MEERDYKE SOLAR FARM
PV GLINT AND GLARE STUDY

CONTENTS

1. Introduction

Ramboll have been commissioned to undertake a Glint and Glare study for the proposed Meerdyke Solar Farm.

The project is a new build solar farm located on the outskirts of Wisbech. The project comprises of multiple arrays covering an area of approximately 87.53 hectares with a capacity up to 49.9MW.

The purpose of this study is to determine potential Solar Photovoltaic (PV) glint and glare risk against the aviation authority requirements for this type of installation in proximity to Cambridge City Airport, RAF Lakenheath, "A47" Main Road and five nearby residential properties.

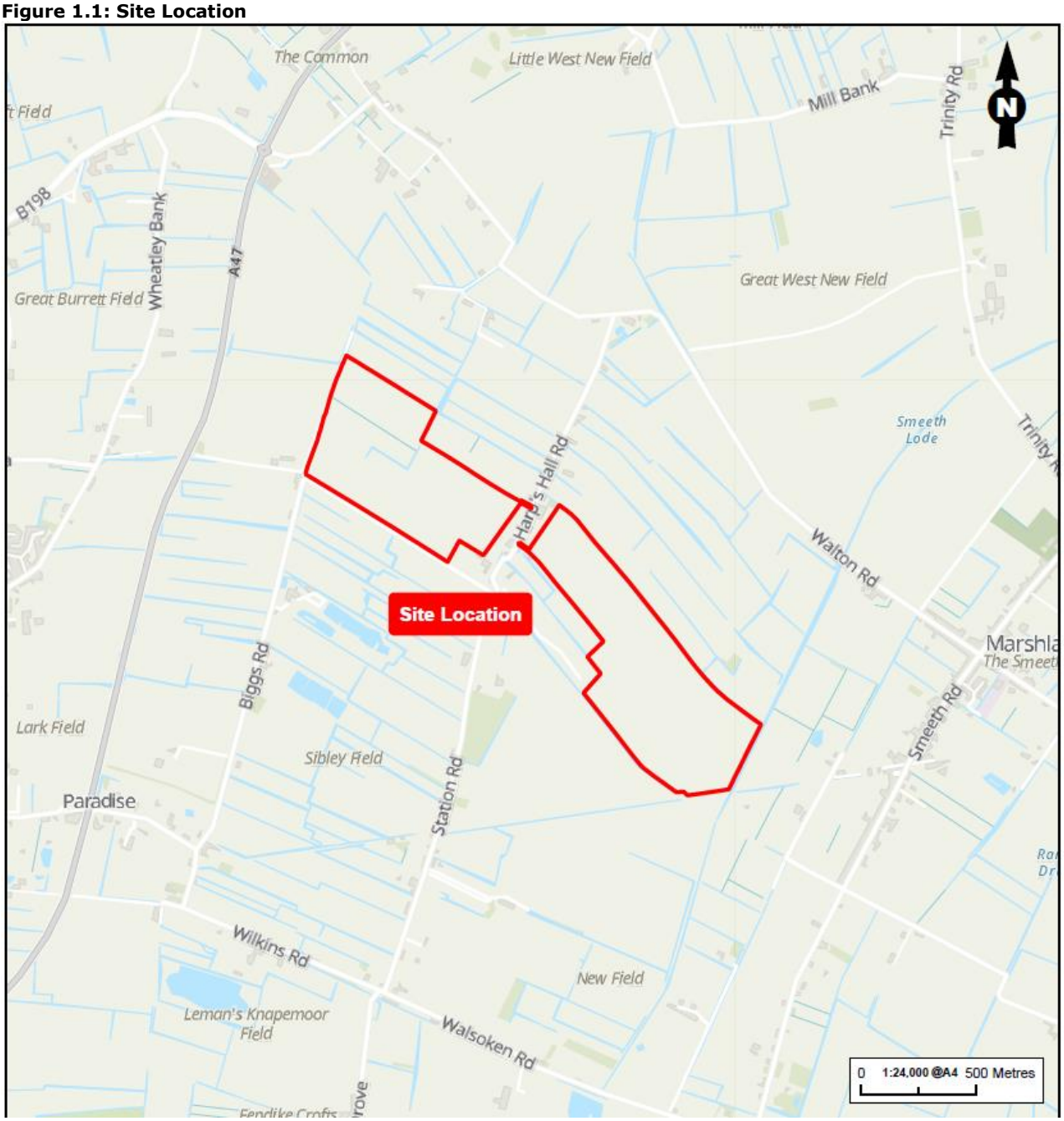
2. Solar Photovoltaic Systems

The solar PV system shall generally consist of monocrystalline panels that are connected to inverters and supply renewable electricity generated directly into the national grid.

The solar PV system shall consist of panels installed on angled frames mounted to the ground throughout the site.

The proposed site location is indicated on **Figure 1.1: Site Location** below:

Figure 1.1: Site Location



The proposed site is located to the west of Wisbech on the opposite side of the A47 main road.

3. Solar Glint and Glare Calculation

We have undertaken a solar glint and glare assessment using 'Forge Solar' software[1] which is recommended by the aviation authorities.
For a solar PV system within proximity of an airport, a glint and glare assessment has been carried out and considers the flight paths and the air traffic control tower.

The Solar photovoltaic panels have been modelled in four sections of array so that the larger gaps between panels such as the road and buildings can be included in the calculations.

For this project, a glint and glare assessment has also been carried out for the adjacent main road, the A47 and five residential properties in the area.

The software considers an unobstructed view to the proposed site development i.e. it does not consider obstructions such as other buildings, trees etc as part of the calculation. The software also assumes 'worst case' atmospheric conditions (i.e. clear cloud free skies) for the full calendar year.

The following three categories are used within the software to quantify the ocular impact of solar glare:

- Green - low potential to cause after-image (flash blindness)
- Yellow - potential to cause temporary after-image
- Red - potential to cause retinal burn (permanent eye damage)

In order to achieve compliance with the aviation guidelines there cannot be any red or yellow glare for the flight paths and there cannot be any red, yellow or green glare for the air traffic control tower.

We have based the flight paths for each runway at Cambridge City Airport and RAF Lakenheath on standard flight paths at either end of the runway thresholds.

As exact information and locations for air traffic control towers is not available, assumed locations have been taken from the map overlays found within 'Forge Solar' and available images online.

There are no current standards for glint and glare requirements for roadways and residential areas so this assessment will take the following approach: green glare shall be taken to indicate no impact; yellow and red glare shall be taken to indicate potential impact and the need for further evaluation of mitigation required to avoid unacceptable impact. Where yellow or red levels of glint or glare have been identified a further evaluation of the receptors has been completed to consider additional factors such as property orientation, location of windows, presence of intervening buildings or vegetation to determine the likely effects rather than theoretical worst-case effects.

A glare receptor has been drawn along the A47 main road from the south of the site up to and beyond the site to provide an assessment over a substantial length rather than at set point receptors. This is shown on **Figure 3.1: A47 Glare Receptor Location** below.

[1] URL: https://www.forgesolar.com/ (accessed 12/09/2022)

Figure 3.1: A47 Glare Receptor Location

The residential receptors used within this assessment correspond to the five observation points within the calculation and are taken as a representative sample of the area surrounding the site. These are as follows and in **Figure 3.2: Residential Receptor Locations** below:

- OP 3 – Residential Receptor 1
- OP 4 – Residential Receptor 2
- OP 5 – Residential Receptor 3
- OP 6 – Residential Receptor 4
- OP 7 – Residential Receptor 5

Figure 3.2: Residential Recepotor Locations

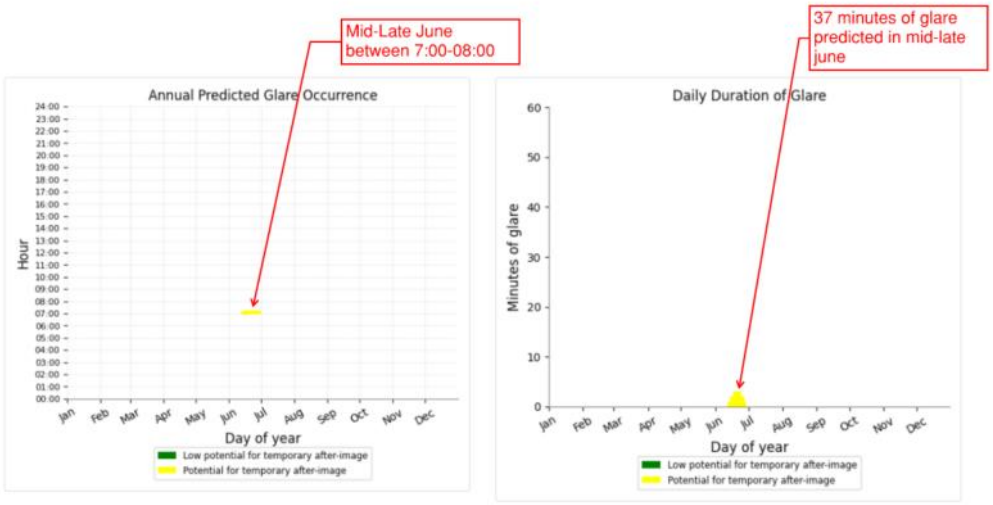
4. Calculation Results

We have modelled the proposed PV areas for the Meerdyke Solar Development and the software has not predicted any red or yellow glare for the four standard flight paths at Cambridge City airport or RAF Lakenheath.

The software has not predicted any red, yellow or green glare at the Air traffic control towers at Cambridge City airport and RAF Lakenheath.

The software has predicted a period of yellow glare on the A47 road during a short period of the year. The total period of glare predicted is 37 minutes annually occurring during the second half of June between the hours of 07:00 and 08:00 as shown on **Figure 4.1: A47 Glare Results** below:

Figure 4.1: A47 Glare Results



The 37 minutes of predicted glare on the A47 occurs from sections of solar array located to the western side of Harp's Hall Rd. The section of road is significantly screened by existing vegetation and as such no impact is predicted.

The residential properties that formed part of the assessment have predicted yellow glare from each area of PV modelled. The periods of glare predicted occur throughout the year generally in the morning between 07:00 and 10:00 and in the evening between 20:00 and 22:00. This generally coincides with sunrise and sunset periods. The extent of this glare is demonstrated within Appendix 1 of this report. Observation Points 4 and 7 have no predicted yellow glare annually. **Table 4.1 Calculation Results** below highlights the results of the calculation.

Table 4.1: Calculation Results

Receptor	Results		Comments
	Reflections at receptors possible (Y/N)		
	AM	PM	
OP3	Y	N	Solar reflections are predicted to be significantly screened by existing vegetation. No impact is predicted.
OP5	Y	Y	Variable levels of screening present at this group of dwellings – some dwellings have good screening from farm buildings and vegetation and others have relatively open aspects and therefore there is potential for impact (albeit for a short duration each day) in the absence of mitigation.
OP6	Y	N	Solar reflections are predicted to be significantly screened by existing vegetation. No impact is predicted.

The full calculation output from the software in enclosed within Appendix 1 of this report.

5. Additional Mitigation

The assessment shows that a number of receptors have the potential for Glint and Glare impact. As stated above the assessment deals with a theoretical worst-case scenario which does not account for existing screening (from buildings or vegetation), topography or for weather conditions other than a clear, cloudless sky.
The likely effects of glint and glare would be significantly lower than the theoretical worst case scenario. However, as the assessment shows it is possible for glint and glare to occur at a number of receptors additional mitigation in the form of a grievance mechanism will be applied.

The grievance mechanism will be open to all community members. All grievances from community members or stakeholders about project performance will follow the procedure set out below:

Step 1
Stakeholders can submit grievances in writing to Downing LLP The following email address is to be used when dealing with grievances: asset.management@downing.co.uk . All responses will be provided within 14 days from receipt of the grievance.

Step 2
Within 24 hours of receipt of the grievance it will be recorded in a grievance log.

Step 3
Downing LLP will organise telephone or face-to-face meetings to investigate the complainant's grievance in order to verify the validity and gravity of the grievance. Once investigated corrective or preventive measures to properly address the grievance will be identified and implemented if required (i.e., planting or fencing at the affected receptor).

Step 4
Once grievance investigations are completed, Downing PLC shall draft a formal communication to the complainant, advising of findings and the outcome. Downing PLC will communicate the response, stipulate mutual commitments, and ask for the complainants' agreement. If the complainant is not satisfied with the resolution, or the outcome of the agreed corrective actions the response should be reviewed and if appropriate amended considering any discussions or negotiations.

6. Conclusion

We have used Forge Solar software to predict the Glint and Glare risk associated with the proposed Solar PV installation for the Meerdyke Solar Farm.

The software has predicted zero occurrences of 'yellow' or 'red' glare for the standard flight paths of each runway at Cambridge City airport and RAF Lakenheath.

The software has predicted 0 minutes of 'yellow', 'red' or 'green glare for the Air traffic Control Towers at either Cambridge City airport or RAF Lakenheath across an entire year.

The software has predicted instances of 'yellow' glare for the A47 main road and three of the five residential receptors included within this glint and glare assessment. These periods of 'yellow' glare predicted by the software do not meet the requirements set out within this report however once existing screening is taken into account no impacts are predicted on the A47 main road, OP3 or OP6. Additional mitigation in the form of a grievance mechanism will be implemented.

The detailed calculation output from the Forge Solar calculation is appended to this report.

7. Appendix 1 – Forge Solar Calculation Output

FORGESOLAR GLARE ANALYSIS

Project: **Meerdyke Solar Farm**
Proposed 49.9MW Solar farm

Site configuration: **Meerdyke Configuration 1**

Created 17 Aug, 2022
Updated 17 Aug, 2022
Time-step 1 minute
Timezone offset UTC0
Site ID 74186.13086
Category 10 MW to 100 MW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Summary of Results

Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	20.0	225.0	73	1.2	119	2.0	1,069,000.0
PV array 2	20.0	225.0	0	0.0	2,381	39.7	1,070,000.0
PV array 3	20.0	225.0	103	1.7	8,491	141.5	1,069,000.0
PV array 4	20.0	225.0	0	0.0	1,126	18.8	1,069,000.0

Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Route 1	0	0.0	37	0.6
FP 1 Cambridge City	0	0.0	0	0.0
FP 2 - Cambridge City	0	0.0	0	0.0
FP 3 - RAF Lakenheath	0	0.0	0	0.0
FP 4 - RAF Lakenheath	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
OP 3	0	0.0	3,371	56.2
OP 4	176	2.9	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 5	0	0.0	8,427	140.4
OP 6	0	0.0	282	4.7
OP 7	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 20.0°
Orientation: 225.0°
Rated power: 555.0 kW
Panel material: Light textured 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	52.675664	0.217164	1.55	0.00	1.55
2	52.673765	0.215426	1.39	0.00	1.39
3	52.674532	0.213388	1.99	0.00	1.99
4	52.674310	0.213188	1.33	0.00	1.33
5	52.674936	0.211392	1.79	0.00	1.79
6	52.676080	0.212508	2.20	0.00	2.20
7	52.676230	0.212122	2.02	0.00	2.02
8	52.677219	0.213162	2.28	0.00	2.28

Name: PV array 2
Axis tracking: Fixed (no rotation)
Tilt: 20.0°
Orientation: 225.0°
Rated power: 555.0 kW
Panel material: Light textured 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	52.674316	0.216850	0.94	0.00	0.94
2	52.672482	0.221463	1.08	0.00	1.08
3	52.669788	0.218631	1.23	0.00	1.23
4	52.672690	0.211550	0.92	0.00	0.92
5	52.673913	0.212837	1.53	0.00	1.53
6	52.673632	0.213540	1.67	0.00	1.67
7	52.674007	0.213926	1.61	0.00	1.61
8	52.673314	0.215766	0.58	0.00	0.58

Name: PV array 3
Axis tracking: Fixed (no rotation)
Tilt: 20.0°
Orientation: 225.0°
Rated power: 555.0 kW
Panel material: Light textured 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	52.671256	0.225312	0.08	0.00	0.08
2	52.669740	0.223864	1.13	0.00	1.13
3	52.667019	0.227061	0.09	0.00	0.09
4	52.666551	0.228391	0.14	0.00	0.14
5	52.667296	0.230076	0.00	0.00	0.00

Name: PV array 4
Axis tracking: Fixed (no rotation)
Tilt: 20.0°
Orientation: 225.0°
Rated power: 555.0 kW
Panel material: Light textured 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	52.666069	0.225031	1.72	0.00	1.72
2	52.661690	0.230327	0.14	0.00	0.14
3	52.660518	0.232773	0.44	0.00	0.44
4	52.660752	0.235777	1.29	0.00	1.29
5	52.662000	0.236909	0.60	0.00	0.60
6	52.664553	0.234447	1.00	0.00	1.00
7	52.665947	0.232591	1.65	0.00	1.65
8	52.666778	0.230520	0.44	0.00	0.44
9	52.666140	0.229018	0.37	0.00	0.37
10	52.665348	0.229233	1.00	0.00	1.00
11	52.665252	0.229050	1.00	0.00	1.00
12	52.665849	0.227055	1.80	0.00	1.80
13	52.666456	0.226137	0.97	0.00	0.97

Route Receptors

Name: Route 1
Path type: Two-way
Observer view angle: 50.0°

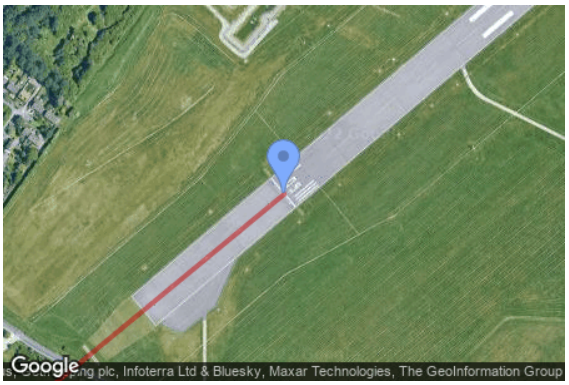
Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	52.660676	0.194662	2.31	0.00	2.31
2	52.669772	0.198671	4.07	0.00	4.07
3	52.670748	0.199058	4.71	0.00	4.71
4	52.672088	0.199845	2.75	0.00	2.75
5	52.672621	0.200210	3.72	0.00	3.72
6	52.674933	0.202275	4.11	0.00	4.11
7	52.676274	0.203133	3.62	0.00	3.62
8	52.677971	0.203949	3.36	0.00	3.36
9	52.678520	0.204122	4.00	0.00	4.00
10	52.682338	0.205180	2.02	0.00	2.02
11	52.683828	0.205742	2.55	0.00	2.55
12	52.685851	0.206912	4.01	0.00	4.01
13	52.687127	0.207958	5.11	0.00	5.11
14	52.688545	0.209325	4.83	0.00	4.83
15	52.689645	0.210667	3.49	0.00	3.49
16	52.690193	0.211488	4.09	0.00	4.09
17	52.690733	0.212475	4.11	0.00	4.11

Flight Path Receptors

Name: FP 1 Cambridge City
Description:
Threshold height: 15 m
Direction: 229.7°
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	52.209872	0.184411	15.94	15.24	31.18
Two-mile	52.228572	0.220438	6.63	193.24	199.87

Name: FP 2 - Cambridge City
Description:
Threshold height: 15 m
Direction: 50.5°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

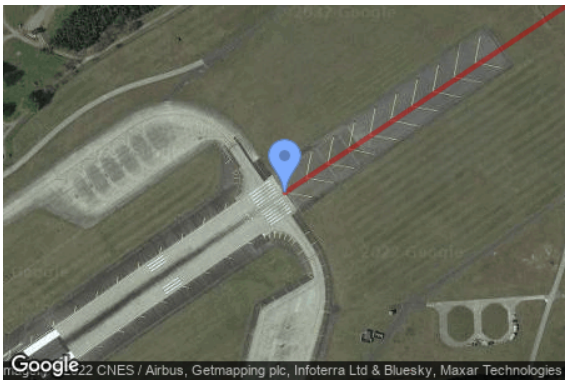


Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	52.200578	0.166463	13.00	15.24	28.24
Two-mile	52.182187	0.130020	15.06	181.86	196.92

Name: FP 3 - RAF Lakenheath
Description:
Threshold height: 15 m
Direction: 56.0°
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	52.402454	0.544392	5.35	15.24	20.59
Two-mile	52.386286	0.505058	3.48	185.79	189.27

Name: FP 4 - RAF Lakenheath
Description:
Threshold height: 15 m
Direction: 236.4°
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	52.416363	0.577642	9.22	15.24	24.46
Two-mile	52.432350	0.617186	23.99	169.15	193.14

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	52.208124	0.172746	20.00	20.00
2-ATCT	2	52.404348	0.558168	8.09	20.00
OP 3	3	52.672938	0.208558	2.82	2.00
OP 4	4	52.661378	0.241958	1.57	2.00
OP 5	5	52.670904	0.222424	2.15	2.00
OP 6	6	52.659198	0.216611	3.36	2.00
OP 7	7	52.678361	0.220474	3.03	2.00

Map image of 1-ATCT

Map image of 2-ATCT

Glare Analysis Results

Summary of Results

Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	20.0	225.0	73	1.2	119	2.0	1,069,000.0
PV array 2	20.0	225.0	0	0.0	2,381	39.7	1,070,000.0
PV array 3	20.0	225.0	103	1.7	8,491	141.5	1,069,000.0
PV array 4	20.0	225.0	0	0.0	1,126	18.8	1,069,000.0

Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Route 1	0	0.0	37	0.6
FP 1 Cambridge City	0	0.0	0	0.0
FP 2 - Cambridge City	0	0.0	0	0.0
FP 3 - RAF Lakenheath	0	0.0	0	0.0
FP 4 - RAF Lakenheath	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
OP 3	0	0.0	3,371	56.2
OP 4	176	2.9	0	0.0
OP 5	0	0.0	8,427	140.4
OP 6	0	0.0	282	4.7
OP 7	0	0.0	0	0.0

PV: PV array 1 potential temporary after-image

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Route 1	0	0.0	0	0.0
FP 1 Cambridge City	0	0.0	0	0.0
FP 2 - Cambridge City	0	0.0	0	0.0
FP 3 - RAF Lakenheath	0	0.0	0	0.0
FP 4 - RAF Lakenheath	0	0.0	0	0.0
OP 5	0	0.0	119	2.0
OP 4	73	1.2	0	0.0
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0

PV array 1 and Route 1

Receptor type: Route

No glare found

PV array 1 and FP 1 Cambridge City

Receptor type: 2-mile Flight Path

No glare found

PV array 1 and FP 2 - Cambridge City

Receptor type: 2-mile Flight Path

No glare found

PV array 1 and FP 3 - RAF Lakenheath

Receptor type: 2-mile Flight Path

No glare found

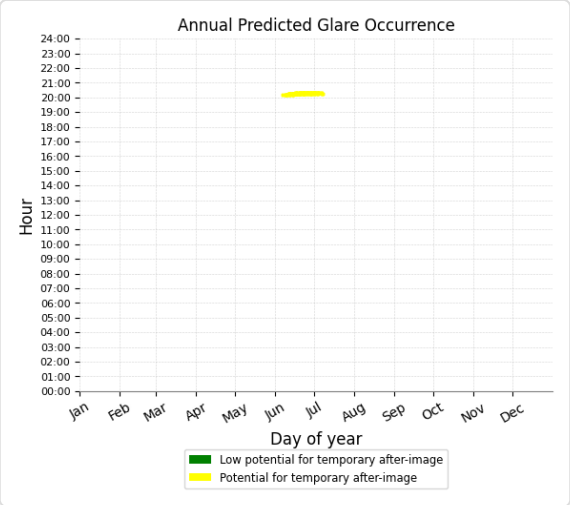
PV array 1 and FP 4 - RAF Lakenheath

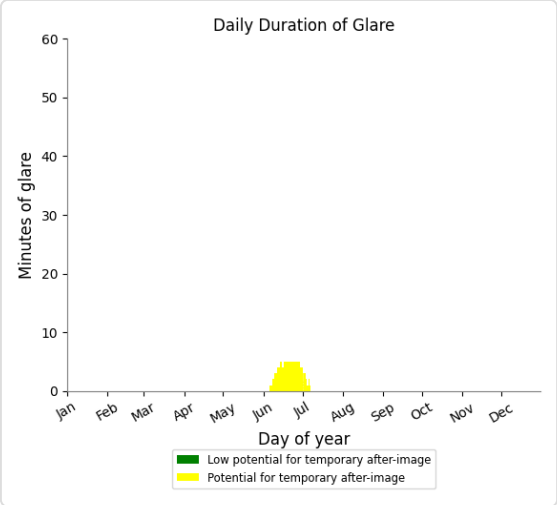
Receptor type: 2-mile Flight Path

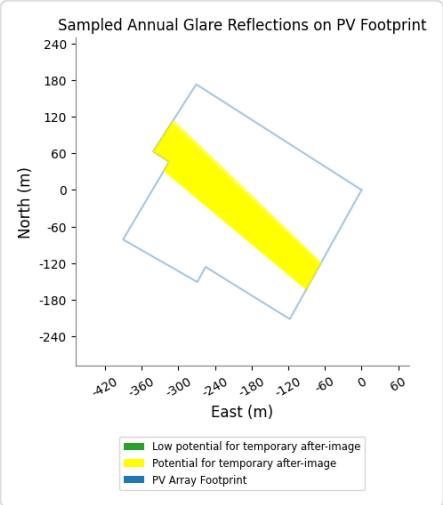
No glare found

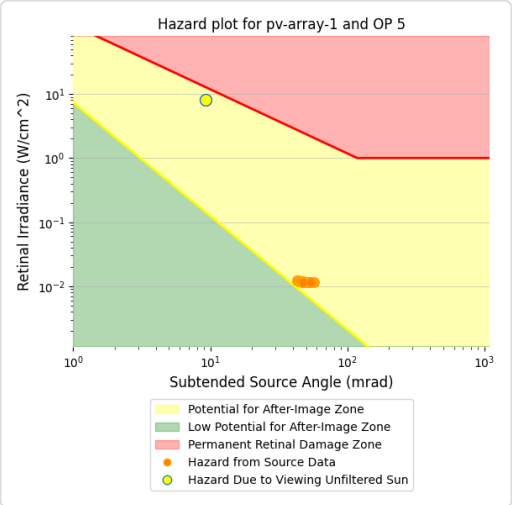
PV array 1 and OP 5

Receptor type: Observation Point
119 minutes of yellow glare
0 minutes of green glare



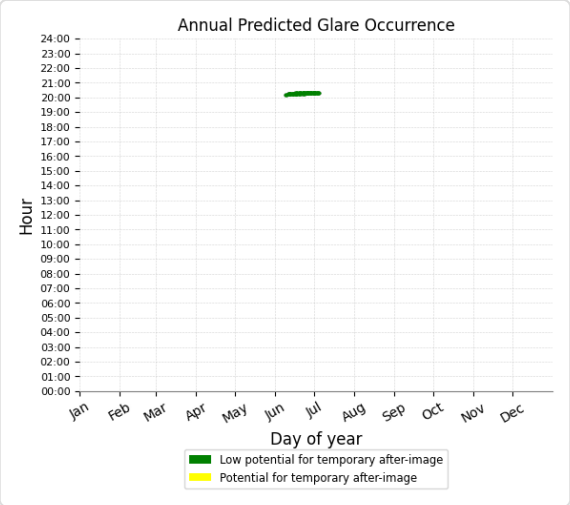


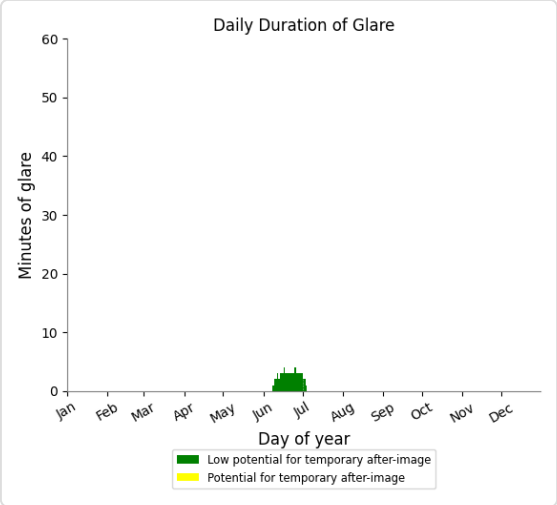


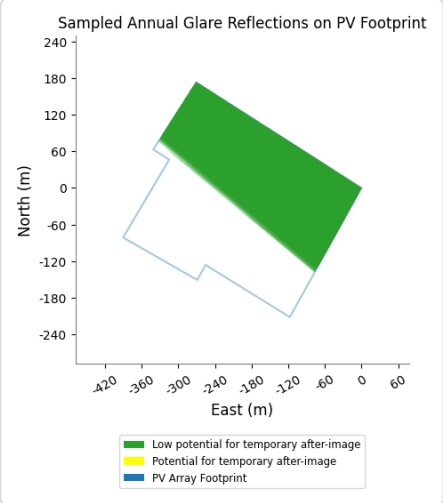


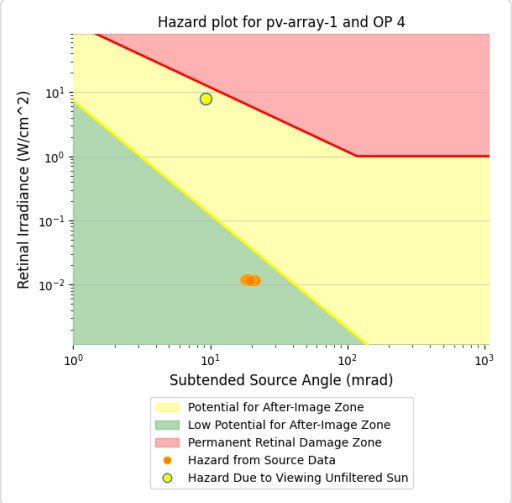
PV array 1 and OP 4

Receptor type: Observation Point
0 minutes of yellow glare
73 minutes of green glare









PV array 1 and 1-ATCT

Receptor type: Observation Point
No glare found

PV array 1 and 2-ATCT

Receptor type: Observation Point
No glare found

PV array 1 and OP 3

Receptor type: Observation Point
No glare found

PV array 1 and OP 6

Receptor type: Observation Point
No glare found

PV array 1 and OP 7

Receptor type: Observation Point
No glare found

PV: PV array 2 potential temporary after-image

Receptor results ordered by category of glare

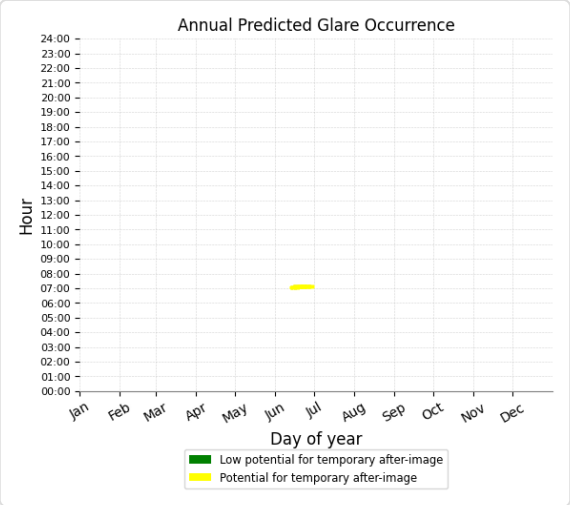
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Route 1	0	0.0	37	0.6
FP 1 Cambridge City	0	0.0	0	0.0
FP 2 - Cambridge City	0	0.0	0	0.0
FP 3 - RAF Lakenheath	0	0.0	0	0.0
FP 4 - RAF Lakenheath	0	0.0	0	0.0
OP 3	0	0.0	2,344	39.1
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0

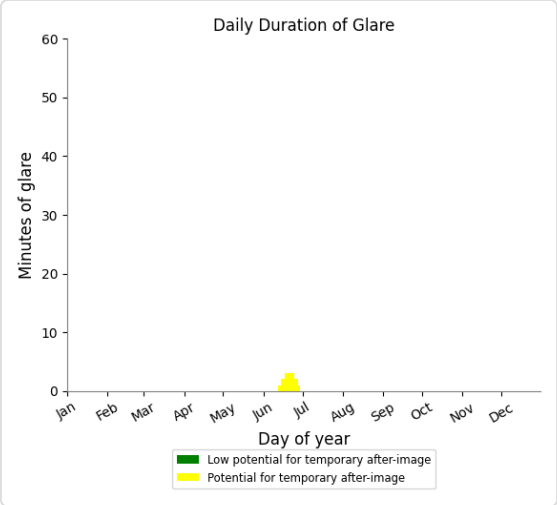
PV array 2 and Route 1

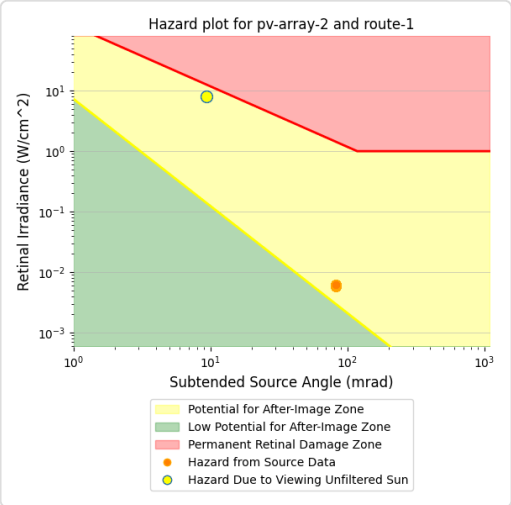
Receptor type: Route

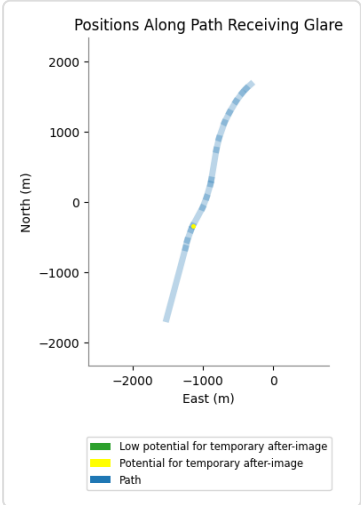
37 minutes of yellow glare

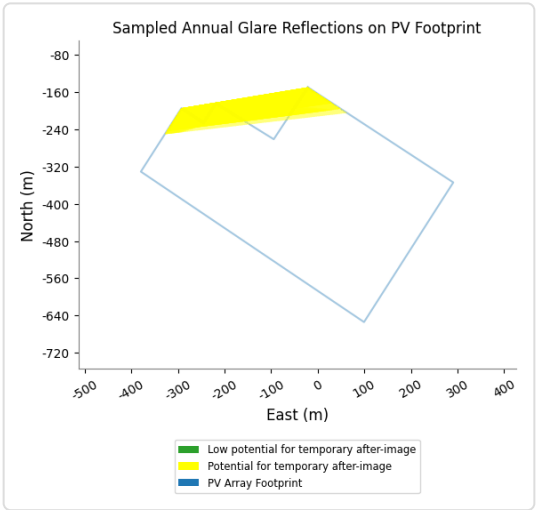
0 minutes of green glare











PV array 2 and FP 1 Cambridge City

Receptor type: 2-mile Flight Path

No glare found

PV array 2 and FP 2 - Cambridge City

Receptor type: 2-mile Flight Path

No glare found

PV array 2 and FP 3 - RAF Lakenheath

Receptor type: 2-mile Flight Path

No glare found

PV array 2 and FP 4 - RAF Lakenheath

Receptor type: 2-mile Flight Path

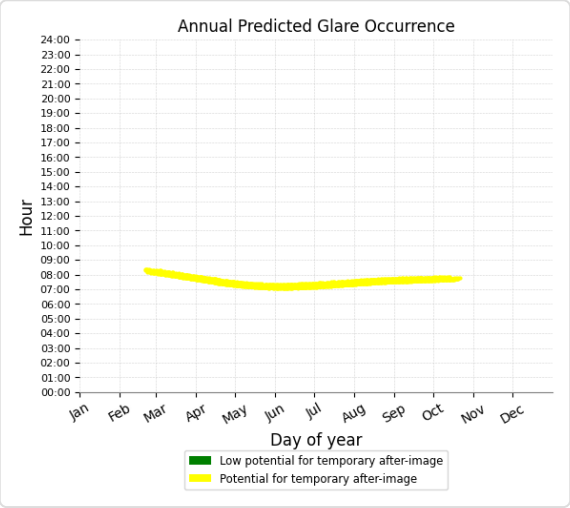
No glare found

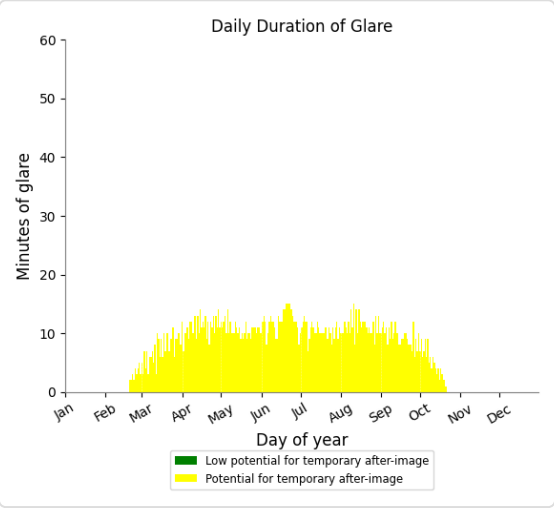
PV array 2 and OP 3

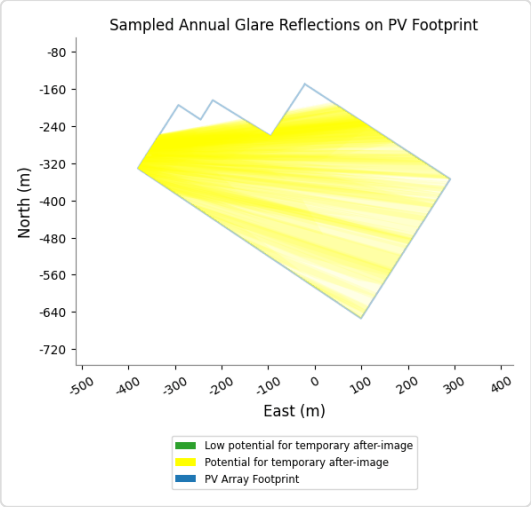
Receptor type: Observation Point

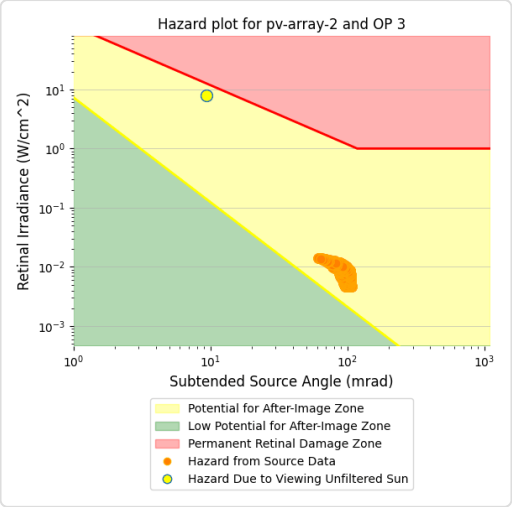
2,344 minutes of yellow glare

0 minutes of green glare









PV array 2 and 1-ATCT

Receptor type: Observation Point

No glare found

PV array 2 and 2-ATCT

Receptor type: Observation Point

No glare found

PV array 2 and OP 4

Receptor type: Observation Point
No glare found

PV array 2 and OP 5

Receptor type: Observation Point
No glare found

PV array 2 and OP 6

Receptor type: Observation Point
No glare found

PV array 2 and OP 7

Receptor type: Observation Point
No glare found

PV: PV array 3 potential temporary after-image

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Route 1	0	0.0	0	0.0
FP 1 Cambridge City	0	0.0	0	0.0
FP 2 - Cambridge City	0	0.0	0	0.0
FP 3 - RAF Lakenheath	0	0.0	0	0.0
FP 4 - RAF Lakenheath	0	0.0	0	0.0
OP 3	0	0.0	1,009	16.8
OP 5	0	0.0	7,482	124.7
OP 4	103	1.7	0	0.0
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0

PV array 3 and Route 1

Receptor type: Route
No glare found

PV array 3 and FP 1 Cambridge City

Receptor type: 2-mile Flight Path
No glare found

PV array 3 and FP 2 - Cambridge City

Receptor type: 2-mile Flight Path
No glare found

PV array 3 and FP 3 - RAF Lakenheath

Receptor type: 2-mile Flight Path

No glare found

PV array 3 and FP 4 - RAF Lakenheath

Receptor type: 2-mile Flight Path

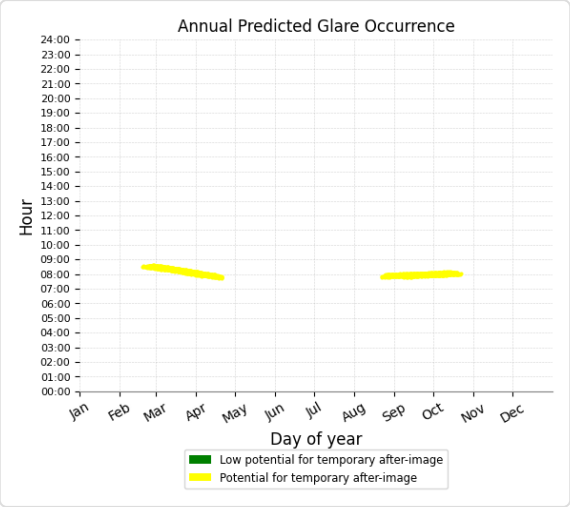
No glare found

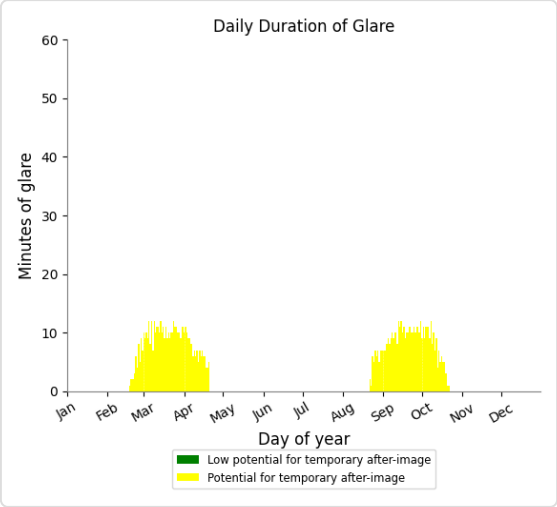
PV array 3 and OP 3

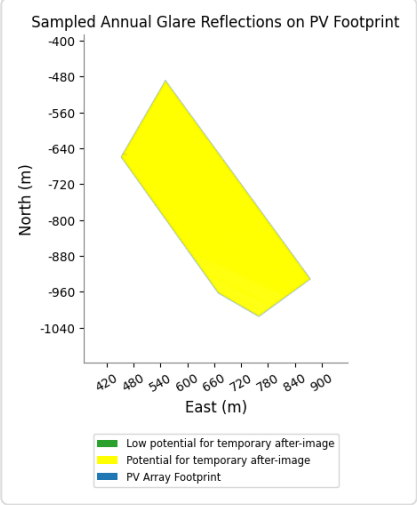
Receptor type: Observation Point

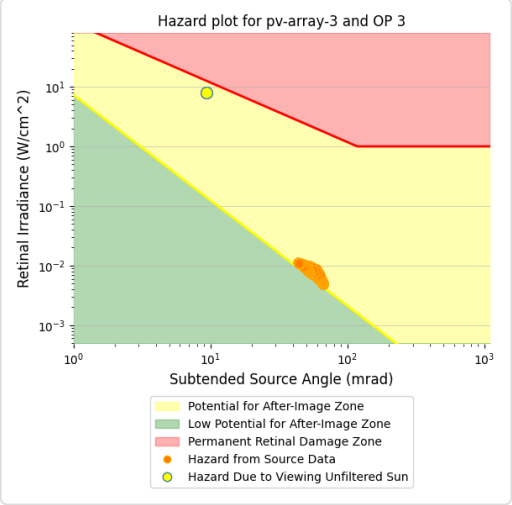
1,009 minutes of yellow glare

0 minutes of green glare



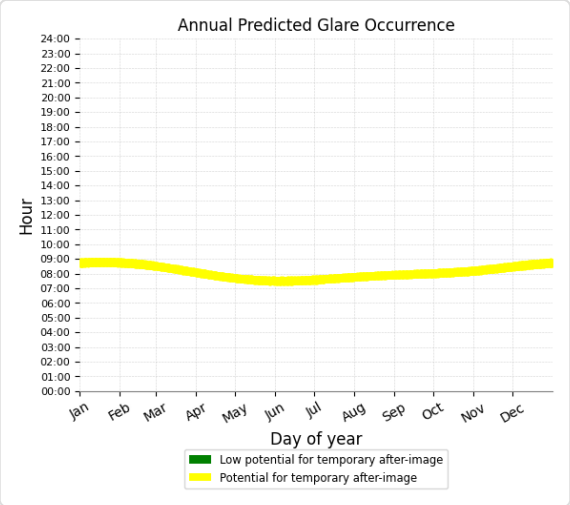


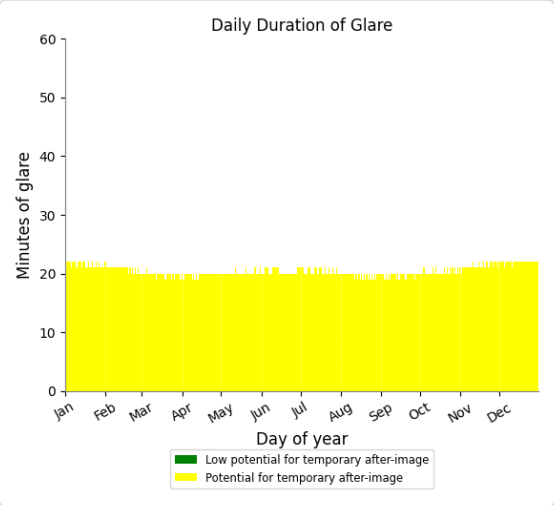


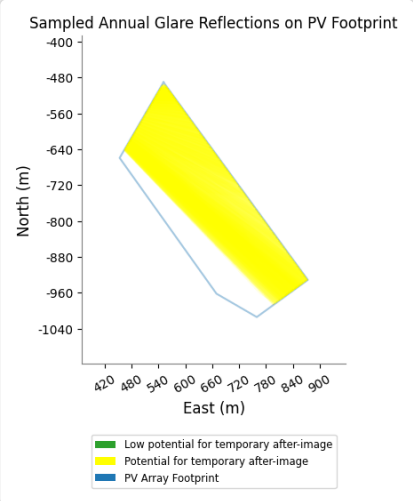


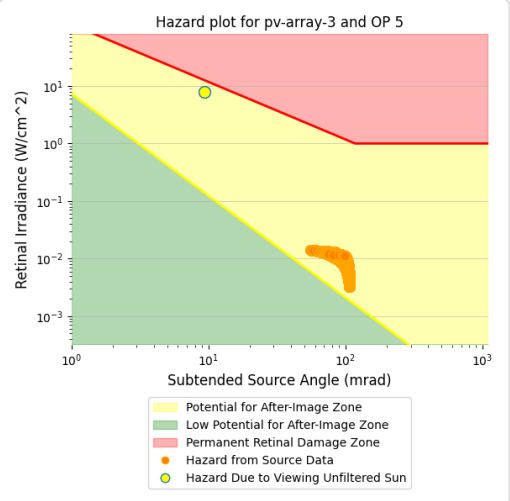
PV array 3 and OP 5

Receptor type: Observation Point
7,482 minutes of yellow glare
0 minutes of green glare



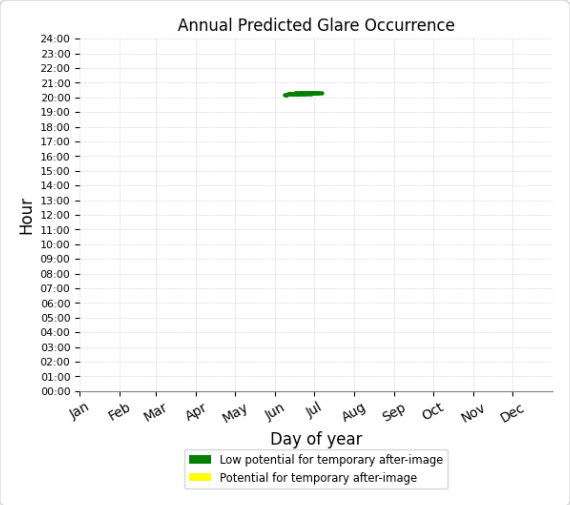


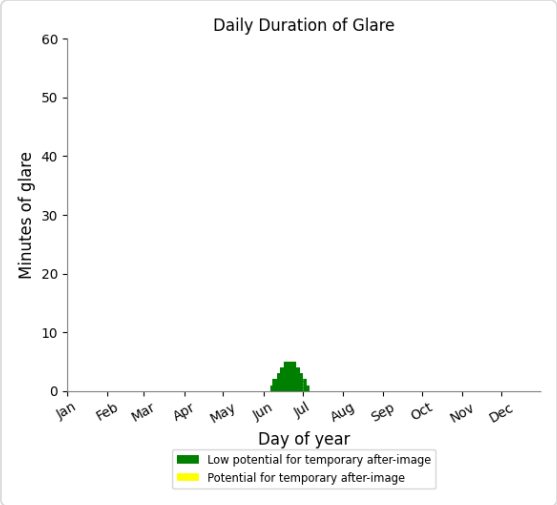


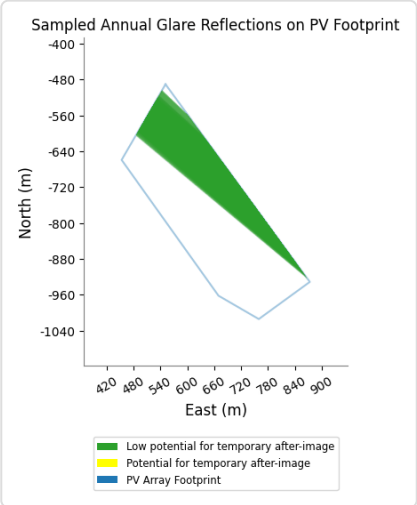


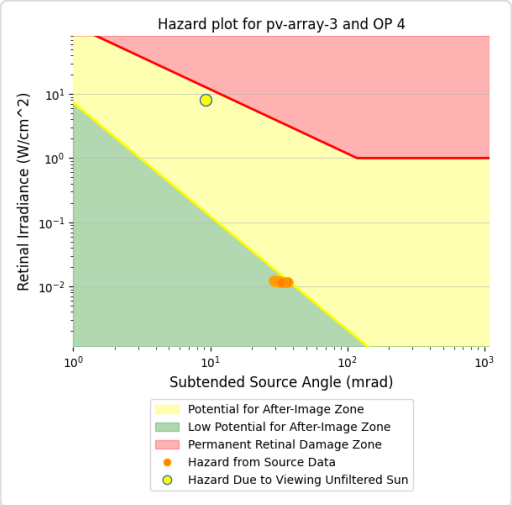
PV array 3 and OP 4

Receptor type: Observation Point
0 minutes of yellow glare
103 minutes of green glare









PV array 3 and 1-ATCT

Receptor type: Observation Point
No glare found

PV array 3 and 2-ATCT

Receptor type: Observation Point
No glare found

PV array 3 and OP 6

Receptor type: Observation Point
No glare found

PV array 3 and OP 7

Receptor type: Observation Point
No glare found

PV: PV array 4 potential temporary after-image

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Route 1	0	0.0	0	0.0
FP 1 Cambridge City	0	0.0	0	0.0
FP 2 - Cambridge City	0	0.0	0	0.0
FP 3 - RAF Lakenheath	0	0.0	0	0.0
FP 4 - RAF Lakenheath	0	0.0	0	0.0
OP 3	0	0.0	18	0.3
OP 5	0	0.0	826	13.8
OP 6	0	0.0	282	4.7
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 7	0	0.0	0	0.0

PV array 4 and Route 1

Receptor type: Route
No glare found

PV array 4 and FP 1 Cambridge City

Receptor type: 2-mile Flight Path
No glare found

PV array 4 and FP 2 - Cambridge City

Receptor type: 2-mile Flight Path
No glare found

PV array 4 and FP 3 - RAF Lakenheath

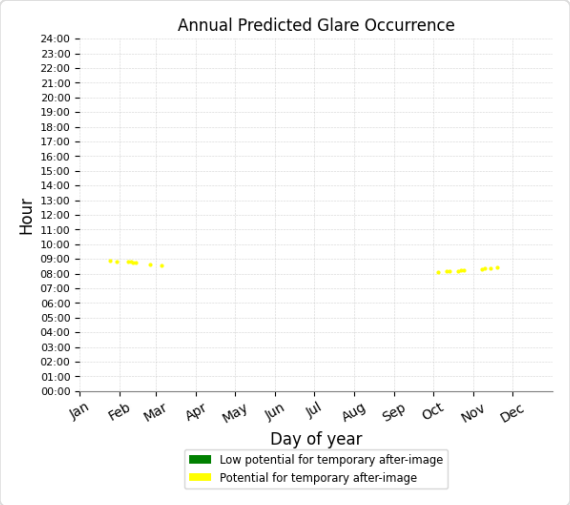
Receptor type: 2-mile Flight Path
No glare found

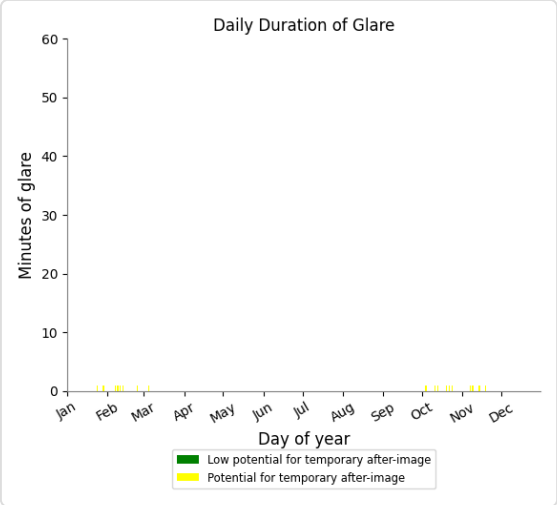
PV array 4 and FP 4 - RAF Lakenheath

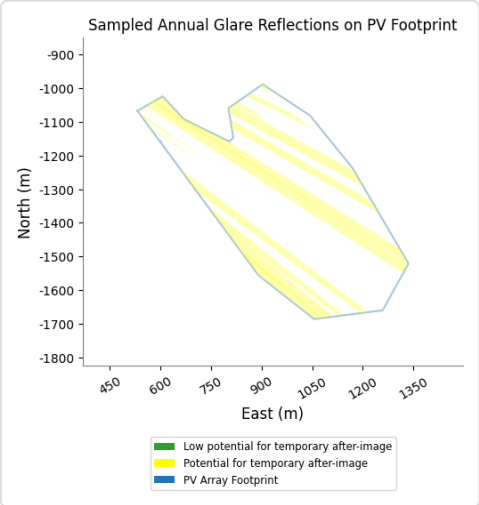
Receptor type: 2-mile Flight Path
No glare found

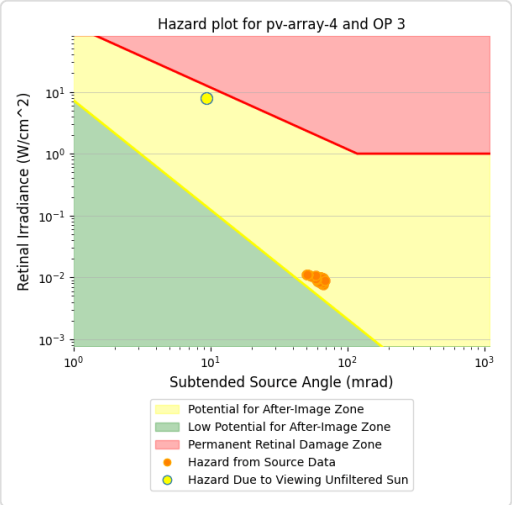
PV array 4 and OP 3

Receptor type: Observation Point
18 minutes of yellow glare
0 minutes of green glare



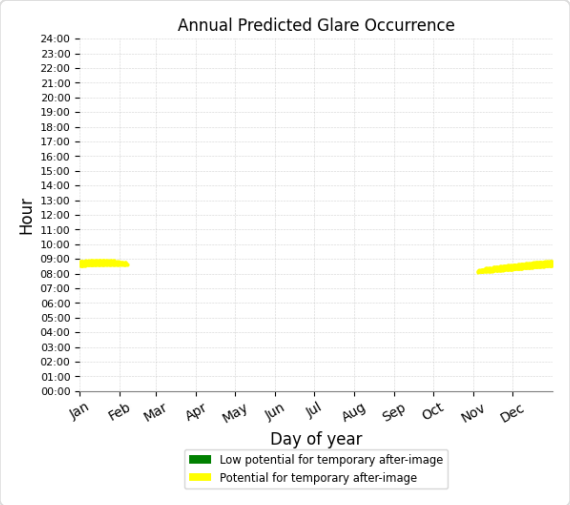


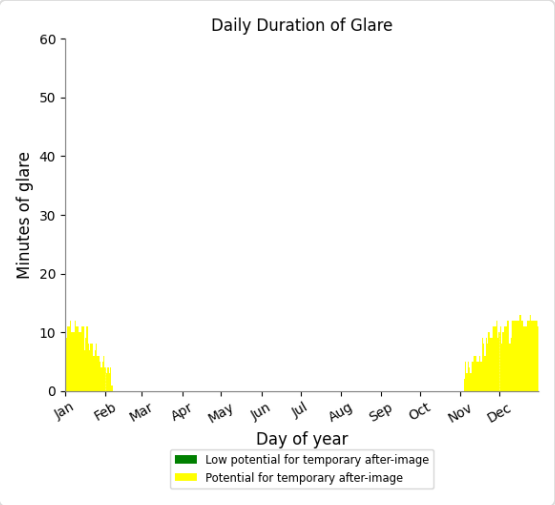


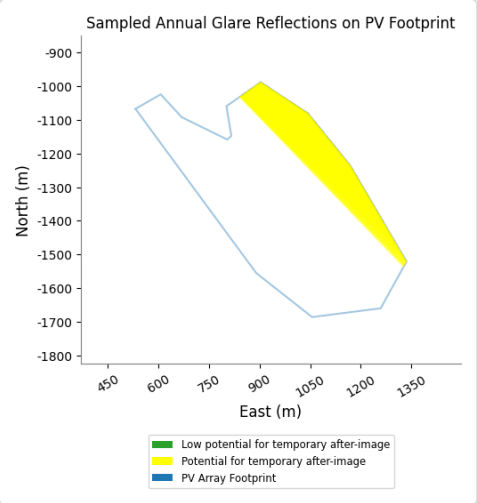


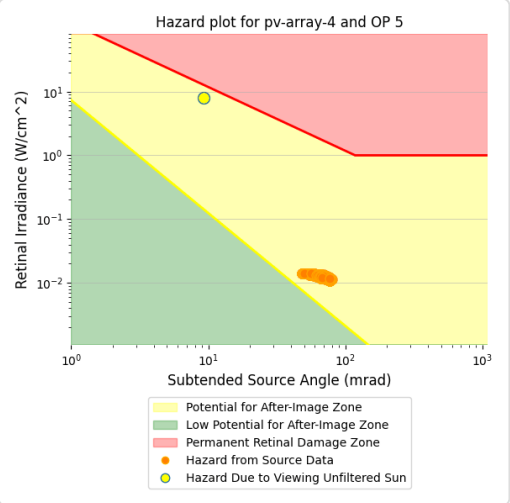
PV array 4 and OP 5

Receptor type: Observation Point
826 minutes of yellow glare
0 minutes of green glare



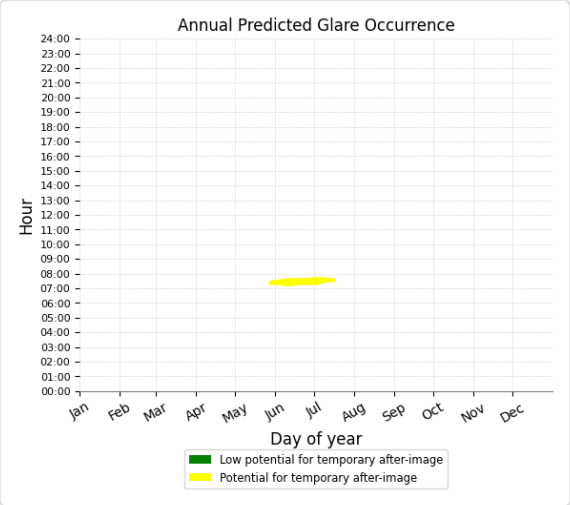


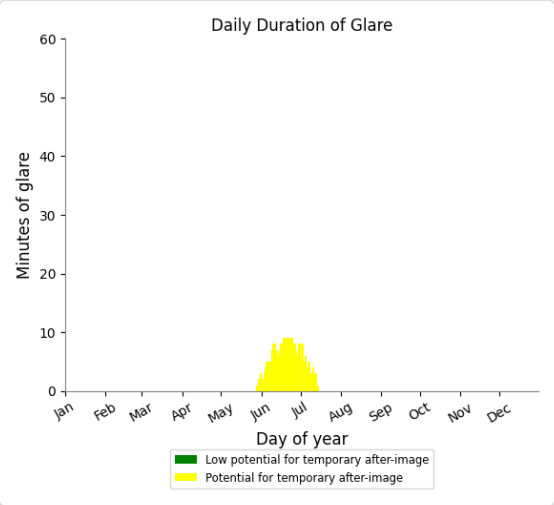


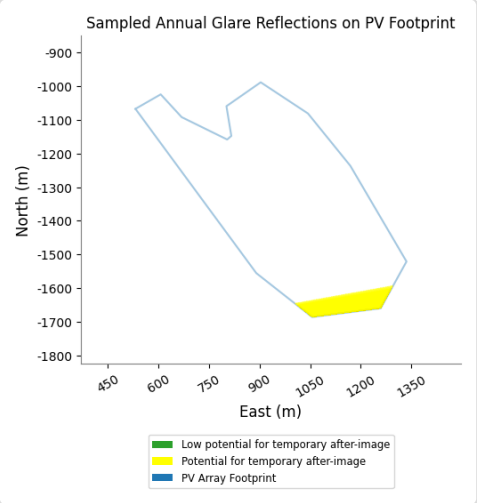


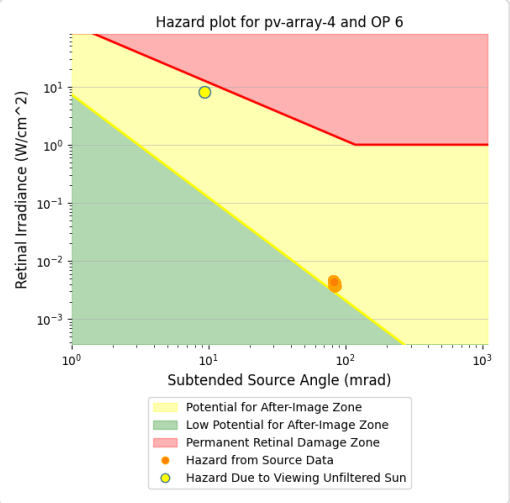
PV array 4 and OP 6

Receptor type: Observation Point
282 minutes of yellow glare
0 minutes of green glare









PV array 4 and 1-ATCT

Receptor type: Observation Point
No glare found

PV array 4 and 2-ATCT

Receptor type: Observation Point
No glare found

PV array 4 and OP 4

Receptor type: Observation Point
No glare found

PV array 4 and OP 7

Receptor type: Observation Point
No glare found

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.
The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
Several V1 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. This primarily affects V1 analyses of path receptors.
Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
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.)
The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
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.
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

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