Great Harmeston Solar Farm

Environmental Statement

Technical Appendix 8.1
Glint and Glare Technical Report

Development of National Significance
Pre-Application Consultation

March 2026

PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

ASUK HoldCo 4 Ltd

Great Harmeston Solar Farm

March 2026





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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from a ground mounted solar photovoltaic development, located near Johnston, Haverfordwest, UK. This assessment pertains to the potential impact upon road safety, residential amenity, railway infrastructure and operations, and aviation activity associated with Rosemarket Airfield and Haverfordwest Airport. Cumulative effects with a nearby existing solar development have also been considered.

Overall Conclusions

A moderate impact is predicted upon road safety. Mitigation is recommended (see Section 5.5).

No significant impacts are predicted upon, residential amenity, railway operations and infrastructure or aviation activity. No significant cumulative impacts are predicted. Mitigation is not required.

Guidance and Studies

Guidelines exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. The UK CAA guidance is relatively high-level and does not prescribe a formal methodology. A specific national guidance policy for determining the impact of glint and glare on road safety, and residential amenity has also not been produced to date. Therefore, in the absence of this, Pager Power reviewed more general existing planning guidelines and the available studies (discussed below) in the process of defining its own glint and glare assessment guidance and methodology[1]. This methodology defines the process for determining the impact upon road safety, residential amenity, railway infrastructure and operations, and aviation activity.

Pager Power's approach is to undertake geometric reflection calculations and, where a solar reflection is predicted, consider the screening (existing and/or proposed) between the receptor and the reflecting solar panels. For aviation activity, where appropriate, solar intensity calculations are undertaken in line with the Sandia National Laboratories' FAA methodology[2]. The scenario in which a solar reflection can occur for all receptors is then identified and discussed, and a comparison is made against the available solar panel reflection studies to determine the overall impact.

The available studies have measured the intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. The results show that the reflections

[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.

produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel[3].

Assessment Conclusions – Aviation Activity

Rosemarket Airfield

Solar reflections with intensities of 'potential for temporary after-image' ('yellow' glare) are predicted towards the splayed approach paths and visual circuits for runway threshold 08 at Rosemarket Airfield. Due to the low duration of 'yellow' glare, reflections coinciding with the sun, a much more significant source of glare, and the low volume of air traffic expected at the aerodrome, a low impact is predicted.

Solar reflections with intensities of 'low-potential for temporary after-image' ('green' glare) are geometrically possible towards the visual circuits and 1-mile splayed approach path for runway threshold 26 at Rosemarket Airfield. This intensity of glare is acceptable in accordance with the associated guidance (Appendix D) and industry best practice pertaining to 2-mile approach paths are licenced aerodromes, it can reliably be concluded it is also acceptable at this aerodrome. A low impact is predicted, and mitigation is not required.

Solar reflections towards the 1-mile splayed approach paths for runway threshold 08 occur outside a pilot's primary field-of-view (defined as 50° horizontally either side of the direction of travel). This glare intensity is not considered significant in accordance with the associated guidance (Appendix D) and industry best practice pertaining to approach paths. A low impact is predicted, and mitigation is not required.

Assessment Conclusions – Roads

Solar reflections are geometrically possible towards a 1.8km section of the A4076, 300m section of the Bulford Road Bypass, and a 1.5km section of the A477.

A moderate impact is predicted on a 100m section of the A477 and a 100m section of Bulford Road Bypass because solar reflections are predicted to originate from **inside** of a road user's primary horizontal field of view with existing vegetation providing only partial screening. Mitigation is recommended (see Section 5.5.1 for further details).

For 400m of the A4076 and 300m of the A477, screening in the form of existing vegetation and intervening terrain is predicted to significantly obstruct views of reflecting panels such that the remaining visible reflections originate from **outside** of a road user's primary horizontal field of view. A low impact is predicted, and mitigation is not recommended.

For a 200m section of the A477, screening in the form of existing vegetation is predicted to partially obstruct views of reflecting panels such that only fleeting views of the solar reflections are predicted to be experienced by road users in practice. Visible reflections from the reflecting panels will coincide with direct sunlight. A low impact is predicted, and mitigation is not recommended.

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

For all remaining sections of the A4076, Bulford Road Bypass and the A477, screening in the form of existing vegetation is predicted to significantly obstruct views of reflecting panels such that solar reflections are not predicted to be experienced by road users in practice. No impact is predicted, and mitigation is not required.

Assessment Conclusions – Dwellings

Solar reflections are geometrically possible towards 41 of the 51 assessed dwellings.

For all dwellings, screening in the form of existing vegetation is predicted to significantly obstruct views of reflecting panels such that solar reflections are not predicted to be experienced by residents. No impact is predicted, and mitigation is not required.

Assessment Conclusions – Railway Signals

Solar reflections are geometrically possible towards both of the assessed railway signals.

Screening in the form of existing vegetation is predicted to significantly obstruct glare from the reflecting panels such that solar reflections will not reach the signal. No impact is predicted, and no mitigation is required.

Assessment Conclusions – Train Drivers and Signal Sighting

Solar reflections are geometrically possible towards all 2.6km of the assessed railway.

For all sections of railway, screening in the form of existing vegetation is predicted to significantly obstruct views of reflecting panels such that solar reflections are not predicted to be experienced by road users in practice. No impact is predicted, and mitigation is not required.

Reflections do not occur directly behind a signal where signal sighting is required.

High Level Aviation Assessment Conclusions

The proposed development size, distance between the aerodrome and proposed development, geometric results Rosemarket Airfield, assessed in this report, and industry experience are considered during the assessment.

When considering Haverfordwest Airport, the following can be concluded;

- Any solar reflections towards the ATC Tower will be significantly screened by existing vegetation, buildings and intervening terrain such the views of the reflecting panels are not predicted;
- Glare intensities towards pilots on approach towards thresholds in the direction of the proposed development and on the visual circuits are predicted to be no greater than 'low potential for temporary after-image'. This level of glare is acceptable in accordance with the associated guidance and industry best practice;
- Any possible solar reflections will be outside the pilot's primary field-of-view (50 degrees either side of the direction of travel) for pilots approaching runway thresholds directed away from the proposed development. This level of glare is acceptable in accordance with the associated guidance and industry best practice.

No significant impact is predicted upon Haverfordwest Airport. Detailed modelling is not recommended, and mitigation is not required.

High Level Assessment Conclusions – Cumulative Effects

For all receptors shared between the proposed and existing development, no impact is predicted from the proposed development. Therefore, no cumulative impacts are predicted and no mitigation is required.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 64 countries within Europe, Africa, America, Asia and Australasia.

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

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

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

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

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

1 INTRODUCTION

1.1 Overview

Pager Power has been retained to assess the possible effects of glint and glare from a ground mounted solar photovoltaic development, located near Johnston, Haverfordwest, UK. This assessment pertains to the potential impact upon road safety, residential amenity, railway infrastructure and operations, and aviation activity associated with Rosemarket Airfield and Haverfordwest Airport. Cumulative effects with a nearby existing solar development have also been considered.

This report contains the following:

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

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

1.2 Pager Power's Experience

Pager Power has undertaken over 1,800 Glint and Glare assessments in the UK and internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Glint and Glare Definition

The definition of glint and glare is as follows[4]:

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

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

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

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Site Layout

The proposed development site layout[5] is shown in Figure 1 below.

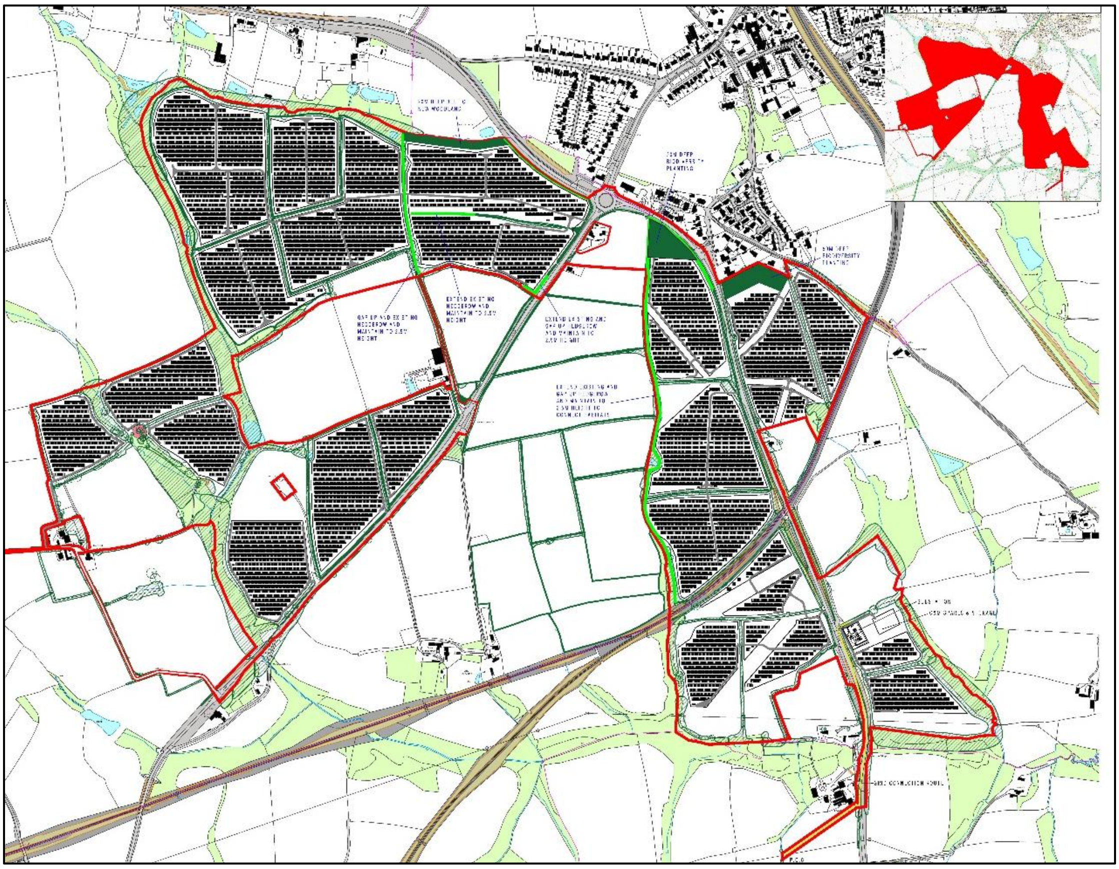

Figure 1 *Proposed development site layout*

[5] Source: Harmeston_Site Layout Plan_030226 PDF [edited].

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 below shows the assessed reflector areas that have been used for modelling purposes.

Figure 2 *Proposed solar array boundary*

The Pager Power model has used a resolution of 20m for this assessment. This means that a geometric calculation is undertaken for each identified receptor every 20m 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 angle[7]: 12.5°;
- Assessed height[8]: 2.3m above ground level.

Further information regarding the modelled surface material is presented in Section 5.2.1

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[6] Direction the panels are facing relative to True North (0°).

[7] Pitch above horizontal.

[8] Assessed at the midpoint of the panel above ground level.

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Guidance and Studies

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

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

3.2 Background

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

3.3 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 and studies. The methodology for this glint and glare assessment is as follows:

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

3.3.2 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 Railway and Glint and Glare

3.4.1 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.

3.4.2 Disability Glare

As well as the glint and glare definition presented in Section 1.3, 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)[9] 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).

3.4.3 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;
3. The development producing solar reflections that affect railway signals.

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[9] CIE 146:2002 & CIE 147:2002 Collection on glare (2002).

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, or where the driver's workload is particularly high, the solar reflection may affect operations. This is deemed to be the most concern with respect to solar reflections.

Following 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 below:

'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.[10]*'*

3.4.4 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 main field of view, defined as 30 degrees either side of the railway line with respect to the direction of travel;
- The contrast of sensitivity (i.e. a dark environment into a light environment), 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;
  - Road or pedestrian crossings being present.
- The duration of the solar reflection;
- If the development is in keeping with those around it and near to the assessed railway line.

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

3.5 Assessment Methodology and Limitations

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

4 IDENTIFICATION OF RECEPTORS

4.1 Aviation Details

4.1.1 Rosemarket Airfield Runway Details

Rosemarket Airfield is an unlicensed General Aviation (GA) aerodrome that has one operational runway and is not understood to have an Air Traffic Control (ATC) Tower. Details of the runways are presented below[11]:

- 08/26 measuring 600 x 15m (grass).

4.1.2 Aviation Receptors

Rosemarket Airfield is a GA airfield 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 a 5-degree splayed approach path based on the extended runway centreline, and the final sections of the visual circuits and joins on approach to the corresponding runway thresholds.

The assessed receptors are based 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 aerodrome threshold altitude.

Figure 3 on the following page illustrates the splayed approach and final sections of the visual circuits.

[11] Aerial imagery

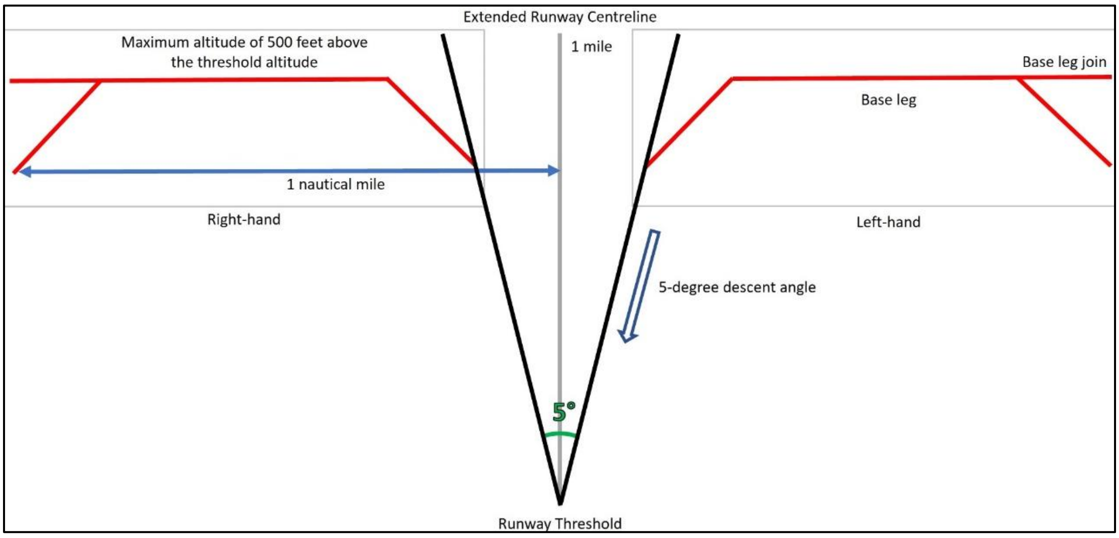

Figure 3 *Splayed approach and final sections of visual circuits*

Figure 4 below illustrates the assessed splayed approach and final sections of the visual circuits for Rosemarket Airfield.

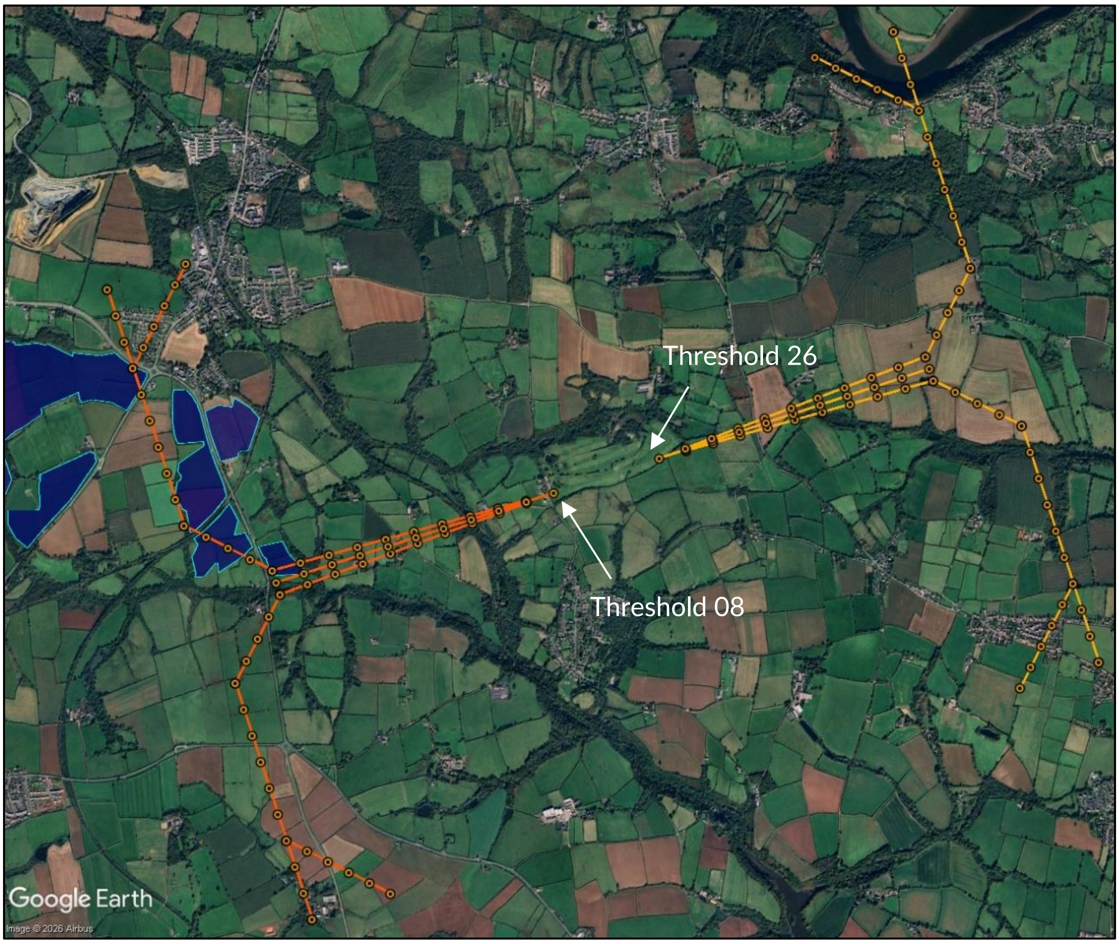

Figure 4 *Rosemarket Airfield aviation receptors*

4.2 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.

A 1km assessment area is considered appropriate for glint and glare effects on ground-based receptors, and a 500m assessment area appropriate for railway receptors – bounded by the yellow and orange outlined areas respectively in Figure 5 below. Receptors within this distance are identified based on mapping and aerial photography of the region. Receptors to the north of the development are not included because solar reflections would not be geometrically possible towards the north when the azimuth angle is considered[12].

The receptor details are presented in Appendix G and the terrain elevations have been interpolated based on OS Terrain 50 DTM[13] data.

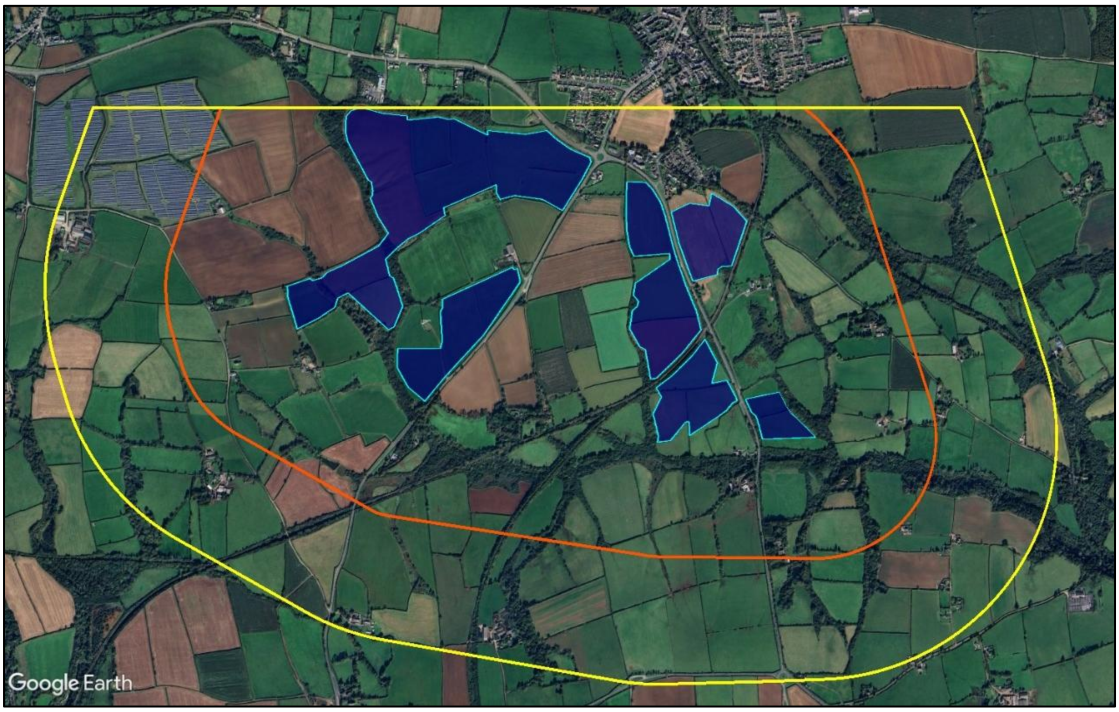

Figure 5 *1km and 500m assessment area*

[12] For fixed, south-facing panels at this latitude, reflections towards ground-based receptors located further north than any proposed panel are highly unlikely
[13] Digital Terrain Model

4.3 Road Receptors

4.3.1 Road Receptors Overview

Road types can generally be categorised as:

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

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

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

4.3.2 Identified Road Receptors

The assessed receptors placed circa 100m along 2.5km of the A4076 [A1 – A26], 300m of the Bulford Road Bypass [B1 – B4] and 2.9km of the A477 [C1 – C30] are shown in Figure 6 on the following page. A height of 1.5 metres above ground level has been taken as the typical eye level of a road user[14].

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

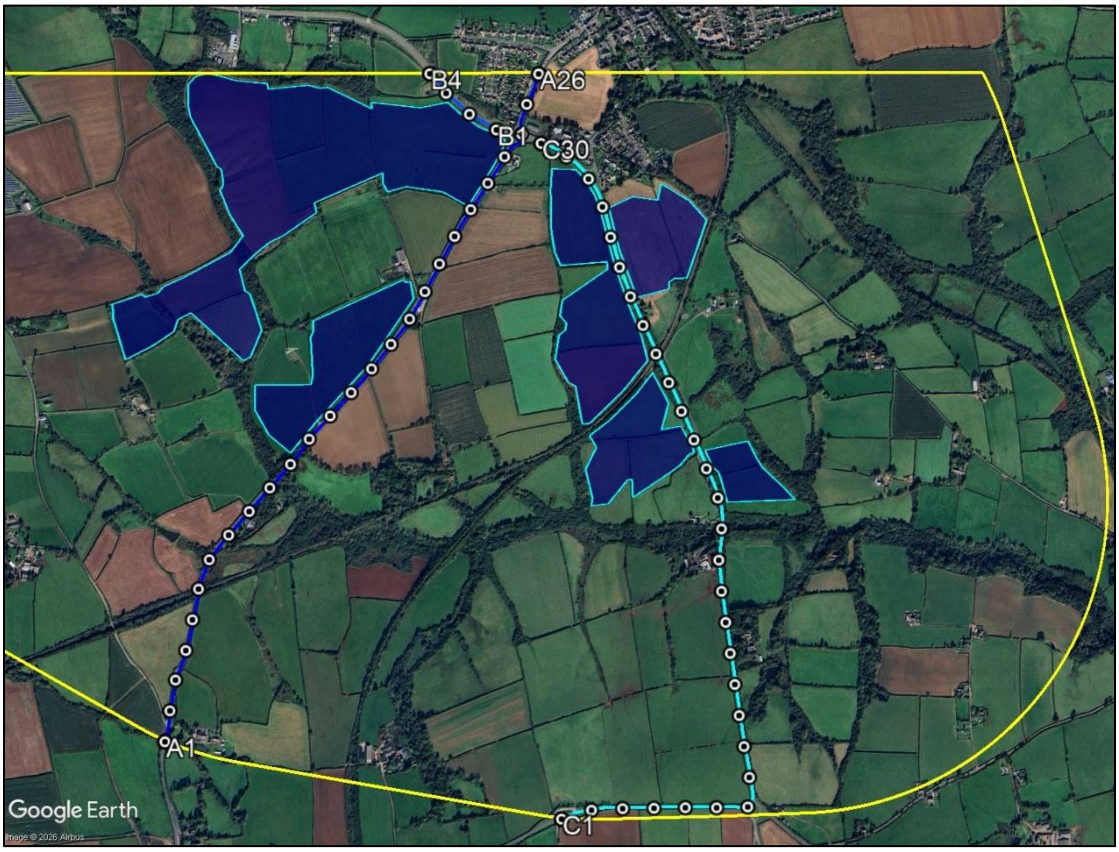

Figure 6 *Assessed road receptors*

4.4 Dwelling Receptors

4.4.1 Dwelling Receptors Overview

The analysis has considered dwellings that:

- Are situated within the 1km 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.

4.4.2 Identified Dwelling Receptors

The assessed dwelling receptors are shown in Figure 7 below. In total, 51 dwellings have been assessed. An additional 1.8m height above ground is used in the modelling to simulate the typical viewing height of an observer on the ground floor[15].

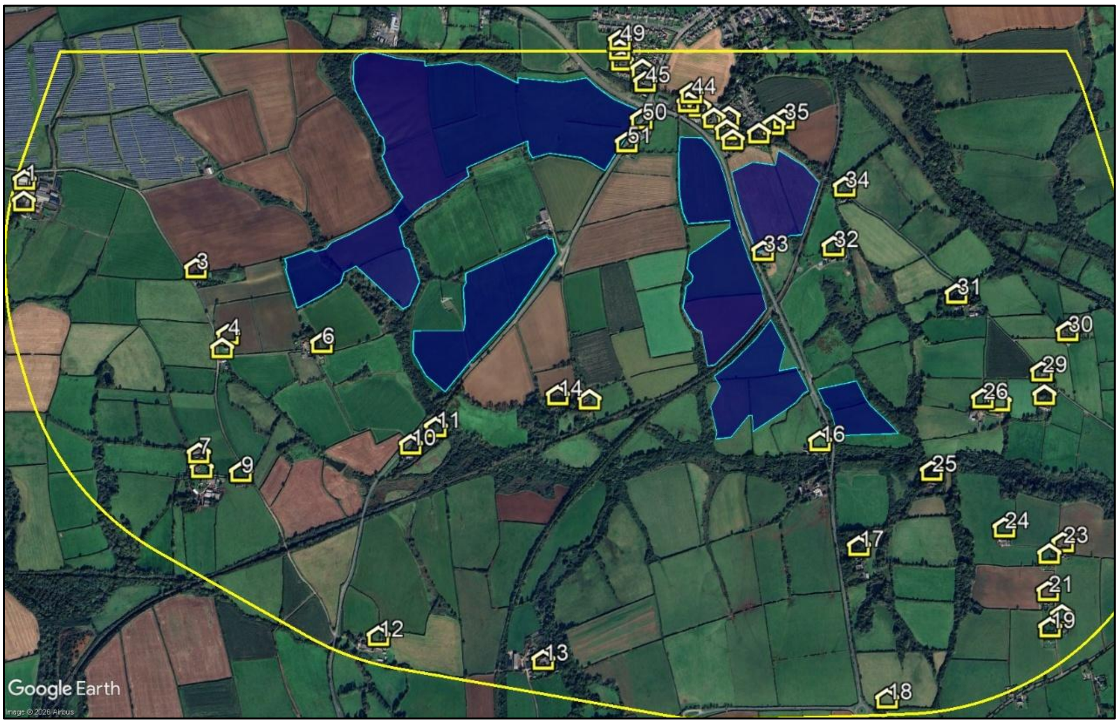

Figure 7 *Overview of all dwellings receptors*

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

4.5 Railway Operations and Infrastructure Overview

Railway receptors within close proximity (typically within 100m to 200m) to a solar development are often required for assessment. When required, a 500m assessment area (outlined white in the following figures) is considered appropriate and has been designed accordingly.

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.

4.5.1 Railway Signal Overview

The analysis has considered railway signals that are within the 500m assessment area and have a potential view of the reflecting panels.

The heights[16] above ground level (agl) for a signal are[17]:

- Gantry signals – 5.10m;
- Trackside signals – 3.35m.

4.5.2 Identified Railway Signals

Table 1 below summarises the identified signals and orientations.

Signals	Type	Orientation
CR 25	Trackside	Northeast
CR 28	Trackside	West

Table 1 *Identified signals*

The signal receptors, relative to the proposed development, are shown in Figure 7 on the following pages.

[16] Consultation undertaken with Network Rail in the UK.

[17] This fixed height for the railway signals is for modelling purposes. Small changes to the modelled signal height, within a few metres, is not expected to significantly change the modelling results. The coordinate location of a signal relative to the reflector area is a significant factor.

Figure 8 *Railway signal receptors*

Figures 8 and 9 below and on the following page show imagery of a driver's point-of-view towards the signals.

Figure 9 *AIVR imagery showing CR 25*

Figure 10 *AIVR imagery showing CR 28*

4.6 Train Driver Receptors

4.6.1 Train Driver Receptors Overview

The analysis has considered train driver receptors that:

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

4.6.2 Identified Railway Receptors

A 2.6km section of railway operates within the assessment area. In total, 27 receptors have been placed circa 100m along the railway line, as shown in Figure 10 on the following page.

Based on the previous consultation[18], an additional 2.75m height above ground is used in the modelling as the typical viewing height of a train operator[19].

[18] Consultation undertaken with Network Rail in the UK.
[19] This height may vary based on driver height however this figure is used as the industry standard.

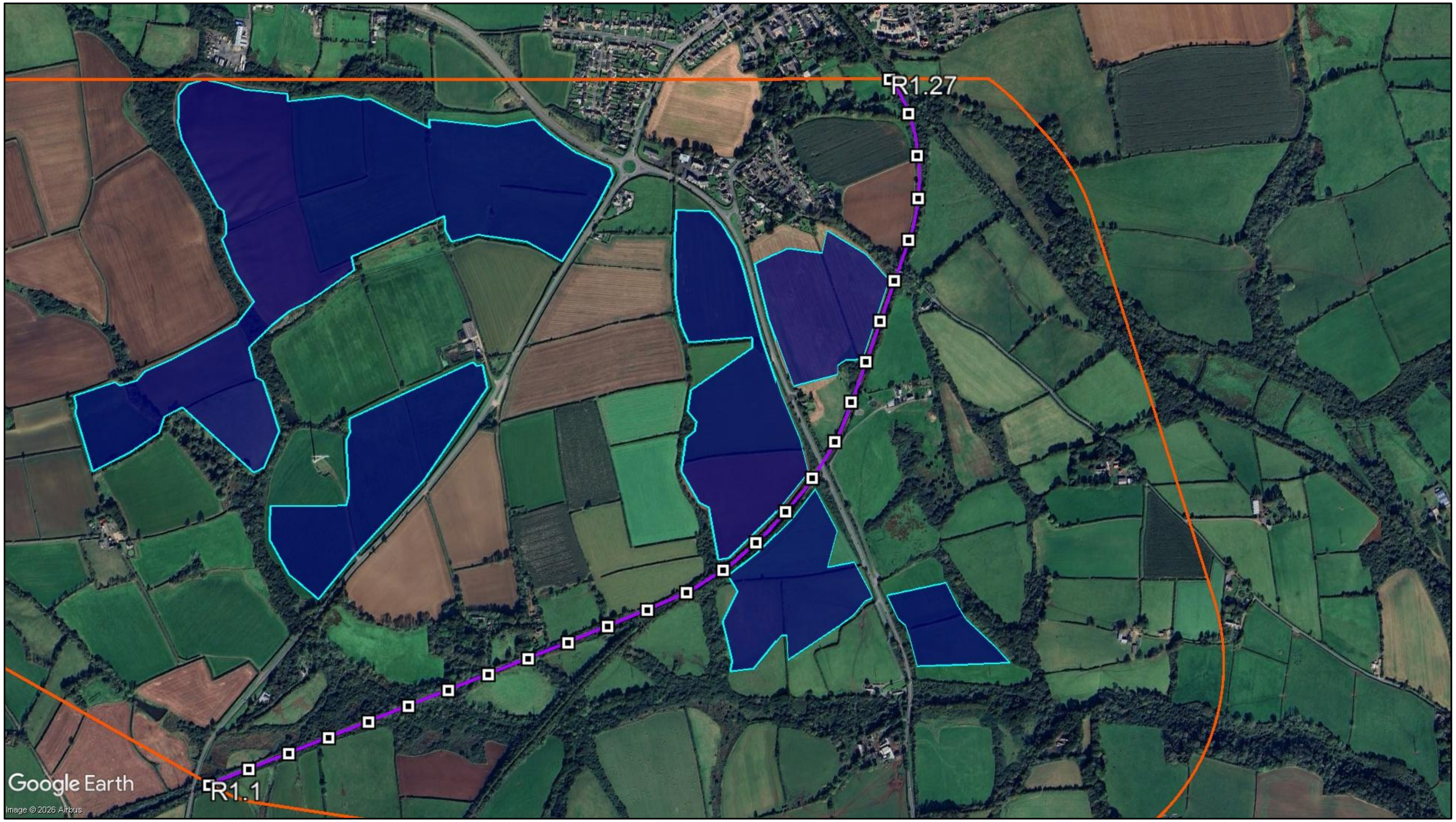

Figure 11 *Train driver receptors within the assessment area*

5 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

5.1 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 H, presents the precise predicted times and the reflecting panel areas;
- Whether a reflection will be experienced in practice. When determining the visibility of the reflecting panels for an observer, a conservative review of the available imagery, landscape strategy plan, google earth viewshed (high-level terrain analysis), and/or site photography (if available) is undertaken, whereby it is assumed views of the panels are possible if it cannot be reliably determined that existing and/or proposed screening will remove effects. Detailed screening analysis may be undertaken to determine visibility, where appropriate;
- The impact significance and any mitigation recommendations/requirements.;
- The desk-based review of the available imagery, where appropriate.

5.2 Aviation Receptors

5.2.1 Glare Intensity Categorisation

The Pager Power and Forge models have been used to determine whether reflections are possible for aviation receptors. Intensity calculations (Forge Model) in line with the Sandia National Laboratories methodology have been undertaken. These calculations are routinely required for solar photovoltaic developments on or near aerodromes. The intensity model calculates the expected intensity of a reflection with respect to the potential for an after-image (or worse) occurring. The designation used by the model is presented in Table 2 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 2 *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 H presents the results charts showing specific times and dates.

5.2.2 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 approach paths, along with any feedback or comments regarding the proposed development.

5.2.3 Assessment Results

Table 3 on the following pages present the geometric modelling results for receptors associated with Rosemarket Airfield.

[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.

Receptor	Geometric Modelling Result	Glare Intensity	Predicted Impact
Splayed Approach Runway 08	Solar reflections are geometrically possible	'Glare beyond 50°'	Considering the associated guidance (Appendix D) and industry best practice pertaining to 2-mile approach paths, which states that this level of glare intensity is acceptable, it can be concluded that this level of glare is also acceptable for these receptors Low impact
Splayed Approach Runway 26	Solar reflections are geometrically possible	'Green'	Considering the associated guidance (Appendix D) and industry best practice pertaining to 2-mile approach paths, which states that this level of glare intensity is acceptable, it can be concluded that this level of glare is also acceptable for these receptors Low impact
Final Sections of Visual Circuits Runway 08	Solar reflections are geometrically possible	'Yellow'	Low impact Discussed further in Section 5.2.6
Final Sections of Visual Circuits Runway 26	Solar reflections are geometrically possible	'Green'	Considering the associated guidance (Appendix D) and industry best practice pertaining to 2-mile approach paths, which states that this level of glare intensity is acceptable, it can be concluded that this level of glare is also acceptable for these receptors Low impact

Table 3 *Geometric modelling results – Rosemarket Airfield*

5.2.4 Further Considerations and Conclusions – Yellow Glare

When considering 'yellow' glare towards Rosemarket Airfield, the following can be concluded:

- All instances of 'yellow' glare occur in the late hours of the available daylight, and will therefore coincide with direct sunlight, a much more significant source of glare;
- Glare predicted for a maximum of 3838 minutes per year. This represents approximately 1.46% of time compared to average daylight hours[22] in any one year;
- Instances of 'yellow' glare are only predicted towards the visual circuit, which is considered a less critical stage of flight compared to the final approach;
- At any given point on the final sections of the visual circuits for runway approach 08, the solar development will mostly be directly underneath a pilot, making visibility of the reflecting panels less likely;
- The volume of air traffic at Rosemarket Airfield is expected to be low;
- The weather would have to be clear and sunny at the specific times when glare is possible. A pilot would also have to be on approach at these times.

Overall, it is judged that 'yellow' glare along the final sections of the visual circuits for runway 08 at Rosemarket Airfield can be operationally accommodated. Considering the points made above, there are mitigating factors that reduce the overall impact. In particular, the low duration of solar reflections.

[22] Assuming an average of 12 hours of daylight per day (262,800 minutes per year).

5.3 Road Results

5.3.1 Key Considerations

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

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

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

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

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

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

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

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

5.3.2 Geometric Modelling Results Overview

The results of the modelling indicate that solar reflections are geometrically possible towards a 1.8km section of the A4076, 300m section of the Bulford Road Bypass, and a 1.5km section of the A477.

Table 4 on the following pages presents the following:

- Geometric modelling results (without consideration of screening);
- Desk-based review of identified screening (presented in more detail in Appendix I);
- Consideration of any mitigating factors (where appropriate);
- Predicted impact significance.

The screening review is presented in Appendix I.

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)	Mitigating Factors	Predicted Impact Classification
A1 – A7	Solar reflections are **not geometrically possible**	N/A	N/A	N/A	No impact
A8 – A13	Solar reflections are **geometrically possible.** Solar reflections occur **inside** a road user's primary FOV (50 degrees either side of direction of travel)	Existing vegetation Predicted to significantly obstruct views of reflecting panels such that views are not predicted in practice	N/A	N/A	No impact
A14 – A17	Solar reflections are **geometrically possible.** Solar reflections occur **inside** a road user's primary FOV (50 degrees either side of direction of travel)	Existing vegetation Predicted to partially obstruct views of reflecting panels	Remaining visible solar reflections will occur **outside** a road user's primary FOV	Reflections will coincide with direct sunlight Remaining visible reflections will be partially screened by existing vegetation	Low impact

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)	Mitigating Factors	Predicted Impact Classification
A18 – A21	Solar reflections are **geometrically possible.** Solar reflections occur **inside** a road user's primary FOV (50 degrees either side of direction of travel)	Existing vegetation Predicted to significantly obstruct views of reflecting panels such that views are not predicted in practice	N/A	N/A	No impact
A22 – A23	Solar reflections are **geometrically possible.** Solar reflections occur **inside** a road user's primary FOV (50 degrees either side of direction of travel)	Existing vegetation Predicted to partially obstruct views of reflecting panels	Remaining visible solar reflections will occur **outside** a road user's primary FOV	Reflections will coincide with direct sunlight Remaining visible reflections will be partially screened by existing vegetation	Low impact

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)	Mitigating Factors	Predicted Impact Classification
A24 – A26	Solar reflections are **geometrically possible.** Solar reflections occur **outside** a road user's primary FOV (50 degrees either side of direction of travel)	Existing vegetation Predicted to significantly obstruct views of reflecting panels such that views are not predicted in practice	N/A	N/A	No impact
B1	Solar reflections are **geometrically possible.** Solar reflections occur **inside** a road user's primary FOV (50 degrees either side of direction of travel)	Existing vegetation Predicted to partially obstruct views of reflecting panels	Yes	Reflections will coincide with direct sunlight	**Moderate Impact** Mitigation recommended (see Section 5.5.1)

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)	Mitigating Factors	Predicted Impact Classification
B2 – B4	Solar reflections are **geometrically possible.** Solar reflections occur **inside** a road user's primary FOV (50 degrees either side of direction of travel)	Existing vegetation Predicted to significantly obstruct views of reflecting panels such that views are not predicted in practice	N/A	N/A	No impact
C1 – C14	Solar reflections are **not geometrically possible**	N/A	N/A	N/A	No impact
C15 – C19	Solar reflections are **geometrically possible.** Solar reflections occur **inside** a road user's primary FOV (50 degrees either side of direction of travel)	Existing vegetation Predicted to significantly obstruct views of reflecting panels such that views are not predicted in practice	N/A	N/A	No impact

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)	Mitigating Factors	Predicted Impact Classification
C20	Solar reflections are **geometrically possible.** Solar reflections occur **inside** a road user's primary FOV (50 degrees either side of direction of travel)	Existing vegetation Predicted to partially obstruct views of reflecting panels	Yes	Reflections will coincide with direct sunlight	**Moderate Impact** Mitigation recommended (see Section 5.5.1)
C21 – C23	Solar reflections are **geometrically possible.** Solar reflections occur **inside** a road user's primary FOV (50 degrees either side of direction of travel)	Existing vegetation Predicted to partially obstruct views of reflecting panels such that only fleeting views are predicted in practice	Yes	Reflections will coincide with direct sunlight	Low impact

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)	Mitigating Factors	Predicted Impact Classification
C24 – C27	Solar reflections are **geometrically possible.** Solar reflections occur **inside** a road user's primary FOV (50 degrees either side of direction of travel)	Existing vegetation Predicted to partially obstruct views of reflecting panels	Remaining visible solar reflections will occur **outside** a road user's primary FOV	Reflections will coincide with direct sunlight Remaining visible reflections will be partially screened by existing vegetation	Low impact
C28 – C30	Solar reflections are **geometrically possible.** Solar reflections occur **inside** a road user's primary FOV (50 degrees either side of direction of travel)	Existing vegetation Predicted to significantly obstruct views of reflecting panels such that views are not predicted in practice	N/A	N/A	No impact

Table 4 *Geometric modelling results – road receptors*

5.4 Dwelling Results

5.4.1 Key Considerations

The key considerations for quantifying the impact significance for dwelling receptors are:

- Whether a reflection is predicted to be experienced in practice;
- The duration of the predicted effects, relative to thresholds of:
  - 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 three months per year and for **more** than 60 minutes on any given day, and there are no mitigating factors, the impact significance is high, and mitigation is required.

5.4.2 Geometric Modelling Results and Discussion

Table 5 on the following pages presents the geometric modelling results and predicted impact significance for the assessed dwelling receptors. The screening review is presented in Appendix I.

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 - 11	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not predicted** in practice	None	N/A	No impact
12 - 13	Solar reflections are **not geometrically possible**	N/A	N/A	N/A	No impact
14 - 16	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not predicted** in practice	None	N/A	No impact
17 - 21	Solar reflections are **not geometrically possible**	N/A	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
22 – 34	Solar reflections <u>are</u> <u>geometrically possible</u> for: More than three months Less than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are <u>not predicted</u> in practice	None	N/A	No impact
35	Solar reflections are <u>not</u> <u>geometrically possible</u>	N/A	N/A	N/A	No impact
36 – 43	Solar reflections <u>are</u> <u>geometrically possible</u> for: More than three months Less than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are <u>not predicted</u> in practice	None	N/A	No impact
44 – 47	Solar reflections <u>are</u> <u>geometrically possible</u> for: Less than three months Less than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are <u>not predicted</u> in practice	None	N/A	No impact
48 – 49	Solar reflections are <u>not</u> <u>geometrically possible</u>	N/A	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
50 - 51	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not predicted** in practice	None	N/A	No impact

Table 5 *Geometric modelling results - dwelling receptors*

5.5 Mitigation Strategy

5.5.1 Road Mitigation

A moderate impact has been predicted upon a 100m section of the A477 and a 100m section of Bulford Road Bypass.

The locations identified for proposed screening is shown as the pink line in Figures 12 and 13 on the following pages. This screening could be in the form of planting or a fence and should be of a height such that views of the reflecting panels are obscured from the view of the affected sections of road for a typical road user. Existing significant vegetation screening is shown in green where relevant.

If vegetation is used, it should be ensured that the screening significantly obstructs the reflecting panels during the periods when solar reflections are geometrically possible.

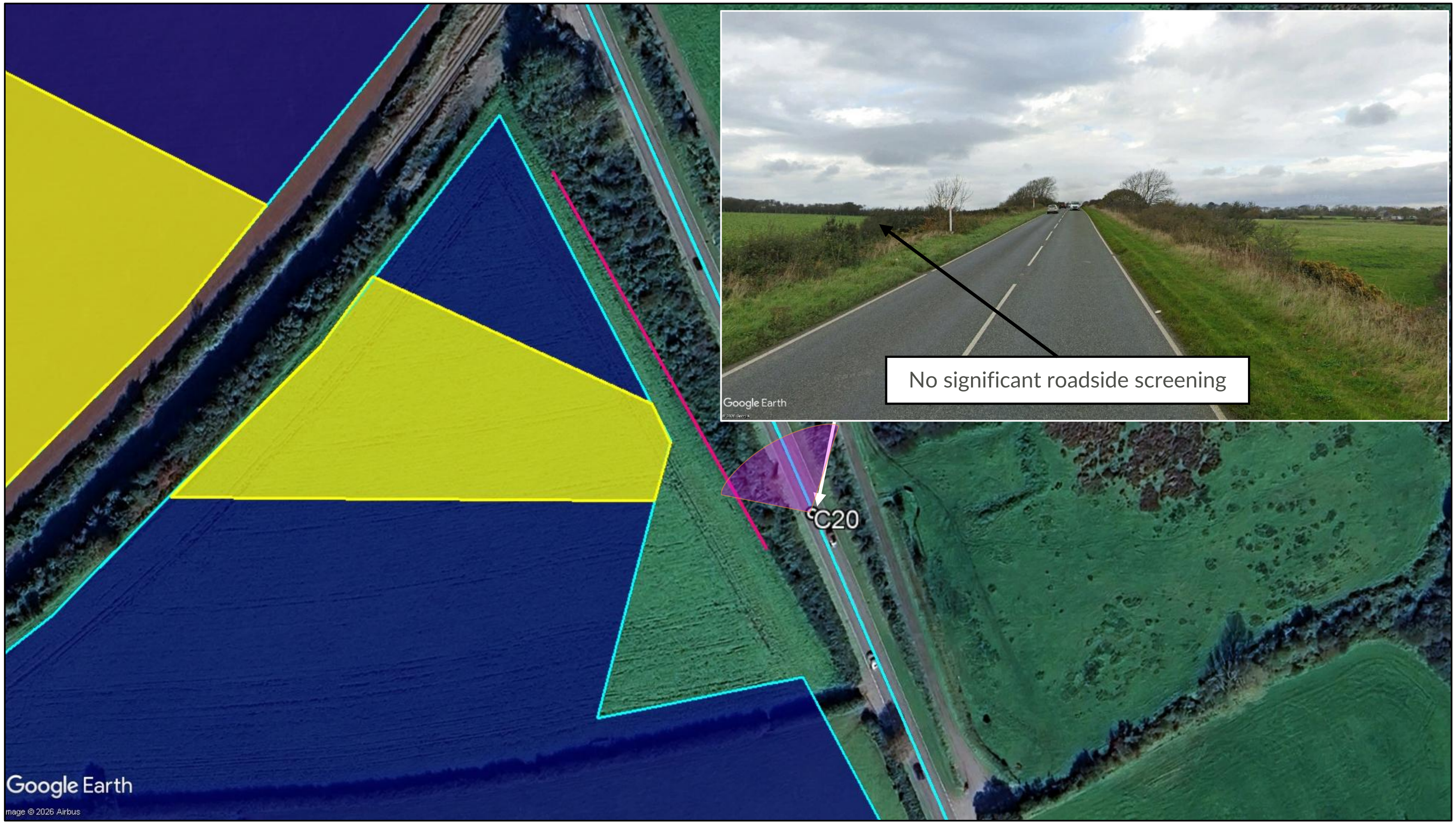

Figure 12 *Reflective panel area and proposed screening for road receptor C20*

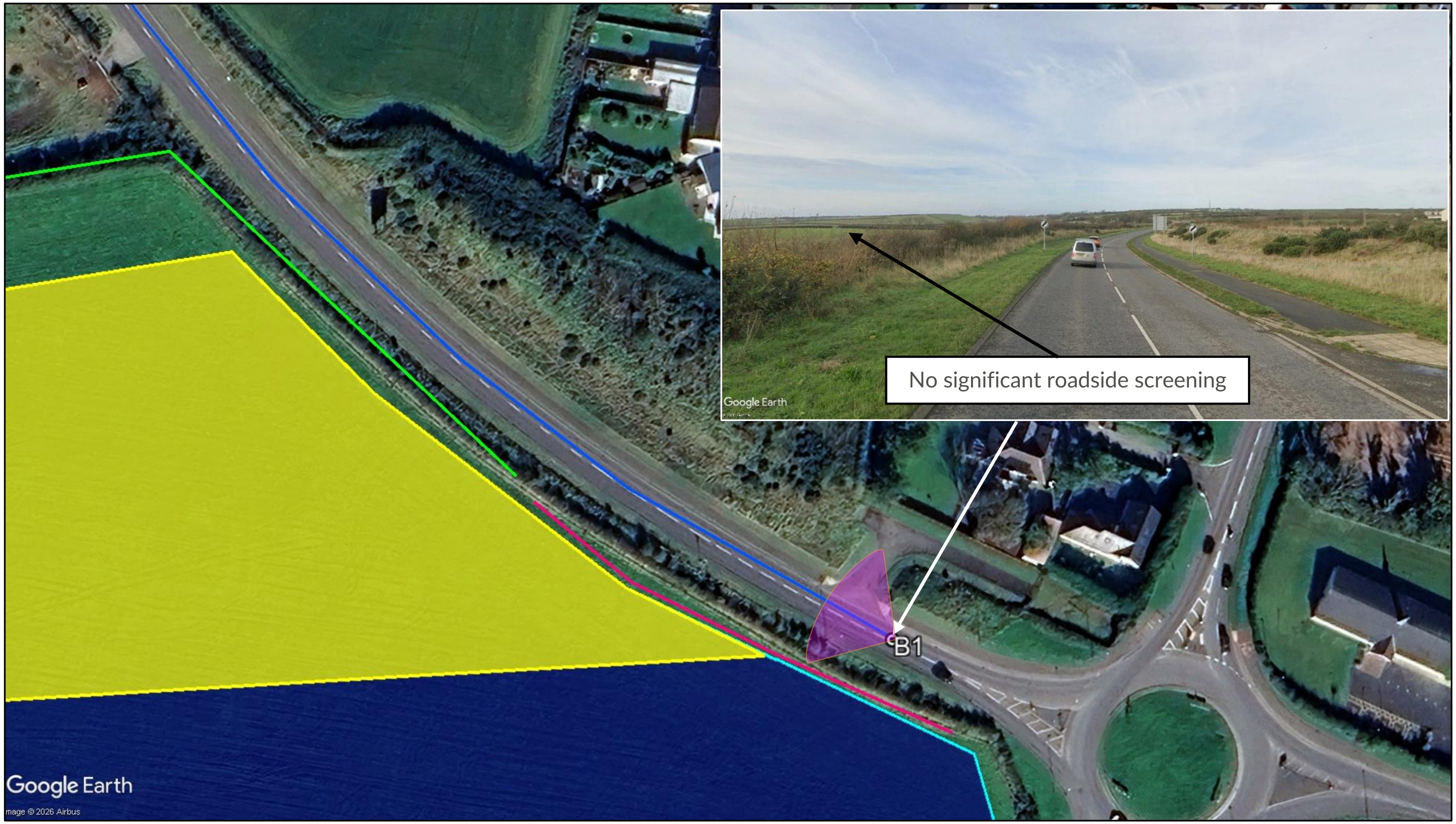

Figure 13 *Reflective panel area and proposed screening for road receptor B1*

5.6 Train Driver Results

5.6.1 Key Considerations

The process for quantifying the impact significance concerning railway safety is outlined in Appendix D. 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 main 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 main field of view, expert assessment of the following relevant 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 relevant factors, where the solar reflection is not deemed significant, a low impact is predicted, and mitigation is not recommended. Where the solar reflection is deemed significant, the impact significance is moderate, and mitigation is recommended.

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

5.6.2 Geometric Modelling Results Overview

The modelling indicates that solar reflections are geometrically possible towards train drivers along approximately 2.6km of railway line.

Table 6 on the following page presents the following:

- Geometric modelling results (without consideration of screening);
- Desk-based review of identified screening (presented in more detail in the following sub-section);
- Consideration of relevant mitigating factors (where appropriate);
- Predicted impact significance.

The screening review is presented in Appendix I.

Railway Receptors	Geometric Modelling Results (without consideration of screening)	Identified Screening (desk-based review)	Mitigating Factors	Predicted Impact Classification
R1.1 – R1.16	Solar reflections predicted from **inside** a train driver's main horizontal field of view	Existing vegetation Predicted to significantly obstruct views of reflecting areas	N/A	No impact
R1.17 – R1.27	Solar reflections predicted from **outside** a train driver's main horizontal field of view	Existing vegetation Predicted to significantly obstruct views of reflecting areas	N/A	No impact

Table 6 *Geometric modelling results and assessment of impact significance - railway receptors*

5.7 Railway Signal Receptors

5.7.1 Geometric Calculation Results

The results of the geometric calculations for the signal receptors are presented in Table 7 on the following page.

Signal Receptor	Geometric Modelling Results	Relevant Factors	Identified Screening (desk-based review of imagery)	Impact Classification
CR 25	Solar reflections are geometrically possible	Existing vegetation Predicted to significantly obstruct reflections	None	No impact
CR 28	Solar reflections are geometrically possible Solar reflections occur behind the signal	Existing vegetation Predicted to significantly obstruct reflections	None	No impact

Table 7 *Geometric modelling results - Train signal receptors*

6 HIGH-LEVEL AVIATION CONSIDERATIONS

6.1 Overview

Glint and glare assessment for aviation receptors are typically undertaken for licensed aerodromes within 10km of a proposed solar development. Geometric modelling for GA aerodromes is typically required within 5km of a proposed development. At ranges of 10-20km, the requirement for assessment is much less common particularly for unlicensed aerodromes. Assessment of any aviation effects for developments over 20km is not a usual requirement.

The following section presents an overview of the possible effects of glint and glare concerning aviation activity at Haverfordwest Airport, located approximately 8.9km north of the proposed development.

6.2 Aerodrome Details

6.2.1 Haverfordwest Airport

Haverfordwest Airport is a licensed aerodrome, and it is understood to have an Air Traffic Control (ATC) Tower. The aerodrome has two runways, 03/21 and 09/27. The location of the aerodrome relative to the proposed development and 2-mile approach paths are shown in Figure 14 on the following page.

6.3 High-Level Assessment Conclusions

The proposed development size, distance between the aerodrome and proposed development, geometric results Rosemarket Airfield, assessed in this report, and industry experience are considered during the assessment.

When considering Haverfordwest Airport, the following can be concluded;

- Any solar reflections towards the ATC Tower will be significantly screened by existing vegetation, buildings and intervening terrain such the views of the reflecting panels are not predicted;
- Glare intensities towards pilots on approach towards thresholds in the direction of the proposed development and on the visual circuits are predicted to be no greater than 'low potential for temporary after-image'. This level of glare is acceptable in accordance with the associated guidance and industry best practice;
- Any possible solar reflections will be outside the pilot's primary field-of-view (50 degrees either side of the direction of travel) for pilots approaching runway thresholds directed away from the proposed development. This level of glare is acceptable in accordance with the associated guidance and industry best practice.

No significant impact is predicted upon Haverfordwest Airport. Detailed modelling is not recommended, and mitigation is not required.

Figure 14 *Location of Haverfordwest Airport relative to the proposed development*

7 HIGH-LEVEL ASSESSMENT OF CUMULATIVE EFFECTS

7.1 Overview

This section presents analysis of cumulative effects of solar reflections, from the existing solar development in the surrounding area in respect to shared receptors between the proposed development and the existing development.

The cumulative assessment considers the solar farm located west of the proposed development. Figure 15 below shows the existing development (bounded in white) relative to the proposed development.

Figure 15 *Existing development relative to proposed development*

7.2 Assessment

Shared receptors considering the proposed development and the existing development are as follows:

- Dwelling Receptors 1 to 6.

Dwelling receptors 1 to 6 are predicted to experience no impact from the proposed development due to the presence of significant screening obstructing views of reflecting panels. Therefore, no cumulative impacts are predicted.

8 OVERALL CONCLUSIONS

8.1 Assessment Conclusions – Aviation Activity

8.1.1 Rosemarket Airfield

Solar reflections with intensities of 'potential for temporary after-image' ('yellow' glare) are predicted towards the splayed approach paths and visual circuits for runway threshold 08 at Rosemarket Airfield. Due to the low duration of 'yellow' glare, reflections coinciding with the sun, a much more significant source of glare, and the low volume of air traffic expected at the aerodrome, a low impact is predicted.

Solar reflections with intensities of 'low-potential for temporary after-image' ('green' glare) are geometrically possible towards the visual circuits and 1-mile splayed approach path for runway threshold 26 at Rosemarket Airfield. This intensity of glare is acceptable in accordance with the associated guidance (Appendix D) and industry best practice pertaining to 2-mile approach paths are licenced aerodromes, it can reliably be concluded it is also acceptable at this aerodrome. A low impact is predicted, and mitigation is not required.

Solar reflections towards the 1-mile splayed approach paths for runway threshold 08 occur outside a pilot's primary field-of-view (defined as 50° horizontally either side of the direction of travel). This glare intensity is not considered significant in accordance with the associated guidance (Appendix D) and industry best practice pertaining to approach paths. A low impact is predicted, and mitigation is not required.

8.2 Assessment Conclusions – Roads

Solar reflections are geometrically possible towards a 1.8km section of the A4076, 300m section of the Bulford Road Bypass, and a 1.5km section of the A477.

A moderate impact is predicted on a 100m of the A477 and 100m of Bulford Road Bypass because solar reflections are predicted to originate from **inside** of a road user's primary horizontal field of view with existing vegetation providing only partial screening. Mitigation is recommended (see Section 5.5.1 for further details).

For 400m of the A4076 and 300m of the A477, screening in the form of existing vegetation and intervening terrain is predicted to significantly obstruct views of reflecting panels such that the remaining visible reflections originate from **outside** of a road user's primary horizontal field of view. A low impact is predicted, and mitigation is not recommended.

For a 200m section of the A477, screening in the form of existing vegetation is predicted to partially obstruct views of reflecting panels such that only fleeting views of the solar reflections are predicted to be experienced by road users in practice. Visible reflections from the reflecting panels will coincide with direct sunlight. A low impact is predicted, and mitigation is not recommended.

For all remaining sections of the A4076, Bulford Road Bypass and the A477, screening in the form of existing vegetation is predicted to significantly obstruct views of reflecting panels such that solar reflections are not predicted to be experienced by road users in practice. No impact is predicted, and mitigation is not required.

8.3 Assessment Conclusions – Dwellings

Solar reflections are geometrically possible towards 41 of the 51 assessed dwellings.

For all dwellings, screening in the form of existing vegetation is predicted to significantly obstruct views of reflecting panels such that solar reflections are not predicted to be experienced by residents. No impact is predicted, and mitigation is not required.

8.4 Assessment Conclusions – Railway Signals

Solar reflections are geometrically possible towards both of the assessed railway signals.

Screening in the form of existing vegetation is predicted to significantly obstruct glare from the reflecting panels such that solar reflections will not reach the signal. No impact is predicted, and no mitigation is required.

8.5 Assessment Conclusions – Train Drivers and Signal Sighting

Solar reflections are geometrically possible towards all 2.6km of the assessed railway.

For all sections of railway, screening in the form of existing vegetation is predicted to significantly obstruct views of reflecting panels such that solar reflections are not predicted to be experienced by road users in practice. No impact is predicted, and mitigation is not required.

Reflections do not occur directly behind a signal where signal sighting is required.

8.6 High Level Aviation Assessment Conclusions

The proposed development size, distance between the aerodrome and proposed development, geometric results Rosemarket Airfield, assessed in this report, and industry experience are considered during the assessment.

When considering Haverfordwest Airport, the following can be concluded;

- Any solar reflections towards the ATC Tower will be significantly screened by existing vegetation, buildings and intervening terrain such the views of the reflecting panels are not predicted;
- Glare intensities towards pilots on approach towards thresholds in the direction of the proposed development and on the visual circuits are predicted to be no greater than 'low potential for temporary after-image'. This level of glare is acceptable in accordance with the associated guidance and industry best practice;
- Any possible solar reflections will be outside the pilot's primary field-of-view (50 degrees either side of the direction of travel) for pilots approaching runway thresholds directed away from the proposed development. This level of glare is acceptable in accordance with the associated guidance and industry best practice.

No significant impact is predicted upon Haverfordwest Airport. Detailed modelling is not recommended, and mitigation is not required.

8.7 High Level Assessment Conclusions – Cumulative Effects

For all receptors shared between the proposed and existing development, no impact is predicted from the proposed development. Therefore, no cumulative impacts are predicted and no mitigation is required.

8.8 Overall Conclusions

A moderate impact is predicted upon road safety. Mitigation is recommended (see Section 5.5).

No significant impacts are predicted upon, residential amenity, railway operations and infrastructure or aviation activity. No significant cumulative impacts are predicted. Mitigation is not required.

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[24] (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.'

[24] Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 14 August 2023, accessed on: 05/03/2024

National Policy Statement for Renewable Energy Infrastructure

The National Policy Statement for Renewable Energy Infrastructure (EN-3)[25] 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.[26] 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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[25] National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Energy Security & Net Zero, date: January 2024.

[26] *'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[27] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

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

Assessment Process – Railways

Railway operations is not mentioned specifically within this guidance however it is stated that a developer will need to consider *'the proposal's visual impact, the effect on landscape of glint and glare and on neighbouring uses…'*. In the UK, Network Rail is a statutory consultee when a development is located in close proximity to its infrastructure.

No process for determining and contextualising the effects of glint and glare are, however, provided. Therefore, the Pager Power approach is to determine whether a reflection from a development is geometrically possible and then to compare the results against the relevant guidance/studies to determine whether the reflection is significant.

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 other countries, the general principles within the guidance is expected to apply.

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 on the following pages. These relate specifically to the sighting distance for railway signals.

Reflections and Glare

The extract below and on the following page is taken from Section A5 – Reflections and glare (pages 64-65) of the 'Signal Sighting Assessment Requirements'[28] 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.

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

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.*
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 on the following pages is taken from Appendix F - Guidance on Field of Vision (pages 98-101) of the 'Signal Sighting Assessment Requirements'[29] 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.

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

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 (0^{o}) to approximately 30^{o} 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.

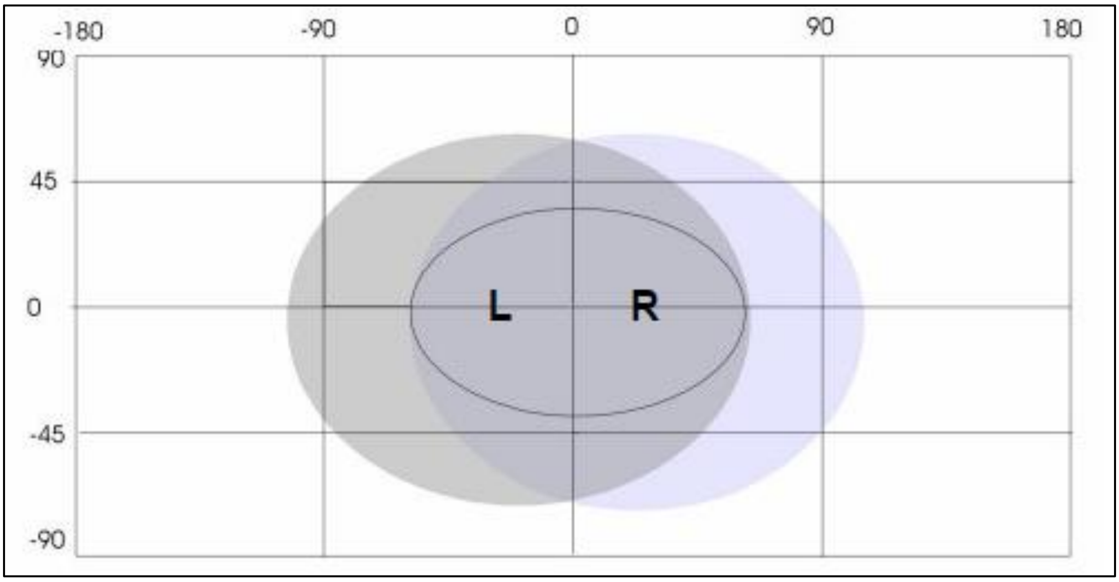

Figure G 21 - Field of view

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 + 8^{o} 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.

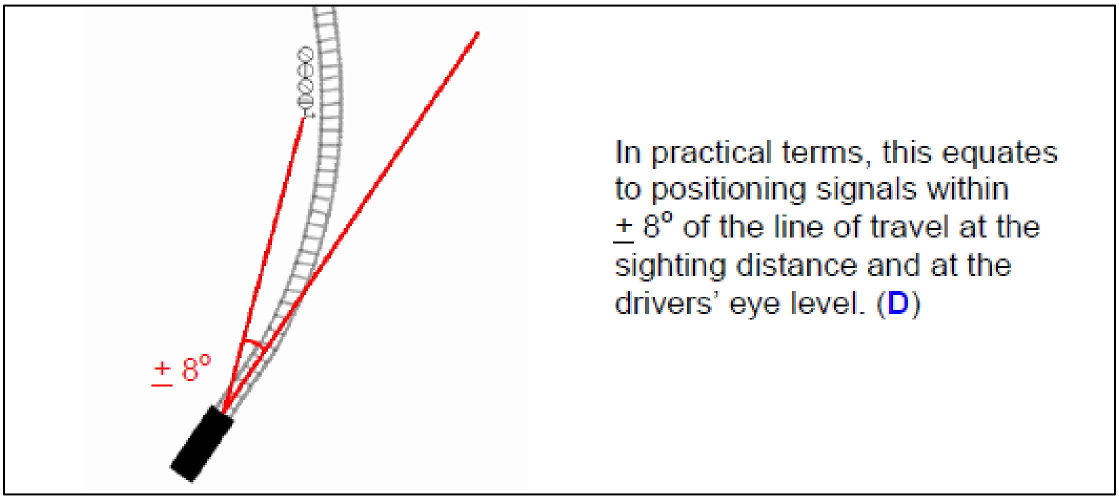

Figure G 22 - Signal positioning

'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 8° 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 8° 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 8° cone at 25.46 m in front of the driver*

Table G 5 – 8° 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 extract below is taken from section B5 (pages 8-9) of the 'Guidance on Signal Positioning and Visibility' which details the required minimum reading time for a train driver when approaching a signal.

'B5.2.2 Determining the assessed minimum reading time

GE/RT8037

The assessed minimum reading time shall be no less than eight seconds travelling time before the signal.

The assessed minimum reading time shall be greater than eight seconds where there is an increased likelihood of misread or failure to observe. Circumstances where this applies include, but are not necessarily limited to, the following:

- *a) the time taken to identify the signal is longer (for example, because the signal being viewed is one of a number of signals on a gantry, or because the signal is viewed against a complex background)*
- *b) the time taken to interpret the information presented by the signal is longer (for example, because the signal is capable of presenting route information for a complex layout ahead)*
- *c) there is a risk that the need to perform other duties could cause distraction from viewing the signal correctly (for example, the observance of lineside signs, a station stop between the caution and stop signals, or DOO (P) duties)*
- *d) the control of the train speed is influenced by other factors (for example, anticipation of the signal aspect changing).*

The assessed minimum reading time shall be determined using a structured format approved by the infrastructure controller.'

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.

Signal Design and Lighting System

Many railway signals are now LED lights and not filament (incandescent) bulbs. 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[30];

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[30] Source: Wayside LED Signals – Why it's Harder than it Looks, Bill Petit.

- No reflective mirror is present within the LED signal itself unlike a filament bulb. The presence of the reflective surfaces greatly increases the likelihood of incoming light being reflecting out making the signal appear illuminated.

Many LED signal manufacturers[31,32,33] claim that LED signal lights significantly reduce or completely remove the likelihood of a phantom aspect illumination occurring.

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[34] however the advice is still applicable[35] until a formal policy is developed. The relevant aviation guidance from the CAA is presented in the section below.

CAA Interim Guidance

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

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

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

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

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

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

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[31] Source: http://www.unipartdorman.co.uk/assets/unipart_dorman_rail_brochure.pdf. (Last accessed 21.02.18).
[32] Source: http://www.vmstech.co.uk/downloads/Rail.pdf. (Last accessed 21.02.18).
[33] Source: Siemens, Sigmaguard LED Tri-Colour L Signal – LED Signal Technology at Incandescent Prices. Datasheet 1A-23. (Last accessed 22.02.18).
[34] Archived at Pager Power
[35] Reference email from the CAA dated 19/05/2014.

responsibility of the ALH[36]*, 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.'

[36] 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'*[37], the 2013 update is entitled '*Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'*[38], and the 2021 final policy is entitled '*Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports'*[39].

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.

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[37] Archived at Pager Power

[38] 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.

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

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

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

In 2018, the FAA released the latest version (Version 1.1) of the '*Technical Guidance for Evaluating Selected Solar Technologies on Airports*'[40]. 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*[41].
- *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*[42]*, 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;*

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

[41] 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.

[42] First figure in Appendix B.

- *A geometric analysis to determine days and times when an impact is predicted.*
- *The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and system design.*
- ***1. Assessing Baseline Reflectivity Conditions** – Reflection in the form of glare is present in current aviation operations. The existing sources of glare come from glass windows, auto surface parking, rooftops, and water bodies. At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing. Operators also wear polarized eye wear. Potential glare from solar panels should be viewed in this context. Any airport considering a solar PV project should first review existing sources of glare at the airport and the effectiveness of measures used to mitigate that glare.*
- ***2. Tests in the Field** – Potential glare from solar panels can easily be viewed at the airport through a field test. A few airports have coordinated these tests with FAA Air Traffic Controllers to assess the significance of glare impacts. To conduct such a test, a sponsor can take a solar panel out to proposed location of the solar project, and tilt the panel in different directions to evaluate the potential for glare onto the air traffic control tower. For the two known cases where a field test was conducted, tower personnel determined the glare was not significant. If there is a significant glare impact, the project can be modified by ensuring panels are not directed in that direction.*
- ***3. Geometric Analysis** – Geometric studies are the most technical approach for reflectivity issues. They are conducted when glare is difficult to assess through other methods. Studies of glare can employ geometry and the known path of the sun to predict when sunlight will reflect off of a fixed surface (like a solar panel) and contact a fixed receptor (e.g., control tower). At any given site, the sun moves across the sky every day and its path in the sky changes throughout year. This in turn alters the destination of the resultant reflections since the angle of reflection for the solar panels will be the same as the angle at which the sun hits the panels. The larger the reflective surface, the greater the likelihood of glare impacts.*
- *Facilities placed in remote locations, like the desert, will be far from receptors and therefore potential impacts are limited to passing aircraft. Because the intensity of the light reflected from the solar panel decreases with increasing distance, an appropriate question is how far you need to be from a solar reflected surface to avoid flash blindness. It is known that this distance is directly proportional to the size of the array in question*[43] *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*

[43] 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.

the tower and airfield, or for installations with inadequate or no reflectivity analysis. Adequate reflectivity analysis and alternative siting addressed initial issues at those installations.

Air Navigation Order (ANO) 2016

In some instances, an aviation stakeholder can refer to the ANO 2016[44] 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

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

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

Civil Aviation Authority consolidation of UK Regulation 139/2014

The Civil Aviation Authority (CAA) published a consolidating document[45] 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. <u>the dazzling caused by large and highly reflective surfaces;</u>
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.

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

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

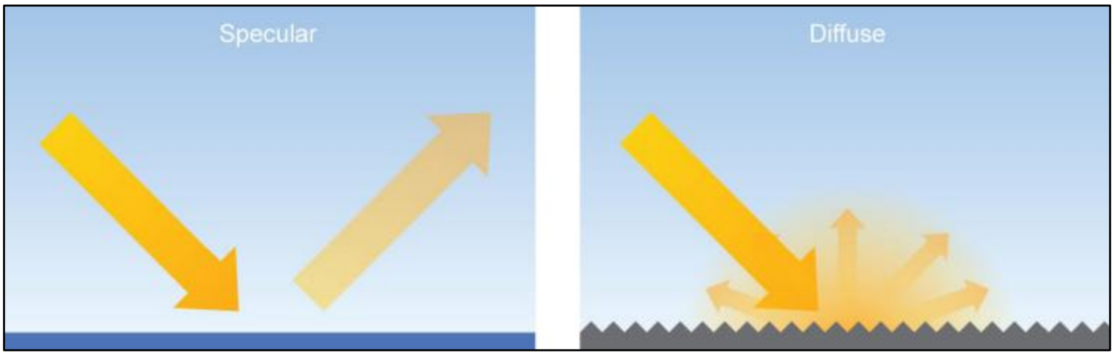
Overview

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[46], 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

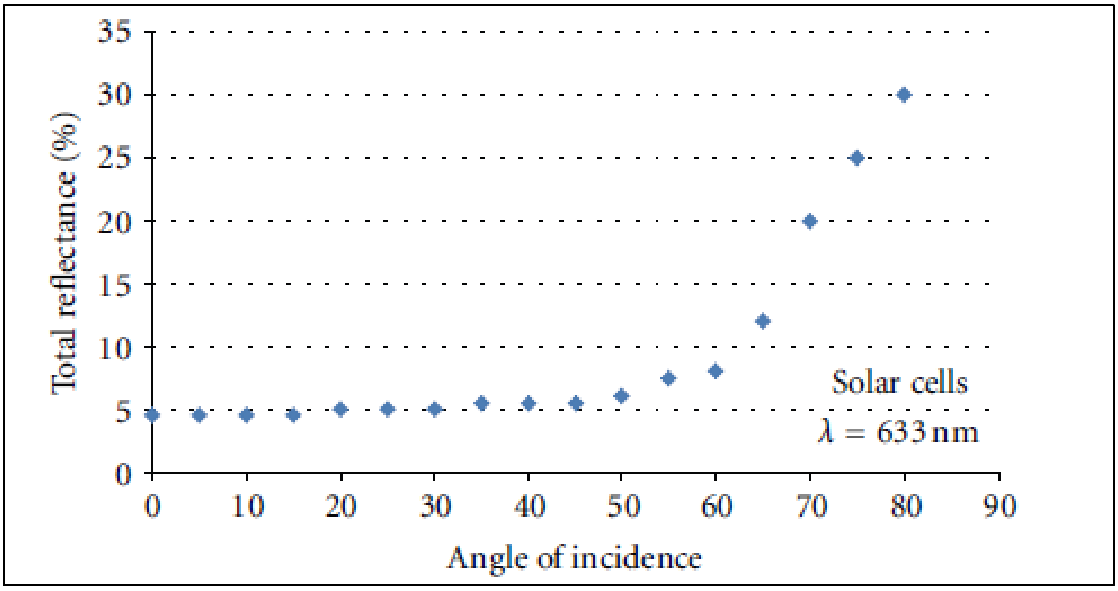
[46] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.

Solar Reflection Studies

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

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

Evan Riley and Scott Olson published in 2011 their study titled: A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems[47]". 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.

[47] 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"[48]

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[49]
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).

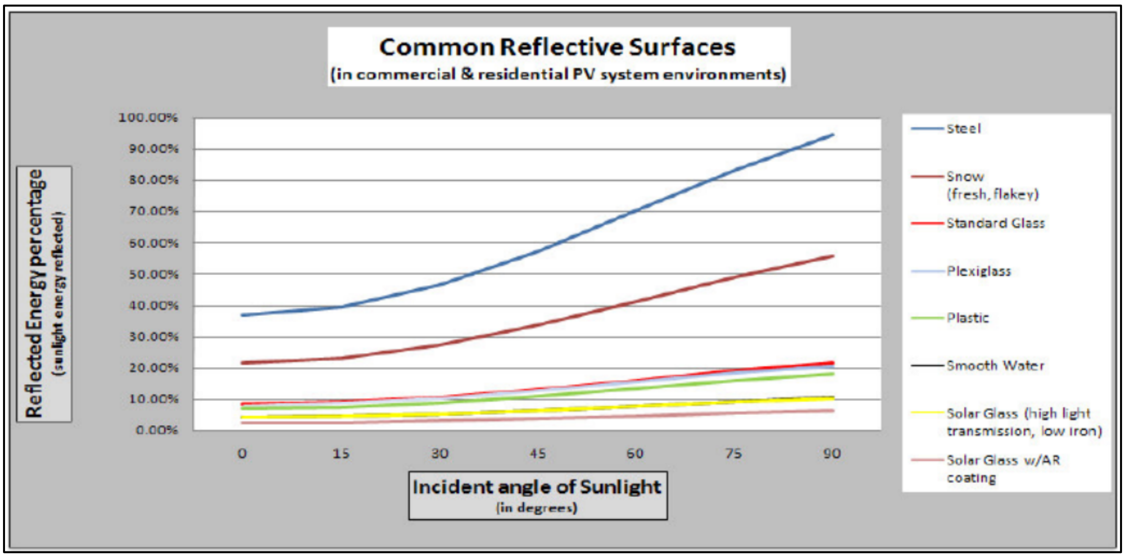
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

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

SunPower Technical Notification (2009)

SunPower published a technical notification[50] 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.

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

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

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

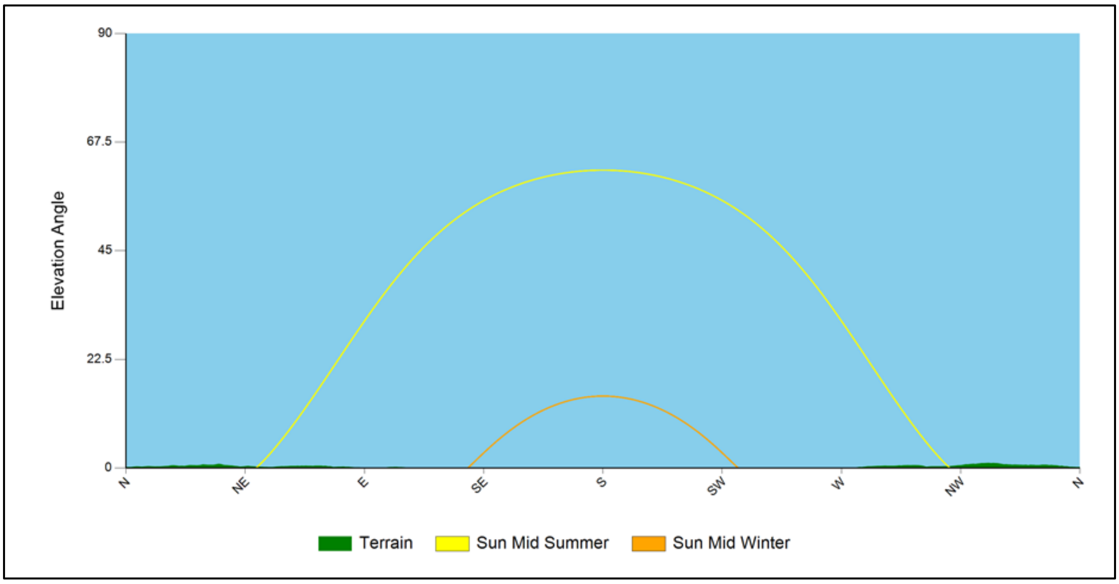
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

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

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

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

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



Sunrise and sunset curves

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact Significance Definition

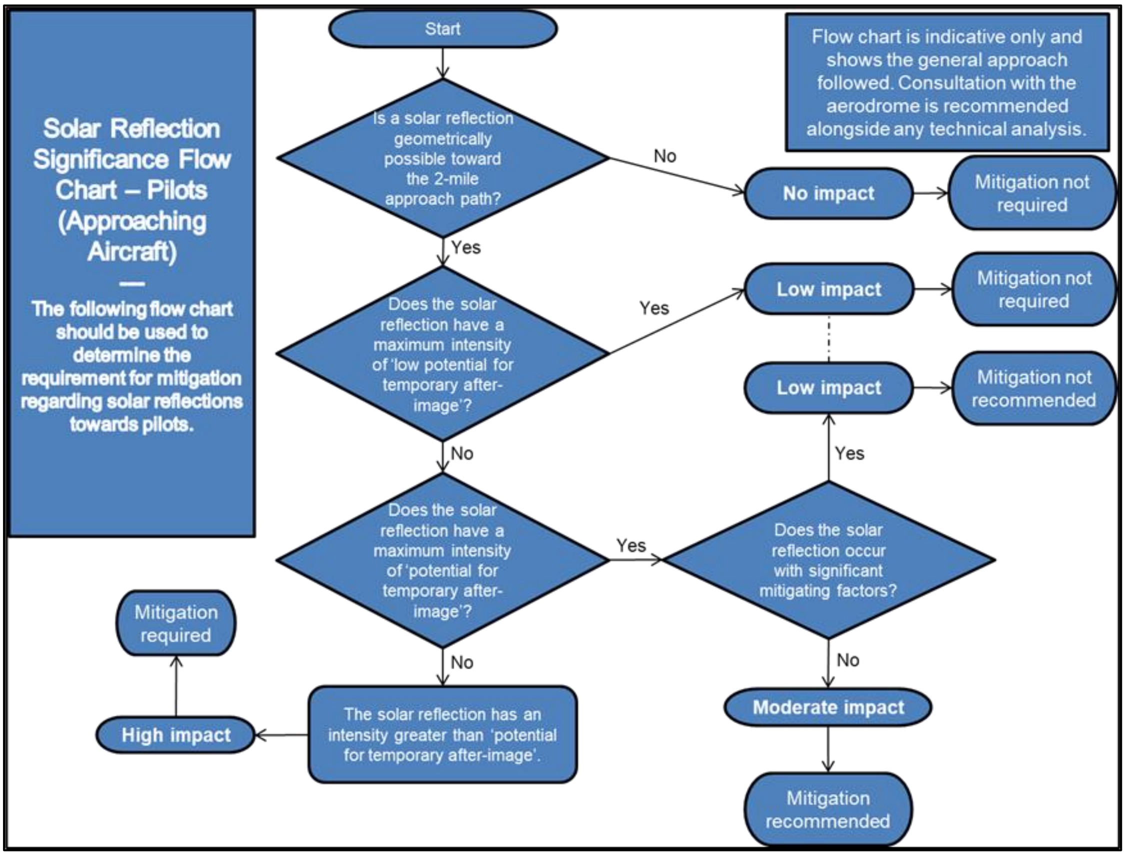
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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

Impact significance definition

Impact Significance Determination for Approaching Aircraft

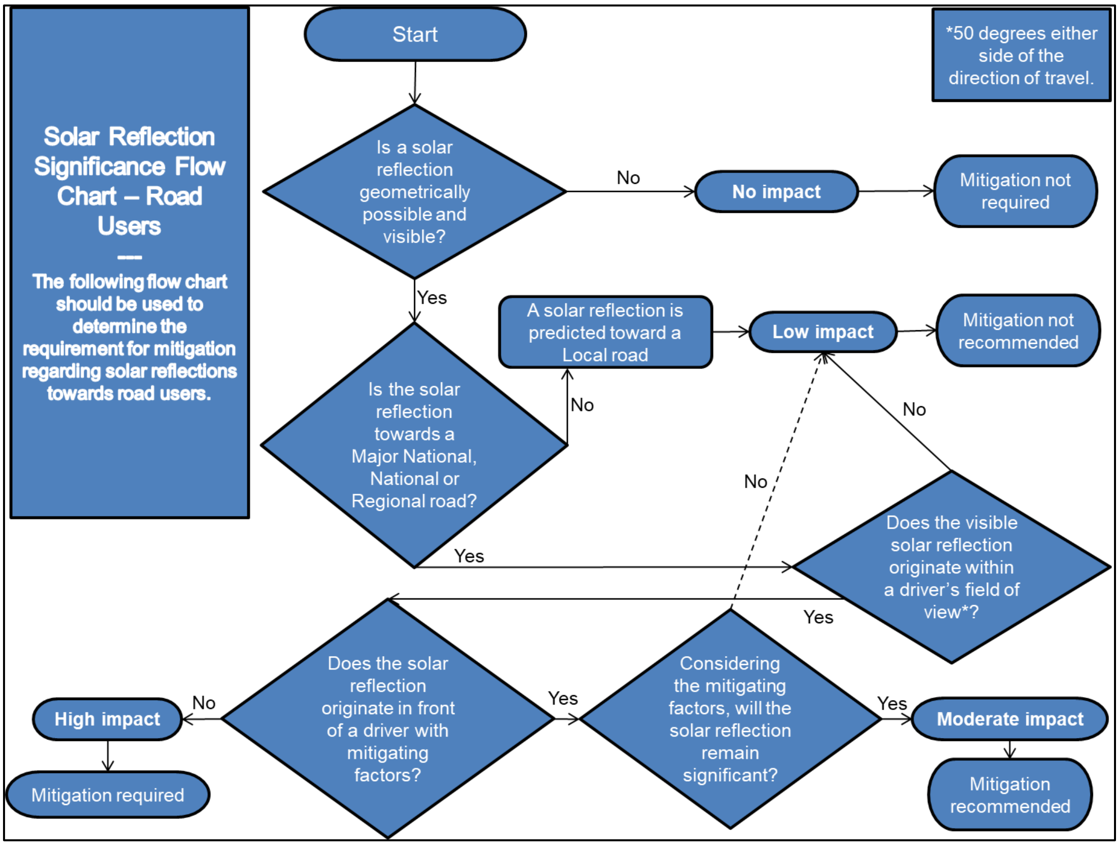
The flow chart presented below has been followed when determining the impact significance for approaching aircraft.



Approaching aircraft receptor impact significance flow chart

Impact Significance Determination for Road Receptors

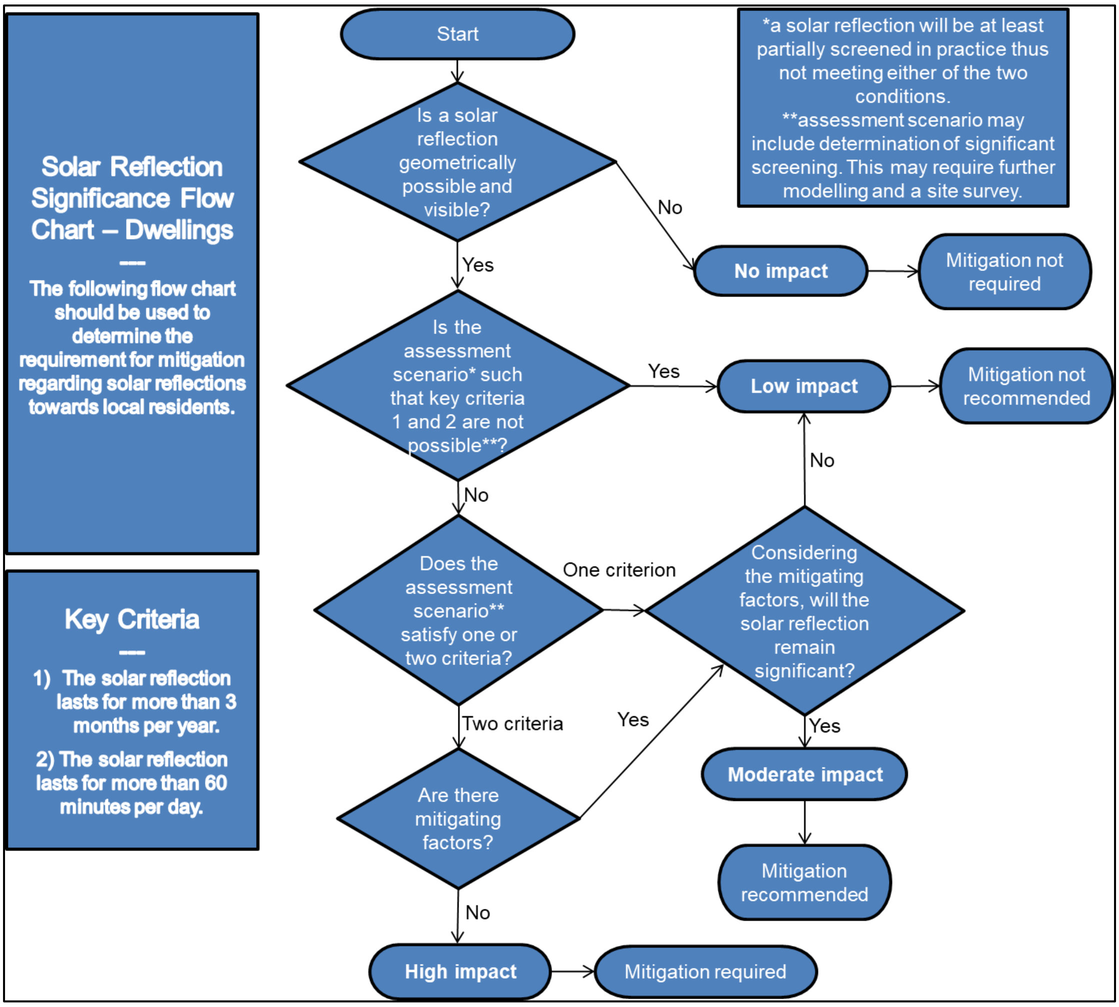
The flow chart presented below has been followed when determining the impact significance for road receptors.



Road user impact significance flow chart

Impact Significance Determination for Dwelling Receptors

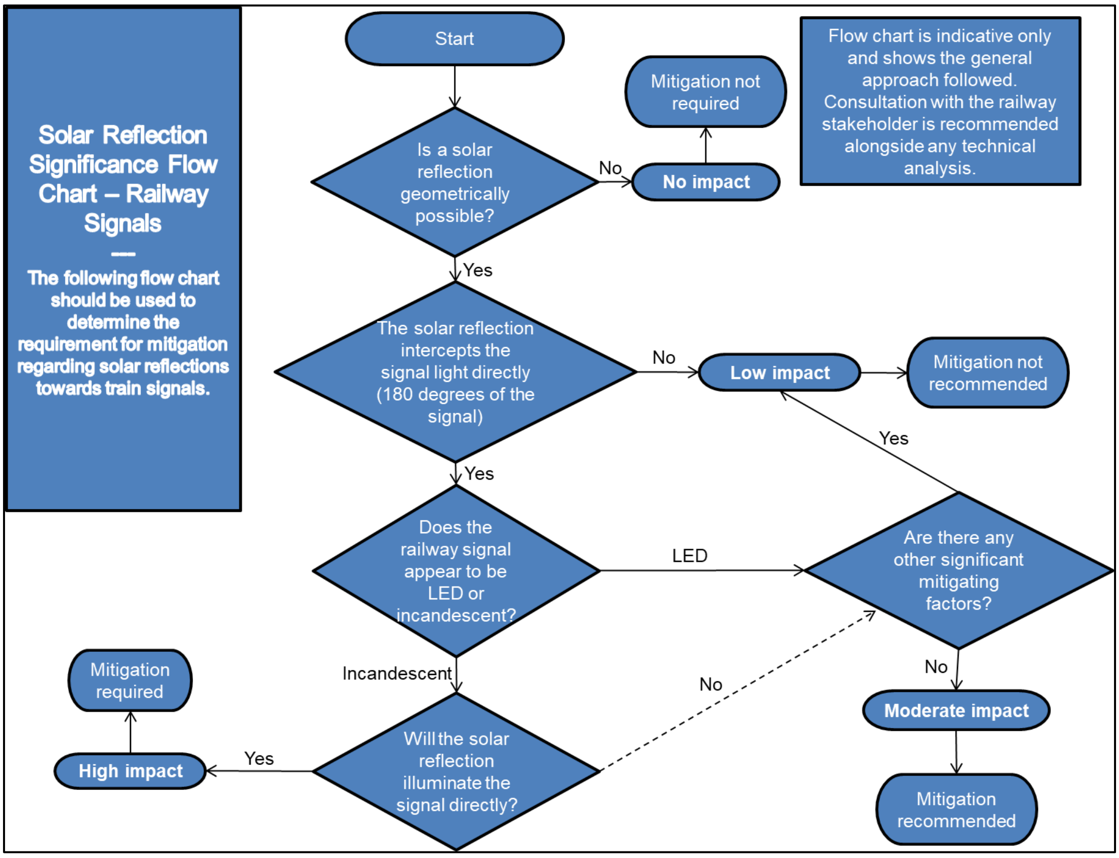
The flow chart presented below has been followed when determining the impact significance for dwelling receptors.



Dwelling impact significance flow chart

Impact Significance Determination for Railway Signals

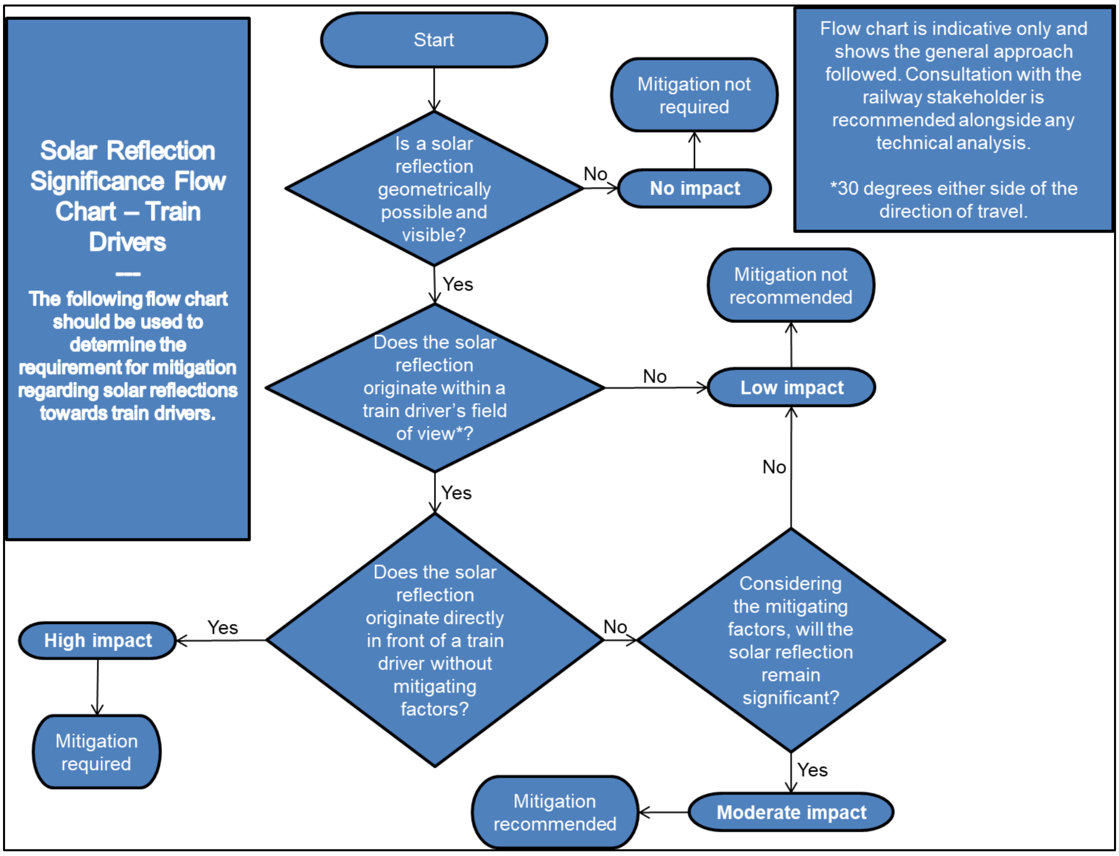
The flow chart presented below has been followed when determining the impact significance mitigation requirement for railway signals.



Railway signal impact significance flow chart

Impact Significance Determination for 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

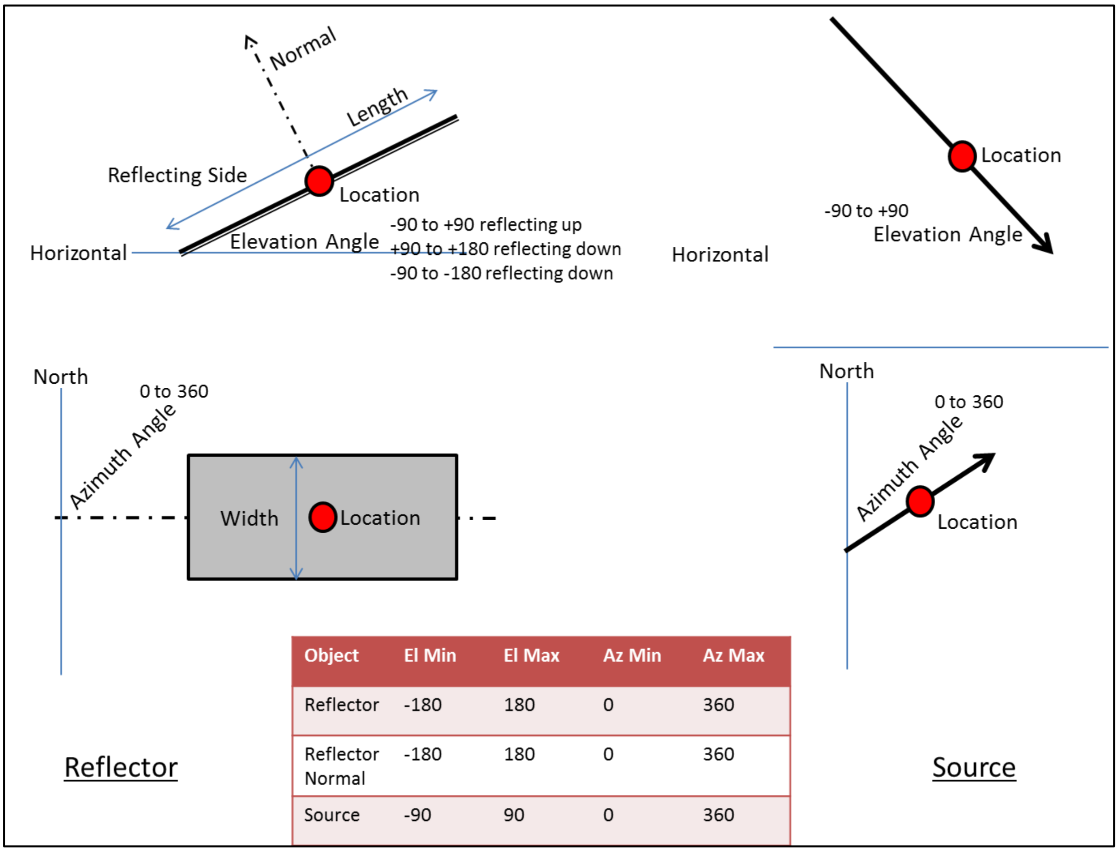
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Pager Power Methodology

The calculations are three dimensional and complex, accounting for:

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

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



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

Reflection calculation process

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

- Use the Latitude and Longitude of reflector as the reference for calculation purposes;
- Calculate the Azimuth and Elevation of the normal to the reflector;
- Calculate the 3D angle between the source and the normal;
- If this angle is less than 90 degrees a reflection will occur. If it is greater than 90 degrees no reflection will occur because the source is behind the reflector;
- Calculate the Azimuth and Elevation of the reflection in accordance with the following:
    - The angle between source and normal is equal to angle between normal and reflection;
    - Source, Normal and Reflection are in the same plane.

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Pager Power's Model

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

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

The model considers terrain between the reflecting solar panels and the visible horizon (where the sun may be obstructed from view of the panels)[51].

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

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

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

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

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

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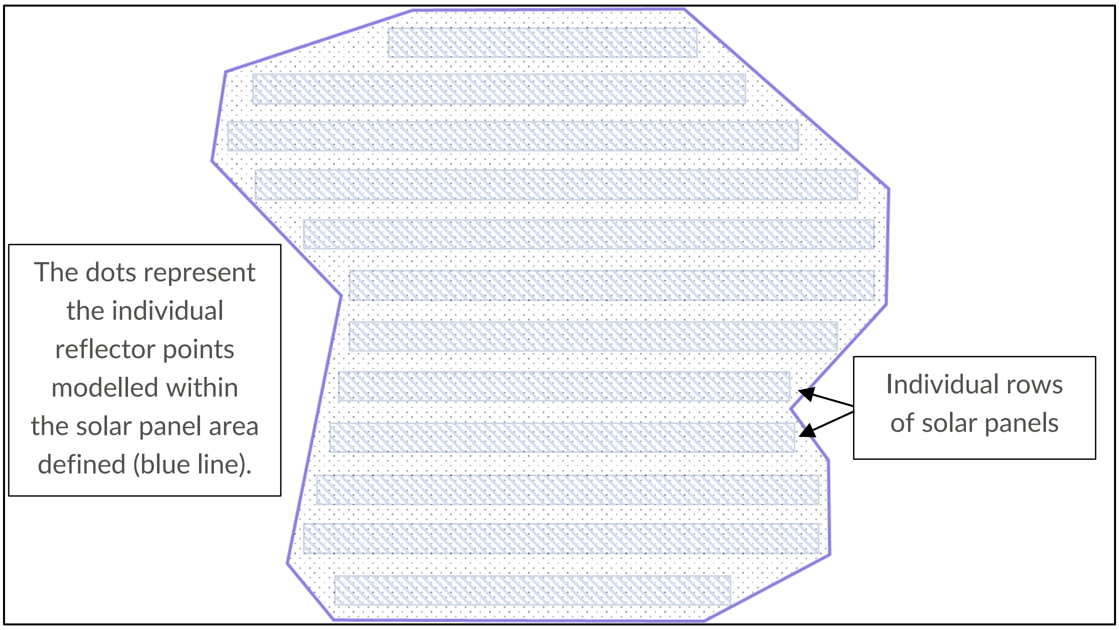
[51] UK only.



Solar panel area modelling overview

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

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

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

Forge's Sandia National Laboratories' (SGHAT) Model

The following text is taken from Forge[52] and is presented for reference.

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.

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

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Rosemarket Airfield Runways

The tables below present data for the thresholds of runway 08/26.

Receptor	Longitude (°)	Latitude (°)	Assessed Altitude (m amsl)
08 Threshold	-4.96813	51.74443	68.35
26 Threshold	-4.95940	51.74619	77.48

Rosemarket Airfield Threshold Data

Details of approach path and visual circuit receptors can be provided upon request.

Dwelling Receptor Data

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

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
1	51.74796	-5.03397	76.18	27	51.74086	-4.98354	48.21
2	51.74728	-5.03401	71.36	28	51.74107	-4.98122	51.20
3	51.74513	-5.02510	68.67	29	51.74182	-4.98135	56.88
4	51.74301	-5.02344	63.39	30	51.74311	-4.98001	57.29
5	51.74257	-5.02375	62.81	31	51.74431	-4.98576	51.93
6	51.74274	-5.01858	57.80	32	51.74584	-4.99213	53.43
7	51.73921	-5.02496	61.50	33	51.74569	-4.99576	61.26
8	51.73873	-5.02480	58.95	34	51.74775	-4.99154	57.72
9	51.73860	-5.02277	56.98	35	51.74992	-4.99469	67.80
10	51.73948	-5.01399	43.30	36	51.74973	-4.99522	70.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
11	51.74004	-5.01269	40.86	37	51.74945	-4.99598	71.80
12	51.73335	-5.01566	50.98	38	51.74925	-4.99734	72.80
13	51.73258	-5.00714	59.72	39	51.74957	-4.99765	73.08
14	51.74106	-5.00638	49.13	40	51.75000	-4.99755	72.80
15	51.74092	-5.00475	46.50	41	51.74995	-4.99832	72.91
16	51.73959	-4.99283	31.83	42	51.75031	-4.99907	73.80
17	51.73623	-4.99082	46.53	43	51.75045	-4.99963	73.80
18	51.73134	-4.98936	70.07	44	51.75074	-4.99947	73.80
19	51.73362	-4.98093	61.80	45	51.75111	-5.00187	73.80
20	51.73402	-4.98032	61.11	46	51.75151	-5.00201	73.80
21	51.73478	-4.98102	58.17	47	51.75179	-5.00307	73.80
22	51.73598	-4.98098	53.07	48	51.75214	-5.00319	73.80
23	51.73635	-4.98025	50.52	49	51.75244	-5.00317	73.80
24	51.73682	-4.98329	52.32	50	51.74991	-5.00204	73.80
25	51.73864	-4.98705	29.56	51	51.74917	-5.00281	73.46
26	51.74096	-4.98440	47.82				

Dwelling receptor data

Road Receptor Data

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

A4076

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
A1	51.73332	-5.01797	48.50	A14	51.74334	-5.00933	54.50
A2	51.73421	-5.01774	49.89	A15	51.74402	-5.00838	56.50
A3	51.73509	-5.01748	51.50	A16	51.74473	-5.00748	59.75
A4	51.73594	-5.01700	51.50	A17	51.74545	-5.00662	62.00
A5	51.73682	-5.01670	51.50	A18	51.74624	-5.00591	64.89
A6	51.73770	-5.01641	50.27	A19	51.74703	-5.00523	69.46
A7	51.73855	-5.01592	45.85	A20	51.74782	-5.00453	71.50
A8	51.73925	-5.01502	42.66	A21	51.74859	-5.00378	71.50
A9	51.73993	-5.01406	44.22	A22	51.74935	-5.00299	72.60
A10	51.74061	-5.01310	41.41	A23	51.75011	-5.00221	73.50
A11	51.74128	-5.01215	42.09	A24	51.75076	-5.00142	73.50
A12	51.74200	-5.01128	47.77	A25	51.75161	-5.00119	73.50
A13	51.74267	-5.01030	52.55	A26	51.75248	-5.00063	73.50

A4076 receptor data

Bulford Road Bypass

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
B1	51.75087	-5.00259	73.36	B3	51.75193	-5.00492	72.25
B2	51.75133	-5.00384	72.83	B4	51.75249	-5.00568	72.27

Bulford Road Bypass receptor data

A477

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
C1	51.73110	-4.99958	70.75	C16	51.73943	-4.99215	31.11
C2	51.73136	-4.99819	71.25	C17	51.74031	-4.99232	39.94
C3	51.73140	-4.99674	71.50	C18	51.74115	-4.99285	43.30
C4	51.73141	-4.99529	71.50	C19	51.74198	-4.99343	45.65
C5	51.73143	-4.99384	72.50	C20	51.74280	-4.99401	50.48
C6	51.73143	-4.99238	71.50	C21	51.74363	-4.99460	53.26
C7	51.73145	-4.99094	71.50	C22	51.74445	-4.99519	55.80
C8	51.73230	-4.99086	69.64	C23	51.74527	-4.99579	59.60
C9	51.73318	-4.99111	63.24	C24	51.74609	-4.99637	62.50
C10	51.73407	-4.99133	56.07	C25	51.74693	-4.99688	65.65
C11	51.73496	-4.99153	51.50	C26	51.74780	-4.99729	69.66
C12	51.73585	-4.99175	50.42	C27	51.74867	-4.99767	72.29
C13	51.73675	-4.99196	44.80	C28	51.74947	-4.99832	73.37
C14	51.73764	-4.99215	41.94	C29	51.75010	-4.99934	73.50
C15	51.73853	-4.99228	35.48	C30	51.75049	-5.00052	73.50

A477 receptor data

Railway Signal Data

The railway signal data is presented in the table below.

Reference	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
CR 25	51.74260	-4.99755	54.45
CR 28	51.74021	-5.00588	45.21

Railway Signal data

Railway Receptor Data

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

No.	Longitude (°)	Latitude (°)	Assessed Height (m) (amsl)
R1.1	51.73770	-5.01588	50.50
R1.2	51.73803	-5.01453	44.03
R1.3	51.73836	-5.01318	41.75
R1.4	51.73870	-5.01182	41.88
R1.5	51.73903	-5.01047	41.75
R1.6	51.73936	-5.00912	41.75
R1.7	51.73969	-5.00777	41.56
R1.8	51.74002	-5.00642	43.13
R1.9	51.74035	-5.00507	44.97
R1.10	51.74069	-5.00372	45.55
R1.11	51.74103	-5.00237	46.06
R1.12	51.74137	-5.00103	48.41
R1.13	51.74174	-4.99970	47.73
R1.14	51.74221	-4.99846	51.78
R1.15	51.74278	-4.99735	54.42
R1.16	51.74343	-4.99635	56.20
R1.17	51.74413	-4.99545	56.81
R1.18	51.74490	-4.99468	57.35
R1.19	51.74573	-4.99413	58.62
R1.20	51.74657	-4.99363	60.33
R1.21	51.74742	-4.99315	61.98
R1.22	51.74827	-4.99266	62.52
R1.23	51.74912	-4.99218	62.75

No.	Longitude (°)	Latitude (°)	Assessed Height (m) (amsl)
R1.24	51.74999	-4.99185	60.05
R1.25	51.75089	-4.99189	57.95
R1.26	51.75177	-4.99218	60.74
R1.27	51.75249	-4.99282	63.76

Railway receptor data

Modelled Reflector Areas

The modelled reflector areas are presented in the tables below.

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-2.11287	52.67091	20	-2.12140	52.66612
2	-2.11424	52.67127	21	-2.11979	52.66613
3	-2.11584	52.67126	22	-2.11700	52.66637
4	-2.11633	52.67112	23	-2.11697	52.66650
5	-2.11728	52.67050	24	-2.11619	52.66658
6	-2.11727	52.67008	25	-2.11597	52.66749
7	-2.11802	52.67007	26	-2.11651	52.66897
8	-2.11892	52.66962	27	-2.11594	52.66906
9	-2.12103	52.66926	28	-2.11485	52.66906
10	-2.12194	52.66917	29	-2.11350	52.66910
11	-2.12197	52.66862	30	-2.11301	52.66931
12	-2.12241	52.66862	31	-2.11261	52.66931
13	-2.12242	52.66801	32	-2.11201	52.66931
14	-2.12266	52.66801	33	-2.11081	52.66938
15	-2.12264	52.66775	34	-2.11035	52.66983
16	-2.12241	52.66775	35	-2.11032	52.67017
17	-2.12244	52.66694	36	-2.11001	52.67018

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
18	-2.12224	52.66694	37	-2.10974	52.67089
19	-2.12227	52.66638			

Panel Area

APPENDIX H – DETAILLED MODELLING RESULTS

Overview

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

- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of the report;
- The reflecting panels – bottom right image. The reflecting area is shown in yellow. If the yellow panels are not visible from the observer location, no issues will occur in practice. Additional obstructions which may obscure the panels from view are considered separately within the analysis;
- The reflection date/time graph – left hand side of image. The blue line indicates the dates and times at which geometric reflections are possible. This relates to reflections from the yellow areas;
- The sunrise and sunset curves throughout the year (red and yellow lines).

The Forge charts for the 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.

Full modelling results can be provided upon request.

Aviation Receptors

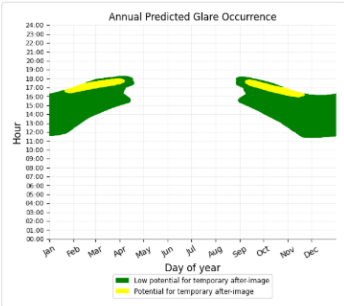
Selective results are presented for reference. Full modelling results are available upon request.

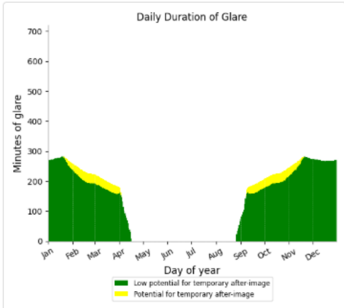
Forge

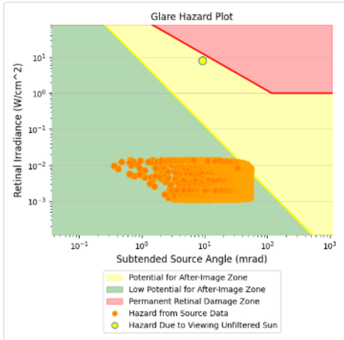
West: OP 55

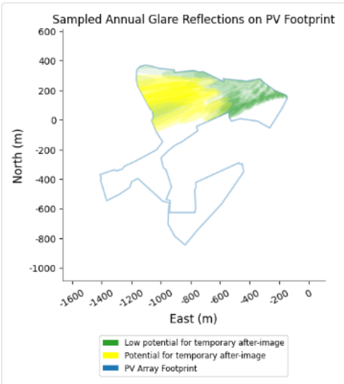
PV array is expected to produce the following glare for this receptor:

- 47,711 minutes of "green" glare with low potential to cause temporary after-image.
- 3,838 minutes of "yellow" glare with potential to cause temporary after-image.





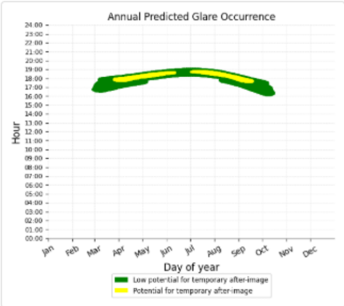


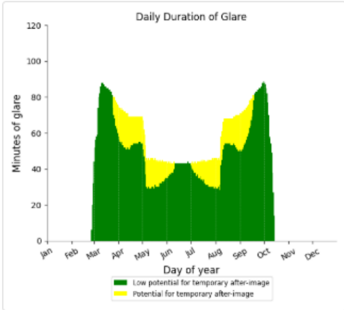


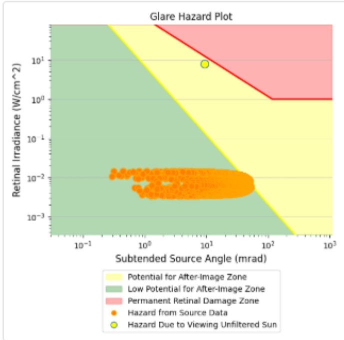
East: OP 8

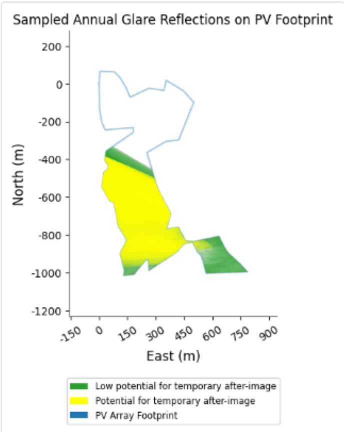
PV array is expected to produce the following glare for this receptor:

- 11,716 minutes of "green" glare with low potential to cause temporary after-image.
- 2,216 minutes of "yellow" glare with potential to cause temporary after-image.



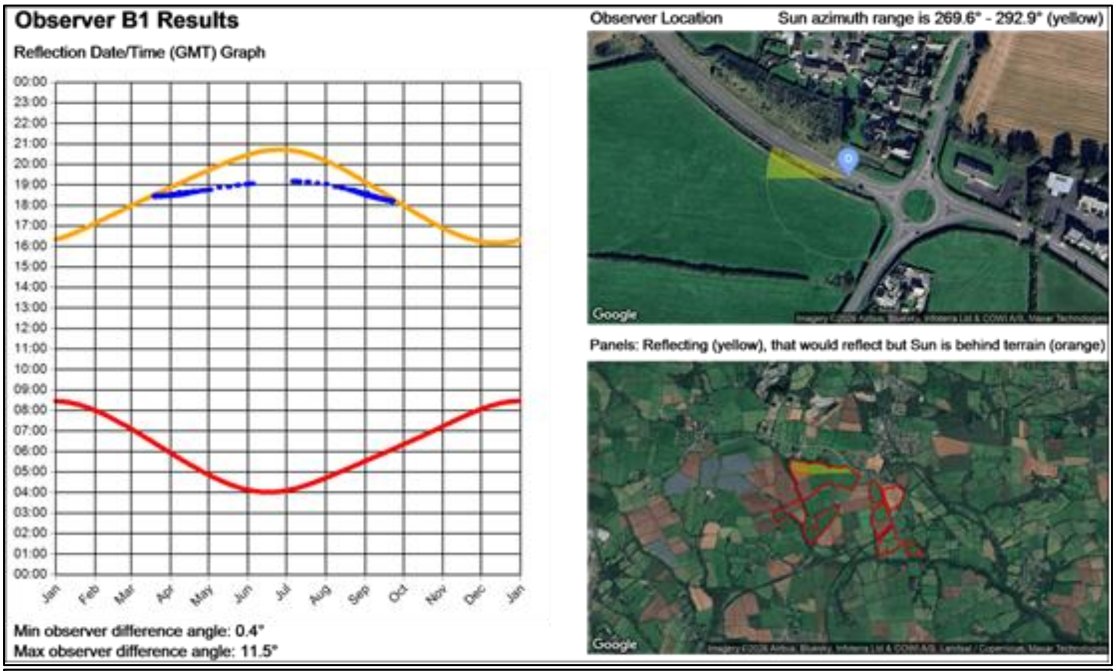


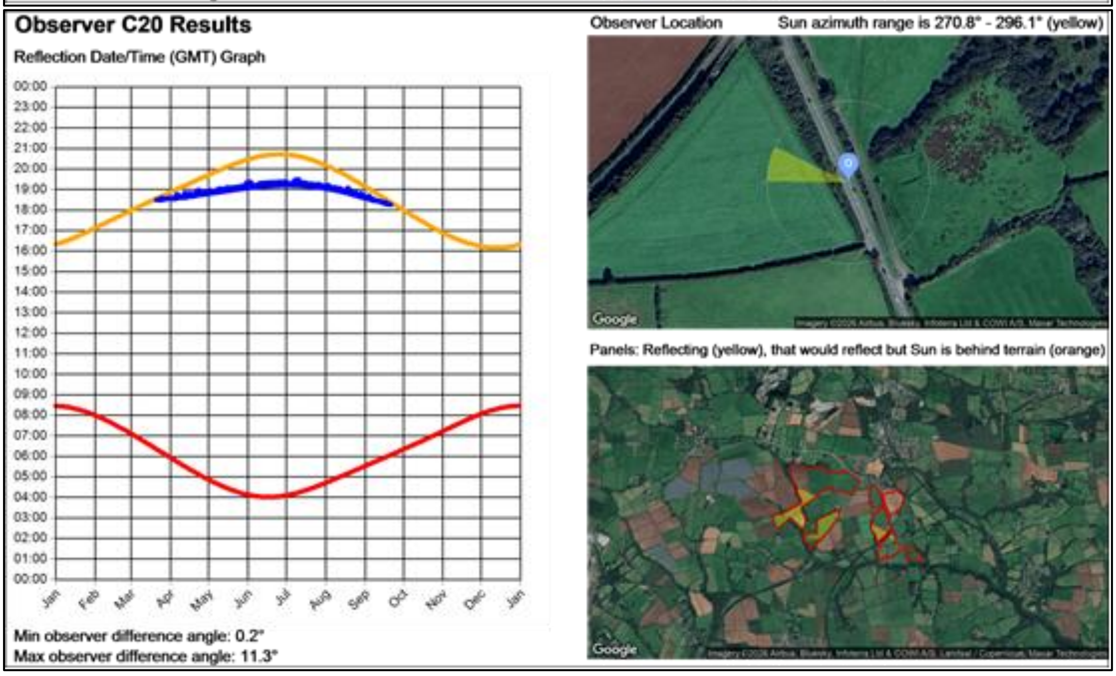




Road Receptors

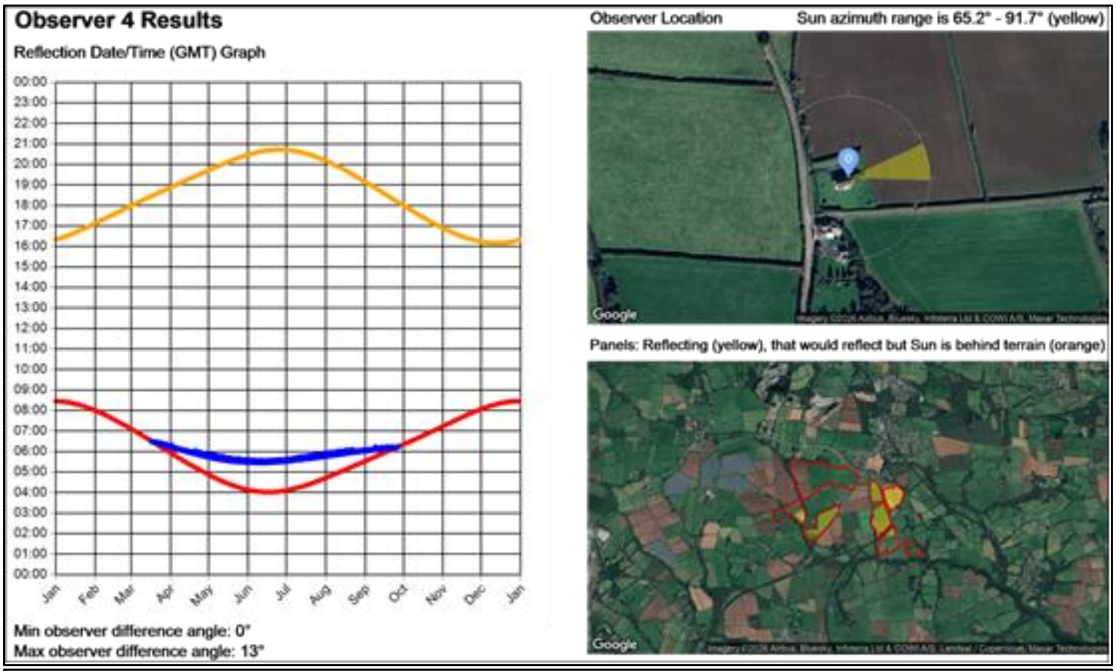
Results have been included for all road receptors where a moderate impact is predicted.

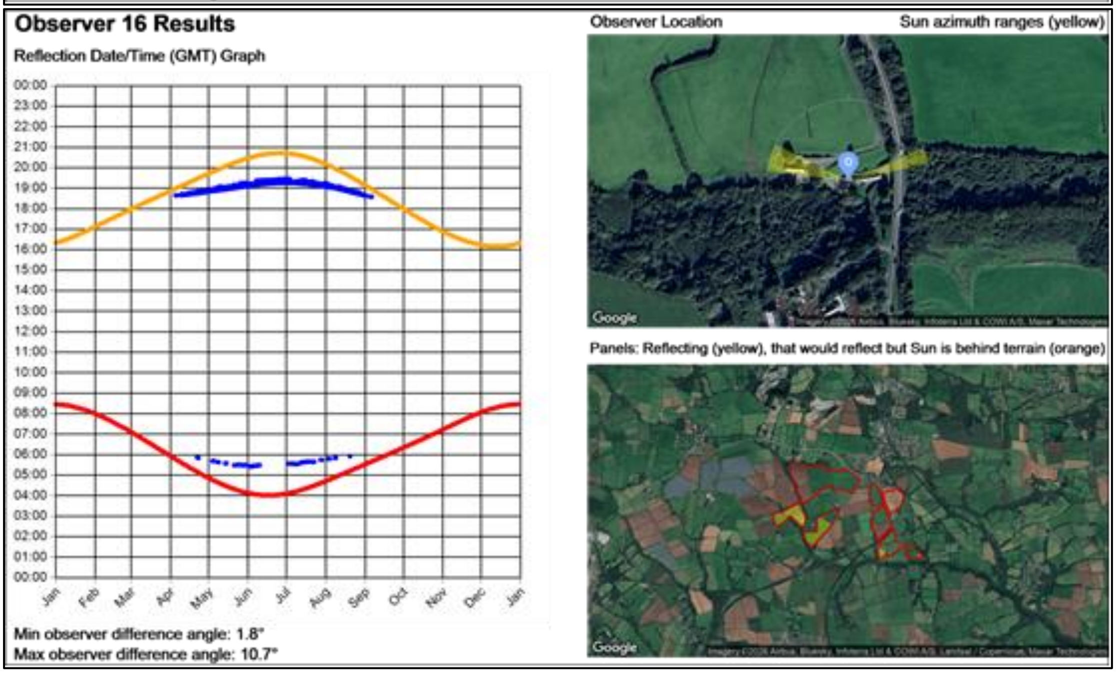


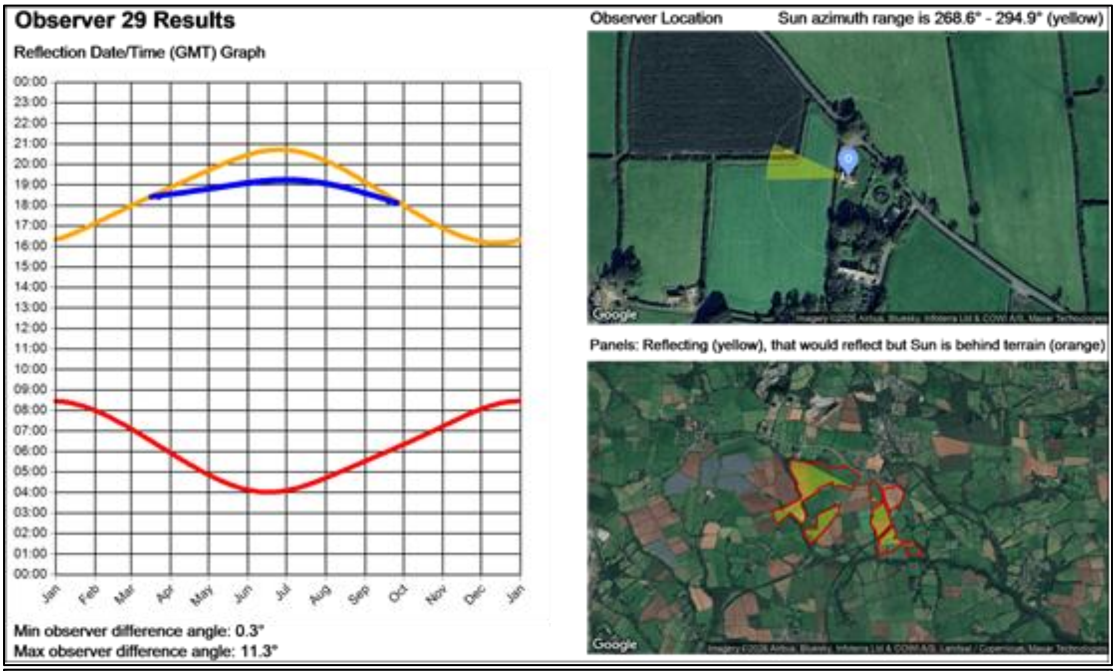


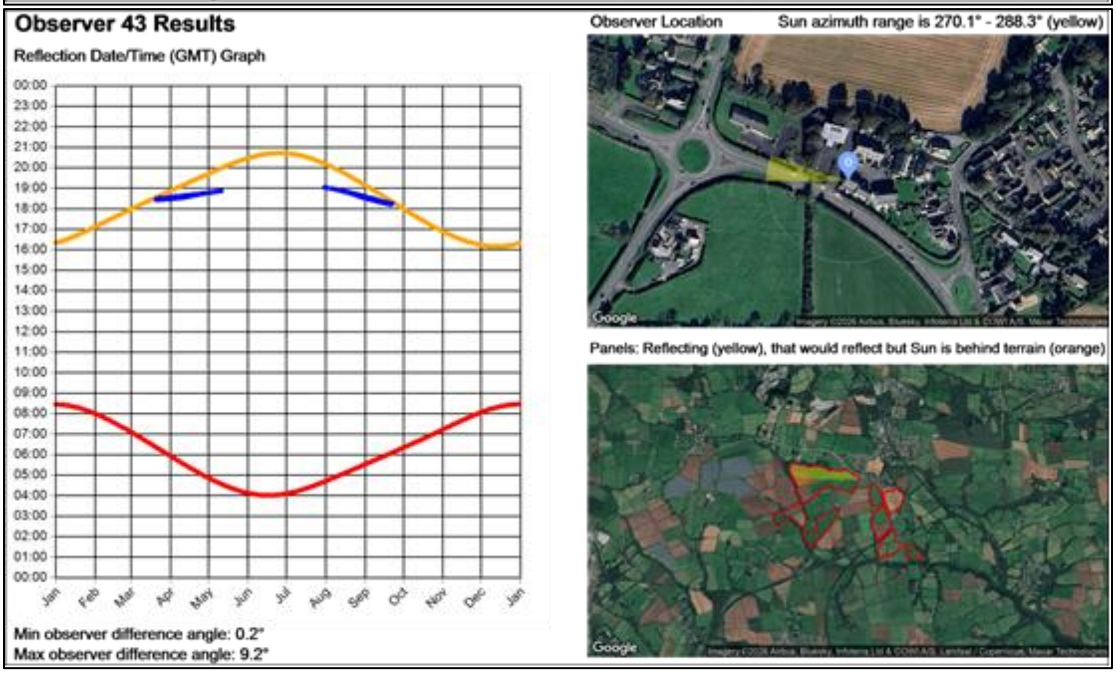
Dwelling Receptors

Results have been included for dwelling receptors to be representative of all results.



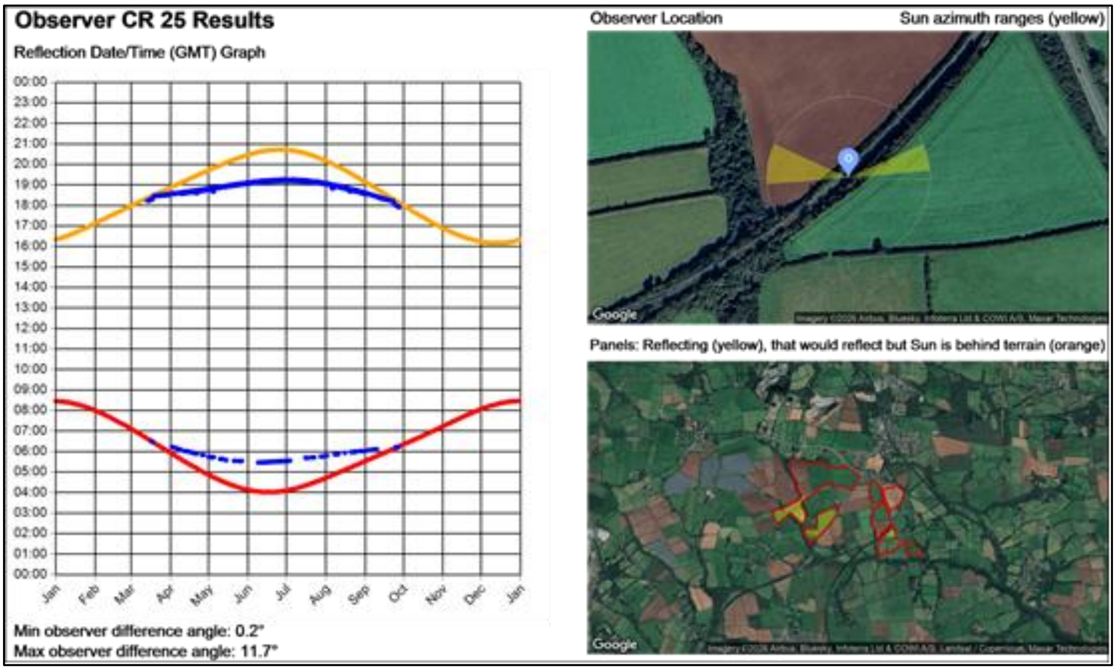


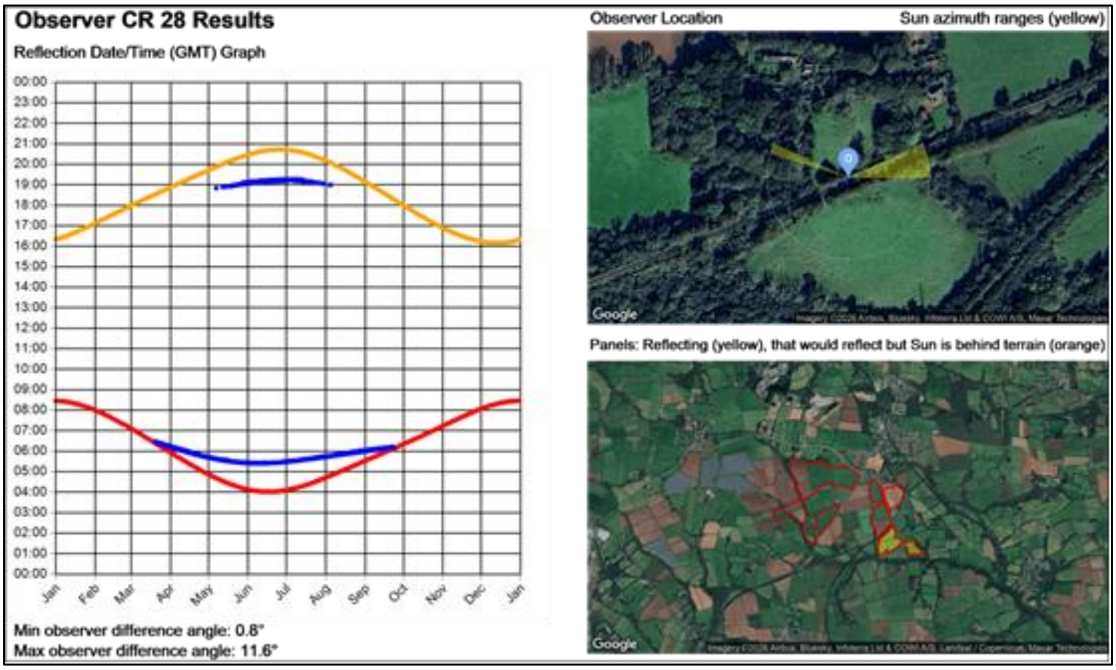

Observer 29 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.3°
Max observer difference angle: 11.3°
Observer Location
Sun azimuth range is 268.6° - 294.9° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 43 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: 9.2°
Observer Location
Sun azimuth range is 270.1° - 288.3° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

Railway Signals

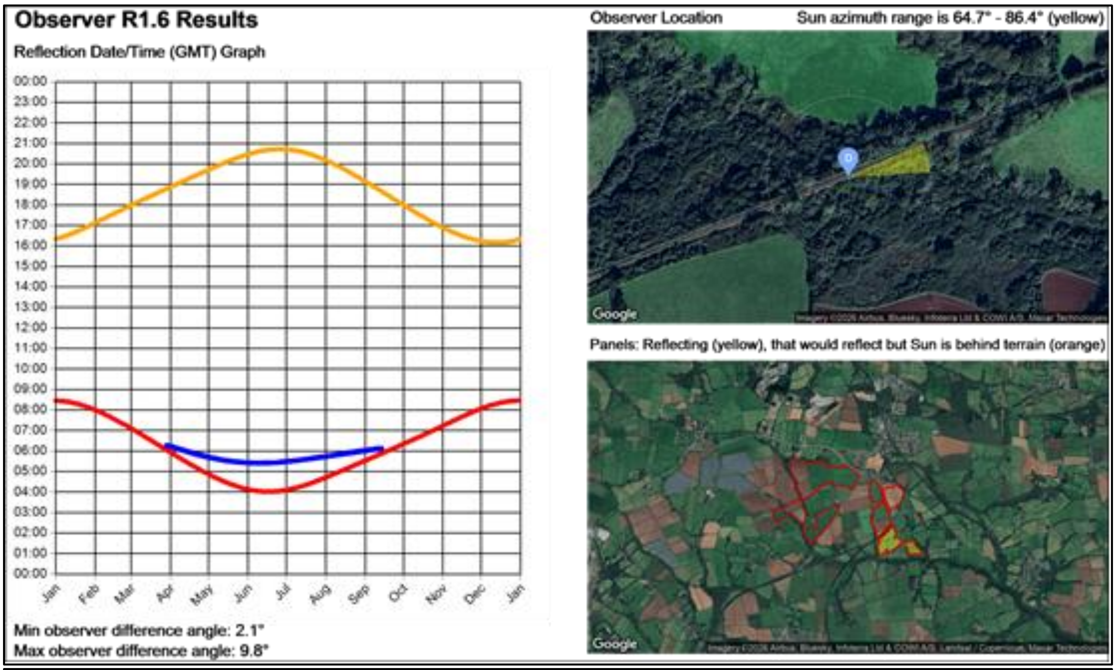
Results have been included for all railway signals.

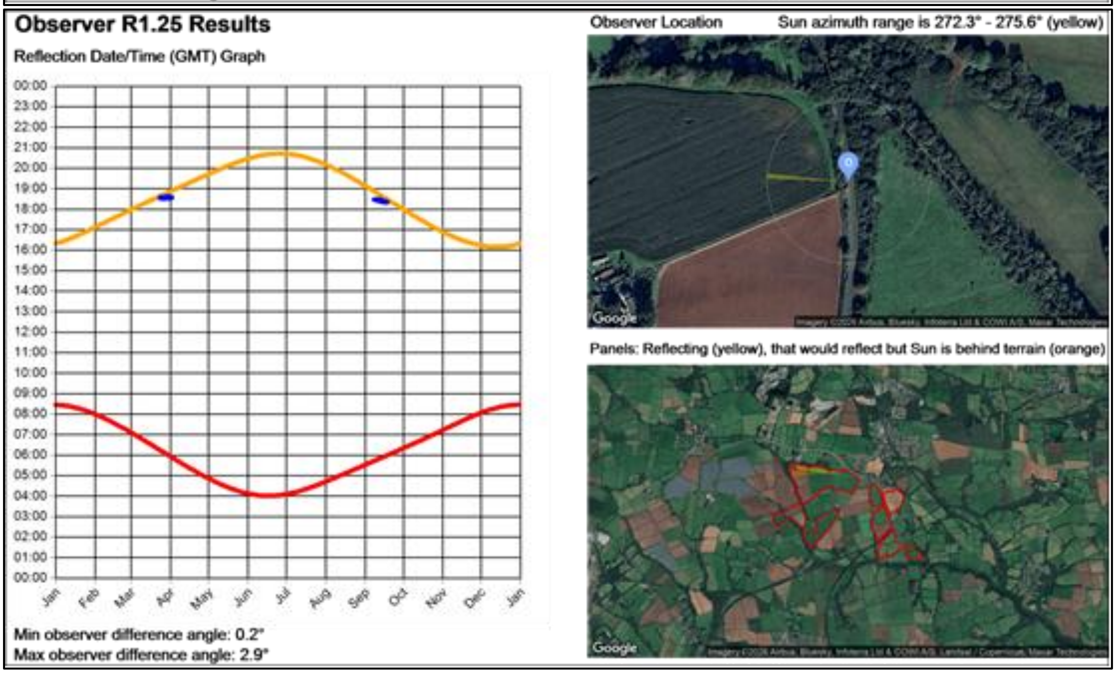




Railway Receptors

Results have been included for a selection of railway receptors to show a range of representative results.





APPENDIX I – SCREENING REVIEW

Overview

A desk-based review of the available imagery is presented in the following subsections.

Road Receptors

The identified screening in the form of existing vegetation is outlined green, with cumulative reflecting panel areas shown in yellow in the figures (in this Appendix) on the following pages. Street view imagery represents views of the proposed development along the sections of road where the reflecting panels are predicted to be significantly obstructed.

Screening review – Roads: List

Dwelling Receptors

A desk-based review of the available imagery is presented in the figures (in this Appendix) 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 are outlined in green.

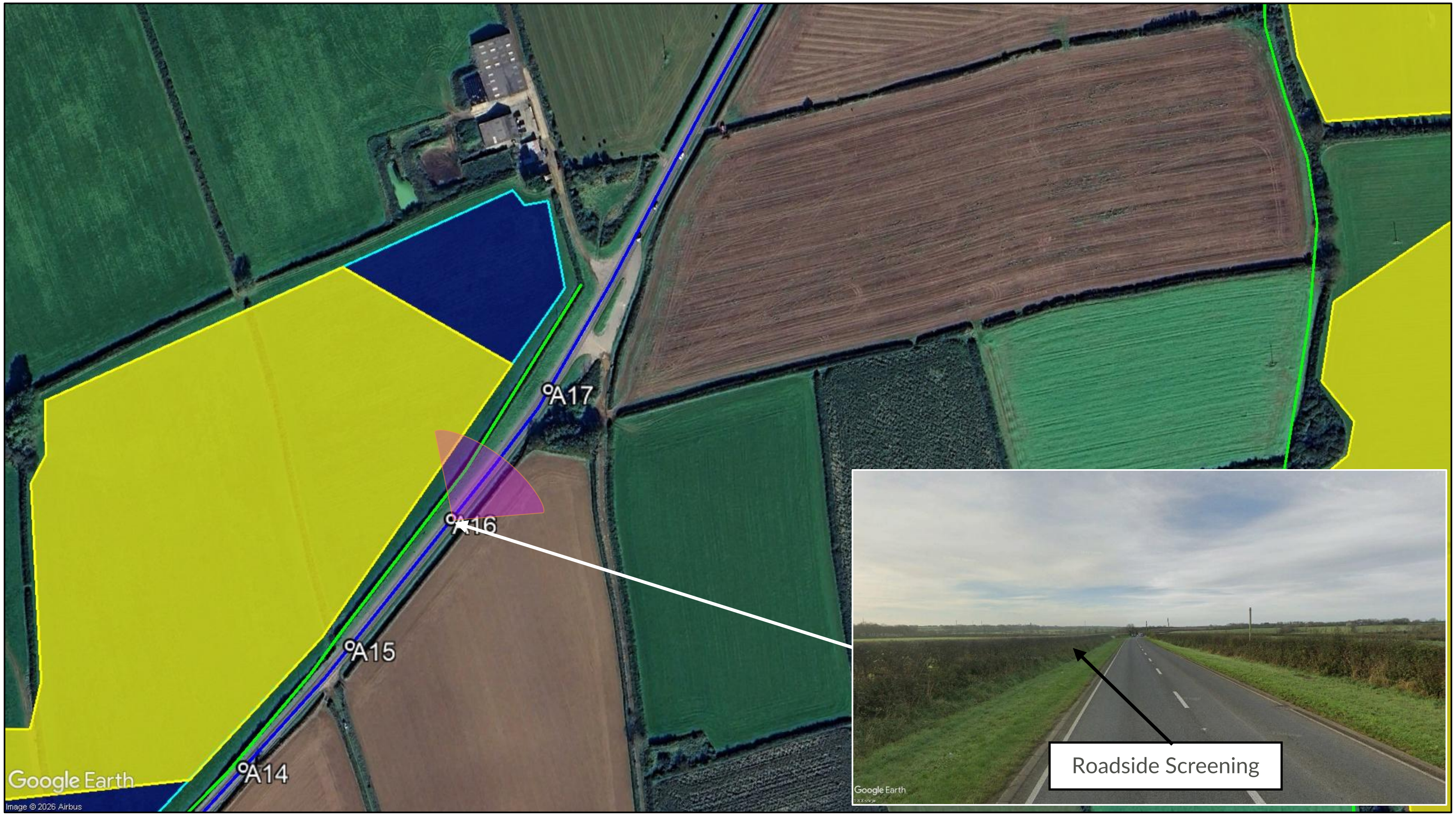
Screening review – Dwellings: List

Railway Receptors

The identified screening in the form of existing vegetation is outlined green, with cumulative reflecting panel areas shown in yellow in the figures (in this Appendix) on the following pages. AIVR imagery represents views of the proposed development along the sections of railway where the reflecting panels are predicted to be significantly obstructed.

Screening review – Railway: List

Screening Review - Roads 1 *Screening relevant to road receptors A8 to A13*



Screening Review - Roads 2 *Screening relevant to road receptors A14 to A17*

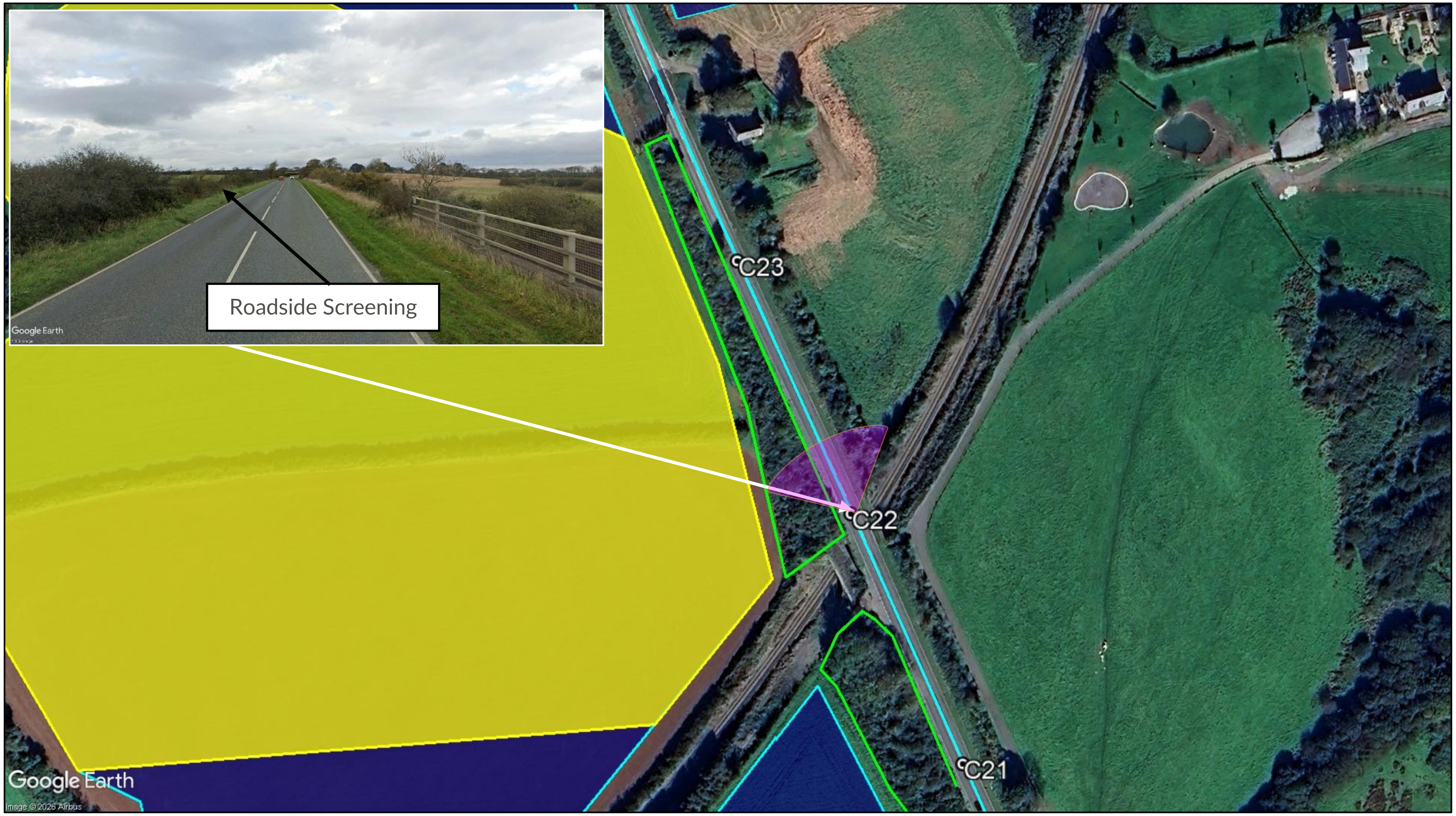
Screening Review - Roads 3 *Screening relevant to road receptors A18 to A21*

Screening Review - Roads 4 *Screening relevant to road receptors A22 to A23*

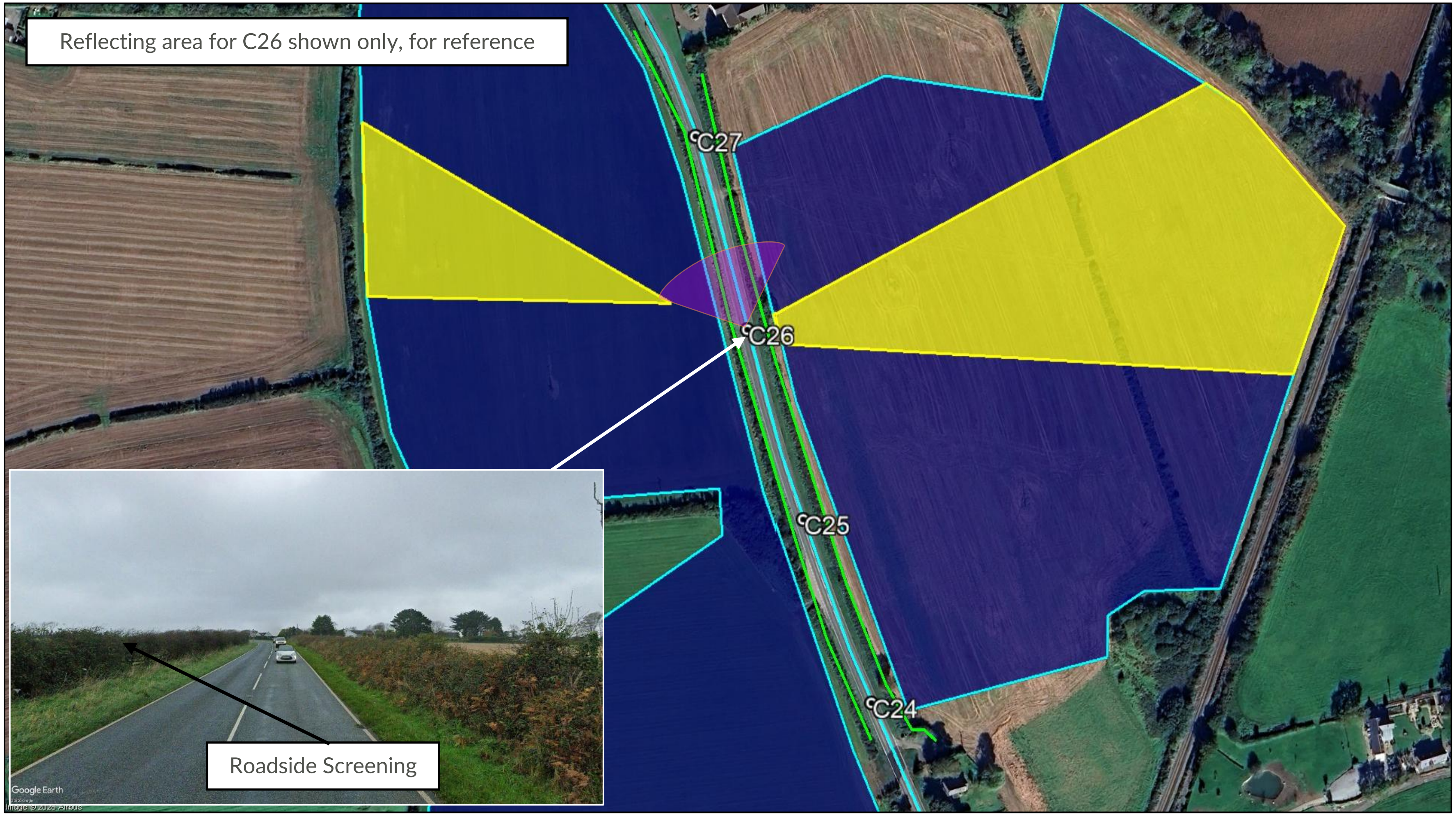
Screening Review - Roads 5 *Screening relevant to road receptors A24 to A26*

Screening Review - Roads 6 *Screening relevant to road receptors B2 to B4*

Screening Review - Roads 7 *Screening relevant to road receptors C15 to C19*



Screening Review - Roads 8 *Screening relevant to road receptors C21 to C23*



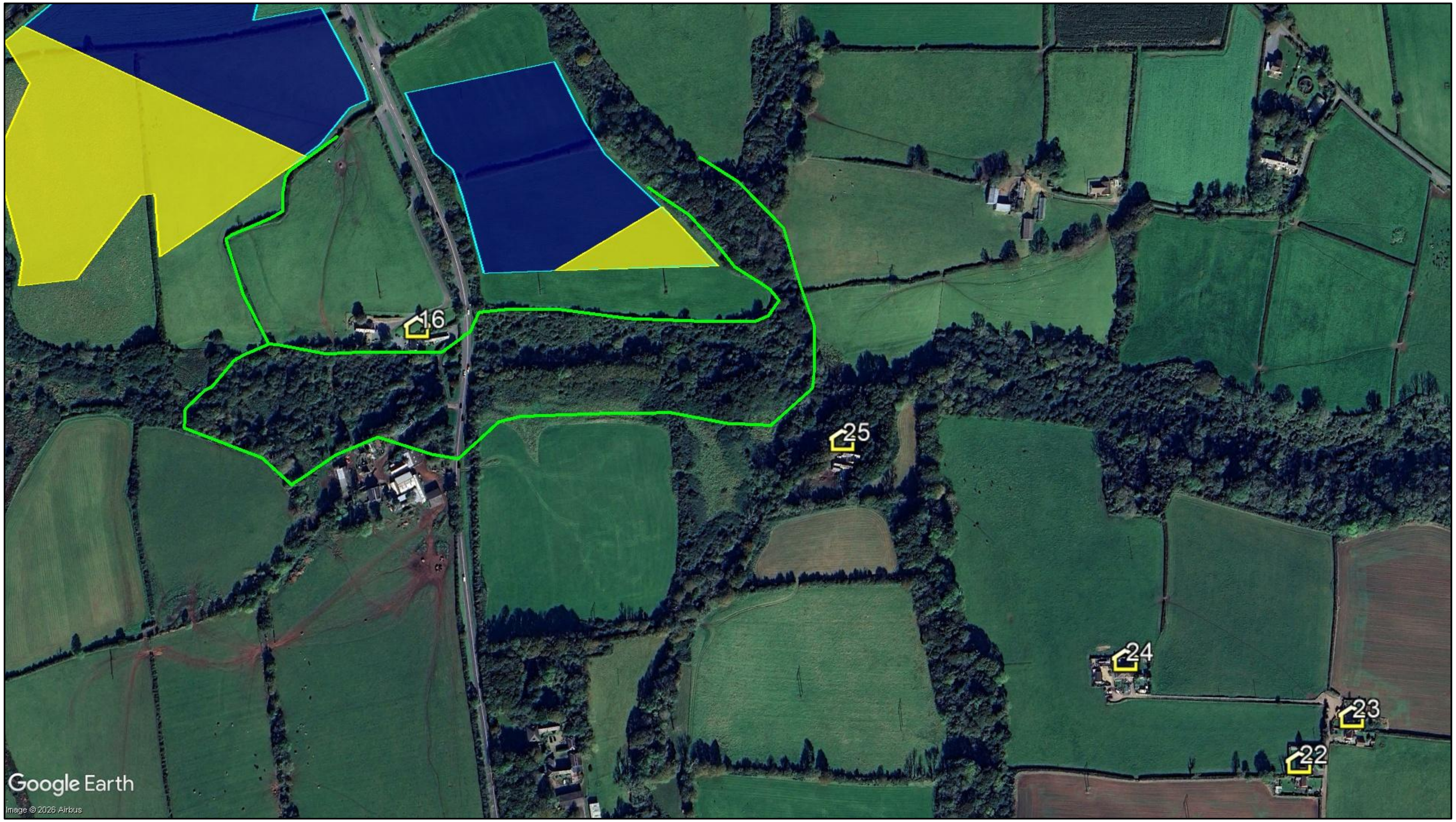
Screening Review - Roads 9 *Screening relevant to road receptors C24 to C27*

Screening Review - Roads 10 *Screening relevant to road receptors C28 to C30*

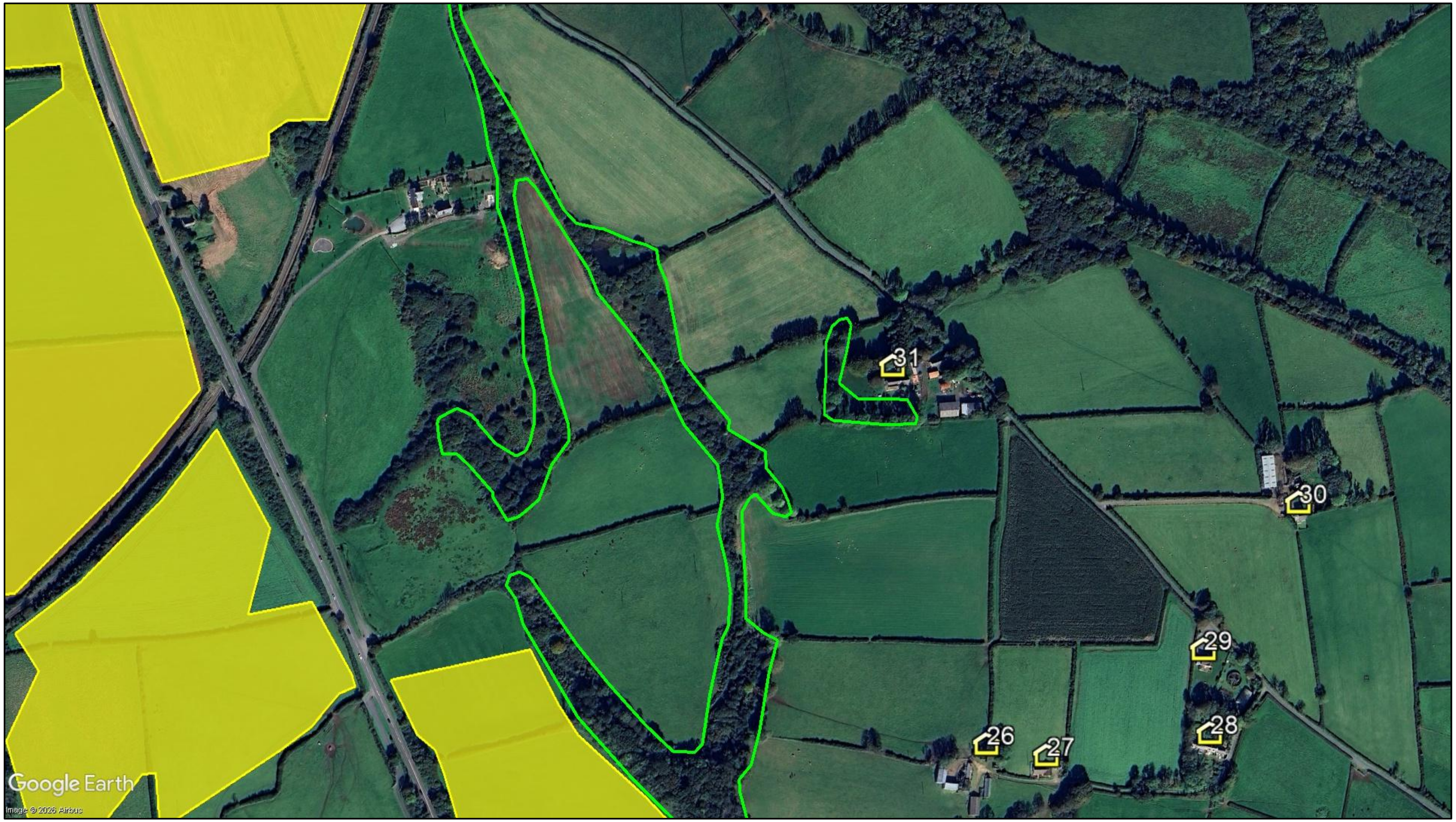
Screening Review - Dwellings 1 *Screening relevant to dwelling receptors 1 to 3*

Screening Review - Dwellings 2 *Screening relevant to dwelling receptors 4 to 11*

Screening Review - Dwellings 3 *Screening relevant to dwelling receptors 14 and 15*

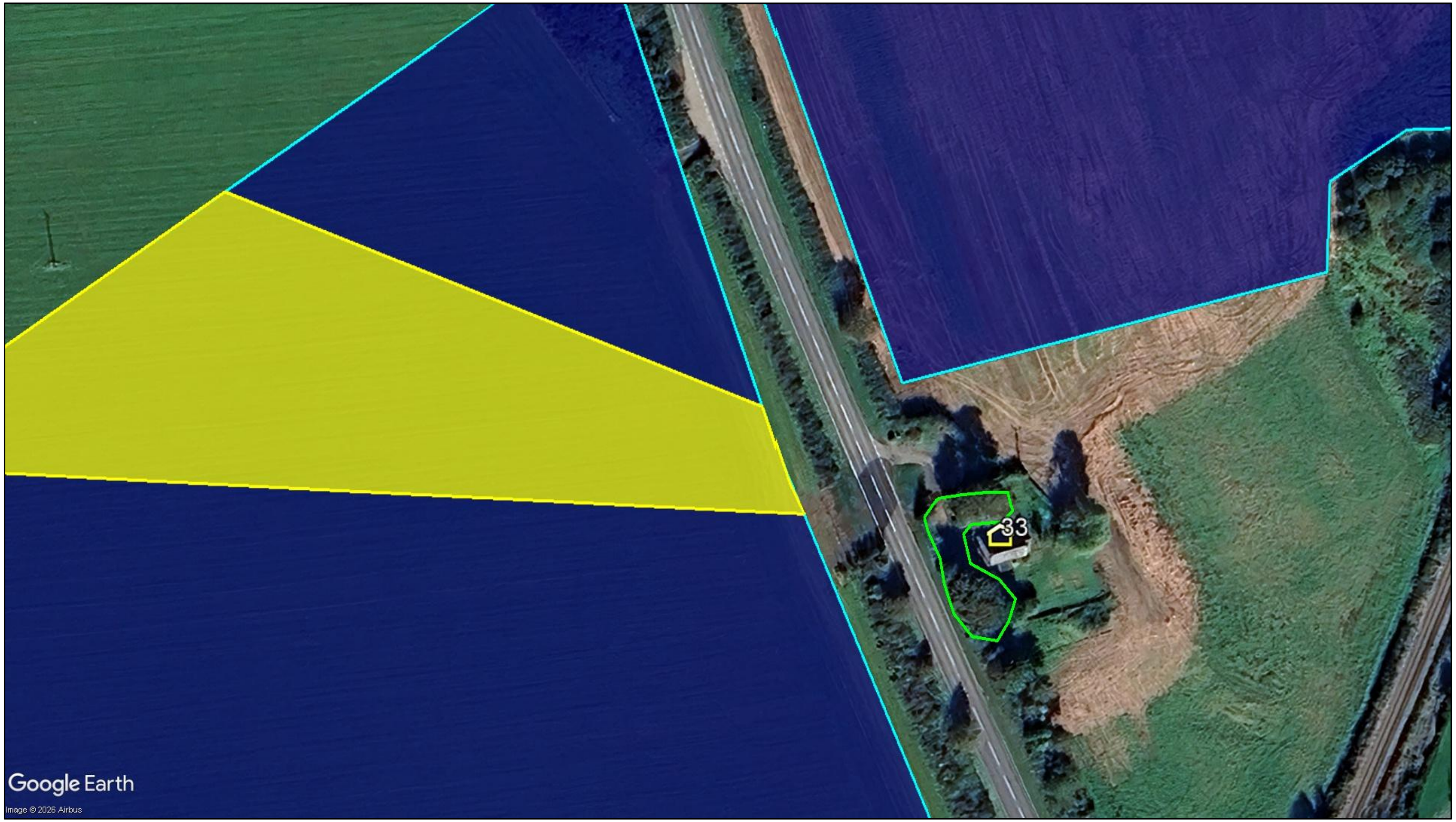


Screening Review - Dwellings 4 *Screening relevant to dwelling receptors 16 and 22 to 25*



Screening Review - Dwellings 5 *Screening relevant to dwelling receptors 26 to 31*

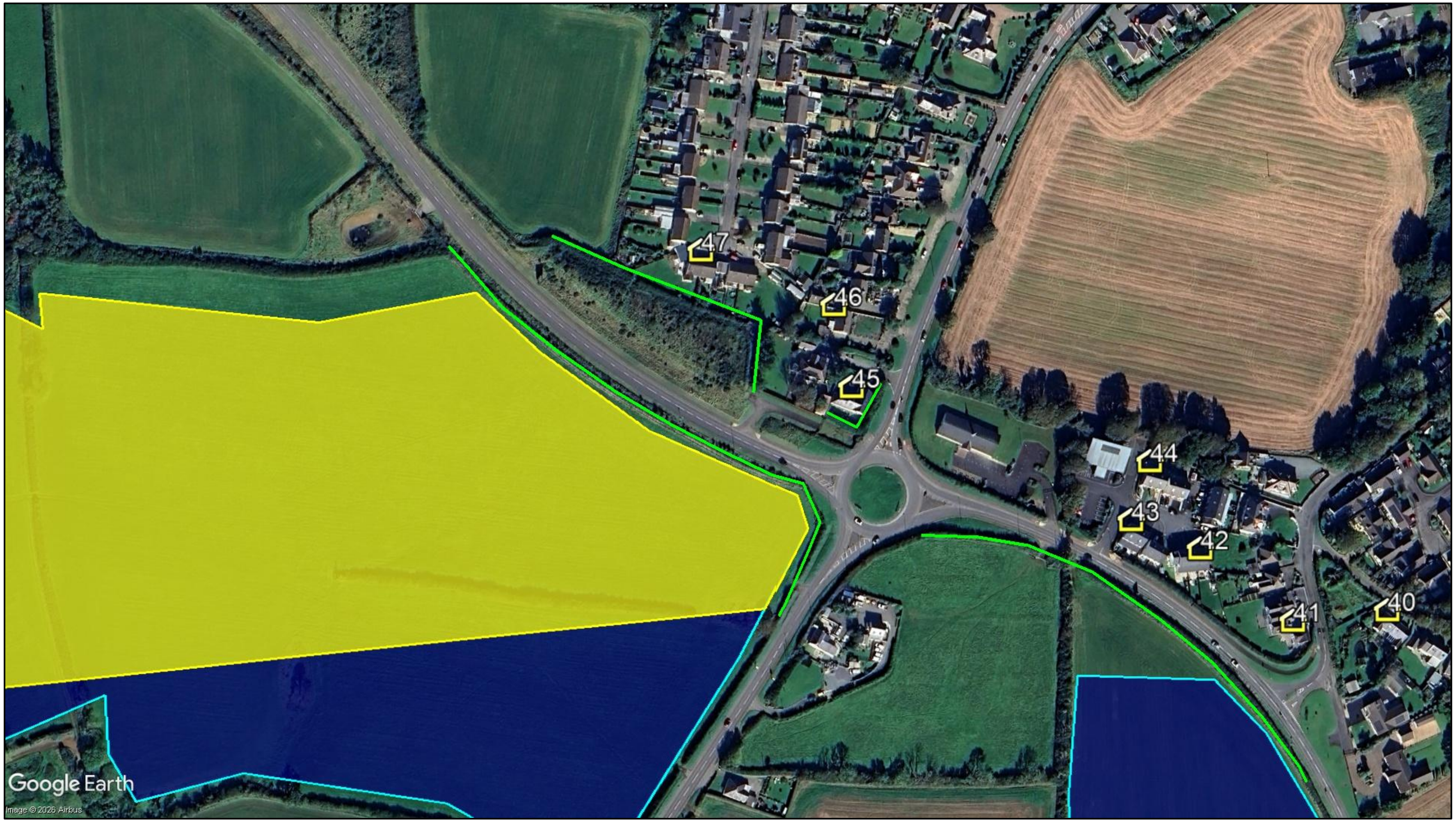
Screening Review - Dwellings 6 *Screening relevant to dwelling receptor 32*



Screening Review - Dwellings 7 *Screening relevant to dwelling receptor 33*

Screening Review - Dwellings 8 *Screening relevant to dwelling receptor 34*

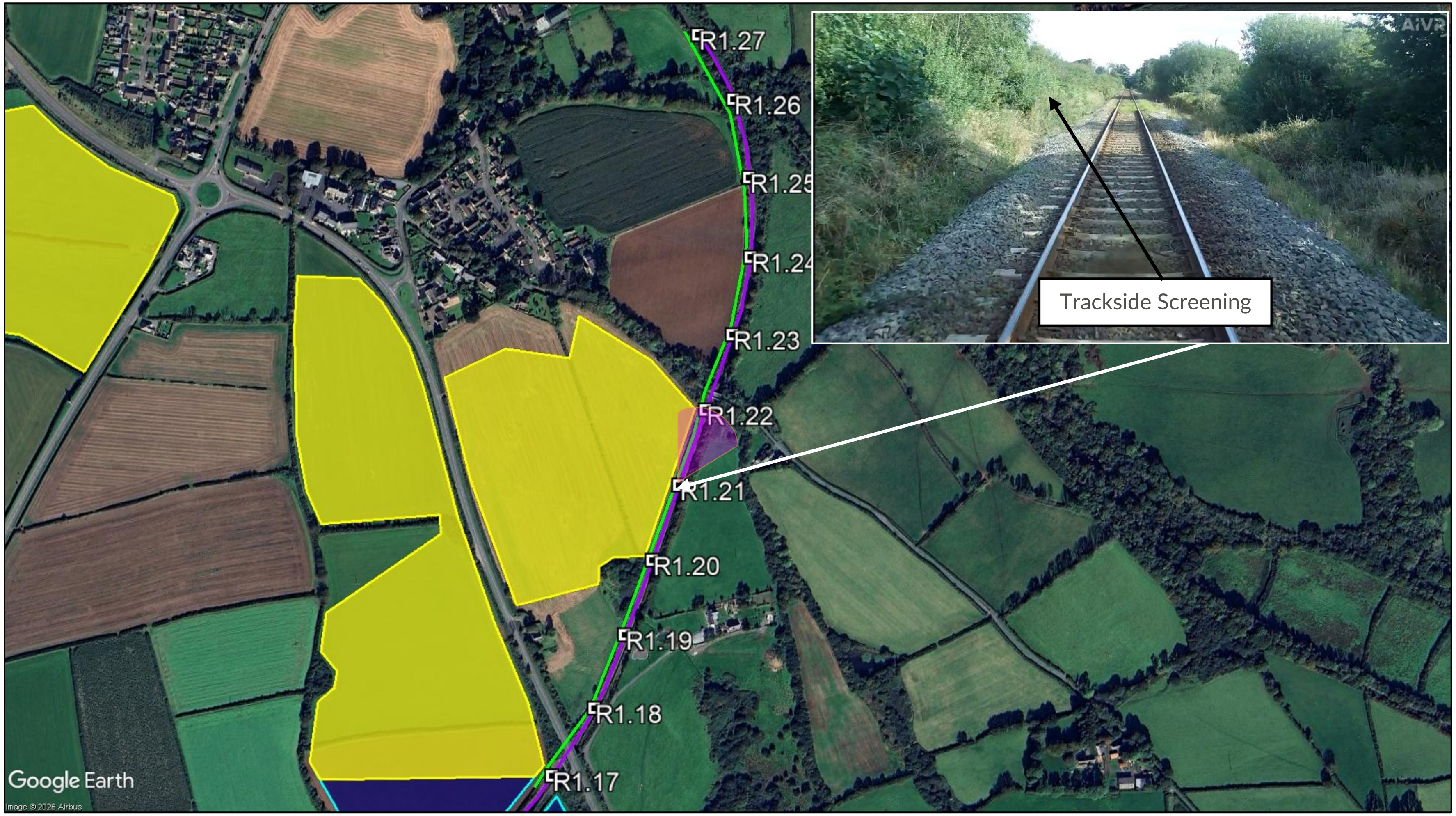
Screening Review - Dwellings 9 *Screening relevant to dwelling receptors 35 to 39*



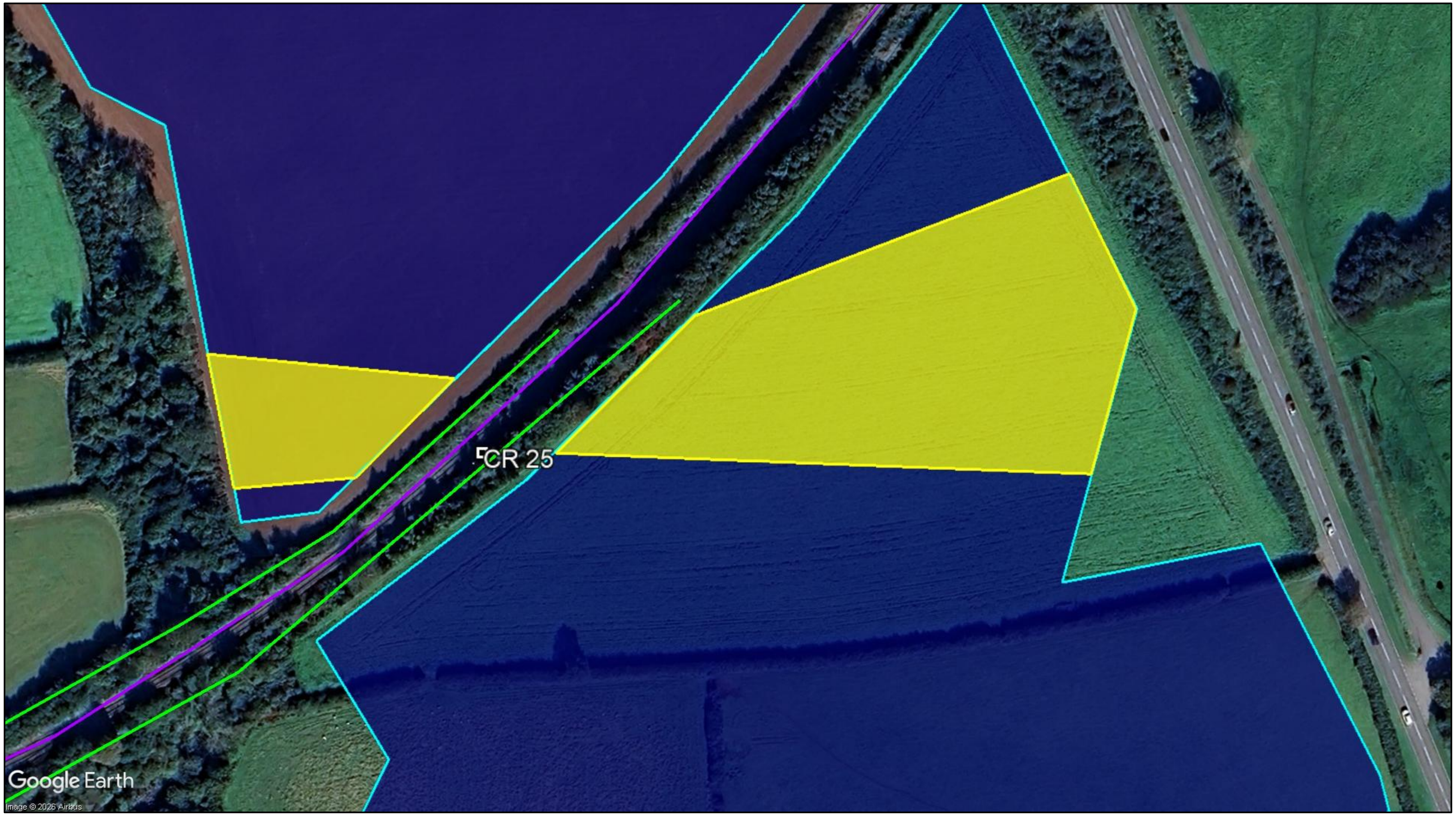
Screening Review - Dwellings 10 *Screening relevant to dwelling receptors 40 to 47*

Screening Review - Dwellings 11 *Screening relevant to dwelling receptors 50 and 51*

Screening Review - Railway 1 *Screening relevant to railway driver receptors R1.1 to R1.16*



Screening Review - Railway 2 *Screening relevant to railway driver receptors R1.17 to R1.27*



Screening Review - Railway 3 *Screening relevant to signal CR 25*

Screening Review - Railway 4 *Screening relevant to signal CR 28*

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