

Solar Photovoltaic Glint and Glare Study

EQUANS Regeneration Ltd.

Barkham Ride Solar

August 2024

PLANNING SOLUTIONS FOR:

- Solar
- Telecoms
- Railways
- Defence
- Buildings
- Wind
- Airports
- Radar
- Mitigation

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1	March 2024	Initial issue
2	July 2024	Consideration of landscape designs
3	August 2024	Administrative revisions

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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 south of Barkham, Berkshire, England. This assessment pertains to the possible impacts upon road safety, residential amenity, public rights of way, and aviation activity associated with Blackbushe Airport, Farnborough Airport, Hatchgate Farm Airfield, and Hopkilm Farm Airfield.

Overall Conclusions

No significant impacts are predicted upon road safety, residential amenity, public rights of way, or aviation activity associated with Blackbushe Airport and Farnborough Airport. Mitigation is not recommended.

Guidance and Studies

Guidelines exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. The UK CAA guidance is relatively high-level and does not prescribe a formal methodology. There is no formal planning guidance for the assessment of solar reflections from solar panels towards roads and nearby dwellings. Pager Power has however produced guidance for glint and glare and solar photovoltaic developments, which was published in early 2017, with the fourth edition¹ published in 2022. This 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 where appropriate in line with the Sandia National Laboratories' FAA methodology². 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 steel³.

¹ Pager Power Glint and Glare Guidance, Fourth Edition, September 2022.

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).

Assessment Conclusions – Blackbushe Airport

Air Traffic Control Tower

Solar reflections are not geometrically possible towards the Air Traffic Control (ATC) Tower at Blackbushe Airport. No impact is predicted, and mitigation is not required.

Approach Paths for Runway 07/25

Solar reflections are not geometrically possible towards the 2-mile approach paths for runway 07/25. No impact is predicted, and mitigation is not required.

Assessment Conclusions – Farnborough Airport

Air Traffic Control Tower

Solar reflections are not geometrically possible towards the ATC Tower at Farnborough Airport. No impact is predicted, and mitigation is not required.

Approach Paths for Runway 06/24

Solar reflections are not geometrically possible towards the 2-mile approach paths for runway 06/24. No impact is predicted, and mitigation is not required.

Assessment Conclusions – Road Safety

Solar reflections are geometrically possible towards a 2.1km section of Barkham Ride.

Screening in the form of existing and proposed vegetation and/or existing buildings are predicted to significantly obstruct views of the reflecting panels for sections totalling 2.0km such that no reflections will be experienced by road users in practice. No impact is predicted upon this section of road.

For the remaining 100m section, screening in the form of existing and proposed vegetation is predicted to partially obstruct views of reflecting panels such that only fleeting views are considered possible at a site entrance. A low impact is predicted upon this section of road.

Assessment Conclusions – Residential Amenity

Solar reflections are geometrically possible towards 49 of the assessed 78 dwellings.

Screening in the form of existing vegetation that significantly obstructs views of the reflecting panels has been identified for 46 dwellings. No impact is predicted upon these dwellings and mitigation is not required.

For two dwellings, reflections are predicted to occur for more than three months per year but less than sixty minutes on a given day. Screening in the form of existing vegetation is predicted to significantly obstruct views of the reflecting panels from the ground floor. Reflections are also predicted to mostly coincide with direct sunlight. As such a low impact is predicted and mitigation is not recommended.

For the remaining dwelling, reflections are predicted to occur for more than three months per year but less than sixty minutes on a given day. Screening in the form of intervening terrain has been identified that obstructs views of the reflecting panels such that the duration of effects are predicted to be reduced to less than three months per year in practice. As such a low impact is predicted and mitigation is not recommended.

Overall, a low impact is predicted, and mitigation is not recommended.

Assessment Conclusions – Public Rights of Way

The modelling has shown that solar reflections are geometrically possible towards all 14 of the assessed Public Rights of Way viewpoints.

In Pager Power's experience, significant impacts to pedestrians/observers using the surrounding public rights of way are not possible due to glint and glare effects from PV developments. The reasoning is due to the sensitivity of the receptors (in terms of amenity and safety) being concluded to be of low significance. This is because:

- The typical density of pedestrians located at these points is low in a rural environment;
- Any resultant effect is much less serious and has far lesser consequences than, for example, solar reflections experienced towards a road network whereby the resultant impacts of a solar reflection can be much more serious;
- Glint and glare effects towards an observer are transient, and time and location sensitive whereby a pedestrian could move beyond the solar reflection zone with ease with little impact upon safety or amenity;
- Any observable solar reflection towards an observer would be of similar intensity to those experienced whilst navigating the natural and built environment on a regular basis.

Overall, no significant impact on observers using the surrounding public rights of way is predicted and therefore mitigation is not required.

Assessment Conclusions – High-Level Aviation

The proposed development size, distance between the aerodrome and proposed development, and industry experience, have been considered to determine the impact during the assessment.

The following can be concluded for Hatchgate Farm Airfield and Hopkiln Farm Airfield with regards to the proposed development:

- Solar reflections originating from the proposed development towards the approach paths for Hatchgate Farm Airfield and Hopkiln Farm Airfield will be outside a pilot's primary field-of-view (50 degrees either side of the direction of travel) or have glare intensities no greater than 'low potential for temporary after-image'. This is acceptable in accordance with the associated guidance (Appendix D) and industry best practice pertaining to approach paths;
- Solar reflections originating from the proposed development towards the final sections of the visual circuits and joins for Hatchgate Farm Airfield and Hopkiln Farm Airfield will have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for visual circuits and joins.

No significant impacts are predicted upon aviation activity associated with Hatchgate Farm Airfield and Hopkiln Farm Airfield. Detailed modelling is not recommended. Mitigation is not required.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 59 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 south of Barkham, Berkshire, England. This assessment pertains to the possible impacts upon road safety, residential amenity, public rights of way, and aviation activity associated with Blackbushe Airport, Farnborough Airport, Hatchgate Farm Airfield, and Hopkilm Farm Airfield.

This report contains the following:

- Solar development details;
- Explanation of glint and glare;
- Overview of relevant guidance and studies;
- Assessment methodology;
- Identification of receptors;
- Glint and glare assessment for identified receptors;
- Results discussion;
- High-level assessment of aviation activity;
- Overall conclusions and recommendations.

1.2 Pager Power's Experience

Pager Power has undertaken over 1,400 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 definition⁴ of glint and glare is as follows:

- 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 presented within the National Policy Statement for Renewable Energy Infrastructure (EN-3) – published by the Department for Energy Security and Net Zero in November 2023 and the Federal Aviation Administration in the USA.

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Overview

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

2.2 Proposed Development Site Layout

Figures 1 and 2 below on the following page shows the site layout⁵ for the proposed development. Solar panels are outlined as blue rectangles, existing vegetation to be maintained and/or enhanced⁶ as part of the landscape strategy, which has been considered as part of this assessment, is shown by the green areas.

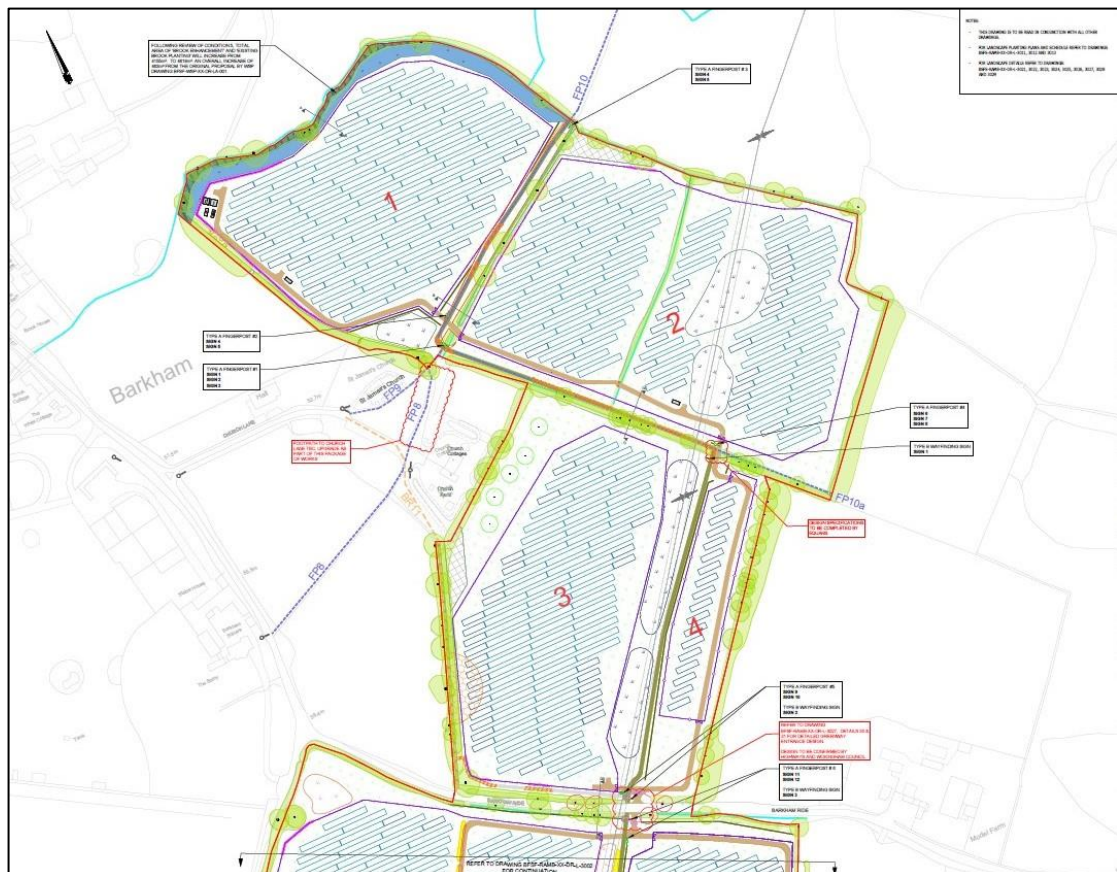


Figure 1 Northern site layout

⁵ Source: BFSF-RAMB-XX-DR-L-3001.pdf (cropped)
BFSF-RAMB-XX-DR-L-3002.pdf (cropped)

⁶ Including hedgerows to be maintained to a height of 2.4m agl
Solar Photovoltaic Glint and Glare Study



Figure 2 Southern site layout

2.3 Solar Panel Technical Information

Summarised below is the technical information of the modelled solar panels used in the assessment.

- Azimuth angle⁷: 180° (South facing);
- Elevation angle⁸: 15.5°;
- Assessed centre height⁹: 1.438m above ground level.

⁷ Direction the panels are facing relative to True North (0°)

⁸ Pitch above horizontal

⁹ Relative to the lowest (0.8m) and highest (2.075m) points above ground level

2.4 Reflector Areas

The bounding coordinates for the proposed development have been extrapolated from the site plans. The data can be found in Appendix G. Figure 3 below shows the assessed reflector areas that has been used for modelling purposes.



Figure 3 Assessed reflector areas (labelled)

The Pager Power model has used a resolution of 12m for this assessment. This means that a geometric calculation is undertaken for each identified receptor every 12m 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 as being generated from adjacent or nearby panels within the proposed solar development.

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Overview

The following sub-sections provide a general overview with respect to the guidance studies and methodology which informs this report. Pager Power has also produced its own Glint and Glare Guidance⁸ which draws on assessment experience, consultation and industry expertise.

3.2 Guidance and Studies

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

- Specular reflections of the Sun from solar panels and glass 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 still water and similar to those from glass. It also shows that reflections from solar panels are significantly less intense than many other reflective surfaces, which are common in an outdoor environment, including steel¹⁰.

3.3 Background

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

3.4 Methodology

3.4.1 Pager Power's Methodology

The glint and glare assessment methodology has been derived from the information provided to Pager Power through consultation with stakeholders and by reviewing the available guidance, studies and Pager Power's practical experience. The methodology for this glint and glare assessment is as follows:

- Identify receptors in the area surrounding the proposed development;
- Consider direct solar reflections from the proposed development towards the identified receptors by undertaking geometric calculations;
- Consider the visibility of the reflectors from the receptor's location. If the reflectors 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 the solar reflection intensity, if appropriate;

¹⁰ SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy,2010).

- Consider both the solar reflection from the proposed 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;
- Determine whether a significant detrimental impact is expected in line with Appendix D.

Within the Pager Power model, the reflector area is defined, as well as the relevant receptor locations. The result is a chart that states whether a reflection can occur, the duration and the panels that can produce the solar reflection towards the receptor.

Where a solar reflection is identified for an aviation approach path receptor, intensity calculations are completed in line with the Sandia National Laboratories methodology.

3.4.2 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.

3.5 Assessment Methodology and Limitations

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

4 IDENTIFICATION OF RECEPTORS

4.1 Overview

The following sections present the relevant receptors geometrically modelled for and assessed within this report. Terrain data has been interpolated based on Ordnance Survey of Great Britain (OSGB) 50 Digital Terrain Model (DTM) data. The receptor details for all receptors are presented in Appendix G.

4.2 Blackbushe Airport & Farnborough Airport Information

Blackbushe Airport is a Civil Aviation Authority (CAA) licensed airport, situated approximately 6.5km south of the proposed development, with an Air Traffic Control (ATC) Tower and one operational runway, the details¹¹ of which are presented below:

- 07/25 measuring 1,285 metres by 46 metres (asphalt).

Farnborough Airport is a Civil Aviation Authority (CAA) licensed airport, situated approximately 13.4km southeast of the proposed development, with an ATC Tower and one operational runway, the details¹¹ of which are presented below:

- 02/20 measuring 2,440 metres by 45 metres (asphalt).

The aerodrome charts for Blackbushe Airport and Farnborough Airport are shown in Figures 4 and 5 on the following pages.

Farnborough Airport has been taken forward for geometric modelling within this report despite being located outside the 10km assessment area for aviation receptors. No significant impacts are predicted at this distance as solar reflections are highly unlikely, and where they do occur, are predicted to be of very low intensity. Geometric modelling has been conducted by request.

4.2.1 ATC Towers

It is standard practice to determine whether a solar reflection can be experienced by personnel within the ATC Tower Visual Control Room. Further details regarding the assessment of ATC Towers are presented in Section 5.2.2.

The location of the ATC Tower receptor at Blackbushe Airport and Farnborough Airport are shown in Figures 6 and 7 respectively, on pages 22 and 23.

¹¹ Source: NATS AIP (last accessed March 2024)
Solar Photovoltaic Glint and Glare Study

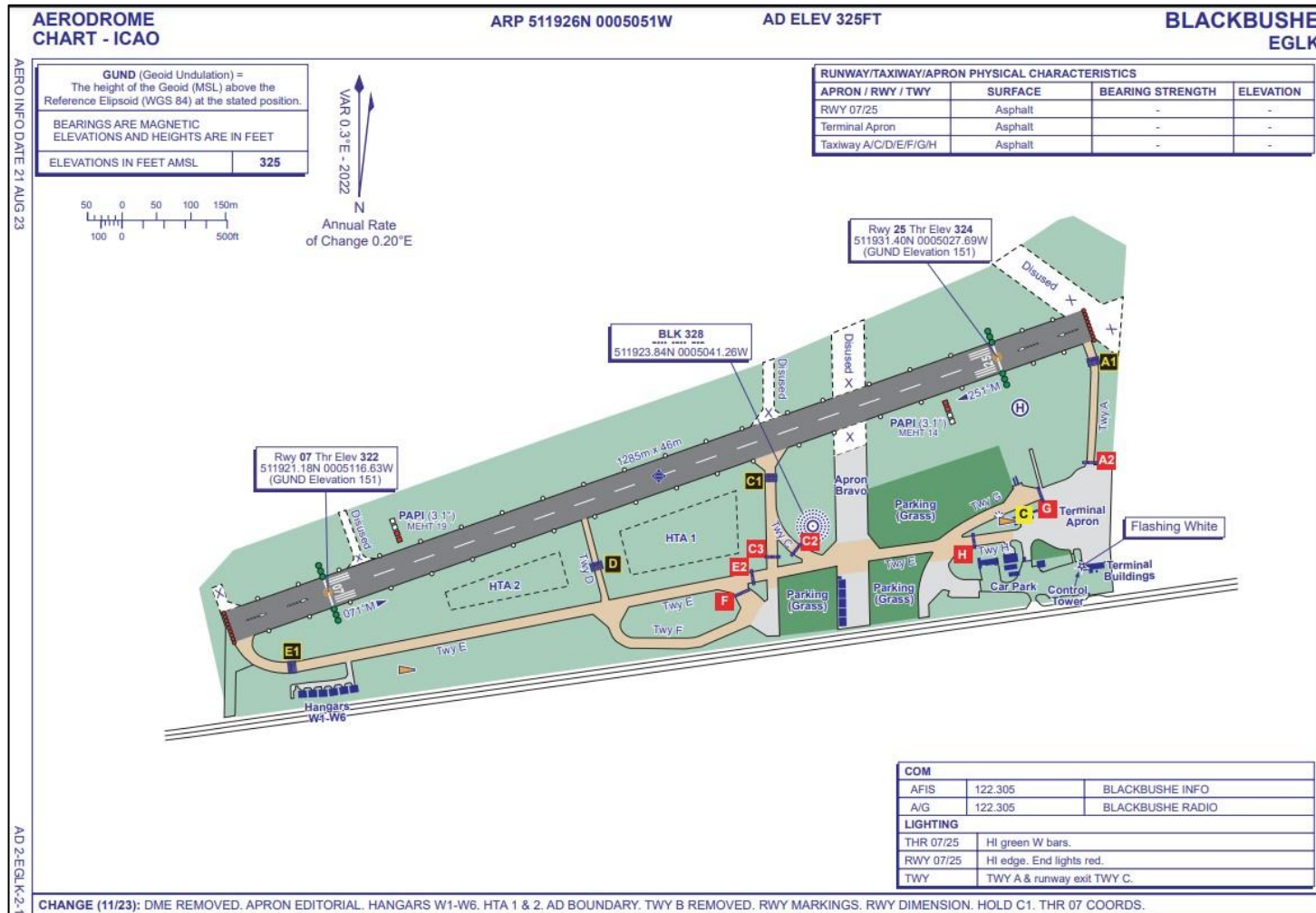


Figure 4 Blackbushe Airport aerodrome chart

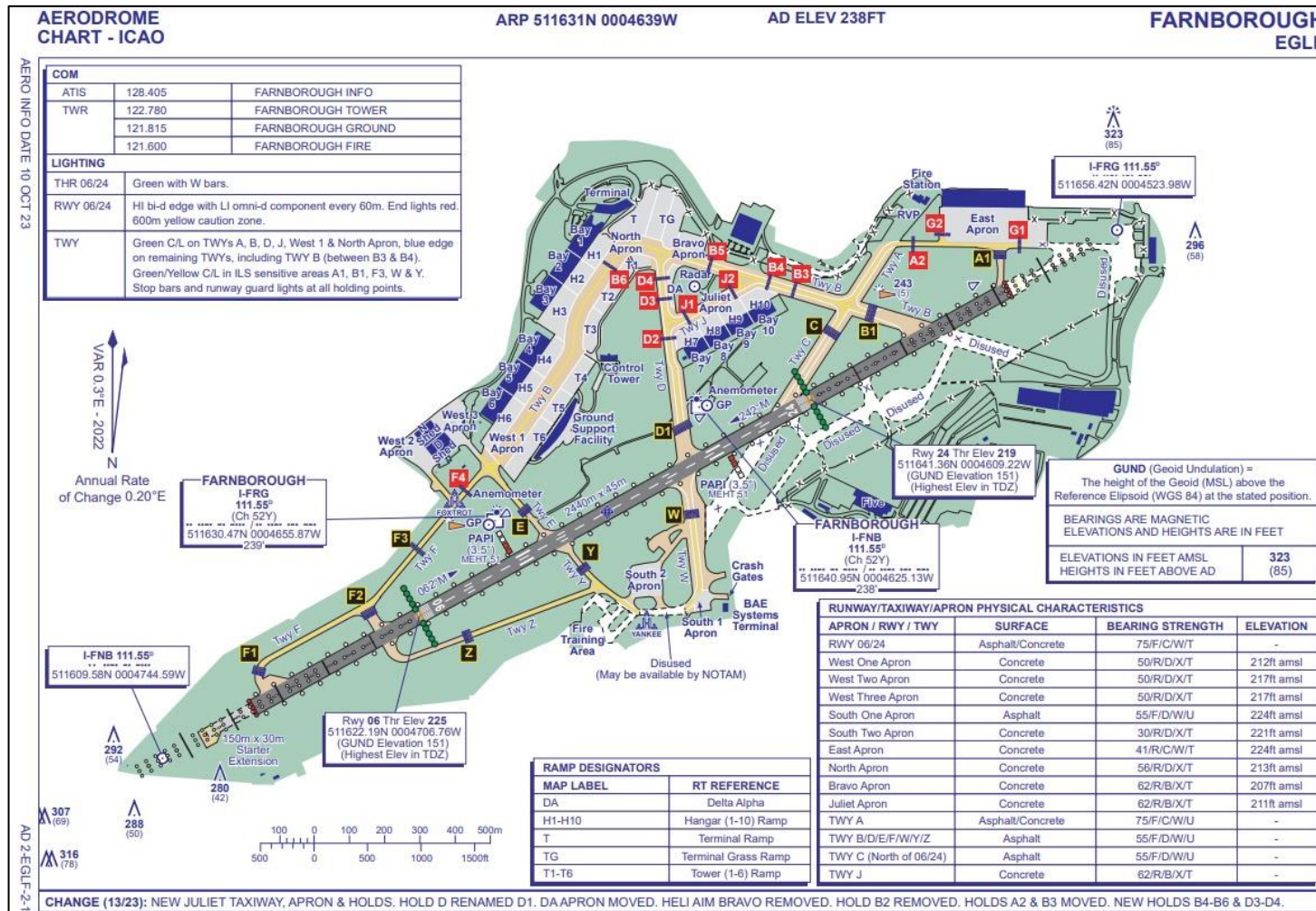


Figure 5 Farnborough Airport aerodrome chart



Figure 6 Blackbushe ATC Tower location on ariel imagery, with Streetview imagery

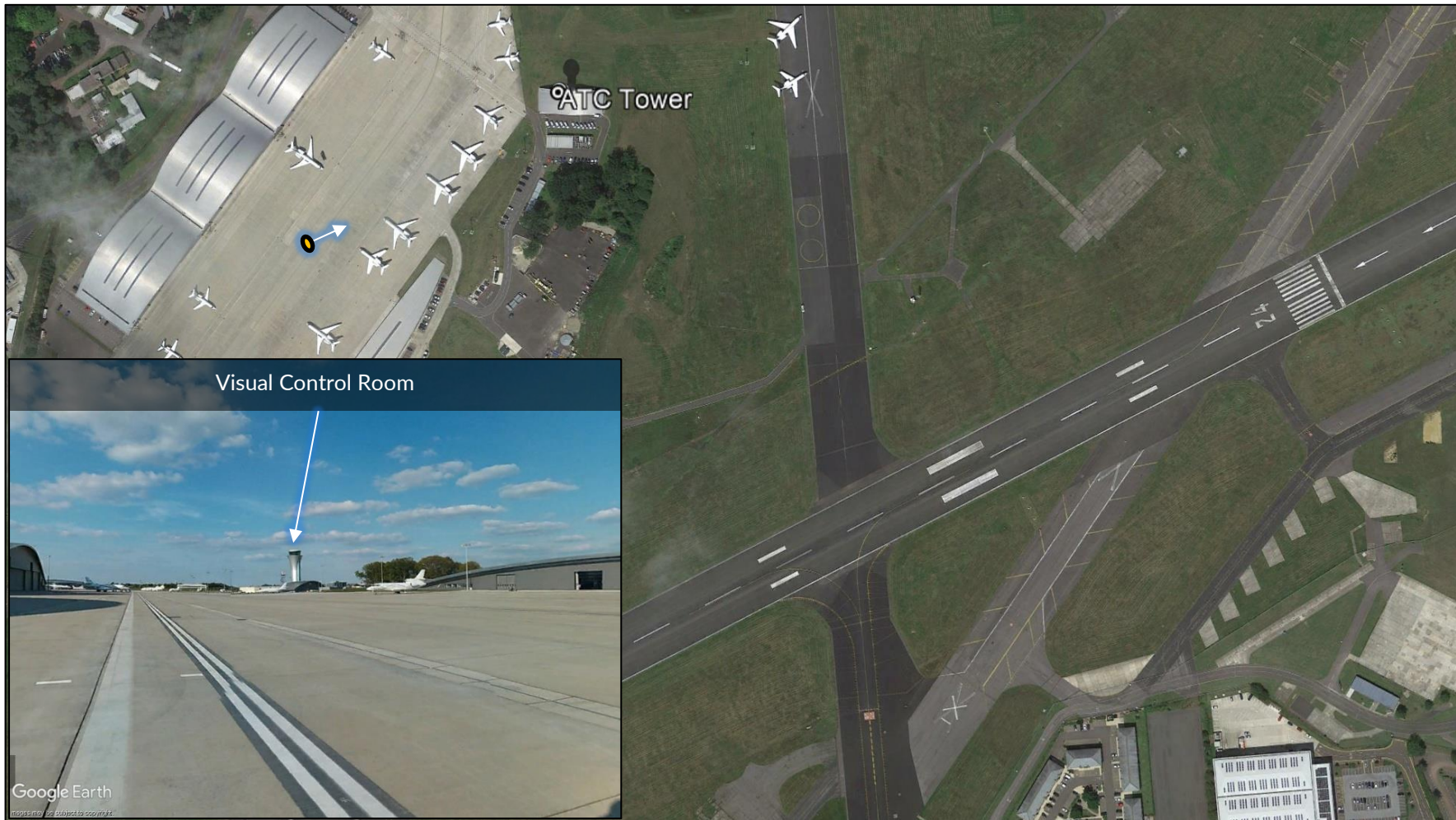


Figure 7 Farnborough ATC Tower location on aerial imagery, with ground-based imagery

4.2.2 Runway Approach Paths

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.

Blackbushe Airport and Farnborough Airport each have one operational runway with two associated approach paths per runway, one for each bearing. 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 altitude of the aircraft is determined by using:

- 3.1-degree descent path relative to 50 ft above the runway threshold for approach paths 07/25 at Blackbushe Airport;
- 3.5-degree descent path relative to 50 ft above the runway threshold for approach paths 06/24 at Farnborough Airport.

The assessed receptors for the runway approach paths at Blackbushe Airport and Farnborough Airport are shown in Figures 8 and 9 respectively, on the following pages.



Figure 8 Blackbushe Airport approach path receptors

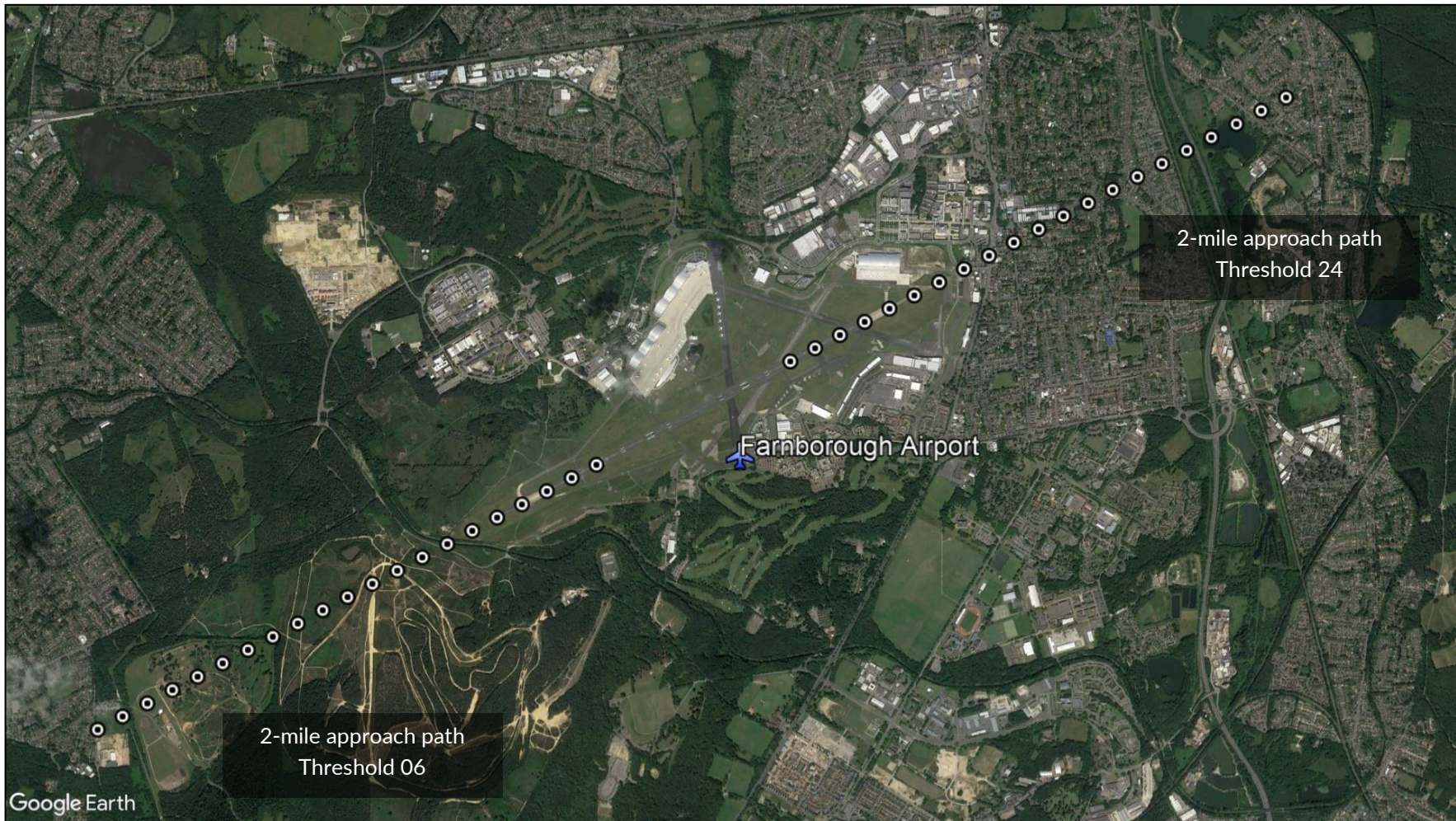


Figure 9 Farnborough Airport approach path receptors

4.3 Ground Based Receptors Overview

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

The above parameters and industry experience over a significant number of glint and glare assessments undertaken, shows that a 1km assessment area from the proposed development is considered appropriate for glint and glare effects on road users and dwellings. Reflections towards ground-based receptors located further north than any proposed panel are highly unlikely¹². Therefore, receptors north of the most northern panel areas have not been modelled. The assessment area (yellow outlined area in the figures on the following pages) has been designed accordingly as 1km from the proposed development, disregarding the area to the north of the north-most solar panels.

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

4.4 Road Receptors

4.4.1 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:

¹² For fixed, south-facing panels at this latitude.

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

4.4.2 Identified Road Receptors

A section of Barkham Ride, totalling approximately 2.1km, has been identified within the assessment area, shown by the orange line in Figure 10 below.

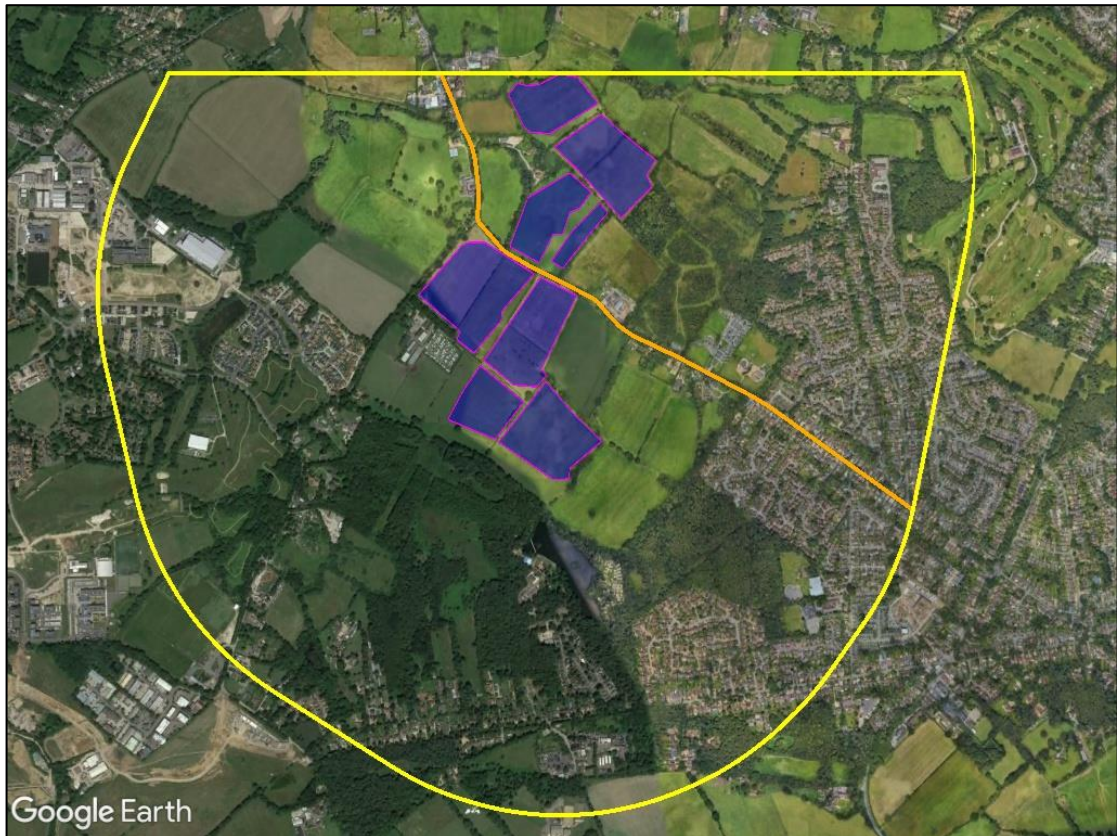


Figure 10 Identified roads within assessment area

Figure 11 on the following page shows the road receptors along Barkham Ride. Receptors are placed approximately 100m apart along the road section. An additional height of 1.5m is added to the terrain height to account for the eye-level¹³ of a typical road user.

¹³This fixed height for the road receptors is for modelling purposes. Small changes to the modelling height by a few metres is not expected to significantly change the modelling results. Views for elevated drivers are also considered in the results discussion, where appropriate.



Figure 11 Road receptors along Barkham Ride

4.5 Dwelling Receptors

4.5.1 Dwelling Receptors Overview

The analysis has considered dwellings that:

- Are within the one-kilometre assessment area;
- 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, at worst, 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.

4.5.2 Identified Dwelling Receptors

An overview of the assessed dwelling receptors is shown in Figure 12 on the following page. In total, 78 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 floor¹⁴.

¹⁴ This fixed height for the dwelling receptors is for modelling purposes. Changes to the modelling height by a few metres is not expected to significantly change the modelling results. Views above ground floor are considered in the results discussion where necessary.

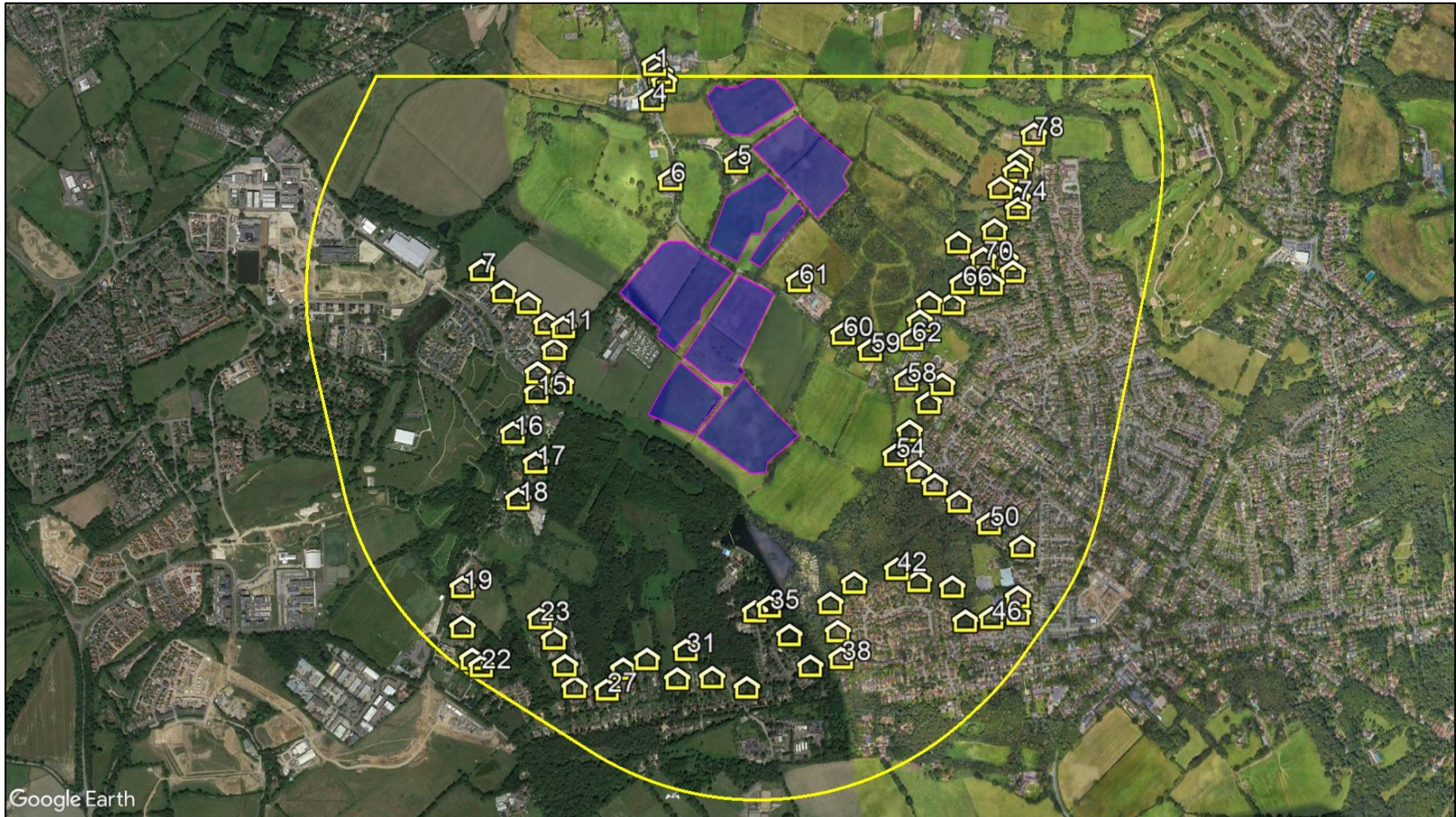


Figure 12 Dwelling receptor overview

4.6 Public Rights of Way Receptors

4.6.1 Public Right of Way Overview

The analysis normally considers public rights of way that:

- Are within, or close to one kilometre of the proposed development;
- Have a potential view of the panels.

Within the site boundary¹⁵ lies a “greenway” to be used by pedestrians and horse riders that is located between several panel areas. An assessment of possible glint and glare effects upon pedestrians and horse riders has been included by request.

The British Horse Society has produced guidance¹⁶ which discusses the potential impacts of glare and glint from solar farms on horses and equestrian activities, highlighting the need for careful consideration during planning and construction, as well as the importance of implementing measures to mitigate potential issues.

4.6.2 Public Right of Way Receptors

The section of a greenway, totalling approximately 1.3km, is shown by the pale blue line in Figure 13 on the following page.

Geometric modelling for this greenway has been conducted by request. Receptors have been placed at regular intervals of approximately 100m. Receptors have been assessed at two heights above ground, 1.8m and 2.6m to model a range of potential users of the greenway, including both pedestrians and horse riders.

¹⁵ See site plan; BFSF-DETR-XX-DR-Y1-0001 Rev1 Solar PV Layout.pdf

¹⁶ [Advice on solar farms](#), The British Horse Society, 2017



Figure 13 Greenway path within proposed development

5 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

5.1 Overview

The following sections present:

- The key considerations for each receptor type. The criteria are determined by the assessment process for each receptor, which are set out in Appendix D;
- Geometric modelling results of the assessment based solely on bare-earth terrain i.e., without consideration of screening in the form of buildings, dwellings, (existing or proposed) vegetation, and/or terrain. The modelling output for receptors, shown in Appendix H, presents the precise predicted times and the reflecting panel areas;
- Whether a reflection will be experienced in practice. When determining the visibility of the reflecting panels for an observer, a conservative review of the available imagery, landscape strategy plan, google earth viewshed (high-level terrain analysis), and/or site photography (if available) is undertaken, whereby it is assumed views of the panels are possible if it cannot be reliably determined that existing and/or proposed screening will remove effects. Detailed screening analysis may be undertaken to determine visibility, where appropriate;
- The impact significance and any mitigation recommendations/requirements;
- The desk-based review of the available imagery, where appropriate.

5.2 Aviation Considerations

5.2.1 Glare Intensity Categorisation

The Pager Power and Forge models have been used to determine whether reflections are possible for aviation receptors. Intensity calculations (Forge Model) in line with the Sandia National Laboratories methodology have been undertaken. 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 1 below along with the associated colour coding.

Coding Used	Intensity Key
Glare beyond 50°	'Glare occurs outside a pilot's primary field-of-view'
'Green'	'Low potential for temporary after-image'
'Yellow'	'Potential for temporary after-image'
'Red'	'Potential for permanent eye damage'

Table 1 Glare intensity designation

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 the assessment of a variety of solar panel surface materials. This assessment has considered solar panels with a surface material of 'smooth glass with an anti-reflective coating'. It is understood that this is the most commonly used solar panel surface material. Other surfaces that could be modelled include:

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

Appendix H presents the results charts showing specific times and dates.

5.2.2 Key Considerations – Air Traffic Control (ATC) Tower

The process for determining the impact significance is defined in Appendix D. For an ATC Tower, the key considerations are:

- Whether a reflection is predicted to be experienced in practice;
- Whether a reflection is predicted to be operationally significant in practice or not.

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

Glare of any kind towards an ATC Tower was formerly not permissible under the interim guidance provided by the Federal Aviation Administration in the USA¹⁷ for on-airfield solar. Pager Power recommends a pragmatic approach to consider glare towards the ATC Tower in an operational context. Where solar reflections are of an intensity of 'low potential for temporary after-image' (green glare) expert assessment of the following factors is required to determine the impact significance¹⁸:

- The likely traffic volumes and level of safeguarding at the aerodrome. Licensed aerodromes typically have higher traffic volumes and are formally safeguarded;
- The time of day at which glare is predicted and whether the ATC Tower be operational at these times;
- The duration of any predicted glare; as glare that is experienced for low durations throughout the year is less significant than longer durations;
- Glare location relative to key operational areas;
- The relative size of the reflecting panel area and whether the reflecting area takes up a large percentage of an ATC controller's field-of-view¹⁹;

¹⁷ This FAA guidance from 2013 has since been superseded by the FAA guidance in 2021 whereby airports are tasked with determining safety requirements themselves.

¹⁸ This approach taken is reflective of the changes made in the 2021 FAA guidance; however, it should be noted that this guidance states that it is up to the airport to determine the safety requirements themselves. Therefore, an airport may not accept any glare towards an ATC Tower.

¹⁹ 210 degrees azimuth field-of-view.

- The location of the source of glare relative to the position of the Sun at the times and dates in which solar reflections are geometrically possible – effects that coincide with direct sunlight appear less prominent than those that do not;
- The level of predicted effect relative to existing sources of glare – a solar reflection is less noticeable by ATC controllers when there are existing reflective surfaces in the surrounding environment.

Following consideration of these mitigating factors, where the solar reflection does not remain significant, a low impact is predicted, and mitigation is not recommended. Where the solar reflection remains significant or where glare is of an intensity of 'potential for temporary after-image' (yellow glare) is predicted, the impact significance is moderate, and mitigation is recommended.

Where solar reflections are of an intensity of 'potential for temporary after-image', the impact significance is high, and mitigation is required.

5.2.3 Key Considerations – Runway Approach Paths

The process for determining impact significance is defined in Appendix D. For the runway approach paths, the key considerations are:

- Whether a reflection is predicted to be experienced in practice;
- The location of glare relative to a pilot's primary field-of-view (FOV), which is defined as 50 degrees either side of the approach bearing;
- The intensity of glare for the solar reflections:
 - Glare with 'low potential for temporary after-image' ('green' glare).
 - Glare with 'potential for temporary after-image' ('yellow' glare).
 - Glare with 'potential for permanent eye damage' ('red' glare).
- Whether a reflection is predicted to be operationally significant in practice or not.

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

Where solar reflections are of an intensity no greater than 'low potential for temporary after-image' (green glare) or occur outside of a pilot's primary field-of-view (50 degrees either side of the runway approach relative to the runway threshold), the impact significance is low, and mitigation is not required.

Glare with 'potential for a temporary after-image' (yellow glare) was formerly not permissible under the interim guidance provided by the Federal Aviation Administration in the USA²⁰ for on-airfield solar. Pager Power recommends a pragmatic approach whereby instances of 'yellow' glare are evaluated in a technical and operational context. Where solar reflections are of an

²⁰ This FAA guidance from 2013 has since been superseded by the FAA guidance in 2021 whereby airports are tasked with determining safety requirements themselves.

intensity of 'potential for temporary after-image' expert assessment of the following mitigating factors is required to determine the impact significance²¹:

- The likely traffic volumes and level of safeguarding at the aerodrome – licensed aerodromes typically have higher traffic volumes and are formally safeguarded;
- The time of day at which glare is predicted and whether the aerodrome will be operational such that pilots can be on the approach at these times;
- The duration of any predicted glare – glare that occurs for low durations throughout the year is less likely to be experienced than glare that occurs for longer durations throughout the year;
- The location and size of the reflecting panel area relative to a pilot's primary field-of-view;
- The location of the source of glare relative to the position of the Sun at the times and dates in which solar reflections are geometrically possible – effects that coincide with direct sunlight appear less prominent than those that do not;
- The level of predicted effect relative to existing sources of glare – a solar reflection is less noticeable by pilots when there are existing reflective surfaces in the surrounding environment.

Following consideration of these mitigating factors, where the solar reflection does not remain significant, a low impact is predicted, and mitigation is not recommended; however, consultation with the aerodrome is recommended to understand their position along with any feedback or comments regarding the proposed development.

Where the solar reflection remains significant, the impact significance is moderate, and mitigation is recommended. Where solar reflections are of an intensity greater than 'potential for temporary after-image', the impact significance is high, and mitigation is required.

5.3 Assessment Results – Aviation Receptors

5.3.1 Geometric Modelling Results and Discussion

Tables 2 and 3 on the following pages presents the following for Blackbushe Airport and Farnborough Airport respectively:

- Geometric modelling results;
- Glare intensity;
- Predicted impact significance.

²¹ This approach taken is reflective of the changes made in the 2021 FAA guidance; however, it should be noted that this guidance states that it is up to the airport to determine the safety requirements themselves. Therefore, an airport may not accept any yellow glare towards approach paths.

Aviation Receptor	Geometric Modelling Result	Glare Intensity	Predicted Impact
ATC Tower	Solar reflections are not geometrically possible from the proposed development	N/A	No impact
2-mile Approach Path Runway 07	Solar reflections are not geometrically possible from the proposed development	N/A	No impact
2-mile Approach Path Runway 25	Solar reflections are not geometrically possible from the proposed development	N/A	No impact

Table 2 Geometric modelling results – Blackbushe Airport receptors

Aviation Receptor	Geometric Modelling Result	Glare Intensity	Predicted Impact
ATC Tower	Solar reflections are not geometrically possible from the proposed development	N/A	No impact
2-mile Approach Path Runway 06	Solar reflections are not geometrically possible from the proposed development	N/A	No impact
2-mile Approach Path Runway 24	Solar reflections are not geometrically possible from the proposed development	N/A	No impact

Table 3 Geometric modelling results – Farnborough Airport receptors

5.4 Assessment Results – Road Receptors

5.4.1 Key Considerations

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

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

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

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

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

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

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

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

5.4.2 Geometric Modelling Results and Discussion

Table 4 on the following pages present the following:

- Geometric modelling results (bare earth terrain i.e. without consideration of screening);
- Desk-based review of identified screening;
- Consideration of relevant factors where appropriate;
- Predicted impact significance.

Reference to a driver's field-of-view (FOV) is made when analysing the geometric modelling results and overall predicted impact significance, which is defined as 50 degrees horizontally either side relative to the direction of travel.

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections remain inside a road user's primary FOV (with consideration of screening) ²²	Mitigating Factors	Predicted Impact Classification
1 – 5	Solar reflections are <u>geometrically possible</u> and occur <u>outside</u> a road user's primary FOV	Existing vegetation and/or buildings predicted to significantly obstruct views of reflecting panels	N/A	N/A	No impact
6 – 7	Solar reflections are <u>geometrically possible</u> and occur <u>inside</u> a road user's primary FOV	Existing and/or proposed vegetation predicted to significantly obstruct views of reflecting panels	N/A	N/A	No impact
8 – 9	Solar reflections are <u>geometrically possible</u> and occur <u>inside</u> a road user's primary FOV	Existing and proposed vegetation predicted to partially obstruct views of reflecting panels Fleeting views through a site entrance are considered possible	Remaining solar reflections occur <u>outside</u> a road user's primary FOV	N/A	Low impact

²² Assessment scenario may include an initial conservative qualitative consideration of screening. The reflecting area of the solar development may be partially screened such that it does not meet the key criteria i.e. whether the solar reflection occurs within a road users' main field of view.

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections remain inside a road user's primary FOV (with consideration of screening) ²²	Mitigating Factors	Predicted Impact Classification
10 – 22	Solar reflections are <u>geometrically possible</u> and occur <u>inside</u> a road user's primary FOV	Existing and/or proposed vegetation, and/or buildings predicted to significantly obstruct views of reflecting panels	N/A	N/A	No impact

Table 4 Geometric Modelling Results - Road Receptors

5.4.3 Desk-Based Review of Available Imagery

A desk-based review of the available imagery is presented in Figures 14 to 19 on the following pages. The cumulative reflecting panel areas are indicated by regions of yellow. Identified screening has been outlined; in the form of existing vegetation (green), proposed vegetation (purple), and buildings (blue). Streetview images are used to show the point-of-view of a road user at specific locations, with blue triangles to illustrate the main field-of-view and direction of travel.



Figure 14 Screening for road receptors 1 to 3, with representative Streetview imagery from receptor 3



Figure 15 Screening for road receptors 4 to 6, with representative Streetview imagery from receptor 6



Figure 16 Screening for road receptors 7 to 9, considering existing and proposed screening

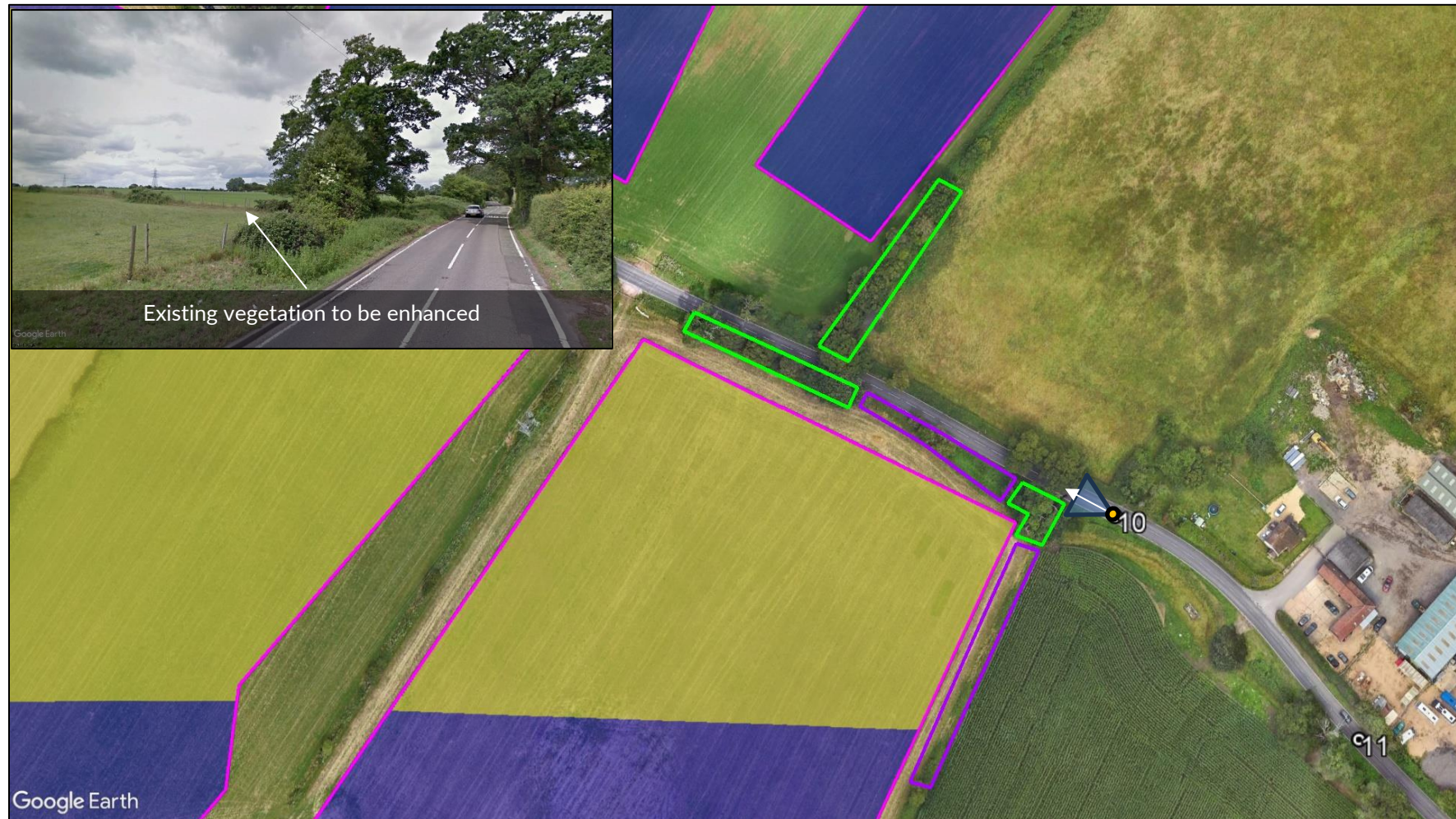


Figure 17 Screening for road receptors 10 and 11, considering existing and proposed screening



Figure 18 Screening for road receptors 12 to 16, with Streetview imagery from receptor 12



Figure 19 Screening for road receptors 17 to 22, with representative Streetview imagery from receptor 17

5.5 Assessment Results – Dwelling Receptors

5.5.1 Key Considerations

The key considerations for residential dwellings 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 on any given day.

Where solar reflections are not geometrically possible, or the reflecting panels are predicted to be significantly obstructed from view, no impact is predicted, and mitigation is not required.

Where effects are predicted to occur for less than three months per year and less than 60 minutes on any given day, or the closest reflecting panel is over 1km from the dwelling, the impact significance is low, and mitigation is not recommended.

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

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

If effects are predicted to last for more than 3 months per year and for more than 60 minutes on any given day, and there are no mitigating factors, the impact significance is high, and mitigation is required.

5.5.2 Geometric Modelling Results and Discussion

Solar reflections are geometrically possible towards 49 of the 78 assessed dwellings.

Table 5 on the following page presents the following:

- Geometric modelling results (bare earth terrain i.e. without consideration of screening);
- Desk-based review of identified screening;
- Consideration of any relevant factors present, where appropriate;
- Predicted impact significance.

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening) ²³	Mitigating Factors	Predicted Impact Classification
1 – 3	Solar reflections <u>are</u> geometrically possible for: <u>Less</u> than 3 months <u>Less</u> than 60 minutes	Existing vegetation predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
4 – 13	Solar reflections <u>are</u> geometrically possible for: <u>More</u> than 3 months <u>Less</u> than 60 minutes	Existing vegetation predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
14	Solar reflections <u>are</u> geometrically possible for: <u>More</u> than 3 months <u>Less</u> than 60 minutes	Intervening terrain predicted to partially obstruct views of reflecting panels with a small number of panels remaining visible	<u>Less</u> than 3 months <u>Less</u> than 60 minutes	N/A	Low impact

²³ Assessment scenario may include an initial conservative qualitative consideration of screening in determining the duration of predicated effects in practice. The reflecting area of the solar development may be partially screened such that it does not meet the two key criteria i.e. 1) The solar reflection occurs for more than 3 months per year. 2) and/or for more than 60 minutes on any given day.

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening) ²³	Mitigating Factors	Predicted Impact Classification
15 – 18	Solar reflections <u>are</u> geometrically possible for: <u>More</u> than 3 months <u>Less</u> than 60 minutes	Existing vegetation predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
19	Solar reflections <u>are</u> geometrically possible for: <u>Less</u> than 3 months <u>Less</u> than 60 minutes	Existing vegetation predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
20 – 48	Solar reflections <u>are not</u> geometrically possible	N/A	N/A	N/A	No impact
49 – 59	Solar reflections <u>are</u> geometrically possible for: <u>More</u> than 3 months <u>Less</u> than 60 minutes	Existing vegetation predicted to significantly obstruct views of reflecting panels	None	N/A	No impact

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening) ²³	Mitigating Factors	Predicted Impact Classification
60 - 61	Solar reflections <u>are</u> geometrically possible for: <u>More</u> than 3 months <u>Less</u> than 60 minutes	Existing vegetation predicted to significantly obstruct views of reflecting panels from the ground floor	<u>More</u> than 3 months <u>Less</u> than 60 minutes	Views of reflecting panes are restricted to above the ground floor Reflections will mostly coincide with direct sunlight	Low impact
62 - 78	Solar reflections <u>are</u> geometrically possible for: <u>More</u> than 3 months <u>Less</u> than 60 minutes	Existing vegetation predicted to significantly obstruct views of reflecting panels	None	N/A	No impact

Table 5 Geometric Modelling Results - Dwelling Receptors

5.5.3 Desk-Based Review of Available Imagery

A desk-based review of the available imagery is presented in Figures 20 to 28 on the following pages. The cumulative reflecting panel areas are indicated by regions of yellow. The identified screening in the form of existing vegetation is outlined in green. Google Streetview images are used to show assist visualisation of screening, with white arrows to illustrate the direction of imagery. High-level Zones of Theoretical Visibility (ZTV Viewshed) generated²⁴ by Google Earth have been used to show the intervening terrain between the proposed development and relevant road receptors, visible areas are illustrated by scattered green regions.

²⁴ From a height above ground of 5m, to account for views above the ground floor of a dwelling



Figure 20 Screening for dwelling receptors 1 to 3



Figure 21 Screening for dwelling receptors 4 to 6



Figure 22 Screening for dwelling receptors 7 to 13, with representative Streetview imagery



Figure 23 Screening for dwelling receptors 14, with ZTV viewshed from dwelling 14

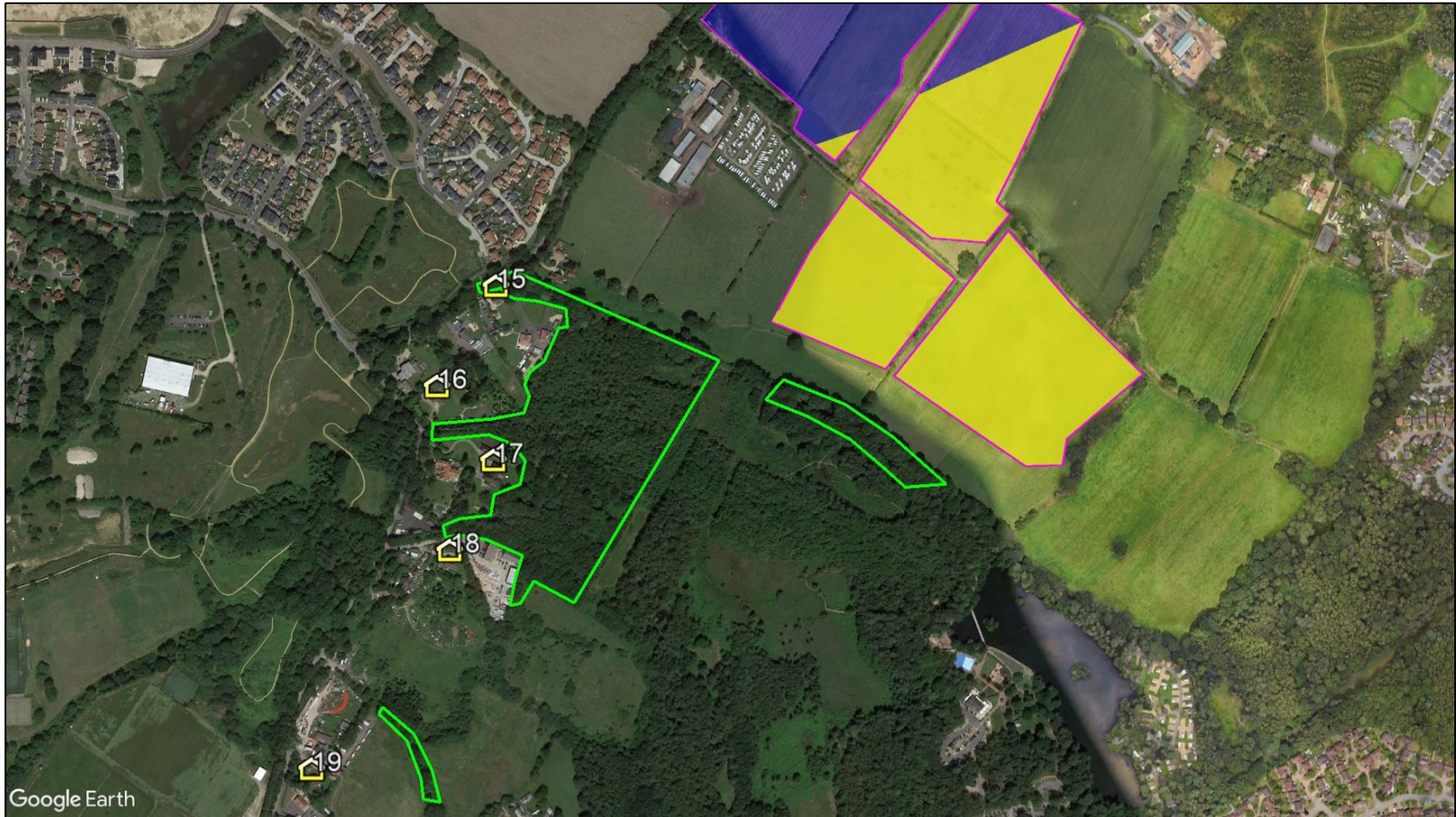


Figure 24 Screening for dwelling receptors 15 to 19



Figure 25 Screening for dwelling receptors 49 to 57, with representative Streetview imagery



Figure 26 Screening for dwelling receptors 58 & 59



Figure 27 Screening for dwelling receptors 60 & 61, with Streetview imagery of 61 (left) & 3D imagery of dwelling 60 (right)



Figure 28 Screening for dwelling receptors 62 to 78

5.6 Assessment Results - Public Rights of Way

The modelling has shown that solar reflections are predicted towards all 14 of the public right of way receptors. Modelling results at both assessed heights are very similar and as such no further distinction is made between assessed heights. Solar reflections are predicted to occur between approximately 5:30-6:00 and 18:00-18:30 (GMT) from late March until late September.

Following a conservative review of the available imagery, views of the reflecting panels are considered possible as it cannot be reliably determined that sufficient existing screening is present.

The following is true:

- Effects would last for less than 60 minutes per day for a static observer, however, in practice, effects would likely be perceptible for less time to a moving observer. Public rights of way, as opposed to residential dwellings, are not continually occupied and in many cases potential reflections would not be observed at all;
- Most solar reflections are also predicted when the Sun is low in the sky beyond the reflecting panels. This is significant because direct sunlight is a far more significant source of light.

In Pager Power's experience, significant impacts to pedestrians/observers using the surrounding public rights of way are not possible due to glint and glare effects from PV developments. The reasoning is due to the sensitivity of the receptors (in terms of amenity and safety) being concluded to be of low significance. This is because:

- The typical density of pedestrians located at these points is low in a rural environment;
- Any resultant effects are less serious than, for example, solar reflections experienced towards a road network whereby the resultant impacts of a solar reflection can be much more serious. Safety concerns are considered to a greater extent for horse riders and the possible event of being thrown by a scared animal;
- Glint and glare effects towards an observer are transient, and time and location sensitive whereby a pedestrian could move beyond the solar reflection zone with ease with little impact upon safety or amenity;
- Any observable solar reflection towards an observer would be of similar intensity to those experienced whilst navigating the natural and built environment on a regular basis.

Overall, no significant impact on observers using the surrounding public rights of way is predicted and therefore mitigation is not required.

6 HIGH-LEVEL ASSESSMENT OF AVIATION ACTIVITY

6.1 Overview

Glint and glare assessment for aviation receptors are typically undertaken for licensed aerodromes within 10km of a proposed solar development. Geometric modelling for unlicensed general aviation aerodromes is typically required within 5km of a proposed development. At ranges of 10-20km, the requirement for assessment is much less common, 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.

The following sections present a high-level assessment (not geometrically modelled for given the distance between the aerodrome and proposed development) and conclusions of aviation implications for Hatchgate Farm Airfield and Hopkiln Farm Airfield.

The proposed development size, distance between the aerodrome and proposed development, and industry experience are considered to determine the impact during the assessment.

Reference to a pilot's primary field-of-view is made when determining the predicted impact significance, which is defined as 50 degrees horizontally either side of the approach path, relative to the direction of travel.

6.2 High-Level Assessment of Hatchgate Farm Airfield

Hatchgate Farm Airfield is an unlicensed airfield approximately 8.25km west of the proposed development with three operational runways and is understood not to have an ATC Tower. The runway details²⁵ are presented below:

- 04/22 measuring 410 metres x 15 metres (grass);
- 08/26 measuring 530 metres x 15 metres (grass);
- 11/29 measuring 570 metres x 15 metres (grass).

The location of Hatchgate Farm Airfield and 1-mile splayed approach paths for each runway threshold relative to the proposed development is shown in Figure 29 on the following page.

²⁵ As determined from aerial imagery



Figure 29 Hatchgate Farm Airfield relative to proposed development

6.2.1 Assessment

The following can be concluded for Hatchgate Farm Airfield with regards to the proposed development:

- Solar reflections originating from the proposed development towards the 1-mile splayed approach path for runway thresholds 04 and 08 will have glare intensities no greater than 'low potential for temporary after-image', which is considered acceptable in accordance with the associated guidance (Appendix D) and industry best practice;
- Solar reflections originating from the proposed development towards the 1-mile splayed approach path for runway thresholds 11, 22, 26, and 29 will be outside a pilot's primary field-of-view, and would therefore not be considered significant in accordance with the associated guidance (Appendix D) and industry best practice;
- Solar reflections originating from the proposed development towards the visual circuits for runway thresholds 04, 08, 11, 22, 26, & 29 are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for the visual circuits and joins.

6.2.2 Conclusions

No significant impacts upon aviation activity associated with Hatchgate Farm Airfield are predicted. Mitigation is not required. Detailed modelling of Hatchgate Farm Airfield is not recommended.

6.3 High-level Assessment of Hopkiln Farm Airfield

Hopkiln Farm Airfield is an unlicensed airfield approximately 8.6km Northwest of the proposed development with one operational runway and is understood to not have an ATC Tower. The runway details²² are presented below:

- 01/19 measuring 270 metres x 25 metres (grass).

The location of Hopkiln Farm Airfield and 1-mile splayed approach paths for each runway threshold relative to the proposed development is shown in Figure 30 below.



Figure 30 Hopkiln Farm Airfield relative to proposed development

6.3.1 Assessment

The following can be concluded for Hopkiln Farm Airfield with regards to the proposed development:

- Solar reflections originating from the proposed development towards the 1-mile splayed approach path for runway thresholds 01 and 19 will be outside a pilot's field-of-view, and would therefore not be considered significant in accordance with the associated guidance (Appendix D) and industry best practice;
- Solar reflections originating from the proposed development towards the visual circuits for runway thresholds 01 and 19 are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for the visual circuits and joins.

6.3.2 Conclusions

No significant impacts upon aviation activity associated with Hopkiln Farm Airfield are predicted. Mitigation is not required. Detailed modelling of Hopkiln Farm Airfield is not recommended.

7 OVERALL CONCLUSIONS

7.1 Assessment Conclusions – Blackbushe Airport

Air Traffic Control Tower

Solar reflections are not geometrically possible towards the Air Traffic Control (ATC) Tower at Blackbushe Airport. No impact is predicted, and mitigation is not required.

Approach Paths for Runway 07/25

Solar reflections are not geometrically possible towards the 2-mile approach paths for runway 07/25. No impact is predicted, and mitigation is not required.

7.2 Assessment Conclusions – Farnborough Airport

Air Traffic Control Tower

Solar reflections are not geometrically possible towards the ATC Tower at Farnborough Airport. No impact is predicted, and mitigation is not required.

Approach Paths for Runway 06/24

Solar reflections are not geometrically possible towards the 2-mile approach paths for runway 06/24. No impact is predicted, and mitigation is not required.

7.3 Assessment Conclusions – Road Safety

Solar reflections are geometrically possible towards a 2.1km section of Barkham Ride.

Screening in the form of existing and proposed vegetation and/or existing buildings are predicted to significantly obstruct views of the reflecting panels for sections totalling 2.0km such that no reflections will be experienced by road users in practice. No impact is predicted upon this section of road.

For the remaining 100m section, screening in the form of existing and proposed vegetation is predicted to partially obstruct views of reflecting panels such that only fleeting views are considered possible at a site entrance. A low impact is predicted upon this section of road.

7.4 Assessment Conclusions – Residential Amenity

Solar reflections are geometrically possible towards 49 of the assessed 78 dwellings.

Screening in the form of existing vegetation that significantly obstructs views of the reflecting panels has been identified for 46 dwellings. No impact is predicted upon these dwellings and mitigation is not required.

For two dwellings, reflections are predicted to occur for more than three months per year but less than sixty minutes on a given day. Screening in the form of existing vegetation is predicted to significantly obstruct views of the reflecting panels from the ground floor. Reflections are also predicted to mostly coincide with direct sunlight. As such a low impact is predicted and mitigation is not recommended.

For the remaining dwelling, reflections are predicted to occur for more than three months per year but less than sixty minutes on a given day. Screening in the form of intervening terrain has been identified that obstructs views of the reflecting panels such that the duration of effects are predicted to be reduced to less than three months per year in practice. As such a low impact is predicted and mitigation is not recommended.

Overall, a low impact is predicted, and mitigation is not recommended.

7.5 Assessment Conclusions – Public Rights of Way

The modelling has shown that solar reflections are geometrically possible towards all 14 of the assessed Public Rights of Way viewpoints.

In Pager Power's experience, significant impacts to pedestrians/observers using the surrounding public rights of way are not possible due to glint and glare effects from PV developments. The reasoning is due to the sensitivity of the receptors (in terms of amenity and safety) being concluded to be of low significance. This is because:

- The typical density of pedestrians located at these points is low in a rural environment;
- Any resultant effect is much less serious and has far lesser consequences than, for example, solar reflections experienced towards a road network whereby the resultant impacts of a solar reflection can be much more serious;
- Glint and glare effects towards an observer are transient, and time and location sensitive whereby a pedestrian could move beyond the solar reflection zone with ease with little impact upon safety or amenity;
- Any observable solar reflection towards an observer would be of similar intensity to those experienced whilst navigating the natural and built environment on a regular basis.

Overall, no significant impact on observers using the surrounding public rights of way is predicted and therefore mitigation is not required.

7.6 Assessment Conclusions – High-level aviation

The proposed development size, distance between the aerodrome and proposed development, and industry experience, have been considered to determine the impact during the assessment.

The following can be concluded for Hatchgate Farm Airfield and Hopkiln Farm Airfield with regards to the proposed development:

- Solar reflections originating from the proposed development towards the approach paths for Hatchgate Farm Airfield and Hopkiln Farm Airfield will be outside a pilot's primary field-of-view (50 degrees either side of the direction of travel) or have glare intensities no greater than 'low potential for temporary after-image'. This is acceptable in accordance with the associated guidance (Appendix D) and industry best practice pertaining to approach paths;
- Solar reflections originating from the proposed development towards the final sections of the visual circuits and joins for Hatchgate Farm Airfield and Hopkiln Farm Airfield will have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining

to approach paths, it can be reliably determined that this level of glare is acceptable for visual circuits and joins.

No significant impacts are predicted upon aviation activity associated with Hatchgate Farm Airfield and Hopkilm Farm Airfield. Detailed modelling is not recommended. Mitigation is not required.

7.7 Overall Conclusions

No significant impacts are predicted upon road safety, residential amenity, public rights of way, or aviation activity associated with Blackbushe Airport and Farnborough Airport. Mitigation is not recommended.

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

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

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

UK Planning Policy

Renewable and Low Carbon Energy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy²⁶ (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.'

²⁶ Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 18 June 2015, accessed on: 01/11/2021

National Policy Statement for Renewable Energy Infrastructure

The National Policy Statement for Renewable Energy Infrastructure (EN-3)²⁷ sets out the primary policy for decisions by the Secretary of State for nationally significant renewable energy infrastructure. Sections 2.10.102-106 state:

'2.10.102 Solar panels are specifically designed to absorb, not reflect, irradiation.²⁸ However, solar panels may reflect the sun's rays at certain angles, causing glint and glare. Glint is defined as a momentary flash of light that may be produced as a direct reflection of the sun in the solar panel. Glare is a continuous source of excessive brightness experienced by a stationary observer located in the path of reflected sunlight from the face of the panel. The effect occurs when the solar panel is stationed between or at an angle of the sun and the receptor.'

2.10.103 Applicants should map receptors to qualitatively identify potential glint and glare issues and determine if a glint and glare assessment is necessary as part of the application.

2.10.104 When a quantitative glint and glare assessment is necessary, applicants are expected to consider the geometric possibility of glint and glare affecting nearby receptors and provide an assessment of potential impact and impairment based on the angle and duration of incidence and the intensity of the reflection.

2.10.105 The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and design. This may need to account for 'tracking' panels if they are proposed as these may cause differential diurnal and/or seasonal impacts.

2.10.106 When a glint and glare assessment is undertaken, the potential for solar PV panels, frames and supports to have a combined reflective quality may need to be assessed, although the glint and glare of the frames and supports is likely to be significantly less than the panels.'

The EN-3 does not state which receptors should be considered as part of a quantitative glint and glare assessment. Based on Pager Power's extensive project experience, typical receptors include residential dwellings, road users, aviation infrastructure, and railway infrastructure.

Sections 2.10.134-136 state:

'2.10.134 Applicants should consider using, and in some cases the Secretary of State may require, solar panels to comprise of (or be covered with) anti-glare/anti-reflective coating with a specified angle of maximum reflection attenuation for the lifetime of the permission.

2.10.135 Applicants may consider using screening between potentially affected receptors and the reflecting panels to mitigate the effects.

2.10.136 Applicants may consider adjusting the azimuth alignment of or changing the elevation tilt angle of a solar panel, within the economically viable range, to alter the angle of incidence.

²⁷ National Policy Statement for Renewable Energy Infrastructure (EN-3). Department for Energy Security & Net Zero, date: November 2023, accessed on: 09/12/2023.

²⁸ 'Most commercially available solar panels are designed with anti-reflective glass or are produced with anti-reflective coating and have a reflective capacity that is generally equal to or less hazardous than other objects typically found in the outdoor environment, such as bodies of water or glass buildings.'

In practice this is unlikely to remove the potential impact altogether but in marginal cases may contribute to a mitigation strategy.'

The mitigation strategies listed within the EN-3 are relevant strategies that are frequently utilised to eliminate or reduce glint and glare effects towards surrounding observers. The most common form of mitigation is the implementation of screening along the site boundary.

Sections 2.10.158-159 state:

2.10.158 Solar PV panels are designed to absorb, not reflect, irradiation. However, the Secretary of State should assess the potential impact of glint and glare on nearby homes, motorists, public rights of way, and aviation infrastructure (including aircraft departure and arrival flight paths).

2.10.159 Whilst there is some evidence that glint and glare from solar farms can be experienced by pilots and air traffic controllers in certain conditions, there is no evidence that glint and glare from solar farms results in significant impairment on aircraft safety. Therefore, unless a significant impairment can be demonstrated, the Secretary of State is unlikely to give any more than limited weight to claims of aviation interference because of glint and glare from solar farms.

The EN-3 goes some way in acknowledging that the issue is more complex than presented in the early draft issues; though, this is still unlikely to be welcomed by aviation stakeholders, who will still request a glint and glare assessment on the basis that glare may lead to a potentially significant impact upon aviation safety.

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

Assessment Process – Ground-Based Receptors

No process for determining and contextualising the effects of glint and glare has been determined when assessing the impact of solar reflections upon surrounding roads and dwellings. Therefore, the Pager Power approach is to determine whether a reflection from the proposed solar development is geometrically possible and then to compare the results against the relevant guidance/studies to determine whether the reflection is significant. The Pager Power approach has been informed by the policy presented above, current studies (presented in Appendix B) and stakeholder consultation. Further information can be found in Pager Power's Glint and Glare Guidance document²⁹ which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

²⁹ Solar Photovoltaic Development Glint and Glare Guidance, Fourth Edition, September 2022. Pager Power.

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, 2012³⁰ however the advice is still applicable³¹ 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 ALH³², as part of a condition of a CAA Aerodrome Licence, the ALH is required to obtain prior consent from CAA Aerodrome Standards Department before any work is begun or 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.

³⁰ Archived at Pager Power

³¹ Reference email from the CAA dated 19/05/2014.

³² Aerodrome Licence Holder.

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

FAA Guidance

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

The 2010 document is entitled 'Technical Guidance for Evaluating Selected Solar Technologies on Airports'³³, the 2013 update is entitled 'Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'³⁴, and the 2021 final policy is entitled 'Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports'³⁵.

Key excerpts from the final policy are presented below:

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

The policy in this document updates and replaces the previous policy by encouraging airport sponsors to conduct an ocular analysis of potential impacts to ATCT cabs prior to submittal of a Notice of Proposed Construction or Alteration Form 7460-1 (hereinafter Form 7460-1). Airport sponsors are no longer required to submit the results of an ocular analysis to FAA. Instead, to demonstrate compliance with 14 CFR 77.5(c), FAA will rely on the submittal of Form 7460-1 in which the sponsor confirms that it has analyzed the potential for glint and glare and determined there is no potential for ocular impact to the airport's ATCT cab. This process will enable FAA to evaluate the solar energy system project, with assurance that the system will not impact the ATCT cab.

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

³³ Archived at Pager Power

³⁴ [Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports](#), Department of Transportation, Federal Aviation Administration (FAA), date: 10/2013, accessed on: 08/12/2021.

³⁵ [Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports](#), Federal Aviation Administration, date: May 2021, accessed on: 08/12/2021.

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

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

In 2018, the FAA released the latest version (Version 1.1) of the '*Technical Guidance for Evaluating Selected Solar Technologies on Airports*'³⁶. Whilst the 2021 final policy also supersedes this guidance, many of the points are still relevant because aerodromes are still safeguarding against glint and glare irrespective of the FAA guidance. The key points are presented below for reference:

- *Reflectivity refers to light that is reflected off surfaces. The potential effects of reflectivity are glint (a momentary flash of bright light) and glare (a continuous source of bright light). These two effects are referred to hereinafter as "glare," which can cause a brief loss of vision, also known as flash blindness*³⁷.
- *The amount of light reflected off a solar panel surface depends on the amount of sunlight hitting the surface, its surface reflectivity, geographic location, time of year, cloud cover, and solar panel orientation.*
- *As illustrated on Figure 16*³⁸, *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;*

³⁶ *Technical Guidance for Evaluating Selected Solar Technologies on Airports*, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 09/12/2023.

³⁷ 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.

³⁸ First figure in Appendix B.

- A geometric analysis to determine days and times when an impact is predicted.
- The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and system design.
- **1. Assessing Baseline Reflectivity Conditions** – Reflection in the form of glare is present in current aviation operations. The existing sources of glare come from glass windows, auto surface parking, rooftops, and water bodies. At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing. Operators also wear polarized eye wear. Potential glare from solar panels should be viewed in this context. Any airport considering a solar PV project should first review existing sources of glare at the airport and the effectiveness of measures used to mitigate that glare.
- **2. Tests in the Field** – Potential glare from solar panels can easily be viewed at the airport through a field test. A few airports have coordinated these tests with FAA Air Traffic Controllers to assess the significance of glare impacts. To conduct such a test, a sponsor can take a solar panel out to proposed location of the solar project, and tilt the panel in different directions to evaluate the potential for glare onto the air traffic control tower. For the two known cases where a field test was conducted, tower personnel determined the glare was not significant. If there is a significant glare impact, the project can be modified by ensuring panels are not directed in that direction.
- **3. Geometric Analysis** – Geometric studies are the most technical approach for reflectivity issues. They are conducted when glare is difficult to assess through other methods. Studies of glare can employ geometry and the known path of the sun to predict when sunlight will reflect off of a fixed surface (like a solar panel) and contact a fixed receptor (e.g., control tower). At any given site, the sun moves across the sky every day and its path in the sky changes throughout year. This in turn alters the destination of the resultant reflections since the angle of reflection for the solar panels will be the same as the angle at which the sun hits the panels. The larger the reflective surface, the greater the likelihood of glare impacts.
- Facilities placed in remote locations, like the desert, will be far from receptors and therefore potential impacts are limited to passing aircraft. Because the intensity of the light reflected from the solar panel decreases with increasing distance, an appropriate question is how far you need to be from a solar reflected surface to avoid flash blindness. It is known that this distance is directly proportional to the size of the array in question³⁹ 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.

³⁹ 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.

Adequate reflectivity analysis and alternative siting addressed initial issues at those installations.

Air Navigation Order (ANO) 2016

In some instances, an aviation stakeholder can refer to the ANO 2016⁴⁰ with regard to safeguarding. Key points from the document are presented below.

Lights liable to endanger

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

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

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

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

(a) to extinguish or screen the light; and

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

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

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

Lights which dazzle or distract

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

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

Endangering safety of an aircraft

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

Endangering safety of any person or property

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

⁴⁰ The Air Navigation Order 2016. [online] Available at:
<<https://www.legislation.gov.uk/uksi/2016/765/contents/made>> [Accessed 4 February 2022].

Civil Aviation Authority consolidation of UK Regulation 139/2014

The Civil Aviation Authority (CAA) published a consolidating document⁴¹ of UK regulations, (Implementing Rules, Acceptable Means of Compliance and Guidance Material), in 2023. A summary of material relevant to aerodrome safeguarding is presented below:

- (a) The aerodrome operator should have procedures to monitor the changes in the obstacle environment, marking and lighting, and in human activities or land use on the aerodrome and the areas around the aerodrome, as defined in coordination with the CAA. The scope, limits, tasks and responsibilities for the monitoring should be defined in coordination with the relevant air traffic services providers, and with the CAA and other relevant authorities.
- (b) The limits of the aerodrome surroundings that should be monitored by the aerodrome operator are defined in coordination with the CAA and should include the areas that can be visually monitored during the inspections of the manoeuvring area.
- (c) The aerodrome operator should have procedures to mitigate the risks associated with changes on the aerodrome and its surroundings identified with the monitoring procedures. The scope, limits, tasks, and responsibilities for the mitigation of risks associated to obstacles or hazards outside the perimeter fence of the aerodrome should be defined in coordination with the relevant air traffic services providers, and with the CAA and other relevant authorities.
- (d) The risks caused by human activities and land use which should be assessed and mitigated should include:
 - 1. obstacles and the possibility of induced turbulence;
 - 2. the use of hazardous, confusing, and misleading lights;
 - 3. the dazzling caused by large and highly reflective surfaces;
 - 4. sources of non-visible radiation, or the presence of moving, or fixed objects which may interfere with, or adversely affect, the performance of aeronautical communications, navigation and surveillance systems; and
 - 5. non-aeronautical ground light near an aerodrome which may endanger the safety of aircraft and which should be extinguished, screened, or otherwise modified so as to eliminate the source of danger.

⁴¹ <https://regulatorylibrary.caa.co.uk/139-2014-pdf/PDF.pdf>

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

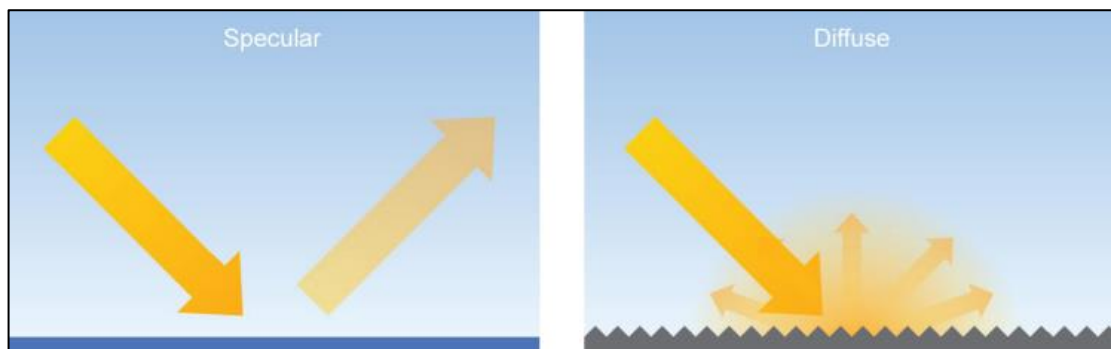
Overview

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 guidance⁴², 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

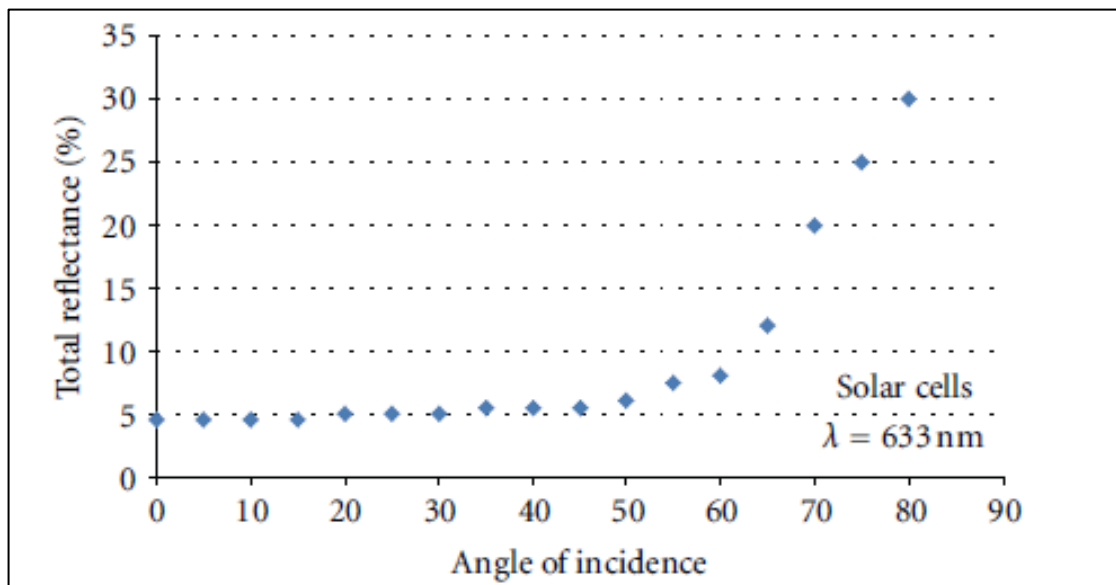
⁴²Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 09/12/2023.

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*⁴³. 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.

⁴³ 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”⁴⁴

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 ⁴⁵
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.

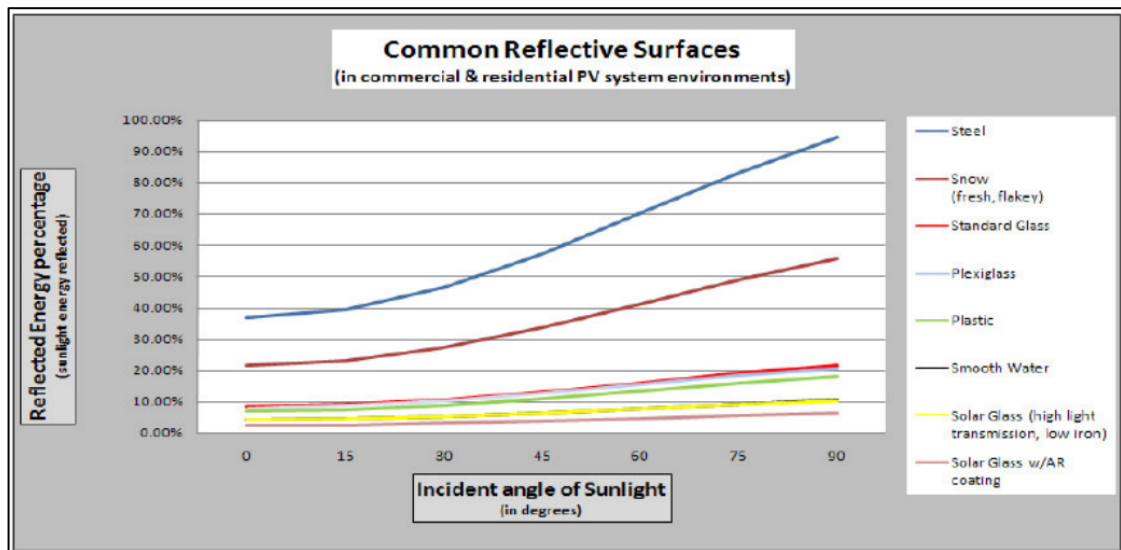
⁴⁴ [Technical Guidance for Evaluating Selected Solar Technologies on Airports](#), Federal Aviation Administration (FAA), date: 04/2018, accessed on: 09/12/2023.

⁴⁵ Extrapolated data, baseline of 1,000 W/m² for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification⁴⁶ 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.

⁴⁶ Source: Technical Support, 2009. SunPower Technical Notification – Solar Module Glare and Reflectance.

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

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

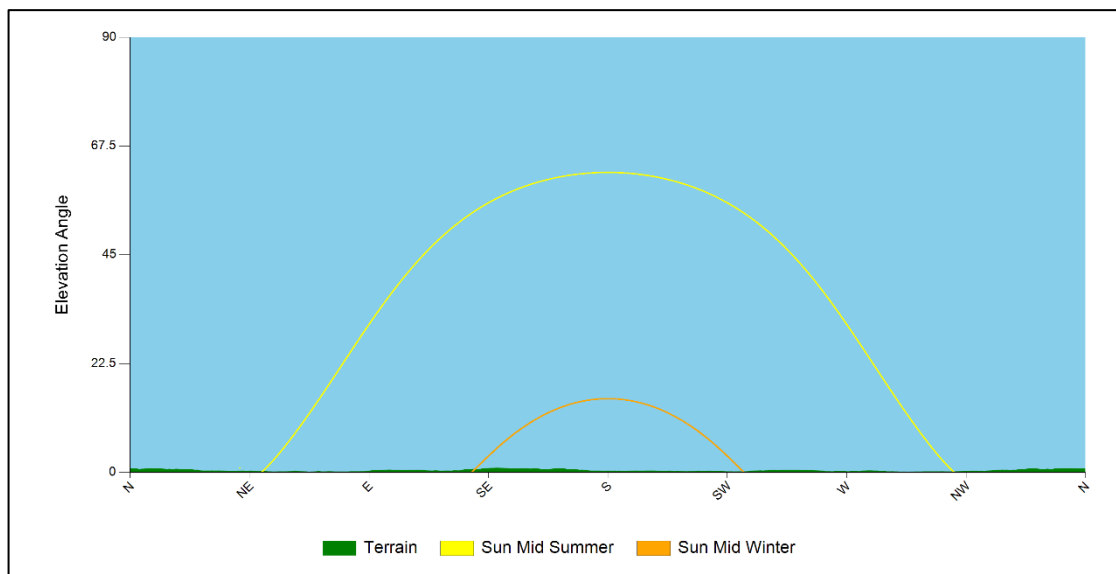
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

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

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

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

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



Terrain at the visible horizon and sun paths

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact Significance Definition

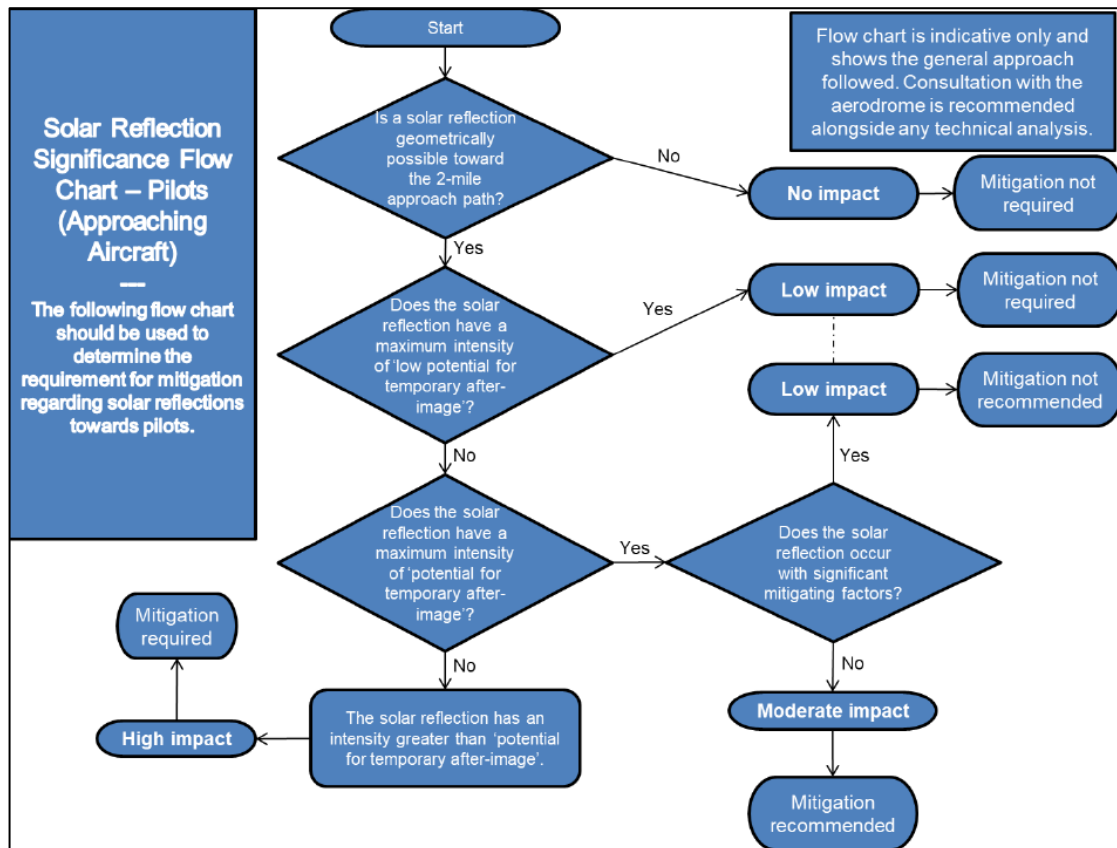
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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

Impact significance definition

Impact Significance Determination for Approaching Aircraft

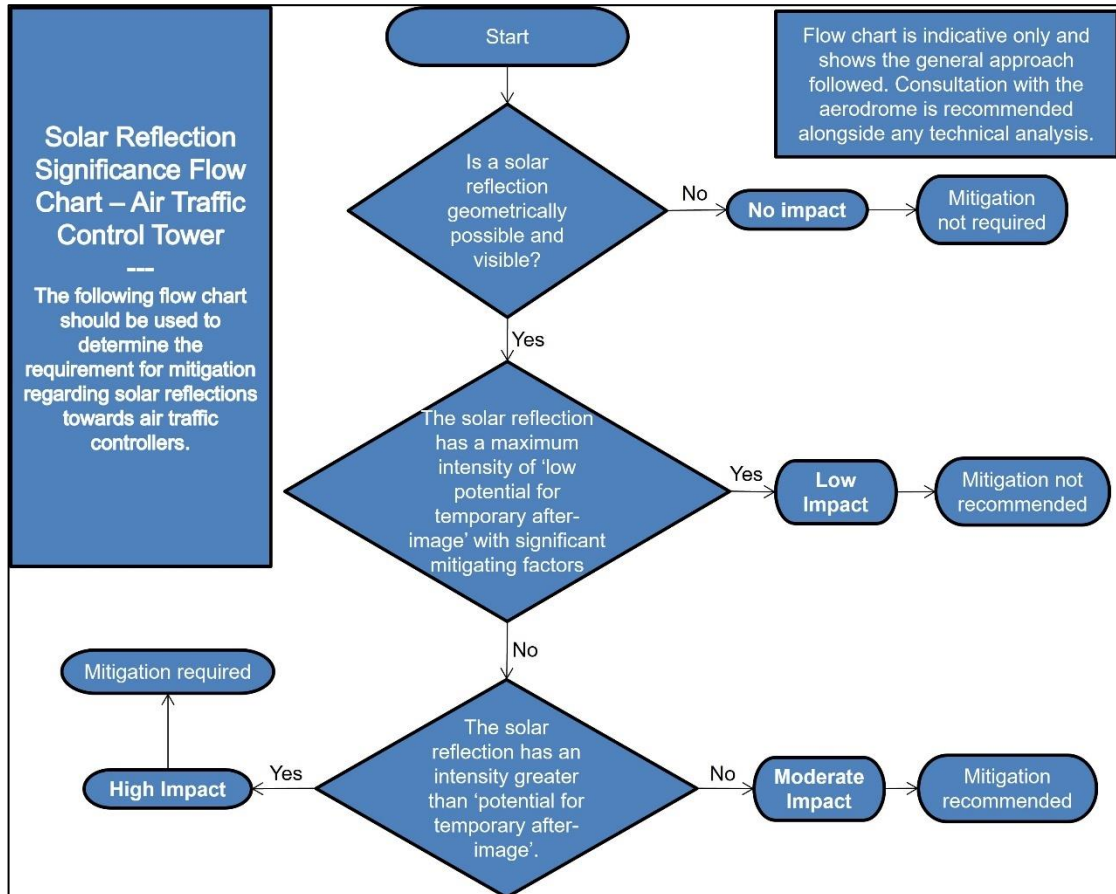
The flow chart presented below has been followed when determining the impact significance for approaching aircraft.



Approach path receptor impact significance flow chart

Impact Significance Determination for ATC Towers

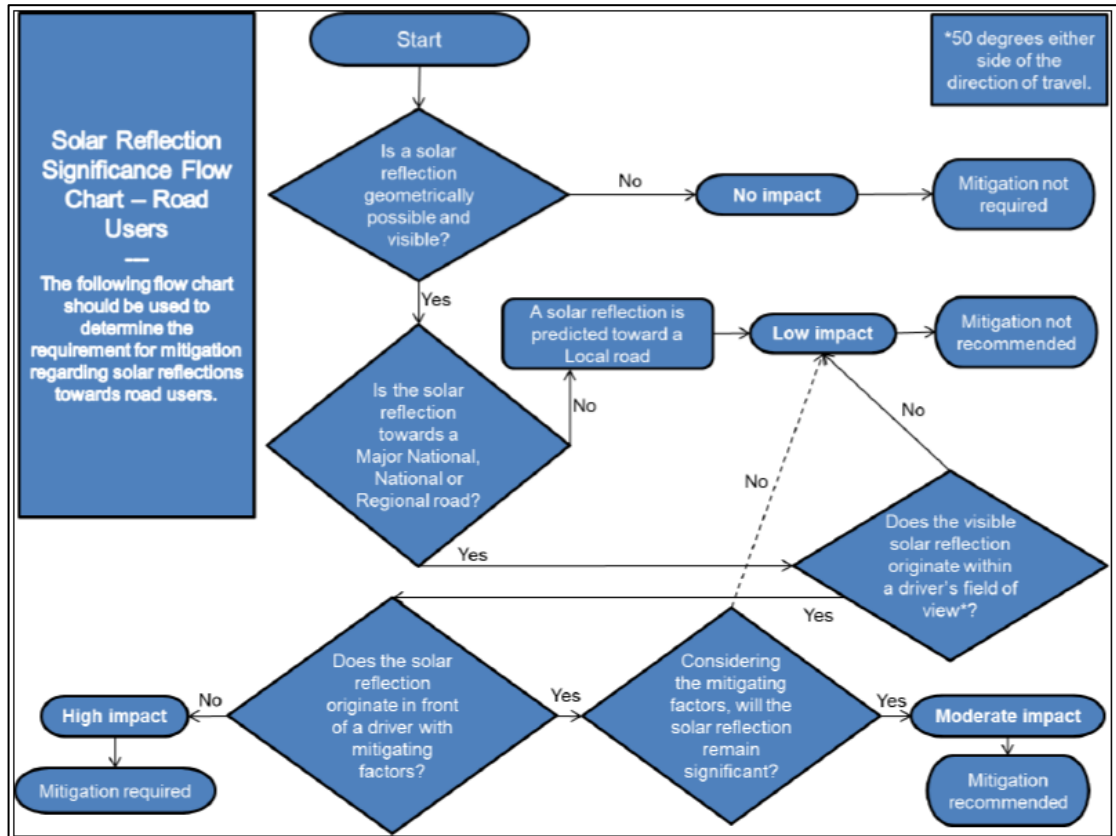
The flow chart presented below has been followed when determining the mitigation requirement for ATC Towers.



ATC Tower receptor mitigation requirement flow chart

Impact Significance Determination for Road Receptors

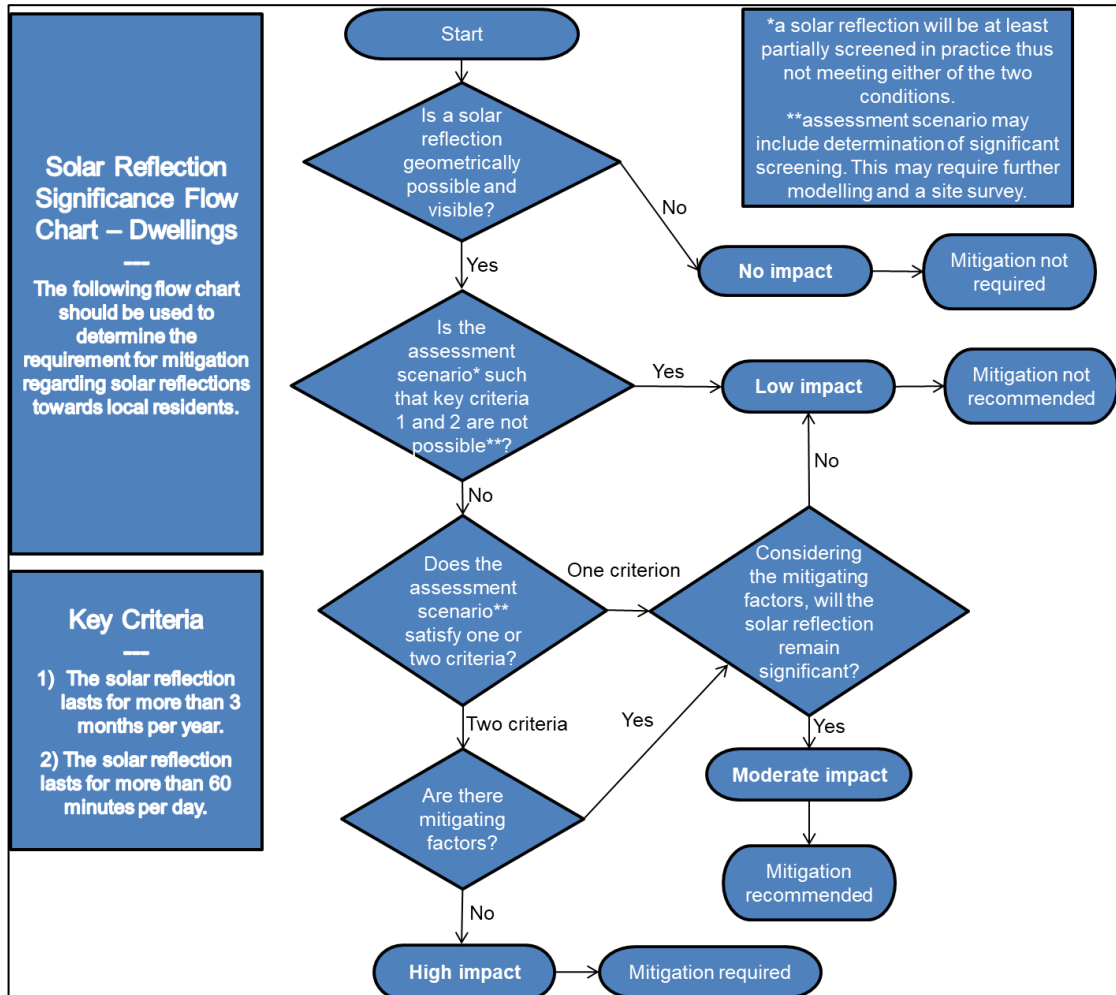
The flow chart presented below has been followed when determining the impact significance for road receptors.



Road receptor impact significance flow chart

Impact Significance Determination for Dwelling Receptors

The flow chart presented below has been followed when determining the impact significance for dwelling receptors.



Dwelling receptor impact significance flow chart

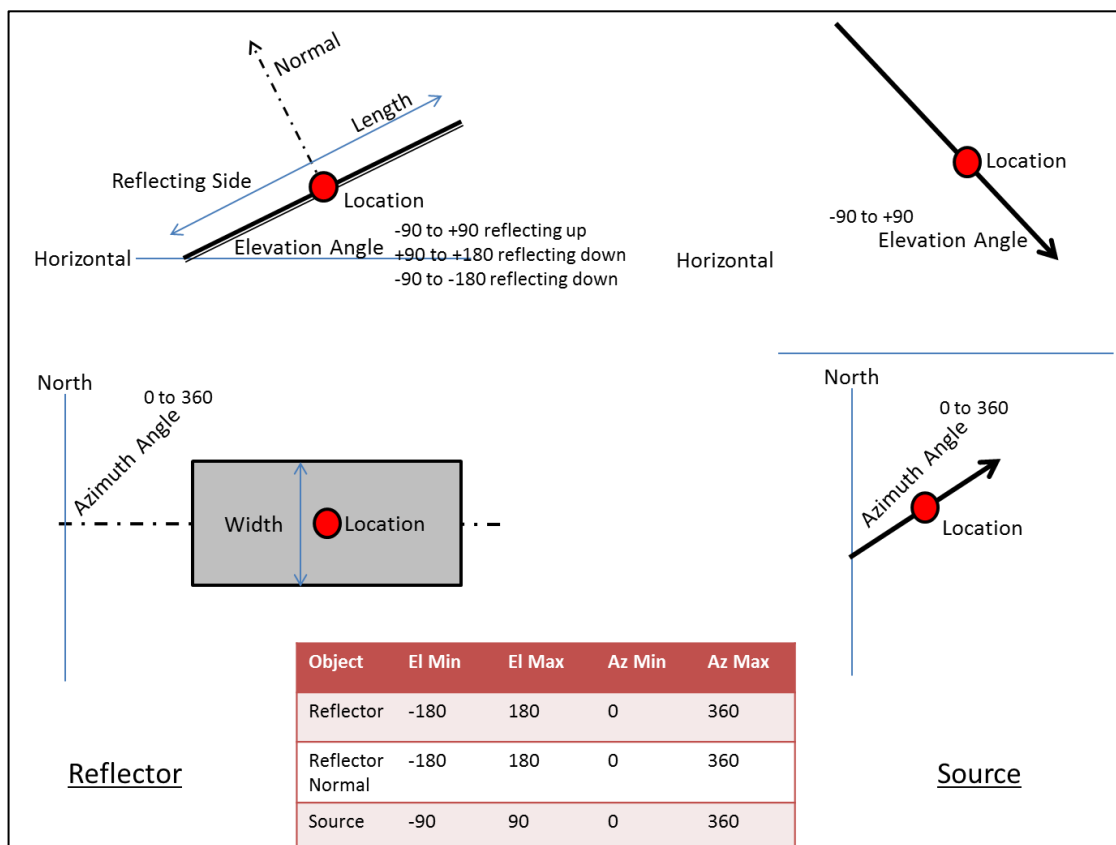
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

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.



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)⁴⁷.

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

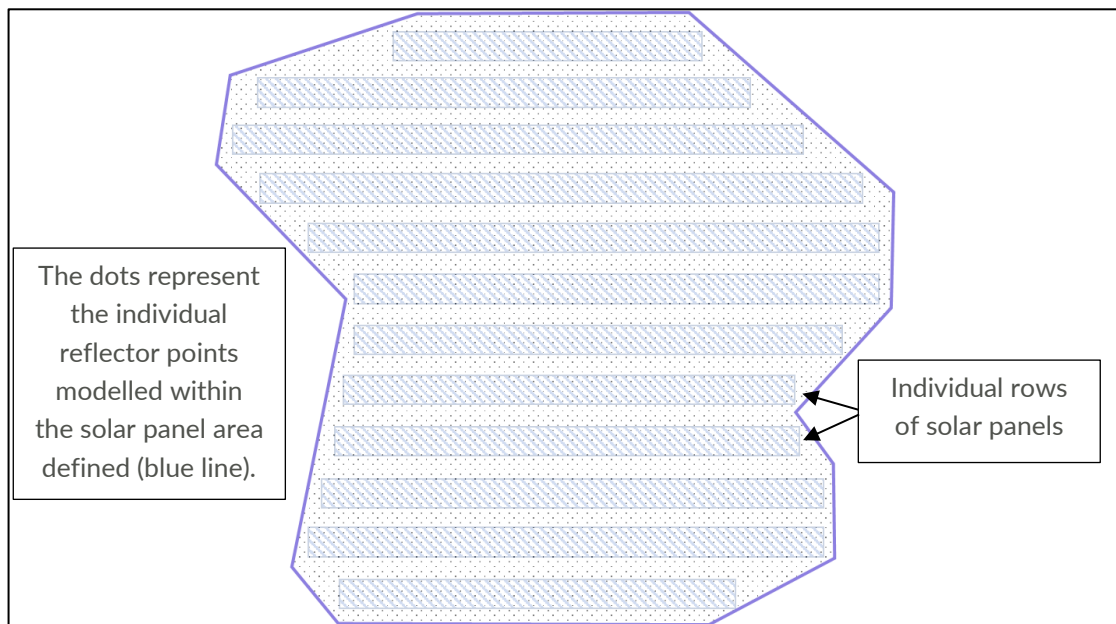
It is assumed that the panel azimuth angle assessed represents the azimuth angle for all of the panels within each solar panel area defined.

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.

⁴⁷ 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) Model⁴⁸

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.

⁴⁸ <https://www.forgesolar.com/help/#assumptions>

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Overview

Data and terrain heights are ascertained from OSGB data.

Airport ATC Tower Data

The co-ordinates and overall altitude of the ATC Towers has been extrapolated from available maps and imagery. The ground height has been taken from Pager Power's database⁴⁹ based on the co-ordinates of the ATC Towers. The details are presented in the table below.

Airport	Latitude (°)	Longitude (°)	Ground Height Altitude (m) (amsl)	ATC Tower Observer Height (m)	Overall Assessed Height (m)
Blackbushe	51.32270	-0.83936	100	12	112.00
Farnborough	51.27939	-0.77745	67.5	34	101.50

ATC Tower receptor details

Airport Runway Data

The table below presents the runway details for Blackbushe and Farnborough Airport. Full receptor details are available upon request.

Airport	Runway Threshold	Latitude (°)	Longitude (°)	Elevation (m amsl)
Blackbushe	07	51.32255	0.85462	98.05
	25	51.32539	0.84103	98.76
Farnborough	06	51.27283	0.78521	68.46
	24	51.27816	0.76923	66.63

Airport runway details

⁴⁹ Based on OS Panorama 50m DTM

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 road user.

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
1	51.39366	-0.87864	51.9	12	51.38626	-0.86992	60.5
2	51.39283	-0.87808	51.5	13	51.38587	-0.86862	61.13
3	51.39200	-0.87754	51.69	14	51.38546	-0.86733	61.5
4	51.39115	-0.87708	53.66	15	51.38504	-0.86605	61.02
5	51.39026	-0.87693	55.63	16	51.38462	-0.86478	62.5
6	51.38939	-0.87682	58.51	17	51.38415	-0.86355	62.67
7	51.38871	-0.87587	59.43	18	51.38362	-0.86239	63.06
8	51.38824	-0.87465	59.03	19	51.38310	-0.86122	63.34
9	51.38783	-0.87336	59.9	20	51.38257	-0.86004	63.7
10	51.38742	-0.87207	59.75	21	51.38205	-0.85887	63.59
11	51.38682	-0.87103	59.5	22	51.38152	-0.85770	64.5

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 amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
1	51.39358	-0.87803	51.96	40	51.37809	-0.86991	61.80
2	51.39335	-0.87778	51.80	41	51.37867	-0.86881	62.49
3	51.39311	-0.87760	51.80	42	51.37907	-0.86683	64.80
4	51.39258	-0.87813	51.80	43	51.37872	-0.86582	66.56
5	51.39079	-0.87424	53.80	44	51.37856	-0.86428	68.66
6	51.39029	-0.87729	56.12	45	51.37758	-0.86367	70.65
7	51.38768	-0.88603	53.80	46	51.37767	-0.86245	71.05
8	51.38706	-0.88500	56.80	47	51.37777	-0.86124	71.39
9	51.38673	-0.88387	58.68	48	51.37827	-0.86124	70.25
10	51.38614	-0.88303	60.05	49	51.37973	-0.86105	67.00
11	51.38603	-0.88224	60.54	50	51.38038	-0.86256	66.65
12	51.38540	-0.88267	59.80	51	51.38101	-0.86396	66.14
13	51.38472	-0.88343	59.80	52	51.38151	-0.86509	65.80
14	51.38442	-0.88236	60.08	53	51.38188	-0.86582	65.56
15	51.38416	-0.88346	59.80	54	51.38236	-0.86690	64.80
16	51.38299	-0.88456	59.80	55	51.38304	-0.86625	64.76
17	51.38213	-0.88351	59.80	56	51.38386	-0.86536	63.75
18	51.38109	-0.88432	58.80	57	51.38439	-0.86475	62.80
19	51.37855	-0.88690	58.80	58	51.38452	-0.86638	61.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
20	51.37740	-0.88691	58.80	59	51.38538	-0.86806	61.80
21	51.37648	-0.88645	58.80	60	51.38585	-0.86931	61.46
22	51.37627	-0.88603	58.80	61	51.38736	-0.87135	59.30
23	51.37765	-0.88331	59.80	62	51.38569	-0.86615	60.80
24	51.37706	-0.88267	60.40	63	51.38622	-0.86578	60.52
25	51.37629	-0.88216	61.62	64	51.38675	-0.86534	59.80
26	51.37567	-0.88172	61.40	65	51.38671	-0.86427	60.63
27	51.37560	-0.88021	61.80	66	51.38730	-0.86380	60.15
28	51.37620	-0.87948	62.19	67	51.38728	-0.86247	60.20
29	51.37647	-0.87838	61.80	68	51.38763	-0.86148	59.80
30	51.37591	-0.87698	62.80	69	51.38799	-0.86182	59.68
31	51.37674	-0.87656	61.97	70	51.38802	-0.86284	59.13
32	51.37595	-0.87537	62.67	71	51.38848	-0.86399	58.66
33	51.37566	-0.87377	63.29	72	51.38884	-0.86233	57.87
34	51.37785	-0.87339	59.80	73	51.38946	-0.86124	57.55
35	51.37799	-0.87272	60.60	74	51.38976	-0.86126	57.33
36	51.37716	-0.87180	60.80	75	51.39005	-0.86204	56.80
37	51.37628	-0.87083	60.93	76	51.39052	-0.86135	56.09
38	51.37651	-0.86940	61.28	77	51.39084	-0.86113	55.80
39	51.37727	-0.86956	60.96	78	51.39160	-0.86051	55.65

Dwelling receptor data

Public Rights of Way Receptor Data

The Public Rights of Way receptor data is presented in the table below. Receptors have been modelled with additional heights of 1.8m and 2.6m added to the elevation to account for the eye-level of a range of users including pedestrians and horse riders.

No.	Longitude (°)	Latitude (°)	Assessed Height Pedestrians (m amsl)	Assessed Height Horse Riders (m amsl)
1	51.39259	-0.87136	52.29	53.09
2	51.39210	-0.87258	52.72	53.52
3	51.39158	-0.87370	52.90	53.70
4	51.39092	-0.87271	53.80	54.60
5	51.39029	-0.87169	54.80	55.60
6	51.38965	-0.87217	56.30	57.10
7	51.38897	-0.87312	57.77	58.57
8	51.38825	-0.87398	59.06	59.86
9	51.38749	-0.87475	60.99	61.79
10	51.38673	-0.87551	62.76	63.56
11	51.38599	-0.87633	64.44	65.24
12	51.38525	-0.87715	63.00	63.80
13	51.38448	-0.87791	61.80	62.60
14	51.38369	-0.87858	60.98	61.78

Public Rights of Way receptor data

Modelled Reflector Areas

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.87249	51.39359	6	-0.87560	51.39309
2	-0.87326	51.39367	7	-0.87490	51.39219
3	-0.87423	51.39336	8	-0.87460	51.39202
4	-0.87478	51.39334	9	-0.87374	51.39198
5	-0.87518	51.39341	10	-0.87154	51.39283

Panel area 1

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.87138	51.39252	5	-0.86911	51.39048
2	-0.87349	51.39161	6	-0.86934	51.39081
3	-0.87218	51.39077	7	-0.86895	51.39124
4	-0.87049	51.38960	8	-0.87042	51.39199

Panel area 2

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.87472	51.39016	6	-0.87281	51.38976
2	-0.87553	51.38878	7	-0.87237	51.38988
3	-0.87421	51.38833	8	-0.87185	51.39033
4	-0.87357	51.38913	9	-0.87283	51.39087
5	-0.87315	51.38914			

Panel area 3

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.87146	51.39002	4	-0.87314	51.38817
2	-0.87273	51.38921	5	-0.87207	51.38902
3	-0.87364	51.38838	6	-0.87111	51.38975

Panel area 4

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.87664	51.38889	7	-0.87715	51.38578
2	-0.87737	51.38890	8	-0.87593	51.38669
3	-0.87769	51.38881	9	-0.87587	51.38697
4	-0.87964	51.38742	10	-0.87444	51.38802
5	-0.87776	51.38639	11	-0.87577	51.38854
6	-0.87792	51.38616			

Panel area 5

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.87550	51.38665	6	-0.87413	51.38531
2	-0.87668	51.38557	7	-0.87375	51.38578
3	-0.87534	51.38488	8	-0.87251	51.38740
4	-0.87431	51.38483	9	-0.87413	51.38790
5	-0.87388	51.38516			

Panel area 6

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.87390	51.38497	5	-0.87289	51.38223
2	-0.87493	51.38414	6	-0.87281	51.38254
3	-0.87604	51.38327	7	-0.87139	51.38329
4	-0.87358	51.38222	8	-0.87268	51.38409

Panel area 7 & 9

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.87762	51.38473	4	-0.87490	51.38441
2	-0.87833	51.38391	5	-0.87686	51.38542
3	-0.87620	51.38335			

Panel area 8

APPENDIX H – DETAILED MODELLING RESULTS

Overview

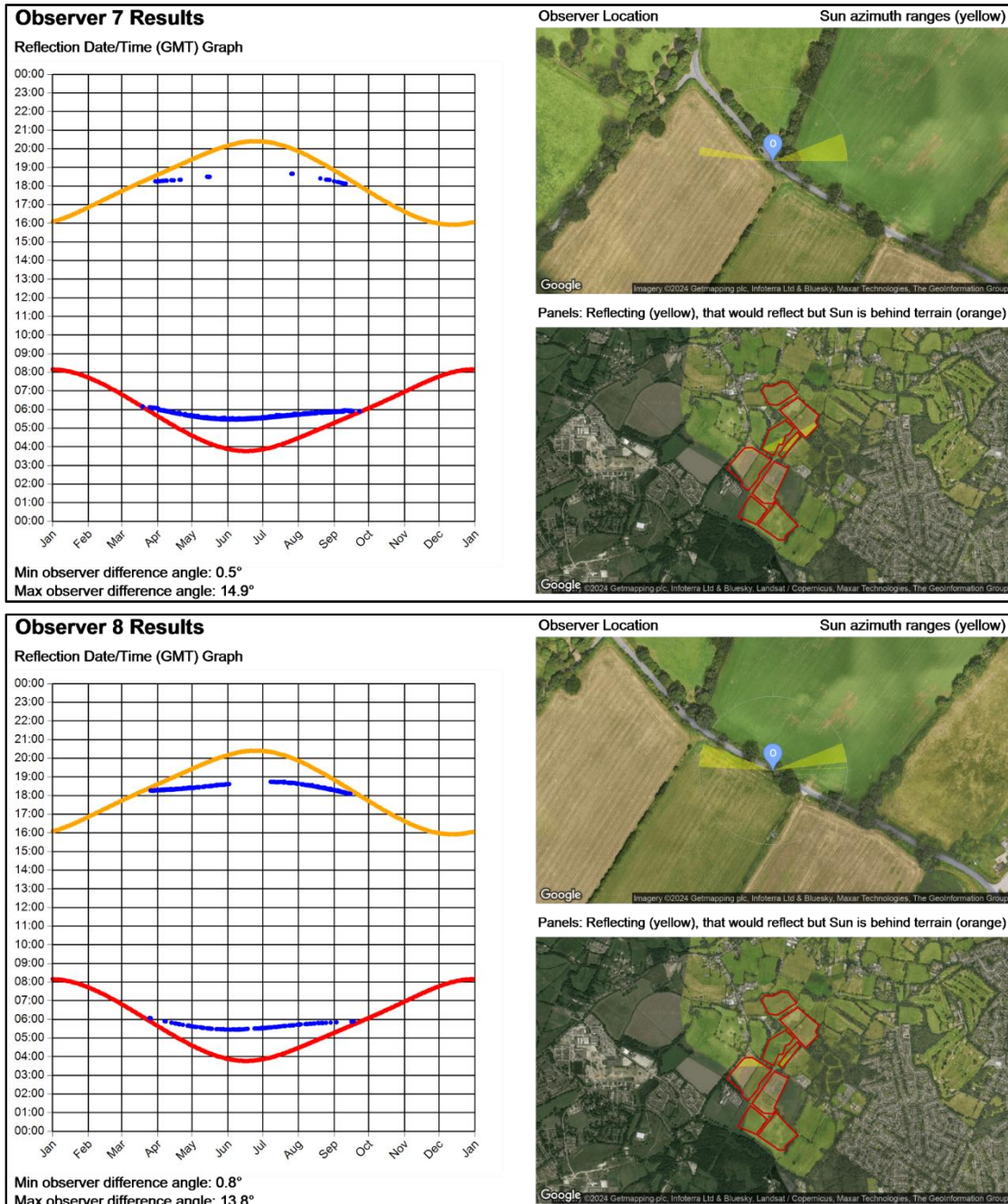
The Pager Power charts for a selection of representative receptors where solar reflections are predicted to be geometrically possible, are shown on the following pages. Full modelling results are available upon request. Each chart shows:

- 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 the page. The blue line indicates the dates and times at which geometric reflections are possible. This relates to reflections from the yellow areas.
- The sunrise and sunset curves throughout the year (red and yellow lines).

No glare intensity charts from Forge Solar are shown as no solar reflections are geometrically possible toward aviation receptors.

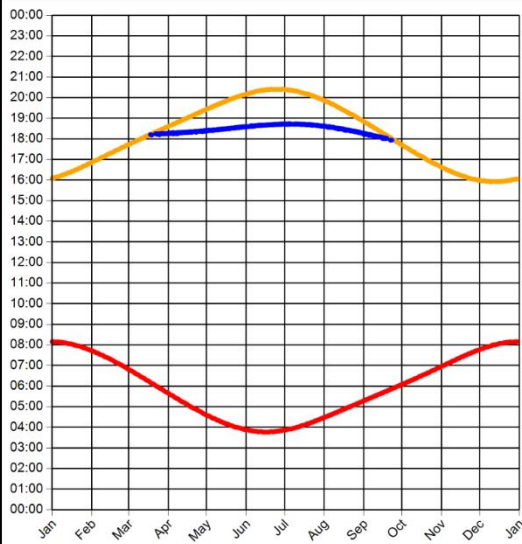
Road Receptors

Results have been shown for those receptors for which mitigation is recommended or required. Full modelling results are available upon request.



Observer 9 Results

Reflection Date/Time (GMT) Graph



Observer Location Sun azimuth range is 269.9° - 291.7° (yellow)

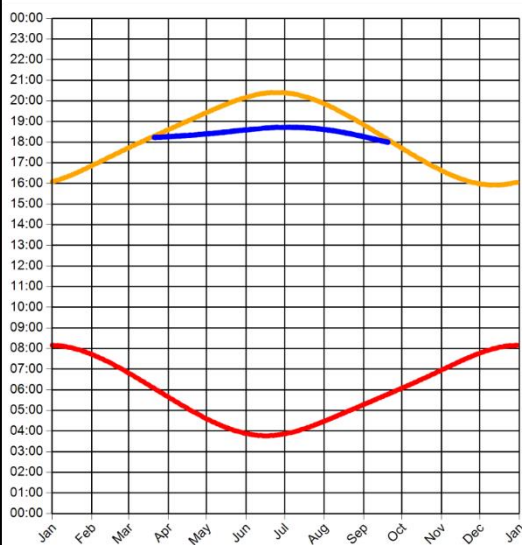


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 10 Results

Reflection Date/Time (GMT) Graph



Observer Location Sun azimuth range is 271° - 292° (yellow)

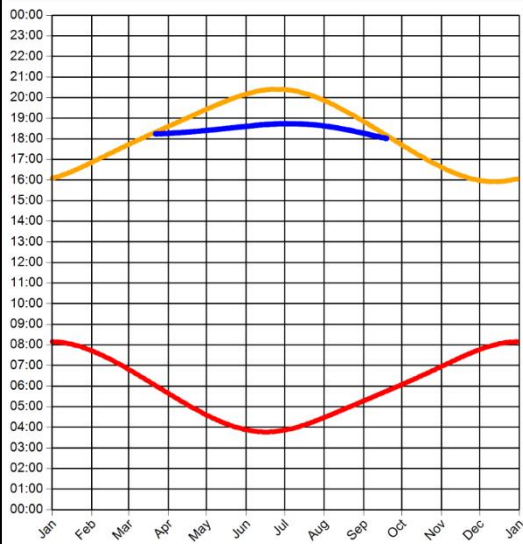


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 11 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.2°
Max observer difference angle: 13.1°

Observer Location Sun azimuth range is 271.4° - 292.2° (yellow)

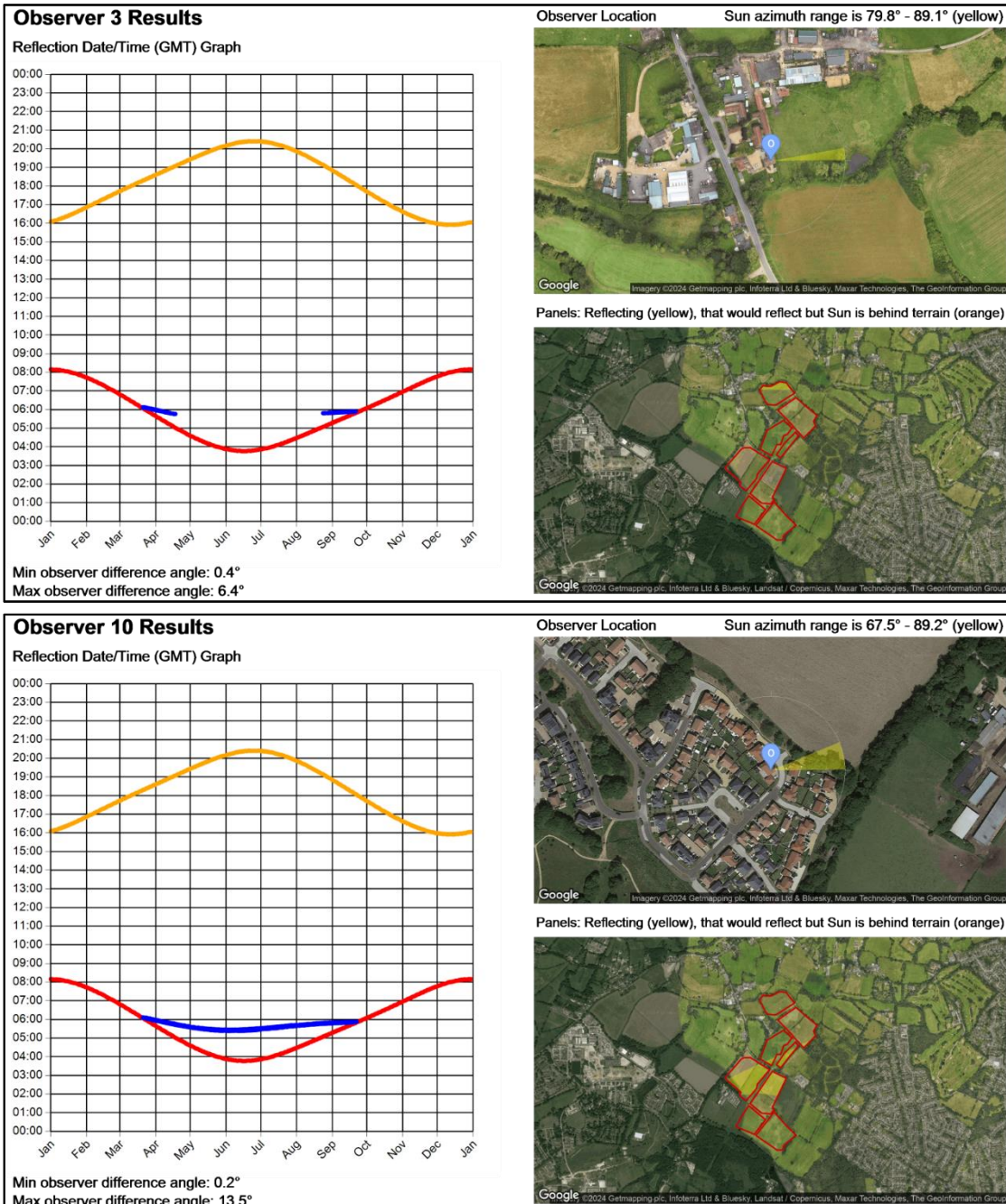


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



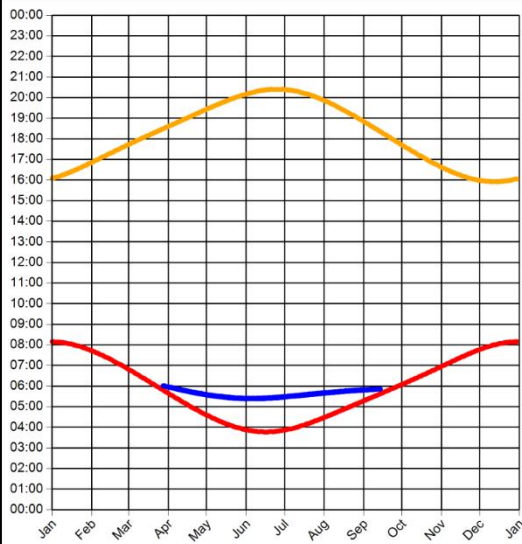
Dwelling Receptors

A selection of representative results have been shown for completeness. Full modelling results are available upon request.



Observer 17 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 1.5°
Max observer difference angle: 12.7°

Observer Location Sun azimuth range is 67.6° - 86.6° (yellow)

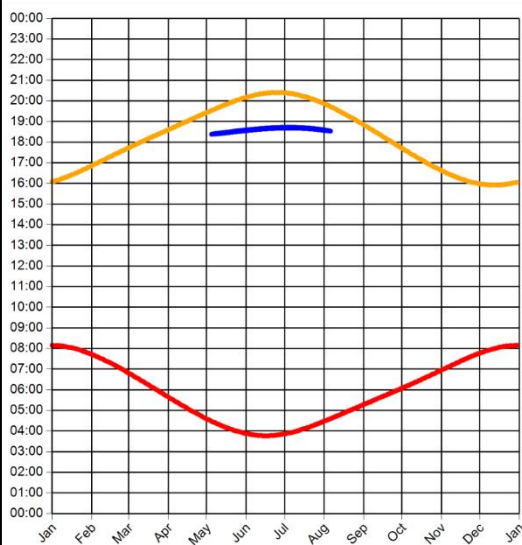


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 49 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 10°
Max observer difference angle: 13.7°

Observer Location Sun azimuth range is 284.8° - 291.8° (yellow)

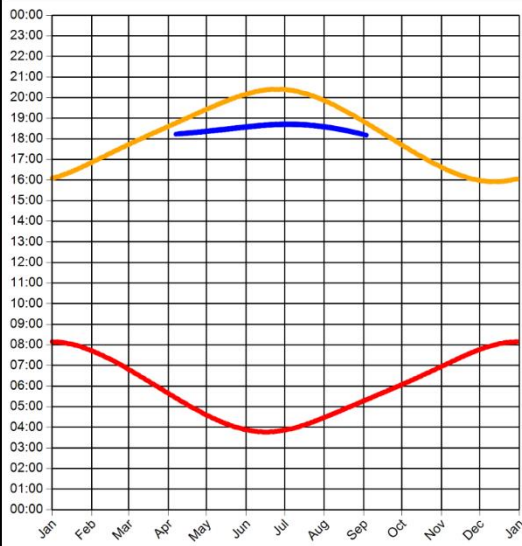


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 52 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 5.1°
Max observer difference angle: 13.7°

Observer Location Sun azimuth range is 276.1° - 291.9° (yellow)

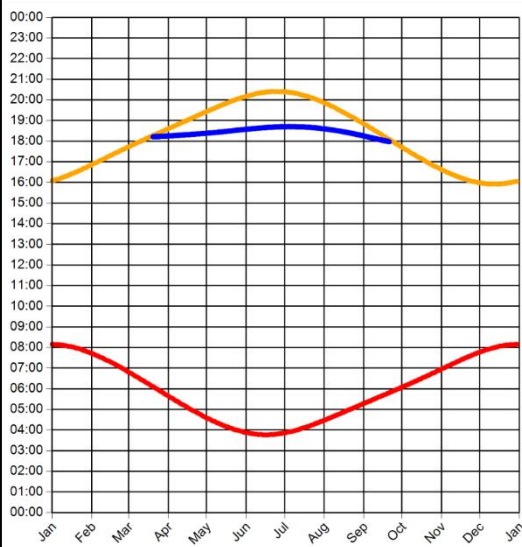


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 64 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.3°
Max observer difference angle: 13.8°

Observer Location Sun azimuth range is 270.5° - 291.7° (yellow)

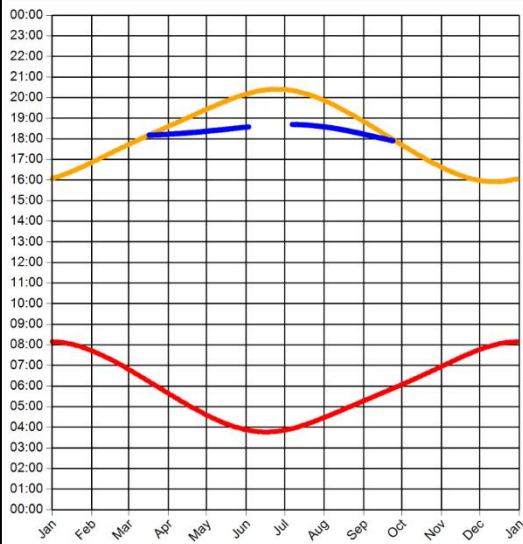


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 76 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.2°
Max observer difference angle: 13.2°

Observer Location Sun azimuth range is 269.2° - 290.6° (yellow)



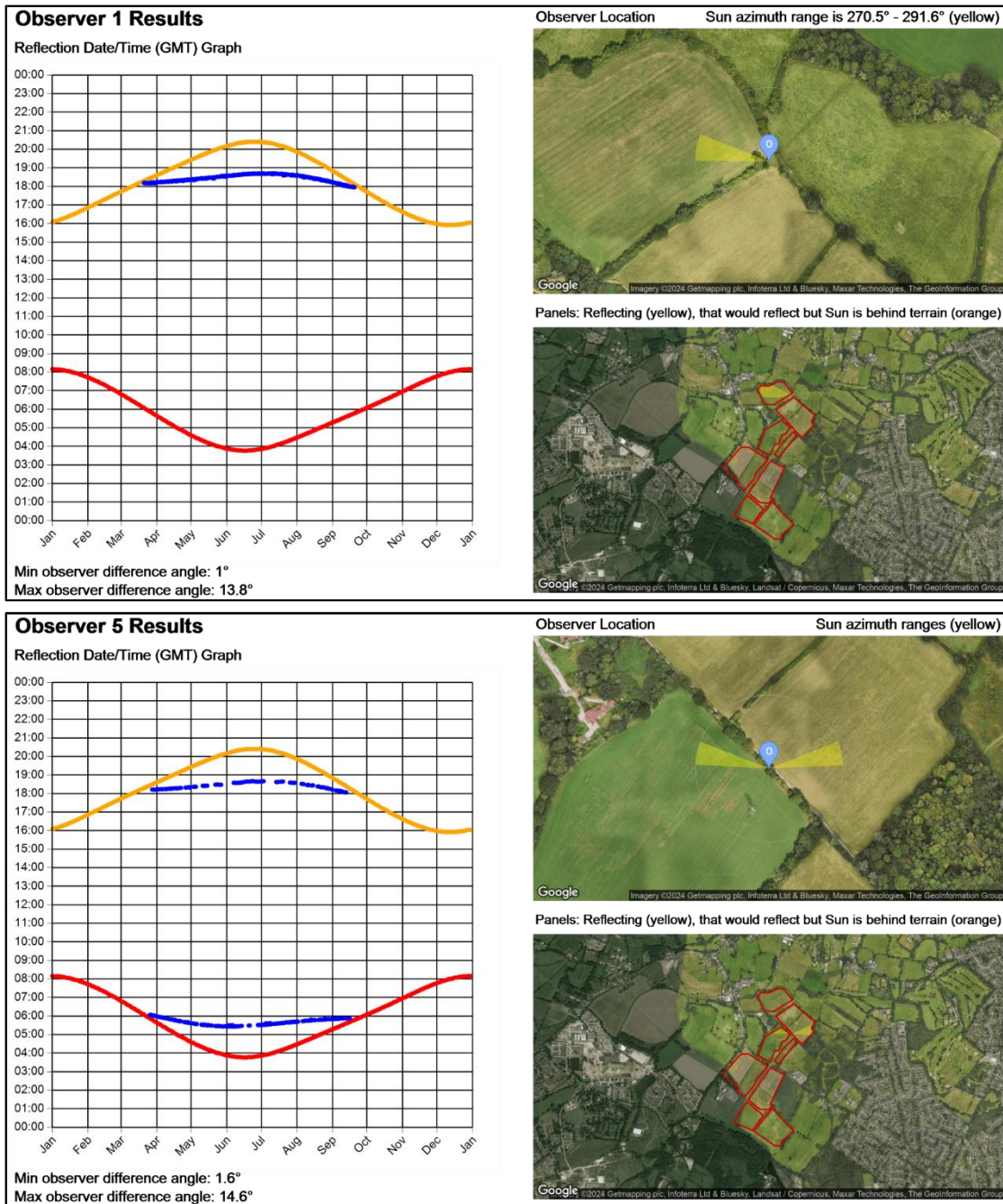
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Public Rights of Way Receptors

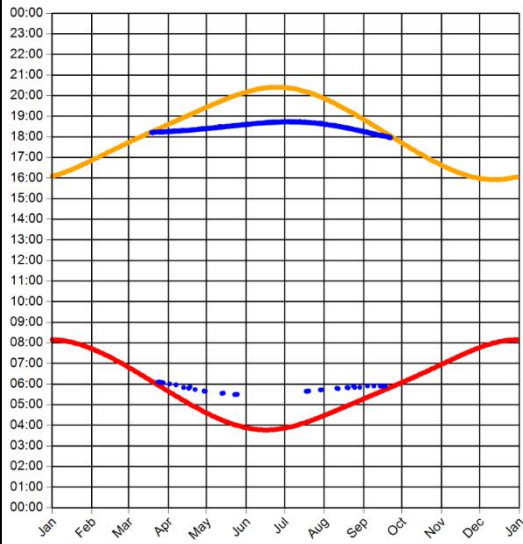
Selective results have been shown for completeness. Full modelling results are available upon request.

Pedestrians



Observer 9 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.2°
Max observer difference angle: 13.3°

Observer Location

Sun azimuth ranges (yellow)

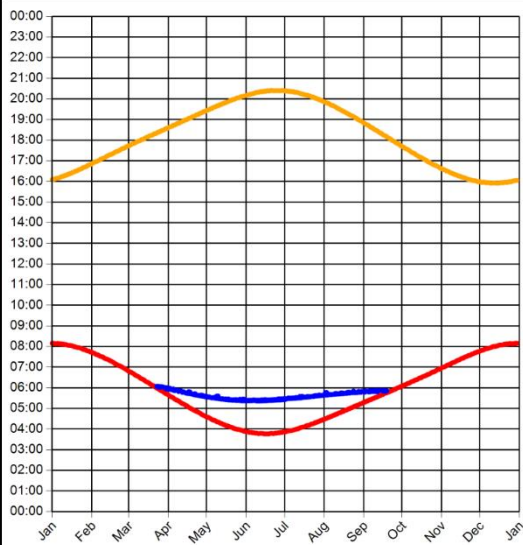


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 13 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0°
Max observer difference angle: 12.5°

Observer Location

Sun azimuth range is 67.3° - 88.1° (yellow)



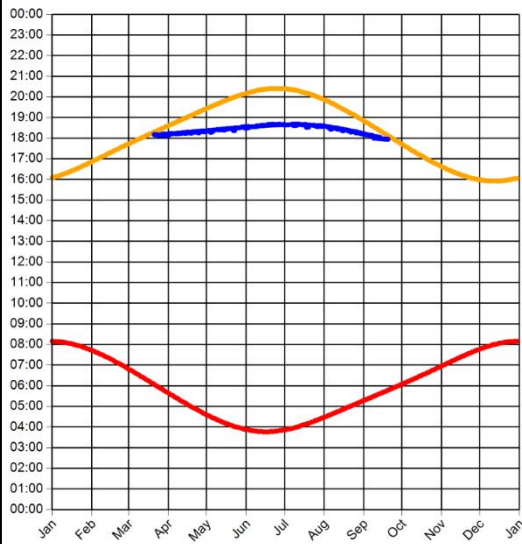
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Horse Riders

Observer 1 Results

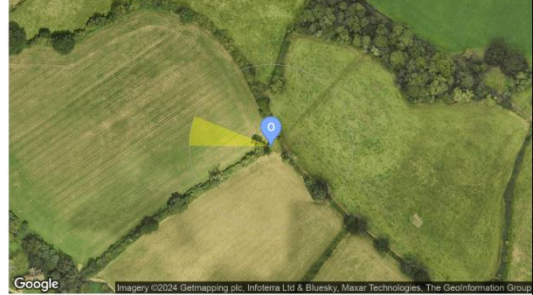
Reflection Date/Time (GMT) Graph



Min observer difference angle: 1.4°
Max observer difference angle: 15.5°

Observer Location

Sun azimuth range is 270.4° - 291.5° (yellow)

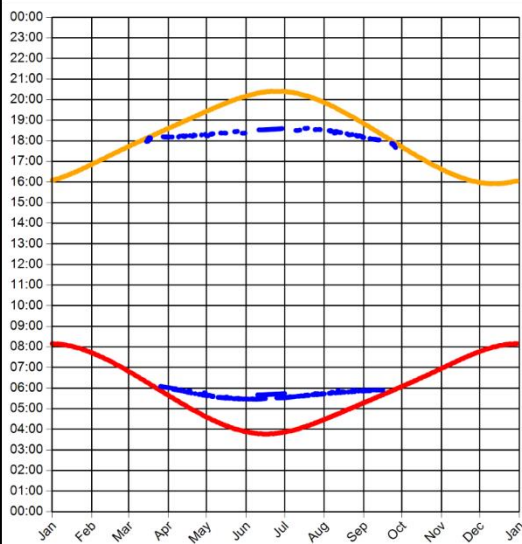


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 5 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 1°
Max observer difference angle: 18.5°

Observer Location

Sun azimuth ranges (yellow)

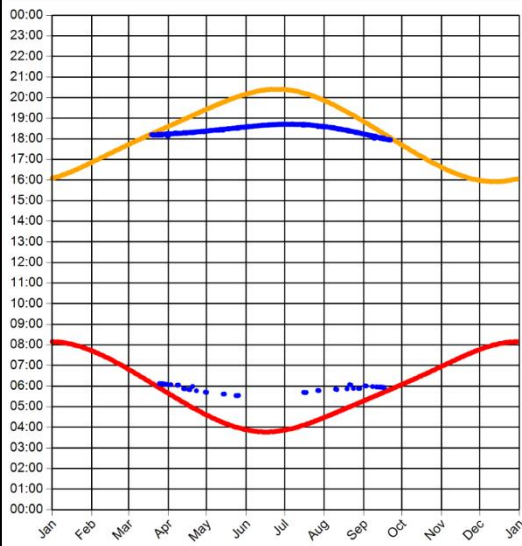


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 9 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.4°
Max observer difference angle: 14.1°

Observer Location

Sun azimuth ranges (yellow)

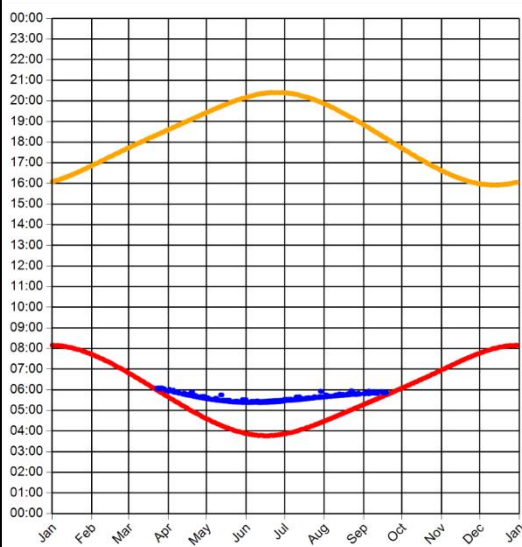


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 13 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.3°
Max observer difference angle: 16.2°

Observer Location

Sun azimuth range is 67.4° - 88.2° (yellow)



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





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