RWE

Peartree Hill Solar Farm

Environmental Statement

Volume 4

Appendix 5.4: Glint and Glare Assessment

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 – Regulation 5(2)(a)

Application Document Ref: EN010157/APP/6.4

February 2025

Prepared by PAGERPOWER Urban & Renewables on behalf of RWE Renewables UK Solar and Storage

EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from the proposed ground-mounted solar photovoltaic development, Peartree Hill Solar Farm, which will be located in East Riding of Yorkshire, UK. This glint and glare study assesses the potential impacts on surrounding road safety, residential amenity, and aviation activity at Beverley Airfield, Hill Farm Airfield, and Burton-Constable Airfield.

Overall Conclusions

A moderate impact is predicted on one dwelling under baseline conditions due to the duration of effects and a lack of sufficient mitigating factors. Proposed vegetation screening is expected to reduce the impact level to low impact, and further mitigation is not recommended.

No significant impacts are predicted on surrounding road safety, and aviation activity associated with Beverley Airfield, Hill Farm Airfield and Burton-Constable Airfield.

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. Pager Power has however produced guidance for glint and glare and solar photovoltaic developments, which was first published in early 2017, with the fourth edition produced in 2022[1]. The guidance document sets out the methodology for assessing road safety, residential amenity, and aviation activity with respect to solar reflections from solar panels.

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. 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[2].

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

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

Assessment Results

Roads

The modelling has shown that solar reflections are geometrically possible towards:

- A 0.5km section of the A1035;
- A 1.1km section of the A1035;
- A 0.7km section of the A1035;
- A 1.8km section of Beverley Road/A165.

A low impact is predicted on a 0.1km section of the A1035, and a 1.4km section of Beverley Road/A165, because solar reflections are predicted from **outside** of a road user's primary horizontal field of view[3], or where solar reflections are predicted from **inside** of a road user's primary horizontal field of view, following consideration of relevant factors, it is deemed that the solar reflection would not remain significant. The relevant points include:

- There is partial screening such that reflections will be filtered and marginal views of reflecting panels are expected to be possible;
- There is a significant clearance distance between the road user and the closest reflecting panel; and/pr
- Reflections are possible when the Sun is low in the sky beyond the reflecting panels. The sun is a much more significant source of irradiance.

No impacts are predicted on the remaining assessed sections of roads, because there is significant screening such that views of reflecting panels are not expected to be possible in practice.

No mitigation is recommended for any sections of road.

Dwellings

The modelling has shown that solar reflections are geometrically possible towards 89 of the 225 assessed dwelling locations.

No impacts are predicted on 64 of these dwellings, because there is significant screening such that views of reflecting panels are not expected to be possible in practice.

A low impact is predicted on 24 dwellings, because there is significant screening such the duration of effects is expected to be reduced to **less** than three months per year and **less** than 60 minutes on any given day, or following consideration of relevant factors, it is deemed that the solar reflection would not remain significant. The relevant points include:

- There is a significant distance between the dwelling observer and closest reflecting panel; and
- Reflections are only possible when the Sun is low in the sky beyond the reflecting panels.

[3] 50-degrees either side of the direction of travel

A moderate impact is predicted on one dwelling under baseline conditions due to the duration of effects and a lack of sufficient mitigating factors. Proposed vegetation screening along panel boundaries to the west of the dwelling will reduce the duration of effects to **less** than three months per year and **less** than 60 minutes on any given day, once it matures to 2.5 metres above ground level. The impact will be reduced to low impact, and further mitigation is not recommended.

Beverley Airfield

The analysis has shown that solar reflections with a maximum intensity of 'low potential for temporary after image' ('green' glare) are geometrically possible towards parts of the 1-mile splayed approach paths and visual circuits at Beverley Airfield.

Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, which states that this level of glare is acceptable, it can be reliably concluded that this level of glare is also acceptable for the 1-mile splayed approach paths and visual circuits. No significant impacts are predicted, and no mitigation is required.

Hill Farm Airfield & Burton-Constable Airfield

The analysis has shown that solar reflections with a maximum intensity of 'low potential for temporary after image' ('green' glare) are geometrically possible towards parts of the 1-mile splayed approach paths and final sections of the visual circuits and joins at Hill Farm Airfield and Burton-Constable Airfield.

Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, which states that this level of glare is acceptable, it can be reliably concluded that this level of glare is also acceptable for the 1-mile splayed approach paths and final sections of the visual circuits and joins. No significant impacts are predicted, and no mitigation is required.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 60 countries internationally.

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

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems.

Over the years, the company has expanded into numerous fields including:

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

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

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

1 INTRODUCTION

1.1 Overview

Pager Power has been retained to assess the possible effects of glint and glare from the proposed ground-mounted solar photovoltaic (PV) development, Peartree Hill Solar Farm, which will be located in East Riding of Yorkshire, UK. This glint and glare study assesses the potential impacts on surrounding road safety, residential amenity, and aviation activity at Beverley Airfield, Hill Farm Airfield, and Burton-Constable Airfield.

This report contains the following:

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

1.2 Pager Power's Experience

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

1.3 Glint and Glare Definition

The definition 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.

These definitions are aligned with those presented within the National Policy Statement for Renewable Energy Infrastructure (EN-3) – published by the Department for Business, Energy & Industrial Strategy in January 2024 and the Federal Aviation Administration in the USA.

The term 'solar reflection' is used in this report to refer to both reflection types.

2 PROPOSED SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Solar Development Location

The overall site design[4] is shown in Figure 1 on the following page. The proposed solar panel areas have been extracted from the site plans overlaid onto aerial imagery, and the solar panel areas are shown in blue on aerial imagery in Figure 2 on page 15.

2.2 Solar Panel Technical Information

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

Tracking Panels Technical Information	
Assessed centre-height[5]	2.5m above ground level (agl)
Tracking	Horizontal Single Axis tracks Sun East to West
Tilt of tracking axis	0°
Orientation of tracking axis	0°
Offset angle of module	0°
Tracker Range of Motion	±60°
Resting angle	0°
Backtracking Method	Instant (for modelling purposes)
Surface material	Smooth glass with ARC (anti-reflective coating)

Table 1 *Solar panels technical information*

[4] Source: J002_1000_Z.pdf

[5] Assessed based on a minimum panel height of 1.5m agl, and maximum panel height of 3.5m agl. The design has since changed to a minimum panel height of 0.8m agl, and a maximum height of 3m agl. Based on Pager Power's professional judgement and previous experience, this is not a significant change such that remodelling is required.

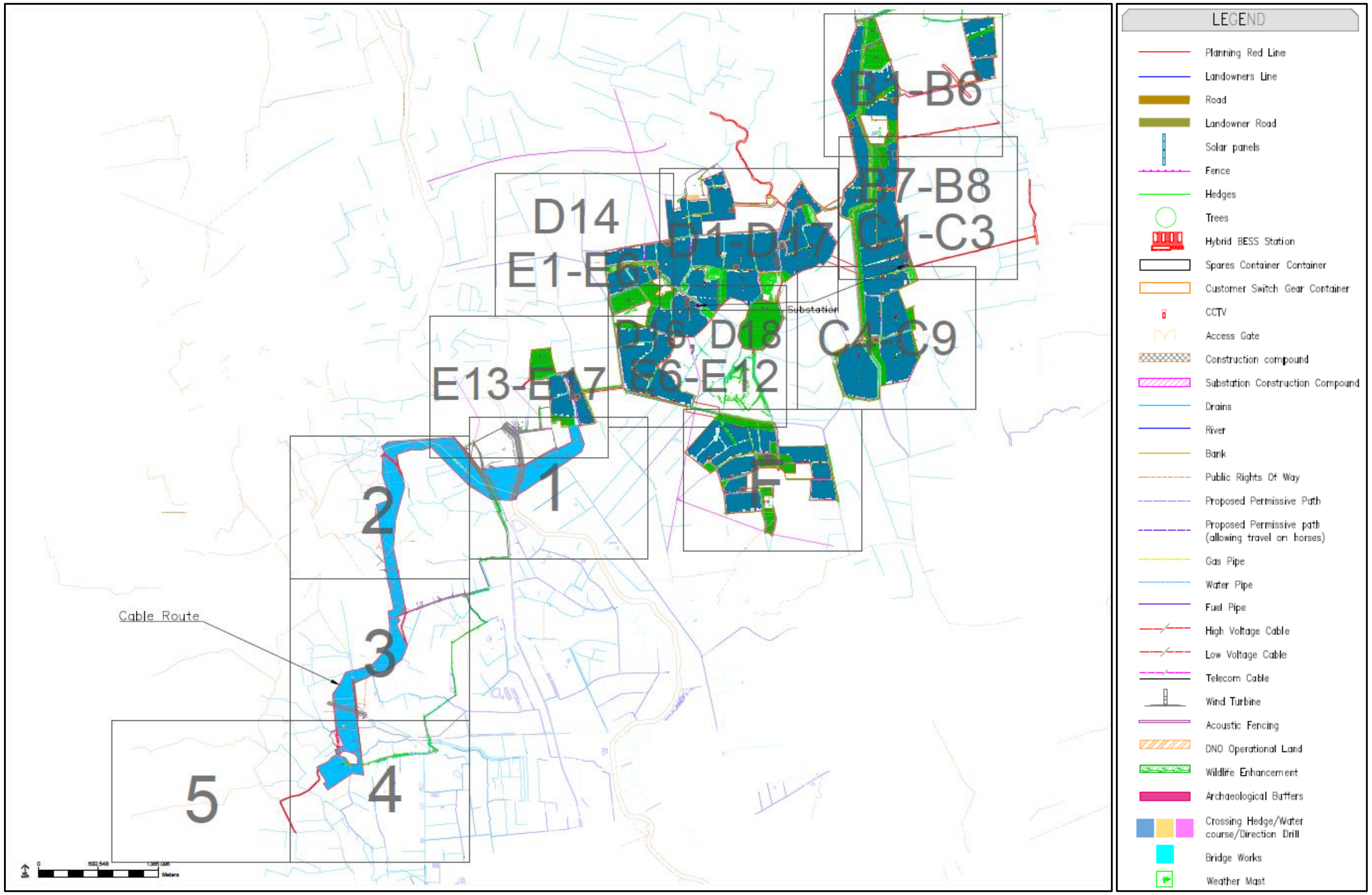

Figure 1 *Overall site design*

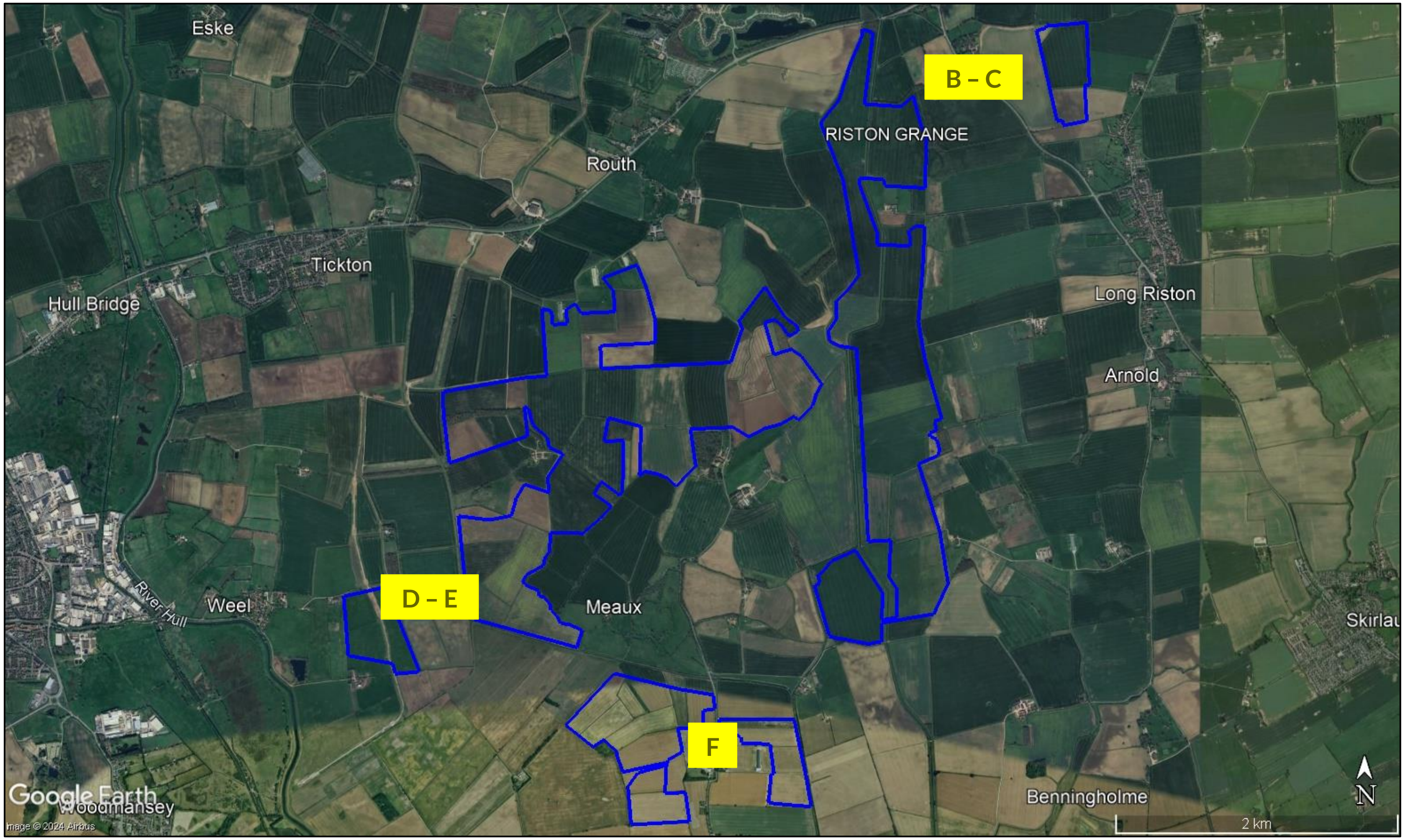

Figure 2 *Panel Areas – aerial image*

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 3 below illustrates[6] this.

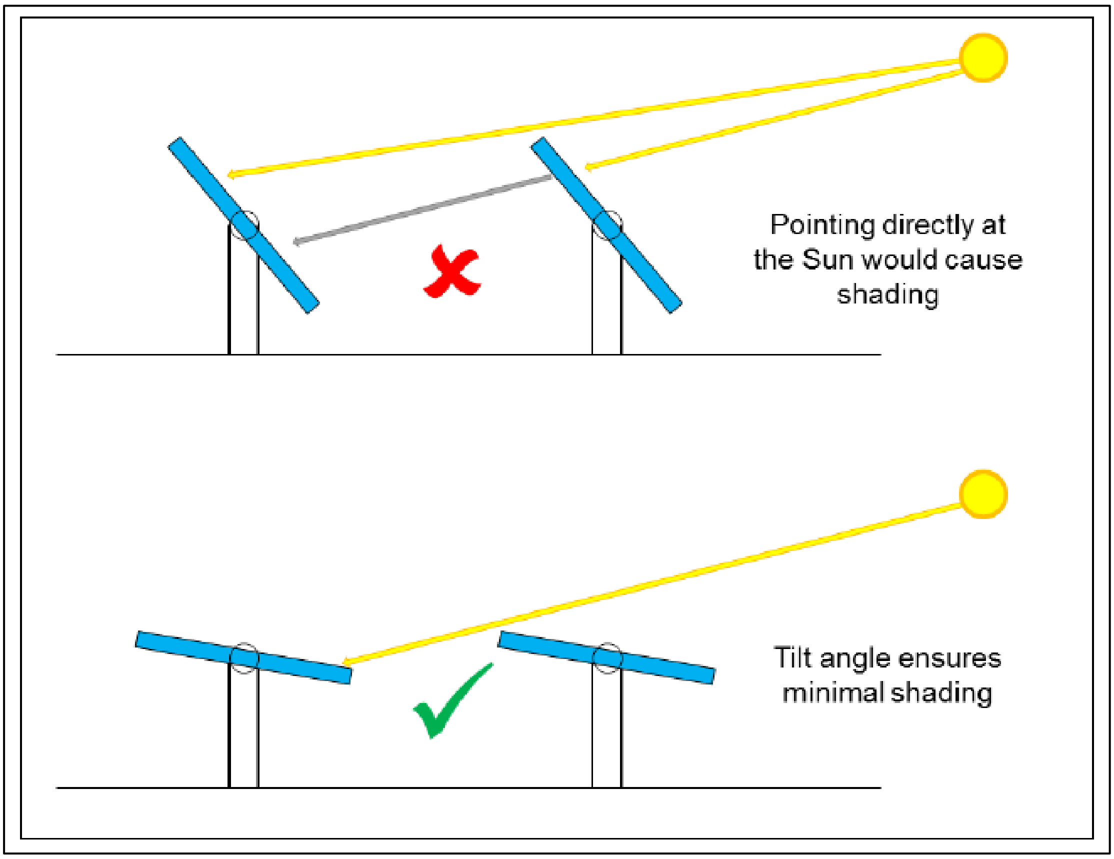

Figure 3 *Shading Considerations*

Later in the day, the panels can be directed towards the Sun without any shading issues. This is illustrated[6] in Figure 4 on the following page.

[6] Note the graphics in Figure 3 and Figure 4 Figure 3show 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.

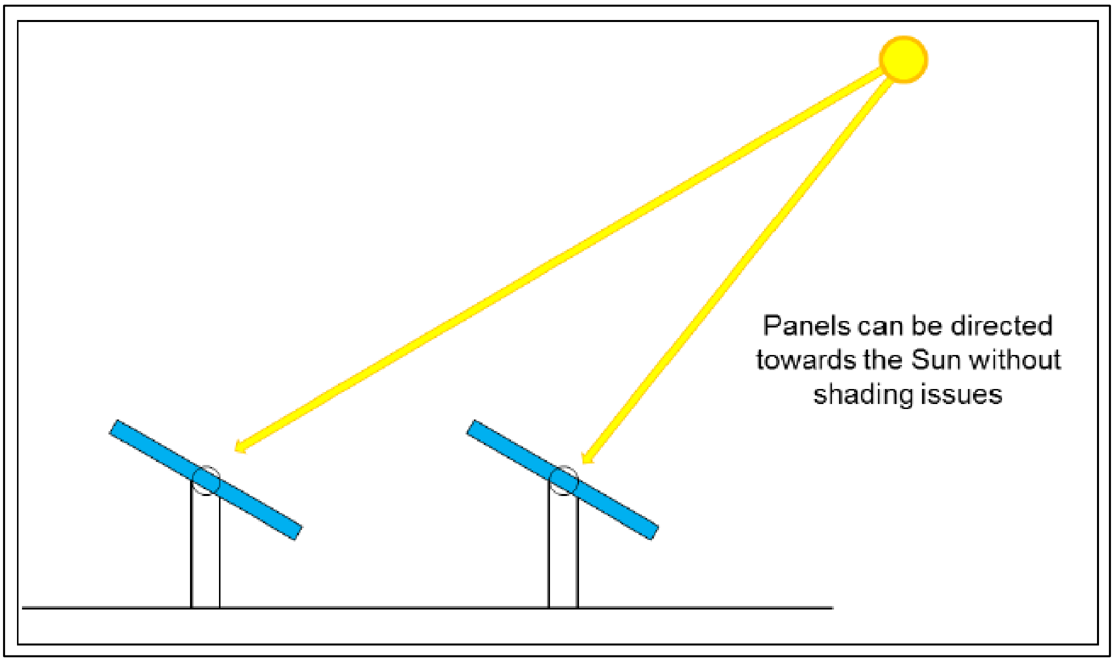

Figure 4 *Panel alignment at high solar angles*

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.

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Overview

Appendix A 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, studies and Pager Power's practical experience. The methodology for this glint and glare assessment is as follows:

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

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

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.

Pager Power has undertaken many glint and glare assessments with both models (SGHAT and Pager Power's) producing similar results. In this study the Forge model was used exclusively.

3.4 Assessment Methodology and Limitations

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

4 IDENTIFICATION OF AVIATION RECEPTORS

4.1 Overview of Aviation Receptors

Three active unlicensed general aviation (GA) airfields have been identified for the assessment; these are Beverley Airfield, Hill Farm Airfield, and Burton-Constable Airfield. The locations of these airfields relative to the proposed development are shown in Figure 5 below.

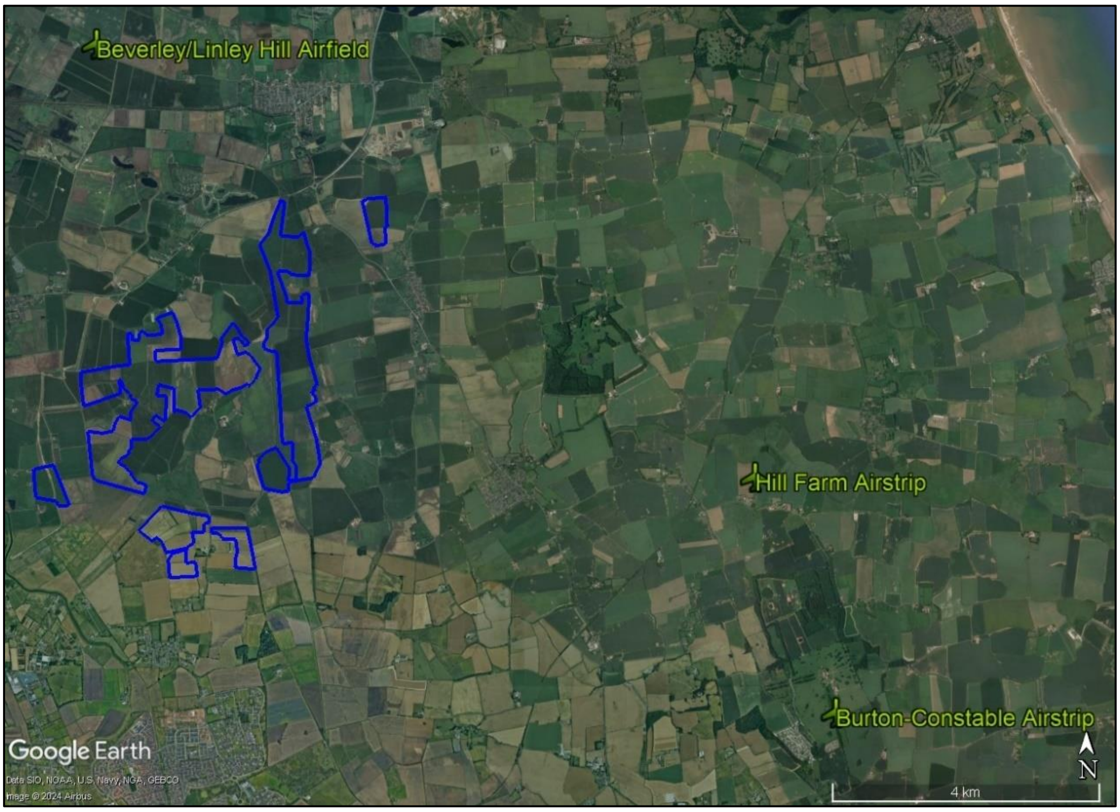

Figure 5 *Identified aerodromes for assessment – aerial image*

4.2 Airfield Information

4.2.1 Beverley Airfield

Beverley Airfield is an unlicensed general aviation aerodrome operated by Hull Aero Club, and understood not to have an Air Traffic Control (ATC) Tower. It has one operational runway, the details[7] of which are presented below:

- 12/30 measuring 710 metres by 30 metres (grass).

Beverley Airfield is located approximately 3.3km north-west of panel area B.

[7] Source: Pooley's Flight Guide 2024

4.2.2 Hill Farm Airfield

Hill Farm Airfield is an unlicensed general aviation aerodrome and understood not to have an ATC Tower. It has one operational runway, the details[8] of which are presented below:

- 18/36 measuring 500 metres by 45 metres (grass).

Hill Farm Airfield is located approximately 6.5km east of panel area C.

4.2.3 Burton-Constable Airfield

Burton-Constable Airfield is an unlicensed general aviation aerodrome and understood not to have an ATC Tower. It has one operational runway, the details[8] of which are presented below:

- 16/34 measuring 940 metres by 50 metres (grass).

Burton-Constable Airfield is located approximately 8.5km south-east of panel area C.

4.3 Aviation Receptors

4.3.1 Overview

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

Figure 6 on the following page illustrates a typical 1-mile splayed approach and final sections of visual circuits/joins.

[8] Approximated from aerial imagery

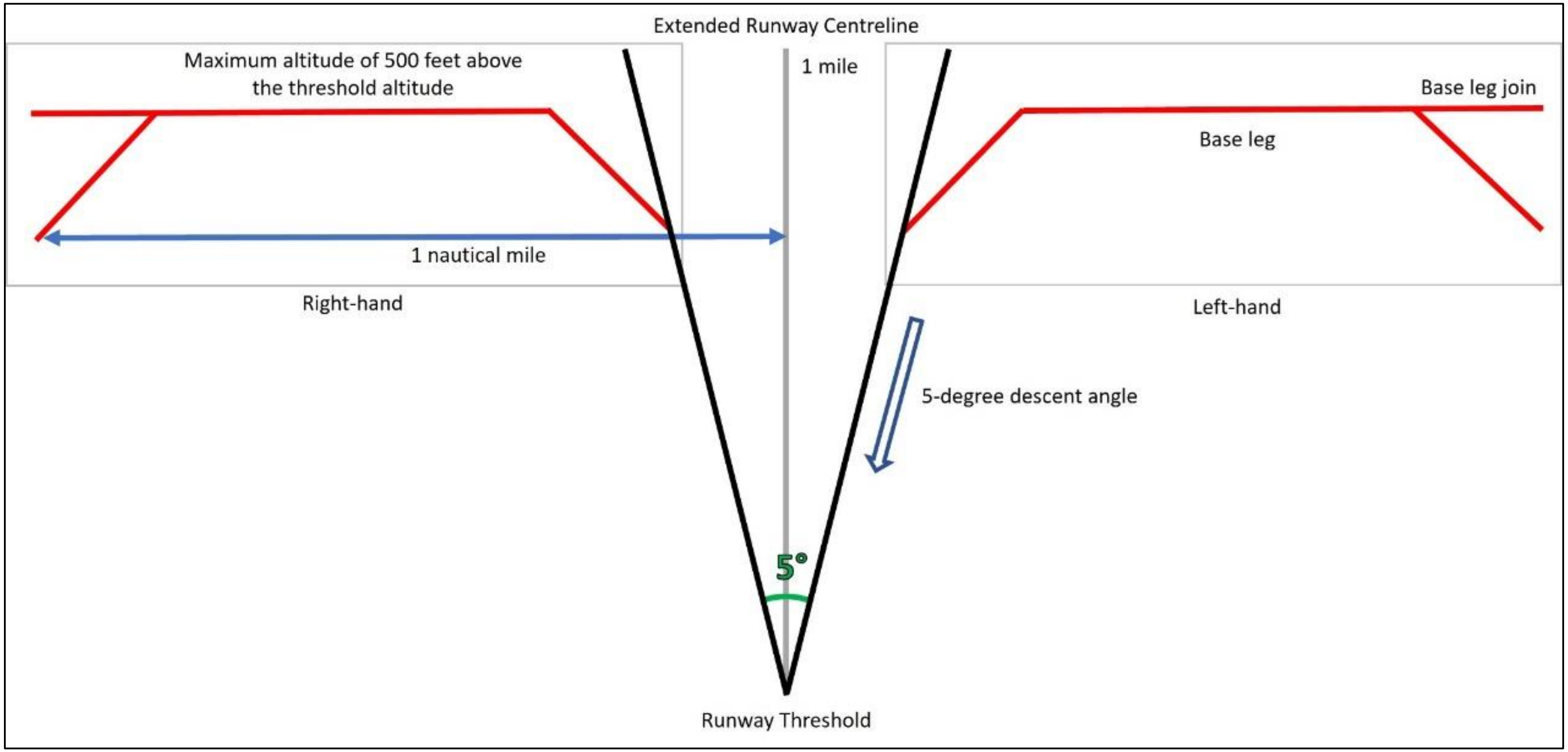

Figure 6 *Splayed approach and final sections of visual circuits*

4.3.2 Identification of Receptors

For GA airfields, it is Pager Power's methodology is to assess whether a solar reflection can be experienced on the 1-mile approach path with a splay angle of 5 degrees, considering 2.5 degrees either side of the extended runway centreline.

Hull Aero Club have published circuits[9] for Beverley Airfield. Four circuits have been assessed with the following characteristics:

- A descent angle of 5 degrees;
- Circuit resolution of 0.1 nautical miles (distance between assessed points);
- Maximum altitude of 700/1000 feet above ground level.

In the absence of published circuits information, as is the case for Hill Farm Airfield and Burton-Constable Airfield, it is Pager Power's methodology is to assess whether a solar reflection can be experienced on final sections of the visual circuits/joins using the following characteristics:

- A descent angle of 5 degrees;
- Circuit width of 1 nautical mile from runway centreline;
- Maximum altitude of 500 feet above the average threshold altitude.

Figures 7 to 11 on the following pages give a breakdown of all aircraft receptor points assessed for the three airfields. The runway threshold details can be found in Appendix G.

[9] https://hullaeroclub.co.uk/airfield-info/

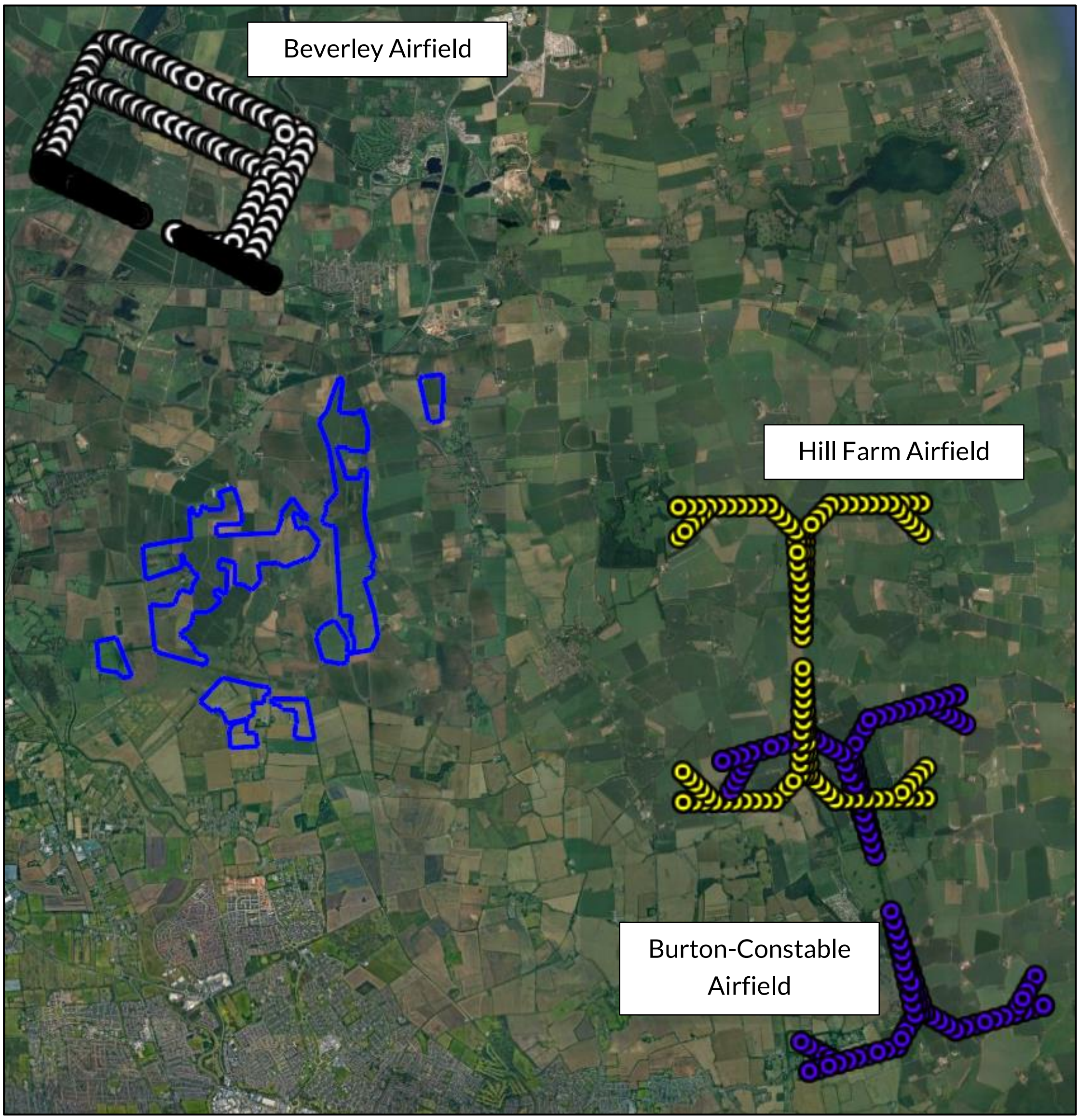

Figure 7 *Identified aerodromes and associated receptors – aerial image*

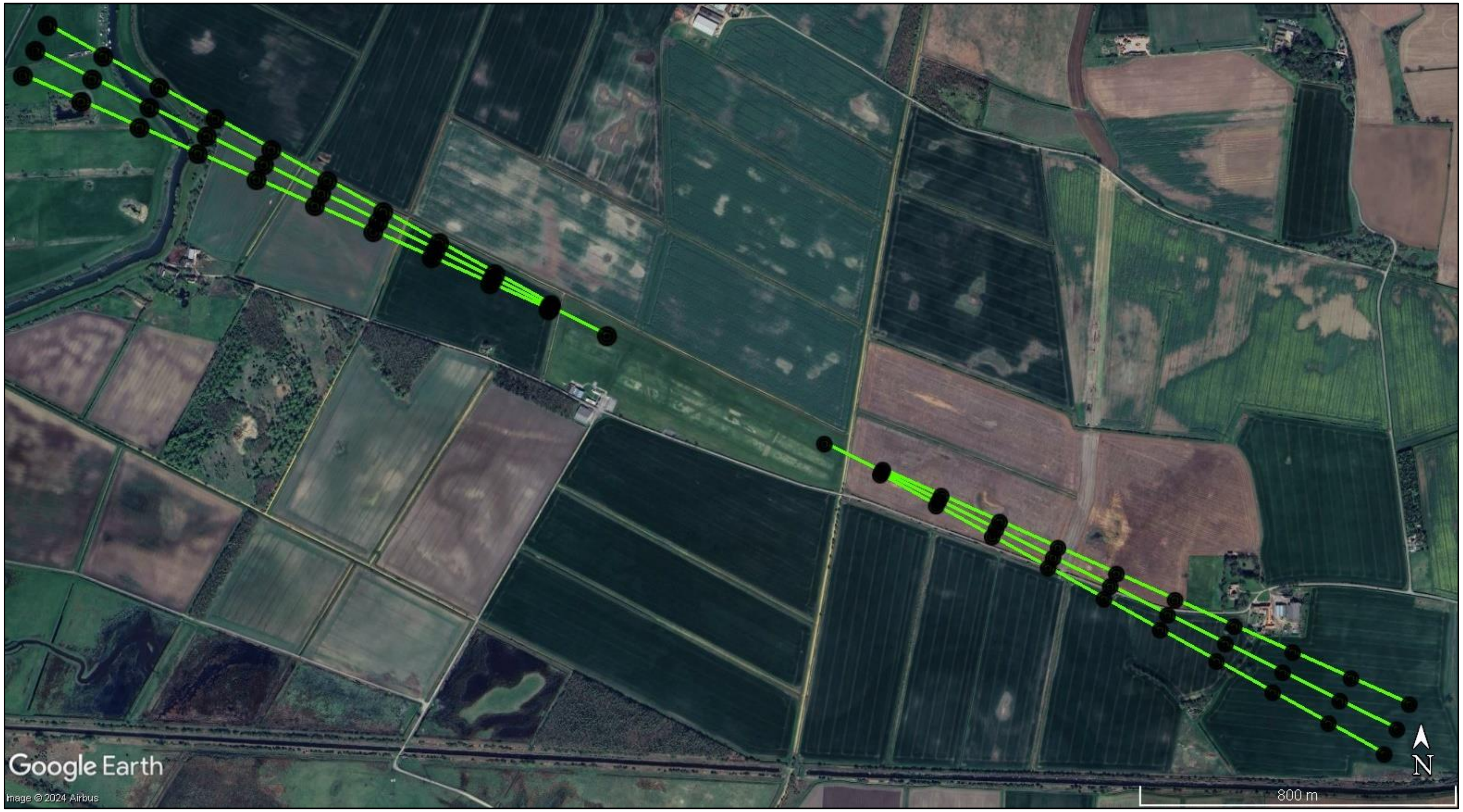

Figure 8 *1-mile splayed approach paths (green lines) and assessed receptors (black icons) at Beverley Airfield – aerial image*

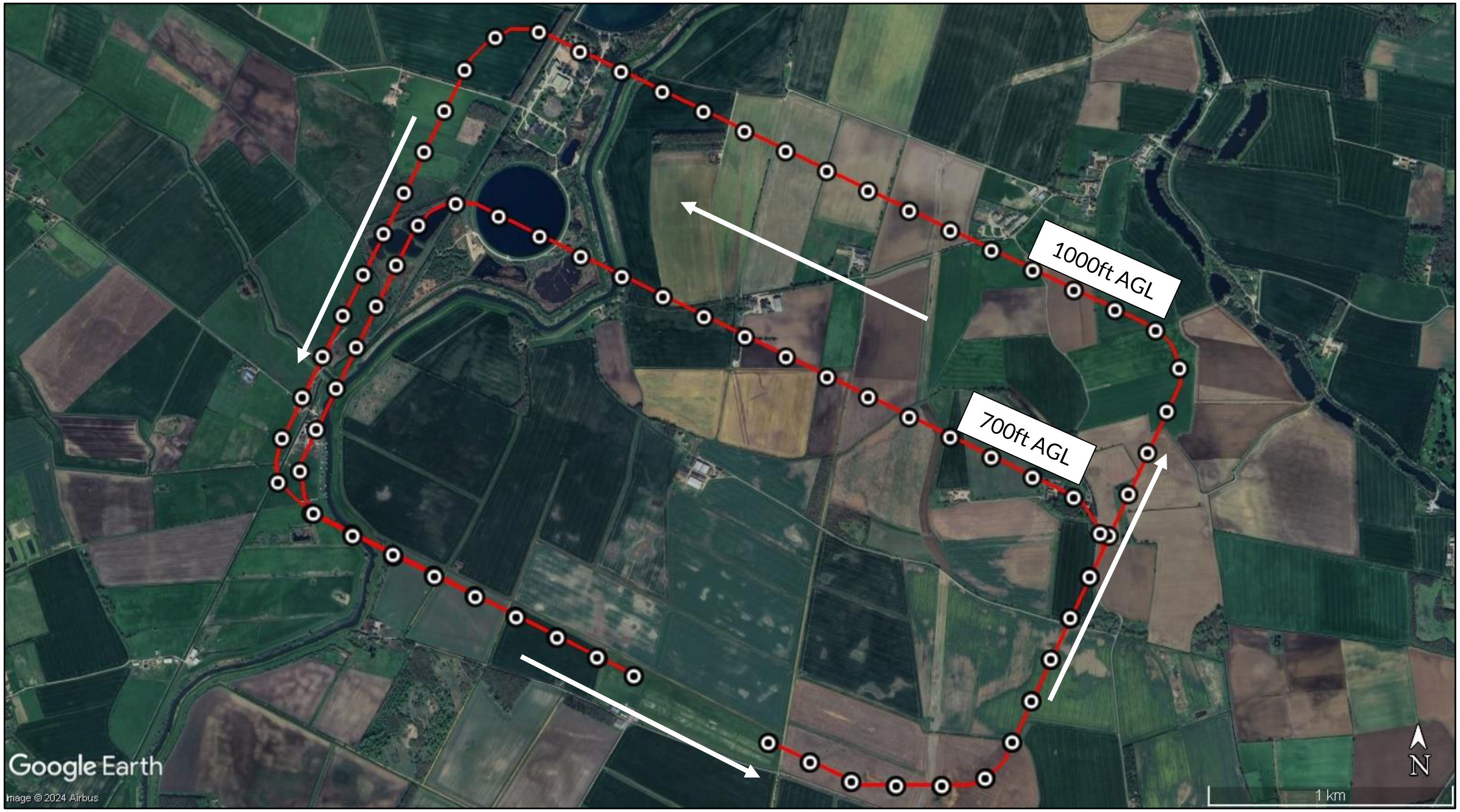

Figure 9 *Runway 12 LH visual circuits (red lines) and assessed receptors (black/white icons) at Beverley Airfield – aerial image*

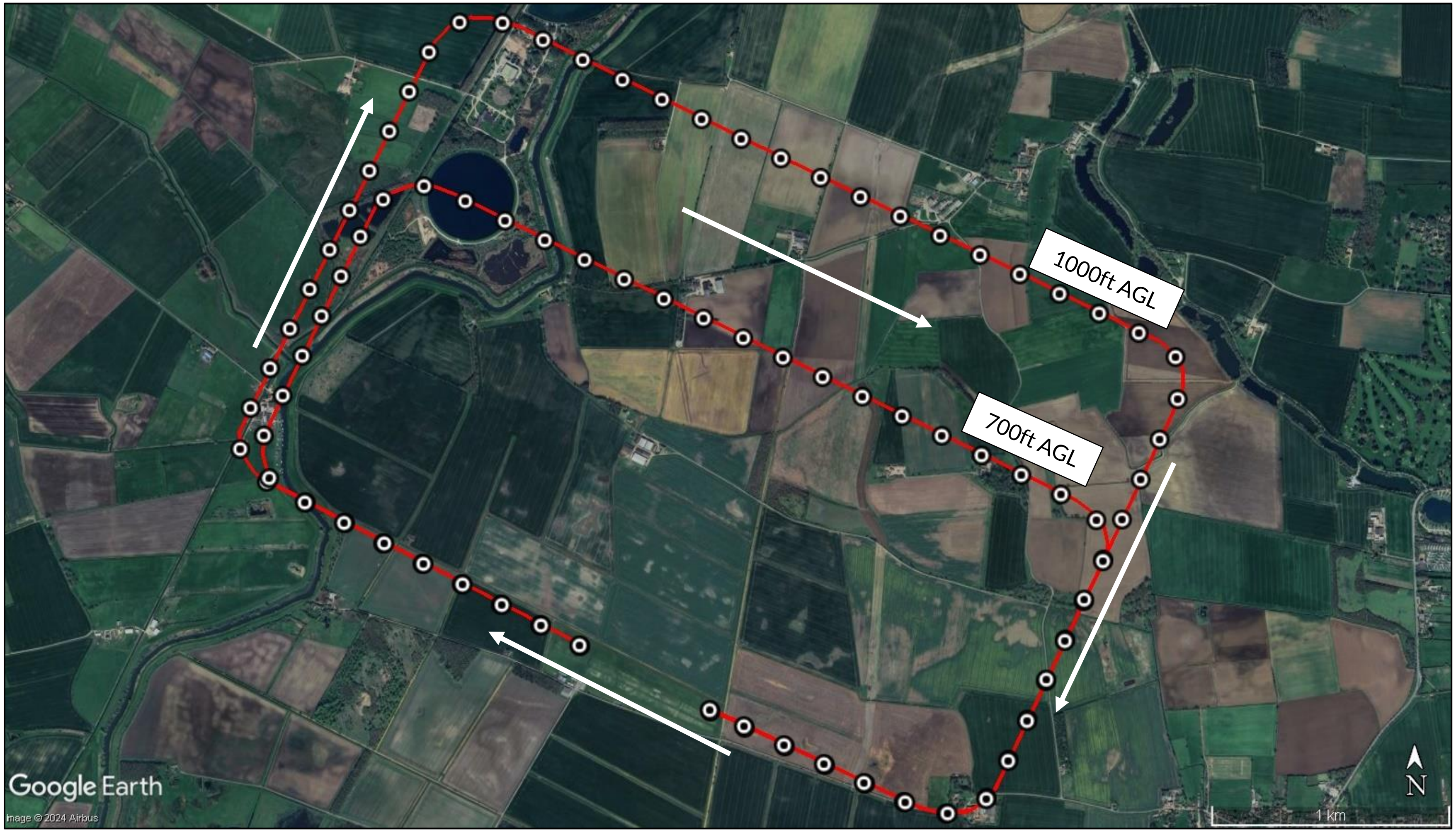

Figure 10 *Runway 30 RH visual circuits (red lines) and assessed receptors (black/white icons) at Beverley Airfield – aerial image*

Figure 11 *1-mile splayed approach path and final sections of visual circuit/join receptors at Hill Farm Airfield and Burton-Constable Airfield – aerial image*

5 IDENTIFICATION OF GROUND-BASED RECEPTORS

5.1 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 extensive experience over a significant number of glint and glare assessments undertaken show that consideration of receptors within 1km of solar PV module areas is appropriate for glint and glare effects on roads and dwellings. Therefore, the study area has been designed accordingly (red outlined areas on the proceeding figures).

Potential receptors are identified based on mapping and aerial photography of the region. The initial judgement is made based on a 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.

Receptor details can be found in Appendix G.

5.2 Road Receptors

5.2.1 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 of up to 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; and
- 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 therefore considers major national, national, and regional roads that:

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

A height of 1.5 metres above ground level has been taken as a typical eye-level for a road user[10]. This height has therefore been added to the ground height at each receptor location. Visibility and direction of travel are considered in the assessment of all receptors.

5.2.2 Identification

86 receptors have been identified distanced circa 100m apart across three road sections:

- A1035 (road receptors 1 to 20 and 21 to 53);
- Beverley Road/A165 (road receptors 54 to 86).

These are shown in Figure 12 below and in Figures 13 to 15 on the following pages.

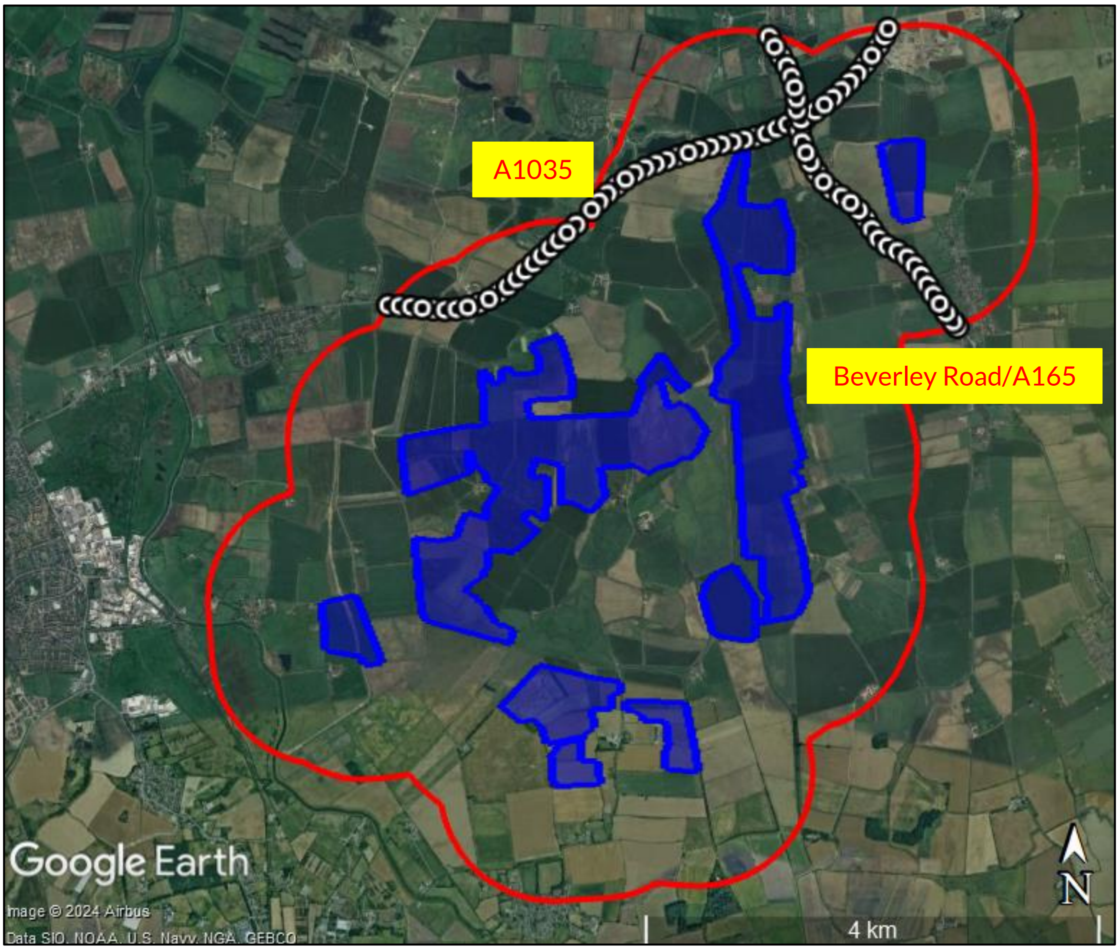

Figure 12 *Overview of road receptors – aerial image*

[10] This height is chosen for modelling purposes, elevated drivers are considered in the results discussion where appropriate.

Figure 13 *A1035: road receptors 1 to 20 – aerial image*

Figure 14 *A1035: road receptors 21 to 53 – aerial image*

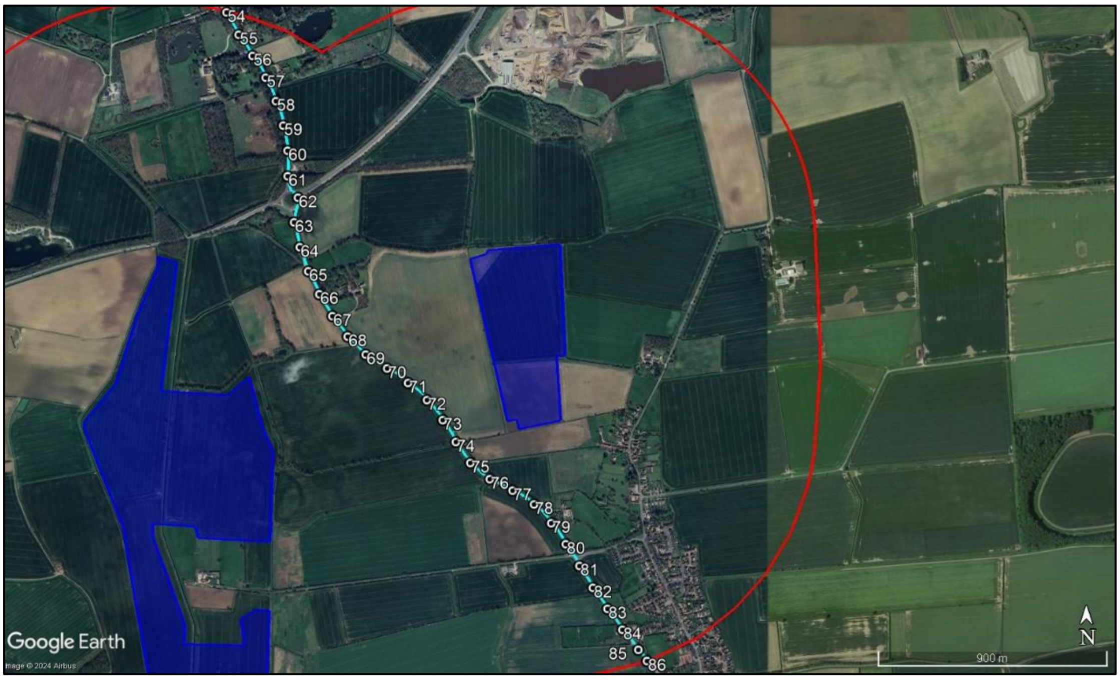

Figure 15 *Beverley Road/A165: road receptors 54 to 86 – aerial image*

5.3 Dwelling Receptors

5.3.1 Overview

The analysis has considered dwellings that:

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

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

In some cases, one physical structure is split into multiple separate addresses. In such cases, the results for the assessed location will be applicable to all associated addresses. The sampling resolution is sufficiently high to capture the level of effect for all potentially affected dwellings.

A height of 1.8 metres above ground level has been taken as typical eye level for an observer on the ground floor[11] of the dwelling since this is typically the most occupied floor of a dwelling throughout the day.

[11] This fixed height for the dwelling 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 above ground floor are considered in the results discussion where necessary.

5.3.2 Identification

In total, 212 dwellings were identified for assessment, these are shown in Figure 16 below. These are shown in more detail in Appendix H.

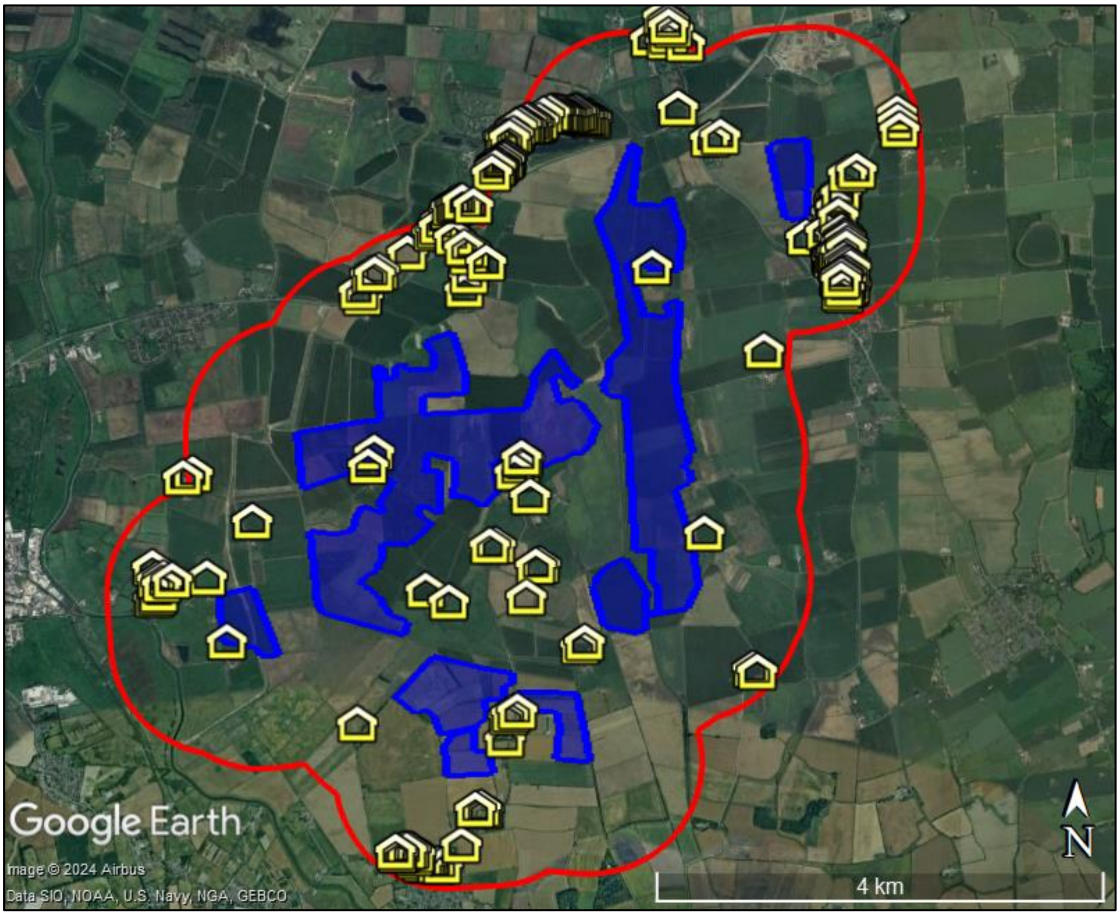

Figure 16 *Overview of dwelling receptors – aerial image*

6 ASSESSMENT RESULTS AND DISCUSSION

6.1 Overview

The following sub-sections present the modelling results as well as the significance of any predicted impact in the context of existing screening, as well as the relevant criteria set out in the next subsection. The criteria are determined by the assessment process for each receptor, which are set out in Appendix D.

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

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

6.2 Roads

6.2.1 Impact Significance Methodology

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

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

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

Where solar reflections are not experienced as a sustained source of glare, originate from outside of a road user's primary horizontal field of view (50 degrees either side of the direction of travel), or the closest reflecting panel is over 1km from the road user, the impact significance is low, and mitigation is not recommended.

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

- 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;
- Whether visibility is likely for elevated drivers (applicable to dual carriageways and motorways only) – there is typically a higher density of elevated drivers along dual carriageways and motorways compared to other types of road;
- 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.

If following consideration of the relevant factors, the solar reflections are not deemed to remain significant, the impact significance is low, and mitigation is not recommended.

If following consideration of the relevant factors, the solar reflections are deemed to remain significant, then the impact significance is moderate, and mitigation is recommended.

Where solar 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.

6.2.2 Geometric Modelling Results

The modelling has shown that solar reflections are geometrically possible[12] towards:

- A 0.5km section of the A1035 (road receptors 7 to 12);
- A 1.1km section of the A1035 (road receptors 22 to 33);
- A 0.7km section of the A1035 (road receptors 39 to 46);
- A 1.8km section of Beverley Road/A165 (road receptors 59 to 77).

These sections are represented by the orange lines in Figure 17 on the following page.

The modelling results for road receptors are presented in Table 2.

Appendix J details some of the significant screening for the assessed receptors which receive solar reflections from panel areas within 1km and inside of a road user's primary horizontal field of view.

[12] Only considering reflections from solar panels within 1km of the receptor. Reflections outside of 1km are not considered to be significant.

Figure 17 *Sections of roads towards which solar reflections are geometrically possible (orange) – aerial image*

Road Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)[13]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
1 – 6	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No
7 – 9	Solar reflections are geometrically possible from **inside** of a road user's primary horizontal field of view	Intervening terrain, buildings and/or vegetation Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	No	N/A	No impact	No

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

Road Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)[13]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
10 – 12	Solar reflections are geometrically possible from **outside** of a road user's primary horizontal field of view	Intervening terrain and vegetation Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	No	N/A	No impact	No
13 – 21	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No
22 – 24	Solar reflections are geometrically possible from **inside** of a road user's primary horizontal field of view	Intervening terrain and vegetation Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	No	N/A	No impact	No

Road Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)[13]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
25 – 26	Solar reflections are geometrically possible from **inside** of a road user's primary horizontal field of view	Intervening terrain and vegetation It cannot be reliably concluded that views of reflecting panels would be obstructed It is assumed that views of reflecting panels may be **possible**	Yes	Reflecting panels are at least 750m away Reflections are possible within 2 hours of sunrise when the Sun is low in the sky	Low impact	No
27 – 33	Solar reflections are geometrically possible from **inside** of a road user's primary horizontal field of view	Intervening terrain and vegetation Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	No	N/A	No impact	No

Road Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)[13]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
34 – 38	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No
39 – 46	Solar reflections are geometrically possible from **inside** of a road user's primary horizontal field of view	Intervening terrain and vegetation Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	No	N/A	No impact	No
47 – 58	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No

Road Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)[13]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
59 – 62	Solar reflections are geometrically possible from **inside** of a road user's primary horizontal field of view	Intervening terrain and vegetation Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	No	N/A	No impact	No
63 – 66	Solar reflections are geometrically possible from **outside** of a road user's primary horizontal field of view	Intervening terrain and vegetation It cannot be reliably concluded that views of reflecting panels would be obstructed It is assumed that minor views of reflecting panels may be **possible**	No	N/A	Low impact	No

Road Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)[13]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
67 – 77	Solar reflections are geometrically possible from **inside** of a road user's primary horizontal field of view	Intervening terrain and vegetation It cannot be reliably concluded that views of reflecting panels would be obstructed It is assumed that views of reflecting panels may be **possible**	Yes	Reflecting panels are at least 400m away Reflections are possible within 2 hours of sunset when the Sun is low in the sky	Low impact	No
78 – 86	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No

Table 2 *Geometric modelling results, assessment of impact significance, and mitigation recommendation/requirement – road receptors*

6.3 Dwellings

6.3.1 Impact Significance Methodology

The key considerations for residential dwellings are:

- Whether a reflection is predicted to be experienced in practice;
- The duration of the predicted effects, relative to thresholds of:
    - Three months per year;
    - 60 minutes on any given day.

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

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

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

- Whether visibility is likely from all storeys – the ground floor is typically considered the main living space and has a greater significance with respect to residential amenity;
- 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;
- Whether the dwelling appears to have windows facing the reflecting area – factors that restrict potential views of a reflecting area reduce the level of impact;
- The position of the Sun – effects that coincide with direct sunlight appear less prominent than those that do not.

If following consideration of the relevant factors, the solar reflections are not deemed to remain significant, the impact significance is low, and mitigation is not recommended.

If following consideration of the relevant factors, the solar reflections are deemed to remain significant, then the impact significance is moderate, and mitigation is recommended.

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

6.3.2 Geometric Modelling Results

The modelling has shown that solar reflections are geometrically possible[14] towards 89 of the 212 dwelling receptors. A summary of geometric results is shown in Figure 18 on the following page, where yellow icons represent receptors where solar reflections are geometrically possible, and green icons represent receptors where solar reflections are not geometrically possible.

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[14] Only considering reflections from solar panels within 1km of the receptor. Reflections outside of 1km are not considered to be significant.

The modelling results for dwelling receptors are analysed in more detail in Table 3. Where a low impact is predicted, blue text is used to distinguish these results. Where a moderate impact is predicted, red text is used to distinguish these results.

Appendix J details some of the significant screening[15] for the assessed receptors where a low impact or no impact is predicted due to the screening obstructing views of panels.

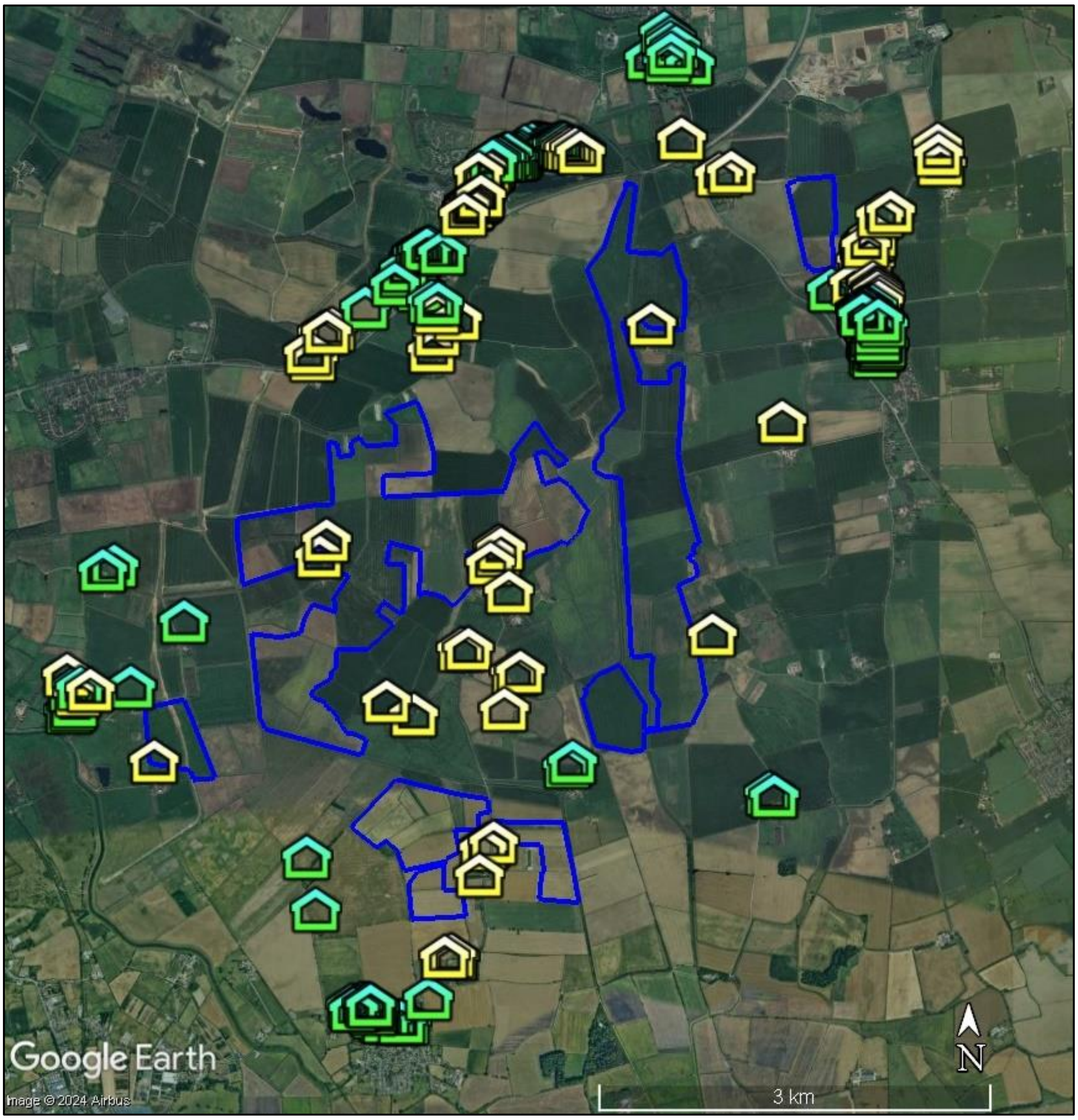

Figure 18 *Summary of dwellings results– aerial image*

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[15] Details of proposed vegetation screening can be found in the Outline Landscape and Ecological Management Plan [EN010157/APP/7.5] and Environmental Statement Volume 3, Figure 3.4: Indicative Environmental Masterplan [EN010157/APP/6.3]

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
1 – 8	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No

[16] With respect to the ground floor only

[17] 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 from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
9 – 13	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No
14 – 44	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
45 – 58	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation, buildings, and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
59 – 69	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation, buildings, and terrain screening Predicted to reduce views of reflecting panels Views of some reflecting panels are assumed to be **possible**	**Less** than three months per year **Less** than 60 minutes per day	N/A	Low impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
70 – 71	Solar reflections **are geometrically possible** for: **Less** than three months per year **Less** than 60 minutes per day	Existing vegetation and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No
72	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
73 – 78	Solar reflections **are geometrically possible** for: **Less** than three months per year **Less** than 60 minutes per day	Existing vegetation and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No
79 – 107	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
108	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation, buildings, and terrain screening Predicted to reduce views of reflecting panels Views of some reflecting panels are expected to be **possible**	**Less** than three months per year **Less** than 60 minutes per day	N/A	Low impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
109	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	No significant screening identified Views of reflecting panels are assumed to be **possible**	**More** than three months per year **Less** than 60 minutes per day	Reflecting panels are at least 750m away Reflections are only predicted within a few hours of sunset when the Sun is low in the sky beyond the reflecting panels	Low impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
110	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Some existing vegetation screening identified Proposed vegetation screening[18] along panel boundaries to the west of the dwelling (see Figure on page 200) Views of reflecting panels are assumed to be **possible**	**Baseline:** **More** than three months per year **Less** than 60 minutes per day **Once proposed screening matures to 2.5m agl:** **Less** than three months per year **Less** than 60 minutes per day	None	**Baseline:** Moderate impact **Once proposed screening matures to 2.5m agl:** Low impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
111 – 112	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No
113 – 125	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No

[18] Details of proposed vegetation screening can be found in the Outline Landscape and Ecological Management Plan [EN010157/APP/7.5] and Environmental Statement Volume 3, Figure 3.4: Indicative Environmental Masterplan [EN010157/APP/6.3]

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
126 – 140	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No
141 – 143	Solar reflections **are geometrically possible** for: **Less** than three months per year **Less** than 60 minutes per day	Existing vegetation and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
144	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation and terrain screening Predicted to reduce views of reflecting panels Views of some reflecting panels are expected to be **possible**	**Less** than three months per year **Less** than 60 minutes per day	N/A	Low impact	No
145	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
146 – 148	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation, buildings, and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
149 – 150	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation, buildings, and terrain screening Predicted to reduce views of reflecting panels Views of some reflecting panels are expected to be **possible**	**More** than three months per year **Less** than 60 minutes per day	Reflecting panels are at least 550m away Reflections are possible within a few hours of sunrise when the Sun is low in the sky	Low impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
151	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
152	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation, buildings, and terrain screening predicted to reduce views of reflecting panels Views of some reflecting panels are expected to be **possible**	**Less** than three months per year **Less** than 60 minutes per day	None	Low impact	No
153 – 156	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
157	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No
158	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
159	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No
160	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
161	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No
162 – 164	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
165	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation, buildings, and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No
166	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
167	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
168	Solar reflections **are geometrically possible** for: **Less** than three months per year **Less** than 60 minutes per day	Existing vegetation and terrain screening Views of some reflecting panels are assumed to be **possible**	**Less** than three months per year **Less** than 60 minutes per day	N/A	Low impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
169 – 175	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation, buildings, and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
176 – 177	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation of unknown height and density and terrain screening Views of some reflecting panels are assumed to be **possible**	**Less** than three months per year **Less** than 60 minutes per day	N/A	Low impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
178	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation of unknown height and density and terrain screening Views of some reflecting panels are assumed to be **possible**	**More** than three months per year **Less** than 60 minutes per day	Reflecting panels are at least 600m away; Reflections are possible within a few hours of sunrise/sunset when the Sun is low in the sky;	Low impact	No
179 – 180	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
181 – 183	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation, buildings, and terrain screening Views of some reflecting panels are assumed to be **possible**	**Less** than three months per year **Less** than 60 minutes per day	N/A	Low impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
184	Solar reflections **are geometrically possible** for: **More** than three months per year **Less** than 60 minutes per day	Existing vegetation, buildings, and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening) All times in GMT	Identified screening and predicted visibility (desk-based review)	Duration of effects[16] (with consideration of screening)[17]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
185 – 187	Solar reflections **are geometrically possible** for: **Less** than three months per year **Less** than 60 minutes per day	Existing vegetation, buildings, and terrain screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact	No
188 – 212	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No

Table 3 *Geometric modelling results, assessment of impact significance, and mitigation recommendation/requirement – dwelling receptors*

6.4 Aviation

6.4.1 Glare Intensity Categorisation

The Forge model has been used to determine whether reflections are possible for aviation receptors. Intensity calculations in line with the Sandia National Laboratories methodology have been undertaken. These calculations are routinely required for solar photovoltaic developments on or near aerodromes. The intensity model calculates the expected intensity of a reflection with respect to the potential for an after-image (or worse) occurring. The designation used by the model is presented in Table 4 below along with the associated colour coding.

Coding Used	Intensity Key
Glare beyond 50°	'Glare occurs outside of a pilot's primary field of view (50 degrees horizontally either side of the direction of travel)'
'Green Glare'	'Low potential for temporary after-image'
'Yellow Glare'	'Potential for temporary after-image'
'Red Glare'	'Potential for permanent eye damage'

Table 4 *Glare intensity designation*

This coding has been used in the table where a reflection has been calculated and is in accordance with Sandia National Laboratories' methodology. In addition, the intensity model allows for the assessment of a variety of solar panel surface materials. This assessment has considered solar panels with a surface material of 'smooth glass with an anti-reflective coating'. It is understood that this is the most commonly used solar panel surface material. Other surfaces that could be modelled include:

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

6.4.2 Key Considerations – Runway Approach Paths

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

- Whether a reflection is predicted to be experienced in practice;
- The location of glare relative to a pilot's primary field of view (50 degrees either side of the approach bearing).
- The intensity of glare for the solar reflections:
  - Glare with 'low potential for temporary after-image' (green glare);
  - Glare with 'potential for temporary after-image' (yellow glare);
  - Glare with 'potential for permanent eye damage' (red glare).

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

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

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

Glare with 'potential for a temporary after-image' (yellow glare) was formerly not permissible under the interim guidance provided by the Federal Aviation Administration in the USA[19] for on-airfield solar. Pager Power recommends a pragmatic approach whereby instances of 'yellow' glare are evaluated in a technical and operational context. Where solar reflections are of an intensity of 'potential for temporary after-image' expert assessment of the following mitigating factors is required to determine the impact significance[20]:

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

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

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

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

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

6.4.3 Assessment Results – Beverley Airfield

Table 5 on the following page presents the following:

- Geometric modelling results[21] for Beverley Airfield;
- Glare intensity;
- Comment and predicted impact significance.

[21] Reference to a pilot's primary field-of-view is made when analysing the geometric results. A pilot's primary field-of-view is defined as 50 degrees either side of the runway approach relative to the runway threshold.

Receptor/Runway	Geometric Modelling Result	Worst-Case Glare Coding (as per Table 4)	Impact Classification	Mitigation Recommended?
1-mile splayed approaches to Runway 12	Solar reflections with a low potential for temporary after-image are predicted	'Green'	Low impact	No
1-mile splayed approaches to Runway 30	Solar reflections originating from outside of a pilot's primary field of view (50 degrees horizontally either side of the direction of travel)	'Glare outside FOV'	Low impact	No
Runway 12 LH 700ft Visual Circuit	Solar reflections with a low potential for temporary after-image are predicted	'Green'	Low impact	No
Runway 30 RH 700ft Visual Circuit	Solar reflections with a low potential for temporary after-image are predicted	'Green'	Low impact	No
Runway 12 LH 1000ft Visual Circuit	Solar reflections with a low potential for temporary after-image are predicted	'Green'	Low impact	No
Runway 30 RH 1000ft Visual Circuit	Solar reflections with a low potential for temporary after-image are predicted	'Green'	Low impact	

Table 5 *Geometric modelling results and assessment of impact significance – Beverley Airfield receptors*

6.4.4 Assessment Results – Hill Farm Airfield and Burton-Constable Airfield

Table 6 below presents the following:

- Geometric modelling results[22] for Hill Farm Airfield and Burton-Constable Airfield;
- Glare intensity;
- Comment and predicted impact significance.

Receptor/Runway	Geometric Modelling Result	Worst-Case Glare Coding (as per Table 4)	Impact Classification	Mitigation Recommended?
Hill Farm Airfield Approach Paths, Visual Circuits, and Joins	Solar reflections with a low potential for temporary after-image are predicted	Green	Low impact	No
Burton-Constable Airfield Approach Paths, Visual Circuits, and Joins	Solar reflections with a low potential for temporary after-image are predicted	Green	Low impact	No

Table 6 *Geometric modelling results and assessment of impact significance – Hill Farm Airfield and Burton-Constable Airfield receptors*

[22] Reference to a pilot's primary field-of-view is made when analysing the geometric results. A pilot's primary field-of-view is defined as 50 degrees either side of the runway approach relative to the runway threshold.

7 CONCLUSIONS

7.1 Roads

The modelling has shown that solar reflections are geometrically possible towards:

- A 0.5km section of the A1035;
- A 1.1km section of the A1035;
- A 0.7km section of the A1035;
- A 1.8km section of Beverley Road/A165.

A low impact is predicted on a 0.1km section of the A1035, and a 1.4km section of Beverley Road/A165, because solar reflections are predicted from **outside** of a road user's primary horizontal field of view[23], or where solar reflections are predicted from **inside** of a road user's primary horizontal field of view, following consideration of relevant factors, it is deemed that the solar reflection would not remain significant. The relevant points include:

- There is partial screening such that reflections will be filtered and marginal views of reflecting panels are expected to be possible;
- There is a significant clearance distance between the road user and the closest reflecting panel; and/pr
- Reflections are possible when the Sun is low in the sky beyond the reflecting panels. The sun is a much more significant source of irradiance.

No impacts are predicted on the remaining assessed sections of roads, because there is significant screening such that views of reflecting panels are not expected to be possible in practice.

No mitigation is recommended for any sections of road.

7.2 Dwellings

The modelling has shown that solar reflections are geometrically possible towards 89 of the 225 assessed dwelling locations.

No impacts are predicted on 64 of these dwellings, because there is significant screening such that views of reflecting panels are not expected to be possible in practice.

A low impact is predicted on 24 dwellings, because there is significant screening such the duration of effects is expected to be reduced to **less** than three months per year and **less** than 60 minutes on any given day, or following consideration of relevant factors, it is deemed that the solar reflection would not remain significant. The relevant points include:

- There is a significant distance between the dwelling observer and closest reflecting panel; and

[23] 50-degrees either side of the direction of travel

- Reflections are only possible when the Sun is low in the sky beyond the reflecting panels.

A moderate impact is predicted on one dwelling under baseline conditions due to the duration of effects and a lack of sufficient mitigating factors. Proposed vegetation screening along panel boundaries to the west of the dwelling will reduce the duration of effects to **less** than three months per year and **less** than 60 minutes on any given day, once it matures to 2.5 metres above ground level. The impact will be reduced to low impact, and further mitigation is not recommended.

7.3 Beverley Airfield

The analysis has shown that solar reflections with a maximum intensity of 'low potential for temporary after image' ('green' glare) are geometrically possible towards parts of the 1-mile splayed approach paths and visual circuits at Beverley Airfield.

Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, which states that this level of glare is acceptable, it can be reliably concluded that this level of glare is also acceptable for the 1-mile splayed approach paths and visual circuits. No significant impacts are predicted, and no mitigation is required.

7.4 Hill Farm Airfield & Burton-Constable Airfield

The analysis has shown that solar reflections with a maximum intensity of 'low potential for temporary after image' ('green' glare) are geometrically possible towards parts of the 1-mile splayed approach paths and final sections of the visual circuits and joins at Hill Farm Airfield and Burton-Constable Airfield.

Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, which states that this level of glare is acceptable, it can be reliably concluded that this level of glare is also acceptable for the circuit paths. No significant impact is predicted, and no mitigation is required.

7.5 Overall Conclusions

A moderate impact is predicted on one dwelling under baseline conditions due to the duration of effects and a lack of sufficient mitigating factors. Proposed vegetation screening is expected to reduce the impact level to low impact, and further mitigation is not recommended.

No significant impacts are predicted on surrounding road safety, and aviation activity associated with Beverley Airfield, Hill Farm Airfield and Burton-Constable Airfield.

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

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

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

UK Planning Policy

Renewable and Low Carbon Energy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[24] (specifically regarding the consideration of solar farms, paragraph 013) states:

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

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

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

…

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

…

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

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

National Policy Statement for Renewable Energy Infrastructure

The National Policy Statement for Renewable Energy Infrastructure (EN-3)[25] sets out the primary policy for decisions by the Secretary of State for nationally significant renewable energy infrastructure. Sections 2.10.102-106 state:

'2.10.102 Solar panels are specifically designed to absorb, not reflect, irradiation.[26] However, solar panels may reflect the sun's rays at certain angles, causing glint and glare. Glint is defined as a momentary flash of light that may be produced as a direct reflection of the sun in the solar panel. Glare is a continuous source of excessive brightness experienced by a stationary observer located in the path of reflected sunlight from the face of the panel. The effect occurs when the solar panel is stationed between or at an angle of the sun and the receptor.

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

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

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

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

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

Sections 2.10.134-136 state:

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

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

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

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[25] National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Energy Security & Net Zero, date: January 2024, accessed on: 21/12/2023.

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

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

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

Sections 2.10.158-159 state:

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

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

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

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

Assessment Process – Ground-Based Receptors

No process for determining and contextualising the effects of glint and glare has been determined when assessing the impact of solar reflections upon surrounding roads and dwellings. Therefore, the Pager Power approach is to determine whether a reflection from the proposed solar development is geometrically possible and then to compare the results against the relevant guidance/studies to determine whether the reflection is significant. The Pager Power approach has been informed by the policy presented above, current studies (presented in Appendix B) and stakeholder consultation. Further information can be found in Pager Power's Glint and Glare Guidance document[27] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

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

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[28] however the advice is still applicable[29] 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[30], 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.

[28] Archived at Pager Power

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

[30] 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'*[31], the 2013 update is entitled '*Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'*[32], and the 2021 final policy is entitled '*Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports'*[33].

Key excerpts from the final policy are presented below:

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

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

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

[31] Archived at Pager Power

[32] 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.

[33] 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.

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*'[34]. 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*[35].
- *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*[36]*, flat, smooth surfaces reflect a more concentrated amount of sunlight back to the receiver, which is referred to as specular reflection. The more a surface is polished, the more it shines. Rough or uneven surfaces reflect light in a diffused or scattered manner and, therefore, the light will not be received as bright.*
- *Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:*

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

[35] 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.

[36] First figure in Appendix B.

   - *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[37] but still requires further research to definitively answer.*

[37] 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.

- ***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[38] with regard to safeguarding. Key points from the document are presented below.

Lights liable to endanger

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

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

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

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

(a) to extinguish or screen the light; and

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

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

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

Lights which dazzle or distract

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

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

Endangering safety of an aircraft

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

Endangering safety of any person or property

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

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

Civil Aviation Authority consolidation of UK Regulation 139/2014

The Civil Aviation Authority (CAA) published a consolidating document[39] of UK regulations, (Implementing Rules, Acceptable Means of Compliance and Guidance Material), in 2023. A summary of material relevant to aerodrome safeguarding is presented below:

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

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

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

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

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

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

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

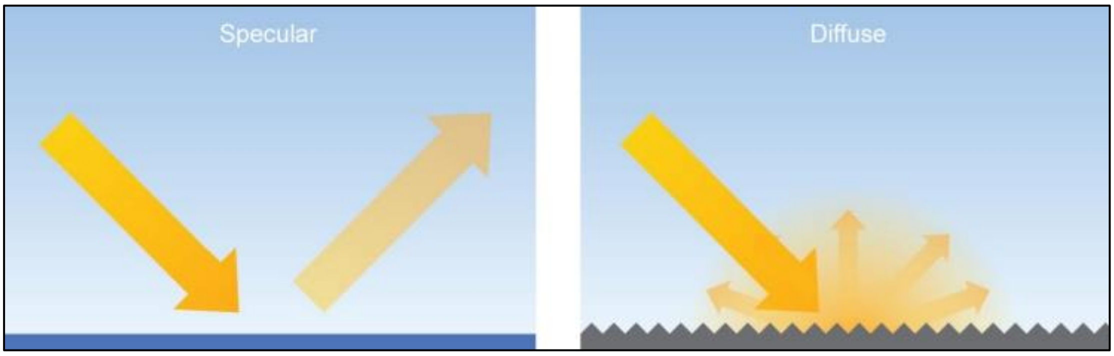
Overview

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[40], 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

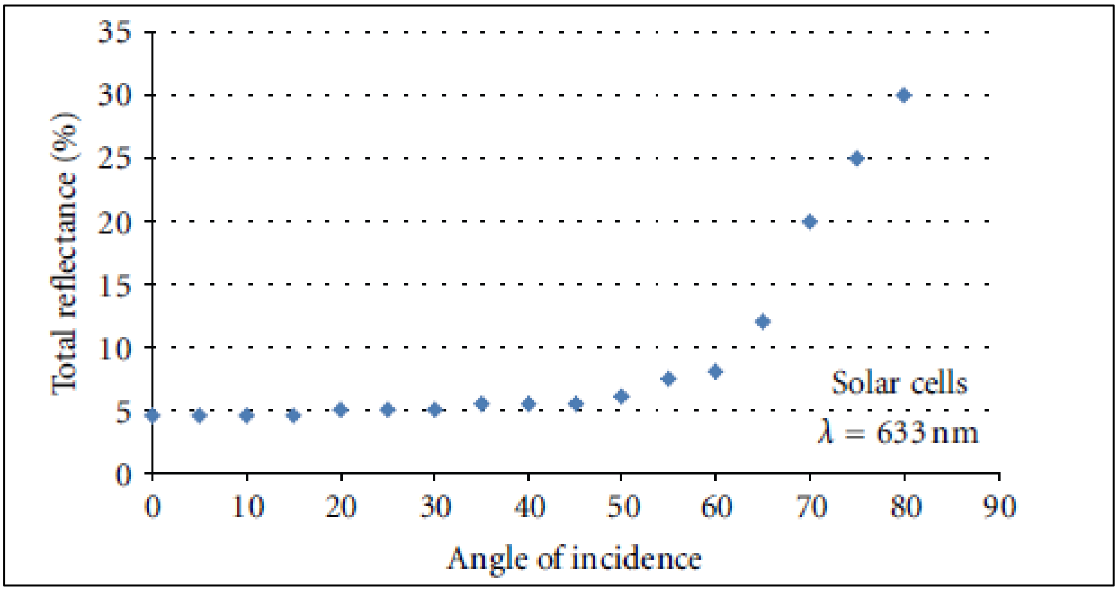
[40] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, last accessed on: 19/12/2023.

Solar Reflection Studies

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

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

Evan Riley and Scott Olson published in 2011 their study titled: *A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems*[41]". 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.

FAA Guidance – "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[40]

[41] 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

The 2018 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[42]
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).

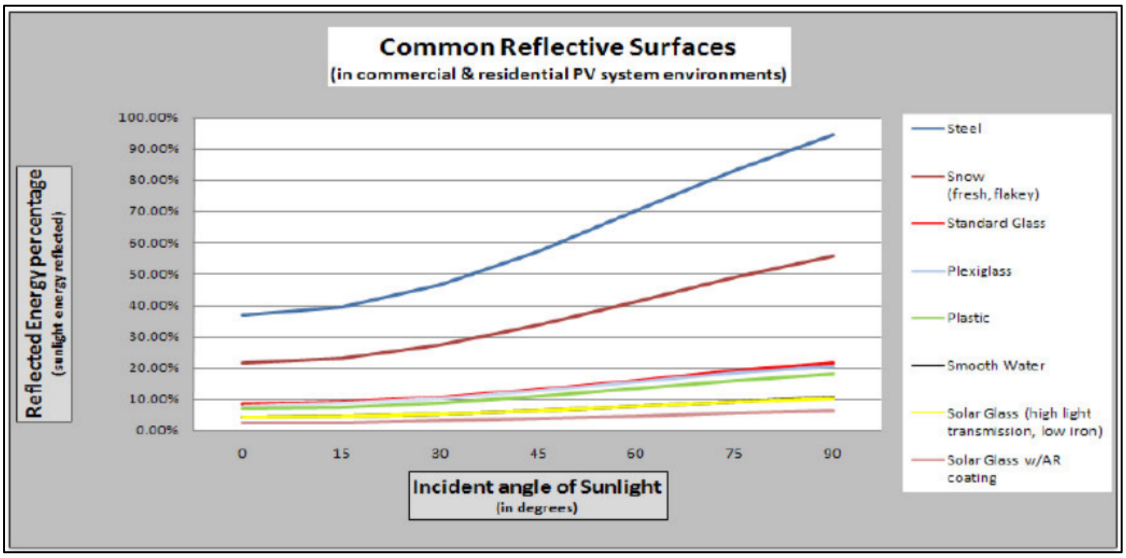
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

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

SunPower Technical Notification (2009)

SunPower published a technical notification[43] 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.

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

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

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

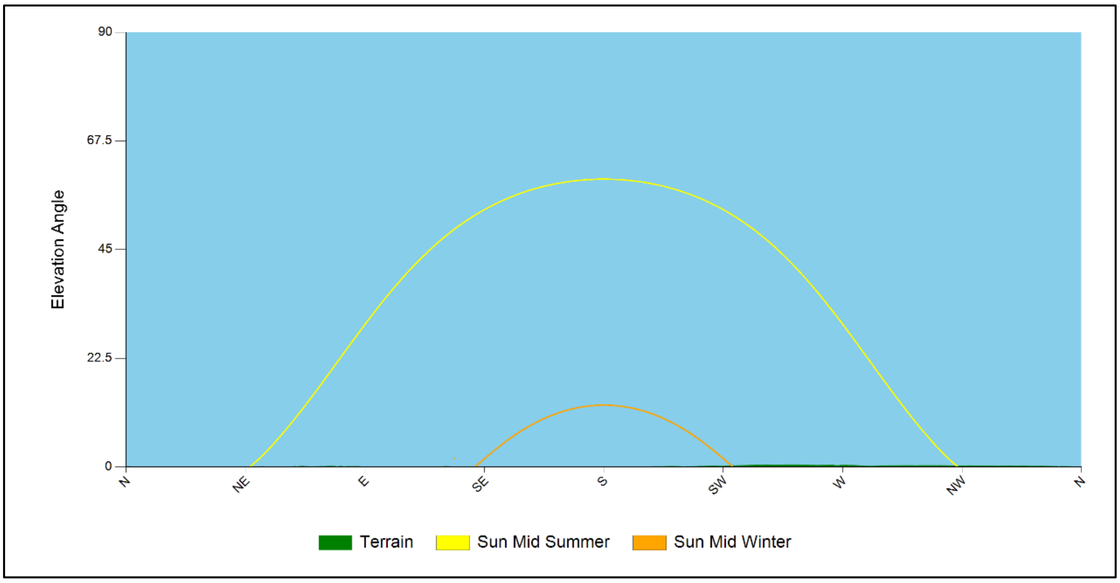
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

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

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

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

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



Terrain elevation at the horizon

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact Significance Definition

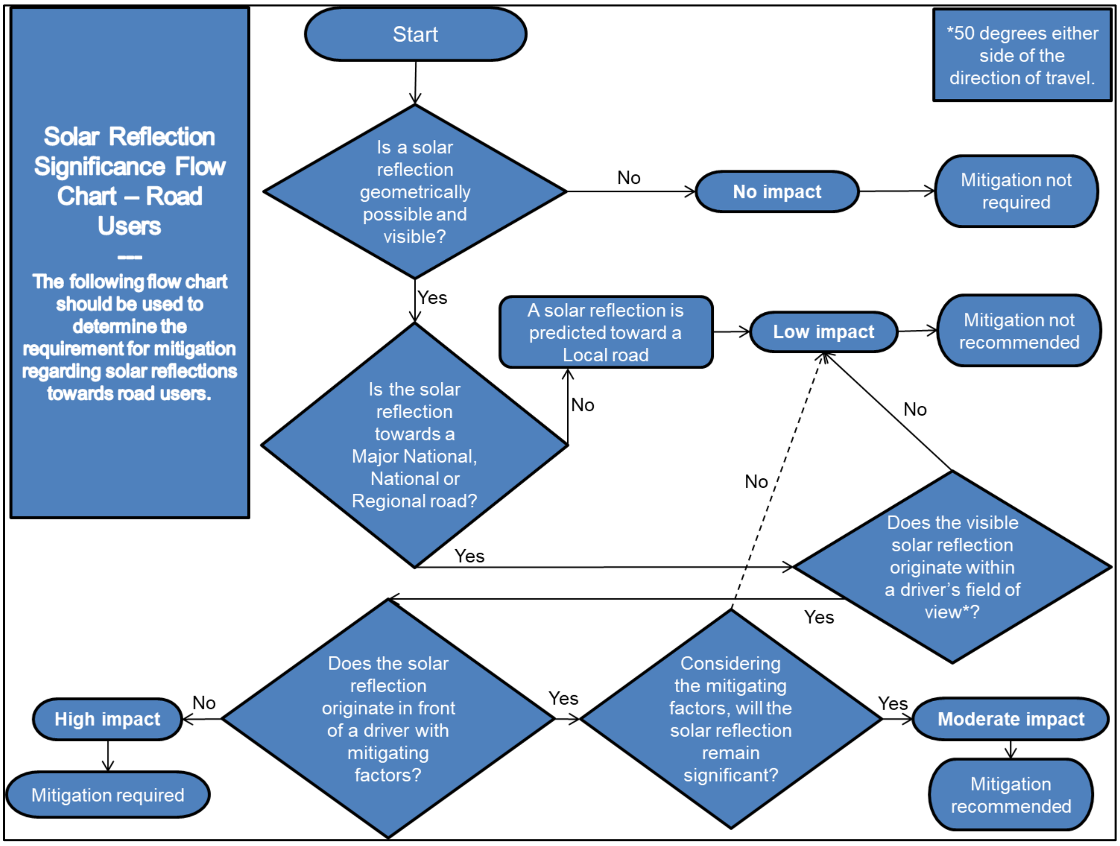
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not required e.g., intervening screening will limit the view of the reflecting solar panels significantly.	No mitigation 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

Assessment Process for Road Receptors

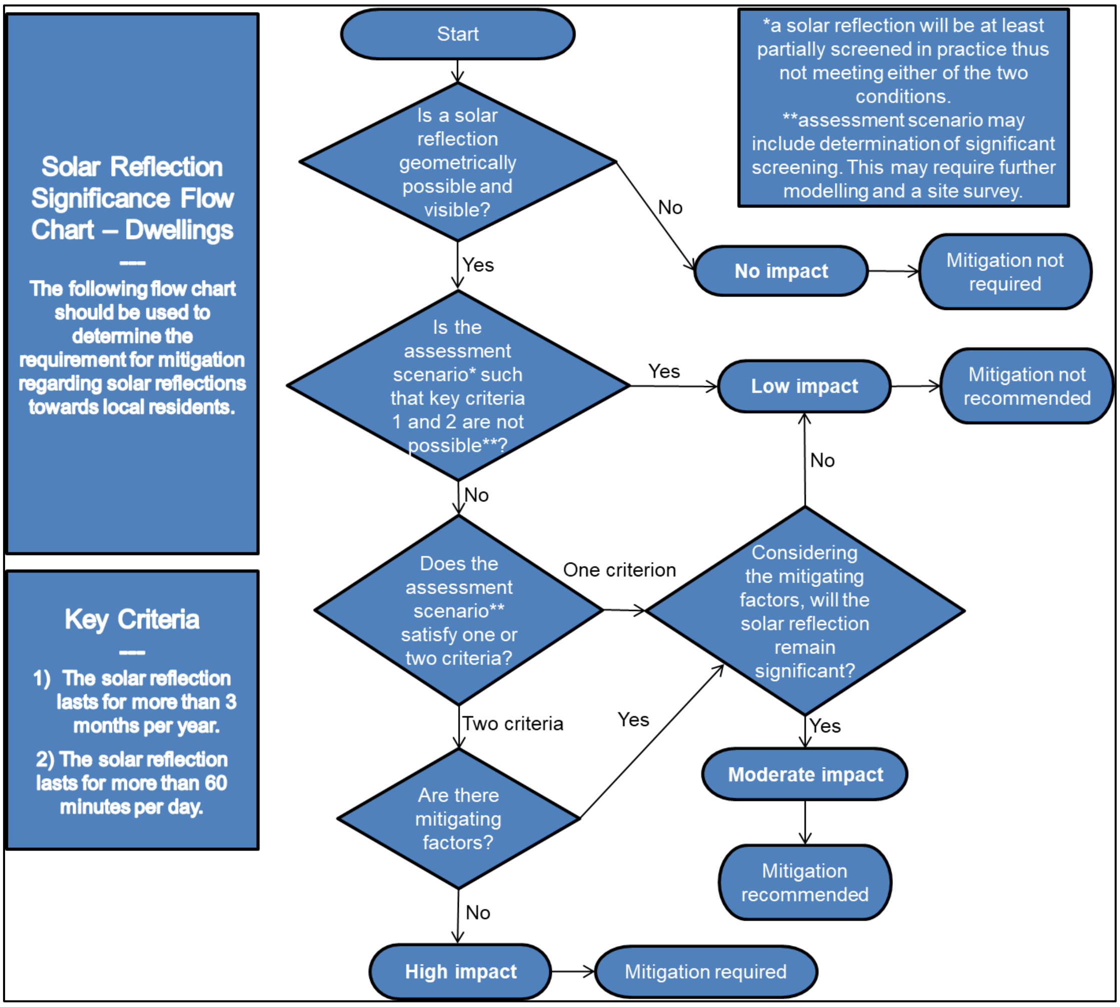
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road receptor mitigation requirement flow chart

Assessment Process for Dwelling Receptors

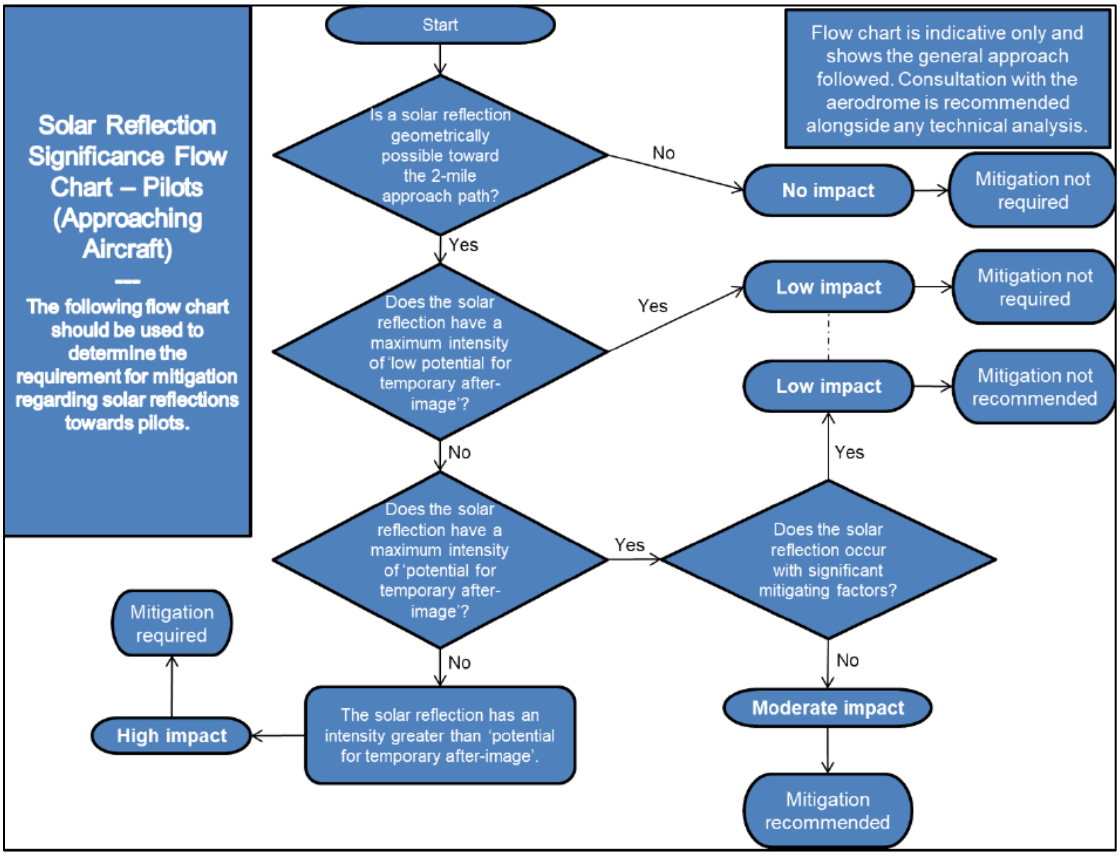
The flow chart presented below has been followed when determining the mitigation requirement for dwelling receptors.



Dwelling receptor mitigation requirement flow chart

Assessment Process for Approaching Aircraft

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



Approach path receptor mitigation requirement flow chart

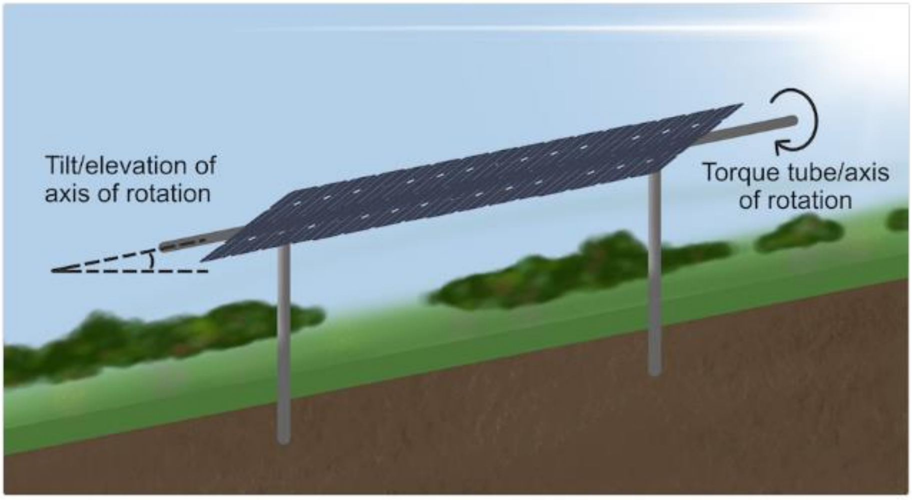
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

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[44]

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.

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

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Terrain Height

Terrain Height is calculated from SRTM data, based on the coordinates of the point of interest.

Aviation Receptor Data

Full receptor details are available upon request.

Beverley Airfield

Runway Threshold	Latitude (°)	Longitude (°)	Elevation (m amsl)
12	53.899592	-0.365430	0.157
30	53.897154	-0.357103	0

Beverley Airfield

Hill Farm Airfield

Receptor	Latitude (°)	Longitude (°)	Elevation (m amsl)
18	53.842047	-0.212002	10.03
36	53.837759	-0.211894	15

Hill Farm Airfield

Burton-Constable Airfield

Receptor	Latitude (°)	Longitude (°)	Elevation (m amsl)
16	53.812302	-0.195171	15
34	53.80458	-0.191526	16

Burton-Constable Airfield

Road Receptor Details

The road receptors details are presented in the table below.

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
1	53.864734	-0.366414	44	53.880505	-0.308111
2	53.864686	-0.36489	45	53.881064	-0.306915
3	53.864607	-0.36337	46	53.881672	-0.30579

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
4	53.864504	-0.361854	47	53.882303	-0.304702
5	53.864416	-0.360335	48	53.882966	-0.303671
6	53.864367	-0.358812	49	53.883657	-0.302692
7	53.864426	-0.357291	50	53.884372	-0.301766
8	53.864575	-0.355787	51	53.885119	-0.300915
9	53.864835	-0.354328	52	53.885885	-0.300114
10	53.865211	-0.352942	53	53.886466	-0.299605
11	53.865677	-0.351639	54	53.885855	-0.315487
12	53.866219	-0.350422	55	53.885064	-0.31476
13	53.866814	-0.349278	56	53.884312	-0.313922
14	53.867424	-0.348156	57	53.883544	-0.313132
15	53.868021	-0.347014	58	53.882718	-0.312526
16	53.868621	-0.345876	59	53.881858	-0.312093
17	53.869229	-0.34475	60	53.880972	-0.311831
18	53.869836	-0.343625	61	53.880072	-0.311824
19	53.870436	-0.342487	62	53.879316	-0.311211
20	53.871085	-0.341235	63	53.87845	-0.31145
21	53.872245	-0.339211	64	53.877573	-0.311113
22	53.872901	-0.338167	65	53.876725	-0.310606
23	53.873524	-0.337066	66	53.875914	-0.309946
24	53.874099	-0.335892	67	53.875142	-0.309167
25	53.874654	-0.334693	68	53.874421	-0.308253
26	53.875138	-0.333405	69	53.873787	-0.307176
27	53.875534	-0.332036	70	53.873297	-0.305897
28	53.875867	-0.330619	71	53.872786	-0.304643

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
29	53.876163	-0.329177	72	53.872181	-0.303516
30	53.876449	-0.32773	73	53.871474	-0.302572
31	53.876717	-0.326273	74	53.870702	-0.301793
32	53.876974	-0.32481	75	53.869963	-0.300925
33	53.877197	-0.323331	76	53.869391	-0.299766
34	53.8774	-0.321844	77	53.868989	-0.298402
35	53.877581	-0.320349	78	53.868503	-0.29712
36	53.877757	-0.318852	79	53.86784	-0.296093
37	53.877951	-0.317361	80	53.867103	-0.295224
38	53.87823	-0.315912	81	53.86634	-0.294413
39	53.878606	-0.314526	82	53.865574	-0.293613
40	53.878967	-0.313128	83	53.864835	-0.292742
41	53.878889	-0.311676	84	53.864103	-0.291855
42	53.879472	-0.310611	85	53.863398	-0.290906
43	53.879978	-0.309349	86	53.863004	-0.290388

Road receptor locations

Dwelling Receptor Details

The dwelling receptors details are presented in the table below.

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
1	53.884021	-0.316946	107	53.863563	-0.290674
2	53.883795	-0.314788	108	53.865773	-0.316715
3	53.884293	-0.314426	109	53.859066	-0.301537
4	53.885779	-0.31519	110	53.844499	-0.309649
5	53.885356	-0.314449	111	53.833608	-0.303072
6	53.885025	-0.314477	112	53.833427	-0.302477

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
7	53.884768	-0.313849	113	53.873279	-0.338436
8	53.883618	-0.312215	114	53.873741	-0.337971
9	53.876122	-0.336762	115	53.873745	-0.3378
10	53.876015	-0.336493	116	53.873829	-0.33767
11	53.876094	-0.336061	117	53.873926	-0.337615
12	53.876242	-0.335801	118	53.874021	-0.337656
13	53.876348	-0.33558	119	53.874101	-0.337714
14	53.876427	-0.335325	120	53.874113	-0.337295
15	53.876616	-0.335265	121	53.874211	-0.33707
16	53.876816	-0.335218	122	53.874277	-0.33683
17	53.876981	-0.335113	123	53.874335	-0.336709
18	53.877081	-0.334845	124	53.874463	-0.336582
19	53.877125	-0.334576	125	53.874561	-0.336477
20	53.877136	-0.334315	126	53.870671	-0.340958
21	53.877067	-0.333947	127	53.870991	-0.342461
22	53.877405	-0.333755	128	53.870904	-0.342763
23	53.877425	-0.3334	129	53.870811	-0.343101
24	53.877184	-0.333102	130	53.870747	-0.343344
25	53.877172	-0.332808	131	53.870678	-0.343694
26	53.877184	-0.332506	132	53.87056	-0.343905
27	53.877252	-0.332279	133	53.870243	-0.34416
28	53.877422	-0.332111	134	53.86951	-0.34533
29	53.877576	-0.331894	135	53.869041	-0.345647
30	53.877926	-0.33144	136	53.868727	-0.346013

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
31	53.878096	-0.330599	137	53.868512	-0.346473
32	53.878099	-0.330378	138	53.868153	-0.343565
33	53.878096	-0.330123	139	53.8673	-0.342196
34	53.878096	-0.329912	140	53.867195	-0.341442
35	53.878066	-0.329674	141	53.866612	-0.341589
36	53.878071	-0.329441	142	53.866126	-0.339209
37	53.878033	-0.329152	143	53.865056	-0.341508
38	53.878015	-0.328888	144	53.863948	-0.34217
39	53.877944	-0.328611	145	53.866916	-0.349907
40	53.877949	-0.328313	146	53.865422	-0.353788
41	53.877998	-0.3279	147	53.865209	-0.354362
42	53.878062	-0.327568	148	53.865154	-0.354857
43	53.878133	-0.327127	149	53.863823	-0.356531
44	53.878108	-0.326776	150	53.863358	-0.356003
45	53.877893	-0.326592	151	53.850964	-0.354433
46	53.877806	-0.326182	152	53.849861	-0.355262
47	53.877821	-0.325871	153	53.849225	-0.379086
48	53.877788	-0.325538	154	53.848917	-0.380404
49	53.877706	-0.325148	155	53.845415	-0.370976
50	53.877545	-0.324921	156	53.840908	-0.377149
51	53.87849	-0.313205	157	53.840703	-0.381851
52	53.876029	-0.308821	158	53.840825	-0.382994
53	53.876216	-0.307432	159	53.841719	-0.384547
54	53.878059	-0.283461	160	53.840724	-0.383905

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
55	53.877377	-0.28337	161	53.840372	-0.383246
56	53.876714	-0.283101	162	53.839619	-0.38364
57	53.873202	-0.29011	163	53.839397	-0.383865
58	53.873487	-0.28893	164	53.839217	-0.384285
59	53.871849	-0.290907	165	53.83581	-0.374436
60	53.871646	-0.291045	166	53.829232	-0.356732
61	53.871528	-0.291296	167	53.839928	-0.347453
62	53.871346	-0.291582	168	53.839005	-0.344303
63	53.87115	-0.291789	169	53.843478	-0.338753
64	53.870879	-0.291879	170	53.843516	-0.337956
65	53.870687	-0.291638	171	53.849361	-0.335392
66	53.870548	-0.291701	172	53.849726	-0.33457
67	53.870404	-0.291826	173	53.85039	-0.334172
68	53.870087	-0.29232	174	53.850524	-0.334435
69	53.869849	-0.291405	175	53.84743	-0.333268
70	53.868554	-0.290989	176	53.841947	-0.331927
71	53.868585	-0.293162	177	53.841863	-0.332502
72	53.868121	-0.295815	178	53.839372	-0.333779
73	53.868199	-0.290582	179	53.835765	-0.325871
74	53.8681	-0.290441	180	53.835462	-0.326468
75	53.867936	-0.290491	181	53.830263	-0.335005
76	53.867723	-0.290951	182	53.830057	-0.3358
77	53.867564	-0.290188	183	53.829818	-0.336155
78	53.86729	-0.290342	184	53.828009	-0.336682

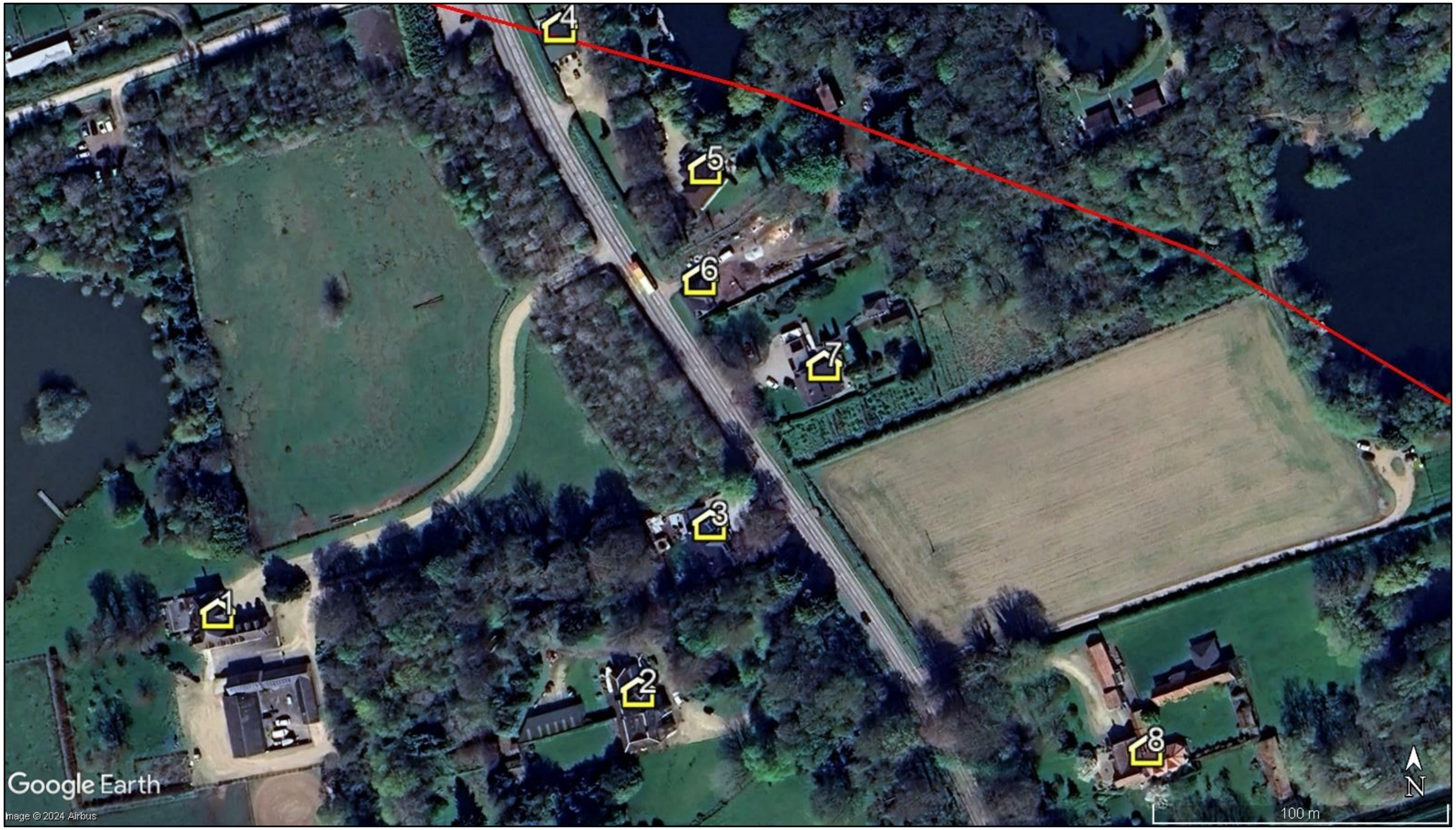
No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
79	53.866978	-0.291064	185	53.822355	-0.339644
80	53.866995	-0.291426	186	53.822503	-0.339944
81	53.866804	-0.291627	187	53.822401	-0.340706
82	53.866772	-0.291767	188	53.819574	-0.342583
83	53.866722	-0.291978	189	53.817894	-0.345177
84	53.866759	-0.292399	190	53.817945	-0.3457
85	53.866672	-0.292319	191	53.817975	-0.345903
86	53.866582	-0.292251	192	53.818003	-0.346802
87	53.866482	-0.292202	193	53.818019	-0.34719
88	53.866386	-0.292162	194	53.818012	-0.347512
89	53.866316	-0.290633	195	53.818068	-0.347919
90	53.866043	-0.290364	196	53.818309	-0.348784
91	53.865949	-0.28999	197	53.81856	-0.349006
92	53.865705	-0.289806	198	53.818693	-0.349006
93	53.865218	-0.290424	199	53.818847	-0.348893
94	53.865122	-0.290821	200	53.818992	-0.349124
95	53.865039	-0.291004	201	53.819084	-0.349309
96	53.864919	-0.291304	202	53.819135	-0.349565
97	53.864844	-0.291222	203	53.819094	-0.349753
98	53.864722	-0.291041	204	53.819102	-0.35001
99	53.86468	-0.290416	205	53.81907	-0.350241
100	53.864589	-0.290275	206	53.819159	-0.350464
101	53.864325	-0.289818	207	53.81891	-0.350791
102	53.864133	-0.289926	208	53.818894	-0.350926

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
103	53.864099	-0.290112	209	53.818862	-0.351106
104	53.864068	-0.290424	210	53.818803	-0.351269
105	53.864039	-0.290654	211	53.819045	-0.351535
106	53.863749	-0.291046	212	53.825639	-0.355683

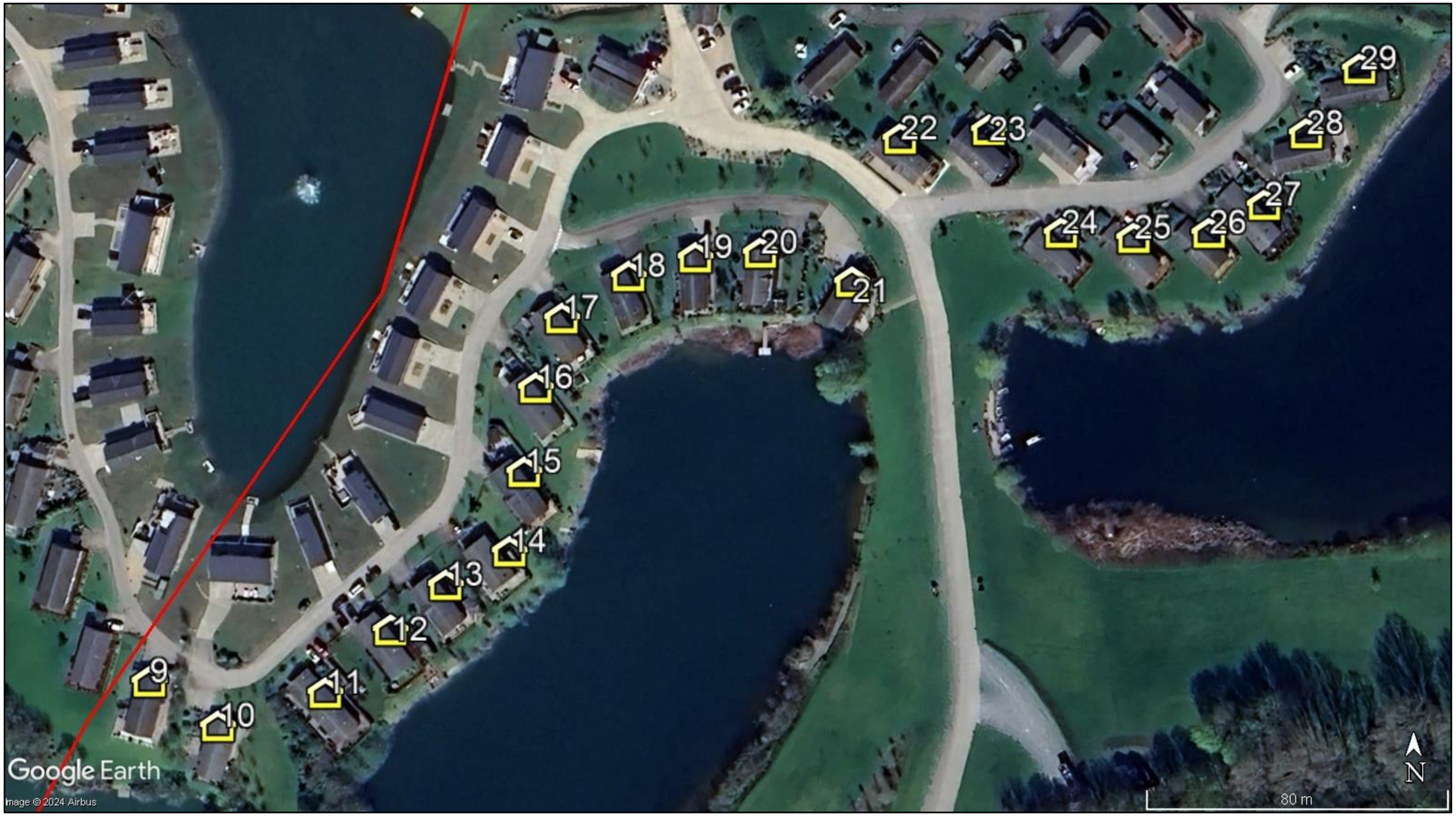
Dwelling receptor locations

APPENDIX H – DETAILED IDENTIFICATION OF DWELLING RECEPTORS

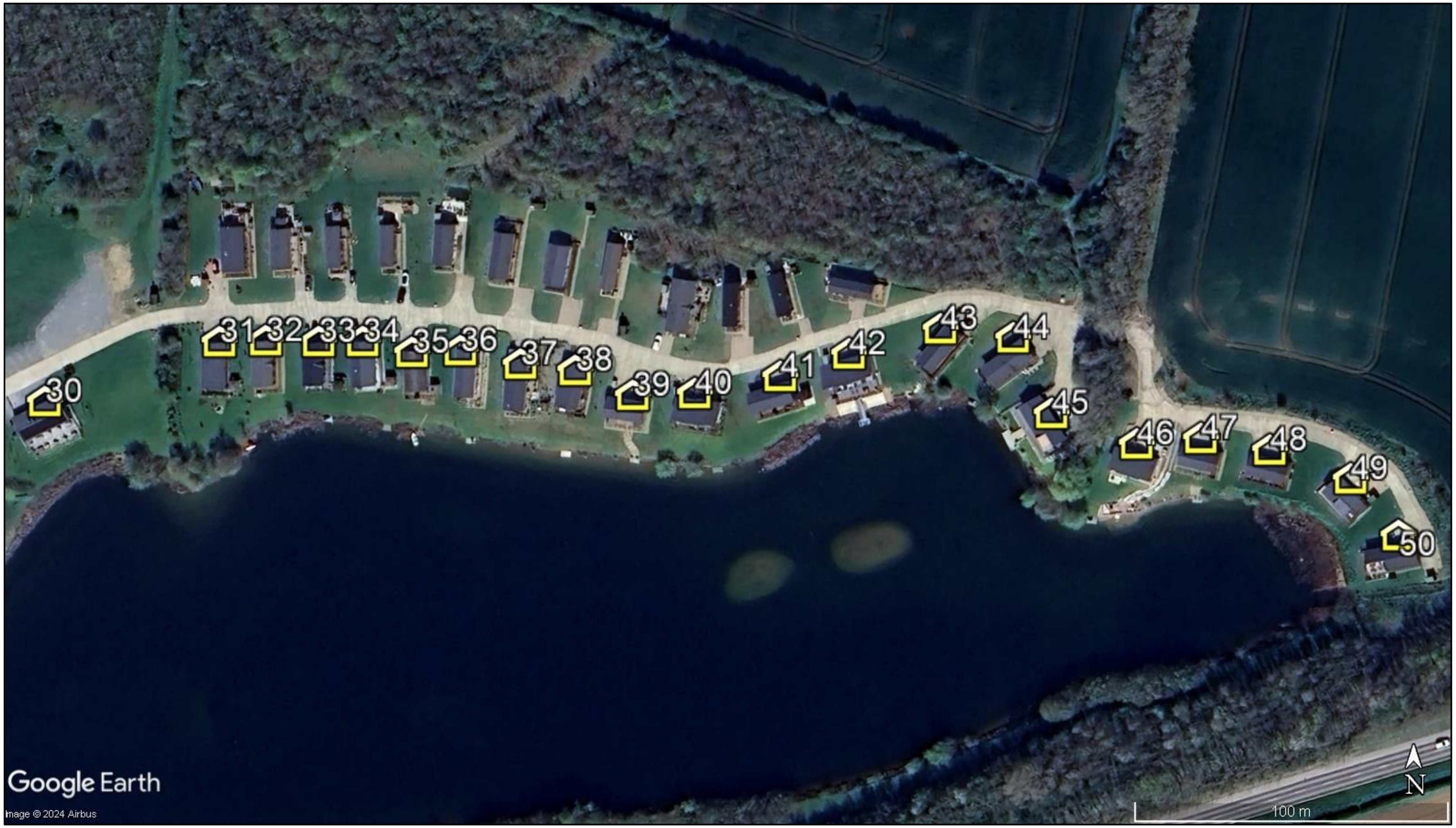
Dwelling receptors are shown in detail in the following figures.



Dwelling receptors 1 to 8 – aerial image



Dwelling receptors 9 to 29 – aerial image

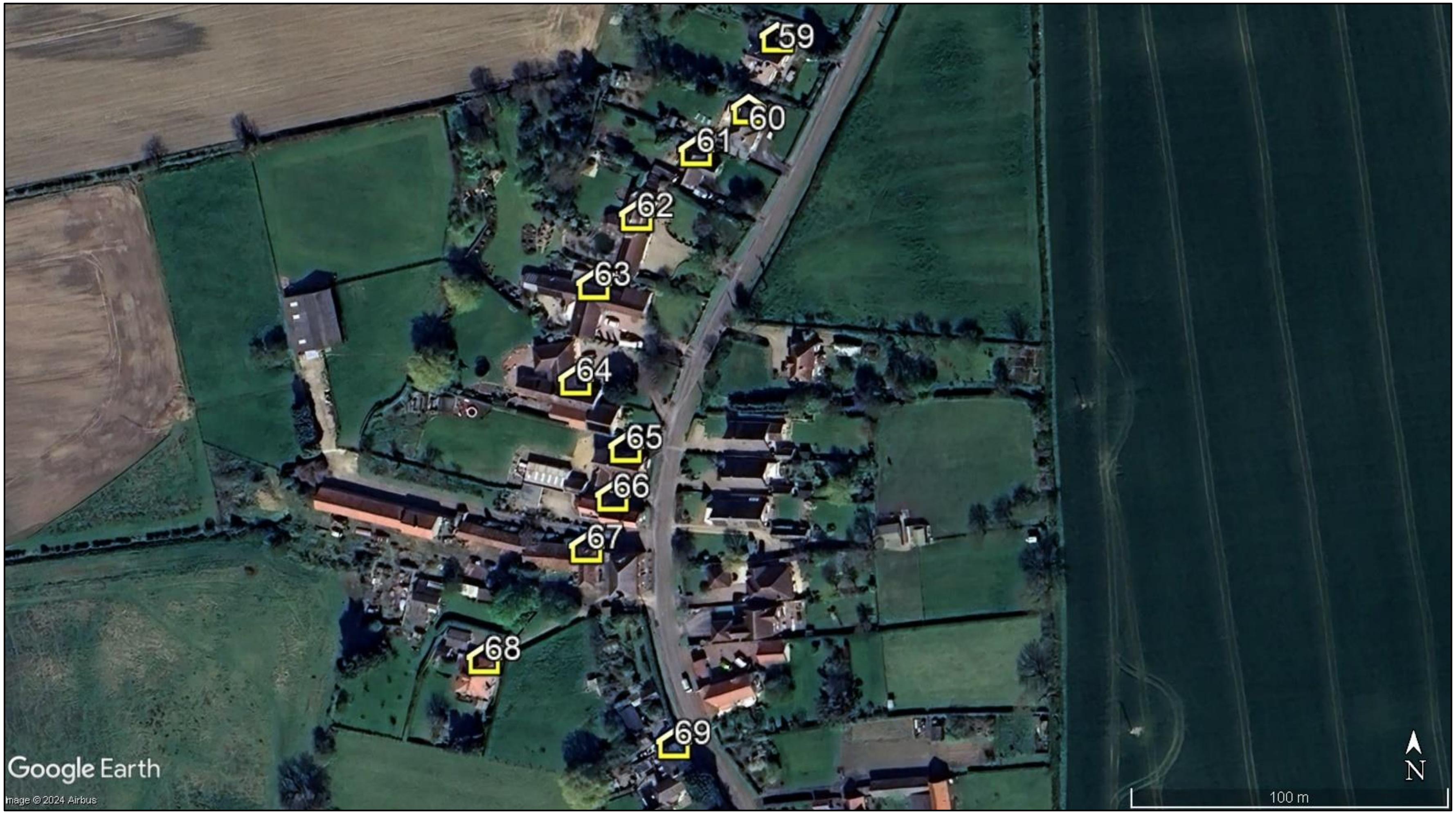


Dwelling receptors 30 to 50 – aerial image

Dwelling receptors 51 to 53 – aerial image

Dwelling receptors 54 to 56 – aerial image

Dwelling receptors 57 and 58 – aerial image



Dwelling receptors 59 to 69 – aerial image

Dwelling receptors 70 to 78 – aerial image

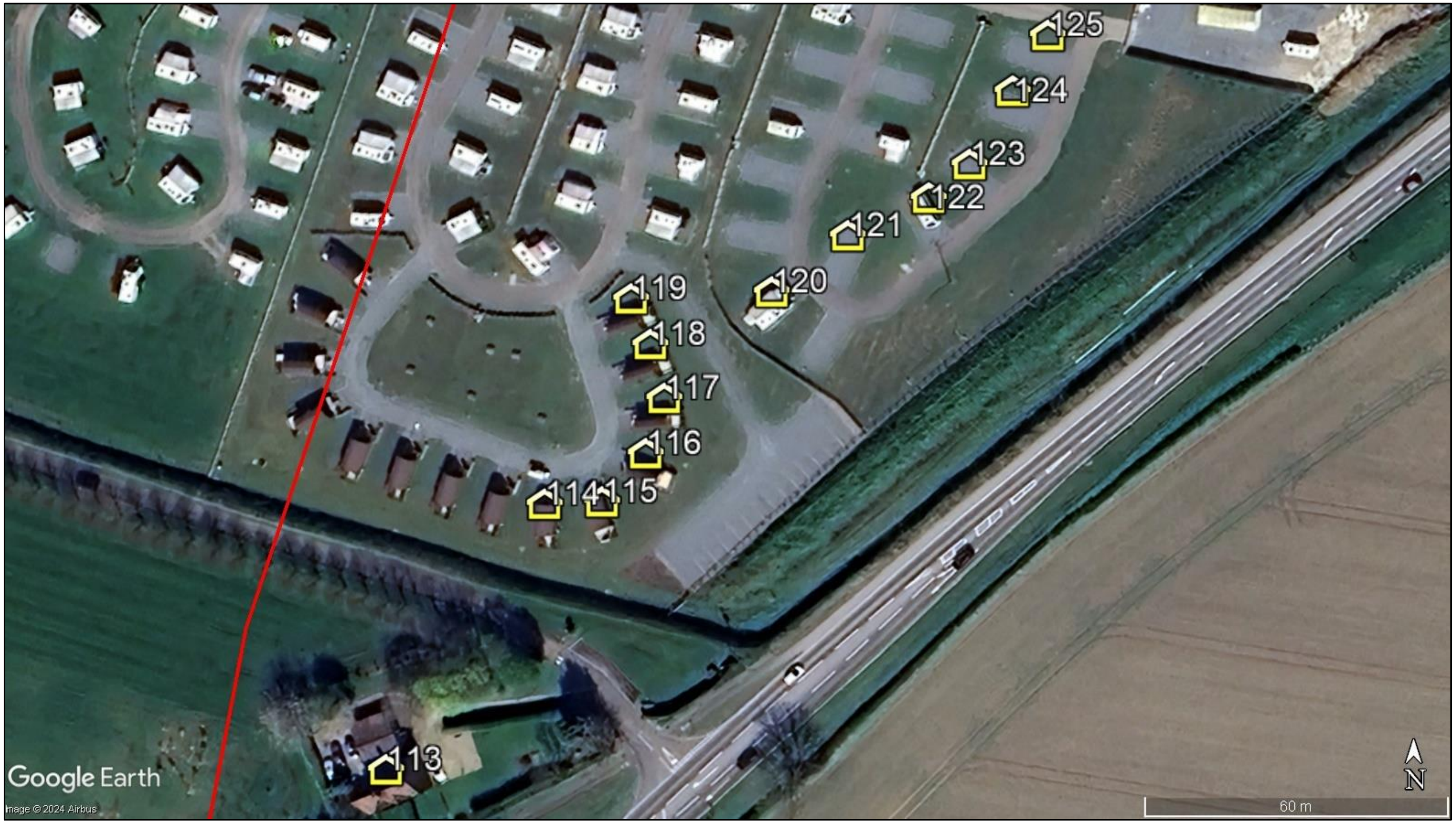
Dwelling receptors 79 to 92 – aerial image

Dwelling receptors 93 to 107 – aerial image

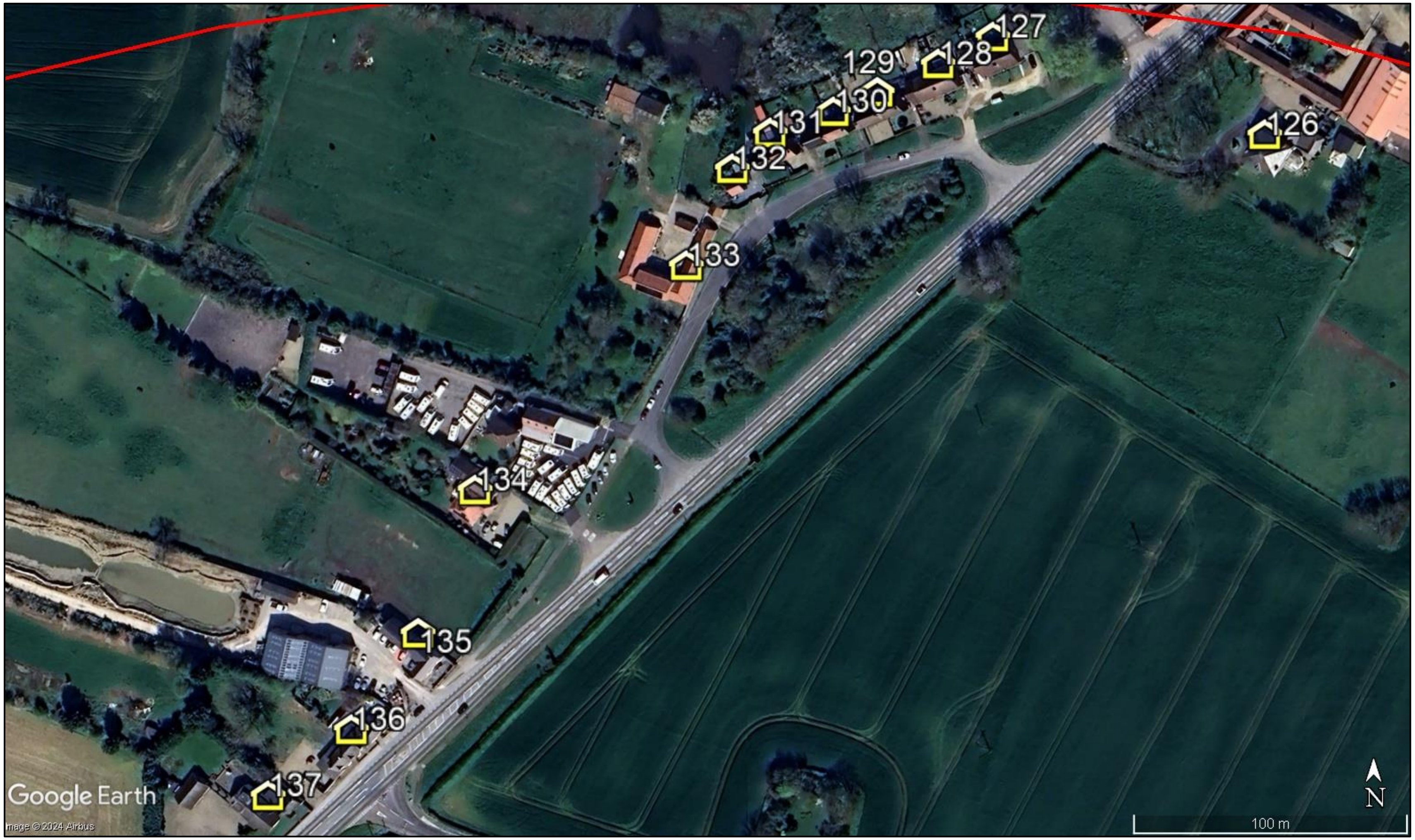
Dwelling receptors 108 and 109 – aerial image

Dwelling receptor 110 – aerial image

Dwelling receptors 111 and 112 – aerial image

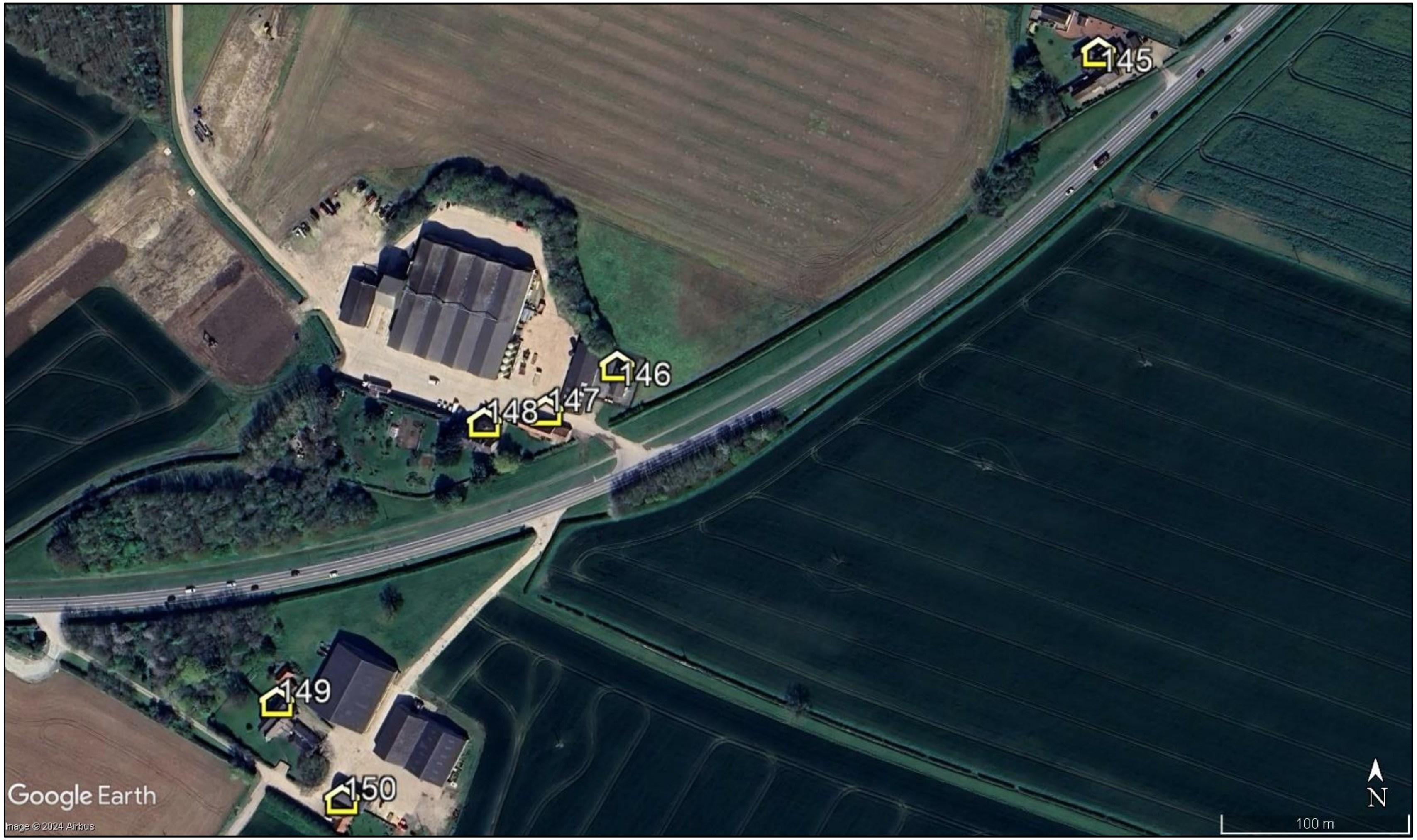


Dwelling receptors 113 to 125 – aerial image



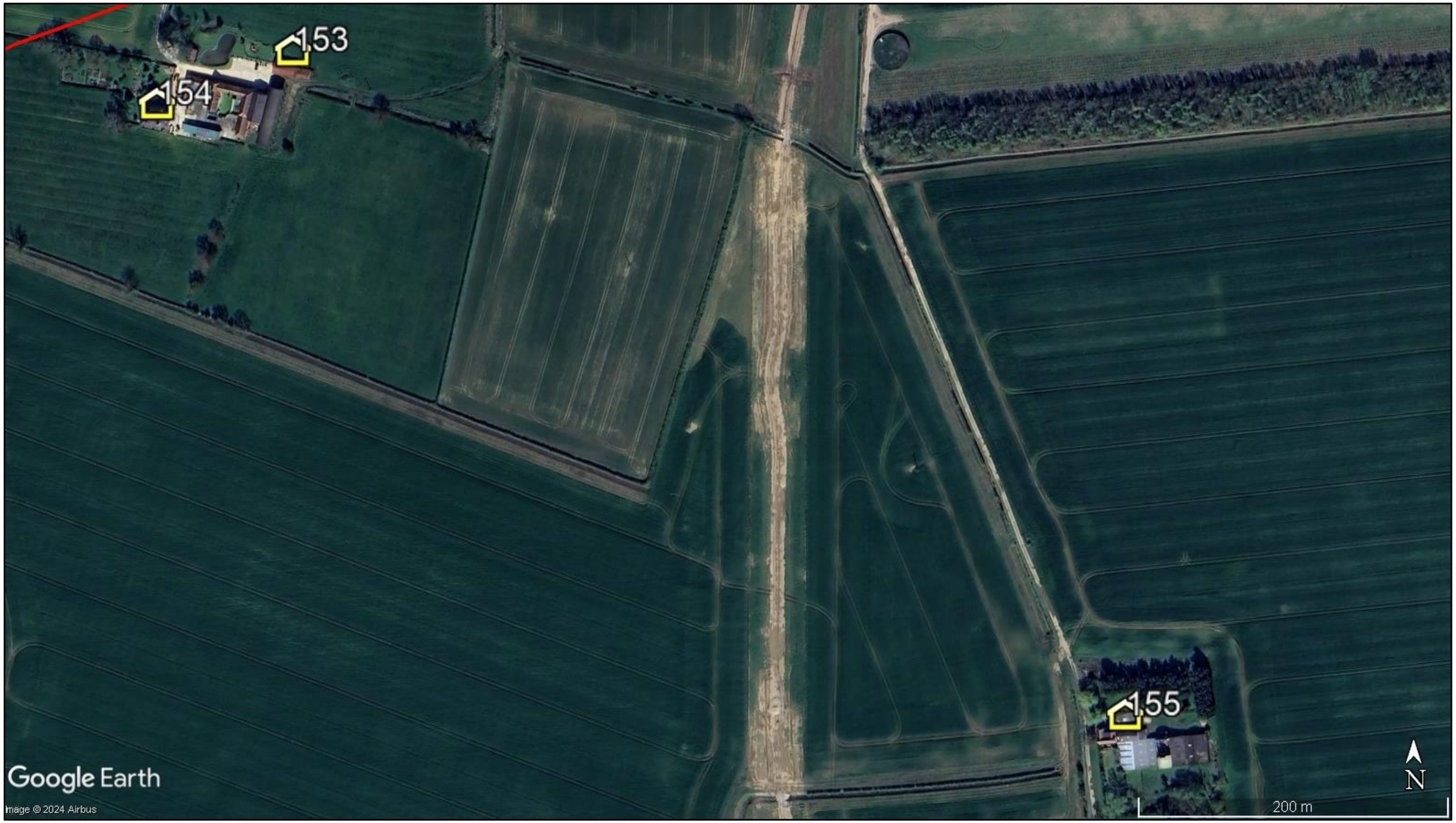
Dwelling receptors 126 to 137 – aerial image

Dwelling receptors 138 to 144 – aerial image



Dwelling receptors 145 to 150 – aerial image

Dwelling receptors 151 and 152 – aerial image



Dwelling receptors 153 to 155 – aerial image

Dwelling receptors 156 to 164 – aerial image

Dwelling receptor 165 – aerial image

Dwelling receptor 166 – aerial image

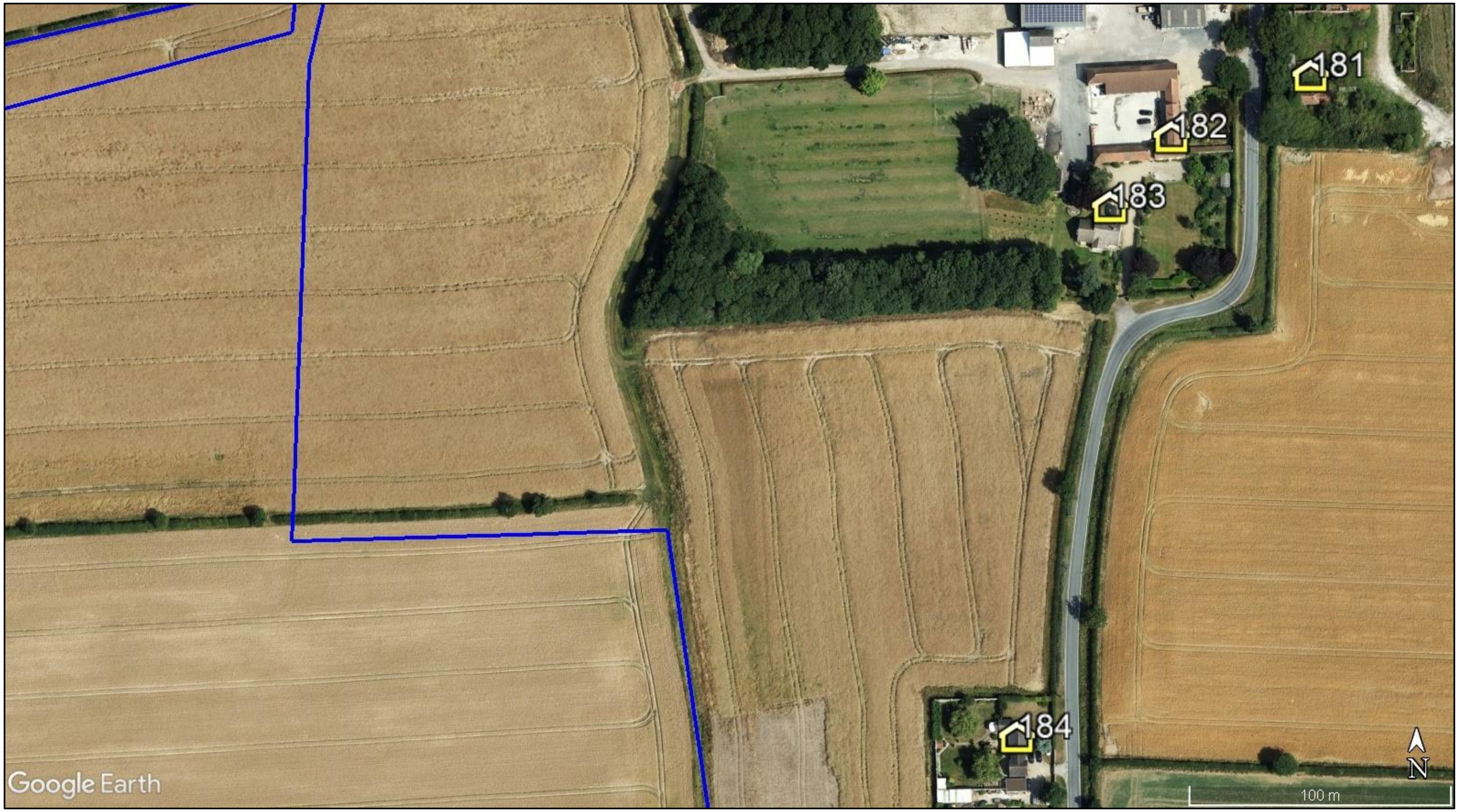
Dwelling receptors 167 to 168 – aerial image

Dwelling receptors 169 to 170 – aerial image

Dwelling receptors 171 to 175 – aerial image

Dwelling receptors 176 to 178 – aerial image

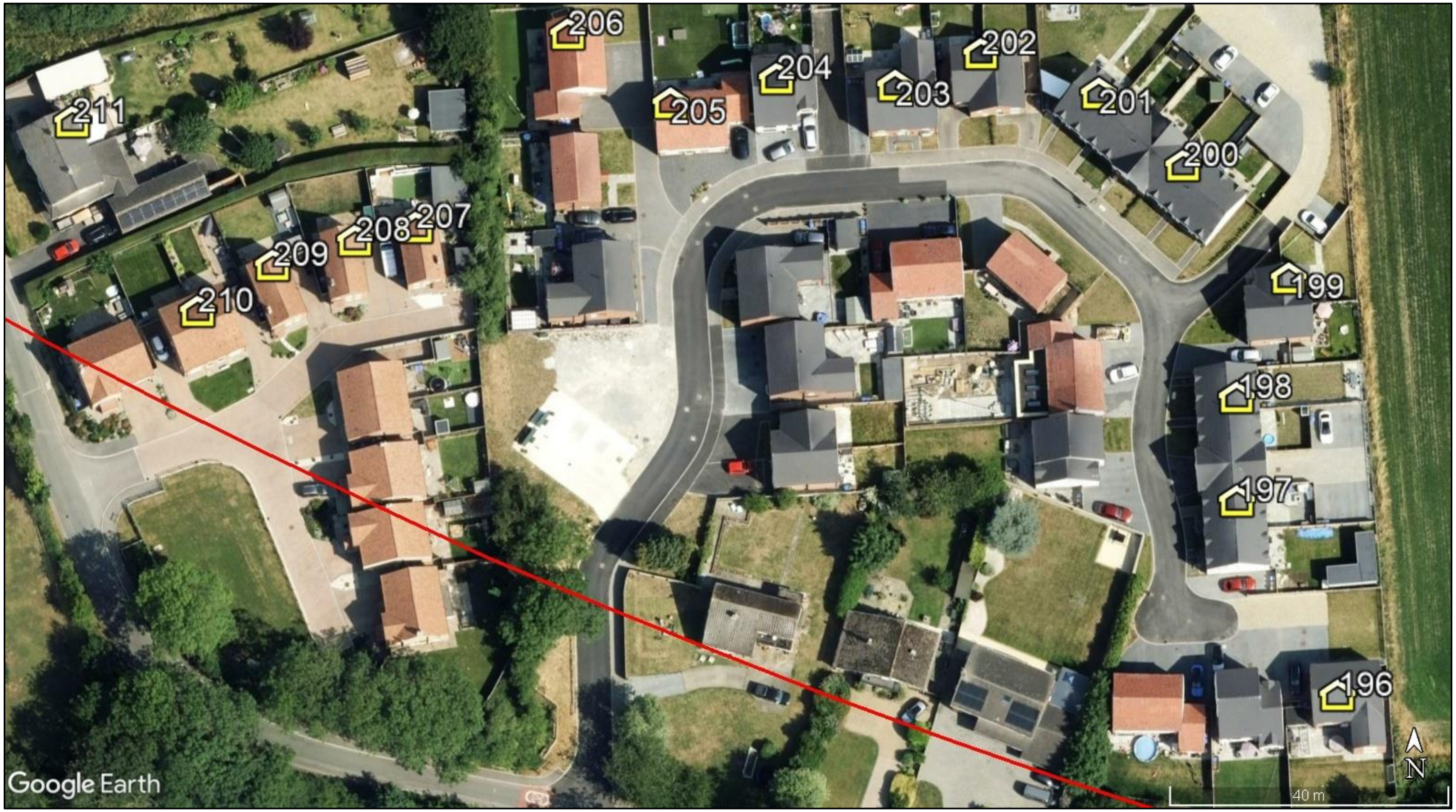
Dwelling receptors 179 and 180 – aerial image



Dwelling receptors 181 to 184 – aerial image

Dwelling receptors 185 to 187 – aerial image

Dwelling receptors 188 to 195 – aerial image



Dwelling receptors 196 to 211 – aerial image

Dwelling receptor 212 – aerial image

APPENDIX I – DETAILED MODELLING RESULTS

Overview

Each of the solar reflection charts show the following:

- The annual predicted solar reflections and their intensities – top left;
- The daily duration of the solar reflections – top centre;
- The location of the proposed development where glare will originate – bottom left;
- The calculated intensity of the predicted solar reflections – top right. This is not relevant for receptors other than aviation.

Dwelling Receptors

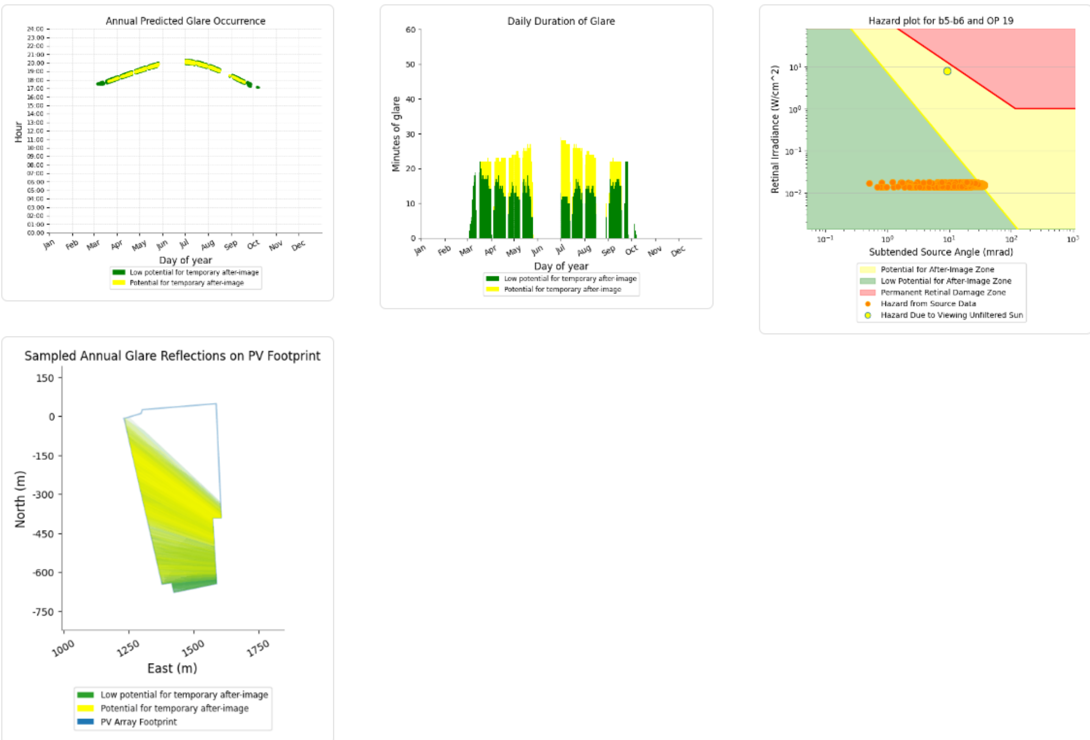
The charts for the receptors where any level of impact is predicted are shown on the following pages.

Dwelling 59

B5-B6: OP 19

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

- 1,876 minutes of "green" glare with low potential to cause temporary after-image.
- 1,140 minutes of "yellow" glare with potential to cause temporary after-image.

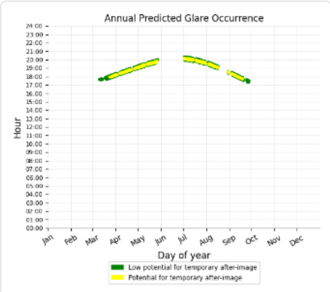


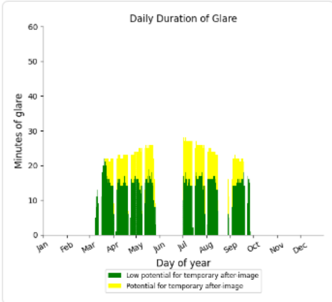
Dwelling 60

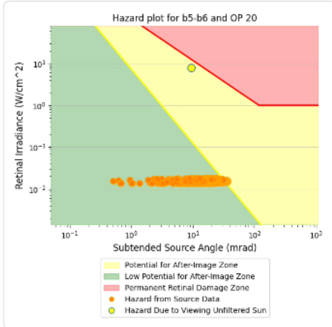
B5-B6: OP 20

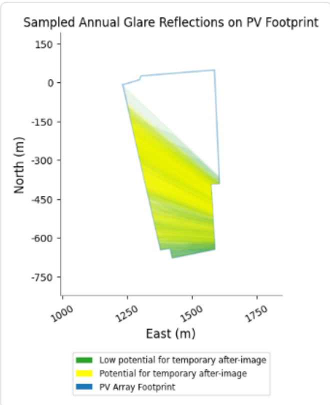
PV array is expected to produce the following glare for this receptor:

- 1,928 minutes of "green" glare with low potential to cause temporary after-image.
- 964 minutes of "yellow" glare with potential to cause temporary after-image.







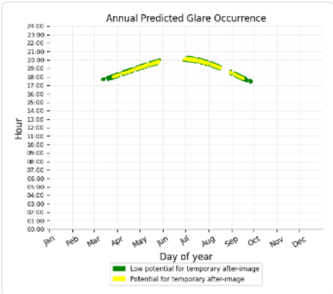


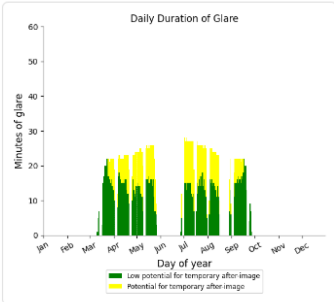
Dwelling 61

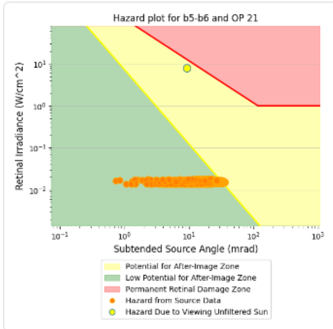
B5-B6: OP 21

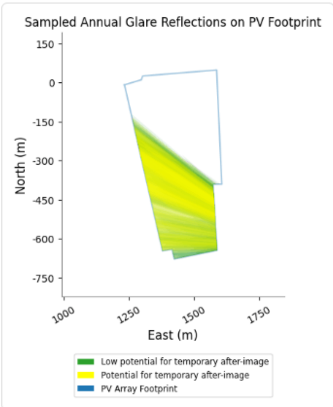
PV array is expected to produce the following glare for this receptor:

- 1,772 minutes of "green" glare with low potential to cause temporary after-image.
- 1,041 minutes of "yellow" glare with potential to cause temporary after-image.







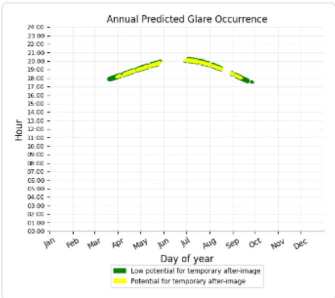


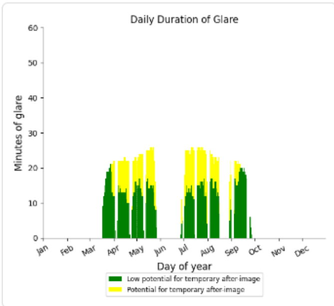
Dwelling 62

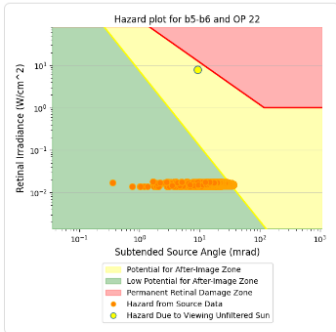
B5-B6: OP 22

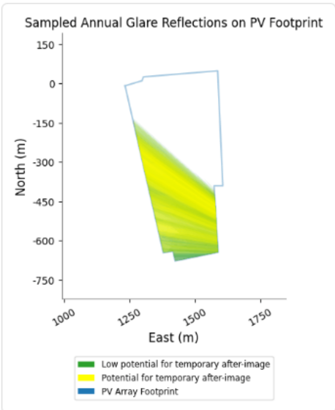
PV array is expected to produce the following glare for this receptor:

- 1,730 minutes of "green" glare with low potential to cause temporary after-image.
- 929 minutes of "yellow" glare with potential to cause temporary after-image.







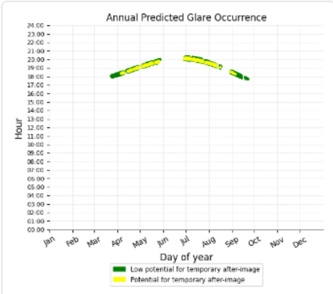


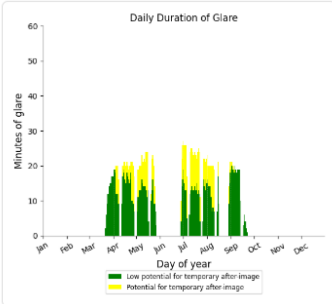
Dwelling 63

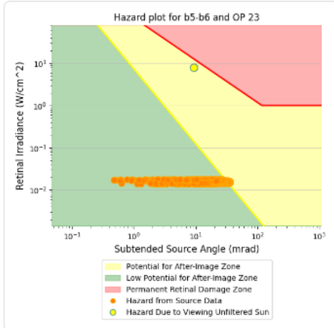
B5-B6: OP 23

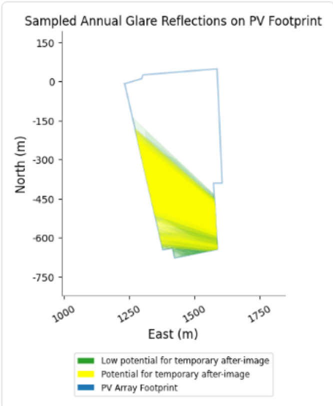
PV array is expected to produce the following glare for this receptor:

- 1,575 minutes of "green" glare with low potential to cause temporary after-image.
- 667 minutes of "yellow" glare with potential to cause temporary after-image.







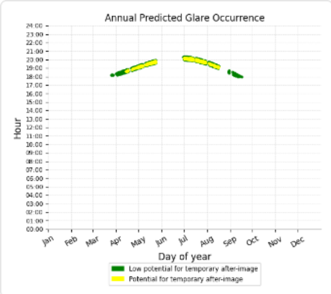


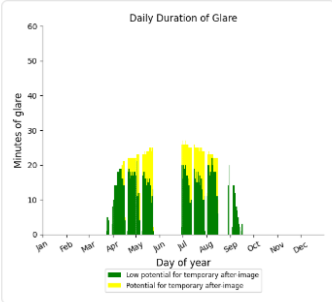
Dwelling 64

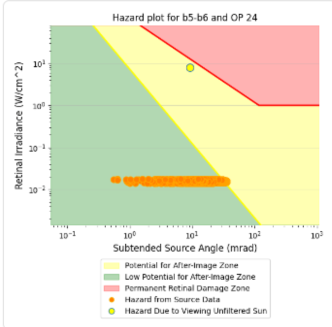
B5-B6: OP 24

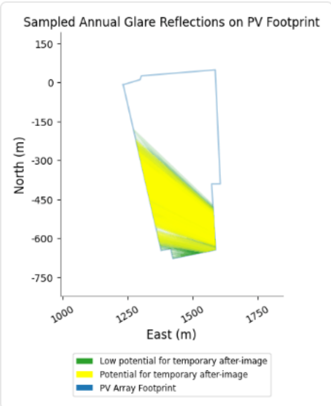
PV array is expected to produce the following glare for this receptor:

- 1,524 minutes of "green" glare with low potential to cause temporary after-image.
- 580 minutes of "yellow" glare with potential to cause temporary after-image.







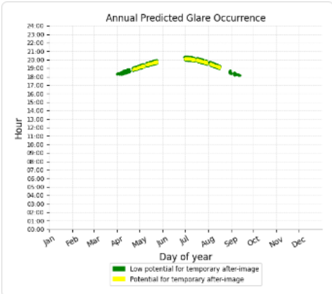


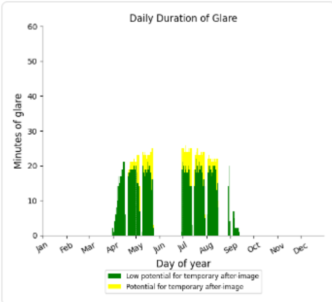
Dwelling 65

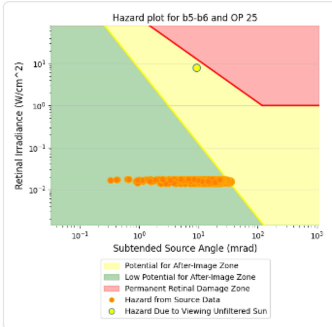
B5-B6: OP 25

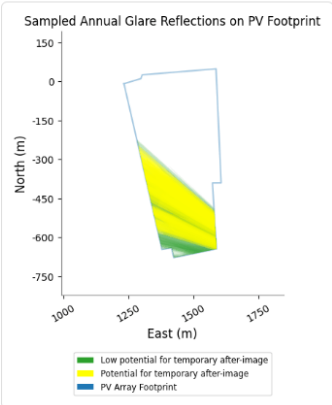
PV array is expected to produce the following glare for this receptor:

- 1,555 minutes of "green" glare with low potential to cause temporary after-image.
- 337 minutes of "yellow" glare with potential to cause temporary after-image.







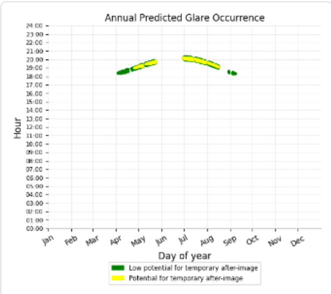


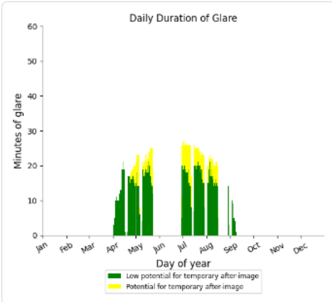
Dwelling 66

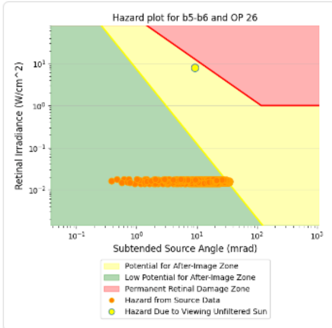
B5-B6: OP 26

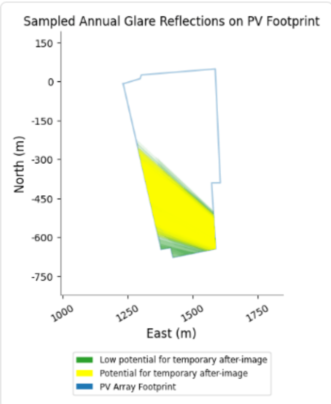
PV array is expected to produce the following glare for this receptor:

- 1,439 minutes of "green" glare with low potential to cause temporary after-image.
- 402 minutes of "yellow" glare with potential to cause temporary after-image.







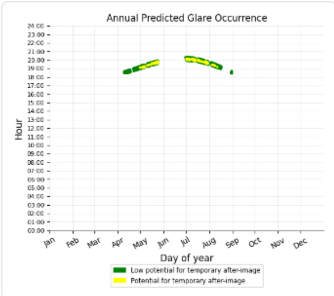


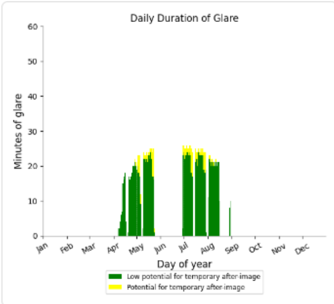
Dwelling 67

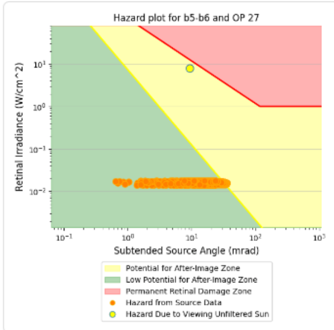
B5-B6: OP 27

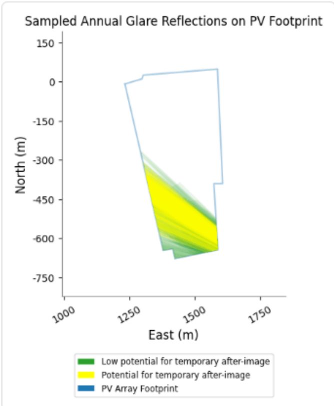
PV array is expected to produce the following glare for this receptor:

- 1,573 minutes of "green" glare with low potential to cause temporary after-image.
- 159 minutes of "yellow" glare with potential to cause temporary after-image.







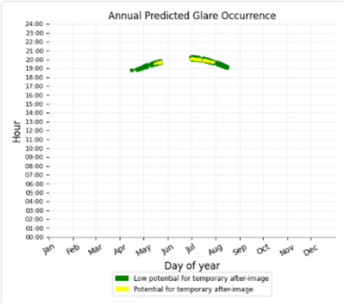


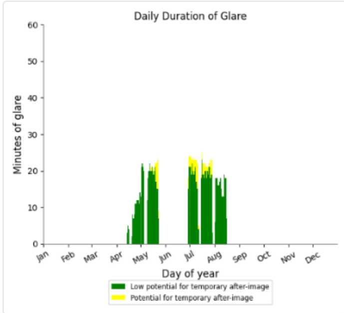
Dwelling 68

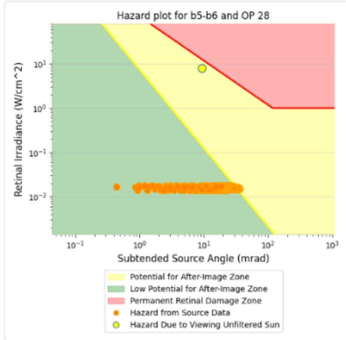
B5-B6: OP 28

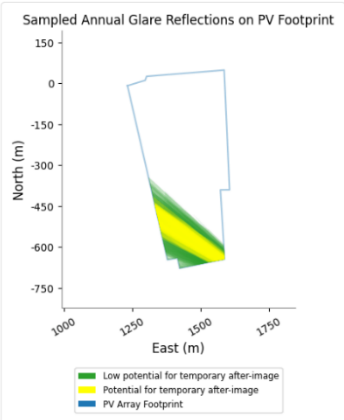
PV array is expected to produce the following glare for this receptor:

- 1,250 minutes of "green" glare with low potential to cause temporary after-image.
- 113 minutes of "yellow" glare with potential to cause temporary after-image.







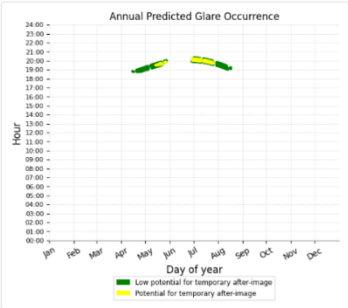


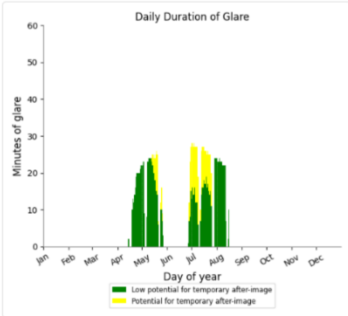
Dwelling 69

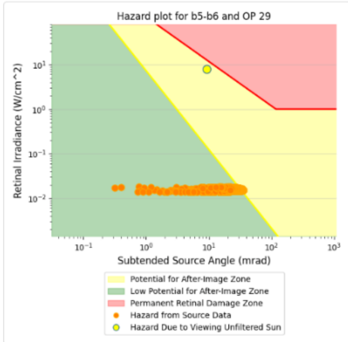
B5-B6: OP 29

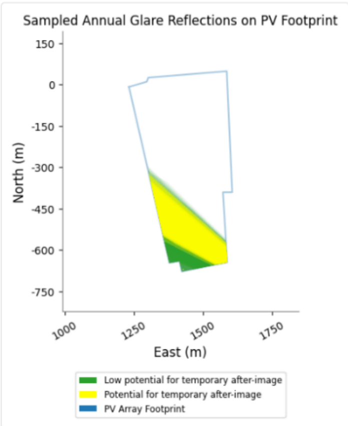
PV array is expected to produce the following glare for this receptor:

- 1,297 minutes of "green" glare with low potential to cause temporary after-image.
- 346 minutes of "yellow" glare with potential to cause temporary after-image.







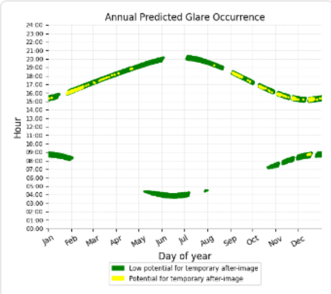


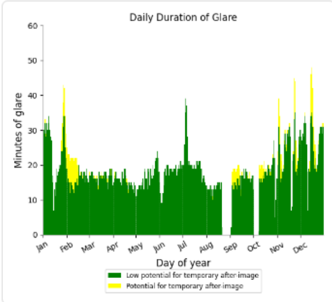
Dwelling 108

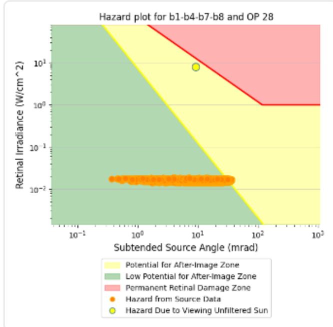
B1-B4_B7-B8_C: OP 28

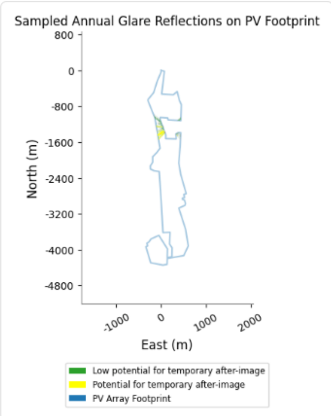
PV array is expected to produce the following glare for this receptor:

- 6,512 minutes of "green" glare with low potential to cause temporary after-image.
- 430 minutes of "yellow" glare with potential to cause temporary after-image.







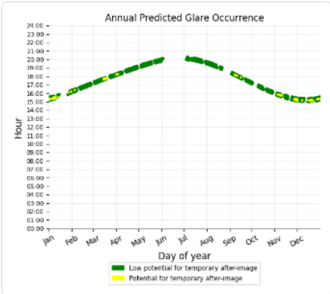


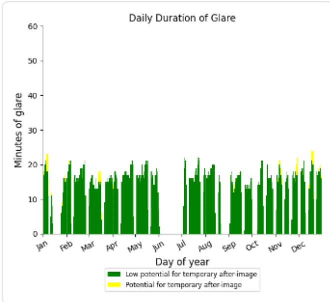
Dwelling 109

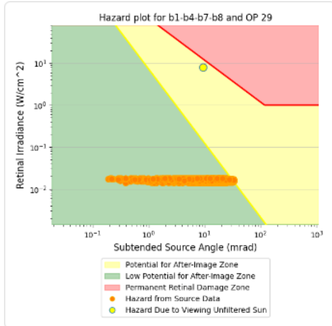
B1-B4_B7-B8_C: OP 29

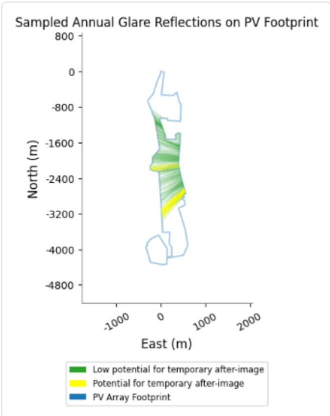
PV array is expected to produce the following glare for this receptor:

- 3,965 minutes of "green" glare with low potential to cause temporary after-image.
- 81 minutes of "yellow" glare with potential to cause temporary after-image.







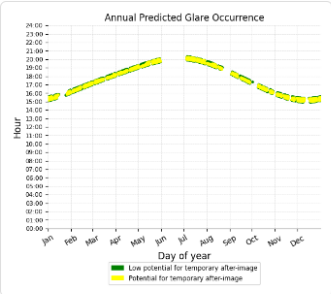


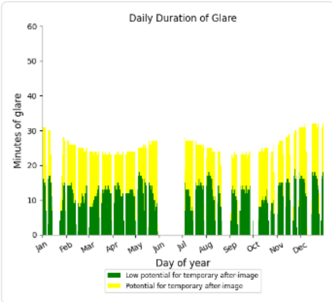
Dwelling 110 (without consideration of screening)

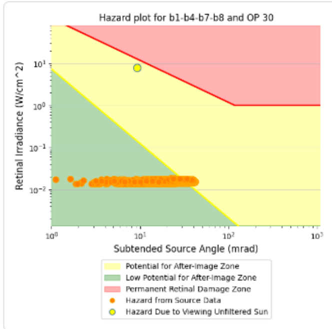
B1-B4_B7-B8_C: OP 30

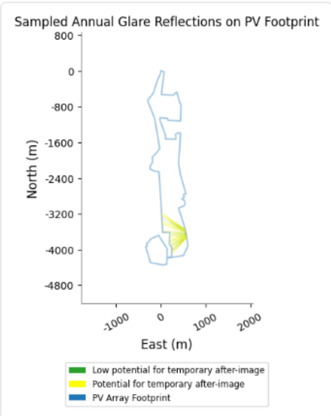
PV array is expected to produce the following glare for this receptor:

- 3,077 minutes of "green" glare with low potential to cause temporary after-image.
- 2,933 minutes of "yellow" glare with potential to cause temporary after-image.







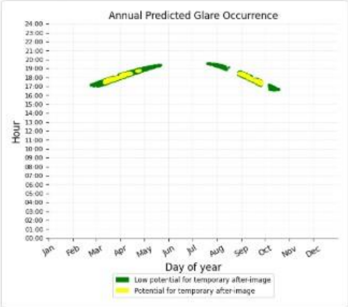


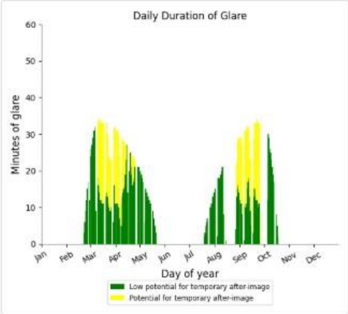
Dwelling 110 (with consideration of existing screening)

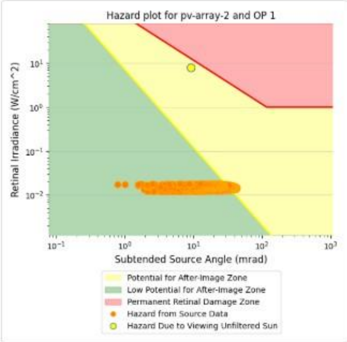
PV array 2: OP 1

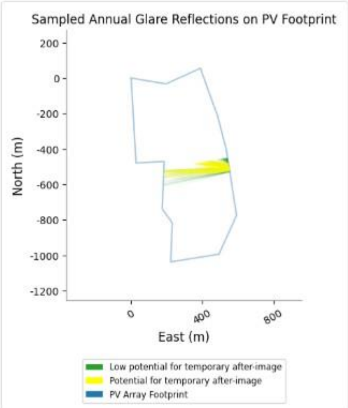
PV array is expected to produce the following glare for this receptor:

- 1,960 minutes of "green" glare with low potential to cause temporary after-image.
- 994 minutes of "yellow" glare with potential to cause temporary after-image.

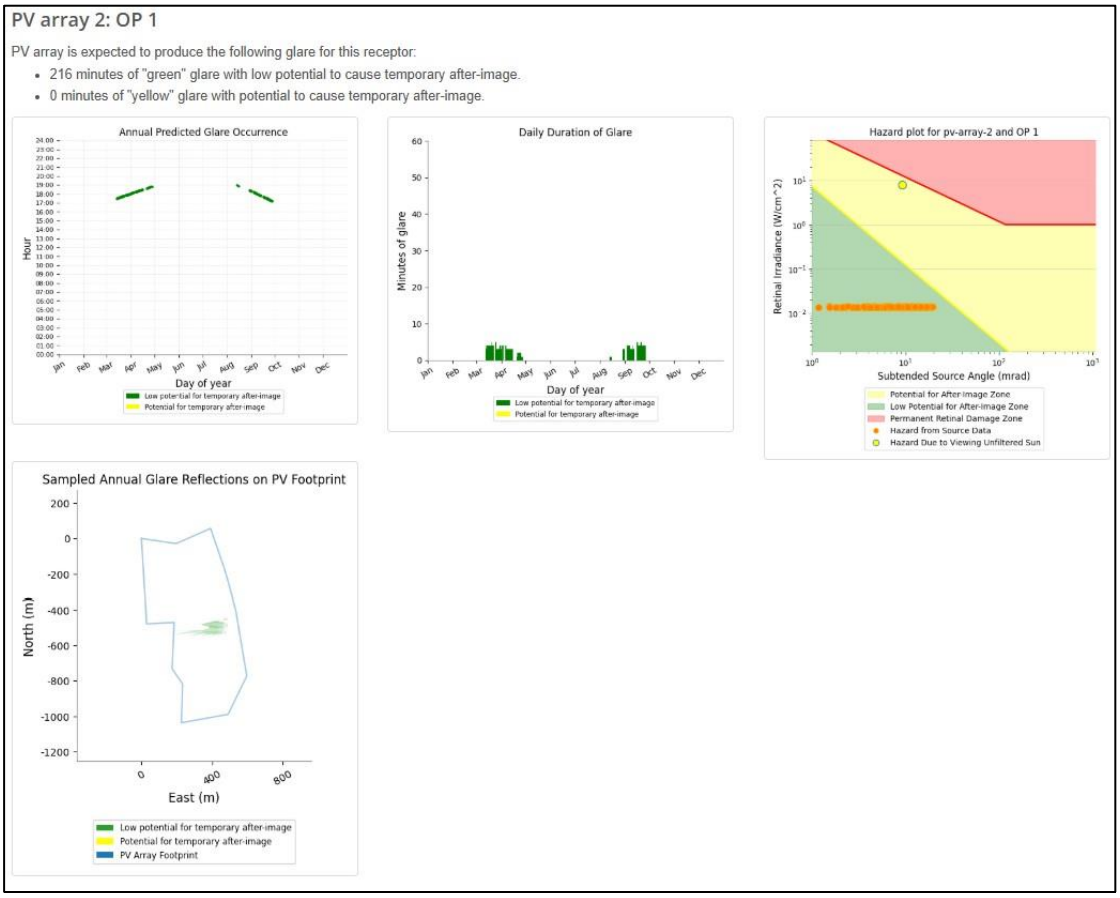








Dwelling 110 (with consideration of existing screening, and proposed vegetation screening at 2.5m above ground level)

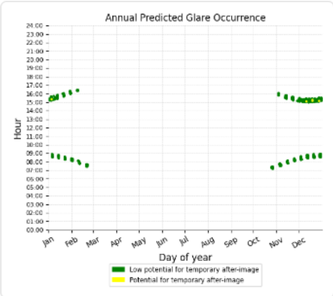


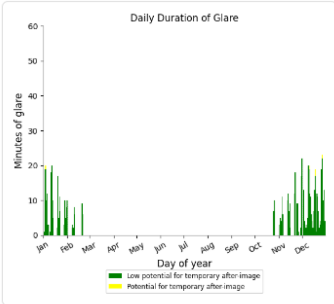
Dwelling 144

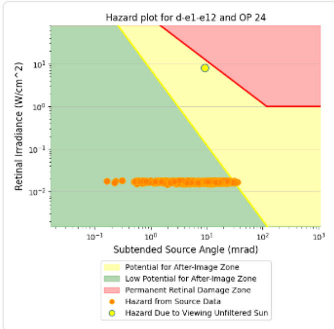
D_E1-E12: OP 24

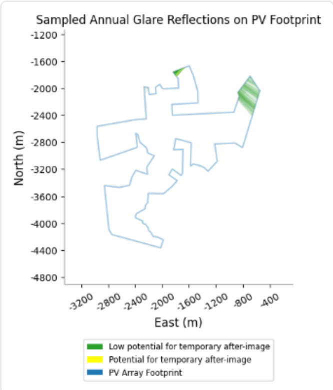
PV array is expected to produce the following glare for this receptor:

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







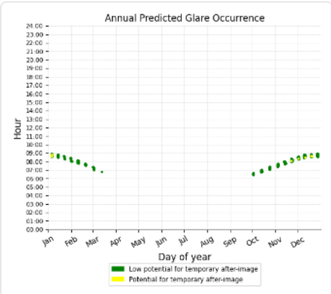


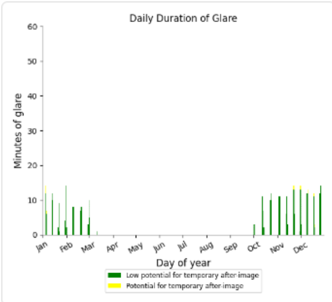
Dwelling 149

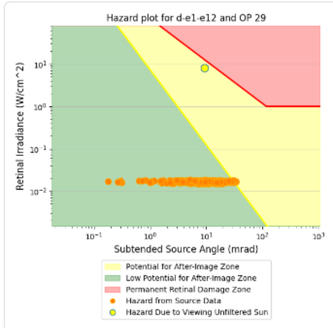
D_E1-E12: OP 29

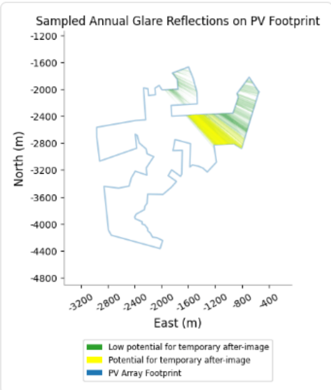
PV array is expected to produce the following glare for this receptor:

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







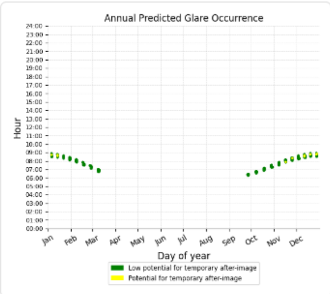


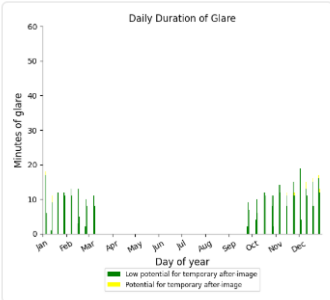
Dwelling 150

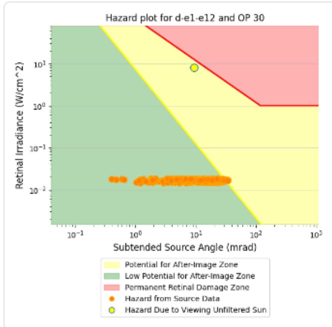
D_E1-E12: OP 30

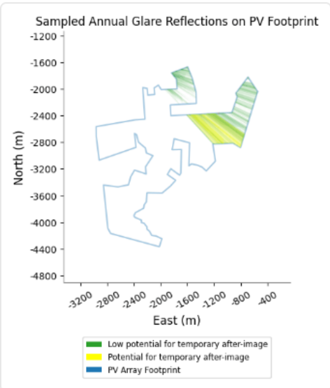
PV array is expected to produce the following glare for this receptor:

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







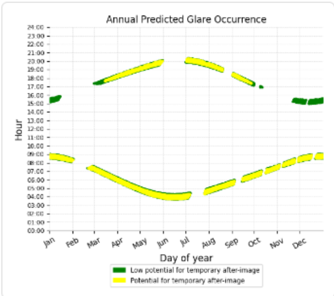


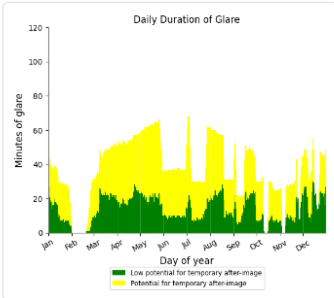
Dwelling 151

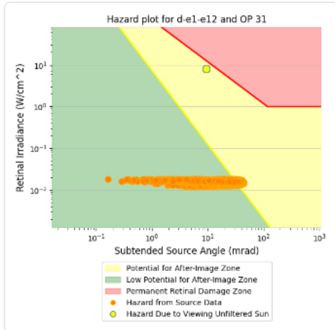
D_E1-E12: OP 31

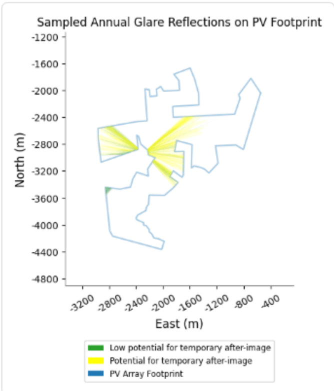
PV array is expected to produce the following glare for this receptor:

- 5,070 minutes of "green" glare with low potential to cause temporary after-image.
- 8,632 minutes of "yellow" glare with potential to cause temporary after-image.







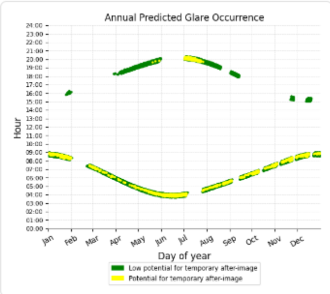


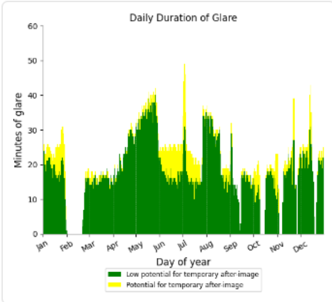
Dwelling 152

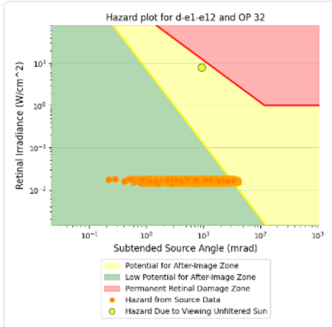
D_E1-E12: OP 32

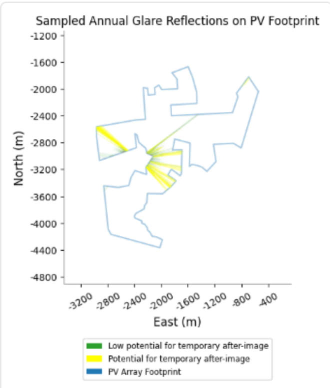
PV array is expected to produce the following glare for this receptor:

- 6,594 minutes of "green" glare with low potential to cause temporary after-image.
- 1,185 minutes of "yellow" glare with potential to cause temporary after-image.







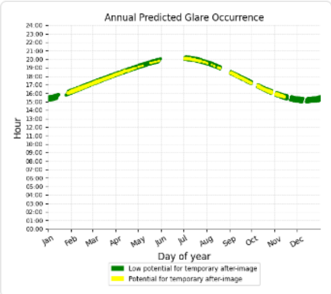


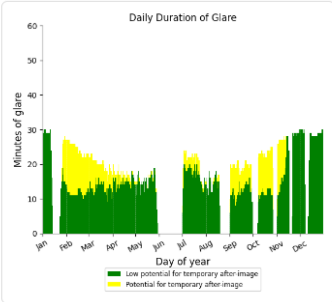
Dwelling 167

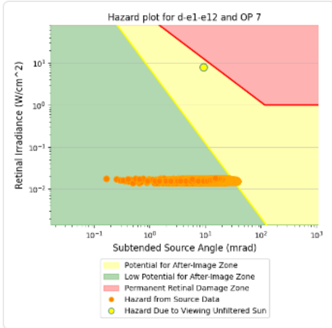
D_E1-E12: OP 7

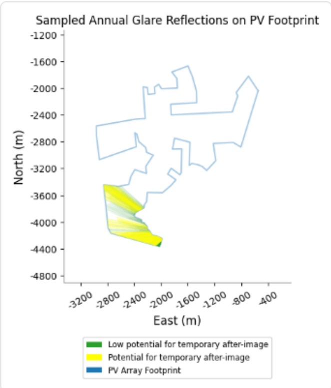
PV array is expected to produce the following glare for this receptor:

- 4,824 minutes of "green" glare with low potential to cause temporary after-image.
- 1,411 minutes of "yellow" glare with potential to cause temporary after-image.





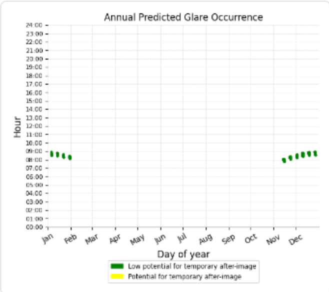


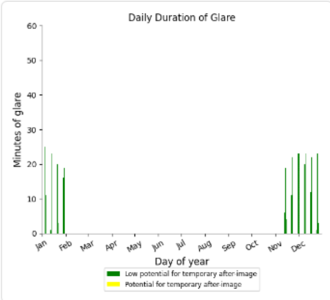


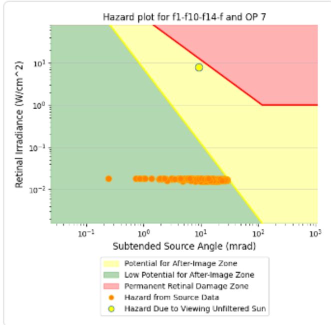
F1-F10_F14-F17: OP 7

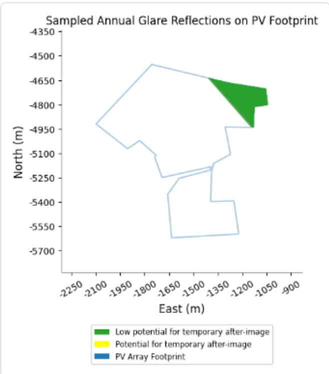
PV array is expected to produce the following glare for this receptor:

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







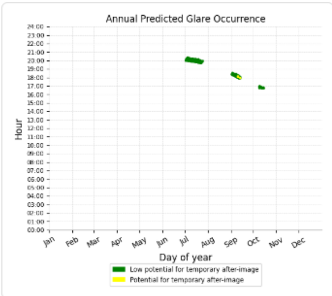


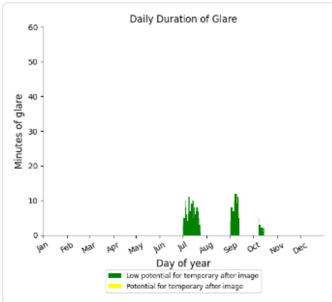
Dwelling 168

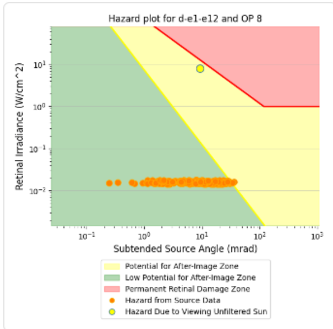
D_E1-E12: OP 8

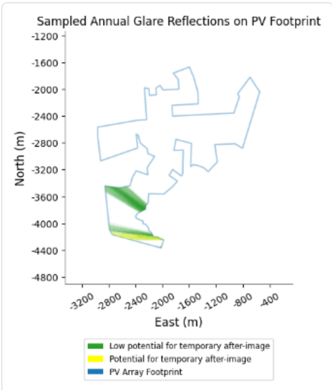
PV array is expected to produce the following glare for this receptor:

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







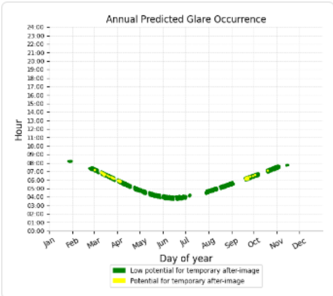


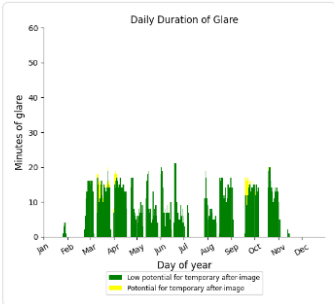
Dwelling 176

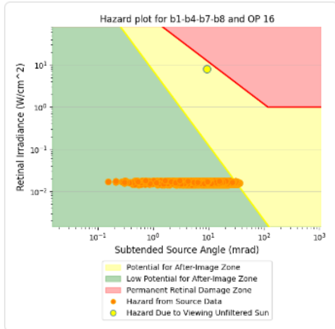
B1-B4_B7-B8_C: OP 16

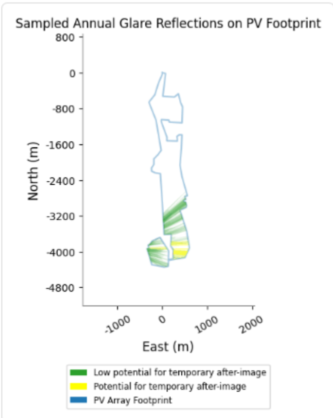
PV array is expected to produce the following glare for this receptor:

- 2,120 minutes of "green" glare with low potential to cause temporary after-image.
- 65 minutes of "yellow" glare with potential to cause temporary after-image.





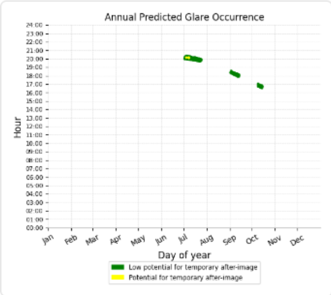


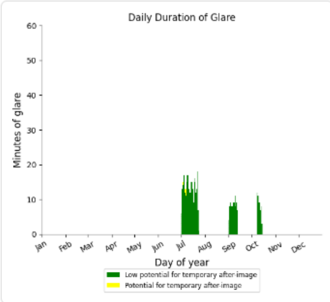


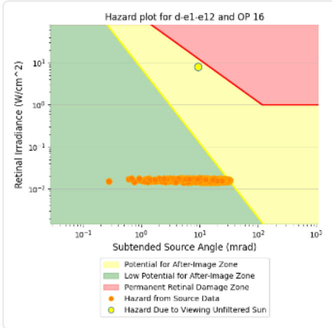
D_E1-E12: OP 16

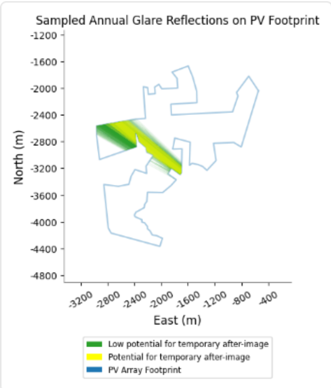
PV array is expected to produce the following glare for this receptor:

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





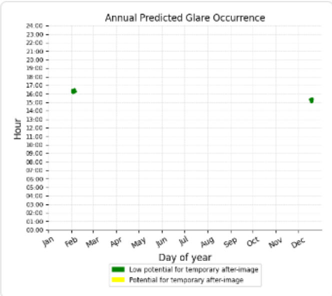


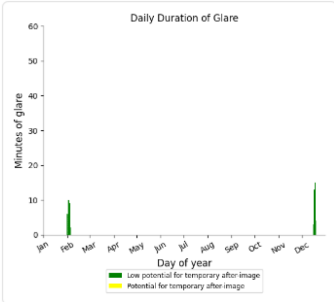


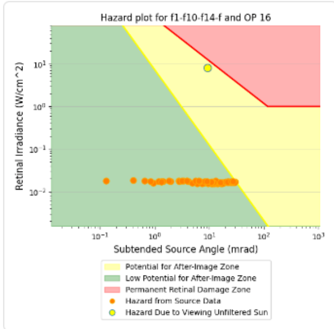
F1-F10_F14-F17: OP 16

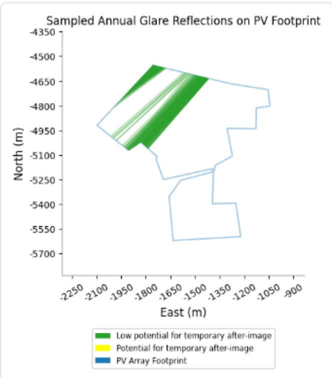
PV array is expected to produce the following glare for this receptor:

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







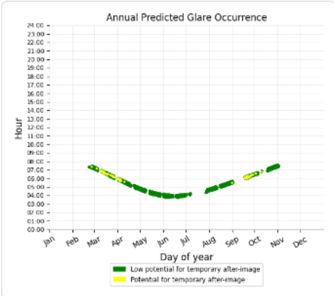


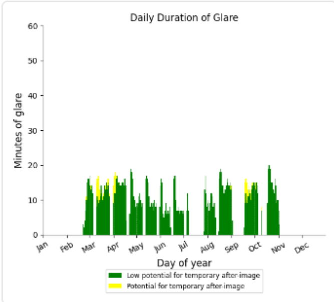
Dwelling 177

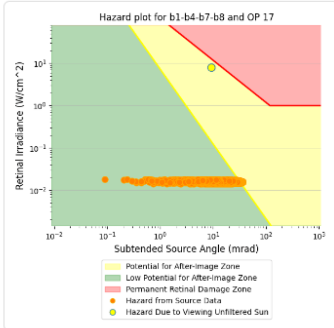
B1-B4_B7-B8_C: OP 17

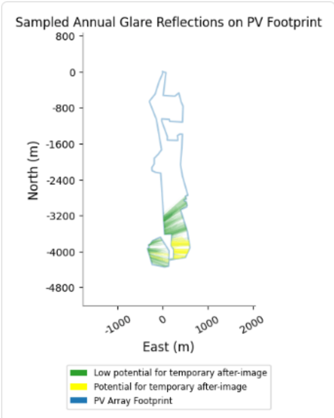
PV array is expected to produce the following glare for this receptor:

- 2,095 minutes of "green" glare with low potential to cause temporary after-image.
- 102 minutes of "yellow" glare with potential to cause temporary after-image.





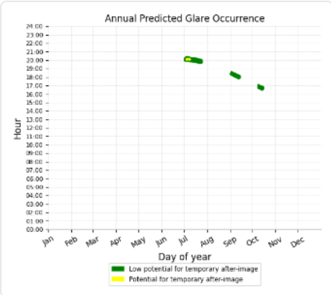


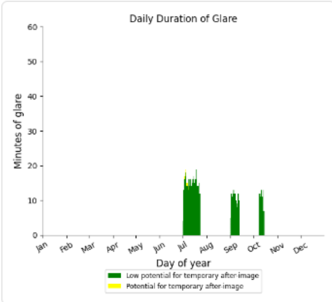


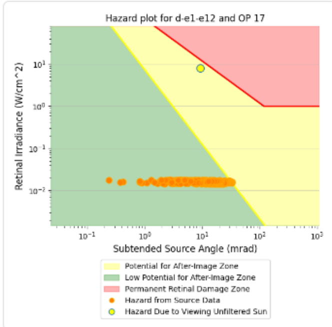
D_E1-E12: OP 17

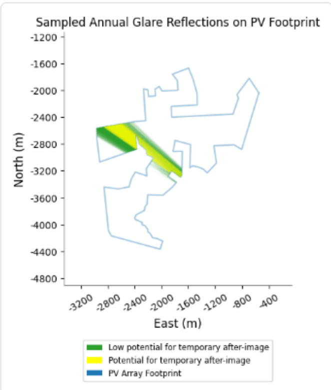
PV array is expected to produce the following glare for this receptor:

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





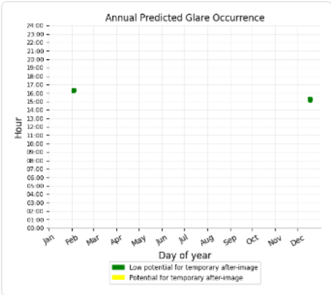


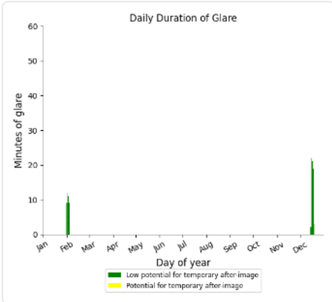


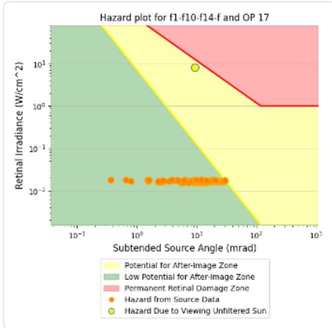
F1-F10_F14-F17: OP 17

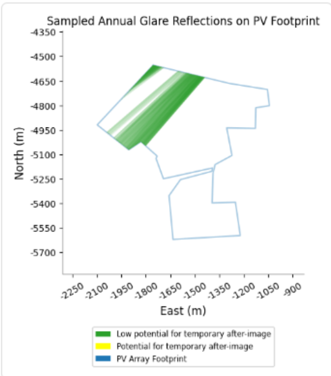
PV array is expected to produce the following glare for this receptor:

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







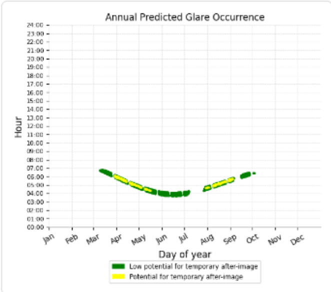


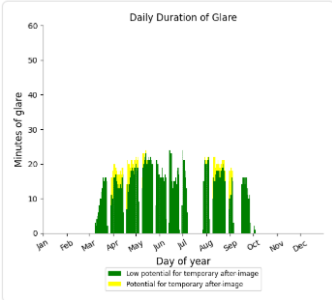
Dwelling 178

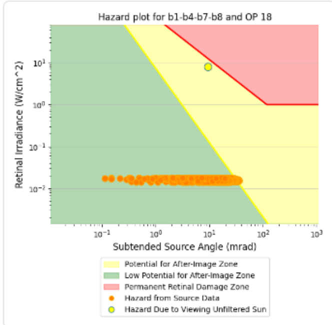
B1-B4_B7-B8_C: OP 18

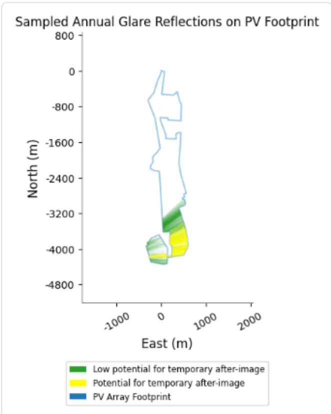
PV array is expected to produce the following glare for this receptor:

- 2,266 minutes of "green" glare with low potential to cause temporary after-image.
- 234 minutes of "yellow" glare with potential to cause temporary after-image.





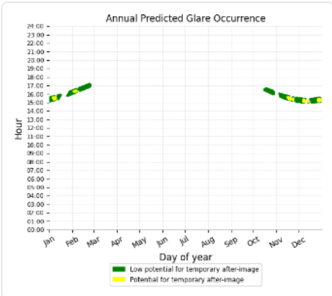


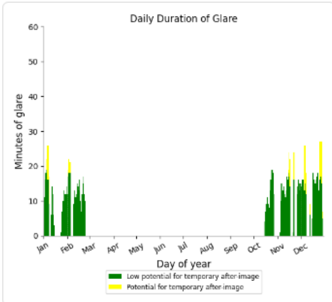


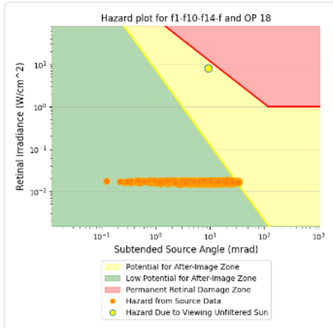
F1-F10_F14-F17: OP 18

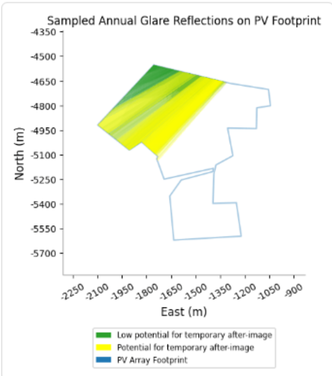
PV array is expected to produce the following glare for this receptor:

- 1,263 minutes of "green" glare with low potential to cause temporary after-image.
- 135 minutes of "yellow" glare with potential to cause temporary after-image.







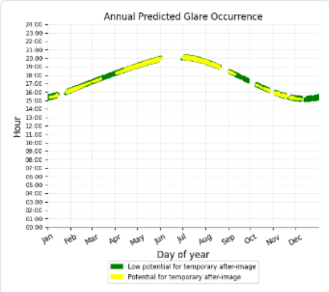


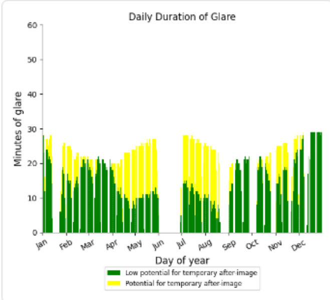
Dwelling 181

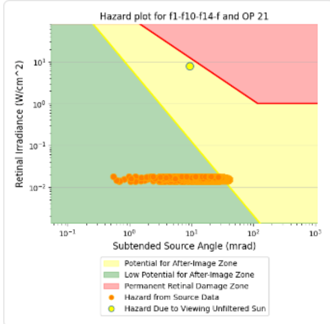
F1-F10_F14-F17: OP 21

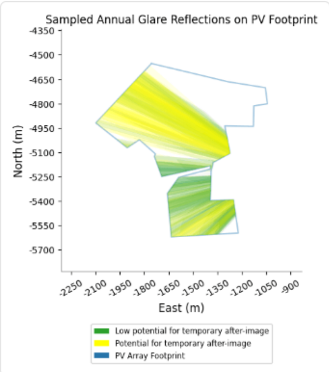
PV array is expected to produce the following glare for this receptor:

- 3,866 minutes of "green" glare with low potential to cause temporary after-image.
- 1,810 minutes of "yellow" glare with potential to cause temporary after-image.





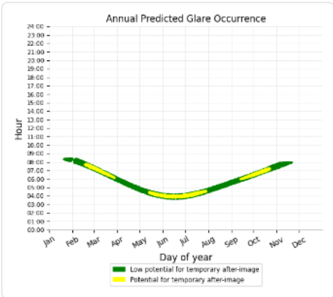


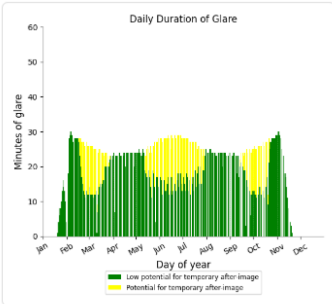


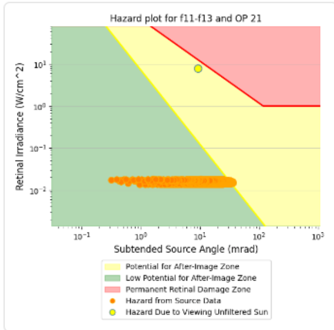
F11-F13: OP 21

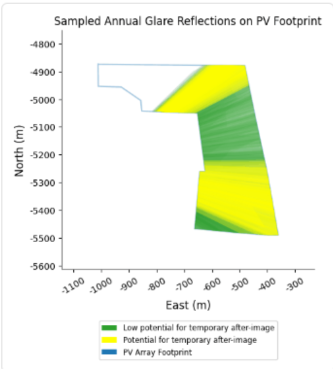
PV array is expected to produce the following glare for this receptor:

- 4,329 minutes of "green" glare with low potential to cause temporary after-image.
- 1,216 minutes of "yellow" glare with potential to cause temporary after-image.







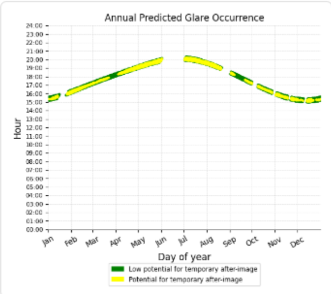


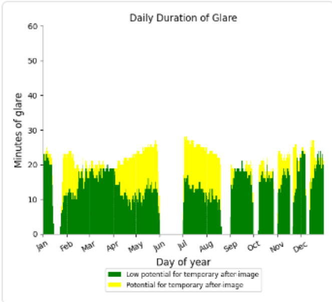
Dwelling 182

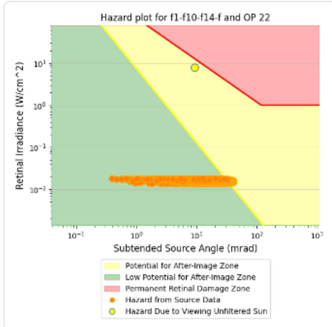
F1-F10_F14-F17: OP 22

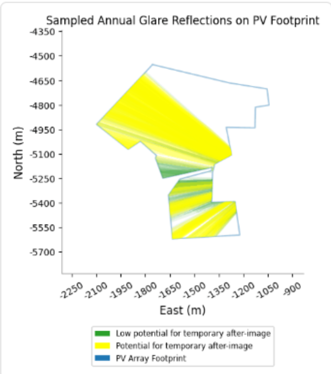
PV array is expected to produce the following glare for this receptor:

- 4,414 minutes of "green" glare with low potential to cause temporary after-image.
- 1,971 minutes of "yellow" glare with potential to cause temporary after-image.





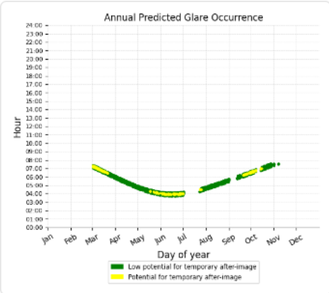


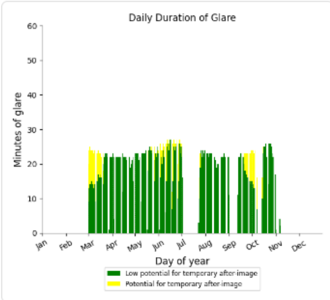


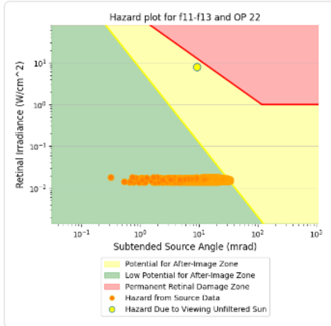
F11-F13: OP 22

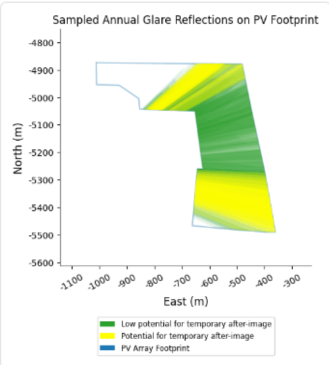
PV array is expected to produce the following glare for this receptor:

- 3,460 minutes of "green" glare with low potential to cause temporary after-image.
- 394 minutes of "yellow" glare with potential to cause temporary after-image.







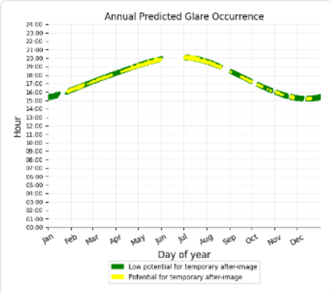


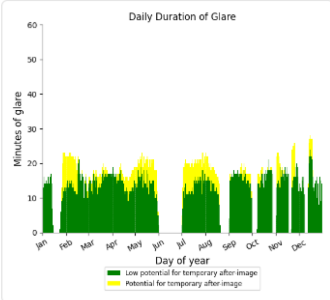
Dwelling 183

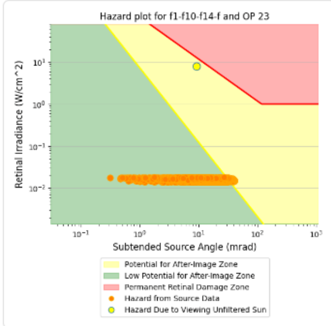
F1-F10_F14-F17: OP 23

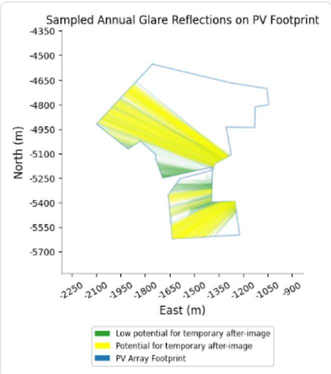
PV array is expected to produce the following glare for this receptor:

- 4,280 minutes of "green" glare with low potential to cause temporary after-image.
- 989 minutes of "yellow" glare with potential to cause temporary after-image.





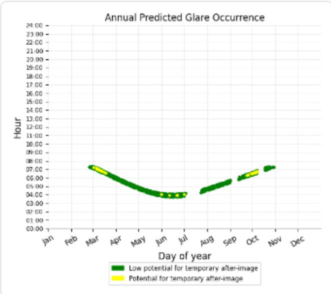


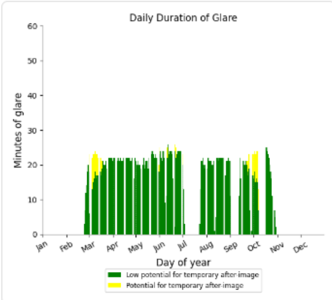


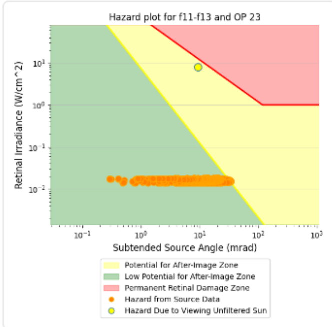
F11-F13: OP 23

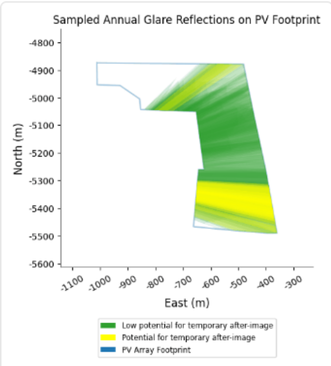
PV array is expected to produce the following glare for this receptor:

- 3,407 minutes of "green" glare with low potential to cause temporary after-image.
- 168 minutes of "yellow" glare with potential to cause temporary after-image.









APPENDIX J – SCREENING REVIEW

Overview

The following pages show a selection of images detailing the significant screening for the assessed receptors.

Red polygons are used to represent buildings screening, and green polygons used to represent vegetation screening.

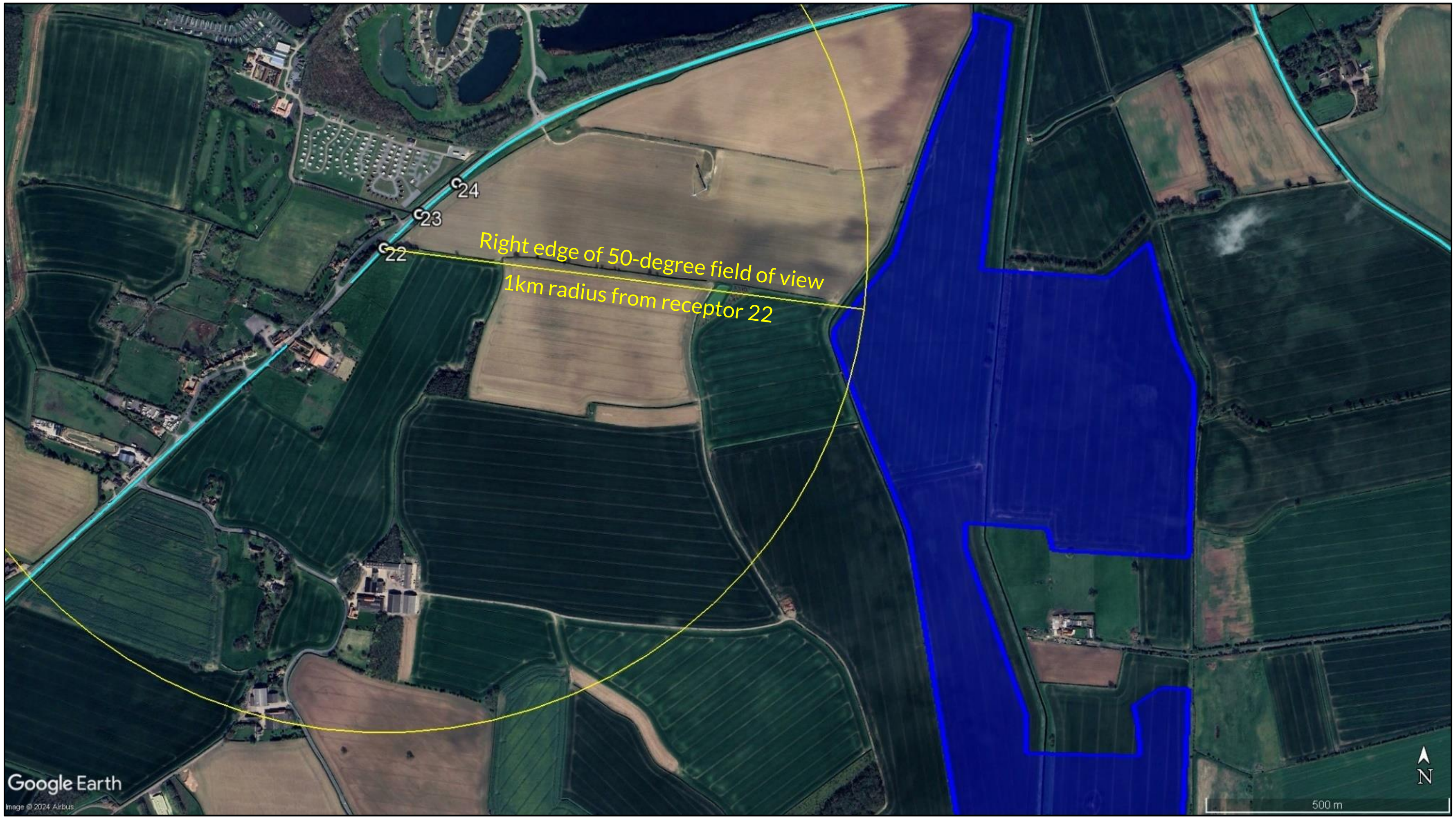
Where appropriate, a single image is used to represent the screening for multiple receptors. Further imagery can be provided on request.

Roads

The following pages shows images detailing some of the significant screening for the assessed road receptors which receive solar reflections from panel areas within 1km and inside of a road user's primary horizontal field of view.

Road section 7-9 relative to locations of panels

View towards reflecting panels from road receptor 8 travelling eastbound (representative of the extent of screening for road section 7-9)



Road section 22-24 relative to locations of panels within 1km

View towards reflecting panels from road receptor 23 travelling eastbound (representative of the extent of screening for road section 22-24)

View towards reflecting panels from between road receptor 25 and 26 travelling eastbound (representative of the extent of screening for road section 25-26)

View towards reflecting panels from road receptor 27 travelling eastbound

View towards reflecting panels from road receptor 30 travelling eastbound

View towards reflecting panels from road receptor 33 travelling eastbound

View towards reflecting panels from road receptor 39 travelling westbound (representative of the extent of screening for road section 39-46)

View towards reflecting panels from road receptor 46 travelling south-west bound (representative of the extent of screening for road section 39-46)

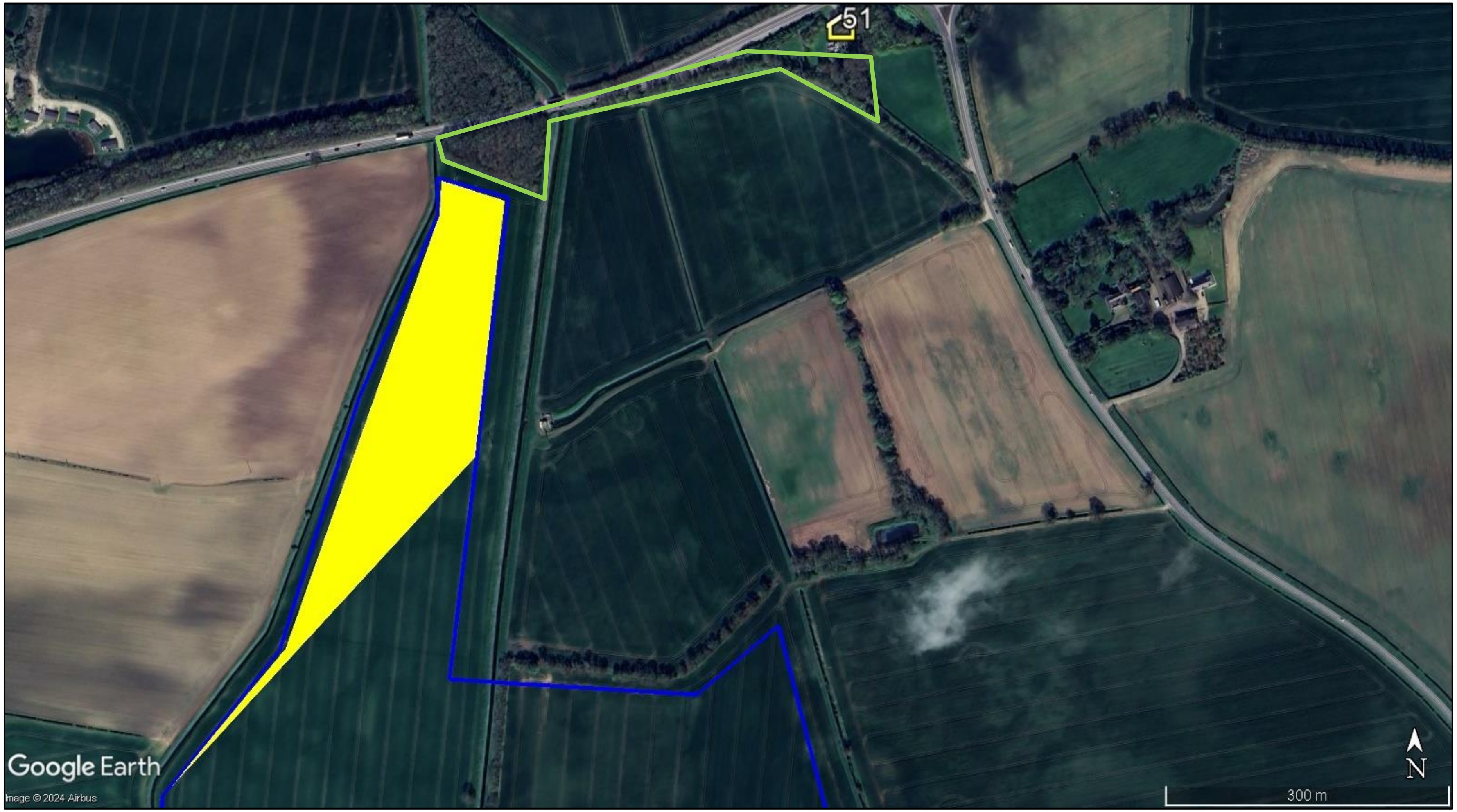
View towards reflecting panels from road receptor 59 travelling south bound (representative of the extent of screening for road section 59-62)

Dwellings

The following pages shows images detailing some of the significant screening for the assessed dwelling receptors which receive solar reflections for **more** than 3 months of the year. Red polygons are used to represent buildings screening, and green polygons used to represent vegetation screening.

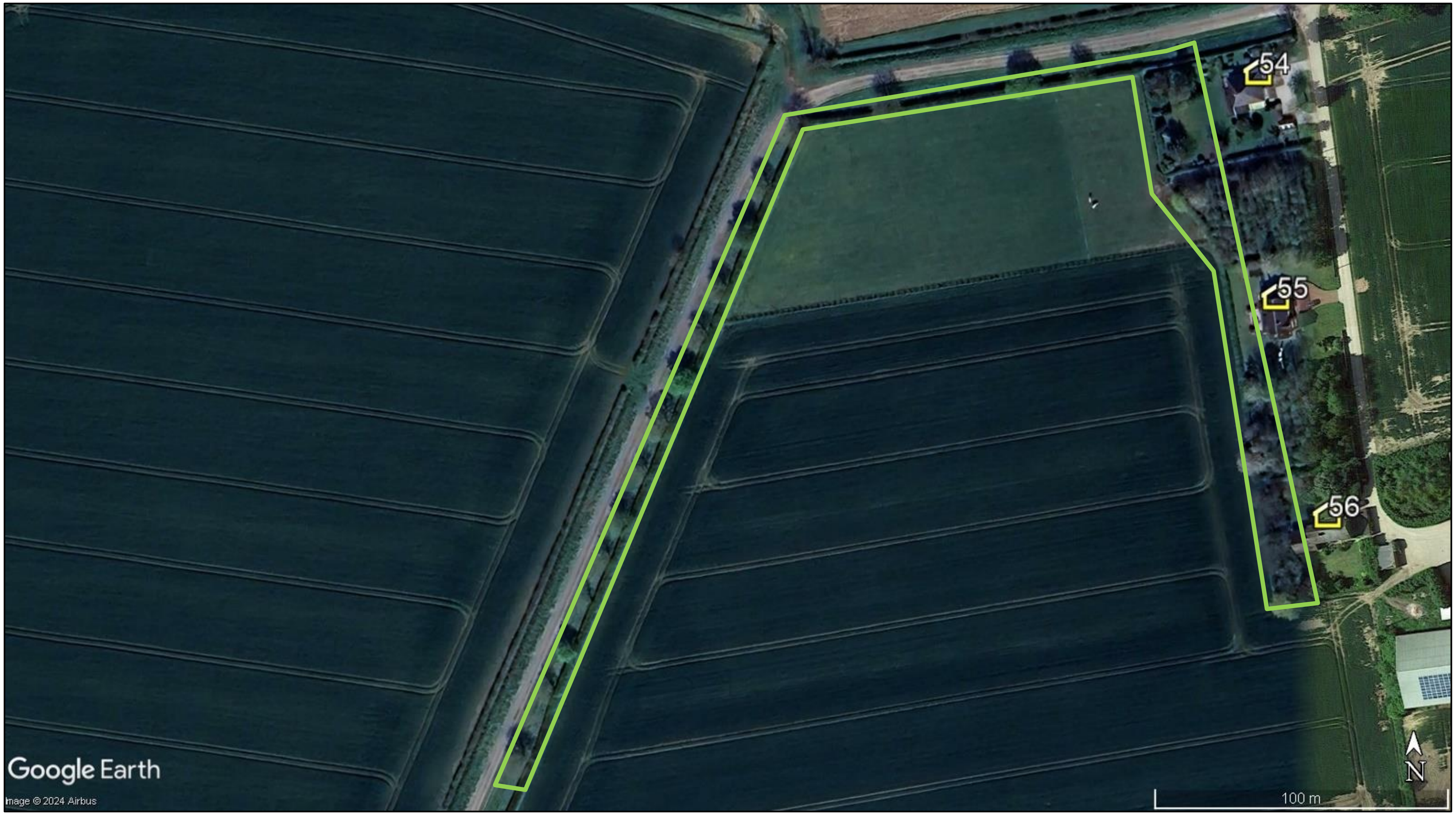
Significant vegetation screening for dwelling receptors 9-13

Significant vegetation screening for dwelling receptors 45-50 and approximate cumulative reflecting panel area



Significant vegetation screening for dwelling receptor 51 and approximate reflecting panel area

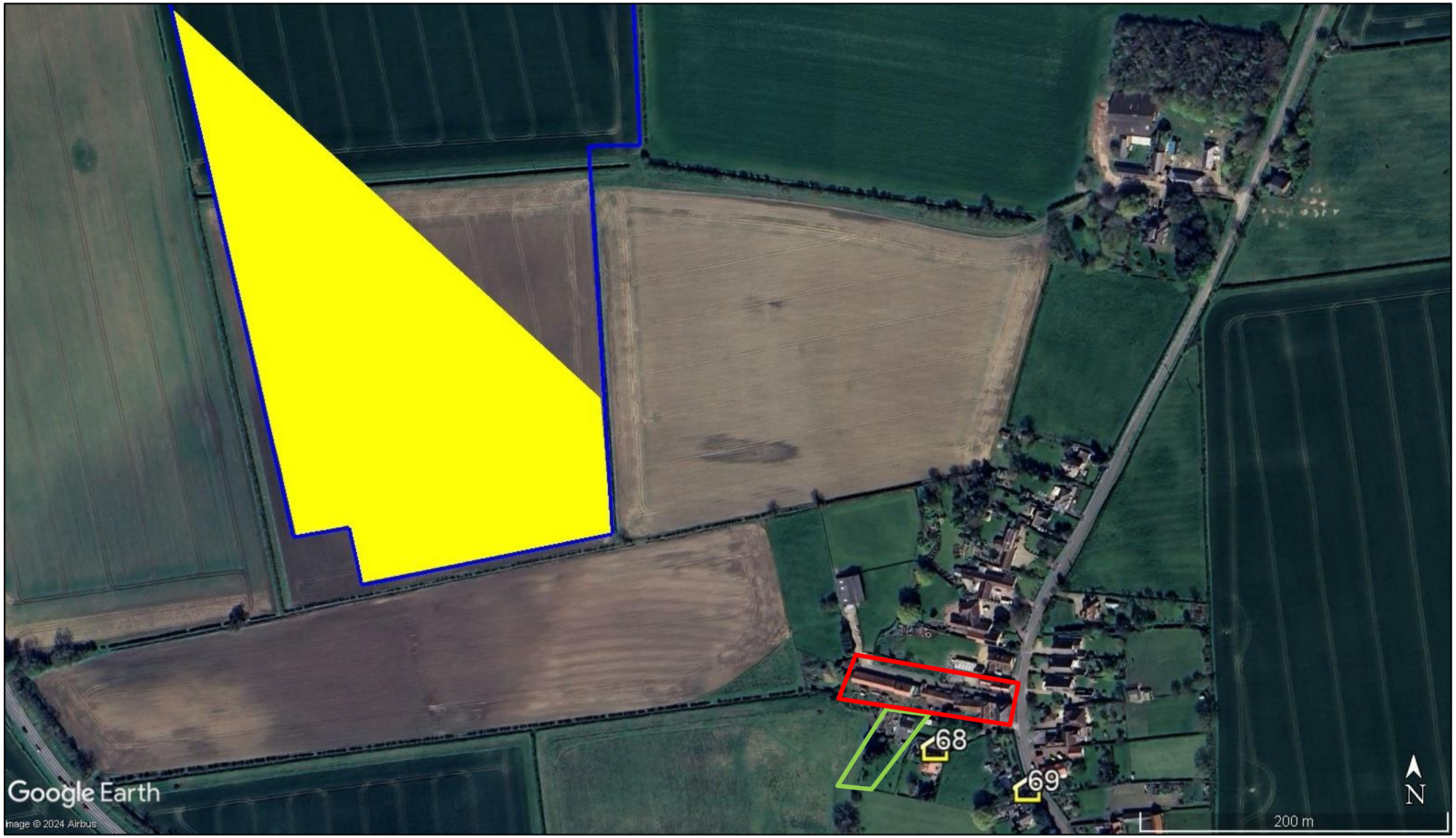
Significant vegetation screening for dwelling receptors 52-53 and approximate cumulative reflecting panel area



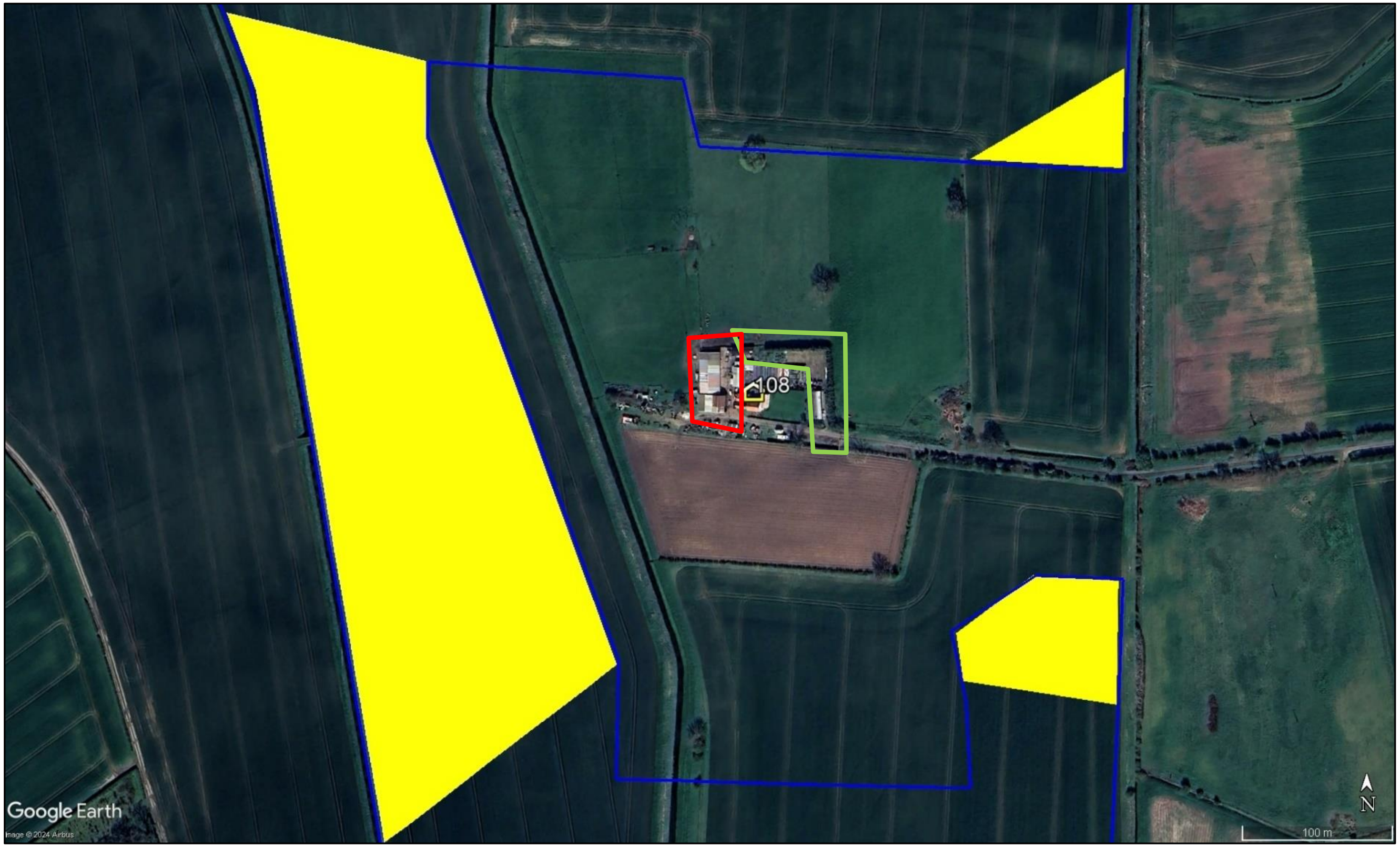
Significant vegetation screening near dwelling receptors 54-56

Significant screening near dwelling receptors 57 and 58

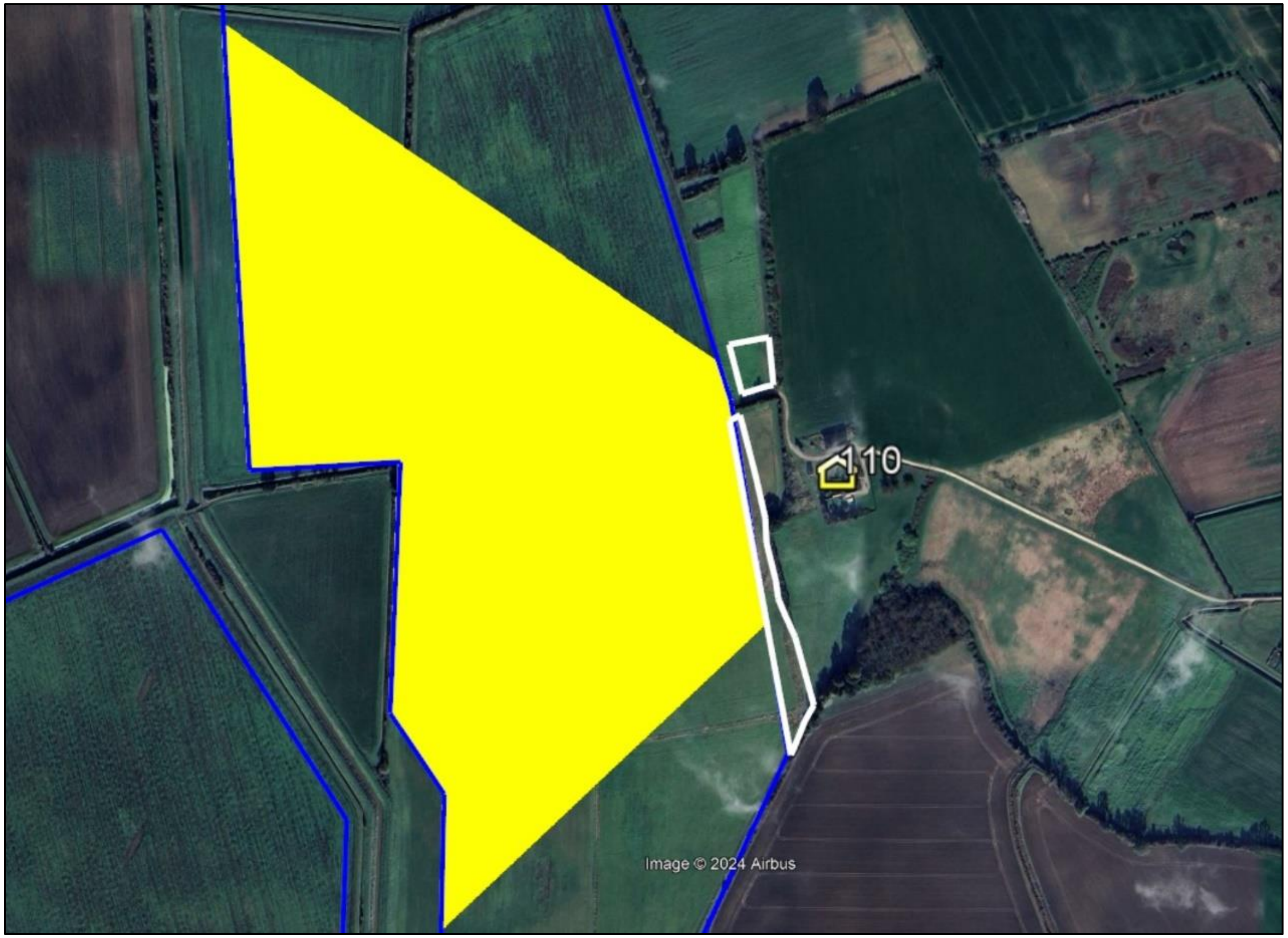
Screening for dwelling receptors 59 to 67 and approximate cumulative reflecting panel area



Screening for dwelling receptors 68 and 69 and approximate cumulative reflecting panel area



Screening for dwelling receptor 108 and reflecting panel areas



Proposed vegetation screening relevant to dwelling 110 (white polygons)

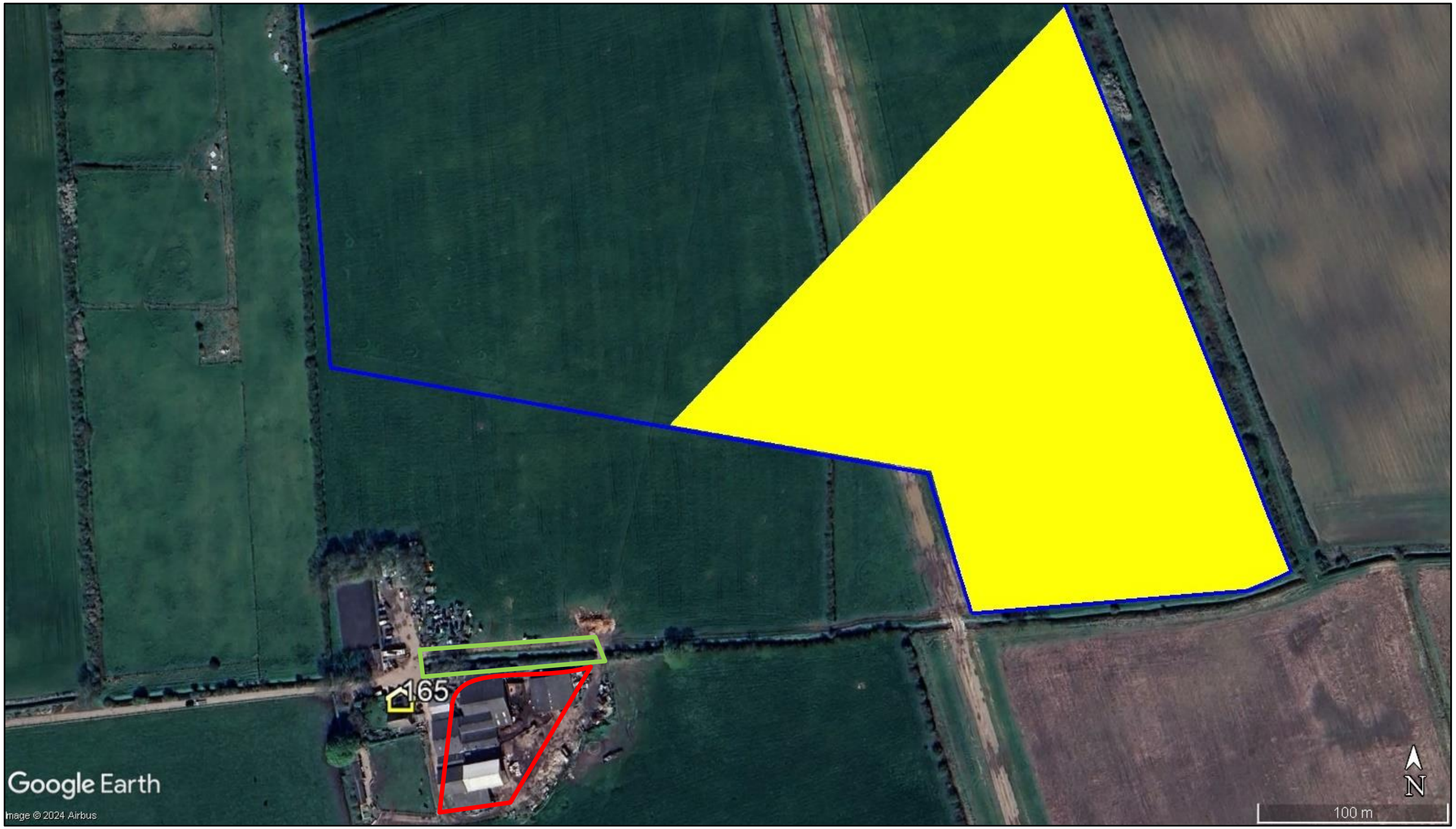
Significant vegetation screening for dwelling receptors 113-125 and approximate cumulative reflecting panel area

Screening for dwelling receptor 144 and reflecting panel areas

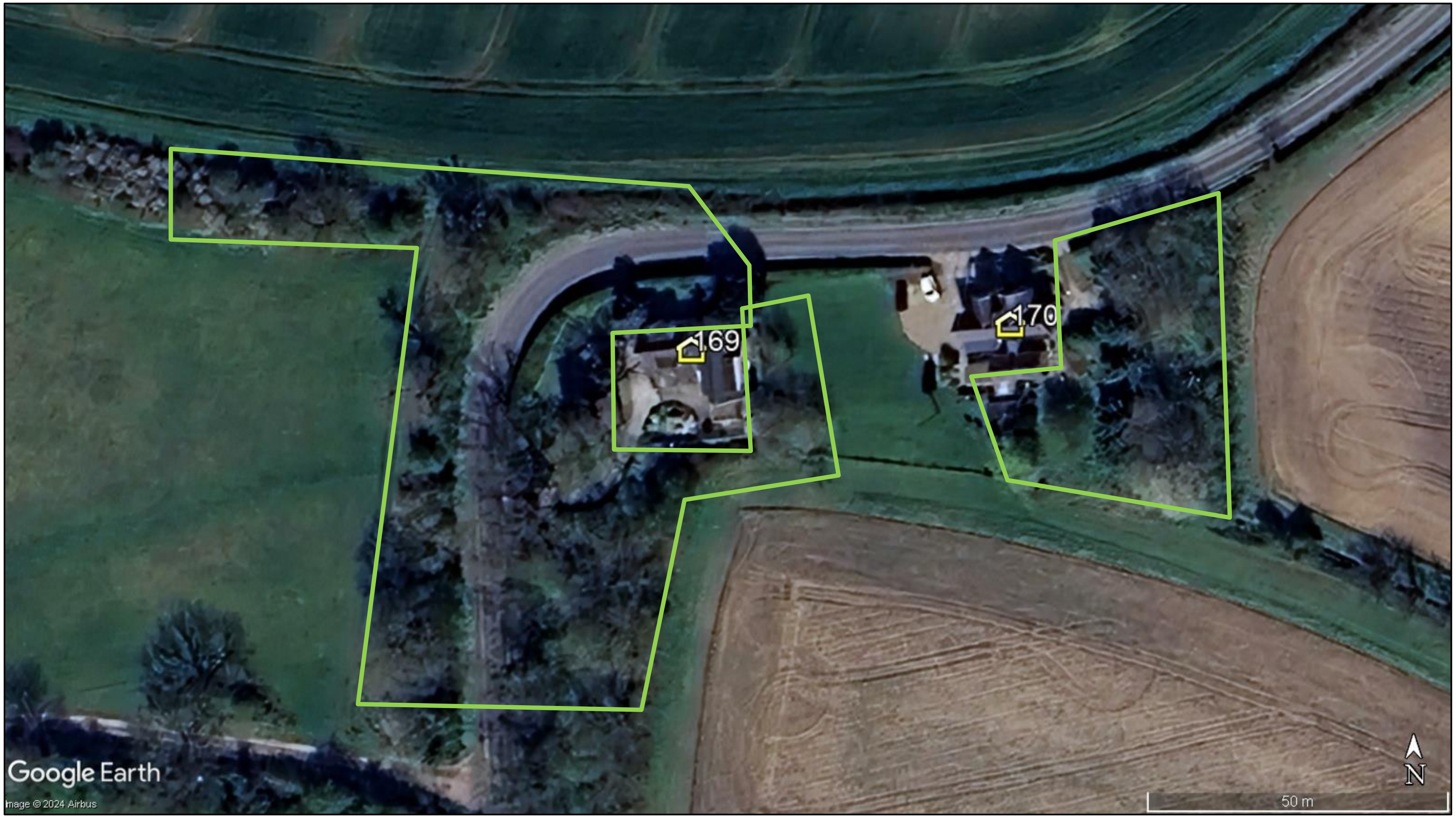
Significant screening for dwelling receptors 146-148 and approximate cumulative reflecting panel area

Significant vegetation screening near dwelling receptors 146-148

Significant screening around dwelling receptor 159 and approximate reflecting panel area



Significant screening around dwelling receptor 165 and approximate reflecting panel area



Vegetation screening around dwelling receptors 169 and 170

Vegetation screening around dwelling receptors 171-174

Significant screening around dwelling receptor 175

Vegetation screening around dwelling receptor 184

APPENDIX K – 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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