Steeple Renewables Project

Appendix 16.1: Solar Photovoltaic Glint and Glare Study

Environmental Statement – Volume 2

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Solar Photovoltaic Glint and Glare Study

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Solar Photovoltaic Glint and Glare Study

Pegasus Group PLC

Steeple Solar

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the potential effects of glint and glare from a ground-mounted solar photovoltaic development located in Surton le Steeple, Nottinghamshire UK. This assessment pertains to the potential impact upon road safety, residential amenity, railway infrastructure and operations, aviation activity, and public rights of way including canal users and bridleways.

Overall Conclusions

Solar reflections towards West Burton Airfield and Grove Farm Airfield are deemed operationally accommodatable (Section 6.2.4).

No significant impacts are predicted upon road safety, residential amenity, railway infrastructure and operations, aviation activity at remaining aerodromes, and public rights of way including canal users and bridleways. 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 railway guidance with respect to signal sighting; however, no guidance with respect to glint and glare from solar developments upon railway operations and infrastructure has been specifically produced. Pager Power has, however, produced guidance for glint and glare and solar photovoltaic developments which was published in early 2017, with the fourth edition published in 2022[1]. This methodology defines a comprehensive process for determining the impact upon road safety, residential amenity, railway infrastructure and operations, and aviation activity.

Pager Power's approach is to identify receptors, 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, whilst comparing the results against available solar reflection studies. For aviation activity, where a solar reflection is predicted, solar intensity calculations are undertaken where appropriate in line with the Sandia National Laboratories' FAA methodology[2]. The scenario in which a solar reflection can occur for all receptors is then identified and discussed, and a comparison is made against the available solar panel reflection studies to determine the overall impact. Previous consultation with Network Rail and completing glint and glare assessment for railway infrastructure has been used to produce an overall methodology.

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[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.

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 steel[3].

Assessment Results – Aviation Activity

West Burton Airfield

Solar reflections with intensities of 'yellow' glare are geometrically possible towards the 1-mile splayed approach paths and the final sections of visual circuits for threshold 01. There are sufficient mitigating factors (Section 6.2.4) that decrease the level of impact. The instances of 'yellow' glare could potentially be operationally accommodated.

Solar reflections are not geometrically possible towards the splayed approach paths and final sections of visual circuits for threshold 19. No impact is predicted, and mitigation is not required.

Grove Farm Airfield

Solar reflections with intensities of 'yellow' glare are geometrically possible towards the 1-mile splayed approach paths for threshold 12. There are sufficient mitigating factors (Section 6.2.4) that decrease the level of impact. The instances of 'yellow' glare could potentially be operationally accommodated.

Solar reflections are not geometrically possible towards the splayed approach paths for threshold 30. No impact is predicted, and mitigation is not required.

Forwood Farm Airfield

Solar reflections towards the splayed approach and final sections of visual circuits for threshold 02 occur outside a pilot's primary field-of-view (50 degrees either side of the approach bearing) and therefore not considered significant in accordance with the associated guidance (Appenidx D) and industry best practice. No significant impact is predicted, and mitigation is not recommended.

Solar reflections are not geometrically possible towards the splayed approach paths for threshold 20. No impact is predicted, and mitigation is not required.

Assessment Results – Railway Operations and Infrastructure

Train Drivers

The table below summarises the impact upon the assessed sections of railway.

	Length of Railway
Number of railway lines assessed	2
Total length of railway assessed	Railway line 1: 4.3km Railway line 2: 2.4km

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

	Length of Railway
Length of railway where a solar reflection is geometrically possible	Railway line 1: 4.3km Railway line 2: 2.4km
Length of railway predicted to experience no impact due to screening	Railway line 1: 2.9km Railway line 2: 2.4km
Length of railway predicted to experience a low impact due to fleeting views and sufficient mitigating factors	Railway 1: 1.4km Railway line 2: N/A

Summary of assessment for train drivers

Overall, no significant impact is predicted upon train drivers. Mitigation is not recommended.

Railway Signals

The table below summarises the impact upon the assessed railway signals.

	Number of Signals
Number of railway signals assessed	8 (4 trackside signals, 2 cantilever signals, 2 ground mounted signals)
Number of railway signals predicted to experience no impact due to screening	5 (1 trackside signal, 2 cantilever signals, 2 ground mounted signals)
Number of signals predicted to experience a low impact due to partial screening towards the signal and sufficient mitigating factors	3 (3 trackside signals)

Summary of assessment for railway signals

Assessment Results – Road Safety

Screening in the form of existing vegetation and intervening terrain obstructs views of the Proposed Development for road users along the A156/Gainsborough Road, such that no impact is predicted upon road users. Mitigation is not required.

Assessment Results – Residential Amenity

The table below summarises the impact upon the assessed dwellings receptors.

	Number of Receptors
Number of dwelling receptors assessed	212

	Number of Receptors
Number of dwelling receptors where a solar reflection is geometrically possible	212
Number of dwelling receptors predicted to experience no impact due to screening	200
Number of dwelling receptors predicted to experience a low impact due to marginal views and sufficient mitigating factors	12

Summary of assessment for dwellings

Overall, no significant impact is predicted upon residential amenity. Mitigation is not recommended.

High-Level Assessment Results – Aviation Activity

Solar reflections towards the Air Traffic Control (ATC) Towers (as applicable), approach paths and final sections of visual circuits at RAF Scampton, Retford Gamson Airport, Carr Farm Airfield, Dalton Gliding Airfield, Headon Airfield, Stow Airfield, Sturgate Airfield, Willow Farm Airfield, and Robin Hood Doncaster Sheffield Airport are predicted to screened (for ATC Towers), occur outside a pilot's primary field-of-view (50 degrees either side relative to the runway threshold bearing) or have intensities no greater than 'low potential for temporary after-image'; which is considered acceptable for approach paths and therefore considered acceptable for activity at these aerodromes. No significant impact is predicted and mitigation is not required.

High-Level Assessment Results – Public Rights of Way, Canal Users and Bridleways

No significant impacts are predicted due to sufficient mitigating factors such as a large separation distance and reflections coinciding with the Sun reducing the level of impact. Mitigation is not recommended.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 61 countries within Europe, Africa, America, Asia and Australasia/ Oceania.

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 potential effects of glint and glare from a ground-mounted solar photovoltaic development located in Surton le Steeple, Nottinghamshire UK. This assessment pertains to the potential impact upon road safety, residential amenity, railway infrastructure and operations, aviation activity, and public rights of way/bridleways.

This report contains the following:

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

1.2 Pager Power's Experience

Pager Power has undertaken over 1,500 Glint and Glare assessments in the UK and internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Glint and Glare Definition

The definition[4] 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.

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[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 and the Federal Aviation Administration in the USA.

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Site Layout

Figure 1 below shows the site layout[5] for the Proposed Development.

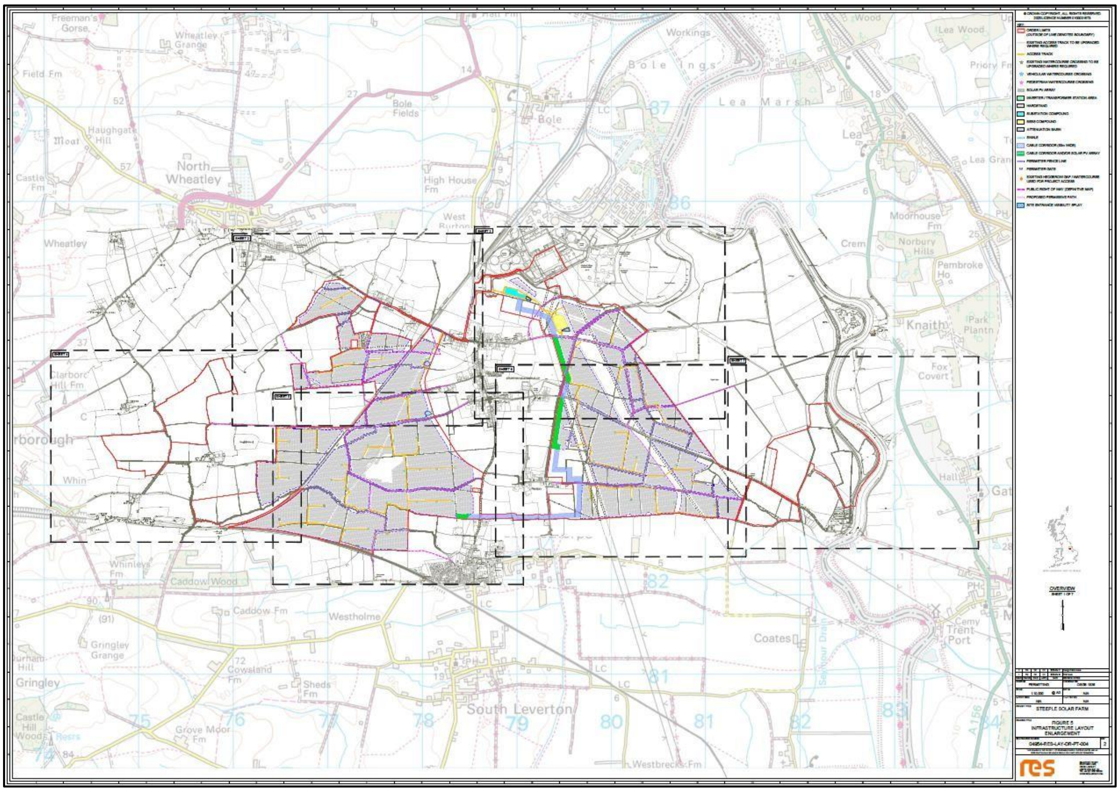

Figure 1 *Site layout*

2.2 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 2 on the following page shows the assessed reflector areas that have been used for modelling purposes.

[5] Source: SPRI_Figure_3_1_DCO_Zonal_Masterplan (3)

Figure 2 *Assessed reflector areas*

The Pager Power model has used a resolution of 10m for this assessment. This means that a geometric calculation is undertaken for each identified receptor every 10m from within the defined areas. This resolution is sufficiently high to maximise the accuracy of the results – increasing the resolution further would not significantly change the modelling output. If a reflection is experienced from an assessed panel location, then it is likely that a reflection will be viewable from similarly located panels within the proposed solar development.

2.3 Solar Panel Technical Information

The technical information of the modelled solar panels used in this assessment is summarised below:

- Azimuth angle[6]: 180°;
- Elevation angles[7]: Assessed at both 10° and 30°;
- Assessed centre height[8]: 1.90m above ground level.

Further information regarding the modelled surface material is presented in Section 6.2.

[6] Direction the panels are facing relative to True North (0°)
[7] Pitch above horizontal
[8] Relative to the lowest (0.80m) and highest (3.00m) points above ground level

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 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 railway guidance with respect to signal sighting; however, no guidance with respect to glint and glare from solar developments and railway infrastructure has been specifically produced. Pager Power has however produced guidance for glint and glare and solar photovoltaic developments, which was published in early 2017, with the fourth edition[9] published in 2022. This methodology defines a comprehensive process for determining the impact upon railway infrastructure and operations, and aviation activity.

The Pager Power approach is to identify receptors, undertake geometric reflection calculations and review the scenario under which a solar reflection can occur, whilst comparing the results against available solar reflection 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 steel[10].

3.2 Background

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

3.3 Methodology

3.3.1 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;

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[9] Pager Power Glint and Glare Guidance, Fourth Edition, September 2022.

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

- 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;
- 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, laid out in the following sub-section.

3.3.2 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.

3.4 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 RAILWAYS ASSESSMENT METHODOLOGY

4.1 Overview

A railway stakeholder, such as Network Rail, may request further information regarding the potential effects of glint and glare from reflective surfaces when a development is located adjacent to a railway line (typically 50-100m from its infrastructure). The request may depend on the scale, percentage of reflective surfaces and the complexity of the nearby railway, for example.

The following section presents details regarding the most common concerns relating to glint and glare.

4.2 Disability Glare for Railway Considerations

Glare can also be categorised as causing visual discomfort whereby an observer would instinctively look away, or cause disability whereby objects become difficult to see. The guidance produced by the Commission Internationale de L'Eclairage (CIE) describes disability glare as:

> *'Disability glare is glare that impairs vision. It is caused by scattering of light inside the eye…The veiling luminance of scattered light will have a significant effect on visibility when intense light sources are present in the peripheral visual field and contrast of objects is seen to be low.'*
>
> *'Disability glare is most often of importance at night when contrast sensitivity is low and there may well be one or more bright light sources near to the line of sight, such as car headlights, streetlights, or floodlights. But even in daylight conditions disability glare may be of practical significance: think of traffic lights when the sun is close to them, or the difficulty viewing paintings hanging next to windows.'*

These types of glare are of particular importance in the context of railway operations as they may cause a distraction to a train driver (discomfort) or may cause railway signals to be difficult to see (disability).

4.3 Guidance and Studies

Appendix A presents a review of planning and rail guidance, and Appendix B presents independent studies with regard to glint and glare issues. The following key findings are relevant:

- Studies have measured the intensity of solar reflections from various naturally occurring and manmade surfaces such as solar panels and glass;
- Specular reflections from glass and solar panels are possible, with the incoming light reflected in a particular direction relative to the angle of incidence;
- The results show that the solar reflections from glass are similar to those from solar panels and are slightly more intense than those from still water but significantly less than those from steel.

4.4 Common Concerns and Signal Overview

Typical reasons stated by a railway stakeholder for requesting a glint and glare assessment often relate to the following:

1. The development producing solar reflections towards train drivers;
2. The development producing solar reflections, which causes a train driver to take action; and
3. The development producing solar reflections that affect railway signals.

With respect to point 1, a reflective façade could produce solar reflections towards a train driver. If this reflection occurs where a railway signal, crossing etc., is present, where the driver's workload is particularly high, or in a scenario where contrast sensitivity is low, the solar reflection may affect operations. This is deemed to be the most concern with respect to solar reflections.

Following on from point 1, point 2 identifies whether a modelled solar reflection could be significant by determining its intensity. Only where a solar reflection occurs under certain conditions and is of a particular intensity may it cause a reaction from a train driver and thus potentially affect safe operations. Therefore, intensity calculations are undertaken where a solar reflection is identified and where its presence could potentially affect the safety of operations. Points 1 and 2 are completed in a 2-step approach.

With respect to all points, railway lines use light signals to manage trains on approach towards particular sections of track. If a signal is passed when not permitted, a SPAD (Signal Passed At Danger) is issued. The concerns will relate specifically to the possibility of the reflections appearing to illuminate signals that are not switched on (known as a phantom aspect illusion) or a distraction caused by the glare itself, both of which could lead to a SPAD. The definition is presented on the following page:

'Light emitted from a Signal lens assembly that has originated from an external source (usually the sun) and has been internally reflected within the Signal Head in such a way that the lens assembly gives the appearance of being lit.[11]'

This is a particular problem for filament bulbs with a reflective mirror incorporated into the bulb design. Many railway signals are, however, now LED. The benefits of an LED signal over a filament bulb signal with respect to possible phantom aspect illuminations are as follows:

- An LED railway signal produces a more intense light making them more visible to approaching trains when compared to the traditional filament bulb technology[12].

Details regarding the identified railway receptors are presented in Section 5 of this report.

4.5 Methodology and Consultation

The railway glint and glare assessment methodology has been based on Pager Power's experience within the UK following previous consultation with Network Rail.

[11] Source: Glossary of Signalling Terms, Railway Group Guidance Note GK/GN0802. Issue One. Date April 2004.

[12] Source: Wayside LED Signals – Why it's Harder than it Looks, [redacted]

Details of the Sun's movements at the development location are presented in Appendix C and details of the modelling approach itself are presented in Appendix E.

The general methodology for this glint and glare assessment is as follows:

1. Identify the receptors of concern. In this instance the concern is reflections of the Sun from the reflecting panels towards surrounding railway receptors (potential signal and train driver locations) within 500 metres of the development;
2. Choose appropriate receptor locations;
3. Define the reflectors for the development and choose an appropriate assessment resolution;
4. Undertake geometric calculations[13] to determine whether a solar reflection may occur from a defined reflector area, and if so, when it will occur;
5. If a reflection can occur, determine whether the modelled reflectors will be visible from the identified receptor locations;
6. Consider the above together with the solar reflection's location of origin with respect to the location of the Sun in the sky, its angle above the horizontal and the time of day at which a solar reflection could occur;
7. If a scenario is possible which presents the potential for a significant solar reflection, calculate the intensity of the solar reflection;
8. Determine whether the solar reflection is likely to be a significant hazard or nuisance factoring in all of the above;
9. Consider mitigation, if appropriate.

4.6 Railway Specific Criteria

The specific parameters for a railway glint and glare assessment are presented below:

- Whether the solar reflection originates within a train driver's primary field-of-view, defined as 30 degrees either side of the railway line with respect to the direction of travel;
- The contrast of sensitivity, considering a low sensitivity is where disability glare is more likely to occur;
- The reflecting area compared to the façade as a whole, with a significant area considered more than 50%;
- Solar reflections occurring towards a significant section of railway line where, for example:
    - A point of multiple lines with switch points;
    - At a station;
    - Signals being present;

[13] Within the model, the development reflector area is defined, as well as the relevant receptor locations. The result is a chart that states whether a reflection can occur considering the location of the Sun throughout a given year and the duration of the solar reflection towards the receptor.

    - Road or pedestrian crossings being present.
- The duration of the solar reflection;
- If the development in keeping with those around it and near to the assessed railway line.

4.7 Assumptions and Limitations

Key assumptions and limitations regarding the analysis in this report are listed below:

- Screening at the site boundary or anywhere between the railway line and the development is not included within the modelling output – which considers only the relative heights and geometric relationship between the Sun and the modelled reflectors;
- The assessment assumes that a view of the entire reflector area is possible from the receptor location when in reality this may not occur. A solar reflection can only be experienced by a receptor where the source of the reflection is visible;
- The modelling is output is therefore conservative and further interpretation of the results is required to provide a more accurate result and determine any impact.

Further assumptions and limitations are presented in Appendix E.

5 IDENTIFICATION OF RECEPTORS

5.1 Overview

The following sections present the relevant receptors 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.

5.2 Aviation Receptors

5.2.1 Identified Aerodrome Receptors

Table 1 below summarises the assessed aerodromes for this Proposed Development.

Aerodrome	Type	ATC Tower	Operational Runway(s)	Distance from Proposed Development
West Burton Airfield	Unlicensed General Aviation (GA)	N/A	01/19	1.20km north
Grove Farm Airfield	Unlicensed GA	N/A	12/30	2.64km southwest
Forwood Farm Airfield	Unlicensed GA	N/A	02/20	3.33km south

Table 1 *Identified aerodromes*

The identified aerodromes relative to the Proposed Development are shown in Figure 3 on the following page.

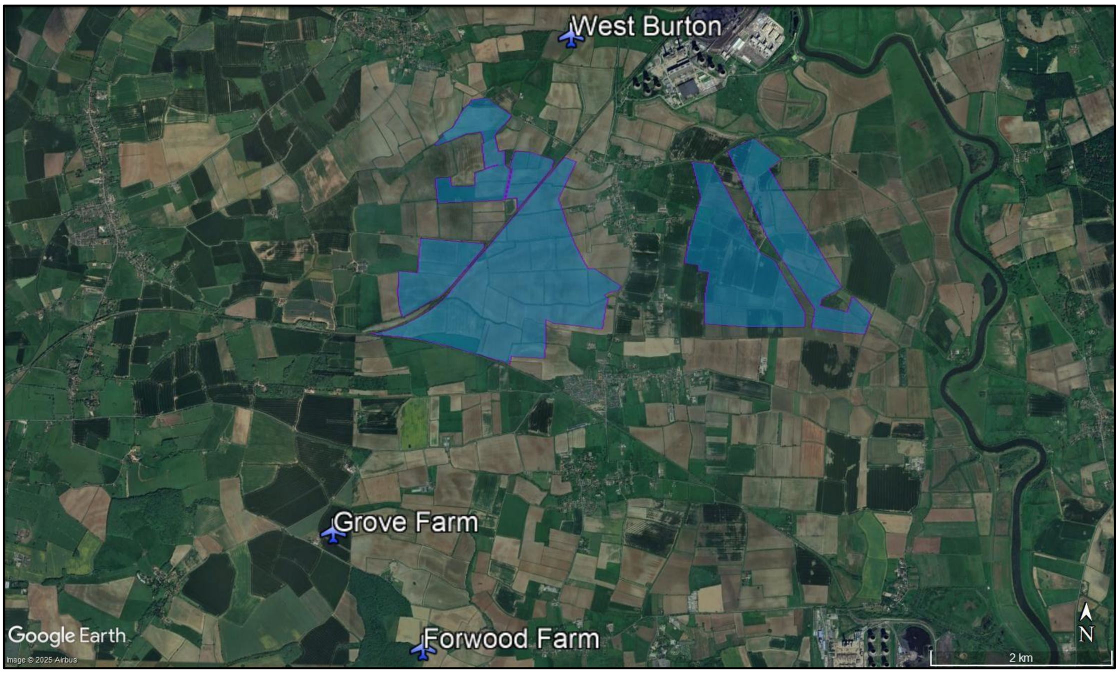

Figure 3 *Identified aerodromes relative to Proposed Development*

5.2.2 General Aviation Runway Approach Paths and Final Sections of Visual Circuits

West Burton Airfield, Grove Farm Airfield and Forwood Farm Airfield are GA aerodromes where aviation activity is dynamic and does not necessarily follow the typical approaches / flight paths of a larger licensed aerodrome or airport. It is not possible to assess every single location of airspace that an aircraft travels in flight around an aerodrome; however, it is possible to assess the most frequently flown flight paths and the most critical stages of flight, which would cover most, or all, of the relevant locations.

As such, Pager Power's methodology is to assess whether a solar reflection can be experienced on the following characteristics:

- 1-mile approach path with a splay angle of 5 degrees, considering 2.5 degrees either side of the extended runway centreline;
- A descent angle of 5 degrees;
- Circuit width of 1 nautical mile from runway centreline;
- Maximum altitude of 500 feet above the average threshold altitude.

Figures 4 to 6 on the following pages show the assessed aircraft receptor points of the splayed approach and final sections of the visual circuits at each airfield.

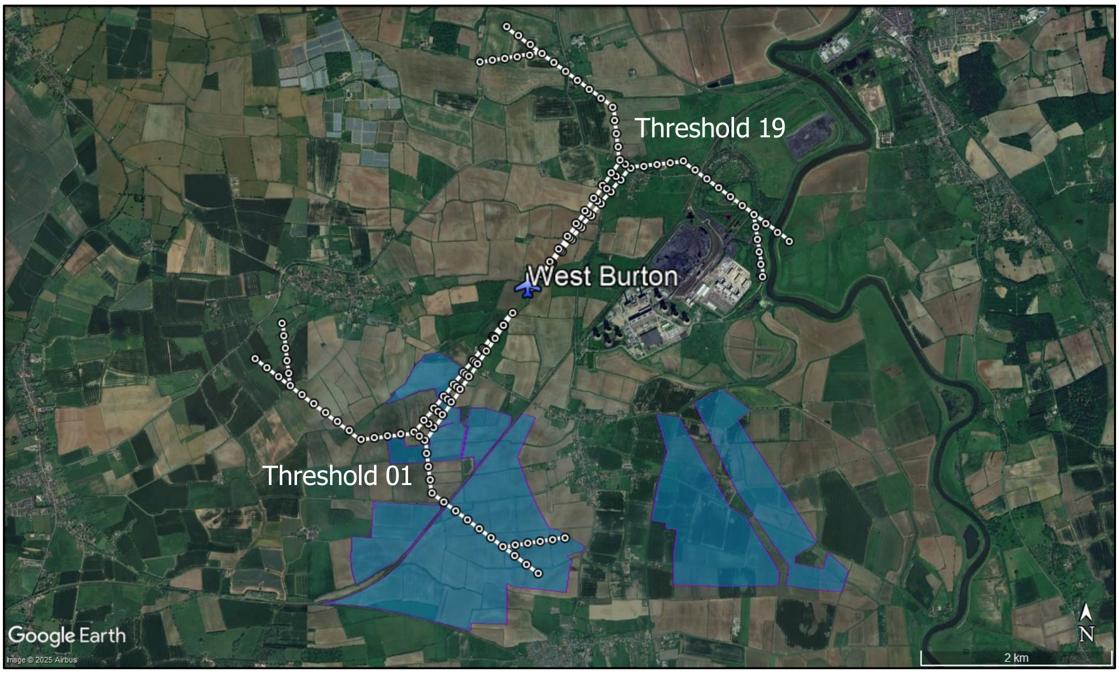

Figure 4 *Modelled receptors for West Burton Airfield*

Figure 5 *Modelled receptors for Grove Farm Airfield*

Figure 6 *Modelled receptors for Forwood Farm Airfield*

5.3 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 show that a 1km assessment area from the Proposed Development is considered appropriate for glint and glare effects on road users and dwellings. Railway receptors within close proximity to a solar development are often required for assessment. When required, a 500m assessment area is considered appropriate and has been designed accordingly.

Reflections towards ground-based receptors located further north than any proposed panel are highly unlikely[14]. Therefore, receptors north of the most northern panel areas have not been modelled. The assessment area (white outlined area in the following figures) has been designed accordingly as 1km from the Proposed Development, excluding 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

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

no visibility would be possible. A more detailed assessment is made if the modelling reveals a reflection would be geometrically possible.

5.4 Railway Receptors

Receptors within the 500m assessment area are identified based on mapping and aerial photography of the region. A more detailed assessment is made if the modelling reveals that a reflection would be geometrically possible. The significance of a reflection 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.

5.4.1 Train Driver Receptors

The analysis has considered train driver receptors that:

- Are within the 500-metre assessment area;
- Have a potential view of the development.

An additional height of 2.75m above rail level is used to model the eye-level[15] of train drivers, based on previous consultation[16].

5.4.2 Identified Train Driver Receptors

Two separate 4.3km and 2.4km sections of the Network Rail Eastern Region North and East Route is identified within 500m of the Proposed Development. The railway operating south of the Proposed Development (route 2) is no longer in active use but has been considered in this assessment as a worst-case and for completeness.

Table 2 below summarises the receptors modelled for each section of the railway.

Route	Receptors	Length Assessed (km)
1	1 – 44	4.3
2	45 – 68	2.4

Table 2 *Modelled train driver receptors*

Figure 7 on the following page shows the two identified sections of railway, and modelled receptors.

[15] This fixed height for the train driver receptors is for modelling purposes. Small changes to the modelling height by a few metres is not expected to significantly change the modelling results.

[16] Consultation with Network Rail

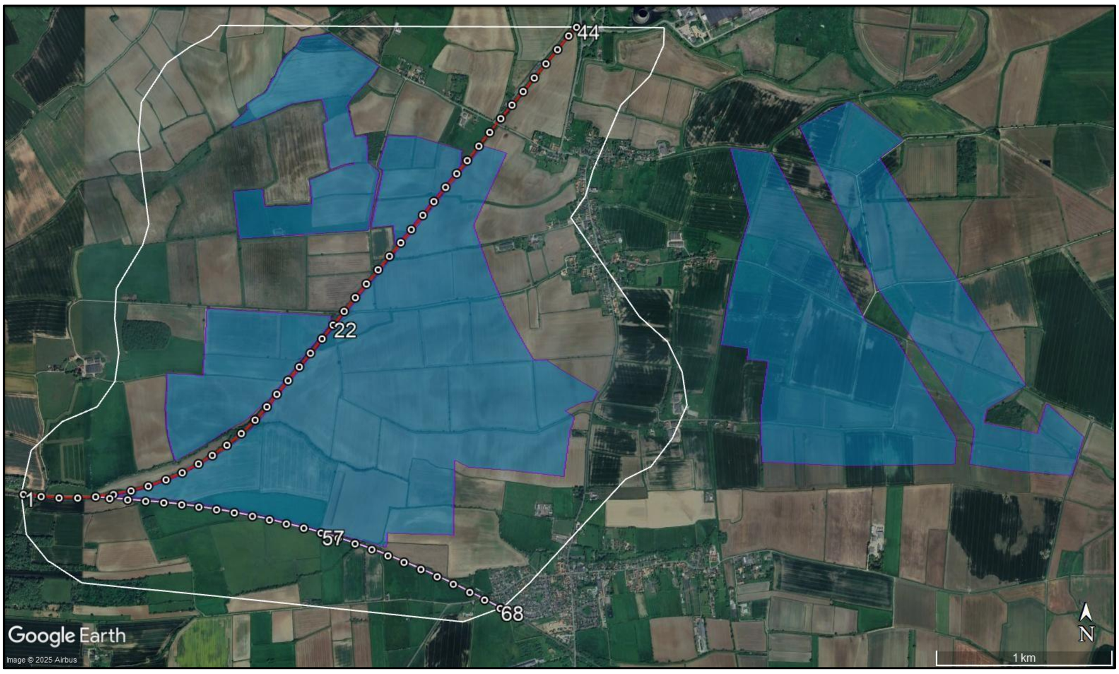

Figure 7 *Assessed train driver receptors*

5.5 Railway Signal Receptors

5.5.1 Railway Signal Overview

Railway signals, including assets of Network Rail, are identified from the available imagery. This report can be updated following further signals and assets identified by Network Rail.

The assessment has considered both gantry and trackside signals within 500m of the development and a line-of-sight of the development. The typical heights above ground level of each signal have been provided by Network Rail[17]. The heights[18] used for the assessment are:

- Gantry signal – 5.10m agl;
- Cantilever/Trackside signal – 3.30m agl.

An estimated height of 0.30m above ground level has been used to model ground mounted signals.

5.5.2 Identified Railway Signals

Table 3 below and on the following page summarises the signals modelled.

Signal	Type	Orientation
TN 8331	Trackside	Southwest
TN 8329	Trackside	Southwest

[17] Consultation undertaken with Network Rail in the UK

[18] These fixed heights for signal receptors is for modelling purposes. Small changes to the modelling height by a few metres is not expected to significantly change the modelling results.

Signal	Type	Orientation
TN 8327	Trackside	Southwest
TN 8325	Trackside	Southwest
TN 8354	Cantilever	Northeast
TN 8366	Cantilever	Southwest
1	Ground mounted	Northeast
2	Ground mounted	Southwest

Table 3 Identified railway signals

The signal receptor relative to the Proposed Development is shown in Figure 8 below. The orientation of the signal is labelled.

Figure 8 *Assessed trackside signal*

5.6 Road Receptors

5.6.1 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 one or more carriageways with a maximum speed limit of 60mph or 70mph. These roads typically have fast-moving vehicles with moderate to busy traffic density;

- Regional – Typically a single carriageway with a maximum speed limit of up to 60mph. The speed of vehicles will vary with a typical traffic density of low to moderate;
- Local – Typically roads and lanes with the lowest traffic densities. Speed limits vary.

Technical modelling is not recommended for local roads, where traffic densities are likely to be relatively low. Any solar reflections from the Proposed Development that are experienced by a road user along a local road would be considered low impact in the worst case in accordance with the guidance presented in Appendix D. The analysis has also considered major national, national, and regional roads that:

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

5.6.2 Identified Road Receptors

A 200m section of the A156/Gainsborough Road operated within the assessment area, but has not been geometrically modelled due to existing vegetation and intervening terrain obstructing views of the Proposed Development for road users. Therefore, no impact is predicted upon the A156/Gainsborough Road, and mitigation is not required. Figures 9 and 10 on the following page shows the section on the A156/Gainsborough Road within the assessment area and the screening identified.

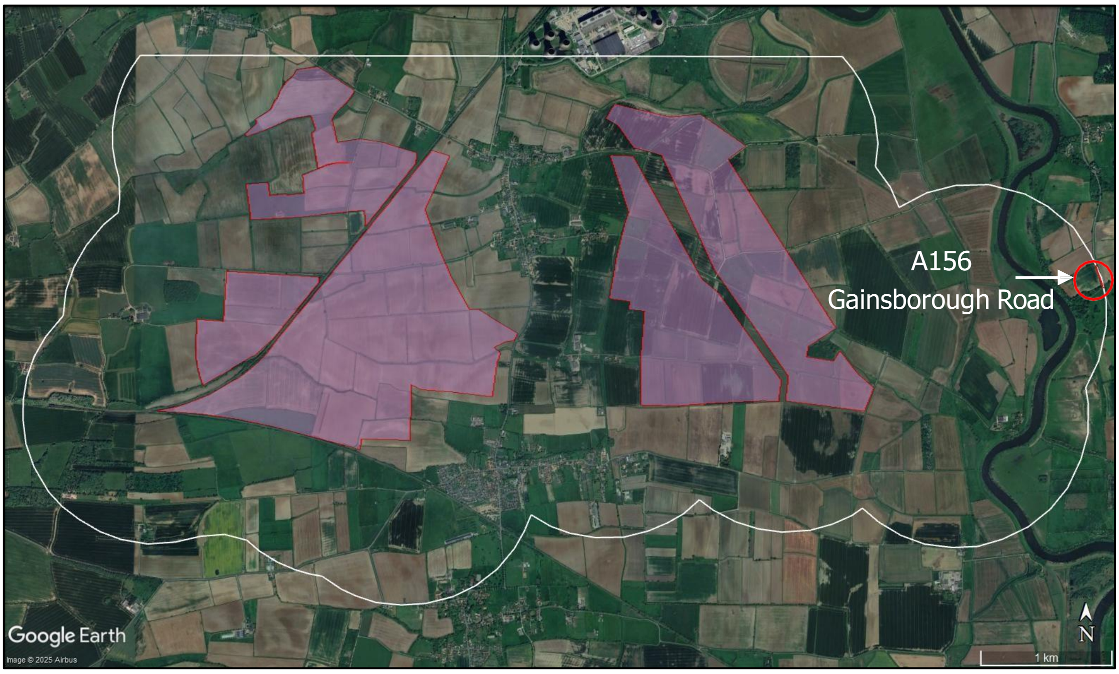

Figure 9 *Section of A156/Gainsborough Road within assessment area*

Figure 10 *Views along the A156/Gainsborough Road*

5.7 Dwelling Receptors

5.7.1 Dwelling Receptors Overview

The analysis has considered dwellings that:

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

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

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

A height of 1.8 metres above ground level has been used to model the typical eye-level from the ground floor[19].

5.7.2 Identified Dwelling Receptors

In total, 212 dwelling receptors have been assessed. An overview of the dwelling receptors is shown in Figure 11 below. Detailed identification of dwelling receptors is presented in Appendix H.

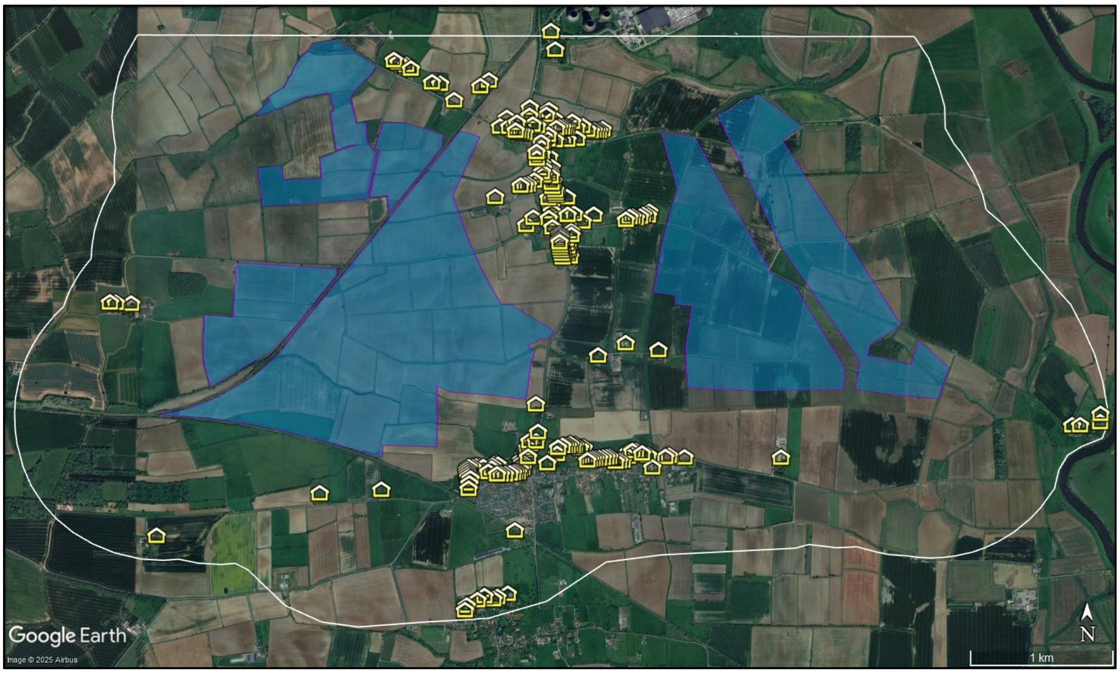

Figure 11 *Overview of dwelling receptors*

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

6 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

6.1 Overview

The following sub-sections summarise the results of the assessment:

- 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 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 I, 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.

6.2 Aviation Receptors

6.2.1 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 4 below along with the associated colour coding.

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

Table 4 *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.

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 I presents the results charts showing specific times and dates.

6.2.2 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 (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 approach bearing), 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 USA[20] 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 no greater than 'low potential for temporary after-image' expert assessment of the following mitigating factors is required to determine the impact significance[21]:

- 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.

In all cases, however, consultation with the aerodrome is recommended to understand their position pertaining to solar reflections towards the ATC Tower or approach paths, along with any feedback or comments regarding the Proposed Development.

6.2.3 Geometric Modelling Results

Tables 5 to 7 on the following pages presents the geometric modelling results (considering both 10- and 30-degree panel tilts) for receptors associated with each aerodrome.

[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.

6.2.3.1 West Burton Airfield

Receptor	Geometric Modelling Result	Glare Intensity	Predicted Impact
Splayed Approach Runway 01	Solar reflections are geometrically possible towards a 0.5-mile section, between 0.5 miles and 1.0 miles from the threshold	Yellow	Low impact Discussed in Section 6.2.4
Splayed Approach Runway 19	Solar reflections are not geometrically possible towards the final splayed approach	N/A	No impact
Final Sections of Visual Circuits 01/19	Solar reflections are geometrically possible towards sections of the visual circuits for threshold 01	Yellow	Low impact Discussed in Section 6.2.4

Table 5 *Geometric modelling results - West Burton Airfield*

6.2.3.2 Grove Farm Airfield

Receptor	Geometric Modelling Result	Glare Intensity	Predicted Impact
Splayed Approach Runway 12	Solar reflections are geometrically possible towards a 1.0-mile section, between 0.0 miles and 1.0 miles from the threshold	Yellow	Low impact Discussed in Section 6.2.4
Splayed Approach Runway 30	Solar reflections not geometrically possible towards the final splayed approach	N/A	No impact
Final Sections of Visual Circuits 12/30	Solar reflections are geometrically possible towards sections of the visual circuits for threshold 12	Green	Low impact Considering the associated guidance (Appendix D) for approach paths at licensed aerodromes which states this intensity is acceptable, it can also be considered acceptable for the approach for these receptors

Table 6 *Geometric modelling results - Grove Farm Airfield*

6.2.3.3 Forwood Farm Airfield

Receptor	Geometric Modelling Result	Glare Intensity	Predicted Impact
Splayed Approach Runway 02	Solar reflections are geometrically possible outside a pilot's primary field-of-view	Outside FOV	Low impact Solar reflections occur outside a pilot's FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)
Splayed Approach Runway 20	Solar reflections are not geometrically possible	N/A	No impact
Final Sections of Visual Circuits 02/20	Solar reflections are geometrically possible outside a pilot's primary field-of-view	Outside FOV	Low impact Solar reflections occur outside a pilot's FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)

Table 7 *Geometric modelling results - Forwood Farm Airfield*

6.2.4 Further Analysis of Yellow Glare

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 USA 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 intensity no greater than 'low potential for temporary after-image' expert assessment of the following mitigating factors, with respect to the airfield's specific operations.

Table 8 below presents the maximum duration of 'yellow' glare annually for each respective aerodrome. The duration is also considered as a percentage relative to average daylight hours[22] in any given year.

Aerodrome	Receptor	Annual Duration (mins)	Percentage of Daylight Hours (%)	Time (GMT)
West Burton	Base leg section of circuit for threshold 01 (30° panel tilt)	16,209	6.17	Between 06:00 – 07:00
Grove Farm	1.0 miles from threshold 12 during splayed approach (30° panel tilt)	1,667	0.63	Between 06:00 – 07:00

Table 8 *Maximum duration of 'yellow' glare*

The following points are also considered for all instances of 'yellow glare' for both aerodromes:

- Solar reflections with 'yellow' glare are predicted at times when the Sun is low in the sky beyond the reflecting panels. This means that a pilot will likely have a view of the Sun within the same viewpoint of the reflecting solar. The Sun is a far more significant source of light, and therefore the glare originating from the Proposed Development will be less significant;
- The 'yellow' glare only marginally exceeds the 'yellow' threshold on the intensity chart. 'Green' glare (or glare with 'low potential for temporary after-image') is considered an acceptable level of glare intensity for aircrafts on approach. The glare intensity does not border onto a greater level of intensity than 'yellow';
- Instances of 'yellow' glare for both aerodromes will not occur for more than 30 minutes on any given day;

[22] Based on 12 hours of sunlight a day / 262,800 minutes per year

- The volume of air traffic at both GA aerodromes is expected to be relatively low compared to licensed aerodromes and understood not to undertake training exercises (for trainee pilots);
- The weather would have to be clear and sunny at the specific times when the glare was possible to be experienced. A pilot would also have to be on approach/the circuit path at the times when solar reflections are possible.

It is expected that operational measures used by pilots to mitigate the effects of direct sunlight could potentially be used to mitigate the effects of solar glare from the panels. The instances of 'yellow' glare could potentially be operationally accommodated, subject to consultation with the airfields.

6.3 Railway Train Driver Receptors

6.3.1 Key Considerations

The key considerations for quantifying impact significance for train driver receptors are:

- Whether a reflection is predicted to be experienced in practice;
- The location of the reflecting panel relative to a train driver's direction of travel;
- The workload of a train driver experiencing a solar reflection.

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 train driver's primary field-of-view (30 degrees either side of the direction of travel), or where the separation distance to the nearest visible reflecting panel is over 500m, the impact significance is low, and mitigation is not recommended.

Where reflections originate from inside of a train driver's primary field-of-view, expert assessment of the following mitigating factors is required to determine the impact significance:

- Whether the solar reflection originates from directly in front of a train driver. Solar reflections that are directly in front of a road user are more hazardous;
- 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 train driver;
- 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 workload of a train driver experiencing a solar reflection. Is there visibility of a railway signal or level crossing when solar reflections are predicted to be received? Is there a switch in the railway line when solar reflections are predicted to be received?
- The position of the Sun. Effects that coincide with direct sunlight appear less prominent than those that do not. The Sun is a far more significant source of light.

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

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

6.3.2 Geometric Modelling Results

The results of the geometric modelling results (considering both 10- and 30-degree panel tilts) for the train driver receptors are presented in Table 9 on the following pages. The screening review is presented in Appendix J.

Train Driver Receptor	Geometric Modelling Results	Relevant Factors	Impact Classification (Without Vegetation Screening)	Identified Screening (desk-based review of imagery)	Impact Classification
1 – 5	Solar reflections are geometrically possible **inside** a train driver's field-of-view	Solar reflections coincide with the Sun Sight of a signal TN 8366 and two ground-mounted (heading northeast) is required during this section of the railway	Moderate impact	Existing vegetation and intervening terrain are predicted to significantly obstruct views of reflecting areas	No impact
6 – 7	Solar reflections are geometrically possible **inside** a train driver's field-of-view	Solar reflections coincide with the Sun Sight of a signal is not required during this section of the railway	Low impact	Existing vegetation and intervening terrain are predicted to obstruct views of reflecting areas with fleeting views considered possible	Low impact
8	Solar reflections are geometrically possible **inside** a train driver's field-of-view	Solar reflections coincide with the Sun Sight of signal TN 8329 is required (heading northeast) during this section of the railway	Low impact	Existing vegetation and intervening terrain are predicted to significantly obstruct views of reflecting areas	No impact

Train Driver Receptor	Geometric Modelling Results	Relevant Factors	Impact Classification (Without Vegetation Screening)	Identified Screening (desk-based review of imagery)	Impact Classification
9 – 17	Solar reflections are geometrically possible **inside** a train driver's field-of-view	Solar reflections coincide with the Sun Sight of a signal is not required during this section of the railway	Low impact	Existing vegetation and intervening terrain are predicted to obstruct views of reflecting areas with fleeting views considered possible	Low impact
18	Solar reflections are geometrically possible **inside** a train driver's field-of-view	Solar reflections coincide with the Sun Sight of signal TN 8331 is required (heading northeast) during this section of the railway	Moderate impact	Existing vegetation and intervening terrain are predicted to significantly obstruct views of reflecting areas	No impact
19 – 21	Solar reflections are geometrically possible **inside** a train driver's field-of-view	Solar reflections coincide with the Sun Sight of a signal is not required during this section of the railway	Low impact	Existing vegetation and intervening terrain are predicted to significantly obstruct views of reflecting areas	No impact

Train Driver Receptor	Geometric Modelling Results	Relevant Factors	Impact Classification (Without Vegetation Screening)	Identified Screening (desk-based review of imagery)	Impact Classification
22	Solar reflections are geometrically possible **inside** a train driver's field-of-view	Solar reflections coincide with the Sun Sight of signal TN 8356 is required (heading northeast) during this section of the railway	Moderate impact	Existing vegetation and intervening terrain are predicted to significantly obstruct views of reflecting areas	No impact
23 – 28	Solar reflections are geometrically possible **inside** a train driver's field-of-view	Solar reflections coincide with the Sun Sight of a signal is not required during this section of the railway	Low impact	Existing vegetation and intervening terrain are predicted to significantly obstruct views of reflecting areas	No impact
29	Solar reflections are geometrically possible **inside** a train driver's field-of-view	Solar reflections coincide with the Sun Sight of signal TN 8327 is required (heading southwest) during this section of the railway but does not occur behind the signal (i.e. phantom aspect illusion) or impede its readability	Moderate impact	Existing vegetation and intervening terrain are predicted to obstruct views of reflecting areas with fleeting views considered possible	Low impact

Train Driver Receptor	Geometric Modelling Results	Relevant Factors	Impact Classification (Without Vegetation Screening)	Identified Screening (desk-based review of imagery)	Impact Classification
30 – 34	Solar reflections are geometrically possible **inside** a train driver's field-of-view	Solar reflections coincide with the Sun Sight of a signal is not required during this section of the railway	Low impact	Existing vegetation and intervening terrain are predicted to obstruct views of reflecting areas with fleeting views considered possible	Low impact
35 – 44	Solar reflections are geometrically possible **outside** a train driver's field-of-view	Sight of a signal is not required during this section of the railway	Low impact	Existing vegetation and intervening terrain are predicted to significantly obstruct views of reflecting areas	No impact
45 – 68	Solar reflections are geometrically possible **inside** a train driver's field-of-view	Section of railway is not in active use Solar reflections coincide with the Sun	Low impact	Existing vegetation and intervening terrain are predicted to significantly obstruct views of reflecting areas	No impact

Table 9 *Geometric modelling results - railway train driver receptors*

6.4 Railway Signal Receptors

6.4.1 Key Considerations

The process for quantifying impact significance is defined in the report appendices. The key considerations for railway signals are:

- Whether a reflection is predicted to reach the signal lens or not;
- Whether the railway signal appears to be LED or incandescent;
- Whether the solar reflections illuminates the signal directly.

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 90 degrees either side of the direction of the signal or where the separation distance to the nearest visible reflecting panel is over 500m, the impact significance is low, and mitigation is not recommended.
Where reflections are predicted to reach the signal from within 90 degrees either side of the direction of the signal, expert assessment of the following relevant factors is required to determine the impact significance:

- Whether the railway signal appears to be LED or incandescent;
- Whether the solar reflection originates from directly in front of the signal;
- Whether the railway signal has a hood fitted or not;
- The separation distance to the reflecting area. Larger separation distances reduce the likelihood of phantom aspect illusion.

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 an incandescent signal and there are no mitigating factors, the impact significance is high, and mitigation is required.

6.4.2 Geometric Modelling Results

The results of the geometric modelling results (considering both 10- and 30-degree panel tilts) for the train signal receptors are presented in Table 10 on the following pages. The screening review is presented in Appendix J.

Signal Receptor	Geometric Modelling Results	Relevant Factors	Impact Classification (Without Vegetation Screening)	Identified Screening (desk-based review of imagery)	Impact Classification
Trackside TN 8331	Solar reflections are geometrically possible	Solar reflections do not occur behind the signal (i.e. phantom aspect illusion) and do not impede its readability	Low	No significant screening identified	Low
Trackside TN 8329	Solar reflections are geometrically possible	Solar reflections do not occur behind the signal (i.e. phantom aspect illusion) and do not impede its readability	Low	No significant screening identified	Low
Trackside TN 8327	Solar reflections are geometrically possible	Solar reflections do not occur behind the signal (i.e. phantom aspect illusion) and do not impede its readability	Low	No significant screening identified	Low

Signal Receptor	Geometric Modelling Results	Relevant Factors	Impact Classification (Without Vegetation Screening)	Identified Screening (desk-based review of imagery)	Impact Classification
Trackside TN 8325	Solar reflections are geometrically possible	Solar reflections are within field-of-view when sighting signal	Moderate	Existing vegetation and intervening terrain predicted to obstruct views of reflecting panels	No impact
Cantilever TN 8354	Solar reflections are geometrically possible	Solar reflections are not within field-of-view when sighting signal	Low	Existing vegetation and intervening terrain predicted to obstruct views of reflecting panels	No impact
Cantilever TN 8356	Solar reflections are geometrically possible	Solar reflections are within field-of-view when sighting signal	Moderate	Existing vegetation and intervening terrain predicted to obstruct views of reflecting panels	No impact
Cantilever TN 8366	Solar reflections are geometrically possible	Solar reflections are within field-of-view when sighting signal	Moderate	Existing vegetation and intervening terrain predicted to obstruct views of reflecting panels	No impact

Signal Receptor	Geometric Modelling Results	Relevant Factors	Impact Classification (Without Vegetation Screening)	Identified Screening (desk-based review of imagery)	Impact Classification
Ground-mounted 1	Solar reflections are geometrically possible	Solar reflections are within field-of-view when sighting signal	Moderate	Existing vegetation and intervening terrain predicted to obstruct views of reflecting panels	No impact
Ground-mounted 2	Solar reflections are geometrically possible	Solar reflections are not within field-of-view when sighting signal	Low	Existing vegetation and intervening terrain predicted to obstruct views of reflecting panels	No impact

Table 10 *Geometric modelling results - railway train signal receptors*

6.5 Dwelling Receptors

6.5.1 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:
    - Three 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 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 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.

If effects 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.

6.5.2 Geometric Modelling Results

Table 11 on the following pages presents the geometric modelling results (considering both 10- and 30-degree panel tilts) and predicted impact significance for the assessed dwelling receptors. The screening review is presented in Appendix J.

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[23]	Mitigating Factors	Predicted Impact Classification
1	Solar reflections are geometrically possible for **less** than three months per year and **less** than 60 minutes on any given day	Existing vegetation, buildings and intervening terrain predicted to significantly obstruct views of reflecting panels	N/A	N/A	No impact
2 – 6	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation, buildings and intervening terrain predicted to significantly obstruct views of reflecting panels	N/A	N/A	No impact
7 – 10	Solar reflections are geometrically possible for **less** than three months per year and **less** than 60 minutes on any given day	Existing vegetation, buildings and intervening terrain predicted to significantly obstruct views of reflecting panels	N/A	N/A	No 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 three months per year 2) and/or for more than 60 minutes on any given day.

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[23]	Mitigating Factors	Predicted Impact Classification
11	Solar reflections are geometrically possible for **less** than three months per year and **less** than 60 minutes on any given day	Existing vegetation predicted to significantly obstruct views from ground floor, with views above ground floor considered possible	**Less** than three months per year and **less** than 60 minutes on any given day	N/A	Low impact
12 – 17	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation, buildings and intervening terrain predicted to significantly obstruct views of reflecting panels	N/A	N/A	No impact
18 – 24	Solar reflections are geometrically possible for **less** than three months per year and **less** than 60 minutes on any given day	Existing vegetation, buildings and intervening terrain predicted to significantly obstruct views of reflecting panels	N/A	N/A	No impact

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Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[23]	Mitigating Factors	Predicted Impact Classification
25 – 104	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation, buildings and intervening terrain predicted to significantly obstruct views of reflecting panels	N/A	N/A	No impact
105	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation predicted to obstruct views with partial views considered possible	**More** than three months per year but **less** than 60 minutes on any given day	Reflections will coincide with the Sun Separation distance greater than 400m	Low impact
106 – 147	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation, buildings and intervening terrain predicted to significantly obstruct views of reflecting panels	N/A	N/A	No impact

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[23]	Mitigating Factors	Predicted Impact Classification
148	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation predicted to obstruct views with partial views considered possible	**More** than three months per year but **less** than 60 minutes on any given day	Views will coincide with the Sun Separation distance greater than 300m	Low impact
149	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation, buildings and intervening terrain predicted to significantly obstruct views of reflecting panels	N/A	N/A	No impact
150 – 155	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation predicted to obstruct views with partial views considered possible	**More** than three months per year but **less** than 60 minutes on any given day	Views will coincide with the Sun Separation distance greater than 800m	Low impact

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[23]	Mitigating Factors	Predicted Impact Classification
156 – 158	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation predicted to obstruct views with partial views considered possible	**More** than three months per year but **less** than 60 minutes on any given day	Views will coincide with the Sun Separation distance greater than 400m	Low impact
159 – 212	Solar reflections are geometrically possible for **more** than three months per year but **less** than 60 minutes on any given day	Existing vegetation, buildings and intervening terrain predicted to significantly obstruct views of reflecting panels	N/A	N/A	No impact

Table 11 *Geometric modelling results - dwelling receptors*

7 HIGH-LEVEL AVIATION ASSESSMENTS

7.1 Overview

Glint and glare assessment for aviation receptors are typically undertaken for licensed aerodromes within 10km of a proposed solar development. Geometric modelling for general aviation unlicensed aerodromes is typically required within 5km of a Proposed Development. At ranges of 10-20km, the requirement for assessment is much less common for unlicensed aerodromes, with typically assessment only being undertaken for licensed aerodromes at these ranges. The assessment of any aviation effects for developments over 20km is not a usual requirement.

7.2 Identified Aerodromes

Table 12 below and on the following page summarises identified aerodromes within 20km from the Proposed Development.

Aerodrome	Type	ATC Tower	Operational Runway(s)	Distance from Proposed Development
RAF Scampton	Military	One	04/22	15.4km east
Retford Gamson	CAA Licensed	One	03/21 14/32	8.6km southwest
Carr Farm Airfield	Unlicensed GA	N/A	07/25	13.2km south
Dalton Gliding Airfield	Unlicensed GA/Gliding	N/A	05/23	9.8km south
Headon Airfield	Unlicensed GA	N/A	05/23 14/32	6.1km south
Stow Airfield	Unlicensed GA	N/A	07/25	6.9km east
Sturgate Airfield	Unlicensed GA	N/A	09/27	7.9km northeast
Willow Farm Airfield	Unlicensed GA	N/A	06/24	8.7km northwest

Aerodrome	Type	ATC Tower	Operational Runway(s)	Distance from Proposed Development
Robin Hood Doncaster Sheffield Airport	Non-active[24] CAA licensed	One	02/20	16.9km northwest

Table 12 *Identified aerodromes for high-level assessment*

Figure 12 on the following page shows the identified aerodromes relative to the Proposed Development.

[24] Robin Hood Doncaster Sheffield Airport has been permanently closed since November 2022. It has been included for completeness due to its planned reopening in 2026.

Figure 12 *Identified aerodromes for high-level assessments*

7.3 High-Level Assessments

Table 13 below and on the following pages summarises the predicted impact upon each aerodrome. Assessment conclusions are based on the Proposed Development size, distance from the aerodrome, geometric modelling assessment results for the aerodromes geometrically modelled in this assessment, and Pager Power's industry experience.

Reference to glare intensity and a pilot's primary field-of-view is made during the analysis as defined in sections 6.2.1 and 6.2.2 respectively.

<table>
<tr><th>Aerodrome</th><th>Receptor/Runway Threshold</th><th>Assessment</th><th>Impact</th><th>Recommendations</th></tr>
<tr><td rowspan="3">RAF Scampton</td><td>ATC Tower</td><td>Solar reflections predicted to be screened, therefore not predicted to impact personnel within the control room</td><td>None</td><td rowspan="3">Mitigation is not required
Detailed modelling is not recommended</td></tr>
<tr><td>04</td><td>Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)</td><td>Low</td></tr>
<tr><td>22</td><td>Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)</td><td>Low</td></tr>
<tr><td rowspan="2">Retford Gamson</td><td>ATC Tower</td><td>Solar reflections predicted to be screened, therefore not predicted to impact personnel within the control room</td><td>None</td><td rowspan="2">Mitigation is not required
Detailed modelling is not recommended</td></tr>
<tr><td>03</td><td>Solar reflections are predicted to have a maximum glare intensity of 'green' and therefore considered acceptable in accordance with the associated guidance (Appendix D) and industry best practice</td><td>Low</td></tr>
</table>

Aerodrome	Receptor/Runway Threshold	Assessment	Impact	Recommendations
Retford Gamson	21	Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)	Low	Mitigation is not required Detailed modelling is not recommended
	14	Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)	Low	
	32	Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)	Low	
Carr Farm Airfield	07	Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)	Low	Mitigation is not required Detailed modelling is not recommended
	25	Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)	Low	

Aerodrome	Receptor/Runway Threshold	Assessment	Impact	Recommendations
Dalton Gliding Airfield	05	Solar reflections are predicted to have a maximum glare intensity of 'green'. Considering the associated guidance (Appendix D) for approach paths at licensed aerodromes which states this intensity is acceptable, it can also be considered acceptable for the approach for this unlicensed aerodrome	Low	Mitigation is not required Detailed modelling is not recommended
	23	Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)	Low	
Headon Airfield	05	Solar reflections are predicted to have a maximum glare intensity of 'green'. Considering the associated guidance (Appendix D) for approach paths at licensed aerodromes which states this intensity is acceptable, it can also be considered acceptable for the approach for this unlicensed aerodrome	Low	Mitigation is not required Detailed modelling is not recommended
	23	Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)	Low	

Aerodrome	Receptor/Runway Threshold	Assessment	Impact	Recommendations
Headon Airfield	14	Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)	Low	Mitigation is not required Detailed modelling is not recommended
	32	Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)	Low	
Stow Airfield	07	Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)	Low	Mitigation is not required Detailed modelling is not recommended
	25	Solar reflections are predicted to have a maximum glare intensity of 'green'. Considering the associated guidance (Appendix D) for approach paths at licensed aerodromes which states this intensity is acceptable, it can also be considered acceptable for the approach for this unlicensed aerodrome	Low	

Aerodrome	Receptor/Runway Threshold	Assessment	Impact	Recommendations
Sturgate Airfield	09	Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)	Low	Mitigation is not required Detailed modelling is not recommended
	27	Solar reflections are predicted to have a maximum glare intensity of 'green'. Considering the associated guidance (Appendix D) for approach paths at licensed aerodromes which states this intensity is acceptable, it can also be considered acceptable for the approach for this unlicensed aerodrome	Low	
Willow Farm Airfield	06	Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)	Low	Mitigation is not required Detailed modelling is not recommended
	24	Solar reflections are predicted to have a maximum glare intensity of 'green'. Considering the associated guidance (Appendix D) for approach paths at licensed aerodromes which states this intensity is acceptable, it can also be considered acceptable for the approach for this unlicensed aerodrome	Low	

Aerodrome	Receptor/Runway Threshold	Assessment	Impact	Recommendations
Robin Hood Doncaster Sheffield Airport	ATC Tower	Solar reflections predicted to be screened, therefore not predicted to impact personnel within the control room	Low	Mitigation is not required Detailed modelling is not recommended
	02	Solar reflections occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated guidance (Appendix D)	Low	
	20	Solar reflections are predicted to have a maximum glare intensity of 'green' and therefore considered acceptable in accordance with the associated guidance (Appendix D) and industry best practice	Low	

Table 13 *High-level aviation assessments*

7.4 Conclusions

No significant impacts are predicted upon aviation activity associated with the (additional) identified aerodromes.

8 HIGH-LEVEL PUBLIC RIGHTS OF WAY ASSESSMENT

8.1 Overview

The following sections present an overview of considerations for public rights of way (PRoW), including canal users and bridleways relative to the Proposed Development.

8.2 Assessment

In Pager Power's experience, significant impacts from glint and glare are not possible upon pedestrians/observers along PRoW. The reasoning is due to the sensitivity of the receptors (in terms of amenity and safety) being concluded to be of low significance due to:

- The typical density of pedestrians at these locations is usually low;
- 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 to safety;
- Glint and glare effects towards receptors 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;
- There is no safety hazard associated with reflections towards an observer on a footpath.

Furthermore, any impact will be of a low magnitude when considering the worst case due-to:

- The existing screening is predicted significantly reduce/obstruct the visibility of the Proposed Development for any potential observers;
- The separation distance between the canal and solar panels for the Proposed Development is greater than 900m at it's closest point
- Solar reflections towards observers could therefore be experienced under certain conditions (typically within a few hours of sunrise/sunset i.e. when the Sun is low in the sky beyond the panels). Therefore, if effects are possible and unscreened, they would typically coincide the Sun, a far more significant source of light;
- The reflection intensity is similar for solar panels and still water (and significantly less than reflections from glass and steel[25]) which is frequently a feature of the outdoor environment surrounding rivers, including the river water itself. Therefore, the reflections are likely to be comparable to those from common outdoor sources whilst navigating the river on a regular basis;.

8.3 Conclusions

No significant impact is predicted upon public rights of way, canal users and bridleways. Mitigation is not required.

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

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

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

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

UK Planning Policy

Renewable and Low Carbon Energy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[26] (specifically regarding the consideration of solar farms, paragraph 013) states:

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

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

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

…

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

…

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

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26 Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 14 August 2023, accessed on: 07/01/2025

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.

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[27] National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Energy Security & Net Zero, date: January 2024.

[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 document[29] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

Railway Assessment Guidelines

The following section provides an overview of the relevant railway guidance with respect to the siting of signals on railway lines. Network Rail is the stakeholder of the UK's railway infrastructure. Whilst the guidance is not strictly applicable in Ireland, the general principles within the guidance is expected to apply.

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

A railway operator's concerns would likely to relate to the following:

1. The development producing solar glare that affects train drivers; and
2. The development producing solar reflections that affect railway signals and create a risk of a phantom aspect signal.

Railway guidelines are presented below. These relate specifically to the sighting distance for railway signals.

Reflections and Glare

The extract below is taken from Section A5 – Reflections and glare (pages 64-65) of the 'Signal Sighting Assessment Requirements'30 which details the requirement for assessing glare towards railway signals.

Reflections and glare

Rationale

Reflections can alter the appearance of a display so that it appears to be something else.

Guidance

A5 is present if direct glare or reflected light is directed into the eyes or into the lineside signalling asset that could make the asset appear to show a different aspect or indication to the one presented.

A5 is relevant to any lineside signalling asset that is capable of presenting a lit signal aspect or indication.

The extent to which excessive illumination could make an asset appear to show a different signal aspect or indication to the one being presented can be influenced by the product being used. Requirements for assessing the phantom display performance of signalling products are set out in GKRT0057 section 4.1.

Problems arising from reflection and glare occur when there is a very large range of luminance, that is, where there are some objects that are far brighter than others. The following types of glare are relevant:

a) Disability glare, caused by scattering of light in the eye, can make it difficult to read a lit display.

b) Discomfort glare, which is often associated with disability glare. While being unpleasant, it does not affect the signal reading time directly, but may lead to distraction and fatigue.

Examples of the adverse effect of disability glare include:

a) When a colour light signal presenting a lit yellow aspect is viewed at night but the driver is unable to determine whether the aspect is a single yellow or a double yellow.

b) Where a colour light signal is positioned beneath a platform roof painted white and the light reflecting off the roof can make the signal difficult to read.

Options for militating against A5 include:

a) Using a product that is specified to achieve high light source: phantom ratio values.

b) Alteration to the features causing the glare or reflection.

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[30] Source: Signal Sighting Assessment Requirements, June 2016. Railway Group Guidance Note. Last accessed 18.10.2016.

c) *Provision of screening.*

Glare is possible and should be assessed when the luminance is much brighter than other light sources. Glare may be unpleasant and therefore cause distraction and fatigue, or may make the signal difficult to read and increase the reading time.

Determining the Field of Focus

The extract below is taken from Appendix F - Guidance on Field of Vision (pages 98-101) of the 'Signal Sighting Assessment Requirements'31 which details the visibility of signals, train drivers' field of vision and the implications with regard to signal positioning.

Asset visibility

The effectiveness of an observer's visual system in detecting the existence of a target asset will depend upon its:

a) *Position in the observer's visual field.*

b) *Contrast with its background.*

c) *Luminance properties.*

d) *The observer's adaptation to the illumination level of the environment.*

It is also influenced by the processes relating to colour vision, visual accommodation, and visual acuity. Each of these issues is described in the following sections.

Field of vision

The field of vision, or visual field, is the area of the visual environment that is registered by the eyes when both eyes and head are held still. The normal extent of the visual field is approximately 135o in the vertical plane and 200o in the horizontal plane.

The visual field is usually described in terms of central and peripheral regions: the central field being the area that provides detailed information. This extends from the central point (0º) to approximately 30º at each eye. The peripheral field extends from 30o out to the edge of the visual field.

F.6.3 Objects positioned towards the centre of the observer's field of vision are seen more quickly and identified more accurately because this is where our sensitivity to contrast is the highest. Peripheral vision is particularly sensitive to movement and light.

[31] Source: Signal Sighting Assessment Requirements, June 2016. Railway Group Guidance Note. Last accessed 28.08.2020.

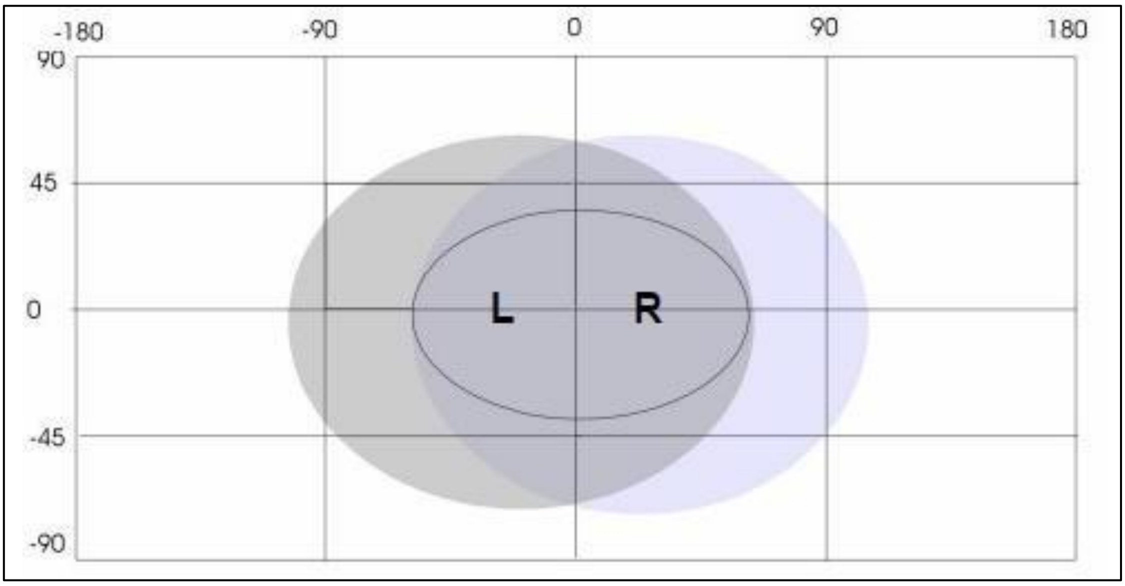

Figure G 21 - Field-of-view

In Figure G 21, the two shaded regions represent the view from the left eye (L) and the right eye (R) respectively. The darker shaded region represents the region of binocular overlap. The oval in the centre represents the central field of vision.

Research has shown that drivers search for signs or signals towards the centre of the field of vision. Signals, indicators and signs should be positioned at a height and distance from the running line that permits them to be viewed towards the centre of the field of vision. This is because:

a) *As train speed increases, drivers become increasingly dependent on central vision for asset detection. At high speeds, drivers demonstrate a tunnel vision effect and focus only on objects in a field of + 8º from the direction of travel.*
b) *Sensitivity to movement in the peripheral field, even minor distractions can reduce the visibility of the asset if it is viewed towards the peripheral field of vision. The presence of clutter to the sides of the running line can be highly distracting (for example, fence posts, lamp-posts, traffic, or non-signal lights, such as house, compatibility factors or security lights).*

Figure G 22 and Table G 5 identify the radius of an 8o cone at a range of close-up viewing distances from the driver's eye. This shows that, depending on the lateral position of a stop signal, the optimal (normal) train stopping point could be as far as 25 m back from the signal to ensure that it is sufficiently prominent.

The dimensions quoted in Table G 5 assume that the driver is looking straight ahead. Where driver-only operation (DOO) applies, the drivers' line of sight at the time of starting the train is influenced by the location of DOO monitors and mirrors. In this case it may be appropriate to provide supplementary information alongside the monitors or mirrors using one of the following:

a) *A co-acting signal.*
b) *A miniature banner repeater indicator.*
c) *A right away indicator.*
d) *A sign to remind the driver to check the signal aspect.*

In order to prevent misreading by trains on adjacent lines, the co-acting signal or miniature banner repeater may be configured so that the aspect or indication is presented only when a train is at the platform to which it applies.

'Car stop' signs should be positioned so that the relevant platform starting signals and / or indicators can be seen in the driver's central field of vision.

If possible, clutter and non-signal lights in a driver's field-of-view should be screened off or removed so that they do not cause distraction.

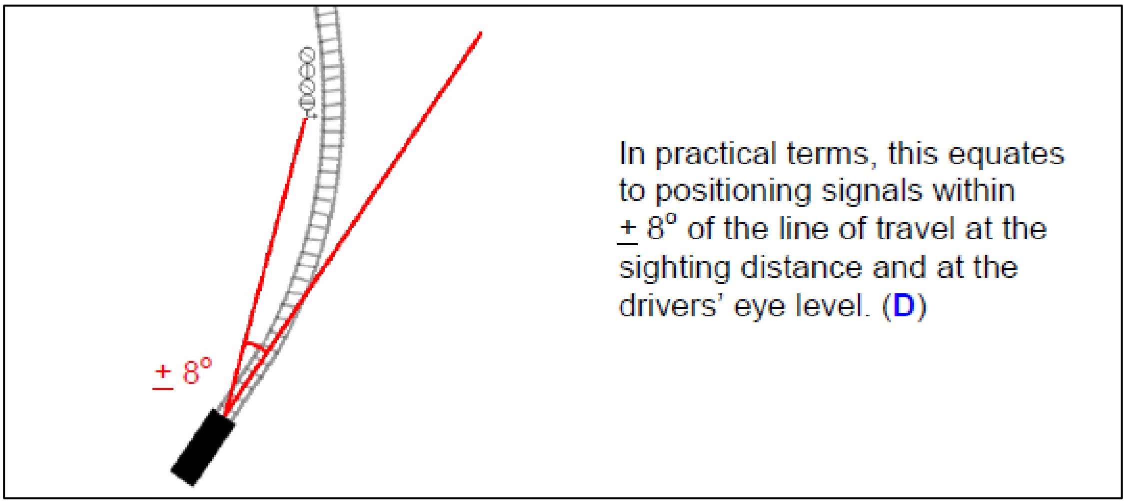

Figure G 22 - Signal positioning

'A' (m)	'B' (m)	Typical display positions
5	*0.70*	-
6	*0.84*	-
7	*0.98*	-
8	*1.12*	-
9	*1.26*	-
10	*1.41*	-
11	*1.55*	-
12	*1.69*	-
13	*1.83*	-
14	*1.97*	-
15	*2.11*	*A stop aspect positioned 3.3 m above rail level and 2.1 m from the left hand rail is within the 8º cone at 15.44 m in front of the driver*
16	*2.25*	-
17	*2.39*	-
18	*2.53*	*A stop aspect positioned 5.1 m above rail level and 0.9 m from the left hand rail is within the 8º cone at 17.93 m in front of the driver*
19	*2.67*	-
20	*2.81*	-
21	*2.95*	-
22	*3.09*	-
23	*3.23*	-
24	*3.37*	-
25	*3.51*	*A stop aspect positioned 3.3 m above rail level and 2.1 m from the right hand rail is within the 8º cone at 25.46 m in front of the driver*

Table G 5 – 8º cone angle co-ordinates for close-up viewing

The distance at which the 8° cone along the track is initiated is dependent on the minimum reading time and distance which is associated to the speed of trains along the track. This is discussed below.

Determining the Assessed Minimum Reading Time

The extracts below are taken from the RIS-0737-CCS-1 of the 'Signal Sighting Assessment Requirements' which details the required minimum reading time for a train driver when approaching a signal.

The following abbreviations are defined within the 'Definitions and Abbreviations':

'Baseline response time

The minimum time value that can be used by the SSC to specify the MRT for a particular signalling asset type.

Supplementary response time

The assessed amount of extra time that the SSC adds to the BRT to determine the MRT value for a specific lineside signalling asset.'

The following extract is taken from page 114 of the RIS-0737-CCS-1:

'Minimum response time (MRT)

The assessed minimum time needed by a driver (or other authorised user) to respond to the information presented by a specific lineside signalling asset, taking account of the following human tasks:

a) Read the display or display combination.

a) Interpret the display or display combination

b) Assimilate all of the available information

c) Decide what action to take (if any), and when it needs to be taken

d) Take the action, where necessary, before the train passes the asset.

MRT = BRT + SRT'

The distance at which a signal should be clearly viewable is determined by the maximum speed of the trains along the track. If there are multiple signals present at a location then an additional 0.2 seconds reading time is added to the overall viewing time.

Aviation Assessment Guidance

The UK Civil Aviation Authority (CAA) issued interim guidance relating to Solar Photovoltaic Systems (SPV) on 17 December 2010 and was subject to a CAA information alert 2010/53. The formal policy was cancelled on September 7th, 2012[32] however the advice is still applicable[33] until a formal policy is developed. The relevant aviation guidance from the CAA is presented in the section below.

[32] Archived at Pager Power

[33] Reference email from the CAA dated 19/05/2014.

CAA Interim Guidance

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

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

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

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

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

12. If an installation of SPV systems is planned on-aerodrome (i.e. within its licensed boundary) then it is recommended that data on the reflectivity of the solar panel material should be included in any assessment before installation approval can be granted. Although approval for installation is the responsibility of the ALH[34], 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.

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

[34] Aerodrome Licence Holder.

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'*[35], the 2013 update is entitled '*Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'*[36], and the 2021 final policy is entitled '*Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports'*[37].

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.

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

[35] Archived at Pager Power

[36] 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.

[37] 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.

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*'[38]. 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*[39].
- *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*[40]*, flat, smooth surfaces reflect a more concentrated amount of sunlight back to the receiver, which is referred to as specular reflection. The more a surface is polished, the more it shines. Rough or uneven surfaces reflect light in a diffused or scattered manner and, therefore, the light will not be received as bright.*
- *Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:*
    - *A qualitative analysis of potential impact in consultation with the Control Tower, pilots and airport officials;*
    - *A demonstration field test with solar panels at the proposed site in coordination with FAA Tower personnel;*
    - *A geometric analysis to determine days and times when an impact is predicted.*

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[38] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.
[39] 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.
[40] First figure in Appendix B.

- *The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and system design.*
- ***1. Assessing Baseline Reflectivity Conditions** – Reflection in the form of glare is present in current aviation operations. The existing sources of glare come from glass windows, auto surface parking, rooftops, and water bodies. At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing. Operators also wear polarized eye wear. Potential glare from solar panels should be viewed in this context. Any airport considering a solar PV project should first review existing sources of glare at the airport and the effectiveness of measures used to mitigate that glare.*
- ***2. Tests in the Field** – Potential glare from solar panels can easily be viewed at the airport through a field test. A few airports have coordinated these tests with FAA Air Traffic Controllers to assess the significance of glare impacts. To conduct such a test, a sponsor can take a solar panel out to proposed location of the solar project, and tilt the panel in different directions to evaluate the potential for glare onto the air traffic control tower. For the two known cases where a field test was conducted, tower personnel determined the glare was not significant. If there is a significant glare impact, the project can be modified by ensuring panels are not directed in that direction.*
- ***3. Geometric Analysis** – Geometric studies are the most technical approach for reflectivity issues. They are conducted when glare is difficult to assess through other methods. Studies of glare can employ geometry and the known path of the sun to predict when sunlight will reflect off of a fixed surface (like a solar panel) and contact a fixed receptor (e.g., control tower). At any given site, the sun moves across the sky every day and its path in the sky changes throughout year. This in turn alters the destination of the resultant reflections since the angle of reflection for the solar panels will be the same as the angle at which the sun hits the panels. The larger the reflective surface, the greater the likelihood of glare impacts.*
- *Facilities placed in remote locations, like the desert, will be far from receptors and therefore potential impacts are limited to passing aircraft. Because the intensity of the light reflected from the solar panel decreases with increasing distance, an appropriate question is how far you need to be from a solar reflected surface to avoid flash blindness. It is known that this distance is directly proportional to the size of the array in question[41] 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.*

[41] 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 2016[42] 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.

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[42] 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 document[43] 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.

[43] https://regulatorylibrary.caa.co.uk/139-2014-pdf/PDF.pdf

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

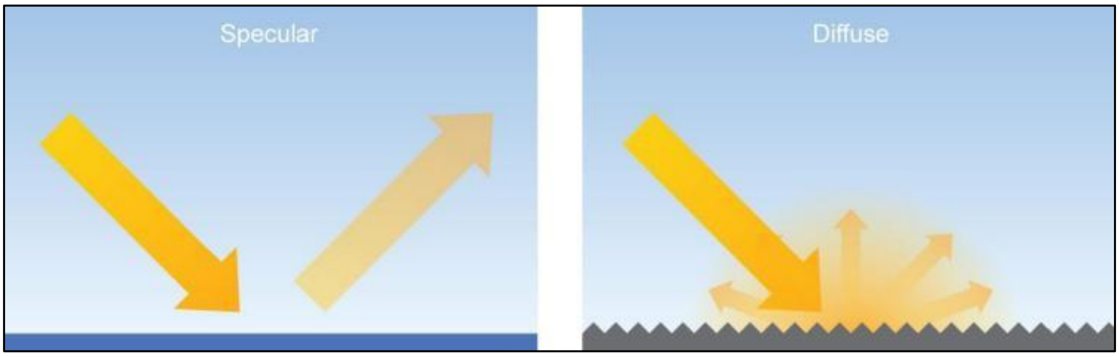
Overview

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 guidance[44], 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

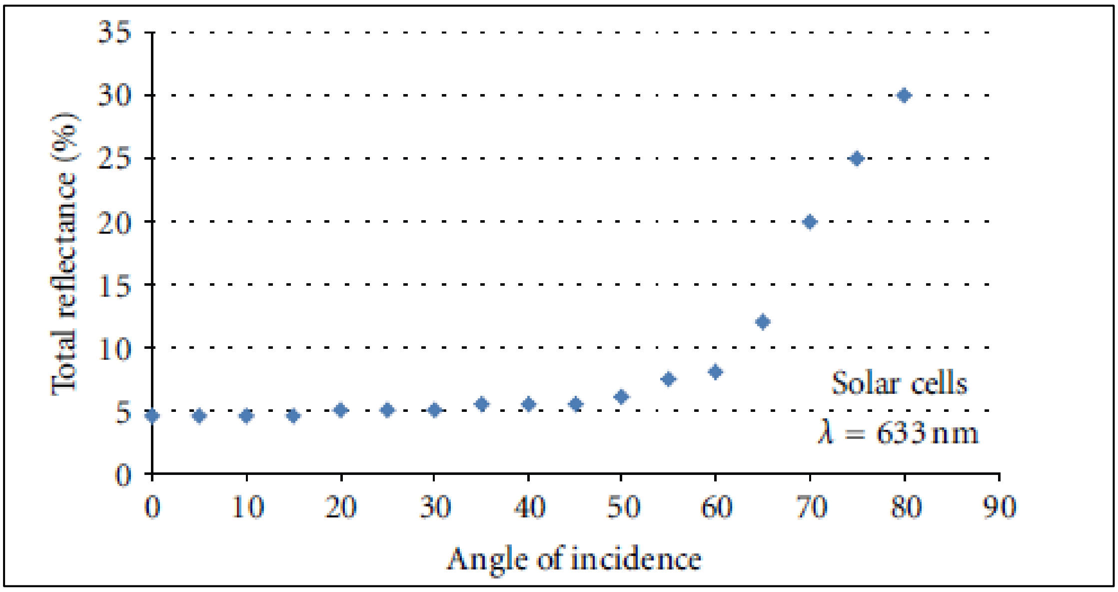
[44] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

Solar Reflection Studies

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

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

Evan Riley and Scott Olson published in 2011 their study titled: *A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems*[45]". 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.

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[45] 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"[46]

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[47]
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).

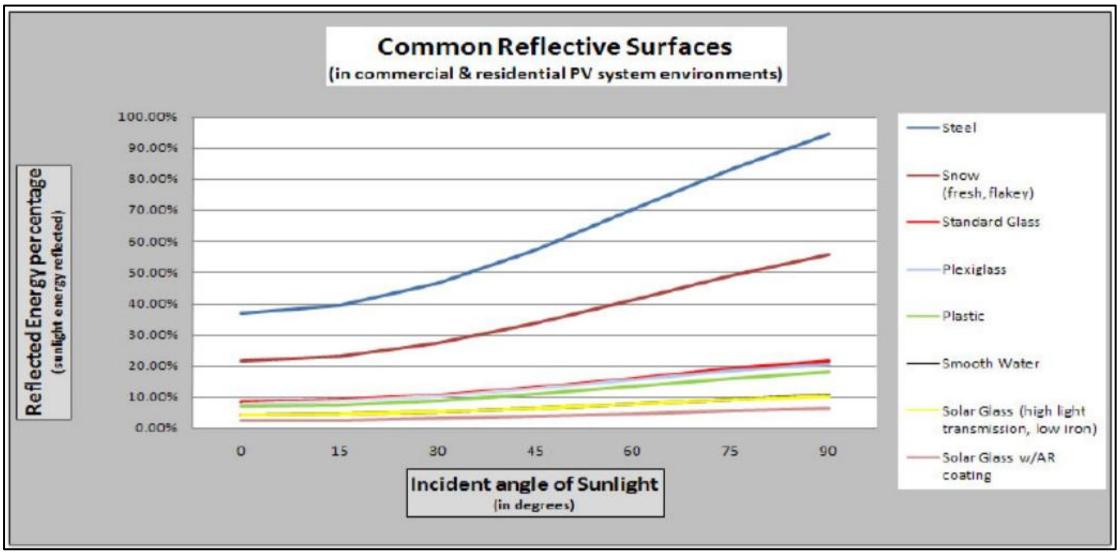
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

[46] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.
[47] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification[48] 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.

[48] 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).

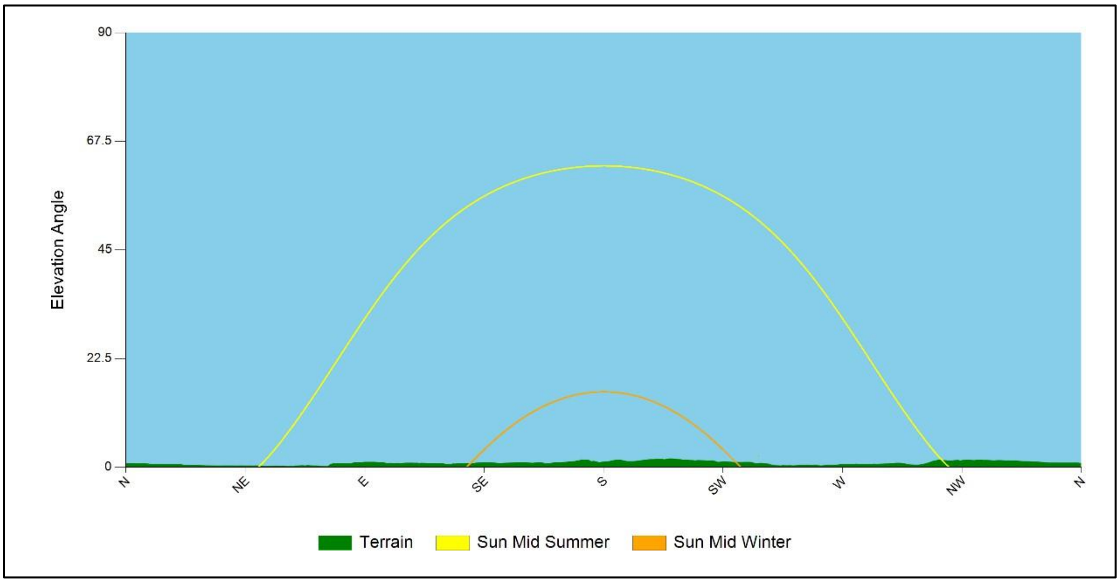
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

- 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 (the longest day);
- On 21 December, the maximum elevation reached by the Sun is at its lowest (shortest day).

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



Terrain at Sun horizon at location of the Proposed Development

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact Significance Definition

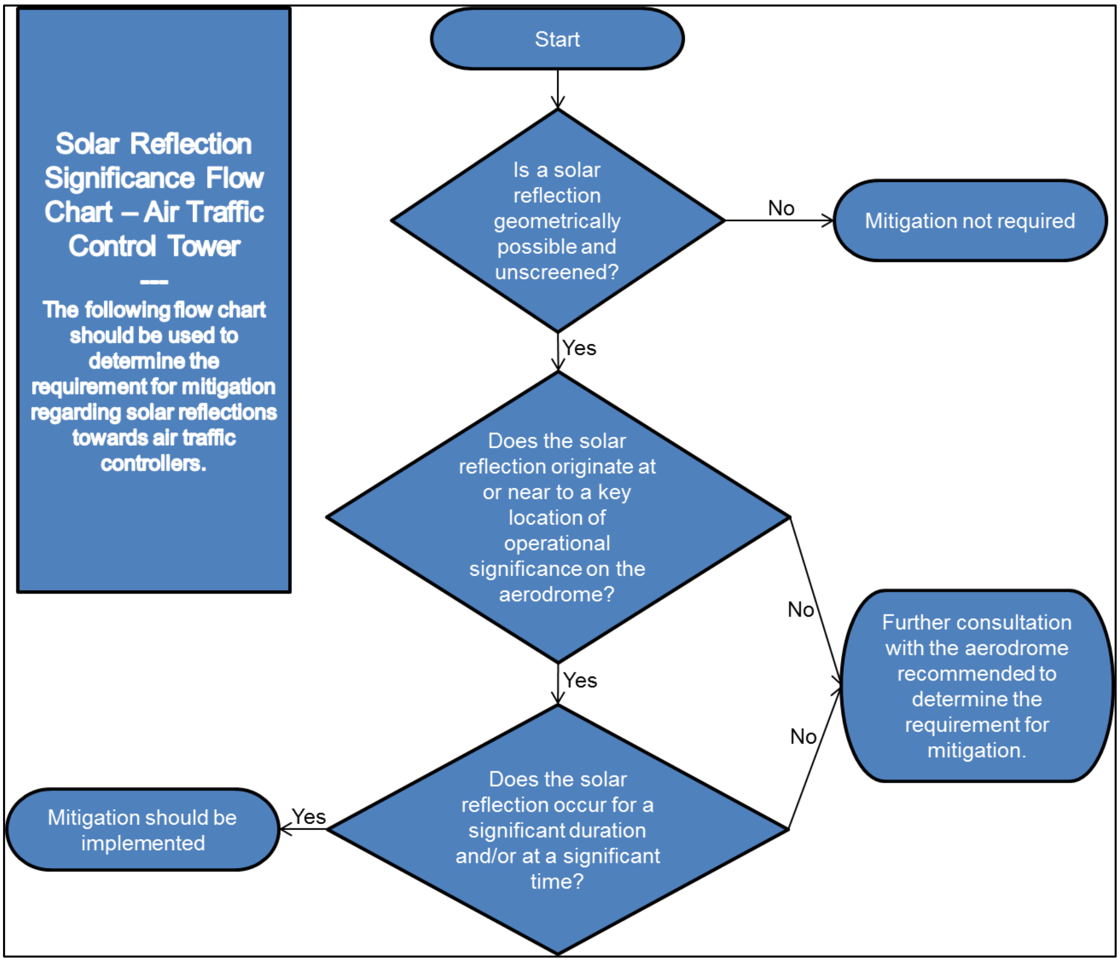
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not required e.g. intervening screening will limit the view of the reflecting solar panels.	No mitigation required.
Moderate	A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case.	Whilst the impact may be acceptable, consultation and/or further analysis should be undertaken to determine the requirement for mitigation.
High	A solar reflection is geometrically possible and visible under conditions that will produce a significant impact. Mitigation and consultation is recommended.	Mitigation will be required if the proposed solar development is to proceed.

Impact significance definition

Impact Significance Determination for an ATC Tower

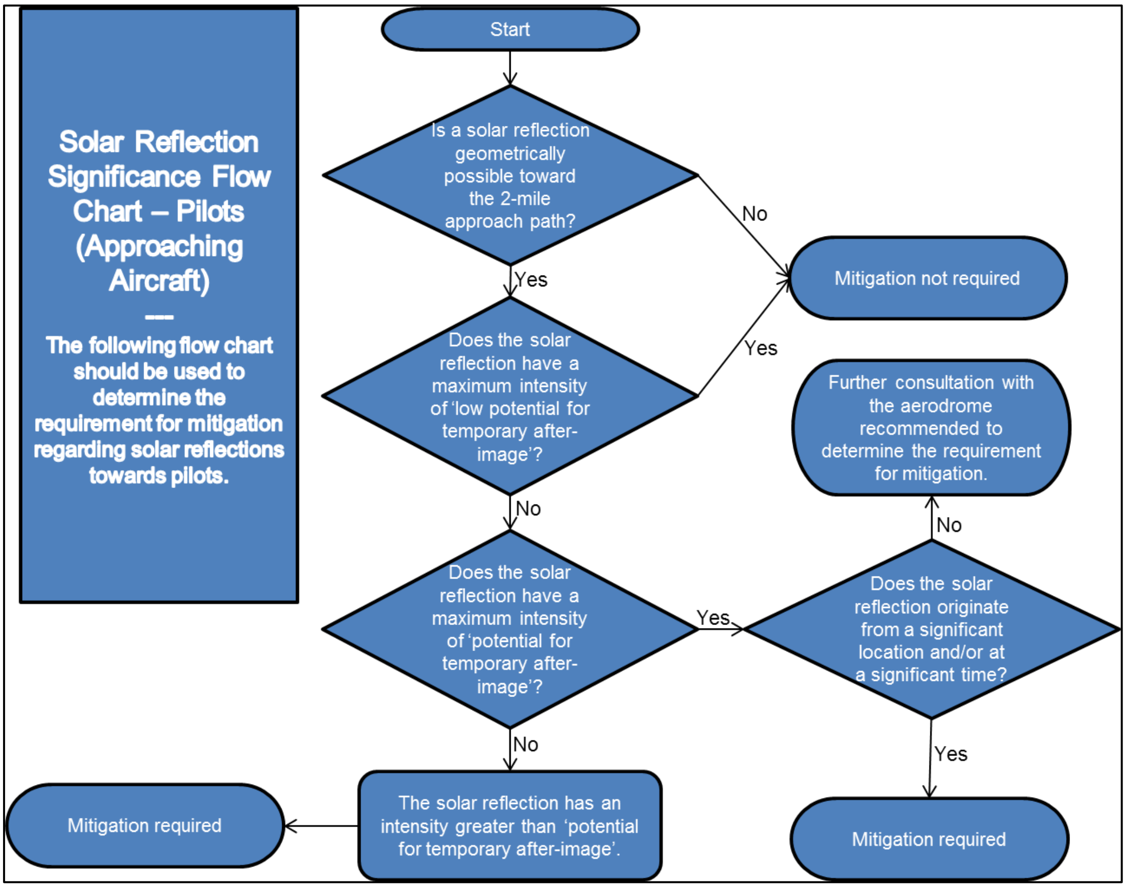
The flow chart presented below has been followed when determining the mitigation requirement for an ATC Tower.



ATC Tower mitigation requirement flow chart

Impact Significance Determination for Approaching Aircraft

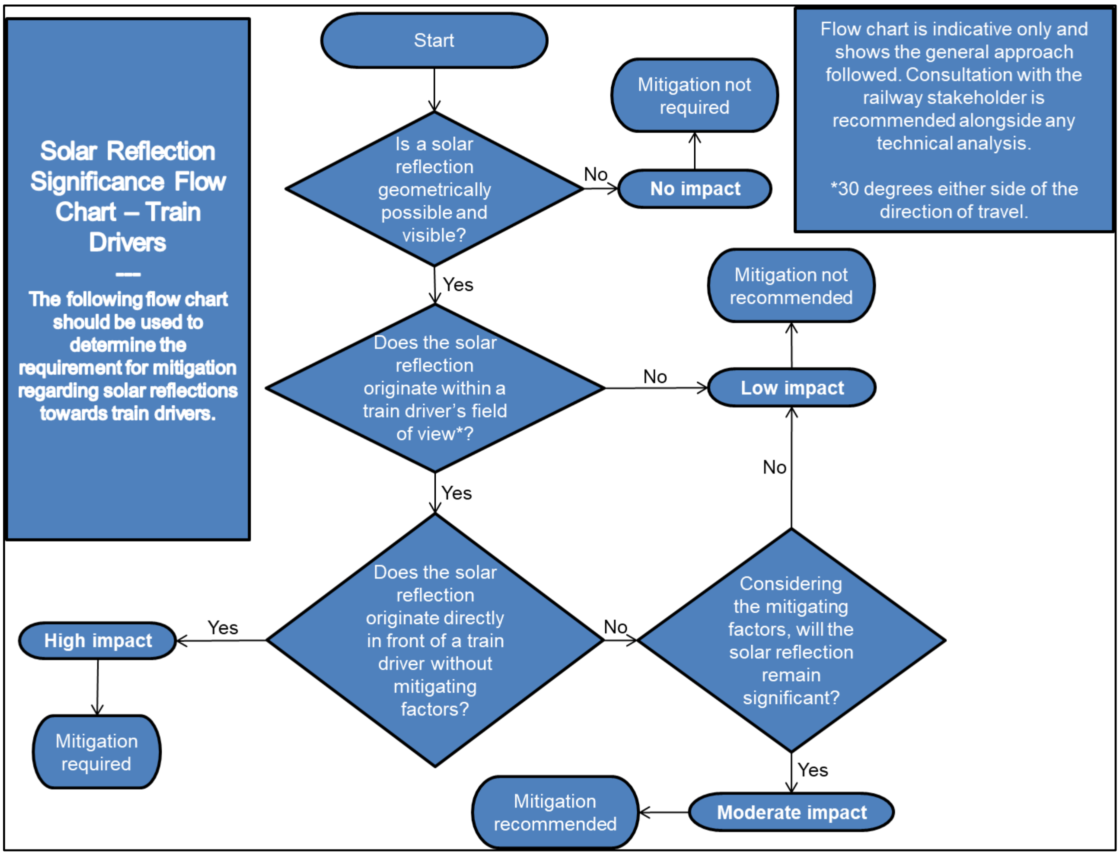
The flow chart presented below has been followed when determining the mitigation requirement for approaching aircraft.



Approaching aircraft receptor mitigation requirement flow chart

Impact Significance Determination for Train Drivers

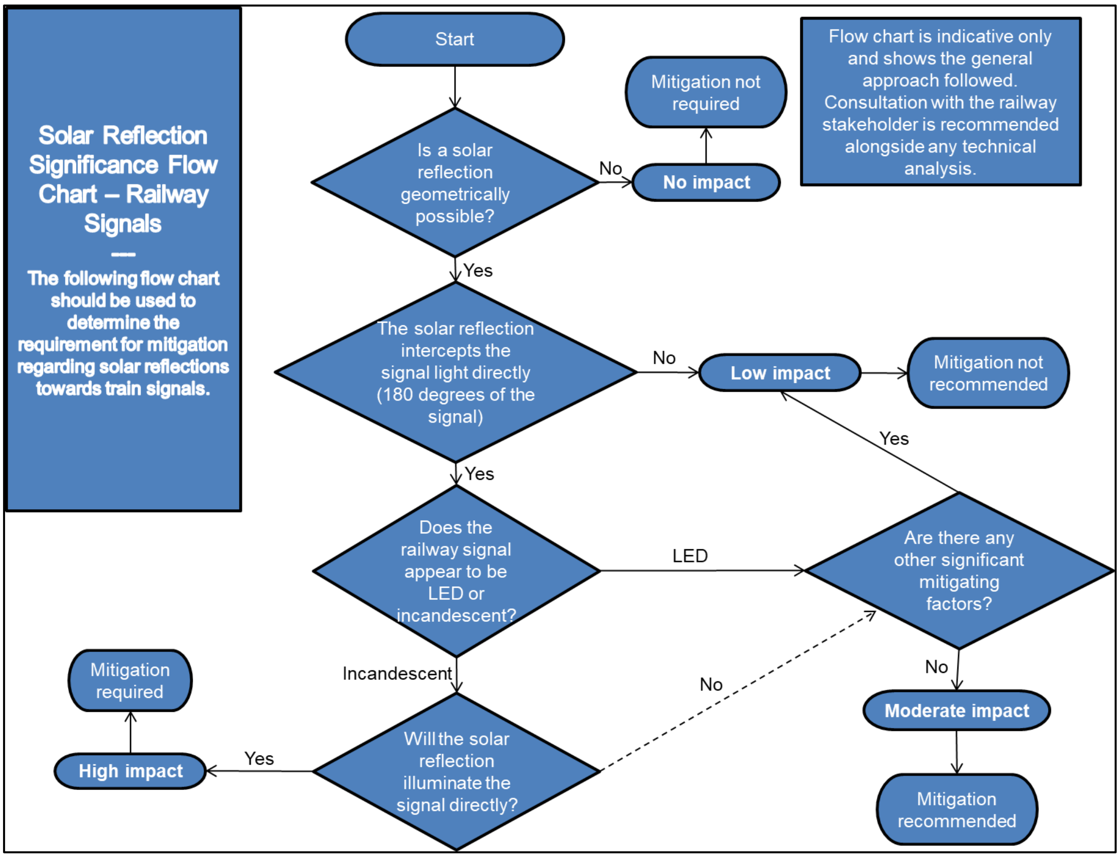
The flow chart presented below has been followed when determining the impact significance and mitigation requirement for train drivers.



Train Driver impact significance flow chart

Impact Significance Determination for Railway Signals

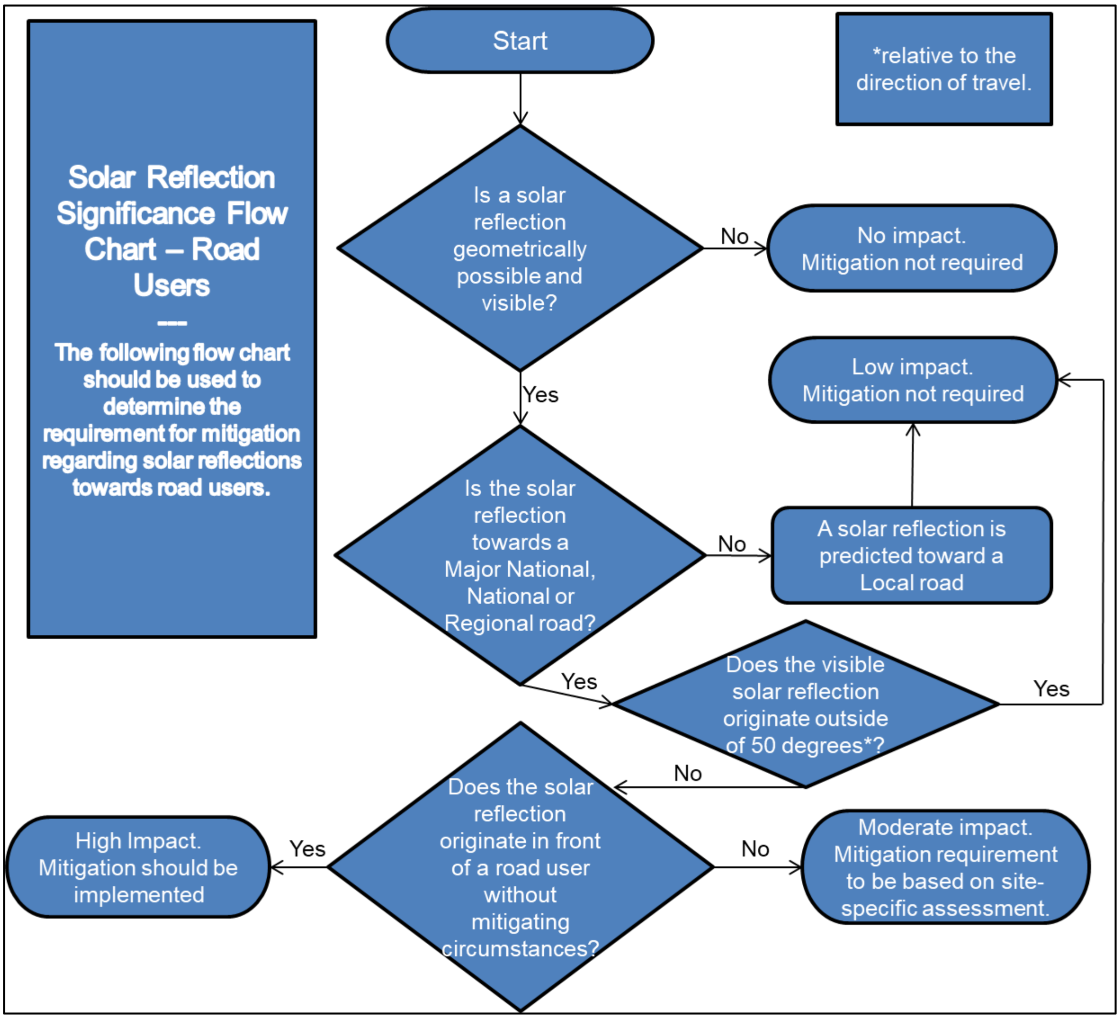
The flow chart presented below has been followed when determining the impact significance mitigation requirement for railway signals.



Railway signal impact significance flow chart

Impact Significance Determination for Road Receptors

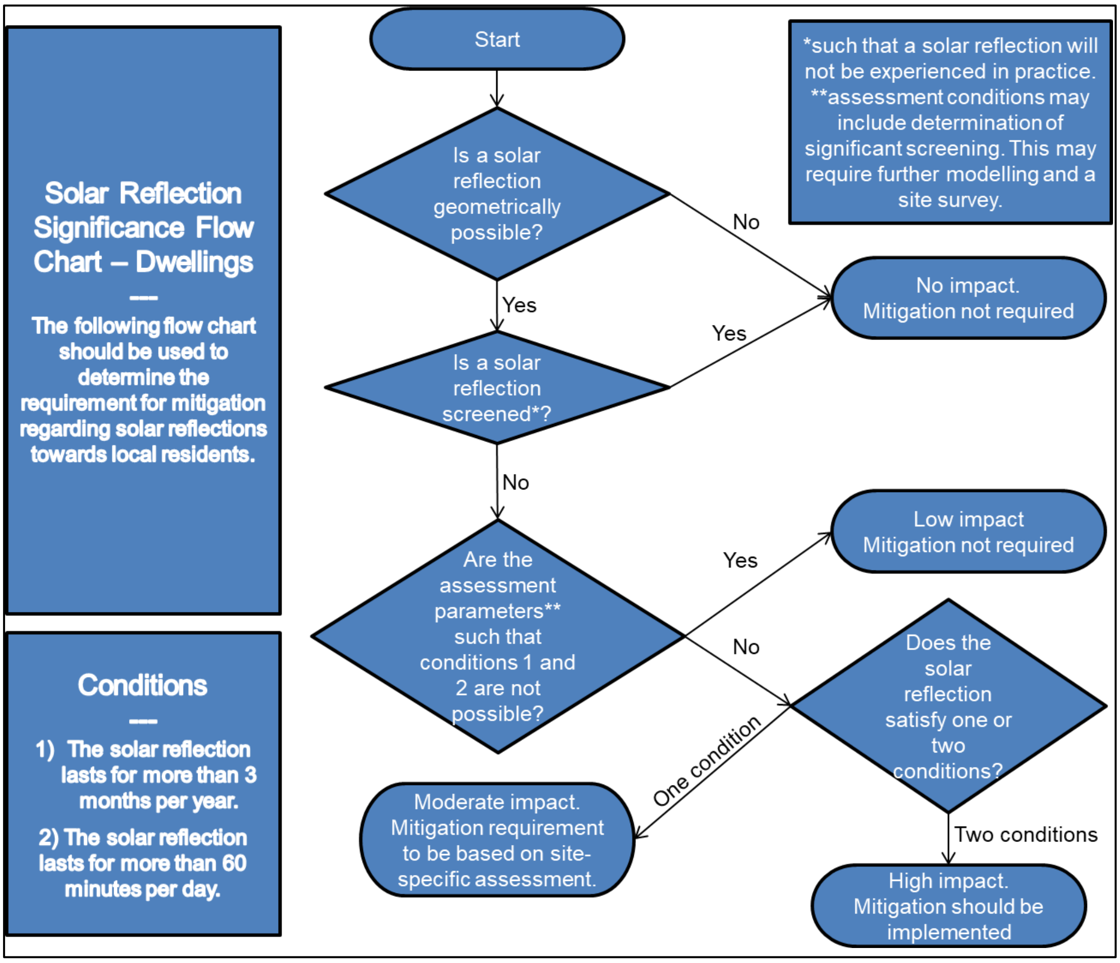
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road user impact significance flow chart

Impact Significance Determination for Dwelling Receptors

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



Dwelling impact significance flow chart

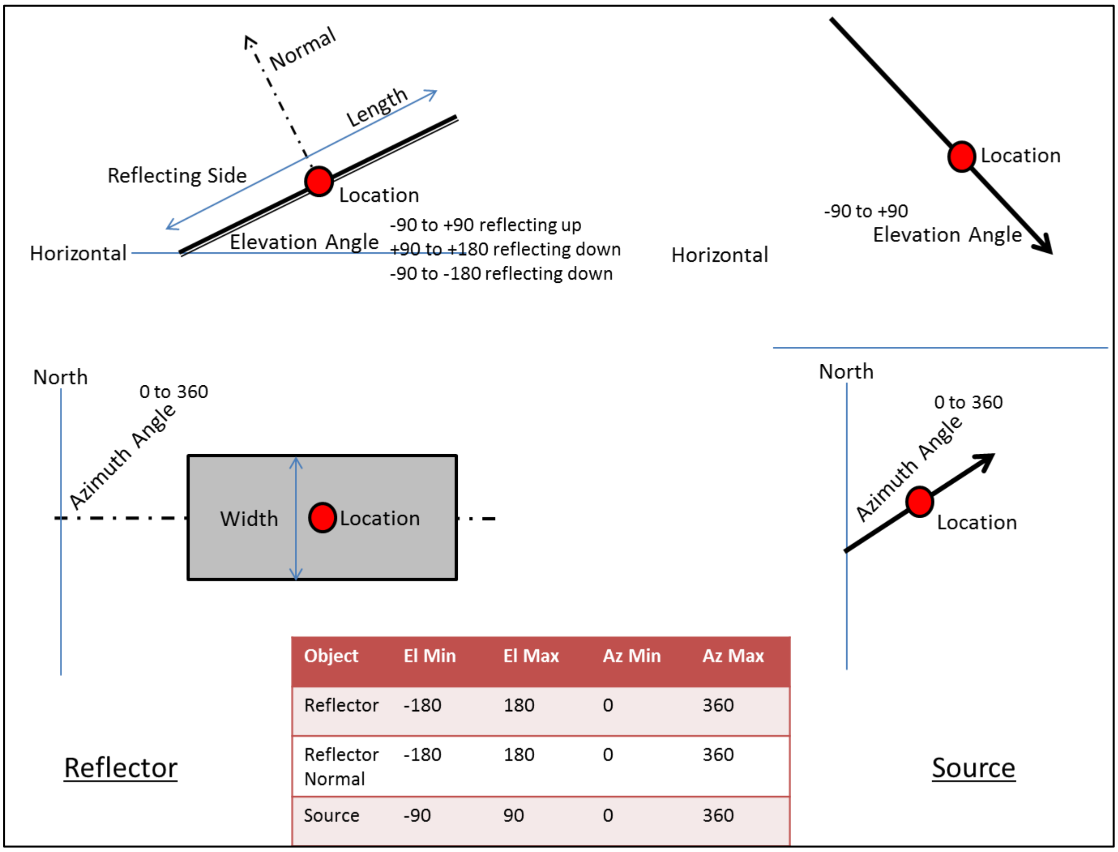
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Pager Power Methodology

The calculations are three dimensional and complex, accounting for:

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

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



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

Reflection calculation methodology

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;

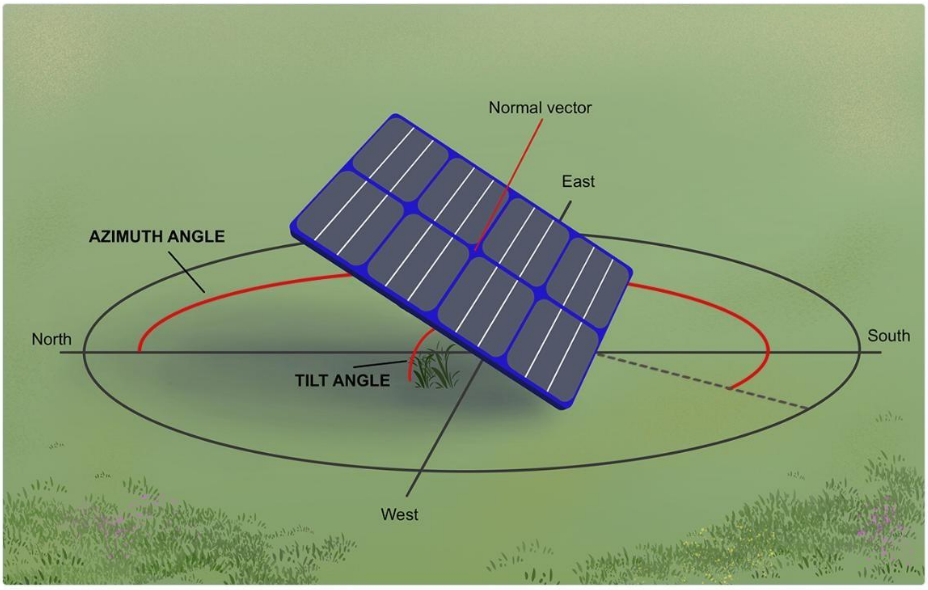
- Calculate the 3D angle between the source and the normal;
- If this angle is less than 90 degrees a reflection will occur. If it is greater than 90 degrees no reflection will occur because the source is behind the reflector;
- Calculate the Azimuth and Elevation of the reflection in accordance with 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.

Forge Reflection Calculations Methodology

Extracts taken from the Forge Solar Model are shown in the figures below and on the following page.

Fixed-Mount Parameters

Fixed-mount PV panels are described by a tilt and orientation. These parameters are referred to as the **module configuration** of the PV array.



PV module orientation/azimuth and tilt. Sample illustrates south-facing module typical in northern hemisphere

Module orientation/azimuth (°)
The azimuthal facing or direction toward which the PV panels are positioned. Orientation is measured clockwise from true north. Panels which face north, which is typical in the southern hemisphere, have an orientation of 0°. Panels which face south, which is typical in the northern hemisphere, have an orientation of 180°. If a known orientation is based on magnetic north, the location-specific declination must be used to determine the orientation from true north.

Module tilt (°)
The elevation angle of the panels, measured up from flat ground. Panels lying flat on the ground (facing up) have a tilt of 0°. Tilt values between 0° and 40° are typical.

Fixed System Parameters

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Forge's Sandia National Laboratories' (SGHAT) Model[49]

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.

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

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Modelled Reflector Areas

The modelled cumulative reflector area is presented in the tables below and on the following pages.

Panel Area 1

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.84616	53.35683	21	-0.84125	53.35114
2	-0.84652	53.35651	22	-0.84425	53.35042
3	-0.84689	53.35616	23	-0.84404	53.34918
4	-0.84718	53.35567	24	-0.84601	53.34910
5	-0.84740	53.35562	25	-0.84803	53.34906
6	-0.84790	53.35495	26	-0.84827	53.34995
7	-0.84819	53.35482	27	-0.85065	53.34983
8	-0.84961	53.35429	28	-0.85015	53.34746
9	-0.84952	53.35397	29	-0.83932	53.34791
10	-0.85084	53.35325	30	-0.83839	53.35083
11	-0.85066	53.35311	31	-0.83933	53.35131
12	-0.84857	53.35354	32	-0.83946	53.35267
13	-0.84579	53.35430	33	-0.84046	53.35260
14	-0.84325	53.35455	34	-0.84111	53.35421
15	-0.84273	53.35343	35	-0.84070	53.35462
16	-0.84312	53.35329	36	-0.83917	53.35554
17	-0.84252	53.35096	37	-0.83841	53.35622
18	-0.84128	53.35123	38	-0.84259	53.35785
19	-0.84048	53.35132	39	-0.84497	53.35762

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
20	-0.84045	53.35122	40	-0.84544	53.35718

Panel Area 1

Panel Area 2

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.83845	53.35111	6	-0.83152	53.35115
2	-0.83805	53.35092	7	-0.83140	53.35193
3	-0.83904	53.34803	8	-0.83524	53.35262
4	-0.83720	53.34814	9	-0.83765	53.35265
5	-0.83701	53.34708			

Panel Area 2

Panel Area 3

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.85323	53.34053	9	-0.85291	53.33713
2	-0.85626	53.34066	10	-0.85067	53.33796
3	-0.85622	53.34006	11	-0.84962	53.33829
4	-0.85637	53.33900	12	-0.84759	53.33941
5	-0.85633	53.33821	13	-0.84254	53.34314
6	-0.85622	53.33753	14	-0.84254	53.34353
7	-0.85591	53.33681	15	-0.85284	53.34392
8	-0.85558	53.33621			

Panel Area 3

Panel Area 4

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.85589	53.33428	20	-0.82423	53.34133
2	-0.85159	53.33391	21	-0.82535	53.34133
3	-0.84762	53.33340	22	-0.82751	53.34364

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
4	-0.84256	53.33260	23	-0.82887	53.34553
5	-0.83778	53.33184	24	-0.83041	53.34815
6	-0.83771	53.33256	25	-0.82760	53.35179
7	-0.83209	53.33245	26	-0.82959	53.35215
8	-0.83204	53.33626	27	-0.84108	53.34376
9	-0.83081	53.33589	28	-0.84703	53.33941
10	-0.82725	53.33573	29	-0.84828	53.33841
11	-0.82276	53.33542	30	-0.84928	53.33778
12	-0.82220	53.33783	31	-0.85036	53.33722
13	-0.82206	53.33796	32	-0.85138	53.33675
14	-0.82187	53.33840	33	-0.85302	53.33618
15	-0.82263	53.33875	34	-0.85494	53.33552
16	-0.82113	53.33919	35	-0.85665	53.33512
17	-0.82032	53.33921	36	-0.85825	53.33477
18	-0.81988	53.33971	37	-0.86075	53.33446
19	-0.82298	53.34082			

Panel Area 4

Panel Area 5

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.79466	53.34250	9	-0.80706	53.34188
2	-0.79701	53.34323	10	-0.80715	53.34135
3	-0.80508	53.35179	11	-0.80536	53.34124
4	-0.80857	53.35206	12	-0.80599	53.33880
5	-0.80691	53.34857	13	-0.80590	53.33616
6	-0.80758	53.34725	14	-0.79883	53.33592

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
7	-0.80858	53.34486	15	-0.78954	53.33602
8	-0.80937	53.34210	16	-0.78940	53.33733

Panel Area 5

Panel Area 6

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.80269	53.35319	9	-0.78167	53.33909
2	-0.79606	53.34496	10	-0.78246	53.33756
3	-0.78779	53.33780	11	-0.78703	53.33810
4	-0.78821	53.33601	12	-0.78677	53.33882
5	-0.78420	53.33567	13	-0.78346	53.34001
6	-0.77958	53.33542	14	-0.79589	53.35157
7	-0.77897	53.33655	15	-0.79386	53.35247
8	-0.77855	53.33739	16	-0.79840	53.35446

Panel Area 6

Aviation Receptor Data

Full receptor data is available upon request.

Aerodrome	Threshold	Longitude (°)	Latitude (°)	Elevation (m amsl)
West Burton	01	-0.83105	53.36164	28.24
	19	-0.82797	53.36406	27.24
Grove Farm	12	-0.86913	53.31506	87.24
	30	-0.86338	53.31320	83.24
Forwood Farm	02	-0.85010	53.30454	55.24
	20	-0.85155	53.30155	56.24

Aviation Receptor Data

PAGERPOWER
Urban & Renewables

Train Driver Receptor Data

The train driver receptor data is presented in the table below. An additional 2.75m height has been added to the terrain elevation to account for the eye-level of a train driver at these locations.

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
1	53.33460	-0.86816	51.47	38	53.35426	-0.82708	22.75
2	53.33449	-0.86668	48.59	39	53.35495	-0.82613	22.21
3	53.33441	-0.86519	45.78	40	53.35564	-0.82519	18.84
4	53.33441	-0.86363	45.33	41	53.35636	-0.82420	17.03
5	53.33446	-0.86214	43.30	42	53.35709	-0.82322	15.75
6	53.33458	-0.86066	42.71	43	53.35778	-0.82227	14.11
7	53.33475	-0.85920	41.08	44	53.35856	-0.82119	13.05
8	53.33499	-0.85776	40.41	45	53.33438	-0.86098	43.93
9	53.33530	-0.85630	39.62	46	53.33430	-0.85947	43.33
10	53.33566	-0.85493	33.87	47	53.33423	-0.85797	43.89
11	53.33610	-0.85356	34.03	48	53.33415	-0.85647	43.77
12	53.33653	-0.85240	32.76	49	53.33404	-0.85497	44.45
13	53.33705	-0.85118	31.82	50	53.33392	-0.85352	43.68
14	53.33763	-0.84998	31.00	51	53.33379	-0.85203	42.75
15	53.33831	-0.84882	30.75	52	53.33363	-0.85054	40.30
16	53.33898	-0.84783	31.20	53	53.33345	-0.84902	36.75
17	53.33962	-0.84698	31.27	54	53.33327	-0.84759	34.75
18	53.34031	-0.84603	31.18	55	53.33306	-0.84617	31.75

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
19	53.34100	-0.84508	29.75	56	53.33284	-0.84470	28.91
20	53.34169	-0.84415	28.75	57	53.33259	-0.84326	26.80
21	53.34242	-0.84317	26.75	58	53.33232	-0.84182	25.57
22	53.34312	-0.84223	25.02	59	53.33204	-0.84038	25.47
23	53.34381	-0.84130	24.00	60	53.33175	-0.83896	25.13
24	53.34451	-0.84036	23.75	61	53.33143	-0.83759	25.67
25	53.34520	-0.83942	23.75	62	53.33110	-0.83623	24.75
26	53.34592	-0.83842	23.22	63	53.33074	-0.83480	24.45
27	53.34660	-0.83747	23.38	64	53.33037	-0.83343	22.75
28	53.34729	-0.83651	23.75	65	53.32999	-0.83206	22.18
29	53.34795	-0.83561	22.75	66	53.32957	-0.83067	21.75
30	53.34868	-0.83464	20.75	67	53.32918	-0.82941	21.75
31	53.34938	-0.83370	20.75	68	53.32876	-0.82808	22.67
32	53.35010	-0.83272	21.23	69	53.32828	-0.82675	21.75
33	53.35079	-0.83177	21.85	70	53.32782	-0.82546	21.62
34	53.35145	-0.83087	23.34	71	53.32736	-0.82421	20.75
35	53.35218	-0.82989	23.75	72	53.32690	-0.82291	19.75
36	53.35288	-0.82897	22.75	73	53.32642	-0.82158	19.75
37	53.35357	-0.82803	22.75	74	53.32619	-0.82099	19.49

Train Signal Receptors

The modelled receptors for the signals identified are presented in the table below.

Signal	Longitude (°)	Latitude (°)	Assessed Height (m)
Ground Mounted 1	53.33448	-0.86201	40.94
Ground Mounted 2	53.33433	-0.86419	45.09
TN 8325	53.35515	-0.82571	21.33
TN 8327	53.34786	-0.83562	23.00
TN 8329	53.34079	-0.84526	30.76
TN 8331	53.33516	-0.85668	40.87
TN 8354	53.35713	-0.82324	15.66
TN 8356	53.34335	-0.84198	25.58
TN 8366	53.33456	-0.86739	48.86

Dwelling Receptor Data

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

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
1	53.35781	-0.82014	12.37	107	53.33789	-0.80889	9.80
2	53.35472	-0.82662	21.80	108	53.34368	-0.81892	13.25
3	53.35436	-0.82751	21.80	109	53.34374	-0.81815	12.80
4	53.35349	-0.83024	21.80	110	53.34392	-0.81900	13.21
5	53.35452	-0.83170	21.80	111	53.34390	-0.81822	12.67
6	53.35461	-0.83256	22.27	112	53.34412	-0.81908	13.24
7	53.35546	-0.83476	22.44	113	53.34407	-0.81827	12.60

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
8	53.35568	-0.83524	22.52	114	53.34430	-0.81918	12.90
9	53.35585	-0.83607	21.80	115	53.34423	-0.81834	12.80
10	53.35592	-0.83629	21.80	116	53.34445	-0.81918	12.80
11	53.35599	-0.83654	21.80	117	53.34436	-0.81842	12.80
12	53.34078	-0.86367	64.80	118	53.34463	-0.81924	12.80
13	53.34083	-0.86527	63.97	119	53.34460	-0.81858	12.80
14	53.34085	-0.86587	64.80	120	53.34474	-0.81928	12.80
15	53.32637	-0.86108	61.45	121	53.34484	-0.81857	12.76
16	53.32897	-0.84424	31.48	122	53.34486	-0.81916	12.80
17	53.32919	-0.83783	26.84	123	53.34508	-0.81800	11.80
18	53.32168	-0.82911	24.80	124	53.34499	-0.81916	12.80
19	53.32196	-0.82892	24.80	125	53.34530	-0.81803	11.80
20	53.32230	-0.82781	25.31	126	53.34511	-0.81921	12.80
21	53.32255	-0.82708	24.60	127	53.34592	-0.81681	11.80
22	53.32236	-0.82615	23.80	128	53.34635	-0.81565	11.80
23	53.32249	-0.82574	23.80	129	53.34603	-0.81230	10.80
24	53.32269	-0.82465	22.80	130	53.34620	-0.81191	10.80
25	53.32662	-0.82391	19.80	131	53.34623	-0.81161	10.80
26	53.32924	-0.82875	20.80	132	53.34614	-0.81125	10.80
27	53.32957	-0.82866	20.80	133	53.34623	-0.81080	10.80
28	53.32987	-0.82854	20.80	134	53.34634	-0.81051	9.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
29	53.32997	-0.82877	20.80	135	53.34631	-0.80998	9.80
30	53.33011	-0.82881	20.65	136	53.34653	-0.80985	9.80
31	53.33025	-0.82887	20.29	137	53.34640	-0.81772	11.80
32	53.33040	-0.82890	19.98	138	53.34634	-0.81839	11.80
33	53.33057	-0.82874	19.80	139	53.34556	-0.81998	13.80
34	53.33056	-0.82833	19.80	140	53.34571	-0.82273	16.67
35	53.33062	-0.82799	19.80	141	53.34616	-0.82197	16.19
36	53.33060	-0.82763	19.64	142	53.34612	-0.82036	14.21
37	53.33058	-0.82721	19.69	143	53.34656	-0.82004	11.96
38	53.33028	-0.82669	19.24	144	53.34685	-0.82014	13.76
39	53.33049	-0.82634	18.80	145	53.34703	-0.82024	14.40
40	53.33065	-0.82626	18.80	146	53.34721	-0.82030	14.80
41	53.33076	-0.82615	18.80	147	53.34739	-0.82039	14.80
42	53.33080	-0.82587	18.80	148	53.34746	-0.82596	21.80
43	53.33072	-0.82568	18.80	149	53.34744	-0.81846	13.80
44	53.33013	-0.82577	18.80	150	53.34759	-0.81957	14.23
45	53.33012	-0.82538	18.80	151	53.34773	-0.81964	14.33
46	53.33013	-0.82494	18.80	152	53.34790	-0.81970	14.44
47	53.33022	-0.82473	18.80	153	53.34810	-0.81999	14.80
48	53.33018	-0.82443	18.80	154	53.34834	-0.82006	14.80
49	53.33022	-0.82411	18.80	155	53.34844	-0.81988	14.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
50	53.33025	-0.82388	18.50	156	53.34816	-0.82330	20.10
51	53.33026	-0.82360	18.12	157	53.34818	-0.82288	19.22
52	53.33045	-0.82339	17.86	158	53.34822	-0.82255	18.52
53	53.33051	-0.82313	17.80	159	53.34847	-0.82189	17.30
54	53.33066	-0.82311	17.80	160	53.34881	-0.82093	14.94
55	53.33085	-0.82314	17.80	161	53.34875	-0.82015	14.80
56	53.33102	-0.82322	17.80	162	53.34901	-0.82107	15.73
57	53.33122	-0.82253	17.80	163	53.34892	-0.82017	14.80
58	53.33134	-0.82297	17.56	164	53.34924	-0.82096	15.65
59	53.33147	-0.82281	17.52	165	53.34907	-0.82023	14.80
60	53.33159	-0.82274	17.20	166	53.34948	-0.82106	16.25
61	53.33167	-0.82267	16.97	167	53.34931	-0.82006	14.80
62	53.33180	-0.82260	16.80	168	53.34986	-0.82159	16.80
63	53.33203	-0.82231	16.80	169	53.34996	-0.82031	15.31
64	53.33220	-0.82239	16.80	170	53.35003	-0.82158	16.80
65	53.33218	-0.82170	16.80	171	53.35015	-0.82109	16.33
66	53.33083	-0.82053	15.80	172	53.35026	-0.82164	16.80
67	53.33140	-0.81950	14.80	173	53.35030	-0.82110	16.34
68	53.33179	-0.81940	14.53	174	53.35051	-0.82112	16.34
69	53.33190	-0.81894	13.80	175	53.35070	-0.82111	16.43
70	53.33190	-0.81869	13.80	176	53.35088	-0.82116	16.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
71	53.33190	-0.81840	12.80	177	53.35184	-0.82545	21.47
72	53.33200	-0.81814	12.80	178	53.35238	-0.82474	20.29
73	53.33191	-0.81786	12.80	179	53.35183	-0.82449	19.80
74	53.33194	-0.81763	12.80	180	53.35165	-0.82404	19.34
75	53.33178	-0.81711	12.50	181	53.35159	-0.82382	18.80
76	53.33179	-0.81673	11.89	182	53.35156	-0.82355	18.80
77	53.33099	-0.81633	11.39	183	53.35208	-0.82369	18.80
78	53.33104	-0.81607	11.33	184	53.35151	-0.82324	18.26
79	53.33108	-0.81579	11.23	185	53.35144	-0.82290	17.80
80	53.33109	-0.81551	11.24	186	53.35252	-0.82238	16.80
81	53.33112	-0.81511	11.11	187	53.35304	-0.82234	16.54
82	53.33115	-0.81471	10.80	188	53.35197	-0.82204	16.86
83	53.33118	-0.81435	10.80	189	53.35188	-0.82158	16.02
84	53.33121	-0.81405	10.80	190	53.35258	-0.82061	14.80
85	53.33092	-0.81337	10.80	191	53.35287	-0.82034	14.80
86	53.33095	-0.81301	10.80	192	53.35233	-0.81981	13.90
87	53.33098	-0.81264	10.80	193	53.35174	-0.81957	13.91
88	53.33123	-0.81207	10.80	194	53.35179	-0.81927	12.80
89	53.33151	-0.81202	10.80	195	53.35179	-0.81895	12.80
90	53.33157	-0.81163	10.80	196	53.35180	-0.81873	12.80
91	53.33157	-0.81126	10.80	197	53.35181	-0.81852	12.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
92	53.33142	-0.81061	10.80	198	53.35215	-0.81790	12.02
93	53.33131	-0.81001	9.80	199	53.35181	-0.81745	11.80
94	53.33055	-0.80954	10.26	200	53.35189	-0.81684	11.67
95	53.33120	-0.80818	9.80	201	53.35166	-0.81632	11.42
96	53.33127	-0.80780	9.80	202	53.35158	-0.81596	11.61
97	53.33118	-0.80617	9.80	203	53.35161	-0.81567	11.45
98	53.33115	-0.79607	7.80	204	53.35158	-0.81541	11.68
99	53.33316	-0.76560	2.80	205	53.35159	-0.81512	11.53
100	53.33317	-0.76478	2.80	206	53.35169	-0.81474	10.80
101	53.33336	-0.76267	2.80	207	53.35110	-0.81742	12.64
102	53.33388	-0.76263	2.80	208	53.35103	-0.81841	13.75
103	53.33277	-0.82149	15.64	209	53.35100	-0.81971	14.80
104	53.33451	-0.82171	14.80	210	53.35105	-0.82048	15.80
105	53.33755	-0.81521	10.80	211	53.35134	-0.82043	15.80
106	53.33832	-0.81233	10.80	212	53.35667	-0.81968	11.80

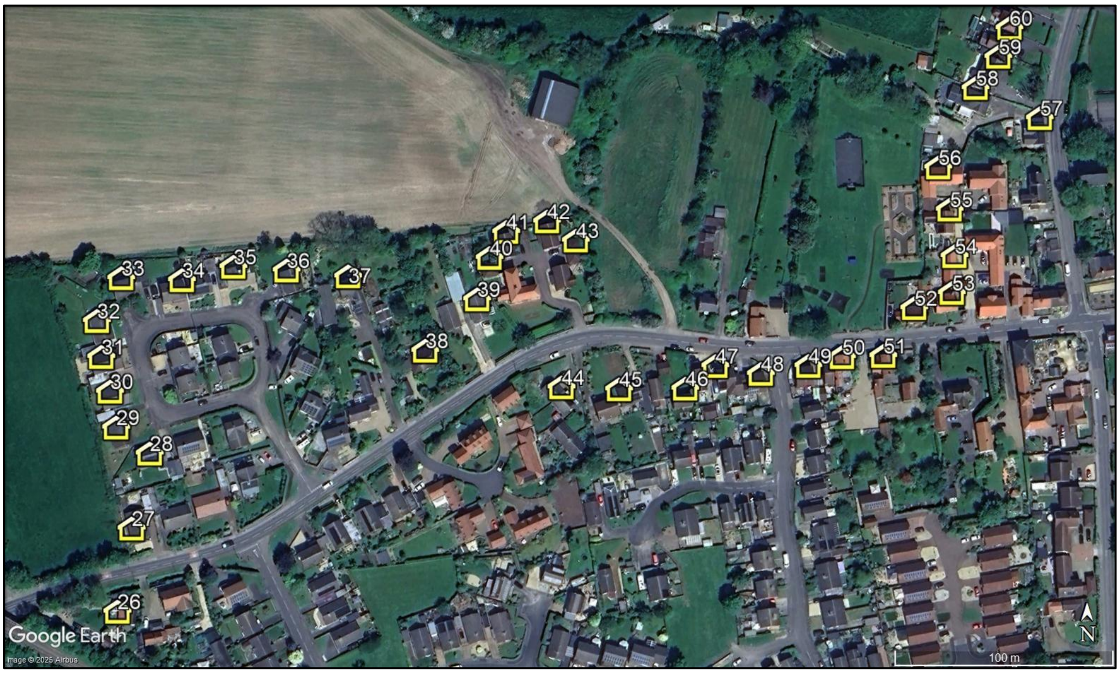
Dwelling receptor data

APPENDIX H – DETAILED IDENTIFICATION OF DWELLING RECEPTORS

Dwelling receptors 1 to 11

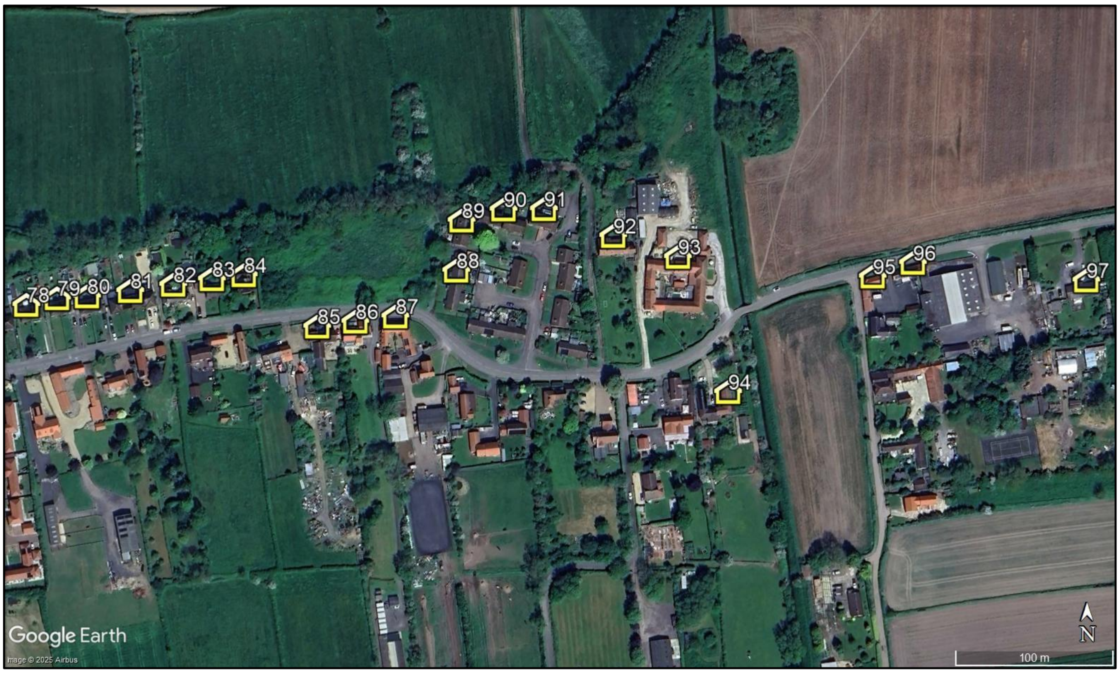
Dwellings receptors 12 to 17

Dwellings receptors 18 to 25



Dwellings receptors 26 to 60

Dwelling receptors 61 to 77



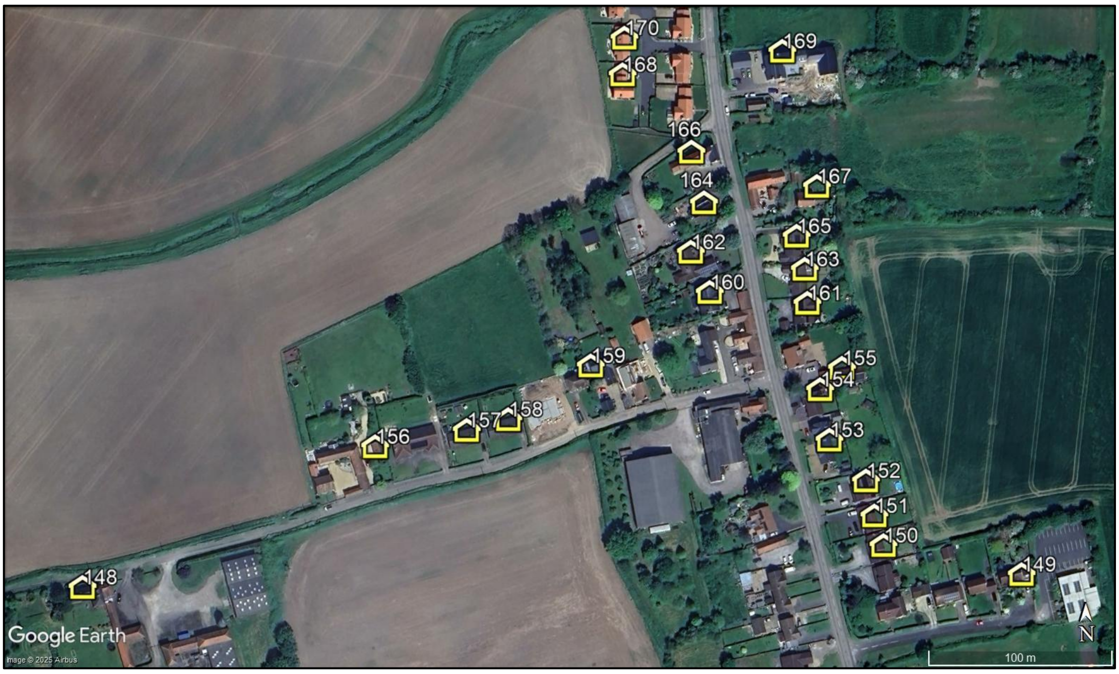
Dwelling receptors 78 to 97

Dwelling receptors 98 to 102

Dwelling receptors 103 to 107

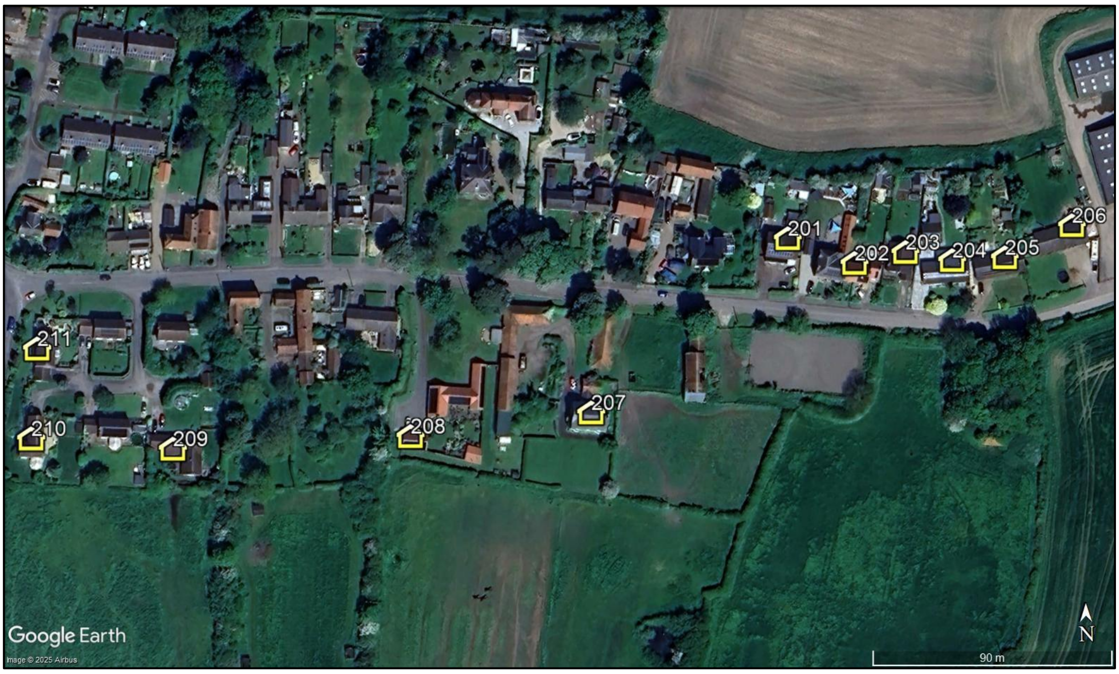
Dwelling receptors 108 to 133

Dwelling receptors 134 to 147

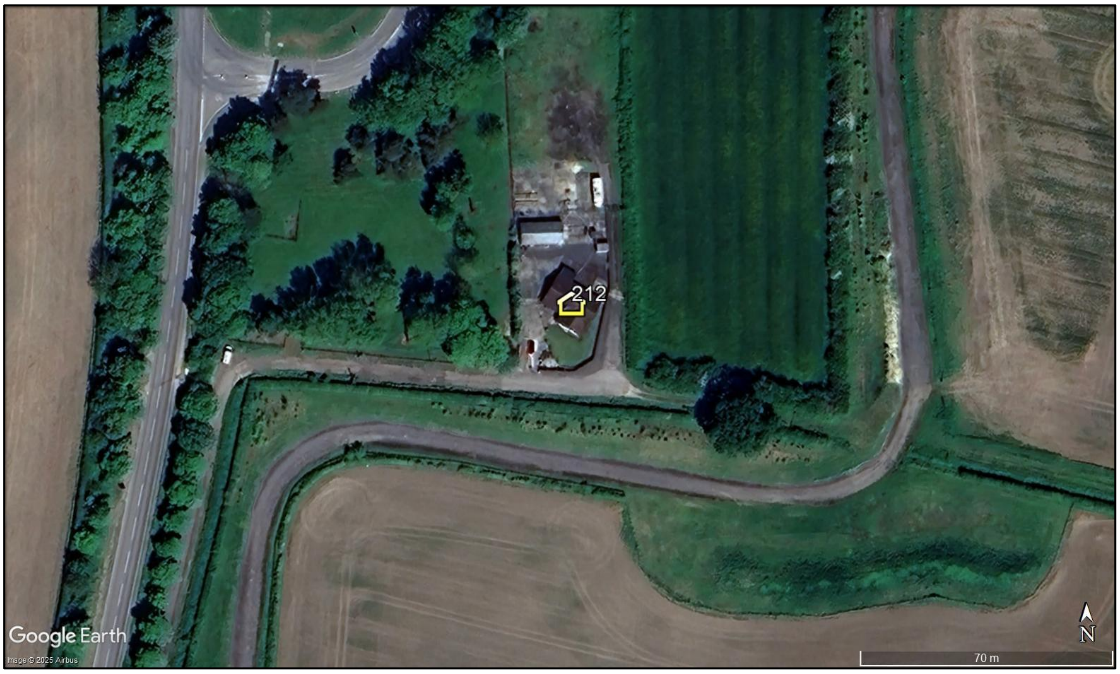


Dwelling receptors 148 170

Dwelling receptors 171 to 200



Dwelling receptors 201 to 211



Dwelling receptor 212

APPENDIX I – DETAILLED MODELLING RESULTS

Overview

The Pager Power charts for the assessed receptors are shown on the following pages. 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).

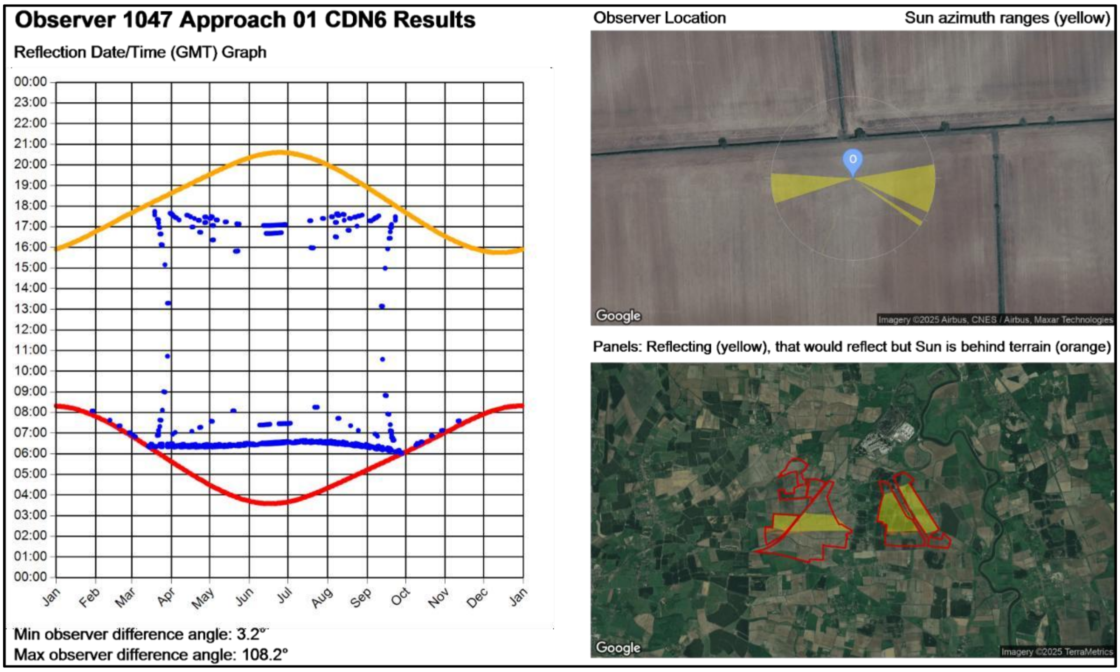
The Forge charts for the aviation receptors are shown on the following pages. Each chart shows:

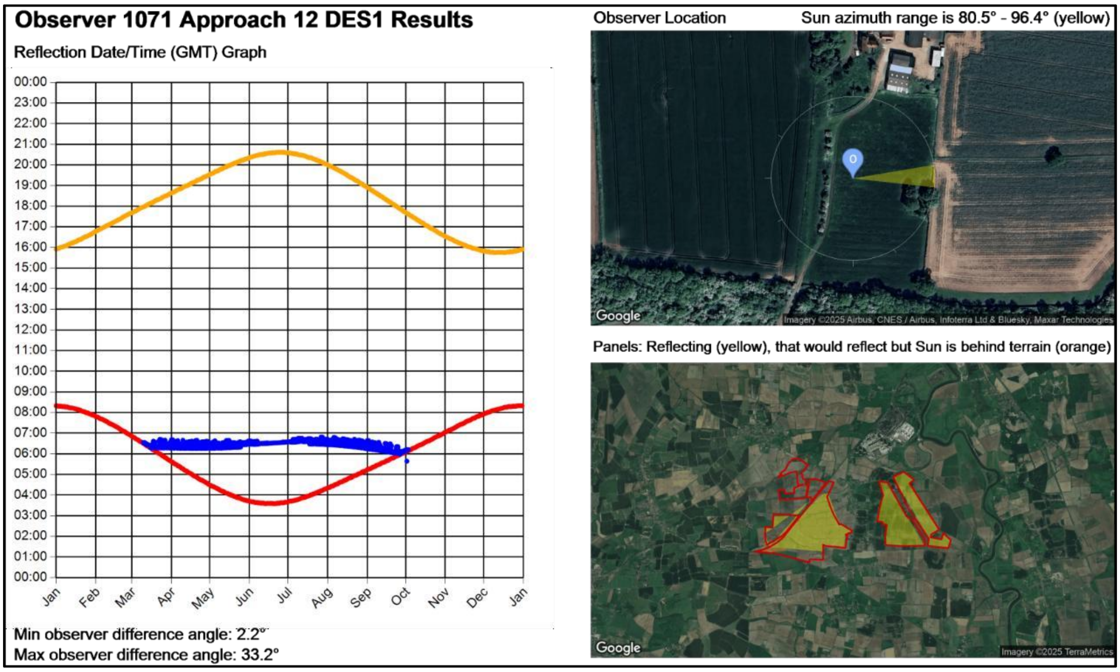
- The annual predicted solar reflections.
- The daily duration of the solar reflections.
- The location of the Proposed Development where glare will originate.
- The calculated intensity of the predicted solar reflections.

Aviation Receptors

Modelling results for receptors discussed in Section 6.2.4 are presented. Full modelling results are available upon request.

Pager Power



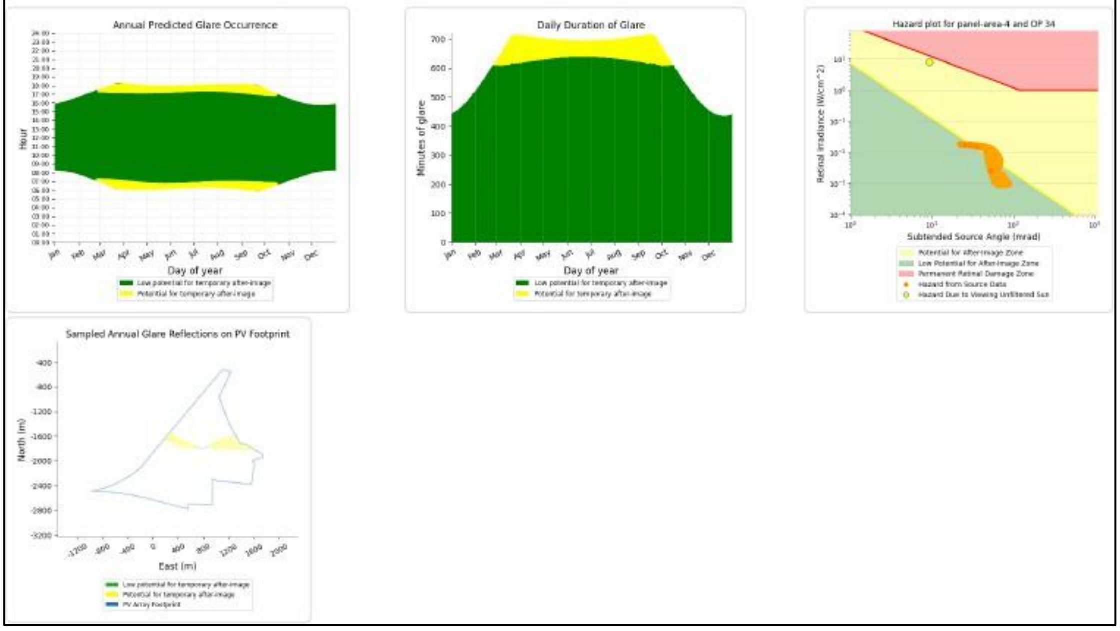


Forge

Panel Area 4: OP 34

PV array is expected to produce the following glare for this receptor:

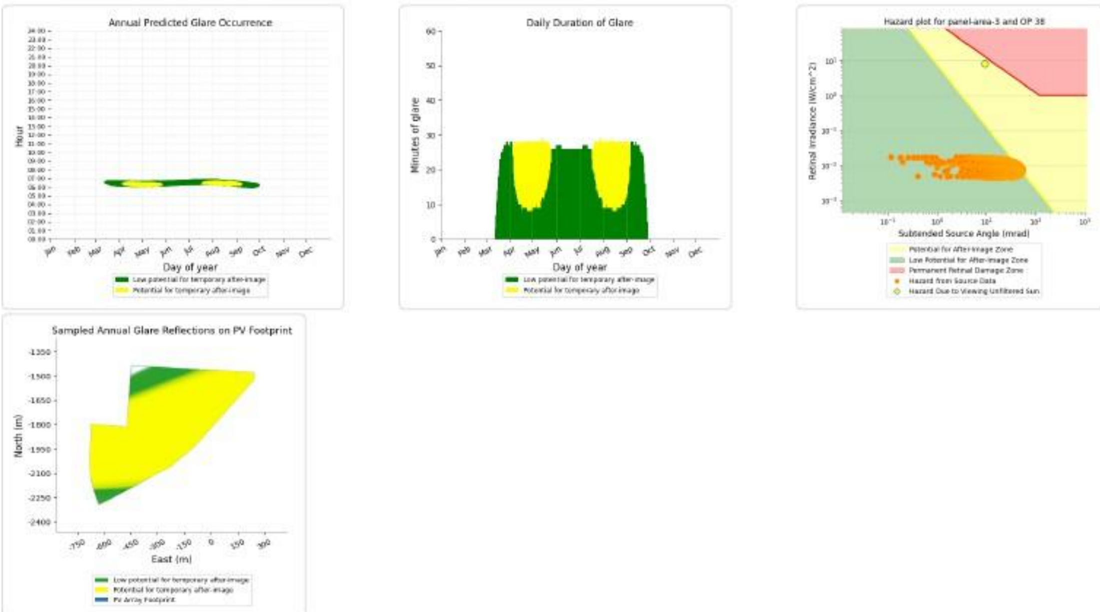
- 211,710 minutes of "green" glare with low potential to cause temporary after-image.
- 16,209 minutes of "yellow" glare with potential to cause temporary after-image.



Panel Area 3: OP 38

PV array is expected to produce the following glare for this receptor:

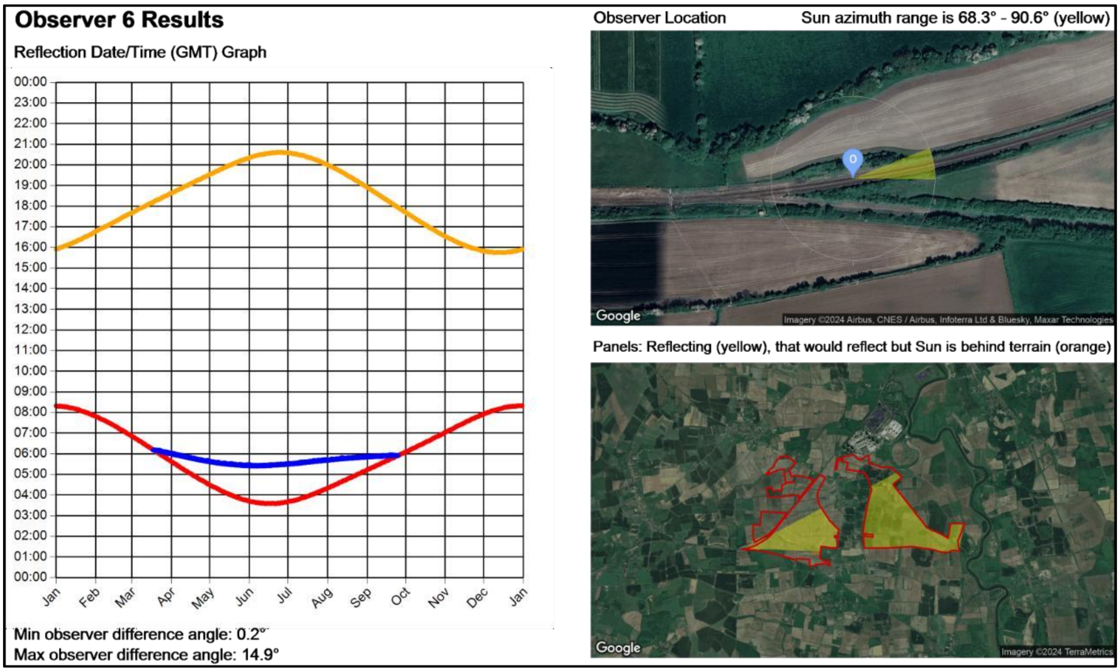
- 3,635 minutes of "green" glare with low potential to cause temporary after-image.
- 1,667 minutes of "yellow" glare with potential to cause temporary after-image.

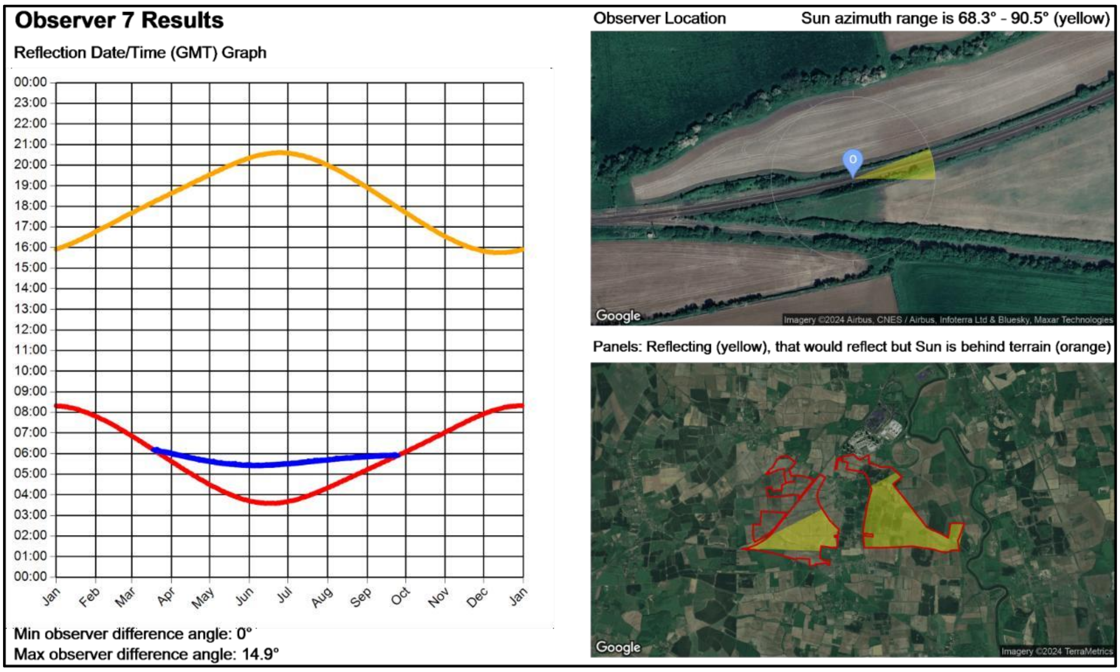


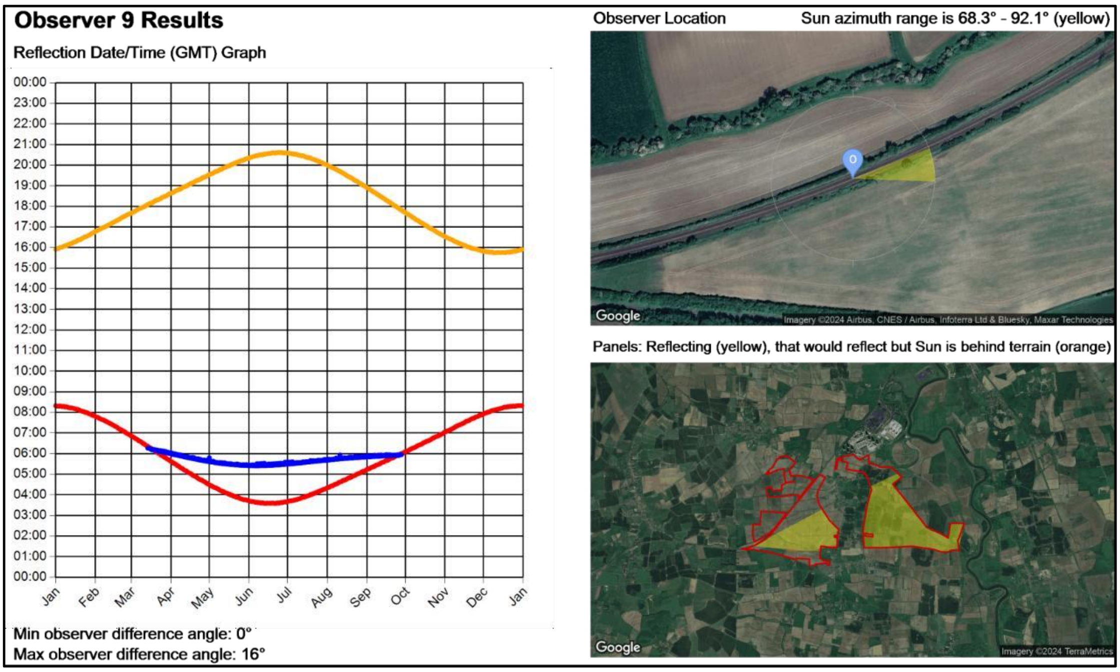
Railway Receptors

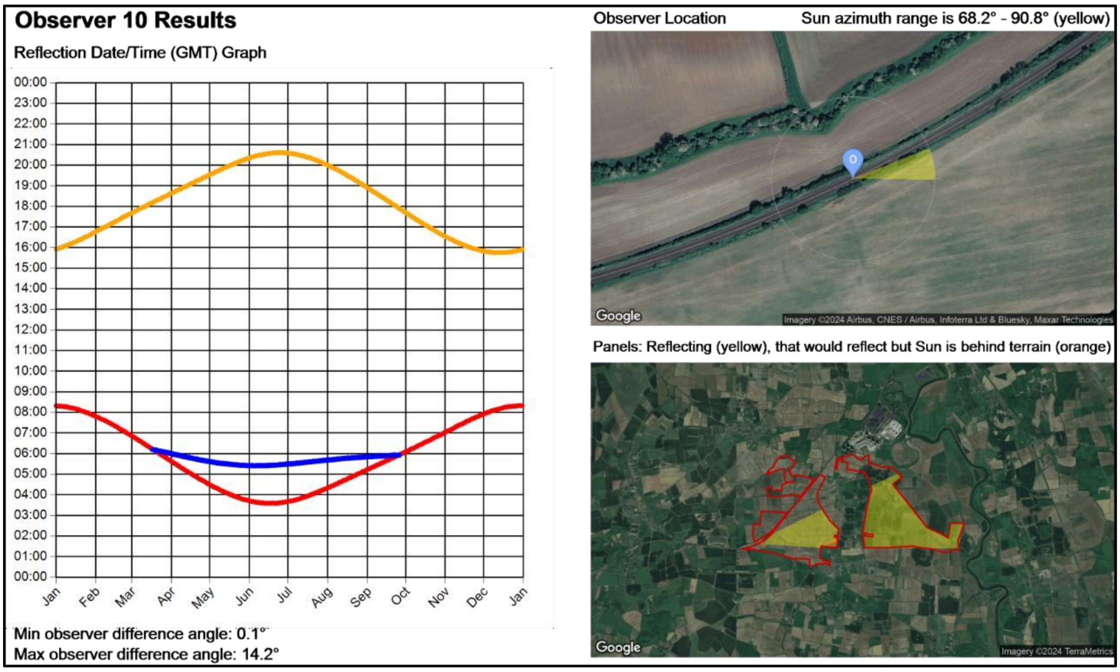
Modelling results for receptors predicted a low impact are presented. Full modelling results are available upon request.

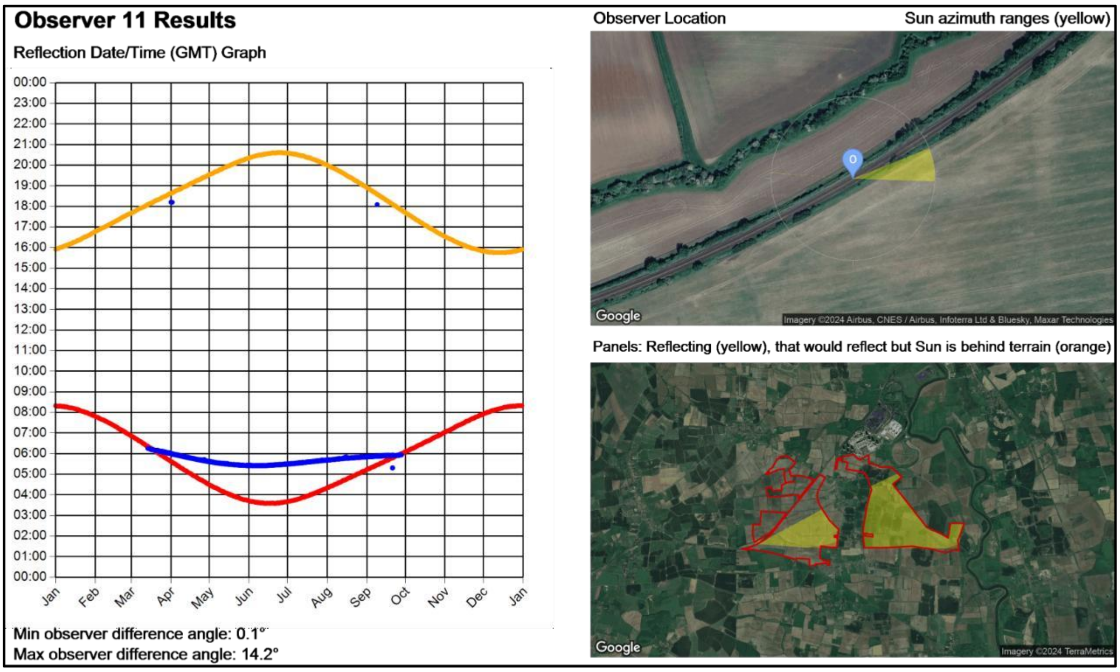
Train Driver Receptors

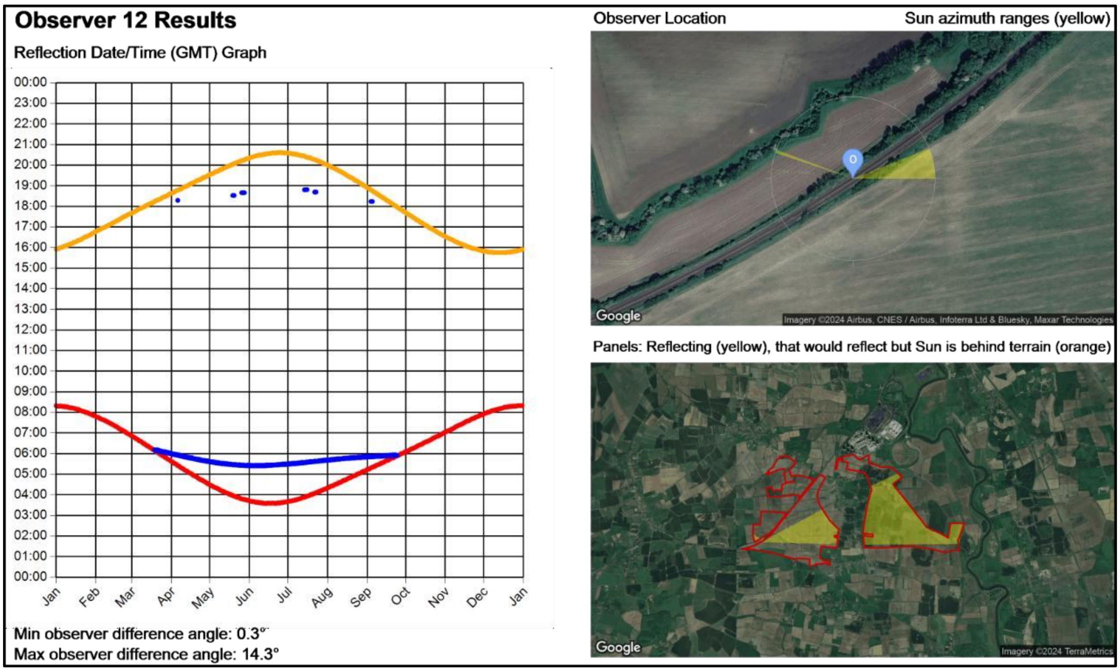





Observer 9 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0°
Max observer difference angle: 16°
Observer Location
Sun azimuth range is 68.3° - 92.1° (yellow)
Google
Imagery ©2024 Airbus, CNES / Airbus, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2024 TerraMetrics

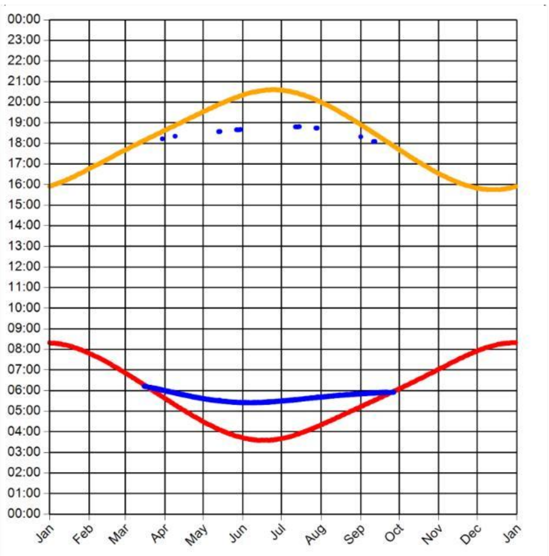

Observer 10 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.1°
Max observer difference angle: 14.2°
Observer Location
Sun azimuth range is 68.2° - 90.8° (yellow)
Google
Imagery ©2024 Airbus, CNES / Airbus, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2024 TerraMetrics


Observer 11 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.1°
Max observer difference angle: 14.2°
Observer Location
Sun azimuth ranges (yellow)
Google
Imagery ©2024 Airbus, CNES / Airbus, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2024 TerraMetrics


Observer 12 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.3°
Max observer difference angle: 14.3°
Observer Location
Sun azimuth ranges (yellow)
Google
Imagery ©2024 Airbus, CNES / Airbus, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2024 TerraMetrics

Observer 13 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°

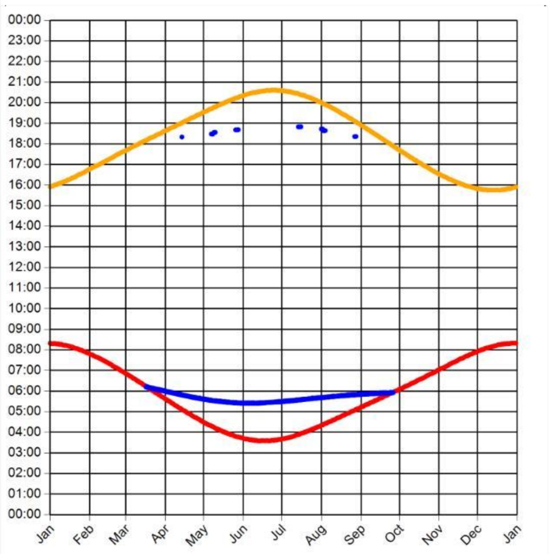
Max observer difference angle: 14.3°

Observer Location | Sun azimuth ranges (yellow)

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

Observer 14 Results

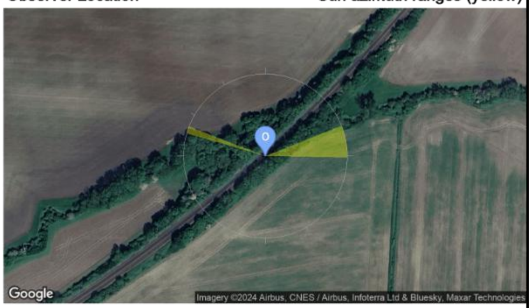
Reflection Date/Time (GMT) Graph



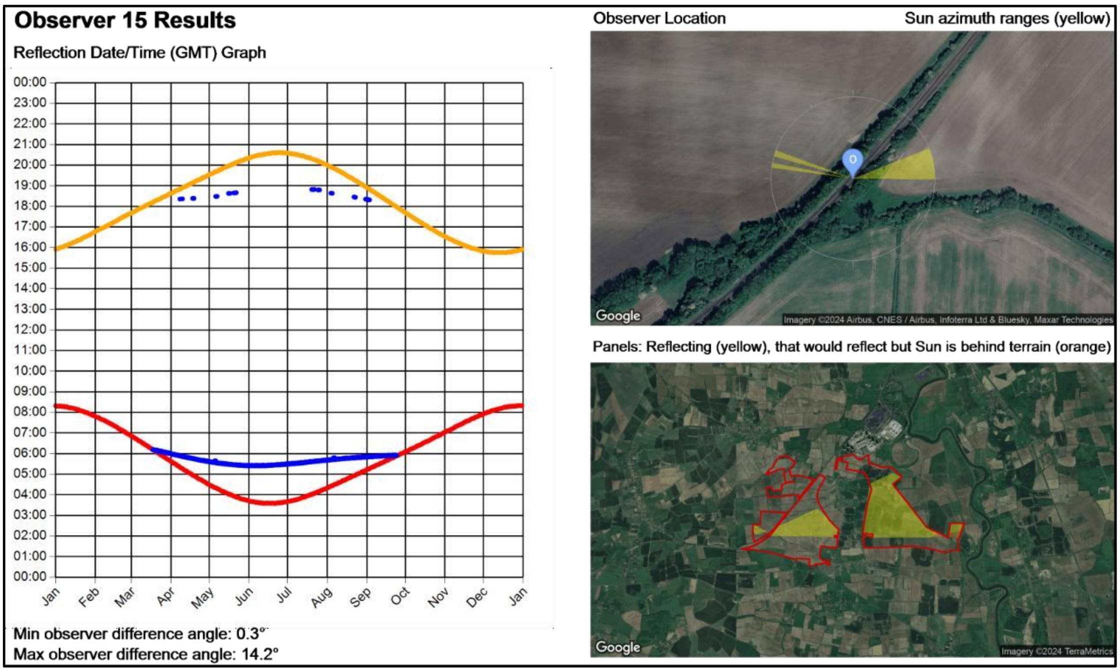
Min observer difference angle: 0.1°

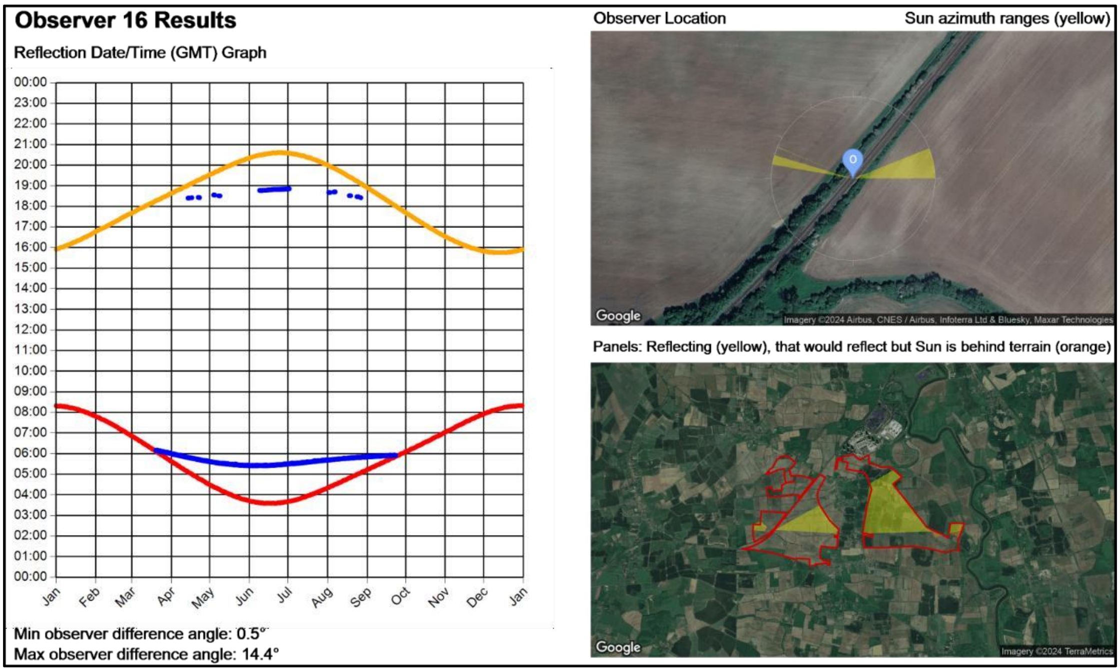
Max observer difference angle: 14.3°

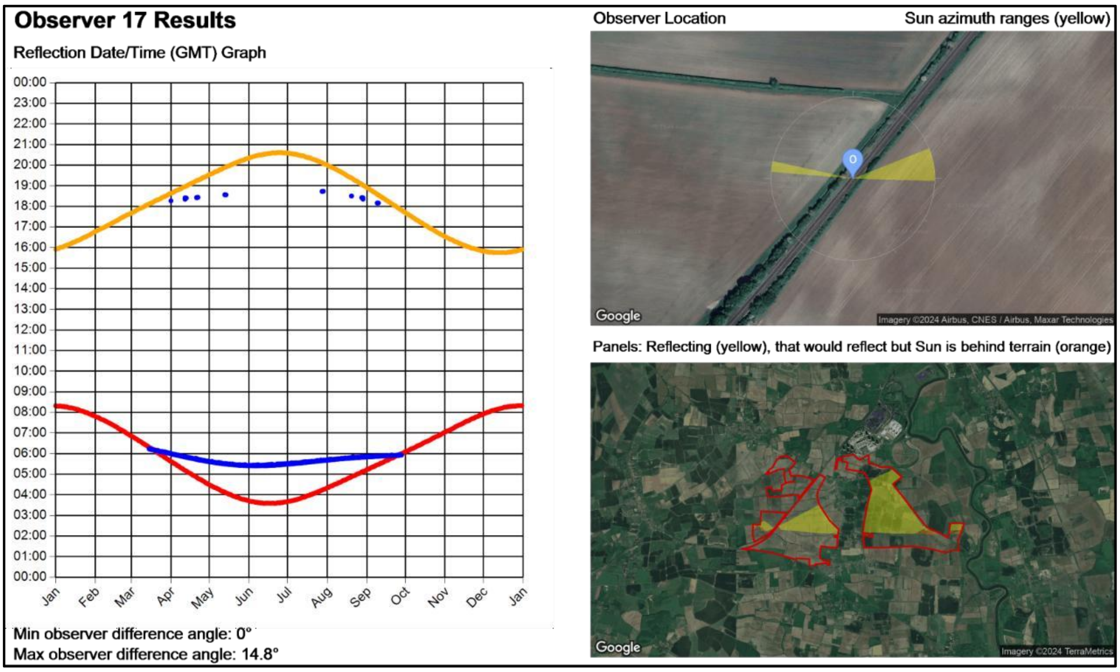
Observer Location | Sun azimuth ranges (yellow)

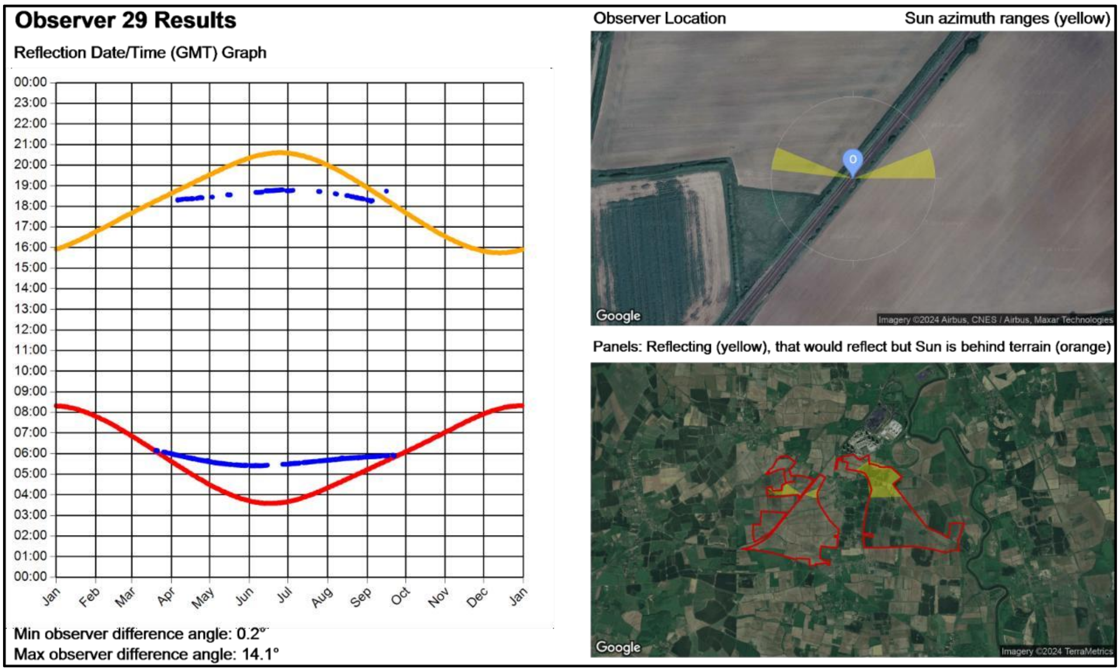


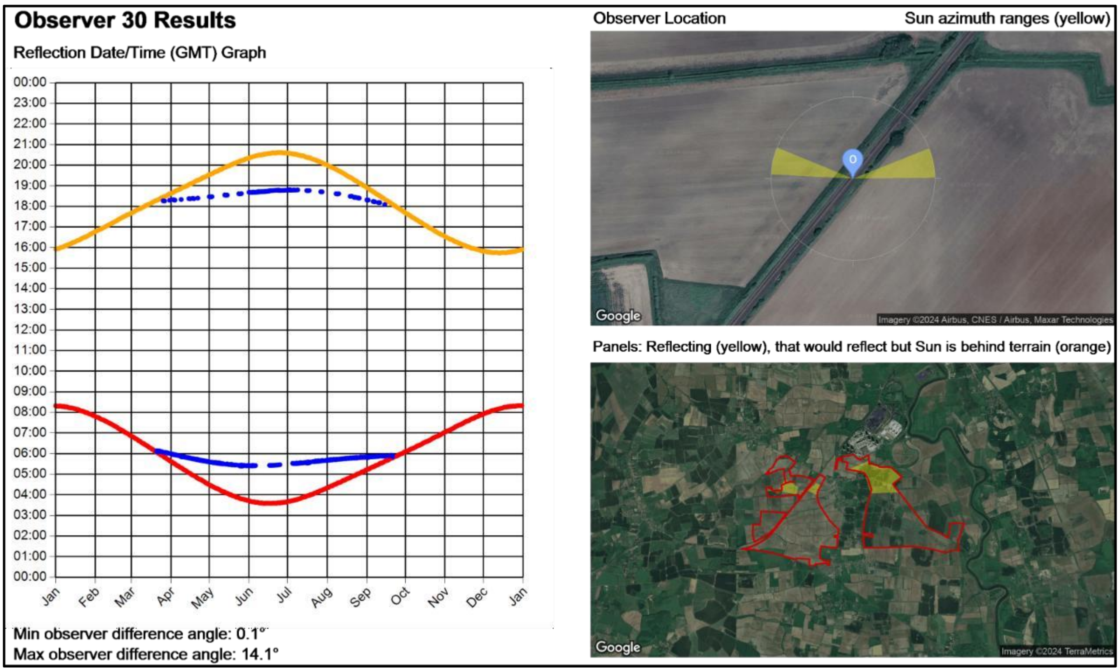
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

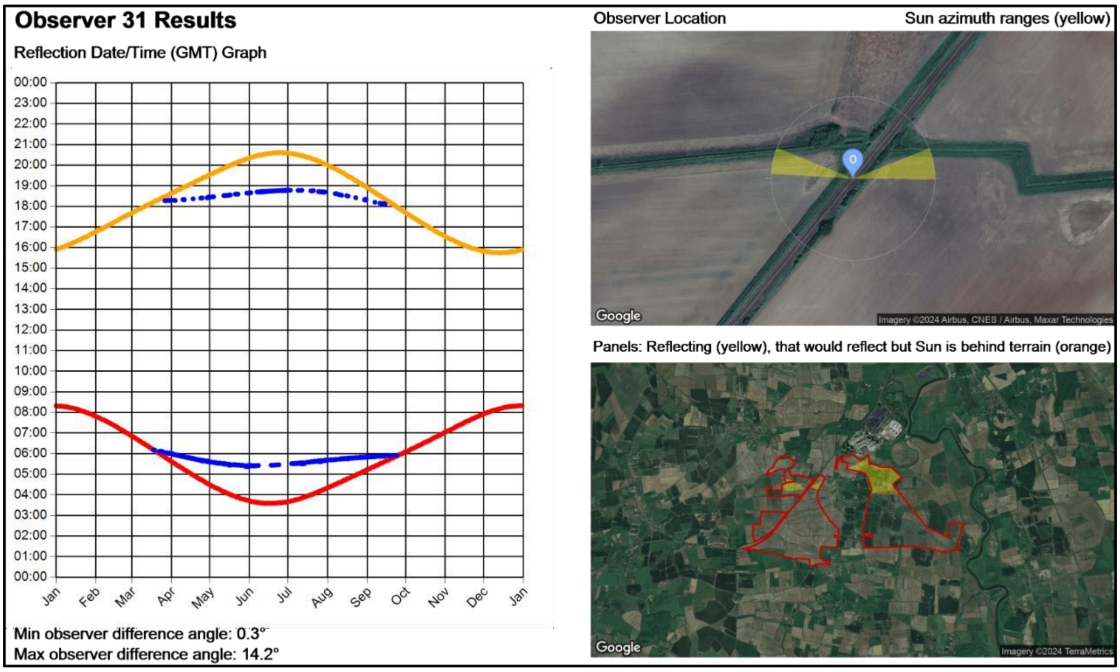

Observer 15 Results
Reflection Date/Time (GMT) Graph
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.3°
Max observer difference angle: 14.2°
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

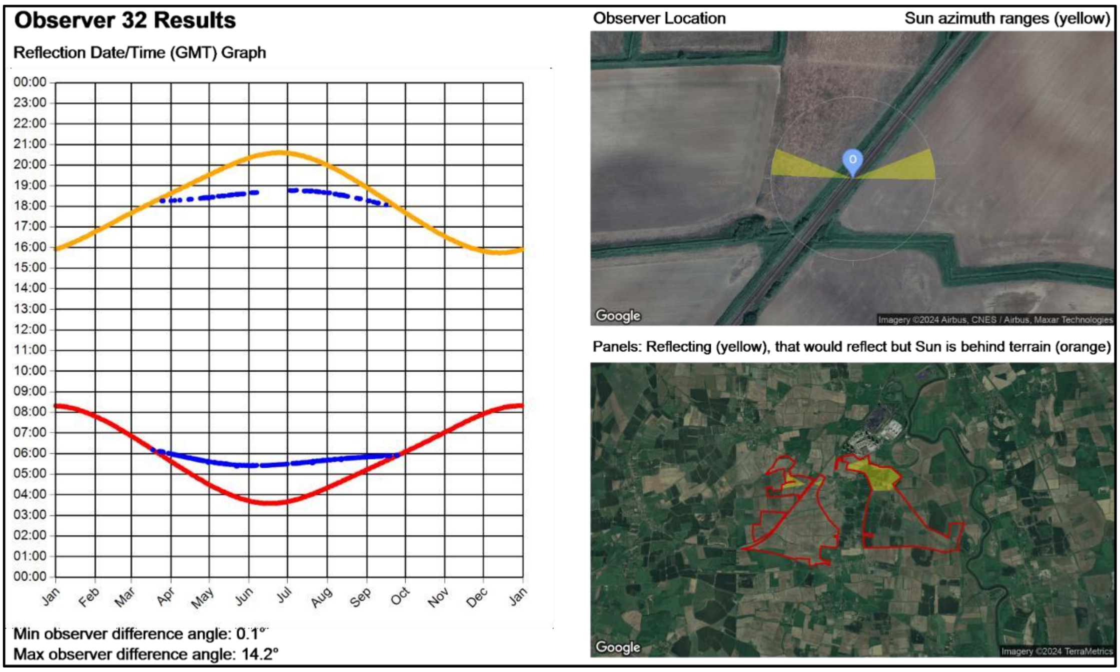

Observer 16 Results
Reflection Date/Time (GMT) Graph
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.5°
Max observer difference angle: 14.4°
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

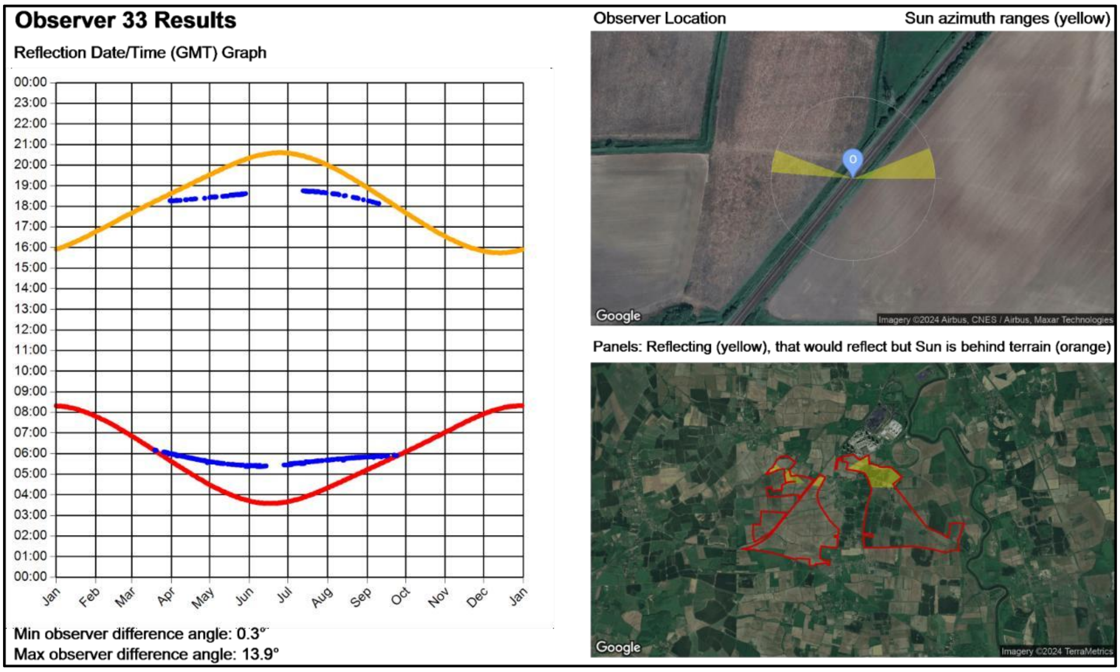

Observer 17 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0°
Max observer difference angle: 14.8°
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

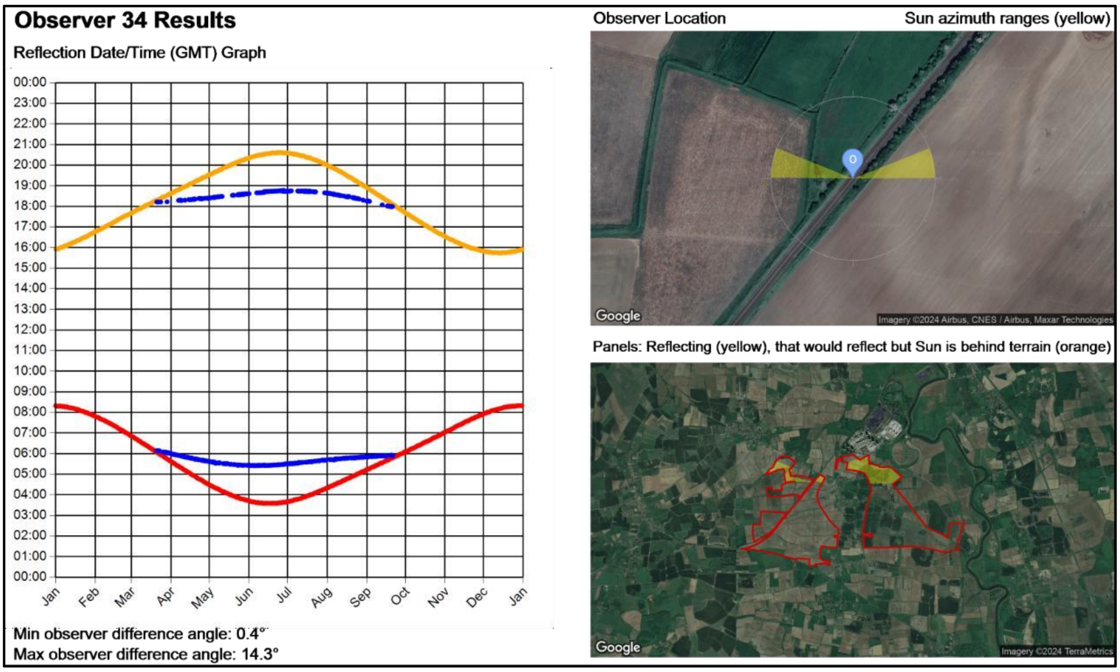

Observer 29 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.2°
Max observer difference angle: 14.1°
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 30 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.1°
Max observer difference angle: 14.1°
Observer Location
Sun azimuth ranges (yellow)
Google
Imagery ©2024 Airbus, CNES / Airbus, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2024 TerraMetrics

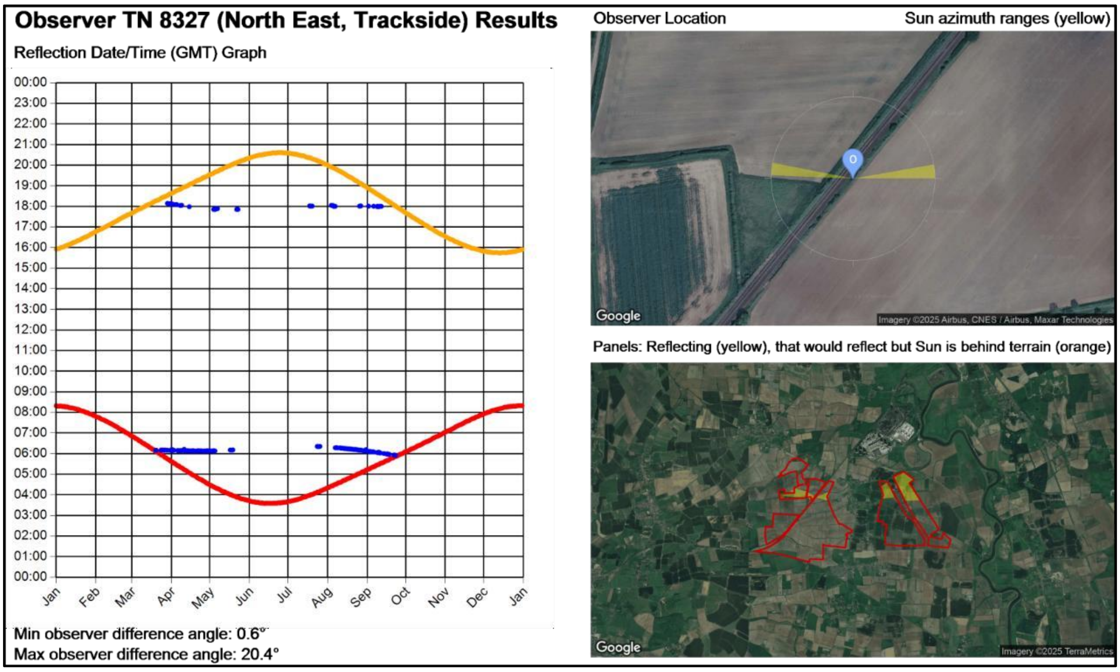

Observer 31 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.3°
Max observer difference angle: 14.2°
Observer Location
Sun azimuth ranges (yellow)
Google
Imagery ©2024 Airbus, CNES / Airbus, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2024 TerraMetrics

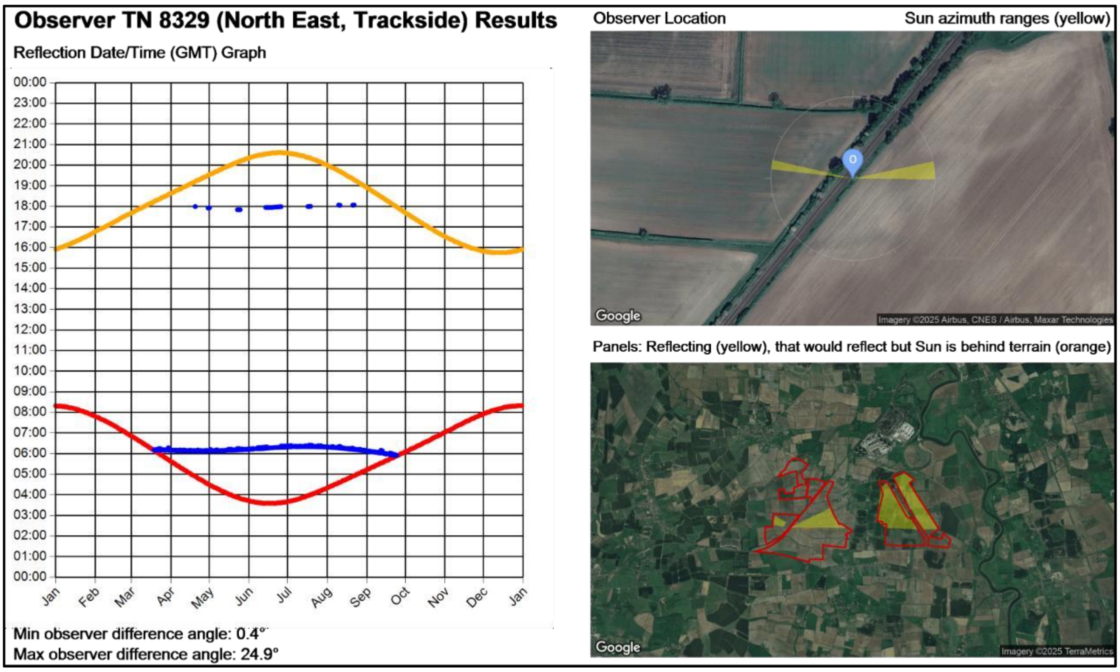

Observer 32 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 0.1°
Max observer difference angle: 14.2°

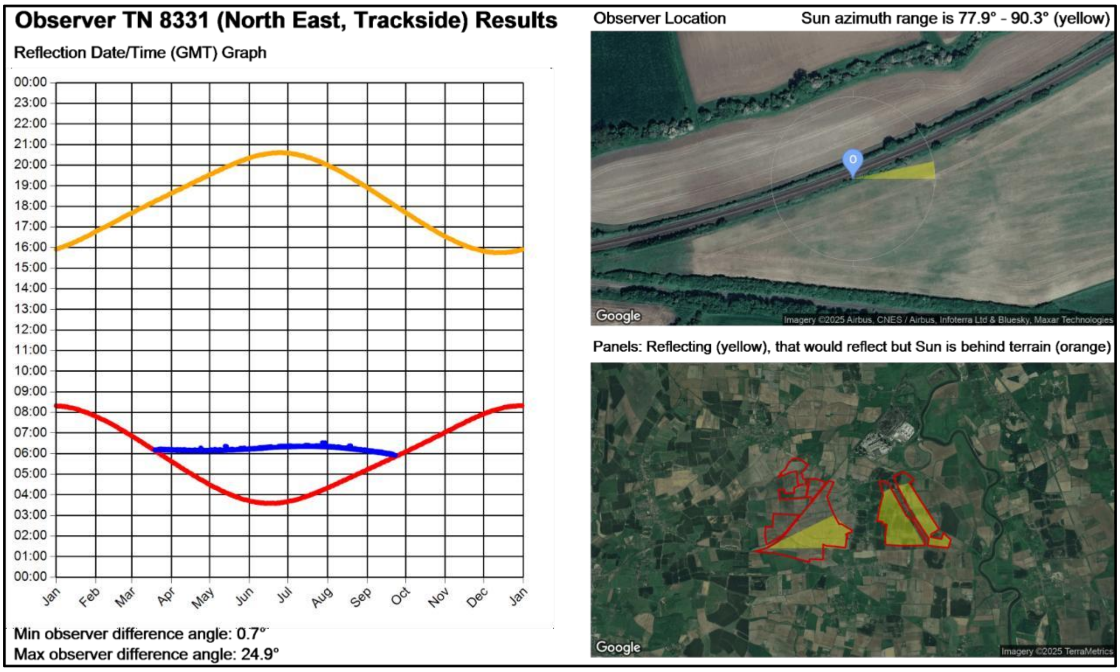

Observer 33 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 0.3°
Max observer difference angle: 13.9°



Train Signal Receptors

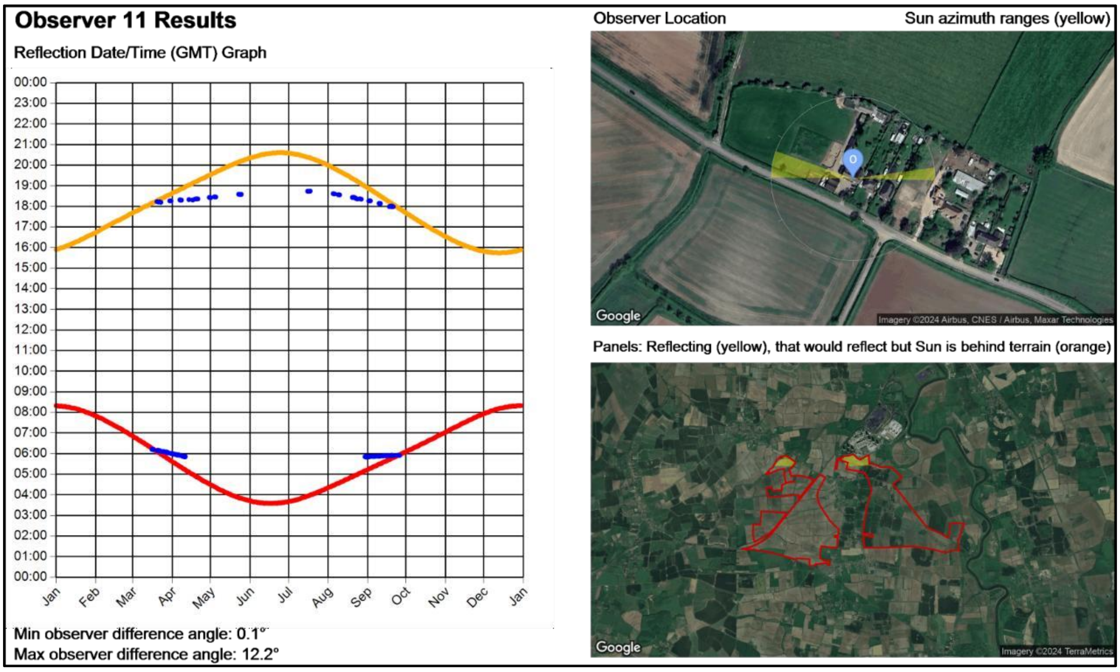


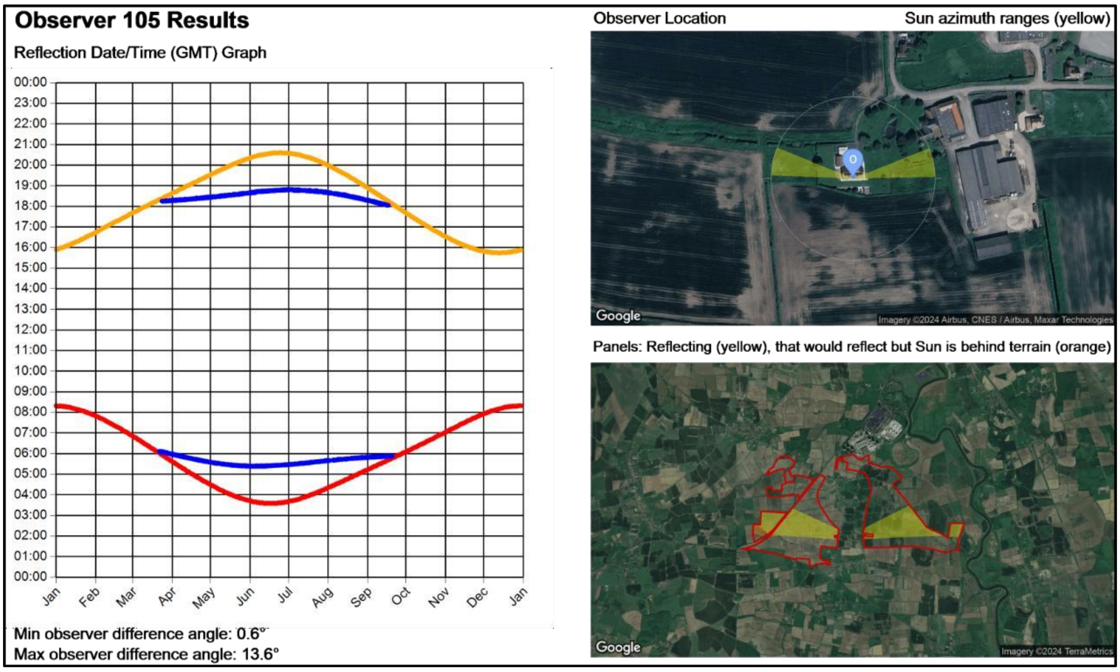

Observer TN 8329 (North East, Trackside) Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.4°
Max observer difference angle: 24.9°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

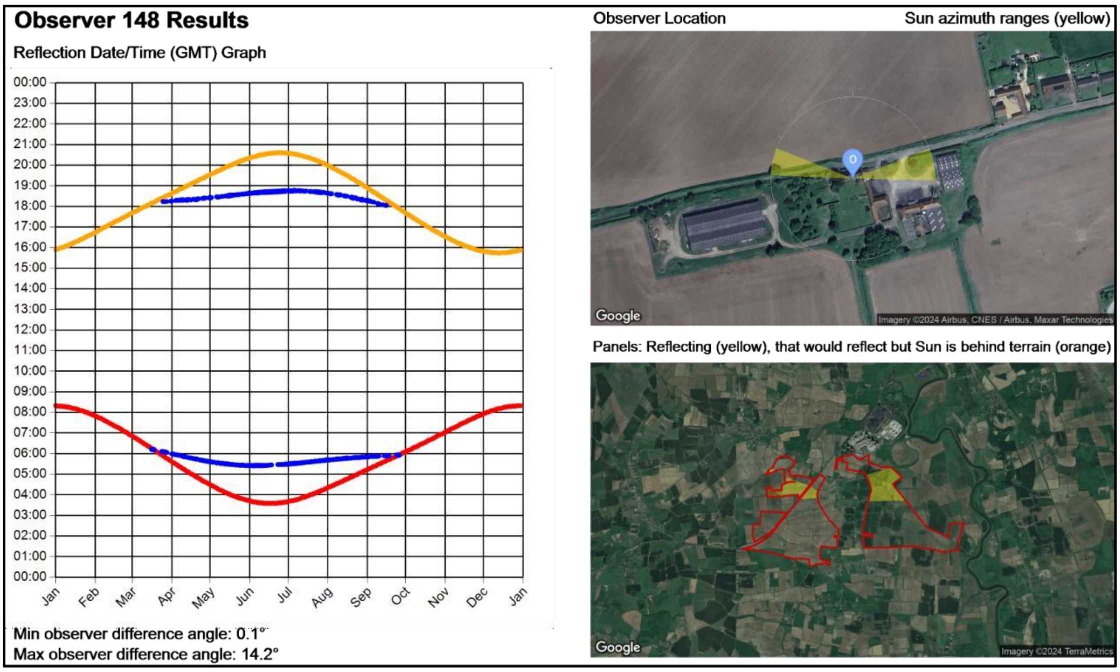

Observer TN 8331 (North East, Trackside) Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.7°
Max observer difference angle: 24.9°
Observer Location
Sun azimuth range is 77.9° - 90.3° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

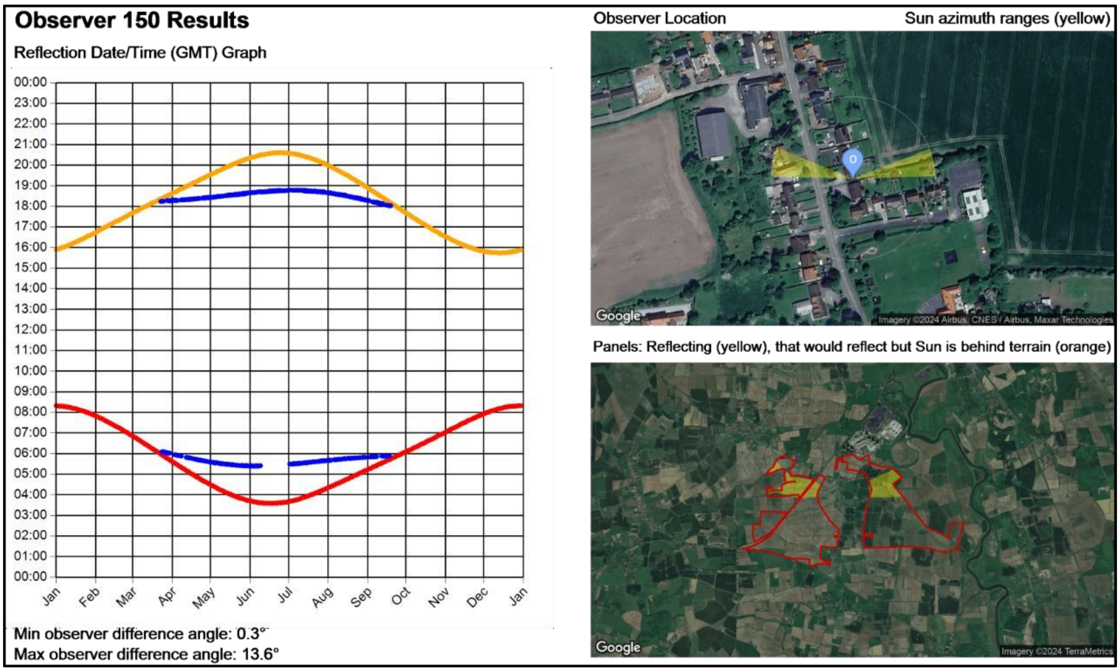
Dwelling Receptors

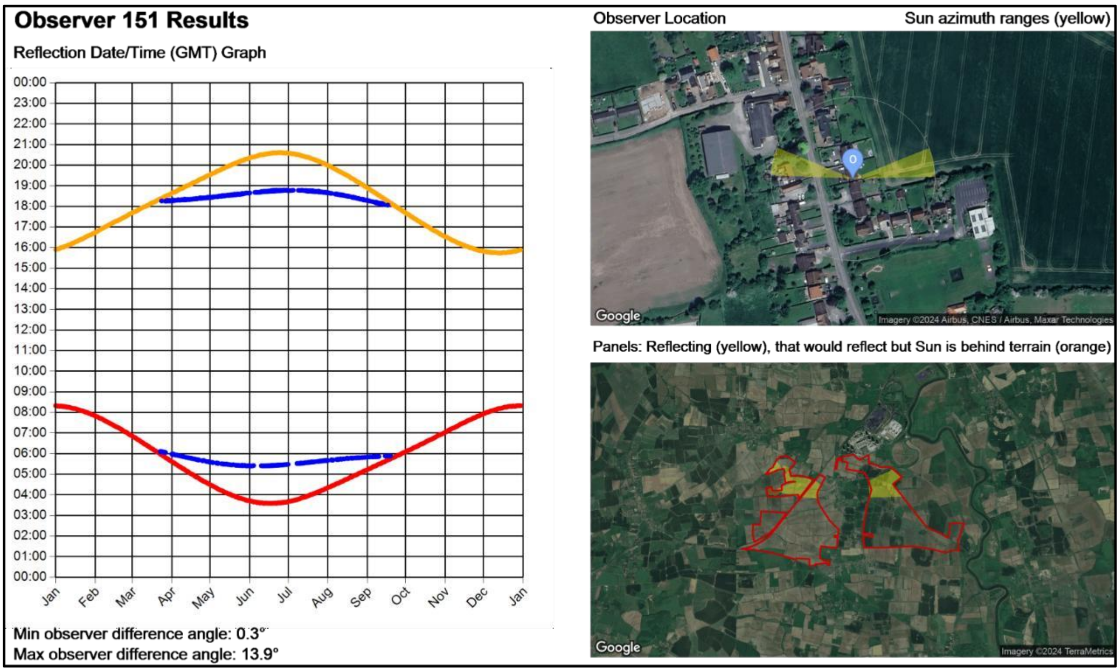
Modelling results for receptors predicted a low impact are presented. Full modelling results are available upon request.

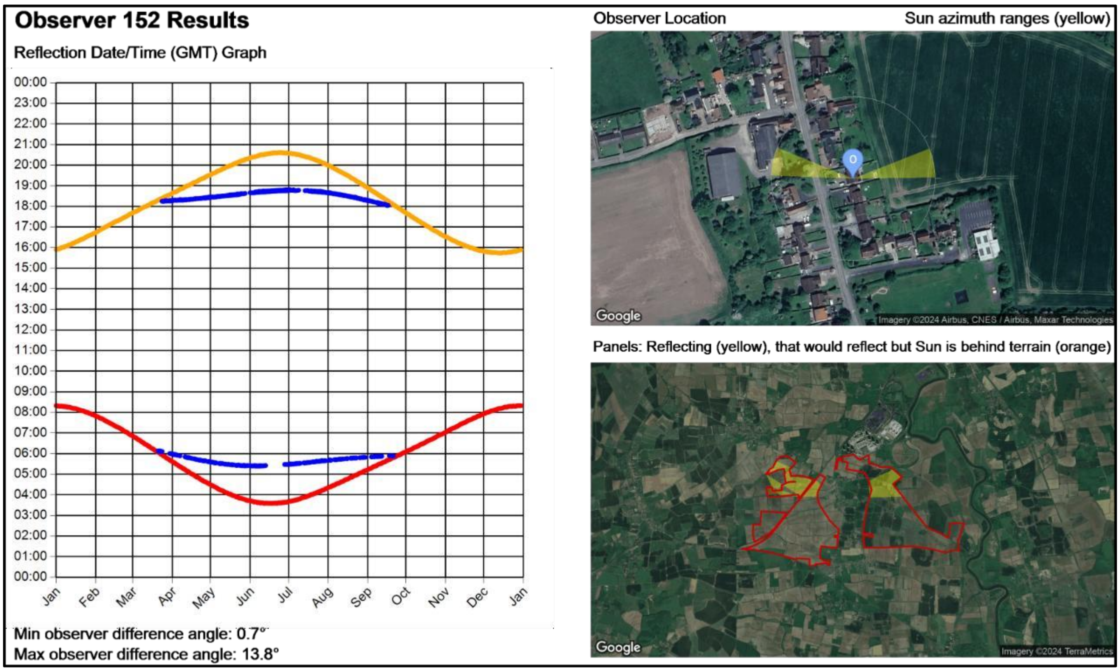


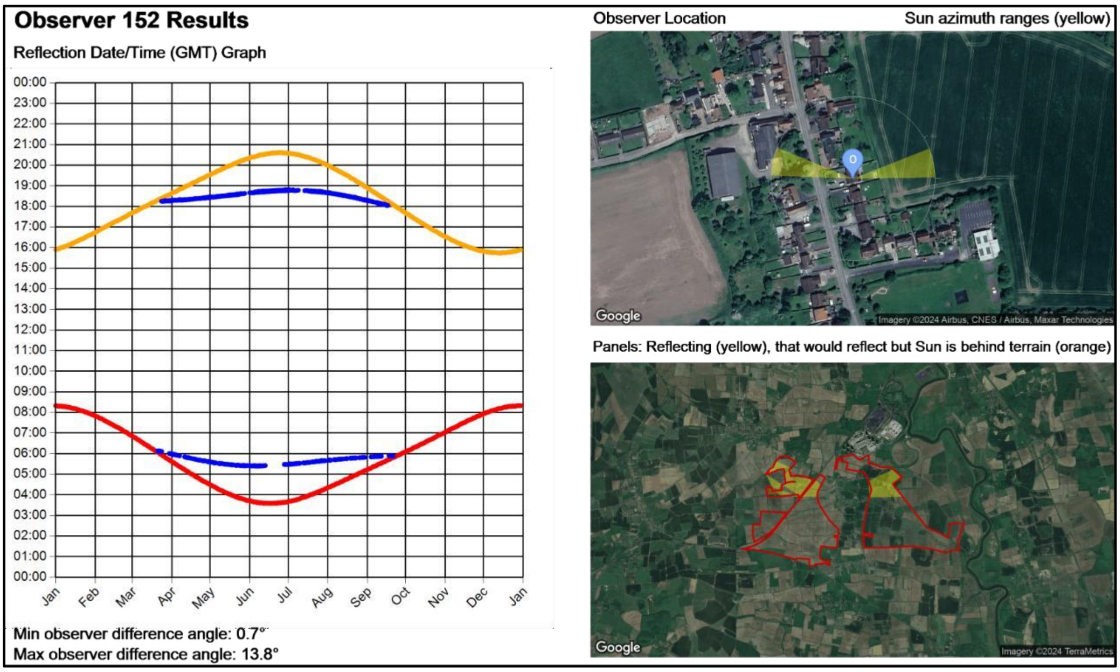


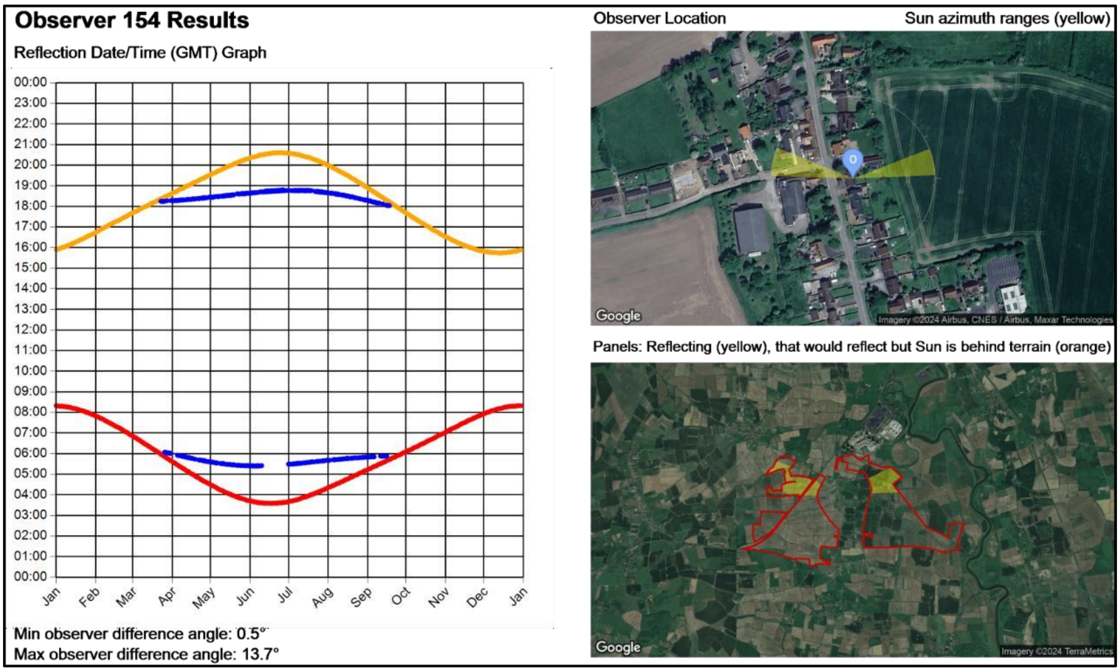

Observer 148 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.1°
Max observer difference angle: 14.2°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

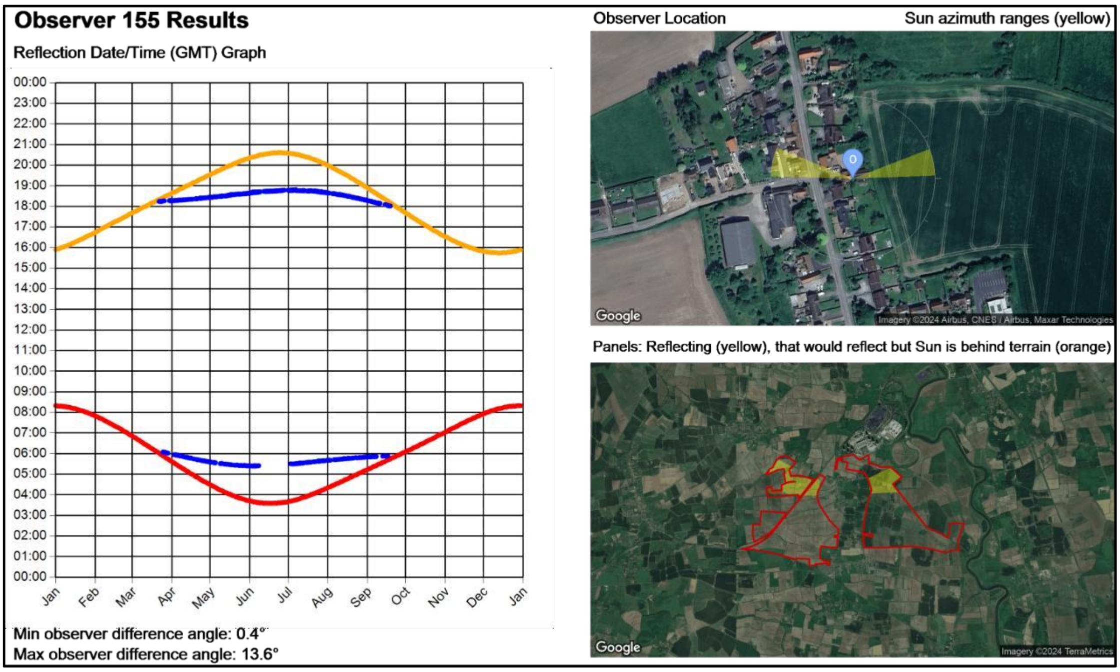

Observer 150 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.3°
Max observer difference angle: 13.6°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

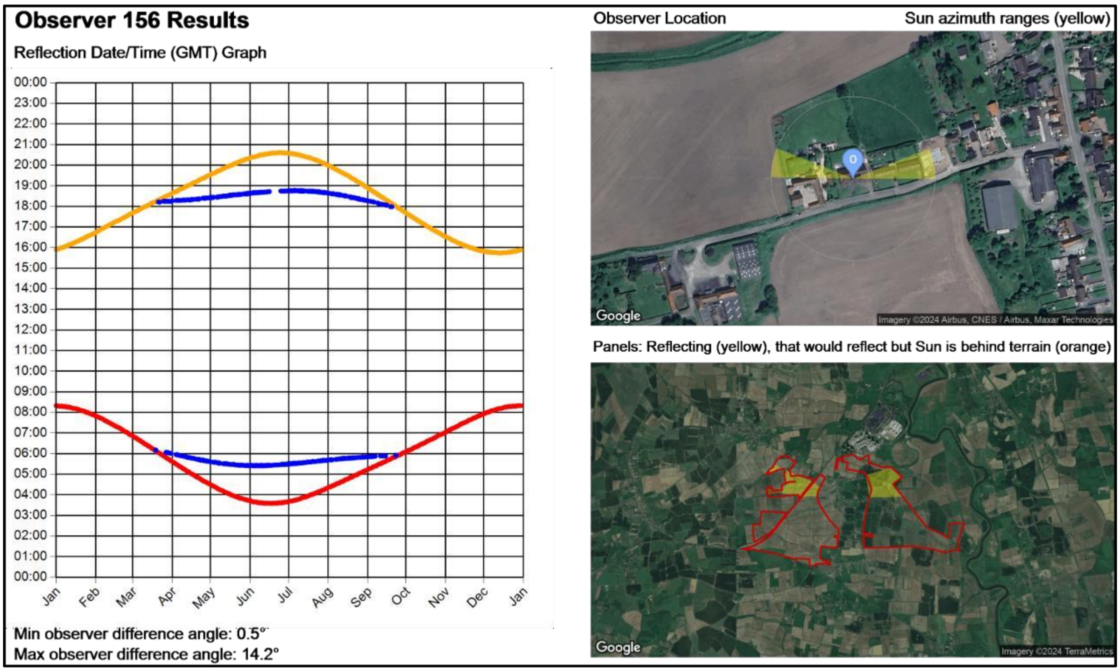

Observer 151 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.3°
Max observer difference angle: 13.9°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2024 TerraMetrics

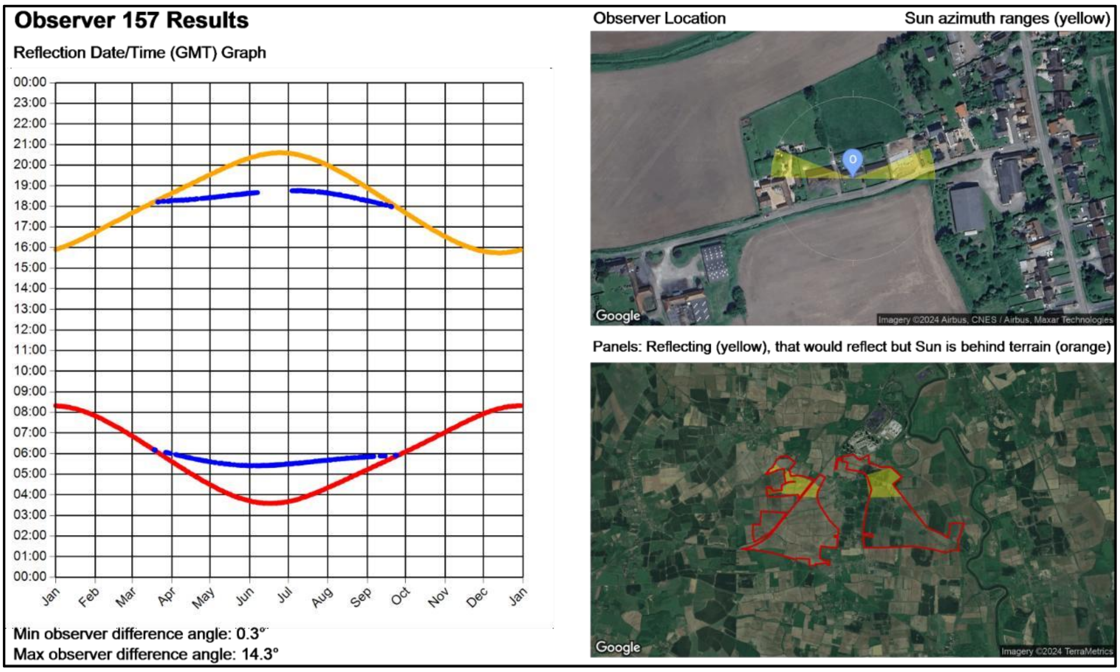

Observer 152 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.7°
Max observer difference angle: 13.8°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2024 TerraMetrics

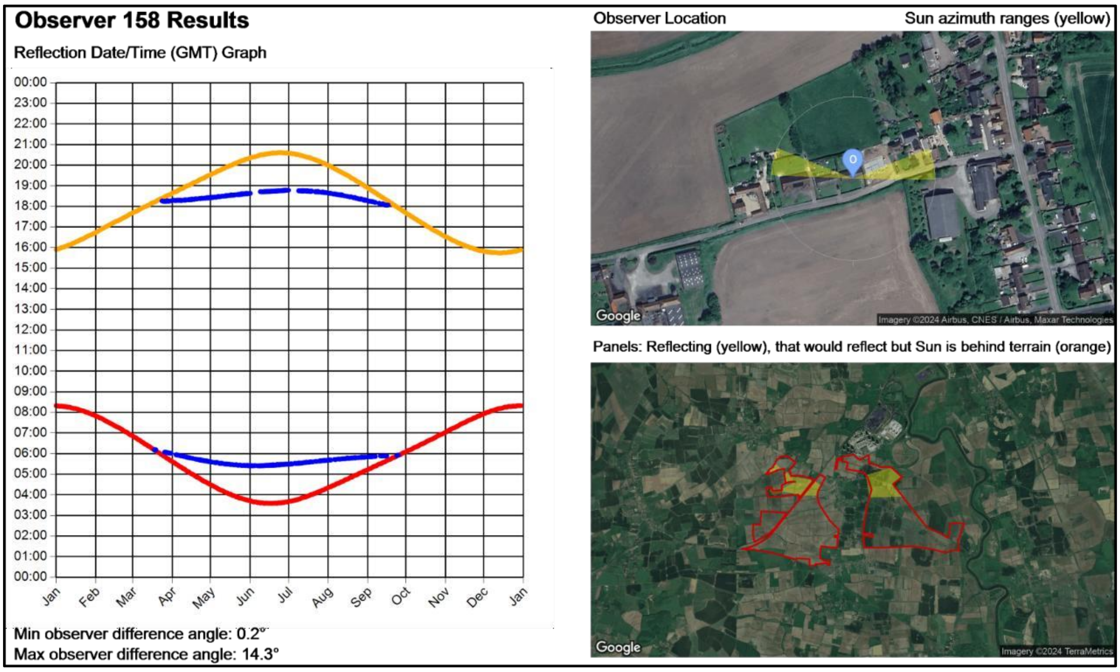

Observer 152 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.7°
Max observer difference angle: 13.8°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 154 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.5°
Max observer difference angle: 13.7°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 155 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.4°
Max observer difference angle: 13.6°
Observer Location
Sun azimuth ranges (yellow)
Google
Imagery ©2024 Airbus, CNES / Airbus, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2024 TerraMetrics


Observer 156 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.5°
Max observer difference angle: 14.2°
Observer Location
Sun azimuth ranges (yellow)
Google
Imagery ©2024 Airbus, CNES / Airbus, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2024 TerraMetrics


Observer 157 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.3°
Max observer difference angle: 14.3°
Observer Location
Sun azimuth ranges (yellow)
Google
Imagery ©2024 Airbus, CNES / Airbus, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2024 TerraMetrics


Observer 158 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.2°
Max observer difference angle: 14.3°
Observer Location
Sun azimuth ranges (yellow)
Google
Imagery ©2024 Airbus, CNES / Airbus, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2024 TerraMetrics

APPENDIX J – SCREENING REVIEW

Overview

A desk-based review of the screening review for the relevant ground-based receptors is presented in the following subsections.

Railway Receptors

Screening for train signal TN 8366

Screening for train signal ground mounted 1

Screening for train signal TN 8256

Screening for train signal TN 8354

Screening for train signal TN 8325

Screening for train signal TN 8327

Screening for train signal TN 8329

Screening for train signal TN 8331

Screening for train signal ground mounted 2

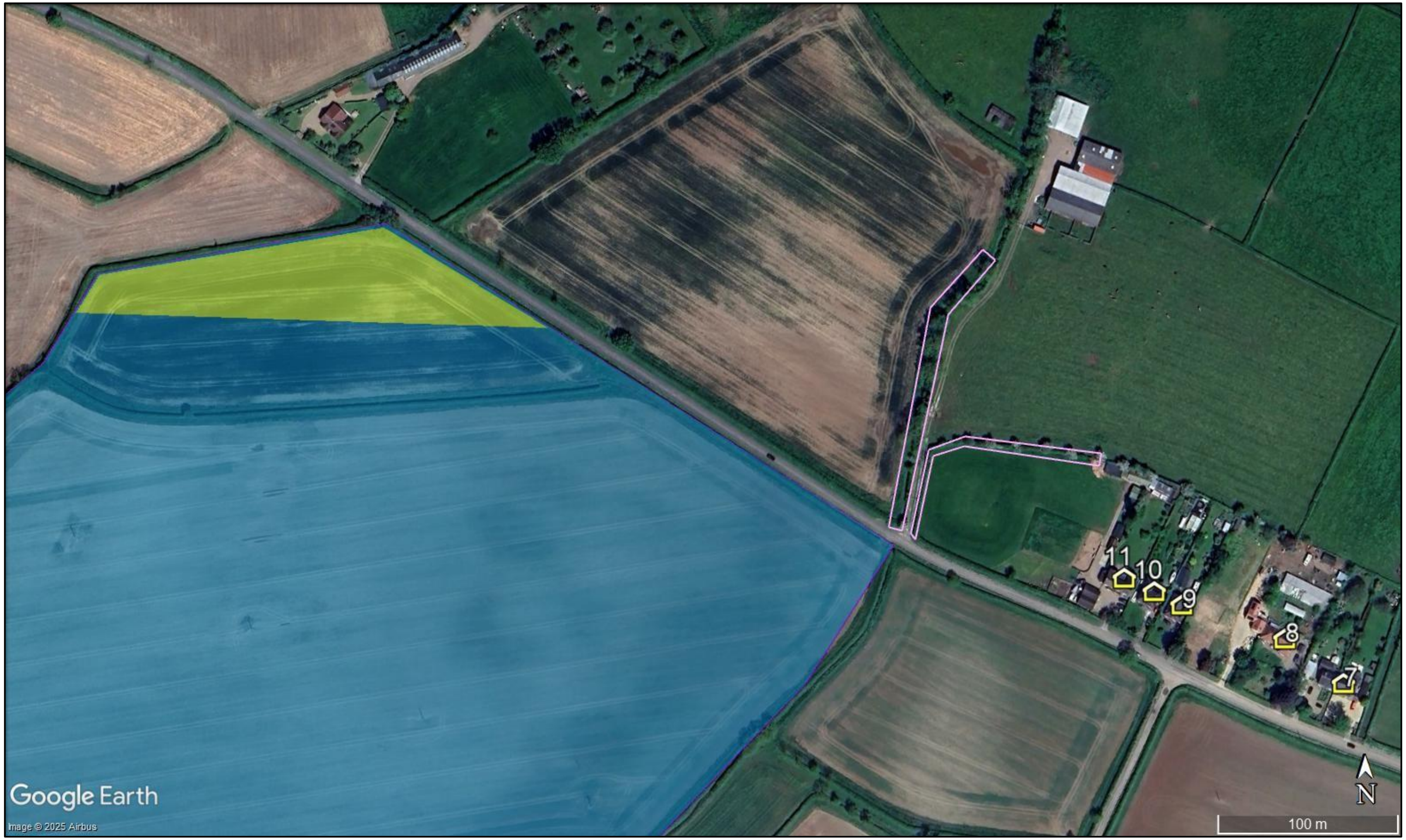
Dwelling Receptors

A desk-based review of the available imagery is presented in the figures (in this subsection) on the following pages. The cumulative reflecting panel areas are indicated by regions of yellow within the figures. The identified screening in the form of existing vegetation and buildings and is outlined in pink and blue respectively. High-level Zones of Visible Terrain[50] (ZTV) show regions visible from a point and are indicated by shaded regions of green.

[50] Generated by Google Earth Viewshed at a height of 5.00m above ground level

Screening for dwelling receptor 1

Screening for dwelling receptors 2 to 6



Screening for dwelling receptors 7 to 11

Screening for dwelling receptors 12 to 14

Screening for dwelling receptors 12 to 14

Screening for dwelling receptors 18 to 24

Screening for dwelling receptor 25

Screening for dwelling receptors 26 to 50

Screening for dwelling receptors 51 to 70

Screening for dwelling receptors 71 to 94

Screening for dwelling receptors 95 to 98

Screening for dwelling receptors 99 to 102

Screening for dwelling receptors 103 to 104

Screening for dwelling receptors 105 to 107

Screening for dwelling receptors 108 to 126

Screening for dwelling receptors 58 to 67

Screening for dwelling receptors 140 to 148

Screening for dwelling receptors 58 to 67

Screening for dwelling receptors 156 to 160

Screening for dwelling receptors 161 to 176

Screening for dwelling receptors 177 to 190

Screening for dwelling receptors 191 to 211

Screening for dwelling receptor 212

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