MAG

Glint and Glare Assessment – WCHG Phase 2



Version	Date	Changes
V1.0	13/11/2025	
V2.0	26/11/2025	Scheme change

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Purpose

Manchester Airports Group (MAG) have been commissioned by Wythenshawe Community Housing Group to produce a glint and glare assessment relating to proposed solar PV installation upon four of their housing units in Wythenshawe.

The purpose of this report is to identify any glint and glare implications upon aviation receptors established for Manchester Airport.

Executive Summary

The solar PV installations have been assessed and show that no glare is predicted. No detrimental impact is expected towards the aviation receptors established at Manchester Airport.

Context

Regulatory

The Air Navigation Order-

The Air Navigation Order 2016 is a statutory instrument that consolidates and amends the provisions of the Air Navigation Order 2009. It regulates various aspects of aviation safety standards and aircraft navigation in the United Kingdom. The order covers a wide range of topics, including aircraft, air crew, passengers, cargo, air traffic, and aerodromes.

The Air Navigation Order 2016 was established to ensure compliance with the Convention on International Civil Aviation and to regulate aviation safety.

Namely, the Air Navigation Order Part 10, 240 & 241 outlines the following provisions:

-Part 10: 240: A person must not recklessly or negligently act in a manner likely to endanger an aircraft, or any person in an aircraft.

-Part 10: 241: A person must not recklessly or negligently cause or permit an aircraft to endanger any person or property.

The Air Navigation Order may be used to safeguard aerodromes where a development or activity is found to cause a hazard to aviation; a glint and glare hazard may be deemed to a present a hazard to aviation. This assessment identifies any issues, at planning stage, and aims to avoid the creation of a hazard that would otherwise necessitate enforcement under the Air Navigation Order.

CAP 738-

CAP 738 is a document published by the Civil Aviation Authority (CAA) that offers guidance to those responsible for the safe operation of an aerodrome or a technical site. It helps them to assess the impact of proposed development or construction on the operation of an aerodrome. The document provides valuable information on safeguarding aerodromes and

technical sites. It is designed to help assess the potential impact of development or construction projects on the safe operation of an aerodrome.

Chapter 1, Section 1.1 (h) outlines glint and glare as a specific area of interest when safeguarding aerodromes.

Interim Civil Aviation Authority Guidance

The Civil Aviation Authority (CAA) sought to develop its policy on Solar Photovoltaic Panels (SPV) in 2010. To achieve this, the CAA examined the results of research conducted by the Federal Aviation Administration (FAA) on the effects of SPV on aviation. Additionally, they reviewed guidance issued by other organizations on this subject. The CAA has issued interim guidance on solar photovoltaic systems while it continues to develop its policy and guidance material.

UK Regulation 139/2014

UK Regulation 139/2014, specifically, GM1 ADR-DSN.M.615 General, provides guidance on visual aids for navigation, specifically addressing potential hazards that could impair visibility for pilots and air traffic controllers. Within this context, the regulation highlights that installations such as solar photovoltaic (PV) panels near aerodromes must be assessed for glint and glare impacts. The guidance emphasizes that reflective surfaces should not create conditions that compromise the effectiveness of visual aids or distract pilots during critical phases of flight. It is expected that any solar PV installations do not introduce excessive glare that could interfere with aviation safety. GM 1 M.615 outlines aviation receptors that should be protected and provides a maximum luminance threshold associated with certain receptors.

CAST Guidance

The Combined Aerodrome Safeguarding Team (CAST) are an industry body supported by the Civil Aviation Authority who convene on a quarterly basis to forward the safeguarding cause. CAST also consists of various working groups which focus upon specific tasks and safeguarding disciplines. The Technical Focus Group and General Aviation Focus Group produced a guidance note with regards to the use of photovoltaic within proximity to aerodromes. Glint and glare is one of the primary hazards outlined within the guidance document, and a Glint and Glare Assessment is listed as one of the methodologies to mitigate against the glint and glare hazard.

Glint and glare

Glint and glare are important considerations in aviation, especially in relation to solar renewable energy systems near airports. Glint refers to the momentary flash of bright light, while glare is a continuous source of bright light. These phenomena can potentially affect pilots and air traffic control personnel, leading to safety concerns.

It is important for developers and planning authorities to consider the potential effects of glint and glare when proposing solar projects near airports. By adhering to glint and glare regulations, aviation safety can be maintained while harnessing the benefits of solar energy.

For aviation purposes, glint and glare output has been split into 3 broad categories:

Key	Impact
Green	A low potential for temporary after image
Yellow	Potential for temporary after image
Red	Potential for permanent eye damage

It is *generally* accepted that green glare is operationally acceptable to aviation operations, and is regularly encountered during flying activities, although any glint and glare should be taken into an operational context resulting in each output being bespoke. Both yellow and red glare are generally not acceptable towards aviation receptors. As outlined within 139/2014 expected luminance should also be taken into consideration, with a 20,000cd/m2 limit being outlined towards certain receptors, along with FAA guidance outlining that glint and glare should be avoided towards air traffic control.

Development Plans

The proposed scheme is to install PV arrays across the west and east facing roofs of four housing units located on Foscarn Drive, Bracken Drive, Glazebury Drive, and Wendon Drive in Wythenshawe. A planning application was submitted to Manchester City Council for the aforementioned works reference: 143950/FO/2025. The scheme is located circa 2.2kms north of Manchester Airport. Figure 1 below shows the units:



Figure 1

Aviation Receptors

Manchester Airport Air Traffic Control Tower

The current Manchester Airport Air Traffic Control Tower was built in 2013 and is 60 metres above ground level – making it the 2nd tallest in the UK. Glint and glare can have a considerable impact upon the ability of the air traffic control tower to operate; it is crucial that effective visuals are maintained from the tower to ensure sound situational awareness by air traffic control personnel. It is important that any glint and glare towards the tower is managed accordingly to maintain safe operations. The Manchester Airport Air Traffic Control Tower can be seen in Figure 2.

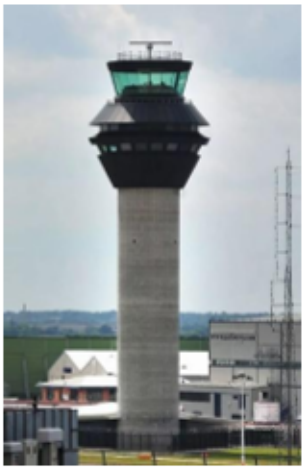


Figure 2

Runway 23R/05L & 23L/05R 10 Nautical Mile Approach/Departure Paths

When aircraft operate in and out of Manchester Airport, they utilise the approach/departure paths established for Manchester Airport. For aircraft approaches, standard practice is for a 10 nautical mile approach path on a 3-degree glide slope to be established. This enables aircraft to utilise the instrument landing system.

This phase of flight is one of the most critical for safe aircraft operations, and results in high workloads for flight crew. Therefore, it is important that the 10 nautical mile approach/departure paths are protected, and the risk of incident is not increased by introducing a glint and glare hazard during this critical phase of flight.

The UK Aeronautical Information Package contains charts depicting the Manchester Airport standard approach, an example of which can be seen below:

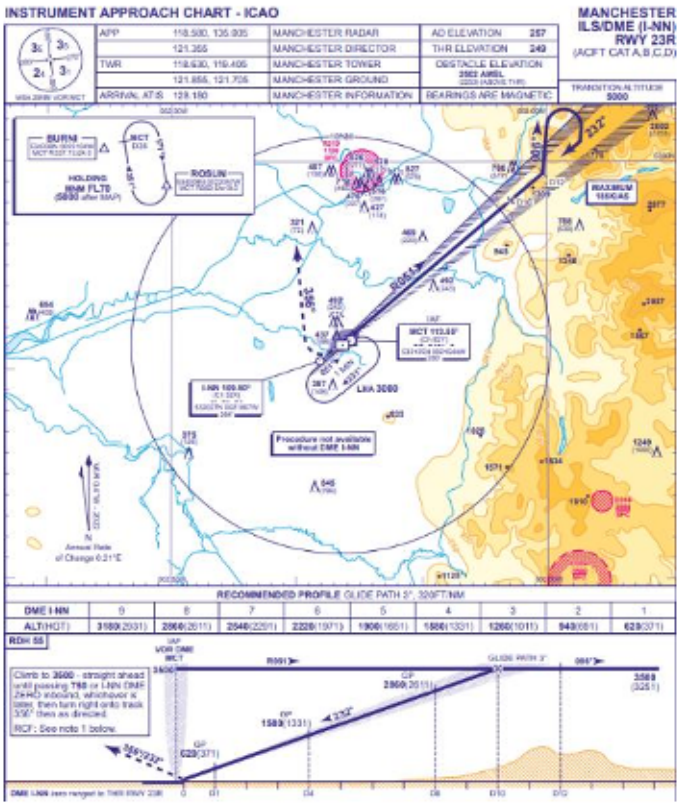


Figure 3

Manchester Airport Runway 23R/05L & 23L/05R 2-Mile Approach Path

The 2-mile approach path is a critical segment of flight where aircraft are on final approach, requiring precise visual alignment with the runway. During this phase, pilots experience high workload and depend heavily on visual cues, making any external distraction a potential safety hazard. Glint and glare from solar photovoltaic panels located near the aerodrome can impair visibility or cause temporary after-images, which could compromise situational awareness. To mitigate this risk, Glint and Glare Assessments include a dedicated parameter for the 2-mile approach path that evaluates glare intensity and duration. In accordance with UK Regulation 139/2014 guidance, installations must ensure that glare does not exceed acceptable thresholds. Specifically, a maximum luminance limit of 20,000 cd/m² is applied to prevent conditions that could interfere with visual aids or distract pilots during critical flight phases.

Runway Ground Based Receptors

UK Regulation 139/2014 GM1 ADR-DSN.M.615 General emphasises the importance of safeguarding visual aids and maintaining clear visibility for pilots and air traffic controllers during all phases of flight, including ground operations. When aircraft are on the runway for landing or take-off, pilots rely heavily on visual cues such as runway markings, approach lighting systems etc. to maintain alignment and situational awareness. Any unexpected glare from nearby reflective surfaces—such as solar photovoltaic panels—can cause temporary visual impairment or distraction at a critical moment when reaction time is limited. This is particularly significant during low sun angles or wet conditions, where glare intensity can increase. Assessing glint and glare impacts on runway receptors ensures that reflective

hazards do not compromise operational safety, interfere with visual navigation aids, or create conditions that could lead to runway excursions or misalignment.

Visual Flight Rules Lanes

Aircraft generally operate on either Visual Flight Rules (VFR) or Instrument Flight Rules (IFR), where aircraft are operating under VFR this is done via the tracking of ground-based objects and visual reference points (such as roads, rivers, and landmarks). Most commercial air traffic will utilise IFR flight rules, meaning that generally they follow the defined SIDs, and STARs stipulated within the UK AIP. To reduce the potential for conflict between VFR and IFR flights, VFR lanes have been established at Manchester Airport. The VFR lanes are depicted below shown by the blue arrows:

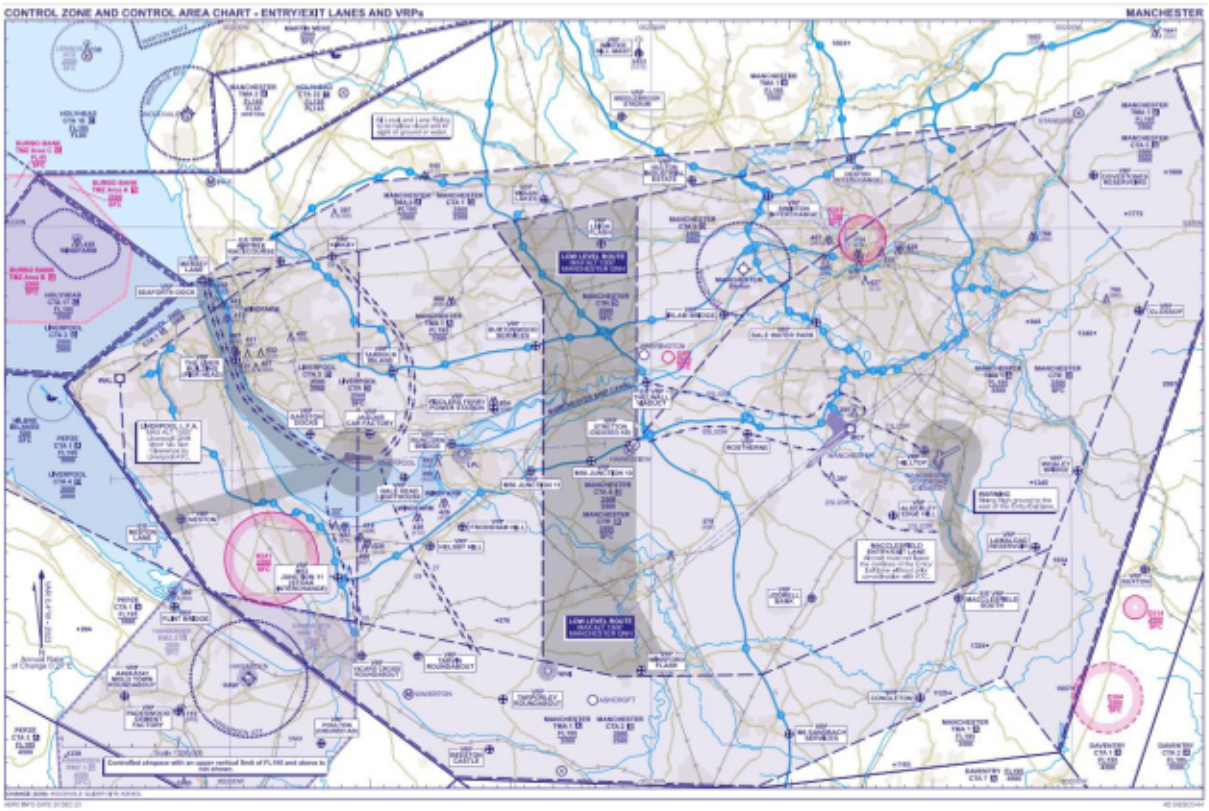


Figure 4

A requirement of flying VFR is that the pilot maintains visual reference with the ground and landmarks. This means that VFR flight is required to maintain below cloud level and clear outside visibility is essential to maintain safe operations. Therefore, the introduction of a glint and glare hazard within a VFR lane has the potential to prevent safe operations, and also could constitute a health hazard should the reflector have the potential to generate permanent ocular damage.

Assessment Methodology

The Solar Glare Hazard Analysis Tool (SGHAT) tool has been utilised to inform this glint and glare assessment. The SGHAT tool is utilised internationally and is an industry leader in glint/glare analysis for aviation receptors.

The Assessment Process

MAG has developed detailed models for their airports within the SGHAT software. These models consist of the relevant aviation receptors outlined above; to develop these models a mixture of published aeronautical information, charts and real-world aircraft data have been utilised.

The specific scheme parameters are then entered into the SGHAT assessment tool to create an accurate model of the proposals. Documentation of the proposals are utilised to inform the assessed reflector areas.

Once the proposal details have been entered into the assessment model and verified, the programme will execute, and the predictions will be delivered.

Following successful operation of the SGHAT assessment, the Aerodrome Safeguarding Authority will complete a sense-check of the outcomes provided by the model and rectify any identified irregularities.

Finally, the results are analysed for any potential impact to aviation operations and conclusions presented in a report format.

Assessment Limitations

Although the methodology outlined above utilises industry leading software, and expert subject matter analysis, there will always be limitations upon any assessment method.

SGHAT Software Limitations/Assumptions:

The following information is provided by the SGHAT software which outlines the assumptions and limitations of the software:

“"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 modelling 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."

Other Limitations

Although best endeavours are made to ensure the accuracy of the data inputted into the SGHAT model, the risk of incorrect values being inserted cannot be irradicated. Where errors are identified remedial action can be taken to rectify any errors.
Where the proposals subsequently change following the production of this glint and glare report this has the potential to change the glint and glare outcome. Therefore, any changes post the date of this report which are not subsequently assessed may result in unexpected glint and glare impacts.

Array Layout

Based upon the details provided the various arrays were plotted into the assessment software; please see the end of this document for details of the full assessment.

A worst-case scenario panel type of “Smooth glass without AR coating” has been used as a conservative baseline for the assessment. Should the assessment highlight a glint/glare hazard then the panel type can be amended to potentially mitigate glint/glare concerns.

Assessment Results

Pretext

The table below summarises the glint and glare results produced by the model and any potential actions/recommendations suggested. Detailed modelling outputs can be provided upon request.

Overall combined results

Aviation Receptor	Predicted Glint and Glare	Actions/Recommendations
ATC Tower	None	None
RWY 05L APP/DEP 10NM Path	None	None
RWY 23R APP/DEP 10NM Path	None	None
RWY 05R APP/DEP 10NM Path	None	None
RWY 23L APP/DEP 10NM Path	None	None
Macclesfield VFR - Outbound	None	None
Macclesfield VFR South	None	None
Stretton Disused VFR - Inbound	None	None
Thelwall Viaduct VFR - Inbound	None	None
RWY 05L 2-mile Approach	None	None
RWY 23R 2-mile Approach	None	None
RWY 05R 2-mile Approach	None	None
RWY 23L 2-mile Approach	None	None
RWY 1 Ground Based Receptor	None	None
RWY 2 Ground Based Receptor	None	None

Conclusion/Recommendation

Overall, the predicted levels of glint and glare are not expected to have a detrimental impact upon the aviation receptors established at Manchester Airport. On this basis, Manchester Airport Aerodrome Safeguarding Authority would be content with the proposed arrays.

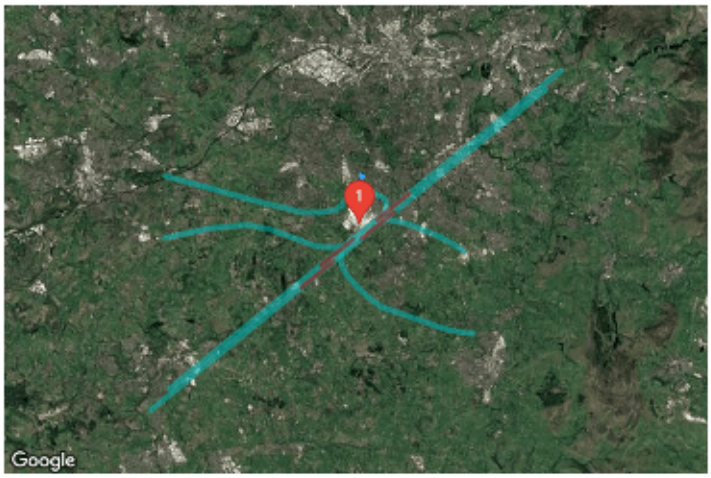

MAG

FORGESOLAR GLARE ANALYSIS

Project: **MAN 4**
Site configuration: **MAN 4-temp-4**

Created 26 Nov, 2025
Updated 26 Nov, 2025
Time-step 1 minute
Timezone offset UTC0
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 500 kW to 1 MW
(1,000 kW / 32,400 m^2 limit)
Site ID 165763.26996

Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
PV analysis methodology V2



Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
Bracken Drive East	35.0	76.0	0	0.0	0	0.0	-
Bracken Drive West	35.0	254.0	0	0.0	0	0.0	-
Foscarn Drive East	35.0	75.0	0	0.0	0	0.0	-
Foscarn Drive West	35.0	253.0	0	0.0	0	0.0	-
Glazebury Drive East	35.0	80.0	0	0.0	0	0.0	-
Glazebury Drive West	35.0	257.0	0	0.0	0	0.0	-
Wendon Road East	35.0	79.0	0	0.0	0	0.0	-
Wendon Road West	35.0	258.0	0	0.0	0	0.0	-

Total 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
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
Macclesfield Outbound	0	0.0	0	0.0
Macclesfield South VRP-Hilltop	0	0.0	0	0.0
RWY 01	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
RWY 02	0	0.0	0	0.0
Stretton Disused AD VRP - Inbound	0	0.0	0	0.0
Thelwall Viaduct VRP - Outbound	0	0.0	0	0.0
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: Bracken Drive East
Axis tracking: Fixed (no rotation)
Tilt: 35.0°
Orientation: 76.0°
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	53.392167	-2.277808	55.02	11.00	66.02
2	53.392129	-2.277865	55.10	11.00	66.10
3	53.391410	-2.277556	55.75	11.00	66.75
4	53.391384	-2.277474	55.67	11.00	66.67

Name: Bracken Drive West
Axis tracking: Fixed (no rotation)
Tilt: 35.0°
Orientation: 254.0°
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	53.392145	-2.277945	55.09	11.00	66.09
2	53.392130	-2.277867	55.10	11.00	66.10
3	53.391409	-2.277557	55.75	11.00	66.75
4	53.391362	-2.277614	55.62	11.00	66.62

Name: Foscarn Drive East
Axis tracking: Fixed (no rotation)
Tilt: 35.0°
Orientation: 75.0°
Rated power: -
Panel material: Smooth glass without AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



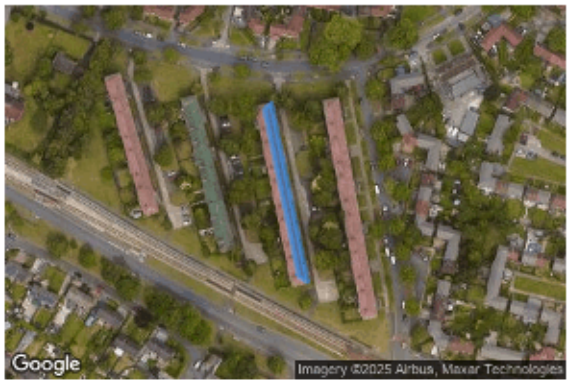
Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.392279	-2.278462	54.93	11.00	65.93
2	53.392240	-2.278514	55.12	11.00	66.12
3	53.391594	-2.278210	56.62	11.00	67.62
4	53.391570	-2.278126	56.57	11.00	67.57

Name: Foscarn Drive West
Axis tracking: Fixed (no rotation)
Tilt: 35.0°
Orientation: 253.0°
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	53.392255	-2.278597	55.17	11.00	66.17
2	53.392239	-2.278514	55.12	11.00	66.12
3	53.391594	-2.278209	56.62	11.00	67.62
4	53.391546	-2.278262	56.80	11.00	67.80

Name: Glazebury Drive East
Axis tracking: Fixed (no rotation)
Tilt: 35.0°
Orientation: 80.0°
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	53.392089	-2.277231	54.66	12.00	66.66
2	53.392124	-2.277171	54.51	12.00	66.51
3	53.391208	-2.276858	55.04	12.00	67.04
4	53.391233	-2.276935	55.23	12.00	67.23

Name: Glazebury Drive West
Axis tracking: Fixed (no rotation)
Tilt: 35.0°
Orientation: 257.0°
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	53.392105	-2.277316	54.73	12.00	66.73
2	53.392088	-2.277230	54.66	12.00	66.66
3	53.391233	-2.276936	55.23	12.00	67.23
4	53.391187	-2.276998	55.11	12.00	67.11

Name: Wendon Road East
Axis tracking: Fixed (no rotation)
Tilt: 35.0°
Orientation: 79.0°
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	53.392151	-2.276589	53.59	12.00	65.59
2	53.392117	-2.276648	53.76	12.00	65.76
3	53.391061	-2.276329	53.57	12.00	65.57
4	53.391033	-2.276247	53.36	12.00	65.36

Name: Wendon Road West
Axis tracking: Fixed (no rotation)
Tilt: 35.0°
Orientation: 258.0°
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	53.392135	-2.276729	53.83	12.00	65.83
2	53.392117	-2.276648	53.76	12.00	65.76
3	53.391061	-2.276328	53.57	12.00	65.57
4	53.391016	-2.276387	53.61	12.00	65.61

Route Receptors

Name: 05L
Path type: Two-way
Azimuthal view angle: 50.0°
Downward view angle: 90.0°



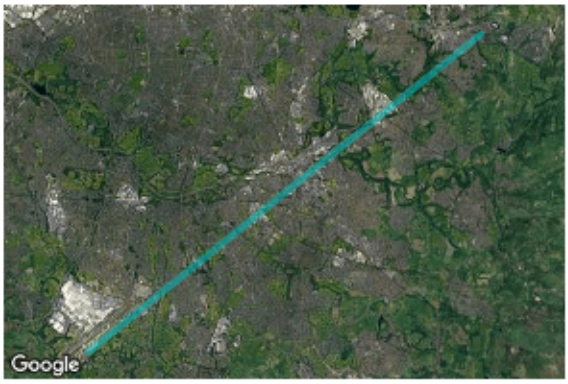
Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.347758	-2.287333	64.60	0.00	64.60
2	53.337326	-2.308813	79.10	100.70	179.80
3	53.326890	-2.330283	79.40	194.90	274.30
4	53.316450	-2.351742	80.90	291.00	371.90
5	53.306006	-2.373191	81.90	387.50	469.40
6	53.295558	-2.394630	84.00	482.90	566.90
7	53.285106	-2.416057	85.90	575.50	661.40
8	53.274651	-2.437475	84.90	674.10	759.00
9	53.264191	-2.458882	81.80	774.70	856.50
10	53.253728	-2.480279	75.30	810.10	885.40
11	53.243261	-2.501665	79.20	835.20	914.40

Name: 05R
Path type: Two-way
Azimuthal view angle: 50.0°
Downward view angle: 90.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.332179	-2.310224	56.70	0.00	56.70
2	53.321742	-2.331691	81.00	86.60	167.60
3	53.311302	-2.353148	80.90	184.30	265.20
4	53.300858	-2.374594	72.60	290.10	362.70
5	53.290410	-2.396029	72.70	387.50	460.20
6	53.279958	-2.417454	89.80	464.90	554.70
7	53.269502	-2.438869	88.10	564.20	652.30
8	53.259042	-2.460273	92.60	657.20	749.80
9	53.248579	-2.481667	95.40	751.90	847.30
10	53.238111	-2.503050	74.20	840.20	914.40
11	53.227640	-2.524423	87.40	827.00	914.40

Name: 23L
Path type: Two-way
Azimuthal view angle: 50.0°
Downward view angle: 90.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.347952	-2.277613	69.20	0.00	69.20
2	53.358379	-2.256120	123.00	126.90	249.90
3	53.368802	-2.234616	152.20	195.30	347.50
4	53.379221	-2.213102	415.70	29.30	445.00
5	53.389636	-2.191577	430.30	112.20	542.50
6	53.400047	-2.170041	199.10	441.00	640.10
7	53.410454	-2.148495	254.90	482.70	737.60
8	53.420857	-2.126939	134.30	697.80	832.10
9	53.431257	-2.105372	97.60	832.00	929.60
10	53.441652	-2.083795	103.40	923.80	1027.20
11	53.452043	-2.062207	164.90	901.90	1066.80

Name: 23R
Path type: Two-way
Azimuthal view angle: 50.0°
Downward view angle: 90.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.361121	-2.259690	77.80	-1.90	75.90
2	53.371544	-2.238183	75.40	113.60	189.00
3	53.381964	-2.216669	71.00	215.50	286.50
4	53.392380	-2.195143	70.00	314.00	384.00
5	53.402792	-2.173607	70.40	411.20	481.60
6	53.413199	-2.152061	72.80	506.30	579.10
7	53.423603	-2.130504	76.70	600.00	676.70
8	53.434003	-2.108936	72.10	702.10	774.20
9	53.444399	-2.087359	71.50	800.20	871.70
10	53.454791	-2.065771	67.60	901.70	969.30
11	53.465180	-2.044172	67.00	999.80	1066.80

Name: Macclesfield Outbound
Path type: One-way (toward increasing index)
Azimuthal view angle: 50.0°
Downward view angle: 90.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.336897	-2.301001	56.50	400.70	457.20
2	53.332694	-2.302203	58.20	399.00	457.20
3	53.328491	-2.300486	61.40	395.80	457.20
4	53.321724	-2.293963	63.60	393.60	457.20
5	53.315366	-2.284522	64.00	393.20	457.20
6	53.307059	-2.270445	71.60	385.60	457.20
7	53.300083	-2.254138	78.60	378.60	457.20
8	53.296595	-2.236971	98.10	359.10	457.20
9	53.285718	-2.185436	164.90	292.30	457.20
10	53.282742	-2.164150	144.30	312.90	457.20
11	53.281511	-2.147328	122.10	335.10	457.20

Name: Macclesfield South VRP-Hilltop
Path type: Two-way
Azimuthal view angle: 50.0°
Downward view angle: 90.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.339131	-2.157992	94.00	363.20	457.20
2	53.344460	-2.171381	88.00	369.20	457.20
3	53.349277	-2.186144	84.10	373.10	457.20
4	53.353683	-2.204340	77.80	379.40	457.20
5	53.357781	-2.221163	82.70	374.50	457.20
6	53.359727	-2.233180	82.50	374.70	457.20
7	53.360957	-2.244509	80.50	376.70	457.20
8	53.361162	-2.250002	79.20	378.00	457.20

Name: RWY 01
Path type: Two-way
Azimuthal view angle: 50.0°
Downward view angle: 90.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.347560	-2.287770	66.21	4.04	70.25
2	53.361330	-2.259260	76.93	4.04	80.97

Name: RWY 02
Path type: Two-way
Azimuthal view angle: 50.0°
Downward view angle: 90.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.332010	-2.310580	56.37	4.04	60.41
2	53.348170	-2.277180	67.52	4.04	71.56

Name: Stretton Disused AD VRP - Inbound
Path type: One-way (toward increasing index)
Azimuthal view angle: 50.0°
Downward view angle: 90.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.348457	-2.507559	61.40	334.80	396.20
2	53.350251	-2.493912	62.10	334.10	396.20
3	53.355333	-2.453913	69.90	326.30	396.20
4	53.357382	-2.412028	51.60	344.60	396.20
5	53.354718	-2.386279	23.00	373.20	396.20
6	53.349185	-2.360186	43.60	352.60	396.20
7	53.343651	-2.335810	42.60	353.60	396.20
8	53.342011	-2.321734	52.70	343.50	396.20
9	53.342011	-2.309031	56.20	340.00	396.20
10	53.342421	-2.299418	59.80	336.40	396.20
11	53.347955	-2.288088	66.30	329.90	396.20

Name: Thelwall Viaduct VRP - Outbound
Path type: One-way (toward increasing index)
Azimuthal view angle: 50.0°
Downward view angle: 90.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.365659	-2.250474	76.40	319.80	396.20
2	53.370246	-2.248777	71.90	324.30	396.20
3	53.374777	-2.249507	68.40	327.80	396.20
4	53.376749	-2.252167	66.50	329.70	396.20
5	53.378182	-2.257832	66.40	329.80	396.20
6	53.380410	-2.266115	61.70	334.50	396.20
7	53.381536	-2.271780	57.50	338.70	396.20
8	53.382867	-2.279032	57.60	338.60	396.20
9	53.382611	-2.283624	58.00	338.20	396.20
10	53.381177	-2.289804	61.00	335.20	396.20
11	53.378387	-2.293280	61.90	334.30	396.20
12	53.373581	-2.298830	59.00	337.20	396.20
13	53.371072	-2.300976	58.00	338.20	396.20
14	53.368460	-2.306898	67.20	329.00	396.20
15	53.367385	-2.312735	62.60	333.60	396.20
16	53.366412	-2.324494	62.40	333.80	396.20
17	53.366361	-2.341746	30.00	366.20	396.20
18	53.366719	-2.350415	34.40	361.80	396.20
19	53.370201	-2.372731	35.00	361.20	396.20
20	53.372608	-2.390924	24.90	371.30	396.20
21	53.391821	-2.507312	21.50	374.70	396.20

Flight Path Receptors

Name: 05L
Description: None
Threshold height: 15 m
Direction: 50.8°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



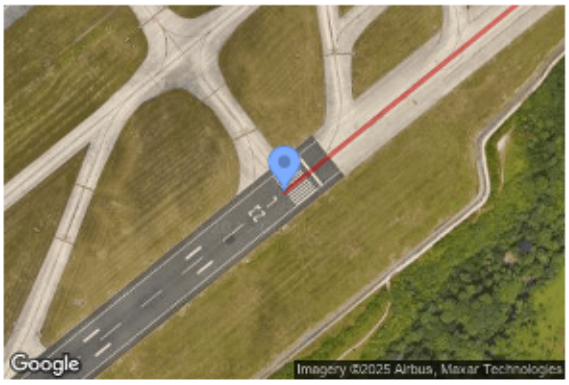
Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	53.347764	-2.287339	66.90	15.00	81.90
Two-mile	53.329490	-2.324916	50.00	200.60	250.60

Name: 05R
Description: None
Threshold height: 15 m
Direction: 50.8°
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	53.332180	-2.310225	56.50	15.00	71.50
Two-mile	53.313906	-2.347788	49.80	190.40	240.20

Name: 23L
Description: None
Threshold height: 15 m
Direction: 230.9°
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	53.347954	-2.277618	66.60	15.00	81.60
Two-mile	53.366188	-2.239987	75.70	174.60	250.30

Name: 23R
Description: None
Threshold height: 15 m
Direction: 230.9°
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	53.361122	-2.259693	77.00	15.00	92.00
Two-mile	53.379357	-2.222051	61.30	199.40	260.70

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	53.357832	-2.279626	70.00	60.00

Map image of 1-ATCT



Glare Analysis Results

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
Bracken Drive East	35.0	76.0	0	0.0	0	0.0	-
Bracken Drive West	35.0	254.0	0	0.0	0	0.0	-
Foscarn Drive East	35.0	75.0	0	0.0	0	0.0	-
Foscarn Drive West	35.0	253.0	0	0.0	0	0.0	-
Glazebury Drive East	35.0	80.0	0	0.0	0	0.0	-
Glazebury Drive West	35.0	257.0	0	0.0	0	0.0	-
Wendon Road East	35.0	79.0	0	0.0	0	0.0	-
Wendon Road West	35.0	258.0	0	0.0	0	0.0	-

Total 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
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
Macclesfield Outbound	0	0.0	0	0.0
Macclesfield South VRP-Hilltop	0	0.0	0	0.0
RWY 01	0	0.0	0	0.0
RWY 02	0	0.0	0	0.0
Stretton Disused AD VRP - Inbound	0	0.0	0	0.0
Thelwall Viaduct VRP - Outbound	0	0.0	0	0.0
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: Bracken Drive East no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
Macclesfield Outbound	0	0.0	0	0.0
Macclesfield South VRP-Hilltop	0	0.0	0	0.0
RWY 01	0	0.0	0	0.0
RWY 02	0	0.0	0	0.0
Stretton Disused AD VRP - Inbound	0	0.0	0	0.0
Thelwall Viaduct VRP - Outbound	0	0.0	0	0.0
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Bracken Drive East and Route: 05L

No glare found

Bracken Drive East and Route: 05R

No glare found

Bracken Drive East and Route: 23L

No glare found

Bracken Drive East and Route: 23R

No glare found

Bracken Drive East and Route: Macclesfield Outbound

No glare found

Bracken Drive East and Route: Macclesfield South VRP-Hilltop

No glare found

Bracken Drive East and Route: RWY 01

No glare found

Bracken Drive East and Route: RWY 02

No glare found

Bracken Drive East and Route: Stretton Disused AD VRP - Inbound

No glare found

Bracken Drive East and Route: Thelwall Viaduct VRP - Outbound

No glare found

Bracken Drive East and FP: 05L

No glare found

Bracken Drive East and FP: 05R

No glare found

Bracken Drive East and FP: 23L

No glare found

Bracken Drive East and FP: 23R

No glare found

Bracken Drive East and 1-ATCT

No glare found

PV: Bracken Drive West no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
Macclesfield Outbound	0	0.0	0	0.0
Macclesfield South VRP-Hilltop	0	0.0	0	0.0
RWY 01	0	0.0	0	0.0
RWY 02	0	0.0	0	0.0
Stretton Disused AD VRP - Inbound	0	0.0	0	0.0
Thelwall Viaduct VRP - Outbound	0	0.0	0	0.0
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Bracken Drive West and Route: 05L

No glare found

Bracken Drive West and Route: 05R

No glare found

Bracken Drive West and Route: 23L

No glare found

Bracken Drive West and Route: 23R

No glare found

Bracken Drive West and Route: Macclesfield Outbound

No glare found

Bracken Drive West and Route: Macclesfield South VRP-Hilltop

No glare found

Bracken Drive West and Route: RWY 01

No glare found

Bracken Drive West and Route: RWY 02

No glare found

Bracken Drive West and Route: Stretton Disused AD VRP - Inbound

No glare found

Bracken Drive West and Route: Thelwall Viaduct VRP - Outbound

No glare found

Bracken Drive West and FP: 05L

No glare found

Bracken Drive West and FP: 05R

No glare found

Bracken Drive West and FP: 23L

No glare found

Bracken Drive West and FP: 23R

No glare found

Bracken Drive West and 1-ATCT

No glare found

PV: Foscarn Drive East no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
Macclesfield Outbound	0	0.0	0	0.0
Macclesfield South VRP-Hilltop	0	0.0	0	0.0
RWY 01	0	0.0	0	0.0
RWY 02	0	0.0	0	0.0
Stretton Disused AD VRP - Inbound	0	0.0	0	0.0
Thelwall Viaduct VRP - Outbound	0	0.0	0	0.0
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Foscarn Drive East and Route: 05L

No glare found

Foscarn Drive East and Route: 05R

No glare found

Foscarn Drive East and Route: 23L

No glare found

Foscarn Drive East and Route: 23R

No glare found

Foscarn Drive East and Route: Macclesfield Outbound

No glare found

Foscarn Drive East and Route: Macclesfield South VRP-Hilltop

No glare found

Foscarn Drive East and Route: RWY 01

No glare found

Foscarn Drive East and Route: RWY 02

No glare found

Foscarn Drive East and Route: Stretton Disused AD VRP - Inbound

No glare found

Foscarn Drive East and Route: Thelwall Viaduct VRP - Outbound

No glare found

Foscarn Drive East and FP: 05L

No glare found

Foscarn Drive East and FP: 05R

No glare found

Foscarn Drive East and FP: 23L

No glare found

Foscarn Drive East and FP: 23R

No glare found

Foscarn Drive East and 1-ATCT

No glare found

PV: Foscarn Drive West no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
Macclesfield Outbound	0	0.0	0	0.0
Macclesfield South VRP-Hilltop	0	0.0	0	0.0
RWY 01	0	0.0	0	0.0
RWY 02	0	0.0	0	0.0
Stretton Disused AD VRP - Inbound	0	0.0	0	0.0
Thelwall Viaduct VRP - Outbound	0	0.0	0	0.0
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Foscarn Drive West and Route: 05L

No glare found

Foscarn Drive West and Route: 05R

No glare found

Foscarn Drive West and Route: 23L

No glare found

Foscarn Drive West and Route: 23R

No glare found

Foscarn Drive West and Route: Macclesfield Outbound

No glare found

Foscarn Drive West and Route: Macclesfield South VRP-Hilltop

No glare found

Foscarn Drive West and Route: RWY 01

No glare found

Foscarn Drive West and Route: RWY 02

No glare found

Foscarn Drive West and Route: Stretton Disused AD VRP - Inbound

No glare found

Foscarn Drive West and Route: Thelwall Viaduct VRP - Outbound

No glare found

Foscarn Drive West and FP: 05L

No glare found

Foscarn Drive West and FP: 05R

No glare found

Foscarn Drive West and FP: 23L

No glare found

Foscarn Drive West and FP: 23R

No glare found

Foscarn Drive West and 1-ATCT

No glare found

PV: Glazebury Drive East no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
Macclesfield Outbound	0	0.0	0	0.0
Macclesfield South VRP-Hilltop	0	0.0	0	0.0
RWY 01	0	0.0	0	0.0
RWY 02	0	0.0	0	0.0
Stretton Disused AD VRP - Inbound	0	0.0	0	0.0
Thelwall Viaduct VRP - Outbound	0	0.0	0	0.0
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Glazebury Drive East and Route: 05L

No glare found

Glazebury Drive East and Route: 05R

No glare found

Glazebury Drive East and Route: 23L

No glare found

Glazebury Drive East and Route: 23R

No glare found

Glazebury Drive East and Route: Macclesfield Outbound

No glare found

Glazebury Drive East and Route: Macclesfield South VRP-Hilltop

No glare found

Glazebury Drive East and Route: RWY 01

No glare found

Glazebury Drive East and Route: RWY 02

No glare found

Glazebury Drive East and Route: Stretton Disused AD VRP - Inbound

No glare found

Glazebury Drive East and Route: Thelwall Viaduct VRP - Outbound

No glare found

Glazebury Drive East and FP: 05L

No glare found

Glazebury Drive East and FP: 05R

No glare found

Glazebury Drive East and FP: 23L

No glare found

Glazebury Drive East and FP: 23R

No glare found

Glazebury Drive East and 1-ATCT

No glare found

PV: Glazebury Drive West no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
Macclesfield Outbound	0	0.0	0	0.0
Macclesfield South VRP-Hilltop	0	0.0	0	0.0
RWY 01	0	0.0	0	0.0
RWY 02	0	0.0	0	0.0
Stretton Disused AD VRP - Inbound	0	0.0	0	0.0
Thelwall Viaduct VRP - Outbound	0	0.0	0	0.0
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Glazebury Drive West and Route: 05L

No glare found

Glazebury Drive West and Route: 05R

No glare found

Glazebury Drive West and Route: 23L

No glare found

Glazebury Drive West and Route: 23R

No glare found

Glazebury Drive West and Route: Macclesfield Outbound

No glare found

Glazebury Drive West and Route: Macclesfield South VRP-Hilltop

No glare found

Glazebury Drive West and Route: RWY 01

No glare found

Glazebury Drive West and Route: RWY 02

No glare found

Glazebury Drive West and Route: Stretton Disused AD VRP - Inbound

No glare found

Glazebury Drive West and Route: Thelwall Viaduct VRP - Outbound

No glare found

Glazebury Drive West and FP: 05L

No glare found

Glazebury Drive West and FP: 05R

No glare found

Glazebury Drive West and FP: 23L

No glare found

Glazebury Drive West and FP: 23R

No glare found

Glazebury Drive West and 1-ATCT

No glare found

PV: Wendon Road East no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
Macclesfield Outbound	0	0.0	0	0.0
Macclesfield South VRP-Hilltop	0	0.0	0	0.0
RWY 01	0	0.0	0	0.0
RWY 02	0	0.0	0	0.0
Stretton Disused AD VRP - Inbound	0	0.0	0	0.0
Thelwall Viaduct VRP - Outbound	0	0.0	0	0.0
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Wendon Road East and Route: 05L

No glare found

Wendon Road East and Route: 05R

No glare found

Wendon Road East and Route: 23L

No glare found

Wendon Road East and Route: 23R

No glare found

Wendon Road East and Route: Macclesfield Outbound

No glare found

Wendon Road East and Route: Macclesfield South VRP-Hilltop

No glare found

Wendon Road East and Route: RWY 01

No glare found

Wendon Road East and Route: RWY 02

No glare found

Wendon Road East and Route: Stretton Disused AD VRP - Inbound

No glare found

Wendon Road East and Route: Thelwall Viaduct VRP - Outbound

No glare found

Wendon Road East and FP: 05L

No glare found

Wendon Road East and FP: 05R

No glare found

Wendon Road East and FP: 23L

No glare found

Wendon Road East and FP: 23R

No glare found

Wendon Road East and 1-ATCT

No glare found

PV: Wendon Road West no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
Macclesfield Outbound	0	0.0	0	0.0
Macclesfield South VRP-Hilltop	0	0.0	0	0.0
RWY 01	0	0.0	0	0.0
RWY 02	0	0.0	0	0.0
Stretton Disused AD VRP - Inbound	0	0.0	0	0.0
Thelwall Viaduct VRP - Outbound	0	0.0	0	0.0
05L	0	0.0	0	0.0
05R	0	0.0	0	0.0
23L	0	0.0	0	0.0
23R	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Wendon Road West and Route: 05L

No glare found

Wendon Road West and Route: 05R

No glare found

Wendon Road West and Route: 23L

No glare found

Wendon Road West and Route: 23R

No glare found

Wendon Road West and Route: Macclesfield Outbound

No glare found

Wendon Road West and Route: Macclesfield South VRP-Hilltop

No glare found

Wendon Road West and Route: RWY 01

No glare found

Wendon Road West and Route: RWY 02

No glare found

Wendon Road West and Route: Stretton Disused AD VRP - Inbound

No glare found

Wendon Road West and Route: Thelwall Viaduct VRP - Outbound

No glare found

Wendon Road West and FP: 05L

No glare found

Wendon Road West and FP: 05R

No glare found

Wendon Road West and FP: 23L

No glare found

Wendon Road West and FP: 23R

No glare found

Wendon Road West and 1-ATCT

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

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