.370423	98.00	4.19	102.19
3	53.295265	-6.370491	98.00	3.48	101.48
4	53.295287	-6.370541	98.00	3.48	101.48
5	53.295344	-6.370474	98.00	4.19	102.19

Name: Canopy 4
Axis tracking: Fixed (no rotation)
Tilt: 5.0°
Orientation: 248.0°
Rated power: -
Panel material: Smooth glass without 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	53.295374	-6.370510	98.00	4.19	102.19
2	53.295344	-6.370474	98.00	4.19	102.19
3	53.295304	-6.370571	98.00	3.48	101.48
4	53.295334	-6.370607	98.00	3.48	101.48
5	53.295374	-6.370510	98.00	4.19	102.19

Name: Canopy 5
Axis tracking: Fixed (no rotation)
Tilt: 5.0°
Orientation: 262.0°
Rated power: -
Panel material: Smooth glass without 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	53.295410	-6.370526	98.00	4.19	102.19
2	53.295374	-6.370510	98.00	4.19	102.19
3	53.295357	-6.370624	98.00	3.48	101.48
4	53.295392	-6.370640	98.00	3.48	101.48
5	53.295410	-6.370526	98.00	4.19	102.19

Name: Canopy 6
Axis tracking: Fixed (no rotation)
Tilt: 5.0°
Orientation: 273.0°
Rated power: -
Panel material: Smooth glass without 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	53.295444	-6.370522	98.00	4.19	102.19
2	53.295410	-6.370526	98.00	4.19	102.19
3	53.295415	-6.370644	98.00	3.48	101.48
4	53.295450	-6.370641	98.00	3.48	101.48
5	53.295444	-6.370522	98.00	4.19	102.19

Name: Canopy 7
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 280.0°
Rated power: -
Panel material: Smooth glass without 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	53.295512	-6.370490	98.00	4.19	102.19
2	53.295444	-6.370522	98.00	4.19	102.19
3	53.295463	-6.370633	98.00	3.48	101.48
4	53.295532	-6.370601	98.00	3.48	101.48
5	53.295512	-6.370490	98.00	4.19	102.19

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	53.289501	-6.376776	104.60	0.00
OP 2	2	53.289501	-6.376776	104.60	100.00
OP 3	3	53.289501	-6.376776	104.60	200.00
OP 4	4	53.289501	-6.376776	104.60	300.00

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
Canopy 1	5.0	180.0	0	0	-
Canopy 2	5.0	104.0	0	0	-
Canopy 3	5.0	230.0	0	0	-
Canopy 4	5.0	248.0	0	0	-
Canopy 5	5.0	262.0	0	0	-
Canopy 6	5.0	273.0	0	0	-
Canopy 7	7.0	280.0	0	0	-

Total annual glare received by each receptor

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

Results for: Canopy 1

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Canopy 2

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Canopy 3

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Canopy 4

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Canopy 5

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Canopy 6

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Results for: Canopy 7

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

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Assumptions

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