PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Land at Nailcote Farm

Enviromena Project Management UK Limited

November 2023

PLANNING SOLUTIONS FOR:

- Solar
- Telecoms
- Railways
- Defence
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ADMINISTRATION PAGE

Job Reference:	11867A
Author:	Andrea Mariano
Telephone:	01787 319001
Email:	andrea@pagerpower.com

Reviewers:	Waqar Qureshi; Michael Sutton
Email:	waqar@pagerpower.com; michael@pagerpower.com

Issue	Date	Detail of Changes
1	12th January 2023	Initial issue
2	11th July 2023	Report updated with National Highway comments and proposed screening
3	21st July 2023	Minor amendments
4	26th October 2023	Updated layout
5	16th November 2023	Finalised layout

Stour Valley Business Centre, Brundon Lane, Sudbury, CO10 7GB

T:*+44 (0)1787 319001* E:*info@pagerpower.com* W: *www.pagerpower.com*

EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from a proposed solar photovoltaic (PV) development located west of Berkswell, Coventry, England. The assessment pertains to the possible impact upon road safety, residential amenity, and aviation activity associated with Birmingham International Airport and Camp Farm Airstrip.

Conclusions

No significant impact is predicted towards nearby residential amenity road users along the B4102 and the M6 and aviation activity associated with Birmingham International Airport and Camp Farm Airstrip. Therefore, further mitigation is not recommended.

Guidance and Studies

Guidelines exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. The UK CAA guidance is relatively high-level and does not prescribe a formal methodology. Pager Power has however produced guidance for glint and glare and solar photovoltaic developments, which was published in early 2017, with the fourth edition originally published in 2022[1]. The guidance document sets out the methodology for assessing roads, dwellings, and aviation activity with respect to solar reflections from solar panels.

Pager Power's approach is to undertake geometric reflection calculations and, where a solar reflection is predicted, consider the screening (existing and/or proposed) between the receptor and the reflecting solar panels. For aviation activity, where a solar reflection is predicted, solar intensity calculations are undertaken where appropriate in line with the Sandia National Laboratories' FAA methodology. The scenario in which a solar reflection can occur for all receptors is then identified and discussed, and a comparison is made against the available solar panel reflection studies to determine the overall impact.

The available studies have measured the intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. The results show that the reflections produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel.

[1] Solar Photovoltaic Development – Glint and Glare Guidance Fourth Edition, September 2022.

Dwelling Receptors

The model has predicted that solar reflections are geometrically possible for 59 out of the 134 identified dwelling receptors. Existing screening, mainly in the form of vegetation, is predicted to significantly obstruct views of the reflective area for 43 out of these 59 dwellings. For the remaining 18 dwelling receptors, views of the reflecting area cannot be ruled out, based on a review of the available imagery. Despite solar reflections being experienced for more than three months per year but less than 60 minutes on any given day, significant mitigating factors have been identified such as:

- The visible reflective area being at a significant distance from an observer within the dwellings;
- The Sun light and the reflected light originating from the same point in space, with the Sun being a much brighter source of light.

Therefore, a low impact is predicted and no mitigation is recommended.

Road Receptors

B4102

The model has predicted that solar reflections are geometrically possible towards all identified road receptors of the B4012 (equivalent to circa 1.7km). Existing screening, mainly in the form of vegetation, is predicted to significantly obstruct the visibility of the reflective area for a section of B4102. For the remaining section (circa 300m) visibility of the reflective area remains possible due to insufficient existing screening in the form of vegetation. However, the reflective area is predicted to be outside the primary field of view (50° either side of the direction of travel) of a road user travelling in either direction. The proposed screening will have a height of at least 2.5m which is predicted to remove visibility of the reflective area for any type of road user (HGV drivers included) and it is expected to be in the form of evergreen vegetation.

Therefore, no impact is predicted, and no further mitigation is recommended.

M6

The model has predicted that solar reflections are geometrically possible towards all identified road receptors of the M6 (equivalent to circa 2.0km). Existing screening, mainly in the form of vegetation, is predicted to significantly obstruct the visibility of the reflective area for a section of M6. For the remaining section (circa 800m), partial visibility of the reflective area is possible. Mitigation is recommended for a circa 600m section due to a lack of significant mitigating factors. The developer has proposed screening in the form of vegetation to reduce the impacts upon road users. The proposed screening will have a height of at least 2.5m which is predicted to remove visibility of the reflective area for any type of road user (HGV drivers included) and it is expected to be in the form of evergreen vegetation.

Therefore, no impact is predicted, and no further mitigation is recommended.

Assessment Results - High-Level Aviation

Considering the size of the proposed development, its location and distance relative to the identified airfields, the following is applicable:

Birmingham International Airport is a licensed airfield located approximately 10km west of the proposed development. Birmingham International Airport has an ATC Tower and one runway: 15/33.

- Approach 15: the proposed development will be within the primary field of view of a pilot approaching runway 15; however, at this distance, any solar reflection will have "low potential for temporary after-image", which is acceptable in accordance with the associated guidance and industry best practice and therefore any impact will not be significant;
- Approach 33: the proposed development will be entirely outside the primary field of view[2] of a pilot travelling along the 2-miles approach. This is acceptable in accordance with the associated guidance and industry best practice and therefore any impact will not be significant;
- ATC Tower: the visibility of the proposed development from personnel within the ATC Tower is unlikely due to terrain screening. Therefore, no impact is predicted.

Camp Farm Airstrip: is an unlicensed airfield located approximately 10km east of the proposed development. Camp Farm Airstrip is understood to not have an ATC Tower. The airfield has one runway: 03/21.

- Approach 03: the proposed development will be entirely outside the primary field of view of a pilot travelling along the 2-miles approach. Therefore, no significant impact is predicted;
- Approach 21: the proposed development will be within the primary field of view of a pilot approaching runway 21; however, at this distance, any solar reflection will have "low potential for temporary after-image" and therefore any impact will not be significant.

Therefore, no significant impacts upon aviation activity associated with Birmingham International Airport and Camp Farm Airstrip are predicted, and modelling is not recommended.

[2] 50° either side of the approach bearing

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 54 countries within Europe, Africa, America, Asia and Australasia.

The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially, the company focus was on modelling the impact of wind turbines on radar systems. Over the years, the company has expanded into numerous fields including:

- Renewable energy projects.
- Building developments.
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable, and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

1 INTRODUCTION

1.1 Overview

Pager Power has been retained to assess the possible effects of glint and glare from a proposed solar photovoltaic (PV) development located west of Berkswell, Coventry, England. The assessment pertains to the possible impact upon road safety, residential amenity, and aviation activity associated with Birmingham International Airport and Camp Farm Airstrip.

This report contains the following:

- Solar development details.
- Explanation of glint and glare.
- Overview of relevant studies and guidance.
- Overview of Sun movement.
- Assessment methodology.
- Identification of receptors.
- Glint and glare assessment for identified receptors.
- High-level overview of aviation concerns.
- Results discussion.

1.2 Pager Power's Experience

Pager Power has undertaken over 1,100 Glint and Glare assessments in the UK and internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Glint and Glare Definition

The definition of glint and glare is as follows[3]:

- Glint – a momentary flash of bright light typically received by moving receptors or from moving reflectors.
- Glare – a continuous source of bright light typically received by static receptors or from large reflective surfaces.

The term 'solar reflection' is used in this report to refer to both reflection types i.e. glint and glare.

[3]These definitions are aligned with those presented within the Draft National Policy Statement for Renewable Energy Infrastructure (EN-3) – published by the Department for Business, Energy & Industrial Strategy in September 2021 and the Federal Aviation Administration in the USA.

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Site Plan

Figure 1 below[4] shows the site layout plan. The blue horizontal lines denote the solar panel locations.

Figure 1 – Proposed development site plan

[4] P.NailcoteFarm_09_PlanningLayout_RevB, cropped.

2.2 Proposed Development Location – Aerial Image

Figure 2 below shows the panel area overlaid onto aerial imagery.

Figure 2 – Aerial image: Proposed development location

2.3 Photovoltaic Panel Mounting Arrangements and Orientation

The solar panel details as assessed within this report are as follows:

- Assessed panel height: 1.515m[5] agl (above ground level);
- Tilt: 25 degrees above the horizontal;
- Azimuth: 180 degrees (south facing).

[5] This is the centre point of the panel calculated considering the max height (2.418m) and the min height (0.600m): ((2.418-0.600)/2)+0.600.

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Guidance and Studies

Appendices A and B present a review of relevant guidance and independent studies with regard to glint and glare issues from solar panels. The overall conclusions from the available studies are as follows:

- Specular reflections of the Sun from solar panels are possible.
- The measured intensity of a reflection from solar panels can vary from 2% to 30% depending on the angle of incidence.
- Published guidance shows that the intensity of solar reflections from solar panels are equal to or less than those from water. It also shows that reflections from solar panels are significantly less intense than many other reflective surfaces, which are common in an outdoor environment.

3.2 Background

Details of the Sun's movements and solar reflections are presented in Appendix C.

3.3 Pager Power's Methodology

The glint and glare assessment methodology has been derived from the information provided to Pager Power through consultation with stakeholders and by reviewing the available guidance and studies. The methodology for a glint and glare assessments is as follows:

- Identify receptors in the area surrounding the solar development.
- Consider direct solar reflections from the solar development towards the identified receptors by undertaking geometric calculations.
- Consider the visibility of the panels from the receptor's location. If the panels are not visible from the receptor then no reflection can occur.
- Based on the results of the geometric calculations, determine whether a reflection can occur, and if so, at what time it will occur.
- Consider both the solar reflection from the solar development and the location of the direct sunlight with respect to the receptor's position.
- Consider the solar reflection with respect to the published studies and guidance - including intensity calculations where appropriate.
- Determine whether a significant detrimental impact is expected in line with the process presented in Appendix D.

3.4 Assessment Methodology and Limitations

Further technical details regarding the methodology of the geometric calculations and limitations are presented in Appendix E and F.

4 IDENTIFICATION OF RECEPTORS

4.1 Overview

There is no formal guidance with regard to the maximum distance at which glint and glare should be assessed. From a technical perspective, there is no maximum distance for potential reflections. The significance of a reflection however decreases with distance because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases. Terrain and shielding by vegetation are also more likely to obstruct an observer's view at longer distances.

The above parameters and extensive experience over a significant number of glint and glare assessments undertaken, shows that a 1km assessment area from the proposed panel area is appropriate for glint and glare effects on ground-based receptors. Reflections towards ground-based receptors located further north than any proposed panel are highly unlikely[6]. Therefore, receptors north of the panel areas have been excluded from the assessment area.

Potential receptors within the assessment areas are identified based on mapping and aerial photography of the region. The initial judgement is made based on high-level consideration of aerial photography and mapping i.e. receptors are excluded if it is clear from the outset that no visibility would be possible. A more detailed assessment is made if the modelling reveals a reflection would be geometrically possible.

Terrain elevation heights have been interpolated based on Ordnance Survey of Great Britain (OSGB) 50m Panorama data. Receptor details can be found in Appendix G.

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[6] For fixed, south-facing panels at this latitude.

4.2 Dwelling Receptors

The analysis has considered dwellings that:

- Are within the 1km assessment area; and
- Have a potential view of the panels.

The assessed dwelling receptors are shown in Figure 3, below, along with the 1km assessment area (the green outlined polygon). A total of 134 dwelling locations have been assessed.

Figure 3 – Assessed dwelling receptors

For the dwellings, a height of 1.8 metres above ground level has been taken as typical eye level for an observer on the ground floor of the dwelling[7]. In residential areas only dwellings located on the residential area boundary have been assessed. These are the dwellings with the highest chance of having an unobstructed line of sight of the proposed development. Close-up images to illustrate the dwelling receptors are presented in Figure 4 to Figure 7 on the following pages.

[7] This height is used for modelling purposes and all floors are considered in the results discussion.

Figure 4 – Dwellings 1-12

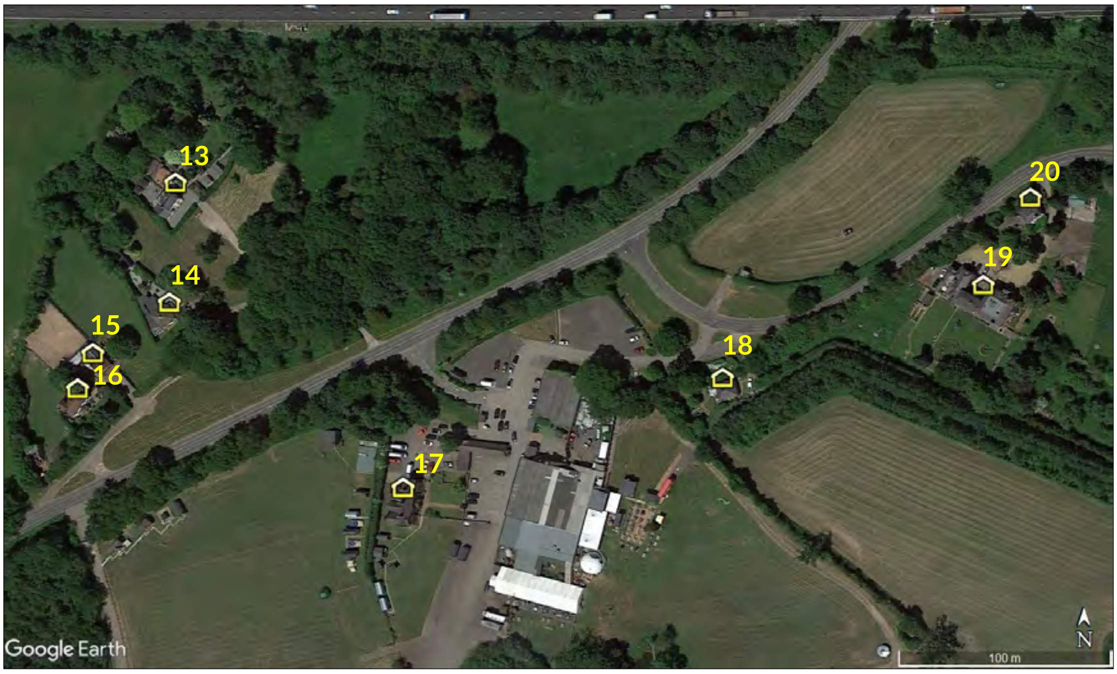

Figure 5 – Dwellings 13-20

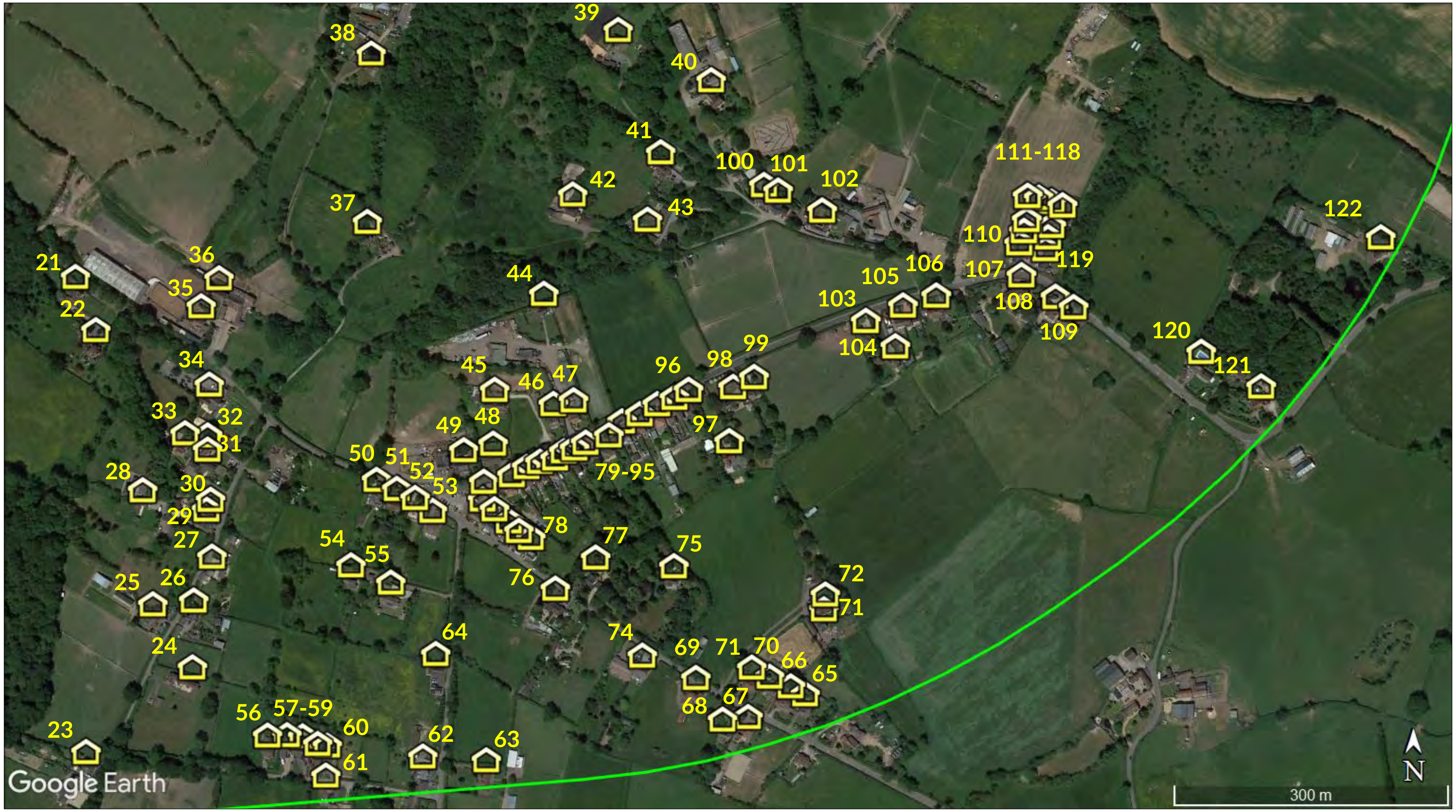

Figure 6 – Dwellings 21-122

Figure 7 – Dwellings 123-134

4.3 Road Receptors

Road types can generally be categorised as:

- Major National – Typically a road with a minimum of two carriageways with a maximum speed limit of up to 70mph. These roads typically have fast moving vehicles with busy traffic;
- National – Typically a road with a one or more carriageways with a maximum speed limit of up to 60mph or 70mph. These roads typically have fast moving vehicles with moderate to busy traffic density;
- Regional – Typically a single carriageway with a maximum speed limit of up to 60mph. The speed of vehicles will vary with a typical traffic density of low to moderate; and
- Local – Typically roads and lanes with the lowest traffic densities. Speed limits vary.

Technical modelling is not recommended for local roads, where traffic densities are likely to be relatively low. Any solar reflections from the proposed development that are experienced by a road user along a local road would be considered low impact in the worst case in accordance with the guidance presented in Appendix D.

The analysis has therefore considered major national, national, and regional roads that:

- Are within the 1km assessment area; and
- Have a potential view of the panels.

The assessed road receptor points along approximately 1.7km of the B4102 (receptors 1-18) and approximately 2.8km of the M6 (receptors 19-47) are shown in Figure 8 on the following page. A height of 1.5 metres above ground level has been taken as typical eye level for a road user. The distance between road receptors is approximately 100m.

Figure 8 – Assessed road receptors

5 ASSESSED REFLECTORS

5.1 Reflector Area

A resolution of 20m has been chosen for this assessment. This means that a geometric calculation is undertaken for each identified receptor from a point every 20m from within the defined area. This resolution is sufficiently high to maximise the accuracy of the results, increasing the resolution further would not significantly change the modelling output. The number of modelled reflector points are determined by the size of the reflector area and the assessment resolution.

The bounding co-ordinates for the proposed solar development have been extrapolated from the site plans. The data can be found in Appendix G. The assessed panel area is shown in Figure 9 below.

Figure 9 – Modelled reflector area

6 GLINT AND GLARE ASSESSMENT – TECHNICAL RESULTS

6.1 Evaluation of Effects

The tables in the following subsections present the results of the geometric modelling. The final column summarises the predicted impact considering the level of identified screening based on a desk-based review of the available imagery.

The significance of the predicted effects has been evaluated in accordance with Pager Power's published guidance document[8].

The flowcharts setting out the impact characterisation and presented in Appendix D[9]. The list of assumptions and limitations are presented in Appendix F. The modelling output for key receptors can be found in Appendix H.

When evaluating visibility in the context of glint and glare, it is only the *reflecting* panel area that must be considered. For example, if the western half of the development is visible, but reflections would only be possible from the eastern half, it can be concluded that the reflecting area is not visible and no impacts are predicted. This is why there can be instances where visibility of the development is predicted, but glint and glare issues are screened.

Receptors are included within the assessment based on the potential visibility of the development as a whole, among other factors. Once the modelling output has been generated, the assessment can be refined to evaluate the visibility of the reflecting area specifically.

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[8] Solar Photovoltaic Development – Glint and Glare Guidance Issue 4, September 2022.

[9] There is no standard methodology for evaluating effects on ground-based receptors beyond a kilometre. These receptors have been considered based on first principles and the general methodology for ground-based receptors, keeping in mind the relative safety/amenity implications for differing receptor types.

6.2 Geometric Calculation Results – Dwelling Receptors

Refer to Section 7.1 for a discussion of the following results.

Dwelling	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1	Between 06:05 and 06:18 from mid- March to the end of April. Between 05:57 and 06:12 from mid- August to the end of September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
2	Between 06:04 and 06:19 from mid- March to the beginning of May. Between 05:57 and 06:13 from mid- August to the end of September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.
3	Between 06:04 and 06:18 from mid- March to the beginning of May. Between 05:58 and 06:13 from mid- August to the end of September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.

Dwelling	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
4	Between 06:04 and 06:18 from mid- March to early May. Between 05:58 and 06:13 from early August to the end of September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.
5	Between 06:04 and 06:18 from mid- March to mid- May. Between 05:57 and 06:14 from early August to the end of September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
6	Between 06:03 and 06:18 from mid- March to mid- May. Between 05:57 and 06:14 from the end of July to the end of September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
7	Between 06:02 and 06:18 from mid- March to late May. Between 05:58 and 06:14 from mid- July to the end of September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.

Dwelling	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
8	Between 06:02 and 06:18 from mid- March to early June. Between 05:57 and 06:14 from early July to the end of September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
9	Between 05:58 and 06:21 from mid- March to the beginning of October.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.
10	Between 05:58 and 06:26 from mid- March to the end of September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.
11	Between 05:58 and 06:25 from mid- March to the end of September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.
12	Between 05:58 and 06:15 from mid- March to late September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.

Dwelling	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
13	Between 05:59 and 06:12 from mid- April to the end of August.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
14	Between 06:00 and 06:12 from late April to late August.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
15	Between 06:00 and 06:12 from late April to late August.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
16	Between 06:01 and 06:12 from late April to mid- August.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
17	Between 06:01 and 06:11 from early May to early August.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.

Dwelling	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
18	Between 06:00 and 06:12 from early May to early August.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
19	Between 05:59 and 06:10 from early May to early August.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
20	Between 05:59 and 06:10 from the end of April to mid- August.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation and terrain is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
21 – 37	None.	None.	Solar reflections are not geometrically possible. No impact is predicted.
38	None.	Between 18:06 and 18:14 from late May to early July. At circa 18:15 during late July.	Solar reflections are geometrically possible. However, they are predicted to occur for less than 3 months per year and less than 60 minutes per day. Furthermore, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.

Dwelling	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
39	None.	Between 18:01 and 18:13 from late April to late August.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
40	None.	Between 18:00 and 18:11 from late April to mid- August.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.
41	None.	Between 18:01 and 18:11 from late May to late July.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
42 – 92	None.	None.	Solar reflections are not geometrically possible. No impact is predicted.
100	None.	Between 18:00 and 18:10 from mid- May to late July.	Solar reflections are geometrically possible. However, they are predicted to occur for less than 3 months per year and less than 60 minutes per day. Furthermore, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.

Dwelling	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
101	None.	Between 17:59 and 18:09 from mid- May to late July.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
102	None.	Between 17:59 and 18:09 from late May to late July.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
103	None.	None.	Solar reflections are not geometrically possible. No impact is predicted.
104	None.	None.	Solar reflections are not geometrically possible. No impact is predicted.
105	None.	Between 18:04 and 18:06 from mid- June to late June.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
106	None.	Between 18:01 and 18:09 from the beginning of June to mid-July.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.

Dwelling	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
107	None.	Between 17:59 and 18:09 from mid- May to late July.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
108	None.	Between 17:59 and 18:09 from late May to late July.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
109	None.	Between 18:00 and 18:09 from late May to late July.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
110	None.	Between 17:58 and 18:09 from mid- May to the end of July.	Solar reflections are geometrically possible. However, they are predicted to occur for less than 3 months per year and less than 60 minutes per day. Furthermore, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.

Dwelling	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
111	None.	Between 17:57 and 18:09 from mid- May to the beginning of August.	Solar reflections are geometrically possible. However, they are predicted to occur for less than 3 months per year and less than 60 minutes per day. Furthermore, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.
112	None.	Between 17:58 and 18:09 from early May to early August.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.
113	None.	Between 17:57 and 18:09 from early May to early August.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.
114	None.	Between 17:57 and 18:09 from early May to early August.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.

Dwelling	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
115	None.	Between 17:57 and 18:09 from early May to early August.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.
116	None.	Between 17:57 and 18:09 from early May to early August.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to obstruct the views of the reflecting area. Low impact is predicted, and no mitigation is required.
117	None.	Between 17:58 and 18:09 from early May to early August.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
118	None.	Between 17:58 and 18:09 from mid- May to the beginning of August.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
119	None.	Between 17:58 and 18:09 from mid- May to the end of July.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.

Dwelling	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
120	None.	Between 18:01 and 18:11 from late May to late July.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
121	None.	Between 18:02 and 18:11 from late May to late July.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
122	None.	Between 18:00 and 18:12 from late April to mid- August.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
123	None.	Between 18:04 and 18:14 from mid- March to early April. Between 17:52 and 17:59 from early September to the end of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.

Dwelling	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
124	None.	Between 18:06 and 18:13 from mid- March to the end of March. Between 17:52 and 17:59 from early September to the end of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
125	None.	Between 18:06 and 18:14 from mid- March to the end of March. Between 17:51 and 17:58 from mid- September to the end of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
126	None.	Between 18:06 and 18:13 from mid- March to the end of March. Between 17:52 and 17:57 from mid- September to the end of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
127	None.	Between 18:08 and 18:13 from mid- March to late March. Between 17:51 and 17:56 from mid- September to the end of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.

Dwelling	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
128	None.	Between 18:05 and 18:13 from mid- March to the end of March. Between 17:50 and 17:56 from mid- September to the beginning of October.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
129	None.	Between 18:05 and 18:13 from mid- March to the end of March. Between 17:50 and 17:56 from mid- September to the end of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
130-134	None.	None.	Solar reflections are not geometrically possible. No impact is predicted, and no mitigation is required.

Table 1 – Geometric analysis results for dwelling receptors

6.3 Geometric Calculation Results – Road Receptors

6.3.1 B4102

Refer to Section 7.2.2 for a discussion of the following results.

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
1	Between 06:03 and 06:13 from mid- May to the end of July.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
2	Between 06:02 and 06:13 from mid- May to the end of July.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
3	Between 06:02 and 06:13 from early May to early August.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
4	Between 06:00 and 06:12 from the beginning of May to mid- August.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
5	Between 06:00 and 06:12 from the end of April to mid- August.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
6	Between 06:01 and 06:12 from late April to mid- August.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
7	Between 06:00 and 06:12 from late April to late August.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
8	Between 05:58 and 06:10 from mid- April to late August.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
9	Between 05:56 and 06:09 from early April to early September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
10	Between 05:56 and 06:11 from late March to late September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
11	Between 05:56 and 06:20 from late March to late September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
12	Between 05:57 and 06:27 from late March to late September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
13	Between 05:57 and 06:30 from late March to late September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
14	Between 05:56 and 06:28 from mid- March to early October.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
15	Between 05:56 and 06:29 from early March to early October.	None.	Solar reflections are geometrically possible. While some existing screening in the form of vegetation is likely to obstruct the views of the reflecting area visibility remain. However, are the reflective area is predicted to be outside the primary field of view of a road user travelling on both directions. Therefore, Low impact is predicted, and no mitigation is required.
16	Between 05:56 and 06:28 from mid- March to the beginning of October.	None.	Solar reflections are geometrically possible. While some existing screening in the form of vegetation is likely to obstruct the views of the reflecting area visibility remain. However, are the reflective area is predicted to be outside the primary field of view of a road user travelling on both directions. Therefore, Low impact is predicted, and no mitigation is required.

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
17	Between 06:01 and 06:18 from mid- March to late May. Between 05:57 and 06:12 from late July to late September.	None.	Solar reflections are geometrically possible. While some existing screening in the form of vegetation is likely to obstruct the views of the reflecting area visibility remain. However, are the reflective area is predicted to be outside the primary field of view of a road user travelling on both directions. Therefore, Low impact is predicted, and no mitigation is required.
18	At circa 06:13 during late March. Between 05:58 and 06:02 during mid- September.	None.	Solar reflections are geometrically possible. While some existing screening in the form of vegetation is likely to obstruct the views of the reflecting area visibility remain. However, are the reflective area is predicted to be outside the primary field of view of a road user travelling on both directions. Therefore, Low impact is predicted, and no mitigation is required.

Table 2 – Geometric analysis results for the road receptors (B4102)

6.3.2 M6

Refer to Section 7.2.3 for a discussion of the following results.

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
19	Between 06:01 and 06:15 from late March to mid-September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
20	Between 06:00 and 06:15 from the end of March to mid-September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
21	Between 06:00 and 06:15 from the end of March to mid-September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
22	Between 06:00 and 06:15 from the end of March to mid-September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
23	Between 06:00 and 06:16 from the end of March to mid-September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
24	Between 06:00 and 06:16 from the beginning of April to mid- September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
25	Between 05:59 and 06:14 from the beginning of April to mid- September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
26	Between 05:58 and 06:12 from early April to early September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
27	Between 05:57 and 06:09 from early April to early September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
28	Between 05:56 and 06:09 from early April to early September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
29	Between 05:51 and 06:08 from early April to early September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
30	Between 05:55 and 06:09 from mid- April to the beginning of September.	None.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
31	Between 05:58 and 06:11 from mid- April to the end of August.	None.	Solar reflections are geometrically possible. Visibility of the reflective area is predicted to be possible due to gaps in the existing vegetation. Reflections are predicted to be within the primary field of view[10] of a road user travelling east. No significant mitigating factors have been identified. The developer has proposed screening in the form of evergreen vegetation. Therefore, no impact is predicted, and no further mitigation is recommended.
32	Between 05:59 and 06:11 from mid- April to the end of August.	At circa 18:07 during mid-April. Between 18:04 and 18:06 from mid- May to the end of May. At circa 18:12 during mid- June. Between 18:14 and 18:16 from mid-July to the beginning of August. At circa 18:10 during late August.	Solar reflections are geometrically possible. Visibility of the reflective area is predicted to be possible due to gaps in the existing vegetation. Reflections are predicted to be within the primary field of view of a road user travelling east. No significant mitigating factors have been identified. The developer has proposed screening in the form of evergreen vegetation. Therefore, no impact is predicted, and no further mitigation is recommended.

[10] 50 degrees on both sides considering the direction of travel

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
33	Between 05:59 and 06:10 from mid- April to late August.	Between 18:02 and 18:16 from the beginning of April to mid- September.	Solar reflections are geometrically possible. Visibility of the reflective area is predicted to be possible due to gaps in the existing vegetation. Reflections are predicted to be within the primary field of view of a road user travelling east. No significant mitigating factors have been identified. The developer has proposed screening in the form of evergreen vegetation. Therefore, no impact is predicted, and no further mitigation is recommended.
34	Between 05:58 and 06:09 from the beginning of May to mid- August.	Between 18:02 and 18:19 from late March to mid- September.	Solar reflections are geometrically possible. Visibility of the reflective area is predicted to be possible due to gaps in the existing vegetation. Reflections are predicted to be within the primary field of view of a road user travelling east. No significant mitigating factors have been identified. The developer has proposed screening in the form of evergreen vegetation. Therefore, no impact is predicted, and no further mitigation is recommended.

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
35	At circa 05:58 during mid-May. Between 06:00 and 06:05 from mid- June to early July. Between 06:07 and 06:08 from late July to the beginning of August.	Between 18:02 and 18:21 from late March to mid-September.	Solar reflections are geometrically possible. Visibility of the reflective area is predicted to be possible due to gaps in the existing vegetation. Reflections are predicted to be within the primary field of view of a road user travelling east. No significant mitigating factors have been identified. The developer has proposed screening in the form of evergreen vegetation. Therefore, no impact is predicted, and no further mitigation is recommended.
36	None.	Between 18:02 and 18:20 from late March to mid-September.	Solar reflections are geometrically possible. Visibility of the reflective area is predicted to be possible due to gaps in the existing vegetation. Reflections are predicted to be within the primary field of view of a road user travelling east. No significant mitigating factors have been identified. The developer has proposed screening in the form of evergreen vegetation. Therefore, no impact is predicted, and no further mitigation is recommended.

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
37	None.	Between 18:00 and 18:17 from late March to late September.	Solar reflections are geometrically possible. Visibility of the reflective area is predicted to be possible due to gaps in the existing vegetation. Reflections are predicted to be within the primary field of view of a road user travelling east. No significant mitigating factors have been identified. The developer has proposed screening in the form of evergreen vegetation. Therefore, no impact is predicted, and no further mitigation is recommended.
38	None.	Between 17:58 and 18:16 from mid- March to late September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
39	None.	Between 17:57 and 18:15 from late March to late September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
40	None.	Between 17:55 and 18:15 from mid- March to late September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
41	None.	Between 17:54 and 18:14 from mid- March to the end of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
42	None.	Between 17:53 and 18:14 from mid- March to the end of September.	Solar reflections are geometrically possible. While some screening is predicted to obstruct the visibility of the reflective area its visibility remains possible. Reflections are predicted to be within the primary field of view of a road user travelling west. However, significant mitigating factors have been identified and therefore low impact is predicted, and mitigation is not recommended.
43	None.	Between 17:53 and 18:14 from mid- March to the end of September.	Solar reflections are geometrically possible. While some screening is predicted to obstruct the visibility of the reflective area its visibility remains possible. Reflections are predicted to be within the primary field of view of a road user travelling west. However, significant mitigating factors have been identified and therefore low impact is predicted, and mitigation is not recommended.

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
44	None.	Between 17:53 and 18:14 from mid- March to the end of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
45	None.	Between 17:53 and 18:14 from mid- March to the end of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
46	None.	Between 17:53 and 18:14 from mid- March to the end of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.
47	None.	Between 17:53 and 18:14 from mid- March to the end of September.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation is likely to significantly obstruct the views of the reflecting area. No impact is predicted, and no mitigation is required.

Table 3 – Geometric analysis results for the road receptors (M6)

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Dwelling Results

7.1.1 Key Considerations

The process for quantifying impact significance is defined in the report appendices. For dwelling receptors, the key considerations are:

- Whether a reflection is predicted to be experienced in practice.
- The duration of the predicted effects, relative to thresholds of:
  - 3 months per year.
  - 60 minutes per day.

Where no solar reflections are geometrically possible or where solar reflections are predicted to be significantly screened, no impact is predicted, and mitigation is not required.

Where effects are predicted to be experienced for less than 3 months per year and less than 60 minutes on any given day, or where the separation distance to the nearest visible reflecting panel is over 1km, the impact significance is low, and mitigation is not recommended.

Where effects are predicted to be experienced for more than 3 months per year and/or for more than 60 minutes on any given day, expert assessment of the following factors is required to determine the impact significance:

- Whether visibility is likely from all storeys – the ground floor is typically considered the main living space and has a greater significance with respect to residential amenity
- The separation distance to the panel area – larger separation distances reduce the proportion of an observer's field of view that is affected by glare.
- Whether the dwelling appears to have windows facing the reflecting area – factors that restrict potential views of a reflecting area reduce the level of impact.
- The position of the Sun – effects that coincide with direct sunlight appear less prominent than those that do not.

Following consideration of these mitigating factors, where the solar reflection does not remain significant, a low impact is predicted, and mitigation is not recommended. Where the solar reflection remains significant, the impact significance is moderate, and mitigation is recommended.

Where effects are predicted to be experienced for more than 3 months per year and more than 60 minutes per day and there are no mitigating factors, the impact significance is high, and mitigation is required.

7.1.2 Results discussion

The model has predicted that solar reflections are geometrically possible for 59 out of the 134 identified dwelling receptors (see Figure 10 below). Existing screening, mainly in the form of vegetation, is predicted to significantly obstruct views of the reflective area for 43 out of these 59 dwellings. For the remaining 16 dwelling receptors, views of the reflecting area cannot be ruled out. Despite solar reflections being experienced for more than three months per year but less than 60 minutes on any given day, based on a review of the available imagery, significant mitigating factors have been identified such as:

- The visible reflective area being at a significant distance from an observer within the dwellings;
- The Sun light and the reflected light originating from the same point in space, with the Sun being a much brighter source of light.

Therefore, a low impact is predicted and no mitigation is recommended.

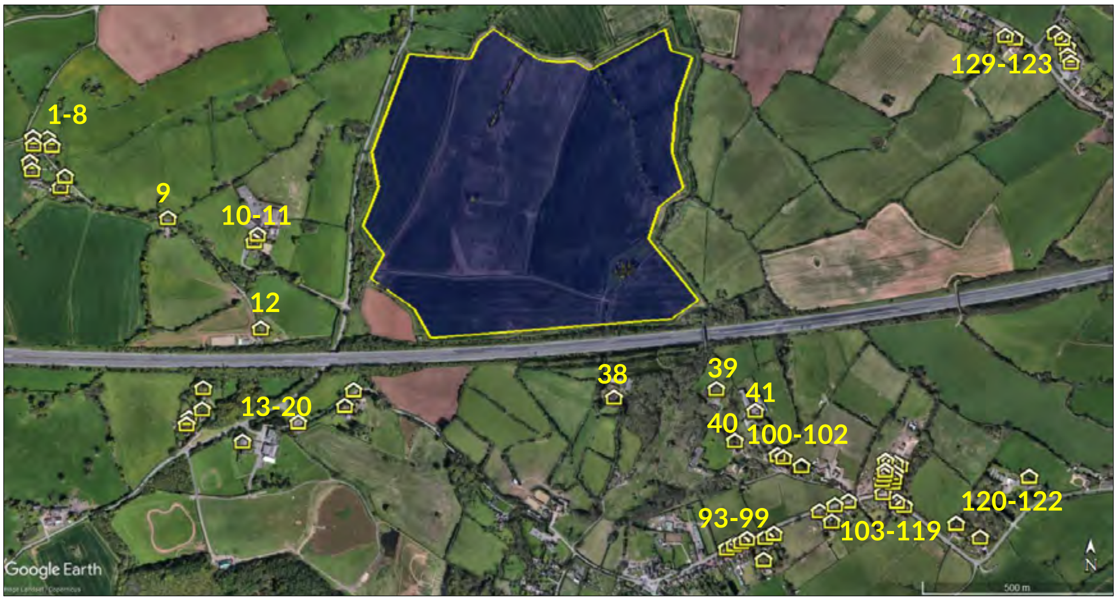

Figure 10 – Dwellings where solar reflections are geometrically possible

7.2 Road Results

7.2.1 Key Considerations

The process for quantifying impact significance is defined in the report appendices. The key considerations for road users along major national, national, and regional roads are:

- Whether a reflection is predicted to be experienced in practice.
- The location of the reflecting panel relative to a road user's direction of travel.

Where no solar reflections are geometrically possible or where solar reflections are predicted to be significantly screened, no impact is predicted, and mitigation is not required.

Where reflections originate from outside of a road user's main field of view (50 degrees either side of the direction of travel), or where the separation distance to the nearest visible reflecting panel is over 1km, the impact significance is low, and mitigation is not recommended.

Where reflections are predicted to be experienced from inside of a road user's main field of view, expert assessment of the following factors is required to determine the impact significance:

- Whether visibility is likely for elevated drivers (applicable to dual carriageways and motorways only) – there is typically a higher density of elevated drivers (such as HGVs) along dual carriageways and motorways compared to other types of road.
- Whether a solar reflection is fleeting in nature. Small gap/s in screening (e.g., an access point to the site) may not result in a sustained reflection for a road user.
- The separation distance to the panel area – larger separation distances reduce the proportion of an observer's field of view that is affected by glare.
- The position of the Sun – effects that coincide with direct sunlight appear less prominent than those that do not.
- Whether the solar reflection originates from directly in front of a road user – a solar reflection that is directly in front of a road user is more hazardous than a solar reflection to one side.

Following consideration of these mitigating factors, where the solar reflection does not remain significant, a low impact is predicted, and mitigation is not recommended. Where the solar reflection remains significant, the impact significance is moderate, and mitigation is recommended.

Where reflections originate from directly in front of a road user and there are no mitigating factors, the impact significance is high, and mitigation is required.

7.2.2 B4102: Results Discussion

The model has predicted that solar reflections are geometrically possible towards all 18 identified road receptors of the B4102 (equivalent to circa 1.7km of road – see Figure 11 on the following page). Existing screening, mainly in the form of vegetation, is predicted to significantly obstruct the visibility of the reflective area for 14 out of the 18 receptors (receptors 1 to 14, see Figure 11 to Figure 16 on the following pages). Solar reflections are predicted to occur between March and October. It is predicted that during this time the existing vegetation will be in almost full or full leaves and therefore they will effectively screen the reflective area.

Figure 11– Stretch of B4102 where solar reflections are predicted to be geometrically possible and relevant screening

Figure 12 – Level of roadside screening at receptor 1 travelling north (towards receptor 2)

Figure 13 – Level of roadside screening at receptor 4 travelling north (towards receptor 5)

Figure 14 – Level of roadside screening at receptor 7 travelling north (towards receptor 8)

Figure 15 – Level of roadside screening at receptor 10 travelling north (towards receptor 11)

Figure 16 – Level of roadside screening at receptor 13 travelling north (towards receptor 14)

For the remaining four receptors (15 to 18 equivalent to circa 300m of road) visibility of the reflective area remains possible due to insufficient existing screening in the form of vegetation. However, the reflective area is predicted to be outside the primary field of view (50° either side of the direction of travel) of a road user travelling in either direction along this stretch of road (see Figure 17 to Figure 20 below and on the following pages).

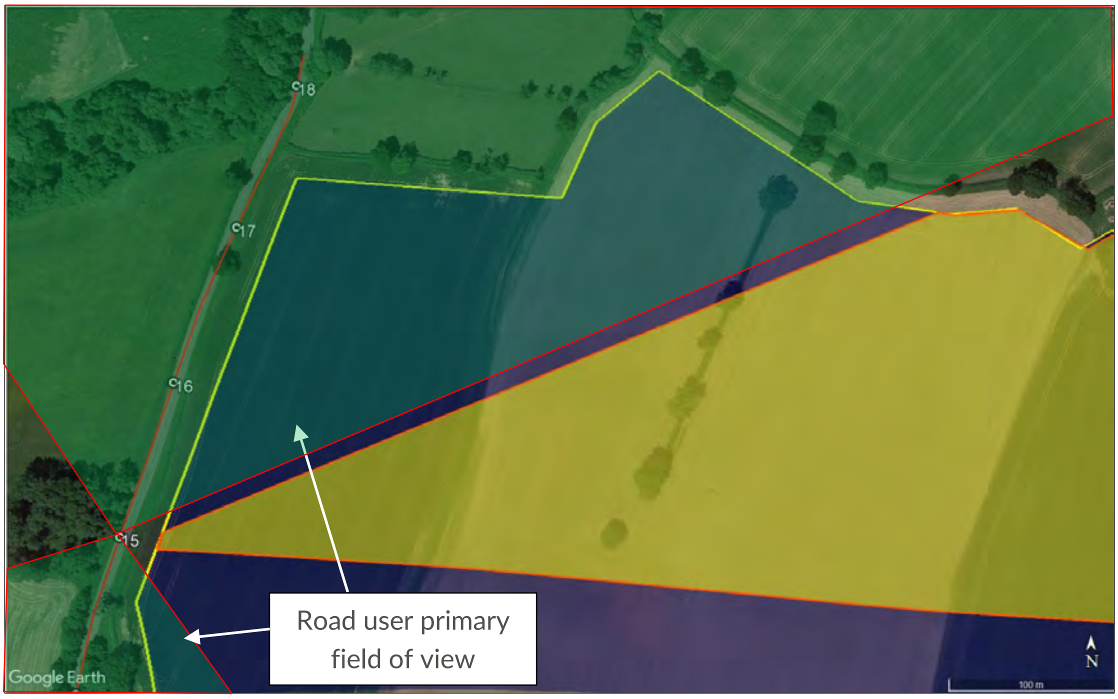

Figure 17 – Location of the reflective area relative to receptor 15

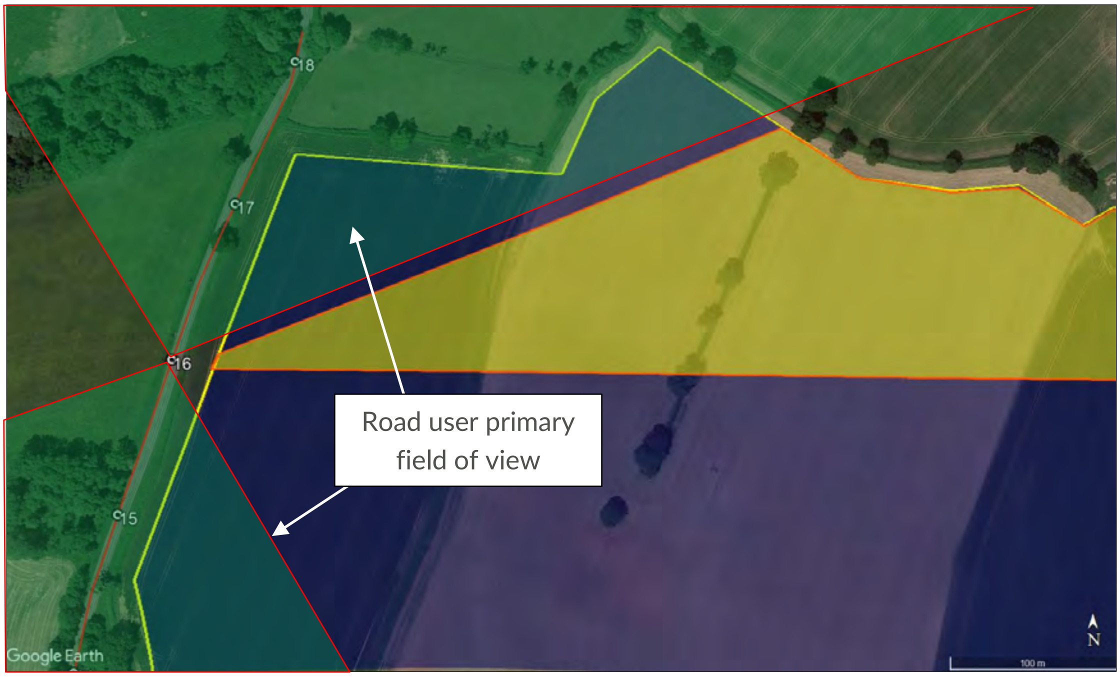

Figure 18 – Location of the reflective area relative to receptor 16

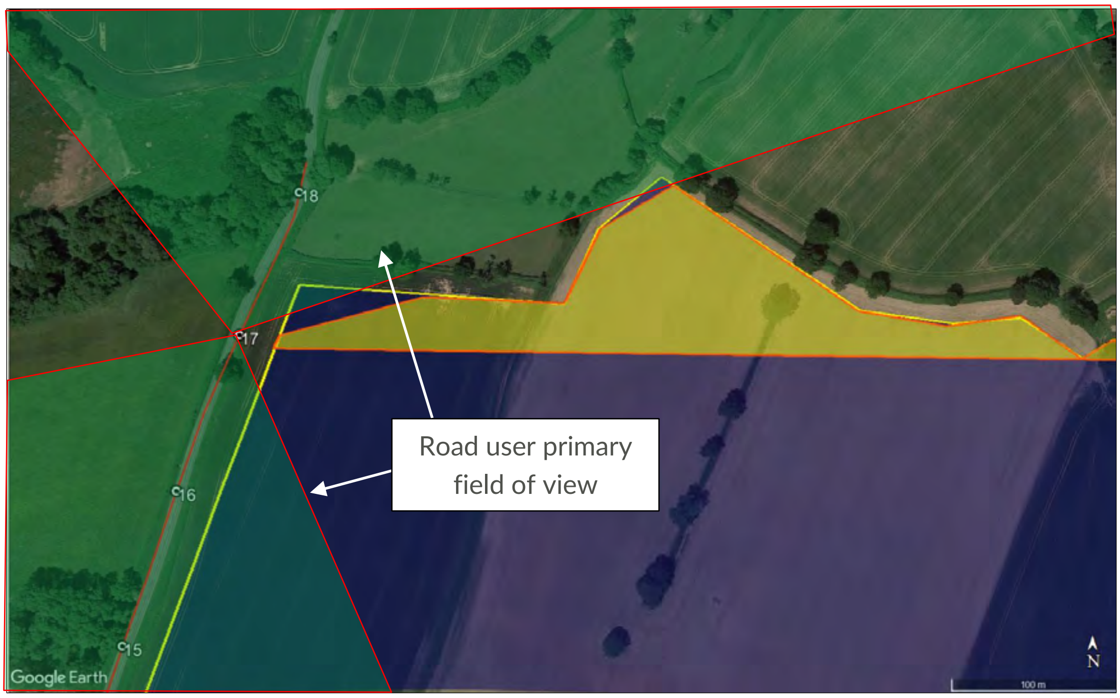

Figure 19 – Location of the reflective area relative to receptor 17

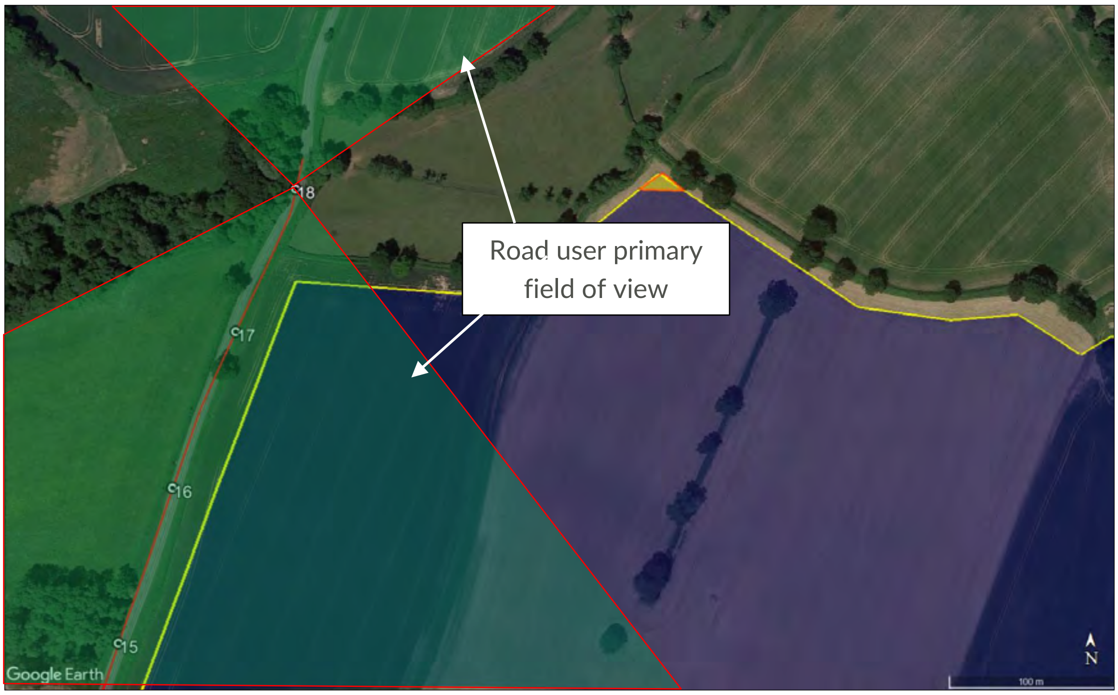

Figure 20 – Location of the reflective area relative to receptor 18

Furthermore, the developer has decided to implement screening in the form of vegetation which is predicted to remove visibility of the reflective area (see Figure 21 and Figure 22 on the following page). The proposed screening will have a height of at least 2.5m which is predicted to remove visibility of the reflective area for any type of road user (HGV drivers included) and it is expected to be in the form of evergreen vegetation.

Therefore, no impact is predicted, and no further mitigation is recommended.

Figure 21 – Proposed mitigation solution B4102

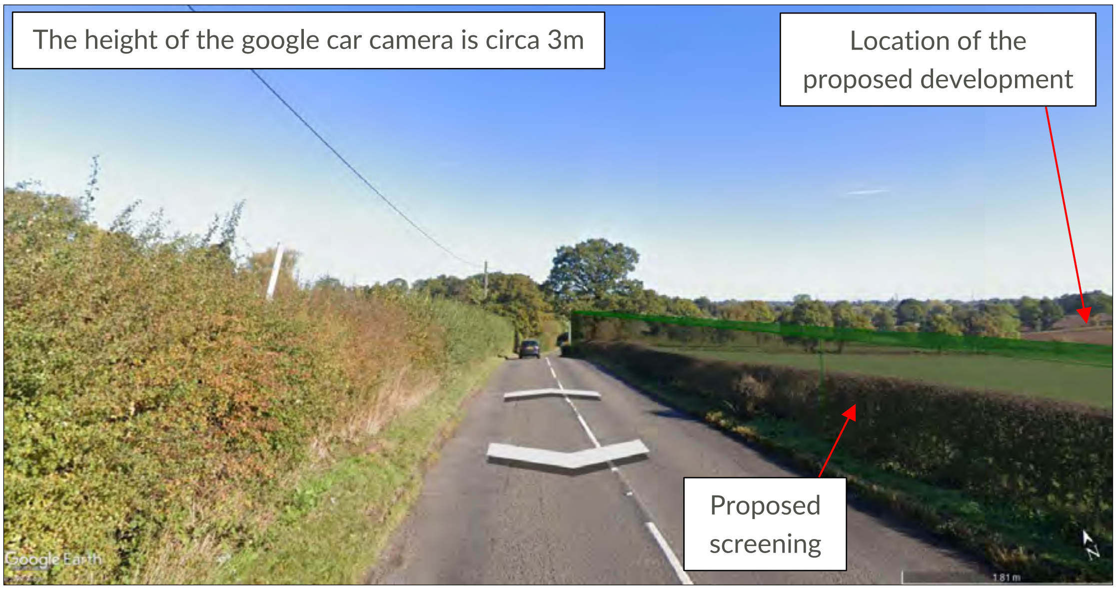

Figure 22 – Proposed screening effectiveness from road receptor 16 travelling north

7.2.3 M6: Results Discussion

The model has predicted that solar reflections are geometrically possible towards all 19 identified road receptors of the M6 (equivalent to circa 2.0km of road – see Figure 23 below). Existing screening, mainly in the form of vegetation, is predicted to significantly obstruct the visibility of the reflective area for 10 receptors (see Figure 23 to Figure 31 below and on the following pages). Solar reflections are predicted to occur between March and October. It is predicted that during this time the existing vegetation will be in almost full or full leaves and therefore they will effectively screen the reflective area.

Figure 23 – Stretch of M6 where solar reflections are predicted to be geometrically possible and relevant screening

Figure 24 – Level of roadside screening at receptor 19 travelling east (towards receptor 20)

Figure 25 – Level of roadside screening at receptor 22 travelling east (towards receptor 23)

Figure 26 – Level of roadside screening at receptor 25 travelling east (towards receptor 26)

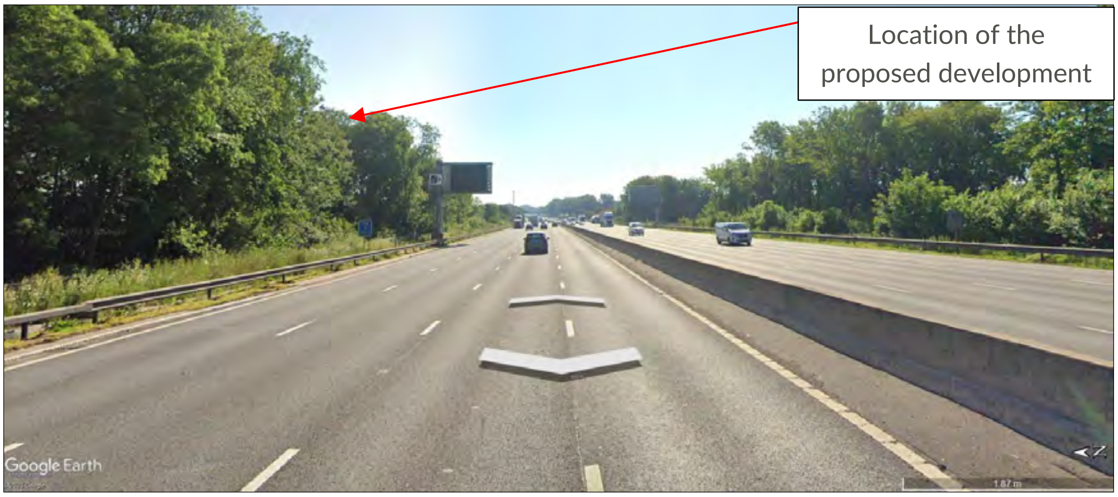

Figure 27 – Level of roadside screening at receptor 28 travelling east (towards receptor 29)

Figure 28 – Level of roadside screening at receptor 38 travelling west (towards receptor 27)

Figure 29 – Level of roadside screening at receptor 41 travelling west (towards receptor 40)

Figure 30 – Level of roadside screening at receptor 44 travelling west (towards receptor 43)

Figure 31 – Level of roadside screening at receptor 47 travelling west (towards receptor 46)

Partial visibility of the reflective area remains for nine receptors (circa 800m of road – see Figure 32 below). For two (42 and 43 circa 200m of road) of these nine receptors significant mitigating factors have been identified, such as:

- Partial existing screening;
- The reflective area being a significant distance from the road user;
- The Sun light and the reflected light originating from the same point in space, with the Sun being a much brighter source of light.

For road users travelling along this section of road the impact is categorised as low and no mitigation is recommended.

For the remaining seven receptors (a section of circa 600m, receptors 31 to 37) mitigation is recommended due to a lack of significant mitigating factors. Existing screening should be reinforced where there are gaps in the vegetation (see Figure 33 to Figure 37 on the following pages).

Figure 32 – Stretch of M6 where solar reflections are predicted to be geometrically possible and relevant screening

Figure 33 – Level of roadside screening at receptor 31 travelling east (towards receptor 32)

Figure 34 – Level of roadside screening at receptor 33 travelling east (towards receptor 34)

Figure 35 – Level of roadside screening at receptor 34 travelling east (towards receptor 35)

Figure 36 – Level of roadside screening at receptor 36 travelling east (towards receptor 37)

Figure 37 – Location along the M6 where gaps in the vegetation have been identified (red lines)

The developer has proposed to reinforce the screening along the southern border of the proposed development to reduce the impacts upon those road users travelling between receptor 31 to 37 (see Figure 38[11] on the following page). The proposed screening will have a height of at least 2.5m which is predicted to remove visibility of the reflective area for any type of road user (HGV drivers included) and it is expected to be in the form of evergreen vegetation.

Therefore, no impact is predicted, and no further mitigation is recommended.

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[11] Source: 11370-FPCR-ZZ-XX-DR-L-0001-P07-Landscape Strategy Plan.pdf

Figure 38 – Proposed mitigation solution M6

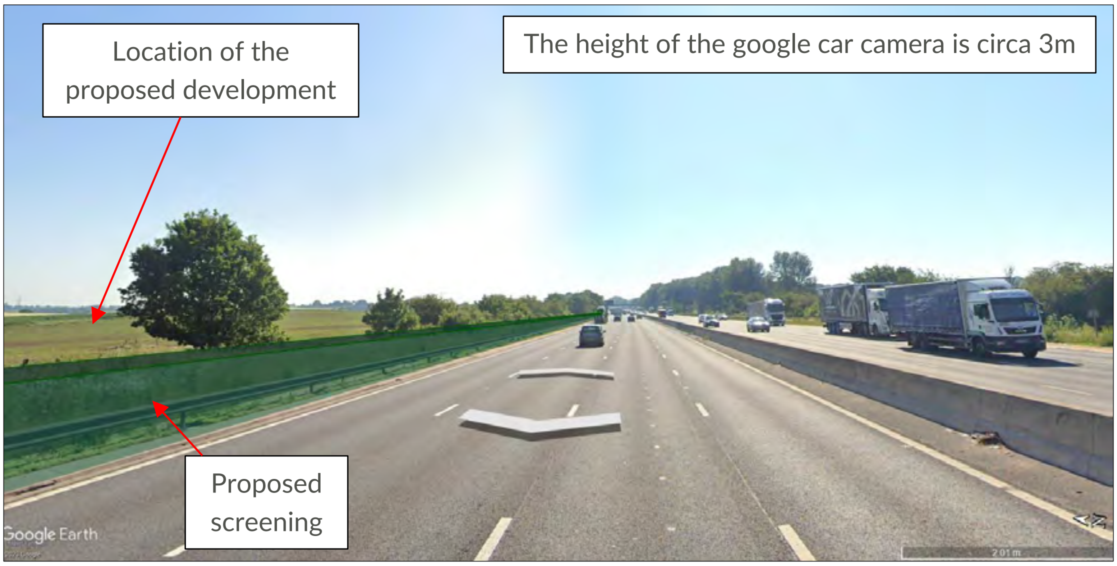

Figure 39 – Proposed screening effectiveness from road receptor 31

8 HIGH-LEVEL AVIATION CONSIDERATIONS

8.1 Overview

There is no formal buffer distance within which aviation effects must be modelled. However, in practice, concerns are most often raised for developments within 10km of a licensed airport. Requests for modelling at ranges of 10-20km are far less common. Assessment of aviation effects for developments over 20km from a licensed airfield is a very unusual requirement.

A high-level aviation assessment has been undertaken considering the nearest aerodromes to the proposed development (close to the 10km modelling area): Birmingham International Airport and Camp Farm Airstrip.

Other airfields exist within 10km to 20km from the proposed development (see Figure 40 on the following page). If effects towards pilots using these airfields are possible it is unlikely that the impact will be significant due to the large separation distance.

8.2 Airfield Details and High-Level Conclusions

Considering the size of the proposed development, its location and distance relative to the identified airfields, the following is applicable:

- Birmingham International Airport is a licensed airfield located approximately 10km west of the proposed development. Birmingham International Airport has an ATC Tower and one runway: 15/33.
  - Approach 15: the proposed development will be within the primary field of view of a pilot approaching runway 15; however, at this distance, any solar reflection will have "low potential for temporary after-image", which is acceptable in accordance with the associated guidance and industry best practice and therefore any impact will not be significant;
  - Approach 33: the proposed development will be entirely outside the primary field of view[12] of a pilot travelling along the 2-miles approach. This is acceptable in accordance with the associated guidance and industry best practice and therefore any impact will not be significant;
  - ATC Tower: the visibility of the proposed development from personnel within the ATC Tower is unlikely due to terrain screening. Therefore, no impact is predicted.
- Camp Farm Airstrip: is an unlicensed airfield located approximately 10km east of the proposed development. Camp Farm Airstrip is understood to not have an ATC Tower. The airfield has one runway: 03/21.

[12] 50° either side of the approach bearing

- Approach 03: the proposed development will be entirely outside the primary field of view of a pilot travelling along the 2-miles approach. Therefore, no significant impact is predicted;
- Approach 21: the proposed development will be within the primary field of view of a pilot approaching runway 21; however, at this distance, any solar reflection will have "low potential for temporary after-image" and therefore any impact will not be significant.

Therefore, no significant impacts upon aviation activity associated with Birmingham International Airport and Camp Farm Airstrip are predicted, and modelling is not recommended.

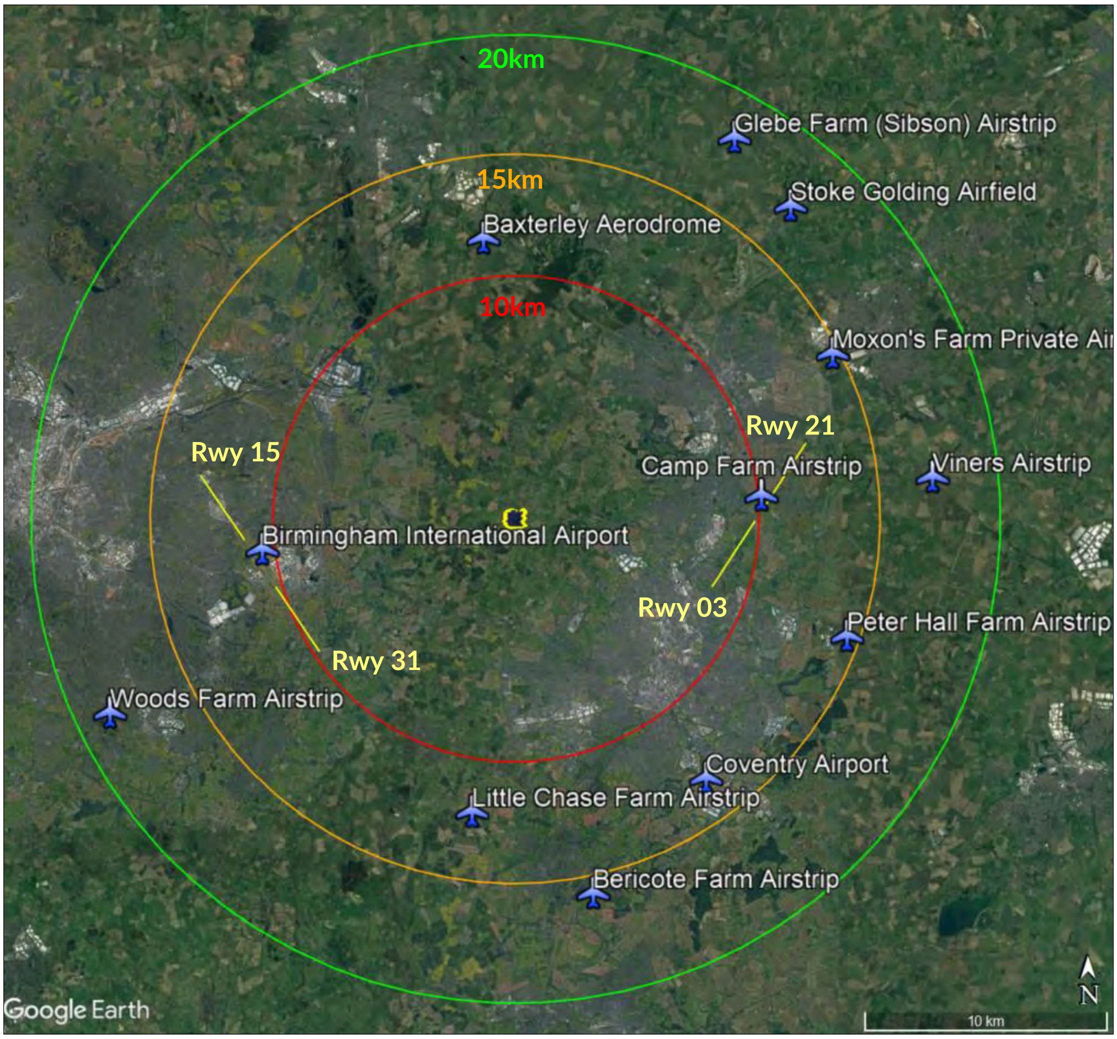

Figure 40 – Identified Airfields relative to the proposed development

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9 OVERALL CONCLUSIONS

9.1 Dwelling Receptors

The model has predicted that solar reflections are geometrically possible for 59 out of the 134 identified dwelling receptors. Existing screening, mainly in the form of vegetation, is predicted to significantly obstruct views of the reflective area for 43 out of these 59 dwellings. For the remaining 18 dwelling receptors, views of the reflecting area cannot be ruled out, based on a review of the available imagery. Despite solar reflections being experienced for more than three months per year but less than 60 minutes on any given day, significant mitigating factors have been identified such as:

- The visible reflective area being at a significant distance from an observer within the dwellings;
- The Sun light and the reflected light originating from the same point in space, with the Sun being a much brighter source of light.

Therefore, a low impact is predicted and no mitigation is recommended.

9.2 Road Receptors

9.2.1 B4102

The model has predicted that solar reflections are geometrically possible towards all identified road receptors of the B4012 (equivalent to circa 1.7km). Existing screening, mainly in the form of vegetation, is predicted to significantly obstruct the visibility of the reflective area for a section of B4102. For the remaining section (circa 300m) visibility of the reflective area remains possible due to insufficient existing screening in the form of vegetation. However, the reflective area is predicted to be outside the primary field of view (50° either side of the direction of travel) of a road user travelling in either direction. The proposed screening will have a height of at least 2.5m which is predicted to remove visibility of the reflective area for any type of road user (HGV drivers included) and it is expected to be in the form of evergreen vegetation.

Therefore, no impact is predicted, and no further mitigation is recommended.

9.2.2 M6

The model has predicted that solar reflections are geometrically possible towards all identified road receptors of the M6 (equivalent to circa 2.0km). Existing screening, mainly in the form of vegetation, is predicted to significantly obstruct the visibility of the reflective area for a section of M6. For the remaining section (circa 800m), partial visibility of the reflective area is possible. Mitigation is recommended for a circa 600m section due to a lack of significant mitigating factors. The developer has proposed screening in the form of vegetation to reduce the impacts upon road users. The proposed screening will have a height of at least 2.5m which is predicted to remove visibility of the reflective area for any type of road user (HGV drivers included) and it is expected to be in the form of evergreen vegetation.

Therefore, no impact is predicted, and no further mitigation is recommended.

9.3 Assessment Results - High-Level Aviation

Considering the size of the proposed development, its location and distance relative to the identified airfields, the following is applicable:

- Birmingham International Airport is a licensed airfield located approximately 10km west of the proposed development. Birmingham International Airport has an ATC Tower and one runway: 15/33.
    - Approach 15: the proposed development will be within the primary field of view of a pilot approaching runway 15; however, at this distance, any solar reflection will have "low potential for temporary after-image", which is acceptable in accordance with the associated guidance and industry best practice and therefore any impact will not be significant;
    - Approach 33: the proposed development will be entirely outside the primary field of view[13] of a pilot travelling along the 2-miles approach. This is acceptable in accordance with the associated guidance and industry best practice and therefore any impact will not be significant;
    - ATC Tower: the visibility of the proposed development from personnel within the ATC Tower is unlikely due to terrain screening. Therefore, no impact is predicted.
- Camp Farm Airstrip: is an unlicensed airfield located approximately 10km east of the proposed development. Camp Farm Airstrip is understood to not have an ATC Tower. The airfield has one runway: 03/21.
    - Approach 03: the proposed development will be entirely outside the primary field of view of a pilot travelling along the 2-miles approach. Therefore, no significant impact is predicted;
    - Approach 21: the proposed development will be within the primary field of view of a pilot approaching runway 21; however, at this distance, any solar reflection will have "low potential for temporary after-image" and therefore any impact will not be significant.

Therefore, no significant impacts upon aviation activity associated with Birmingham International Airport and Camp Farm Airstrip are predicted, and modelling is not recommended.

[13] 50° either side of the approach bearing

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

This section presents details regarding the relevant guidance and studies with respect to the considerations and effects of solar reflections from solar panels, known as 'Glint and Glare'.

This is not a comprehensive review of the data sources, rather it is intended to give an overview of the important parameters and considerations that have informed this assessment.

UK Planning Policy

Renewable and Low Carbon Energy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[14] (specifically regarding the consideration of solar farms, paragraph 013) states:

'What are the particular planning considerations that relate to large scale ground-mounted solar photovoltaic Farms?

The deployment of large-scale solar farms can have a negative impact on the rural environment, particularly in undulating landscapes. However, the visual impact of a well-planned and well-screened solar farm can be properly addressed within the landscape if planned sensitively.

Particular factors a local planning authority will need to consider include:

…

> *the proposal's visual impact, the effect on landscape of glint and glare (see guidance on landscape assessment) and on **neighbouring uses and aircraft safety**;*
>
> *the extent to which there may be additional impacts if solar arrays follow the daily movement of the sun;*

…

The approach to assessing cumulative landscape and visual impact of large scale solar farms is likely to be the same as assessing the impact of wind turbines. However, in the case of ground-mounted solar panels it should be noted that with effective screening and appropriate land topography the area of a zone of visual influence could be zero.'

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[14] Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 18 June 2015, accessed on: 01/11/2021

Draft National Policy Statement for Renewable Energy Infrastructure

The Draft National Policy Statement for Renewable Energy Infrastructure (EN-3)[15] sets out the primary policy for decisions by the Secretary of State for nationally significant renewable energy infrastructure. Section 2.52 states:

'2.52.1 *Solar panels may reflect the sun's rays, causing glint and glare. Glint is defined as a momentary flash of light that may be produced as a direct reflection of the sun in the solar panel. Glare is a continuous source of excessive brightness experienced by a stationary observer located in the path of reflected sunlight from the face of the panel. The effect occurs when the solar panel is stationed between or at an angle of the sun and the receptor.*

2.52.2 *In some instances, it may be necessary to seek a glint and glare assessment as part of the application. This may need to account for 'tracking' panels if they are proposed as these may cause differential diurnal and/or seasonal impacts. The potential for solar PV panels, frames and supports to have a combined reflective quality should be assessed. This assessment needs to consider the likely reflective capacity of all of the materials used*[16] *in the construction of the solar PV farm.*

2.52.3 *Applicants should consider using, and in some cases the Secretary of State may require, solar panels to be of a non-glare/ non-reflective type and the front face of the panels to comprise of (or be covered) with a non-reflective coating for the lifetime of the permission.*

2.52.4 *Solar PV panels are designed to absorb, not reflect, irradiation. However, the Secretary of State should assess the potential impact of glint and glare on nearby homes and motorists.*

2.52.5 *There is no evidence that glint and glare from solar farms interferes in any way with aviation navigation or pilot and aircraft visibility or safety. Therefore, the Secretary of State is unlikely to have to give any weight to claims of aviation interference as a result of glint and glare from solar farms.'*

Consultation to determine whether EN-3 provides a suitable framework to support decision making for nationally significant energy infrastructure ended in November 2021. Pager Power is aware that aviation stakeholders were not consulted prior to the publication of the draft policy and understands that they will still request a glint and glare assessment on the basis that glare may lead to impact upon aviation safety. It is possible that the draft policy will change in light of the consultation responses from aviation stakeholders.

Finally, it should be noted that the EN-3 relates solely to nationally significant renewable energy infrastructure and therefore does not apply to all planning applications for solar farms.

Assessment Process – Ground-Based Receptors

No process for determining and contextualising the effects of glint and glare has been determined when assessing the impact of solar reflections upon surrounding roads and dwellings. Therefore, the Pager Power approach is to determine whether a reflection from the proposed

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[15] Draft National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Business, Energy & Industrial Strategy, date: September 2021, accessed on: 01/11/2021.

[16] In Pager Power's experience, the solar panels themselves are the overriding source of specular reflections which have the potential to cause significant impacts upon safety or amenity.

solar development is geometrically possible and then to compare the results against the relevant guidance/studies to determine whether the reflection is significant. The Pager Power approach has been informed by the policy presented above, current studies (presented in Appendix B) and stakeholder consultation. Further information can be found in Pager Power's Glint and Glare Guidance document[17] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

Aviation Assessment Guidance

The UK Civil Aviation Authority (CAA) issued interim guidance relating to Solar Photovoltaic Systems (SPV) on 17 December 2010 and was subject to a CAA information alert 2010/53. The formal policy was cancelled on September 7th, 2012[18] however the advice is still applicable[19] until a formal policy is developed. The relevant aviation guidance from the CAA is presented in the section below.

CAA Interim Guidance

This interim guidance makes the following recommendations (p.2-3):

'8. It is recommended that, as part of a planning application, the SPV developer provide safety assurance documentation (including risk assessment) regarding the full potential impact of the SPV installation on aviation interests.

9. Guidance on safeguarding procedures at CAA licensed aerodromes is published within CAP 738 Safeguarding of Aerodromes and advice for unlicensed aerodromes is contained within CAP 793 Safe Operating Practices at Unlicensed Aerodromes.

10. Where proposed developments in the vicinity of aerodromes require an application for planning permission the relevant LPA normally consults aerodrome operators or NATS when aeronautical interests might be affected. This consultation procedure is a statutory obligation in the case of certain major airports, and may include military establishments and certain air traffic surveillance technical sites. These arrangements are explained in Department for Transport Circular 1/2003 and for Scotland, Scottish Government Circular 2/2003.

11. In the event of SPV developments proposed under the Electricity Act, the relevant government department should routinely consult with the CAA. There is therefore no requirement for the CAA to be separately consulted for such proposed SPV installations or developments.

12. If an installation of SPV systems is planned on-aerodrome (i.e. within its licensed boundary) then it is recommended that data on the reflectivity of the solar panel material should be included in any assessment before installation approval can be granted. Although approval for installation is the responsibility of the ALH[20], as part of a condition of a CAA Aerodrome Licence, the ALH is required to obtain prior consent from CAA Aerodrome Standards Department before any work is begun or

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[17] Solar Photovoltaic Development Glint and Glare Guidance, Fourth Edition, September 2022. Pager Power.
[18] Archived at Pager Power
[19] Reference email from the CAA dated 19/05/2014.
[20] Aerodrome Licence Holder.

approval to the developer or LPA is granted, in accordance with the procedures set out in CAP 791 Procedures for Changes to Aerodrome Infrastructure.

13. During the installation and associated construction of SPV systems there may also be a need to liaise with nearby aerodromes if cranes are to be used; CAA notification and permission is not required.

14. The CAA aims to replace this informal guidance with formal policy in due course and reserves the right to cancel, amend or alter the guidance provided in this document at its discretion upon receipt of new information.

15. Further guidance may be obtained from CAA's Aerodrome Standards Department via aerodromes@caa.co.uk.'

FAA Guidance

The most comprehensive guidelines available for the assessment of solar developments near aerodromes has been produced by the United States Federal Aviation Administration (FAA). The first guidelines were produced initially in November 2010 and updated in 2013. A final policy was released in 2021, which superseded the interim guidance.

The 2010 document is entitled '*Technical Guidance for Evaluating Selected Solar Technologies on Airports*'[21], the 2013 update is entitled '*Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports*'[22], and the 2021 final policy is entitled '*Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports*'[23].

Key excerpts from the final policy are presented below:

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

The policy in this document updates and replaces the previous policy by encouraging airport sponsors to conduct an ocular analysis of potential impacts to ATCT cabs prior to submittal of a Notice of Proposed Construction or Alteration Form 7460-1 (hereinafter Form 7460-1). Airport sponsors are no longer required to submit the results of an ocular analysis to FAA. Instead, to demonstrate compliance with 14 CFR 77.5(c), FAA will rely on the submittal of Form 7460-1 in which the sponsor confirms that it has analyzed the potential for glint and glare and determined there is no potential for ocular

[21] Archived at Pager Power

[22] Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports, Department of Transportation, Federal Aviation Administration (FAA), date: 10/2013, accessed on: 08/12/2021.

[23] Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports, Federal Aviation Administration, date: May 2021, accessed on: 08/12/2021.

impact to the airport's ATCT cab. This process will enable FAA to evaluate the solar energy system project, with assurance that the system will not impact the ATCT cab.

FAA encourages airport sponsors of federally-obligated towered airports to conduct a sufficient analysis to support their assertion that a proposed solar energy system will not result in ocular impacts. There are several tools available on the open market to airport sponsors that can analyze potential glint and glare to an ATCT cab. For proposed systems that will clearly not impact ATCT cabs (e.g., on-airport solar energy systems that are blocked from the ATCT cab's view by another structure), the use of such tools may not be necessary to support the assertion that a proposed solar energy system will not result in ocular impacts.

The excerpt above states where a solar PV development is to be located on a federally obligated aerodrome with an ATC Tower, it will require a glint and glare assessment to accompany its application. It states that pilots on approach are no longer a specific assessment requirement due to effects from solar energy systems being similar to glint and glare pilots routinely experience from water bodies, glass-façade buildings, parking lots, and similar features. Ultimately it comes down to the specific aerodrome to ensure it is adequately safeguarded, and it is on this basis that glint and glare assessments are routinely still requested.

The policy also states that several different tools and methodologies can be used to assess the impacts of glint and glare, which was previously required to be undertaken by the Solar Glare Hazard Analysis Tool (SGHAT) using the Sandia National Laboratories methodology.

In 2018, the FAA released the latest version (Version 1.1) of the '*Technical Guidance for Evaluating Selected Solar Technologies on Airports'*[24]. Whilst the 2021 final policy also supersedes this guidance, many of the points are still relevant because aerodromes are still safeguarding against glint and glare irrespective of the FAA guidance. The key points are presented below for reference:

> *Reflectivity refers to light that is reflected off surfaces. The potential effects of reflectivity are glint (a momentary flash of bright light) and glare (a continuous source of bright light). These two effects are referred to hereinafter as "glare," which can cause a brief loss of vision, also known as flash blindness*[25].
>
> *The amount of light reflected off a solar panel surface depends on the amount of sunlight hitting the surface, its surface reflectivity, geographic location, time of year, cloud cover, and solar panel orientation.*
>
> *As illustrated on Figure 16*[26]*, flat, smooth surfaces reflect a more concentrated amount of sunlight back to the receiver, which is referred to as specular reflection. The more a surface is polished, the more it shines. Rough or uneven surfaces reflect light in a diffused or scattered manner and, therefore, the light will not be received as bright.*

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[24] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.

[25] Flash Blindness, as described in the FAA guidelines, can be described as a temporary visual interference effect that persists after the source of illumination has ceased. This occurs from many reflective materials in the ambient environment.

[26] First figure in Appendix B.

Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:

- *A qualitative analysis of potential impact in consultation with the Control Tower, pilots and airport officials;*
- *A demonstration field test with solar panels at the proposed site in coordination with FAA Tower personnel;*
- *A geometric analysis to determine days and times when an impact is predicted.*

The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and system design.

1. Assessing Baseline Reflectivity Conditions *– Reflection in the form of glare is present in current aviation operations. The existing sources of glare come from glass windows, auto surface parking, rooftops, and water bodies. At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing. Operators also wear polarized eye wear. Potential glare from solar panels should be viewed in this context. Any airport considering a solar PV project should first review existing sources of glare at the airport and the effectiveness of measures used to mitigate that glare.*

2. Tests in the Field *– Potential glare from solar panels can easily be viewed at the airport through a field test. A few airports have coordinated these tests with FAA Air Traffic Controllers to assess the significance of glare impacts. To conduct such a test, a sponsor can take a solar panel out to proposed location of the solar project, and tilt the panel in different directions to evaluate the potential for glare onto the air traffic control tower. For the two known cases where a field test was conducted, tower personnel determined the glare was not significant. If there is a significant glare impact, the project can be modified by ensuring panels are not directed in that direction.*

3. Geometric Analysis *– Geometric studies are the most technical approach for reflectivity issues. They are conducted when glare is difficult to assess through other methods. Studies of glare can employ geometry and the known path of the sun to predict when sunlight will reflect off of a fixed surface (like a solar panel) and contact a fixed receptor (e.g., control tower). At any given site, the sun moves across the sky every day and its path in the sky changes throughout year. This in turn alters the destination of the resultant reflections since the angle of reflection for the solar panels will be the same as the angle at which the sun hits the panels. The larger the reflective surface, the greater the likelihood of glare impacts.*

Facilities placed in remote locations, like the desert, will be far from receptors and therefore potential impacts are limited to passing aircraft. Because the intensity of the light reflected from the solar panel decreases with increasing distance, an appropriate question is how far you need to be from a solar reflected surface to avoid flash blindness. It is known that this *distance is directly proportional to the size of the array in question*[27] *but still requires further research to definitively answer.*

***Experiences of Existing Airport Solar Projects** – Solar installations are presently operating at a number of airports, including megawatt-sized solar facilities covering multiple acres. Air traffic control towers have expressed concern about glint and glare from a small number of solar installations. These were often instances when solar installations were sited between the tower and airfield, or for installations with inadequate or no reflectivity analysis. Adequate reflectivity analysis and alternative siting addressed initial issues at those installations.*

Air Navigation Order (ANO) 2016

In some instances, an aviation stakeholder can refer to the ANO 2016[28] with regard to safeguarding. Key points from the document are presented below.

Lights liable to endanger

224. (1) A person must not exhibit in the United Kingdom any light which—

(a) by reason of its glare is liable to endanger aircraft taking off from or landing at an aerodrome; or

(b) by reason of its liability to be mistaken for an aeronautical ground light is liable to endanger aircraft.

(2) If any light which appears to the CAA to be a light described in paragraph (1) is exhibited, the CAA may direct the person who is the occupier of the place where the light is exhibited or who has charge of the light, to take such steps within a reasonable time as are specified in the direction—

(a) to extinguish or screen the light; and

(b) to prevent in the future the exhibition of any other light which may similarly endanger aircraft.

(3) The direction may be served either personally or by post, or by affixing it in some conspicuous place near to the light to which it relates.

(4) In the case of a light which is or may be visible from any waters within the area of a general lighthouse authority, the power of the CAA under this article must not be exercised except with the consent of that authority.

Lights which dazzle or distract

225. A person must not in the United Kingdom direct or shine any light at any aircraft in flight so as to dazzle or distract the pilot of the aircraft.'

The document states that no 'light', 'dazzle' or 'glare' should be produced which will create a detrimental impact upon aircraft safety.

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[27] Ho, Clifford, Cheryl Ghanbari, and Richard Diver. 2009. Hazard Analysis of Glint and Glare From Concentrating Solar Power Plants. SolarPACES 2009, Berlin Germany. Sandia National Laboratories.
[28] The Air Navigation Order 2016. [online] Available at: <https://www.legislation.gov.uk/uksi/2016/765/contents/made> [Accessed 4 February 2022].

Endangering safety of an aircraft

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

Endangering safety of any person or property

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

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

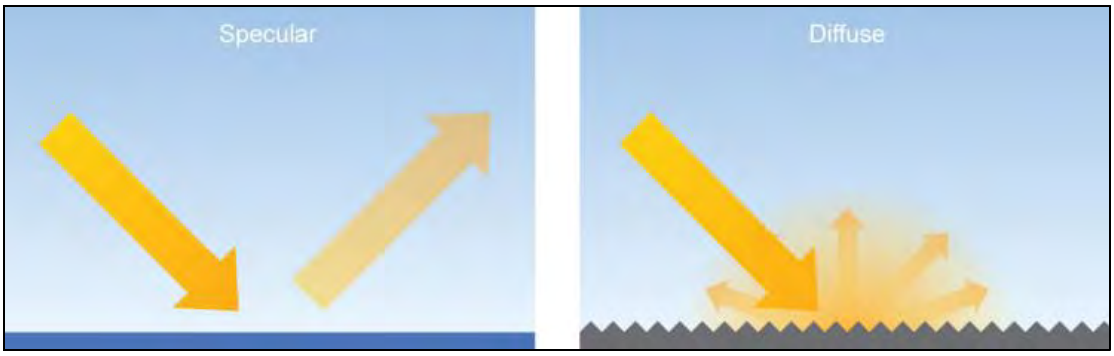
Overview

Studies have been undertaken assessing the type and intensity of solar reflections from various surfaces including solar panels and glass. An overview of these studies is presented below.

The guidelines presented are related to aviation safety. The results are applicable for the purpose of this analysis.

Reflection Type from Solar Panels

Based on the surface conditions reflections from light can be specular and diffuse. A specular reflection has a reflection characteristic similar to that of a mirror; a diffuse will reflect the incoming light and scatter it in many directions. The figure below, taken from the FAA guidance[29], illustrates the difference between the two types of reflections. Because solar panels are flat and have a smooth surface most of the light reflected is specular, which means that incident light from a specific direction is reradiated in a specific direction.



Specular and diffuse reflections

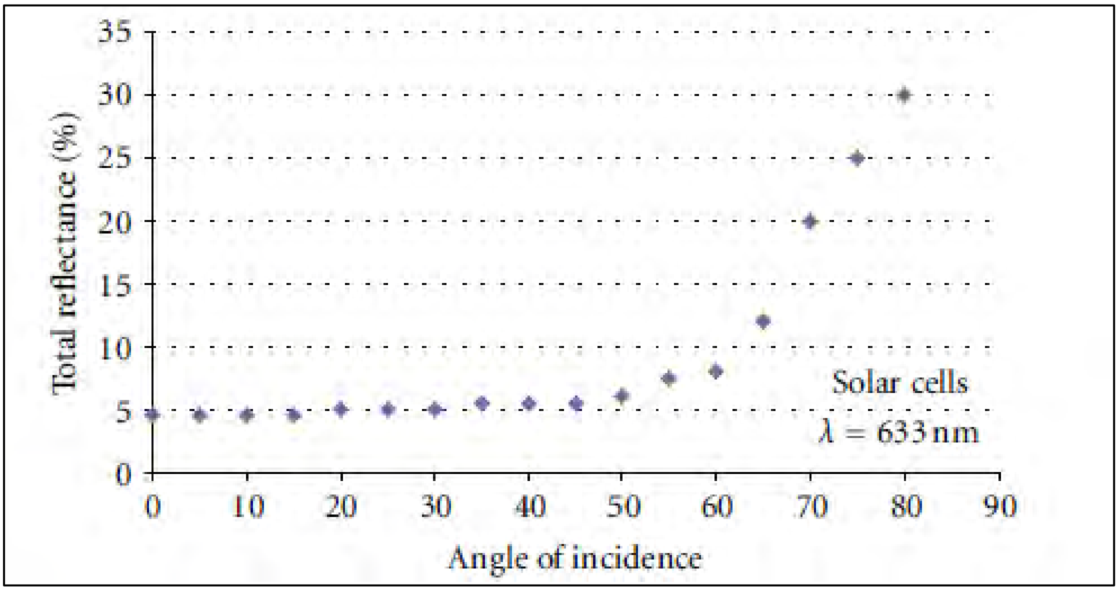
[29] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.

Solar Reflection Studies

An overview of content from identified solar panel reflectivity studies is presented in the subsections below.

Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems"

Evan Riley and Scott Olson published in 2011 their study titled: *A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems*[30]". They researched the potential glare that a pilot could experience from a 25-degree fixed tilt PV system located outside of Las Vegas, Nevada. The theoretical glare was estimated using published ocular safety metrics which quantify the potential for a postflash glare after-image. This was then compared to the postflash glare after-image caused by smooth water. The study demonstrated that the reflectance of the solar cell varied with angle of incidence, with maximum values occurring at angles close to 90 degrees. The reflectance values varied from approximately 5% to 30%. This is shown on the figure below.



Total reflectance % when compared to angle of incidence

The conclusions of the research study were:

- The potential for hazardous glare from flat-plate PV systems is similar to that of smooth water;
- Portland white cement concrete (which is a common concrete for runways), snow, and structural glass all have a reflectivity greater than water and flat plate PV modules.

[30] Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems," ISRN Renewable Energy, vol. 2011, Article ID 651857, 6 pages, 2011. doi:10.5402/2011/651857

FAA Guidance – "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[31]

The 2018 FAA Guidance included a diagram which illustrates the relative reflectance of solar panels compared to other surfaces. The figure shows the relative reflectance of solar panels compared to other surfaces. Surfaces in this figure produce reflections which are specular and diffuse. A specular reflection (those made by most solar panels) has a reflection characteristic similar to that of a mirror. A diffuse reflection will reflect the incoming light and scatter it in many directions. A table of reflectivity values, sourced from the figure within the FAA guidance, is presented below.

Surface	Approximate Percentage of Light Reflected[32]
Snow	80
White Concrete	77
Bare Aluminium	74
Vegetation	50
Bare Soil	30
Wood Shingle	17
Water	5
Solar Panels	5
Black Asphalt	2

Relative reflectivity of various surfaces

Note that the data above does not appear to consider the reflection type (specular or diffuse).

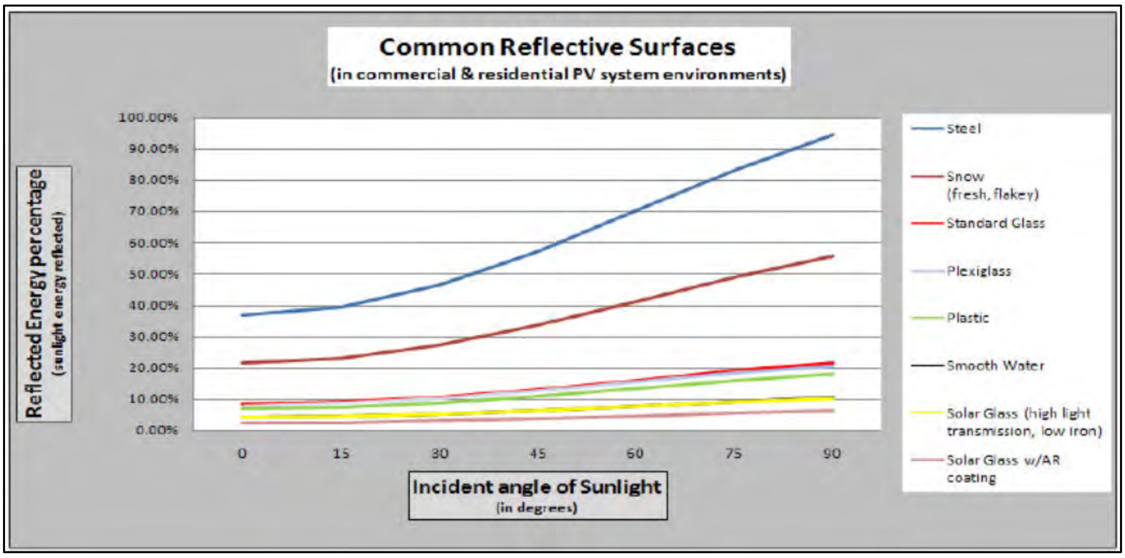
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

[31] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.
[32] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification[33] to '*increase awareness concerning the possible glare and reflectance impact of PV Systems on their surrounding environment*'.

The figure presented below shows the relative reflectivity of solar panels compared to other natural and manmade materials including smooth water, standard glass and steel.



Common reflective surfaces

The results, similarly to those from Riley and Olsen study (2011) and the FAA (2010), show that solar panels produce a reflection that is less intense than those of '*standard glass and other common reflective surfaces*'.

With respect to aviation and solar reflections observed from the air, SunPower has developed several large installations near airports or on Air Force bases. It is stated that these developments have all passed FAA or Air Force standards with all developments considered "No Hazard to Air Navigation". The note suggests that developers discuss any possible concerns with stakeholders near proposed solar farms.

[33] Source: Technical Support, 2009. SunPower Technical Notification – Solar Module Glare and Reflectance.

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

The Sun's position in the sky can be accurately described by its azimuth and elevation. Azimuth is a direction relative to true north (horizontal angle i.e. from left to right) and elevation describes the Sun's angle relative to the horizon (vertical angle i.e. up and down).

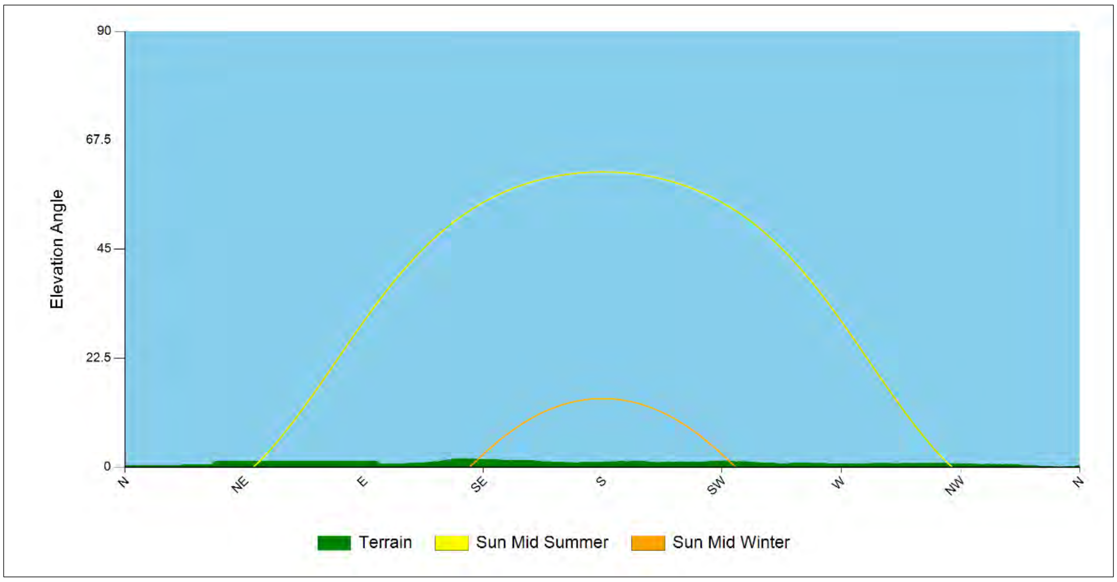
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

- Time.
- Date.
- Latitude.
- Longitude.

The following is true at the location of the solar development:

- The Sun is at its highest around midday and is to the south at this time.
- The Sun rises highest on 21 June (longest day).
- On 21 December, the maximum elevation reached by the Sun is at its lowest (shortest day).

The combination of the Sun's azimuth angle and vertical elevation will affect the direction and angle of the reflection from a reflector. The figure below shows terrain at the horizon as well as the sunrise and sunset curves throughout the year.



Terrain at the visible horizon and Sun paths

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

The significance of glint and glare will vary for different receptors. The following section presents a general overview of the significance criteria with respect to experiencing a solar reflection.

Impact Significance Definition

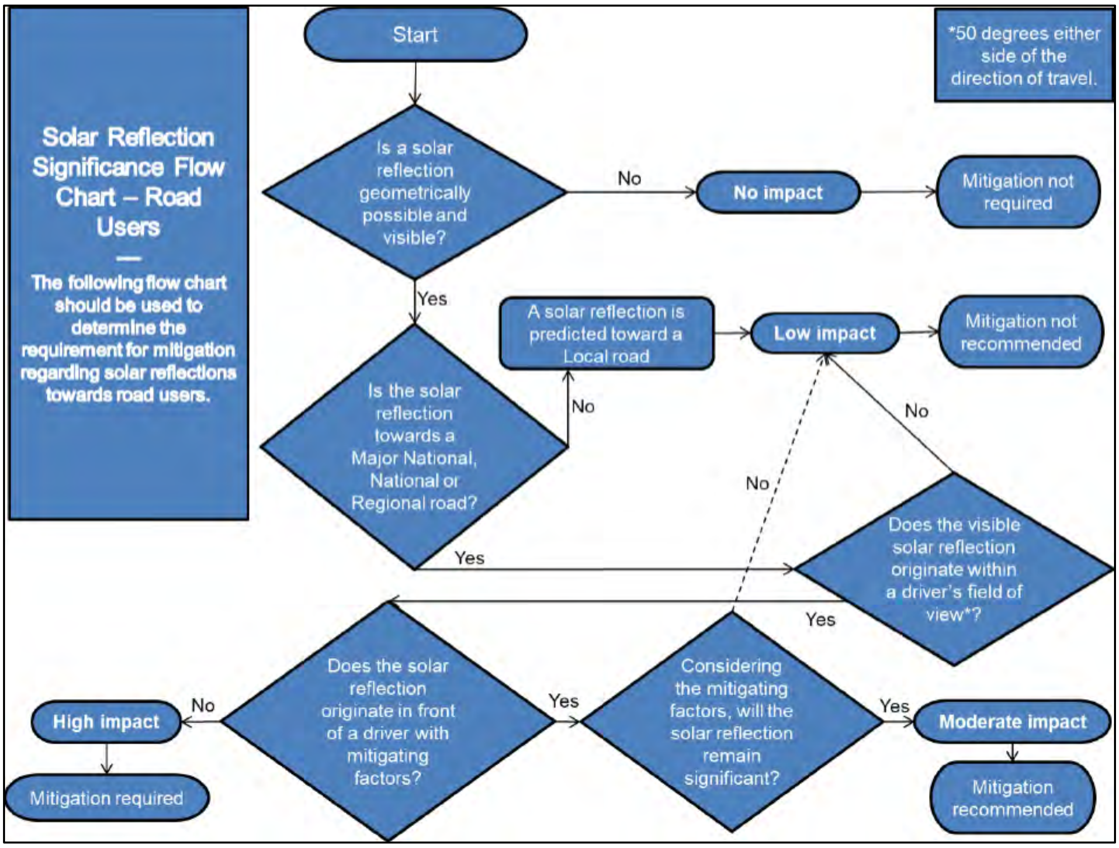
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not required e.g. intervening screening will limit the view of the reflecting solar panels significantly.	No mitigation recommended.
Moderate	A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case given individual receptor criteria.	Mitigation recommended.
High	A solar reflection is geometrically possible and visible under worst-case conditions that will produce a significant impact given individual receptor criteria	Mitigation will be required if the proposed development is to proceed.

Impact significance definition

Assessment Process for Road Receptors

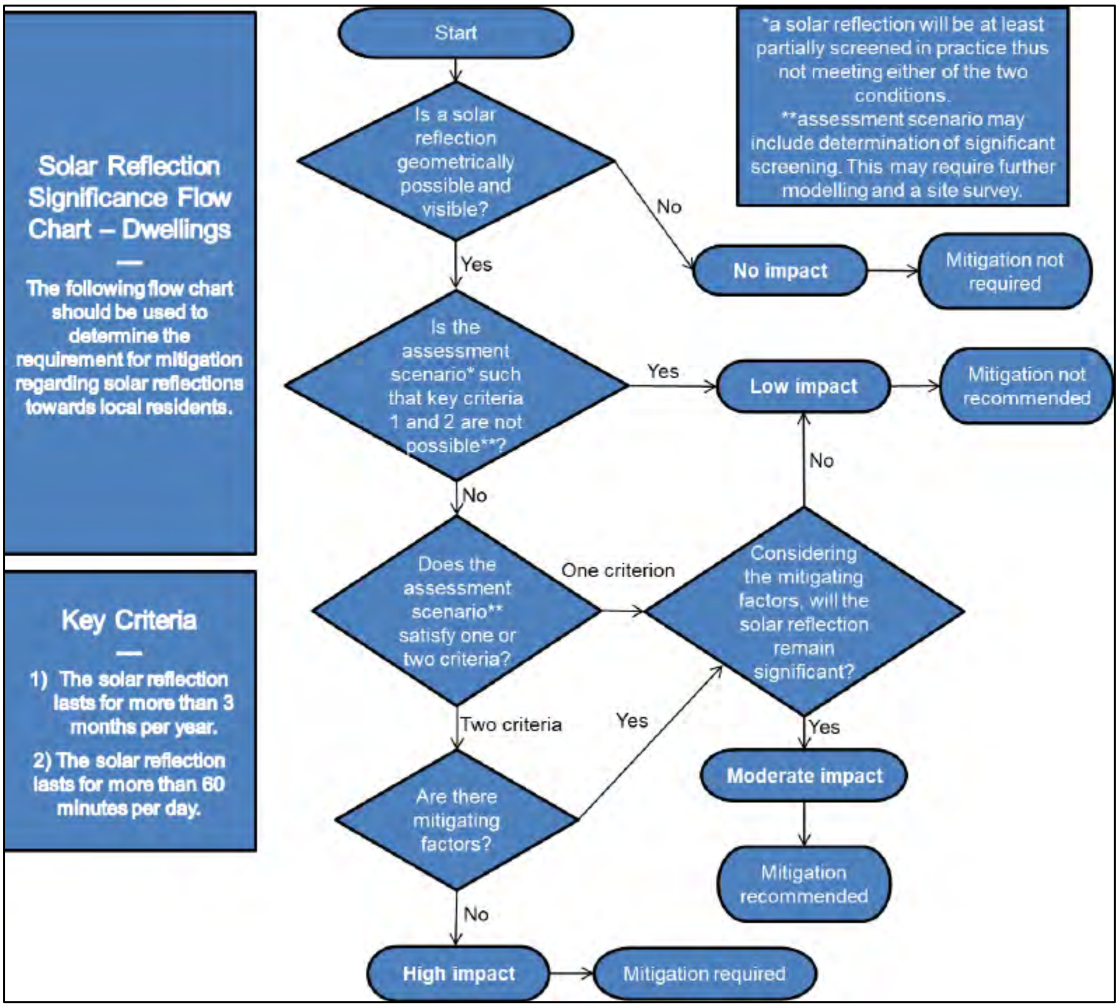
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road receptor mitigation requirement flow chart

Assessment Process for Dwelling Receptors

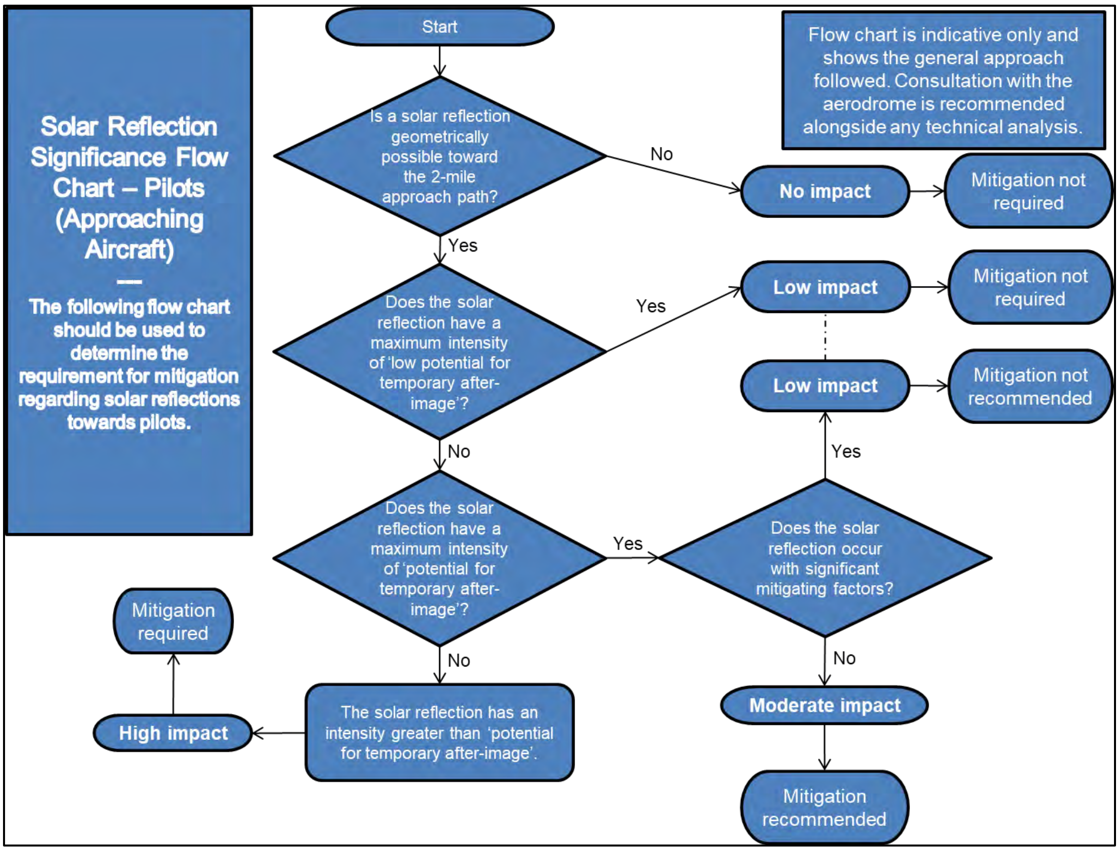
The flow chart presented below has been followed when determining the mitigation requirement for dwelling receptors.



Dwelling receptor mitigation requirement flow chart

Assessment Process – Approaching Aircraft

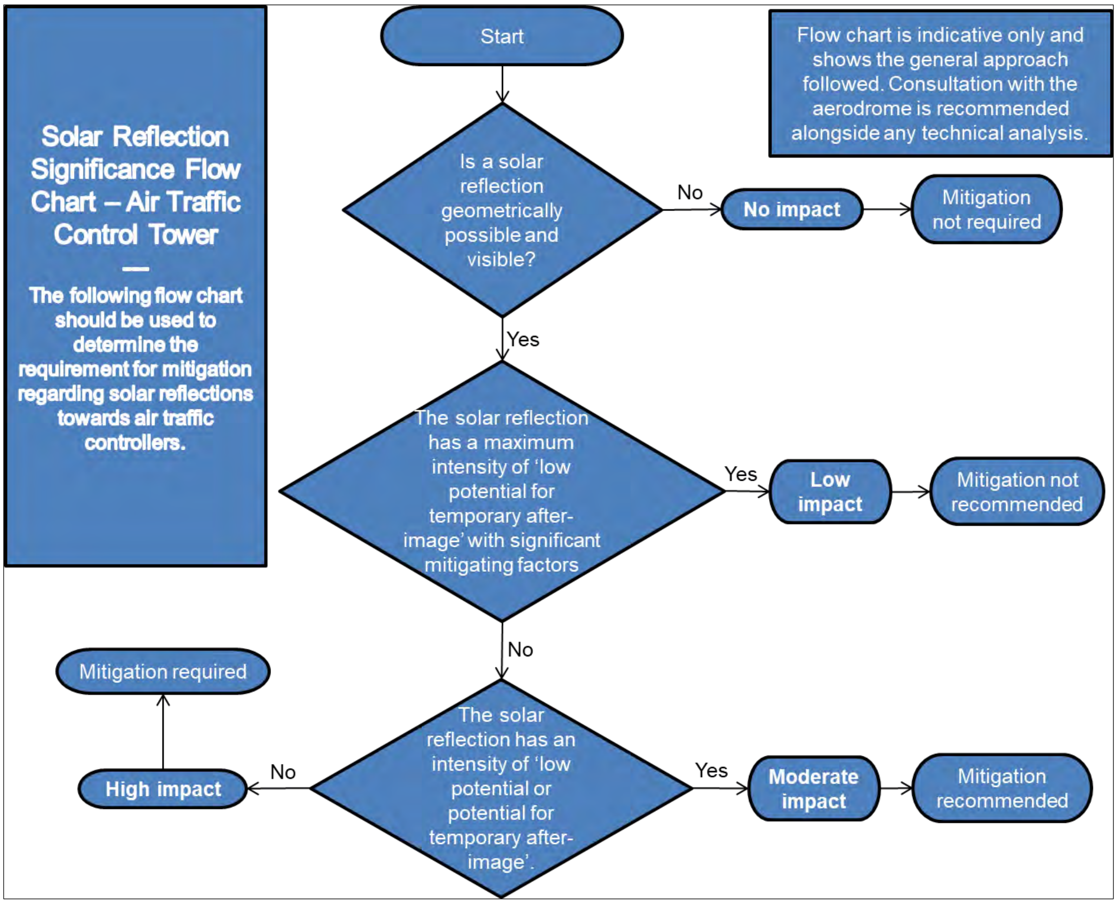
The charts relate to the determining the potential impact upon approaching aircraft.



Pilots (approaching aircraft) impact significance flow chart

Assessment Process – ATC Tower

The charts relate to the determining the potential impact upon ATC Tower personnel.



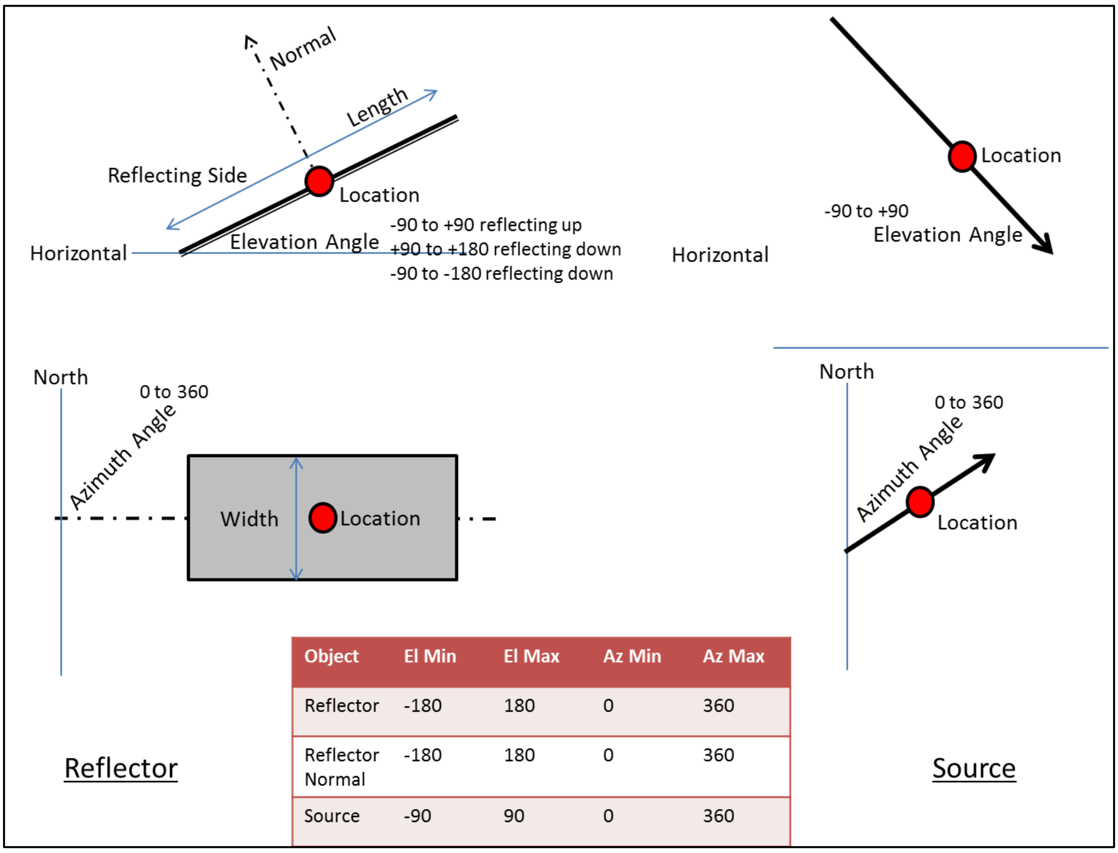
Pilots (approaching aircraft) impact significance flow chart

APPENDIX E – PAGER POWER'S REFLECTION CALCULATIONS METHODOLOGY

The calculations are three dimensional and complex, accounting for:

- The Earth's orbit around the Sun;
- The Earth's rotation;
- The Earth's orientation;
- The reflector's location;
- The reflector's 3D Orientation.

Reflections from a flat reflector are calculated by considering the normal which is an imaginary line that is perpendicular to the reflective surface and originates from it. The diagram below may be used to aid understanding of the reflection calculation process.



Object	El Min	El Max	Az Min	Az Max
Reflector	-180	180	0	360
Reflector Normal	-180	180	0	360
Source	-90	90	0	360

The following process is used to determine the 3D Azimuth and Elevation of a reflection:

- Use the Latitude and Longitude of reflector as the reference for calculation purposes;
- Calculate the Azimuth and Elevation of the normal to the reflector;
- Calculate the 3D angle between the source and the normal;

If this angle is less than 90 degrees a reflection will occur. If it is greater than 90 degrees no reflection will occur because the source is behind the reflector;

Calculate the Azimuth and Elevation of the reflection in accordance with the following:

- The angle between source and normal is equal to angle between normal and reflection;
- Source, Normal and Reflection are in the same plane.

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Pager Power's Model

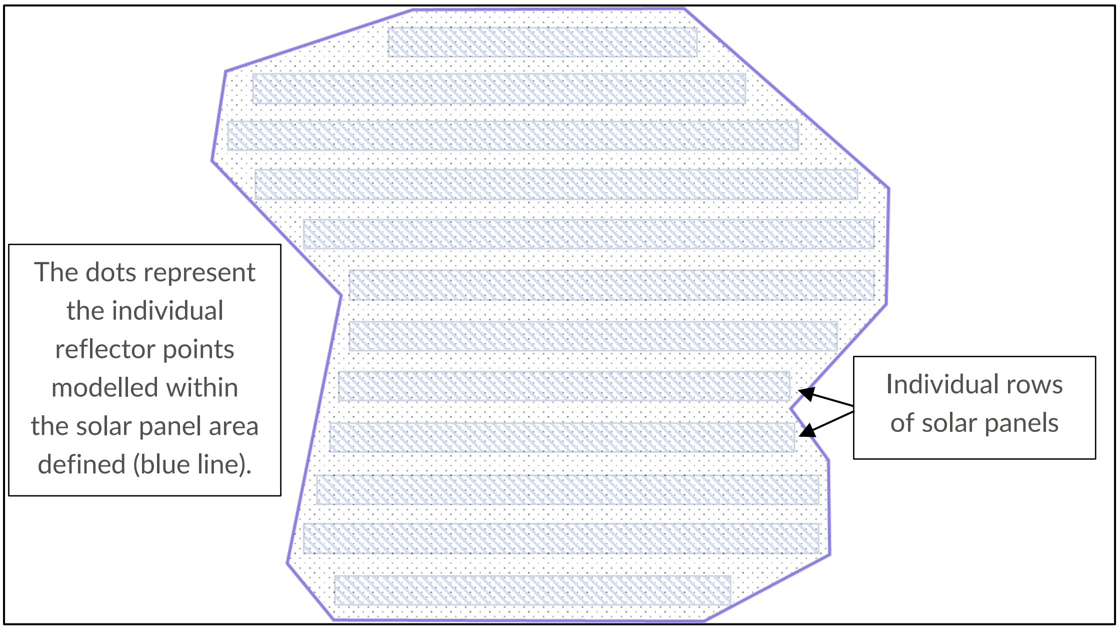
It is assumed that the panel elevation angle provided by the developer represents the elevation angle for all of the panels within each solar panel area defined.

It is assumed that the panel azimuth angle provided by the developer represents the azimuth angle for all of the panels within each solar panel area defined.

Only a reflection from the face of the panel has been considered. The frame or the reverse or frame of the solar panel has not been considered.

The model assumes that a receptor can view the face of every panel within the proposed development area whilst in reality this, in the majority of cases, will not occur. Therefore any predicted solar reflection from the face of a solar panel that is not visible to a receptor will not occur in practice.

A finite number of points within each solar panel area defined is chosen based on an assessment resolution so that a comprehensive understanding of the entire development can be formed. This determines whether a solar reflection could ever occur at a chosen receptor. The model does not consider the specific panel rows or the entire face of the solar panel within the development outline, rather a single point is defined every 'x' metres (based on the resolution) with the geometric characteristics of the panel. A panel area is however defined to encapsulate all possible panel locations. See the figure below which illustrates this process.



Solar panel area modelling overview

A single reflection point is chosen for the geometric calculations. This suitably determines whether a solar reflection can be experienced at a receptor location and the time of year and duration of the solar reflection. Increased accuracy could be achieved by increasing the number of heights assessed however this would only marginally change the results and is not considered significant.

The available street view imagery, satellite mapping, terrain and any site imagery provided by the developer has been used to assess line of sight from the assessed receptors to the modelled solar panel area, unless stated otherwise. In some cases, this imagery may not be up to date and may not give the full perspective of the installation from the location of the assessed receptor.

Any screening in the form of trees, buildings etc. that may obstruct the Sun from view of the solar panels is not within the modelling unless stated otherwise. The terrain profile at the horizon is considered if stated.

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Dwelling Data

The table below presents the coordinate data for assessed dwelling receptors.

Dwelling	Longitude (°)	Latitude (°)	Dwelling	Longitude (°)	Latitude (°)
1	-1.61410	52.47241	68	-1.58591	52.45980
2	-1.61354	52.47239	69	-1.58633	52.46021
3	-1.61407	52.47224	70	-1.58516	52.46021
4	-1.61335	52.47221	71	-1.58545	52.46030
5	-1.61420	52.47183	72	-1.58431	52.46087
6	-1.61411	52.47164	73	-1.58428	52.46101
7	-1.61277	52.47148	74	-1.58717	52.46043
8	-1.61301	52.47124	75	-1.58667	52.46129
9	-1.60879	52.47050	76	-1.58854	52.46107
10	-1.60534	52.47011	77	-1.58790	52.46137
11	-1.60548	52.46995	78	-1.58893	52.46156
12	-1.60526	52.46789	79	-1.58912	52.46163
13	-1.60748	52.46648	80	-1.58927	52.46172
14	-1.60750	52.46598	81	-1.58950	52.46183
15	-1.60800	52.46578	82	-1.58969	52.46193
16	-1.60809	52.46563	83	-1.58967	52.46210
17	-1.60591	52.46523	84	-1.58922	52.46216
18	-1.60377	52.46567	85	-1.58899	52.46224

Dwelling	Longitude (°)	Latitude (°)	Dwelling	Longitude (°)	Latitude (°)
19	-1.60198	52.46606	86	-1.58878	52.46229
20	-1.60165	52.46642	87	-1.58854	52.46232
21	-1.59620	52.46407	88	-1.58840	52.46239
22	-1.59585	52.46356	89	-1.58823	52.46242
23	-1.59594	52.45950	90	-1.58806	52.46247
24	-1.59427	52.46031	91	-1.58769	52.46254
25	-1.59488	52.46092	92	-1.58748	52.46268
26	-1.59424	52.46096	93	-1.58721	52.46275
27	-1.59395	52.46138	94	-1.58693	52.46284
28	-1.59505	52.46202	95	-1.58666	52.46290
29	-1.59404	52.46183	96	-1.58644	52.46298
30	-1.59397	52.46192	97	-1.58580	52.46249
31	-1.59403	52.46241	98	-1.58574	52.46301
32	-1.59403	52.46254	99	-1.58541	52.46310
33	-1.59439	52.46256	100	-1.58526	52.46494
34	-1.59403	52.46303	101	-1.58503	52.46488
35	-1.59418	52.46379	102	-1.58435	52.46469
36	-1.59391	52.46406	103	-1.58367	52.46364
37	-1.59156	52.46461	104	-1.58321	52.46339
38	-1.59152	52.46625	105	-1.58309	52.46378
39	-1.58756	52.46646	106	-1.58257	52.46388

Dwelling	Longitude (°)	Latitude (°)	Dwelling	Longitude (°)	Latitude (°)
40	-1.58609	52.46596	107	-1.58125	52.46407
41	-1.58688	52.46526	108	-1.58071	52.46386
42	-1.58828	52.46486	109	-1.58043	52.46376
43	-1.58709	52.46461	110	-1.58128	52.46437
44	-1.58873	52.46390	111	-1.58121	52.46449
45	-1.58950	52.46298	112	-1.58117	52.46459
46	-1.58857	52.46284	113	-1.58115	52.46482
47	-1.58825	52.46288	114	-1.58098	52.46480
48	-1.58952	52.46246	115	-1.58078	52.46476
49	-1.58998	52.46240	116	-1.58061	52.46473
50	-1.59136	52.46212	117	-1.58079	52.46453
51	-1.59104	52.46203	118	-1.58084	52.46443
52	-1.59075	52.46194	119	-1.58088	52.46431
53	-1.59048	52.46182	120	-1.57843	52.46334
54	-1.59177	52.46129	121	-1.57748	52.46301
55	-1.59115	52.46113	122	-1.57560	52.46443
56	-1.59312	52.45964	123	-1.57381	52.47416
57	-1.59281	52.45965	124	-1.57393	52.47433
58	-1.59257	52.45963	125	-1.57394	52.47454
59	-1.59233	52.45956	126	-1.57412	52.47474
60	-1.59218	52.45954	127	-1.57439	52.47487

Dwelling	Longitude (°)	Latitude (°)	Dwelling	Longitude (°)	Latitude (°)
61	-1.59222	52.45924	128	-1.57598	52.47474
62	-1.59067	52.45943	129	-1.57634	52.47480
63	-1.58965	52.45940	130	-1.57716	52.47510
64	-1.59045	52.46043	131	-1.57754	52.47519
65	-1.58460	52.46004	132	-1.57775	52.47522
66	-1.58483	52.46012	133	-1.57802	52.47530
67	-1.58550	52.45982	134	-1.57832	52.47532

Dwelling data

Road Data

The table below presents the coordinate data for assessed road receptors.

B4102

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.61228	52.46356	10	-1.60211	52.46825
2	-1.61095	52.46393	11	-1.60187	52.46912
3	-1.60974	52.46445	12	-1.60177	52.47004
4	-1.60867	52.46504	13	-1.60167	52.47093
5	-1.60738	52.46546	14	-1.60148	52.47180
6	-1.60603	52.46585	15	-1.60110	52.47266
7	-1.60471	52.46623	16	-1.60063	52.47350
8	-1.60352	52.46670	17	-1.60008	52.47436
9	-1.60260	52.46742	18	-1.59955	52.47516

B4102 data

M6

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
19	-1.61545	52.46748	34	-1.59335	52.46774
20	-1.61397	52.46745	35	-1.59183	52.46781
21	-1.61250	52.46743	36	-1.59049	52.46787
22	-1.61103	52.46740	37	-1.58898	52.46795
23	-1.60955	52.46737	38	-1.58739	52.46807
24	-1.60808	52.46734	39	-1.58605	52.46817
25	-1.60660	52.46734	40	-1.58450	52.46829
26	-1.60509	52.46736	41	-1.58312	52.46839
27	-1.60369	52.46738	42	-1.58161	52.46851
28	-1.60218	52.46740	43	-1.58019	52.46861
29	-1.60066	52.46742	44	-1.57865	52.46876
30	-1.59923	52.46748	45	-1.57728	52.46891
31	-1.59776	52.46755	46	-1.57583	52.46906
32	-1.59637	52.46761	47	-1.57412	52.46923
33	-1.59486	52.46768			

M6 data

Modelled Reflector Data

The tables below present the coordinate data for modelled reflector area used in the assessment.

Vertex number	Longitude (°)	Latitude (°)	Vertex number	Longitude (°)	Latitude (°)
1	-1.60102	52.46929	14	-1.59247	52.47423
2	-1.59931	52.46857	15	-1.59304	52.47445

Vertex number	Longitude (°)	Latitude (°)	Vertex number	Longitude (°)	Latitude (°)
3	-1.59866	52.46788	16	-1.59364	52.47442
4	-1.58928	52.46833	17	-1.59446	52.47449
5	-1.58825	52.46878	18	-1.59623	52.47525
6	-1.59016	52.47023	19	-1.59681	52.47496
7	-1.58975	52.47098	20	-1.59712	52.47453
8	-1.58878	52.47145	21	-1.59955	52.47464
9	-1.58925	52.47232	22	-1.60097	52.47229
10	-1.58904	52.47348	23	-1.60071	52.47147
11	-1.58843	52.47457	24	-1.60131	52.47054
12	-1.58927	52.47473	25	-1.60051	52.46986
13	-1.58950	52.47525	26	-1.60102	52.46929

Modelled reflector area – eastern panel area

APPENDIX H – DETAILLED MODELLING RESULTS

Model Output Charts

Each chart shows:

The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is obstructed as discussed within the body of the report.

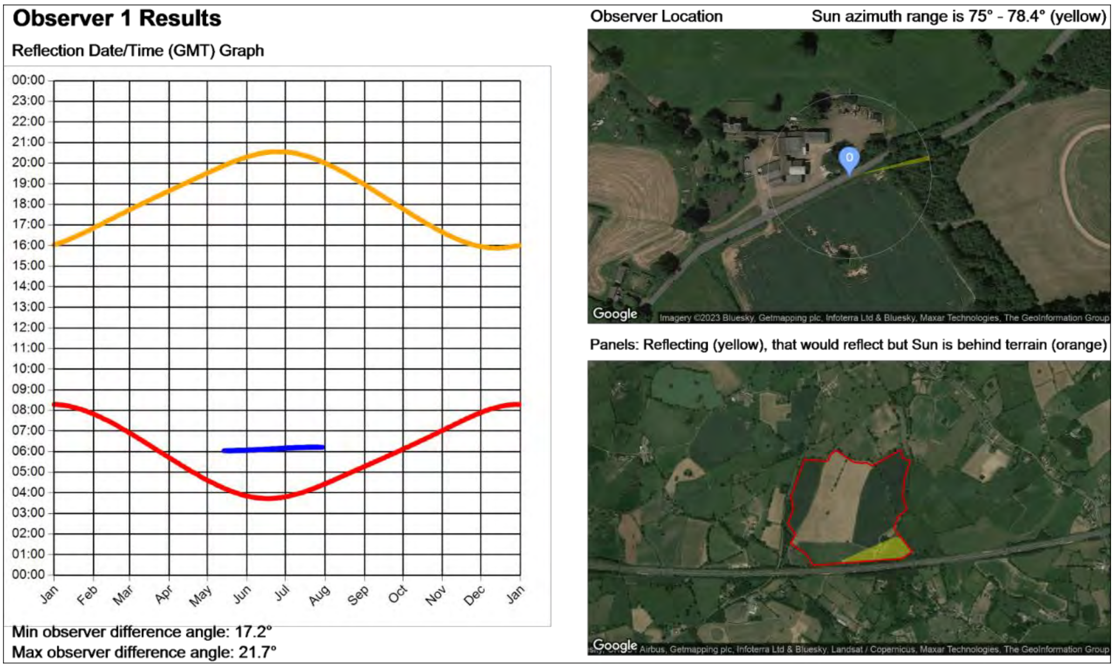
The reflecting panels – bottom right image. The reflecting area is shown in yellow. The orange areas denote panel locations that will not produce glare due to terrain screening at the horizon. If the yellow panels are not visible from the observer location, no issues will occur in practice. Additional obstructions which may obscure the panels from view are considered separately within the analysis.

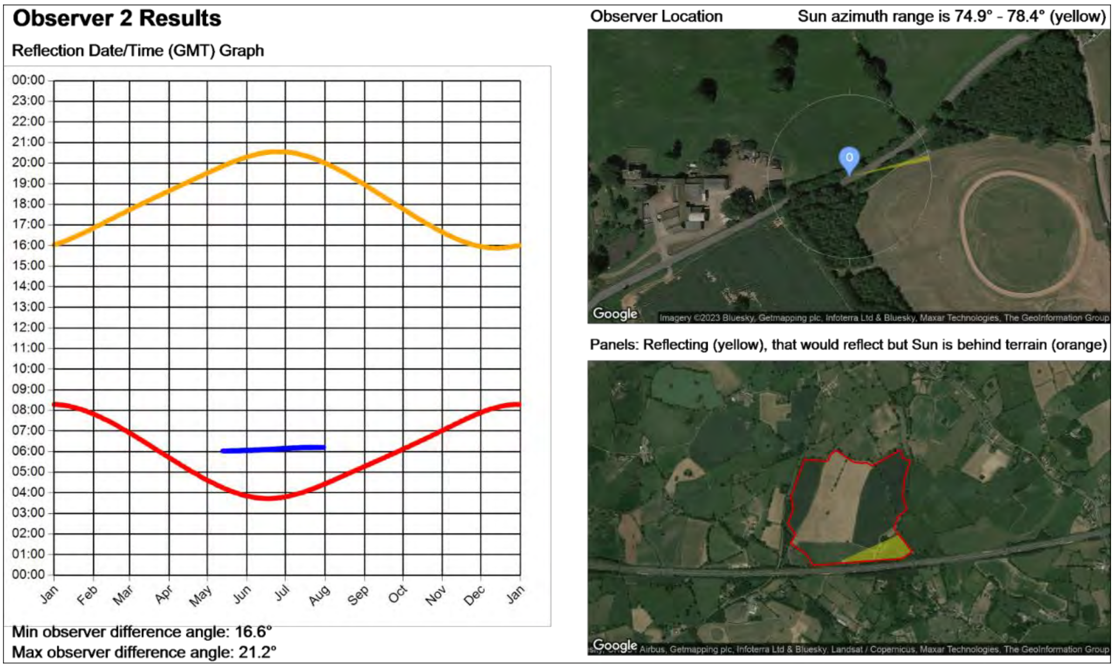
The reflection date/time graph – left hand side of the page. The blue line indicates the dates and times at which geometric reflections are possible. This relates to reflections from the yellow areas.

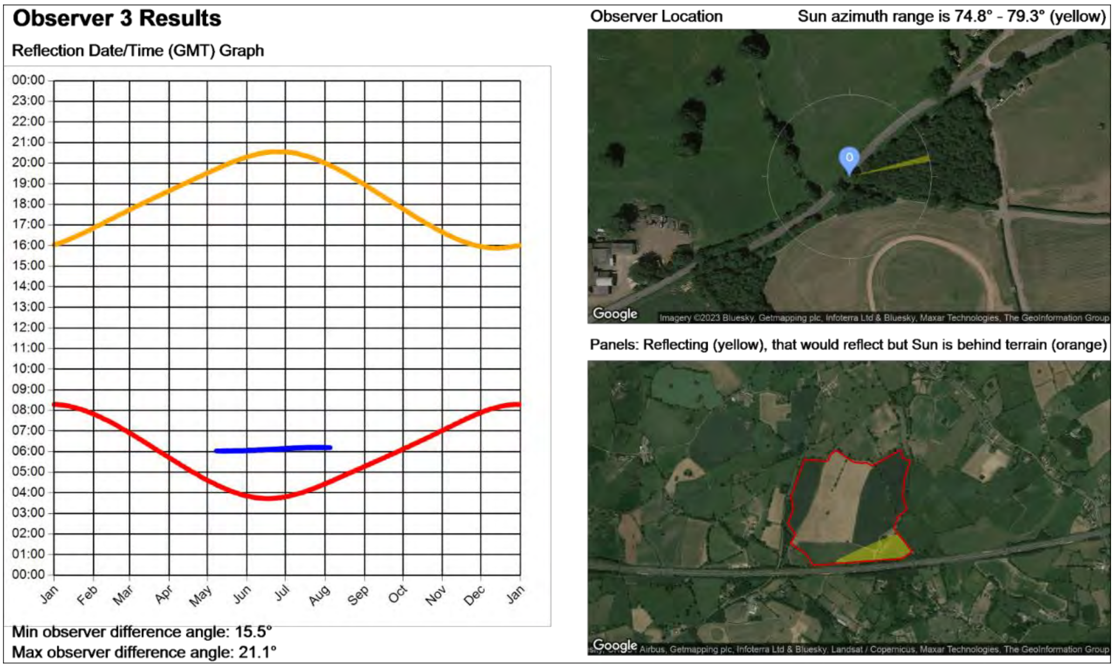
The sunrise and sunset curves throughout the year (red and yellow lines).

Road Receptors

B4102

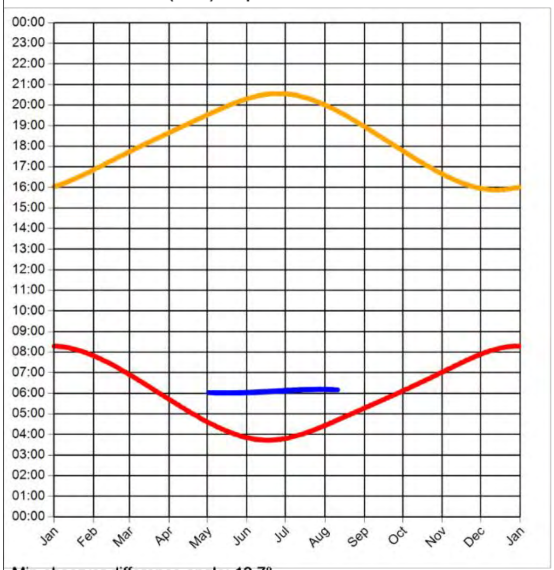



Observer 2 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 16.6°
Max observer difference angle: 21.2°
Observer Location
Sun azimuth range is 74.9° - 78.4° (yellow)
Google
Imagery ©2023 Bluesky, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies, The GeoInformation Group
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Landsat / Copernicus, Maxar Technologies, The GeoInformation Group


Observer 3 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 15.5°
Max observer difference angle: 21.1°
Observer Location
Sun azimuth range is 74.8° - 79.3° (yellow)
Google
Imagery ©2023 Bluesky, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies, The GeoInformation Group
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Landsat / Copernicus, Maxar Technologies, The GeoInformation Group

Observer 4 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 13.7°
Max observer difference angle: 20.7°

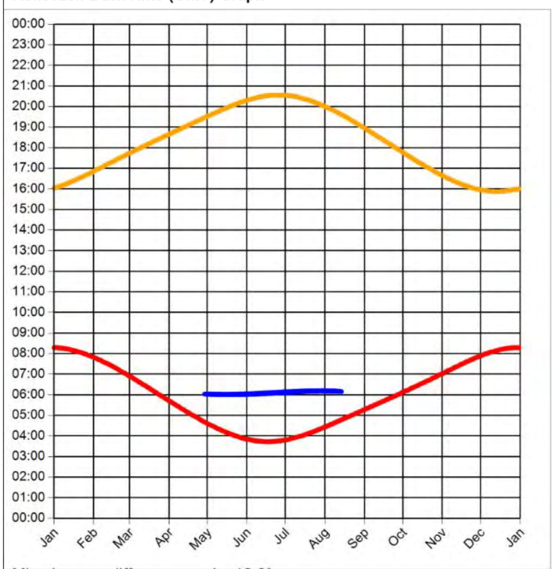
Observer Location

Sun azimuth range is 74.6° - 80.2° (yellow)

Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

Observer 5 Results

Reflection Date/Time (GMT) Graph

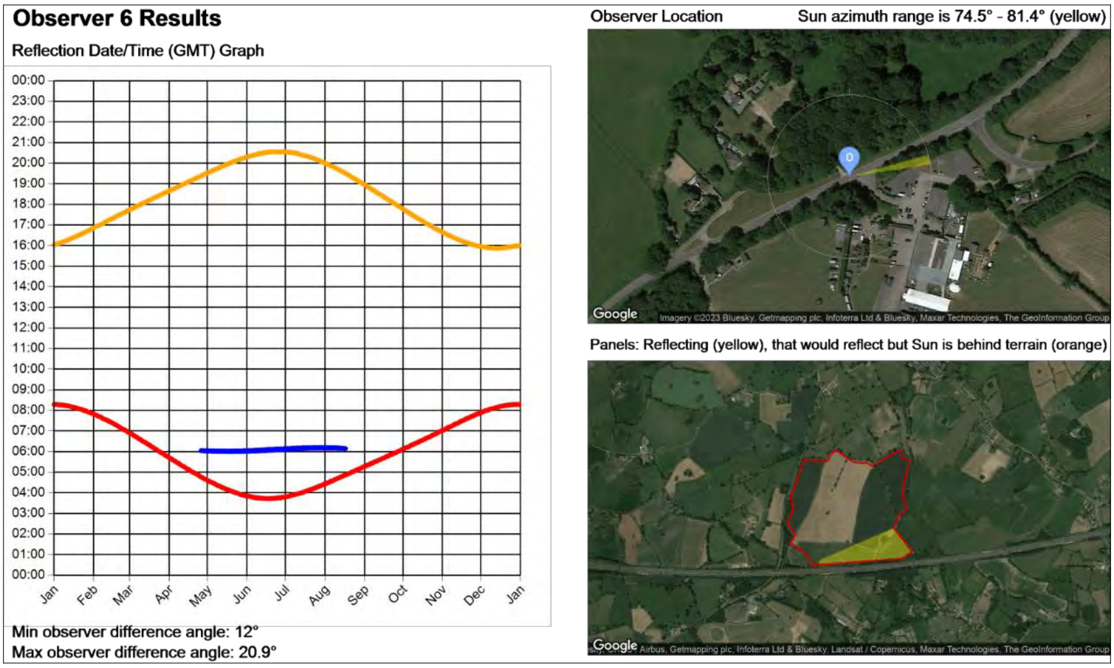


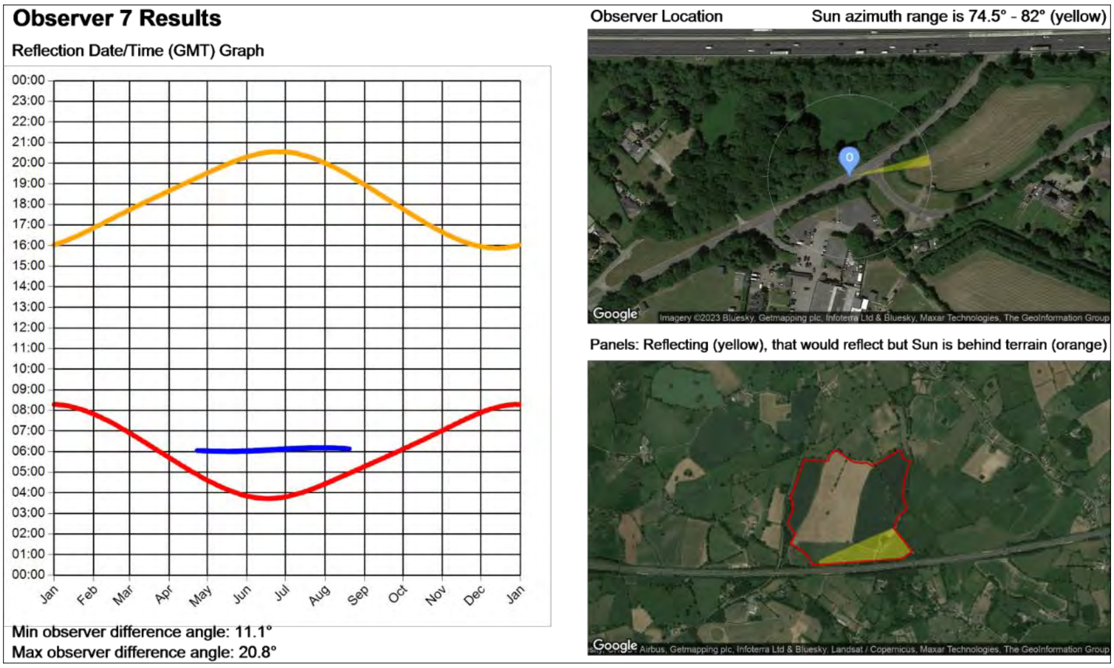
Min observer difference angle: 12.8°
Max observer difference angle: 20.7°

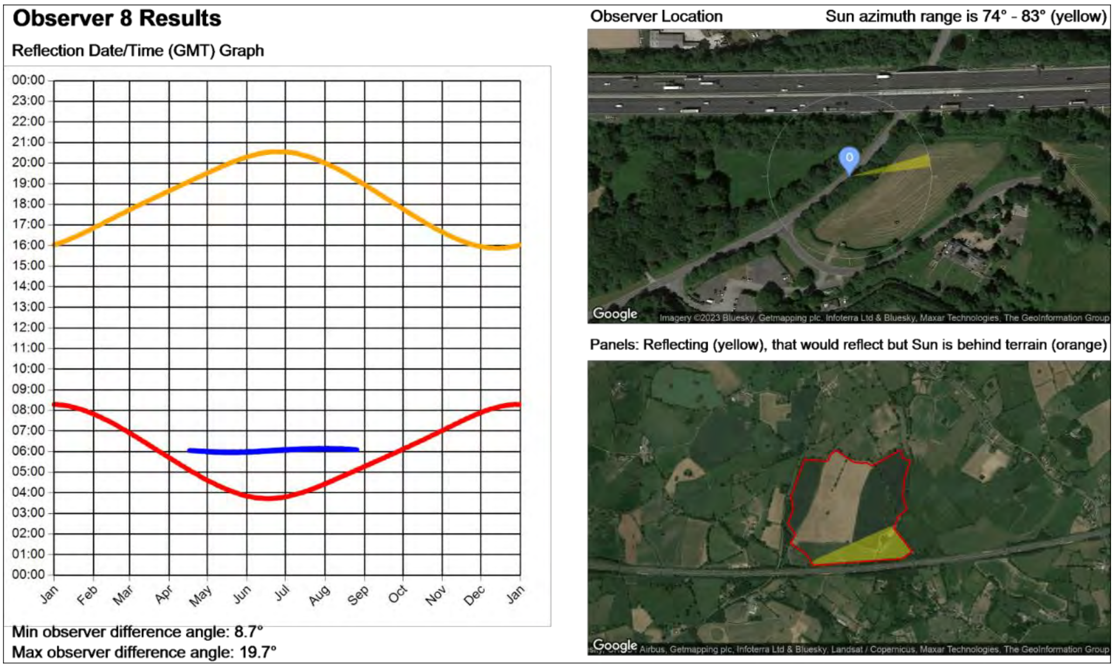
Observer Location

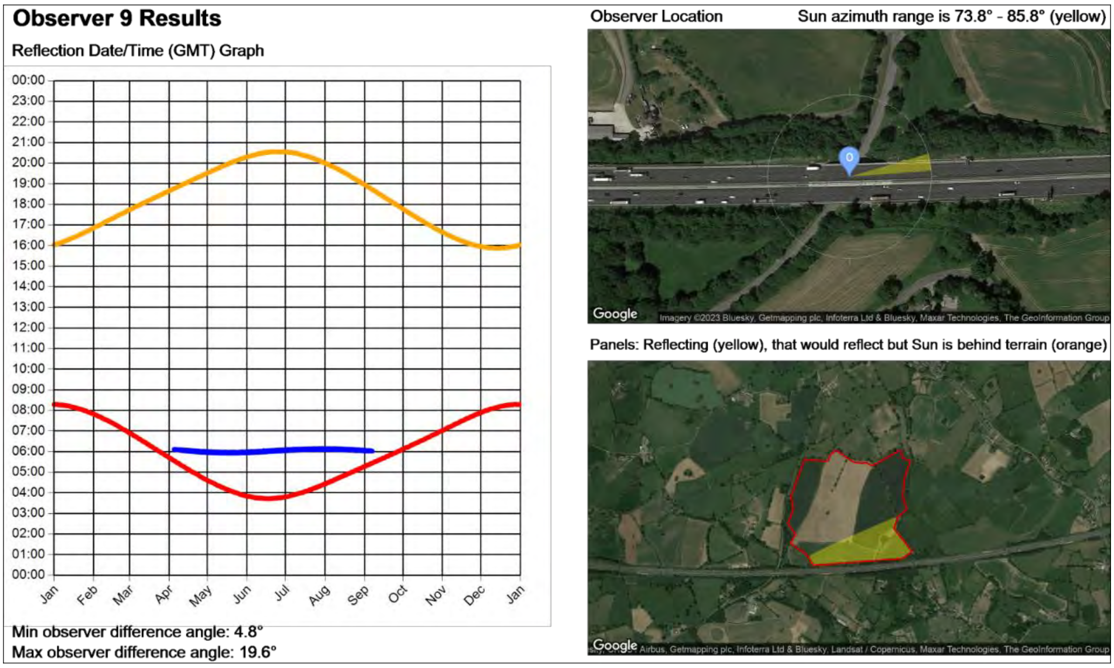
Sun azimuth range is 74.6° - 80.8° (yellow)

Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 6 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 12°
Max observer difference angle: 20.9°
Observer Location
Sun azimuth range is 74.5° - 81.4° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

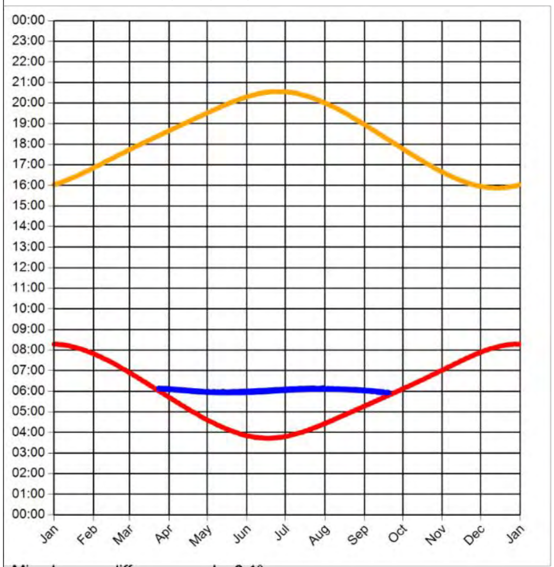

Observer 7 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 11.1°
Max observer difference angle: 20.8°
Observer Location
Sun azimuth range is 74.5° - 82° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 8 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 8.7°
Max observer difference angle: 19.7°
Observer Location
Sun azimuth range is 74° - 83° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 9 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 4.8°
Max observer difference angle: 19.6°
Observer Location
Sun azimuth range is 73.8° - 85.8° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

Observer 10 Results

Reflection Date/Time (GMT) Graph



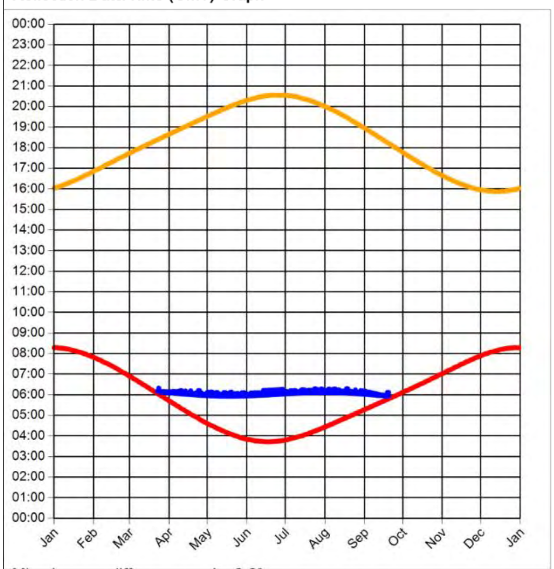
Min observer difference angle: 0.1°
Max observer difference angle: 19.9°

Observer Location — Sun azimuth range is 73.7° - 88.6° (yellow)

Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

Observer 11 Results

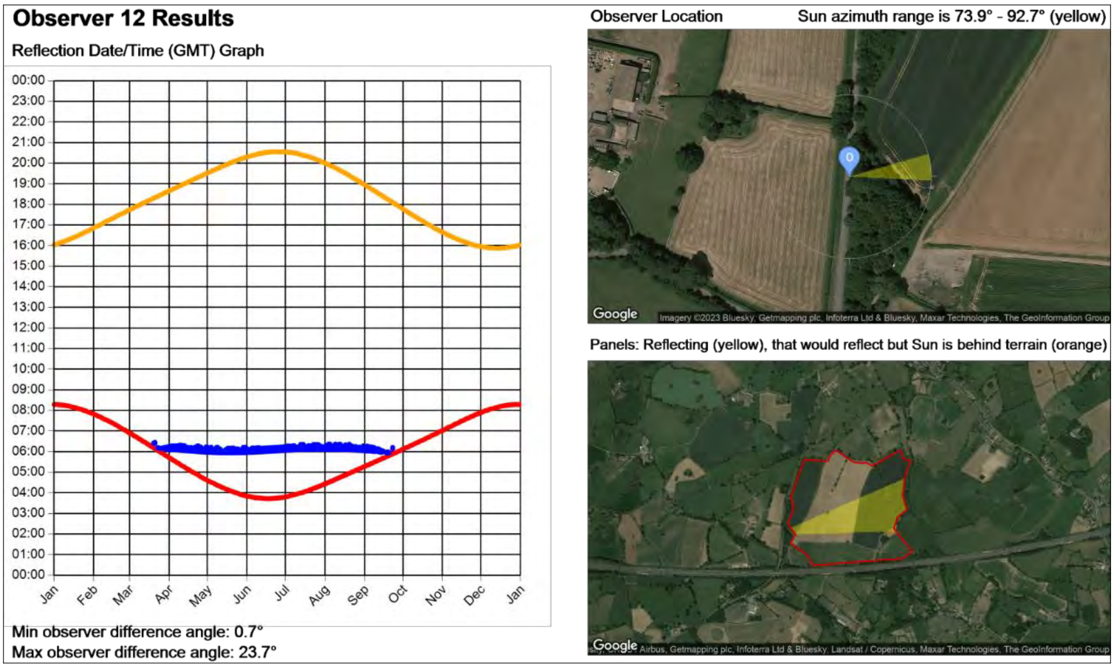
Reflection Date/Time (GMT) Graph

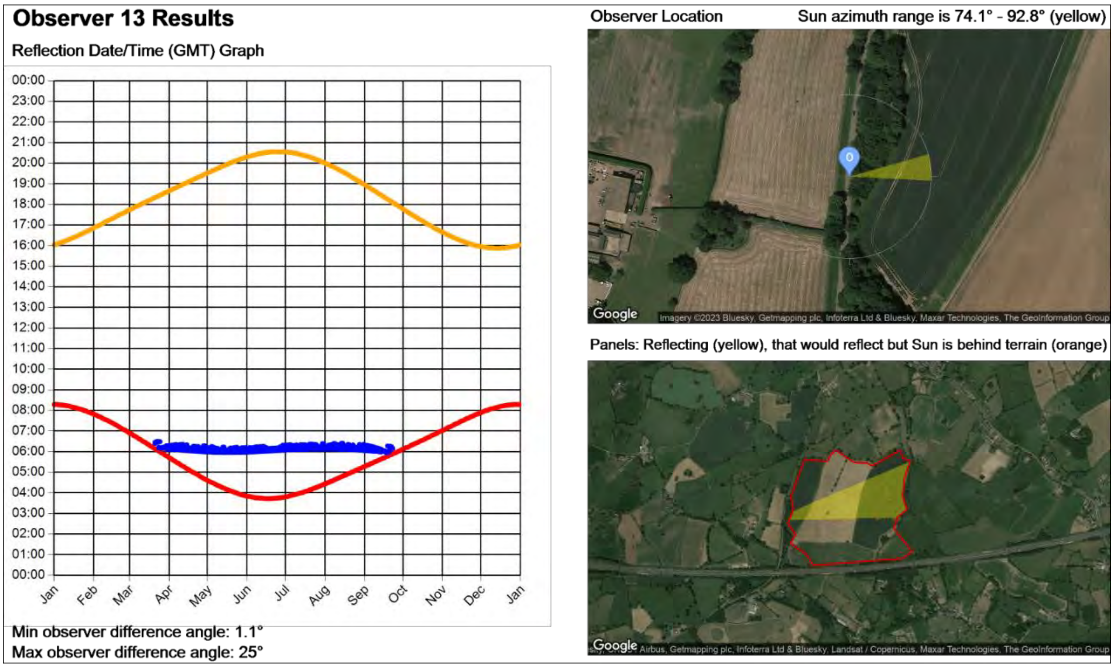


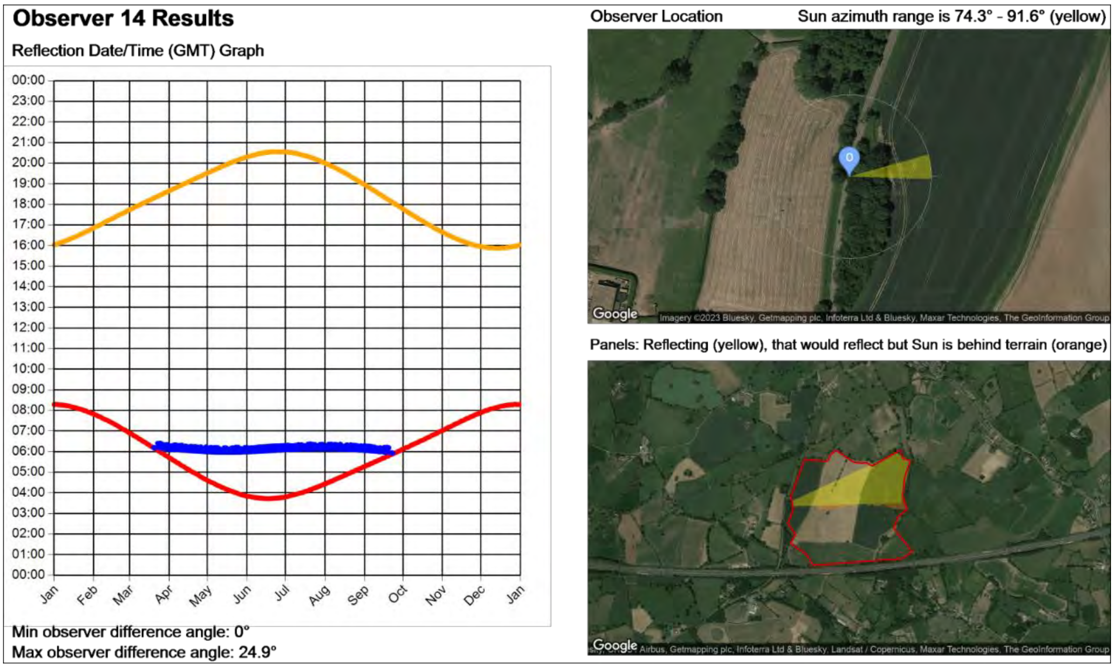
Min observer difference angle: 0.6°
Max observer difference angle: 24°

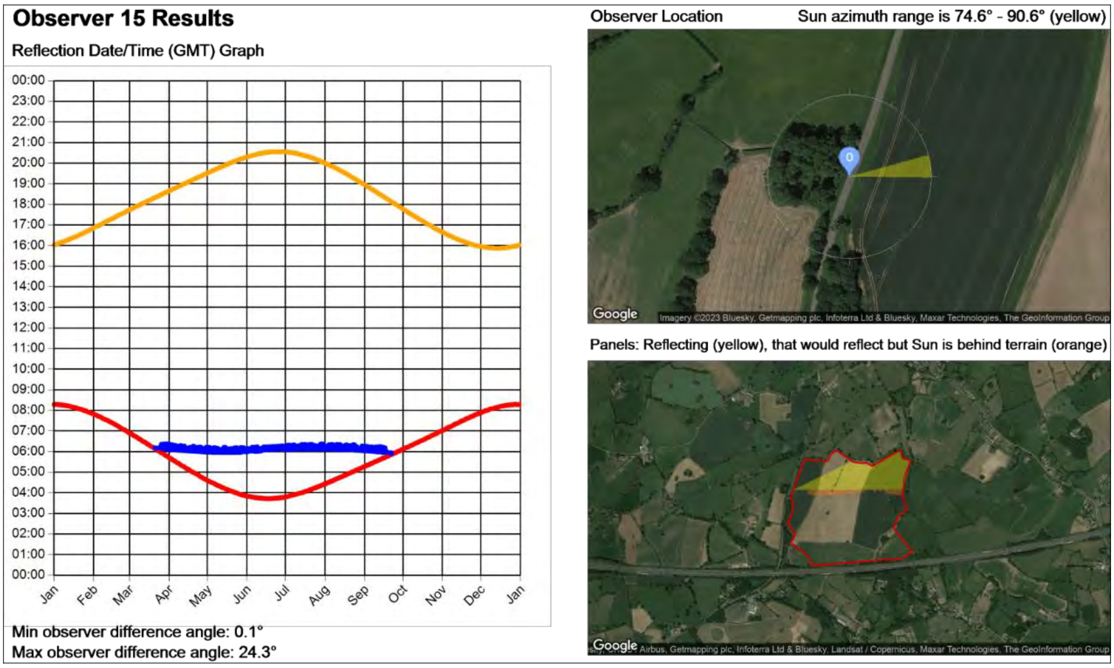
Observer Location — Sun azimuth range is 73.7° - 90.7° (yellow)

Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 12 Results
Reflection Date/Time (GMT) Graph
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.7°
Max observer difference angle: 23.7°
Observer Location
Sun azimuth range is 73.9° - 92.7° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

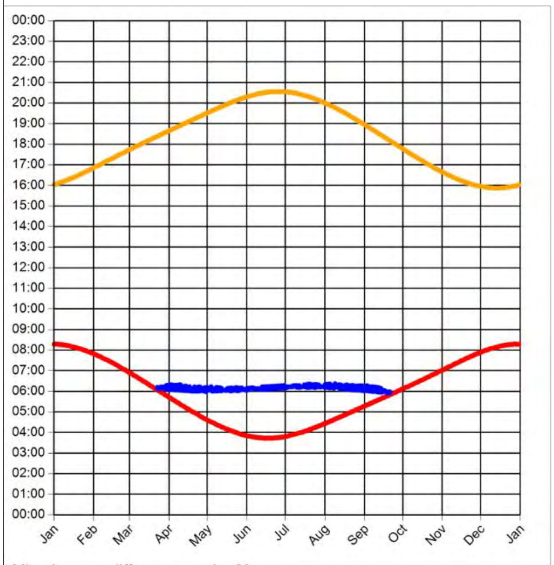

Observer 13 Results
Reflection Date/Time (GMT) Graph
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 1.1°
Max observer difference angle: 25°
Observer Location
Sun azimuth range is 74.1° - 92.8° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 14 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0°
Max observer difference angle: 24.9°
Observer Location
Sun azimuth range is 74.3° - 91.6° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 15 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.1°
Max observer difference angle: 24.3°
Observer Location
Sun azimuth range is 74.6° - 90.6° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

Observer 16 Results

Reflection Date/Time (GMT) Graph



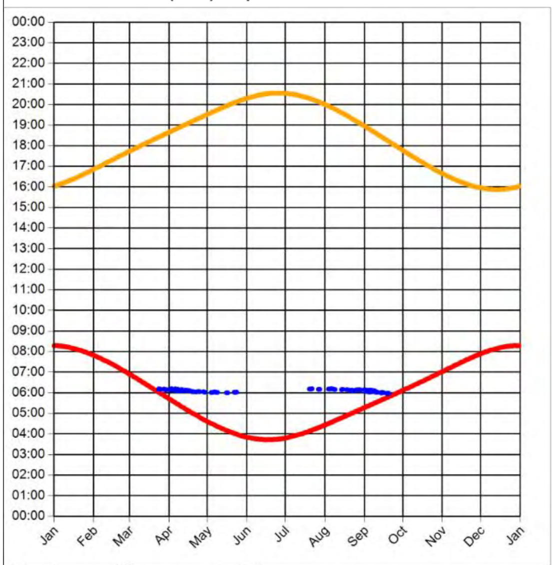
Min observer difference angle: 0°
Max observer difference angle: 24.1°

Observer Location — Sun azimuth range is 75.2° - 89.3° (yellow)

Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

Observer 17 Results

Reflection Date/Time (GMT) Graph

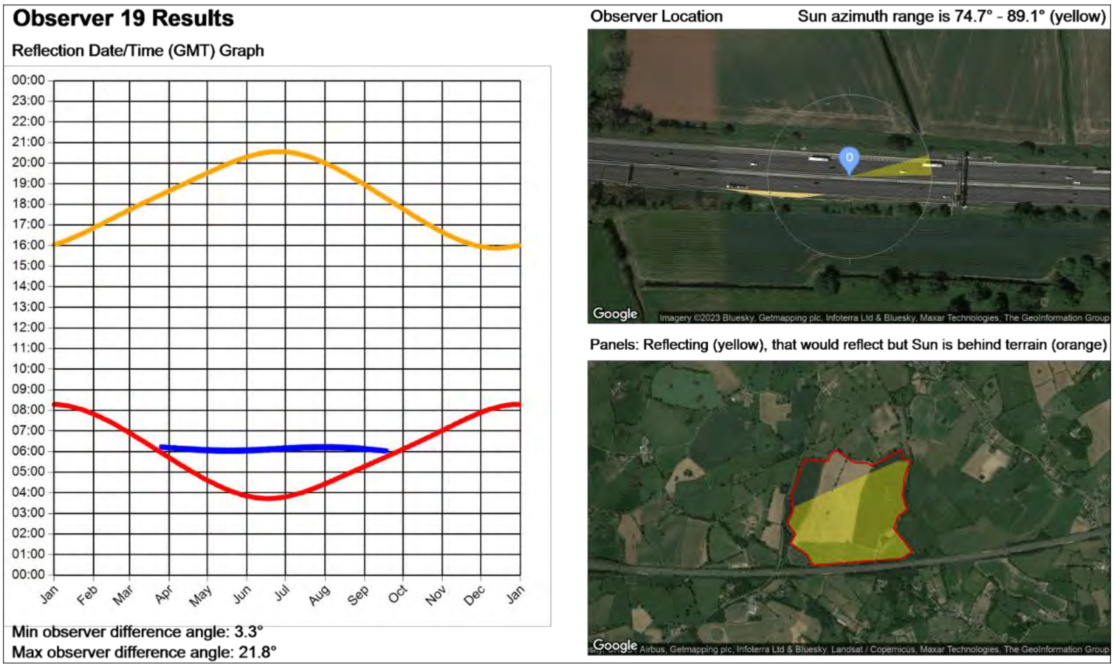


Min observer difference angle: 1.1°
Max observer difference angle: 18.4°

Observer Location — Sun azimuth range is 76.7° - 89° (yellow)

Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

M6


Observer 19 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
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03:00
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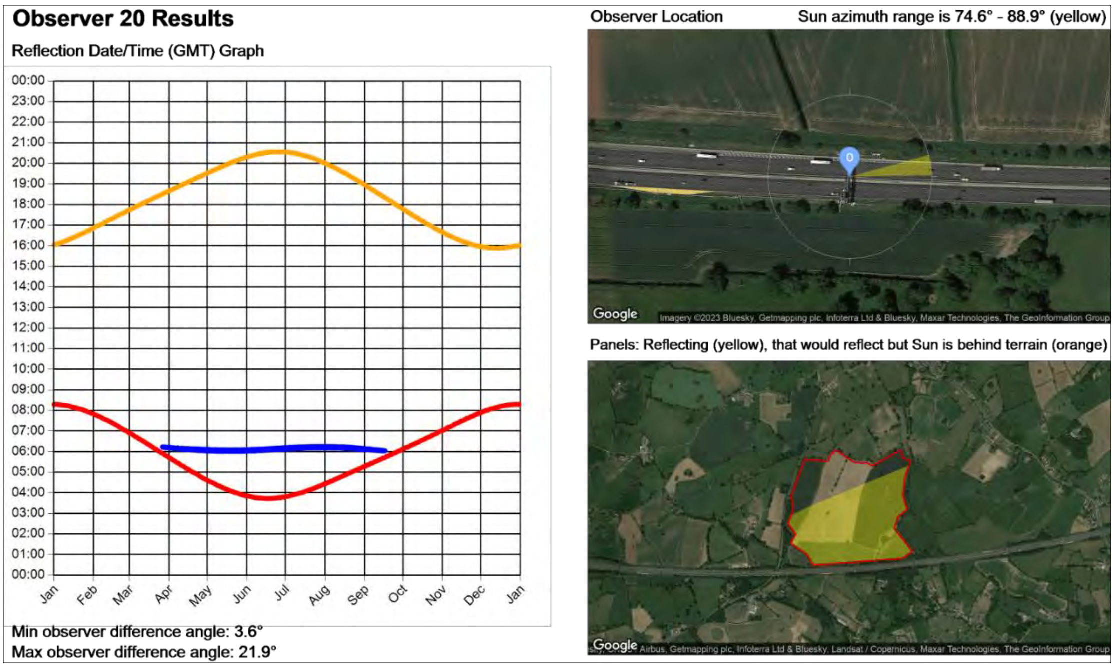
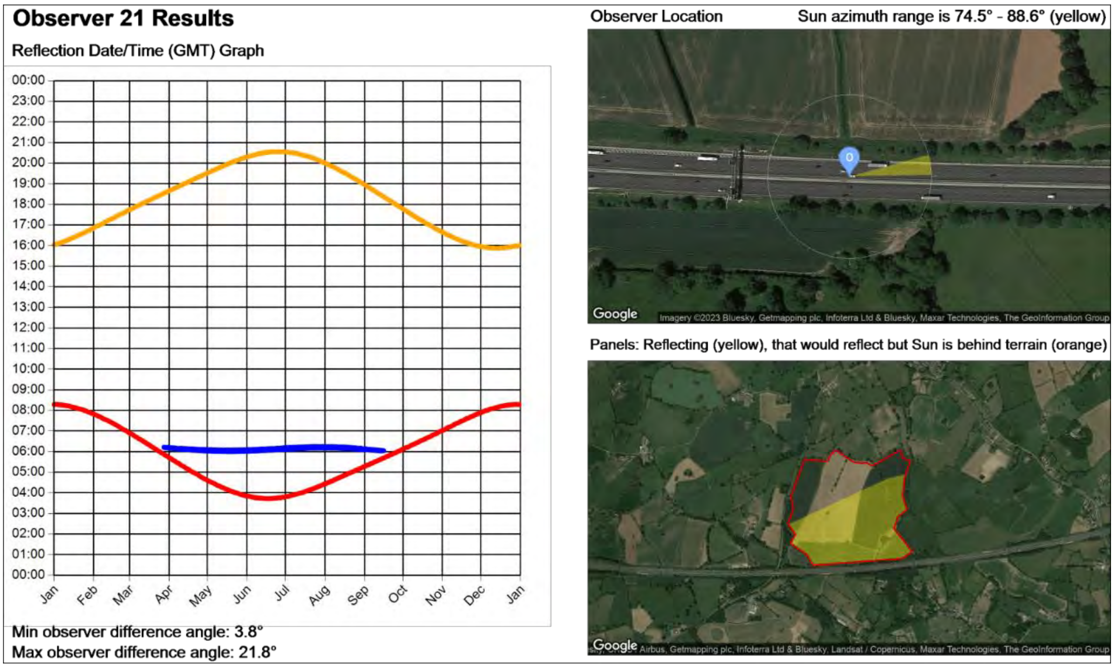
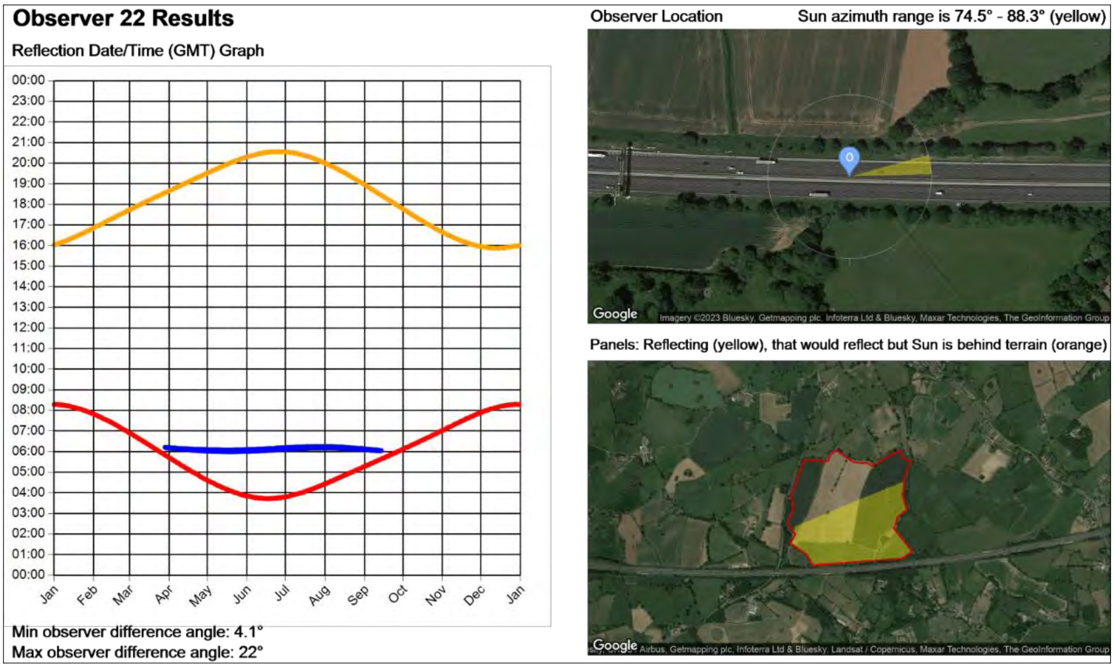
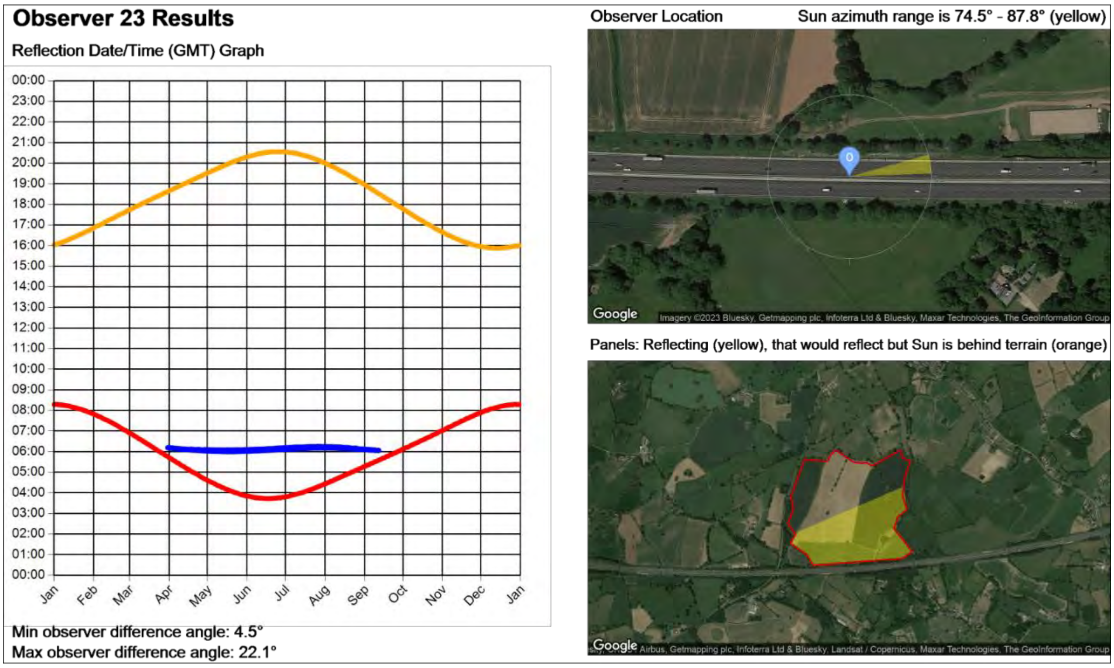
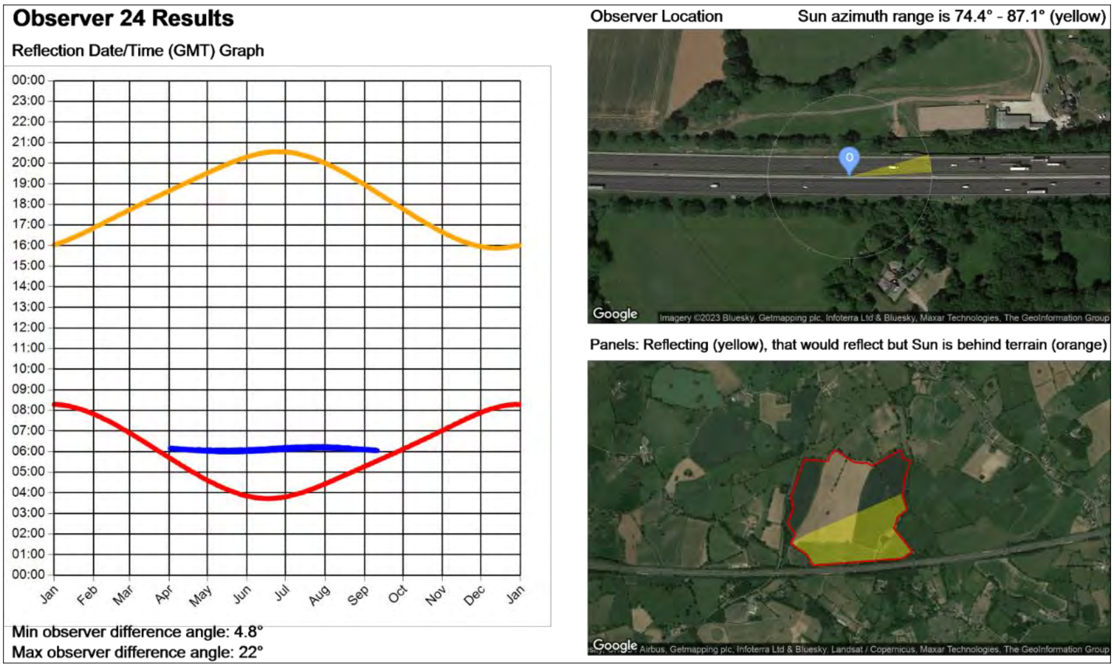
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 3.3°
Max observer difference angle: 21.8°
Observer Location
Sun azimuth range is 74.7° - 89.1° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 20 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 3.6°
Max observer difference angle: 21.9°
Observer Location
Sun azimuth range is 74.6° - 88.9° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 21 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 74.5° - 88.6° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 3.8°
Max observer difference angle: 21.8°

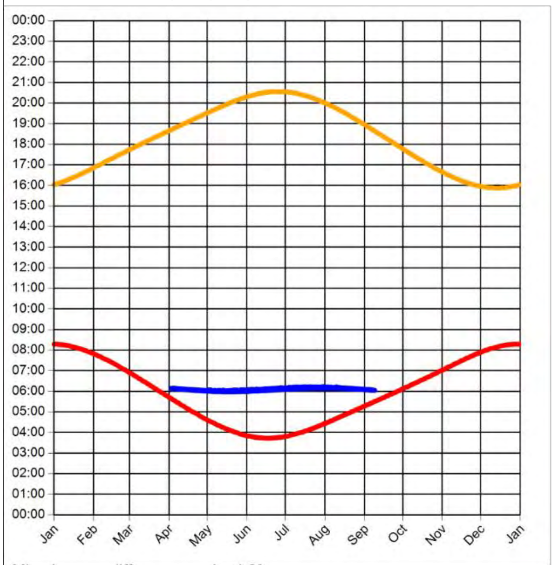

Observer 22 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 74.5° - 88.3° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 4.1°
Max observer difference angle: 22°


Observer 23 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 74.5° - 87.8° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Min observer difference angle: 4.5°
Max observer difference angle: 22.1°


Observer 24 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 74.4° - 87.1° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Min observer difference angle: 4.8°
Max observer difference angle: 22°

Observer 25 Results

Reflection Date/Time (GMT) Graph



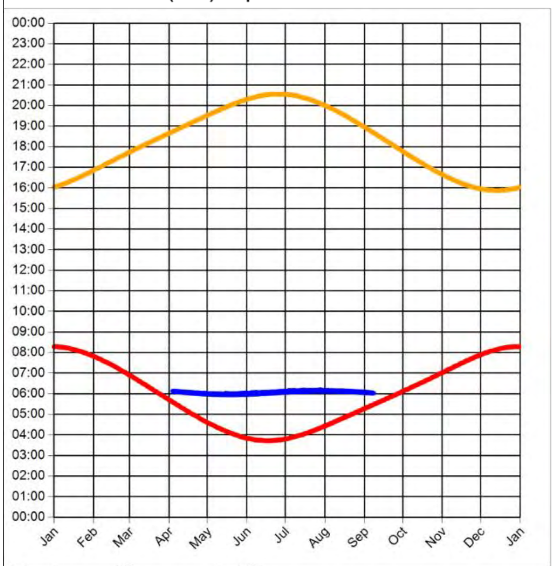
Min observer difference angle: 4.9°
Max observer difference angle: 21.8°

Observer Location — Sun azimuth range is 74.3° - 86.7° (yellow)

Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

Observer 26 Results

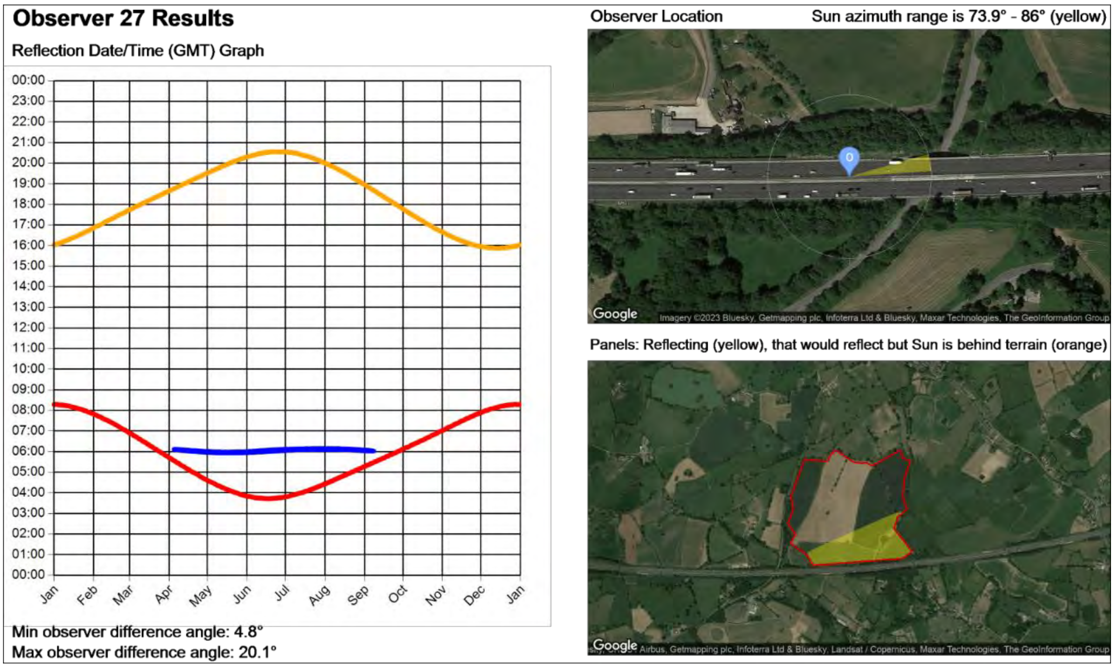
Reflection Date/Time (GMT) Graph

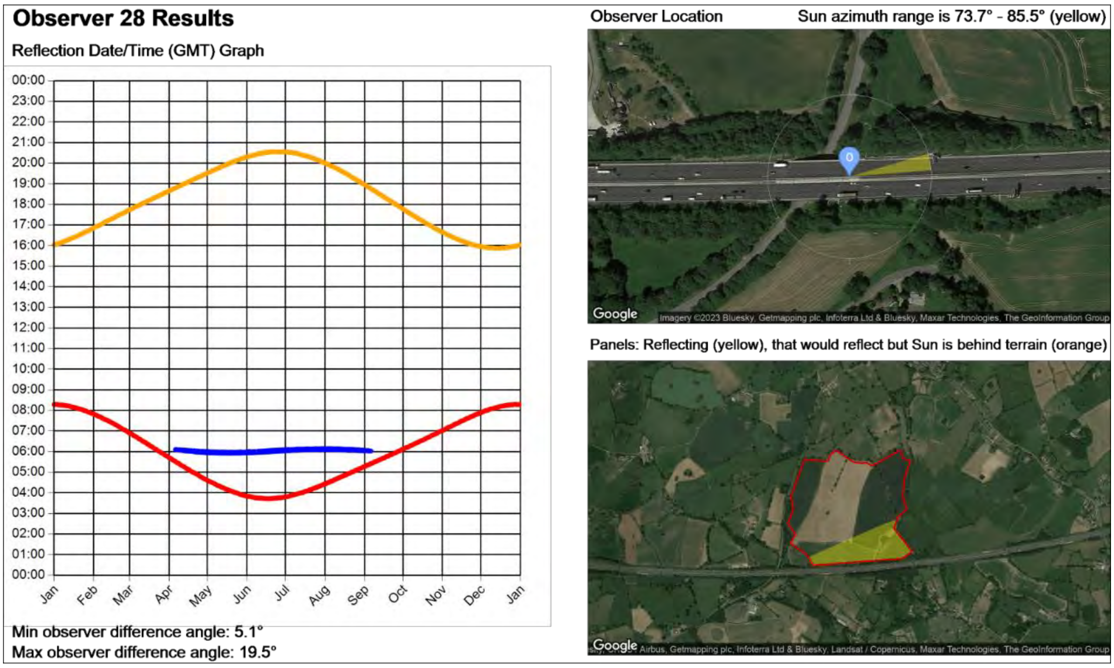


Min observer difference angle: 4.9°
Max observer difference angle: 20.4°

Observer Location — Sun azimuth range is 74.1° - 86.2° (yellow)

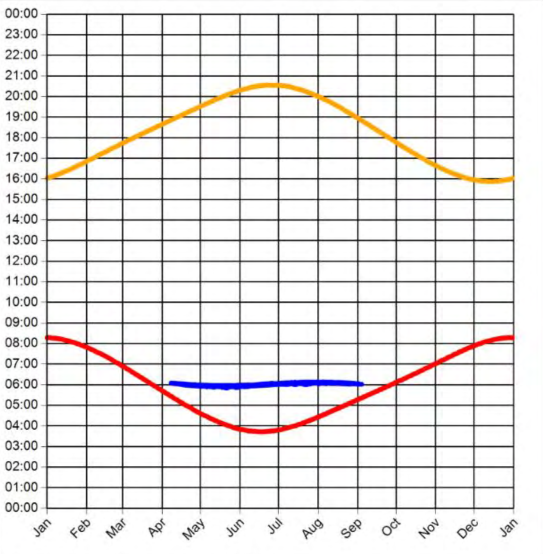
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 27 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 4.8°
Max observer difference angle: 20.1°
Observer Location
Sun azimuth range is 73.9° - 86° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 28 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 5.1°
Max observer difference angle: 19.5°
Observer Location
Sun azimuth range is 73.7° - 85.5° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

Observer 29 Results

Reflection Date/Time (GMT) Graph



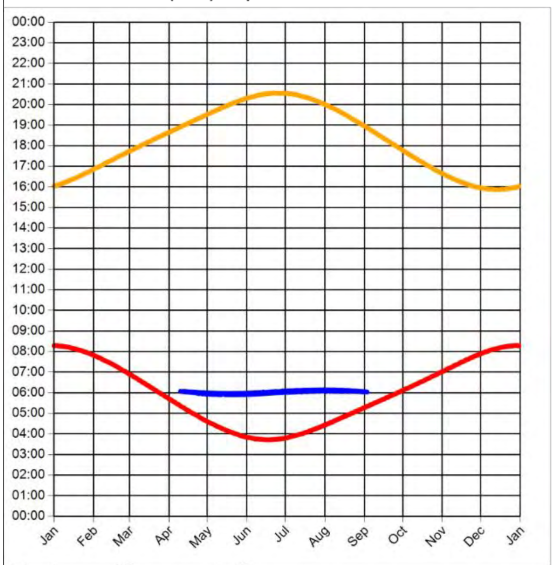
Min observer difference angle: 5.4°
Max observer difference angle: 19.3°

Observer Location | Sun azimuth range is 73.5° - 84.9° (yellow)

Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

Observer 30 Results

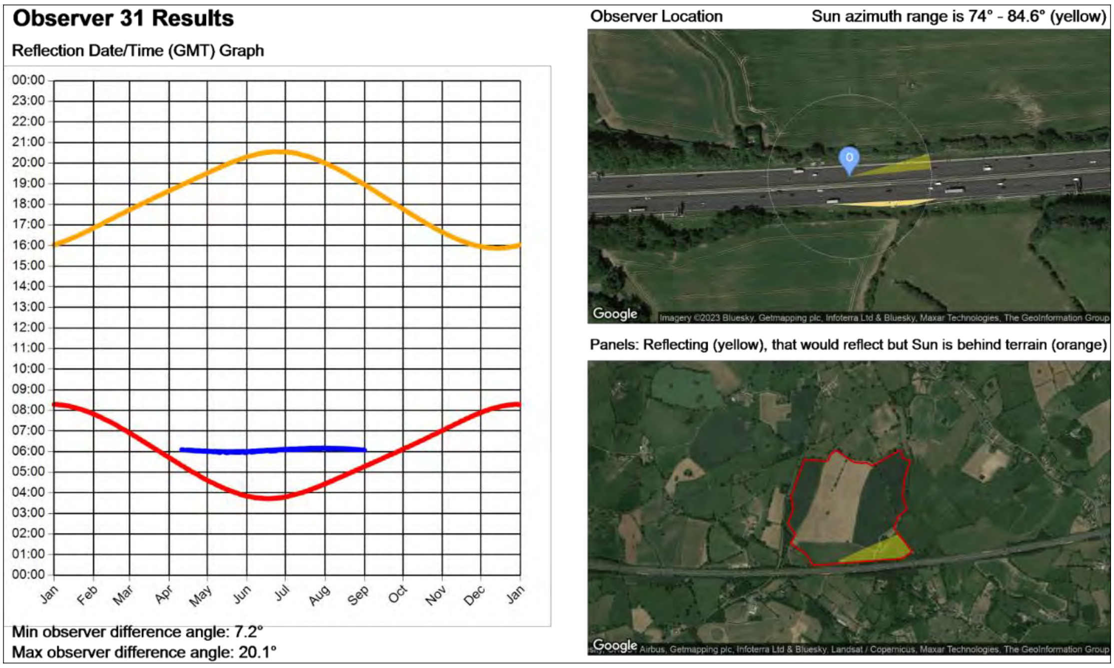
Reflection Date/Time (GMT) Graph

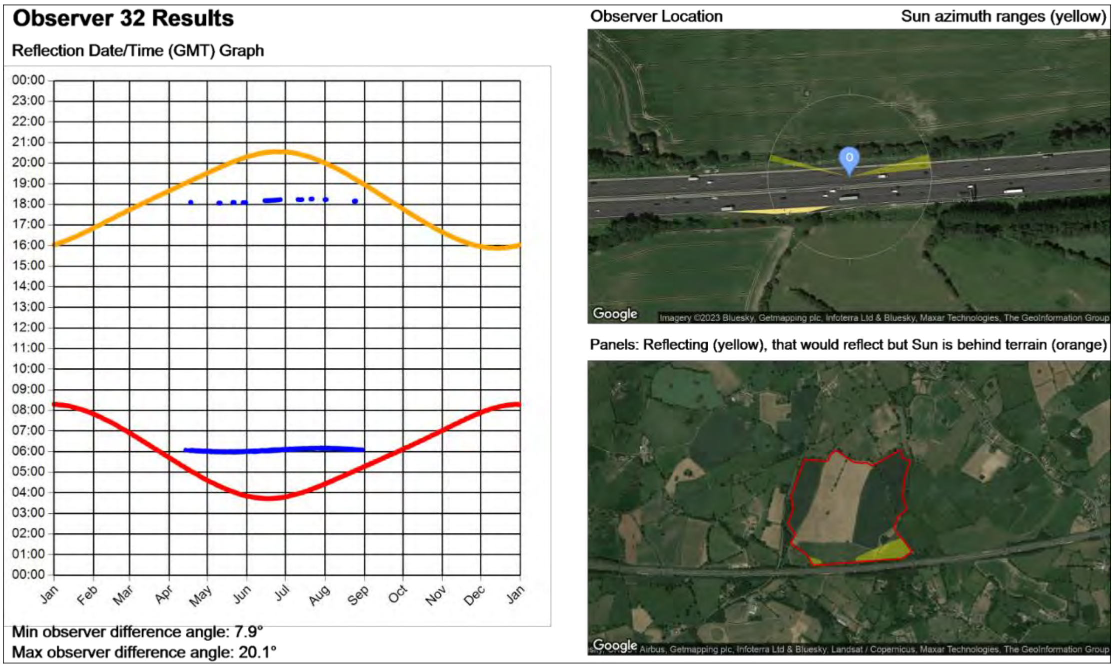


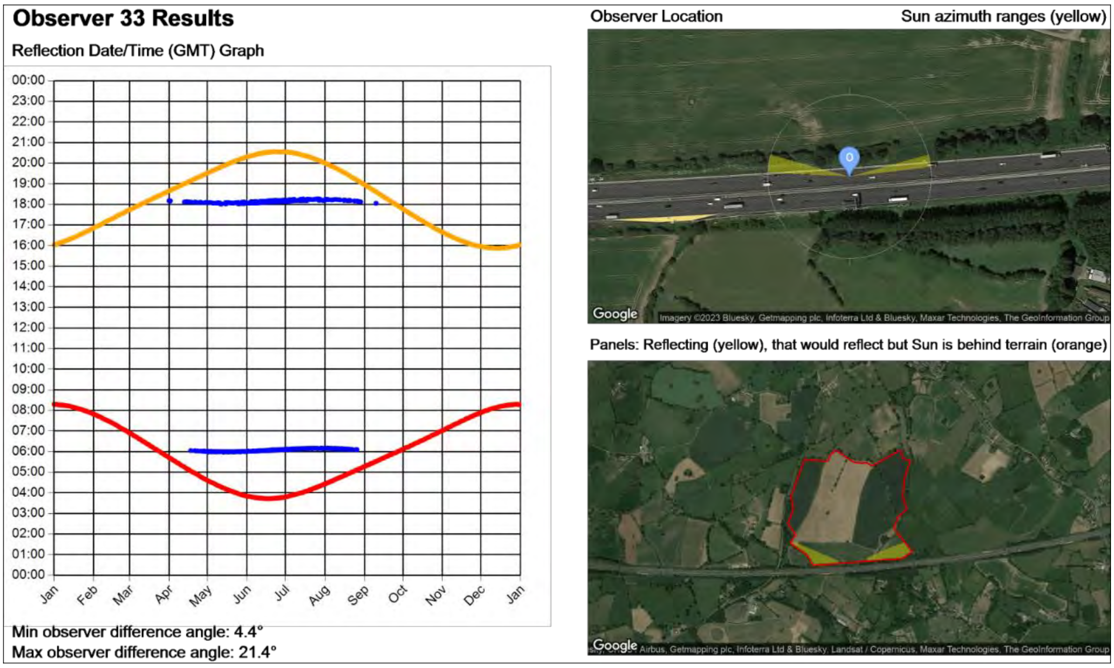
Min observer difference angle: 6°
Max observer difference angle: 19.4°

Observer Location | Sun azimuth range is 73.6° - 84.6° (yellow)

Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 31 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 7.2°
Max observer difference angle: 20.1°
Observer Location
Sun azimuth range is 74° - 84.6° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 32 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 7.9°
Max observer difference angle: 20.1°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 33 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
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01:00
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Jan
Feb
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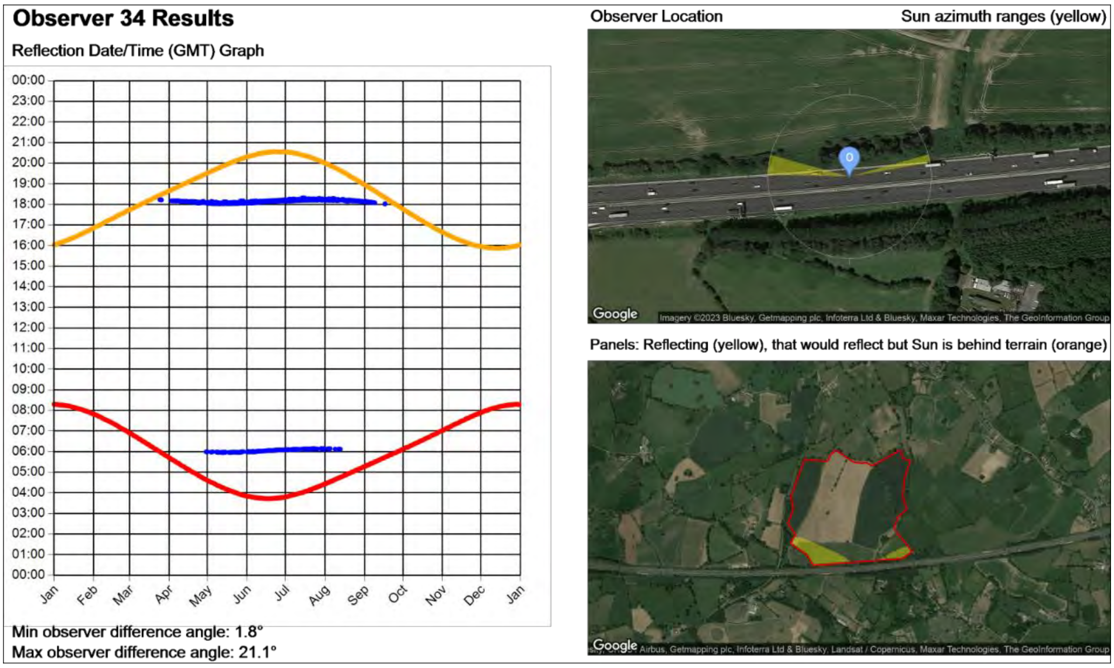
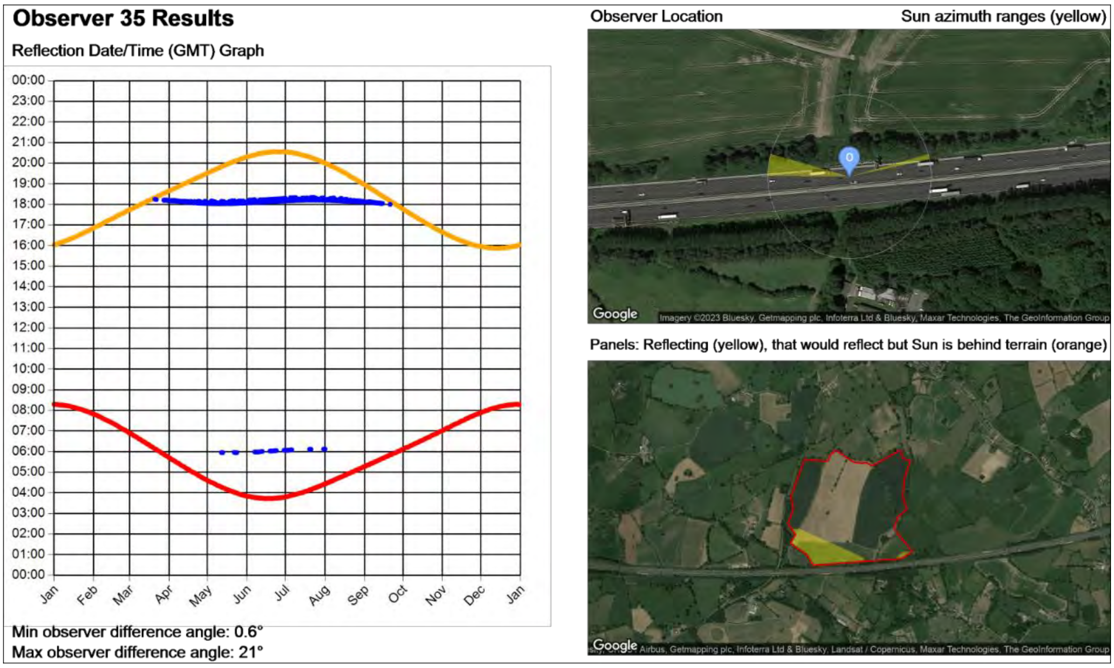
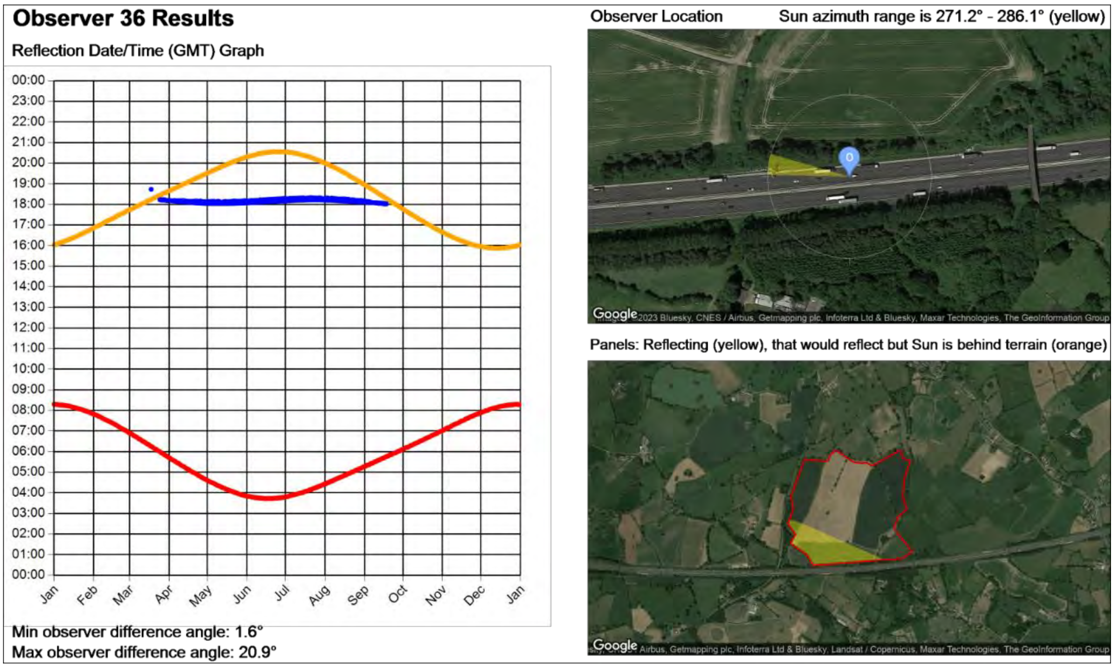
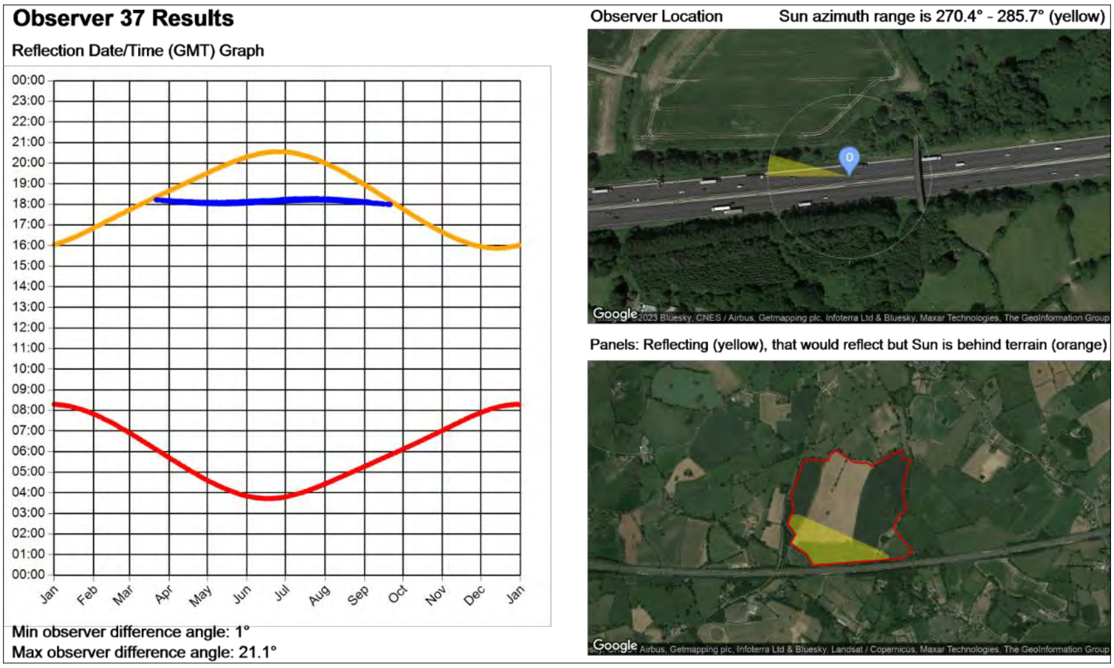
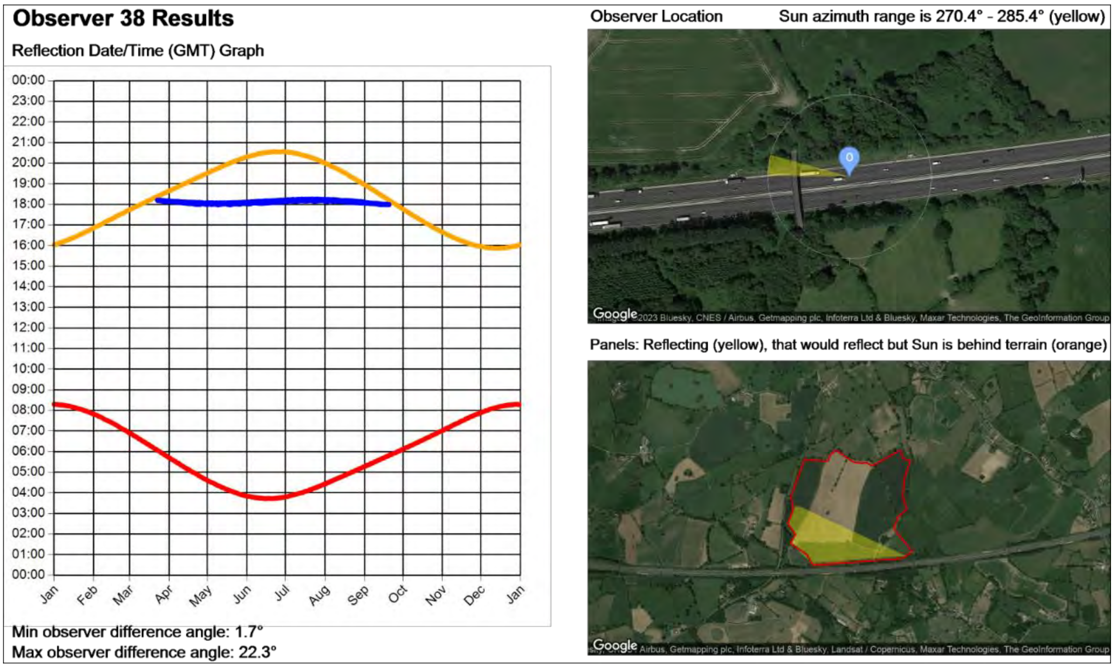
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 4.4°
Max observer difference angle: 21.4°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 34 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 1.8°
Max observer difference angle: 21.1°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 35 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.6°
Max observer difference angle: 21°
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

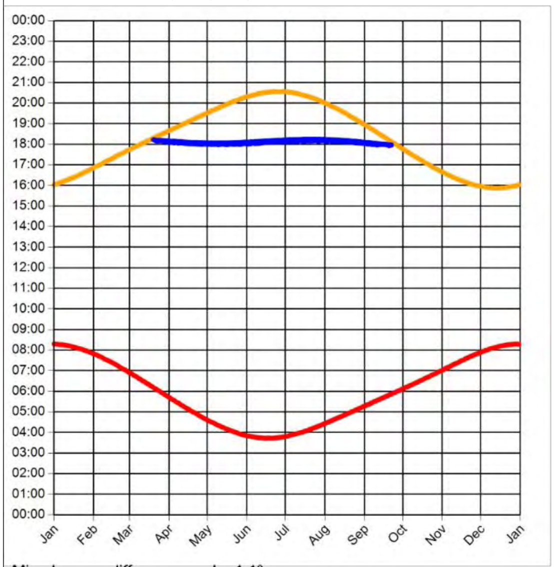

Observer 36 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 1.6°
Max observer difference angle: 20.9°
Observer Location
Sun azimuth range is 271.2° - 286.1° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 37 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 270.4° - 285.7° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 1°
Max observer difference angle: 21.1°


Observer 38 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 270.4° - 285.4° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 1.7°
Max observer difference angle: 22.3°

Observer 39 Results

Reflection Date/Time (GMT) Graph



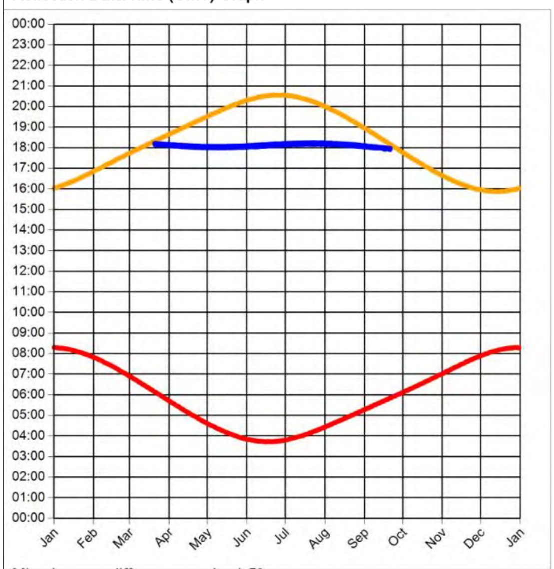
Min observer difference angle: 1.1°
Max observer difference angle: 22°

Observer Location Sun azimuth range is 269.8° - 285.3° (yellow)

Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

Observer 40 Results

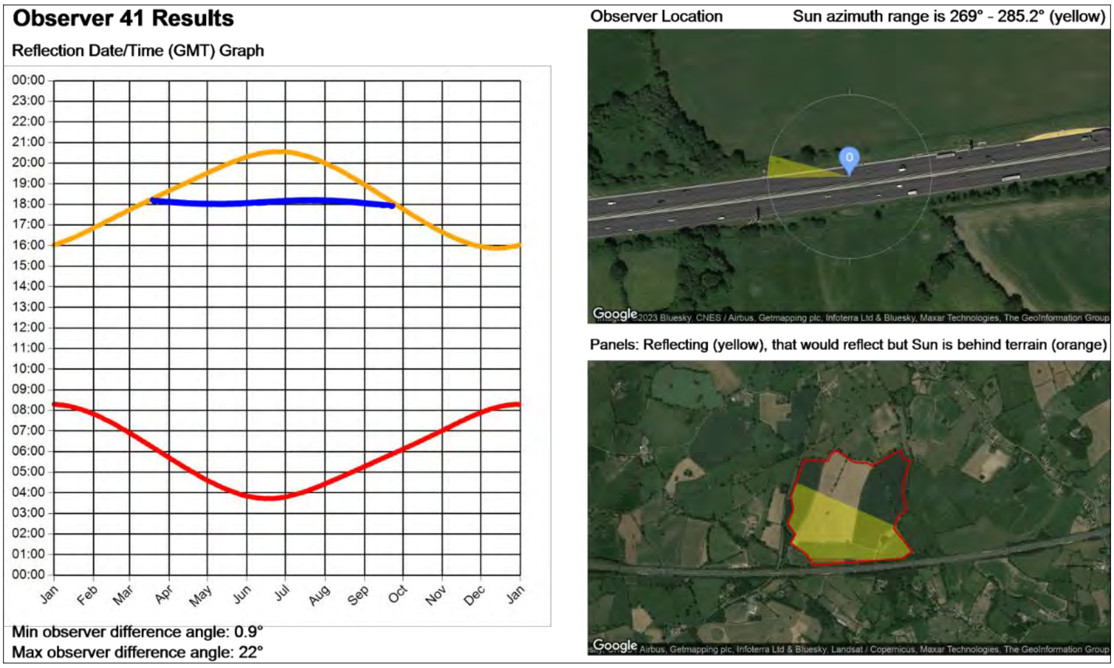
Reflection Date/Time (GMT) Graph

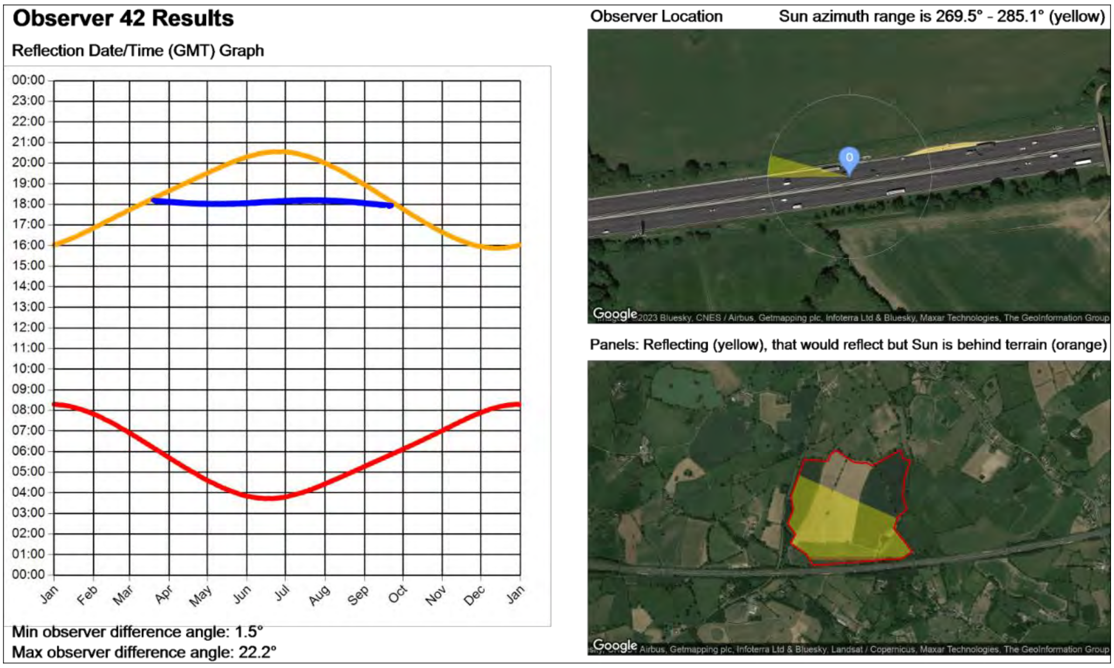


Min observer difference angle: 1.5°
Max observer difference angle: 22°

Observer Location Sun azimuth range is 269.4° - 285.3° (yellow)

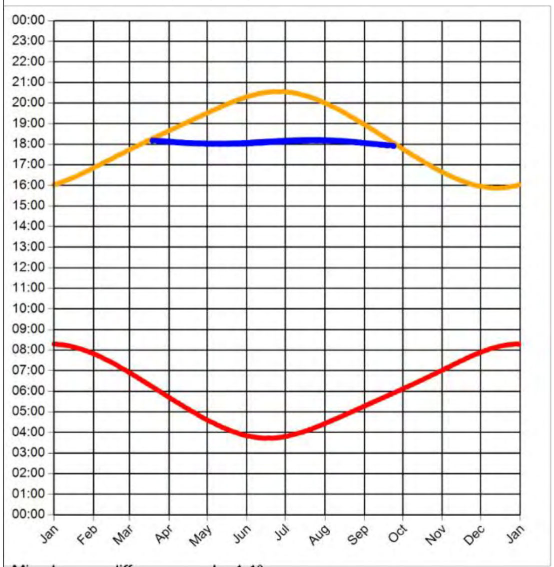
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 41 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.9°
Max observer difference angle: 22°
Observer Location
Sun azimuth range is 269° - 285.2° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 42 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 1.5°
Max observer difference angle: 22.2°
Observer Location
Sun azimuth range is 269.5° - 285.1° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

Observer 43 Results

Reflection Date/Time (GMT) Graph



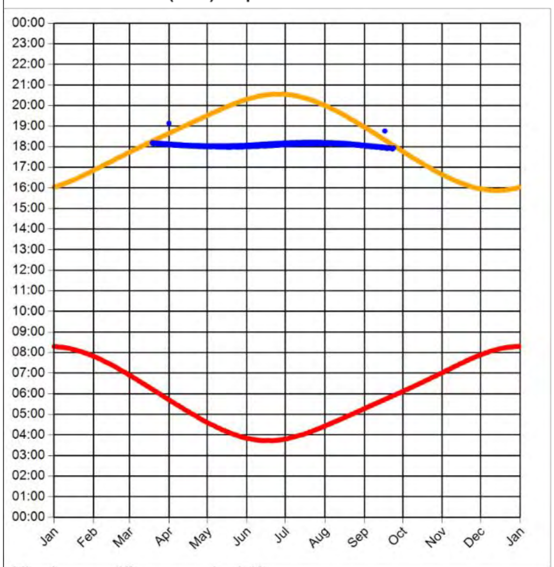
Min observer difference angle: 1.1°
Max observer difference angle: 22.2°

Observer Location — Sun azimuth range is 268.8° - 285.1° (yellow)

Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

Observer 44 Results

Reflection Date/Time (GMT) Graph

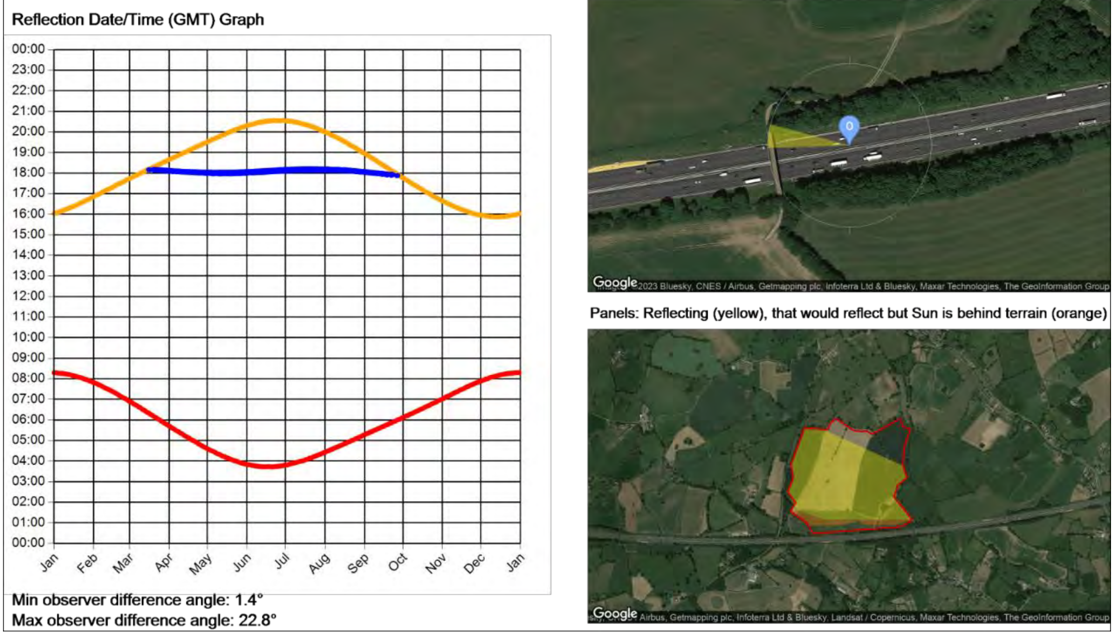


Min observer difference angle: 1.1°
Max observer difference angle: 23.1°

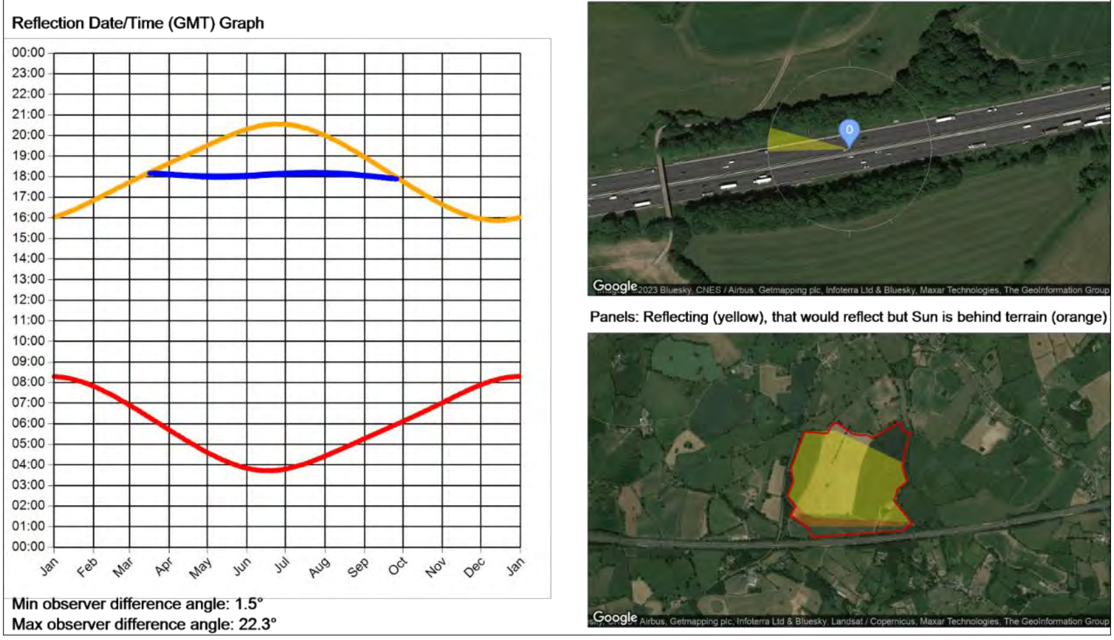
Observer Location — Sun azimuth range is 268.9° - 285° (yellow)

Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

Observer 45 Results



Observer 46 Results



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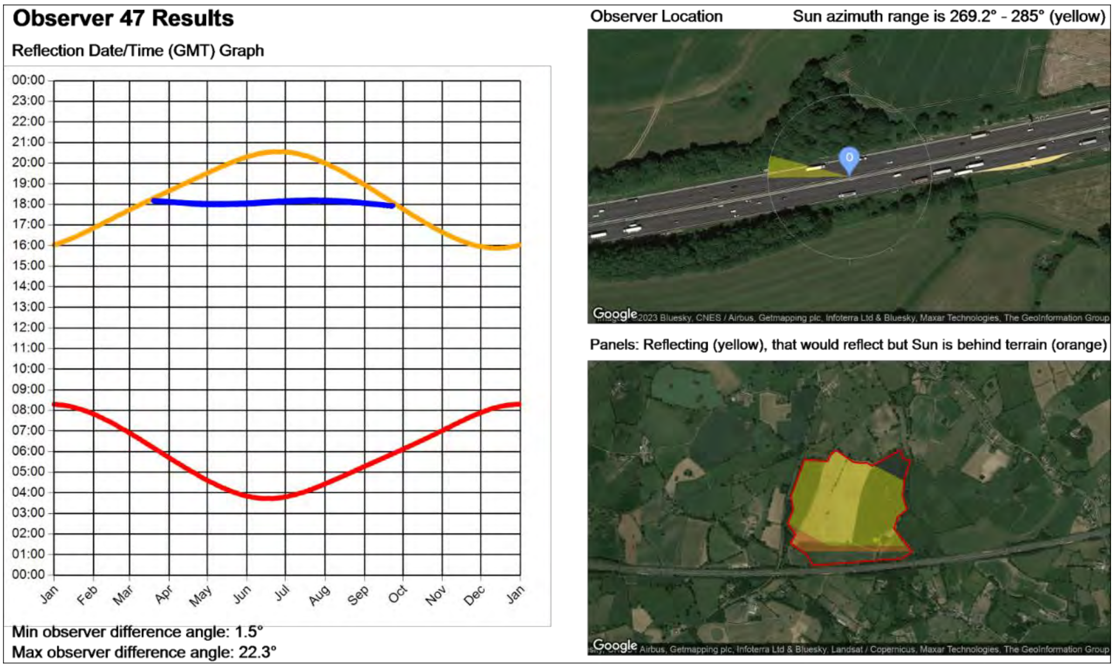

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Urban & Renewables

Pager Power Limited
Stour Valley Business Centre
Sudbury
Suffolk
CO10 7GB

Tel: +44 1787 319001 **Email:** info@pagerpower.com **Web:** www.pagerpower.com