PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

JBM Solar Projects 8 Ltd

Land near Stratton Audley – Padbury Brook

November 2022

ADMINISTRATION PAGE

Job Reference:	11648A
Date:	November 2022
Author:	Abdul Wadud
Telephone:	01787 319001
Email:	abdul@pagerpower.com

Reviewed By:	Andrea Mariano (1st and 2nd Issues); Danny Scrivener (1st Issue)
Email:	andrea@pagerpower.com; danny@pagerpower.com

Issue	Date	Detail of Changes
1	August 2022	Initial issue
2	November 2022	Updated layout and landscape mitigation plan

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 fixed ground-mounted solar photovoltaic development, located at land near to Stratton Audley, Bicester, UK. This assessment pertains to the possible impact upon road safety, residential amenity and aviation activity associated with Bicester Airfield. In addition, Pear Tree Farm and Finmere Airfields are also assessed at a high-level.

Updated Layout

The layout has since been updated with a smaller panel area. The glint and glare modelling of this report is based on a larger panel area and therefore effects are considered conservative. Therefore, with the new layout, the duration of glint and glare is not going to be greater than the one shown in this report. The conclusions of this report have been updated considering the updated layout and the proposed screening.

Overall Conclusions

A low impact is predicted upon aviation activity at Bicester Airfield. Results of the geometric modelling show solar reflections occur outside a pilot's 50-degree field of view.

No impact is predicted upon road users along Main Street and no mitigation is recommended.

No impact is predicted upon residential dwellings and no mitigation is recommended.

Further detailed modelling is not recommended for Pear Tree Farm Airfield and Finmere Airfield. Any solar reflections towards these three aerodromes are predicted to be permissible in accordance with the associated guidance.

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. A specific national guidance policy for determining the impact of glint and glare on road safety and residential amenity has also not been produced to date. Therefore, in the absence of this, Pager Power reviewed more general existing planning guidelines and the available studies (discussed below) in the process of defining its own glint and glare assessment guidance and methodology. This methodology defines the process for determining the impact upon road safety, residential amenity, and aviation activity. Pager Power has reviewed existing guidelines and the available studies to define its own glint and glare assessment guidance document and methodology[1]. This

[1] Pager Power Glint and Glare Guidance, Third Edition (3.1), April 2021.

methodology defines a comprehensive process for determining the impact upon road safety, residential amenity, and aviation activity.

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 in line with the Sandia National Laboratories' FAA methodology[2]. 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[3].

Conclusions – Bicester Airfield

Runway 06/24

Solar reflections are not geometrically possible along the approach path for runway 06. The modelling results has shown solar reflections are possible at 2 miles from the runway threshold along the approach path for runway 24. However, they are predicted to occur outside a pilot's 50-degree field-of-view. A low impact is predicted and therefore no mitigation is required.

The smaller panel area removes the reflecting panel area for runway 24. No impact is predicted, and no mitigation is required.

Runway 16/34

Solar reflections are not geometrically possible along the approach path for runway 34. The modelling has shown solar reflections are possible from 0.1 miles to 2 miles from the runway threshold along the approach path for runway 16. However, they are predicted to occur outside a pilot's 50-degree field- of-view. A low impact is predicted and therefore no mitigation is required.

Conclusions – Roads

Solar reflections are geometrically possible along the assessed 3.1km section of Main Street. Screening in the form of existing vegetation and proposed screening as per the landscape mitigation plan is predicted to significantly obstruct views of reflecting panels. No impacts are predicted upon road safety, and no mitigation requirement has been identified.

---

[2] Formerly mandatory for on-airfield solar developments in the USA under the FAA's interim policy, superseded in 2021 with a policy that effectively requires individual airports to sign off on their on-airfield development as they see fit.

[3] SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy, 2010).

Conclusions – Dwellings

Solar reflections are geometrically possible for all identified dwelling receptors. Screening in the form of existing vegetation and proposed screening as per the landscape mitigation plan is predicted to fully obstruct views of reflecting panels for all identified dwelling receptors, for which no impact is predicted. No mitigation requirement has been identified.

Conclusions – High-Level Aviation

Any solar reflections towards Pear Tree Farm Airfield and Finmere Airfield are predicted to be acceptable in accordance with the associated guidance. Factors determining this are either due to solar reflections occurring outside a pilot's field-of-view (50 degrees either side of the approach bearing) or predicted low glare intensities. Therefore, further detailed modelling of these airfields is not recommended.

PAGERPOWER
Urban & Renewables

LIST OF CONTENTS

PAGERPOWER
Urban & Renewables

LIST OF FIGURES

LIST OF TABLES

PAGERPOWER
Urban & Renewables

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 fixed ground-mounted solar photovoltaic development, located at land near to Stratton Audley, Bicester, UK. This assessment pertains to the possible impact upon road safety, residential amenity and aviation activity associated with Bicester Airfield. In addition, Pear Tree Farm and Finmere Airfields are also assessed at a high-level.

Updated Layout

The layout has since been updated with a smaller panel area. The glint and glare modelling of this report is based on a larger panel area and therefore effects are considered conservative. Therefore, with the new layout, the duration of glint and glare is not going to be greater than the one shown in this report. The conclusions of this report have been updated considering the updated layout and the proposed screening.

This report contains the following:

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

The relevant technical analysis is presented in each section. Following the assessment, conclusions and recommendations are made.

1.2 Pager Power's Experience

Pager Power has undertaken over 900 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[4]:

- 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.

[4] These definitions are aligned with those of the Draft National Policy Statement for Renewable Energy Infrastructure and the Federal Aviation Administration (FAA) in the United States of America

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Overview

The following sections present the solar development location and key details pertaining to this assessment.

The proposed development measures 59.4 hectares (excluding the cables area is described as an: "Installation and operation of a renewable energy generating station comprising ground-mounted photovoltaic solar arrays and battery-based electricity storage containers together with substation, switchgear container, inverter/transformer units, Site access, internal access tracks, security measures, access gates, other ancillary infrastructure and landscaping and biodiversity enhancements."

2.2 Proposed Development Site Boundary

Figures 1[5] and 2[6] below and on the following page show the site layout for the proposed development.

Figure 1 *Site layout*

[5] Source: Typical Fixed Design PDF (cropped)

[6] Source: Site Location Plan A (Issue 01) PDF (cropped)

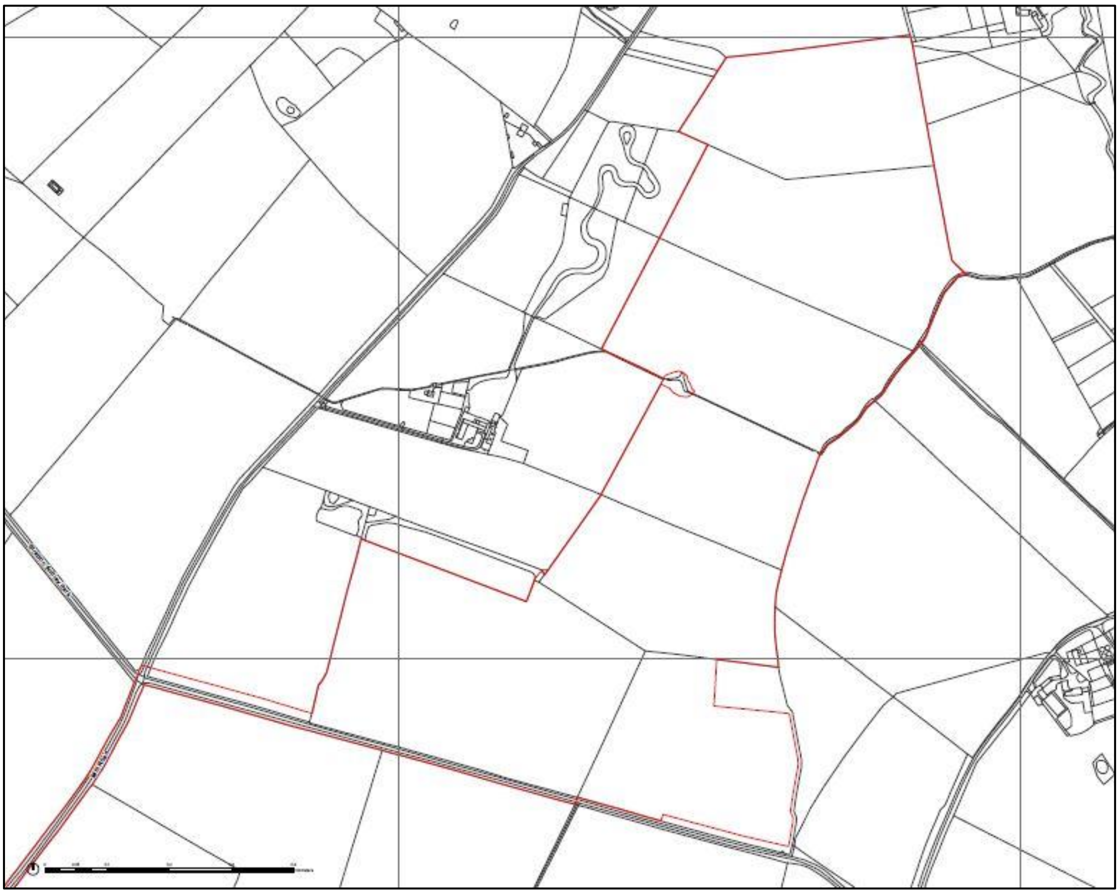


Figure 2 *Site redline boundary*

Figure 3[7] on the following page shows the landscape mitigation plan and proposed screening for the proposed development.

[7] Source: Padbury Site Layout Plans_ Rev 6_Reduced PDF (cropped)

Figure 3 *Site Layout (reduced)*

Figure 4 below shows the proposed development layout overlayed onto aerial imagery.

Figure 4 *Solar panel area for proposed development*

2.3 Solar Panel Technical Information

Figure 5[8] below illustrates the panels to be used for the proposed development.

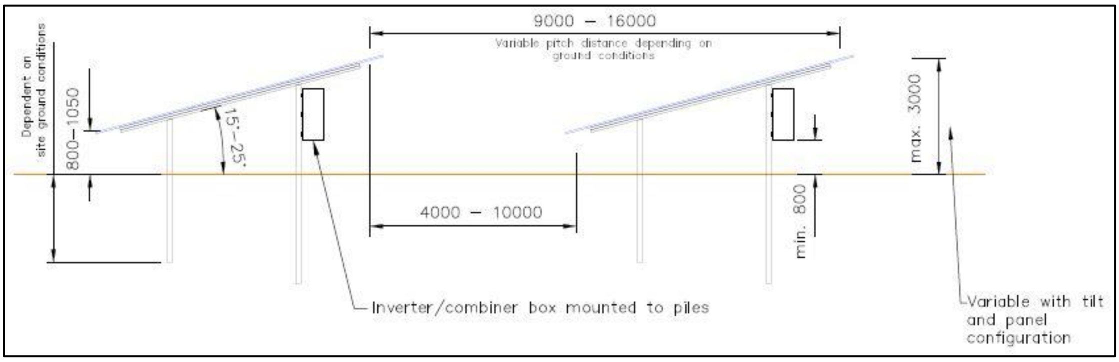


Figure 5 *Technical details of solar panels*

The following has been implemented:

- The average between 15° and 25° has been used as the assessed elevation angle;
- The midpoint between the minimum height of 0.8m and maximum height of 3.0m has been used as the assessed centre height.

[8] Source: PV Table Details PDF (cropped)

Table 1 below summarises the technical information of the modelled solar panels used in the assessment.

Panel Information	
Azimuth angle	180°
Elevation angle	20°
Assessed centre height	1.9 m agl[9]

Table 1 *Solar panel technical information*

[9] above ground level

3 BICESTER AIRFIELD DETAILS

3.1 Overview

The following section presents general details regarding Bicester Airfield.

3.2 Airport Information

Bicester Airfield is an unlicensed aerodrome, and not understood to have an ATC Tower.

3.3 Runway Details

Bicester Airfield has two runways, the details of which are presented below:

- 06/24 measuring 650m by 50m (grass);
- 16/34 measuring 790m by 50m (grass).

The location of Bicester Airfield relative to the proposed development is shown in Figure 6 below.

Figure 6 *Bicester Airfield relative to proposed development*

4 GLINT AND GLARE ASSESSMENT METHODOLOGY

4.1 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.

4.2 Background

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

4.3 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 this 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;
- Consider the solar reflection with respect to the published studies and guidance;
- Determine whether a significant detrimental impact is expected in line with the process presented in Appendix D.

4.3.1 Sandia National Laboratories' Methodology

Sandia National Laboratories developed the Solar Glare Hazard Analysis Tool (SGHAT) which is no longer freely available however it is now developed by Forge Solar. Pager Power uses this model where required for aviation receptors. Whilst strictly applicable in the USA and to solar photovoltaic developments only, the methodology is widely used by aviation stakeholders internationally.

4.4 Assessment Methodology and Limitations

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

5 IDENTIFICATION OF RECEPTORS

5.1 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.

A 1km assessment area is considered appropriate for glint and glare effects on ground-based receptors. Receptors within this distance are identified based on mapping and aerial photography of the region. The assessment area is shown as the white line in the figures in the following sub-sections.

The receptor details are presented in Appendix G and the terrain elevations have been interpolated based on OSGB36 data.

5.2 Aviation Receptors

5.2.1 Runway Receptors Overview

Bicester Airfield has two operational runways with four associated approach paths, one for each bearing.

It is Pager Power's methodology to assess whether a solar reflection can be experienced on the approach paths for the associated runways. This is considered to be the most critical stage of the flight.

A geometric glint and glare assessment has been undertaken for all aircraft approach paths at Bicester Airfield. The Pager Power approach for determining receptor (aircraft) locations on the approach path is to select locations along the extended runway centre line from 50ft above the runway threshold out to a distance of 2 miles. The height of the aircraft is determined by using a 3-degree descent path relative to the runway threshold height. The receptor details for each runway approach are presented in Appendix G.

5.2.2 Runway 06/24

The approach paths for runway 06/24 are shown in Figure 7 on the following page. Receptor 20 denotes the 2-mile point from each runway threshold.

Figure 7 *Approach paths for runway 06/24*

5.2.3 Runway 16/34

The approach paths for runway 16/34 are shown in Figure 8 below. Receptor 20 denotes the 2-mile point from each runway threshold.

Figure 8 *Approach paths for runway 16/34*

5.3 Road Receptors

5.3.1 Road Receptors Overview

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 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;
- 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 also considered major national, national, and regional roads that:

- Are within the one-kilometre assessment area;
- Have a potential view of the panels.

5.3.2 Identified Road Receptors

Main Street (forming onto the A4421) is located within the 1km assessment area. Receptors 1 to 32 along Main Street are placed circa 100m apart, covering a total approximate distance of 3.1km. A height of 1.5 metres above ground level has been taken as the typical eye level of a road user. Figure 9 on the following page shows the assessed road receptors.

Figure 9 *Assessed road receptors*

5.4 Dwelling Receptors

5.4.1 Dwelling Receptors Overview

The analysis has considered dwellings that:

- Are within the one-kilometre assessment area; and
- Have a potential view of the panels.

In residential areas with multiple layers of dwellings, only the outer dwellings have been considered for assessment. This is because they will mostly obscure views of the solar panels to the dwellings behind them, which will therefore not be impacted by the proposed development because line of sight will be removed, or they will experience comparable effects to the closest assessed dwelling.

Additionally, in some cases, a single receptor point may be used to represent a small number of separate addresses. In such cases, the results for the receptor will be representative of the adjacent observer locations, such that the overall level of effect in each area is captured reliably.

5.4.2 Identified Dwelling Receptors

The assessed dwelling receptors are shown in Figures 10-16 below and on the following pages. In total, 23 dwellings have been assessed. An additional 1.8m height above ground is used in the modelling to simulate the typical viewing height of an observer on the ground floor[10].

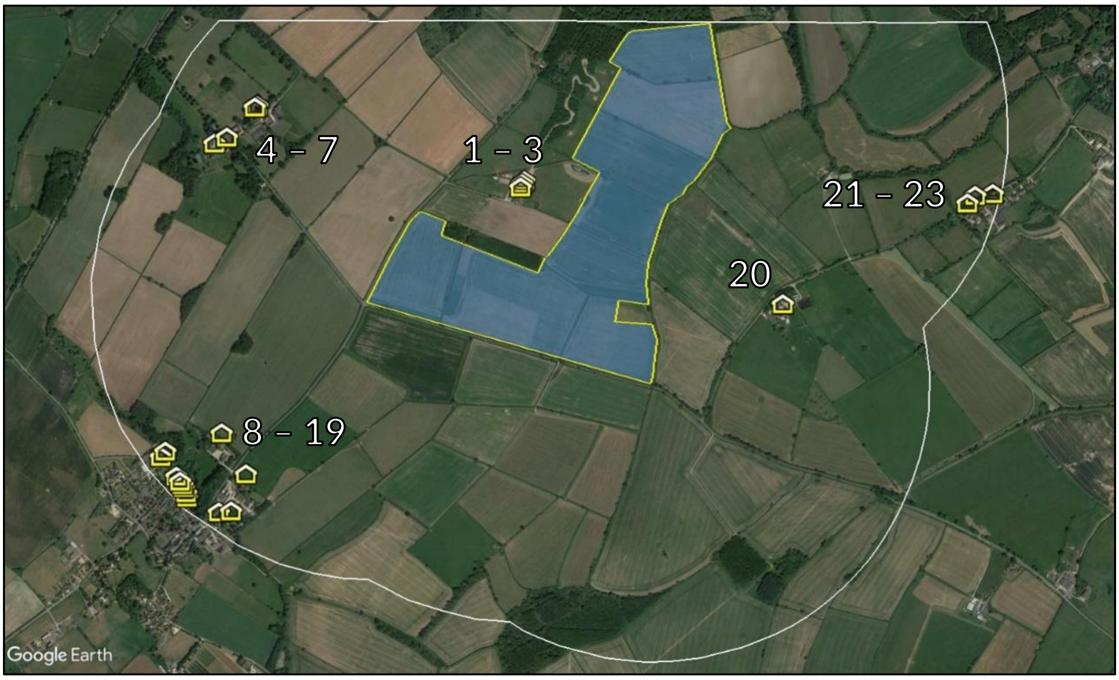


Figure 10 *Overview of all dwellings*

[10] Changes to this height are not significant, and views considered above the ground floor are considered where appropriate

Figure 11 *Assessed dwelling receptors 1 to 3*

Figure 12 *Assessed dwelling receptors 4 to 7*

Figure 13 *Assessed dwelling receptor 8*

Figure 14 *Assessed dwelling receptors 9 to 16*

Figure 15 *Assessed dwelling receptors 17 to 19*

Figure 16 *Assessed dwelling receptors 20 to 23*

6 ASSESSED REFLECTOR AREA

6.1 Reflector Area

The bounding coordinates for the proposed development have been extrapolated from the site plans. The data can be found in Appendix G. Figure 17 below shows the assessed reflector area that has been used for modelling purposes.

A resolution of 15m has been chosen for this assessment. This means that a geometric calculation is undertaken for each identified receptor every 15m from within the defined areas. This resolution is sufficiently high to maximise the accuracy of the results – increasing the resolution further would not significantly change the modelling output. If a reflection is experienced from an assessed panel location, then it is likely that a reflection will be viewable from similarly located panels within the proposed solar development.

Figure 17 *Assessed reflector area*

7 GLINT AND GLARE ASSESSMENT – TECHNICAL RESULTS

7.1 Overview

The Pager Power and Forge model has been used to determine whether reflections are possible. Intensity calculations (Forge model) in line with the Sandia National Laboratories methodology have been undertaken for aviation receptors. These calculations are routinely required for solar photovoltaic developments on or near aerodromes. The intensity model calculates the expected intensity of a reflection with respect to the potential for an after-image (or worse) occurring. The designation used by the model is presented in Table 2 below along with the associated colour coding.

Coding Used	Intensity Key
Glare beyond 50°	Glare beyond 50 deg from pilot line-of-sight
Low potential	Low potential for temporary after-image
Potential	Potential for temporary after-image
Potential for permanent eye damage	Potential for permanent eye damage

Table 2 *Glare intensity categorisation*

This coding has been used in the table where a reflection has been calculated and is in accordance with Sandia National Laboratories' methodology.

In addition, the intensity model allows for assessment of a variety of solar panel surface materials. In the first instance, a surface material of 'smooth glass without an anti reflective coating' is assessed. This is the most reflective surface and allows for a 'worst case' assessment. Other surfaces that could be modelled include:

- Smooth glass with an anti-reflective coating;
- Light textured glass without an anti-reflective coating;
- Light textured glass with an anti-reflective coating; or
- Deeply textured glass.

If significant glare is predicted, modelling of less reflective surfaces could be undertaken.

7.2 Summary of Results

The tables in the following sub-sections summarise the results of the assessment. The tables are based solely on bare-earth terrain i.e., without consideration of screening from buildings and vegetation. Whether a reflection will be experienced in practice, and the significance of any impacts are discussed in the subsequent report sections.

The modelling output showing the precise predicted times and the reflecting panel areas are shown in Appendix H.

7.3 Geometric Calculation Results – Bicester Airfield

7.3.1 Approach Paths for Runway 06/24

The results of the geometric calculations for the approaches for runway 06/24 are presented in Table 3 below.

Receptor	Reflections possible towards the approach? (GMT)		Glare Type (Forge)	Comment
	am	pm		
Runway 06 Threshold – Receptor 20	No	No	N/A	No solar reflections geometrically possible
Runway 24 Threshold – Receptor 19	No	No	N/A	No solar reflections geometrically possible
Runway 24 Receptor 20	No	Yes		Solar reflections are beyond 50 degrees from pilot's direction of travel

Table 3 *Geometric Calculation Results - Runway 06/24*

7.3.2 Approach Paths for Runway 16/34

The results of the geometric calculations for the approaches for runway 06/24 are presented in Table 4 on the following page.

Receptor	Reflections possible towards the approach? (GMT)		Glare Type (Forge)	Comment
	am	pm		
Runway 16 Threshold	No	No	N/A	No solar reflections geometrically possible
Runway 16 Receptors 01 – 20	Yes	No		Solar reflections are beyond 50 degrees from pilot's direction of travel
Runway 34 Threshold – Receptor 20	No	No	N/A	No solar reflections geometrically possible

Table 4 *Geometric Calculation Results - Runway 16/34*

7.4 Geometric Calculation Results – Road Receptors

The results of the geometric calculations for the road receptors are presented in Table 5 below.

Receptor	**Solar Reflection Possible Toward the Road Receptors? (GMT)**		**Comment (screening not considered)**
	am	**pm**	
1 – 9	Yes	No	Solar reflections geometrically possible **outside** an observer's primary field of view
10 – 11	Yes	No	Solar reflections geometrically possible **inside** an observer's primary field of view
12 – 22	Yes	Yes	Solar reflections geometrically possible **inside** an observer's primary field of view
23 – 32	No	Yes	Solar reflections geometrically possible **outside** an observer's primary field of view

Table 5 *Geometric calculation results – road receptors*

7.5 Geometric Calculation Results – Dwelling Receptors

The results of the geometric calculations for the dwelling receptors are presented in Table 3 on the following page.

Receptor	Solar Reflection Possible Toward the Dwelling Receptors? (GMT)		Comment (screening not considered)
	am	pm	
1 – 17	Yes	No	Solar reflections geometrically possible for **more** than 3 months per year but **less** than 60 minutes per day
18 – 19	Yes	No	Solar reflections geometrically possible for **less** than 3 months per year and **less** than 60 minutes per day
20 – 23	No	Yes	Solar reflections geometrically possible for **more** than 3 months per year but **less** than 60 minutes per day

Table 6 *Geometric calculation results – dwelling receptors*

8 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

8.1 Overview

The following sub-section presents the significance of any predicted impact in the context of existing screening and the relevant criteria set out in each sub-section. The criteria are determined by the assessment process for each receptor, which are set out in Appendix D.

When determining the visibility of the reflecting panels for an observer, a conservative review of the available imagery has been undertaken, whereby it is assumed views of the panels are possible if it cannot be reliably determined that existing screening will remove effects.

8.2 Bicester Airfield Results

8.2.1 Approach Paths for Runway 06/24

The modelling results have shown that solar reflections are possible at receptor 20 (2 miles from the runway threshold) along the approach path for runway 24. Solar reflections are not geometrically possible along the approach path for runway 06. Figure 18 below shows the panel area where reflections originate (orange shaded region), and the affected receptor.

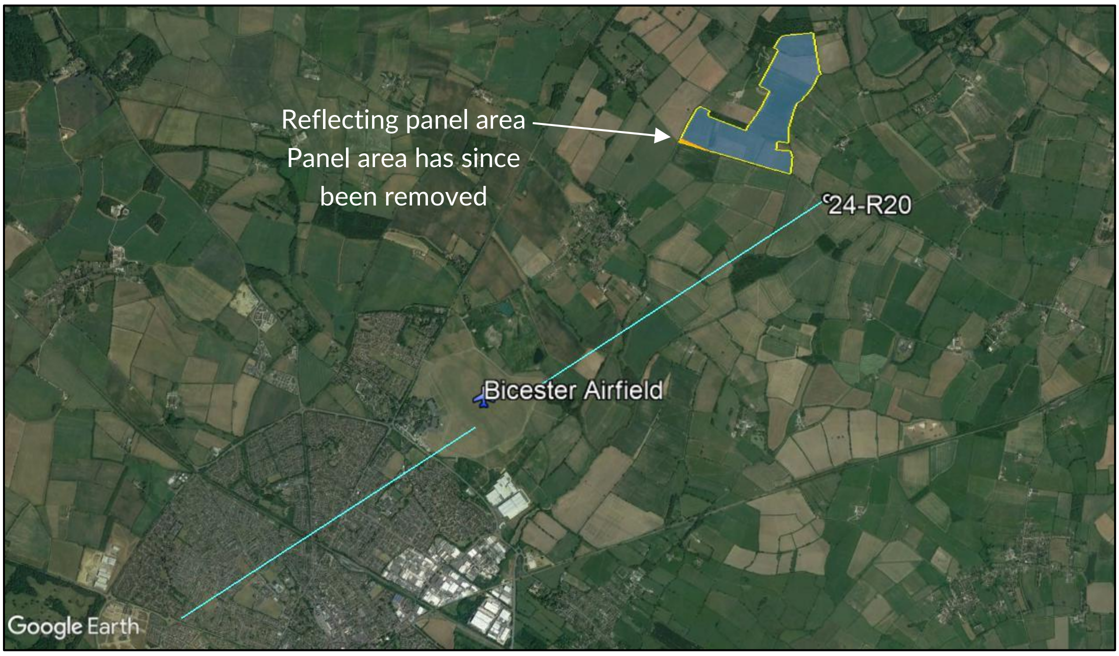


Figure 18 *Reflecting panel area and receptors where solar reflections occur for runway 06/24 approaches*

Solar reflections occur outside of a pilot's field of view of 50 degrees from the direction of travel. This panel area has since been removed. Therefore, no impact is predicted, and no mitigation is required.

The smaller panel area removes the reflecting panel area for runway 24. No impact is predicted, and no mitigation is required.

8.2.2 Approach Paths for Runway 16/34

The modelling has shown that solar reflections are possible towards receptors 1 to 20 (0.1 miles to 2 miles from the runway threshold) along the approach path for runway 16. Solar reflections are not geometrically possible along the approach path for runway 34. Figure 19 below shows the cumulative panel area where reflections originate (orange shaded region), and the receptors observing solar reflections.

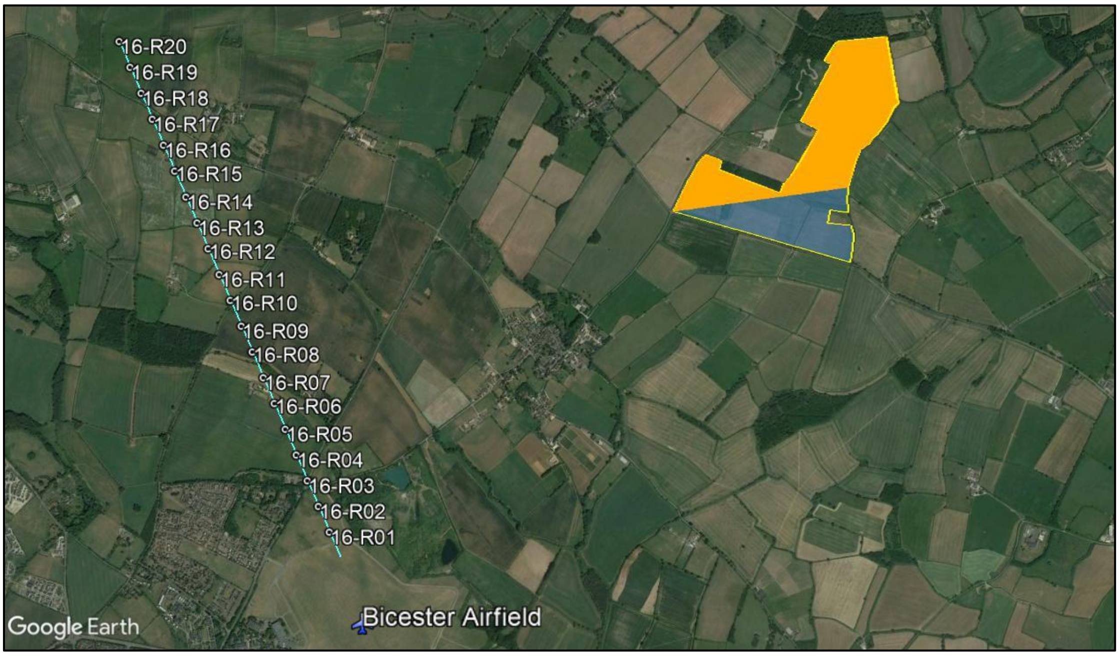


Figure 19 *Reflecting panel area and receptors where solar reflections occur for runway 16/34 approaches*

Solar reflections occur outside of a pilot's field of view of 50 degrees from the direction of travel. Therefore, a low is predicted, and no mitigation is required.

8.3 Road Results

8.3.1 Overview

The key considerations for quantifying impact significance for road users along major national, national, and regional roads are:

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

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 required.

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

- Whether visibility is likely for elevated drivers (relevant to dual carriageways and motorways);
- Whether the solar reflection originates from directly in front of a road user. Solar reflections that are directly in front of a road user are more hazardous;
- 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. The Sun is a far more significant source of light.

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

8.3.2 Results Discussion

The modelling has shown that solar reflections are geometrically possible towards all assessed receptors and occur at different times.

Table 7 below summarises the predicted impact at these receptors. Cases where mitigation is recommended are shown in red for ease of reference and discussed below the table.

Receptor	Identified Screening (desk-based review)	Predicted Impact Classification	Relevant Factors	Mitigation Recommended?
1 – 10	Existing vegetation Predicted to significantly obstruct views of reflecting panels	No impact	N/A	No
11	Existing vegetation	No impact	Panel area has been removed as part of updated layout	No

Receptor	Identified Screening (desk-based review)	Predicted Impact Classification	Relevant Factors	Mitigation Recommended?
12 - 22	Existing vegetation Predicted to significantly obstruct views of reflecting panels	No impact	N/A	No
23	Existing vegetation Implementation of proposed screening predicted to obstruct views of reflecting panels	No	N/A	No
24 – 32	Existing vegetation Predicted to significantly obstruct views of reflecting panels	No impact	N/A	No

Table 7 *Assessment of mitigation requirement – road receptors*

The existing vegetation identified is shown in Figures 20 to 22 on the following pages. The images show the typical views for road users at significant road receptors. The identified screening is expected to significantly obstruct views of reflecting panels between receptors 12 to 22.

Figure 20 on the following page is representative of the screening along the section between receptors 12 and 22.

Figure 20 *Point-of-view for observers at road receptor 16*

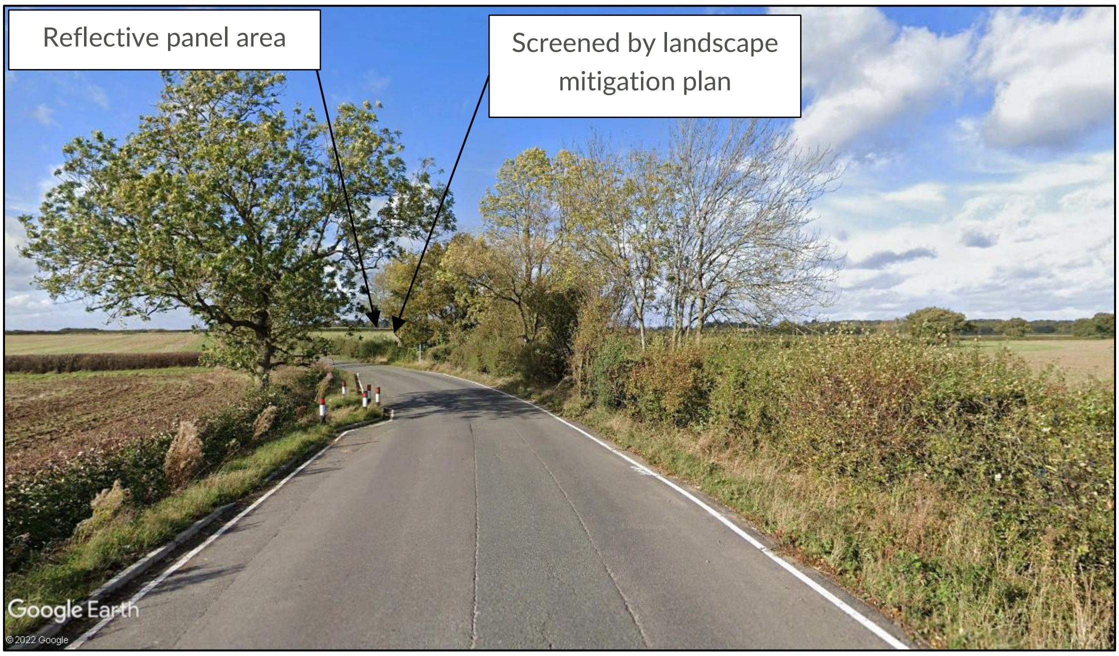


Figure 21 *Point-of-view for observers at road receptor 23*

8.4 Dwelling Results

8.4.1 Overview

The key considerations for quantifying impact significance for dwelling receptors 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 effects are predicted to be experienced for less than 3 months per year and less than 60 minutes per day or the effects originate from panels over 1km away, the impact significance is low, and mitigation is not required.

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

- 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 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;
- 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.

Where effects are predicted to be experienced for more than 3 months per year and more than 60 minutes per day, the impact significance is high, and mitigation is required.

8.4.2 Results Discussion

Table 8 below summarises the predicted impact significance of solar reflections at all dwellings, and the mitigation requirement as required. Cases where mitigation is recommended are shown in red for ease of reference and discussed further in Section 8.4.4.

Dwelling Receptor	Identified Screening (desk-based review)	Predicted Impact Classification	Relevant Factors	Mitigation Recommended?
1 – 3	Existing vegetation Implementation of proposed screening predicted to obstruct views of reflecting panels	No impact	N/A	No

Dwelling Receptor	Identified Screening (desk-based review)	Predicted Impact Classification	Relevant Factors	Mitigation Recommended?
4 – 23	Existing vegetation Predicted to significantly obstruct views of reflecting panels	N/A	N/A	No

Table 8 *Assessment of mitigation requirement – dwelling receptors*

8.4.3 Desk-Based Review of Imagery

The desk-based review of the available imagery is shown in Figures 24 to 28 below and on the following pages. The cumulative reflecting panel areas are shown as orange within the figures. Screening in the form of existing vegetation is outlined in green. Specifically, the figures show:

- Figure 22: Existing vegetation screening for dwellings 1 to 3;
- Figure 23: Existing vegetation screening for dwellings 4 to 7;
- Figure 24: Existing vegetation screening for dwellings 8 to 19;
- Figure 25: Existing vegetation screening for dwelling 20;
- Figure 26: Existing vegetation screening for dwellings 21 to 23.

Figure 22 *Existing vegetation screening for dwellings 1 to 3*

Figure 23 *Existing vegetation screening for dwellings 4 to 7*

Figure 24 *Existing vegetation screening for dwellings 8 to 19*

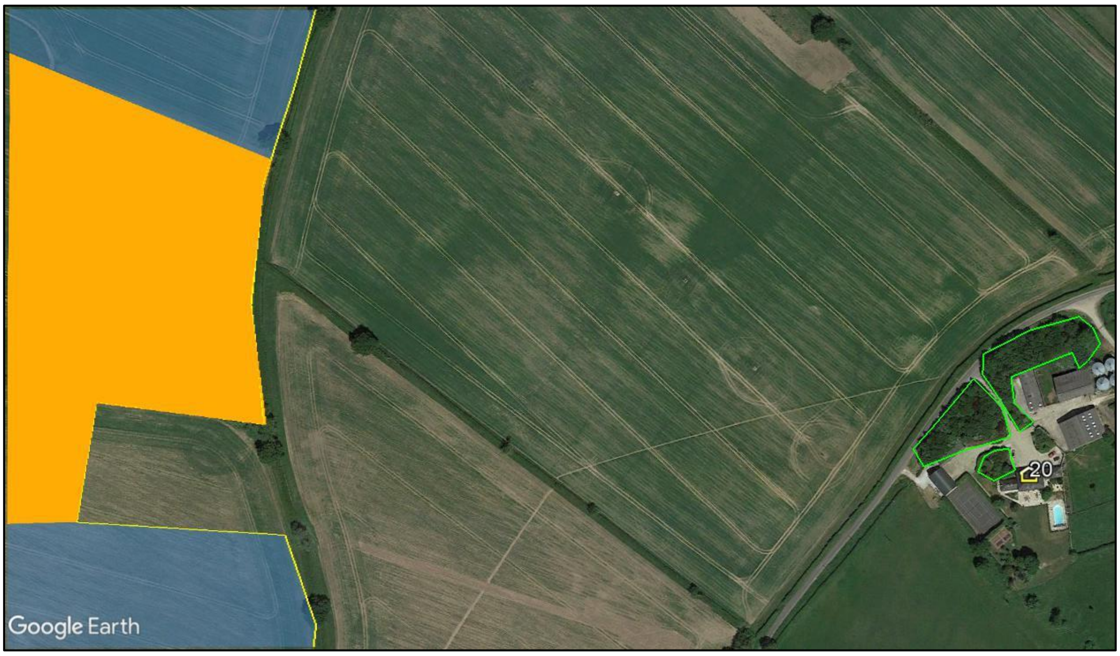


Figure 25 *Existing vegetation screening for dwelling 20*

Figure 26 *Existing vegetation screening for dwellings 20 to 23*

9 HIGH-LEVEL AVIATION CONSIDERATIONS

9.1 Overview

The following section presents an overview, and the aerodromes being considered for possible effects for glint and glare at a high-level.

Glint and glare assessment for aviation receptors are typically undertaken for aerodromes within 10km of a proposed solar development. At ranges of 10-20km, the requirement for assessment is much less common for aerodromes, with typically assessment only being undertaken for licensed aerodromes at these ranges. Assessment of any aviation effects for developments over 20km is not a usual requirement.

9.1.1 Pear Tree Farm Airfield

Pear Tree Airfield is an unlicensed aerodrome located approximately 3.7km south of the proposed development. The location of the aerodrome and 2-mile approach paths for the runway relative to the proposed development is shown in Figure 27 below.

Figure 27 *Pear Tree Farm Airfield and approach paths relative to proposed development*

9.1.2 Finmere Airfield

Finmere Airfield is an unlicensed aerodrome located approximately 4.7km north of the proposed development. The location of the aerodrome and 2-mile approach paths for the runway relative to the proposed development is shown in Figure 28 on the following page.

Figure 28 *Finmere Airfield and approach paths relative to proposed development*

9.2 Aerodrome Details

9.2.1 Pear Tree Airfield

Pear Tree Airfield has one runway and is not understood to have an ATC Tower. The runway details are presented below:

- 09/27 measuring 750 x 30 metres (grass).

9.2.2 Finmere Airfield

Finmere Airfield has one and is not understood to have an ATC Tower. The runway details are presented below:

- 10/28 measuring 701 x 46 metres (asphalt).

9.3 High-Level Assessment Conclusions

9.3.1 Pear Tree Farm Airfield

For aviation activity associated with Pear Tree Farm Airfield, significant impacts are not predicted when considering the following:

- It can be reliably predicted that any solar reflections towards pilots approaching runway threshold 09 would have intensities no greater than 'low potential for temporary after image', given the distance from the proposed development. This level of glare is acceptable in accordance with the associated guidance and industry best practice. This is based upon site size, distance and previous project experience;
- It can be reliably predicted that any solar reflections towards pilots approaching runway threshold 27 would have intensities no greater than 'low potential for temporary after image', given the distance from the proposed development. This level

of glare is acceptable in accordance with the associated guidance and industry best practice. This is based upon site size, distance and previous project experience.

9.3.2 Finmere Airfield

For aviation activity associated with Finmere Airfield, significant impacts are not predicted when considering the following:

- Any solar reflections from the proposed development will be outside a pilot's primary field of view (50 degree either side of the approach bearing) along the 2-mile approach paths towards runway thresholds 10/28, which is permissible in accordance with the associated guidance (Appendix D) and industry best practice.

10 OVERALL CONCLUSIONS

10.1 Conclusions – Bicester Airfield

10.1.1 Runway 06/24

Solar reflections are not geometrically possible along the approach path for runways 06. The modelling results has shown solar reflections are possible at 2 miles from the runway threshold along the approach path for runway 24. However, they are predicted to occur outside a pilot's 50-degree field-of-view. A low impact is predicted and therefore no mitigation is required.

The smaller panel area removes the reflecting panel area for runway 24. No impact is predicted, and no mitigation is required.

10.1.2 Runway 16/34

Solar reflections are not geometrically possible along the approach path for runway 34. The modelling has shown solar reflections are possible from 0.1 miles to 2 miles from the runway threshold along the approach path for runway 16. However, they are predicted to occur outside a pilot's 50-degree field- of-view. A low impact is predicted and therefore no mitigation is required.

10.2 Conclusions - Roads

Solar reflections are geometrically possible along the assessed 3.1km section of Main Street. Screening in the form of existing vegetation and proposed screening as per the landscape mitigation plan is predicted to significantly obstruct views of reflecting panels. No impacts are predicted upon road safety, and no mitigation requirement has been identified.

10.3 Conclusions - Dwellings

Solar reflections are geometrically possible for all identified dwelling receptors. Screening in the form of existing vegetation and proposed screening as per the landscape mitigation plan is predicted to fully obstruct views of reflecting panels for all identified dwelling receptors, for which no impact is predicted. No mitigation requirement has been identified.

10.4 Conclusions – High-Level Aviation

Any solar reflections towards Pear Tree Farm Airfield and Finmere Airfield are predicted to be acceptable in accordance with the associated guidance. Factors determining this are either due to solar reflections occurring outside a pilot's field-of-view (50 degrees either side of the approach bearing) or predicted low glare intensities. Therefore, further detailed modelling of these airfields is not recommended.

10.5 Overall Conclusions

A low impact is predicted upon aviation activity at Bicester Airfield. Results of the geometric modelling show solar reflections occur outside a pilot's 50-degree field of view.

No impact is predicted upon road users along Main Street and no mitigation is recommended.

No impact is predicted upon residential dwellings and no mitigation is recommended.

Further detailed modelling is not recommended for Pear Tree Farm Airfield and Finmere Airfield. Any solar reflections towards these three aerodromes are predicted to be permissible in accordance with the associated guidance.

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

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[11] (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.'

Assessment Process – Ground-Based Receptors

No process for determining and contextualising the effects of glint and glare is provided for 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 solar

[11] Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 18 June 2015, accessed on: 17/06/2020

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[12] 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[13] however the advice is still applicable[14] 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[15], as part of a condition of a CAA Aerodrome Licence, the ALH is required

[12] Pager Power Glint and Glare Guidance, Third Edition (3.1), April 2021.
[13] Archived at Pager Power
[14] Reference email from the CAA dated 19/05/2014.
[15] Aerodrome Licence Holder.

to obtain prior consent from CAA Aerodrome Standards Department before any work is begun or 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 were produced initially in November 2010 by the United States Federal Aviation Administration (FAA) and updated in 2013.

The 2010 document is entitled '*Technical Guidance for Evaluating Selected Solar Technologies on Airports'*[16] and the 2013 update is entitled '*Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'*[17]. In April 2018 the FAA released a new version (Version 1.1) of the '*Technical Guidance for Evaluating Selected Solar Technologies on Airports'*[18].

An overview of the methodology presented within the 2013 interim guidance and adopted by the FAA is presented below. This methodology is not presented within the 2018 guidance.

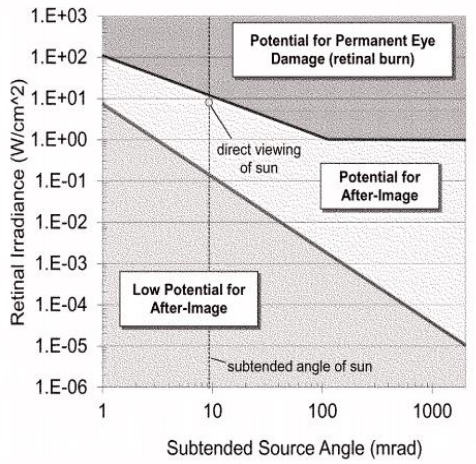
- *Solar energy systems located on an airport that is not federally-obligated or located outside the property of a federally-obligated airport are not subject to this policy.*
- *Proponents of solar energy systems located off-airport property or on non-federally-obligated airports are strongly encouraged to consider the requirements of this policy when siting such system.*
- *FAA adopts the Solar Glare Hazard Analysis Plot.... as the standard for measuring the ocular impact of any proposed solar energy system on a federally-obligated airport. This is shown in the figure below.*

[16] Archived at Pager Power

[17] 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: 20/03/2019

[18] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019

Figure 1



Solar Glare Ocular Hazard Plot: The potential ocular hazard from solar glare is a function of retinal irradiance and the subtended angle (size/distance) of the glare source. It should be noted that the ratio of spectrally weighted solar illuminance to solar irradiance at the earth's surface yields a conversion factor of ~100 lumens/W. Plot adapted from Ho et al., 2011.

Chart References: Ho, C.K., C.M. Ghanbari, and R.B. Diver, 2011, Methodology to Assess Potential Glint and Glare Hazards from Concentrating Solar Power Plants: Analytical Models and Experimental Validation, J. Solar Energy Engineering, August 2011, Vol. 133, 031021-1 – 031021-9.

Solar Glare Hazard Analysis Plot (FAA)

- *To obtain FAA approval to revise an airport layout plan to depict a solar installation and/or a "no objection" ... the airport sponsor will be required to demonstrate that the proposed solar energy system meets the following standards:*
- *No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATC) cab, and*
- *No potential for glare or "low potential for after-image" ... along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath.*
- *Ocular impact must be analysed over the entire calendar year in one (1) minute intervals from when the sun rises above the horizon until the sun sets below the horizon.*

The bullets highlighted above state there should be 'no potential for glare' at that ATC Tower and 'no' or 'low potential for glare' on the approach paths.

Key points from the 2018 FAA guidance are presented below.

- *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[19].

- *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 in the first figure of Appendix B, 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.*
- *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*

---

[19] 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.

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*[20] *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) 2009

In some instances, an aviation stakeholder can refer to the ANO 2009 with regard to safeguarding. Key points from the document are presented below.

Endangering safety of an aircraft
137. A person must not recklessly or negligently act in a manner likely to endanger an aircraft, or any person in an aircraft.

Lights liable to endanger
221.
(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.

---

[20] 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.

(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
222. 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.

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

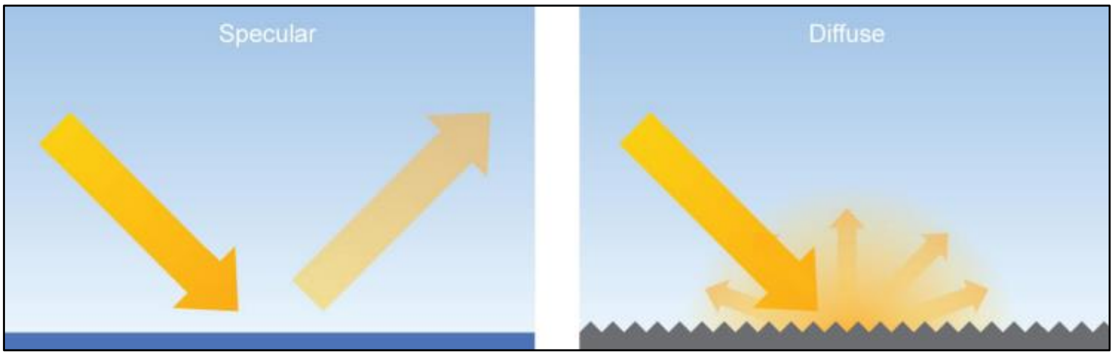
Overview

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[21], 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

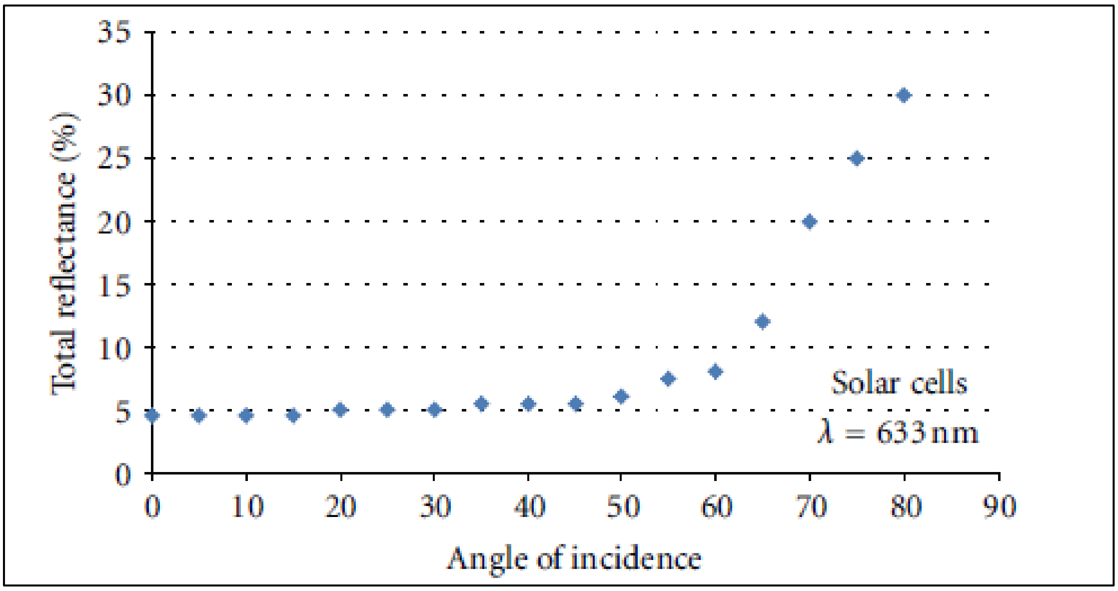
[21] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

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*[22]". 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.

[22] 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"[23]

The 2010 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[24]
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.

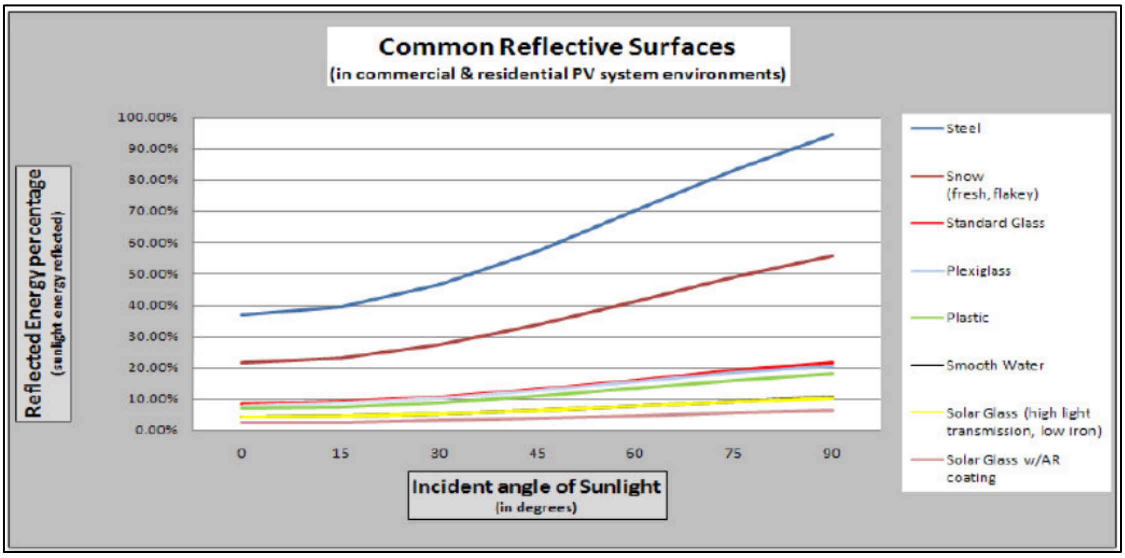
[23] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

[24] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification[25] 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.

[25] 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).

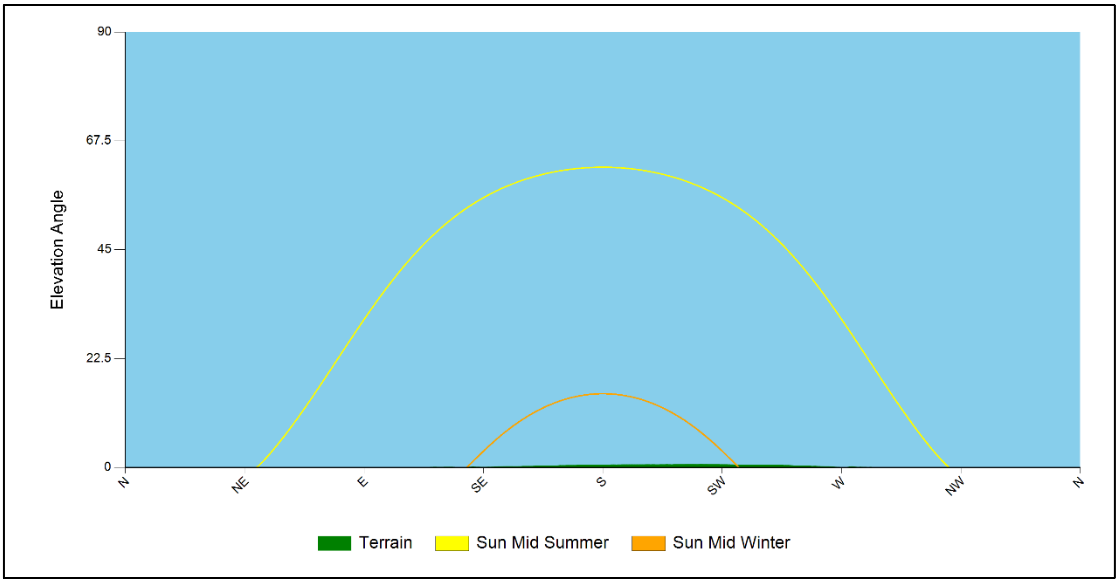
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

- 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 from the proposed development location as well as the sunrise and sunset curves throughout the year.



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

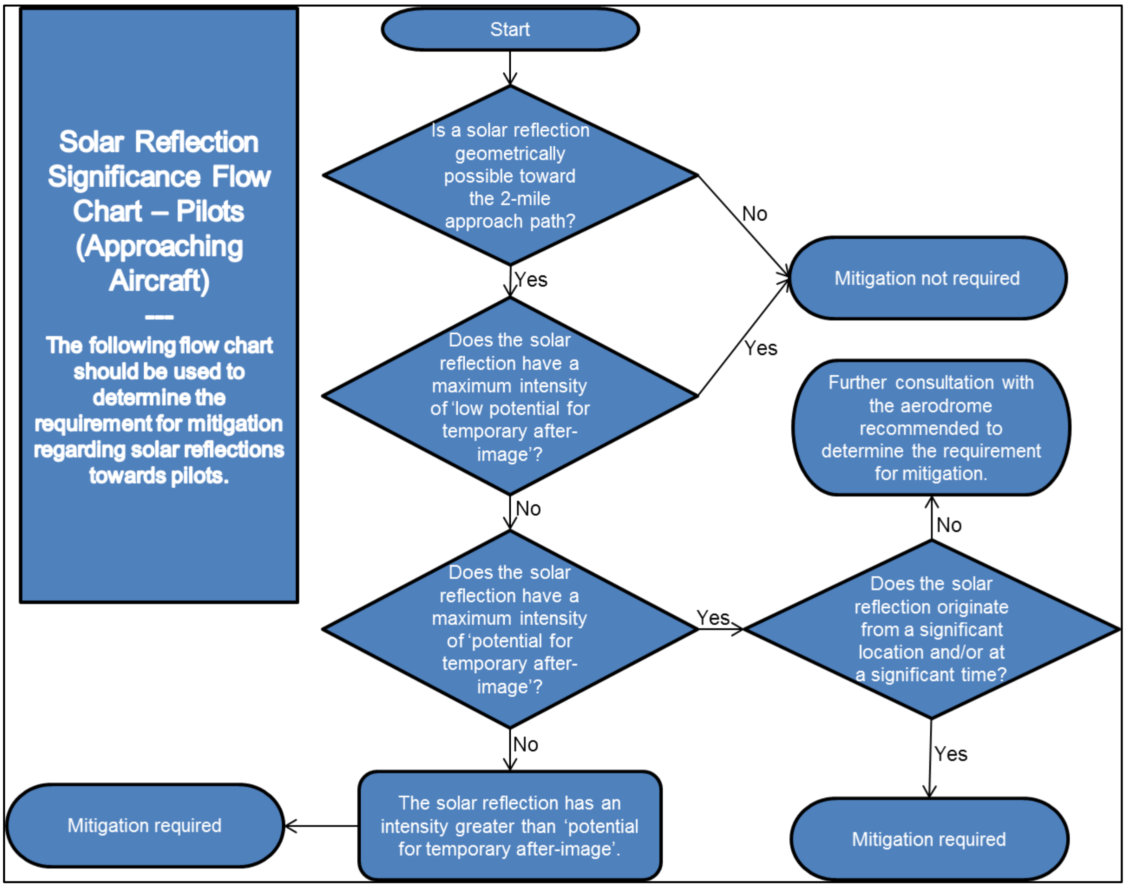
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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.	No mitigation required.
Moderate	A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case.	Whilst the impact may be acceptable, consultation and/or further analysis should be undertaken to determine the requirement for mitigation.
Major	A solar reflection is geometrically possible and visible under conditions that will produce a significant impact. Mitigation and consultation is recommended.	Mitigation will be required if the proposed solar development is to proceed.

Impact significance definition

Impact Significance Determination for Approaching Aircraft

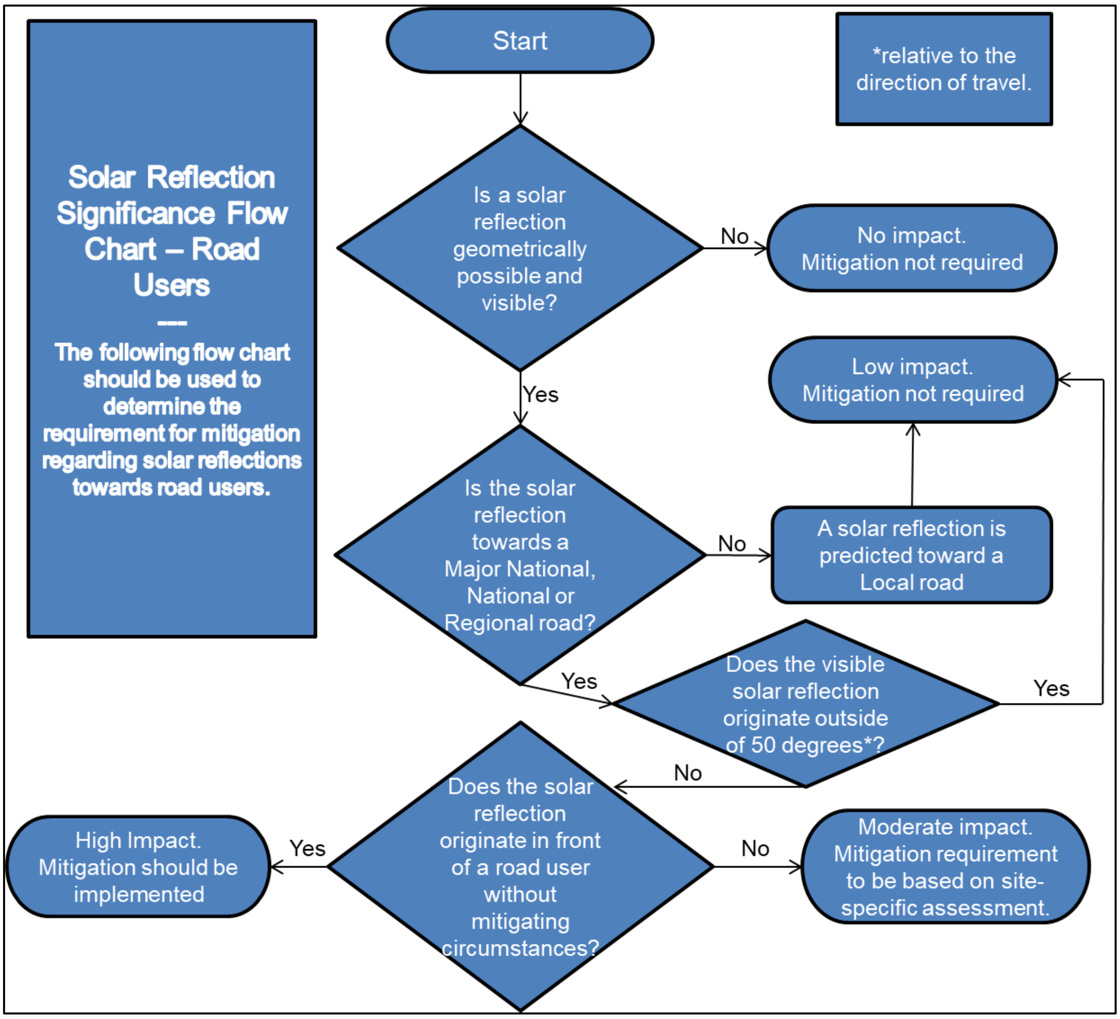
The flow chart presented below has been followed when determining the mitigation requirement for approaching aircraft.



Approaching aircraft receptor mitigation requirement flow chart

Impact Significance Determination for Road Receptors

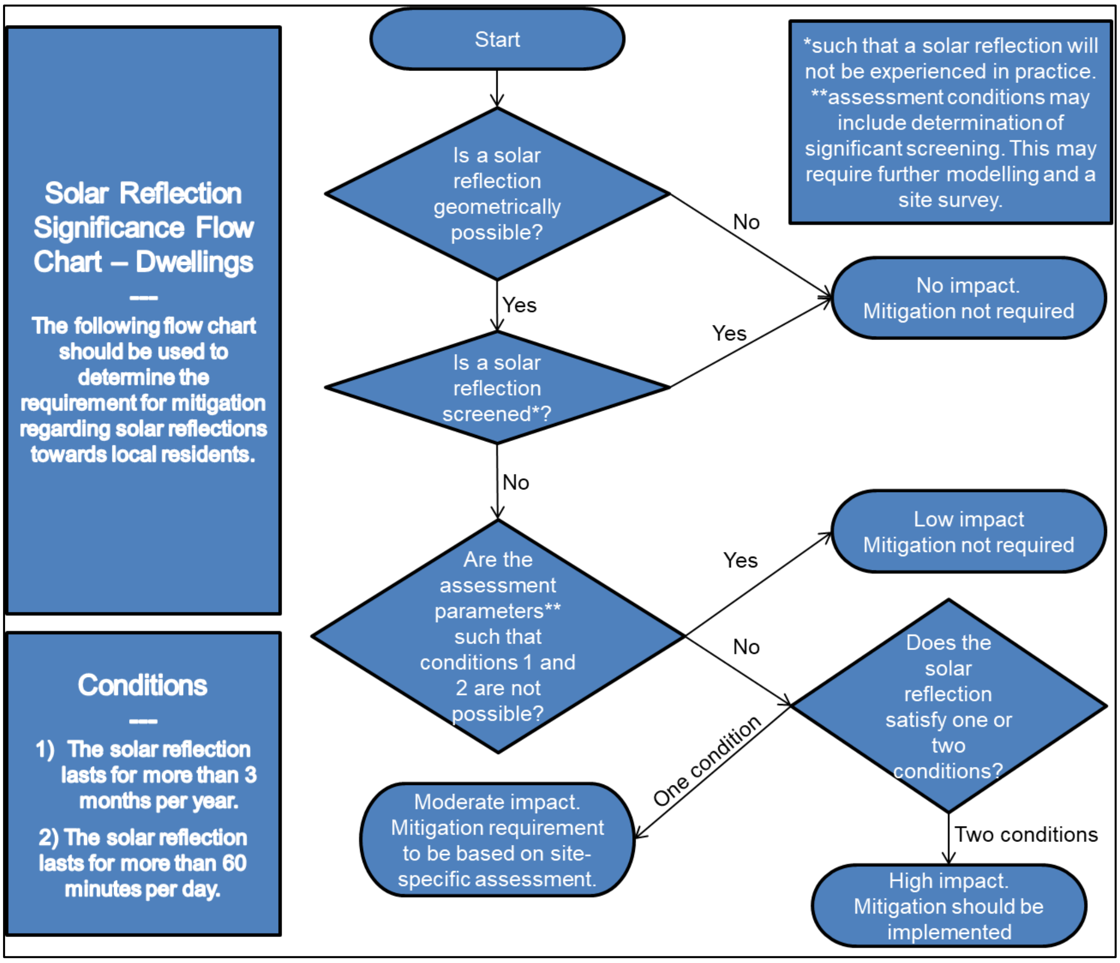
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road user impact significance flow chart

Impact Significance Determination for Dwelling Receptors

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



Dwelling impact significance flow chart

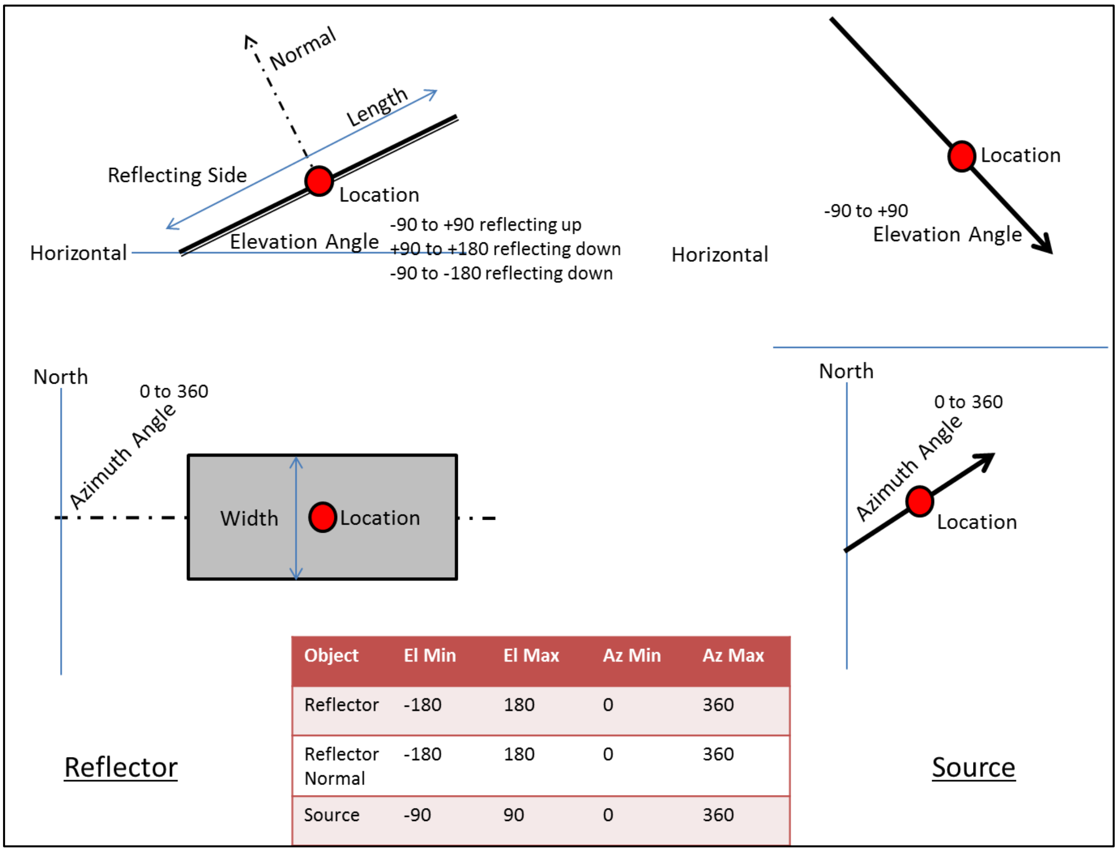
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Pager Power 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

Reflection calculation process

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

The model considers 100% sunlight during daylight hours which is highly conservative.

The model does not account for terrain between the reflecting solar panels and the assessed receptor where a solar reflection is geometrically possible.

The model considers terrain between the reflecting solar panels and the visible horizon (where the sun may be obstructed from view of the panels)[26].

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

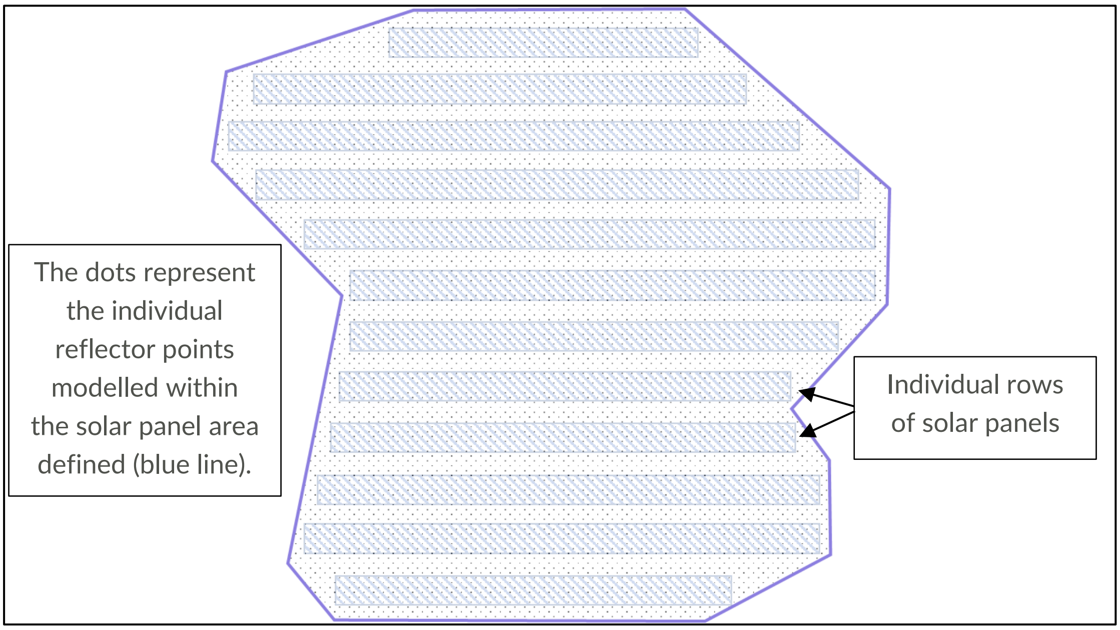
It is assumed that the panel azimuth angle assessed represents the azimuth angle for all of the panels within each solar panel area defined.

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 (point, defined in the following paragraph) within the 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 assessment 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.

[26] UK only.



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.

Forge's Sandia National Laboratories' (SGHAT) Model[27]

Summary of assumptions and abstractions required by the SGHAT/ForgeSolar analysis methodology

1. Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
2. Result data files and plots are now retained for two years after analysis completion. Files should be downloaded and saved if additional persistence is required.
3. The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
4. Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects analyses of path receptors.
5. Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
6. The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
7. The algorithm assumes that the PV array is aligned with a plane defined by the total heights of the coordinates outlined in the Google map. For more accuracy, the user should perform runs using minimum and maximum values for the vertex heights to bound the height of the plane containing the solar array. Doing so will expand the range of observed solar glare when compared to results using a single height value.
8. The algorithm does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
9. The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
10. The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
11. The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
12. Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
13. Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
14. Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
15. PV array tracking assumes the modules move instantly when tracking the sun, and when reverting to the rest position.

[27] https://www.forgesolar.com/help/#assumptions

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

The Approach Path for Bicester Airfield Runway 06

The table below presents the data for the assessed locations for aircraft on runway approach 06. The altitude of the aircraft is based on a 3-degree descent path referenced to 50 feet (15.24m) above the runway threshold (78.03m/256ft amsl) and the first receptor placed at the threshold, and the last receptor denoting the 2-mile point. Data ascertained from OSGB36 data.

Receptor	Longitude (°)	Latitude (°)	Assessed Height (m) (amsl)
1 (Threshold)	-1.13268	51.91440	93.27
2	-1.13465	51.91361	101.70
3	-1.13662	51.91282	110.14
4	-1.13859	51.91203	118.57
5	-1.14056	51.91124	127.01
6	-1.14253	51.91045	135.44
7	-1.14450	51.90966	143.87
8	-1.14646	51.90888	152.31
9	-1.14843	51.90809	160.74
10	-1.15040	51.90730	169.18
11	-1.15237	51.90651	177.61
12	-1.15434	51.90572	186.05
13	-1.15631	51.90493	194.48
14	-1.15828	51.90414	202.91
15	-1.16025	51.90335	211.35
16	-1.16222	51.90257	219.78
17	-1.16419	51.90178	228.22

18	-1.16616	51.90099	236.65
19	-1.16813	51.90020	245.08
20	-1.17009	51.89941	253.52

Assessed receptor (aircraft) locations on the approach path for runway 06

The Approach Path for Bicester Airfield Runway 24

The table below presents the data for the assessed locations for aircraft on runway approach 24. The altitude of the aircraft is based on a 3-degree descent path referenced to 50 feet (15.24m) above the runway threshold (76.20m/256ft amsl) and the first receptor placed at the threshold, and the last receptor denoting the 2-mile point. Data ascertained from OSGB36 data.

Receptor	Longitude (°)	Latitude (°)	Assessed Height (m) (amsl)
1 (Threshold)	-1.12485	51.91752	91.44
2	-1.12288	51.91831	99.87
3	-1.12091	51.91910	108.31
4	-1.11894	51.91989	116.74
5	-1.11697	51.92068	125.18
6	-1.11500	51.92147	133.61
7	-1.11303	51.92226	142.05
8	-1.11107	51.92304	150.48
9	-1.10910	51.92383	158.91
10	-1.10713	51.92462	167.35
11	-1.10516	51.92541	175.78
12	-1.10319	51.92620	184.22
13	-1.10122	51.92699	192.65
14	-1.09925	51.92778	201.08
15	-1.09728	51.92857	209.52

16	-1.09531	51.92935	217.95
17	-1.09334	51.93014	226.39
18	-1.09137	51.93093	234.82
19	-1.08940	51.93172	243.26
20	-1.08743	51.93251	251.69

Assessed receptor (aircraft) locations on the approach path for runway 24

The Approach Path for Bicester Airfield Runway 16

The table below presents the data for the assessed locations for aircraft on runway approach 16. The altitude of the aircraft is based on a 3-degree descent path referenced to 50 feet (15.24m) above the runway threshold (79.86m/262ft amsl) and the first receptor placed at the threshold, and the last receptor denoting the 2-mile point. Data ascertained from OSGB36 data.

Receptor	Longitude (°)	Latitude (°)	Assessed Height (m) (amsl)
1 (Threshold)	-1.13333	51.92001	95.10
2	-1.13424	51.92134	103.53
3	-1.13516	51.92268	111.97
4	-1.13608	51.92401	120.40
5	-1.13700	51.92534	128.83
6	-1.13791	51.92668	137.27
7	-1.13883	51.92801	145.70
8	-1.13975	51.92934	154.14
9	-1.14067	51.93068	162.57
10	-1.14158	51.93201	171.01
11	-1.14250	51.93334	179.44
12	-1.14342	51.93468	187.87
13	-1.14434	51.93601	196.31

14	-1.14525	51.93734	204.74
15	-1.14617	51.93868	213.18
16	-1.14709	51.94001	221.61
17	-1.14801	51.94134	230.05
18	-1.14892	51.94267	238.48
19	-1.14984	51.94401	246.91
20	-1.15076	51.94534	255.35

Assessed receptor (aircraft) locations on the approach path for runway 16

The Approach Path for Bicester Airfield Runway 34

The table below presents the data for the assessed locations for aircraft on runway approach 34. The altitude of the aircraft is based on a 3-degree descent path referenced to 50 feet (15.24m) above the runway threshold (75.90m/249ft amsl) and the first receptor placed at the threshold, and the last receptor denoting the 2-mile point. Data ascertained from OSGB36 data.

Receptor	Longitude (°)	Latitude (°)	Assessed Height (m) (amsl)
1 (Threshold)	-1.12897	51.91360	91.14
2	-1.12805	51.91227	99.57
3	-1.12714	51.91093	108.00
4	-1.12622	51.90960	116.44
5	-1.12530	51.90827	124.87
6	-1.12439	51.90693	133.31
7	-1.12347	51.90560	141.74
8	-1.12255	51.90427	150.17
9	-1.12163	51.90293	158.61
10	-1.12072	51.90160	167.04
11	-1.11980	51.90027	175.48

12	-1.11888	51.89894	183.91
13	-1.11796	51.89760	192.35
14	-1.11705	51.89627	200.78
15	-1.11613	51.89494	209.21
16	-1.11521	51.89360	217.65
17	-1.11429	51.89227	226.08
18	-1.11338	51.89094	234.52
19	-1.11246	51.88960	242.95
20	-1.11154	51.88827	251.39

Assessed receptor (aircraft) locations on the approach path for runway 34

Road Receptor Data

The road receptor data is presented in the table below. An additional 1.5m height has been added to the elevation to account for the eye-level of a road user.

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m) (amsl)
1	-1.11548	51.94492	113.50	17	-1.09784	51.93642	101.50
2	-1.11445	51.94428	114.81	18	-1.09644	51.93617	100.66
3	-1.11352	51.94359	114.87	19	-1.09508	51.93593	97.96
4	-1.11247	51.94297	113.32	20	-1.09368	51.93569	97.44
5	-1.11140	51.94236	112.50	21	-1.09223	51.93543	94.50
6	-1.11051	51.94165	110.50	22	-1.09087	51.93519	94.50
7	-1.10960	51.94094	108.12	23	-1.08954	51.93480	94.50
8	-1.10868	51.94024	106.22	24	-1.08840	51.93424	94.50

9	-1.10777	51.93954	103.57	25	-1.08730	51.93369	94.50
10	-1.10688	51.93886	103.28	26	-1.08600	51.93329	95.24
11	-1.10597	51.93816	103.50	27	-1.08466	51.93294	94.68
12	-1.10479	51.93770	102.65	28	-1.08331	51.93260	94.50
13	-1.10344	51.93745	102.20	29	-1.08190	51.93237	94.50
14	-1.10204	51.93719	101.77	30	-1.08050	51.93212	94.50
15	-1.10064	51.93694	101.50	31	-1.07915	51.93188	94.78
16	-1.09928	51.93669	101.50	32	-1.07739	51.93134	95.42

Road receptor data

Dwelling Receptor Data

The dwelling receptor data is presented in the table below. An additional 1.8m height has been added to the elevation to account for the eye-level of an observer at these dwellings.

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m) (amsl)
1	-1.09720	51.94142	99.75	13	-1.11519	51.93157	83.46
2	-1.09730	51.94132	100.56	14	-1.11512	51.93148	83.60
3	-1.09738	51.94121	101.34	15	-1.11499	51.93131	83.80
4	-1.11111	51.94380	113.80	16	-1.11494	51.93117	83.80
5	-1.11123	51.94375	113.80	17	-1.11183	51.93193	85.03
6	-1.11269	51.94279	113.14	18	-1.11328	51.93069	83.27
7	-1.11333	51.94260	113.73	19	-1.11263	51.93072	82.80
8	-1.11312	51.93325	86.56	20	-1.08368	51.93743	111.72
9	-1.11609	51.93266	84.49	21	-1.07399	51.94068	102.49

10	-1.11632	51.93248	84.11	22	-1.07358	51.94093	101.91
11	-1.11550	51.93185	83.80	23	-1.07265	51.94099	101.63
12	-1.11531	51.93169	83.49				

Dwelling receptor data

Modelled Reflector Area

The modelled reflector area is presented in the table below.

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.09055	51.93524	-1.09106	51.94668	-1.09106
2	-1.09043	51.93552	-1.09149	51.94665	-1.09149
3	-1.09033	51.93605	-1.09174	51.94659	-1.09174
4	-1.09020	51.93664	-1.09208	51.94629	-1.09208
5	-1.09048	51.93716	-1.09273	51.94565	-1.09273
6	-1.09242	51.93725	-1.09213	51.94546	-1.09213
7	-1.09222	51.93794	-1.09468	51.94253	-1.09468
8	-1.09066	51.93780	-1.09323	51.94209	-1.09323
9	-1.09078	51.93849	-1.09382	51.94146	-1.09382
10	-1.09066	51.93917	-1.09441	51.94077	-1.09441
11	-1.09038	51.93971	-1.09512	51.94008	-1.09512
12	-1.08999	51.94051	-1.09596	51.93937	-1.09596
13	-1.08963	51.94105	-1.09610	51.93933	-1.09610
14	-1.08887	51.94137	-1.09648	51.93883	-1.09648
15	-1.08865	51.94162	-1.10153	51.94003	-1.10153
16	-1.08826	51.94180	-1.10131	51.94050	-1.10131
17	-1.08736	51.94253	-1.10264	51.94082	-1.10264
18	-1.08675	51.94332	-1.10318	51.94048	-1.10318

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
19	-1.08633	51.94352	-1.10419	51.93939	-1.10419
20	-1.08655	51.94371	-1.10542	51.93786	-1.10542
21	-1.08744	51.94689	-1.09055	51.93524	-1.09055

Modelled reflector area

APPENDIX H – DETAILLED MODELLING RESULTS

Overview

The Pager Power charts for receptors are shown on the following pages. Further modelling charts can be provided upon request. Each chart shows:

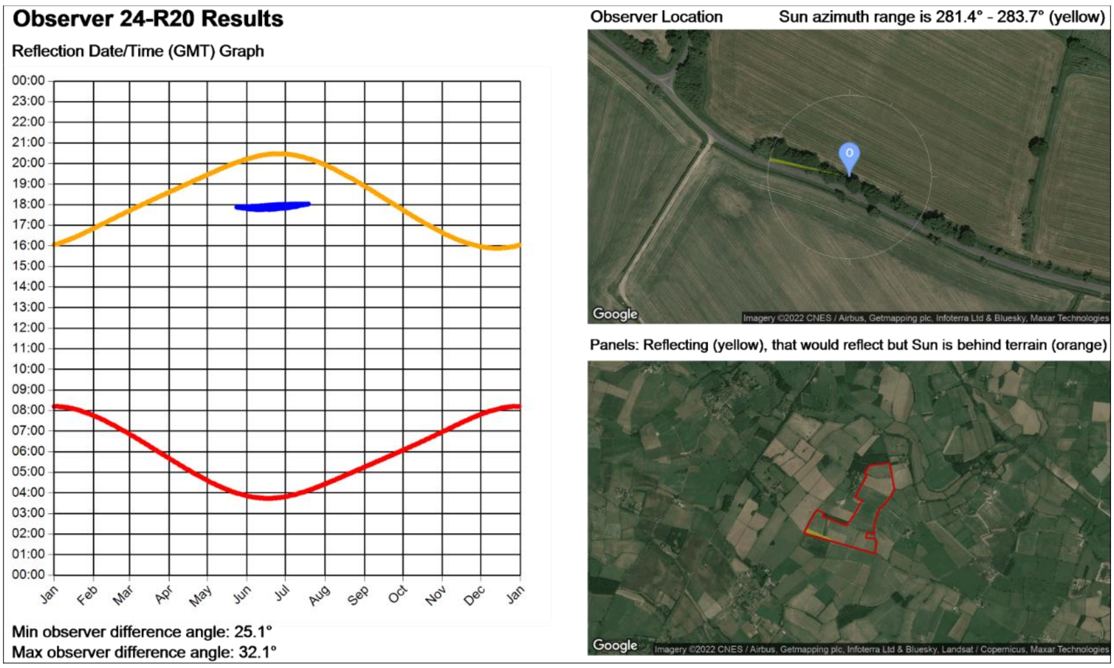
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of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

Full Pager Power modelling results can be provided upon request.

Aviation Receptors – Bicester Airfield

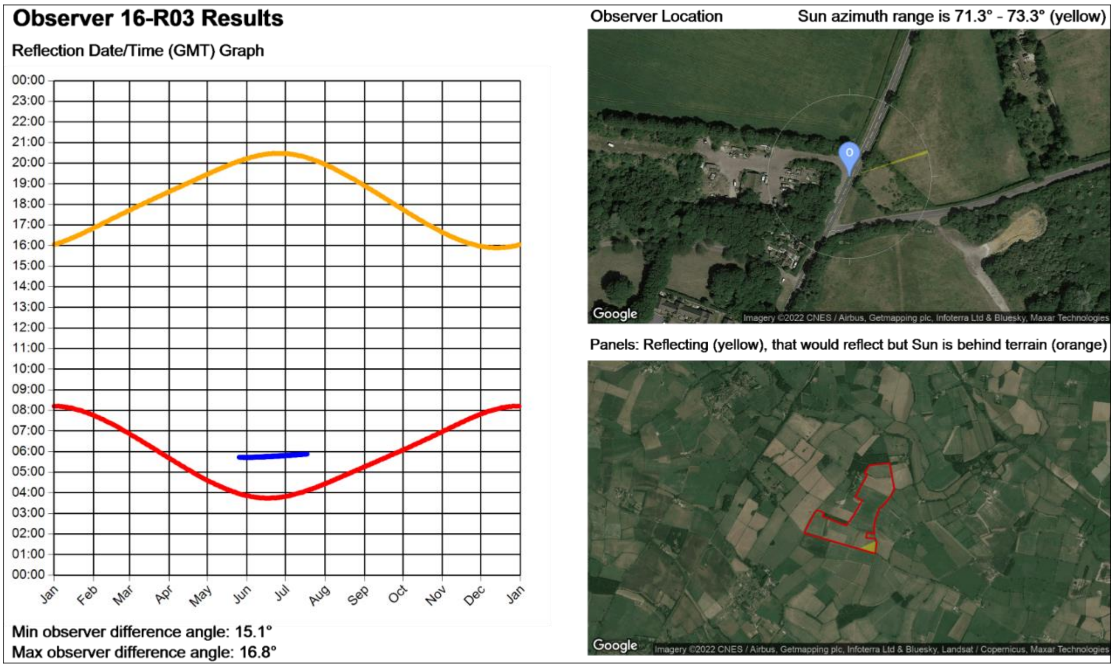
Approach Path Receptors for Runway 24

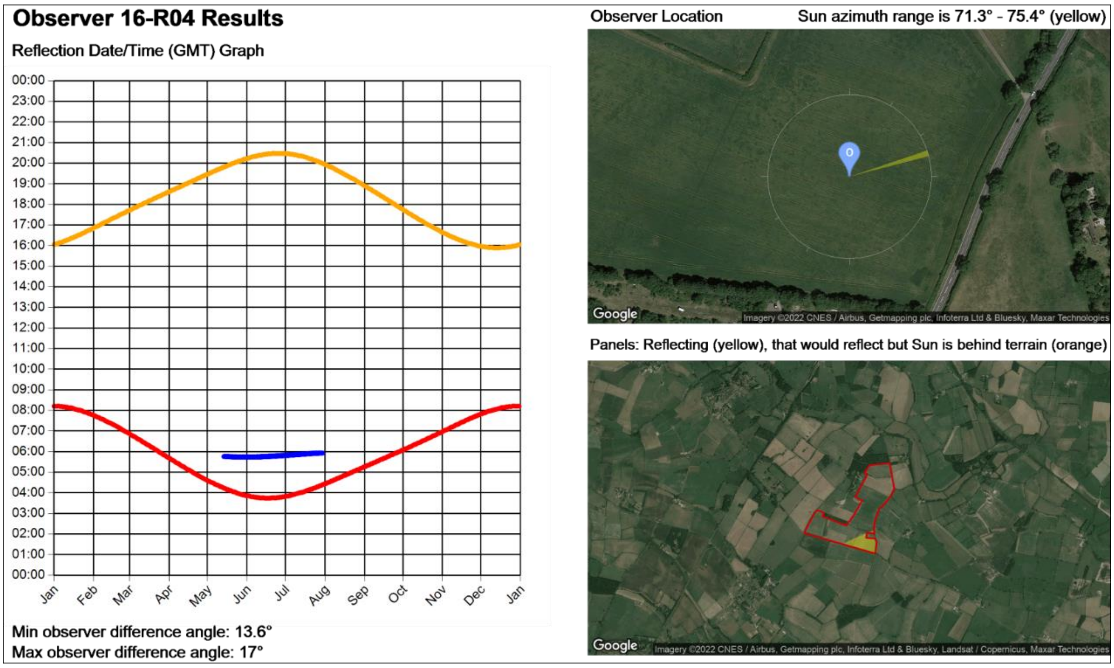
The modelling results are shown for receptors where solar reflections are geometrically possible.



Approach Path Receptors for Runway 16

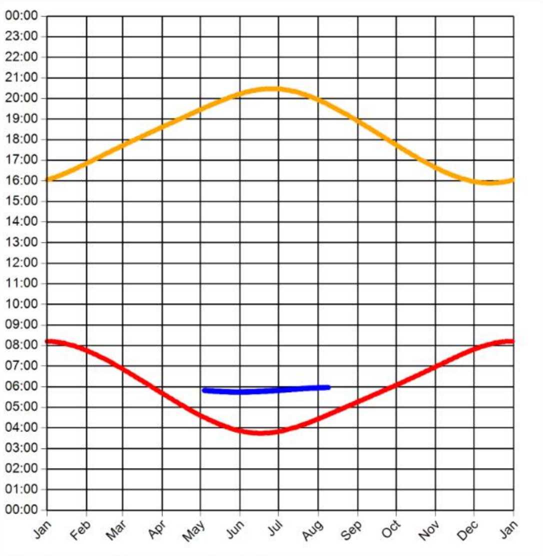
The modelling results are shown for receptors where solar reflections are geometrically possible.





Observer 16-R05 Results

Reflection Date/Time (GMT) Graph



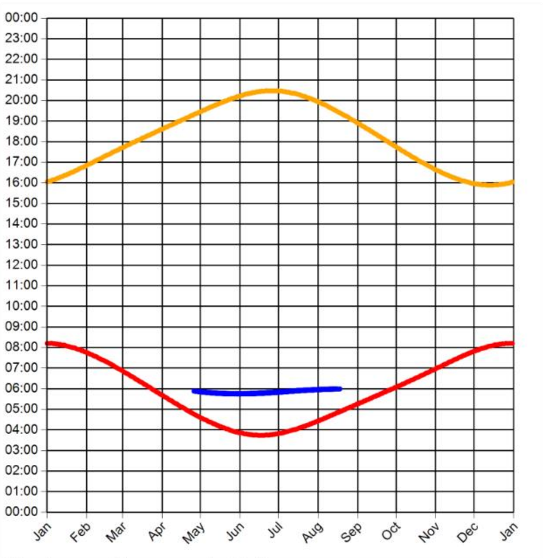
Min observer difference angle: 12.1°
Max observer difference angle: 17.3°

Observer Location — Sun azimuth range is 71.4° - 77.7° (yellow)

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

Observer 16-R06 Results

Reflection Date/Time (GMT) Graph



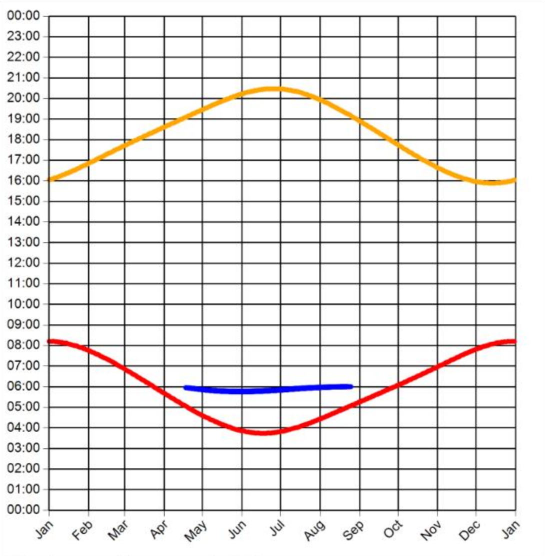
Min observer difference angle: 10.6°
Max observer difference angle: 17.6°

Observer Location — Sun azimuth range is 71.5° - 80.1° (yellow)

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

Observer 16-R07 Results

Reflection Date/Time (GMT) Graph



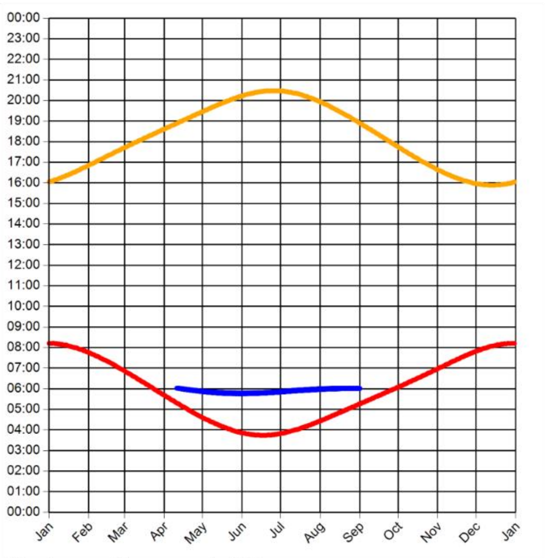
Min observer difference angle: 9.1°
Max observer difference angle: 17.9°

Observer Location | Sun azimuth range is 71.6° - 82.1° (yellow)

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

Observer 16-R08 Results

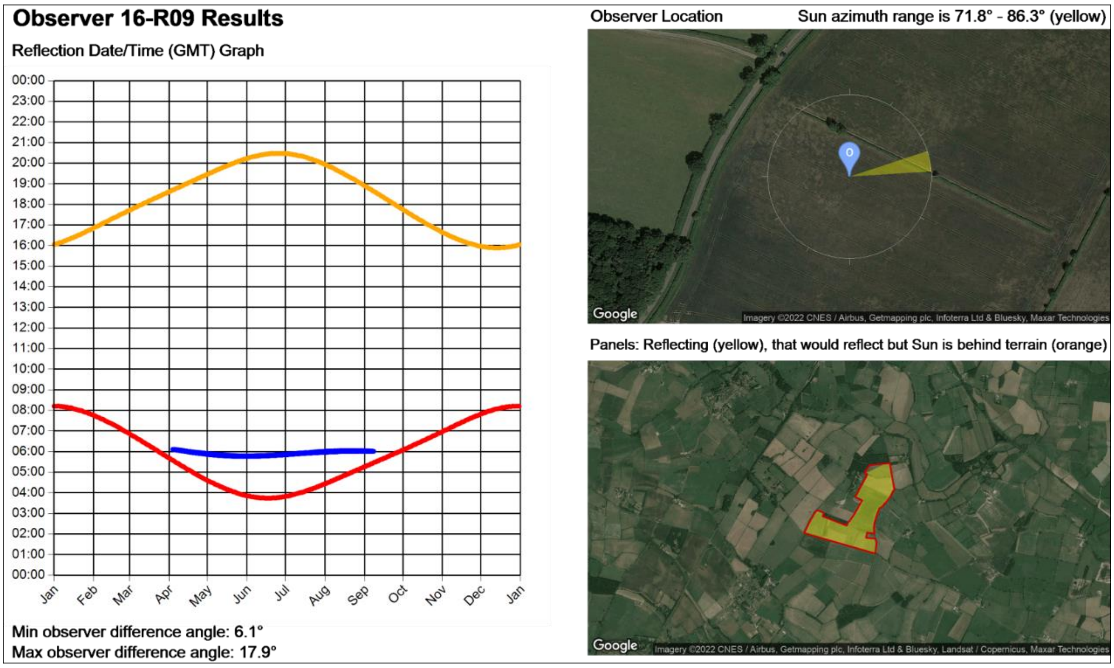
Reflection Date/Time (GMT) Graph

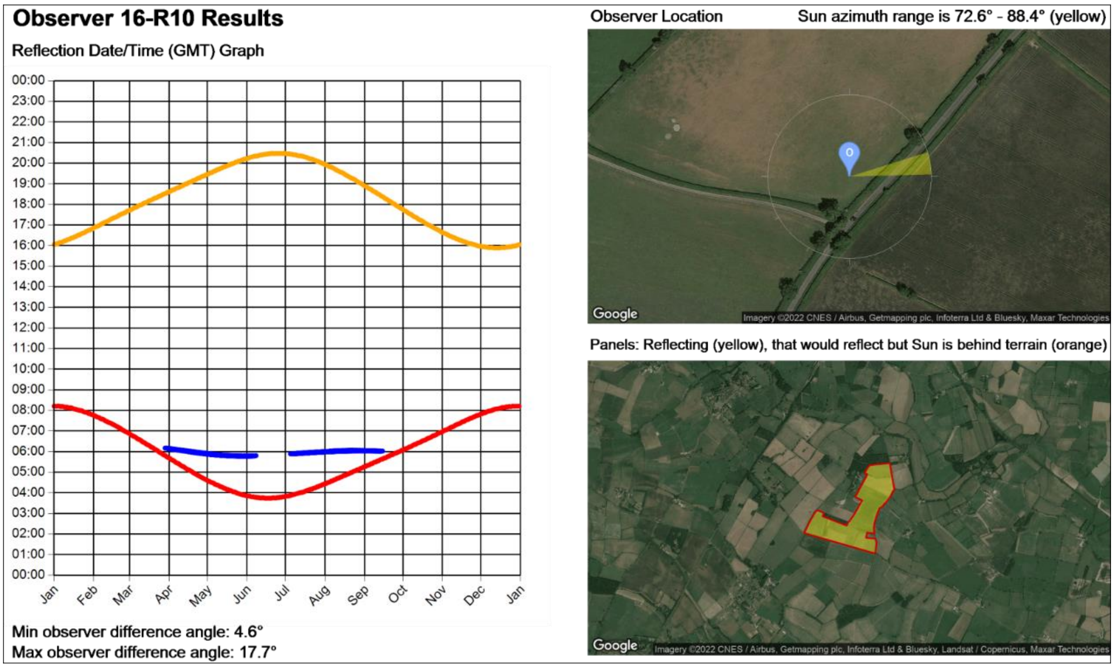


Min observer difference angle: 7.6°
Max observer difference angle: 18°

Observer Location | Sun azimuth range is 71.7° - 84.1° (yellow)

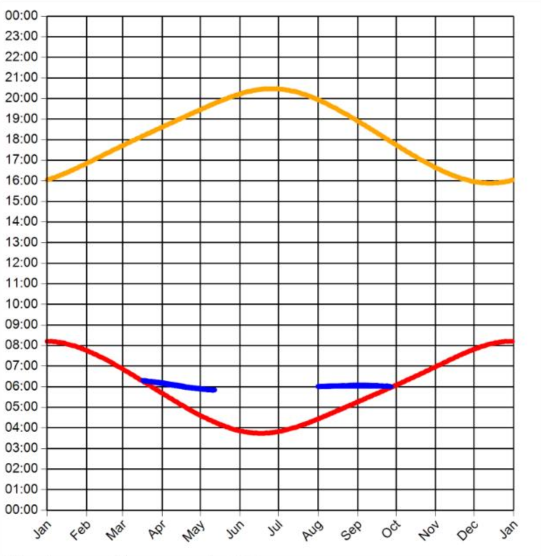
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 16-R09 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 6.1°
Max observer difference angle: 17.9°
Observer Location
Sun azimuth range is 71.8° - 86.3° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 16-R10 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 4.6°
Max observer difference angle: 17.7°
Observer Location
Sun azimuth range is 72.6° - 88.4° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

Observer 16-R12 Results

Reflection Date/Time (GMT) Graph



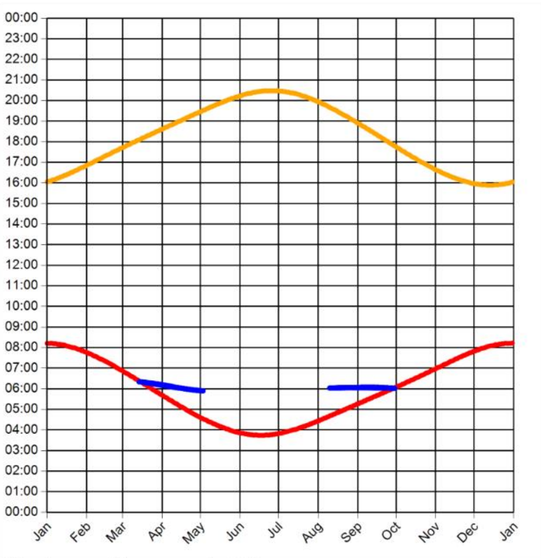
Min observer difference angle: 1.8°
Max observer difference angle: 15°

Observer Location — Sun azimuth range is 76.7° - 91.9° (yellow)

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

Observer 16-R13 Results

Reflection Date/Time (GMT) Graph



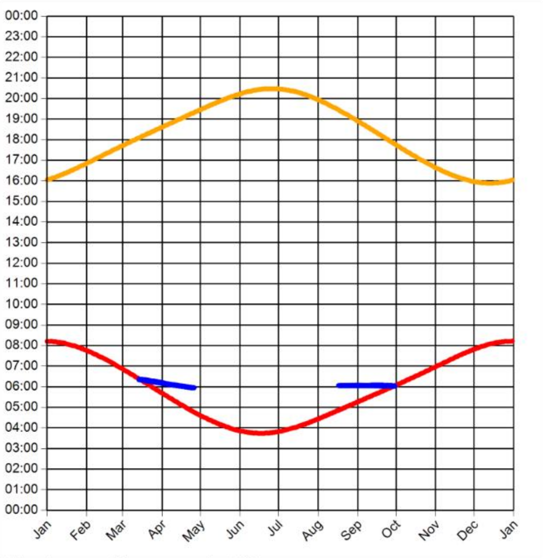
Min observer difference angle: 1.4°
Max observer difference angle: 13.5°

Observer Location — Sun azimuth range is 78.7° - 93° (yellow)

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

Observer 16-R14 Results

Reflection Date/Time (GMT) Graph



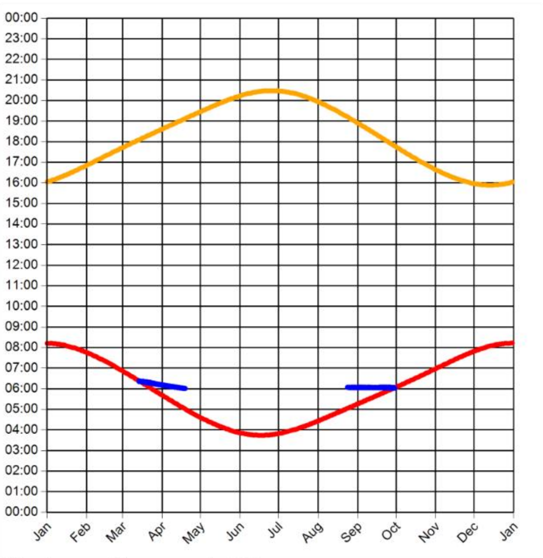
Min observer difference angle: 1.6°
Max observer difference angle: 12.2°

Observer Location — Sun azimuth range is 80.6° - 93.3° (yellow)

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

Observer 16-R15 Results

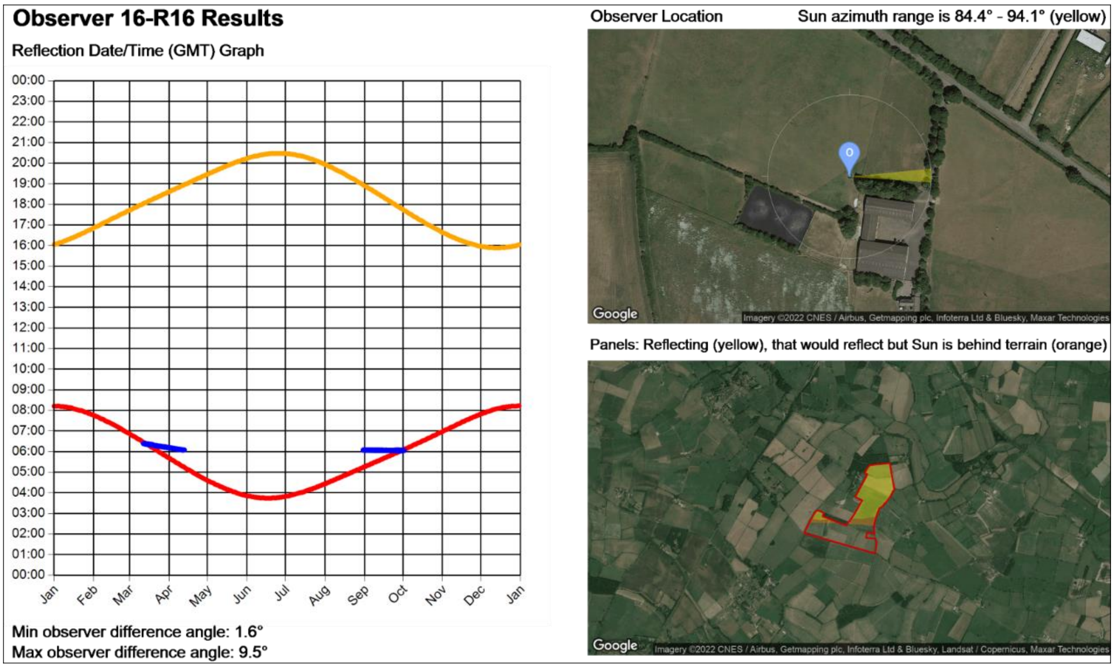
Reflection Date/Time (GMT) Graph

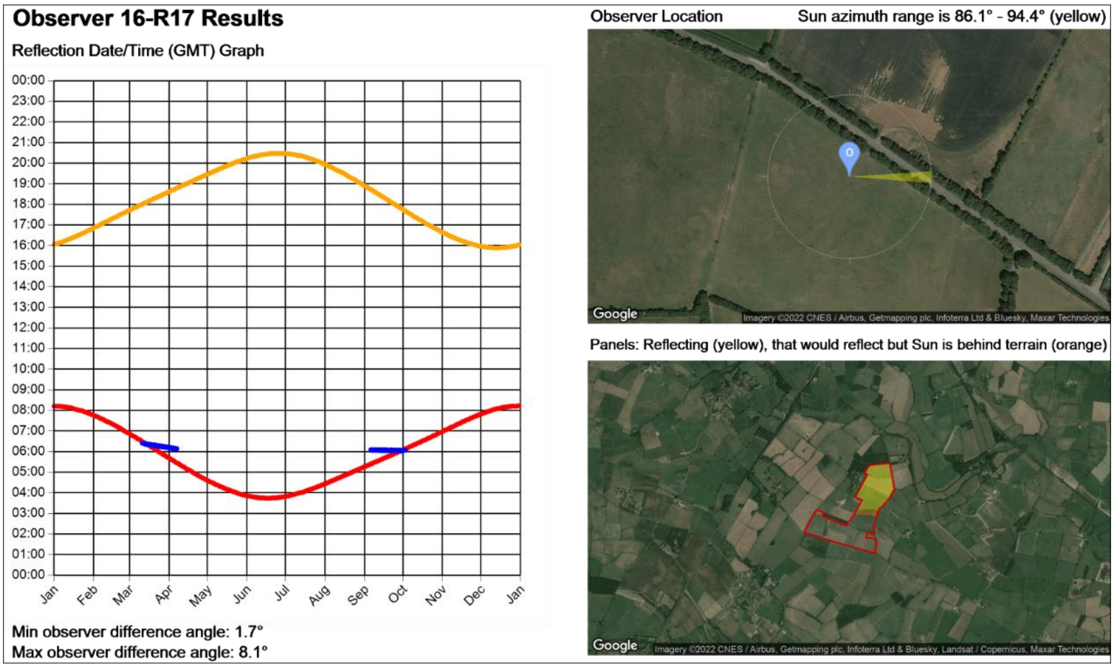


Min observer difference angle: 1.7°
Max observer difference angle: 10.9°

Observer Location — Sun azimuth range is 82.5° - 93.5° (yellow)

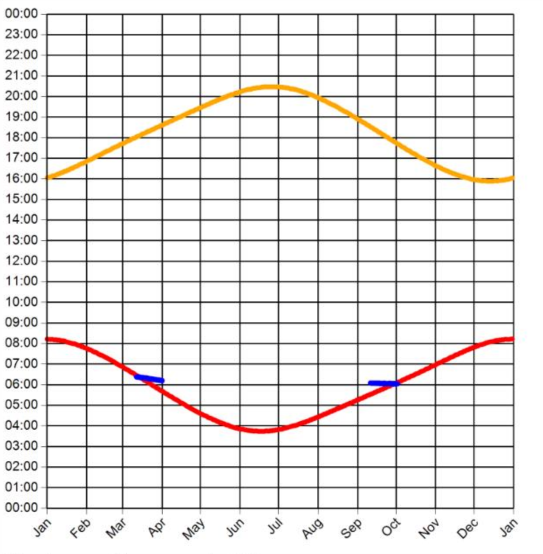
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 16-R16 Results
Reflection Date/Time (GMT) Graph
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 1.6°
Max observer difference angle: 9.5°
Observer Location
Sun azimuth range is 84.4° - 94.1° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 16-R17 Results
Reflection Date/Time (GMT) Graph
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 1.7°
Max observer difference angle: 8.1°
Observer Location
Sun azimuth range is 86.1° - 94.4° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

Observer 16-R18 Results

Reflection Date/Time (GMT) Graph



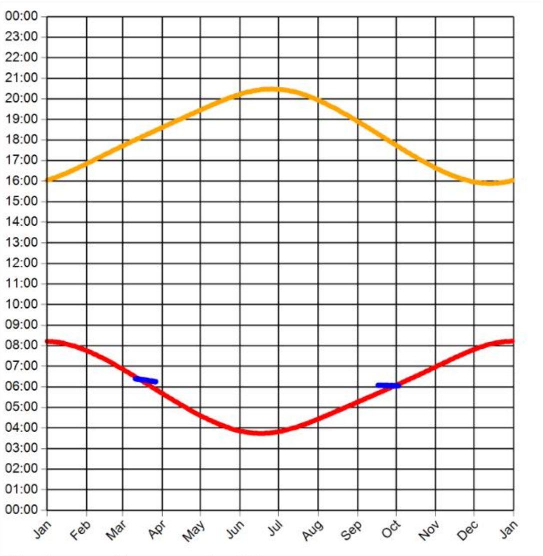
Min observer difference angle: 1.5°
Max observer difference angle: 7°

Observer Location | Sun azimuth range is 87.8° - 93.9° (yellow)

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

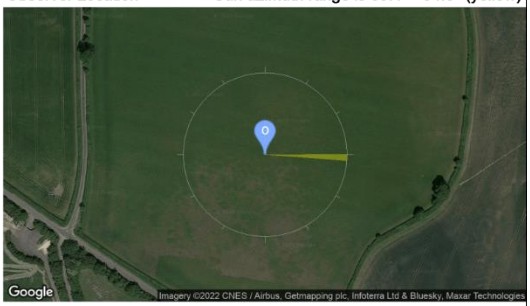
Observer 16-R19 Results

Reflection Date/Time (GMT) Graph

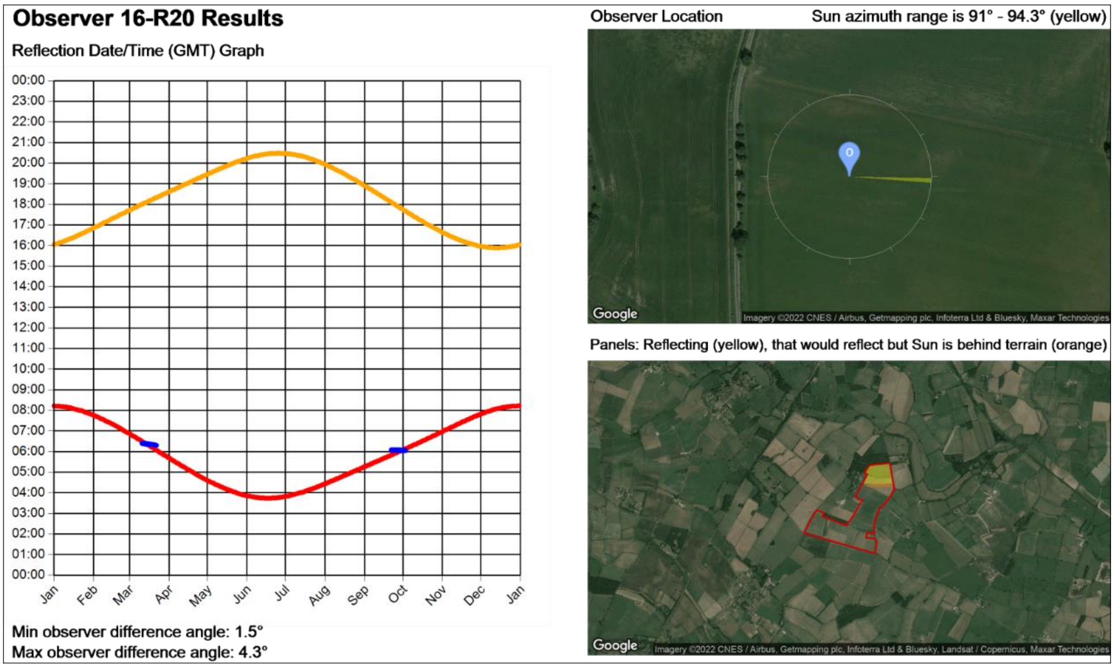


Min observer difference angle: 1.5°
Max observer difference angle: 5.6°

Observer Location | Sun azimuth range is 89.4° - 94.3° (yellow)

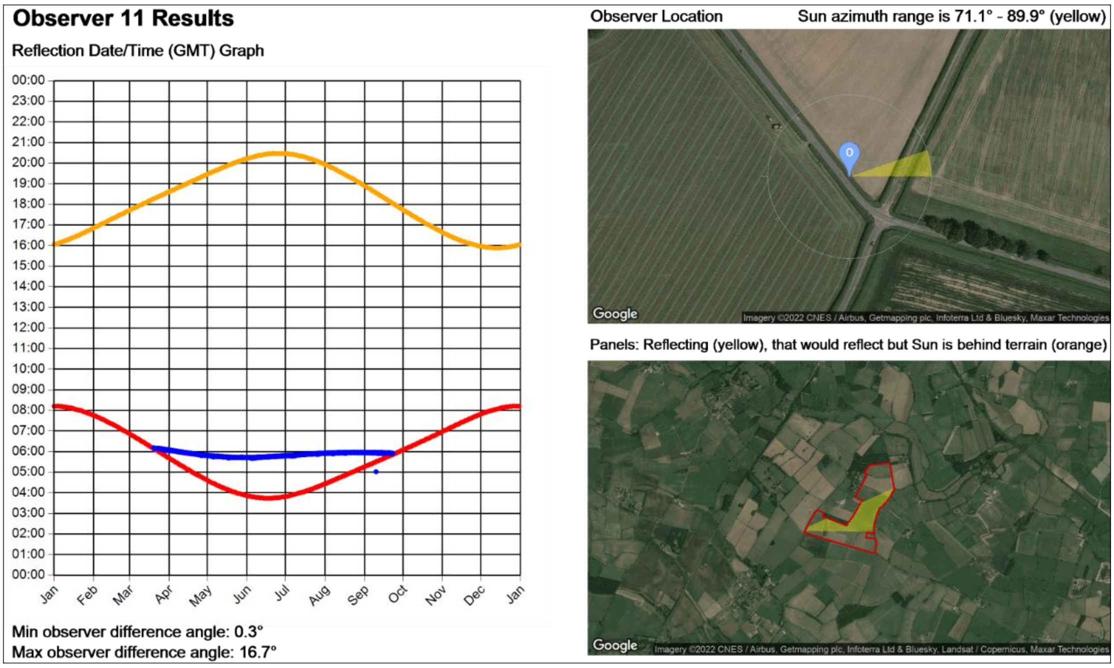


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



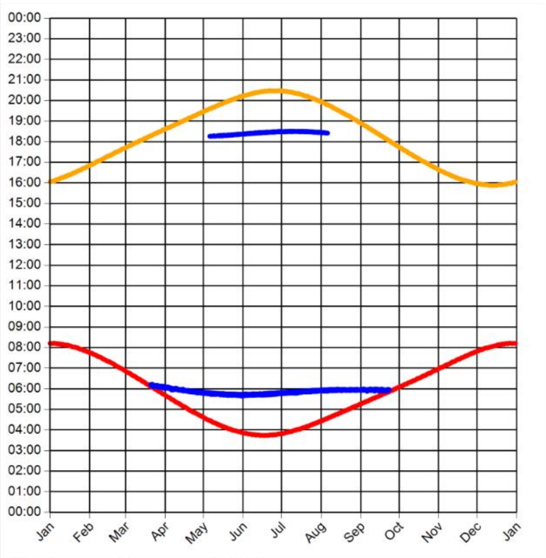
Road Receptors

The modelling results are shown for the receptors for Figures 18 to 20 in the report.



Observer 16 Results

Reflection Date/Time (GMT) Graph



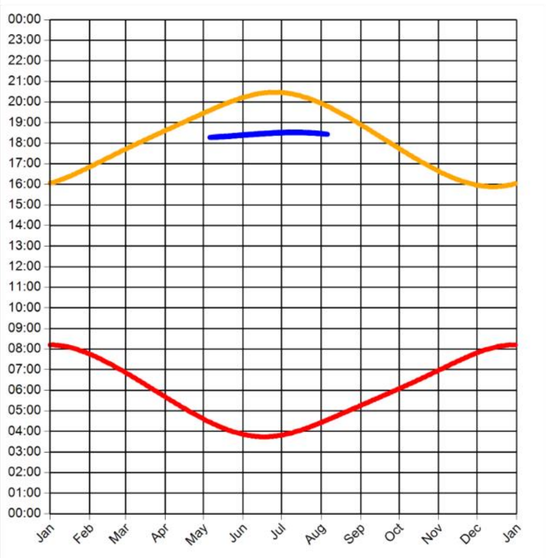
Min observer difference angle: 0.3°
Max observer difference angle: 16.9°

Observer Location — Sun azimuth ranges (yellow)

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

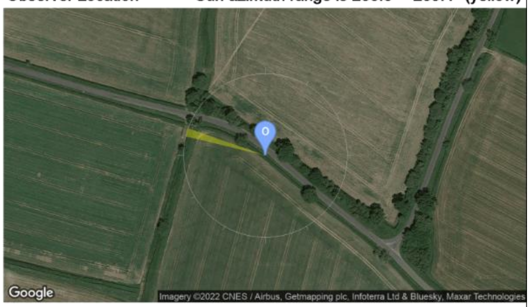
Observer 23 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 10.9°
Max observer difference angle: 15.5°

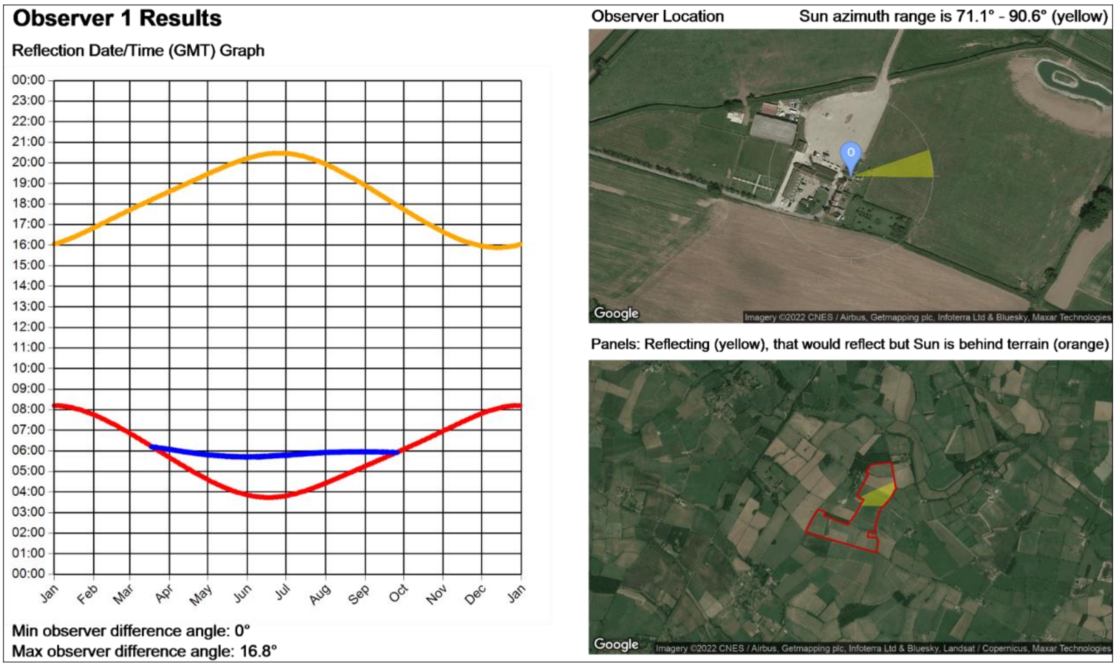
Observer Location — Sun azimuth range is 283.5° - 289.4° (yellow)

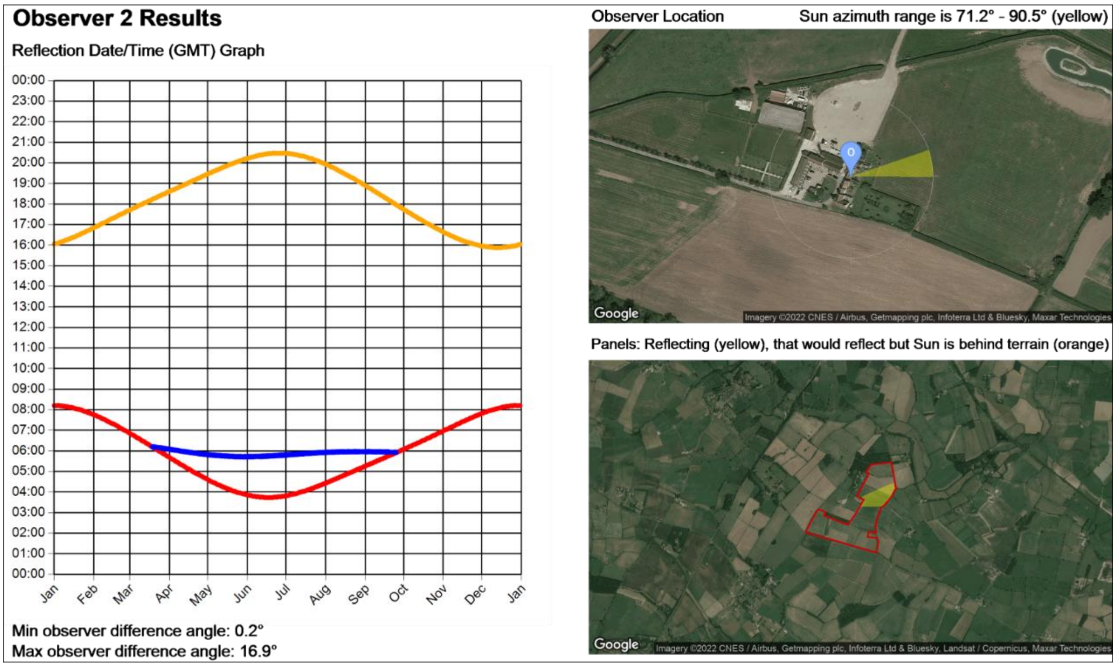


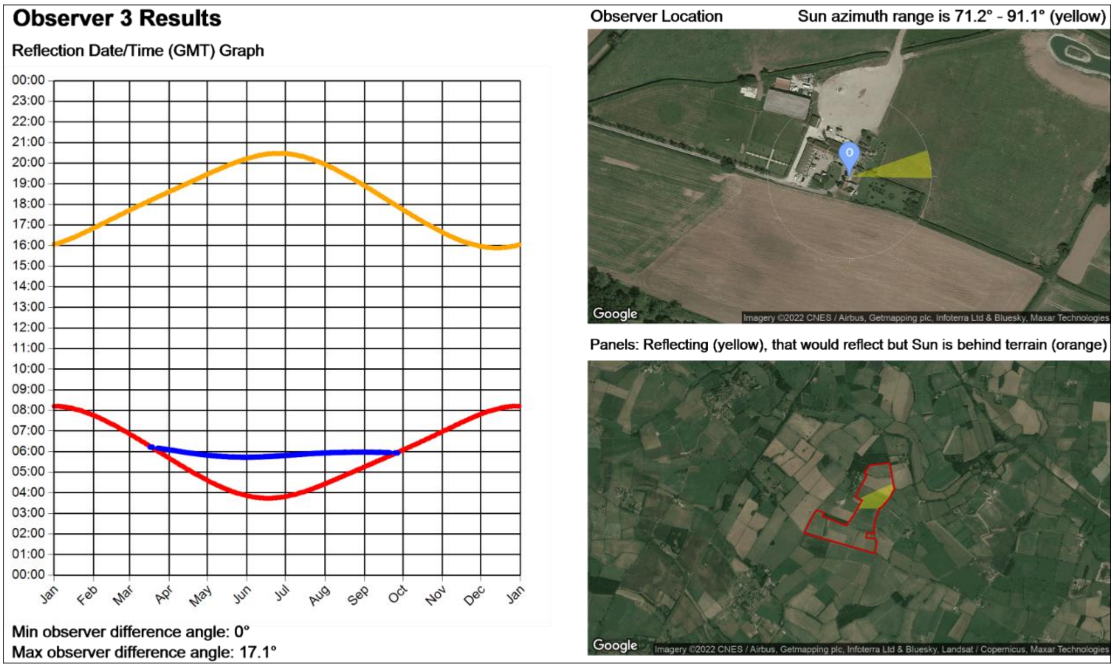
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

Dwelling Receptors

The modelling results are shown for the dwellings where mitigation is recommended.






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: 0°
Max observer difference angle: 17.1°
Observer Location
Sun azimuth range is 71.2° - 91.1° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

PAGERPOWER
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