Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Yardley Road Solar Farm Limited

Yardley Farm Solar Farm

June 2025

PLANNING SOLUTIONS FOR:

- Solar
- Telecoms
- Railways
- Defence
- Buildings
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ADMINISTRATION PAGE

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1	March 2025	Initial issue
2	April 2025	Consideration of landscape plan
3	May 2025	Administrative revisions
4	May 2025	Addition of site location plan
5	June 2025	Administrative revisions
6	June 2025	Administrative revisions

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been instructed to assess the potential effects of glint and glare from a single-axis tracking ground-mounted solar photovoltaic development, located north of Potterspury Northamptonshire. This assessment pertains to the potential impact upon road safety, residential amenity, and aviation activity associated with Hall Farm Airfield, Buttermilk Hall Airfield, Thornborough Grounds Airfield, and New Farm Airfield.

Overall Conclusions

No significant impacts are predicted upon road safety, residential amenity, or aviation activity associated with Hall Farm Airfield, Buttermilk Hall Airfield, Thornborough Grounds Airfield, and New Farm Airfield. Mitigation is not recommended.

Guidance and Studies

Guidelines exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. The UK CAA guidance is relatively high-level and does not prescribe a formal methodology. 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, 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 produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel[3].

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

[2] Formerly mandatory for on-airfield solar developments in the USA under the FAA's interim policy, superseded in 2021 with a policy that effectively requires individual airports to sign off on their on-airfield development as they see fit.

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

Assessment Conclusions – Roads

Solar reflections are not geometrically possible towards the assessed section of the A508. No impact is predicted and mitigation is not required.

Assessment Conclusions – Dwellings

Solar reflections are geometrically possible towards 79 of the 100 assessed dwellings.

Screening in the form of existing vegetation, proposed vegetation, buildings, and/or intervening terrain is predicted to significantly obstruct views of reflecting panels for all 79 dwellings. No impact is predicted and mitigation is not required.

High-Level Aviation Assessment Conclusions

Solar reflections towards the splayed approaches and final sections of visual circuits at Hall Farm Airfield, Buttermilk Hall Airfield, Thornborough Grounds Airfield, and New Farm Airfield are predicted to occur outside a pilot's field-of-view (50 degrees either side relative to the runway threshold bearing) or have intensities no greater than 'low potential for temporary after-image'. No significant impact is predicted and mitigation is not required.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 62 countries within Europe, Africa, America, Asia, and Oceania.

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

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

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

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

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

1 INTRODUCTION

1.1 Overview

Pager Power has been instructed to assess the potential effects of glint and glare from a single-axis tracking ground-mounted solar photovoltaic development, located north of Potterspury Northamptonshire. This assessment pertains to the potential impact upon road safety, residential amenity, and aviation activity associated with Hall Farm Airfield, Buttermilk Hall Airfield, Thornborough Grounds Airfield, and New Farm Airfield.

This report contains the following:

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

1.2 Pager Power's Experience

Pager Power has undertaken over 1,600 Glint and Glare assessments in the UK and internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Glint and Glare Definition

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

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

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

[4] These definitions are aligned with those presented within the National Policy Statement for Renewable Energy Infrastructure (EN-3) – published by the Department for Energy Security and Net Zero in January 2024 and the Federal Aviation Administration in the USA.

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Site Layout

Figure 1 below shows the site location plan[5] of the proposed development and red-line boundary. This assessment pertains to the solar panel areas, and hence the remainder of this report makes reference only to those sections of the site, see Figures 2 and 3.

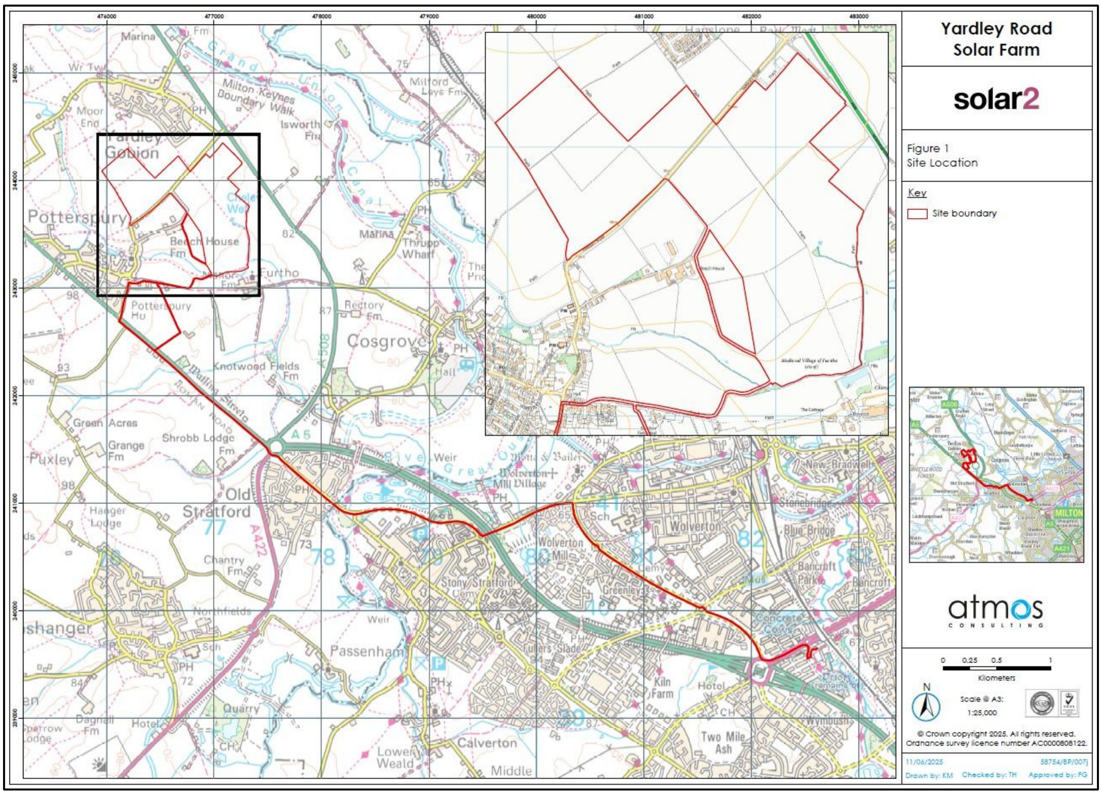

Figure 1 *Proposed development site layout*

Figure 2 on the following page shows the site layout[6] of the proposed development. The blue areas show the locations of panels. The assessment has been carried out using a prior site layout. No significant changes to the location of solar panels have been made, and thus the assessment results present a worst-case scenario.

[5] Source: 58754_Figure 1_BP_007j_Site Location.pdf

[6] Source: 109-024A-250506_25.Yardley_CSI_Tracker_47.5 MWp.pdf

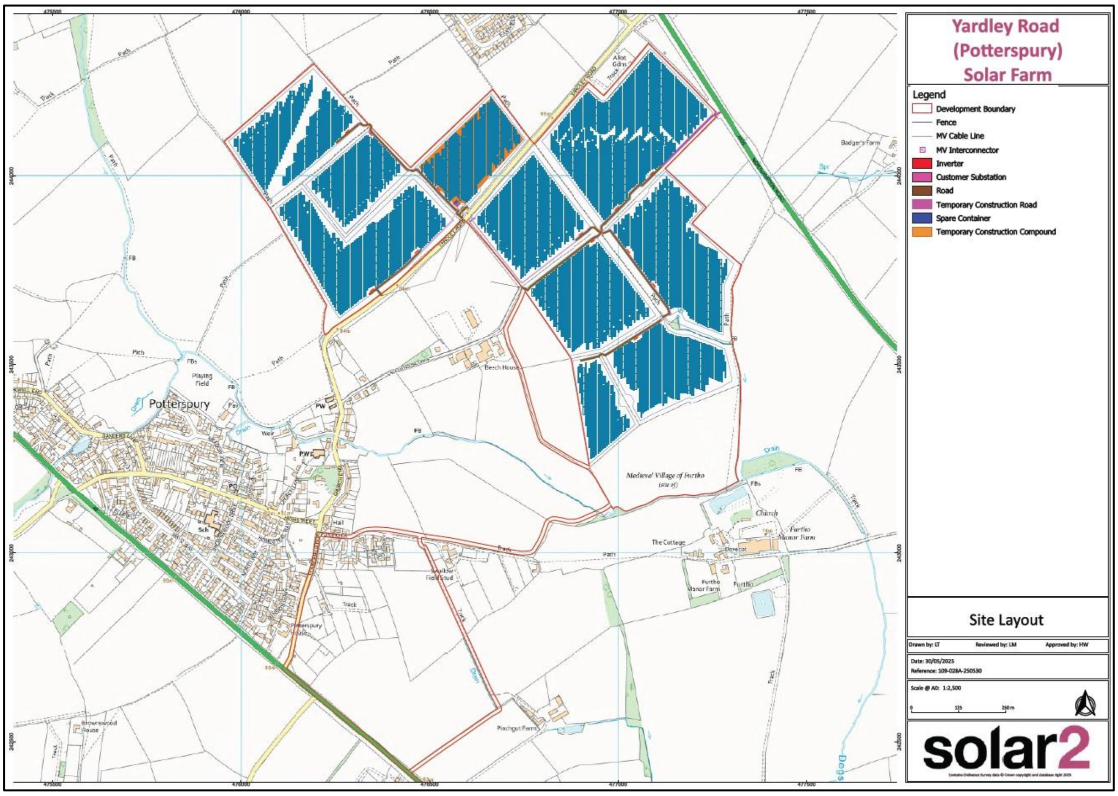

Figure 2 *Proposed development site layout*

Figure 3 on the following page shows the proposed development panel areas overlaid upon aerial imagery.

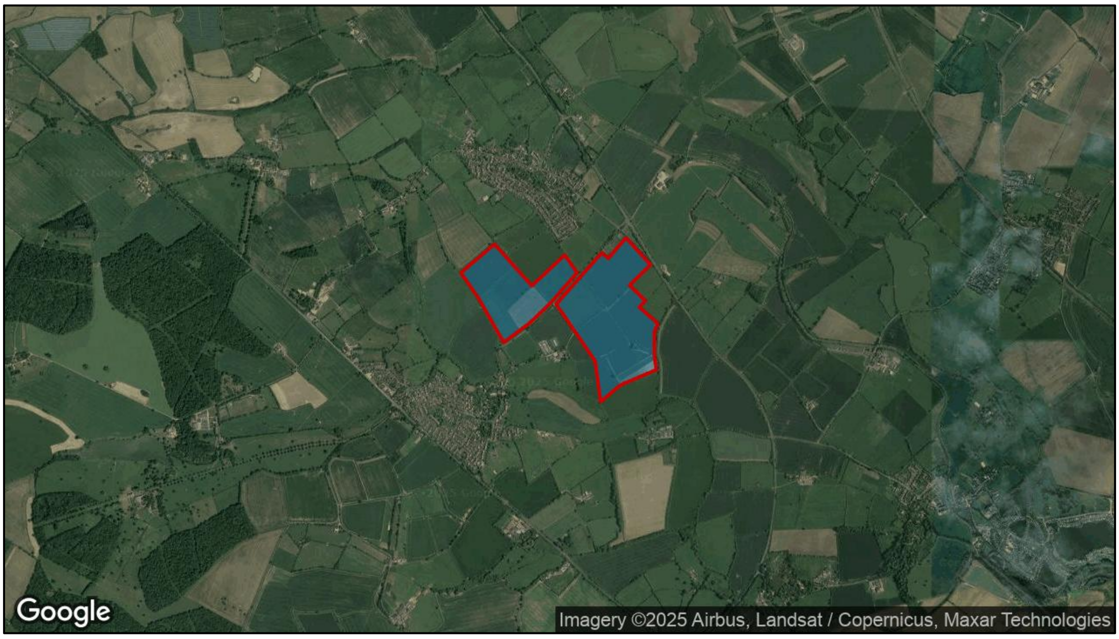

Figure 3 *Solar panel area*

2.2 Solar Panel Technical Information

The technical information used for the modelling is presented in Table 1 below.

Solar Panel Technical Information	
Assessed centre-height	2m agl (above ground level)
Tracking	Horizontal Single Axis tracks Sun East to West
Tilt of tracking axis (°)	0
Orientation of tracking axis (°)	180
Offset angle of module (°)	0
Tracker Range of Motion (°)	±60
Resting angle (°)	0
Backtracking Method	Instant (for modelling purposes). Further discussed in the following subsection and in Appendix I.
Surface material	Smooth glass with an ARC (anti-reflective coating)

Table 1 *Solar panel technical information*

2.2.1 Solar Panel Backtracking

Shading considerations dictate the panel tilt. This is affected by:

- The elevation angle of the Sun;
- The vertical tilt of the panels;
- The spacing between the panel rows.

This means that early in the morning and late in the evening, the panels will not be directed exactly towards the Sun, as the loss from shading of the panels (caused by facing the sun directly when the Sun is low in the horizon), would be greater than the loss from lowering the panels to a less direct angle in order to avoid the shading Figure 4 on the following page illustrates this.

The graphics in Figure 4 show two lines illustrating the paths of light from the Sun towards the solar panels. In reality, the lines from the Sun to each panel would be effectively parallel due to the large separation distance. The figure is for illustrative purposes only.

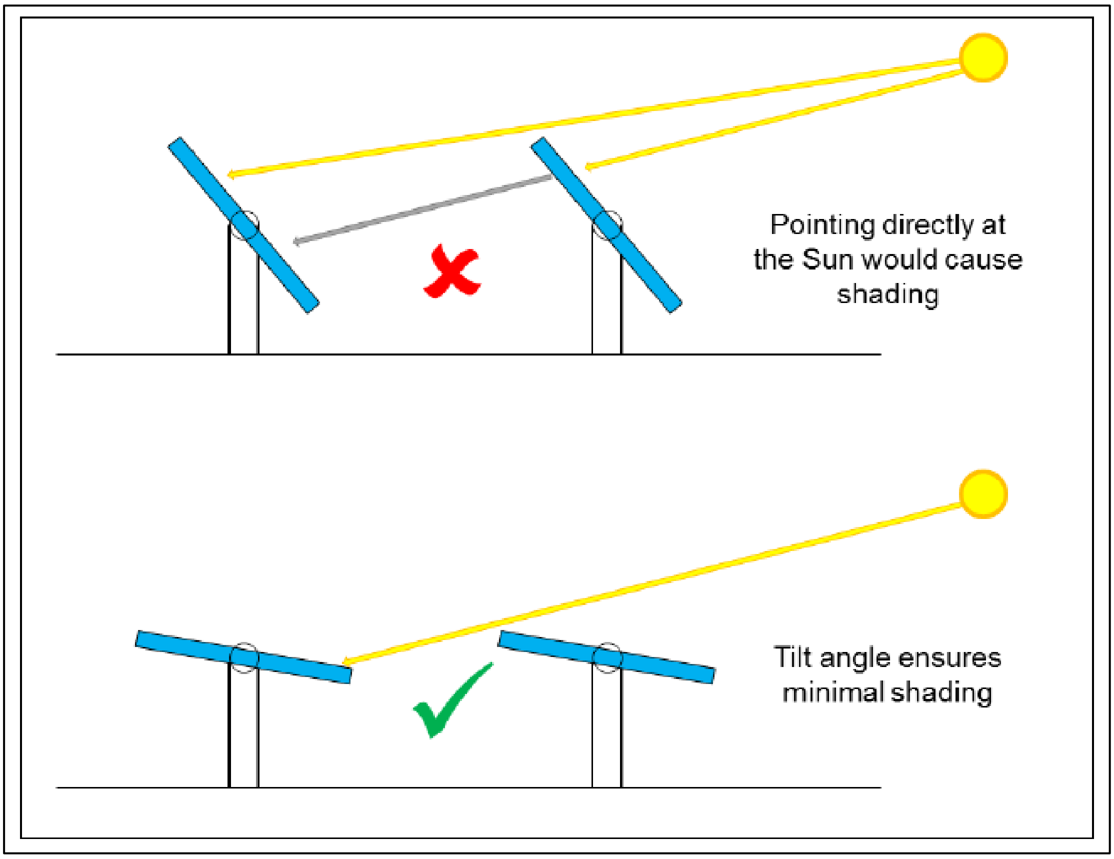

Figure 4 *Shading Considerations*

Later in the day, the panels can be directed towards the Sun without any shading issues. This is illustrated in Figure 5 below.

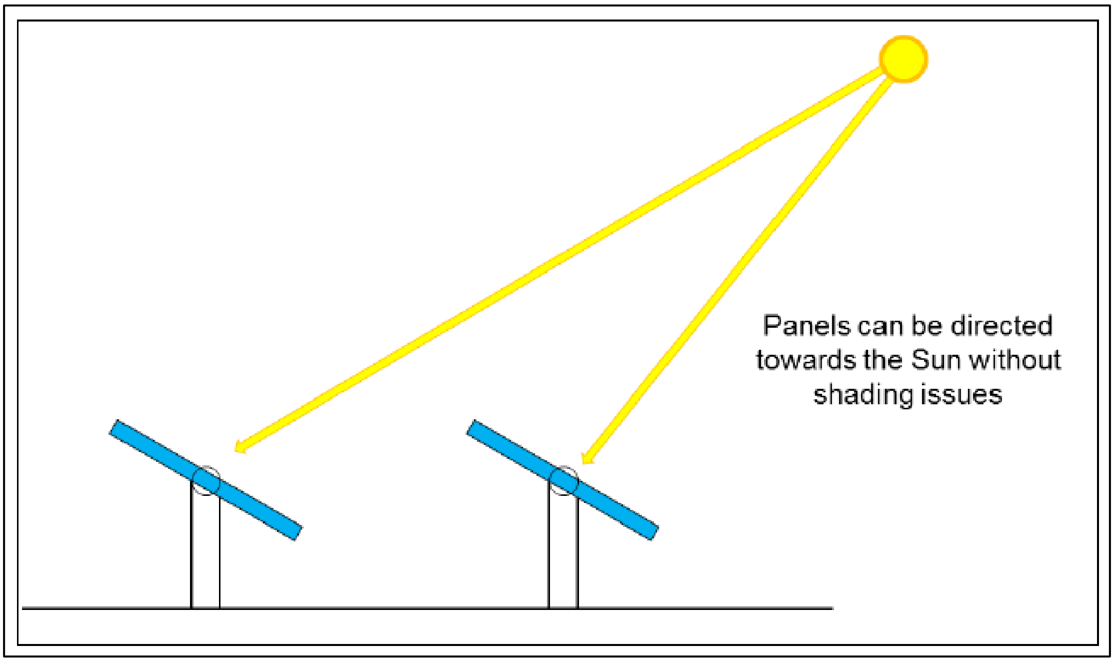

Figure 5 *Panel alignment at high solar angles*

The solar panels backtrack (where the panel angle gradually declines to prevent shading) by reverting to 0 degrees (flat) once the maximum elevation angle of the panels (60 degrees) becomes ineffective due to the low height of the Sun above the horizon and to avoid shading.

2.2.2 Backtracking Solar Panel Model

Backtracking systems are sensitive to panel length, row spacing, topography and the level of shading which varies throughout the year. The Forge Solar model used in this assessment is a widely accepted model within this area. The model approximates a backtracking system by assuming the panels instantaneously revert to its resting angle of 0 degrees whenever the sun is outside the rotation range (60 degrees in this instance). Panels with a maximum tracking angle of 60 degrees and resting angle of 0 degrees would therefore lie horizontally from sunrise until the Sun enters the rotation range, and immediately after the sun leaves the rotation range until sunset daily. This definition is taken from Forge (see Appendix E) and by rotation range it is assumed the panels remain at 0 degrees until the Sun reaches 30 degrees above the horizon – when the Sun is at right angles to the panels at 60 degrees. It is understood that this option was created specifically to account for backtracking to the extent possible.

Whilst this model simplifies the backtracking process to be used by the solar panels within the solar development, panels that revert to their resting angle immediately in many cases present a worst-case scenario for reflectors. This is because flatter panels can produce solar reflections in a much greater range of azimuth angles at ground level. The results would in most cases be more conservative than modelling a detailed backtracking system.

2.3 Landscape Strategy

Figure 6 on the following page shows the landscape strategy plan[7] for the proposed development, which includes introduction of new hedgerows and enhancement of existing hedgerows. These have been considered as part of the assessment.

[7] Source: LEMP-23.Yardley_CSI_Tracker_.... MWp-A2 LEMP.pdf

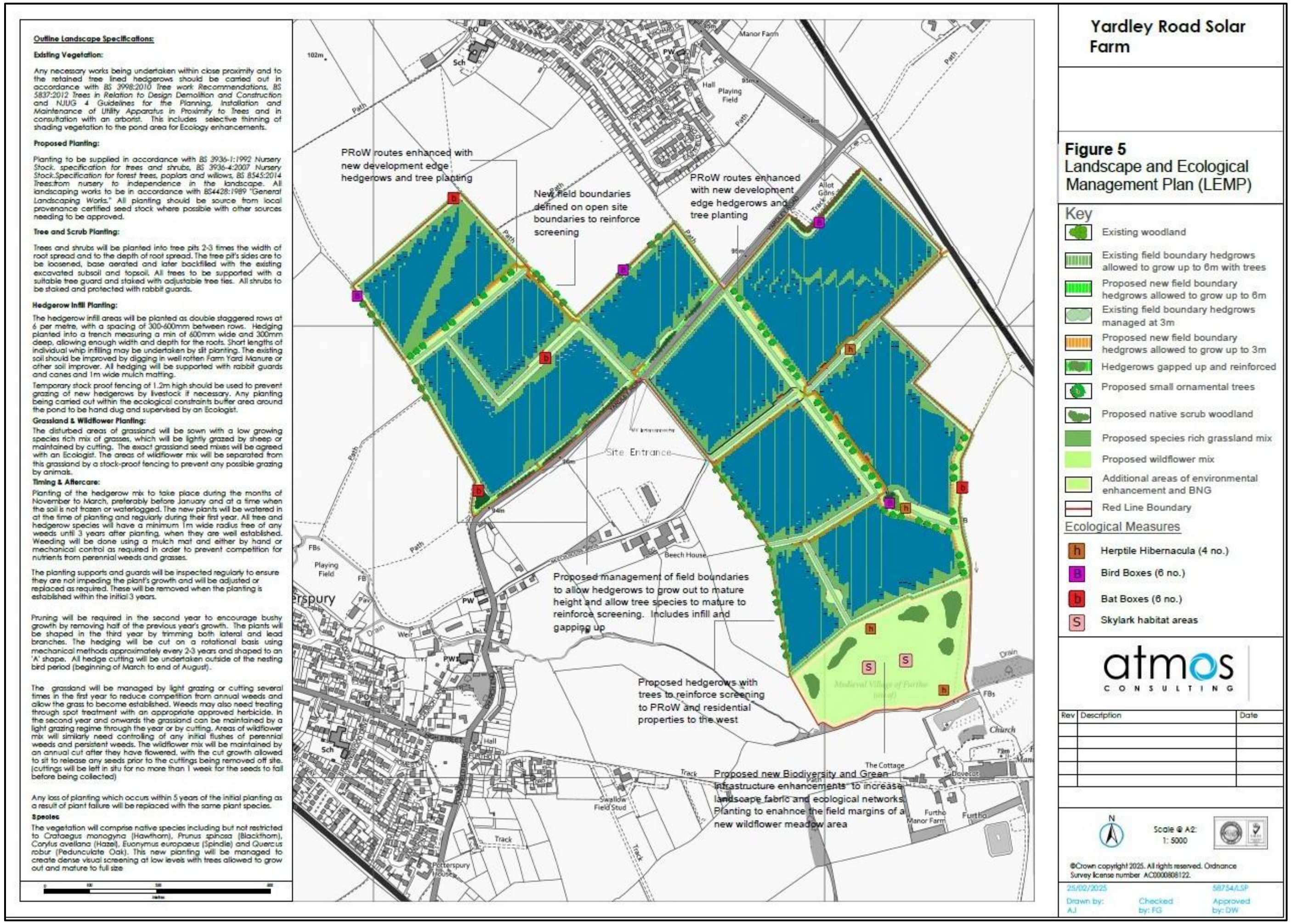

Figure 6 *Landscape Plan*

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 Assessment Methodology and Limitations

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

4 IDENTIFICATION OF RECEPTORS

4.1 Ground Based Receptors Overview

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

The above parameters and industry experience over a significant number of glint and glare assessments undertaken, shows that a 1km assessment area is considered appropriate for glint and glare effects on ground-based receptors – bounded by the yellow outlined area in Figure 7 below. Receptors within this distance are identified based on mapping and aerial photography of the region. The initial judgement is made based on high-level consideration of aerial photography and mapping i.e. receptors are excluded if it is clear from the outset that no visibility would be possible. A more detailed assessment is made if the modelling reveals a reflection would be geometrically possible.

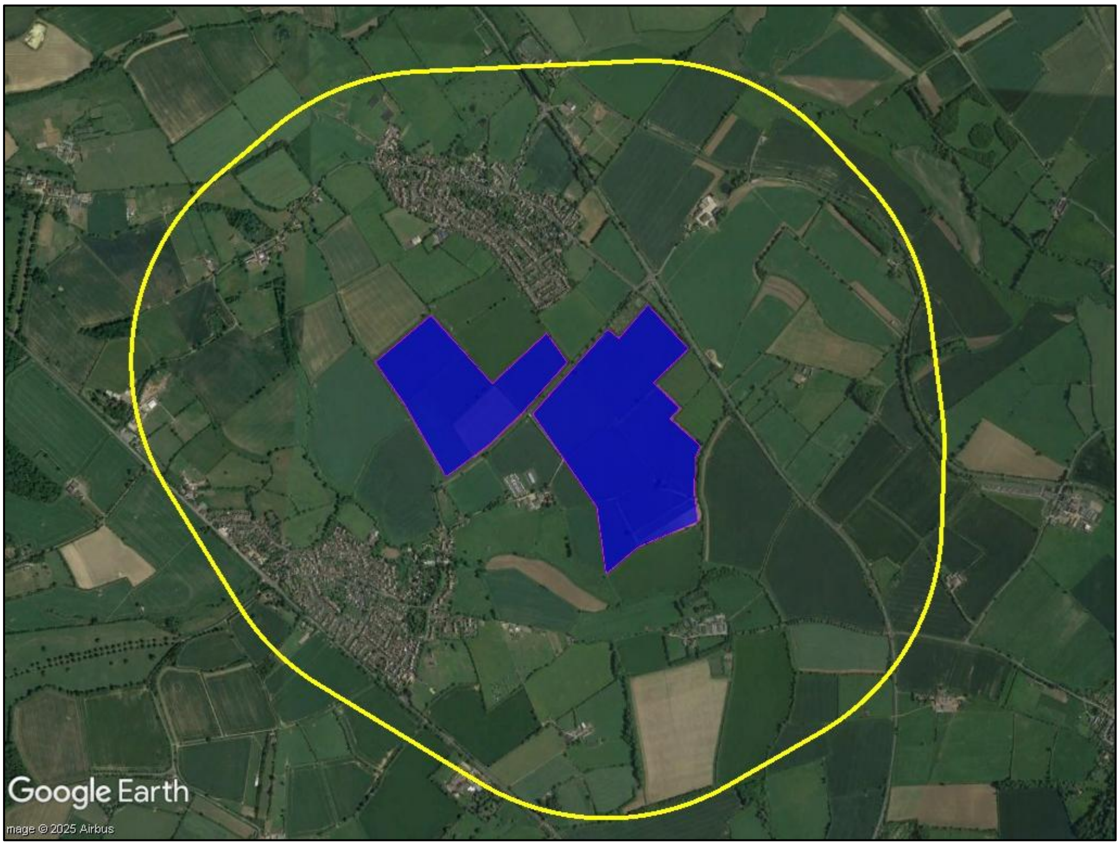

Figure 7 1km *assessment area*

4.2 Road Receptors

4.2.1 Road Receptors Overview

Road types can generally be categorised as:

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

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

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

4.2.2 Identified Road Receptors

A 2.9km section of the A508, and a 2km section of the A5, have been identified within the assessment area. The road sections are shown by the orange and light blue lines respectively in Figure 8 on the following page.

Potential views of the development are not deemed possible from the A5 due to screening in the form of existing vegetation and buildings which are highlighted in green and white respectively in Figure 9. Representative Streetview imagery is shown in Figures 10 and 11. Hence the A5 has not been taken forward for geometric modelling.

Views are considered possible from the A508, and thus this section has been taken forward for geometric modelling. Receptors are placed approximately 100m apart along the A508 and are shown in Figure 12 on page 26. An additional height of 1.5m is added to the terrain height to account for the eye-level[8] of a typical road user.

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

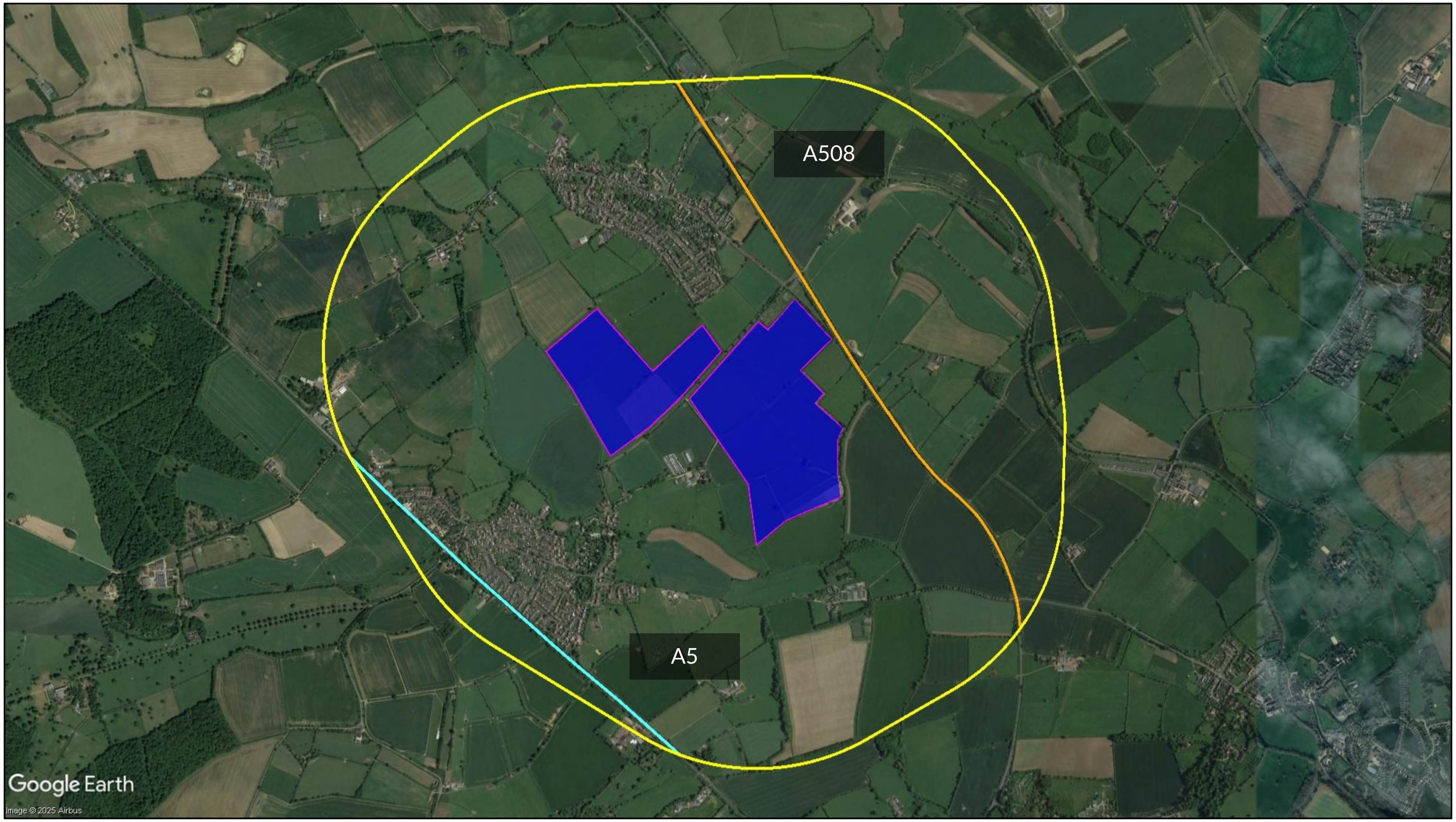

Figure 8 *Assessed roads within the 1km assessment area*

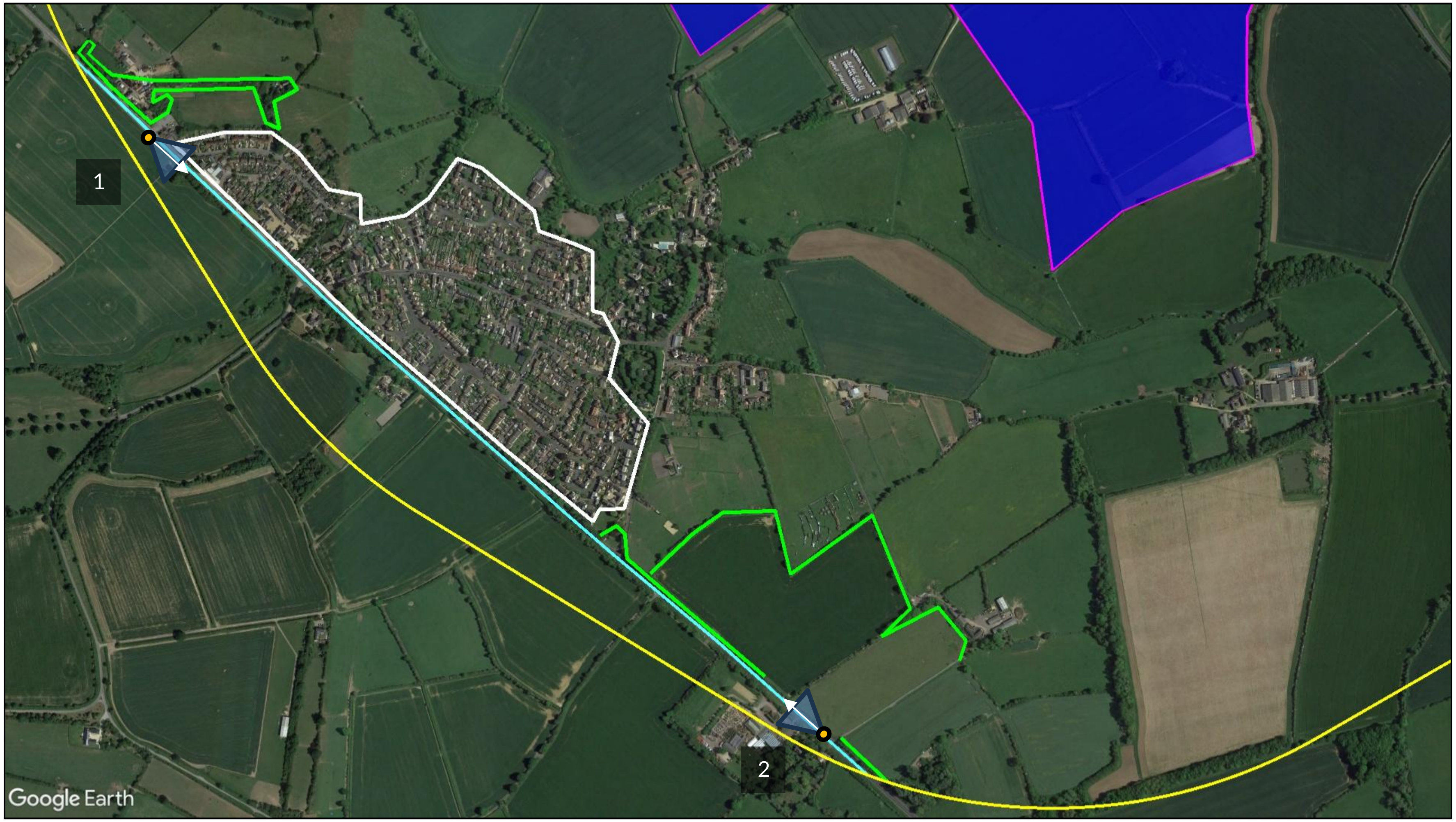

Figure 9 *Screening identified for the A5*

Figure 10 *A5 Streetview imagery – Point 1*

Figure 11 *A5 Streetview imagery – Point 2*

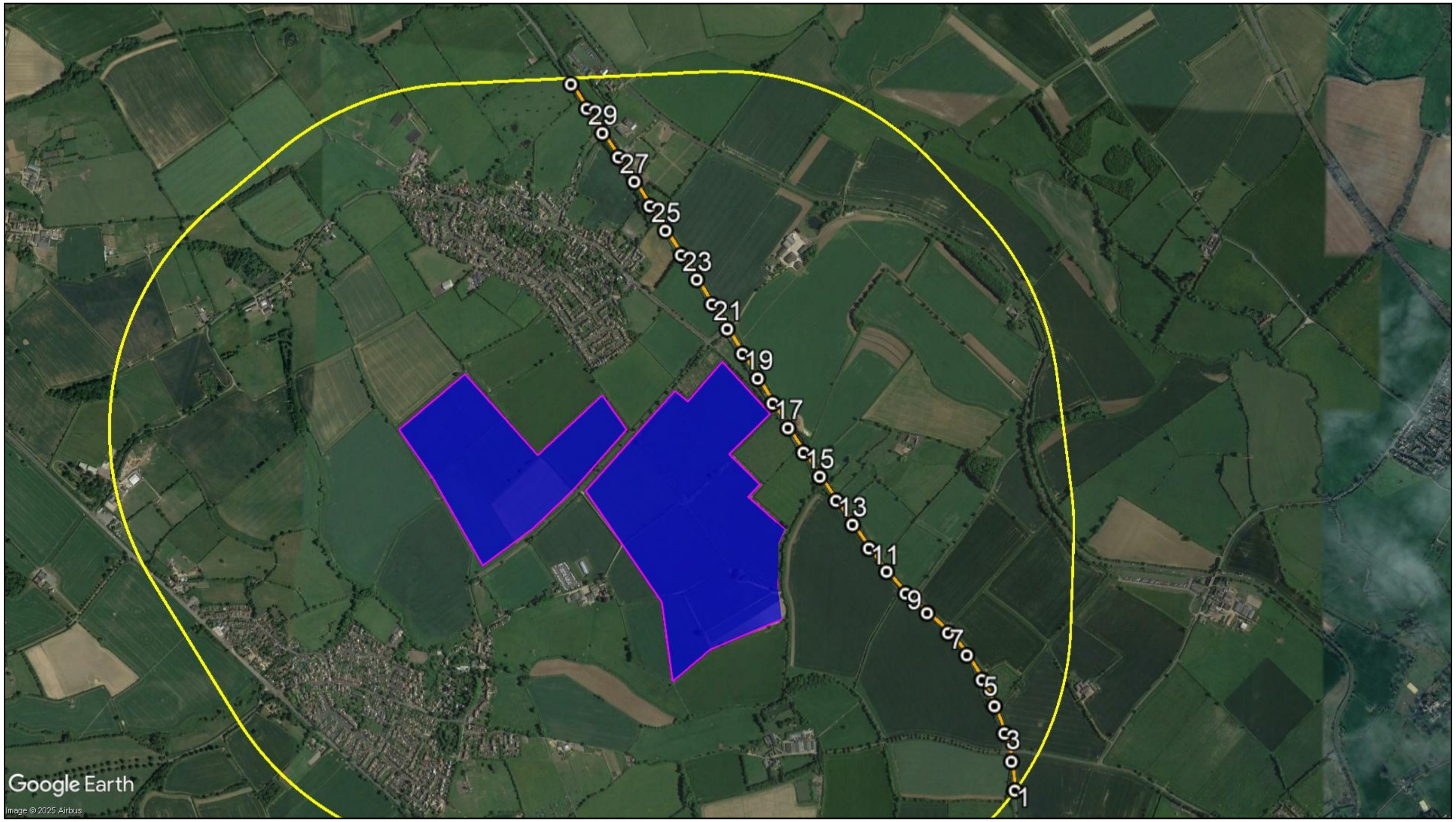

Figure 12 *Road receptors placed along the A508*

4.3 Dwelling Receptors

4.3.1 Dwelling Receptors Overview

The analysis has considered dwellings that:

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

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

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

4.3.2 Identified Dwelling Receptors

100 dwelling receptors have been assessed. The assessed dwelling receptors are shown in Figures 13 to 15 on the following pages. 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[9].

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

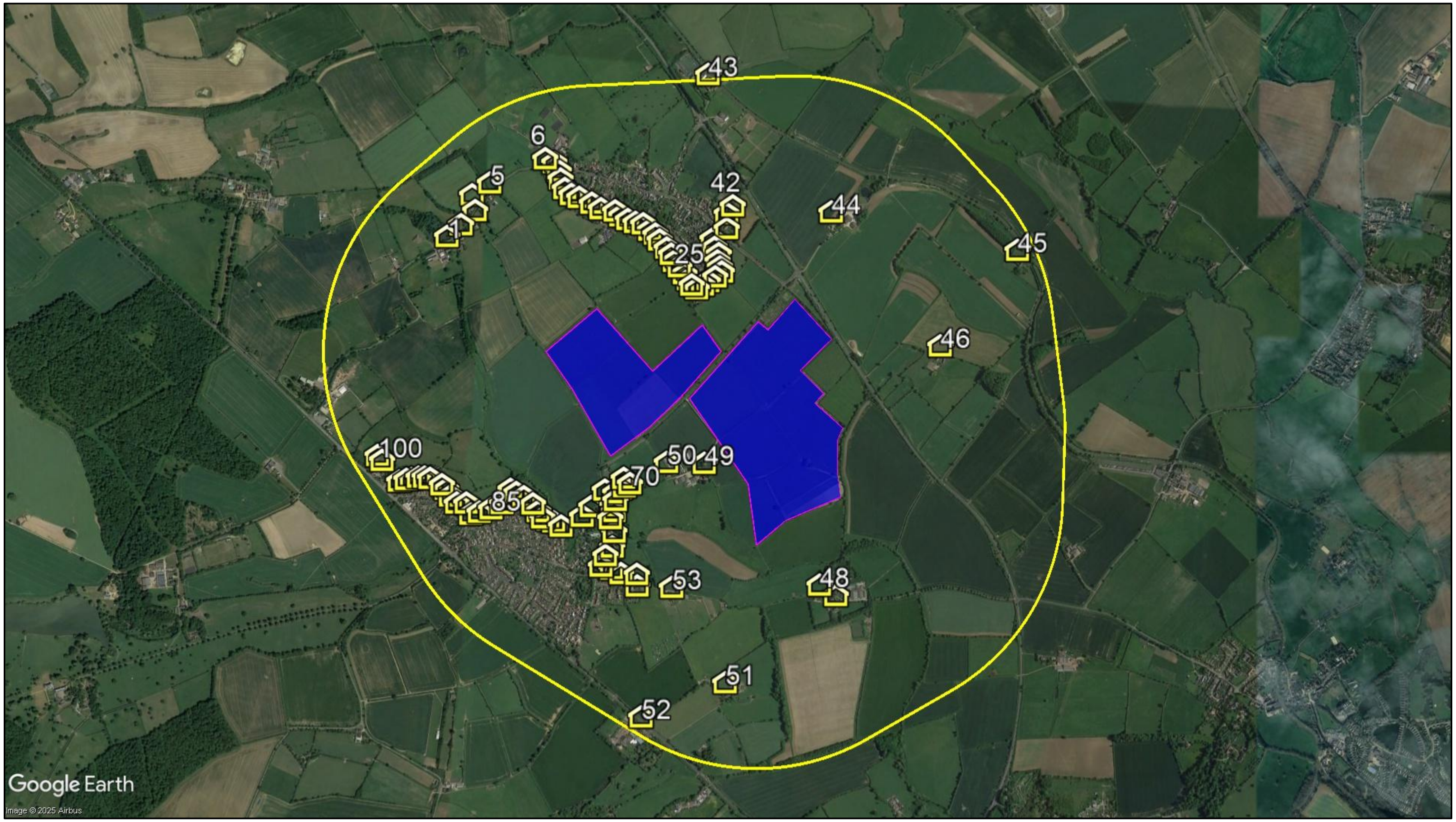

Figure 13 *Overview of dwelling receptors*

Figure 14 *Dwelling receptors zoomed in view - North*

Figure 15 *Dwelling receptors zoomed in view - South*

5 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

5.1 Overview

The following sections present:

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

5.2 Road Results

5.2.1 Key Considerations – Roads

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

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

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

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

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

- Whether visibility is likely for elevated drivers (applicable to dual carriageways and motorways only) – there is typically a higher density of elevated drivers (such as HGVs) along dual carriageways and motorways compared to other types of road;
- Whether a solar reflection is fleeting in nature. Small gap/s in screening (e.g., an access point to the site) may not result in a sustained reflection for a road user;

- The separation distance to the panel area – larger separation distances reduce the proportion of an observer's field of view that is affected by glare;
- The position of the Sun – effects that coincide with direct sunlight appear less prominent than those that do not;
- Whether the solar reflection originates from directly in front of a road user – a solar reflection that is directly in front of a road user is more hazardous than a solar reflection to one side.

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

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

5.2.2 Geometric Modelling Results and Discussion - Roads

Table 2 on the following page present the following:

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

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)[10]	Mitigating Factors	Predicted Impact Classification
1 – 30	Solar reflections **are not** geometrically possible	N/A	N/A	N/A	No impact

Table 2 *Geometric Modelling Results - Road Receptors*

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

5.3 Dwelling Results

5.3.1 Key Considerations - Dwellings

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

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

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

- Whether solar reflections will be experienced from all storeys. The ground floor is typically considered the main living space and therefore has a greater significance with respect to residential amenity;
- The separation distance to the panel area. Larger separation distances reduce the proportion of an observer's field of view that is affected by glare;
- 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;
- Whether the dwelling appears to have windows facing the reflecting areas. An observer may need to look from a wide angle to observe the reflecting areas.

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

5.3.2 Geometric Modelling Results and Discussion - Dwellings

Table 3 on the following pages presents the following:

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

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[11]	Mitigating Factors	Predicted Impact Classification
1	Solar reflections are geometrically possible for: More than 3 months Less than 60 minutes	Intervening terrain is predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
2 – 3	Solar reflections are geometrically possible for: Less than 3 months Less than 60 minutes	Intervening terrain is predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
4 – 5	Solar reflections are geometrically possible for: More than 3 months Less than 60 minutes	Existing vegetation is predicted to significantly obstruct views of reflecting panels	None	N/A	No impact

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

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[11]	Mitigating Factors	Predicted Impact Classification
6 – 8	Solar reflections **are** geometrically possible for: **Less** than 3 months **Less** than 60 minutes	Existing buildings are predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
9 – 10	Solar reflections **are** geometrically possible for: **More** than 3 months **Less** than 60 minutes	Existing buildings are predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
11	Solar reflections **are** geometrically possible for: **Less** than 3 months **Less** than 60 minutes	Existing buildings are predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
12 – 17	Solar reflections **are** geometrically possible for: **More** than 3 months **Less** than 60 minutes	Existing vegetation, buildings, and proposed vegetation are predicted to significantly obstruct views of reflecting panels	None	N/A	No impact

Dwelling Receptor	**Geometric Modelling Results (screening not considered)**	**Identified Screening and Predicted Visibility (desk-based review)**	Duration of effects (with consideration of screening)[11]	**Mitigating Factors**	**Predicted Impact Classification**
18 – 19	Solar reflections **are** geometrically possible for: **Less** than 3 months **Less** than 60 minutes	Existing buildings are predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
20 – 21	Solar reflections **are** geometrically possible for: **More** than 3 months **Less** than 60 minutes	Existing vegetation and buildings are predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
22	Solar reflections **are** geometrically possible for: **Less** than 3 months **Less** than 60 minutes	Proposed vegetation is predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
23 – 30	Solar reflections **are** geometrically possible for: **More** than 3 months **Less** than 60 minutes	Proposed vegetation is predicted to significantly obstruct views of reflecting panels	None	N/A	No impact

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[11]	Mitigating Factors	Predicted Impact Classification
31	Solar reflections **are** geometrically possible for: **Less** than 3 months **Less** than 60 minutes	Proposed vegetation is predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
32	Solar reflections **are not** geometrically possible	N/A	N/A	N/A	No impact
33	Solar reflections **are** geometrically possible for: **Less** than 3 months **Less** than 60 minutes	Proposed vegetation is predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
34	Solar reflections **are not** geometrically possible	N/A	N/A	N/A	No impact
35	Solar reflections **are** geometrically possible for: **Less** than 3 months **Less** than 60 minutes	Existing vegetation and buildings are predicted to significantly obstruct views of reflecting panels	None	N/A	No impact

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[11]	Mitigating Factors	Predicted Impact Classification
36 - 41	Solar reflections **are** geometrically possible for: **More** than 3 months **Less** than 60 minutes	Existing vegetation and buildings are predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
42 – 46	Solar reflections **are not** geometrically possible	N/A	N/A	N/A	No impact
47 – 48	Solar reflections **are** geometrically possible for: **Less** than 3 months **Less** than 60 minutes	Proposed vegetation is predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
49 – 50	Solar reflections **are** geometrically possible for: **More** than 3 months **Less** than 60 minutes	Existing and proposed vegetation is predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
51 – 52	Solar reflections **are not** geometrically possible	N/A	N/A	N/A	No impact

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[11]	Mitigating Factors	Predicted Impact Classification
53	Solar reflections **are** geometrically possible for: **Less** than 3 months **Less** than 60 minutes	Existing buildings and proposed vegetation are predicted to partially obstruct views of reflecting panels	None	N/A	No impact
54 – 64	Solar reflections **are** geometrically possible for: **More** than 3 months **Less** than 60 minutes	Existing vegetation, proposed vegetation, and/or buildings are predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
65 – 72	Solar reflections **are not** geometrically possible	N/A	N/A	N/A	No impact
73 – 82	Solar reflections **are** geometrically possible for: **More** than 3 months **Less** than 60 minutes	Existing vegetation and/or buildings are predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
83	Solar reflections **are not** geometrically possible	N/A	N/A	N/A	No impact

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[11]	Mitigating Factors	Predicted Impact Classification
84 – 90	Solar reflections **are** geometrically possible for: **More** than 3 months **Less** than 60 minutes	Existing vegetation is predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
91	Solar reflections **are not** geometrically possible	N/A	N/A	N/A	No impact
92 – 93	Solar reflections **are** geometrically possible for: **Less** than 3 months **Less** than 60 minutes	Existing vegetation is predicted to significantly obstruct views of reflecting panels	None	N/A	No impact
94 – 98	Solar reflections **are** geometrically possible for: **More** than 3 months **Less** than 60 minutes	Existing vegetation is predicted to significantly obstruct views of reflecting panels	None	N/A	No impact

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[11]	Mitigating Factors	Predicted Impact Classification
99 – 100	Solar reflections **are not** geometrically possible	N/A	N/A	N/A	No impact

Table 3 *Geometric Modelling Results - Dwelling Receptors*

5.3.3 Desk-Based Review of Available Imagery

A desk-based review of the available imagery is presented in Figures 16 to 30 on the following pages. The cumulative reflecting panel areas are indicated by regions of yellow. The identified screening in the form of existing vegetation, proposed vegetation, and buildings are outlined in green, white, and blue respectively. High-level Zones of Theoretical Visibility (ZTV Viewshed) generated[12] by Google Earth have been used to show the intervening terrain between the proposed development and relevant dwelling receptors, visible areas are illustrated by scattered green regions.

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

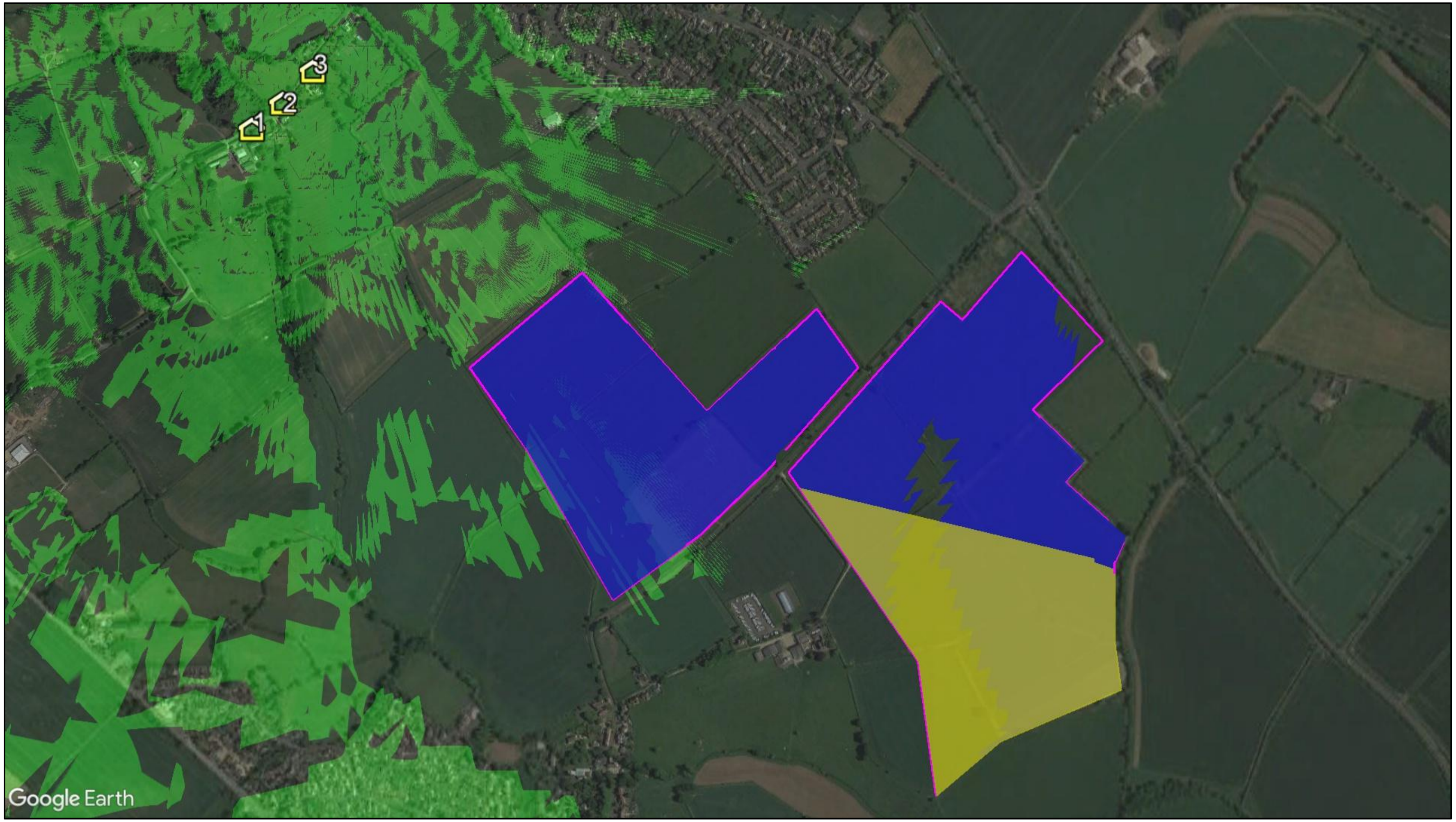

Figure 16 *Screening for dwellings 1 to 3, with representative ZTV from dwelling 3*

Figure 17 *Screening for dwellings 4 to 15*

Figure 18 *Screening for dwellings 16 to 21*

Figure 19 *Screening for dwellings 22 to 34*

Figure 20 *Screening for dwellings 35 to 39*

Figure 21 *Screening for dwellings 40 & 41*

Figure 22 *Screening for dwellings 47 & 48*

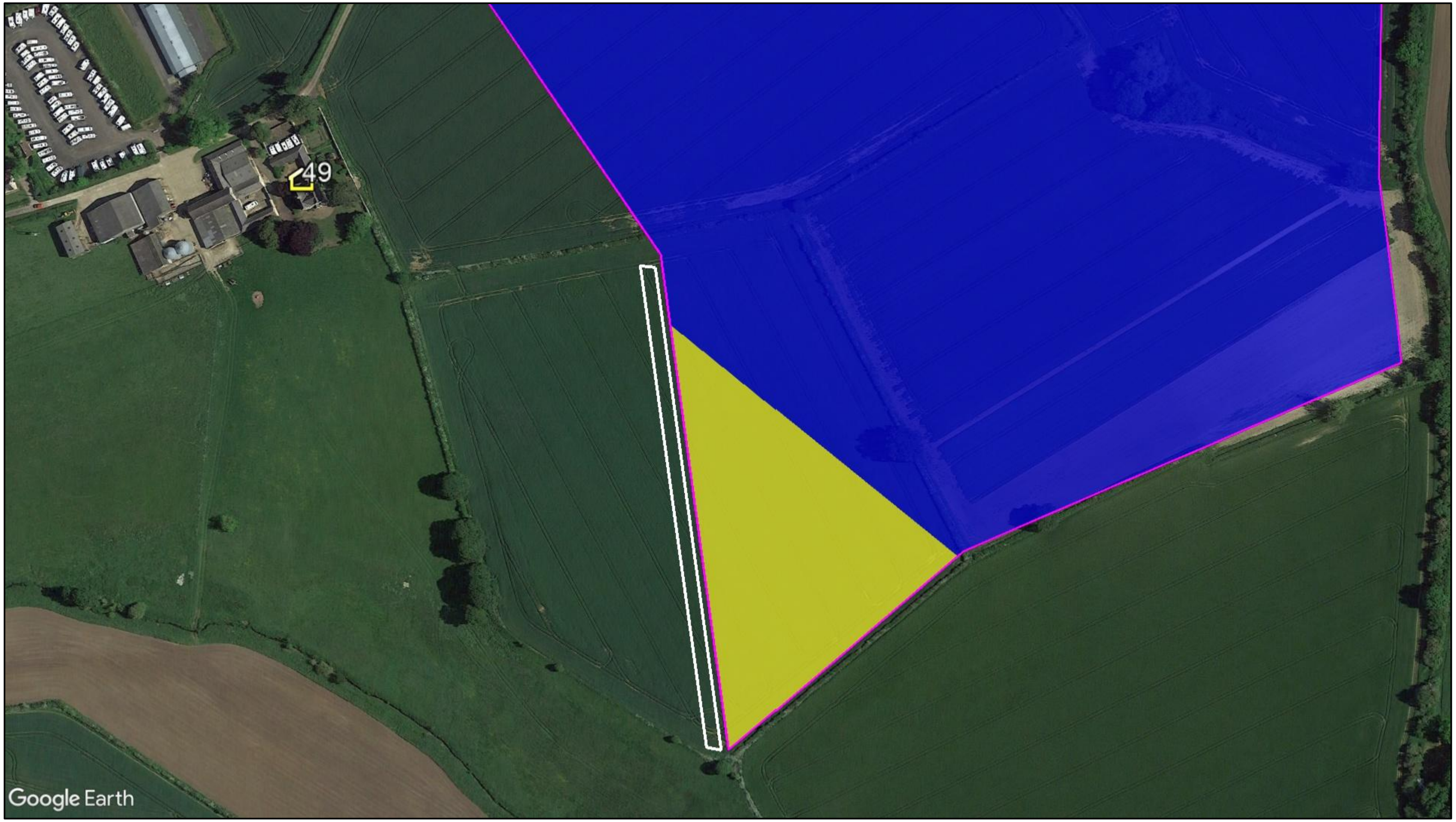

Figure 23 *Screening for dwelling 49*

Figure 24 *Screening for dwelling 50*

Figure 25 *Screening for dwellings 53 to 56*

Figure 26 *Screening for dwellings 57 to 61*

Figure 27 *Screening for dwelling 62*

Figure 28 *Screening for dwellings 63 & 64*

Figure 29 *Screening for dwellings 73 & 74*

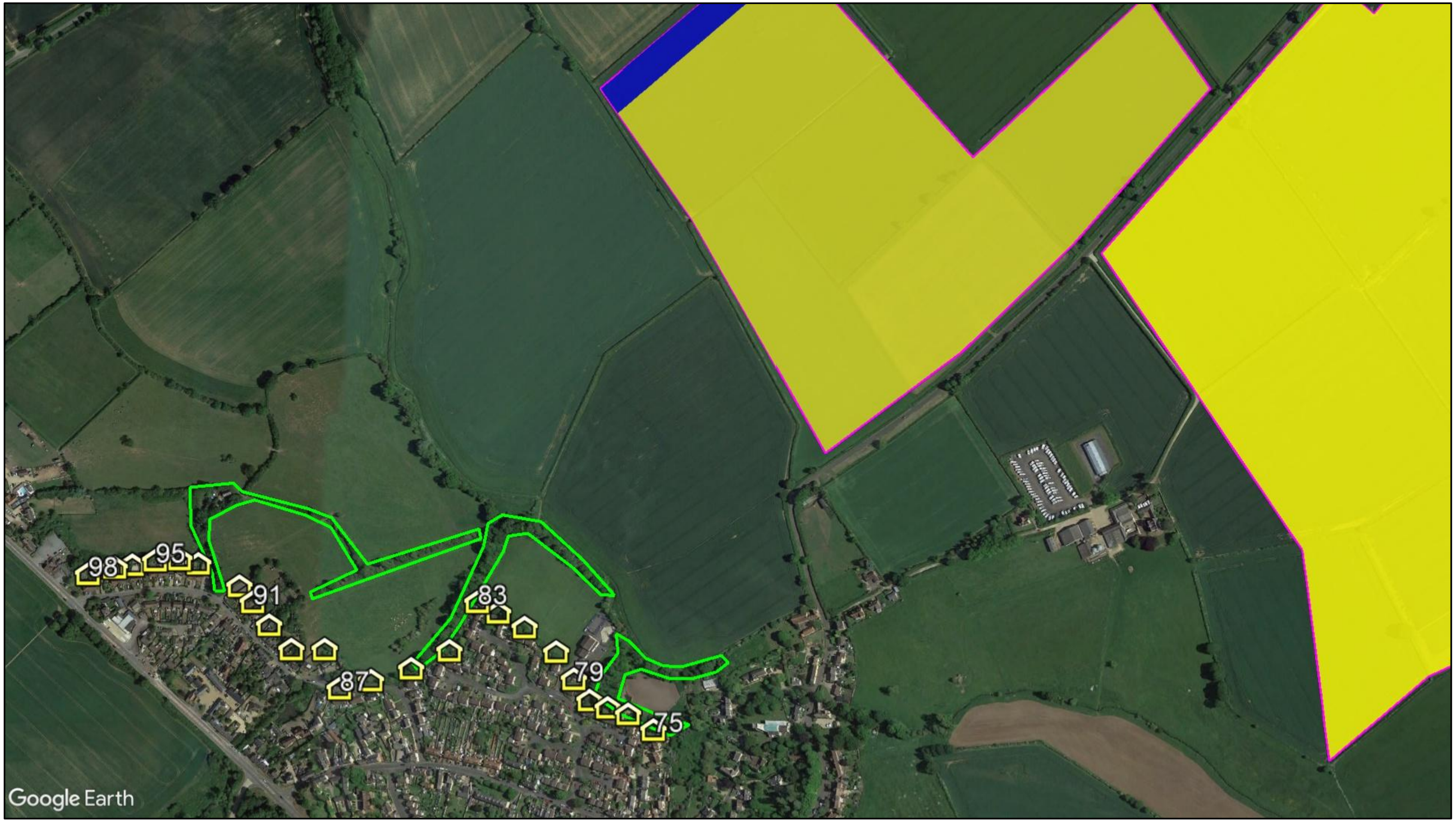

Figure 30 *Screening for dwellings 75 to 98*

6 HIGH-LEVEL ASSESSMENT OF AVIATION ACTIVITY

6.1 Overview

Glint and glare assessments for aviation receptors are typically undertaken for licensed aerodromes within 10km of a proposed solar development. Geometric modelling for General Aviation (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 sections present an overview of the potential effects of glint and glare concerning aviation activity at Hall Farm Airfield, Buttermilk Hall Airfield, Thornborough Grounds Airfield, and New Farm Airfield. The proposed development size, distance between the aerodrome and proposed development, and industry experience are considered to determine the impact during the assessment.

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

6.2 Airfield Details

6.2.1 Hall Farm Airfield

Hall Farm Airfield is approximately 6.5km southwest relative to the proposed development. It is an unlicensed airfield and is understood to not have an Air Traffic Control (ATC) Tower. The aerodrome has one runway, the details[13] of which are presented below:

- 11/29 measuring 335m by 8m (grass).

The locations of the aerodrome relative to the proposed development and 1-mile splayed approach paths for Hall Farm Airfield are shown in Figure 31 below.

Figure 31 *Proposed development relative to the 1-mile splayed approach paths for Hall Farm Airfield*

[13] Source: As determined from available aerial imagery.

6.2.2 Buttermilk Hall Airfield

Buttermilk Hall Airfield is approximately 7.2km northwest relative to the proposed development. It is an unlicensed airfield and is understood to not have an ATC Tower. The aerodrome has one runway, the details[14] of which are presented below:

- 12/30 measuring 550m by 10m (grass).

The locations of the aerodrome relative to the proposed development and 1-mile splayed approach paths for Buttermilk Hall Airfield are shown in Figure 32 below.

Figure 32 *Proposed development relative to the 1-mile splayed approach paths for Buttermilk Hall Airfield*

[14] Source: As determined from available aerial imagery, & Skydemon.

6.2.3 Thornborough Grounds Airfield

Thornborough Grounds Airfield is approximately 9.3km southwest relative to the proposed development. It is an unlicensed airfield and is understood to not have an ATC Tower. The aerodrome has one runway, the details[15] of which are presented below:

- 06/24 measuring 500m by 16m (grass).

The locations of the aerodrome relative to the proposed development and 1-mile splayed approach paths for Thornborough Grounds Airfield are shown in Figure 33 below.

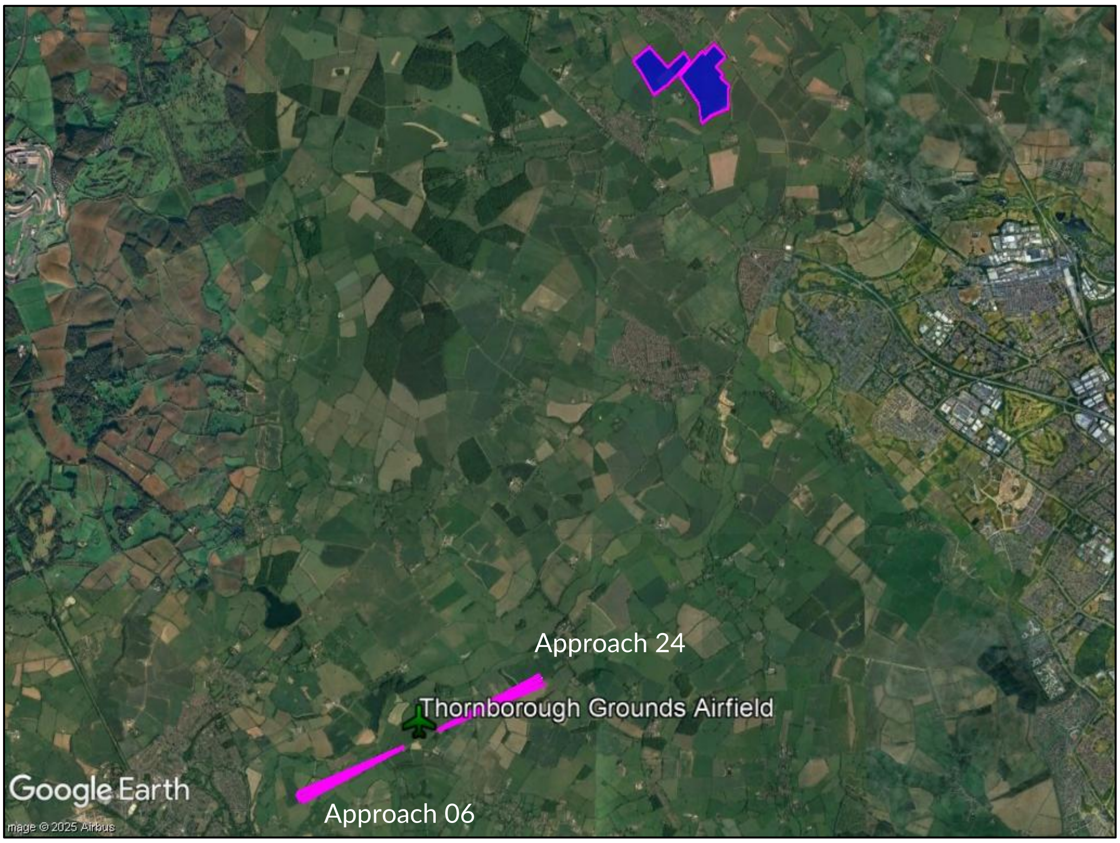

Figure 33 *Proposed development relative to the 1-mile splayed approach paths for Thornborough Grounds Airfield*

[15] Source: As determined from available aerial imagery, & Pooley's Flight Guide (2025).

6.2.4 New Farm Airfield

New Farm Airfield is approximately 9.7km northeast relative to the proposed development. It is an unlicensed airfield and is understood to not have an ATC Tower. The aerodrome has one runway, the details[16] of which are presented below:

- 08/26 measuring 550m by 35m (grass).

The locations of the aerodrome relative to the proposed development and 1-mile splayed approach paths for New Farm Airfield are shown in Figure 34 below.

Figure 34 *Proposed development relative to the 1-mile splayed approach paths for New Farm Airfield*

[16] Source: As determined from available aerial imagery.

6.3 High-Level Assessment Conclusions

Considerations of the proposed development size, distance between the aerodrome and proposed development, and industry experience are made during the assessment. The associated guidance pertaining to approach paths is presented in Appendix D.

For aviation activity associated with Hall Farm Airfield, Buttermilk Hall Airfield, Thornborough Grounds Airfield, and New Farm Airfield, any solar reflections are predicted to be acceptable in accordance with the associated guidance (Appendix D) and industry best practice due to the following two factors:

- Solar reflections towards pilots approaching runway thresholds 11 at Hall Farm Airfield, 12 at Buttermilk Hall Airfield, 06 at Thornborough Grounds Airfields, and 26 at New Farm Airfield, are predicted to have glare intensities no greater than 'low potential for temporary after-image';
- Solar reflections towards pilots approaching runway thresholds 29 at Hall Farm Airfield, 30 at Buttermilk Hall Airfield, 24 at Thornborough Grounds Airfields, and 08 at New Farm Airfield are predicted to occur outside a pilot's primary field-of-view (50 degrees horizontally either side of the direction of travel);
- Solar reflections towards the final sections of visual circuits and joins at all assessed airfields are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance pertaining to approach paths, which states that this level of glare is acceptable, it can reliably be concluded that this level of glare is also acceptable for the visual circuits and joins.

Therefore, a low impact is predicted upon aviation activity at Hall Farm Airfield, Buttermilk Hall Airfield, Thornborough Grounds Airfield, and New Farm Airfield. Detailed modelling is not recommended, and mitigation is not required.

7 OVERALL CONCLUSIONS

7.1 Assessment Conclusions – Roads

Solar reflections are not geometrically possible towards the assessed section of the A508. No impact is predicted and mitigation is not required.

7.2 Assessment Conclusions – Dwellings

Solar reflections are geometrically possible towards 79 of the 100 assessed dwellings.

Screening in the form of existing vegetation, proposed vegetation, buildings, and/or intervening terrain is predicted to significantly obstruct views of reflecting panels for all 79 dwellings. No impact is predicted and mitigation is not required.

7.3 High-Level Aviation Assessment Conclusions

Solar reflections towards the splayed approaches and final sections of visual circuits at Hall Farm Airfield, Buttermilk Hall Airfield, Thornborough Grounds Airfield, and New Farm Airfield are predicted to occur outside a pilot's field-of-view (50 degrees either side relative to the runway threshold bearing) or have intensities no greater than 'low potential for temporary after-image'. No significant impact is predicted and mitigation is not required.

7.4 Overall Conclusions

No significant impacts are predicted upon road safety, residential amenity, or aviation activity associated with Hall Farm Airfield, Buttermilk Hall Airfield, Thornborough Grounds Airfield, and New Farm Airfield. Mitigation is not recommended.

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

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

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

UK Planning Policy

Renewable and Low Carbon Energy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[17] (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.'

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

National Policy Statement for Renewable Energy Infrastructure

The National Policy Statement for Renewable Energy Infrastructure (EN-3)[18] 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.[19] 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.

[18] National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Energy Security & Net Zero, date: January 2024, accessed on: 17/01/2024.

[19] *'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[20] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

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

Aviation Assessment Guidance

The UK Civil Aviation Authority (CAA) issued interim guidance relating to Solar Photovoltaic Systems (SPV) on 17 December 2010 and was subject to a CAA information alert 2010/53. The formal policy was cancelled on September 7th, 2012[21] however the advice is still applicable[22] until a formal policy is developed. The relevant aviation guidance from the CAA is presented in the section below.

CAA Interim Guidance

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

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

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

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

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

12. If an installation of SPV systems is planned on-aerodrome (i.e. within its licensed boundary) then it is recommended that data on the reflectivity of the solar panel material should be included in any assessment before installation approval can be granted. Although approval for installation is the responsibility of the ALH[23], 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.

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[21] Archived at Pager Power

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

[23] Aerodrome Licence Holder.

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

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

FAA Guidance

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

The 2010 document is entitled 'Technical Guidance for Evaluating Selected Solar Technologies on Airports'[24], the 2013 update is entitled 'Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'[25], and the 2021 final policy is entitled 'Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports'[26].

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.

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[24] Archived at Pager Power

[25] 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.

[26] 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.

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

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

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

In 2018, the FAA released the latest version (Version 1.1) of the 'Technical Guidance for Evaluating Selected Solar Technologies on Airports'[27]. 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[28].
- 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[29], 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

[27] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.
[28] 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.
[29] First figure in Appendix B.

land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:

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

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

blindness. It is known that this distance is directly proportional to the size of the array in question[30] but still requires further research to definitively answer.

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

Air Navigation Order (ANO) 2016

In some instances, an aviation stakeholder can refer to the ANO 2016[31] 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.

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[30] 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.

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

Lights which dazzle or distract

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

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

Endangering safety of an aircraft

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

Endangering safety of any person or property

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

Civil Aviation Authority consolidation of UK Regulation 139/2014

The Civil Aviation Authority (CAA) published a consolidating document[32] of UK regulations, (Implementing Rules, Acceptable Means of Compliance and Guidance Material), in 2023. A summary of material relevant to aerodrome safeguarding is presented below:

(a) The aerodrome operator should have procedures to monitor the changes in the obstacle environment, marking and lighting, and in human activities or land use on the aerodrome and the areas around the aerodrome, as defined in coordination with the CAA. The scope, limits, tasks and responsibilities for the monitoring should be defined in coordination with the relevant air traffic services providers, and with the CAA and other relevant authorities.

(b) The limits of the aerodrome surroundings that should be monitored by the aerodrome operator are defined in coordination with the CAA and should include the areas that can be visually monitored during the inspections of the manoeuvring area.

(c) The aerodrome operator should have procedures to mitigate the risks associated with changes on the aerodrome and its surroundings identified with the monitoring procedures. The scope, limits, tasks, and responsibilities for the mitigation of risks associated to obstacles or hazards outside the perimeter fence of the aerodrome should be defined in coordination with the relevant air traffic services providers, and with the CAA and other relevant authorities.

(d) The risks caused by human activities and land use which should be assessed and mitigated should include:

1. obstacles and the possibility of induced turbulence;
2. the use of hazardous, confusing, and misleading lights;
3. the dazzling caused by large and highly reflective surfaces;
4. sources of non-visible radiation, or the presence of moving, or fixed objects which may interfere with, or adversely affect, the performance of aeronautical communications, navigation and surveillance systems; and
5. non-aeronautical ground light near an aerodrome which may endanger the safety of aircraft and which should be extinguished, screened, or otherwise modified so as to eliminate the source of danger.

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

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

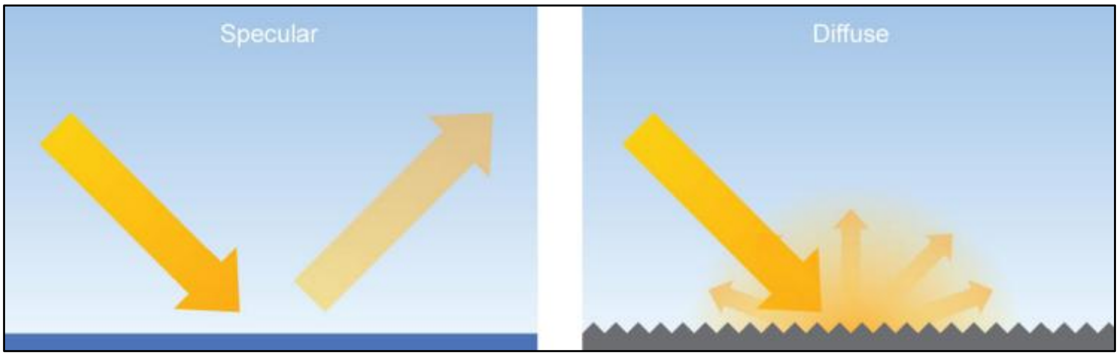
Overview

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[33], 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

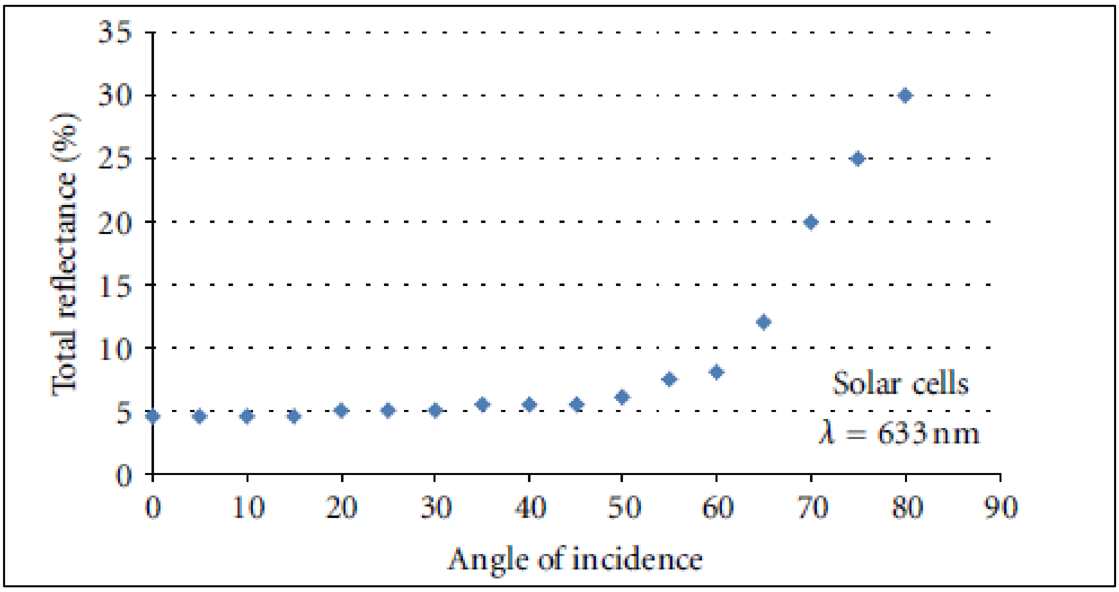
[33] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 12/09/2022.

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*[34]". 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.

[34] 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"[35]

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[36]
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).

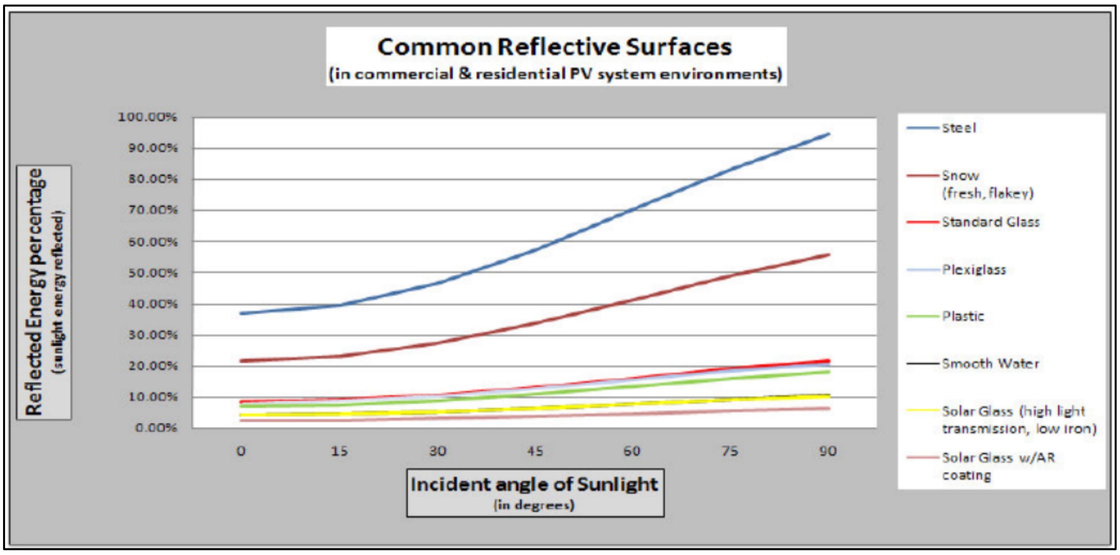
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

[35] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 12/09/2022.
[36] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification[37] 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.

[37] 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).

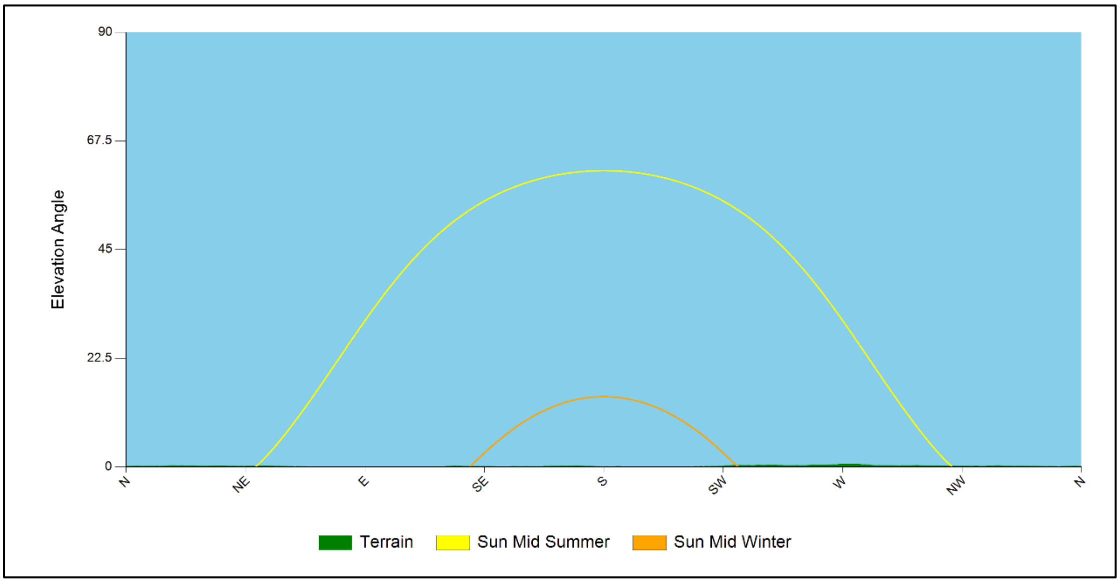
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

- 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.



Terrain at the visible horizon and sun paths

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact Significance Definition

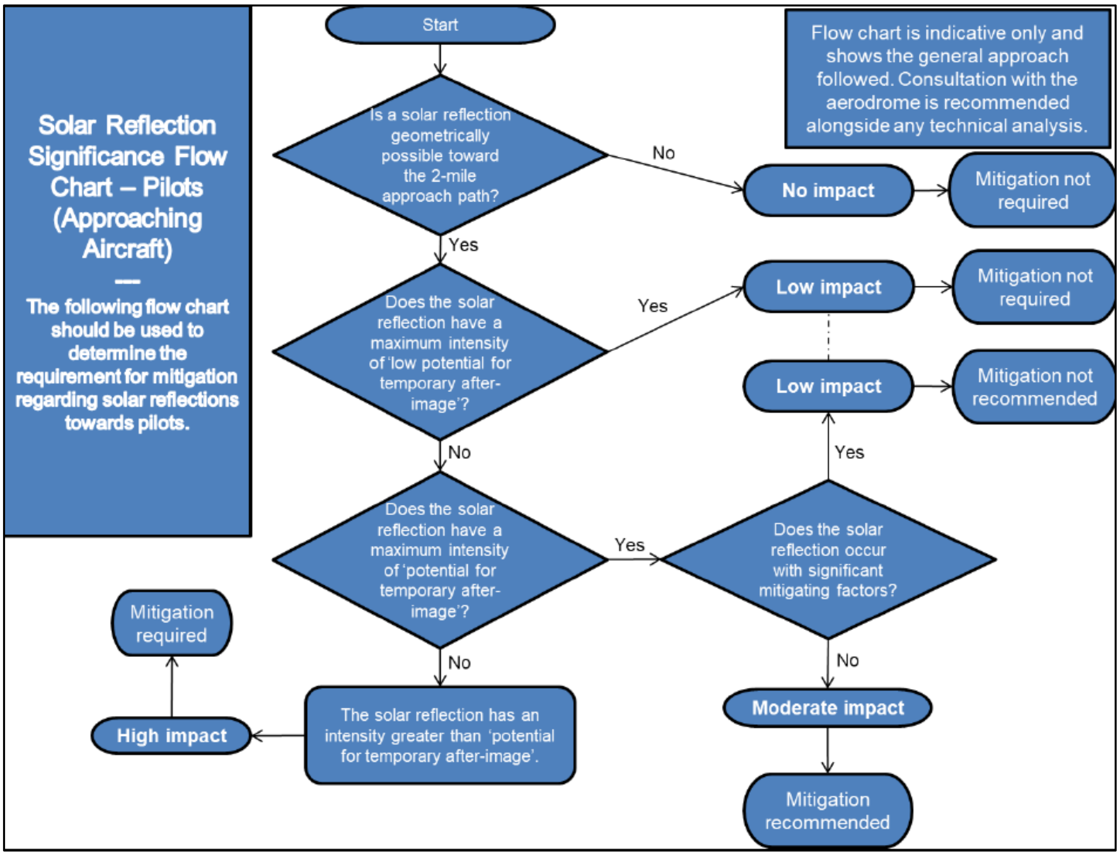
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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

Impact significance definition

Impact Significance Determination for Approaching Aircraft

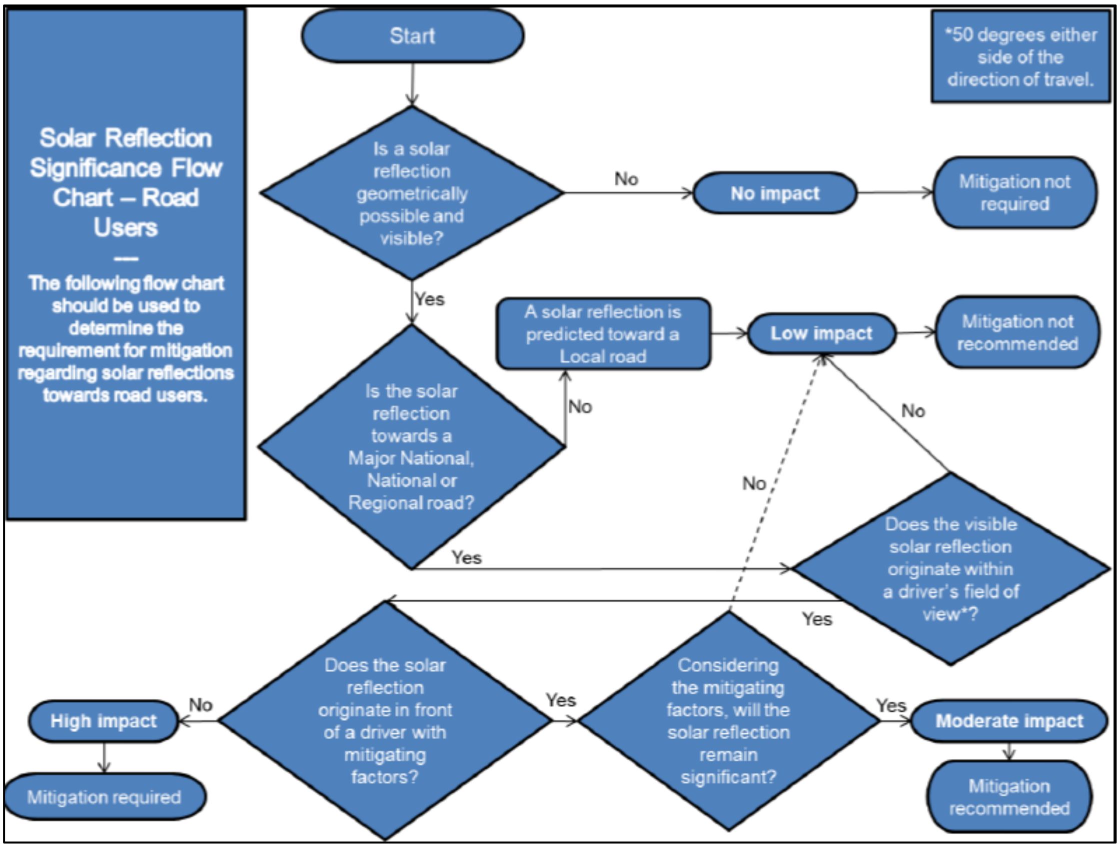
The flow chart presented below has been followed when determining the impact significance for approaching aircraft.



Approach path receptor impact significance flow chart

Impact Significance Determination for Road Receptors

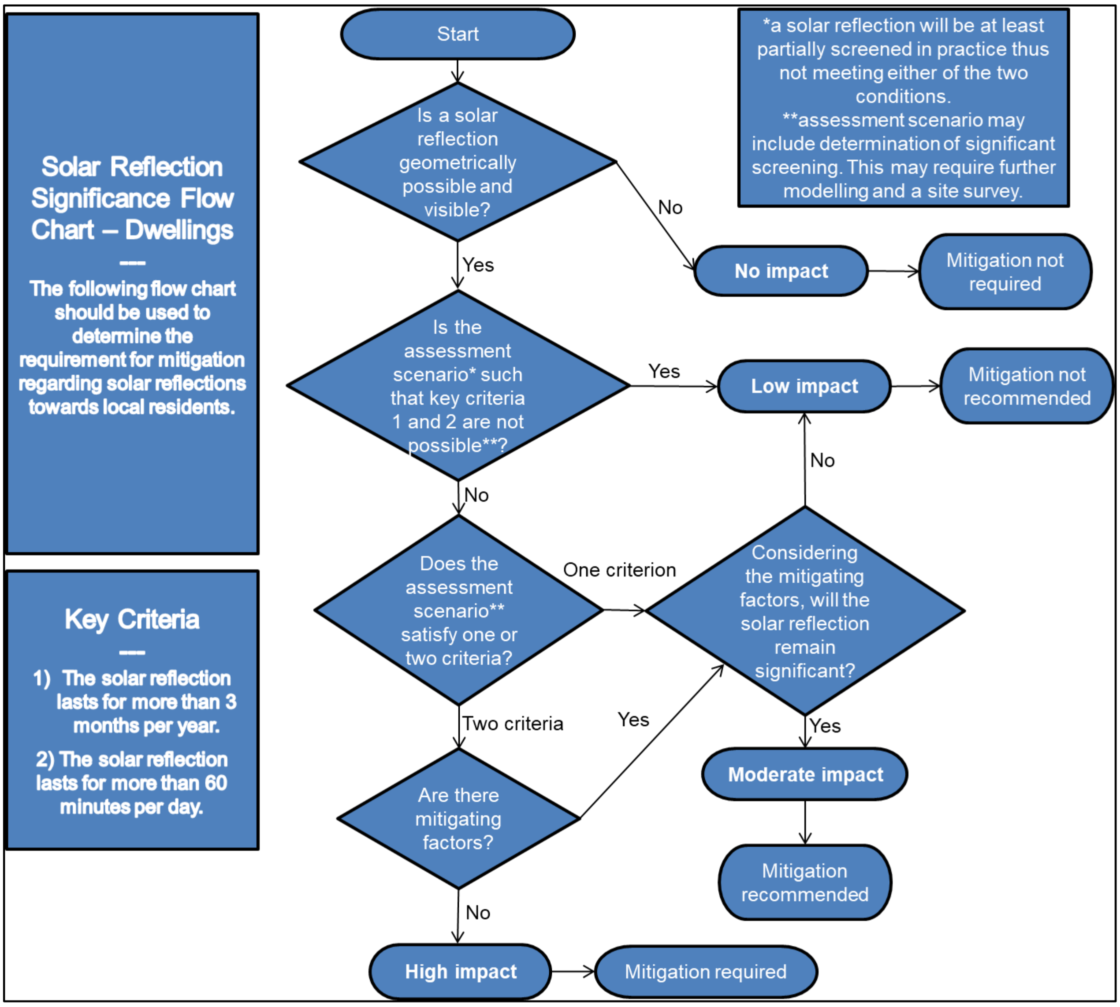
The flow chart presented below has been followed when determining the impact significance for road receptors.



Road receptor impact significance flow chart

Impact Significance Determination for Dwelling Receptors

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



Dwelling receptor impact significance flow chart

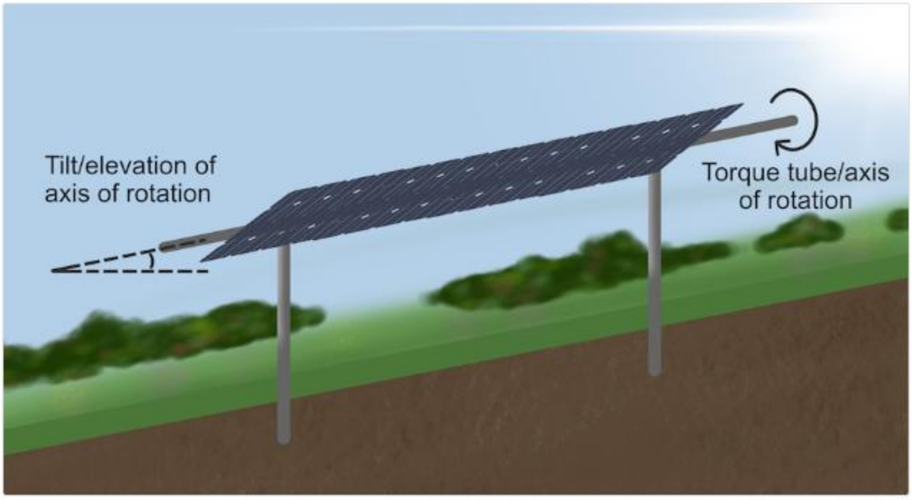
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Forge Reflection Calculations Methodology

Extracts taken from the Forge Solar Model.

Tracking System Parameters

Single-axis module tracking systems are described by a unique set of parameters. These angular inputs model the tracking axis, rotation range and backtracking behavior. Dual-axis module tracking systems are assumed to track the sun at all times.



Single-axis tracking system with torque tube tilted due to geography

Tilt of tracking axis (°)
Tilt above flat ground of axis over which panels rotate (e.g. torque tube). System on flat, level ground would have axis tilt of 0°.

Orientation of tracking axis (°)
Azimuthal angle of axis over which panels rotate. Angle represents the facing of the axis and system. For example, typical tracking system in northern hemisphere has tracking axis oriented north-south with an orientation of 180°, allowing panels to rotate east-west with potential south-facing tilt. Typical tracking system in southern hemisphere runs south-north with axis orientation of 0°, yielding east-west rotation with potential north-facing tilt.

Offset angle of module (°)
Additional tilt angle of PV module elevated above tracking axis/torque tube. Offset angle is measured from the torque tube.

Maximum tracking angle (°)
Maximum angle of rotation of tracking system in one direction. For example, a typical system with a 120° range of rotation has a *max tracking angle* of 60° (east/west).

Resting angle (°)
Angle of rotation of panels when sun is outside tracking range. Used to model backtracking. Panels will revert to the position described by this rotation angle at all times when the sun is outside the rotation range. Setting this equal to the *maximum tracking angle* implies the panels do not backtrack.

ForgeSolar utilizes a simplified model of backtracking which assumes panels instantaneously revert to the *resting angle* whenever the sun is outside the rotation range. For example, panels with *max tracking angle* of 60° and *resting angle* of 0° would lie flat from sunrise until the sun enters the rotation range, and immediately after the sun leaves the rotation range until sunset daily.

Tracking System Parameters

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Forge's Sandia National Laboratories' (SGHAT) Model

The following text is taken from Forge[38] 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.

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

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Overview

Data and terrain heights have been interpolated based on Ordnance Survey (OS) 50 Digital Terrain Model (DTM) data.

Road Receptor Data

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

No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)	No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)
1	52.07880	-0.86153	85.50	16	52.09002	-0.87298	90.93
2	52.07969	-0.86170	86.30	17	52.09079	-0.87375	92.50
3	52.08056	-0.86205	86.04	18	52.09156	-0.87451	92.50
4	52.08141	-0.86255	84.98	19	52.09232	-0.87528	92.50
5	52.08222	-0.86319	84.28	20	52.09309	-0.87605	92.36
6	52.08299	-0.86395	83.44	21	52.09385	-0.87682	91.65
7	52.08367	-0.86489	83.50	22	52.09462	-0.87759	91.95
8	52.08429	-0.86596	82.64	23	52.09538	-0.87838	91.02
9	52.08490	-0.86704	82.66	24	52.09613	-0.87917	88.89
10	52.08557	-0.86800	82.79	25	52.09689	-0.87995	85.31
11	52.08629	-0.86889	83.50	26	52.09765	-0.88074	81.28
12	52.08703	-0.86972	84.59	27	52.09841	-0.88154	80.50
13	52.08777	-0.87055	85.50	28	52.09916	-0.88235	78.81
14	52.08852	-0.87137	87.63	29	52.09991	-0.88315	78.36
15	52.08926	-0.87219	89.57	30	52.10067	-0.88394	78.50

Road receptor data

Dwelling Receptor Data

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

No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)	No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)
1	52.09403	-0.89916	92.80	51	52.07605	-0.88090	80.90
2	52.09450	-0.89825	92.89	52	52.07468	-0.88642	87.42
3	52.09508	-0.89732	97.01	53	52.07990	-0.88441	88.16
4	52.09571	-0.89752	97.04	54	52.07995	-0.88668	92.05
5	52.09619	-0.89636	100.80	55	52.08042	-0.88671	90.21
6	52.09717	-0.89272	102.80	56	52.08045	-0.88775	90.26
7	52.09701	-0.89213	103.80	57	52.08064	-0.88837	89.47
8	52.09667	-0.89184	103.80	58	52.08075	-0.88906	90.26
9	52.09635	-0.89172	103.80	59	52.08118	-0.88877	87.97
10	52.09597	-0.89144	103.09	60	52.08152	-0.88832	86.04
11	52.09572	-0.89100	102.80	61	52.08212	-0.88819	82.69
12	52.09561	-0.89049	102.80	62	52.08267	-0.88844	81.06
13	52.09537	-0.88966	102.80	63	52.08295	-0.88820	81.46
14	52.09515	-0.88907	101.80	64	52.08319	-0.88829	81.90
15	52.09506	-0.88813	101.80	65	52.08340	-0.88811	84.32
16	52.09486	-0.88777	101.80	66	52.08356	-0.88809	85.78
17	52.09472	-0.88730	101.54	67	52.08371	-0.88812	87.40
18	52.09460	-0.88680	101.44	68	52.08387	-0.88778	88.43
19	52.09455	-0.88629	100.57	69	52.08395	-0.88752	89.88

No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)	No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)
20	52.09429	-0.88586	100.34	70	52.08408	-0.88716	91.73
21	52.09413	-0.88549	99.80	71	52.08429	-0.88757	91.67
22	52.09389	-0.88521	99.80	72	52.08381	-0.88881	86.56
23	52.09356	-0.88475	99.80	73	52.08315	-0.88969	81.80
24	52.09332	-0.88445	99.80	74	52.08277	-0.89030	81.18
25	52.09303	-0.88425	99.80	75	52.08236	-0.89168	86.79
26	52.09282	-0.88392	99.80	76	52.08253	-0.89217	87.17
27	52.09254	-0.88359	99.04	77	52.08261	-0.89255	86.77
28	52.09229	-0.88333	98.80	78	52.08270	-0.89290	87.26
29	52.09207	-0.88311	98.80	79	52.08295	-0.89318	86.30
30	52.09193	-0.88278	97.80	80	52.08326	-0.89353	86.06
31	52.09208	-0.88239	97.80	81	52.08355	-0.89412	86.51
32	52.09222	-0.88204	97.80	82	52.08371	-0.89462	86.89
33	52.09241	-0.88156	97.80	83	52.08384	-0.89500	86.26
34	52.09260	-0.88113	97.80	84	52.08327	-0.89555	87.44
35	52.09280	-0.88125	97.30	85	52.08306	-0.89627	88.54
36	52.09304	-0.88142	97.22	86	52.08292	-0.89704	88.15
37	52.09334	-0.88133	96.80	87	52.08284	-0.89761	88.15
38	52.09359	-0.88161	96.80	88	52.08329	-0.89790	87.80
39	52.09393	-0.88174	96.80	89	52.08329	-0.89853	88.21
40	52.09436	-0.88080	95.98	90	52.08358	-0.89894	88.80

No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)	No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)
41	52.09496	-0.88080	95.57	91	52.08385	-0.89922	90.14
42	52.09527	-0.88041	94.75	92	52.08403	-0.89951	91.20
43	52.10056	-0.88202	77.47	93	52.08429	-0.90028	90.89
44	52.09502	-0.87393	83.80	94	52.08434	-0.90064	91.43
45	52.09347	-0.86171	76.58	95	52.08433	-0.90104	91.80
46	52.08963	-0.86678	81.48	96	52.08427	-0.90151	92.53
47	52.07957	-0.87365	82.59	97	52.08424	-0.90184	92.80
48	52.07999	-0.87471	80.65	98	52.08418	-0.90230	93.80
49	52.08490	-0.88228	89.36	99	52.08501	-0.90343	95.80
50	52.08493	-0.88474	92.79	100	52.08520	-0.90373	96.80

Dwelling receptor data

Modelled Reflector Areas

The modelled reflector areas are presented in the tables below.

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.88587	52.08690	6	-0.88935	52.09167
2	-0.88380	52.08812	7	-0.89269	52.08994
3	-0.88117	52.08995	8	-0.89096	52.08843
4	-0.88240	52.09102	9	-0.88845	52.08572
5	-0.88567	52.08915			

Panel Area – East

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.87939	52.08460	9	-0.87443	52.08825
2	-0.87884	52.08213	10	-0.87598	52.08919
3	-0.87694	52.08312	11	-0.87391	52.09044
4	-0.87333	52.08407	12	-0.87633	52.09206
5	-0.87354	52.08500	13	-0.87808	52.09082
6	-0.87352	52.08638	14	-0.87873	52.09115
7	-0.87319	52.08686	15	-0.88324	52.08804
8	-0.87502	52.08786			

Panel Area – West

APPENDIX H – DETAILED MODELLING RESULTS

Overview

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.

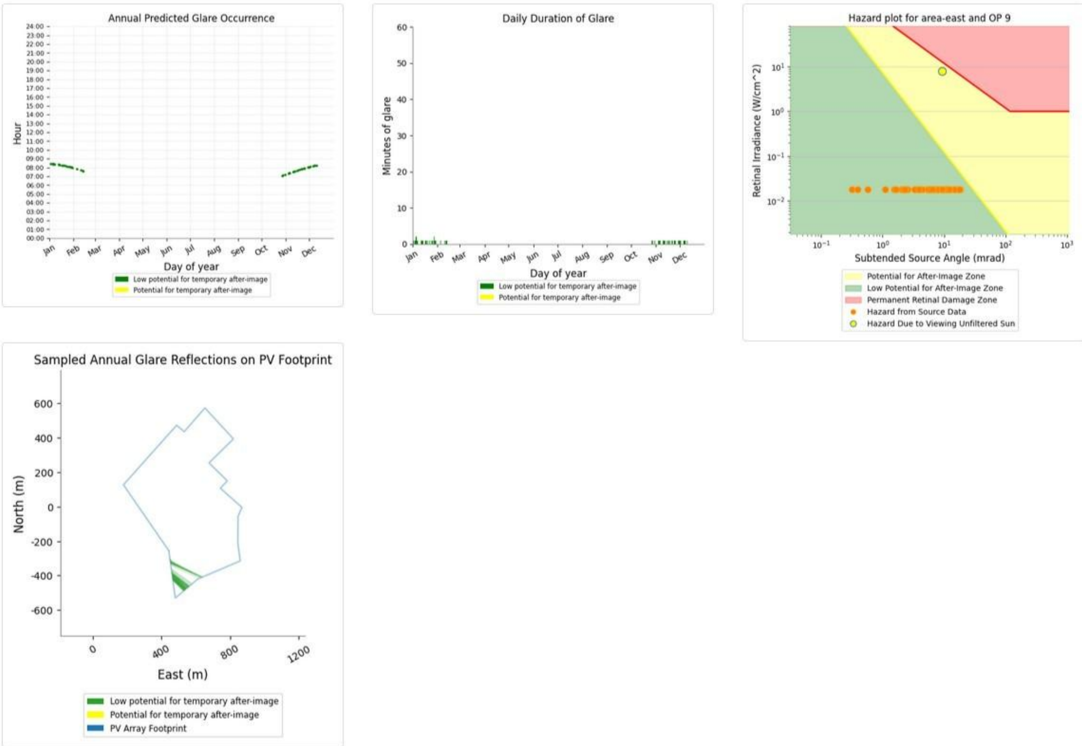
Dwelling Receptors

Modelling results are provided for a selection of receptors where reflections are predicted to be geometrically possible.

Area East: OP 49

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

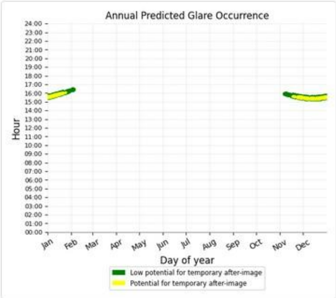
- 48 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

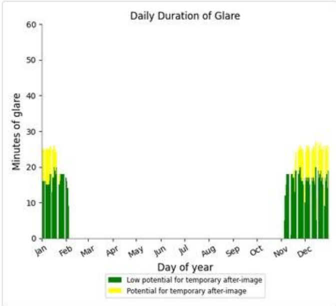


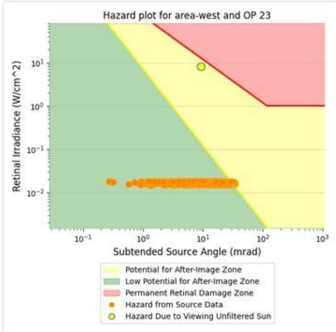
Area West: OP 23

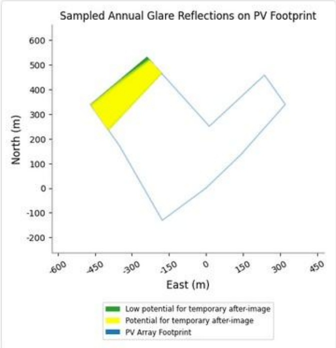
PV array is expected to produce the following glare for this receptor:

- 1,248 minutes of "green" glare with low potential to cause temporary after-image.
- 443 minutes of "yellow" glare with potential to cause temporary after-image.





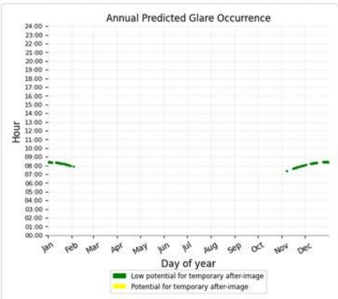


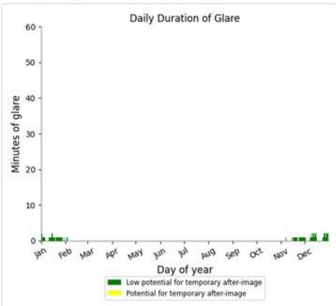


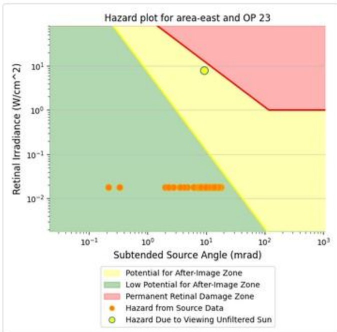
Area East: OP 23

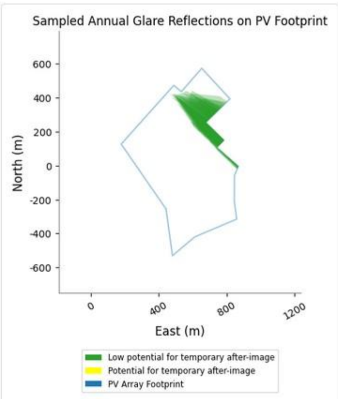
PV array is expected to produce the following glare for this receptor:

- 70 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





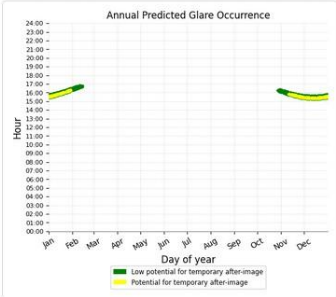


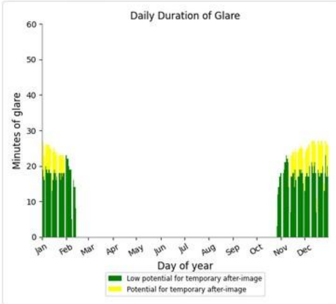


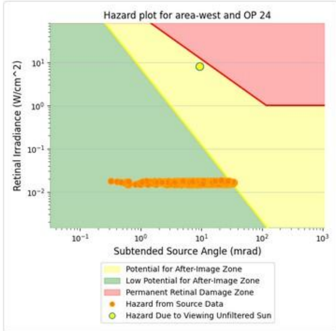
Area West: OP 24

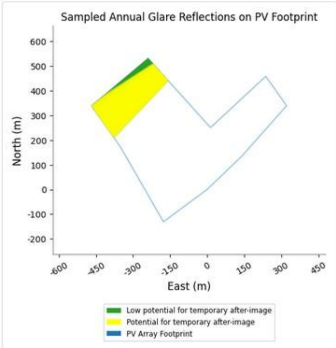
PV array is expected to produce the following glare for this receptor:

- 1,612 minutes of "green" glare with low potential to cause temporary after-image.
- 455 minutes of "yellow" glare with potential to cause temporary after-image.





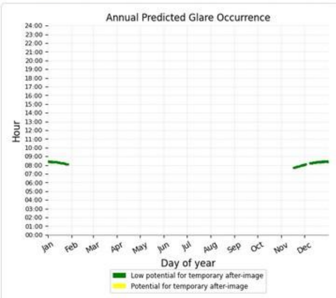


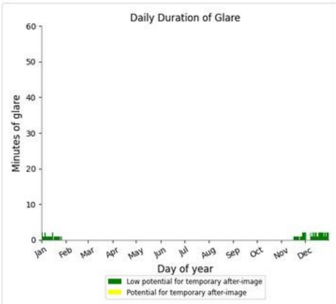


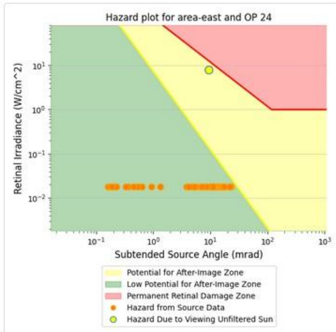
Area East: OP 24

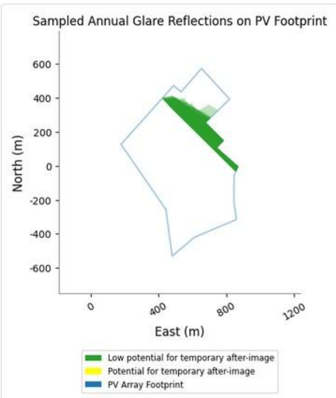
PV array is expected to produce the following glare for this receptor:

- 89 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





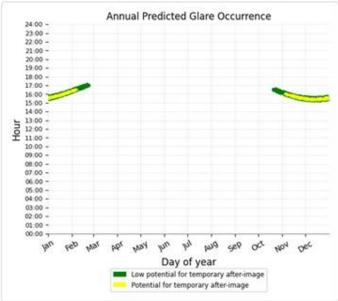


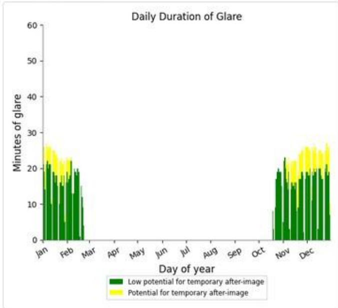


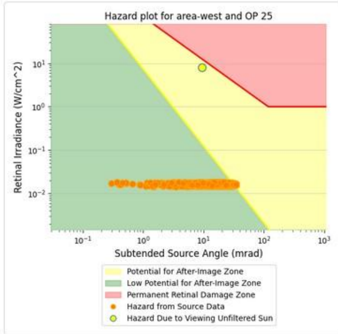
Area West: OP 25

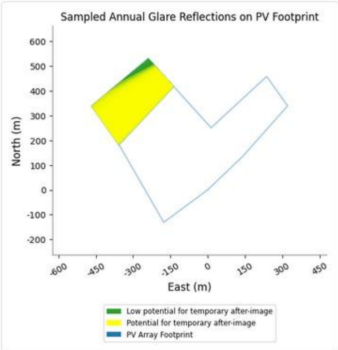
PV array is expected to produce the following glare for this receptor:

- 1,804 minutes of "green" glare with low potential to cause temporary after-image.
- 464 minutes of "yellow" glare with potential to cause temporary after-image.





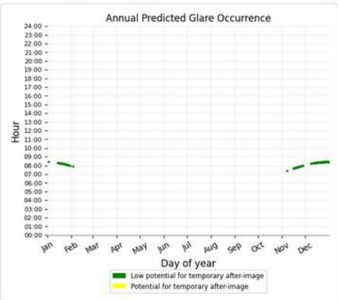


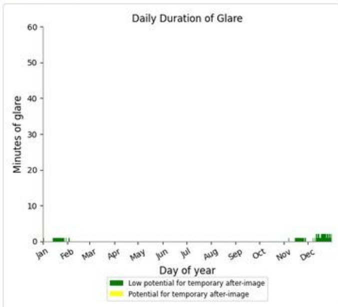


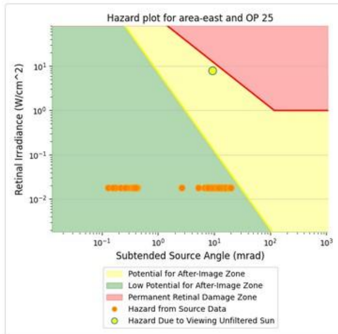
Area East: OP 25

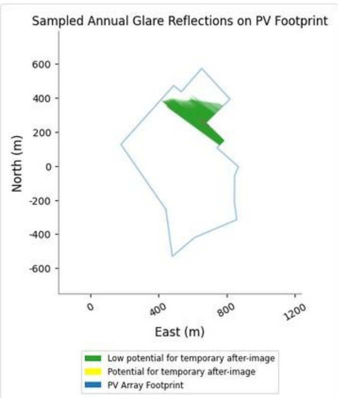
PV array is expected to produce the following glare for this receptor:

- 68 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





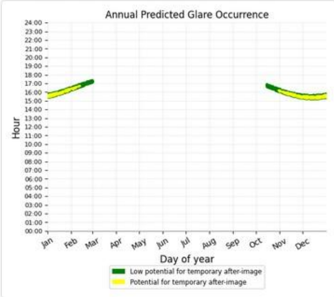


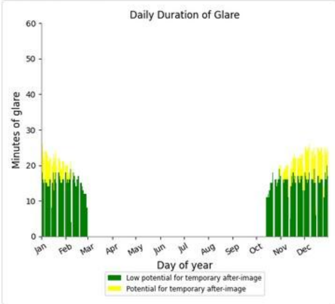


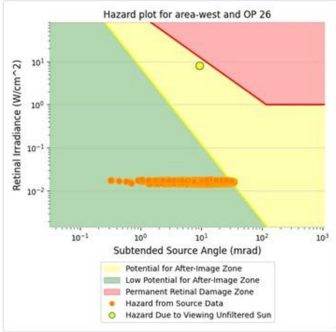
Area West: OP 26

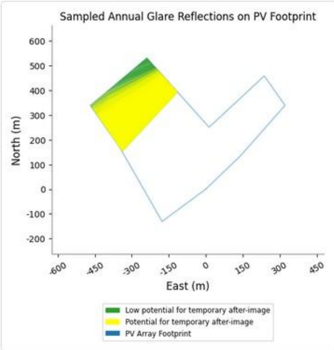
PV array is expected to produce the following glare for this receptor:

- 1,773 minutes of "green" glare with low potential to cause temporary after-image.
- 485 minutes of "yellow" glare with potential to cause temporary after-image.





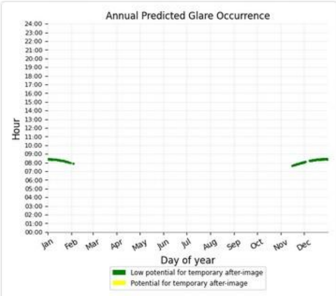


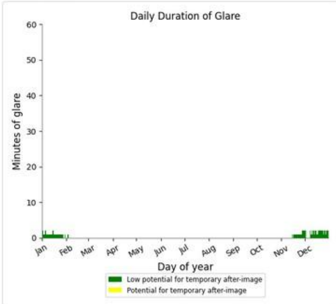


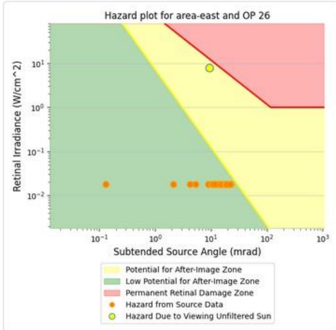
Area East: OP 26

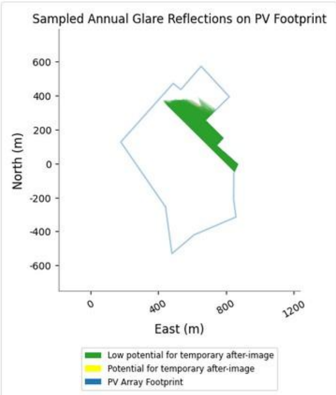
PV array is expected to produce the following glare for this receptor:

- 97 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





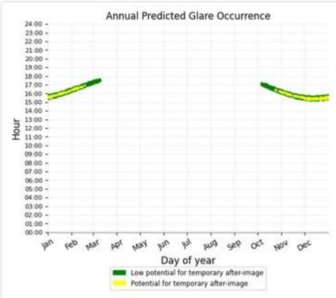


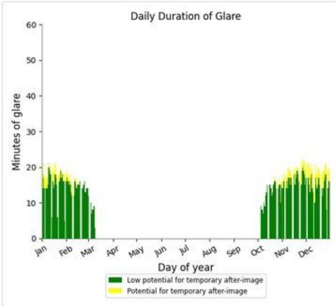


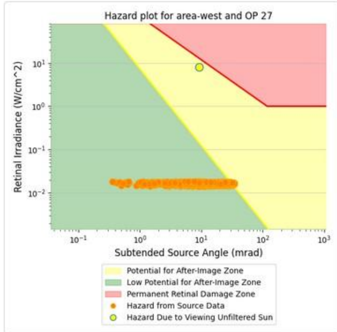
Area West: OP 27

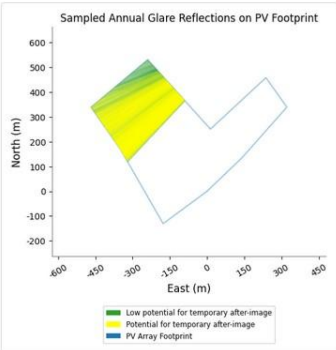
PV array is expected to produce the following glare for this receptor:

- 1,875 minutes of "green" glare with low potential to cause temporary after-image.
- 249 minutes of "yellow" glare with potential to cause temporary after-image.





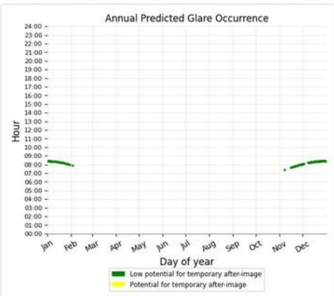


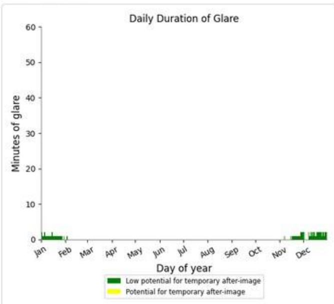


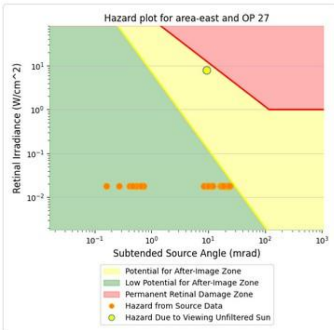
Area East: OP 27

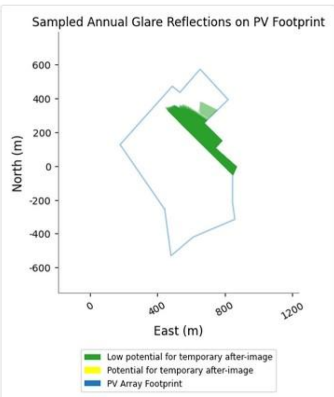
PV array is expected to produce the following glare for this receptor:

- 98 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





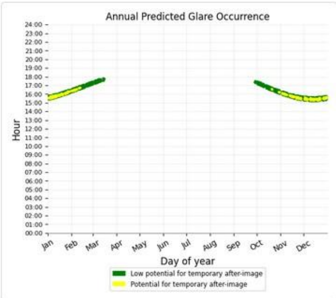


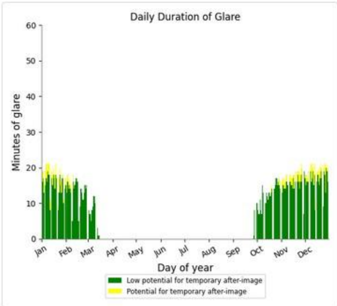


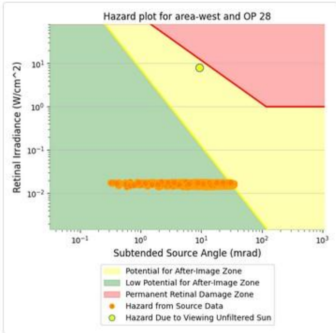
Area West: OP 28

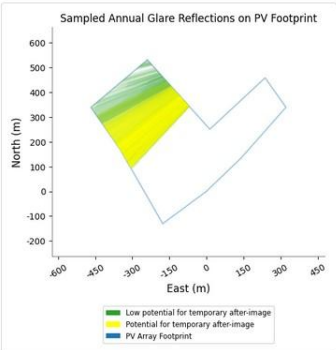
PV array is expected to produce the following glare for this receptor:

- 1,952 minutes of "green" glare with low potential to cause temporary after-image.
- 204 minutes of "yellow" glare with potential to cause temporary after-image.





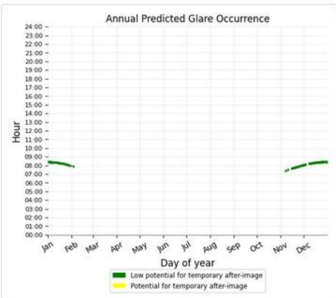


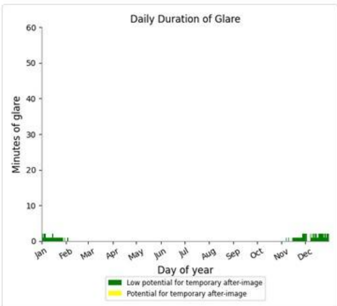


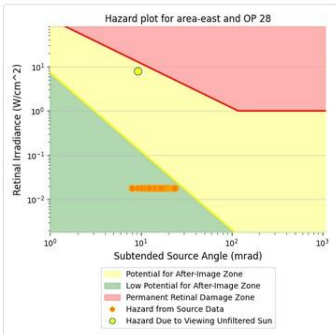
Area East: OP 28

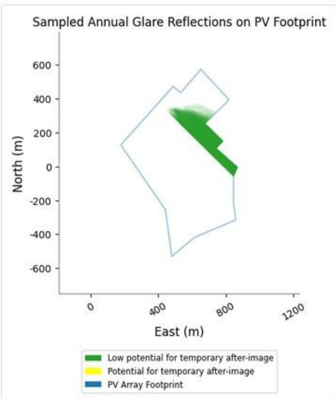
PV array is expected to produce the following glare for this receptor:

- 103 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





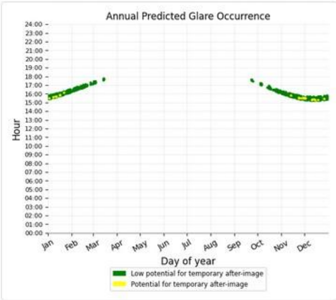


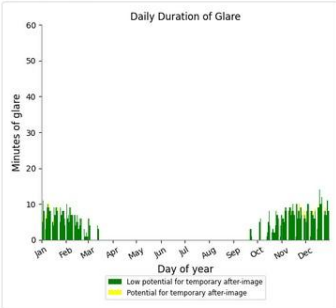


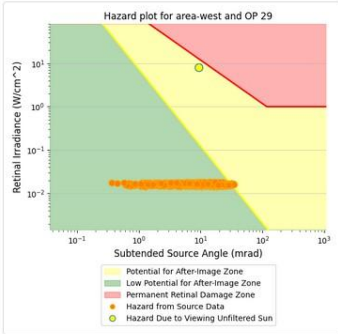
Area West: OP 29

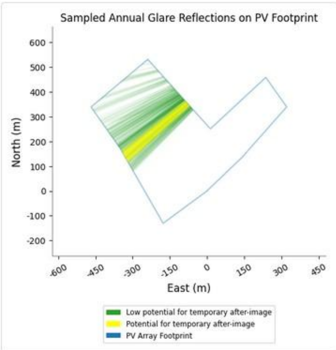
PV array is expected to produce the following glare for this receptor:

- 808 minutes of "green" glare with low potential to cause temporary after-image.
- 22 minutes of "yellow" glare with potential to cause temporary after-image.





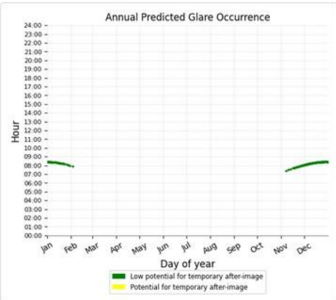


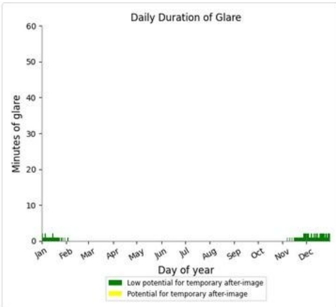


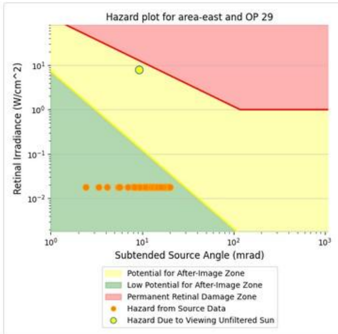
Area East: OP 29

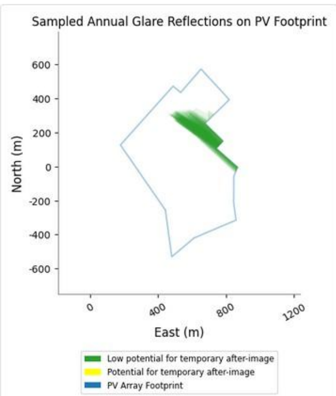
PV array is expected to produce the following glare for this receptor:

- 105 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





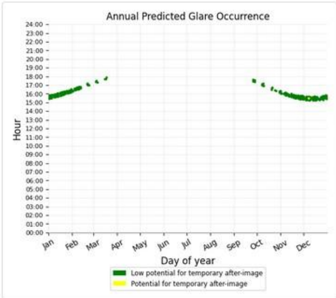


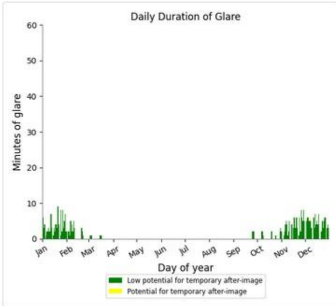


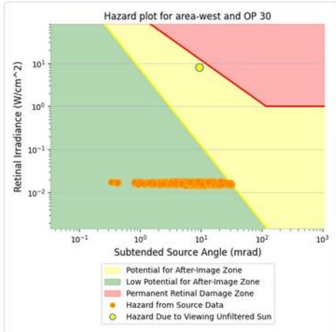
Area West: OP 30

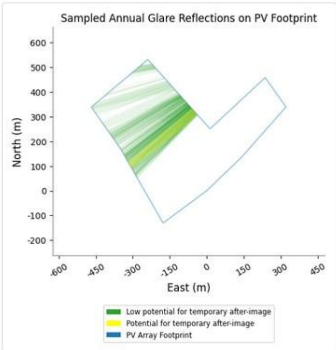
PV array is expected to produce the following glare for this receptor:

- 371 minutes of "green" glare with low potential to cause temporary after-image.
- 1 minutes of "yellow" glare with potential to cause temporary after-image.





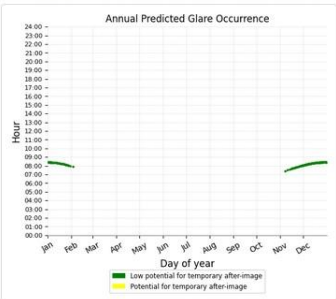


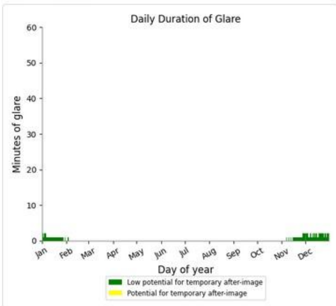


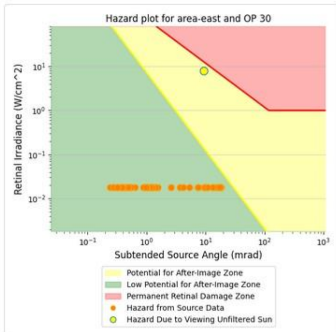
Area East: OP 30

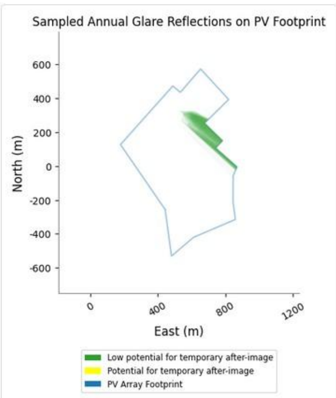
PV array is expected to produce the following glare for this receptor:

- 109 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.









APPENDIX I – BACKTRACKING METHOD DISCUSSION

Modelling Solar Reflections

Modelling output for glint and glare modelling must quantify – at a minimum – the dates and times at which reflections are possible.

To do this requires some assumptions. Assumptions that are applied by Pager Power in its modelling include:

- That the sun is always unobstructed.
- That the panels are exactly aligned as proposed.
- The panels are perfectly smooth.

Responsible assumptions should ensure that the output presents a 'realistic worst-case scenario', that is the most significant impact that could reasonably be expected in real life.

Modelling Tracker Systems vs Modelling Fixed Systems

For fixed systems, the appropriate assumptions for generating a realistic worst-case scenario are relatively apparent and their consequences are quite straightforward to evaluate.

Quantifying predicted reflections from tracker systems leaves space for further assumptions with consequences that are more complex. The industry-standard model for evaluating tracker systems is based on the SGHAT model originally devised by Sandia Laboratories and currently hosted most prolifically by Forge Solar.

Factors that influence modelling output for tracker systems include:

1. Whether the system is a single or dual axis tracker.
2. The range of motion of the panels.
3. The backtracking behaviour of the system.

Point 3 above warrants particular attention. In general terms, the purpose of a tracker system is to keep the panels facing the Sun directly as far as possible for as long as possible. Backtracking is a mechanism by which the panel arrays are tilted to minimise shading each other – because the losses due to shading outweigh the gains from directing the array towards the Sun.

Backtracking occurs when the Sun is relatively low in the sky, this is also the time at which the majority of solar reflections are possible, particularly for ground-based receptors.

Therefore, changes to how backtracking is modelled have significant consequences for the level of predicted impact. This causes a non-linear trade-off between capturing the most realistic backtracking behaviour and ensuring that the results represent a realistic worst-case scenario.

Things that influence backtracking behaviour in a real system include:

a. How it is programmed.
b. The dimensions of the panels on each array.
c. The spacing between the arrays.

d. The slope of the terrain.

The most effective way of quantifying backtracking within the Forge Solar model has historically been via the 'resting angle', which relates to the panel configuration when the Sun's elevation is outside the tracker's range of motion.

More recently, options for more sophisticated parameters have been introduced, that allow incorporation of points a-d above to some extent (but not to their complete extent).

Pager Power's default approach is to model tracker systems using the original method i.e. based on the resting angle only. The predominant reasons for this are threefold:

- The additional modelling options are relatively new.
- The accuracy of the new options is difficult to independently verify.
- To optimise the output with reference to backtracking using the new options can require a level of partitioning that compromises other aspects of the output – specifically the cumulative intensity considerations.

Further evaluation of the effects of backtracking remains a viable option where significant impacts are predicted based on the worst-case.

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