



FORGESOLAR GLARE ANALYSIS

Project: **SGHAT**

Site configuration: **College Lane Greenogue - Block C**

Analysis conducted by Luis Dominguez (luis@macroworks.ie) at 09:15 on 29 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):

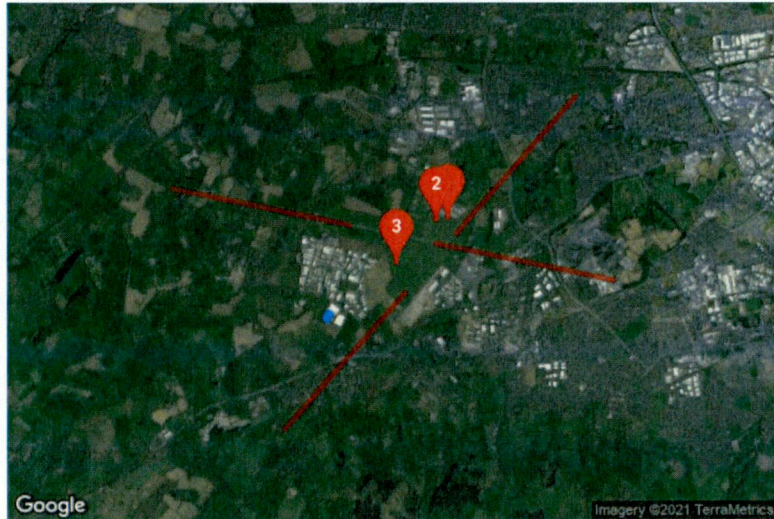
- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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/m²
 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: 55794.9717



PV Array(s)

Name: PA 1
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 230.0°
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 | 53.289828 | -6.475249 | 99.40 | 23.32 | 122.72 |
| 2 | 53.290848 | -6.474288 | 99.40 | 23.32 | 122.72 |
| 3 | 53.290809 | -6.474168 | 99.40 | 23.32 | 122.72 |
| 4 | 53.289787 | -6.475131 | 99.40 | 23.32 | 122.72 |
| 5 | 53.289828 | -6.475249 | 99.40 | 23.32 | 122.72 |

Name: PA 2

Axis tracking: Fixed (no rotation)

Tilt: 10.0°

Orientation: 230.0°

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 | 53.289766 | -6.475070 | 99.40 | 23.32 | 122.72 |
| 2 | 53.290784 | -6.474111 | 99.40 | 23.32 | 122.72 |
| 3 | 53.290735 | -6.473963 | 99.40 | 23.32 | 122.72 |
| 4 | 53.289718 | -6.474918 | 99.40 | 23.32 | 122.72 |
| 5 | 53.289766 | -6.475070 | 99.40 | 23.32 | 122.72 |

Name: PA 3

Axis tracking: Fixed (no rotation)

Tilt: 10.0°

Orientation: 230.0°

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 | 53.289707 | -6.474815 | 99.40 | 23.32 | 122.72 |
| 2 | 53.290707 | -6.473873 | 99.40 | 23.32 | 122.72 |
| 3 | 53.290657 | -6.473721 | 99.40 | 23.32 | 122.72 |
| 4 | 53.289657 | -6.474661 | 99.40 | 23.32 | 122.72 |
| 5 | 53.289707 | -6.474815 | 99.40 | 23.32 | 122.72 |

Name: PA 4

Axis tracking: Fixed (no rotation)

Tilt: 10.0°

Orientation: 230.0°

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 | 53.289634 | -6.474596 | 99.40 | 23.32 | 122.72 |
| 2 | 53.290631 | -6.473656 | 99.40 | 23.32 | 122.72 |
| 3 | 53.290578 | -6.473491 | 99.40 | 23.32 | 122.72 |
| 4 | 53.289579 | -6.474431 | 99.40 | 23.32 | 122.72 |
| 5 | 53.289634 | -6.474596 | 99.40 | 23.32 | 122.72 |

Name: PA 5

Axis tracking: Fixed (no rotation)

Tilt: 10.0°

Orientation: 230.0°

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 | 53.289562 | -6.474376 | 99.40 | 23.32 | 122.72 |
| 2 | 53.290559 | -6.473436 | 99.40 | 23.32 | 122.72 |
| 3 | 53.290525 | -6.473321 | 99.40 | 23.32 | 122.72 |
| 4 | 53.289524 | -6.474261 | 99.40 | 23.32 | 122.72 |
| 5 | 53.289562 | -6.474376 | 99.40 | 23.32 | 122.72 |

Name: PA 6

Axis tracking: Fixed (no rotation)

Tilt: 10.0°

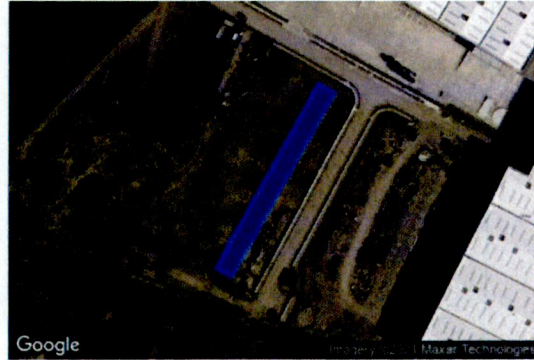
Orientation: 230.0°

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 | 53.289505 | -6.474202 | 99.40 | 23.32 | 122.72 |
| 2 | 53.290499 | -6.473268 | 99.40 | 23.32 | 122.72 |
| 3 | 53.290447 | -6.473114 | 99.40 | 23.32 | 122.72 |
| 4 | 53.289457 | -6.474050 | 99.40 | 23.32 | 122.72 |
| 5 | 53.289505 | -6.474202 | 99.40 | 23.32 | 122.72 |

Flight Path Receptor(s)

Name: Casement 04 Runway

Description: None

Threshold height: 15 m

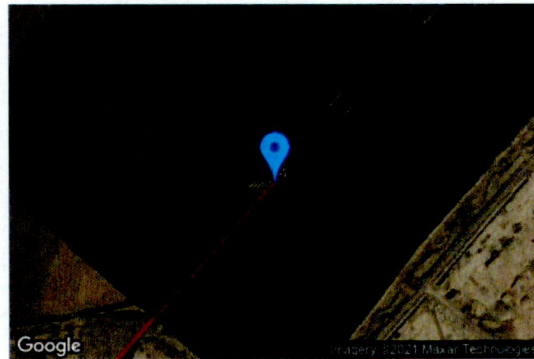
Direction: 42.0°

Glide slope: 3.0°

Pilot view restricted? Yes

Vertical view: 30.0°

Azimuthal view: 50.0°



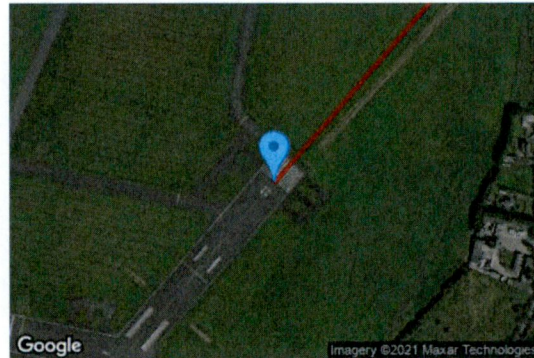
| Point | Latitude (°) | Longitude (°) | Ground elevation (m) | Height above ground (m) | Total elevation (m) |
|-----------|--------------|---------------|----------------------|-------------------------|---------------------|
| Threshold | 53.293853 | -6.453457 | 98.20 | 15.20 | 113.40 |
| Two-mile | 53.272306 | -6.485749 | 152.40 | 129.70 | 282.10 |

Name: Casement 10 Runway
Description: None
Threshold height: 15 m
Direction: 101.6°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



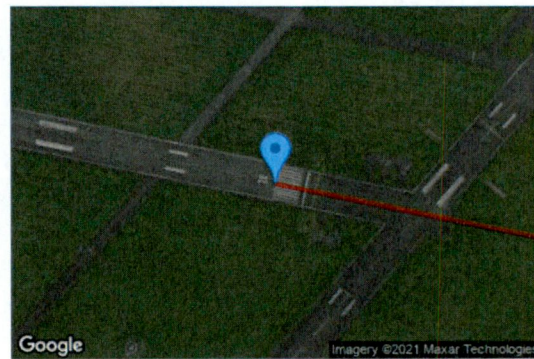
| Point | Latitude (°) | Longitude (°) | Ground elevation (m) | Height above ground (m) | Total elevation (m) |
|-----------|--------------|---------------|----------------------|-------------------------|---------------------|
| Threshold | 53.304625 | -6.468289 | 86.30 | 15.30 | 101.60 |
| Two-mile | 53.310419 | -6.515747 | 73.70 | 196.50 | 270.20 |

Name: Casement 22 Runway
Description: None
Threshold height: 15 m
Direction: 222.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



| Point | Latitude (°) | Longitude (°) | Ground elevation (m) | Height above ground (m) | Total elevation (m) |
|-----------|--------------|---------------|----------------------|-------------------------|---------------------|
| Threshold | 53.303267 | -6.439792 | 93.40 | 15.20 | 108.60 |
| Two-mile | 53.325072 | -6.407981 | 62.40 | 214.90 | 277.30 |

Name: Casement 28 Runway
Description: None
Threshold height: 15 m
Direction: 281.6°
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 | 53.301694 | -6.445155 | 96.10 | 15.20 | 111.30 |
| Two-mile | 53.295880 | -6.397707 | 107.60 | 172.40 | 280.00 |

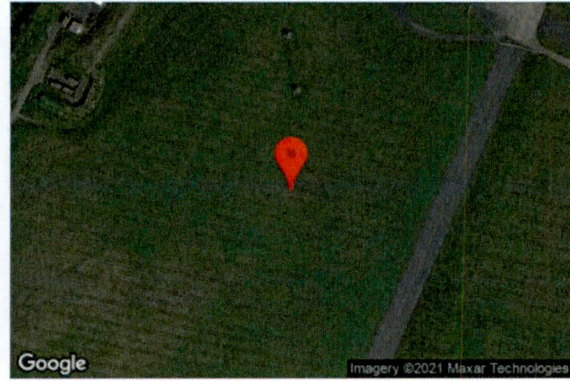
Discrete Observation Receptors

| Name | ID | Latitude (°) | Longitude (°) | Elevation (m) | Height (m) |
|--------|----|--------------|---------------|---------------|------------|
| 1-ATCT | 1 | 53.305525 | -6.441821 | 90.00 | 9.00 |
| 2-ATCT | 2 | 53.305009 | -6.445142 | 92.30 | 28.00 |
| 3-ATCT | 3 | 53.298162 | -6.455575 | 94.60 | 25.00 |

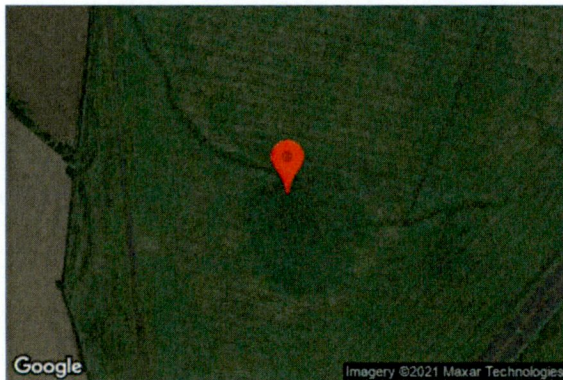
Map image of 1-ATCT



Map image of 2-ATCT



Map image of 3-ATCT



GLARE ANALYSIS RESULTS

Summary of Glare

| PV Array Name | Tilt (°) | Orient (°) | "Green" Glare min | "Yellow" Glare min | Energy kWh |
|---------------|-------------|---------------|----------------------|-----------------------|---------------|
| PA 1 | 10.0 | 230.0 | 3,164 | 0 | - |
| PA 2 | 10.0 | 230.0 | 3,126 | 0 | - |
| PA 3 | 10.0 | 230.0 | 3,164 | 0 | - |
| PA 4 | 10.0 | 230.0 | 3,204 | 0 | - |
| PA 5 | 10.0 | 230.0 | 3,229 | 0 | - |
| PA 6 | 10.0 | 230.0 | 3,220 | 0 | - |

Total annual glare received by each receptor

| Receptor | Annual Green Glare (min) | Annual Yellow Glare (min) |
|--------------------|--------------------------|---------------------------|
| Casement 04 Runway | 0 | 0 |
| Casement 10 Runway | 19107 | 0 |
| Casement 22 Runway | 0 | 0 |
| Casement 28 Runway | 0 | 0 |
| 1-ATCT | 0 | 0 |
| 2-ATCT | 0 | 0 |
| 3-ATCT | 0 | 0 |

Results for: PA 1

| Receptor | Green Glare (min) | Yellow Glare (min) |
|--------------------|-------------------|--------------------|
| Casement 04 Runway | 0 | 0 |
| Casement 10 Runway | 3164 | 0 |
| Casement 22 Runway | 0 | 0 |
| Casement 28 Runway | 0 | 0 |
| 1-ATCT | 0 | 0 |
| 2-ATCT | 0 | 0 |
| 3-ATCT | 0 | 0 |

Flight Path: Casement 04 Runway

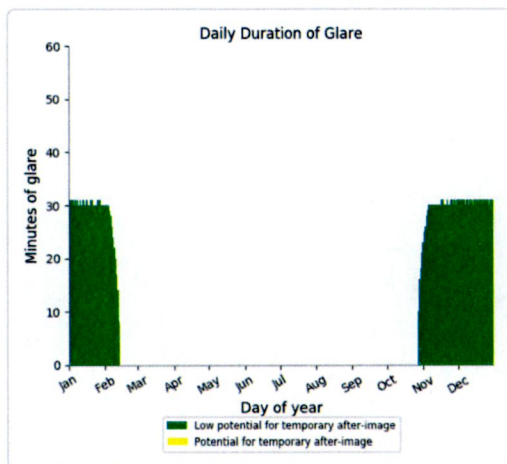
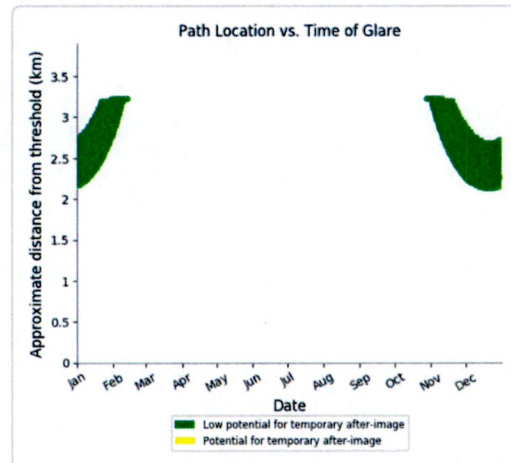
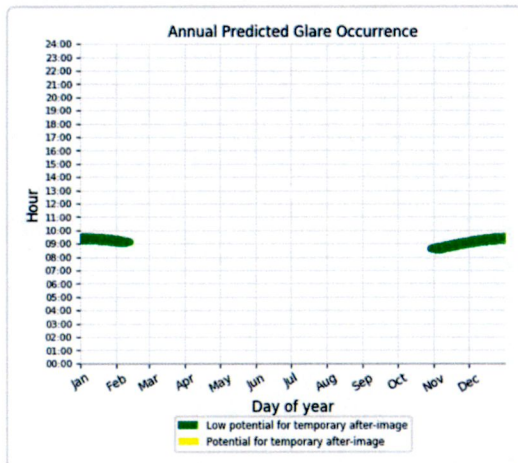
0 minutes of yellow glare

0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare

3164 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

Point Receptor: 2-ATCT

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 3-ATCT

0 minutes of yellow glare
0 minutes of green glare

Results for: PA 2

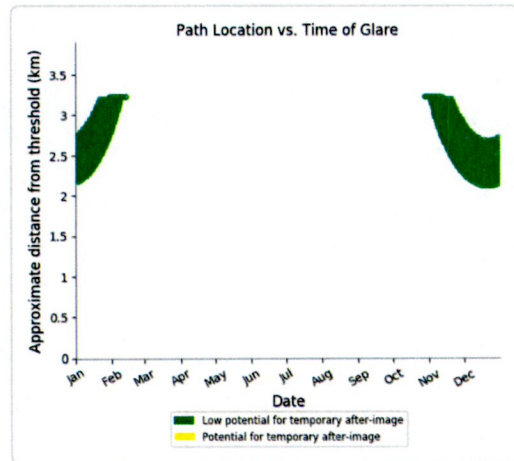
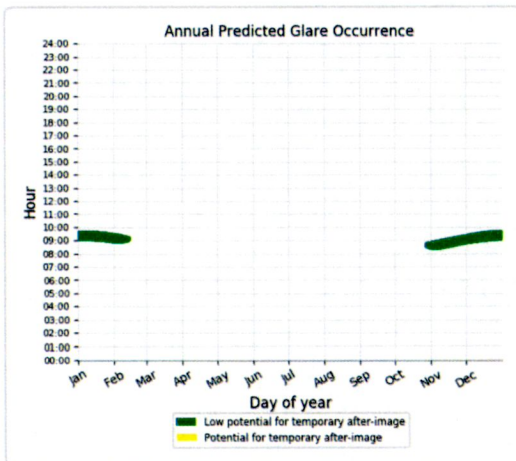
| Receptor | Green Glare (min) | Yellow Glare (min) |
|--------------------|-------------------|--------------------|
| Casement 04 Runway | 0 | 0 |
| Casement 10 Runway | 3126 | 0 |
| Casement 22 Runway | 0 | 0 |
| Casement 28 Runway | 0 | 0 |
| 1-ATCT | 0 | 0 |
| 2-ATCT | 0 | 0 |
| 3-ATCT | 0 | 0 |

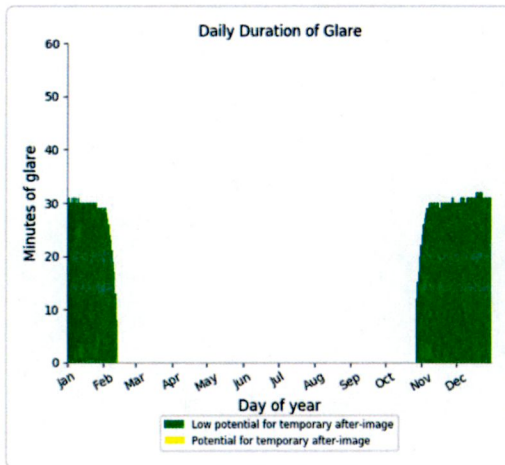
Flight Path: Casement 04 Runway

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare
3126 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

Point Receptor: 2-ATCT

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 3-ATCT

0 minutes of yellow glare
0 minutes of green glare

Results for: PA 3

| Receptor | Green Glare (min) | Yellow Glare (min) |
|--------------------|-------------------|--------------------|
| Casement 04 Runway | 0 | 0 |
| Casement 10 Runway | 3164 | 0 |
| Casement 22 Runway | 0 | 0 |

| Receptor | Green Glare (min) | Yellow Glare (min) |
|--------------------|-------------------|--------------------|
| Casement 28 Runway | 0 | 0 |
| 1-ATCT | 0 | 0 |
| 2-ATCT | 0 | 0 |
| 3-ATCT | 0 | 0 |

Flight Path: Casement 04 Runway

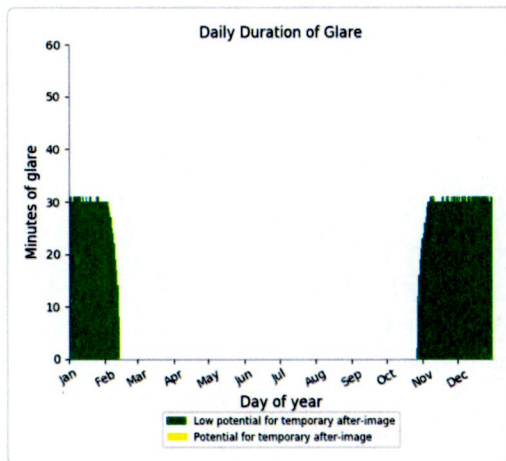
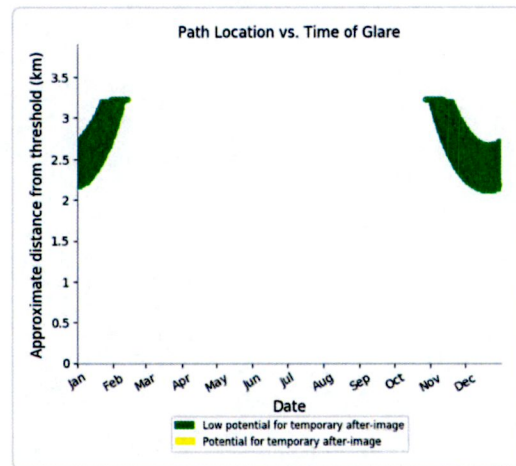
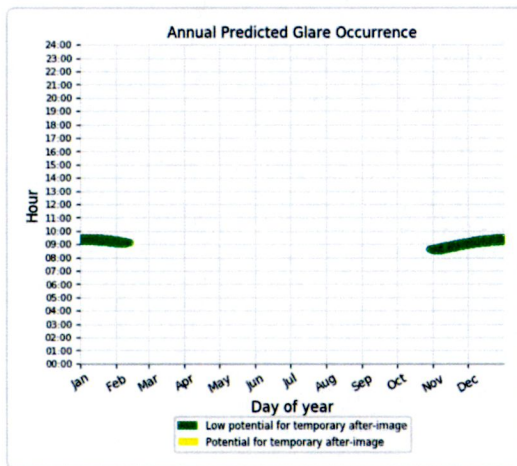
0 minutes of yellow glare

0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare

3164 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

Point Receptor: 2-ATCT

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 3-ATCT

0 minutes of yellow glare
0 minutes of green glare

Results for: PA 4

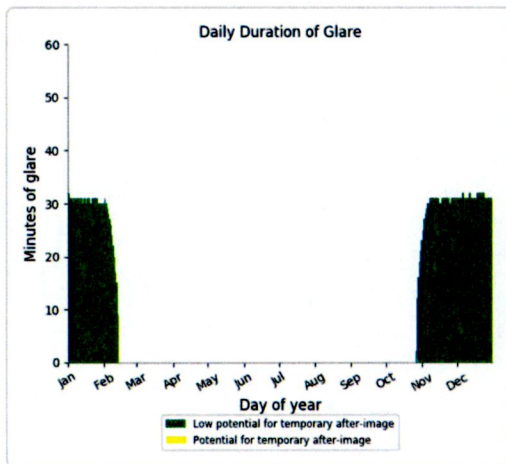
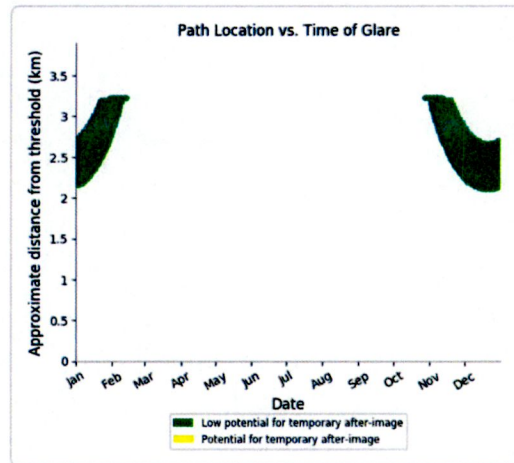
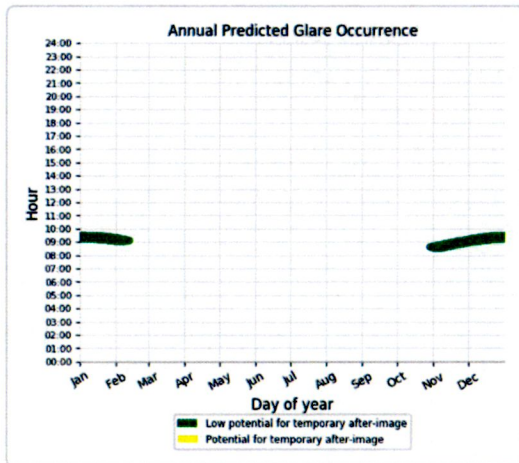
| Receptor | Green Glare (min) | Yellow Glare (min) |
|--------------------|--------------------------|---------------------------|
| Casement 04 Runway | 0 | 0 |
| Casement 10 Runway | 3204 | 0 |
| Casement 22 Runway | 0 | 0 |
| Casement 28 Runway | 0 | 0 |
| 1-ATCT | 0 | 0 |
| 2-ATCT | 0 | 0 |
| 3-ATCT | 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
3204 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

Point Receptor: 2-ATCT

0 minutes of yellow glare

0 minutes of green glare

Point Receptor: 3-ATCT

0 minutes of yellow glare

0 minutes of green glare

Results for: PA 5

| Receptor | Green Glare (min) | Yellow Glare (min) |
|--------------------|-------------------|--------------------|
| Casement 04 Runway | 0 | 0 |
| Casement 10 Runway | 3229 | 0 |
| Casement 22 Runway | 0 | 0 |
| Casement 28 Runway | 0 | 0 |
| 1-ATCT | 0 | 0 |
| 2-ATCT | 0 | 0 |
| 3-ATCT | 0 | 0 |

Flight Path: Casement 04 Runway

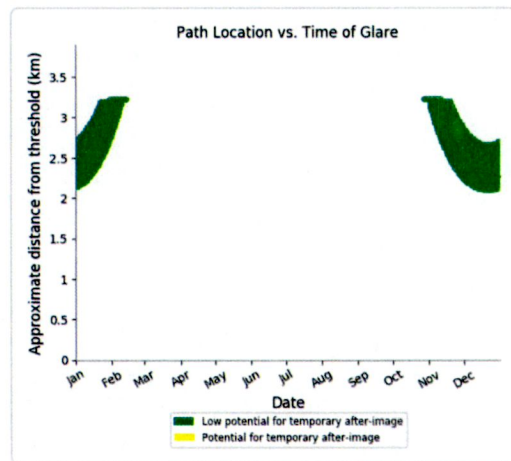
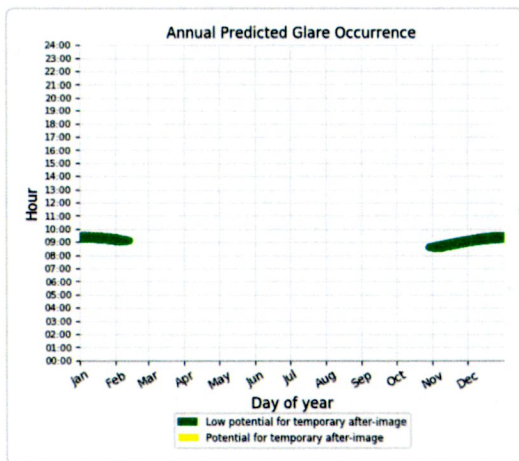
0 minutes of yellow glare

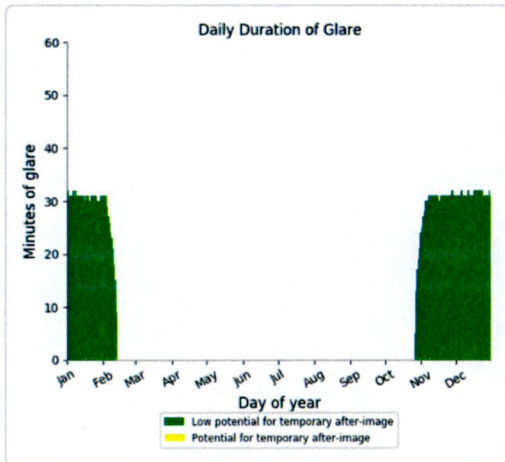
0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare

3229 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

Point Receptor: 2-ATCT

0 minutes of yellow glare
 0 minutes of green glare

Point Receptor: 3-ATCT

0 minutes of yellow glare
 0 minutes of green glare

Results for: PA 6

| Receptor | Green Glare (min) | Yellow Glare (min) |
|--------------------|-------------------|--------------------|
| Casement 04 Runway | 0 | 0 |
| Casement 10 Runway | 3220 | 0 |
| Casement 22 Runway | 0 | 0 |

| Receptor | Green Glare (min) | Yellow Glare (min) |
|--------------------|-------------------|--------------------|
| Casement 28 Runway | 0 | 0 |
| 1-ATCT | 0 | 0 |
| 2-ATCT | 0 | 0 |
| 3-ATCT | 0 | 0 |

Flight Path: Casement 04 Runway

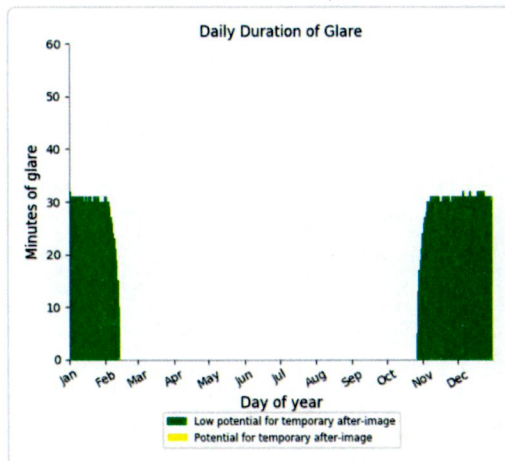
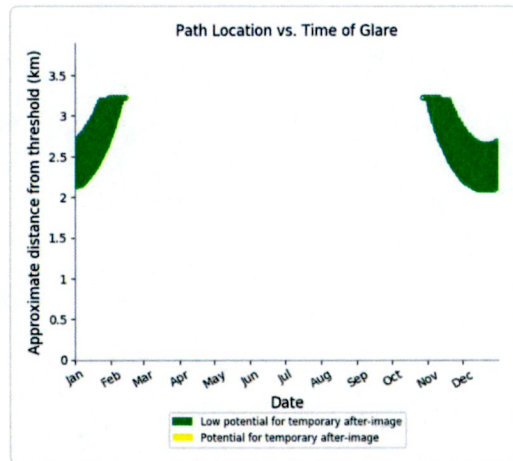
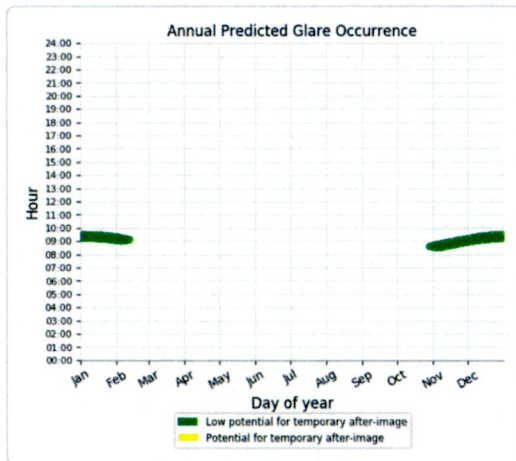
0 minutes of yellow glare

0 minutes of green glare

Flight Path: Casement 10 Runway

0 minutes of yellow glare

3220 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

Point Receptor: 2-ATCT

0 minutes of yellow glare

0 minutes of green glare

Point Receptor: 3-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.