Tween Bridge Solar Farm

Environmental Statement
Appendix 16.2: Glint and Glare Assessment (fixed design)

Planning Act 2008
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

APFP Regulation 5(2)(a)

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Revision 2~~1~~

ADMINISTRATION PAGE

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Issue	Date	Detail of Changes
1	19th June 2025	Initial issue
2	14th July 2025	Updated modelling for Sandtoft Airfield and added modelling for sensitive viewpoints
3	16th July 2025	Administrative amendments
4	21st August 2025	Administrative amendments
5	30th April 2026	Administrative amendments

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the potential effects of glint and glare from the proposed solar photovoltaic (PV) development 'Tween Bridge Solar Farm'. This assessment pertains to the potential impacts from the fixed panel layout upon surrounding road safety, residential amenity, railway operations and infrastructure, and aviation activity associated with Sandtoft Airfield, Finningley Village Airfield, Haxey Airfield and Doncaster Sheffield Airport.

Overall Conclusions

Solar reflections with a maximum intensity of 'potential for temporary after-image' (yellow glare) are predicted towards sections of visual circuits at Sandtoft Airfield, originating from panel areas within a pilot's primary field-of-view (50 degrees horizontally either side of the direction of travel). Considering the glare scenario, it is considered that this glare could be accommodated without significant changes to the operational activity of the airfield. Some of the measures that pilots may typically use to mitigate the effects of direct sunlight could be used to mitigate the effects of direct solar reflections from the solar panels given the operations at this unlicensed airfield. Due to the proximity of panel areas to Sandtoft Airfield, consultation with Yorkshire Aero Club is recommended.

No significant impacts are predicted on aviation activity associated with Finningley Village Airfield, Haxey Airfield, and Doncaster Sheffield Airport.

A moderate impact is predicted on separate 0.2km and1.6km sections of the M180, and a 0.1km section of the A18, under baseline conditions. This is due to solar reflections predicted to originate from inside of a road user's primary horizontal field of view in the absence of sufficient mitigating factors. Proposed vegetation planting is expected to screen panels once sufficiently matured, such that views of reflecting panels are not expected to be possible in practice. Further mitigation is not recommended.

A moderate impact is predicted on seven dwellings under baseline conditions due to the duration of effects (more than three months per year) in the absence of sufficient mitigating factors. Proposed vegetation planting is expected to screen panels from the ground floor once sufficiently matured, such that views of reflecting panels are not expected to be possible in practice. Further mitigation is not recommended.

No significant impacts are predicted on railway operations and infrastructure, and sensitive viewpoints.

An overview of the assessment results is presented on the following pages.

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, railway safety, and aviation safety 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/ façades. 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].

Assessment Conclusions – Roads

A moderate impact is predicted on separate 0.2km and1.6km sections of the M180, and a 0.1km section of the A18, under baseline conditions. This is due to solar reflections predicted to originate from inside of a road user's primary horizontal field of view in the absence of sufficient mitigating factors. Proposed vegetation planting is expected to screen panels once sufficiently matured, such that views of reflecting panels are not expected to be possible in practice. Further mitigation is not recommended.

No significant impacts are predicted on other road users.

Assessment Conclusions – Dwellings

The modelling has shown that solar reflections are geometrically possible[3] towards 281 of the 405 assessed dwelling locations.

No impacts are predicted on 134 dwellings because there is significant existing screening such that views of reflecting panels are not expected to be possible in practice. Mitigation is not required.

A low impact is predicted on 140 dwellings under baseline conditions in accordance with the guidance presented in Appendix D, either because the duration of effects received in practice

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[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).

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

on the ground floor is expected to be reduced to **less** than three months per year and **less** than 60 minutes per any one day, or there are mitigating factors such as a significant separation distance to the closest reflecting panels and effects occurring within a few hours of sunrise/sunset when the Sun is low in the sky. Proposed vegetation planting is expected to screen panels from the ground floor once sufficiently matured, such that views of reflecting panels are not expected to be possible in practice. Further mitigation is not recommended.

A moderate impact is predicted on seven dwellings (receptors 24-25, 169, 199-201, 268) under baseline conditions due to the duration of effects (more than three months per year) in the absence of sufficient mitigating factors. Proposed vegetation planting is expected to screen panels from the ground floor once sufficiently matured, such that views of reflecting panels are not expected to be possible in practice. Further mitigation is not recommended.

Assessment Conclusions – Railway Signals

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

Without consideration of vegetation screening:

- For two signals, a low impact is predicted because solar reflections originate from outside 90 degrees either side of the direction of the signal;
- For the remaining seven signals, a low impact is predicted with consideration of factors such as all signals appearing to be LED, having hoods fitted, reflections don't originate directly in front of the signal, and/or there is a significant clearance distance to the reflecting area.

With consideration of existing and proposed vegetation screening, no impacts are predicted on any signals. Mitigation is not recommended.

Assessment Conclusions – Train Drivers

A low impact is predicted on separate 2.3km, 0.3km, and 0.6km sections of railway line. Where solar reflections are geometrically possible from inside a train driver's primary horizontal field of view, there are mitigating factors such as a significant separation distance to the closest reflecting panels and effects occurring within a few hours of sunrise/sunset when the Sun is low in the sky.

No impacts are predicted on other sections of railway line, because solar reflections are not geometrically possible, or are predicted to be screened.

Further mitigation is not recommended.

Assessment Conclusions – Sensitive Viewpoints

The modelling has shown that solar reflections are predicted towards 32 of the sensitive viewpoints. In Pager Power's experience, significant impacts to pedestrians using public rights of way are not possible due to glint and glare effects from PV developments. The reasoning is due to the sensitivity of the receptors (in terms of amenity and safety) being concluded to be of low significance. This is because:

- The typical density of pedestrians located at these points is low in a rural environment;

- Any resultant effects are less serious than, for example, solar reflections experienced towards a road network whereby the resultant impacts of a solar reflection can be much more serious. Safety concerns are considered to a greater extent for horse riders and the possible event of being thrown by a scared animal, however the risk of this occurring due to glare from solar panels is considered to be small;
- Glint and glare effects towards an observer are transient, and time and location sensitive whereby a pedestrian could move beyond the solar reflection zone with ease with little impact upon safety or amenity;
- Any observable solar reflection towards an observer would be of similar intensity to those experienced whilst navigating the natural and built environment on a regular basis (e.g. bodies of water), and less intense than reflections from glass and other common outdoor surfaces.

Overall, no significant impact on observers at these viewpoints is predicted and therefore mitigation is not required.

Assessment Conclusions – Sandtoft Airfield

1-mile splayed approaches towards Runway 05

Solar reflections originating from outside of a pilot's primary field-of-view are predicted towards the 1-mile splayed approaches towards Runway 05. A low impact is predicted in accordance with the associated guidance and industry best practice. Mitigation is not recommended.

1-mile splayed approaches towards Runway 23

Solar reflections with a maximum intensity of 'low potential for temporary after-image' (green glare) are predicted towards the 1-mile splayed approaches towards Runway 23, originating from panel areas within a pilot's primary field-of-view. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths at licensed aerodromes, which states that this level of glare is acceptable, it can be reliably concluded that this glare is acceptable. A low impact is predicted, and mitigation is not recommended.

Visual Circuits

Solar reflections with a maximum intensity of 'potential for temporary after-image' (yellow glare) are predicted towards sections of visual circuits at Sandtoft Airfield, originating from panel areas within a pilot's primary field-of-view (50 degrees horizontally either side of the direction of travel).

Glare with potential for a temporary after-image was formerly not permissible under the interim guidance provided by the Federal Aviation Administration in the USA for on-airfield solar. This FAA guidance from 2013 has since been superseded by the FAA guidance in 2021 whereby airports are tasked with determining safety requirements themselves.

Pager Power generally recommends a pragmatic approach whereby instances of 'yellow' glare are evaluated in a technical and operational context. Considering the glare scenario (presented in Section 7.7.4), it is considered that this glare could be accommodated without significant changes to the operational activity of the airfield. Some of the measures listed in Section 7.7.5 that pilots may typically use to mitigate the effects of direct sunlight could be used to mitigate the effects of direct solar reflections from the solar panels given the operations at this unlicensed airfield.

Due to the proximity of panel areas to Sandtoft Airfield, consultation with Yorkshire Aero Club is recommended.

Assessment Conclusions – Doncaster Sheffield Airport

Significant impacts are not predicted on aviation activity at Doncaster Sheffield Airport based on the associated guidance and industry best practice. This is because:

- Solar reflections towards the ATC Tower are unlikely to be geometrically possible based on the location of the receptor relative to the Scheme (considering distance, height, and orientation). Any reflections that are geometrically possible are likely to be screened by intervening terrain, buildings, and/or vegetation.
- Any solar reflections geometrically possible towards aircraft on the final two-mile approach towards runway 20 would be outside of a pilot's primary horizontal field of view (50 degrees either side of the approach bearing). At worst, a low impact is predicted on pilots on this approach path based on the associated guidance and industry best practice for licensed airfields.
- Any solar reflections geometrically possible towards aircraft on the final two-mile approach towards runway 02 are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors.

Technical modelling is not recommended.

Assessment Conclusions – Finningley Village Airstrip

Significant impacts are not predicted on aviation activity at Finningley Village Airstrip based on the associated guidance and industry best practice. This is because:

- Any reflections towards aircraft on the final one-mile splayed approach towards runway 19 would be outside of a pilot's primary horizontal field of view. At worst, a low impact is predicted on pilots on this approach path based on the associated guidance and industry best practice for licensed airfields.
- Solar reflections originating from the Scheme towards the final one-mile splayed approach towards runway 01, and the final sections of the visual circuits and joins, are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors.

Technical modelling is not recommended.

Assessment Conclusions – Haxey Airstrip

Significant impacts are not predicted on aviation activity at Haxey Airstrip based on the associated guidance and industry best practice. This is because:

- Any reflections towards aircraft on the final one-mile splayed approach towards runway 36 would be outside of a pilot's primary horizontal field of view. At worst, a low impact is predicted on pilots on this approach path based on the associated guidance and industry best practice for licensed airfields.
- Solar reflections originating from the Scheme towards the final one-mile splayed approach towards runway 18, and the final sections of the visual circuits and joins, are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors.

Technical modelling is not recommended.

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Urban & Renewables

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 62 countries 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 potential effects of glint and glare from the proposed solar photovoltaic (PV) development 'Tween Bridge Solar Farm'. This assessment pertains to the potential impacts from the fixed panel layout upon surrounding road safety, residential amenity, railway operations and infrastructure, and aviation activity associated with Sandtoft Airfield, Finningley Village Airfield, Haxey Airfield and Doncaster Sheffield Airport.

This report contains the following:

- Solar development details;
- Explanation of glint and glare;
- Overview of relevant guidance and relevant studies;
- Overview of Sun movement;
- Assessment methodology;
- Identification of receptors;
- Glint and glare assessment for identified receptors;
- High-level assessment of effects on Haxey Airfield and Doncaster Sheffield Airport;
- Results discussion.

1.2 Pager Power's Experience

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

1.3 Glint and Glare Definition

The definition 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)[4] and the Federal Aviation Administration in the USA. The term 'solar reflection' is used in this report to refer to both reflection types.

[4] Published by the Department for Energy Security and Net Zero in November 2023 and came into force on 17 January 2024

2 PROPOSED SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Reflector Areas

Figure 1Figure 1Figure 1 below shows the assessed reflector areas that have been used for modelling purposes.

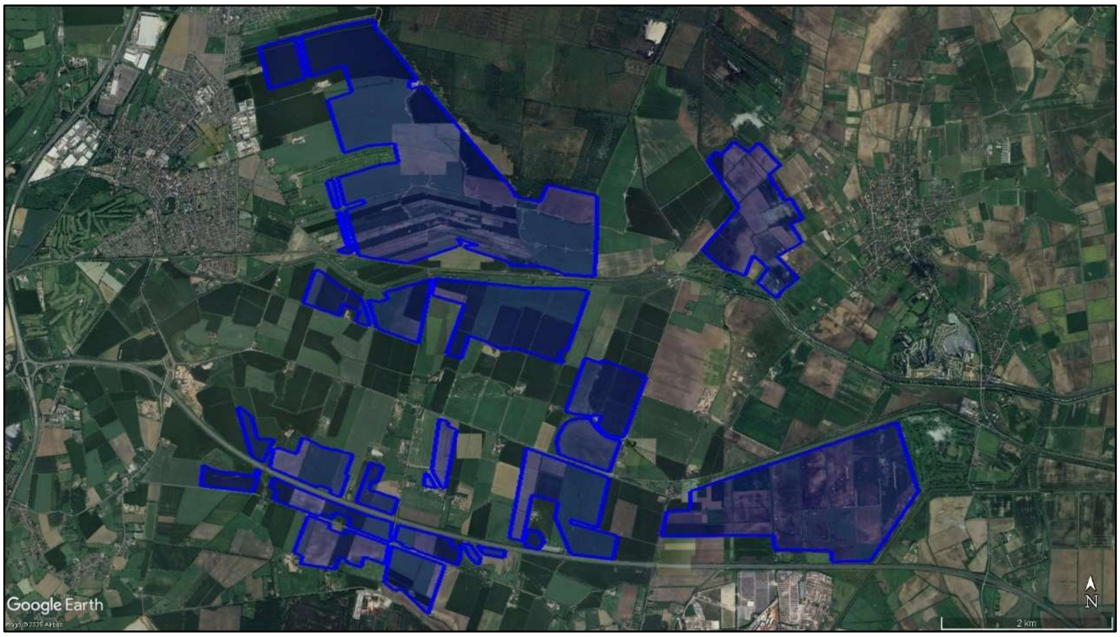

Figure 1 *Assessed reflector areas – aerial image*

A resolution of 40m has been chosen for this assessment. This means that a geometric calculation is undertaken for each identified receptor from a point every 40m from within the defined areas. This resolution is sufficiently high to maximise the accuracy of the results; increasing the resolution further would not significantly change the modelling output. The number of modelled reflector points are determined by the size of the reflector areas and the assessment resolution. The bounding coordinates for the proposed solar development have been extrapolated from the site plans. The data can be provided on request.

2.2 Site Plan

The site plan[5] is shown in Figure 2Figure 2Figure 2 on the following page (for fixed panels).

[5] Source: 6.4.2.2a Indicative Operational Layout Plan (Fixed Solar Panels).pdf (cropped)

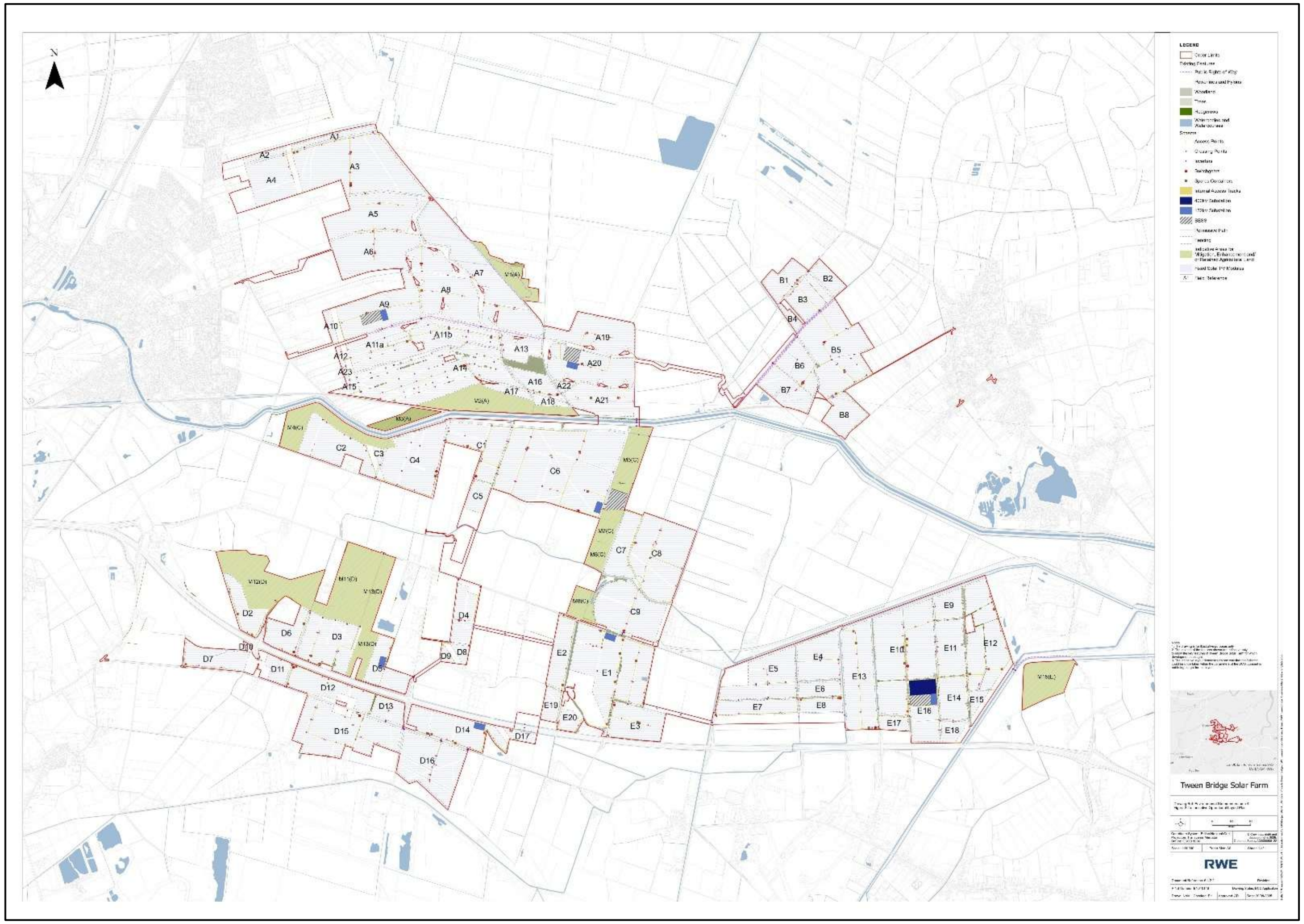

Figure 2 *Site Layout Plan*

2.3 Landscape Plans

The relevant landscape plans[6] are shown in Figure 3~~Figure 3Figure 3~~ to Figure 5~~Figure 5Figure 5~~ on the following pages.

[6] Source: P21-3484_52F Landscape Strategy

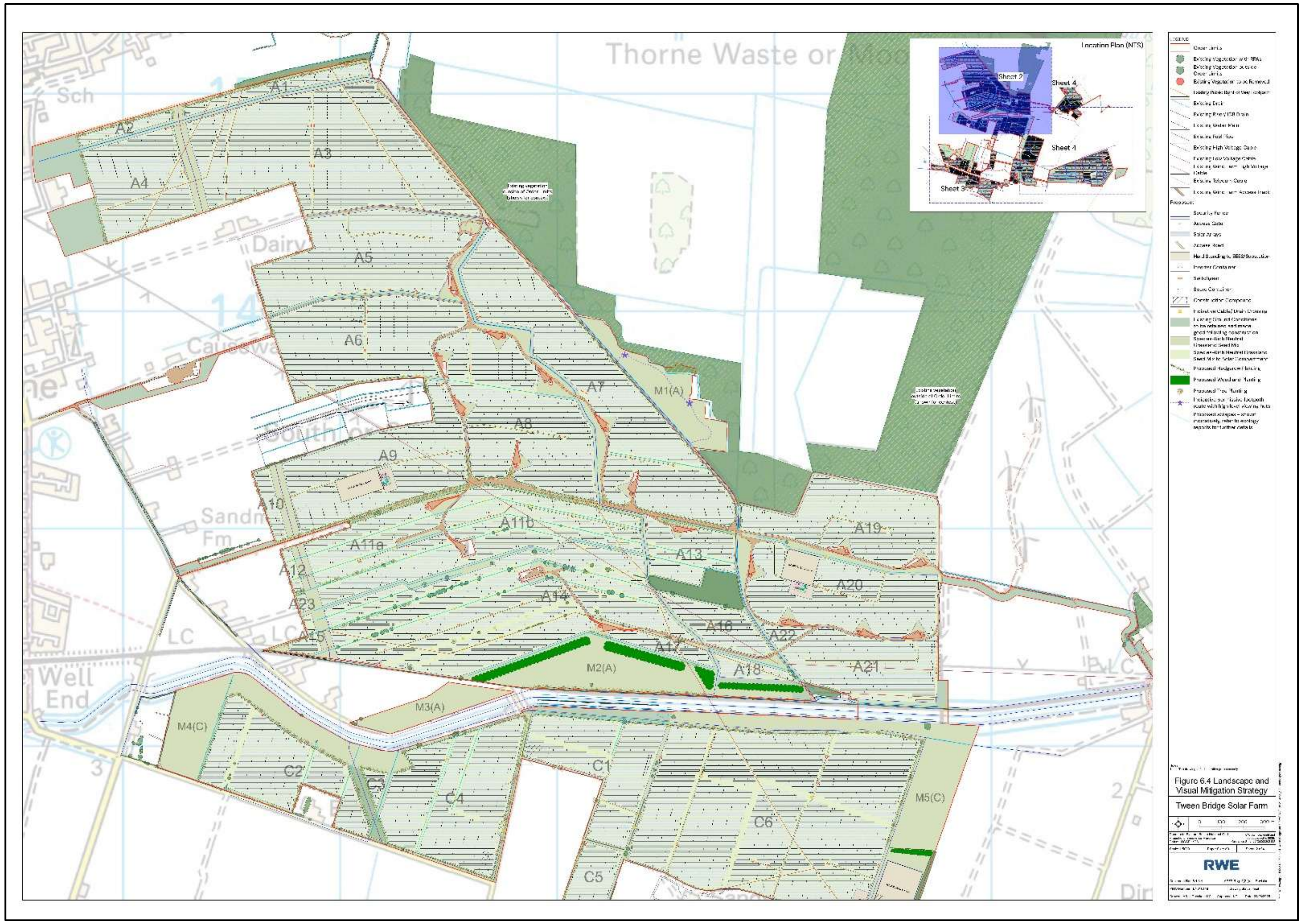

Figure 3 *Landscape and Visual Mitigation Strategy (Sheet 2 of 4)*

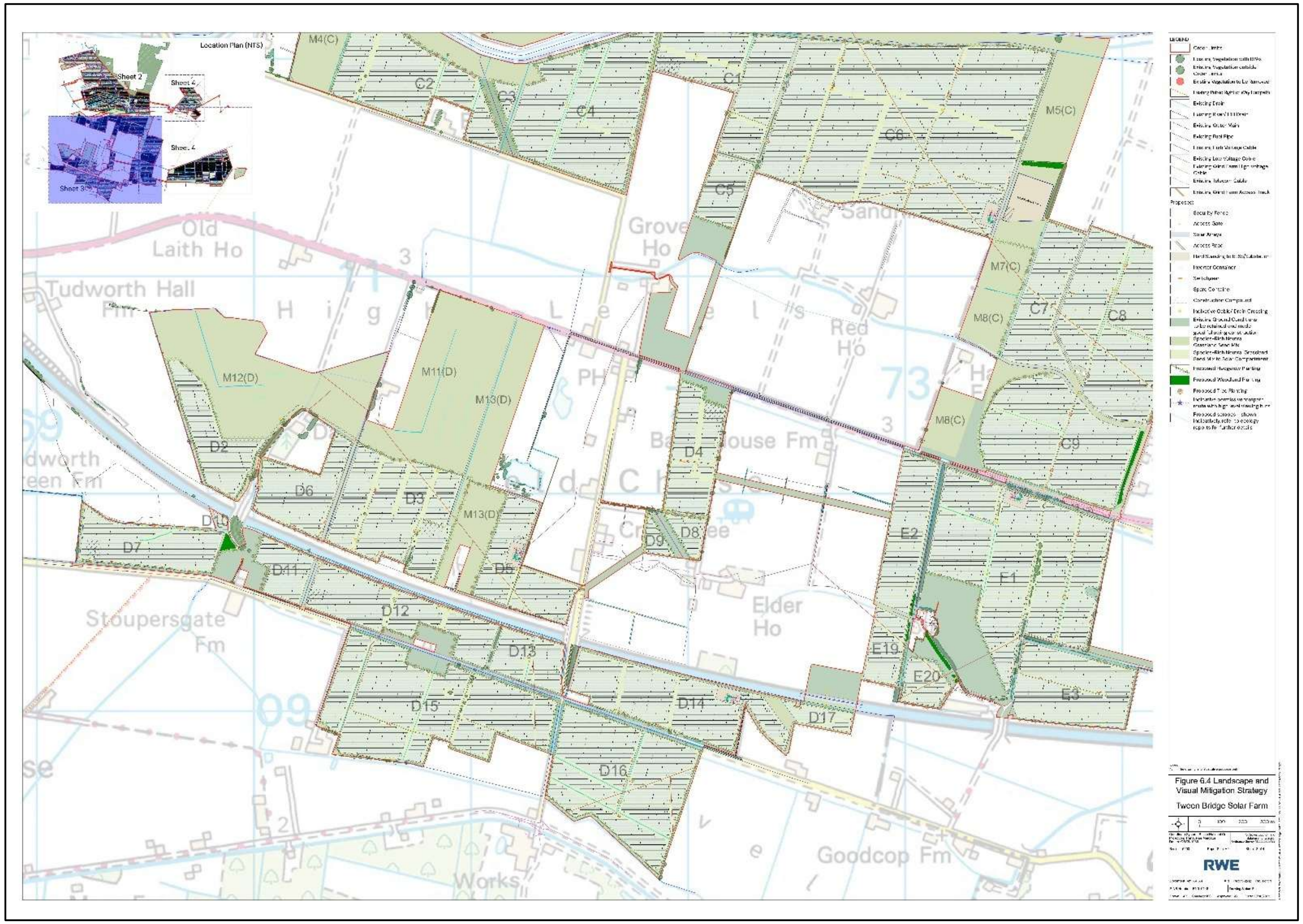

Figure 4 *Landscape and Visual Mitigation Strategy (Sheet 3 of 4)*

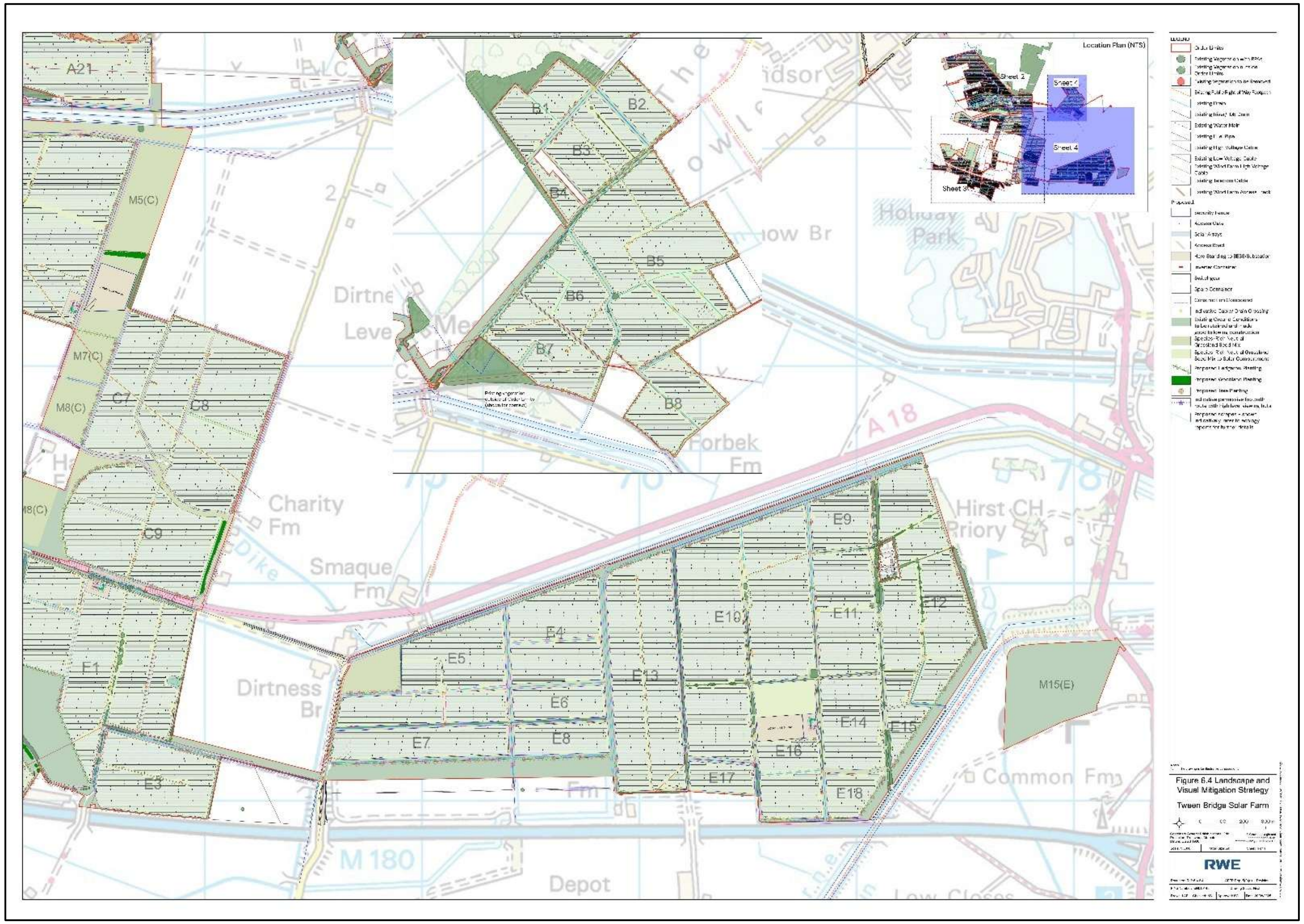

Figure 5 *Landscape and Visual Mitigation Strategy (Sheet 4 of 4)*

2.4 Solar Panel Technical Information

The technical information used for the modelling is presented in Table 1 below. The centre of the solar panel has been used as the assessed height in metres above ground level (agl).

Solar Panel Technical Information	
Azimuth angle[7]	180°
Elevation (tilt) angle[8]	20°
Centre height[9] (agl)	2.2 metres

Table 1 *Solar panel information*

[7] Clockwise orientation the panels are facing relative to True North (0°)

[8] Relative to the horizontal.

[9] Minimum height = 0.8m agl, maximum height = 3.6m agl.

3 RAILWAYS AND GLINT AND GLARE

3.1 Overview

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

3.2 Glint and Glare Definition

As well as the glint and glare definition presented in Section 1.3, glare can also be categorised as causing visual discomfort whereby an observer would instinctively look away, or cause disability whereby objects become difficult to see. The guidance produced by the Commission Internationale de L'Eclairage (CIE)[10] describes disability glare as:

'Disability glare is glare that impairs vision. It is caused by scattering of light inside the eye…The veiling luminance of scattered light will have a significant effect on visibility when intense light sources are present in the peripheral visual field and contrast of objects is seen to be low.'

'Disability glare is most often of importance at night when contrast sensitivity is low and there may well be one or more bright light sources near to the line of sight, such as car headlights, streetlights or floodlights. But even in daylight conditions disability glare may be of practical significance: think of traffic lights when the sun is close to them, or the difficulty viewing paintings hanging next to windows.'

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

3.3 Common Concerns and Signal Overview

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

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

With respect to point 1, a reflective façade (or vertical surface) could produce solar reflections towards a train driver. If this reflection occurs where a railway signal, crossing etc., is present, or

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

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

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

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

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

Details regarding the identified railway signals are presented in Section 5.2.7 of this report.

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

4 GLINT AND GLARE ASSESSMENT METHODOLOGY

4.1 Overview

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

- Specular reflections of the Sun from solar panels and glass are possible;
- The measured intensity of a reflection from solar panels can vary from 2% to 30% depending on the angle of incidence;
- Published guidance shows that the intensity of solar reflections from solar panels are equal to or less than those from still water and similar to those from glass. It also shows that reflections from solar panels are significantly less intense than many other reflective surfaces, which are common in an outdoor environment, including steel[12].

4.2 Background

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

4.3 Methodology

Information regarding the methodology of Pager Power's and Sandia National Laboratories' methodology is presented on the following page.

4.3.1 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 Scheme;
- Consider direct solar reflections from the Scheme towards the identified receptors by undertaking geometric calculations;
- Consider the visibility of the reflectors from the receptor's location. If the reflectors are not visible from the receptor then no reflection can occur;
- Based on the results of the geometric calculations, determine whether a reflection can occur, and if so, at what time it will occur;
- Consider the solar reflection intensity, if appropriate;
- Consider both the solar reflection from the Scheme and the location of the direct sunlight with respect to the receptor's position;

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

- 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.

4.3.2 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.

4.4 Assessment Methodology and Limitations

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

5 IDENTIFICATION OF GROUND-BASED RECEPTORS

5.1 Overview

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

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 panel areas is appropriate for glint and glare effects on roads and dwellings, and within 500m of panel areas is appropriate for glint and glare effects on railway operations and infrastructure. The panels are fixed south facing and solar reflections at ground level towards the north at this latitude are highly unlikely. Therefore, the area to the north of the northern-most solar panels has been excluded.

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

5.2 Road Receptors

5.2.1 Road Receptors Overview

Road types can generally be categorised as:

- Major National – Typically a road with a minimum of two carriageways with a maximum speed limit of up to 70mph. These roads typically have fast-moving vehicles with busy traffic;
- National – Typically a road with 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 Scheme 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 considers any 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[13]. 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 Road Receptors Identification

242 receptors have been identified distanced circa 100m apart across five road sections:

- A 9.97km section of the M180 (road receptors A1 to A101);
- A 1.64km section of the A18 (road receptors B1 to B18);
- A 0.33km section of Tudworth Roundabout (road receptors C1 to C5);
- A 9.95km section of the A18 (road receptors D1 to D101);
- A 1.59km section of the A161 (road receptors E1 to E17).

The road sections are shown in orange in Figure 6~~Figure 6Figure 6~~ on the following page.

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

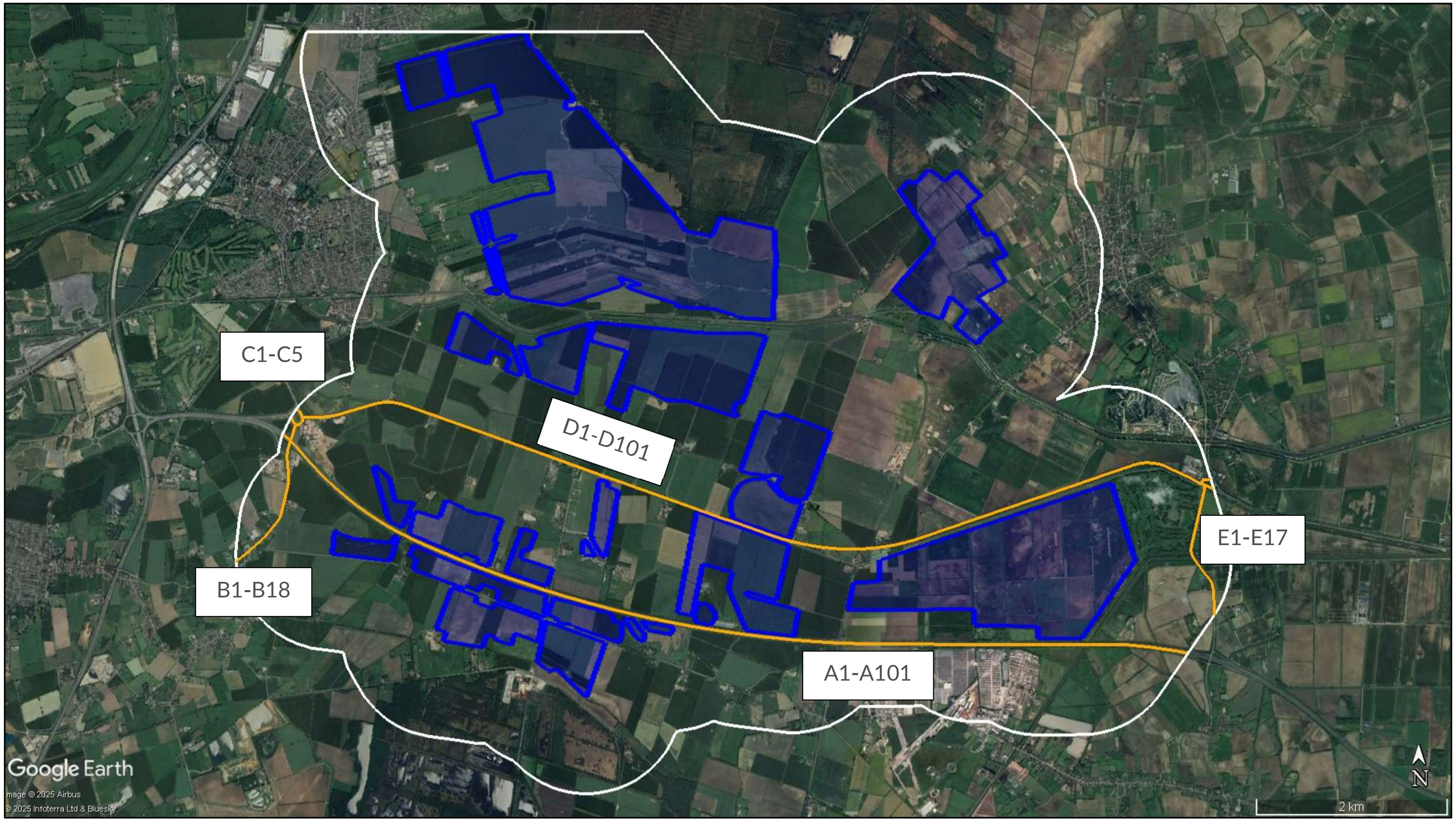

Figure 6 *Assessed road sections (orange lines) – aerial image*

5.3 Dwelling Receptors

5.3.1 Dwelling Receptors Overview

The analysis typically considers 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 Scheme 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[14] of the dwelling since this is typically the most occupied floor of a dwelling throughout the day.

5.3.2 Dwelling Receptors Identification

In total, 405 dwelling receptors were identified for assessment, as shown in Figure 7~~Figure 7~~~~Figure 7~~ on the following page. These are shown in more detail in Appendix H.

[14] 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.

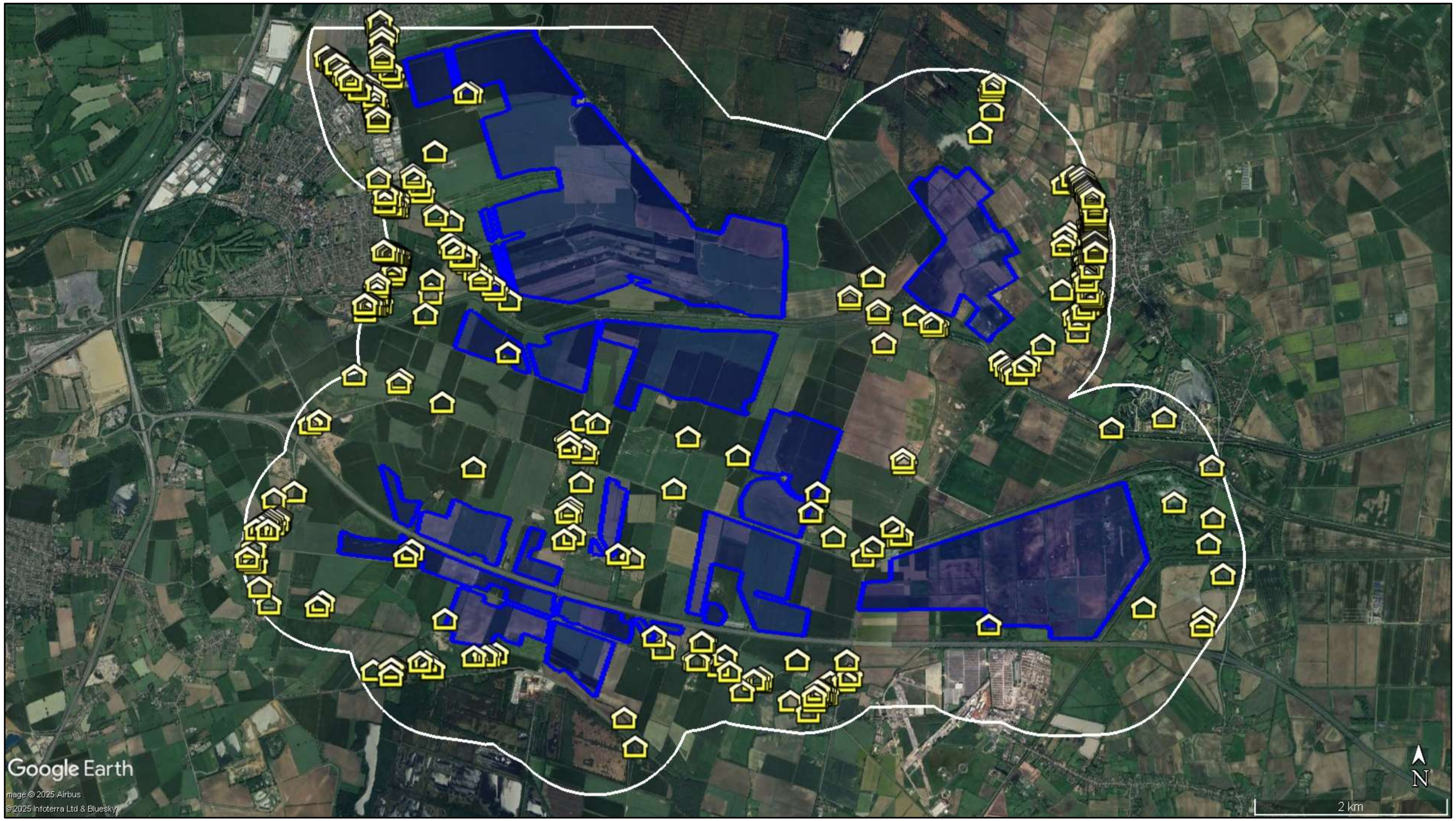

Figure 7 *Assessed dwelling receptor locations*

5.4 Train Driver Receptors

5.4.1 Train Driver Receptors Overview

The analysis has considered train driver receptors that:

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

Based on previous consultation[15], an additional 2.75m height above ground is used in the modelling as the typical viewing height of a train operator[16].

5.4.2 Train Driver Receptors Identification

4.23km and 1.88km sections of railway line were identified for assessment. These are shown by the orange lines in Figure 8~~Figure 8Figure 8~~ on the following page. In total, 64 train driver receptor locations are identified, distanced circa 100m apart.

The specific details of the assessed train driver receptor locations are presented in Appendix G.

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

[16] This height may vary based on driver height however this figure is used as the industry standard.

Figure 8 *Overview of train driver receptors – aerial image*

5.5 Railway Signals

5.5.1 Railway Signals Overview

The analysis has considered railway signals that are within the 500m assessment area (white polygon on Figure 9~~Figure 9Figure 9~~ on page 43~~4237~~) and have a potential unobstructed line of sight of the Scheme. In some cases, multiple signals may be treated as one physical signal structure. In such cases, the results for the assessed location will be applicable to the associated signals. The sampling resolution is sufficiently high to capture the level of effect for all potentially affected signals.

Typical heights[17] above ground level (agl) for a signal are[18]:

- Gantry signals – 5.1m;
- Cantilever – 5.1m;
- Trackside signals – 3.3m.

5.5.2 Railway Signals Identification

Table 2~~Table 2Table 2~~ below and on the following page provides details of the identified signals and their corresponding railway signal receptor assessed in this report.

Signal Receptor	Railway Signal Identification Number	Existing / Proposed	Signal Type	Signal Hood	Orientation
S1	D622	Existing	Trackside	Yes	West
S2	D620	Existing	Trackside	Yes	West
S3	D618	Existing	Trackside	Yes	West
S4	D616	Existing	Trackside	Yes	West
S5	D614	Existing	Trackside	Yes	Northwest
S6	D617	Existing	Trackside	Yes	East
S7	D619	Existing	Trackside	Yes	East
S8	D621	Existing	Trackside	Yes	East
S9	D623	Existing	Trackside	Yes	East

[17] Consultation undertaken with Network Rail in the UK. Typical heights for gantries and trackside signals were provided by Network Rail. Cantilever signals are generally expected to be of a similar height to the gantry signals.

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

Signal Receptor	Railway Signal Identification Number	Existing / Proposed	Signal Type	Signal Hood	Orientation
S10	D625	Existing	Trackside	Yes	East

Table 2 *Signal Identification*

Figure 9~~Figure 9Figure 9~~ on the following page shows the location of the signal receptors relative to the Scheme.

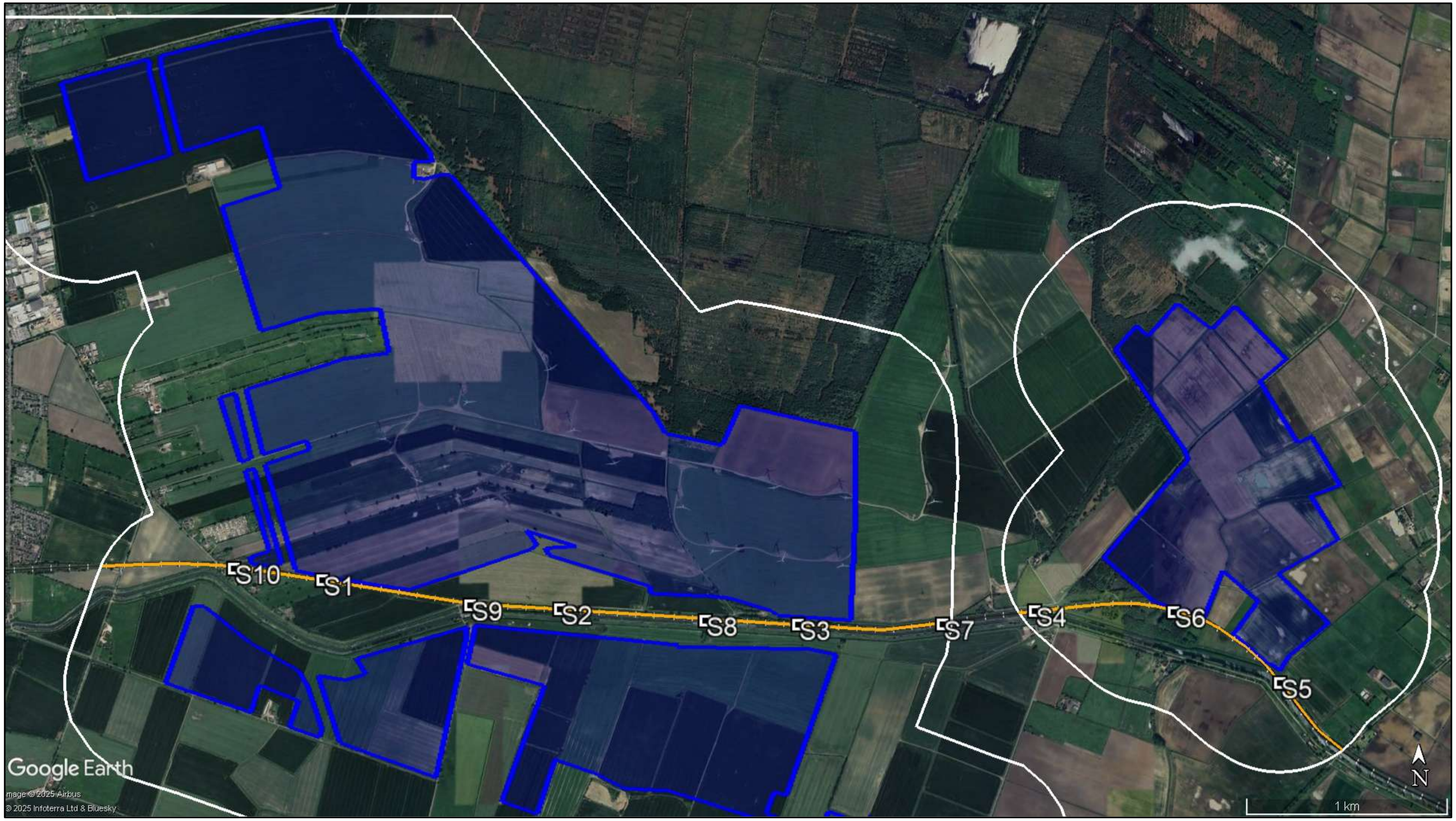

Figure 9 *Identified signal locations*

5.6 Sensitive Viewpoints

The analysis has considered 33 sensitive viewpoints[19] as shown in Figure 10~~Figure 10Figure 10~~ below.

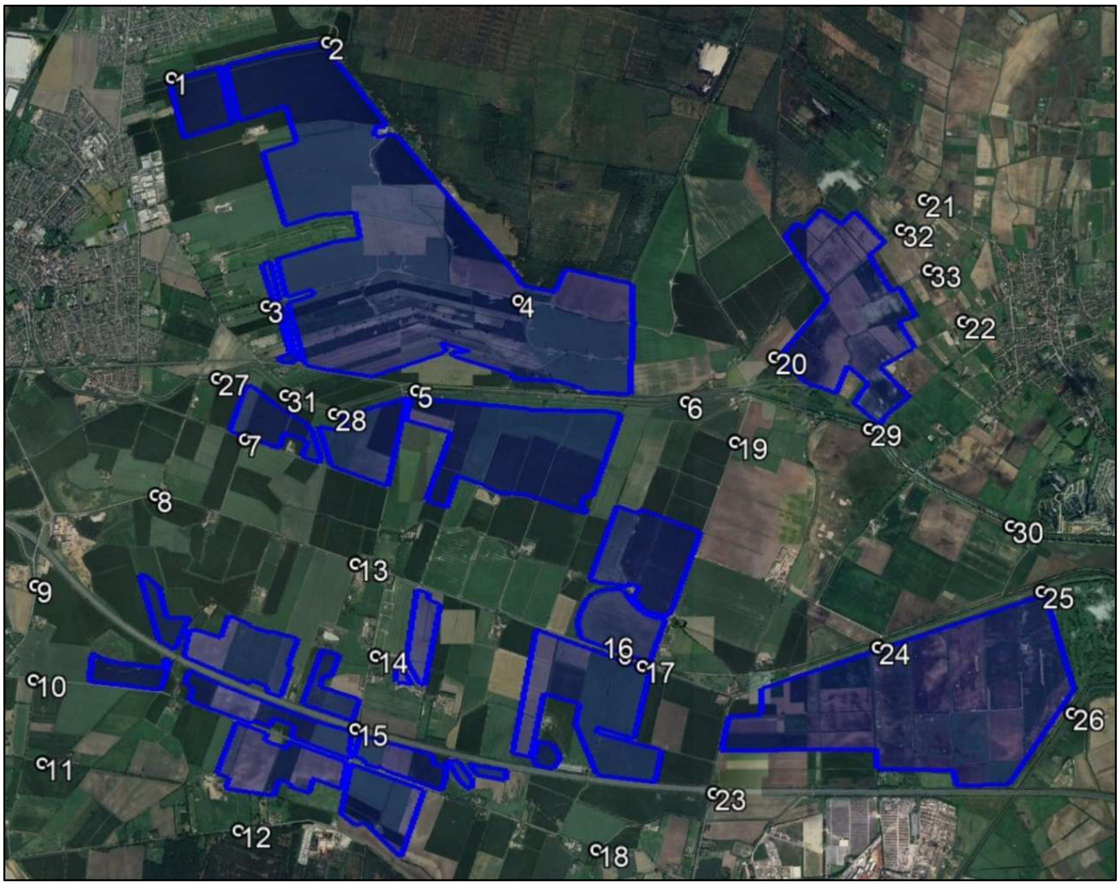

Figure 10 *Sensitive viewpoint receptors*

[19] Provided by Pegasus Group

6 IDENTIFICATION OF AVIATION RECEPTORS

6.1 Overview

Glint and glare analysis is often undertaken for solar developments that are adjacent to large aerodromes. The most common concerns are:

1. Potential reflections towards an Air Traffic Control (ATC) tower;
2. Potential reflections towards approaching pilots of powered aircraft for the final two miles of the approach.

With regard to Point 2, these reflections are typically evaluated in the context of:

- Whether they are in a pilot's primary horizontal field of view (50° either side of the direction of travel);
- The intensity of the solar reflection.

There is no formal assessment distance within which aviation effects must be modelled. However, in practice, concerns are most often raised for developments within 10km of a licensed airport. Requests for modelling at ranges of 10-20km are far less common. Assessment of aviation effects for developments over 20km away is a very unusual requirement.

Sandtoft Airfield is an unlicensed general aviation (GA) airfield located within 5km of the Scheme understood to be operated by Yorkshire Aero Club. This has been identified for assessment with technical modelling. This has one operational runway, the details[20] of which are presented below:

- 05/23 measuring 886 by 20 metres (unknown surface).

Finningley Village Airstrip and Haxey Airstrip are unlicensed GA airfields located outside of 5km but within 10km of the Scheme. These have been considered within the high-level assessment (without technical modelling) presented in Section 7.7.5 of this report.

Doncaster Sheffield Airport (formerly known as Robin Hood Airport) is an inactive (formerly licensed) airport located just outside of 10km of the Scheme. This has also been considered within the high-level assessment (without technical modelling) presented in Section 7.7.5 of this report, due to the possibility of the airport becoming operational again in the near future.

The locations of these airfields are shown in Figure 11~~Figure 11Figure 11~~ on the following page, where the orange polygon represents 5km from the Scheme, and the white polygon represents 10km from the Scheme.

[20] Source: Approximated from aerial imagery

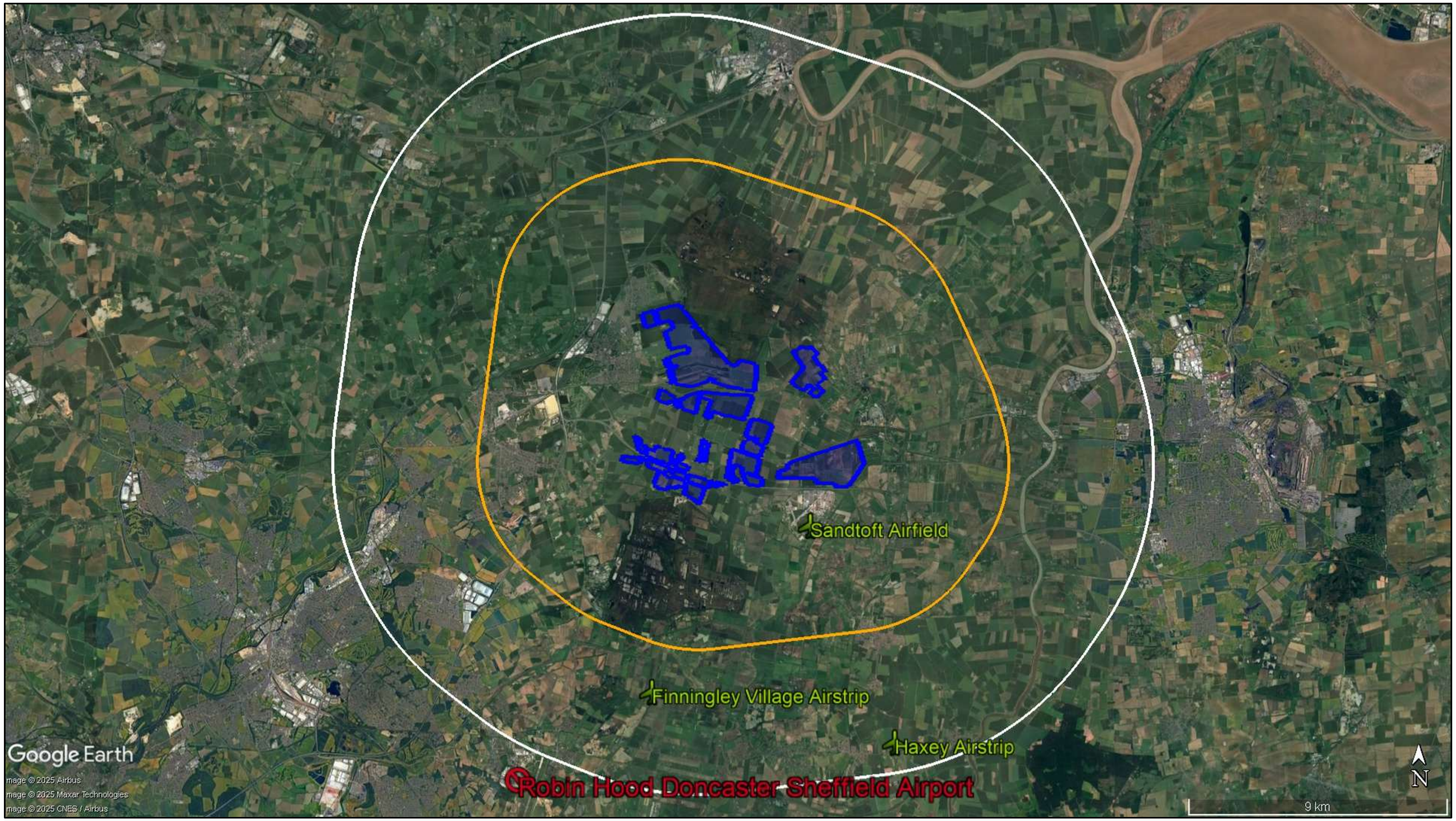

Figure 11 *Locations of aerodromes considered for assessment*

6.2 Sandtoft Airfield Receptors Identification

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

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. Figure 12~~Figure 12Figure 12~~ on the following page illustrates the receptors for the 1-mile splayed approaches.

It is understood that aircraft fly at Sandtoft Airfield in a published circuit pattern to the north-west of the runway. The circuits have been assessed with the following characteristics that have been extrapolated from the information available[21]:

- A descent angle of 4 degrees;
- Circuit resolution of 0.1 nautical miles (distance between assessed points);
- Circuit width of approximately 1.2 nautical miles;
- Maximum altitude of 1000 feet above ground level.

The assessed circuit receptors are shown in Figure *13*~~Figure 13Figure *13*~~ on page 49~~4843~~.

The runway threshold details used can be found in Appendix G.

[21] Pooley's Flight Guide 2025 and SkyDemon Software

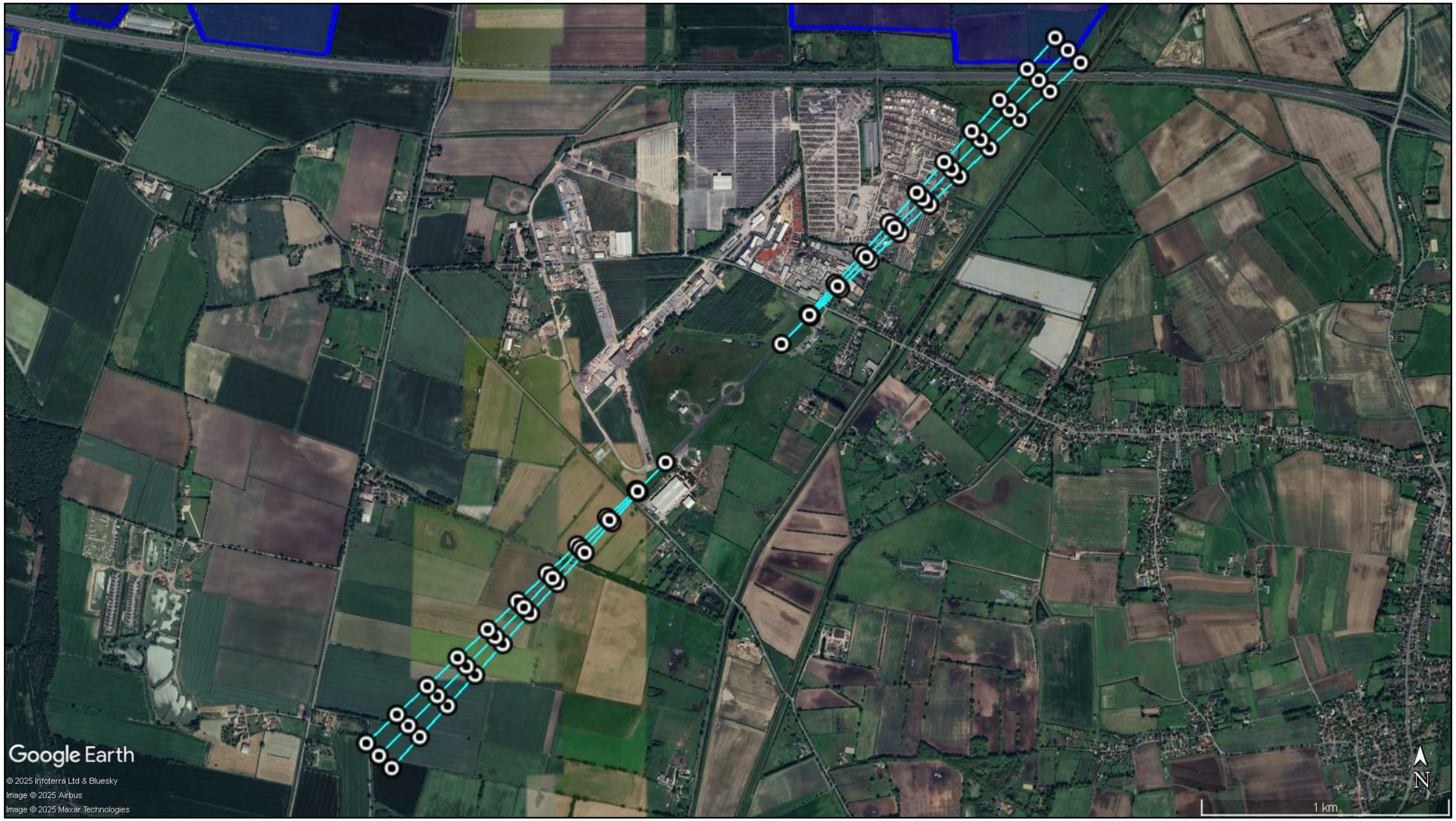

Figure 12 *1-mile splayed approach paths (blue lines) and assessed receptors (white/black icons) at Sandtoft Airfield – aerial image*

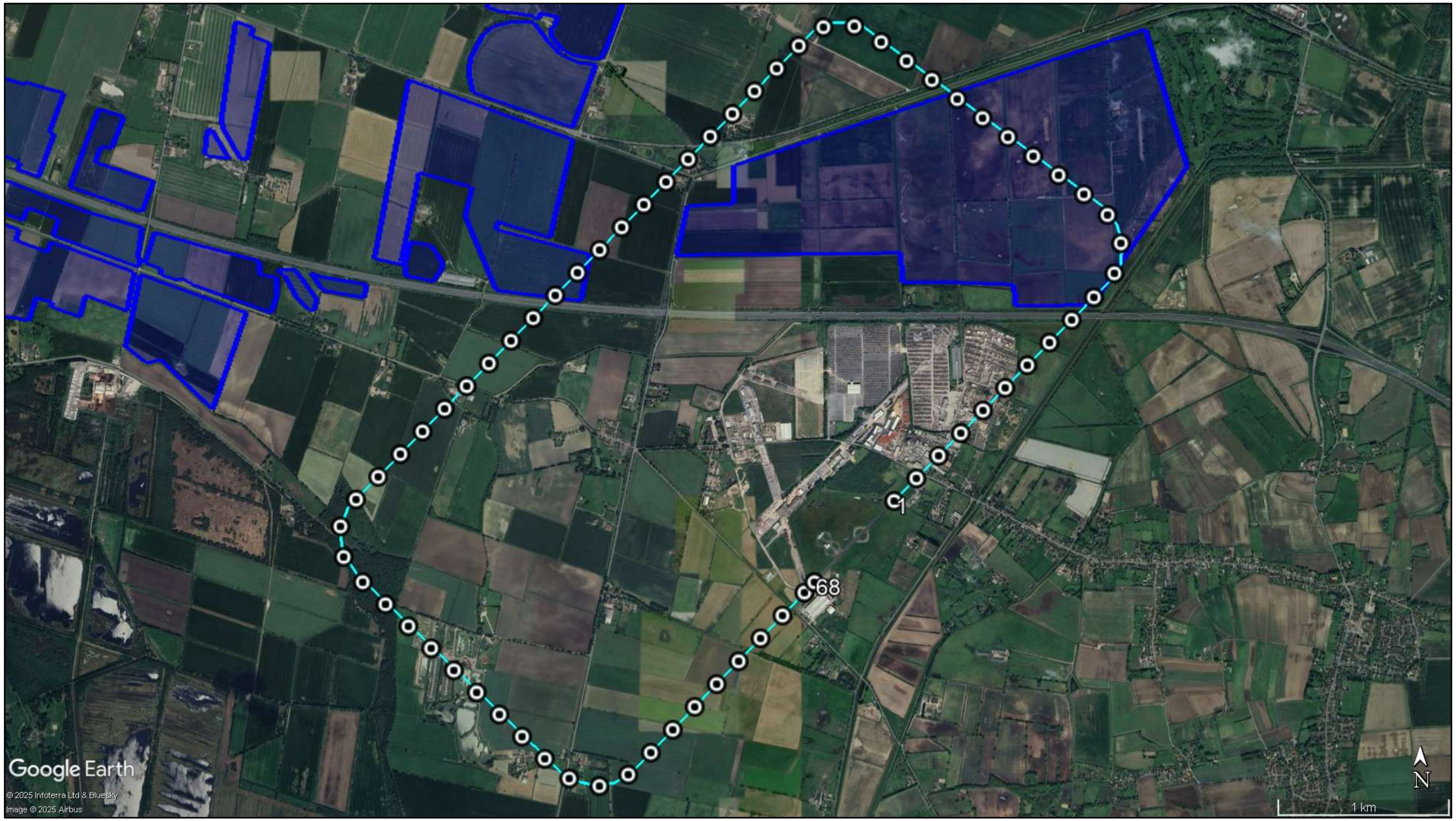

Figure 13 *Runway 05LH/23RH 1000ft visual circuit (blue lines) and assessed receptors (black/white icons) at Sandtoft Airfield – aerial image*

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 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.

7.2 Roads

7.2.1 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, an 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 do not remain significant, the impact significance is low, and mitigation is not recommended.

If following consideration of the relevant factors, the solar reflections 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.

7.2.2 Geometric Modelling Results

The modelling results for road receptors are analysed in Table 3~~Table 3Table 3~~ on the following pages. Blue text is used for receptors where a low impact is predicted. Purple text is used for receptors where a moderate impact is predicted.

The results charts for receptors where an impact is predicted are shown in Appendix I. Appendix J shows a selection of images detailing the significant screening for the assessed receptors.

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A1 – A5	Solar reflections are not geometrically possible	N/A	N/A	N/A	**No impact**	No
A6 – A7	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Terrain screening Views of reflecting panels are not expected to be possible in practice	N/A	N/A	**No impact**	No

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

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A8 – A11	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Intermittent vegetation screening Limited views of some reflecting panels expected to be possible Proposed hedgerow planting expected to screen panels once sufficiently matured	Yes	Reflecting panels are at least 300m away Solar reflection doesn't originate from directly in front of a road user (at least 40 degrees to the left of a road user's direction of travel)	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A12 – A14	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	No significant screening identified Views of reflecting panels expected to be possible Proposed hedgerow planting expected to screen panels once sufficiently matured	Yes	Solar reflection doesn't originate from directly in front of a road user (at least 30 degrees to the left of a road user's direction of travel)	**Baseline: Moderate impact** **With proposed landscape screening: No impact**	No
A15 – A16	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Vegetation screening Views of reflecting panels are not expected to be possible in practice	N/A	N/A	**No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A17	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Terrain and vegetation screening Views of reflecting panels are not expected to be possible in practice	N/A	N/A	**No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A18 – A19	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Terrain and vegetation screening Limited views of some reflecting panels, particularly for elevated road users (e.g. HGV drivers), expected to be possible Proposed hedgerow planting expected to screen panels once sufficiently matured	Yes	Solar reflection doesn't originate from directly in front of a road user (at least 25 degrees to the left of a road user's direction of travel)	**Baseline: Moderate impact** **With proposed landscape screening: No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A20 – A34	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Intermittent vegetation screening Views of some reflecting panels expected to be possible Proposed hedgerow planting expected to screen panels from all road users once sufficiently matured	Yes	Solar reflections occur within 2 hours of sunrise/sunset	**Baseline: Moderate impact** **With proposed landscape screening: No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A35 – A39	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Intermittent vegetation screening Views of some reflecting panels expected to be possible Proposed hedgerow planting expected to screen panels from all road users once sufficiently matured	Yes	Reflecting panels are at least 500m away Solar reflections occur within 2 hours of sunset	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A40 – A53	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Terrain, buildings, and/or vegetation screening Views of reflecting panels are not expected to be possible in practice	No	N/A	**No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A54– A62	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Intermittent vegetation screening Views of some reflecting panels expected to be possible Proposed hedgerow planting expected to screen panels from all road users once sufficiently matured	Yes	Solar reflections occur within 2 hours of sunrise/sunset Solar reflection doesn't originate from directly in front of a road user	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A63 – A81	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Terrain, buildings, and/or vegetation screening Views of reflecting panels are not expected to be possible in practice	No	N/A	**No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A82– A91	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Intermittent vegetation screening Views of some reflecting panels expected to be possible Proposed hedgerow planting expected to screen panels from all road users once sufficiently matured	Yes	Solar reflections occur within 2 hours of sunrise/sunset Solar reflection doesn't originate from directly in front of a road user	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A92 – A101	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Existing vegetation screening Views of reflecting panels are not expected to be possible in practice for most road users Views of some reflecting panels for elevated road users (e.g. HGV drivers) expected to be possible Proposed hedgerow planting expected to screen panels from all road users once sufficiently matured	Yes (for elevated road users only)	Solar reflections occur within 2 hours of sunset Solar reflection doesn't originate from directly in front of a road user	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
B1 – B7	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Terrain, buildings, and/or vegetation screening Views of reflecting panels are not expected to be possible in practice	No	N/A	**No impact**	No
B8 – B12	Solar reflections predicted to originate from **outside** of a road user's primary horizontal field of view	Terrain, buildings, and/or vegetation screening Views of reflecting panels are not expected to be possible in practice	No	N/A	**No impact**	No
B13 – B18	Solar reflections are not geometrically possible	N/A	N/A	N/A	**No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
C1 – C5	Solar reflections are not geometrically possible	N/A	N/A	N/A	**No impact**	No
D1 – D11	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Terrain and vegetation screening Views of reflecting panels are not expected to be possible in practice	No	N/A	**No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
D12 – D25	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Intermittent vegetation screening Limited views of some reflecting panels expected to be possible Proposed hedgerow planting expected to screen panels once sufficiently matured	Yes	Reflecting panels are at least 1km away	**Baseline: Low impact** **With proposed landscape screening: No impact**	No
D26 – D35	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Terrain and vegetation screening Views of reflecting panels are not expected to be possible in practice	No	N/A	**No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
D36 – D37	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Terrain and vegetation screening Views of reflecting panels for road users travelling south-east are not expected to be possible in practice Views of reflecting panels for road users travelling north-west expected to be possible Proposed hedgerow planting expected to screen panels once sufficiently matured	Yes	Visible solar reflections occur within 1.5 hour of sunset and from 10 degrees to the left of a road user's direction of travel (not directly in front)	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
D38 – D47	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Terrain and vegetation screening Views of reflecting panels are not expected to be possible in practice	No	N/A	**No impact**	No
D48 – D53	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Terrain and vegetation screening Limited views of reflecting panels expected to be possible Proposed hedgerow planting expected to screen panels once sufficiently matured	Yes	Visible solar reflections occur within 2 hours of sunrise and sunset Visible solar reflections are not directly in front of a road user	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
D54 – D55	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view travelling both ways	Terrain and vegetation screening Limited views of some reflecting panels for road users travelling north-west expected to be possible Proposed hedgerow planting expected to screen panels once sufficiently matured	Yes	Solar reflections occur within 2 hours of sunset	**Baseline: Moderate impact** **With proposed landscape screening: No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
D56 – D101	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Terrain and vegetation screening Views of reflecting panels are not expected to be possible in practice	No	N/A	**No impact**	No
E1 – E3	Solar reflections predicted to originate from **outside** of a road user's primary horizontal field of view	Terrain and vegetation screening Views of reflecting panels are not expected to be possible in practice	No	N/A	**No impact**	No

Road Receptors	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)[22]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
E4 – E8	Solar reflections predicted to originate from **inside** of a road user's primary horizontal field of view	Terrain and vegetation screening Views of reflecting panels are not expected to be possible in practice	No	N/A	**No impact**	No
E9 – 15	Solar reflections predicted to originate from **outside** of a road user's primary horizontal field of view	Terrain and vegetation screening Views of reflecting panels are not expected to be possible in practice	No	N/A	**No impact**	No
E16 – E17	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 – road receptors*

7.3 Dwellings

7.3.1 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:
  - 3 months per year;
  - 60 minutes on any given day.

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

Where 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 mitigating 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 do not remain significant, the impact significance is low, and mitigation is not recommended. If following consideration of the relevant factors, the solar reflections 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.

7.3.2 Geometric Modelling Results

The modelling results[23] for dwelling receptors are analysed in Table 4~~Table 4Table 4~~ on the following pages. Blue text is used for receptors where a low impact is predicted. Purple text is used for receptors where a moderate impact is predicted.

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

The results charts for receptors where an impact is predicted are shown in Appendix I. Appendix J shows a selection of images detailing the significant screening for the assessed receptors.

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
1 – 4	Solar reflections are not geometrically possible	N/A	N/A	N/A	**No impact**	No
5 – 19	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one 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

[24] With respect to the ground floor only

[25] 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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
20 – 23	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Existing vegetation, buildings, and terrain screening predicted to significantly obstruct views of reflecting panels such that views are not possible in practice from the ground floor Views from upper floors may be possible	None	N/A	**Low impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
24 – 25	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Some existing buildings and vegetation screening Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **More** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	N/A	**Baseline: Moderate impact** **With proposed landscape screening: No impact**	No
26 – 33	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one 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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
34 – 54	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one 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
55 – 72	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	Some intervening buildings and vegetation Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: More than three months per year Less than 60 minutes per any one day With proposed landscape screening: None	Reflecting panels are at least 400m away Reflections are predicted within 2 hours of sunrise	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
73 – 74	Solar reflections are geometrically possible for: Less than three months per year Less than 60 minutes per any one day	Some intervening buildings and vegetation Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: Less than three months per year Less than 60 minutes per any one day With proposed landscape screening: None	N/A	Baseline: Low impact With proposed landscape screening: No impact	No
75 – 80	Solar reflections are geometrically possible for: Less than three months per year Less than 60 minutes per any one 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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
81 – 82	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No
83	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	Existing vegetation, buildings, and terrain screening predicted to significantly obstruct views of reflecting panels to the east such that views are not possible in practice Views of reflecting panels to the north-west are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: More than three months per year Less than 60 minutes per any one day With proposed landscape screening: None	Reflecting panels are at least 275m away Reflections are predicted within 2 hours of sunset	Baseline: Low impact With proposed landscape screening: No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
84	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Existing vegetation, buildings, and terrain screening predicted to significantly obstruct views of reflecting panels to the north-west such that views are not possible in practice Views of reflecting panels to the east are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **More** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	Reflecting panels are at least 350m away Reflections are predicted within 2 hours of sunset	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
85	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	Some intervening buildings Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: More than three months per year Less than 60 minutes per any one day With proposed landscape screening: None	Reflecting panels are at least 550m away Reflections are predicted within 2 hours of sunrise	Baseline: Low impact With proposed landscape screening: No impact	No
86 – 90	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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
91 – 100	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one 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
101	Solar reflections are not geometrically possible	N/A	N/A	N/A	**No impact**	No
102	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one 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
103 – 112	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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
113	Solar reflections are geometrically possible for: Less than three months per year Less than 60 minutes per any one 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
114 – 136	Solar reflections are not geometrically possible	N/A	N/A	N/A	**No impact**	No
137 – 142	Solar reflections are geometrically possible for: Less than three months per year Less than 60 minutes per any one 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
143 – 147	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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
148 – 149	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one 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
150	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	No significant existing screening identified Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: More than three months per year Less than 60 minutes per any one day With proposed landscape screening: None	Reflecting panels are at least 850m away Reflections are predicted within 2 hours of sunrise	Baseline: Low impact With proposed landscape screening: No impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
151	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one 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
152 – 154	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	Some existing buildings and vegetation screening Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: More than three months per year Less than 60 minutes per any one day With proposed landscape screening: **None**	Reflecting panels are at least 300m away Reflections are predicted within 2 hours of sunrise	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
155	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Existing vegetation, buildings, and terrain screening predicted to significantly obstruct views of reflecting panels such that views are not possible in practice from the ground floor Views from upper floors may be possible	None	N/A	**Low impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
156	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	No significant existing screening identified Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **More** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	Reflecting panels are at least 400m away Reflections are predicted within 2 hours of sunrise	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
157 – 158	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Some existing buildings and vegetation screening Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **More** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	Reflecting panels are at least 350m away Reflections are predicted within 2 hours of sunrise	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
159 – 168	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Existing vegetation, buildings, and terrain screening predicted to significantly obstruct views of reflecting panels such that views are not possible in practice from the ground floor Views from upper floors may be possible	None	N/A	**Low impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
169	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	No significant existing screening identified Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently mature	Baseline: **More** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	N/A	**Baseline: Moderate impact** **With proposed landscape screening: No impact**	No
170	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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
171 – 172	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one 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
173 – 174	Solar reflections are not geometrically possible	N/A	N/A	N/A	**No impact**	No
175	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one 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
176	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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
177 – 183	Solar reflections are geometrically possible for: Less than three months per year Less than 60 minutes per any one day	Some intervening vegetation Views of reflecting panels cannot be ruled out under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: Less than three months per year Less than 60 minutes per any one day With proposed landscape screening: **None**	N/A	**Baseline: Low impact** **With proposed landscape screening: No impact**	No
184 – 189	Solar reflections are geometrically possible for: Less than three months per year Less than 60 minutes per any one 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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
190 – 193	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one day	Some intervening vegetation Views of reflecting panels cannot be ruled out under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **Less** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	N/A	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
194	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Some intervening vegetation Views of reflecting panels cannot be ruled out under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **More** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	Reflecting panels are at least 900m away Reflections are predicted within 2 hours of sunrise	**Baseline: Low impact** **With proposed landscape screening: No impact**	No
195 – 198	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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
199 – 201	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	Some intervening vegetation Views of reflecting panels cannot be ruled out under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: More than three months per year Less than 60 minutes per any one day With proposed landscape screening: None	N/A	Baseline: Moderate impact With proposed landscape screening: No impact	No
202	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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
203 – 205	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one 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
206	Solar reflections are not geometrically possible	N/A	N/A	N/A	**No impact**	No
207 – 209	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one 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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
210 – 213	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one 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
214 – 215	Solar reflections are not geometrically possible	N/A	N/A	N/A	**No impact**	No
216 – 221	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one 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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
222	Solar reflections are geometrically possible for: Less than three months per year Less than 60 minutes per any one 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
223 – 245	Solar reflections are not geometrically possible	N/A	N/A	N/A	No impact	No
246	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one 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
247	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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
248	Solar reflections are geometrically possible for: Less than three months per year Less than 60 minutes per any one day	Existing vegetation screening predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	None	N/A	**No impact**	No
249 – 257	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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
258	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Intermittent vegetation screening Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **Less** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	N/A	**Low impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
259	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Existing vegetation screening predicted to significantly obstruct views of reflecting panels to the west such that views are not possible in practice Some intervening vegetation to the east, however, views of reflecting panels cannot be ruled out under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **More** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	Closest reflecting panels are at least 300m away Reflections are predicted within 2 hours of sunrise	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
260 – 262	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	Existing vegetation screening predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	None	N/A	**No impact**	No
263	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	Existing vegetation, buildings, and terrain screening predicted to significantly obstruct views of reflecting panels such that views are not possible in practice from the ground floor Views from upper floors may be possible	None	N/A	**Low impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
264	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one 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
265	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	Intermittent vegetation screening Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: Less than three months per year Less than 60 minutes per any one day With proposed landscape screening: **None**	N/A	**Low impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
266 – 267	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one 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
268	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	Some intervening vegetation Views of reflecting panels cannot be ruled out under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: More than three months per year Less than 60 minutes per any one day With proposed landscape screening: None	N/A	**Baseline: Moderate impact** **With proposed landscape screening: No impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
269	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Intermittent vegetation screening Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **Less** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	N/A	**Low impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
270 – 271	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	Intermittent vegetation screening Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: More than three months per year Less than 60 minutes per any one day With proposed landscape screening: None	No ground floor windows facing the reflecting area Reflections are predicted within 2 hours of sunset	Low impact	No
272 – 274	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one 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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
275 – 276	Solar reflections are geometrically possible for: Less than three months per year Less than 60 minutes per any one day	Intermittent vegetation screening Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: Less than three months per year Less than 60 minutes per any one day With proposed landscape screening: None	N/A	Low impact	No
277	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one 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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
278 – 279	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Some intervening vegetation Views of reflecting panels expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **More** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	Reflecting panels are at least 700m away Reflections are predicted within 2 hours of sunset	**Baseline: Low impact** **With proposed landscape screening: No impact**	No
280	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one day	Existing vegetation, buildings, and/or 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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
281 – 283	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	Some intervening vegetation Views of reflecting panels expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: More than three months per year Less than 60 minutes per any one day With proposed landscape screening: None	Reflecting panels are at least 300m away Reflections are predicted within 2 hours of sunrise	Baseline: Low impact With proposed landscape screening: No impact	No
284 – 287	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	Existing vegetation, buildings, and/or 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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
288 – 289	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Existing vegetation, buildings, and/or terrain screening predicted to significantly obstruct views of reflecting panels such that views are not possible in practice from the ground floor Views from upper floors may be possible	None	N/A	**Low impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
290 – 291	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Some intervening vegetation Views of reflecting panels cannot be ruled out under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **More** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	Reflecting panels are at least 300m away Reflections are predicted within 2 hours of sunrise/sunset	**Baseline: Low impact** **With proposed landscape screening: No impact**	No
292 – 296	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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
297 – 303	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one day	No significant existing screening identified Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **Less** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	N/A	**Low impact**	No
304 – 308	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one day	Existing vegetation, buildings, and/or 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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
309 – 320	Solar reflections are not geometrically possible	N/A	N/A	N/A	**No impact**	No
321	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one day	Existing vegetation, buildings, and/or terrain screening predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	**No impact**	No
322	Solar reflections are not geometrically possible	N/A	N/A	N/A	**No impact**	No
323 – 327	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one day	Existing vegetation, buildings, and/or 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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
328 – 338	Solar reflections are geometrically possible for: **Less** than three months per year **Less** than 60 minutes per any one day	Some intervening buildings and vegetation Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **Less** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	N/A	**Low impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
339 – 361	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Some intervening buildings and vegetation Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **More** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	Reflecting panels are at least 700m away Reflections are predicted within 2 hours of sunset	**Low impact**	No
362 – 363	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one 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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
364 – 383	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Some intervening buildings and vegetation Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **More** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	Reflecting panels are at least 500m away Reflections are predicted within 2 hours of sunset	**Low impact**	No
384 – 394	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)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
395 – 401	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one 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
402 – 403	Solar reflections are geometrically possible for: More than three months per year Less than 60 minutes per any one day	No significant existing screening identified Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: More than three months per year Less than 60 minutes per any one day With proposed landscape screening: None	Reflecting panels are at least 500m away Reflections are predicted within 2 hours of sunset	Low impact	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
404	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	Existing vegetation, buildings, and/or terrain screening predicted to significantly obstruct views of reflecting panels such that views are not possible in practice from the ground floor Views from upper floors may be possible	None	N/A	**Low impact**	No

Dwelling Receptor	Geometric modelling results from panel areas within 1km (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Duration of effects[24] (with consideration of screening)[25]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended?
405	Solar reflections are geometrically possible for: **More** than three months per year **Less** than 60 minutes per any one day	No significant existing screening identified Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels from the ground floor once sufficiently matured	Baseline: **More** than three months per year **Less** than 60 minutes per any one day With proposed landscape screening: **None**	Reflecting panels are at least 400m away Reflections are predicted within 2 hours of sunset	**Low impact**	No

Table 4 *Geometric modelling results, assessment of impact significance, and mitigation recommendation/requirement – dwelling receptors*

7.4 Railway Signals

7.4.1 Impact Significance Methodology

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

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

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

Where reflections originate from outside 90 degrees either side of the direction of the signal or where the separation distance to the nearest visible reflecting panel is over 500m, the impact significance is low, and mitigation is not recommended.

Where reflections are predicted to reach the signal from within 90 degrees either side of the direction of the signal, expert assessment of the following relevant factors is required to determine the impact significance:

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

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

Where reflections originate from directly in front of an incandescent signal and there are no mitigating factors, the impact significance is high, and mitigation is required.

7.4.2 Geometric Modelling Results

The modelling has shown that solar reflections are geometrically possible towards nine of the ten assessed railway signals. Table 5~~Table 5Table 5~~ below summarises the predicted impact at each signal receptor. Blue text is used for receptors where a low impact is predicted. The results charts for receptors where an impact is predicted are shown in Appendix I. Appendix J shows a selection of images detailing the significant screening for the assessed receptors.

Railway Signal	Geometric modelling results (without consideration of screening)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification (Without Vegetation Screening)	Impact Classification (With Existing Vegetation Screening)	Impact Classification (With Proposed Vegetation Screening)
S1	Solar reflections are geometrically possible and originate from **inside** 90 degrees either side of the direction of the signal	Trackside deciduous vegetation screening will filter reflections from solar panels towards the signal Proposed vegetation planting expected to screen reflecting panels from the signal once sufficiently matured	Railway signal appears to be LED and has a hood fitted	**Low impact**	**Low impact**	**No impact**

Railway Signal	Geometric modelling results (without consideration of screening)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification (<u>Without</u> Vegetation Screening)	Impact Classification (<u>With</u> Existing Vegetation Screening)	Impact Classification (<u>With</u> Proposed Vegetation Screening)
S2	Solar reflections are geometrically possible and originate from **<u>inside</u>** 90 degrees either side of the direction of the signal	No significant existing screening Proposed vegetation planting expected to screen reflecting panels from the signal once sufficiently matured	Railway signal appears to be LED and has a hood fitted Reflecting panels within 90 degrees either side of the direction of the signal are at least 500m away from the signal	**<u>Low impact</u>**	**<u>Low impact</u>**	**<u>No impact</u>**
S3	Solar reflections are geometrically possible and originate from **<u>inside</u>** 90 degrees either side of the direction of the signal	No significant existing screening Proposed vegetation planting expected to screen reflecting panels from the signal once sufficiently matured	Railway signal appears to be LED and has a hood fitted Solar reflection doesn't originate from directly in front of the signal	**<u>Low impact</u>**	**<u>Low impact</u>**	**<u>No impact</u>**

Railway Signal	Geometric modelling results (without consideration of screening)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification (Without Vegetation Screening)	Impact Classification (With Existing Vegetation Screening)	Impact Classification (With Proposed Vegetation Screening)
S4	Solar reflections are geometrically possible and originate from **outside** 90 degrees either side of the direction of the signal	Significant existing vegetation screening expected to screen reflecting panels from the signal	N/A	**Low impact**	**No impact**	**No impact**
S5	Solar reflections are not geometrically possible	N/A	N/A	**No impact**	**No impact**	**No impact**
S6	Solar reflections are geometrically possible and originate from **inside** 90 degrees either side of the direction of the signal	Significant existing vegetation screening expected to screen reflecting panels from the signal	Railway signal appears to be LED and has a hood fitted Solar reflection doesn't originate from directly in front of the signal	**Low impact**	**No impact**	**No impact**

Railway Signal	Geometric modelling results (without consideration of screening)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification (Without Vegetation Screening)	Impact Classification (With Existing Vegetation Screening)	Impact Classification (With Proposed Vegetation Screening)
S7	Solar reflections are geometrically possible and originate from **outside** 90 degrees either side of the direction of the signal	Significant existing vegetation screening expected to screen reflecting panels from the signal	N/A	**Low impact**	**No impact**	**No impact**
S8	Solar reflections are geometrically possible and originate from **inside** 90 degrees either side of the direction of the signal	Significant existing vegetation screening expected to screen reflecting panels from the signal	Railway signal appears to be LED and has a hood fitted	**Low impact**	**No impact**	**No impact**

Railway Signal	Geometric modelling results (without consideration of screening)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification (<u>Without</u> Vegetation Screening)	Impact Classification (<u>With</u> Existing Vegetation Screening)	Impact Classification (<u>With</u> Proposed Vegetation Screening)
S9	Solar reflections are geometrically possible and originate from **<u>inside</u>** 90 degrees either side of the direction of the signal	No significant existing screening Proposed vegetation planting expected to screen reflecting panels from the signal once sufficiently matured	Railway signal appears to be LED and has a hood fitted Solar reflection doesn't originate from directly in front of the signal Reflecting panels within 90 degrees either side of the direction of the signal are at least 500m away from the signal	**<u>Low impact</u>**	**<u>Low impact</u>**	**<u>No impact</u>**

Railway Signal	Geometric modelling results (without consideration of screening)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification (Without Vegetation Screening)	Impact Classification (With Existing Vegetation Screening)	Impact Classification (With Proposed Vegetation Screening)
S10	Solar reflections are geometrically possible and originate from **inside** 90 degrees either side of the direction of the signal	Significant existing vegetation screening expected to screen reflecting panels from the signal	Railway signal appears to be LED and has a hood fitted Solar reflection doesn't originate from directly in front of the signal	**Low impact**	**No impact**	**No impact**

Table 5 *Geometric modelling results, assessment of impact significance, and mitigation recommendation/requirement – railway signals*

7.5 Train Drivers

7.5.1 Impact Significance Methodology

The process for quantifying the impact significance concerning railway safety is outlined in Appendix D. The key considerations for quantifying impact significance for train driver receptors are:

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

Where reflections are geometrically possible but expected to be screened, no impact is predicted, and mitigation is not required. Where reflections originate from outside of a train driver's primary horizontal field-of-view (30 degrees either side of the direction of travel), or the closest reflecting surface is over 500m from the railway user, the impact significance is low, and mitigation is not recommended.

Where reflections are predicted to be experienced from inside of a train driver's primary field-of-view, expert assessment of the following relevant factors is required to determine the impact significance and mitigation requirement:

- Whether the solar reflection originates from directly in front of a train driver. Solar reflections that are directly in front of a train driver are more hazardous;
- The separation distance to the reflecting surface. Larger separation distances reduce the proportion of an observer's field of view that is affected by glare;
- The position of the Sun. Effects that coincide with direct sunlight appear less prominent than those that do not. The Sun is a far more significant source of light;
- Whether a signal, station, level crossing, or switching point is located within the reflection zone. These are considered as a factor when assessing the complexity of the affected railway. It is considered that drivers are more likely to be distracted where the track is complex, and their attention could be drawn away from important operations to safely drive the train.

Following consideration of these relevant factors, where the solar reflection is not deemed significant, a low impact is predicted, and mitigation is not recommended. Where the solar reflection is deemed significant, the impact significance is moderate, and mitigation is recommended. Where reflections originate from directly in front of a train driver and there are no further mitigating factors, the impact significance is high, and mitigation is required.

7.5.2 Geometric Modelling Results

The results and analysis are presented in Table 6~~Table 6Table 6~~ on the following pages. Blue text is used for receptors where a low impact is predicted.

The results charts for receptors where an impact is predicted are shown in Appendix I. Appendix J shows a selection of images detailing the significant screening for the assessed receptors.

Train Driver Receptor(s)	Geometric modelling results (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a train driver's primary FOV (with consideration of screening)[26]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A1 – A7	Solar reflections are geometrically possible from **inside** of a train driver's primary horizontal field of view	Existing vegetation, buildings, and terrain screening predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	No	N/A	**No impact**	No

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

Train Driver Receptor(s)	Geometric modelling results (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a train driver's primary FOV (with consideration of screening)[26]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A8 – A31	Solar reflections are geometrically possible from **inside** of a train driver's primary horizontal field of view	Intermittent vegetation screening Some views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels once sufficiently matured	Baseline: Yes With proposed landscape screening: No	Reflections occur within 2 hours of sunrise No signal, station, level crossing, or switching point is located within the reflection zone	**Baseline: Low impact** **With proposed landscape screening: No impact**	No
A32 – A40	Solar reflections are geometrically possible from **inside** of a train driver's primary horizontal field of view	Existing vegetation, buildings, and terrain screening predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	No	N/A	**No impact**	No

Train Driver Receptor(s)	Geometric modelling results (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a train driver's primary FOV (with consideration of screening)[26]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A41	Solar reflections are geometrically possible from **inside** of a train driver's primary horizontal field of view	Intermittent vegetation screening Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels once sufficiently matured	Baseline: Yes With proposed landscape screening: No	Reflecting panels are at least 300m away Reflections occur within 2 hours of sunset No signal, station, level crossing, or switching point is located within the reflection zone	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Train Driver Receptor(s)	Geometric modelling results (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a train driver's primary FOV (with consideration of screening)[26]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
A42 - A44	Solar reflections are geometrically possible from **inside** of a train driver's primary horizontal field of view	Intermittent vegetation screening Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels once sufficiently matured	Baseline: Yes With proposed landscape screening: No	Reflecting panels are at least 400m away Reflections occur within 2 hours of sunset Signal receptor S7 is located within the reflection zone	**Baseline: Low impact** **With proposed landscape screening: No impact**	No
B1 – B7	Solar reflections are geometrically possible from **inside** of a train driver's primary horizontal field of view	Existing vegetation, buildings, and terrain screening predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	No	N/A	**No impact**	No

Train Driver Receptor(s)	Geometric modelling results (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a train driver's primary FOV (with consideration of screening)[26]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
B8 – B10	Solar reflections are geometrically possible from **inside** of a train driver's primary horizontal field of view	Intermittent vegetation screening Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels once sufficiently matured	Baseline: Yes With proposed landscape screening: No	Reflections occur within 2 hours of sunrise No signal, station, level crossing, or switching point is located within the reflection zone	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Train Driver Receptor(s)	Geometric modelling results (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a train driver's primary FOV (with consideration of screening)[26]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
B11 – B12	Solar reflections are geometrically possible from **inside** of a train driver's primary horizontal field of view	Intermittent vegetation screening Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels once sufficiently matured	No	N/A	**Baseline: Low impact** **With proposed landscape screening: No impact**	No

Train Driver Receptor(s)	Geometric modelling results (without consideration of screening)	Identified screening and predicted visibility (desk-based review)	Whether reflections occur inside a train driver's primary FOV (with consideration of screening)[26]	Relevant Factors	Predicted Impact Classification	Further Mitigation Recommended or Required?
B13 - B14	Solar reflections are geometrically possible from **outside** of a train driver's primary horizontal field of view	Intermittent vegetation screening Views of reflecting panels are expected to be possible under baseline conditions Proposed vegetation planting expected to screen panels once sufficiently matured	Baseline: Yes With proposed landscape screening: No	N/A	**Baseline: Low impact** **With proposed landscape screening: No impact**	No
B15 – B20	Solar reflections are not geometrically possible	N/A	N/A	N/A	**No impact**	No

Table 6 *Geometric modelling results, assessment of impact significance, and mitigation recommendation/requirement – train driver receptors*

7.6 Sensitive Viewpoints

The modelling has shown that solar reflections are predicted towards 32 of the sensitive viewpoints (1 and 3-33). The full results are shown in Appendix I. Figure 14~~Figure 14Figure 14~~ below indicates the viewpoints towards which solar reflections are possible.

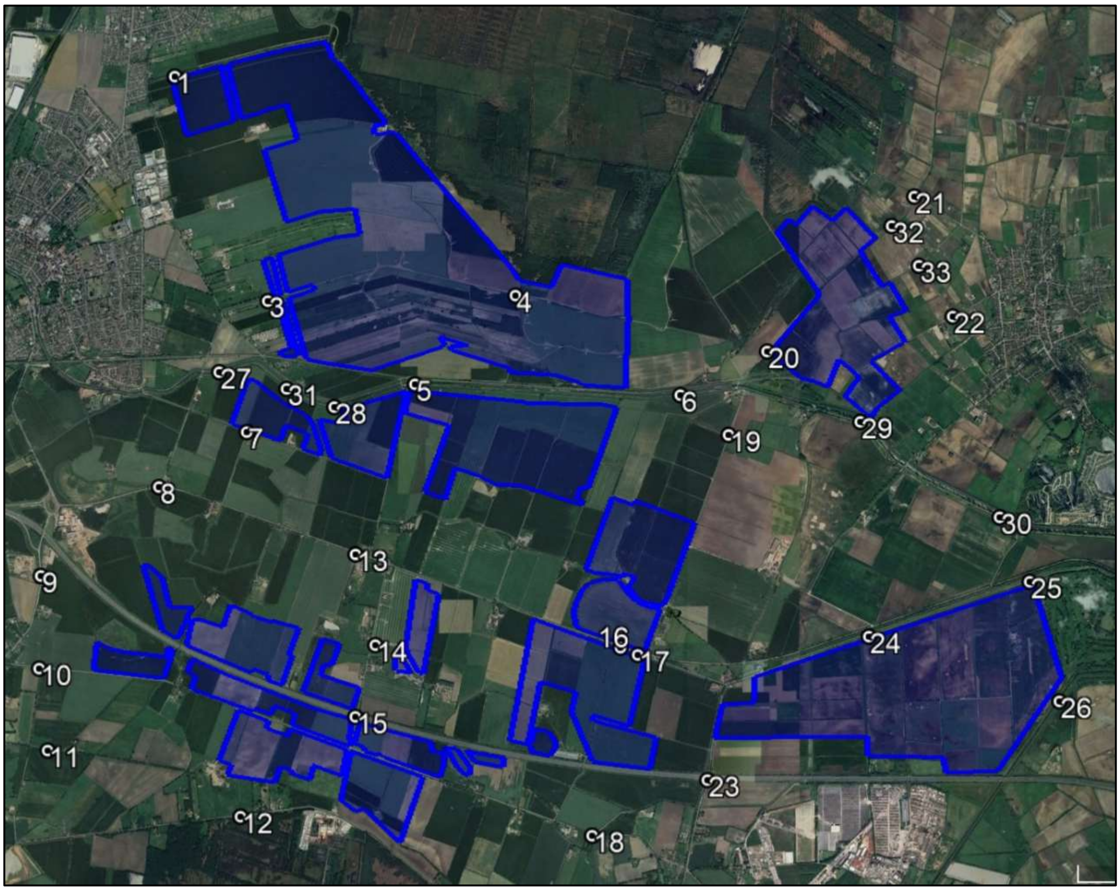

Figure 14 *VPs where solar reflections are geometrically possible – aerial image*

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

- The typical density of pedestrians located at these points is low in a rural environment;
- Any resultant effects are less serious than, for example, solar reflections experienced towards a road network whereby the resultant impacts of a solar reflection can be much more serious. Safety concerns are considered to a greater extent for horse riders and

the possible event of being thrown by a scared animal, however the risk of this occurring due to glare from solar panels is considered to be small[27];

- Glint and glare effects towards an observer are transient, and time and location sensitive whereby a pedestrian could move beyond the solar reflection zone with ease with little impact upon safety or amenity;
- Any observable solar reflection towards an observer would be of similar intensity to those experienced whilst navigating the natural and built environment on a regular basis (e.g. bodies of water), and less intense than reflections from glass and other common outdoor surfaces.

Overall, no significant impact on observers at these viewpoints is predicted and therefore mitigation is not required.

7.7 Aviation – Sandtoft Airfield

7.7.1 Glare Intensity Categorisation

The Pager Power and Forge models have been used to determine whether reflections are possible. Intensity calculations in line with the Sandia National Laboratories methodology have been undertaken for aviation receptors. 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 7~~Table 7Table 7~~ below along with the associated colour coding.

Coding Used	Intensity Key
Glare beyond 50°	'Glare 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 7 *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

[27] This is supported by the 'Advice on Solar Farms' document published by the British Horse Society in April 2024, which states: *"They [standard photovoltaic panels] are designed to absorb rather than reflect light for efficiency (reflected light is wasted energy) and although the amount of reflection varies with the component materials and the angle, the incidence of glare or dazzle is very low compared with glass and will not be uniform throughout a period of sunlight, assuming that the panel is static. Any reflection is unlikely to be a direct problem to horses, riders or carriage-drivers because of the angles and distances involved."*

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.

If significant glare is predicted, modelling of less reflective surfaces could be undertaken.

7.7.2 Impact Significance Methodology – 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 have 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 approach bearing), the impact significance is low, and mitigation is not required.

Glare with 'potential for a temporary after-image' (yellow glare) was formerly not permissible under the interim guidance provided by the Federal Aviation Administration in the USA[28] for on-airfield solar. Whilst this guidance was never formally applicable outside of the USA, it has been a common point of reference internationally. Pager Power recommends a pragmatic approach whereby instances of 'yellow' glare are evaluated in a technical and operational context. As per Pager Power's glint and glare guidance document[29], where solar reflections are of an intensity of

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

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

'potential for temporary after-image', expert assessment of the following relevant factors is required to determine the impact significance[30]:

- The likely traffic volumes and level of safeguarding at the aerodrome – licensed aerodromes typically have higher traffic volumes and are formally safeguarded. Unlicensed aerodromes have greater capacity for operational acceptance;
- 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 the time of day at which glare is predicted;
- 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 a year;
- The location of the source of glare relative to a pilot's primary field-of-view;
- The relative size of the reflecting panel area and whether the reflecting area takes up a large percentage of 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 intensity of the predicted glare;
- 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 relevant factors, where the solar reflection is deemed not 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 Scheme. Where the solar reflection is deemed significant, the impact significance is moderate, and mitigation is recommended.

Where solar reflections have an intensity of 'potential for permanent eye damage', the impact significance is high, and mitigation is required.

7.7.3 Assessment Results

Table 8~~Table 8Table 8~~ on the following pages presents the following:

- Geometric modelling results[31];
- Glare intensity;
- Comment and predicted impact significance.

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[30] 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.

[31] 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	Overview of Modelling Results	Glare Intensity (as per Table 7~~Table 7Table 7~~)	Impact Classification
1-mile splayed approaches to Runway 05	Solar reflections originating from panels outside of a pilot's primary field of view (50 degrees horizontally either side of the direction of travel) are predicted At worst, a low impact is predicted on pilots on these approach paths based on the associated guidance and industry best practice for licensed airfields	Glare outside FOV	Low impact
1-mile splayed approaches to Runway 23	Solar reflections with a maximum intensity of 'low potential for temporary after-image' are predicted, originating from panels within a pilot's primary field of view Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths at licensed aerodromes, which states that this level of glare is acceptable, it can be reliably concluded that this level of glare is also acceptable	Green	Low impact
05LH circuit	Solar reflections with a maximum intensity of 'potential for temporary after-image' originating from panels within a pilot's primary field of view are predicted towards two sections of the 05LH circuit: • A 1.9 nautical mile section covering the crosswind leg and the some of the downwind leg • A 0.5 nautical mile section within the downwind leg	Yellow	Discussed further in Section 7.7.4

Receptor/Runway	Overview of Modelling Results	Glare Intensity (as per Table 7~~Table 7Table 7~~)	Impact Classification
05LH circuit	Solar reflections with a maximum intensity of 'low potential for temporary after-image' originating from panels within a pilot's primary field of view are predicted towards a 0.4 nautical mile section of the downwind leg of the 05LH circuit Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths at licensed aerodromes, which states that this level of glare is acceptable, it can be reliably concluded that this level of glare is also acceptable	Green	Low impact
	Solar reflections originating from panels outside of a pilot's primary field of view are predicted towards three sections of the 05LH circuit: • A 1.1 nautical mile section covering the departure leg • A 0.9 nautical mile section covering some of the downwind leg and base leg • A 0.5 nautical miles section within the approach leg At worst, a low impact is predicted on pilots in these sections of the 05LH circuit based on the associated guidance and industry best practice for licensed airfields	Glare outside FOV	Low impact

Receptor/Runway	Overview of Modelling Results	Glare Intensity (as per Table 7~~Table 7Table 7~~)	Impact Classification
23RH circuit	Solar reflections with a maximum intensity of 'potential for temporary after-image' originating from panels within a pilot's primary field of view are predicted towards two sections of the 23RH circuit: • A 3 nautical mile section covering the downwind leg and some of the base leg • A 0.2 nautical mile section on approach to runway 23	Yellow	Discussed further in Section 7.7.4
	Solar reflections with a maximum intensity of 'low potential for temporary after-image' originating from panels within a pilot's primary field of view are predicted towards a single 0.7 nautical mile section of the approach leg within the 23RH circuit	Green	Low impact
	Solar reflections originating from panels outside of a pilot's primary field of view are predicted towards four sections of the 23RH circuit: • A 0.5 nautical mile section within the departure leg • A 0.5 nautical mile section within the crosswind leg • A 0.5 nautical mile section within the base leg • A 0.1 nautical mile section of the approach leg At worst, a low impact is predicted on pilots in these sections of the 23RH circuit based on the associated guidance and industry best practice for licensed airfields	Glare outside FOV	Low impact

Table 8 *Geometric modelling results and assessment of impact significance – Sandtoft Airfield receptors*

7.7.4 Further Discussion of Yellow Glare

Glare with a maximum intensity of potential for a temporary after-image (yellow glare) within a pilot's primary field-of-view is predicted towards sections of the visual circuits at Sandtoft Airfield. The figures on the following pages show a visualisation of the results. A selection of the modelling results is presented in Appendix I, and the full results charts can be provided on request.

Glare with potential for a temporary after-image was formerly not permissible under the interim guidance provided by the Federal Aviation Administration in the USA for on-airfield solar. This FAA guidance from 2013 has since been superseded by the FAA guidance in 2021 whereby airports are tasked with determining safety requirements themselves. Pager Power generally recommends a pragmatic approach whereby instances of 'yellow' glare are evaluated in a technical and operational context. The following has been considered:

- Sandtoft Airfield is an unlicensed airfield and traffic volume is likely to be relatively low;
- There are no instances of glare that has the potential to cause permanent eye damage and there are no instances of glare that are close to the boundary where such damage would become possible;
- The modelling predicts a maximum of 6,650 minutes of yellow glare per year from any single panel area at any single assessed point in the circuit (receptor 11 on the 23RH circuit) when considering a 50 degrees field-of-view either side of the direction of travel, this is approximately 2.53% of the theoretical maximum daylight per year[32]. The results chart is shown in Figure 15~~Figure 15Figure 15~~ on the following page, and this point is circled red on Figure 17~~Figure 17Figure 17~~ on page 145~~144139~~;
- The modelling shows that the maximum duration of yellow glare on any given day is approximately 100 minutes at any single assessed point when considering a 50 degrees field-of-view either side of the direction of travel;
- The model considers 100% sunlight during daylight hours which is highly conservative; in reality, glare would only be possible in clear skies and sunny conditions;
- Any effects received in reality are likely to be fleeting in nature (noticeable for a few seconds as an aircraft is moving through certain sections of a circuit) based on the direction and speed of the aircraft;
- The modelling considers a worst-case scenario and therefore does not account for the speed at which an aircraft would move through a single circuit, and the small change in the position of the sun during that time;
- Reflections from solar panels are of intensity similar to or less than those produced from bodies of still water and significantly less than reflections from glass and steel[33];

[32] 262,800 minutes

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

- The intensity of the solar glare will be less than that of direct sunlight because the panels are flat and aligned with each other[34] – meaning that only some sunlight is reflected;
- It is understood that the operating hours of the airfield are 09:00 to 17:00 in the Winter, and 09:00 to 18:00 in the Summer[35]. Most of the yellow glare will occur outside of these stated times and therefore any impacts will be limited.

Based on the analysis undertaken, it is considered that this glare could be accommodated without significant changes to the operational activity of the airfield. Some of the measures listed in Section 7.7.5 that pilots may typically use to mitigate the effects of direct sunlight could be used to mitigate the effects of direct solar reflections from the solar panels given the operations at this unlicensed airfield.

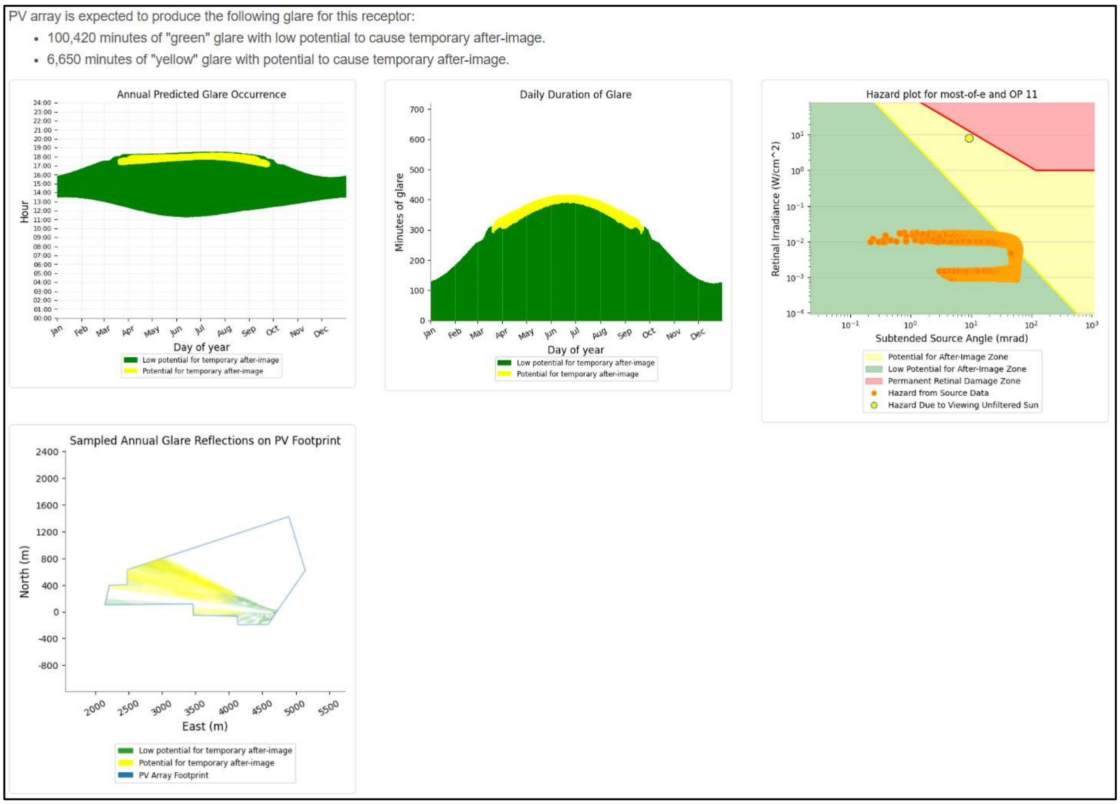

Figure 15 *Yellow glare towards receptor 11 from panels in Areas E4-E18 (ForgeSolar result chart)*

[34] This is significant because it means that there is no potential for the development to focus the sun's rays on one particular location

[35] Source: Pooley's Flight Guide 2025, an common point of reference particularly for unlicensed airfields

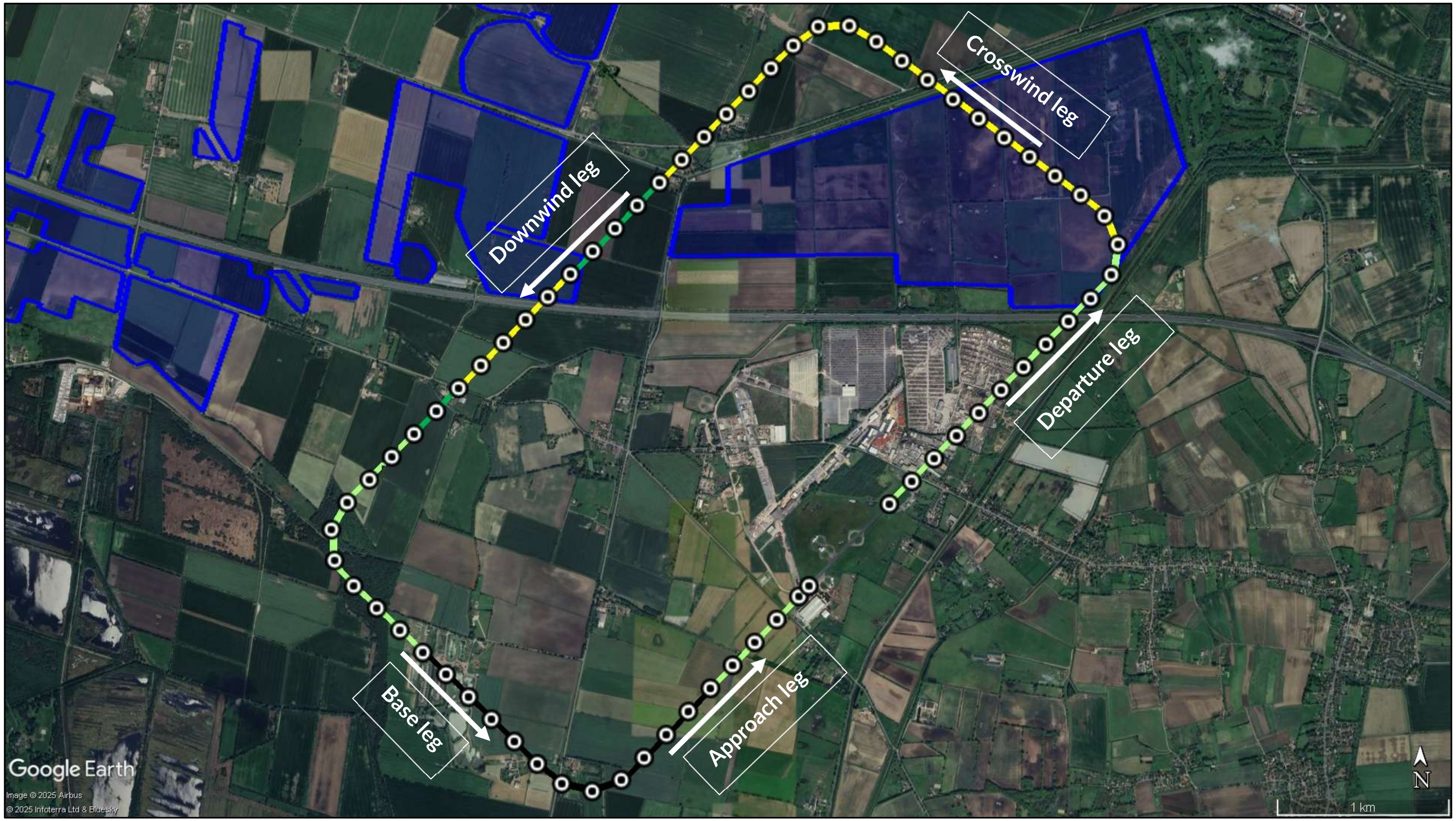

Figure 16 *Visual overview of results for 05LH circuit at Sandtoft Airfield (arrows indicate direction of travel of an aircraft)*

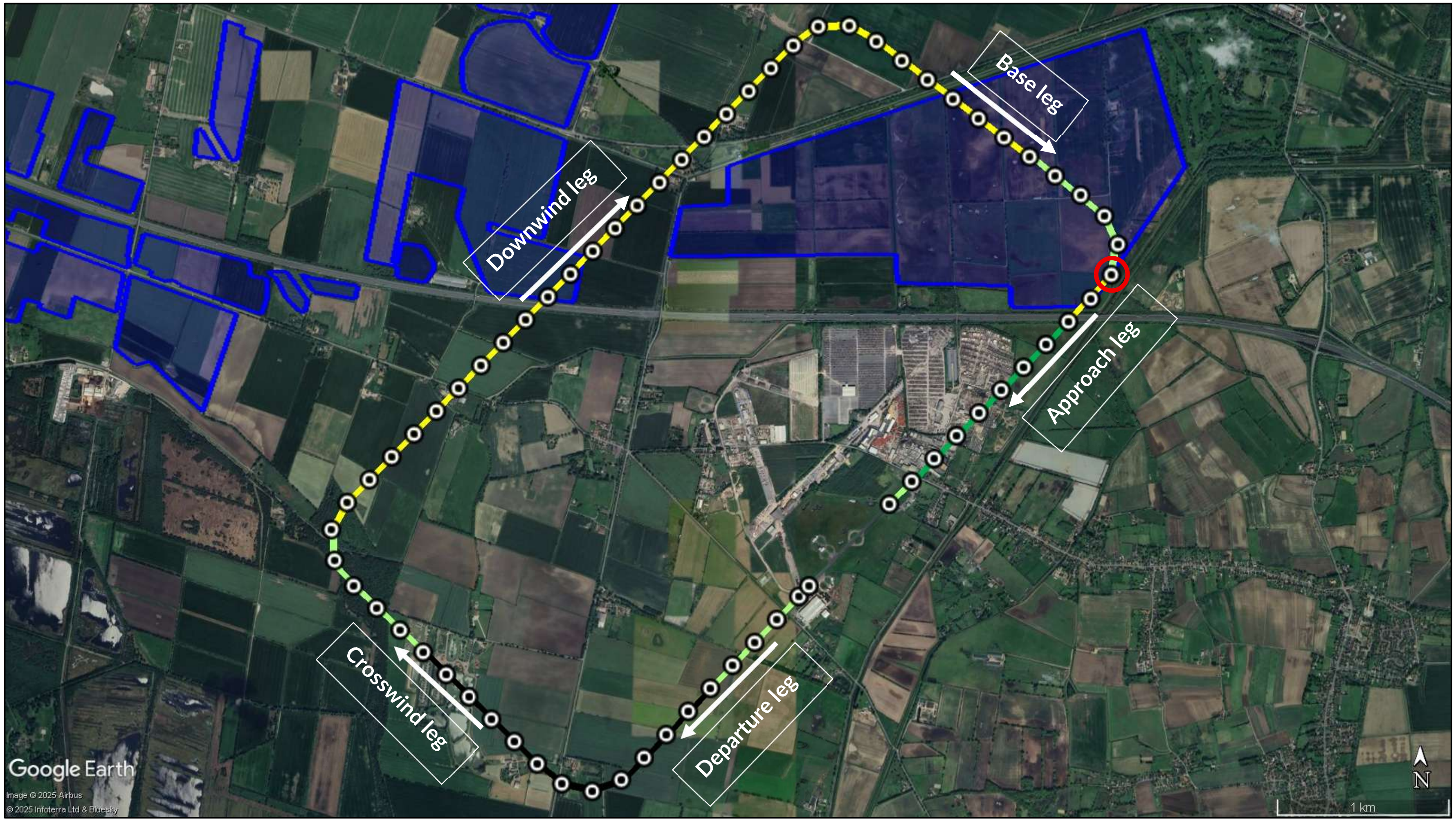

Figure 17 *Visual overview of results for 23RH circuit at Sandtoft Airfield (arrows indicate direction of travel of an aircraft)*

7.7.5 Operational Measures Used to Mitigate Effects of Direct Sunlight

Reflections from the Scheme towards pilots would only be possible in clear, sunny conditions. The sun is a more significant reflector, and the times when solar reflections are possible will be more limited than the times when the sun will be fully visible in the sky. There is therefore a greater risk of pilots being affected by direct sunlight than by solar reflections from the solar panels within the Scheme.

The operational measures pilots use to mitigate the effects of direct sunlight can all be used to mitigate the effects of direct solar reflections from the solar panels given the operations at this unlicensed airfield. These mitigation measures include:

- Wearing sunglasses.
- Using darkened cockpit sun visors to reduce the intensity of the sun.
- Overflying the airfield and inspecting the runway prior to landing.
- Landing in the opposite direction if wind conditions allow.
- Aborting their landing if uncertain that it is to be successful (known as a missed approach or a go-around).

These options may be regularly employed by a pilot in bright sunny conditions. Given that any solar reflection from the solar panels will be many times less intense than direct sunlight, they are deemed appropriate should a solar reflection from the solar development be experienced by a pilot in the circuit given the operations at this small unlicensed airfield. The potential for glare from the proposed solar development could also be included within any warnings for this airfield, in addition to the existing stated warnings. An example of this elsewhere is in the AIP of a licensed military aerodrome, RAF Honington[36].

[36] RAF Honington AIP (Page 5 under Warnings)

8 HIGH-LEVEL AVIATION ASSESSMENT

8.1 Overview

Finningley Village Airstrip, Haxey Airstrip, and Doncaster Sheffield Airport have been considered within this high-level assessment. An ATC Tower has been identified at Doncaster Sheffield Airport (not operational). The location of the aerodromes, ATC Tower, and the runway approach paths[37] are shown in Figure 18~~Figure 18Figure 18~~ on page 149~~148143~~.

8.2 Doncaster Sheffield Airport

Significant impacts are not predicted on aviation activity at Doncaster Sheffield Airport based on the associated guidance and industry best practice. This is because:

- Solar reflections towards the ATC Tower are unlikely to be geometrically possible based on the location of the receptor relative to the Scheme (considering distance, height, and orientation). Any reflections that are geometrically possible are likely to be screened by intervening terrain, buildings, and/or vegetation.
- Any solar reflections geometrically possible towards aircraft on the final two-mile approach towards runway 20 would be outside of a pilot's primary horizontal field of view (50 degrees either side of the approach bearing). At worst, a low impact is predicted on pilots on this approach path based on the associated guidance and industry best practice for licensed airfields.
- Any solar reflections geometrically possible towards aircraft on the final two-mile approach towards runway 02 are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors.

Technical modelling is not recommended.

8.3 Finningley Village Airstrip

Significant impacts are not predicted on aviation activity at Finningley Village Airstrip based on the associated guidance and industry best practice. This is because:

- Any reflections towards aircraft on the final one-mile splayed approach towards runway 19 would be outside of a pilot's primary horizontal field of view. At worst, a low impact is predicted on pilots on this approach path based on the associated guidance and industry best practice for licensed airfields.
- Solar reflections originating from the Scheme towards the final one-mile splayed approach towards runway 01, and the final sections of the visual circuits and joins, are

[37] 1-mile splayed approach paths for unlicensed GA airfields, and 2-mile direct approach paths for licensed airfields. as per Pager Power's typical assessment methodology

predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors.

Technical modelling is not recommended.

8.4 Haxey Airstrip

Significant impacts are not predicted on aviation activity at Haxey Airstrip based on the associated guidance and industry best practice. This is because:

- Any reflections towards aircraft on the final one-mile splayed approach towards runway 36 would be outside of a pilot's primary horizontal field of view. At worst, a low impact is predicted on pilots on this approach path based on the associated guidance and industry best practice for licensed airfields.
- Solar reflections originating from the Scheme towards the final one-mile splayed approach towards runway 18, and the final sections of the visual circuits and joins, are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors.

Technical modelling is not recommended.

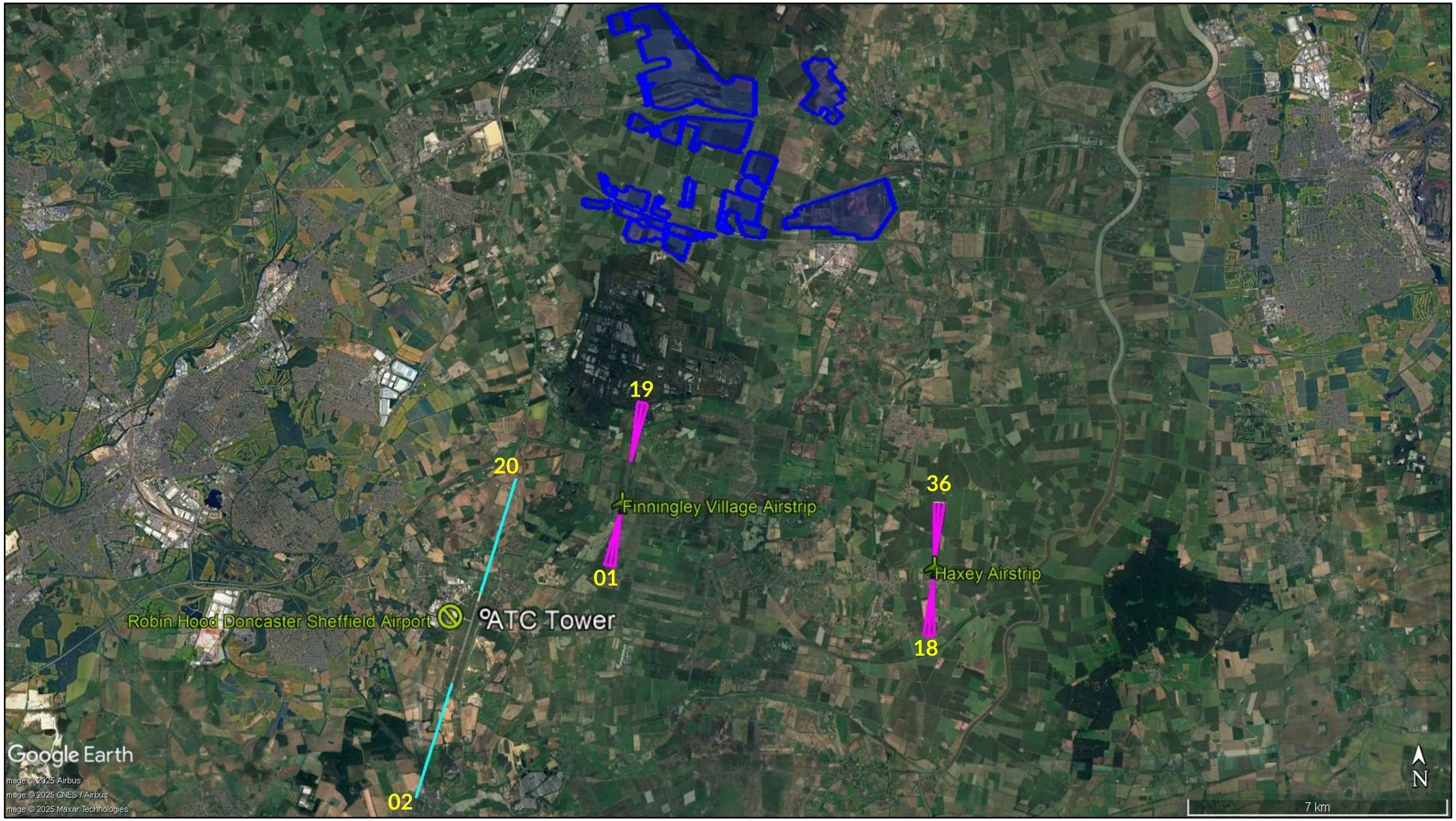

Figure 18 *Locations of aerodrome, ATC Tower, and approach paths considered for high-level assessment*

9 CONCLUSIONS

9.1 Overall Conclusions

Solar reflections with a maximum intensity of 'potential for temporary after-image' (yellow glare) are predicted towards sections of visual circuits at Sandtoft Airfield, originating from panel areas within a pilot's primary field-of-view (50 degrees horizontally either side of the direction of travel). Considering the glare scenario, it is considered that this glare could be accommodated without significant changes to the operational activity of the airfield. Some of the measures that pilots may typically use to mitigate the effects of direct sunlight could be used to mitigate the effects of direct solar reflections from the solar panels given the operations at this unlicensed airfield. Due to the proximity of panel areas to Sandtoft Airfield, consultation with Yorkshire Aero Club is recommended.

No significant impacts are predicted on aviation activity associated with Finningley Village Airfield, Haxey Airfield, and Doncaster Sheffield Airport.

A moderate impact is predicted on separate 0.2km and1.6km sections of the M180, and a 0.1km section of the A18, under baseline conditions. This is due to solar reflections predicted to originate from inside of a road user's primary horizontal field of view in the absence of sufficient mitigating factors. Proposed vegetation planting is expected to screen panels once sufficiently matured, such that views of reflecting panels are not expected to be possible in practice. Further mitigation is not recommended.

A moderate impact is predicted on seven dwellings under baseline conditions due to the duration of effects (more than three months per year) in the absence of sufficient mitigating factors. Proposed vegetation planting is expected to screen panels from the ground floor once sufficiently matured, such that views of reflecting panels are not expected to be possible in practice. Further mitigation is not recommended.

No significant impacts are predicted on railway operations and infrastructure, and sensitive viewpoints.

An overview of the assessment results is presented below and on the following pages.

9.2 Assessment Conclusions – Roads

A moderate impact is predicted on separate 0.2km and1.6km sections of the M180, and a 0.1km section of the A18, under baseline conditions. This is due to solar reflections predicted to originate from inside of a road user's primary horizontal field of view in the absence of sufficient mitigating factors. Proposed vegetation planting is expected to screen panels once sufficiently matured, such that views of reflecting panels are not expected to be possible in practice. Further mitigation is not recommended.

No significant impacts are predicted on other road users.

9.3 Assessment Conclusions – Dwellings

The modelling has shown that solar reflections are geometrically possible[38] towards 281 of the 405 assessed dwelling locations.

No impacts are predicted on 134 dwellings because there is significant existing screening such that views of reflecting panels are not expected to be possible in practice. Mitigation is not required.

A low impact is predicted on 140 dwellings under baseline conditions in accordance with the guidance presented in Appendix D, either because the duration of effects received in practice on the ground floor is expected to be reduced to **less** than three months per year and **less** than 60 minutes per any one day, or there are mitigating factors such as a significant separation distance to the closest reflecting panels and effects occurring within a few hours of sunrise/sunset when the Sun is low in the sky. Proposed vegetation planting is expected to screen panels from the ground floor once sufficiently matured, such that views of reflecting panels are not expected to be possible in practice. Further mitigation is not recommended.

A moderate impact is predicted on seven dwellings (receptors 24-25, 169, 199-201, 268) under baseline conditions due to the duration of effects (more than three months per year) in the absence of sufficient mitigating factors. Proposed vegetation planting is expected to screen panels from the ground floor once sufficiently matured, such that views of reflecting panels are not expected to be possible in practice. Further mitigation is not recommended.

9.4 Assessment Conclusions – Railway Signals

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

Without consideration of vegetation screening:

- For two signals, a low impact is predicted because solar reflections originate from outside 90 degrees either side of the direction of the signal;
- For the remaining seven signals, a low impact is predicted with consideration of factors such as all signals appearing to be LED, having hoods fitted, reflections don't originate directly in front of the signal, and/or there is a significant clearance distance to the reflecting area.

With consideration of existing and proposed vegetation screening, no impacts are predicted on any signals. Mitigation is not recommended.

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

9.5 Assessment Conclusions – Train Drivers

A low impact is predicted on separate 2.3km, 0.3km, and 0.6km sections of railway line. Where solar reflections are geometrically possible from inside a train driver's primary horizontal field of view, there are mitigating factors such as a significant separation distance to the closest reflecting panels and effects occurring within a few hours of sunrise/sunset when the Sun is low in the sky.

No impacts are predicted on other sections of railway line, because solar reflections are not geometrically possible, or are predicted to be screened.

Further mitigation is not recommended.

9.6 Assessment Conclusions – Sensitive Viewpoints

The modelling has shown that solar reflections are predicted towards 32 of the sensitive viewpoints. In Pager Power's experience, significant impacts to pedestrians using public rights of way are not possible due to glint and glare effects from PV developments. The reasoning is due to the sensitivity of the receptors (in terms of amenity and safety) being concluded to be of low significance. This is because:

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

Overall, no significant impact on observers at these viewpoints is predicted and therefore mitigation is not required.

9.7 Assessment Conclusions – Sandtoft Airfield

9.7.1 1-mile splayed approaches towards Runway 05

Solar reflections originating from outside of a pilot's primary field-of-view are predicted towards the 1-mile splayed approaches towards Runway 05. A low impact is predicted in accordance with the associated guidance and industry best practice. Mitigation is not recommended.

9.7.2 1-mile splayed approaches towards Runway 23

Solar reflections with a maximum intensity of 'low potential for temporary after-image' (green glare) are predicted towards the 1-mile splayed approaches towards Runway 23, originating from panel areas within a pilot's primary field-of-view. Considering the associated guidance (Appendix

D) and industry best practice pertaining to approach paths at licensed aerodromes, which states that this level of glare is acceptable, it can be reliably concluded that this glare is acceptable. A low impact is predicted, and mitigation is not recommended.

9.7.3 Visual Circuits

Solar reflections with a maximum intensity of 'potential for temporary after-image' (yellow glare) are predicted towards sections of visual circuits at Sandtoft Airfield, originating from panel areas within a pilot's primary field-of-view (50 degrees horizontally either side of the direction of travel).

Glare with potential for a temporary after-image was formerly not permissible under the interim guidance provided by the Federal Aviation Administration in the USA for on-airfield solar. This FAA guidance from 2013 has since been superseded by the FAA guidance in 2021 whereby airports are tasked with determining safety requirements themselves.

Pager Power generally recommends a pragmatic approach whereby instances of 'yellow' glare are evaluated in a technical and operational context. Considering the glare scenario (presented in Section 7.7.4), it is considered that this glare could be accommodated without significant changes to the operational activity of the airfield. Some of the measures listed in Section 7.7.5 that pilots may typically use to mitigate the effects of direct sunlight could be used to mitigate the effects of direct solar reflections from the solar panels given the operations at this unlicensed airfield.

Due to the proximity of panel areas to Sandtoft Airfield, consultation with Yorkshire Aero Club is recommended.

9.8 Assessment Conclusions – Doncaster Sheffield Airport

Significant impacts are not predicted on aviation activity at Doncaster Sheffield Airport based on the associated guidance and industry best practice. This is because:

- Solar reflections towards the ATC Tower are unlikely to be geometrically possible based on the location of the receptor relative to the Scheme (considering distance, height, and orientation). Any reflections that are geometrically possible are likely to be screened by intervening terrain, buildings, and/or vegetation.
- Any solar reflections geometrically possible towards aircraft on the final two-mile approach towards runway 20 would be outside of a pilot's primary horizontal field of view (50 degrees either side of the approach bearing). At worst, a low impact is predicted on pilots on this approach path based on the associated guidance and industry best practice for licensed airfields.
- Any solar reflections geometrically possible towards aircraft on the final two-mile approach towards runway 02 are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors.

Technical modelling is not recommended.

9.9 Assessment Conclusions – Finningley Village Airstrip

Significant impacts are not predicted on aviation activity at Finningley Village Airstrip based on the associated guidance and industry best practice. This is because:

- Any reflections towards aircraft on the final one-mile splayed approach towards runway 19 would be outside of a pilot's primary horizontal field of view. At worst, a low impact is predicted on pilots on this approach path based on the associated guidance and industry best practice for licensed airfields.
- Solar reflections originating from the Scheme towards the final one-mile splayed approach towards runway 01, and the final sections of the visual circuits and joins, are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors.

Technical modelling is not recommended.

9.10 Assessment Conclusions – Haxey Airstrip

Significant impacts are not predicted on aviation activity at Haxey Airstrip based on the associated guidance and industry best practice. This is because:

- Any reflections towards aircraft on the final one-mile splayed approach towards runway 36 would be outside of a pilot's primary horizontal field of view. At worst, a low impact is predicted on pilots on this approach path based on the associated guidance and industry best practice for licensed airfields.
- Solar reflections originating from the Scheme towards the final one-mile splayed approach towards runway 18, and the final sections of the visual circuits and joins, are predicted to have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (Appendix D) and industry best practice pertaining to approach paths, it can be reliably determined that this level of glare is acceptable for these receptors.

Technical modelling is not recommended.

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

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

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

UK Planning Policy

Renewable and Low Carbon Energy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[39] (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.'

[39] Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, last updated: 14 August 2023, accessed on: 17/05/2024

National Policy Statement for Renewable Energy Infrastructure

The National Policy Statement for Renewable Energy Infrastructure (EN-3)[40] 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.[41] 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.

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

[41] *'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.'*

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

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

Assessment Process – Railways

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

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

Railway Assessment Guidelines

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

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

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

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

Reflections and Glare

The extract below is taken from Section A5 – Reflections and glare (pages 64-65) of the 'Signal Sighting Assessment Requirements'43 which details the requirement for assessing glare towards railway signals.

Reflections and glare

Rationale

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

Guidance

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

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

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

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

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

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

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

Examples of the adverse effect of disability glare include:

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

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

Options for militating against A5 include:

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

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

c) Provision of screening.

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

Determining the Field of Focus

The extract below is taken from Appendix F - Guidance on Field of Vision (pages 98-101) of the 'Signal Sighting Assessment Requirements'44 which details the visibility of signals, train drivers' field of vision and the implications with regard to signal positioning.

Asset visibility

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

a) Position in the observer's visual field.

b) Contrast with its background.

c) Luminance properties.

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

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

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

Field of vision

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

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

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

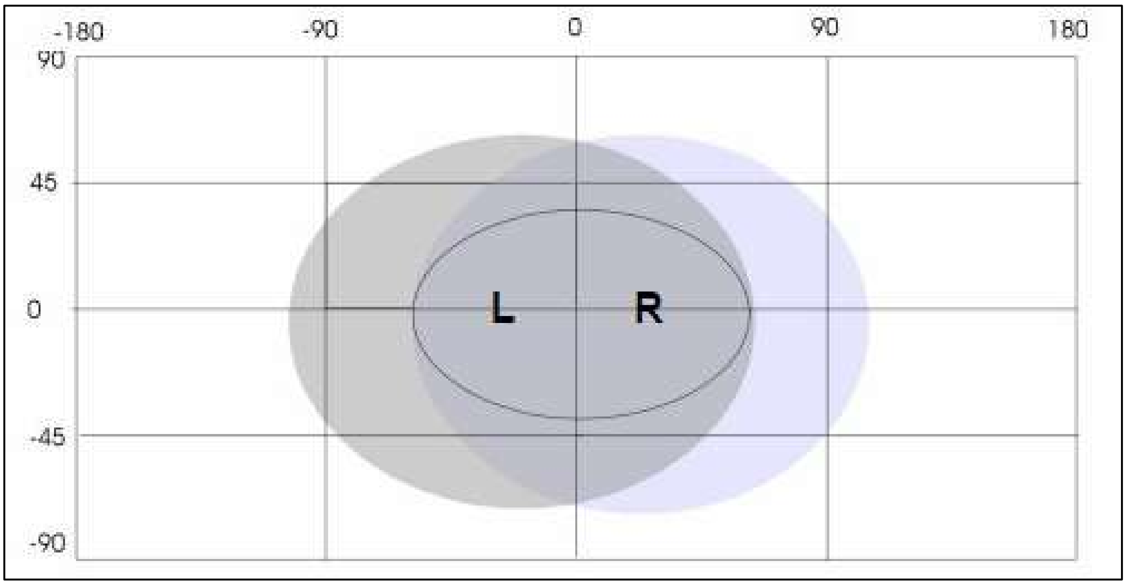

Figure G 21 - Field of view

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

Research has shown that drivers search for signs or signals towards the centre of the field of vision.

Signals, indicators and signs should be positioned at a height and distance from the running line that permits them to be viewed towards the centre of the field of vision. This is because:

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

lamp-posts, traffic, or non-signal lights, such as house, compatibility factors or security lights).

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

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

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

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

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

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

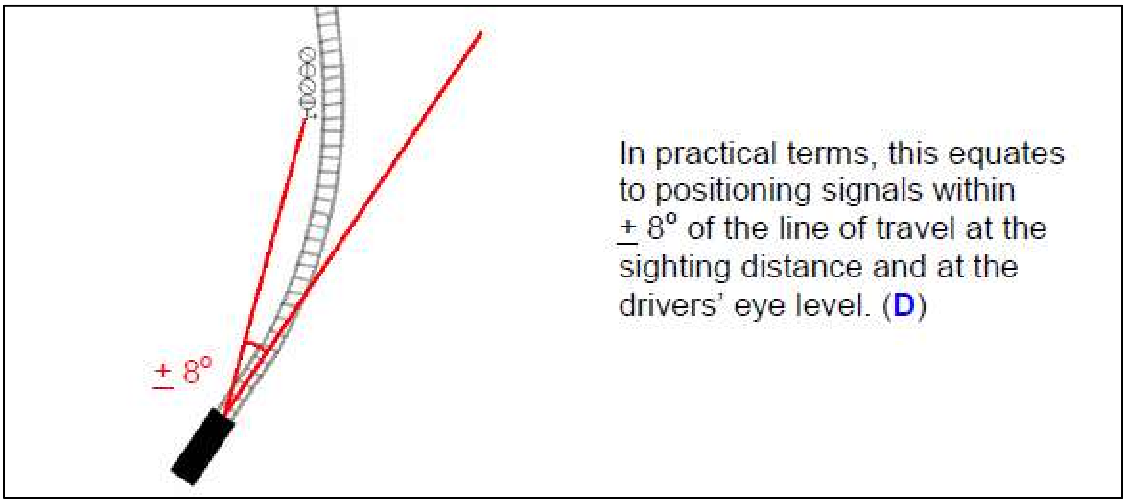

Figure G 22 - Signal positioning

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

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

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

Determining the Assessed Minimum Reading Time

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

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

'Baseline response time

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

Supplementary response time

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

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

'Minimum response time (MRT)

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

a) Read the display or display combination.

a) Interpret the display or display combination

b) Assimilate all of the available information

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

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

MRT = BRT + SRT'

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

Signal Design and Lighting System

Many railway signals are now LED lights and not filament (incandescent) bulbs. The benefits of an LED signal over a filament bulb signal with respect to possible phantom aspect illuminations are as follows:

- An LED railway signal produces a more intense light making them more visible to approaching trains when compared to the traditional filament bulb technology[45];

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

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

Many LED signal manufacturers[46,47,48] claim that LED signal lights significantly reduce or completely remove the likelihood of a phantom aspect illumination occurring.

Aviation Assessment Guidance

The UK Civil Aviation Authority (CAA) issued interim guidance relating to Solar Photovoltaic Systems (SPV) on 17 December 2010 and was subject to a CAA information alert 2010/53. The formal policy was cancelled on September 7th, 2012[49] however the advice is still applicable[50] 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 Schemes 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

[46] Source: http://www.unipartdorman.co.uk/assets/unipart_dorman_rail_brochure.pdf. (Last accessed 21.02.18).

[47] Source: http://www.vmstech.co.uk/downloads/Rail.pdf . (Last accessed 21.02.18).

[48] Source: Siemens, Sigmaguard LED Tri-Colour L Signal – LED Signal Technology at Incandescent Prices. Datasheet 1A-23. (Last accessed 22.02.18).

[49] Archived at Pager Power

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

responsibility of the ALH[51], as part of a condition of a CAA Aerodrome Licence, the ALH is required to obtain prior consent from CAA Aerodrome Standards Department before any work is begun or approval to the developer or LPA is granted, in accordance with the procedures set out in CAP 791 Procedures for Changes to Aerodrome Infrastructure.

13. During the installation and associated construction of SPV systems there may also be a need to liaise with nearby aerodromes if cranes are to be used; CAA notification and permission is not required.

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

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

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'*[52], the 2013 update is entitled '*Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'*[53], and the 2021 final policy is entitled '*Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports'*[54].

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

[51] Aerodrome Licence Holder.

[52] Archived at Pager Power

[53] 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.

[54] 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.

with 14 CFR 77.5(c), FAA will rely on the submittal of Form 7460-1 in which the sponsor confirms that it has analyzed the potential for glint and glare and determined there is no potential for ocular impact to the airport's ATCT cab. This process will enable FAA to evaluate the solar energy system project, with assurance that the system will not impact the ATCT cab.

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

The excerpt above states where a solar PV development is to be located on a federally obligated aerodrome with an ATC Tower, it will require a glint and glare assessment to accompany its 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*'[55]. 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*[56].
- *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.*

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

[56] 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.

- *As illustrated on Figure 16[57], flat, smooth surfaces reflect a more concentrated amount of sunlight back to the receiver, which is referred to as specular reflection. The more a surface is polished, the more it shines. Rough or uneven surfaces reflect light in a diffused or scattered manner and, therefore, the light will not be received as bright.*
- *Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:*
    - *A qualitative analysis of potential impact in consultation with the Control Tower, pilots and airport officials;*
    - *A demonstration field test with solar panels at the proposed site in coordination with FAA Tower personnel;*
    - *A geometric analysis to determine days and times when an impact is predicted.*
- *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*

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[57] First figure in Appendix B.

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

Air Navigation Order (ANO) 2016

In some instances, an aviation stakeholder can refer to the ANO 2016[59] 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.

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[58] 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.

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

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

Lights which dazzle or distract

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

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

Endangering safety of an aircraft

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

Endangering safety of any person or property

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

Civil Aviation Authority consolidation of UK Regulation 139/2014

The Civil Aviation Authority (CAA) published a consolidating document[60] 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;

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

2. the use of hazardous, confusing, and misleading lights;
3. the dazzling caused by large and highly reflective surfaces;
4. sources of non-visible radiation, or the presence of moving, or fixed objects which may interfere with, or adversely affect, the performance of aeronautical communications, navigation and surveillance systems;
5. and 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.

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

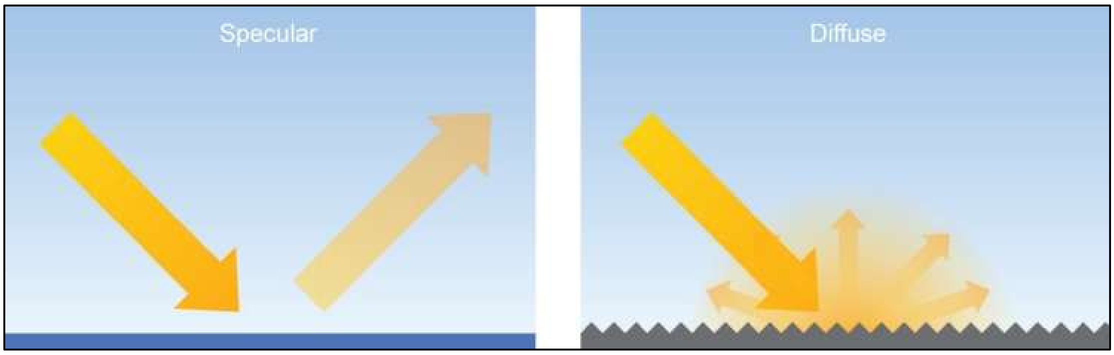
Overview

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[61], 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

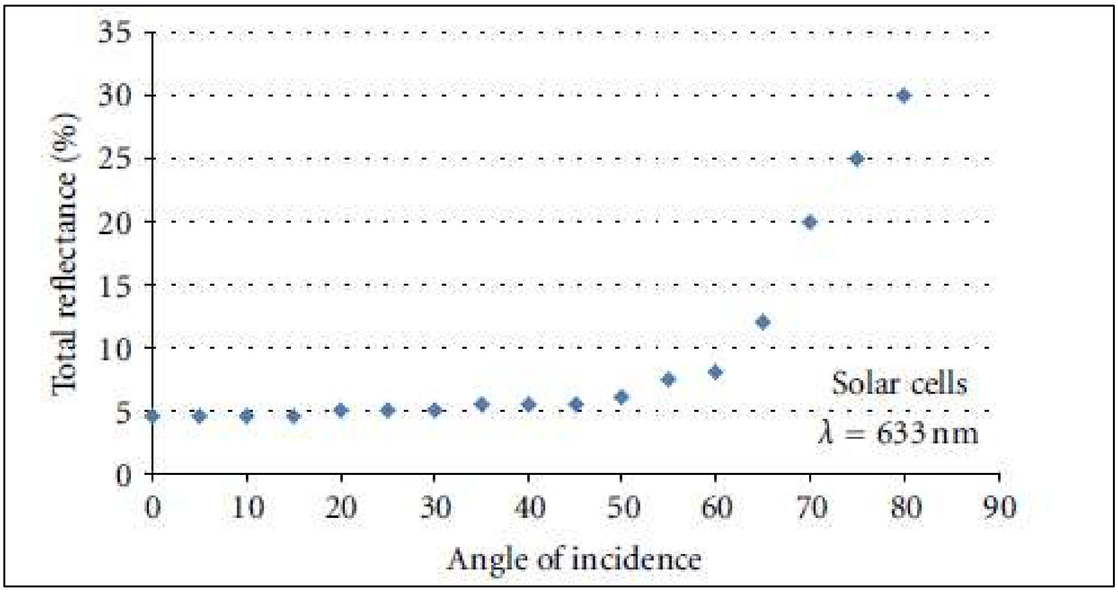
[61] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.

Solar Reflection Studies

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

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

Evan Riley and Scott Olson published in 2011 their study titled: A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems[62]". They researched the potential glare that a pilot could experience from a 25 degree fixed tilt PV system located outside of Las Vegas, Nevada. The theoretical glare was estimated using published ocular safety metrics which quantify the potential for a postflash glare after-image. This was then compared to the postflash glare after-image caused by smooth water. The study demonstrated that the reflectance of the solar cell varied with angle of incidence, with maximum values occurring at angles close to 90 degrees. The reflectance values varied from approximately 5% to 30%. This is shown on the figure below.



Total reflectance % when compared to angle of incidence

The conclusions of the research study were:

- The potential for hazardous glare from flat-plate PV systems is similar to that of smooth water;
- Portland white cement concrete (which is a common concrete for runways), snow, and structural glass all have a reflectivity greater than water and flat plate PV modules.

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[62] Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems," ISRN Renewable Energy, vol. 2011, Article ID 651857, 6 pages, 2011. doi:10.5402/2011/651857

FAA Guidance – "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[63]

The 2010 FAA Guidance included a diagram which illustrates the relative reflectance of solar panels compared to other surfaces. The figure shows the relative reflectance of solar panels compared to other surfaces. Surfaces in this figure produce reflections which are specular and diffuse. A specular reflection (those made by most solar panels) has a reflection characteristic similar to that of a mirror. A diffuse reflection will reflect the incoming light and scatter it in many directions. A table of reflectivity values, sourced from the figure within the FAA guidance, is presented below.

Surface	Approximate Percentage of Light Reflected[64]
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).

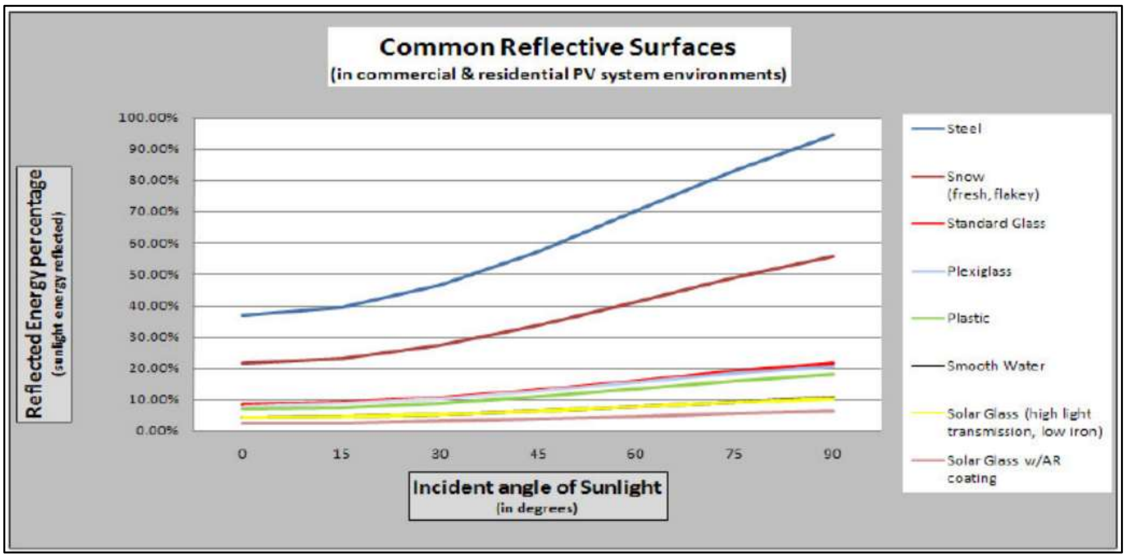
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

[63] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.
[64] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification[65] 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.

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

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

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

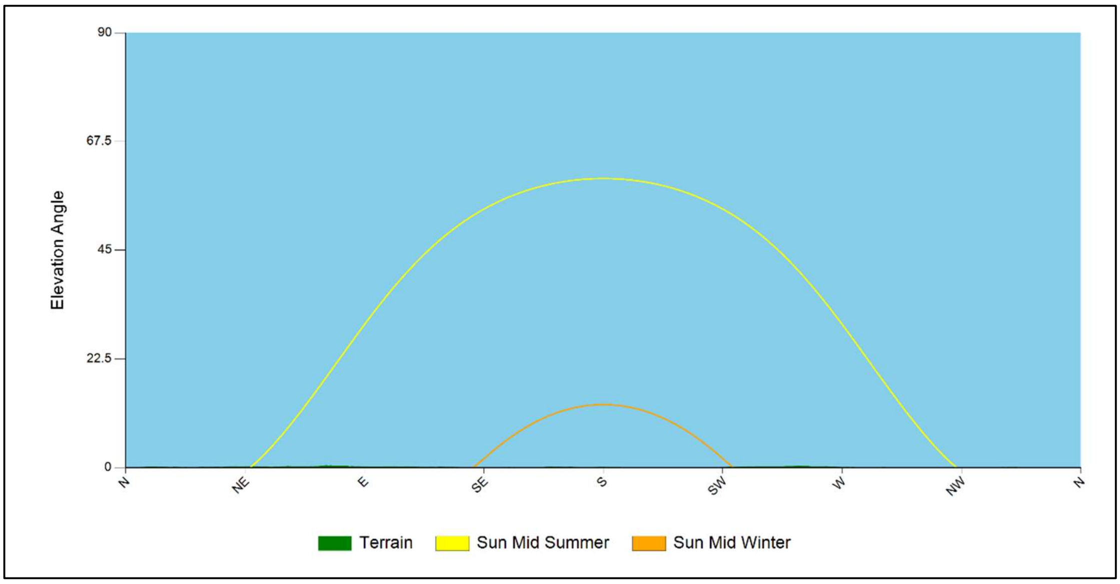
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

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

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

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

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



Terrain at the visible horizon and sun path

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact Significance Definition

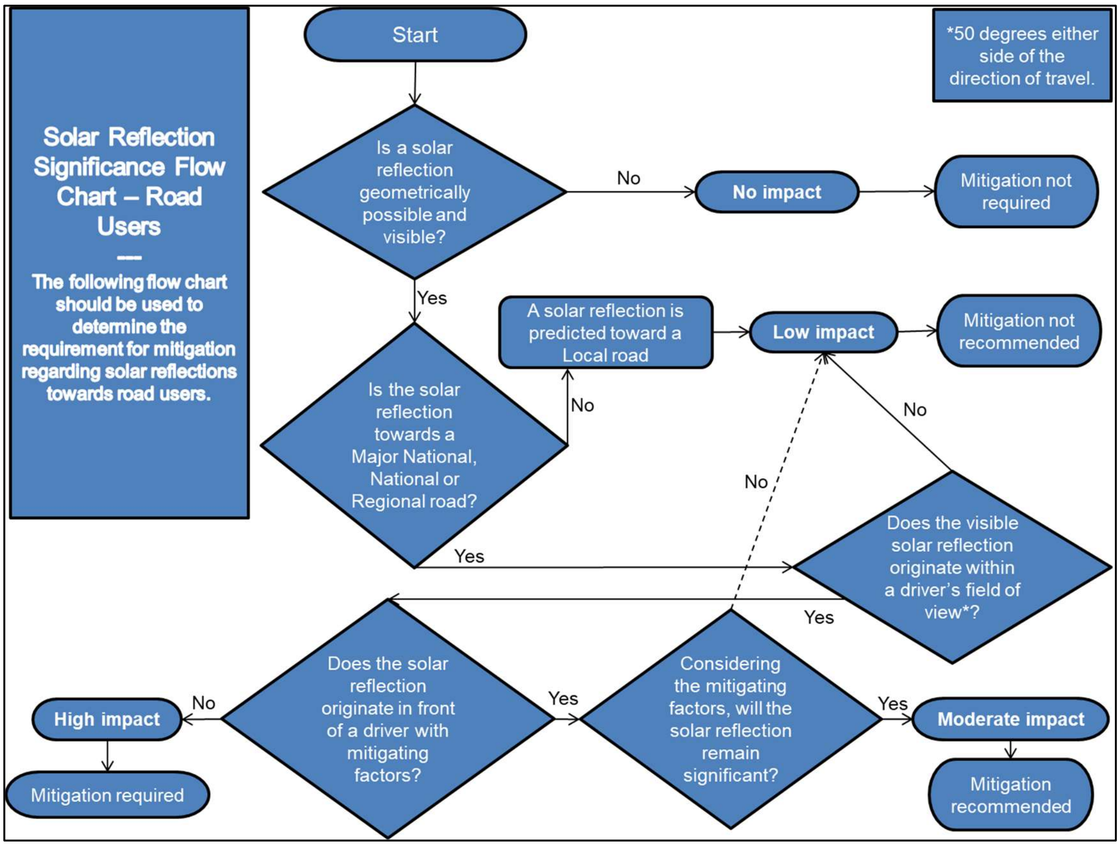
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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

Impact significance definition

Assessment Process for Road Receptors

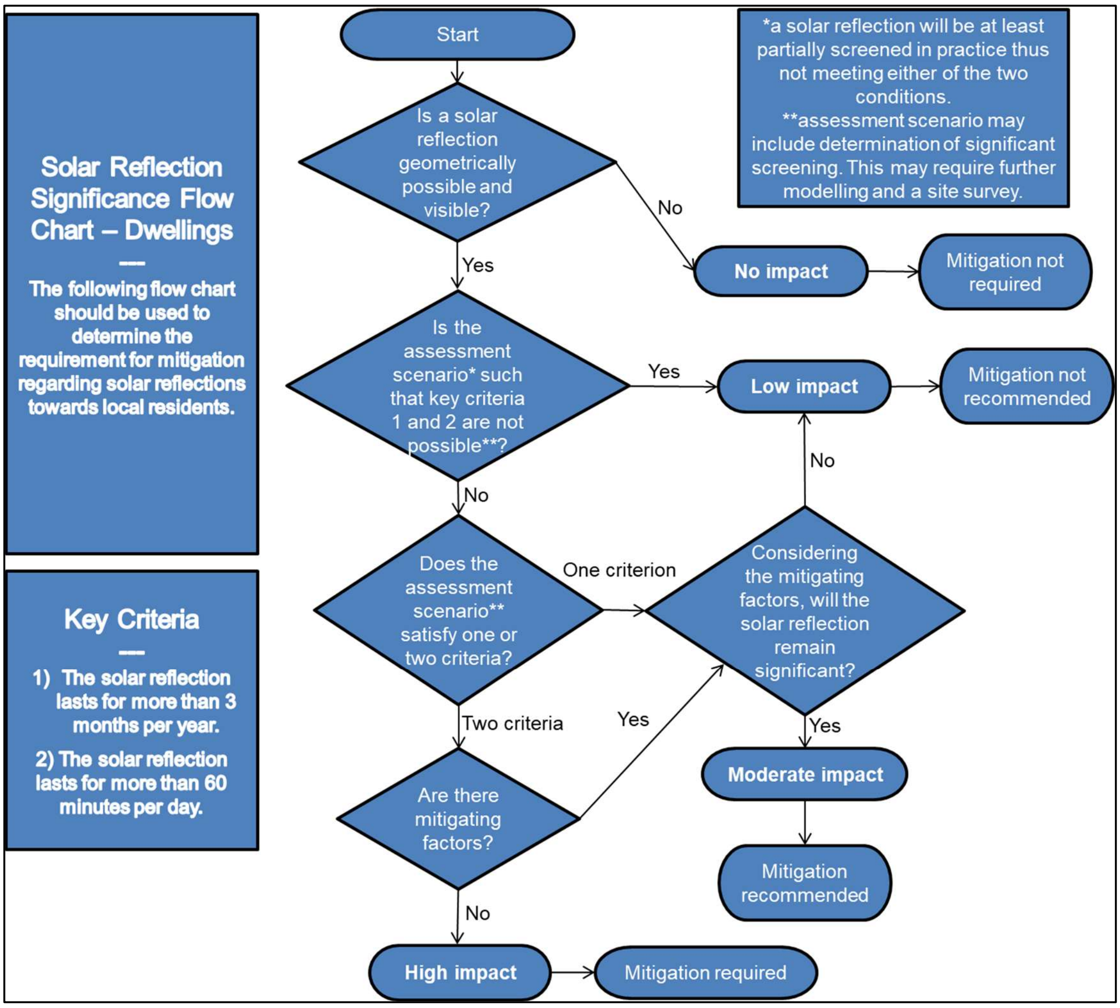
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road receptor mitigation requirement flow chart

Assessment Process for Dwelling Receptors

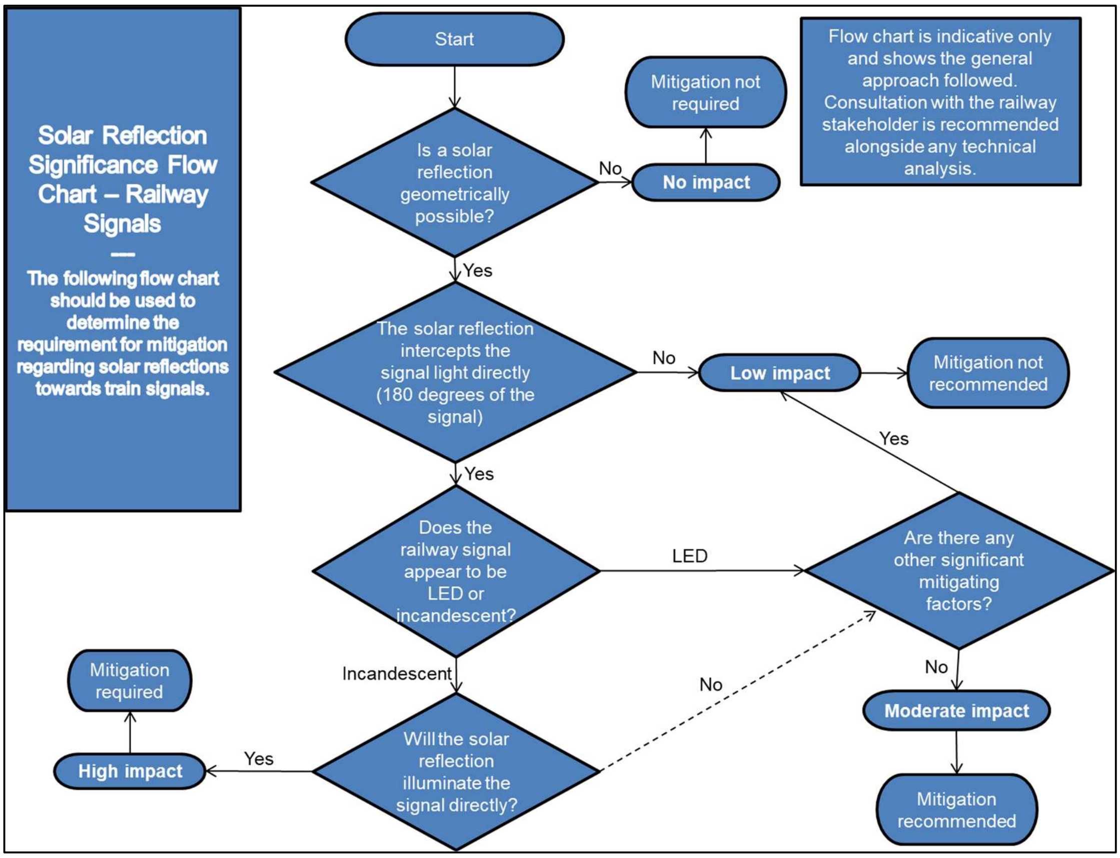
The flow chart presented below has been followed when determining the mitigation requirement for dwelling receptors.



Dwelling receptor mitigation requirement flow chart

Assessment Process for Railway Signals

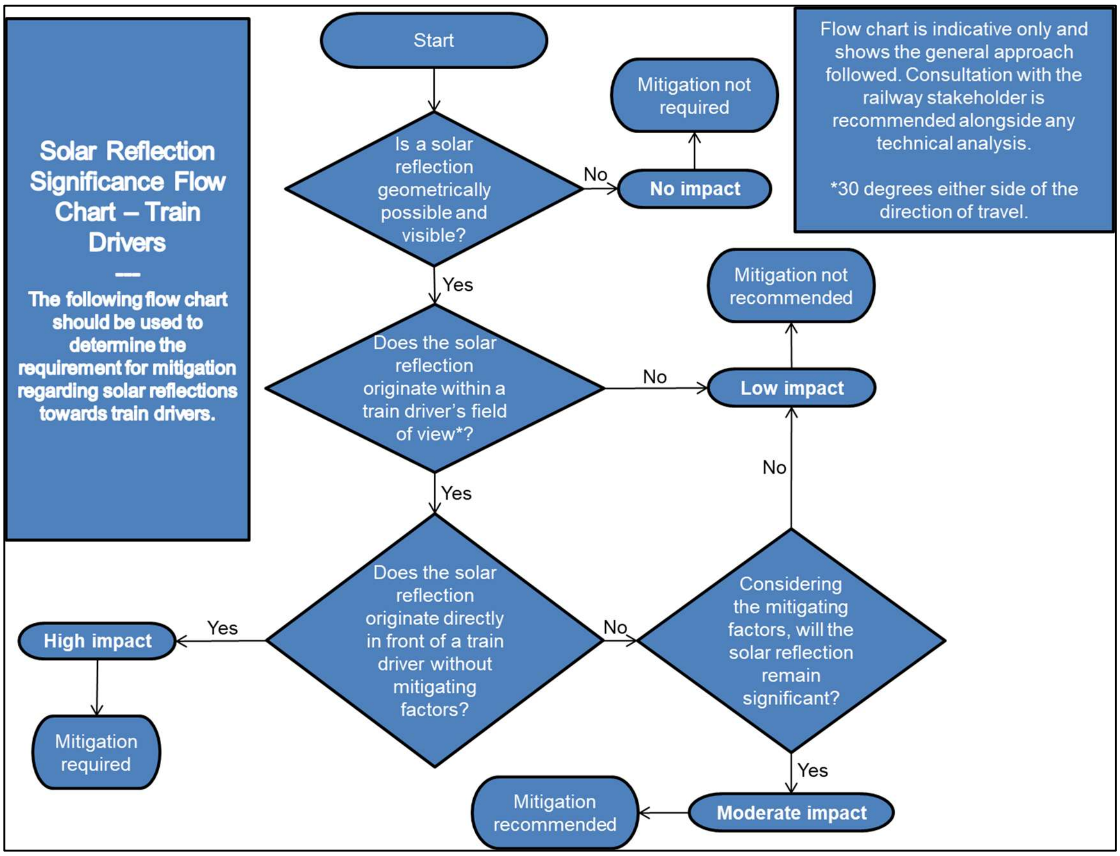
The flow chart presented below has been followed when determining the impact significance and mitigation requirement for railway signals.



Railway signal impact significance flow chart

Assessment Process for Train Driver Receptors

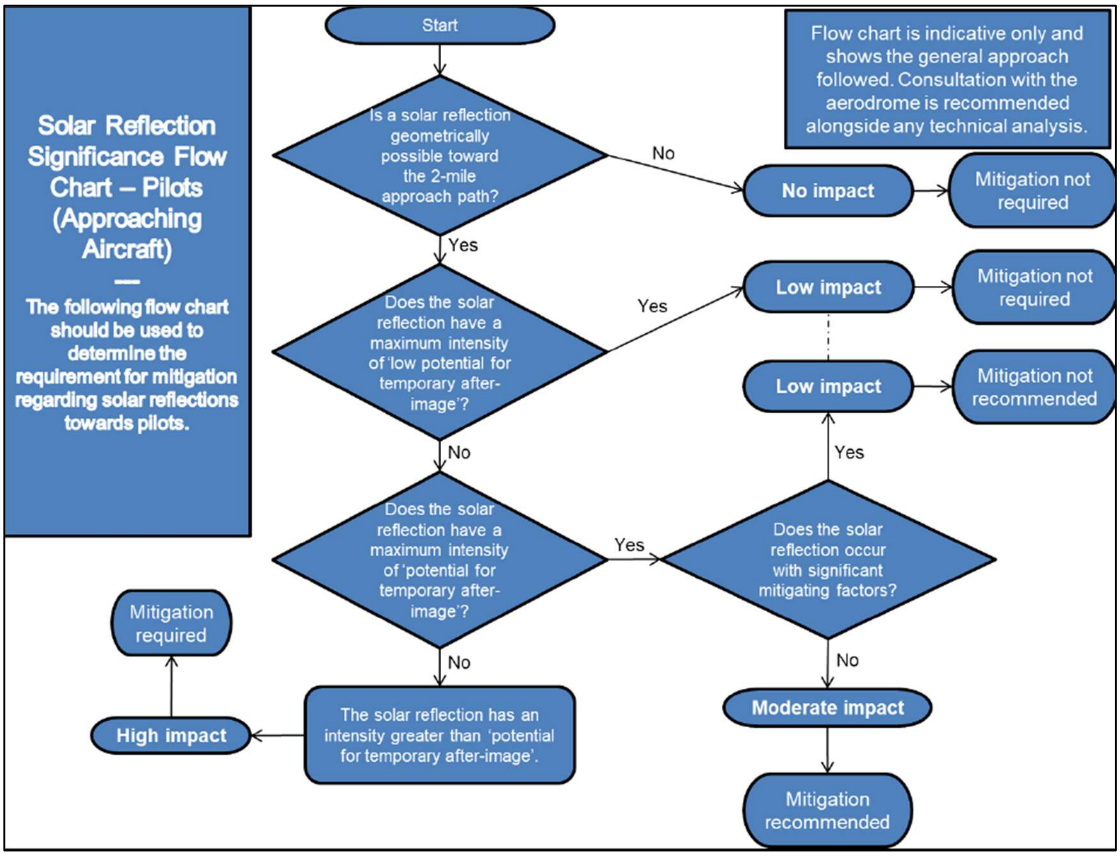
The flow chart presented below has been followed when determining the impact significance and mitigation requirement for train driver receptors.



Train driver impact significance flow chart

Assessment Process for Approaching Aircraft

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



Approach path receptor mitigation requirement flow chart

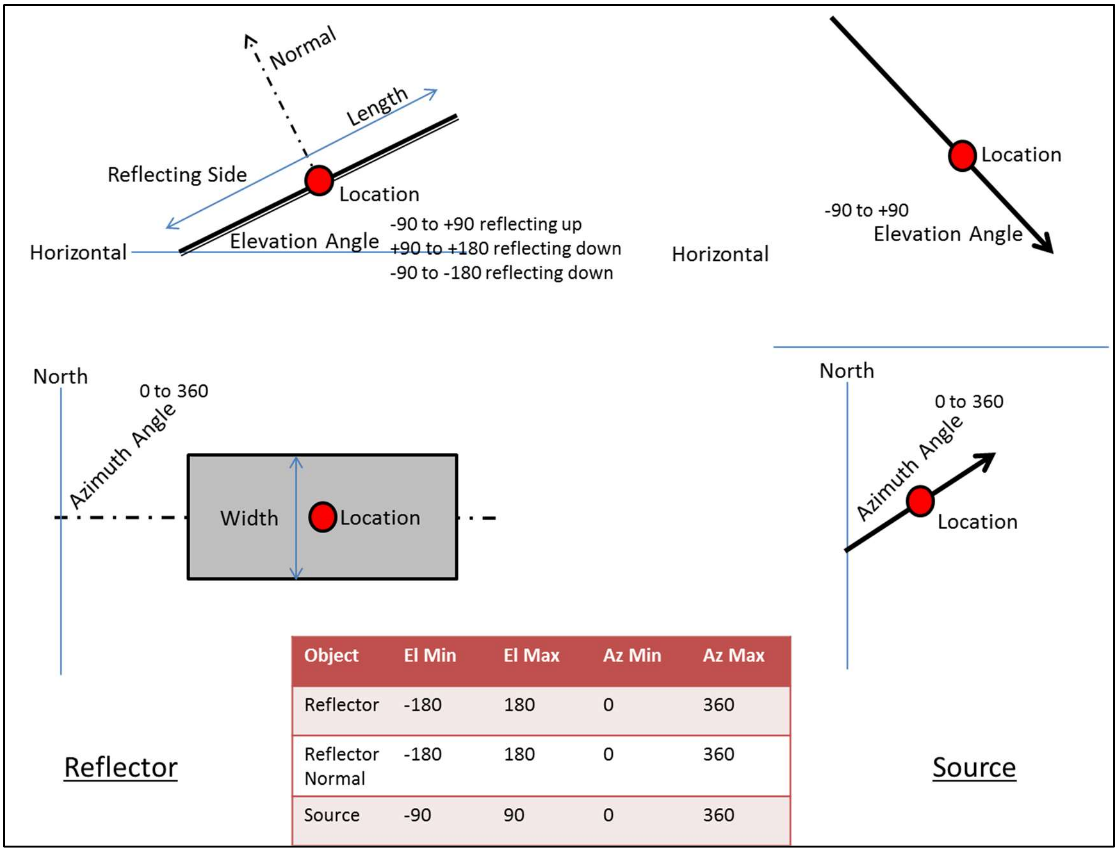
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Pager Power's Reflection Calculations Methodology

The calculations are three dimensional and complex, accounting for:

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

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



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

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

- Use the Latitude and Longitude of reflector as the reference for calculation purposes;
- Calculate the Azimuth and Elevation of the normal to the reflector;
- Calculate the 3D angle between the source and the normal;

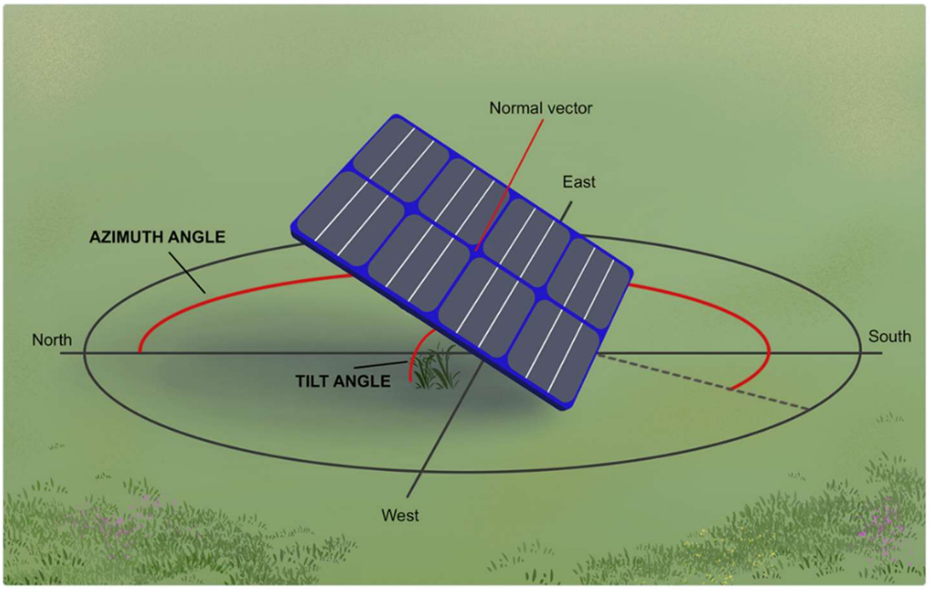
- If this angle is less than 90 degrees a reflection will occur. If it is greater than 90 degrees no reflection will occur because the source is behind the reflector;
- Calculate the Azimuth and Elevation of the reflection in accordance with the following:
    - The angle between source and normal is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

Forge Reflection Calculations Methodology

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

Fixed-Mount Parameters

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



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

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

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

Fixed System Parameters

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Pager Power's Model

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

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

The model considers terrain between the reflecting solar panels and the visible horizon (where the sun may be obstructed from view of the panels)[66].

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

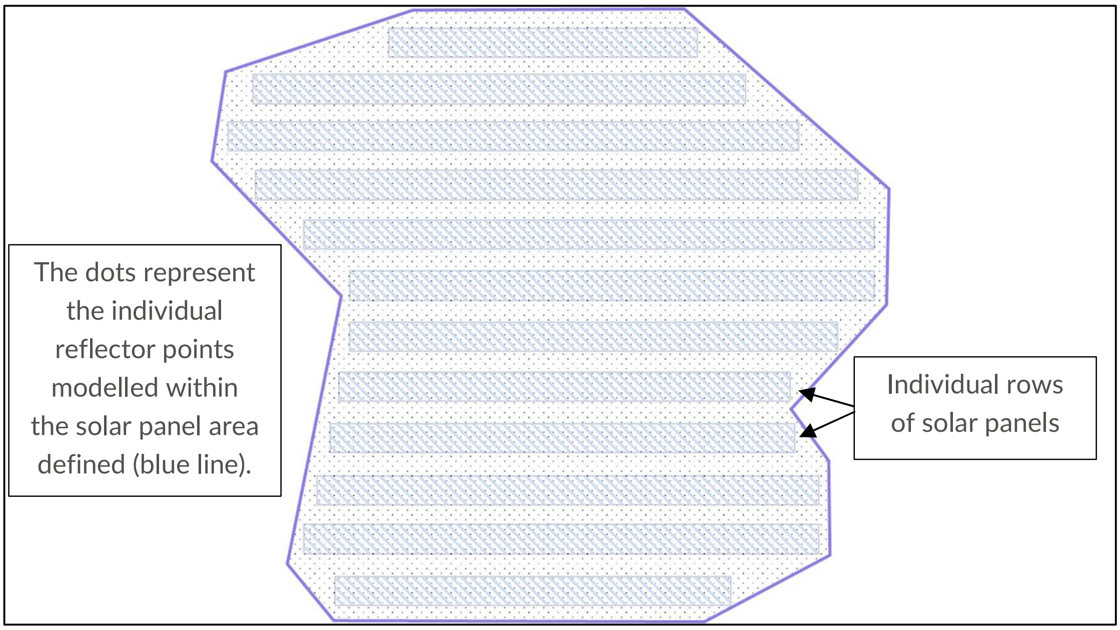
It is assumed that the panel azimuth angle assessed represents the azimuth angle for all of the panels within each solar panel area defined.

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

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

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

[66] UK only.



Solar panel area modelling overview

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

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

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

Forge's Sandia National Laboratories' (SGHAT) Model

The following text is taken from Forge[67] and is presented for reference.

Summary of assumptions and abstractions required by the SGHAT/ForgeSolar analysis methodology

1. Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
2. Result data files and plots are now retained for two years after analysis completion. Files should be downloaded and saved if additional persistence is required.
3. The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
4. Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects analyses of path receptors.
5. Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
6. The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
7. The algorithm assumes that the PV array is aligned with a plane defined by the total heights of the coordinates outlined in the Google map. For more accuracy, the user should perform runs using minimum and maximum values for the vertex heights to bound the height of the plane containing the solar array. Doing so will expand the range of observed solar glare when compared to results using a single height value.
8. The algorithm does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
9. The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
10. The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.

11. The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
12. Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
13. Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
14. Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
15. PV array tracking assumes the modules move instantly when tracking the sun, and when reverting to the rest position.

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

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Terrain Height

Terrain Height was calculated from Pager Power's database (established on OSGB 50m) based on the coordinates of the point of interest.

Road Receptor Data

The table below presents the coordinates for the assessed road receptors.

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
A1	53.590508	-0.964135	A52	53.572148	-0.895134
A2	53.589942	-0.962957	A53	53.572019	-0.893634
A3	53.589291	-0.961912	A54	53.571891	-0.892134
A4	53.588603	-0.960934	A55	53.571774	-0.890631
A5	53.587933	-0.959923	A56	53.571656	-0.889129
A6	53.587271	-0.958896	A57	53.571568	-0.887621
A7	53.586635	-0.957823	A58	53.571473	-0.886114
A8	53.586000	-0.956749	A59	53.571368	-0.884609
A9	53.585405	-0.955611	A60	53.571290	-0.883099
A10	53.584814	-0.954469	A61	53.571215	-0.881589
A11	53.584245	-0.953294	A62	53.571152	-0.880077
A12	53.583693	-0.952098	A63	53.571091	-0.878565
A13	53.583177	-0.950856	A64	53.571034	-0.877053
A14	53.582680	-0.949593	A65	53.571005	-0.875538
A15	53.582188	-0.948323	A66	53.570976	-0.874023
A16	53.581731	-0.947018	A67	53.570949	-0.872509
A17	53.581296	-0.945691	A68	53.570936	-0.870993
A18	53.580899	-0.944331	A69	53.570923	-0.869478
A19	53.580510	-0.942964	A70	53.570915	-0.867963

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
A20	53.580142	-0.941581	A71	53.570915	-0.866447
A21	53.579786	-0.940188	A72	53.570914	-0.864932
A22	53.579440	-0.938789	A73	53.570910	-0.863416
A23	53.579089	-0.937393	A74	53.570905	-0.861901
A24	53.578746	-0.935992	A75	53.570900	-0.860385
A25	53.578420	-0.934579	A76	53.570895	-0.858870
A26	53.578096	-0.933166	A77	53.570890	-0.857354
A27	53.577779	-0.931747	A78	53.570885	-0.855839
A28	53.577470	-0.930324	A79	53.570883	-0.854323
A29	53.577160	-0.928900	A80	53.570883	-0.852808
A30	53.576880	-0.927460	A81	53.570883	-0.851292
A31	53.576602	-0.926019	A82	53.570883	-0.849777
A32	53.576307	-0.924587	A83	53.570883	-0.848262
A33	53.576017	-0.923152	A84	53.570883	-0.846746
A34	53.575753	-0.921703	A85	53.570883	-0.845231
A35	53.575490	-0.920254	A86	53.570883	-0.843715
A36	53.575240	-0.918798	A87	53.570882	-0.842200
A37	53.574996	-0.917339	A88	53.570874	-0.840684
A38	53.574753	-0.915879	A89	53.570866	-0.839169
A39	53.574518	-0.914416	A90	53.570859	-0.837653
A40	53.574284	-0.912953	A91	53.570851	-0.836138
A41	53.574067	-0.911482	A92	53.570844	-0.834623
A42	53.573855	-0.910010	A93	53.570840	-0.833107
A43	53.573656	-0.908531	A94	53.570835	-0.831592
A44	53.573458	-0.907053	A95	53.570754	-0.830083

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
A45	53.573272	-0.905570	A96	53.570662	-0.828576
A46	53.573087	-0.904087	A97	53.570554	-0.827071
A47	53.572910	-0.902601	A98	53.570428	-0.825571
A48	53.572741	-0.901112	A99	53.570302	-0.824070
A49	53.572573	-0.899624	A100	53.570131	-0.822584
A50	53.572429	-0.898127	A101	53.570027	-0.821784
A51	53.572286	-0.896631			

Road Receptors along the M180 (road receptors A1 to A101)

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
B1	53.578650	-0.971445	B10	53.584955	-0.963618
B2	53.579207	-0.970254	B11	53.585833	-0.963293
B3	53.579786	-0.969094	B12	53.586730	-0.963233
B4	53.580380	-0.967954	B13	53.587626	-0.963365
B5	53.581000	-0.966861	B14	53.588524	-0.963454
B6	53.581690	-0.965889	B15	53.589405	-0.963178
B7	53.582396	-0.964950	B16	53.590264	-0.962725
B8	53.583207	-0.964336	B17	53.591123	-0.962272
B9	53.584077	-0.963949	B18	53.591394	-0.962106

Road Receptors along the A18 (road receptors B1 to B18)

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
C1	53.592842	-0.962007	C4	53.591877	-0.962643
C2	53.592190	-0.961111	C5	53.592149	-0.962802
C3	53.591444	-0.961538			

Road Receptors along the Tudworth Roundabout (road receptors C1 to C5)

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
D1	53.592060	-0.960979	D52	53.581140	-0.887535
D2	53.592097	-0.959466	D53	53.580856	-0.886097
D3	53.592121	-0.957950	D54	53.580606	-0.884641
D4	53.592228	-0.956446	D55	53.580389	-0.883170
D5	53.592428	-0.954968	D56	53.580200	-0.881689
D6	53.592683	-0.953514	D57	53.580044	-0.880196
D7	53.592935	-0.952059	D58	53.579927	-0.878693
D8	53.593186	-0.950603	D59	53.579842	-0.877184
D9	53.593422	-0.949140	D60	53.579798	-0.875671
D10	53.593535	-0.947637	D61	53.579794	-0.874155
D11	53.593432	-0.946135	D62	53.579828	-0.872641
D12	53.593188	-0.944677	D63	53.579885	-0.871129
D13	53.592891	-0.943246	D64	53.580017	-0.869629
D14	53.592593	-0.941815	D65	53.580158	-0.868132
D15	53.592299	-0.940382	D66	53.580350	-0.866652
D16	53.591992	-0.938957	D67	53.580574	-0.865184
D17	53.591691	-0.937528	D68	53.580849	-0.863741
D18	53.591398	-0.936095	D69	53.581134	-0.862303
D19	53.591097	-0.934666	D70	53.581435	-0.860875
D20	53.590795	-0.933237	D71	53.581731	-0.859443
D21	53.590491	-0.931810	D72	53.582016	-0.858005
D22	53.590190	-0.930381	D73	53.582302	-0.856568
D23	53.589884	-0.928956	D74	53.582590	-0.855132
D24	53.589582	-0.927528	D75	53.582881	-0.853697
D25	53.589284	-0.926097	D76	53.583172	-0.852263

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
D26	53.588985	-0.924667	D77	53.583464	-0.850829
D27	53.588685	-0.923237	D78	53.583751	-0.849392
D28	53.588384	-0.921809	D79	53.584046	-0.847960
D29	53.588076	-0.920384	D80	53.584337	-0.846526
D30	53.587769	-0.918959	D81	53.584626	-0.845090
D31	53.587465	-0.917532	D82	53.584912	-0.843652
D32	53.587161	-0.916105	D83	53.585205	-0.842219
D33	53.586858	-0.914678	D84	53.585498	-0.840786
D34	53.586555	-0.913250	D85	53.585786	-0.839350
D35	53.586251	-0.911823	D86	53.586078	-0.837916
D36	53.585946	-0.910397	D87	53.586373	-0.836483
D37	53.585640	-0.908971	D88	53.586662	-0.835048
D38	53.585339	-0.907543	D89	53.586950	-0.833611
D39	53.585037	-0.906114	D90	53.587240	-0.832176
D40	53.584733	-0.904688	D91	53.587532	-0.830742
D41	53.584433	-0.903258	D92	53.587776	-0.829286
D42	53.584130	-0.901831	D93	53.587822	-0.827777
D43	53.583824	-0.900405	D94	53.587697	-0.826278
D44	53.583518	-0.898980	D95	53.587382	-0.824862
D45	53.583213	-0.897553	D96	53.586989	-0.823498
D46	53.582910	-0.896126	D97	53.586607	-0.822125
D47	53.582611	-0.894696	D98	53.586195	-0.820779
D48	53.582344	-0.893250	D99	53.585799	-0.819423
D49	53.582049	-0.891817	D100	53.585439	-0.818040
D50	53.581748	-0.890389	D101	53.585316	-0.817665

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
D51	53.581444	-0.888962			

Road Receptors along the A18 (road receptors D1 to D101)

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
E1	53.573585	-0.817664	E10	53.581040	-0.820844
E2	53.574485	-0.817680	E11	53.581916	-0.820494
E3	53.575384	-0.817719	E12	53.582791	-0.820142
E4	53.576278	-0.817883	E13	53.583668	-0.819799
E5	53.577073	-0.818559	E14	53.584545	-0.819461
E6	53.577787	-0.819483	E15	53.585423	-0.819129
E7	53.578507	-0.820392	E16	53.586207	-0.819428
E8	53.579276	-0.821167	E17	53.586316	-0.818178
E9	53.580164	-0.821190			

Road Receptors along the A161 (road receptors E1 to E17)

Dwelling Receptor Data

The table below presents the coordinates for the assessed dwelling receptors.

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
1	53.627487	-0.949959	204	53.567488	-0.94792
2	53.627418	-0.950338	205	53.567494	-0.947742
3	53.627337	-0.950283	206	53.566788	-0.948282
4	53.62715	-0.950326	207	53.568068	-0.943722
5	53.626425	-0.948954	208	53.568124	-0.942799
6	53.626243	-0.949689	209	53.567465	-0.941752
7	53.626088	-0.949634	210	53.568572	-0.935329
8	53.625954	-0.949633	211	53.568591	-0.933583
9	53.625865	-0.949655	212	53.568632	-0.933002
10	53.625741	-0.949673	213	53.568835	-0.93186

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
11	53.625636	-0.949694	214	53.562859	-0.91187
12	53.625481	-0.949715	215	53.560193	-0.910165
13	53.625388	-0.949734	216	53.570416	-0.907161
14	53.625257	-0.949763	217	53.569249	-0.90583
15	53.625047	-0.949765	218	53.568266	-0.900838
16	53.624918	-0.949759	219	53.568157	-0.900435
17	53.624817	-0.949768	220	53.569904	-0.899739
18	53.624724	-0.949774	221	53.569919	-0.899426
19	53.624623	-0.949764	222	53.568648	-0.896109
20	53.624493	-0.949746	223	53.567633	-0.897167
21	53.624377	-0.949848	224	53.567152	-0.895415
22	53.624012	-0.949631	225	53.565347	-0.893448
23	53.623741	-0.949613	226	53.566378	-0.891639
24	53.622868	-0.948473	227	53.566373	-0.89113
25	53.622229	-0.948171	228	53.566279	-0.89068
26	53.624175	-0.958338	229	53.566599	-0.890568
27	53.623888	-0.957811	230	53.568224	-0.884846
28	53.623837	-0.957526	231	53.564412	-0.885918
29	53.623775	-0.957199	232	53.563415	-0.883101
30	53.623681	-0.957051	233	53.564389	-0.882152
31	53.623567	-0.956904	234	53.564848	-0.882185
32	53.623463	-0.956802	235	53.564806	-0.88185
33	53.623381	-0.956657	236	53.565017	-0.881419
34	53.623269	-0.956503	237	53.565249	-0.881588
35	53.623182	-0.95636	238	53.565393	-0.881657

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
36	53.623091	-0.956233	239	53.565315	-0.881136
37	53.622991	-0.956104	240	53.565236	-0.880796
38	53.622898	-0.955973	241	53.565061	-0.880351
39	53.622811	-0.955832	242	53.566187	-0.879686
40	53.622688	-0.955665	243	53.56627	-0.877463
41	53.6226	-0.955561	244	53.566742	-0.876622
42	53.622522	-0.955401	245	53.568186	-0.877106
43	53.622423	-0.955261	246	53.57146	-0.854914
44	53.622349	-0.95516	247	53.592111	-0.94026
45	53.62221	-0.954893	248	53.586099	-0.93535
46	53.622053	-0.954726	249	53.588549	-0.920798
47	53.621951	-0.954556	250	53.588464	-0.920378
48	53.621876	-0.954259	251	53.587902	-0.920346
49	53.621673	-0.953954	252	53.587758	-0.918262
50	53.621474	-0.953838	253	53.587723	-0.918031
51	53.621344	-0.953631	254	53.587405	-0.918272
52	53.621258	-0.953374	255	53.587332	-0.917689
53	53.62109	-0.953256	256	53.590399	-0.918255
54	53.620973	-0.953093	257	53.590162	-0.915991
55	53.621557	-0.951942	258	53.58472	-0.918548
56	53.621421	-0.951914	259	53.582401	-0.920222
57	53.621209	-0.952275	260	53.581963	-0.920252
58	53.621069	-0.952204	261	53.581828	-0.920773
59	53.620876	-0.952155	262	53.579825	-0.919771
60	53.620739	-0.9509	263	53.579392	-0.92123

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
61	53.620518	-0.950967	264	53.578035	-0.912798
62	53.620456	-0.950944	265	53.577658	-0.910541
63	53.620361	-0.950919	266	53.58409	-0.904055
64	53.620269	-0.950889	267	53.588913	-0.901859
65	53.620143	-0.950847	268	53.587185	-0.894062
66	53.620054	-0.950815	269	53.583762	-0.88165
67	53.619959	-0.95076	270	53.582858	-0.882109
68	53.619894	-0.950753	271	53.581937	-0.882571
69	53.619824	-0.95073	272	53.579624	-0.879155
70	53.619739	-0.9507	273	53.577811	-0.874508
71	53.619662	-0.95068	274	53.57871	-0.873048
72	53.619593	-0.950655	275	53.579646	-0.86908
73	53.619468	-0.950597	276	53.579746	-0.868623
74	53.619344	-0.950555	277	53.580536	-0.869953
75	53.619172	-0.950398	278	53.586422	-0.868131
76	53.618977	-0.950437	279	53.586839	-0.868344
77	53.618898	-0.950406	280	53.597585	-0.871246
78	53.618768	-0.950359	281	53.599454	-0.86387
79	53.618624	-0.950319	282	53.599145	-0.863472
80	53.618498	-0.95028	283	53.599269	-0.863034
81	53.618308	-0.950056	284	53.600145	-0.866408
82	53.618124	-0.950262	285	53.600338	-0.872024
83	53.620782	-0.936596	286	53.600612	-0.871802
84	53.620845	-0.935855	287	53.600636	-0.87214
85	53.615395	-0.941406	288	53.601636	-0.87658

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
86	53.612937	-0.950213	289	53.601938	-0.87656
87	53.612665	-0.95021	290	53.603757	-0.873244
88	53.611405	-0.949116	291	53.603726	-0.872947
89	53.611345	-0.948686	292	53.621621	-0.854062
90	53.611257	-0.948429	293	53.621332	-0.854268
91	53.611218	-0.948128	294	53.620957	-0.854599
92	53.611036	-0.947447	295	53.619135	-0.854346
93	53.610817	-0.947453	296	53.617078	-0.856171
94	53.610628	-0.947408	297	53.612342	-0.843115
95	53.61048	-0.94738	298	53.613003	-0.84173
96	53.610247	-0.947346	299	53.61302	-0.840559
97	53.610256	-0.947594	300	53.612905	-0.840336
98	53.610279	-0.947874	301	53.612597	-0.840426
99	53.610396	-0.948284	302	53.612521	-0.840075
100	53.610471	-0.948622	303	53.612189	-0.84013
101	53.610534	-0.948878	304	53.612181	-0.839827
102	53.6106	-0.949252	305	53.61197	-0.839569
103	53.606184	-0.949423	306	53.611871	-0.839486
104	53.60613	-0.949143	307	53.611751	-0.839427
105	53.606082	-0.948929	308	53.611603	-0.839379
106	53.606022	-0.948687	309	53.611438	-0.839054
107	53.605988	-0.948481	310	53.611228	-0.838813
108	53.60593	-0.94819	311	53.611029	-0.838618
109	53.605895	-0.947997	312	53.610711	-0.838819
110	53.605848	-0.947756	313	53.610435	-0.838757

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
111	53.605801	-0.947517	314	53.610282	-0.838684
112	53.605745	-0.94728	315	53.610157	-0.83865
113	53.605689	-0.94703	316	53.609996	-0.838626
114	53.60547	-0.947317	317	53.609793	-0.8384
115	53.605365	-0.947118	318	53.609709	-0.838207
116	53.605194	-0.94721	319	53.60954	-0.83827
117	53.605093	-0.947277	320	53.60944	-0.838158
118	53.604877	-0.947375	321	53.609306	-0.838136
119	53.604427	-0.947688	322	53.609172	-0.838177
120	53.604327	-0.947742	323	53.608983	-0.838168
121	53.604264	-0.947785	324	53.608821	-0.838198
122	53.604206	-0.94786	325	53.608695	-0.838242
123	53.604133	-0.947867	326	53.608692	-0.8384
124	53.604036	-0.948005	327	53.608675	-0.838697
125	53.603926	-0.948079	328	53.608541	-0.839023
126	53.603814	-0.948153	329	53.608265	-0.838869
127	53.60313	-0.950333	330	53.608185	-0.838508
128	53.602871	-0.950321	331	53.608021	-0.838518
129	53.602781	-0.950508	332	53.607852	-0.838457
130	53.602648	-0.950542	333	53.607695	-0.838481
131	53.602543	-0.950398	334	53.607562	-0.838423
132	53.602455	-0.950411	335	53.607423	-0.838423
133	53.602287	-0.95043	336	53.607295	-0.838366
134	53.602196	-0.950456	337	53.607121	-0.838395
135	53.602075	-0.950453	338	53.606955	-0.838273

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
136	53.60198	-0.950556	339	53.606724	-0.838227
137	53.601833	-0.950442	340	53.606575	-0.838202
138	53.601451	-0.950419	341	53.606433	-0.838206
139	53.60132	-0.949899	342	53.606315	-0.838168
140	53.601116	-0.950639	343	53.606147	-0.838148
141	53.601131	-0.950894	344	53.60599	-0.838186
142	53.601155	-0.951256	345	53.605931	-0.838439
143	53.601171	-0.951581	346	53.605904	-0.838692
144	53.601186	-0.951743	347	53.605878	-0.839003
145	53.601188	-0.952129	348	53.605863	-0.839301
146	53.601217	-0.952364	349	53.605747	-0.839552
147	53.600555	-0.952315	350	53.605685	-0.839925
148	53.613241	-0.944847	351	53.605512	-0.8399
149	53.612902	-0.944701	352	53.605339	-0.839645
150	53.612181	-0.943855	353	53.605161	-0.839556
151	53.611582	-0.943372	354	53.604818	-0.839189
152	53.609653	-0.941401	355	53.60449	-0.838763
153	53.609439	-0.941237	356	53.604354	-0.839123
154	53.608938	-0.938809	357	53.604222	-0.839399
155	53.606841	-0.939052	358	53.604149	-0.839517
156	53.606383	-0.938514	359	53.604077	-0.839704
157	53.605541	-0.937075	360	53.603972	-0.839957
158	53.60529	-0.936651	361	53.603698	-0.839965
159	53.60504	-0.936215	362	53.603288	-0.839569
160	53.604383	-0.93518	363	53.602492	-0.843403

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
161	53.604073	-0.934499	364	53.602252	-0.839368
162	53.60347	-0.934294	365	53.602055	-0.838881
163	53.602958	-0.932353	366	53.601858	-0.838596
164	53.602507	-0.931957	367	53.601758	-0.838669
165	53.601581	-0.929787	368	53.60165	-0.838627
166	53.603488	-0.941829	369	53.601527	-0.838437
167	53.60218	-0.942042	370	53.601406	-0.838671
168	53.600324	-0.942885	371	53.60128	-0.83887
169	53.596728	-0.929969	372	53.601164	-0.839104
170	53.594645	-0.953975	373	53.601113	-0.839338
171	53.594261	-0.946691	374	53.600944	-0.839641
172	53.5939	-0.947036	375	53.600846	-0.839854
173	53.590462	-0.959515	376	53.600699	-0.839981
174	53.590129	-0.960871	377	53.600575	-0.840228
175	53.583816	-0.963368	378	53.600448	-0.840427
176	53.583212	-0.966555	379	53.600225	-0.840932
177	53.58143	-0.965725	380	53.600099	-0.841415
178	53.581293	-0.965854	381	53.599707	-0.840766
179	53.581162	-0.96603	382	53.598581	-0.840982
180	53.581019	-0.966254	383	53.597453	-0.846411
181	53.58091	-0.966445	384	53.595876	-0.848598
182	53.580784	-0.966679	385	53.59545	-0.849317
183	53.58029	-0.967482	386	53.594659	-0.850508
184	53.581221	-0.967061	387	53.594818	-0.850554
185	53.581033	-0.967493	388	53.594964	-0.851118

No.	Latitude (°)	Longitude (°)	No.	Latitude (°)	Longitude (°)
186	53.580873	-0.967845	389	53.595086	-0.851464
187	53.580722	-0.968236	390	53.59542	-0.852178
188	53.580595	-0.968508	391	53.595927	-0.852972
189	53.580327	-0.969302	392	53.589685	-0.835693
190	53.578875	-0.96942	393	53.590679	-0.827489
191	53.578661	-0.969651	394	53.586182	-0.820038
192	53.577733	-0.970705	395	53.581343	-0.819886
193	53.577496	-0.970314	396	53.58278	-0.825954
194	53.577219	-0.969444	397	53.578964	-0.820583
195	53.574985	-0.968794	398	53.576121	-0.818353
196	53.573432	-0.967308	399	53.572075	-0.821233
197	53.573195	-0.959762	400	53.571302	-0.821599
198	53.573676	-0.958976	401	53.573038	-0.830721
199	53.57844	-0.945004	402	53.607777	-0.842217
200	53.577818	-0.945956	403	53.607445	-0.842881
201	53.572032	-0.939857	404	53.606738	-0.842223
202	53.567266	-0.951046	405	53.606611	-0.843204
203	53.567449	-0.948205			

Dwelling Receptor Data

Railway Signal Receptor Data

The railway signal data is presented in the table below. An additional 3.3m height has been added to the ground elevation to account for the height of trackside signals.

Reference	Latitude (°)	Longitude (°)	Assessed Height (m agl)
S1	53.603033	-0.926549	3.3
S2	53.601738	-0.908733	3.3

Reference	Latitude (°)	Longitude (°)	Assessed Height (m agl)
S3	53.601044	-0.890883	3.3
S4	53.601638	-0.873138	3.3
S5	53.598426	-0.854767	3.3
S6	53.601584	-0.862735	3.3
S7	53.601051	-0.88005	3.3
S8	53.601224	-0.897835	3.3
S9	53.601913	-0.915459	3.3
S10	53.603548	-0.933173	3.3

Railway Signal Data

Train Driver Receptor Data

The table below presents the coordinates for the assessed train driver receptors. An additional 2.75m height has been added to the ground elevation at each point to account for the eye-level of a train operator.

Receptor	Latitude (°)	Longitude (°)
A1	53.603608	-0.943226
A2	53.603656	-0.941711
A3	53.603686	-0.940196
A4	53.603711	-0.93868
A5	53.603722	-0.937164
A6	53.603692	-0.935648
A7	53.603649	-0.934133
A8	53.60354	-0.932627
A9	53.603405	-0.931128
A10	53.603265	-0.92963
A11	53.603126	-0.928131

Receptor	Latitude (°)	Longitude (°)
A12	53.602983	-0.926634
A13	53.602852	-0.925134
A14	53.602711	-0.923636
A15	53.60257	-0.922138
A16	53.602427	-0.92064
A17	53.602285	-0.919143
A18	53.602145	-0.917645
A19	53.602005	-0.916147
A20	53.601906	-0.914639
A21	53.601847	-0.913126
A22	53.601795	-0.911612
A23	53.601742	-0.910098
A24	53.601688	-0.908584
A25	53.601632	-0.907071
A26	53.601564	-0.905559
A27	53.601507	-0.904045
A28	53.601448	-0.902532
A29	53.60139	-0.901018
A30	53.60133	-0.899505
A31	53.601271	-0.897992
A32	53.601211	-0.896479
A33	53.60115	-0.894966
A34	53.60109	-0.893452
A35	53.601031	-0.891939

Receptor	Latitude (°)	Longitude (°)
A36	53.600971	-0.890426
A37	53.600913	-0.888913
A38	53.600855	-0.887399
A39	53.600805	-0.885885
A40	53.600778	-0.88437
A41	53.600881	-0.882864
A42	53.600984	-0.881357
A43	53.60111	-0.879856
A44	53.601146	-0.879466
B1	53.601514	-0.874383
B2	53.601603	-0.872873
B3	53.601699	-0.871366
B4	53.601798	-0.869858
B5	53.601874	-0.868347
B6	53.601920	-0.866833
B7	53.601908	-0.865320
B8	53.601762	-0.863824
B9	53.601544	-0.862353
B10	53.601252	-0.860919
B11	53.600870	-0.859552
B12	53.600369	-0.858293
B13	53.599826	-0.857087
B14	53.599218	-0.855968
B15	53.598537	-0.854977

Receptor	Latitude (°)	Longitude (°)
B16	53.597838	-0.854025
B17	53.597123	-0.853104
B18	53.596418	-0.852160
B19	53.595825	-0.851026
B20	53.595405	-0.850159

Train Driver Receptor Data

Sensitive Viewpoints Receptor Data

The table below presents the coordinates for the assessed viewpoint receptors.

Location	Latitude (°)	Longitude (°)
1	53.625395	-0.945674
2	53.628085	-0.925722
3	53.608002	-0.933517
4	53.608429	-0.901191
5	53.601555	-0.914305
6	53.600706	-0.879676
7	53.597851	-0.936265
8	53.593593	-0.947719
9	53.586698	-0.963133
10	53.579518	-0.963339
11	53.573171	-0.962226
12	53.568052	-0.937074
13	53.588376	-0.922061
14	53.58135	-0.919475
15	53.575792	-0.922094
16	53.581147	-0.887504

Location	Latitude (°)	Longitude (°)
17	53.580587	-0.885253
18	53.566584	-0.891208
19	53.597626	-0.87338
20	53.604087	-0.868342
21	53.616083	-0.84911
22	53.606785	-0.844103
23	53.570884	-0.876175
24	53.581992	-0.855096
25	53.58623	-0.834104
26	53.576961	-0.830251
27	53.602494	-0.939851
28	53.59979	-0.924838
29	53.598632	-0.856188
30	53.591221	-0.838016
31	53.601203	-0.931073
32	53.613801	-0.852059
33	53.61072	-0.84853

Sensitive Viewpoint Receptor Data

Sandtoft Airfield Runway Details

The table below presents the assessed runway details for Sandtoft Airfield. Full receptor details can be provided upon request.

Runway	Longitude (°)	Latitude (°)	Threshold Altitude (m) (amsl)
05	-0.862981	53.556931	3
23	-0.853826	53.562517	4

Runway details for Sandtoft Airfield

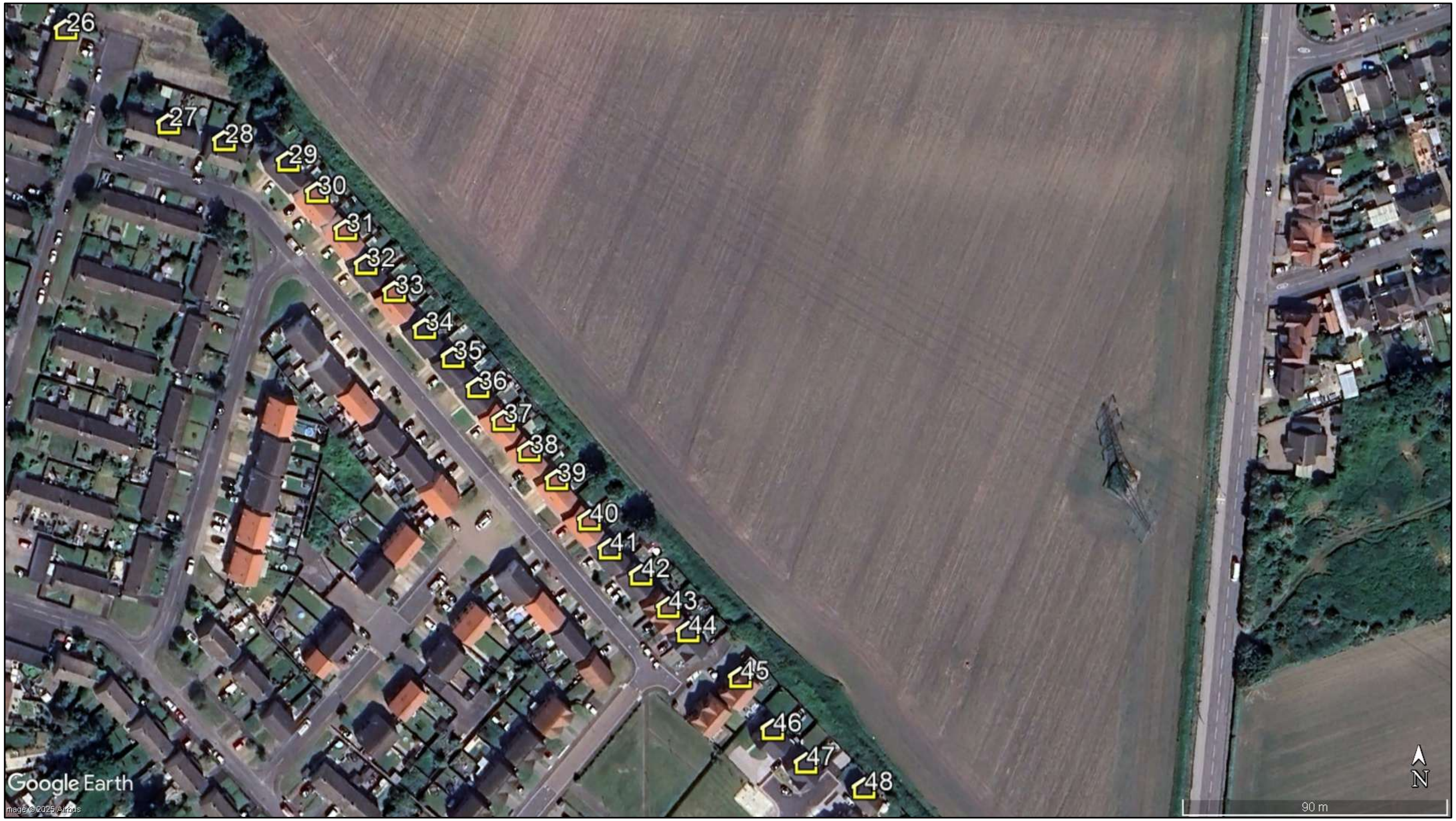
APPENDIX H – DETAILED IDENTIFICATION OF DWELLING RECEPTORS

Dwelling receptors are shown in detail in the following figures.

Dwelling receptors 1 to 4 – aerial image

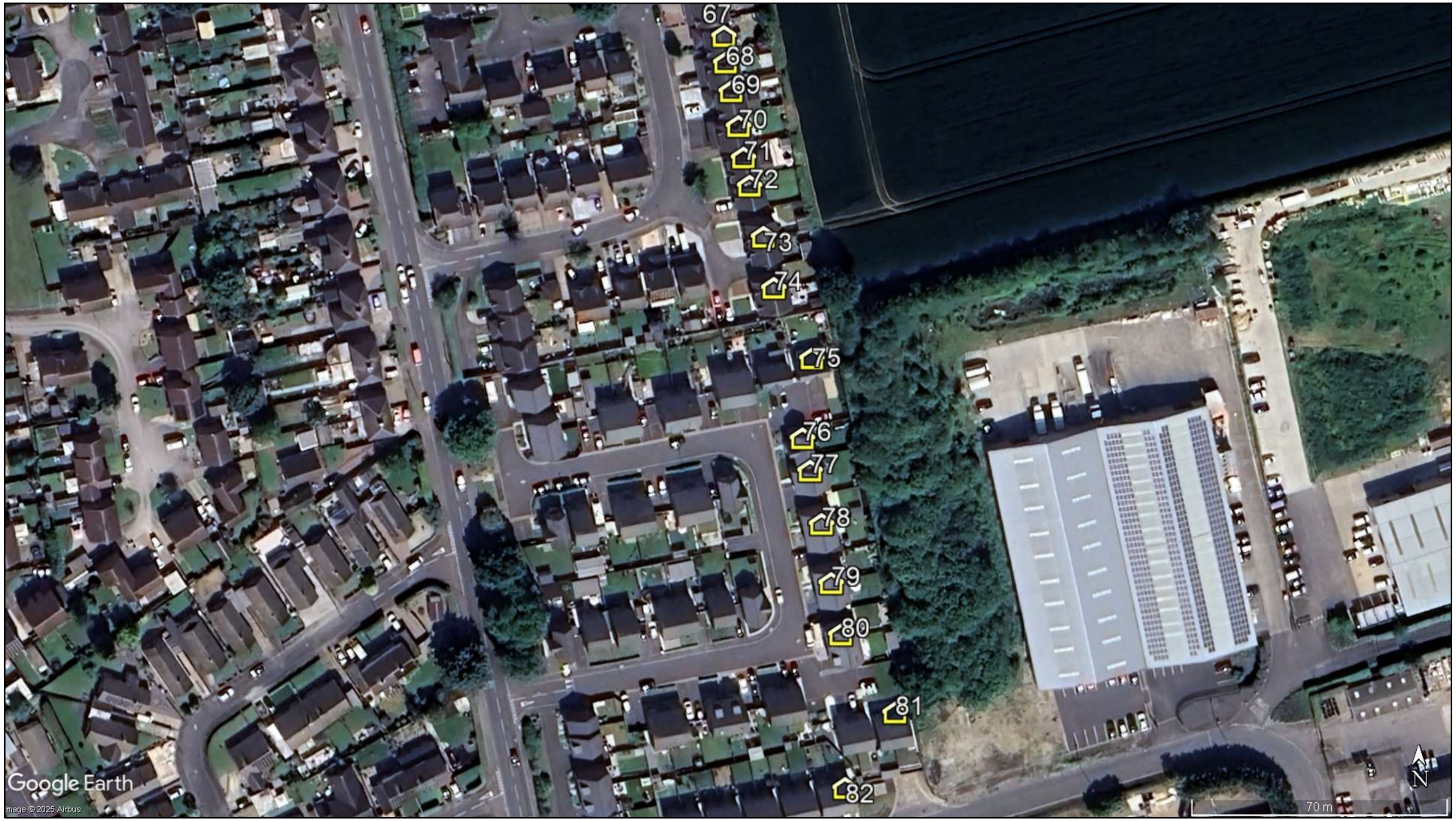
Dwelling receptors 5 to 21 – aerial image

Dwelling receptors 22 to 25 – aerial image



Dwelling receptors 26 to 48 – aerial image

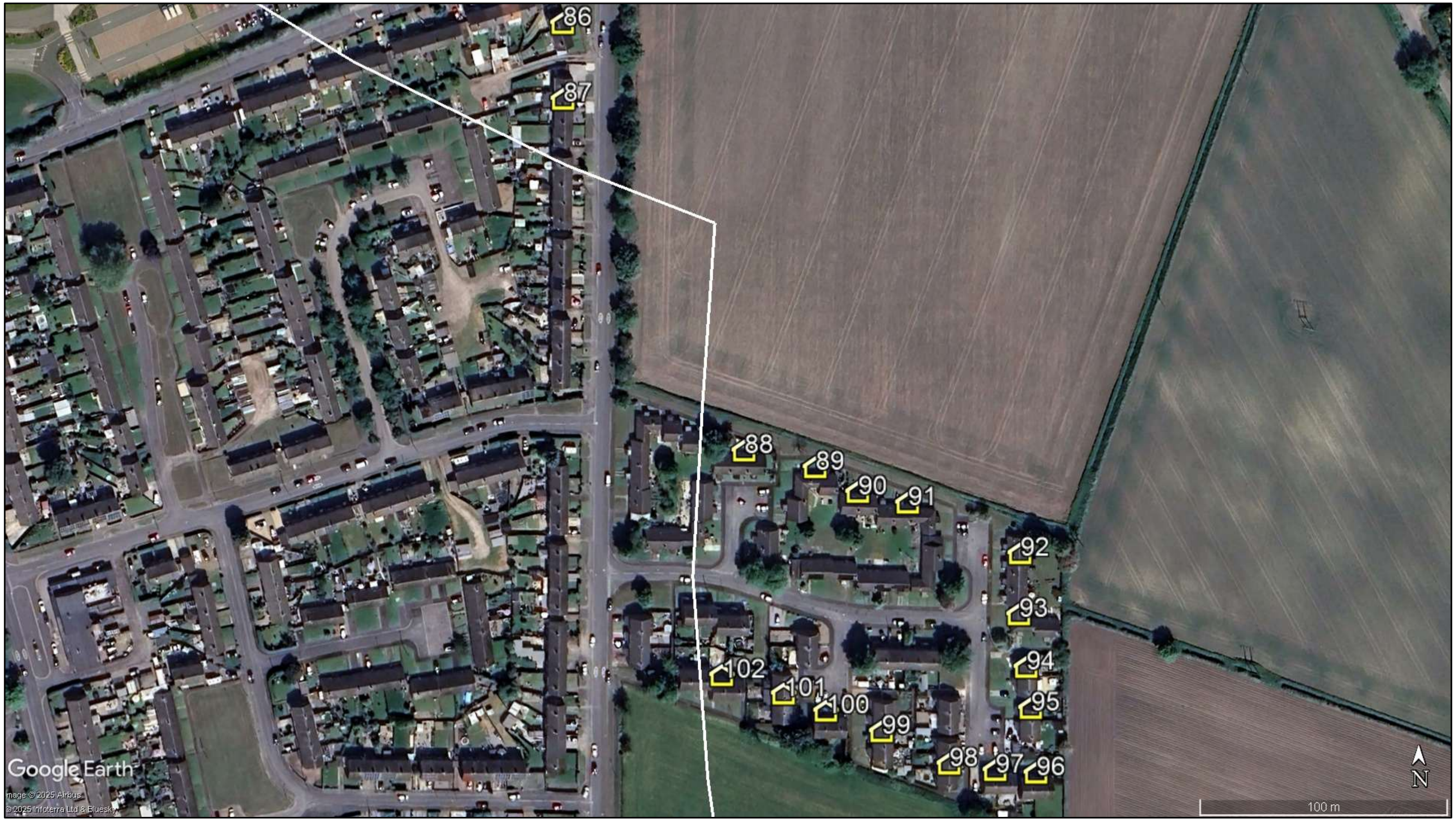
Dwelling receptors 49 to 66 – aerial image



Dwelling receptors 67 to 82 – aerial image

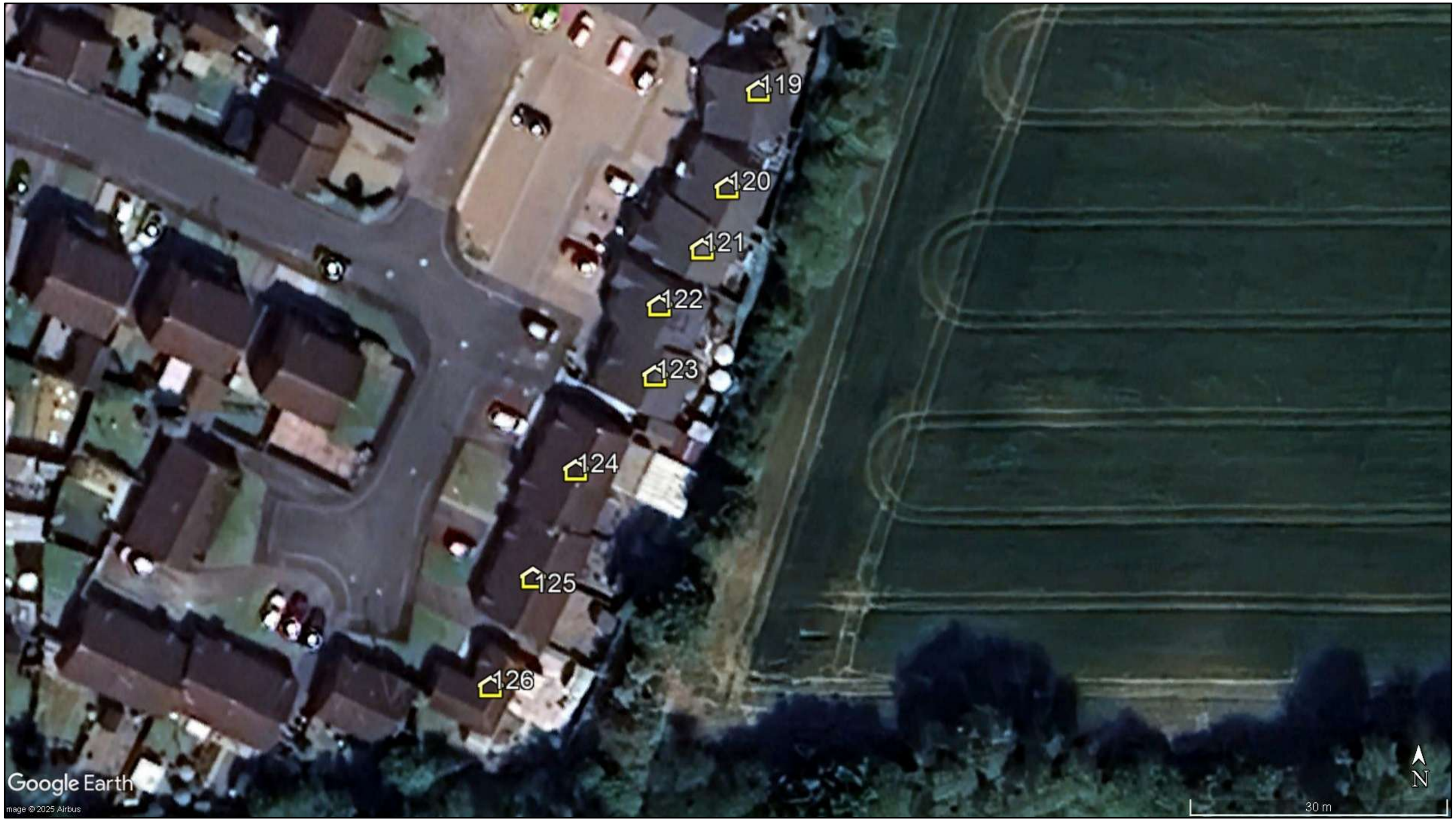
Dwelling receptors 83 and 84 – aerial image

Dwelling receptor 85 – aerial image



Dwelling receptors 86 to 102 – aerial image

Dwelling receptors 103 to 118 – aerial image



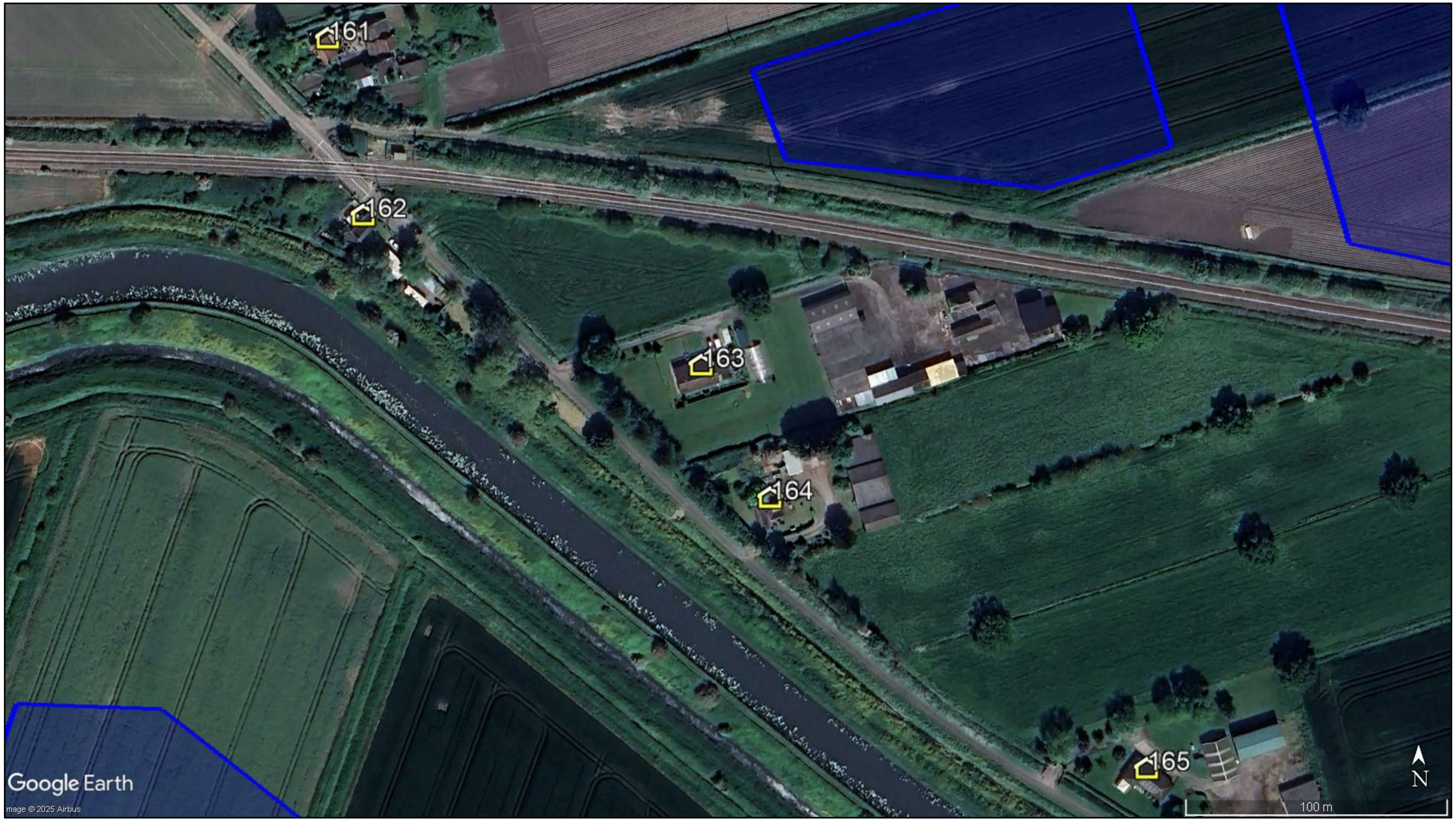
Dwelling receptors 119 to 126 – aerial image

Dwelling receptor 127 – aerial image

Dwelling receptors 128 to 147 – aerial image

Dwelling receptors 148 to 154 – aerial image

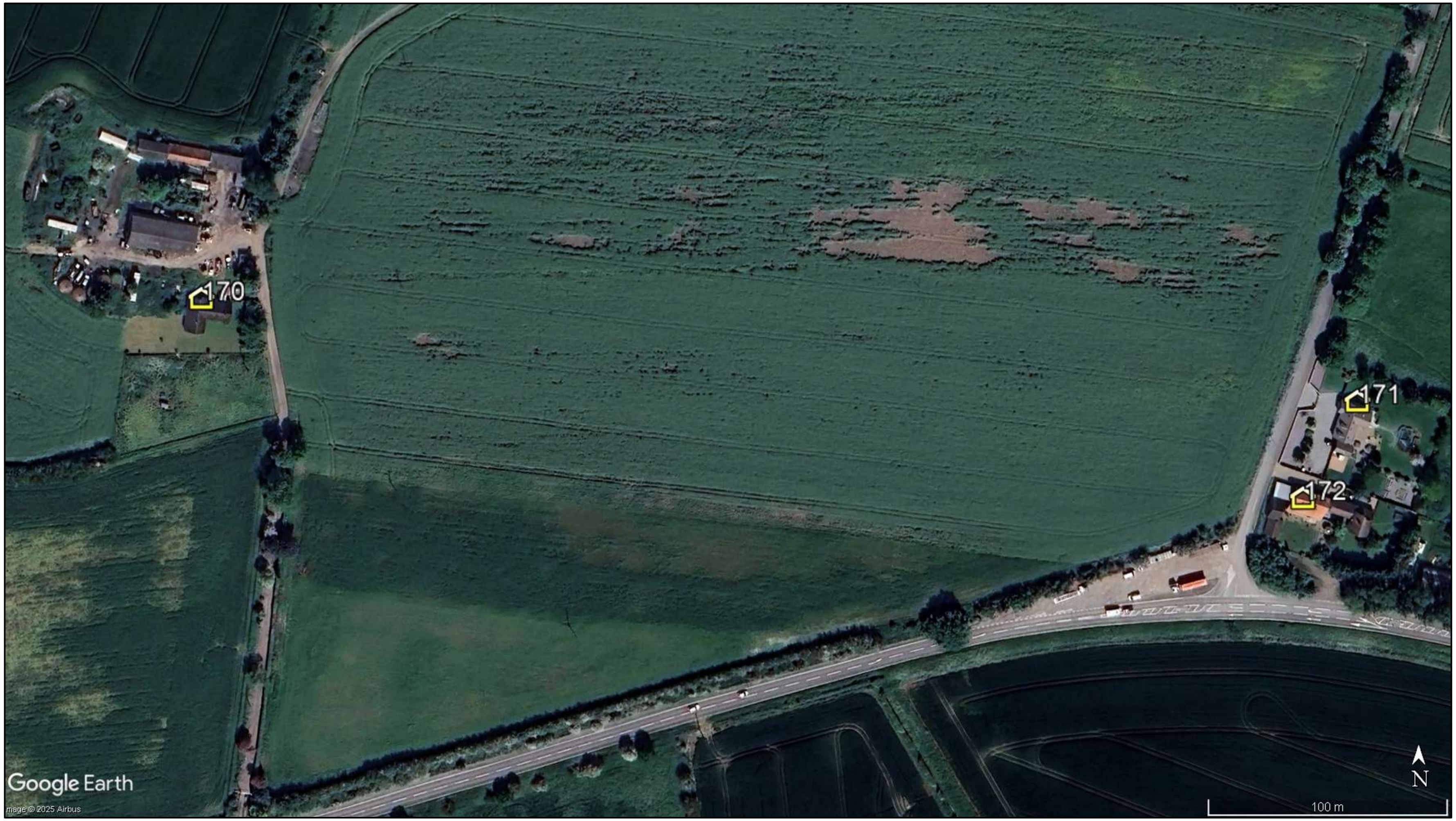
Dwelling receptors 155 to 160 – aerial image



Dwelling receptors 161 to 165 – aerial image

Dwelling receptors 166 to 168 – aerial image

Dwelling receptor 169 – aerial image



Dwelling receptors 170 to 172 – aerial image

Dwelling receptors 173 and 174 – aerial image

Dwelling receptors 175 and 176 – aerial image

Dwelling receptors 177 to 189 – aerial image

Dwelling receptors 190 to 194 – aerial image

Dwelling receptors 195 and 196 – aerial image

Dwelling receptors 197 and 198 – aerial image

Dwelling receptors 199 and 200 – aerial image

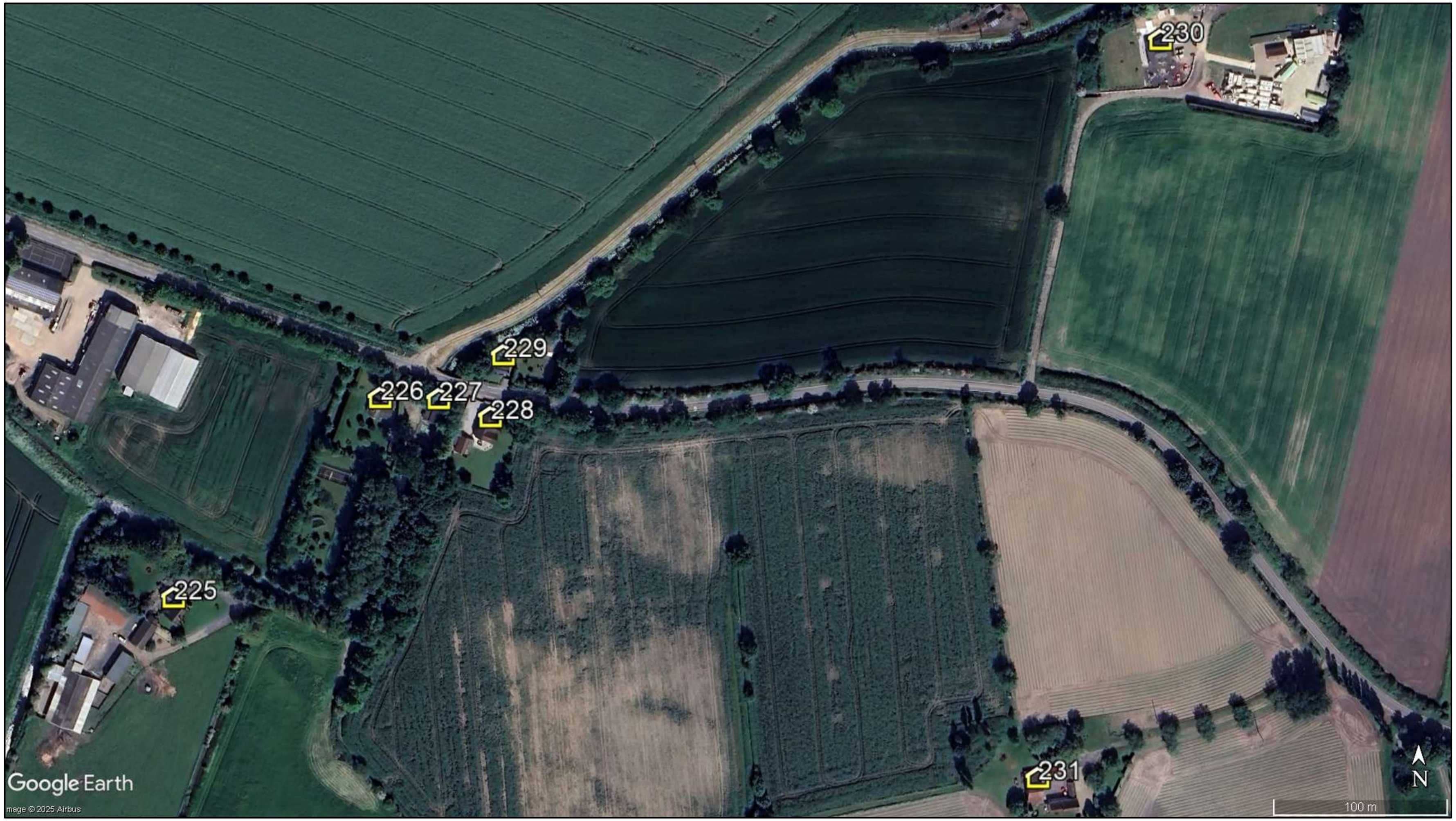
Dwelling receptor 201 – aerial image

Dwelling receptors 202 to 206 – aerial image

Dwelling receptors 207 to 213 – aerial image

Dwelling receptors 214 and 215 – aerial image

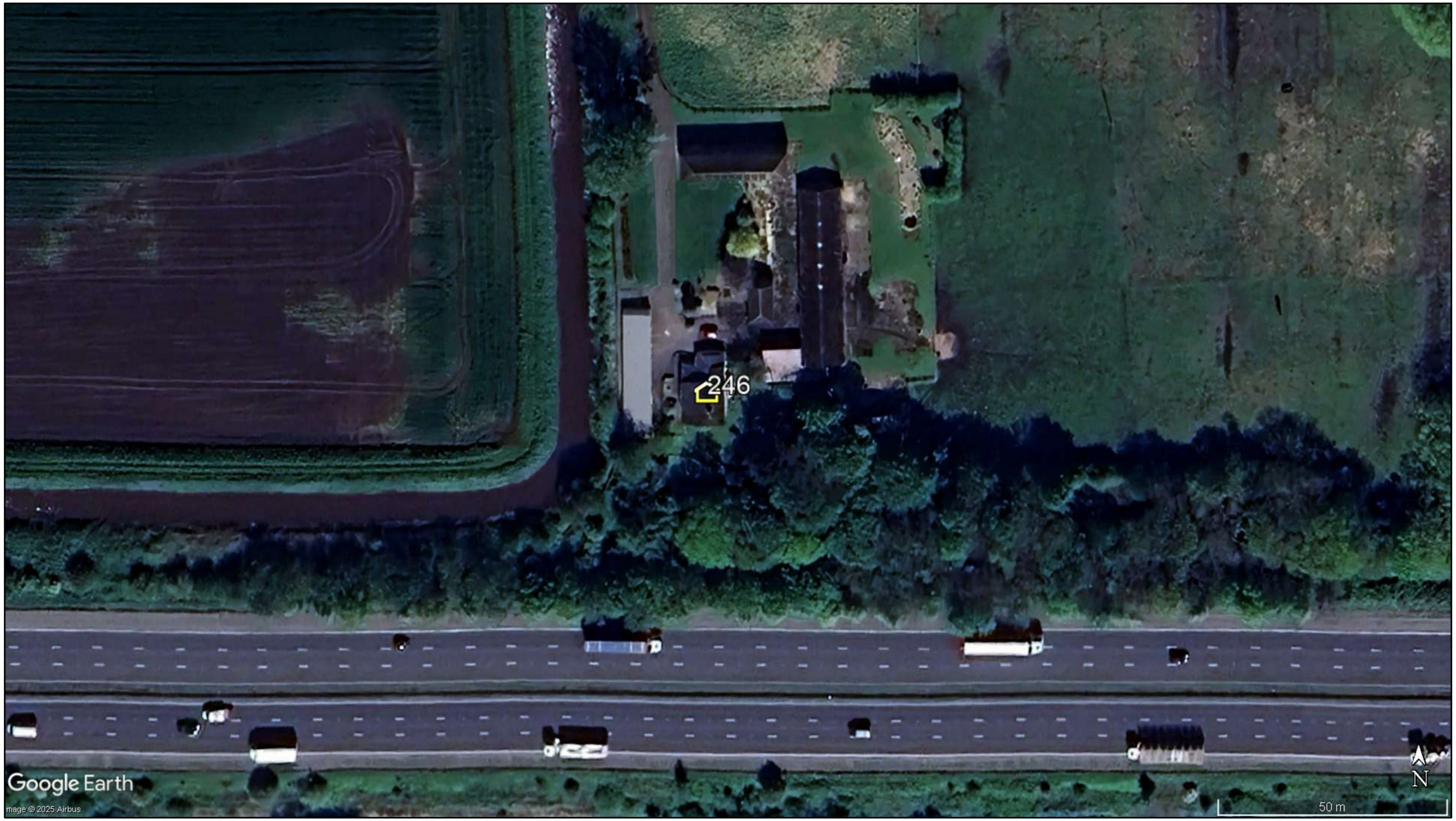
Dwelling receptors 216 to 224 – aerial image



Dwelling receptors 225 to 231 – aerial image

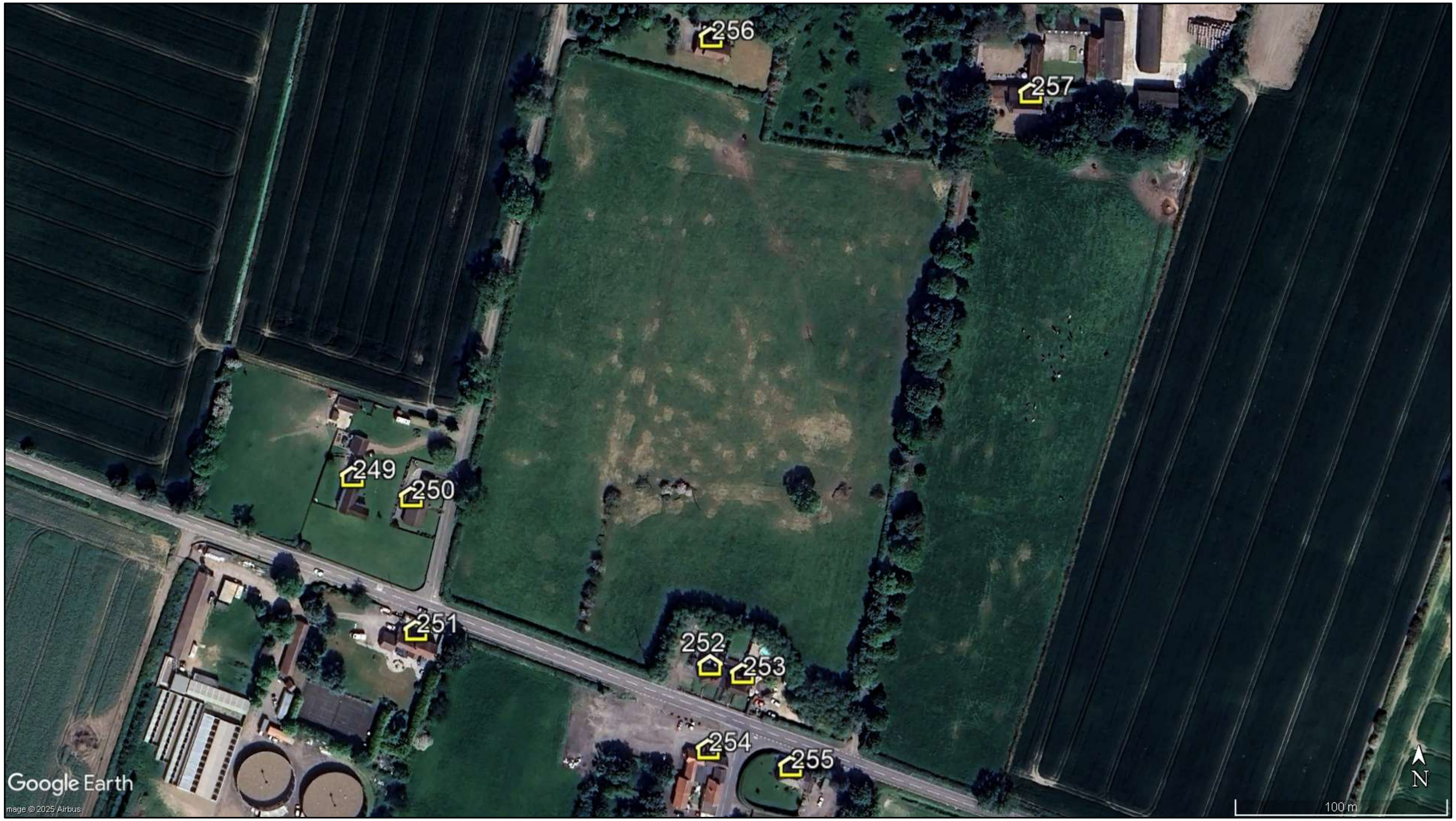
Dwelling receptors 232 to 241 – aerial image

Dwelling receptors 242 to 245 – aerial image

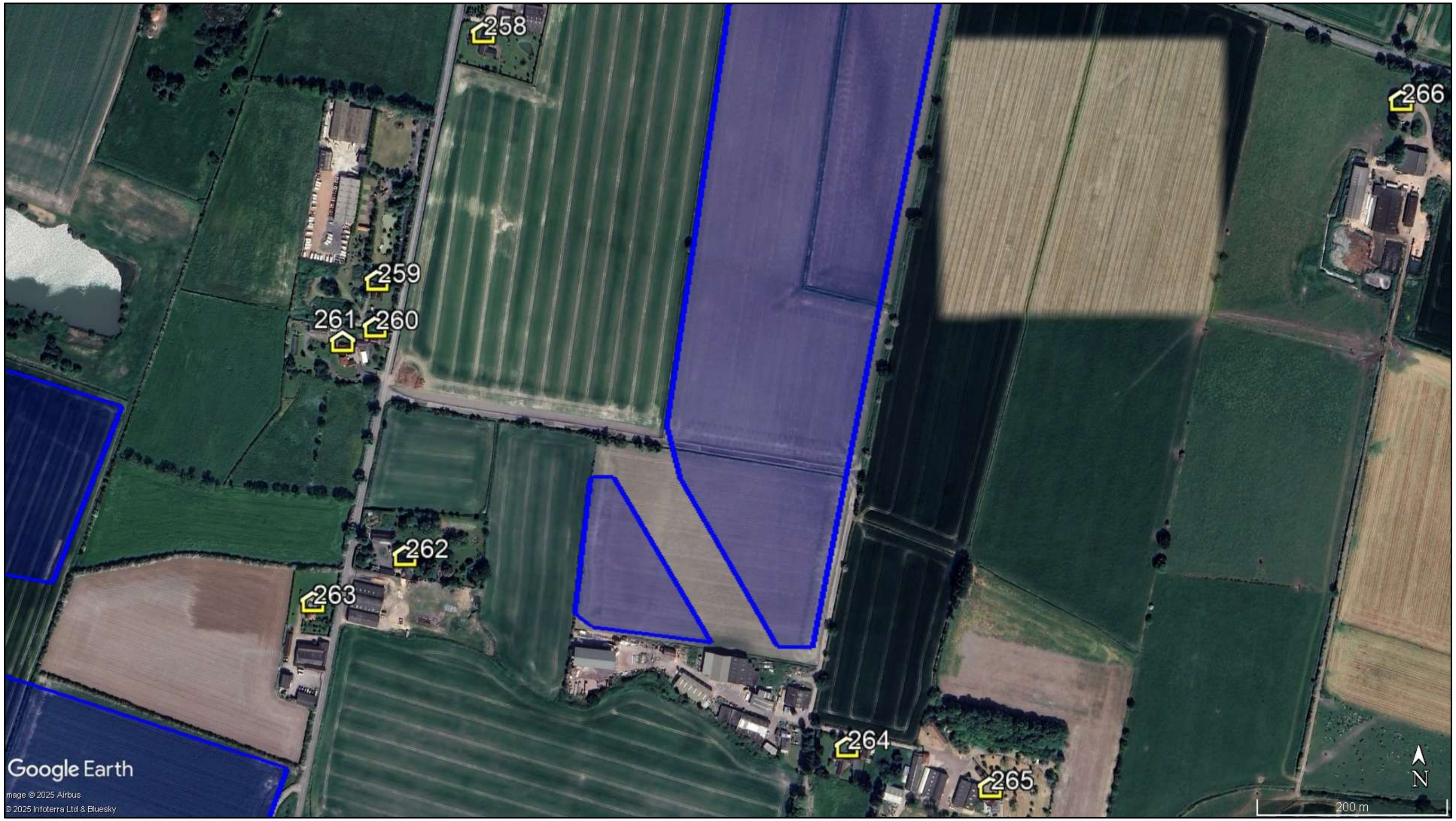


Dwelling receptor 246 – aerial image

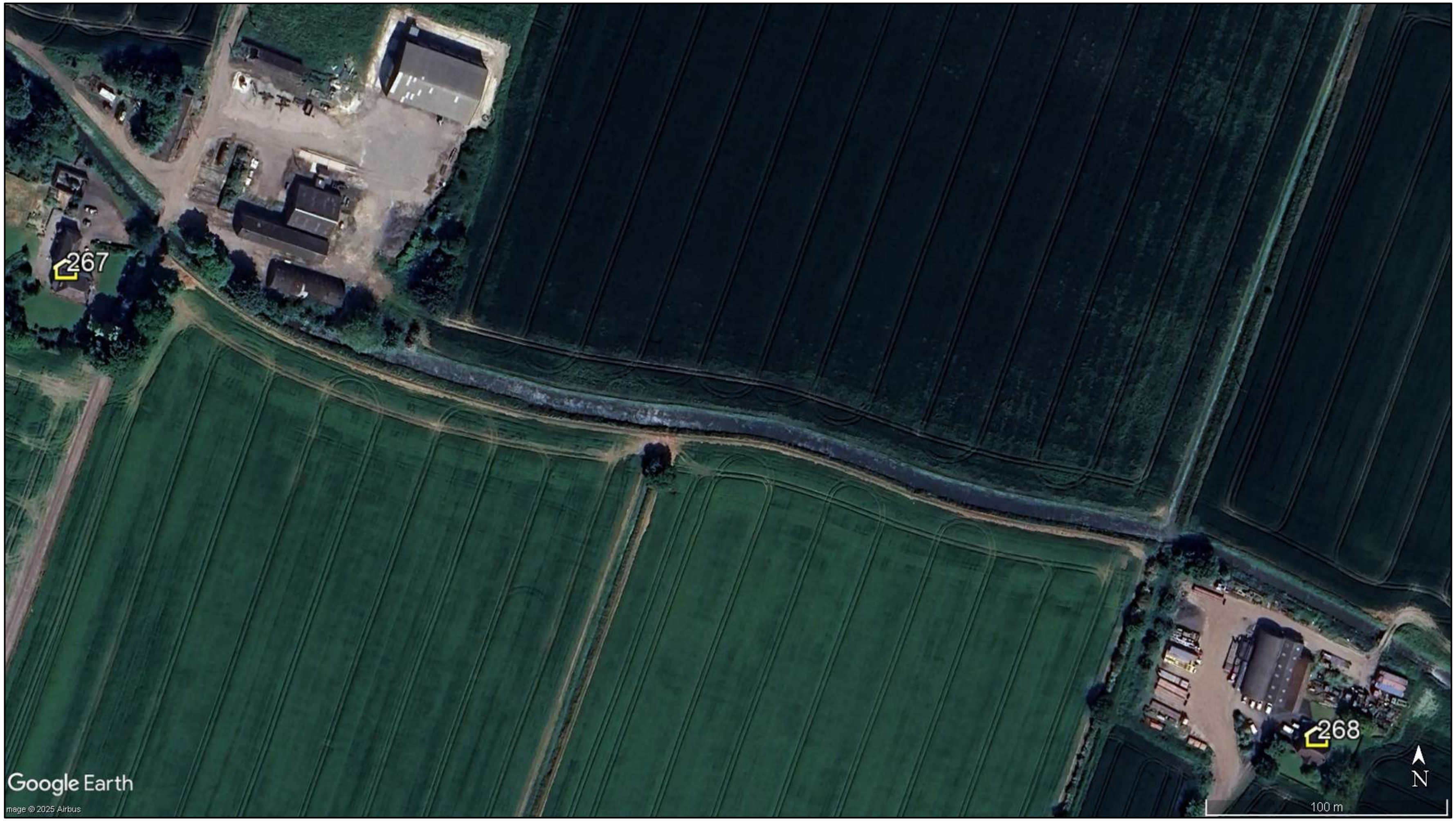
Dwelling receptors 247 and 248 – aerial image



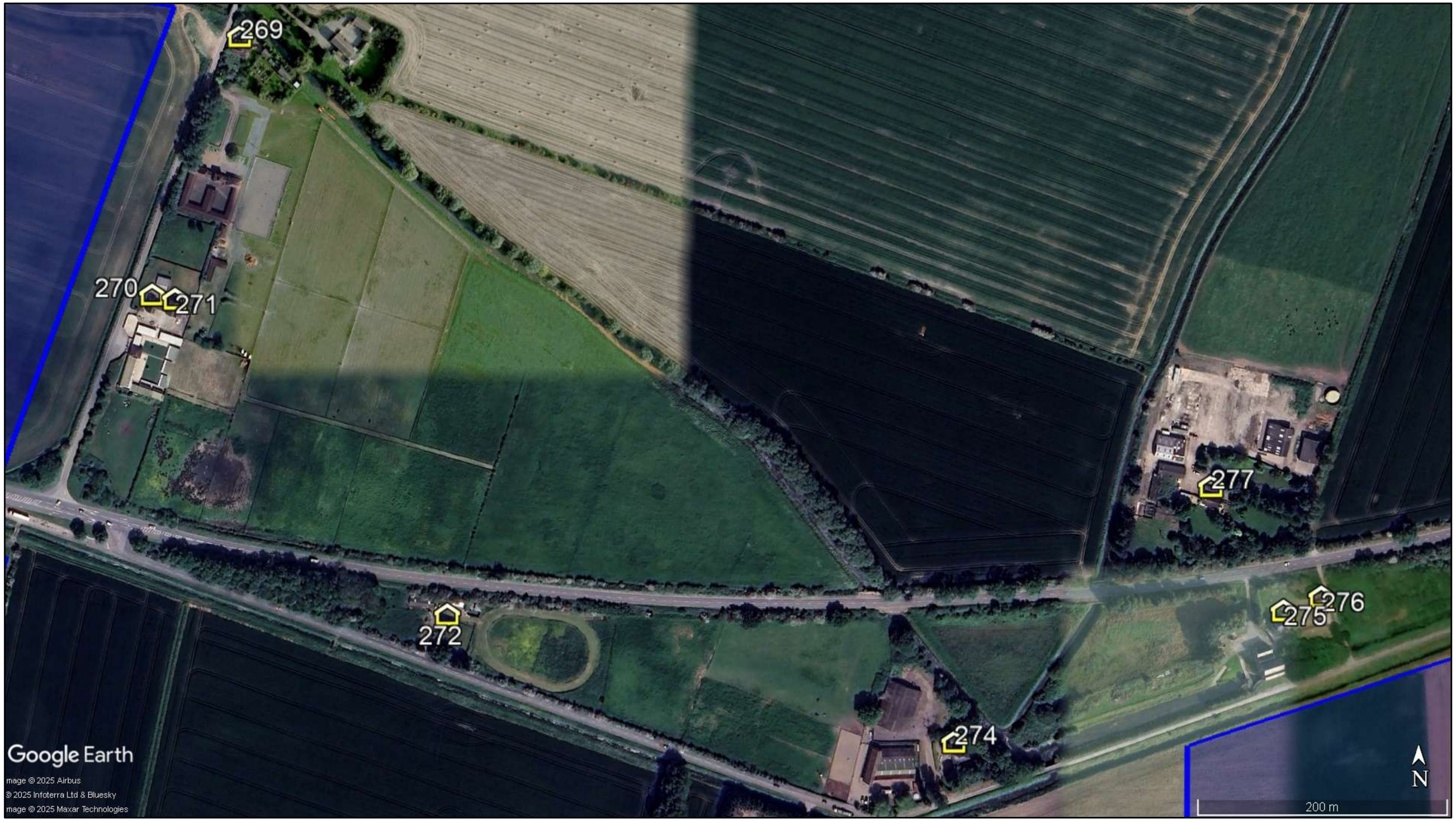
Dwelling receptors 249 to 257 – aerial image



Dwelling receptors 258 to 266 – aerial image



Dwelling receptors 267 and 268 – aerial image

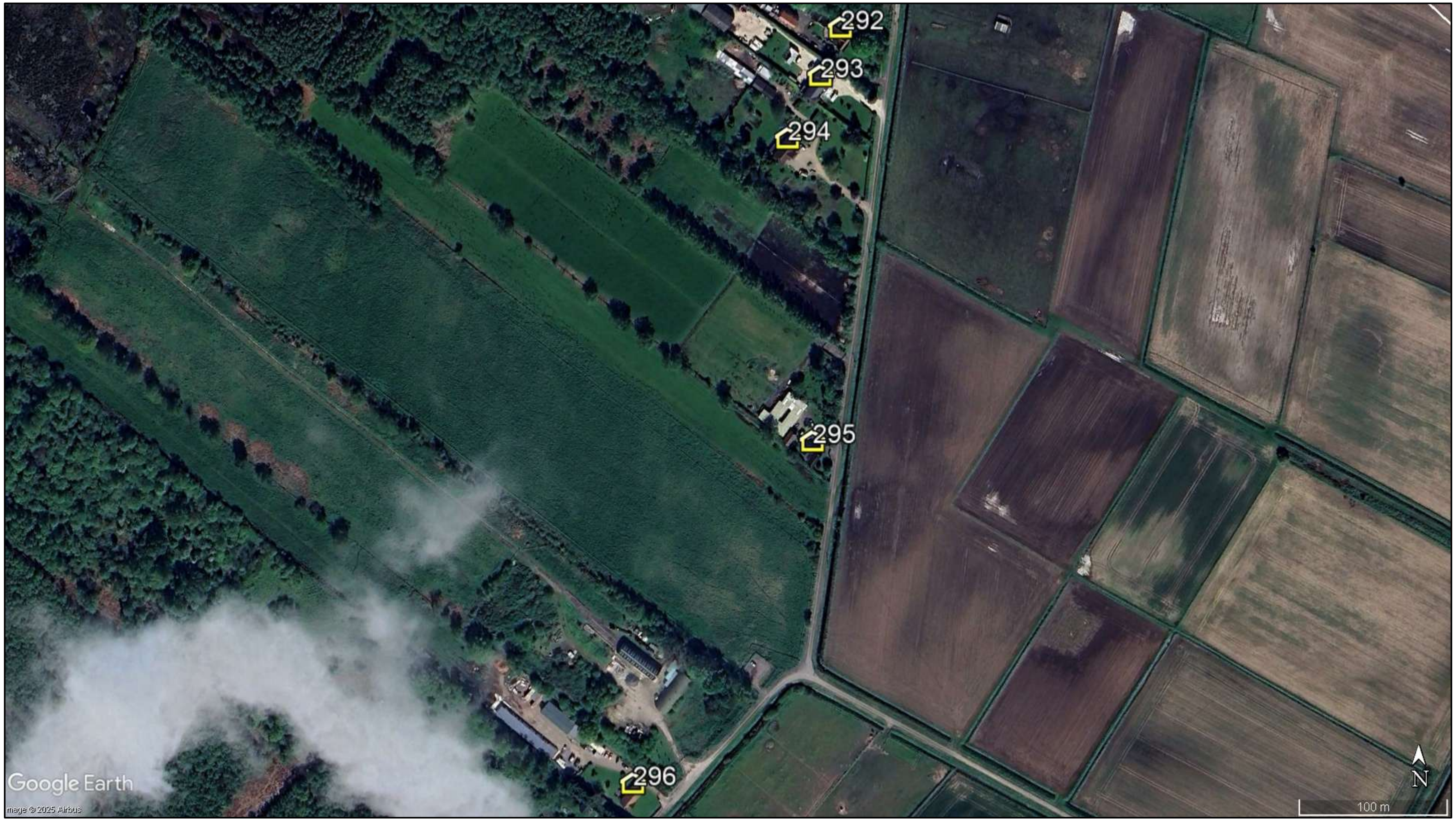


Dwelling receptors 269 to 277 – aerial image

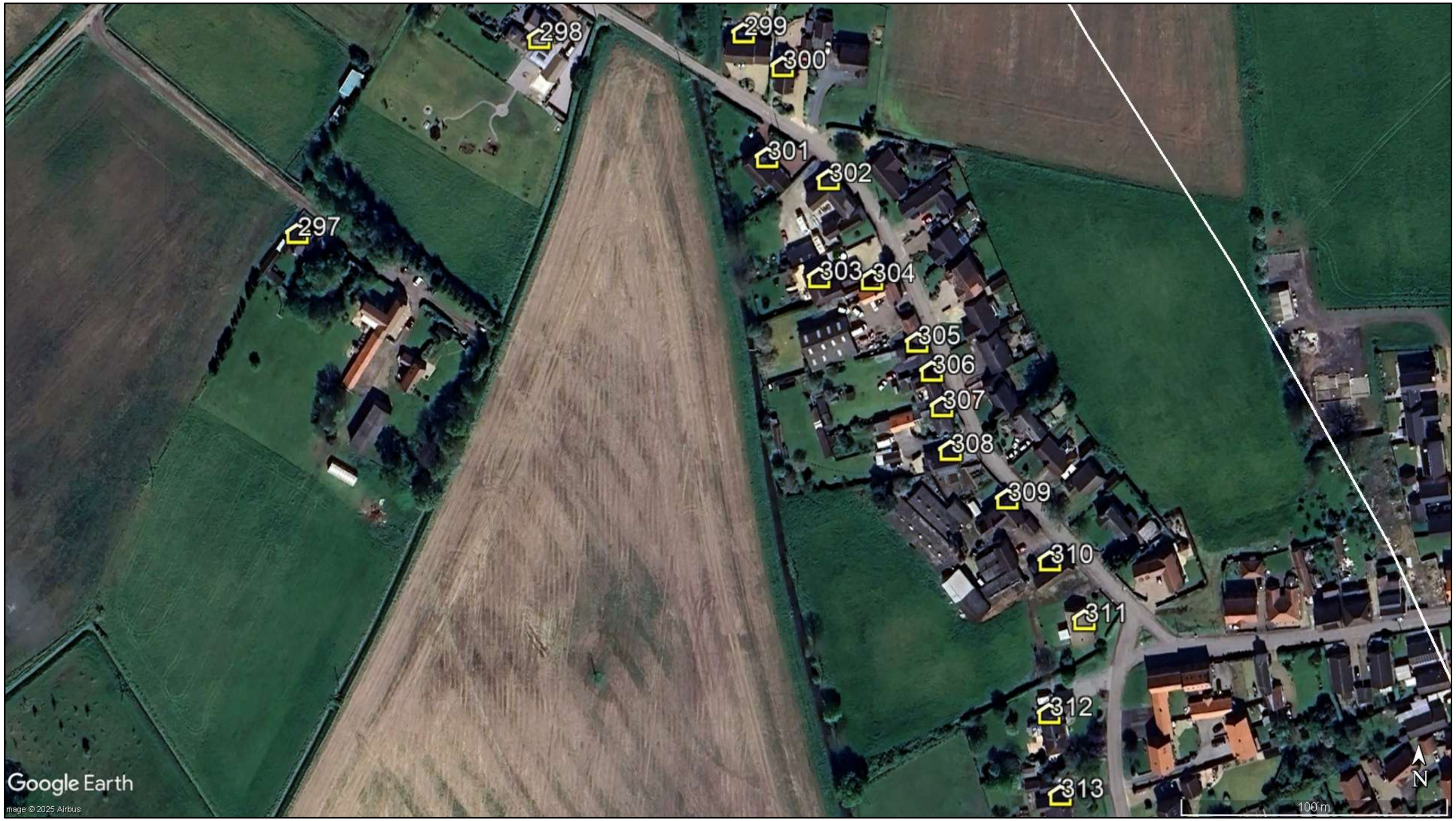
Dwelling receptors 278 and 279 – aerial image

Dwelling receptors 280 to 287 – aerial image

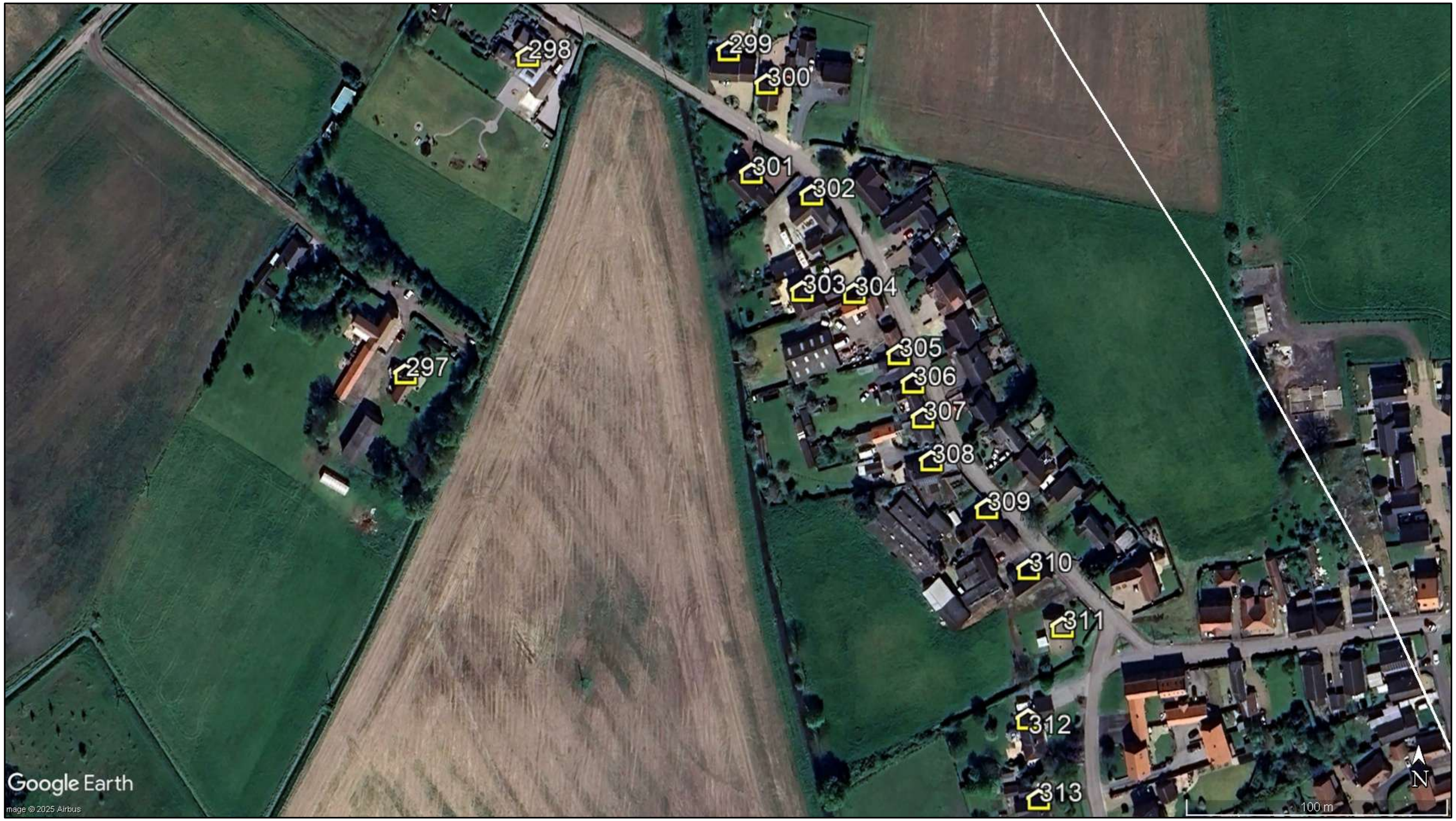
Dwelling receptors 288 to 291 – aerial image



Dwelling receptors 292 to 296 – aerial image

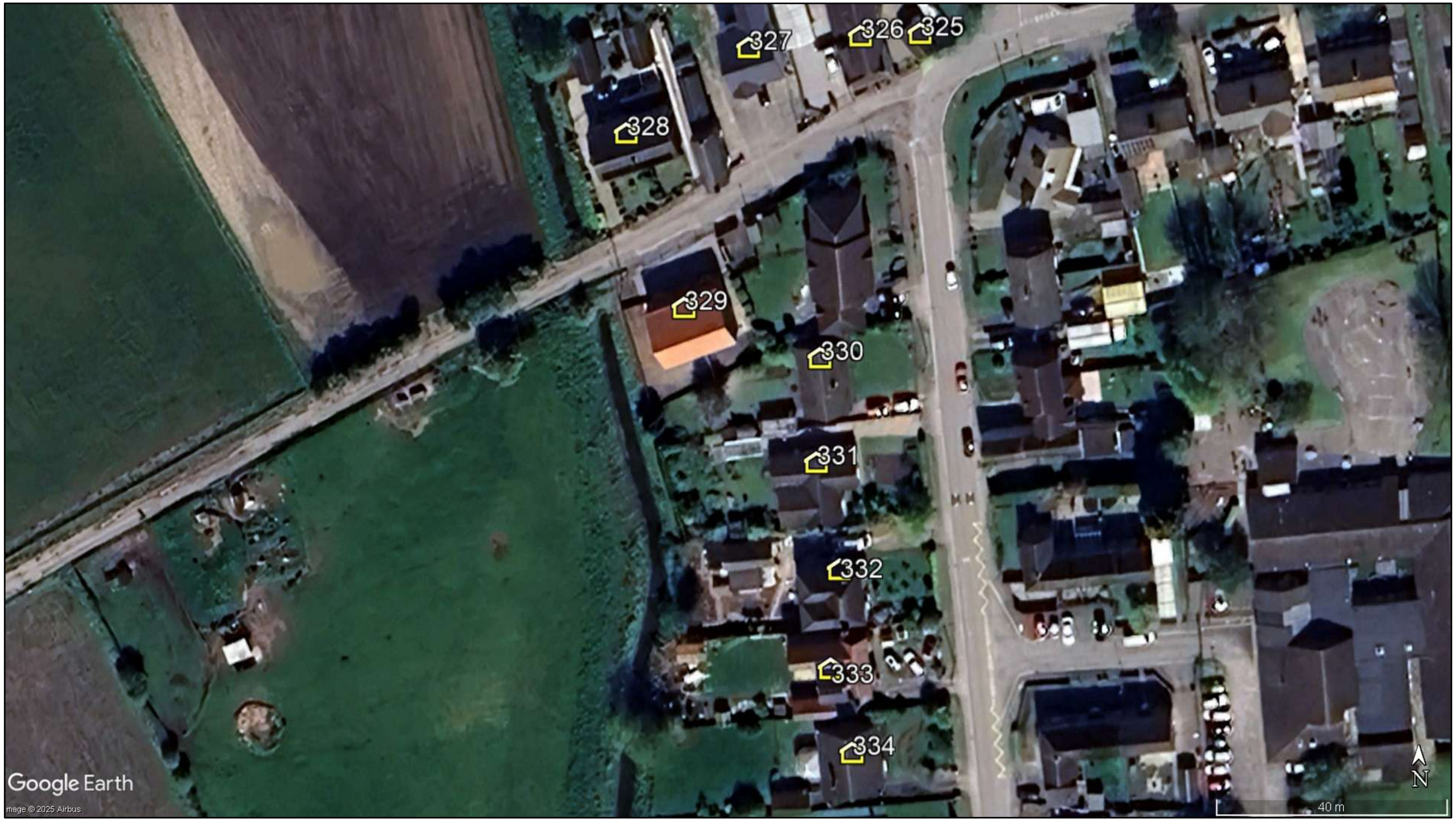


Dwelling receptors 297 to 313 – aerial image



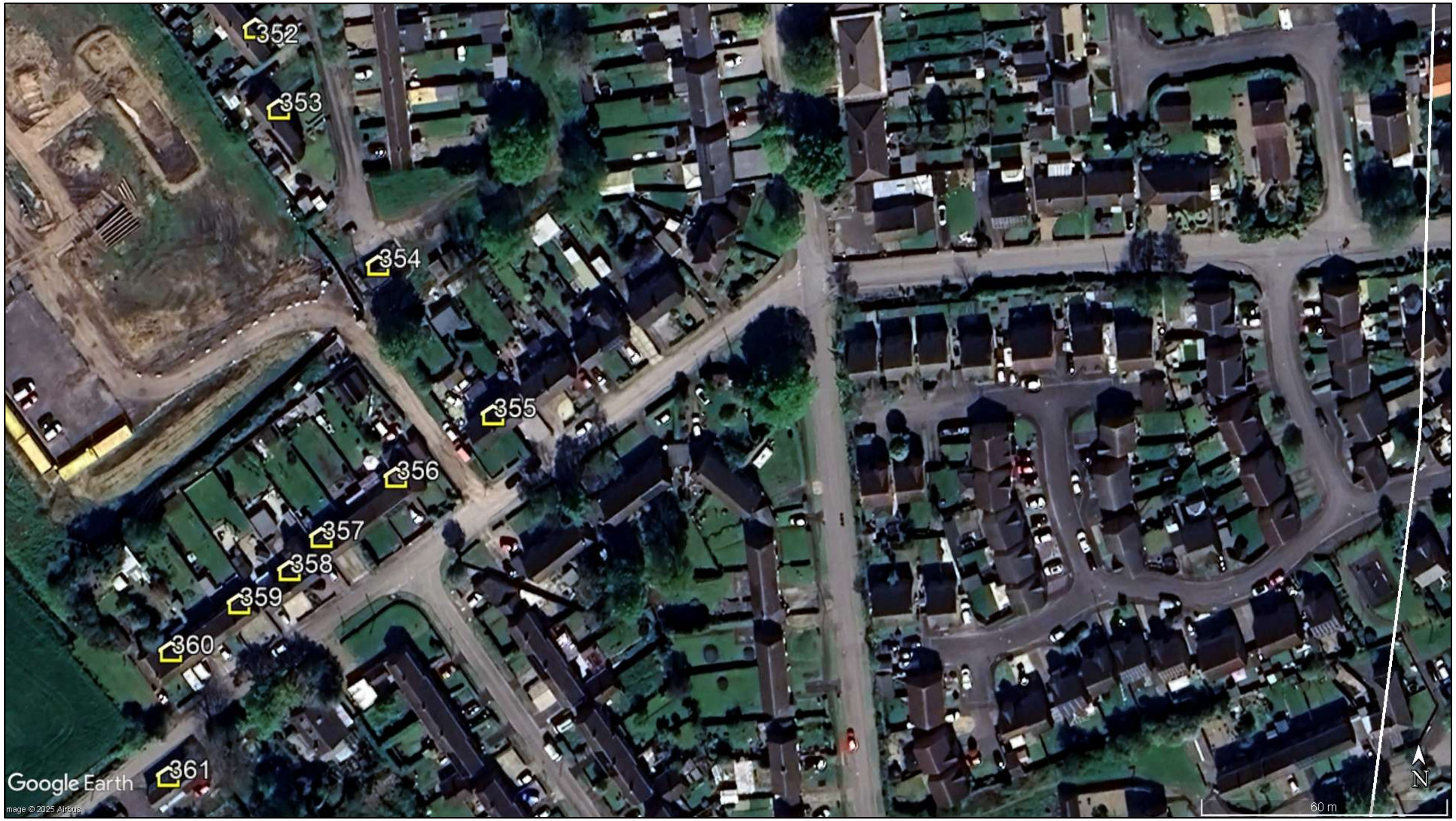
Dwelling receptors 297 to 313 – aerial image

Dwelling receptors 314 to 324 – aerial image



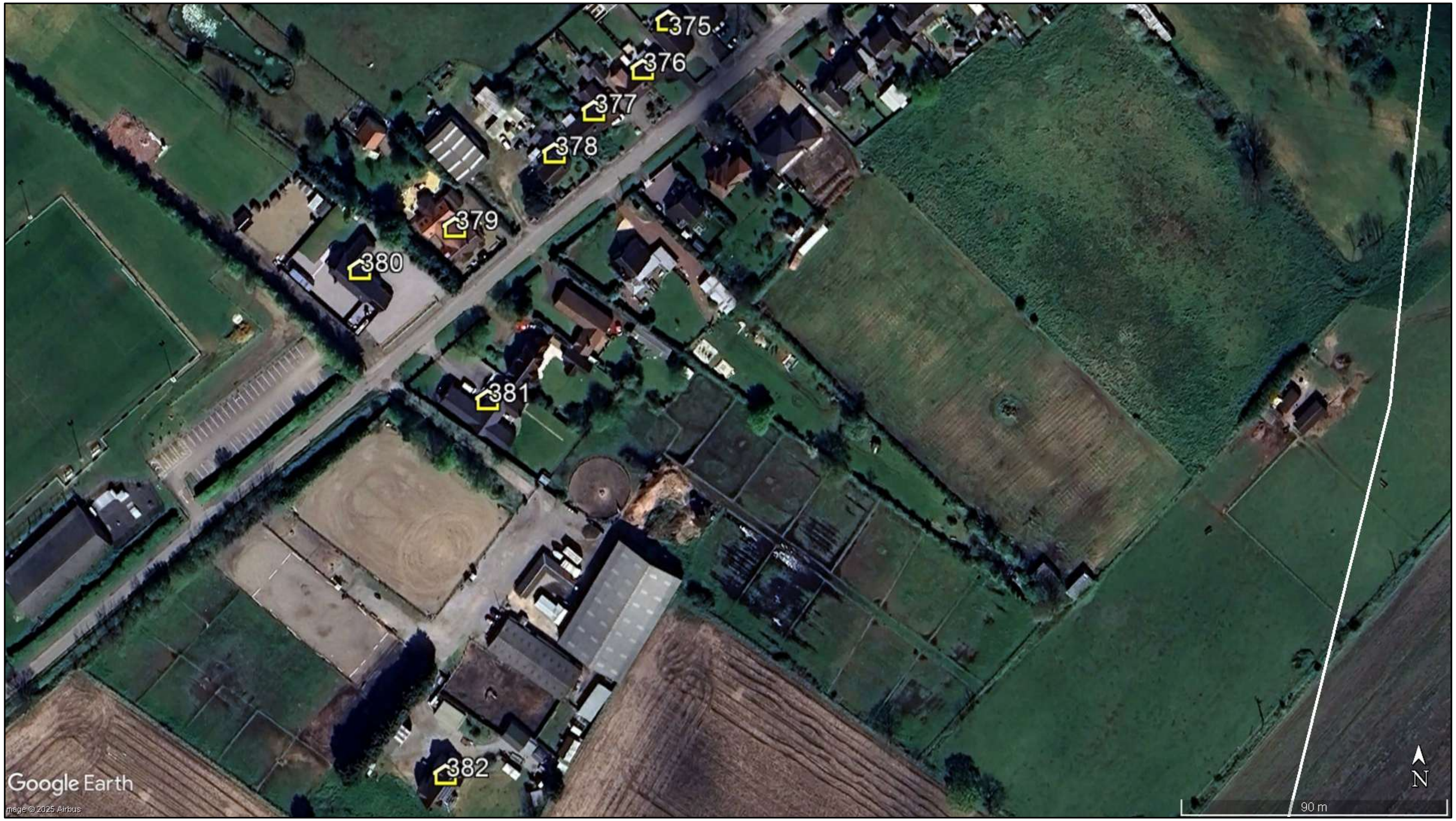
Dwelling receptors 325 to 334 – aerial image

Dwelling receptors 335 to 351 – aerial image



Dwelling receptors 352 to 361 – aerial image

Dwelling receptors 362 to 374 – aerial image



Dwelling receptors 375 to 382 – aerial image

Dwelling receptors 383 to 391 – aerial image

Dwelling receptors 392 to 394 – aerial image

Dwelling receptors 395 to 397 – aerial image

Dwelling receptors 398 to 401 – aerial image

Dwelling receptors 402 to 405 – aerial image

APPENDIX I – DETAILED MODELLING RESULTS

Overview

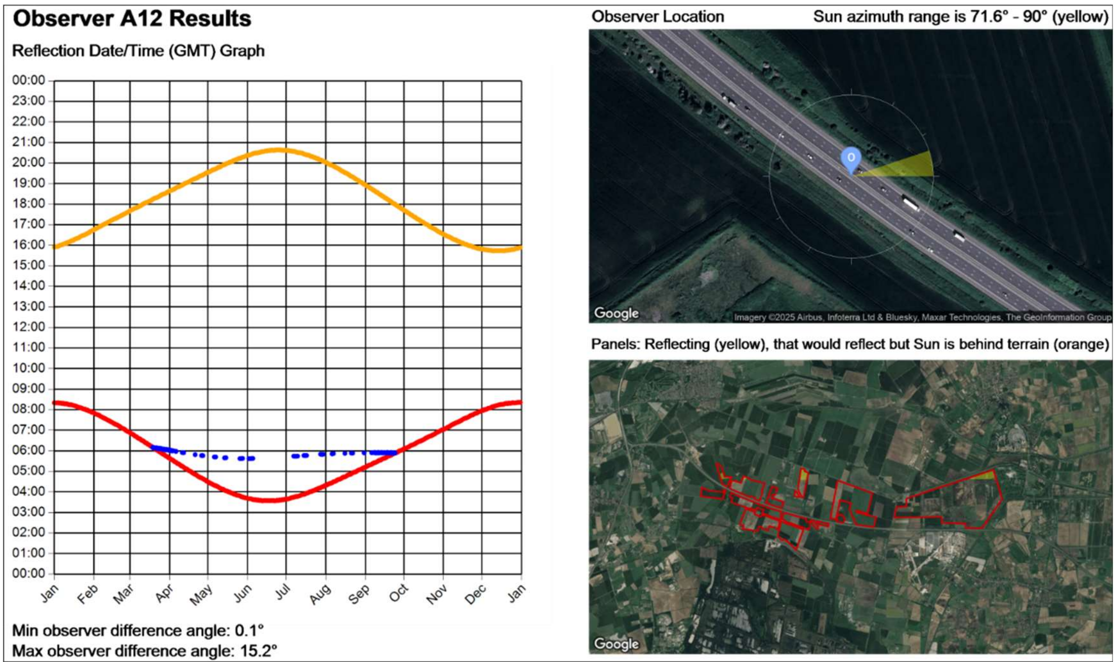
The results charts for a selection of receptors are shown on the following pages. Full results are available on request.

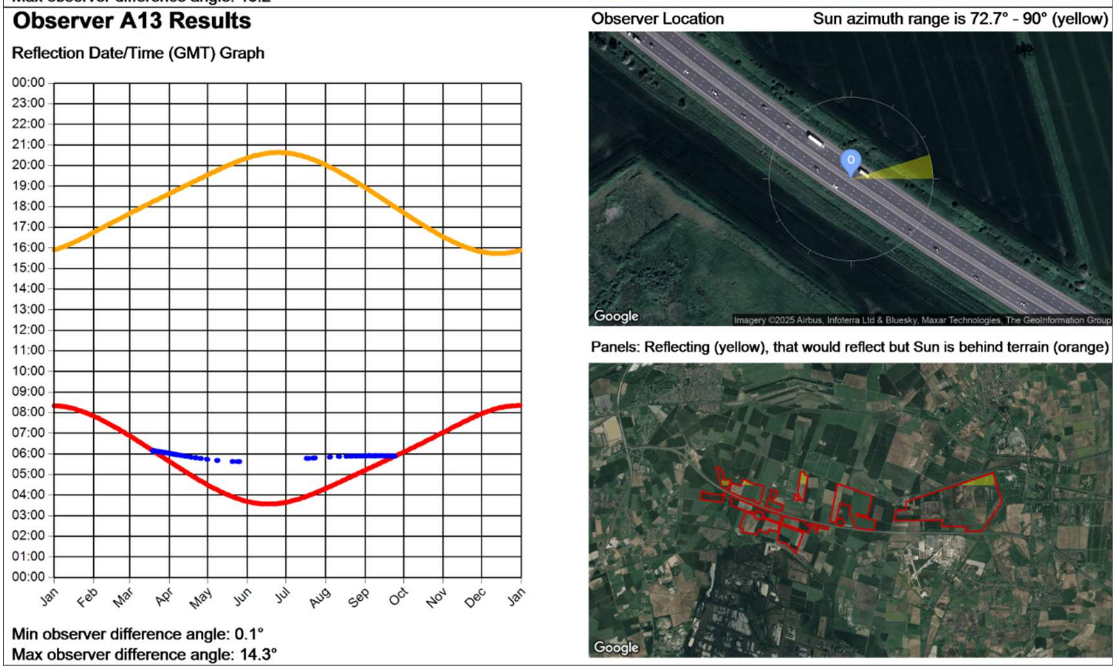
Each Pager Power results chart shows:

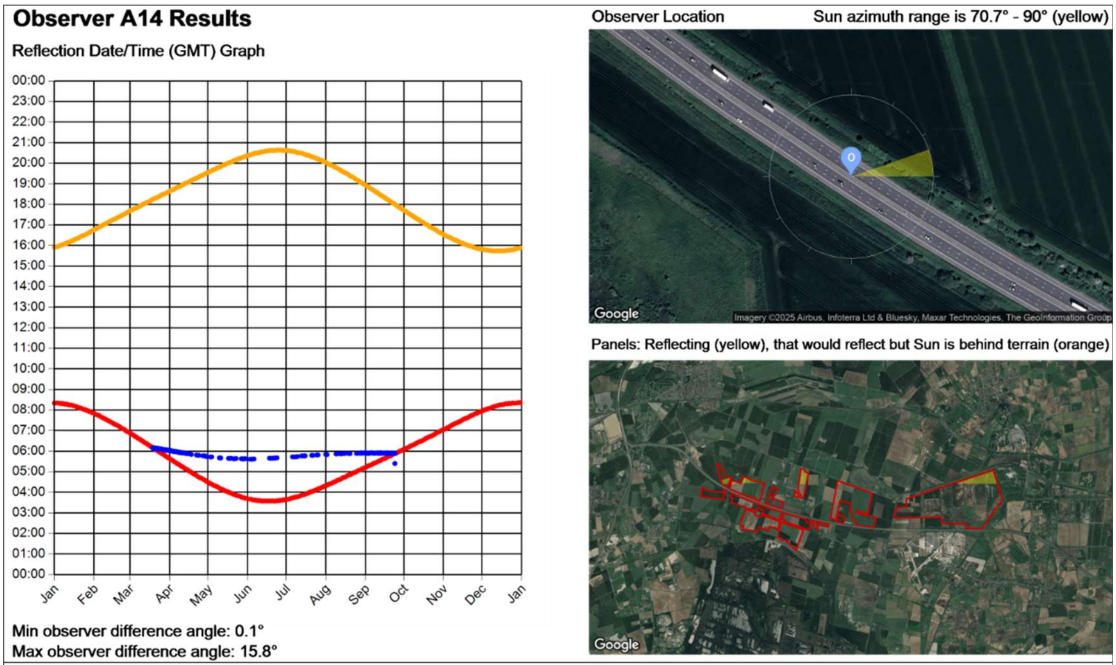
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of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

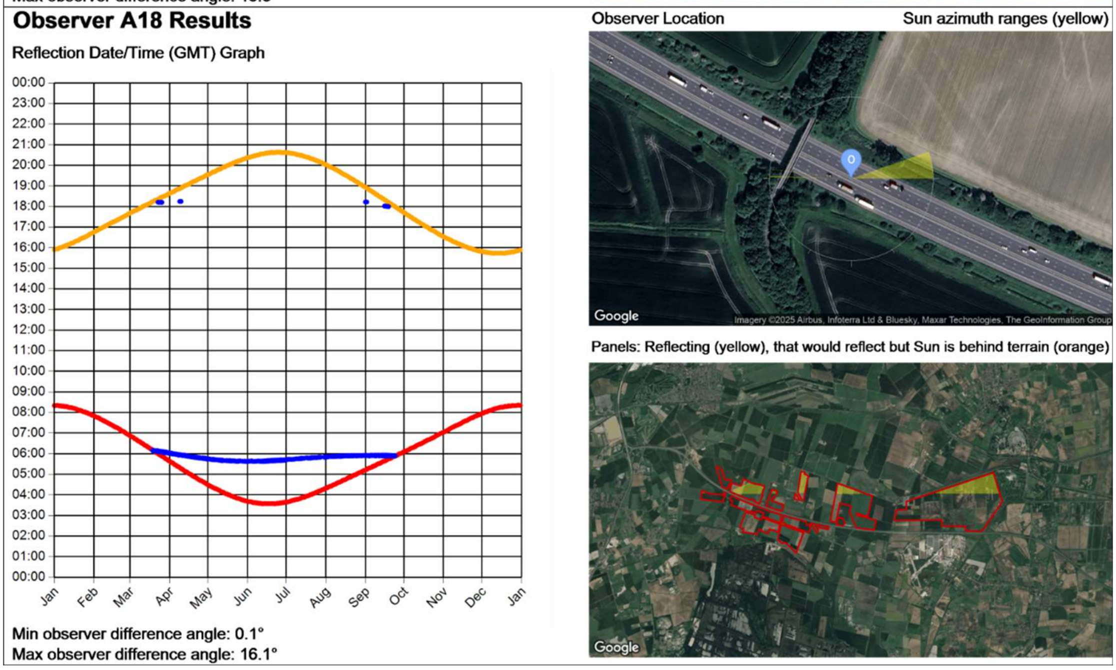
Road Receptors

Results charts are shown for road receptors for which a moderate impact is predicted under baseline conditions.



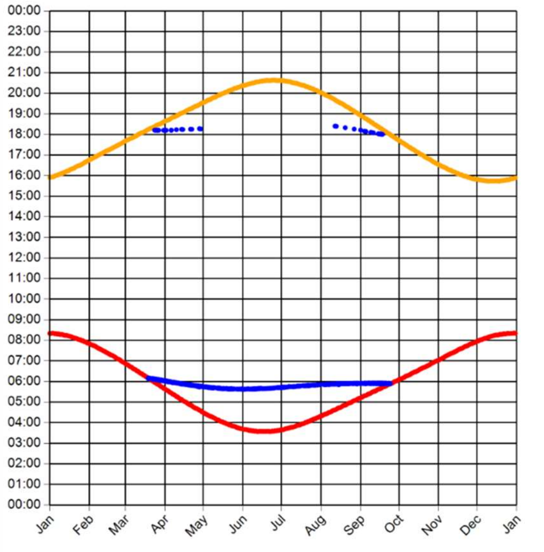



Observer A14 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.1°
Max observer difference angle: 15.8°
Observer Location
Sun azimuth range is 70.7° - 90° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer A18 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.1°
Max observer difference angle: 16.1°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

Observer A19 Results

Reflection Date/Time (GMT) Graph



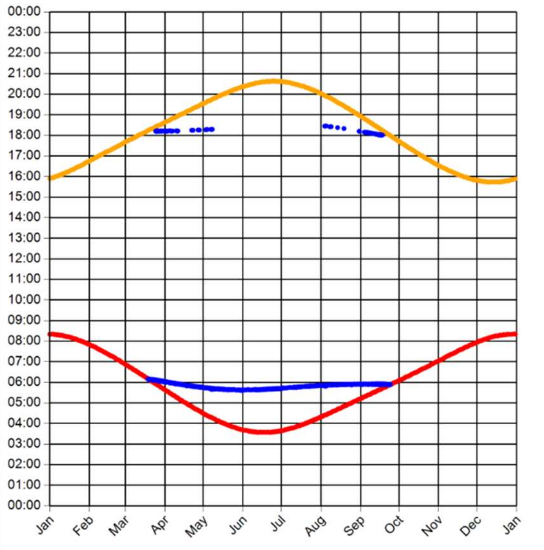
Min observer difference angle: 0.1°
Max observer difference angle: 16°

Observer Location — Sun azimuth ranges (yellow)

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

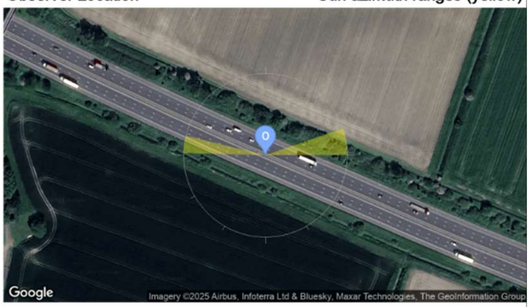
Observer A20 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 16.1°

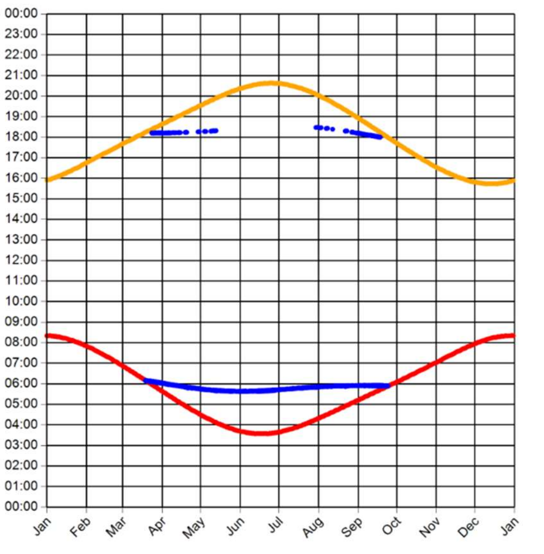
Observer Location — Sun azimuth ranges (yellow)



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

Observer A21 Results

Reflection Date/Time (GMT) Graph



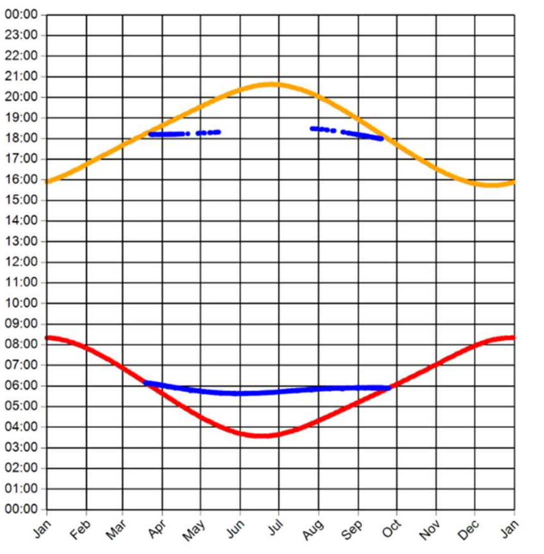
Min observer difference angle: 0.1°
Max observer difference angle: 16.1°

Observer Location — Sun azimuth ranges (yellow)

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

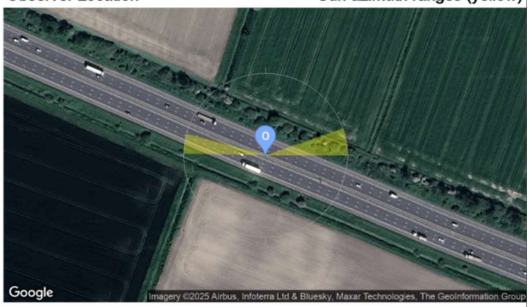
Observer A22 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 16.1°

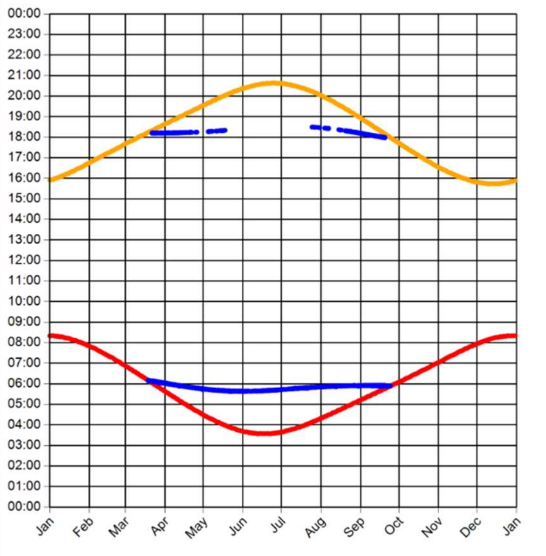
Observer Location — Sun azimuth ranges (yellow)



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

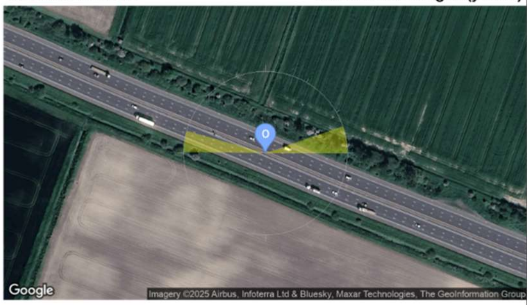
Observer A23 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 16.1°

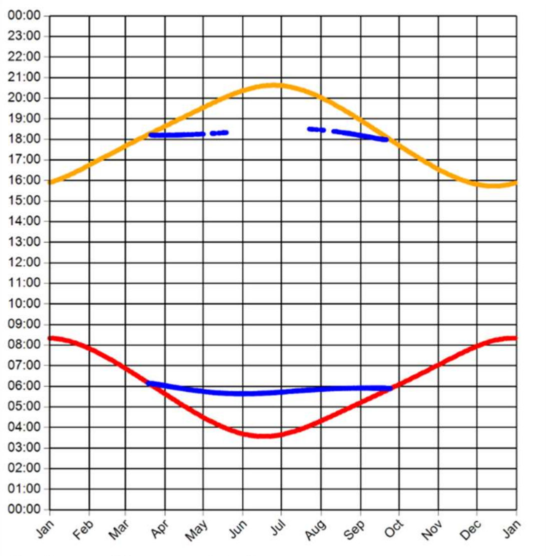
Observer Location — Sun azimuth ranges (yellow)



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

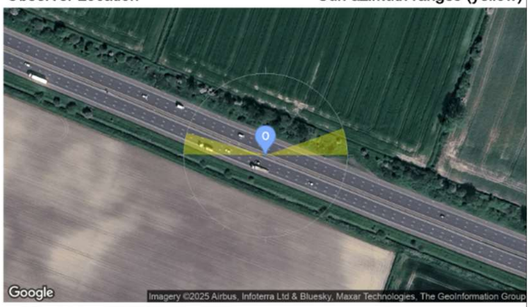
Observer A24 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 16.2°

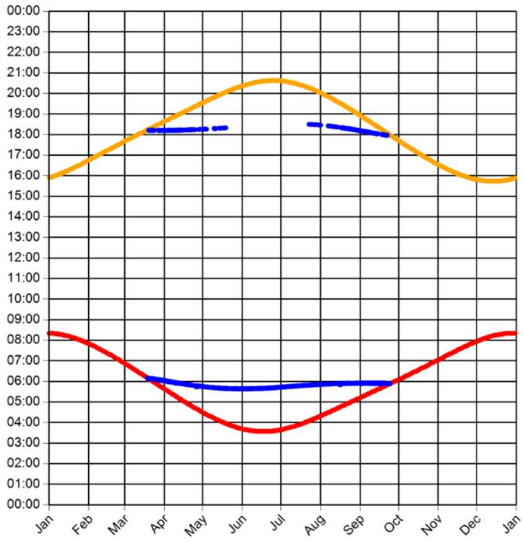
Observer Location — Sun azimuth ranges (yellow)



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

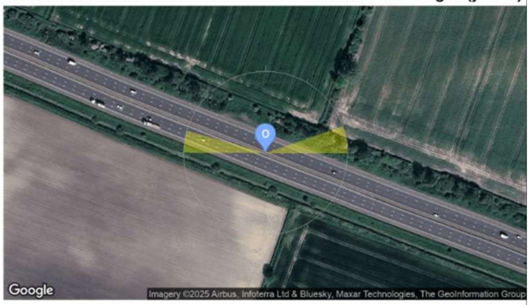
Observer A25 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 16.2°

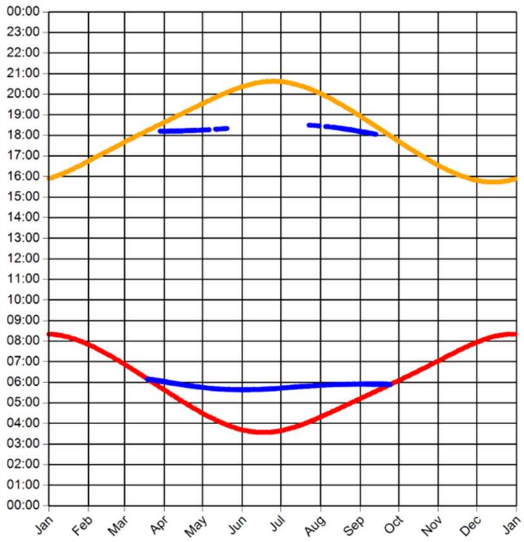
Observer Location | Sun azimuth ranges (yellow)



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

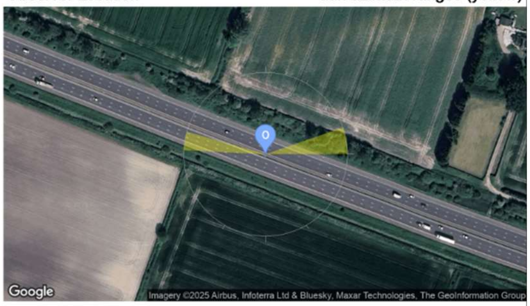
Observer A26 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 16.2°

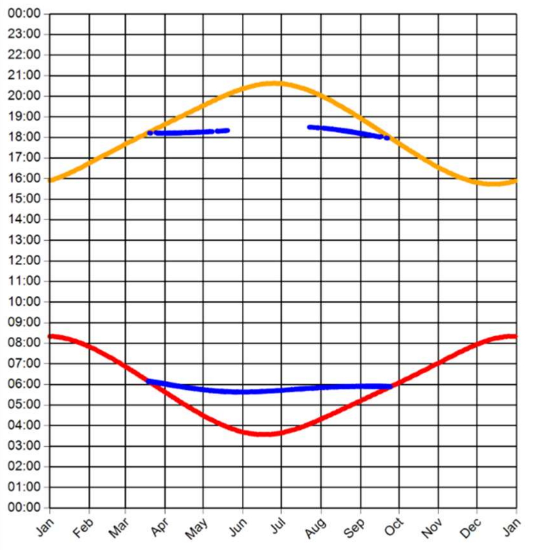
Observer Location | Sun azimuth ranges (yellow)



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

Observer A27 Results

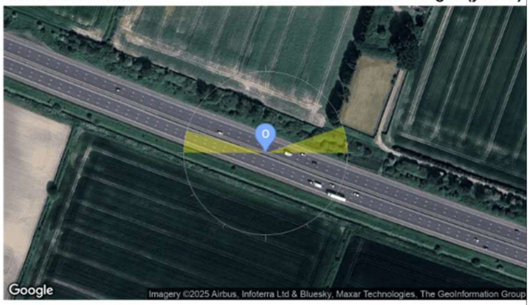
Reflection Date/Time (GMT) Graph



Min observer difference angle: 0°
Max observer difference angle: 16.1°

Observer Location

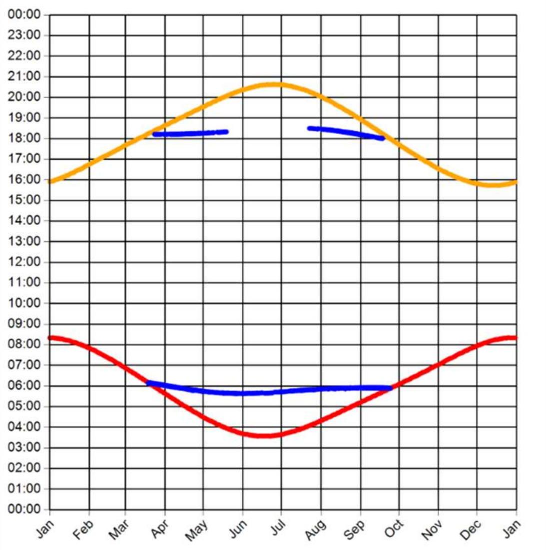
Sun azimuth ranges (yellow)



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

Observer A28 Results

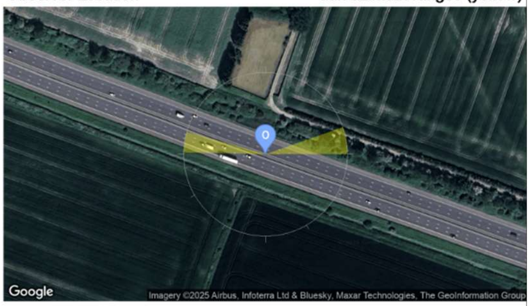
Reflection Date/Time (GMT) Graph



Min observer difference angle: 0°
Max observer difference angle: 16.1°

Observer Location

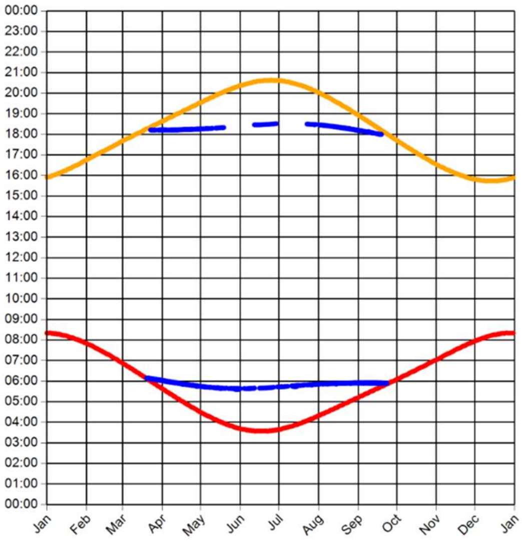
Sun azimuth ranges (yellow)



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

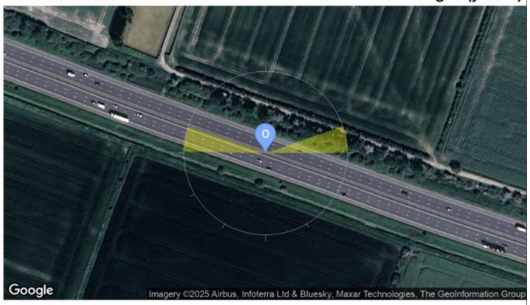
Observer A29 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0°
Max observer difference angle: 16.2°

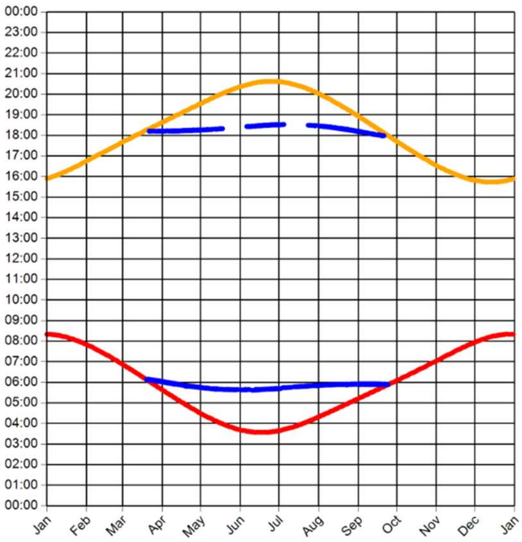
Observer Location | Sun azimuth ranges (yellow)



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

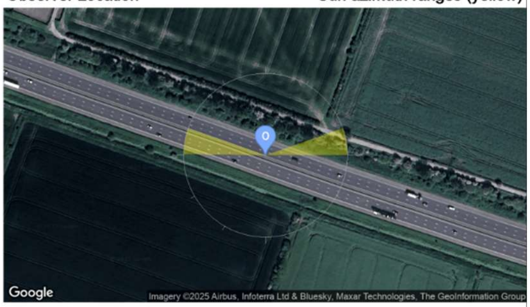
Observer A30 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 16.2°

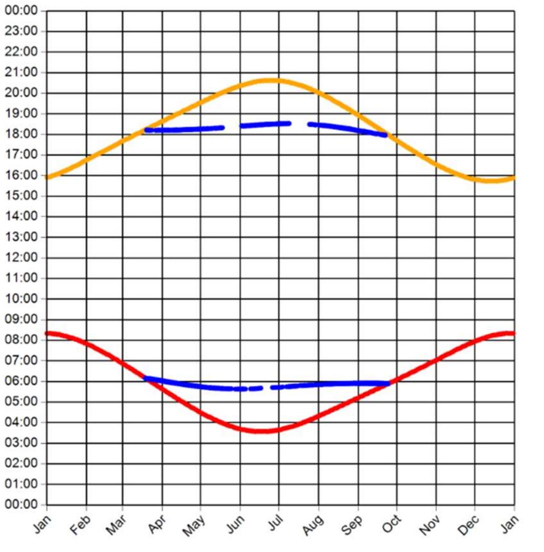
Observer Location | Sun azimuth ranges (yellow)



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

Observer A31 Results

Reflection Date/Time (GMT) Graph



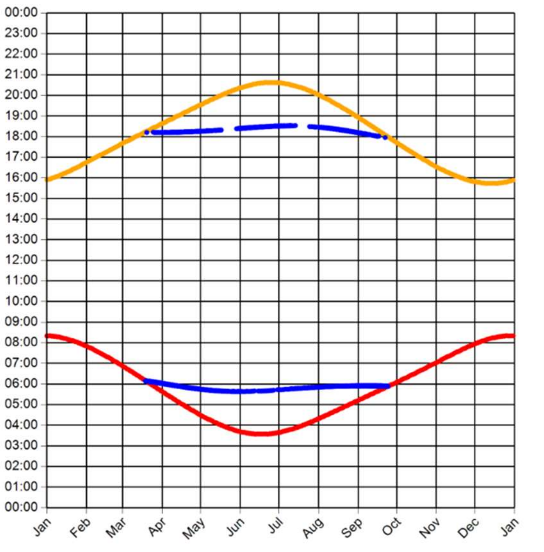
Min observer difference angle: 0.1°
Max observer difference angle: 16.2°

Observer Location — Sun azimuth ranges (yellow)

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

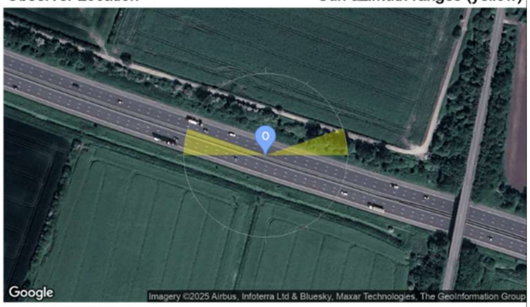
Observer A32 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 16.2°

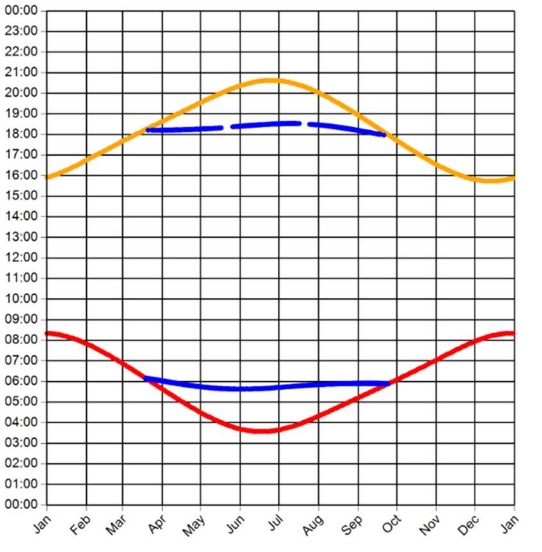
Observer Location — Sun azimuth ranges (yellow)



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

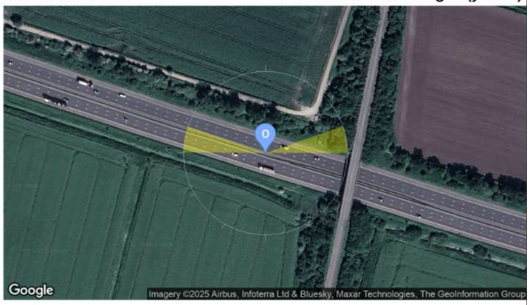
Observer A33 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0°
Max observer difference angle: 16.1°

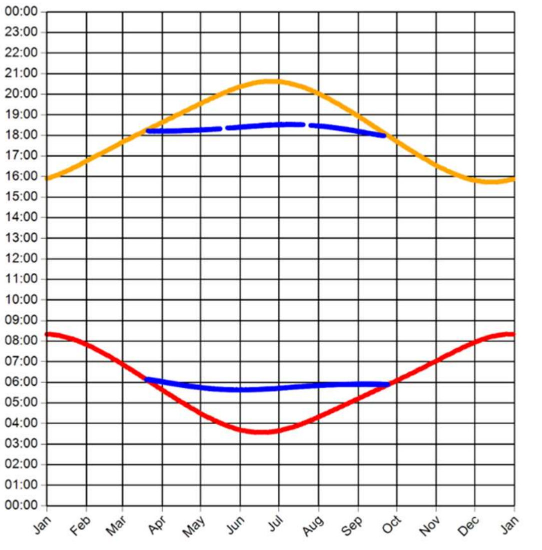
Observer Location | Sun azimuth ranges (yellow)



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

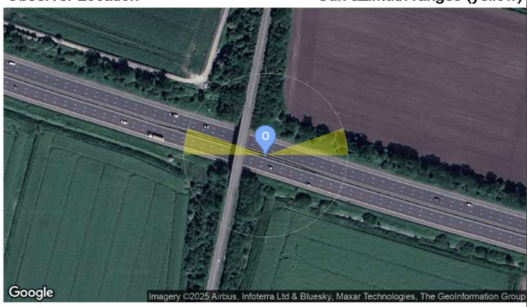
Observer A34 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0°
Max observer difference angle: 16.2°

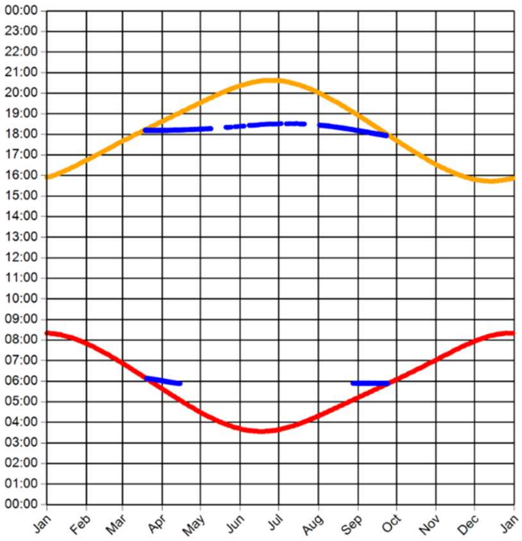
Observer Location | Sun azimuth ranges (yellow)



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

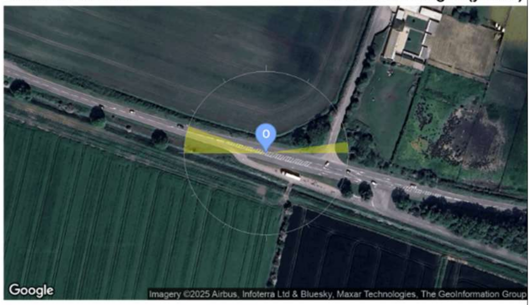
Observer D54 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0°
Max observer difference angle: 16.1°

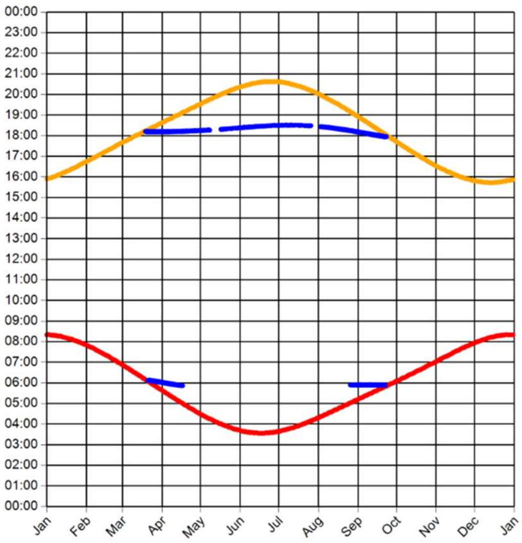
Observer Location | Sun azimuth ranges (yellow)



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

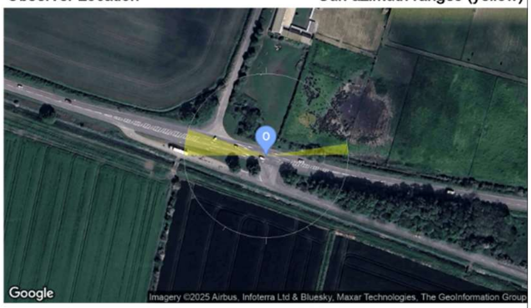
Observer D55 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.2°
Max observer difference angle: 16.4°

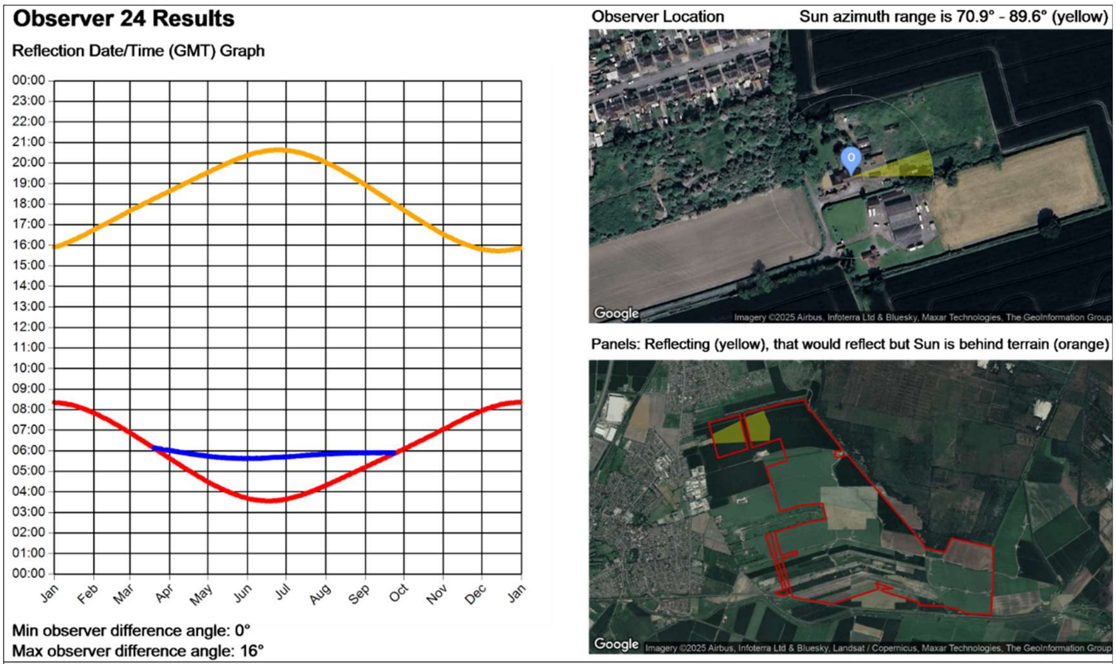
Observer Location | Sun azimuth ranges (yellow)

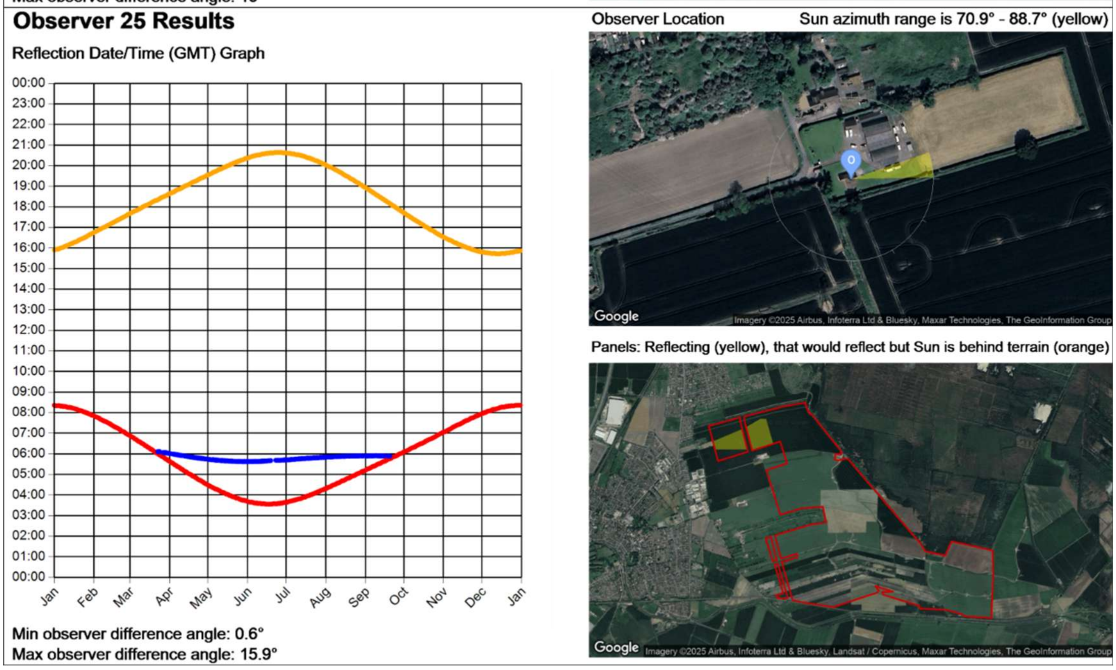


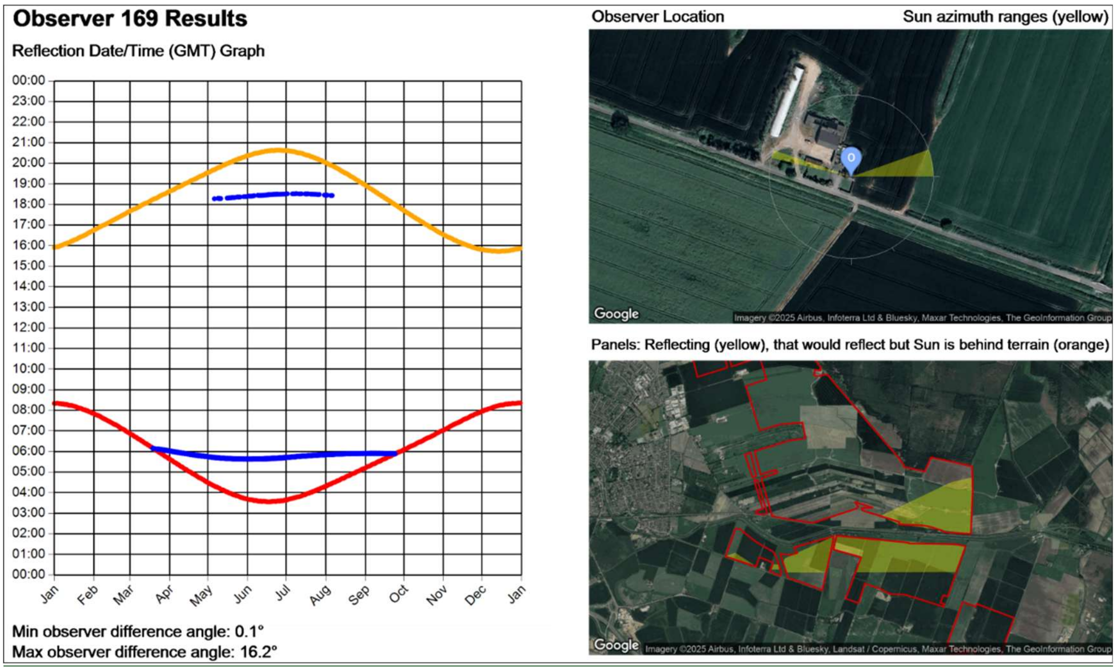
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

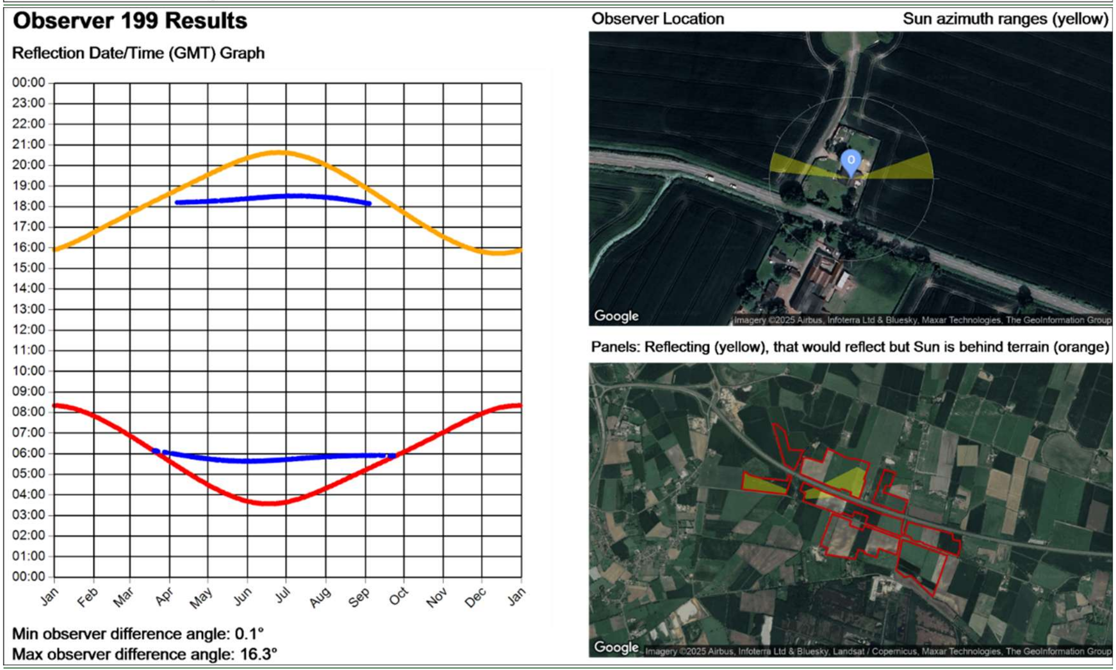
Dwelling Receptors

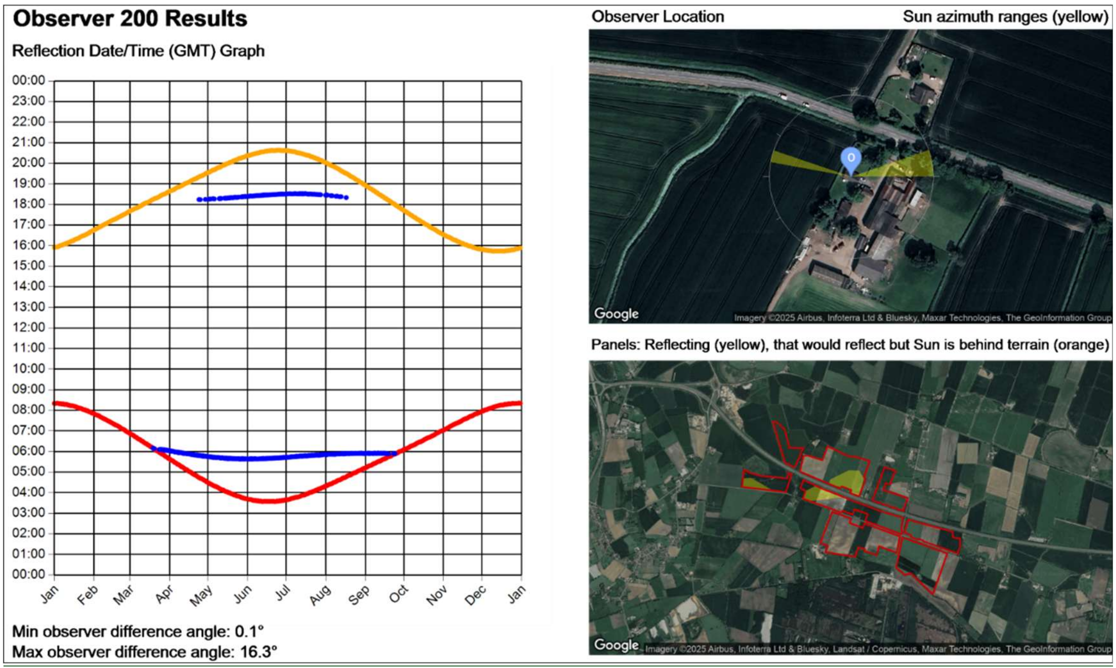
Results charts are shown for dwelling receptors for which a moderate impact is predicted under baseline conditions.

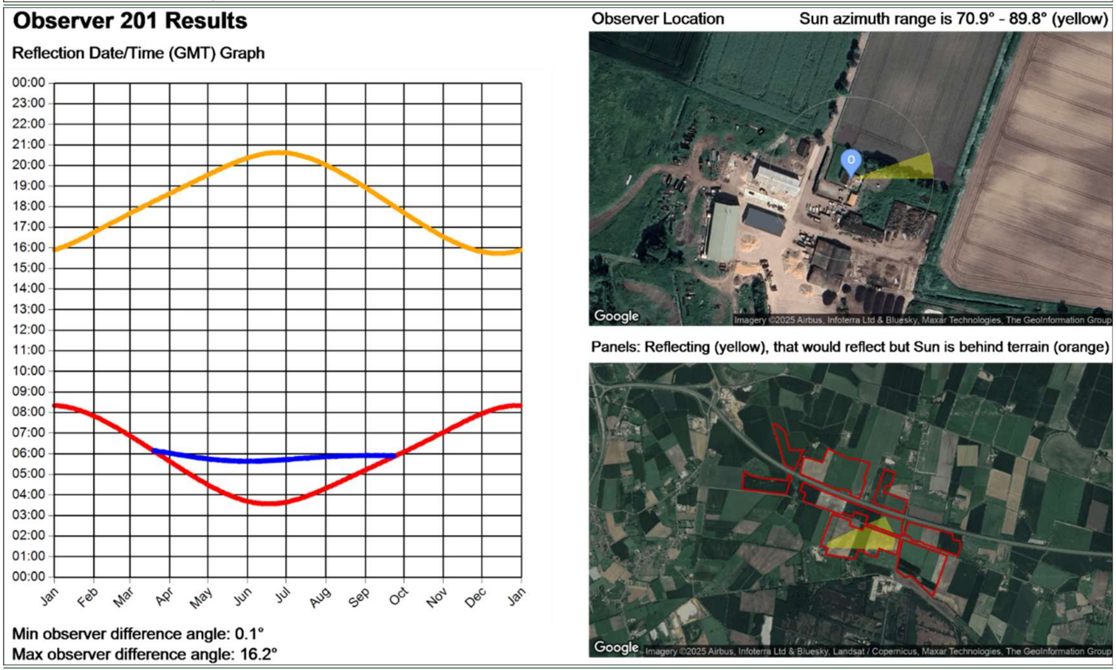


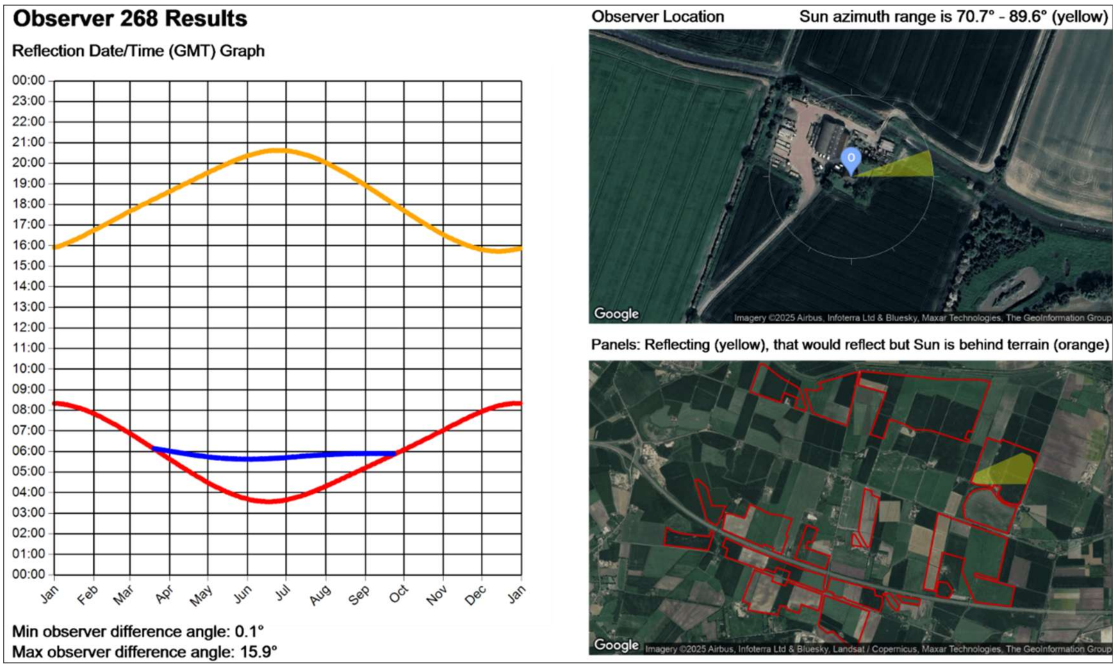



Observer 169 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.1°
Max observer difference angle: 16.2°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 199 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.1°
Max observer difference angle: 16.3°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 200 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.1°
Max observer difference angle: 16.3°
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

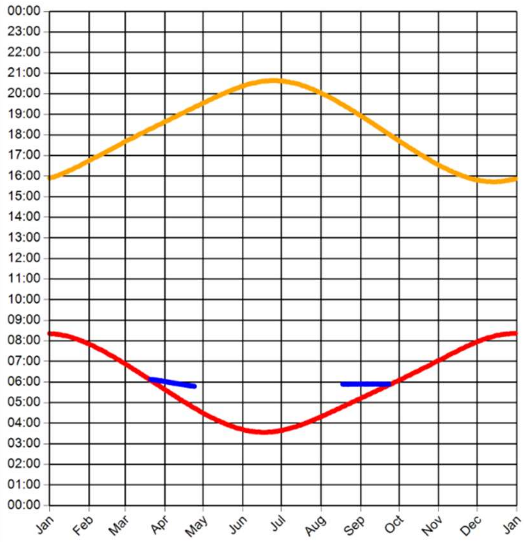

Observer 201 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.1°
Max observer difference angle: 16.2°
Observer Location
Sun azimuth range is 70.9° - 89.8° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 268 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.1°
Max observer difference angle: 15.9°
Observer Location
Sun azimuth range is 70.7° - 89.6° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

Sensitive Viewpoints

Observer 1 Results

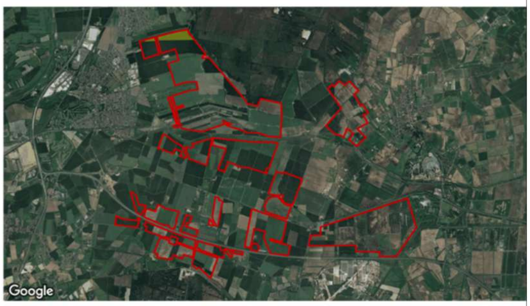
Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 9°

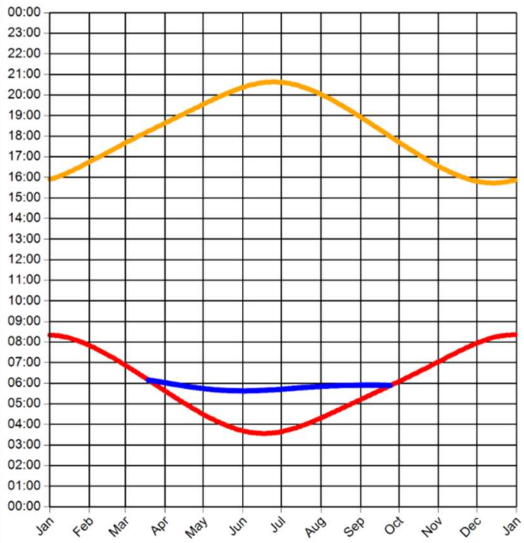
Observer Location — Sun azimuth range is 79.4° - 89.5° (yellow)

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



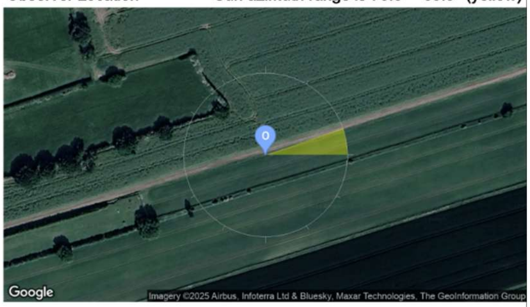
Observer 3 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0°
Max observer difference angle: 16.1°

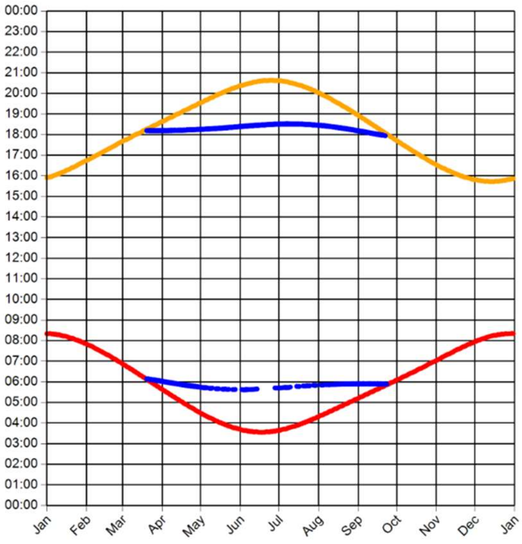
Observer Location — Sun azimuth range is 70.8° - 89.9° (yellow)



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

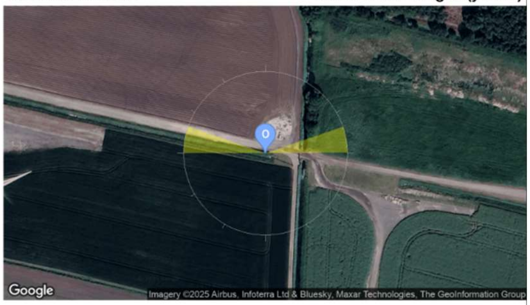
Observer 4 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0°
Max observer difference angle: 16.3°

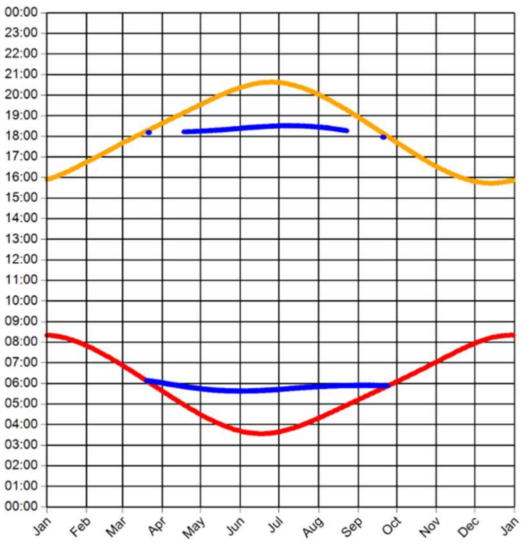
Observer Location | Sun azimuth ranges (yellow)



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

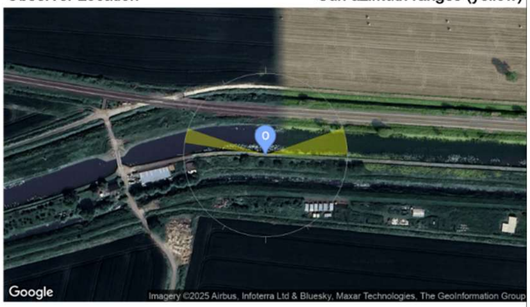
Observer 5 Results

Reflection Date/Time (GMT) Graph

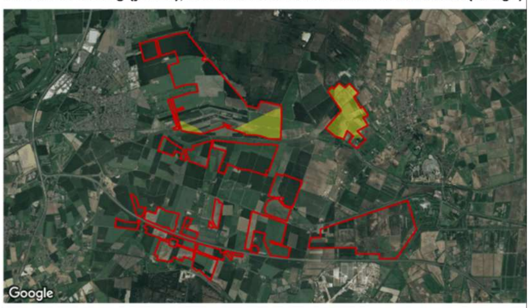


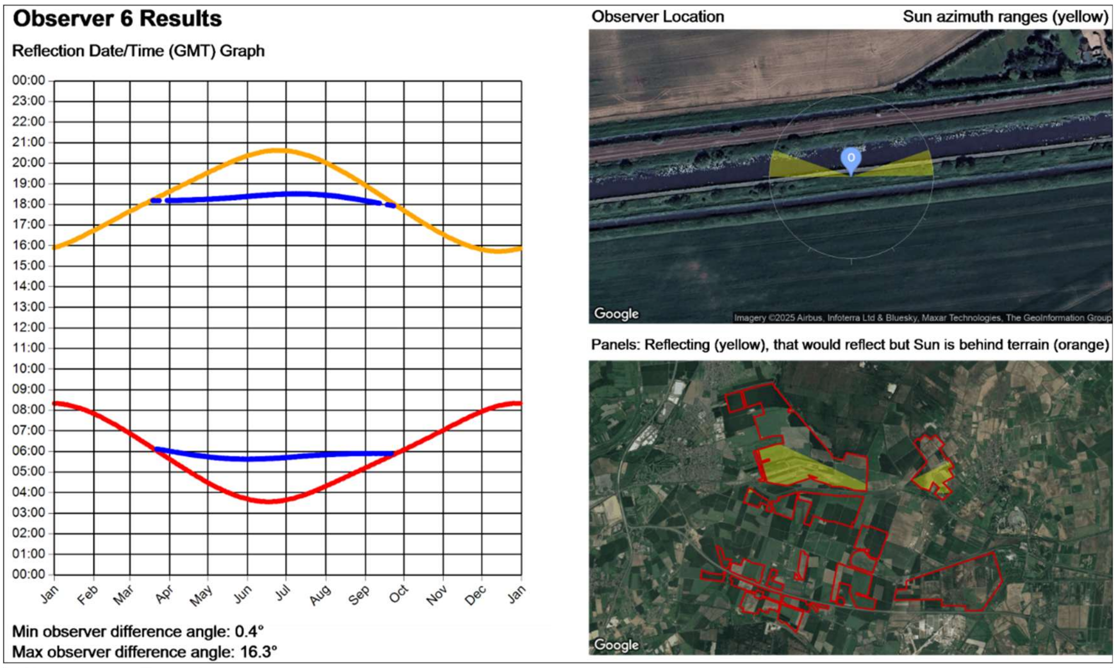
Min observer difference angle: 0°
Max observer difference angle: 16.4°

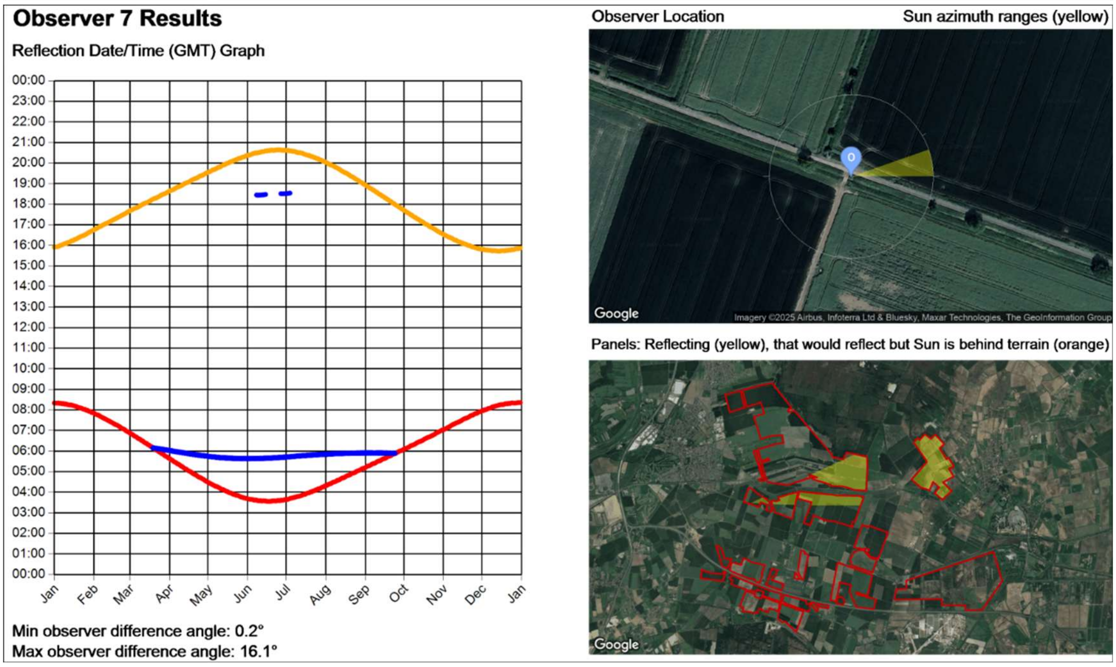
Observer Location | Sun azimuth ranges (yellow)



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

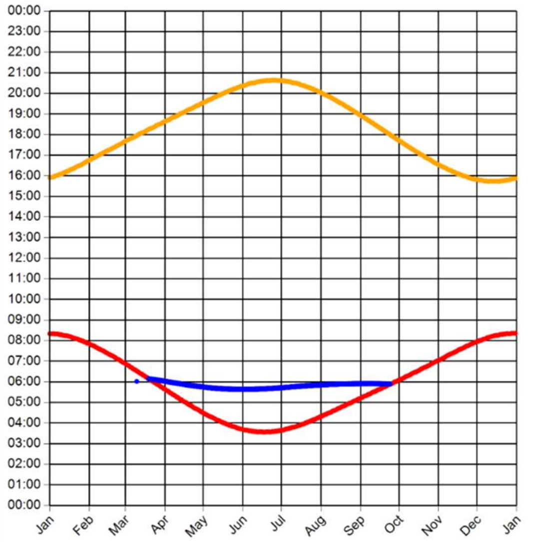



Observer 6 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.4°
Max observer difference angle: 16.3°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 7 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.2°
Max observer difference angle: 16.1°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

Observer 8 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 16.2°

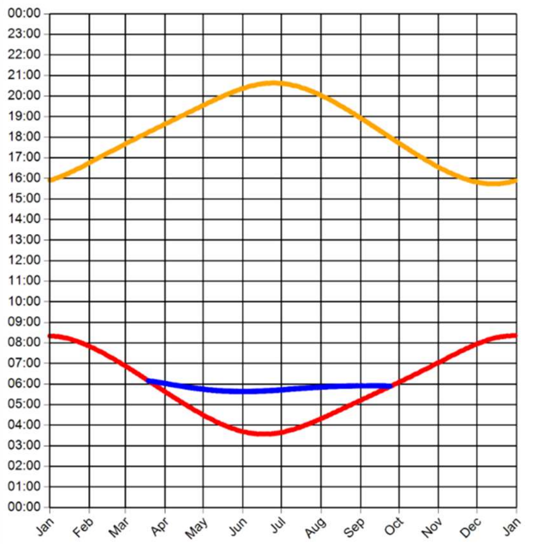
Observer Location

Sun azimuth range is 70.8° - 89.9° (yellow)

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

Observer 9 Results

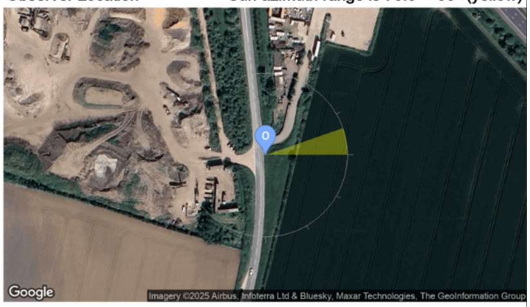
Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 16.2°

Observer Location

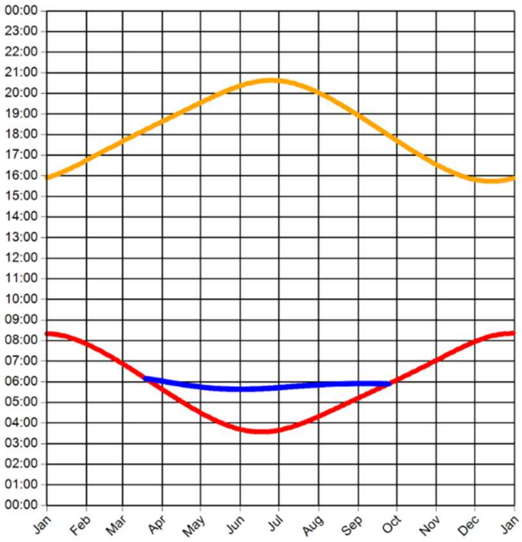
Sun azimuth range is 70.8° - 90° (yellow)



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

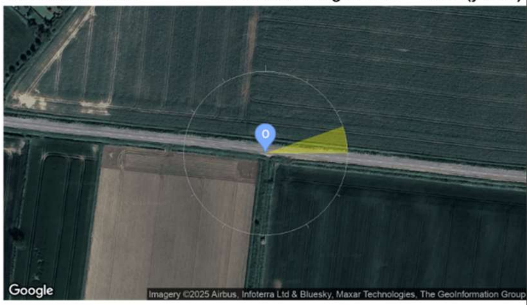
Observer 10 Results

Reflection Date/Time (GMT) Graph

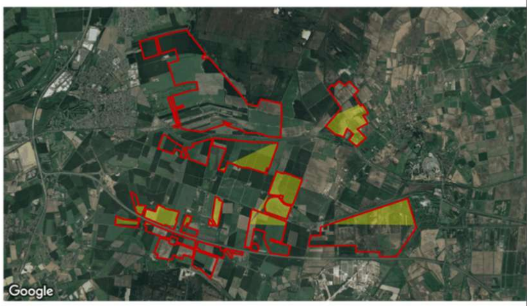


Min observer difference angle: 0.1°
Max observer difference angle: 16.2°

Observer Location   Sun azimuth range is 70.8° - 90.2° (yellow)

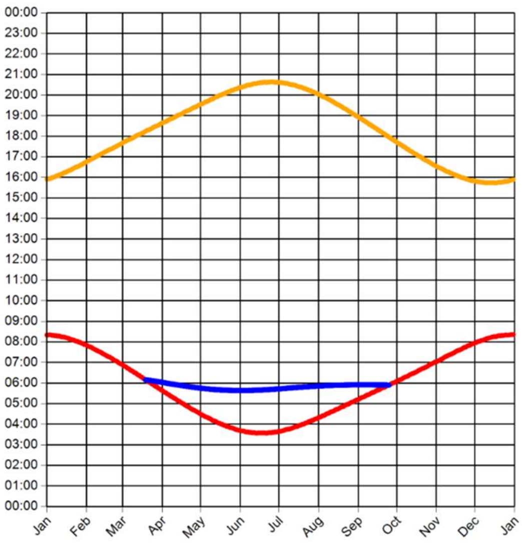


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



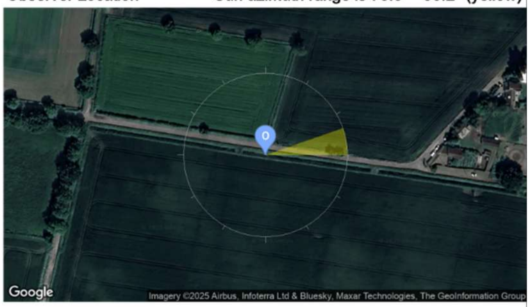
Observer 11 Results

Reflection Date/Time (GMT) Graph

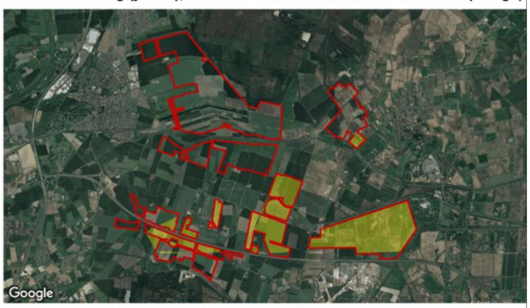


Min observer difference angle: 0.1°
Max observer difference angle: 16.2°

Observer Location   Sun azimuth range is 70.8° - 90.2° (yellow)

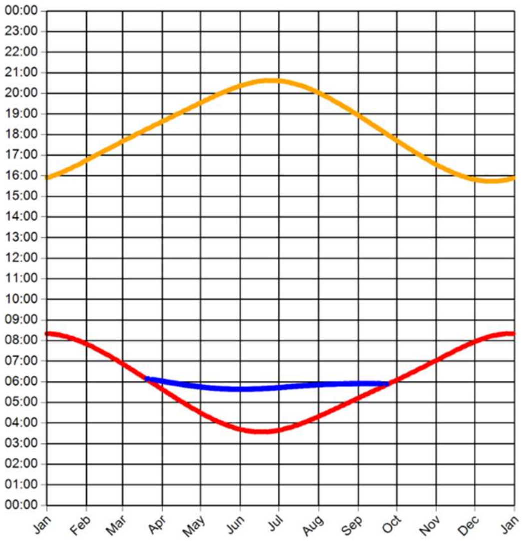


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 12 Results

Reflection Date/Time (GMT) Graph



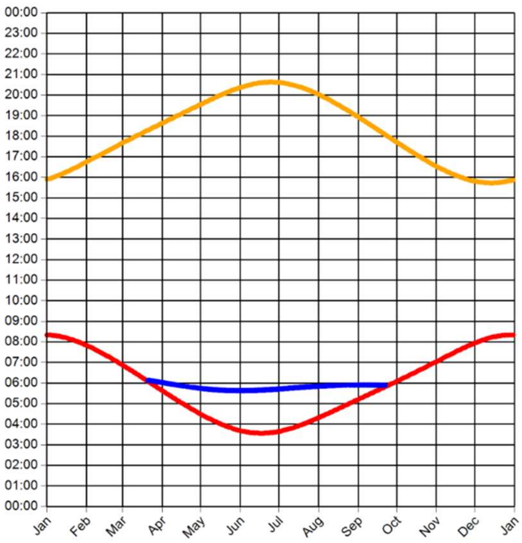
Min observer difference angle: 0.2°
Max observer difference angle: 16.3°

Observer Location Sun azimuth range is 70.8° - 89.6° (yellow)

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

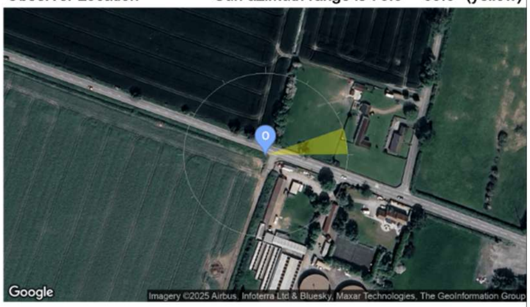
Observer 13 Results

Reflection Date/Time (GMT) Graph

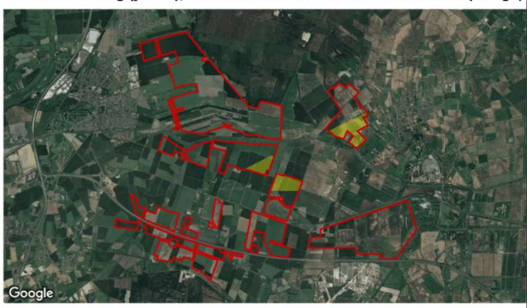


Min observer difference angle: 0.3°
Max observer difference angle: 16.1°

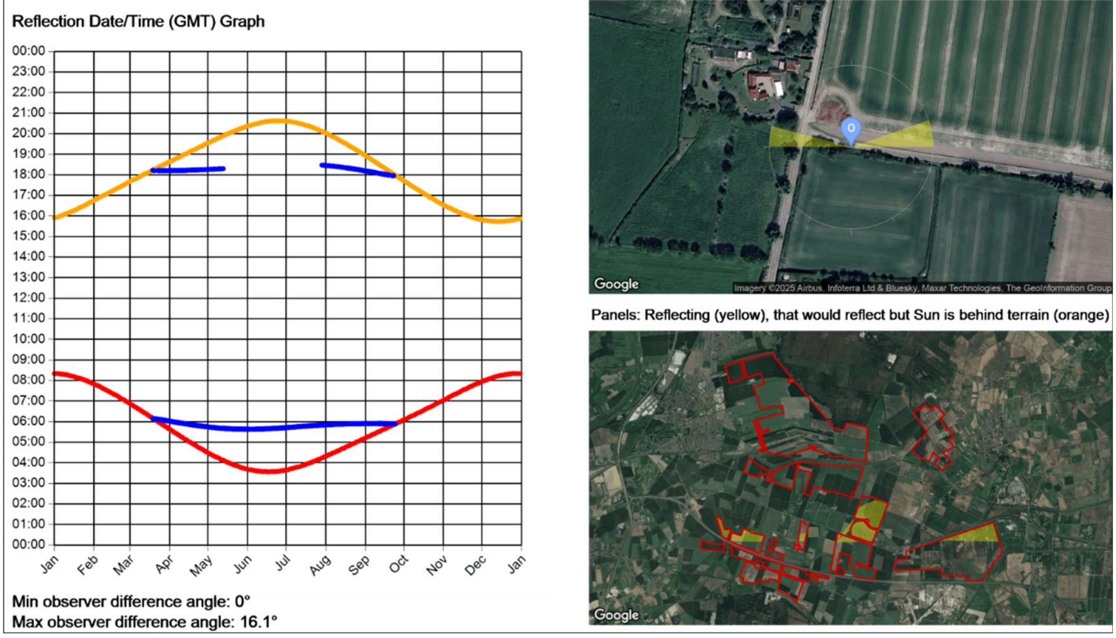
Observer Location Sun azimuth range is 70.8° - 89.3° (yellow)



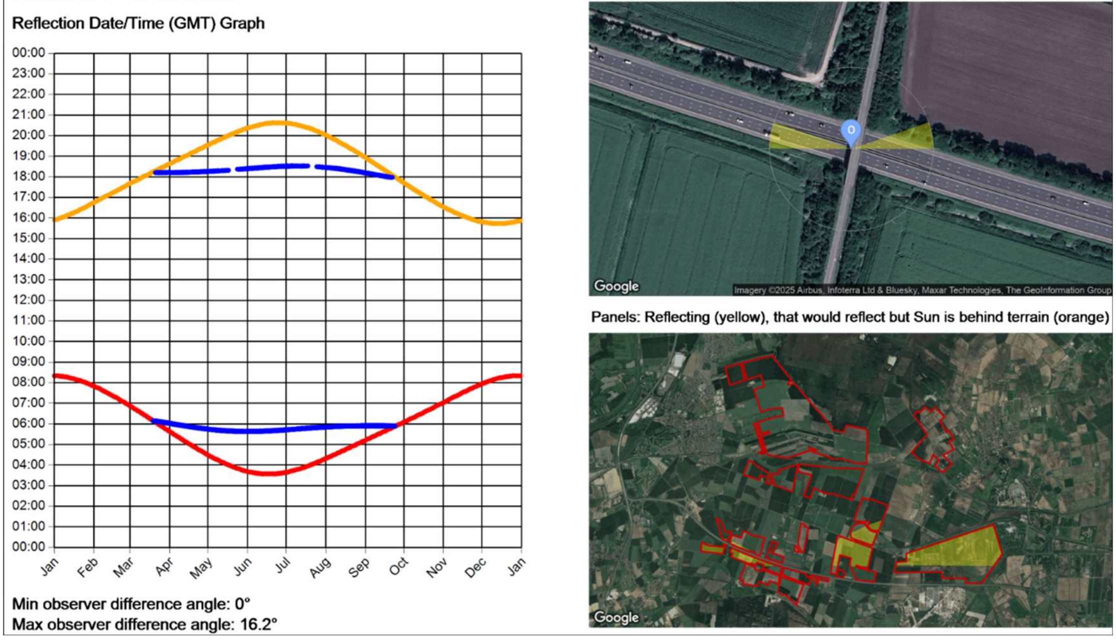
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



Observer 14 Results

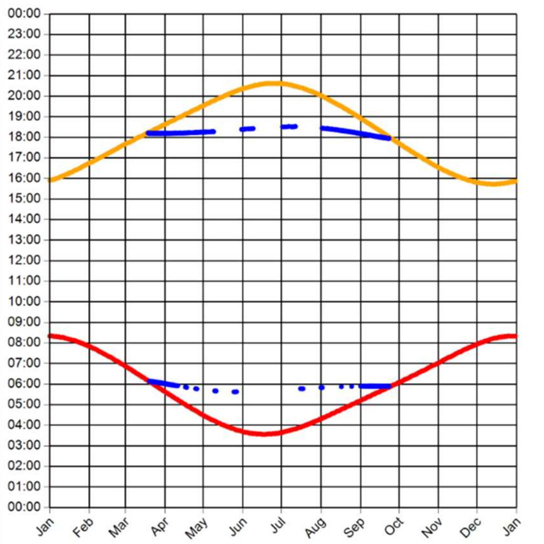


Observer 15 Results



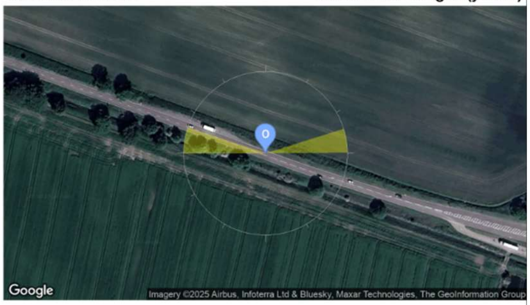
Observer 16 Results

Reflection Date/Time (GMT) Graph

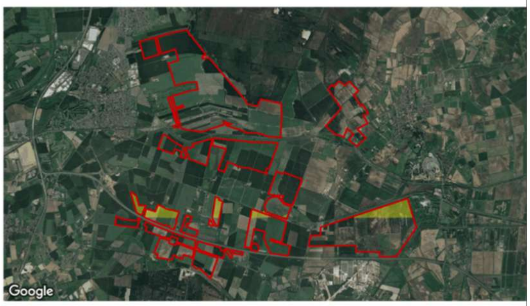


Min observer difference angle: 0.1°
Max observer difference angle: 15.9°

Observer Location — Sun azimuth ranges (yellow)

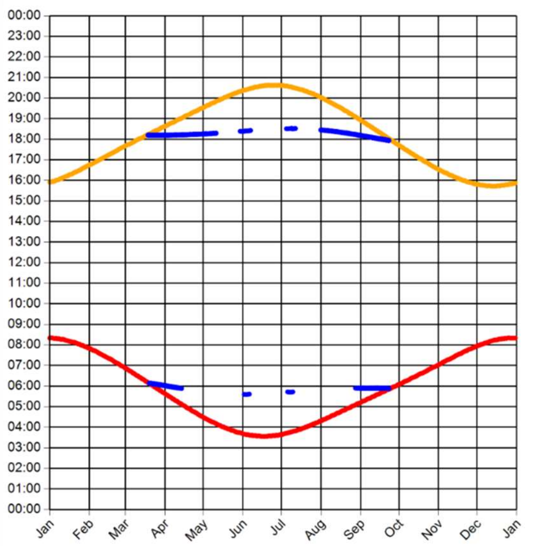


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



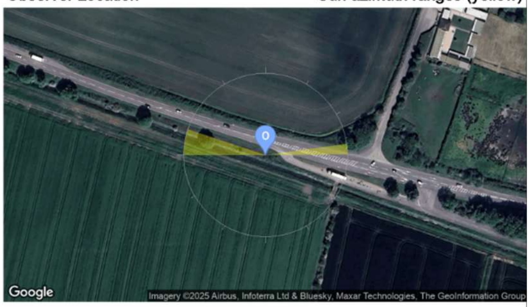
Observer 17 Results

Reflection Date/Time (GMT) Graph

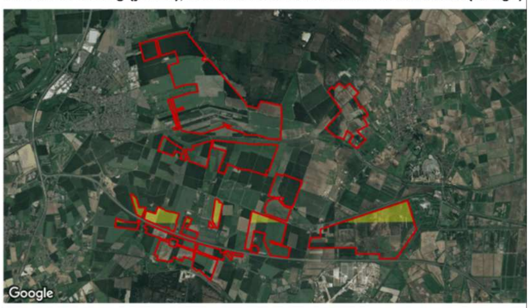


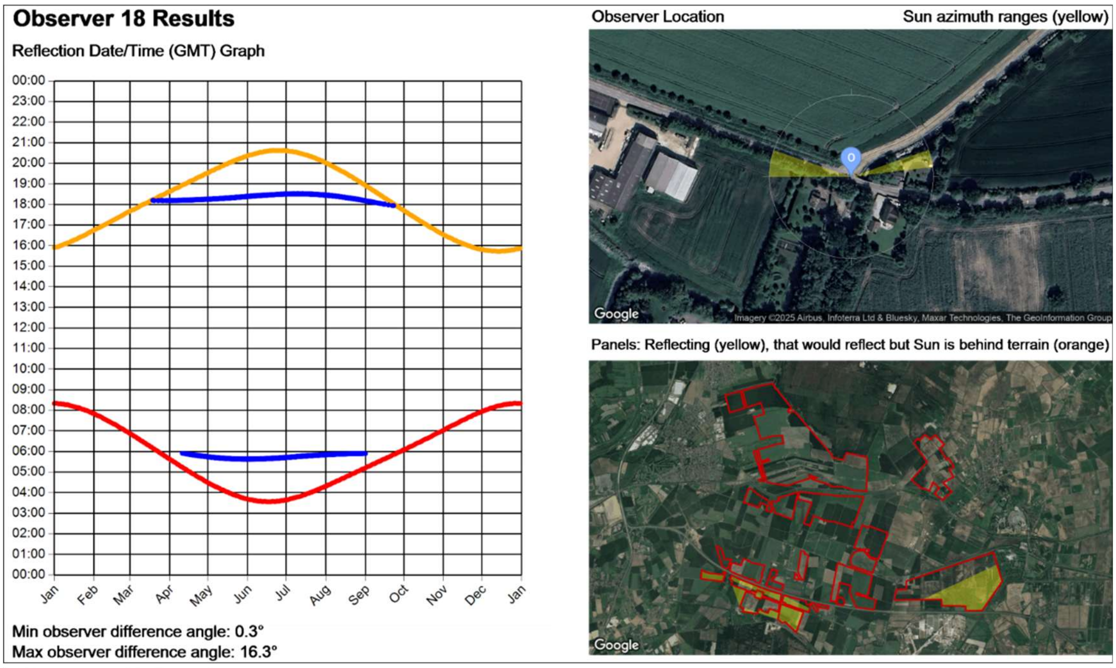
Min observer difference angle: 0°
Max observer difference angle: 15.7°

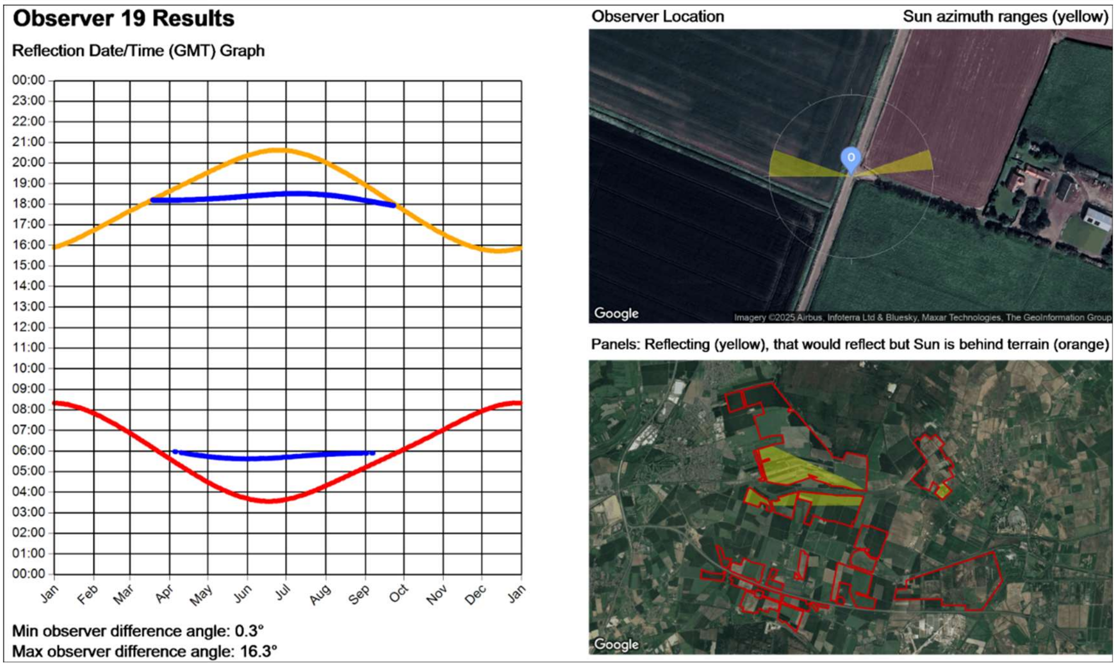
Observer Location — Sun azimuth ranges (yellow)



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




Observer 18 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.3°
Max observer difference angle: 16.3°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 19 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
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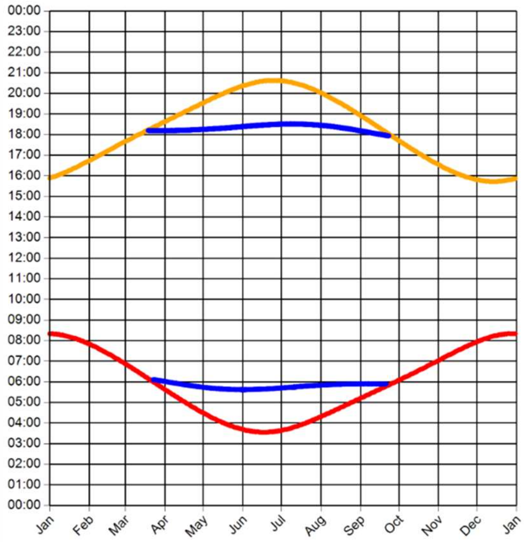
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.3°
Max observer difference angle: 16.3°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

Observer 20 Results

Reflection Date/Time (GMT) Graph



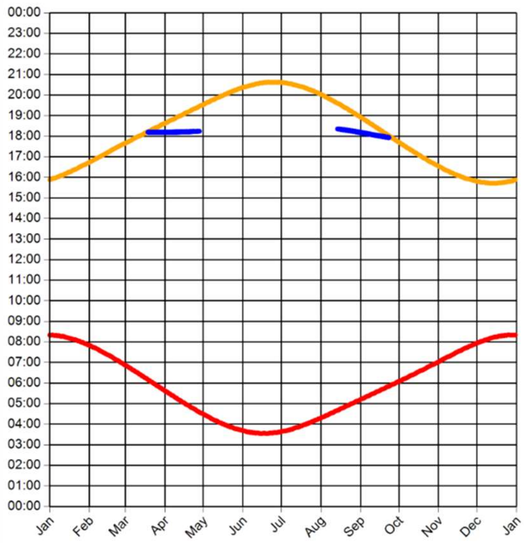
Min observer difference angle: 0.4°
Max observer difference angle: 16.4°

Observer Location — Sun azimuth ranges (yellow)

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

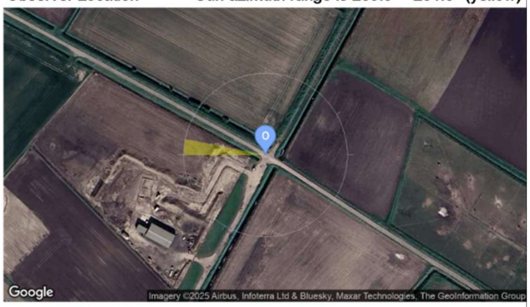
Observer 21 Results

Reflection Date/Time (GMT) Graph

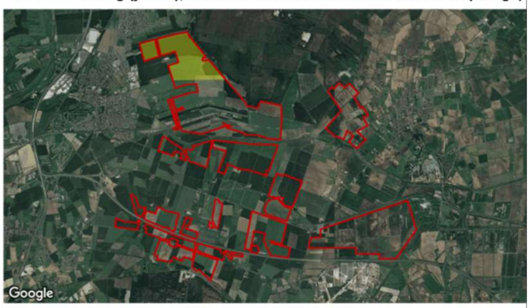


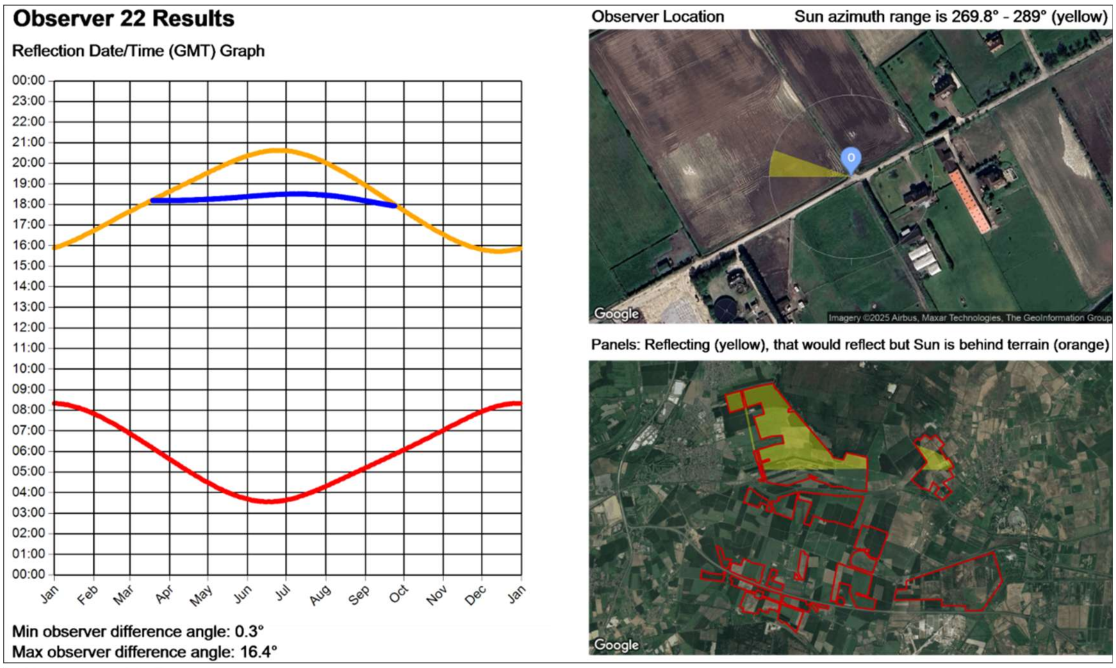
Min observer difference angle: 0.4°
Max observer difference angle: 10.1°

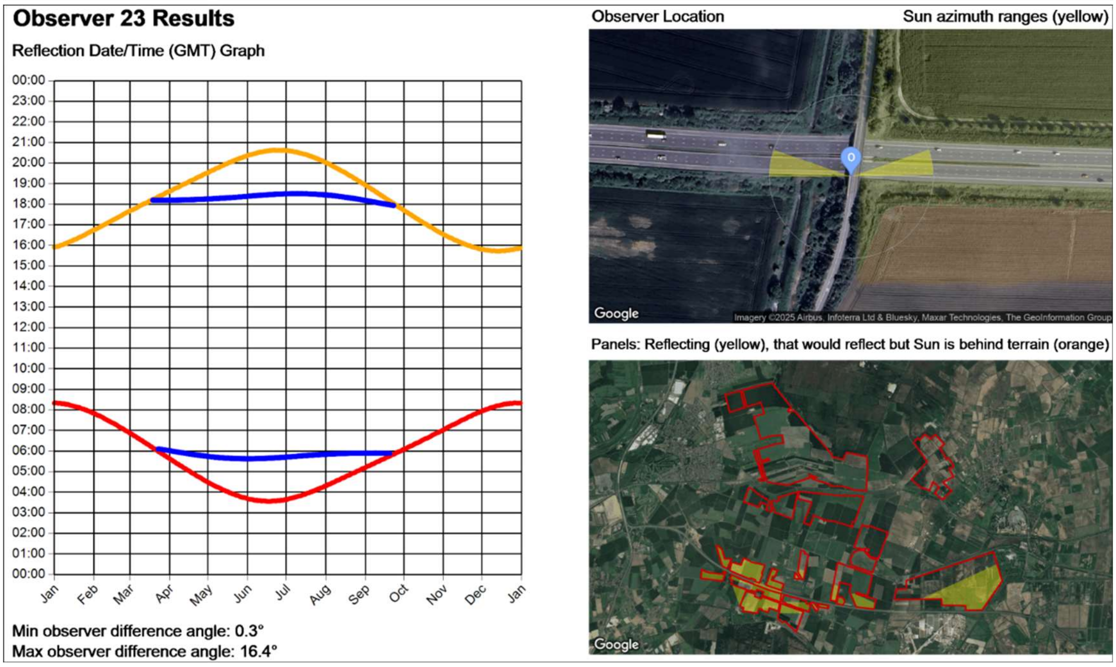
Observer Location — Sun azimuth range is 269.9° - 281.3° (yellow)



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

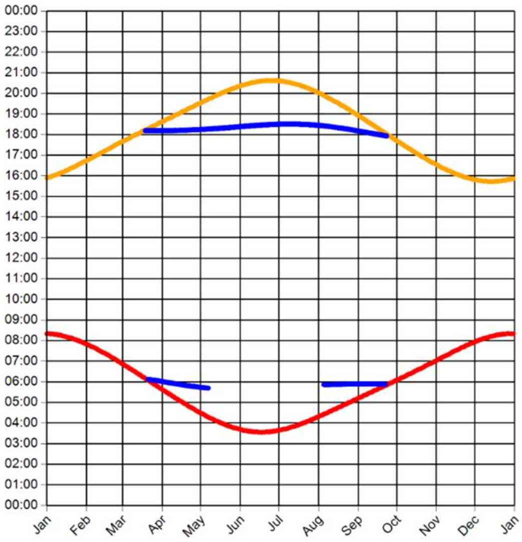



Observer 22 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.3°
Max observer difference angle: 16.4°
Observer Location
Sun azimuth range is 269.8° - 289° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 23 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.3°
Max observer difference angle: 16.4°
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

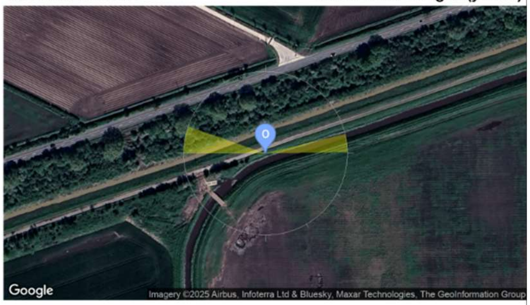
Observer 24 Results

Reflection Date/Time (GMT) Graph

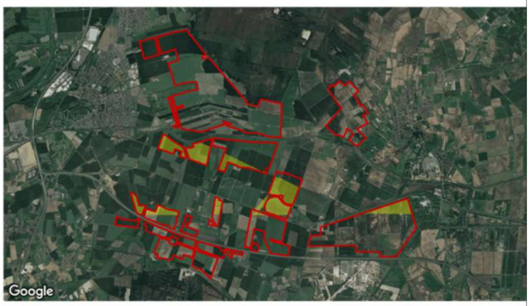


Min observer difference angle: 0.2°
Max observer difference angle: 16.4°

Observer Location | Sun azimuth ranges (yellow)

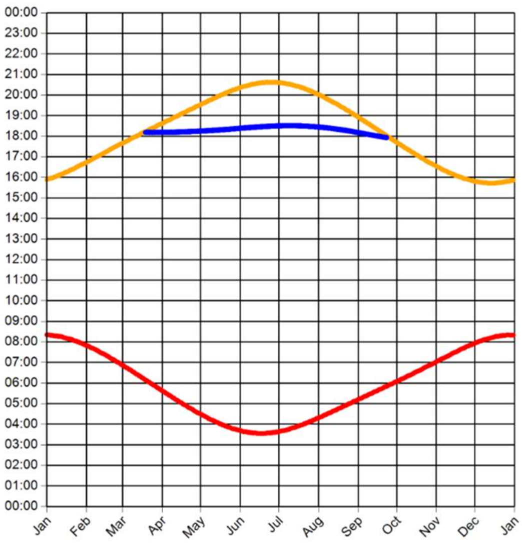


Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



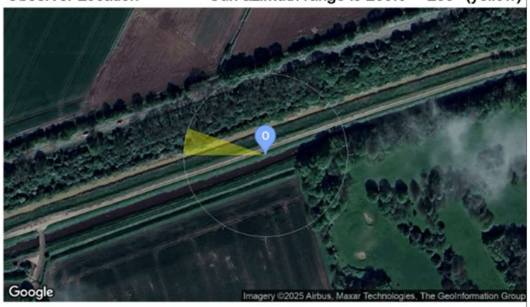
Observer 25 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.4°
Max observer difference angle: 16.4°

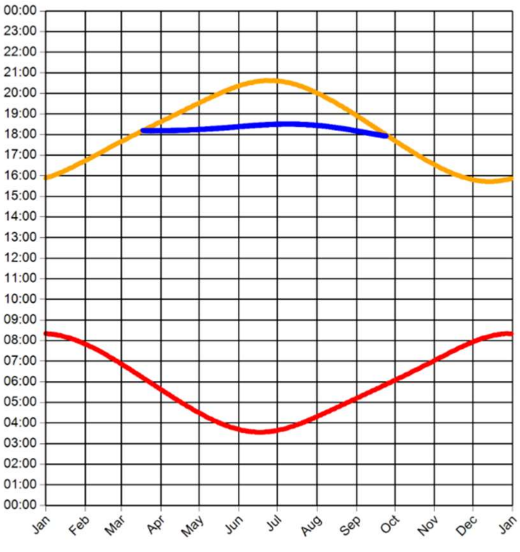
Observer Location | Sun azimuth range is 269.8° - 289° (yellow)



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

Observer 26 Results

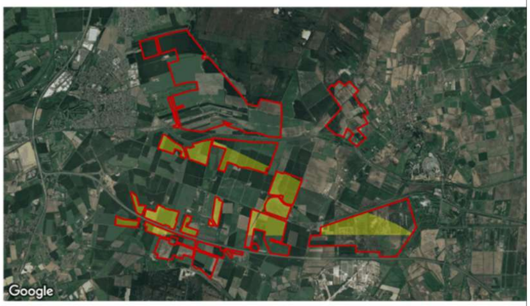
Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.3°
Max observer difference angle: 16.4°

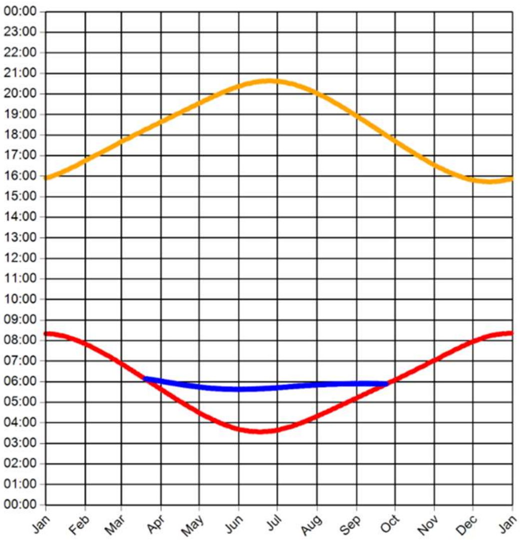
Observer Location — Sun azimuth range is 269.8° - 289° (yellow)

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



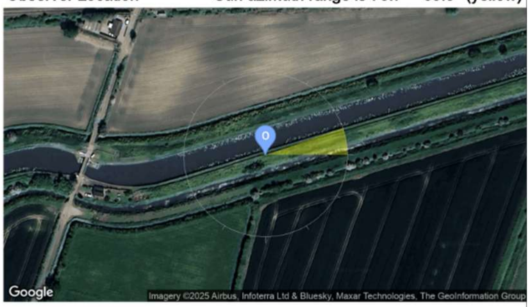
Observer 27 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0°
Max observer difference angle: 16.1°

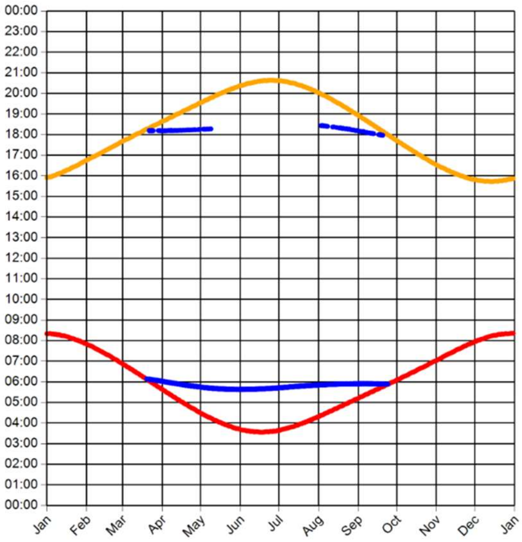
Observer Location — Sun azimuth range is 70.7° - 89.9° (yellow)



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

Observer 28 Results

Reflection Date/Time (GMT) Graph



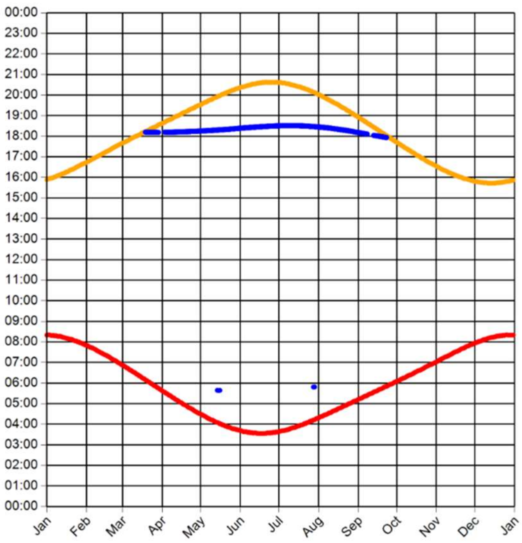
Min observer difference angle: 0.1°
Max observer difference angle: 16.1°

Observer Location | Sun azimuth ranges (yellow)

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

Observer 29 Results

Reflection Date/Time (GMT) Graph



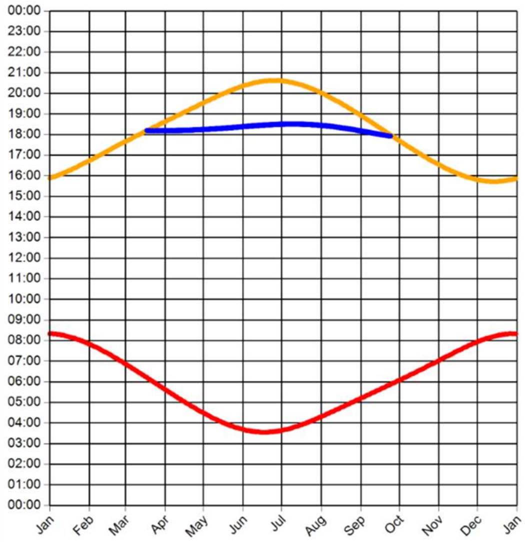
Min observer difference angle: 0.3°
Max observer difference angle: 16.4°

Observer Location | Sun azimuth ranges (yellow)

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

Observer 30 Results

Reflection Date/Time (GMT) Graph



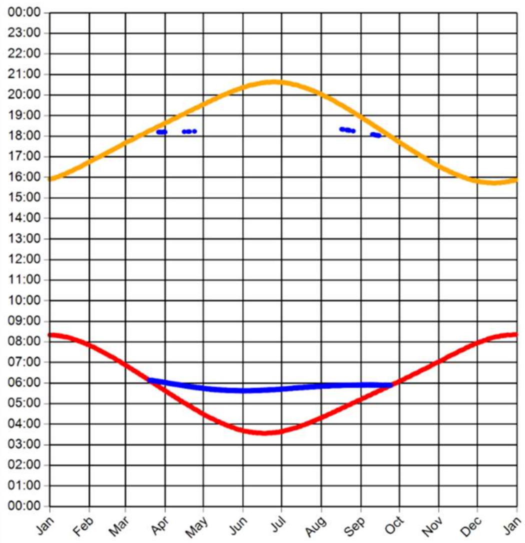
Min observer difference angle: 0.3°
Max observer difference angle: 16.4°

Observer Location | Sun azimuth range is 269.7° - 289° (yellow)

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

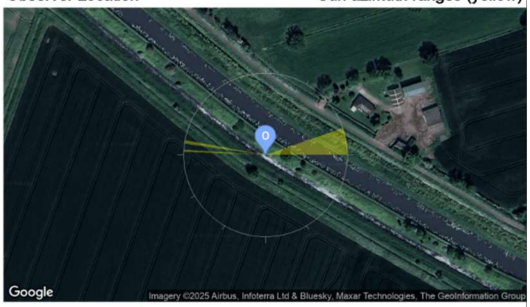
Observer 31 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0°
Max observer difference angle: 16°

Observer Location | Sun azimuth ranges (yellow)

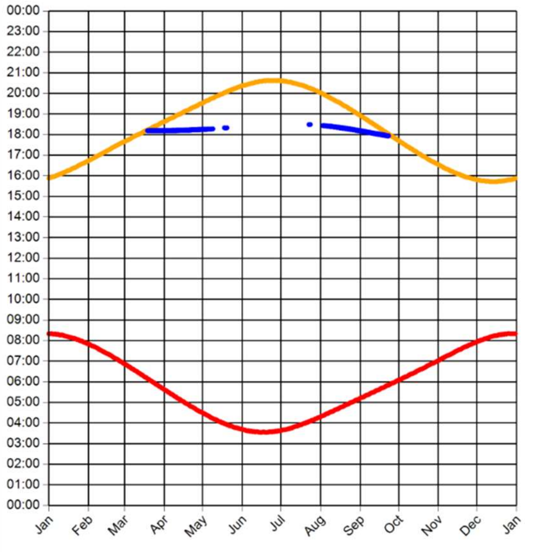


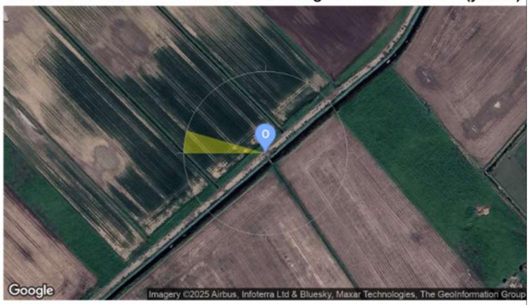
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

Observer 32 Results

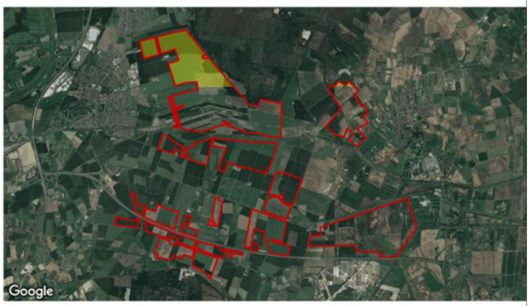
Observer Location | Sun azimuth range is 269.9° - 286.1° (yellow)

Reflection Date/Time (GMT) Graph





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

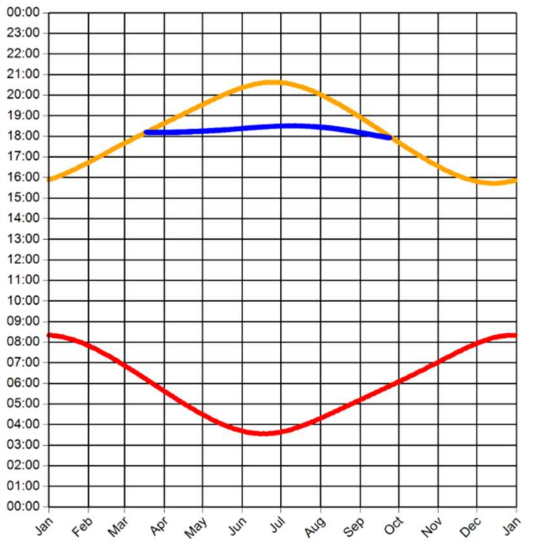


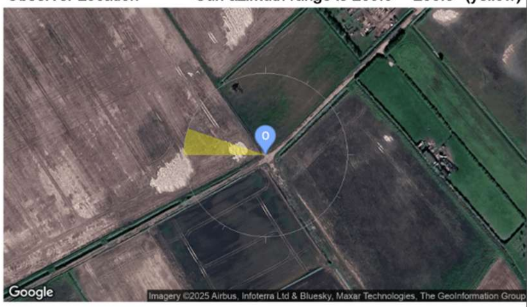
Min observer difference angle: 0.3°
Max observer difference angle: 13.9°

Observer 33 Results

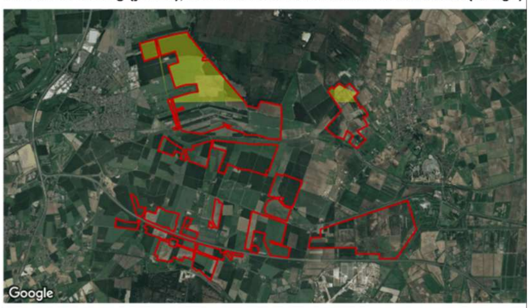
Observer Location | Sun azimuth range is 269.8° - 288.8° (yellow)

Reflection Date/Time (GMT) Graph





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



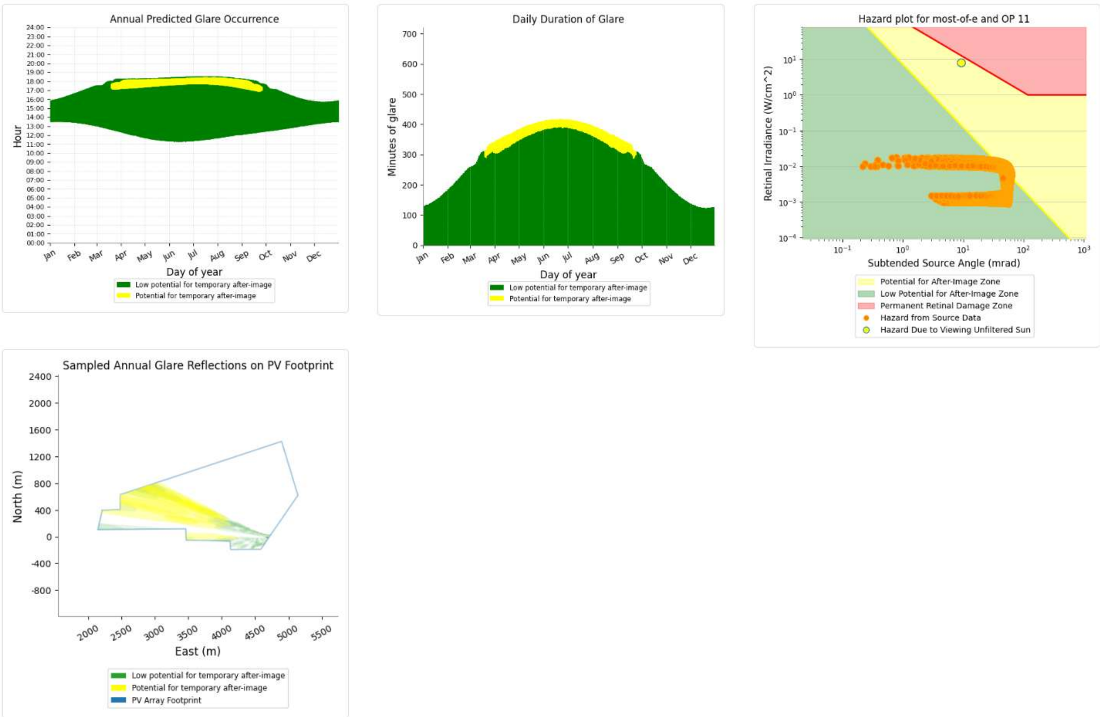
Min observer difference angle: 0.3°
Max observer difference angle: 16.4°

Sandtoft Airfield

The Forge Solar chart is shown below for the visual circuit receptor receiving the most minutes of yellow glare per year. The full modelling results can be provided separately on request.

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

- 100,420 minutes of "green" glare with low potential to cause temporary after-image.
- 6,650 minutes of "yellow" glare with potential to cause temporary after-image.



APPENDIX J – IMAGERY OF EXISTING SCREENING

Overview

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

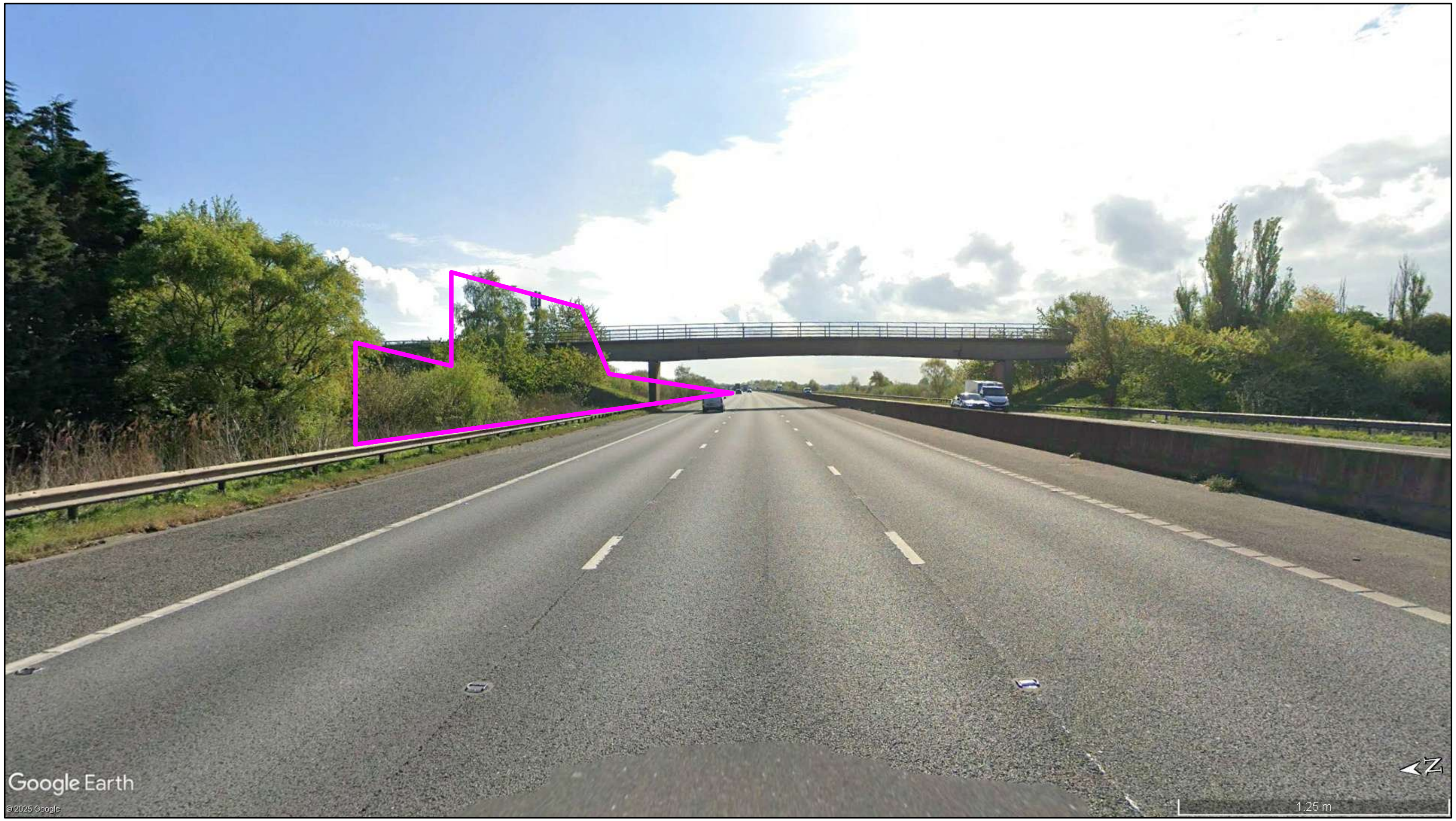
Where appropriate, a single image is used to represent the screening for multiple receptors. Further imagery can be provided on request.

Roads

The following pages shows images detailing a selection of some of the significant screening for the assessed road receptors. Pink polygons are used to represent screening.

Significant roadside terrain screening at road receptor A7 (road user travelling south-east)

Significant roadside terrain and vegetation screening at road receptor A17 (road user travelling south-east)



Significant roadside terrain and vegetation screening at road receptor A53 (road user travelling east)

Significant roadside terrain and vegetation screening at road receptor A63 (road user travelling west)

Significant roadside terrain and vegetation screening at road receptor A63 (road user travelling east)

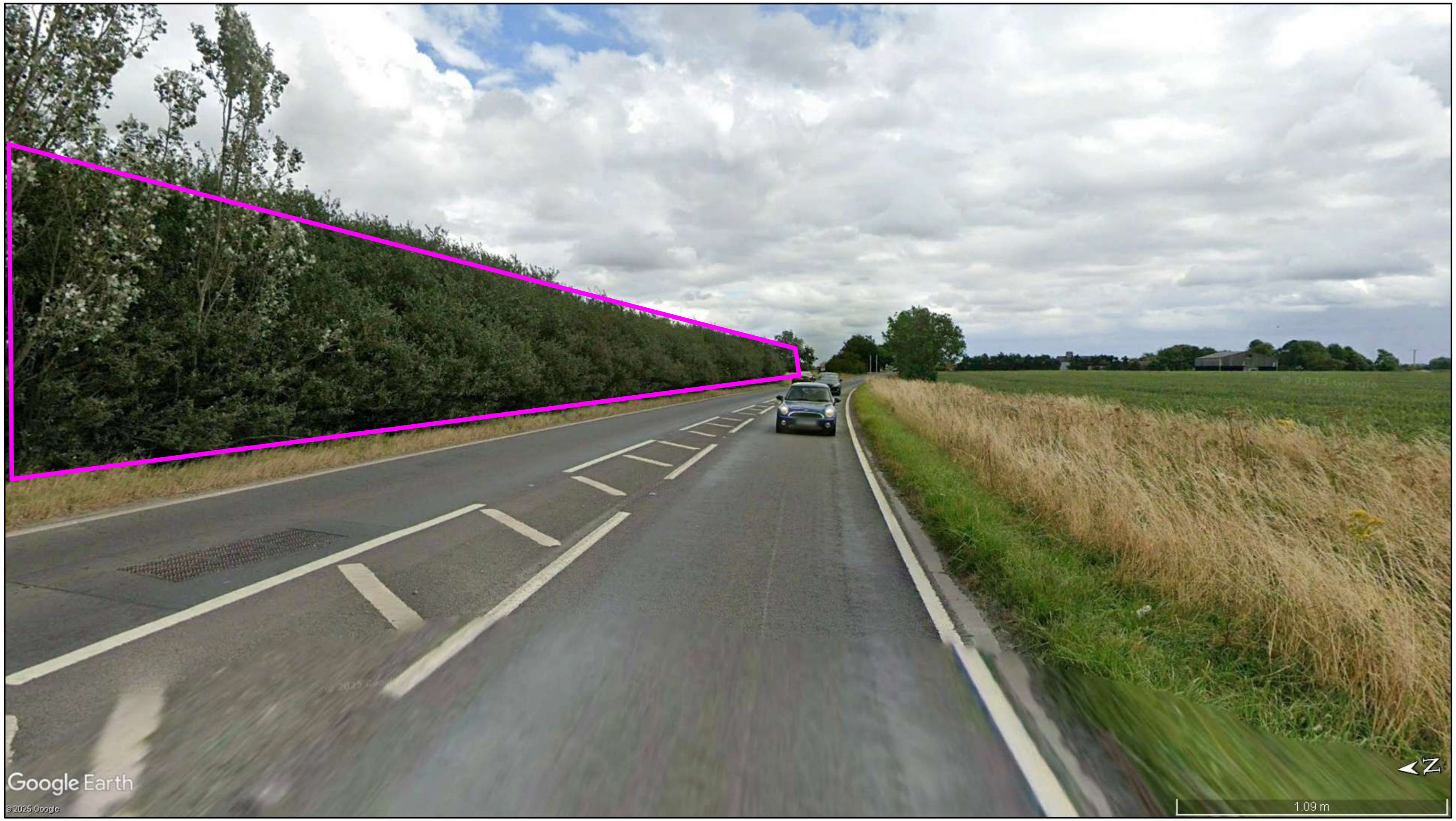
Significant roadside terrain and vegetation screening at road receptor A81 (road user travelling west)

Significant roadside terrain and vegetation screening at road receptor A81 (road user travelling east)

Street view imagery at road receptor B1 (road user travelling north-east)

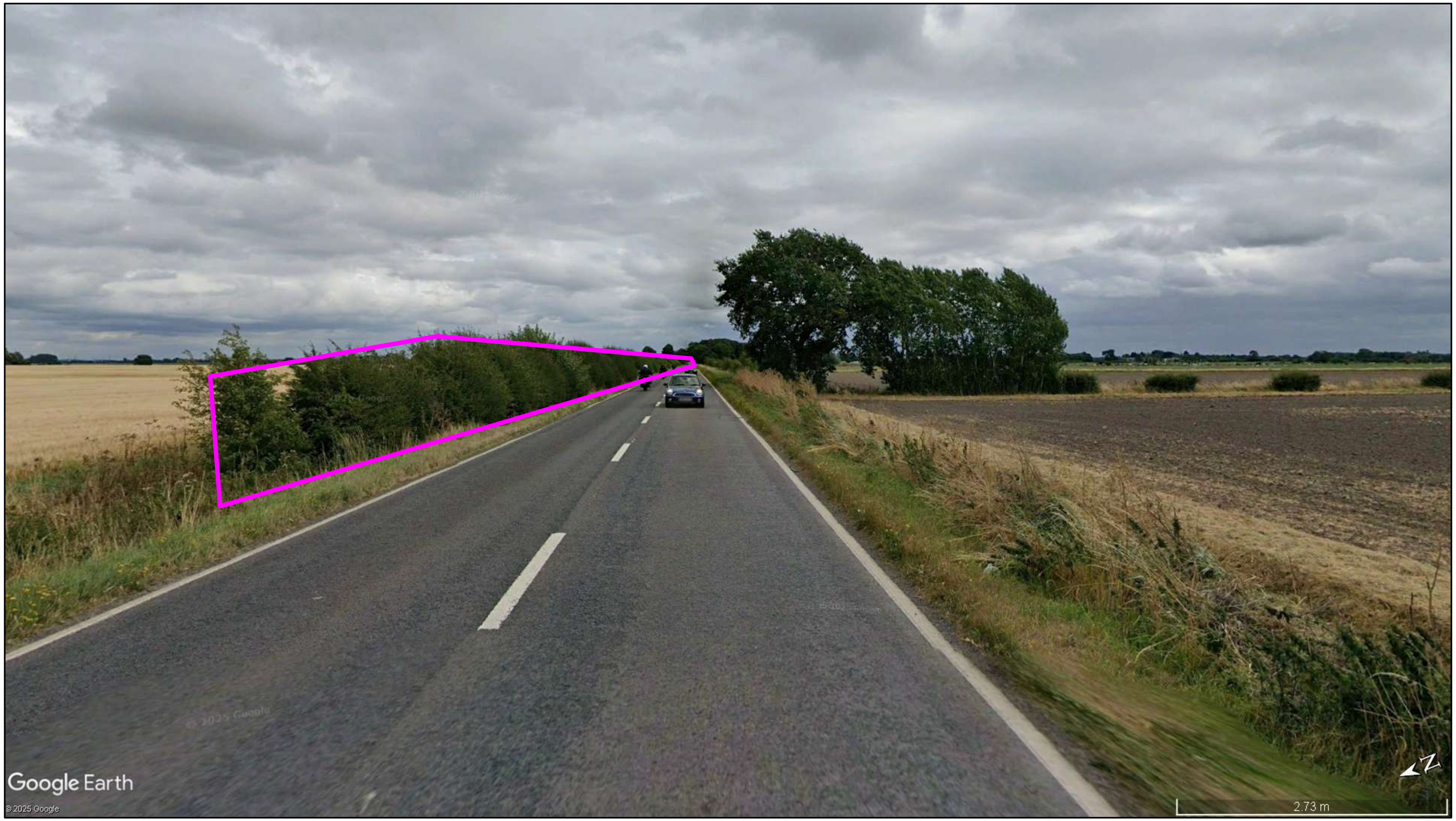
Street view imagery at road receptor B7 (road user travelling north-east)

Significant roadside vegetation screening at road receptor D1 (road user travelling east)



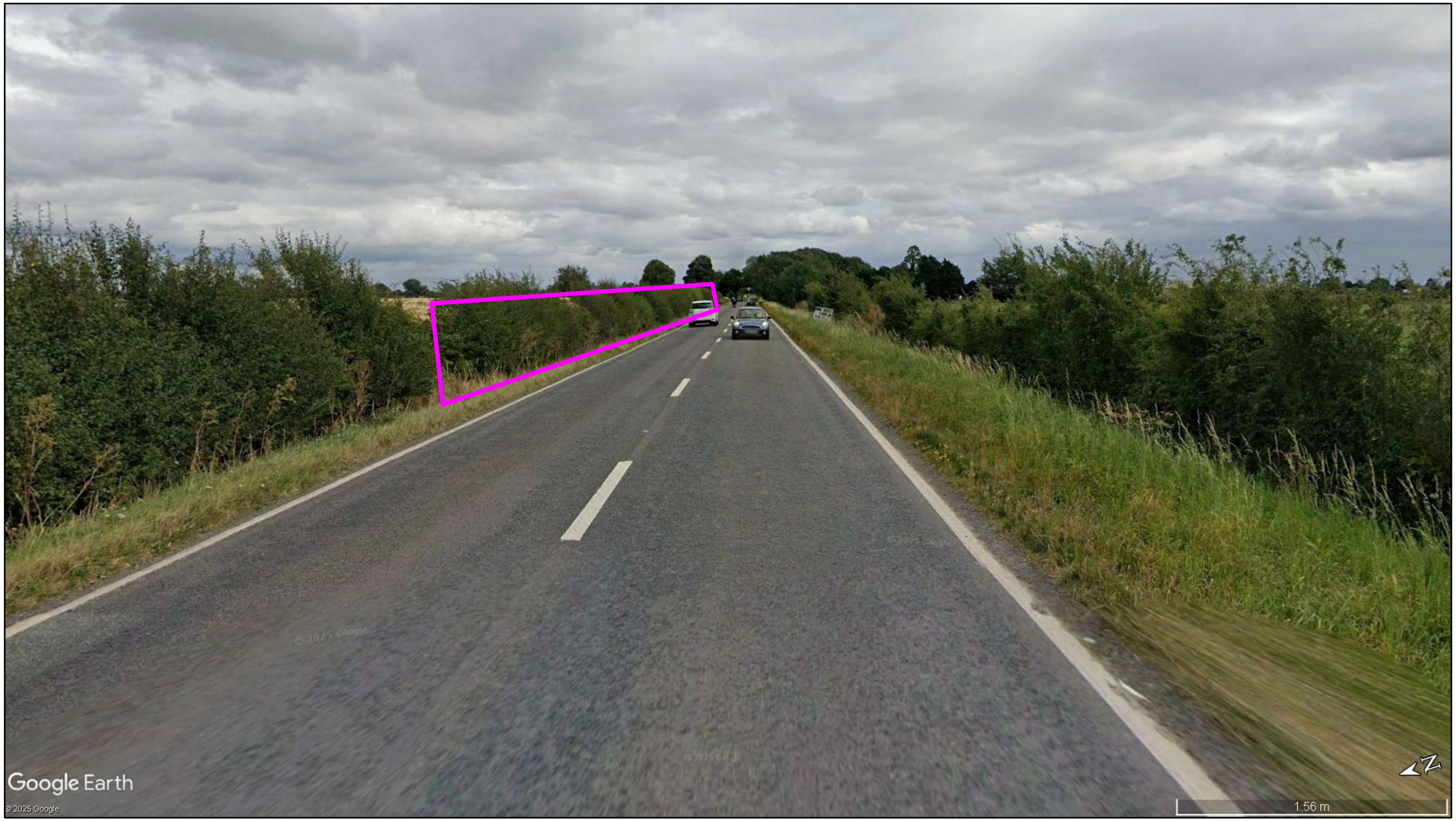
Significant roadside vegetation screening at road receptor D11 (road user travelling south-east)

Significant vegetation screening for road receptor D26 (road user travelling south-east)

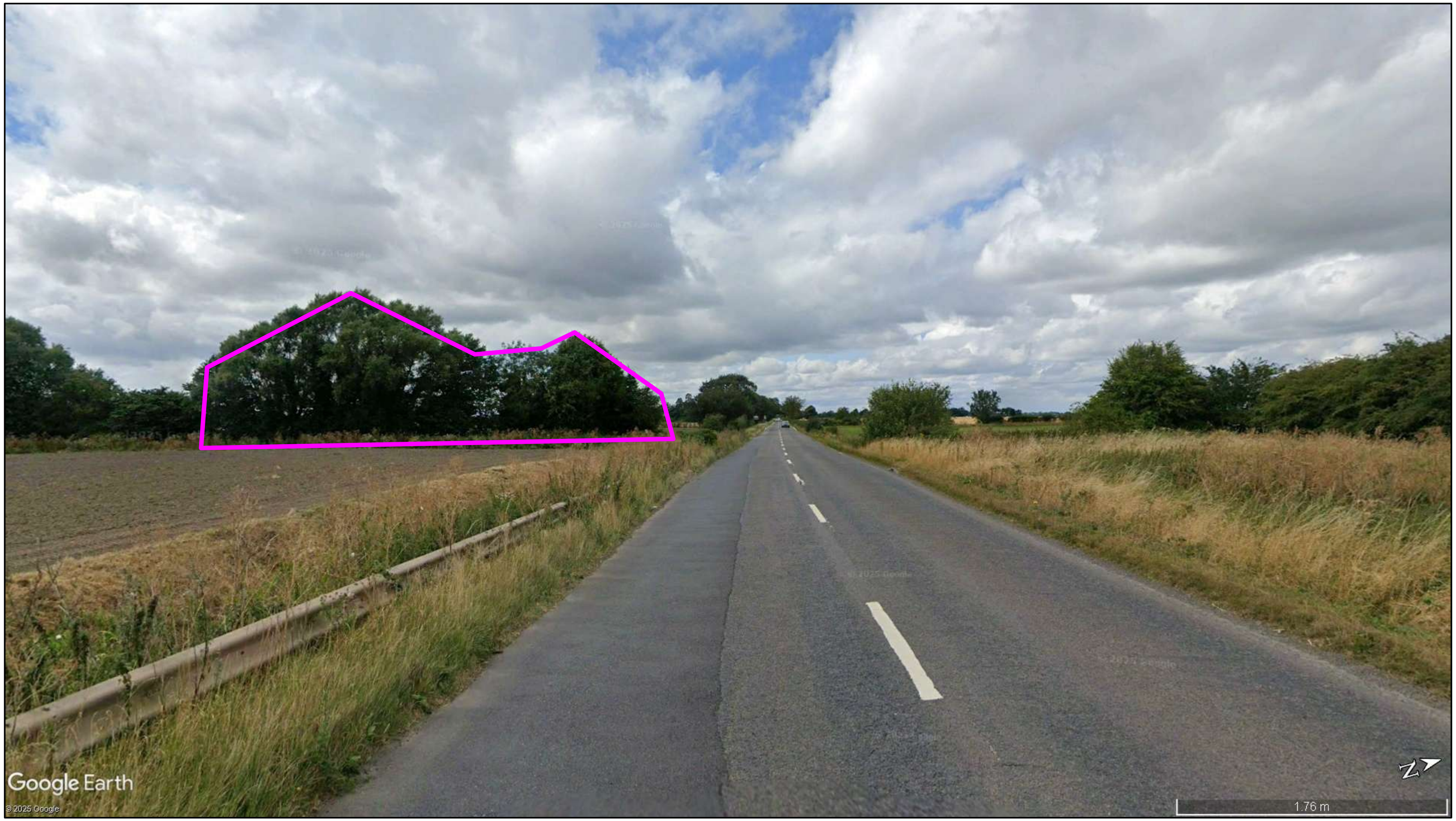


Significant vegetation screening for road receptor D35 (road user travelling south-east)

Significant vegetation screening for road receptor D38 (road user travelling north-west)



Significant vegetation screening for road receptor D38 (road user travelling south-east)



Significant vegetation screening for road receptor D47 (road user travelling north-west)

Significant vegetation screening for road receptor D47 (road user travelling south-east)

Significant vegetation screening for road receptor D56 (road user travelling north-west)

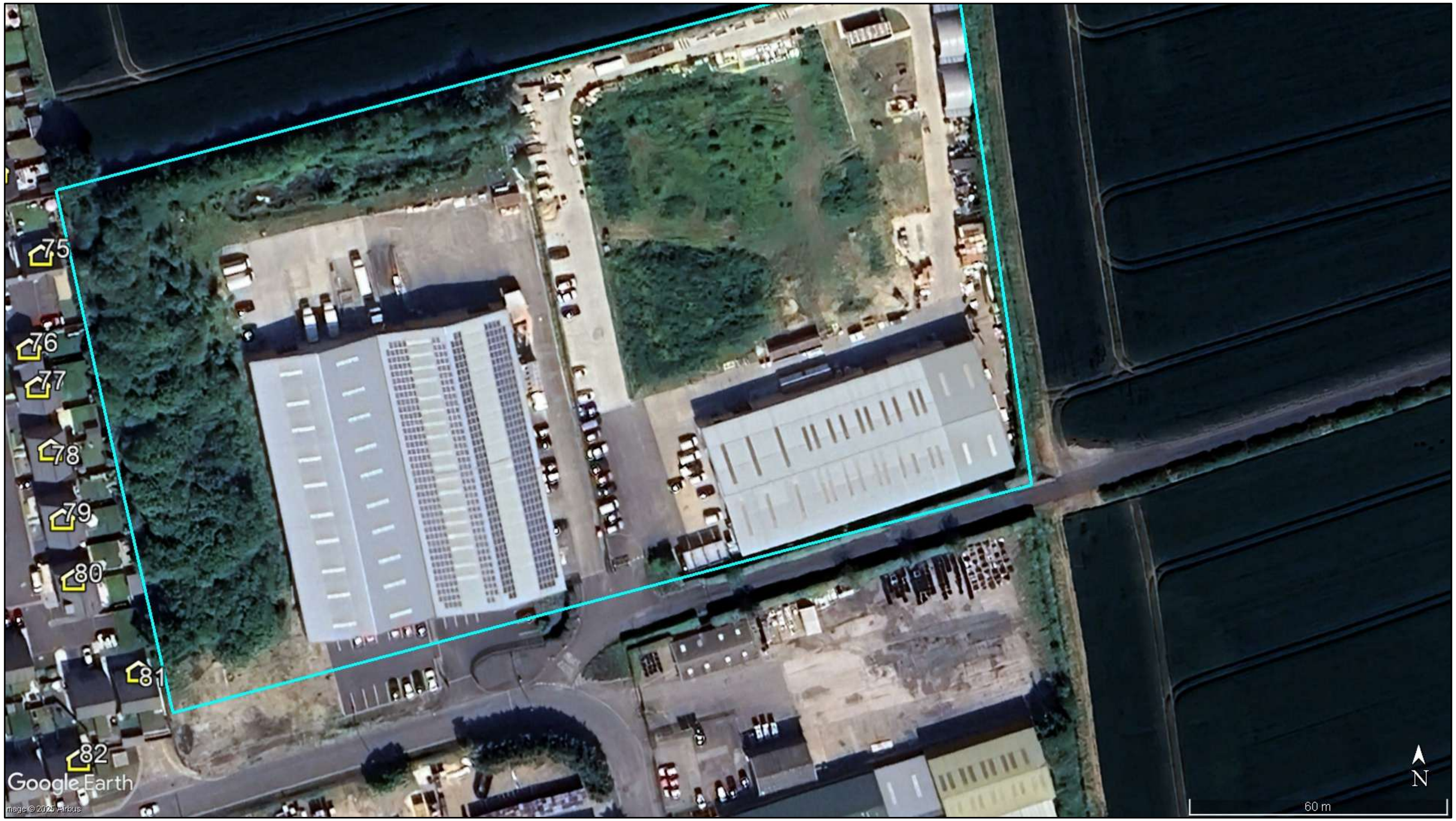
Significant vegetation screening for road receptor D56 (road user travelling south-east)

Significant roadside vegetation screening for road section E represented by street view imagery at road receptor E6 (road user travelling north)

Dwellings

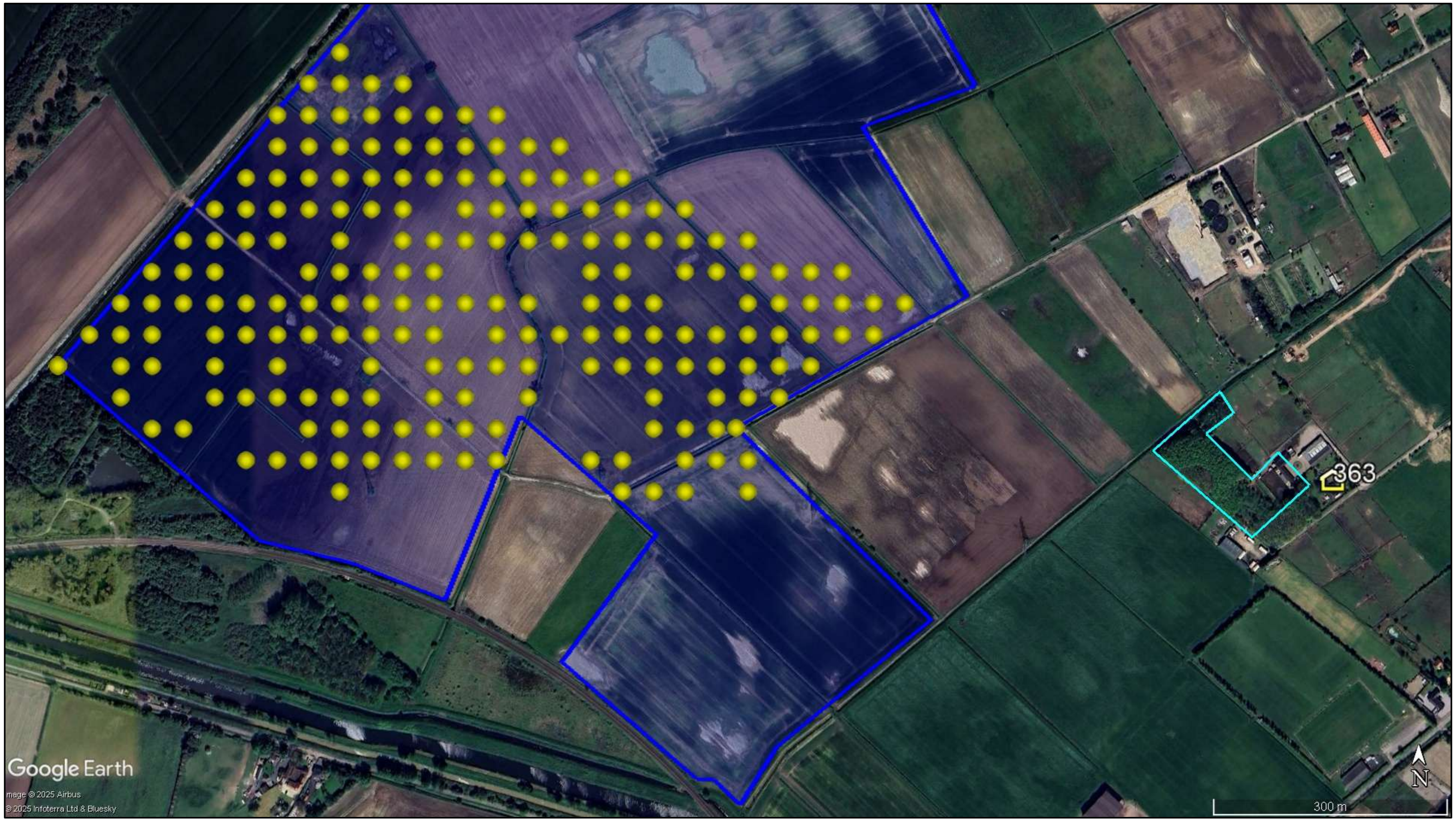
The following pages shows images detailing a selection of some of the significant screening for the assessed dwelling receptors. Light blue polygons are used to represent screening. Further imagery can be provided on request.

Significant screening for dwelling receptors 34 to 54



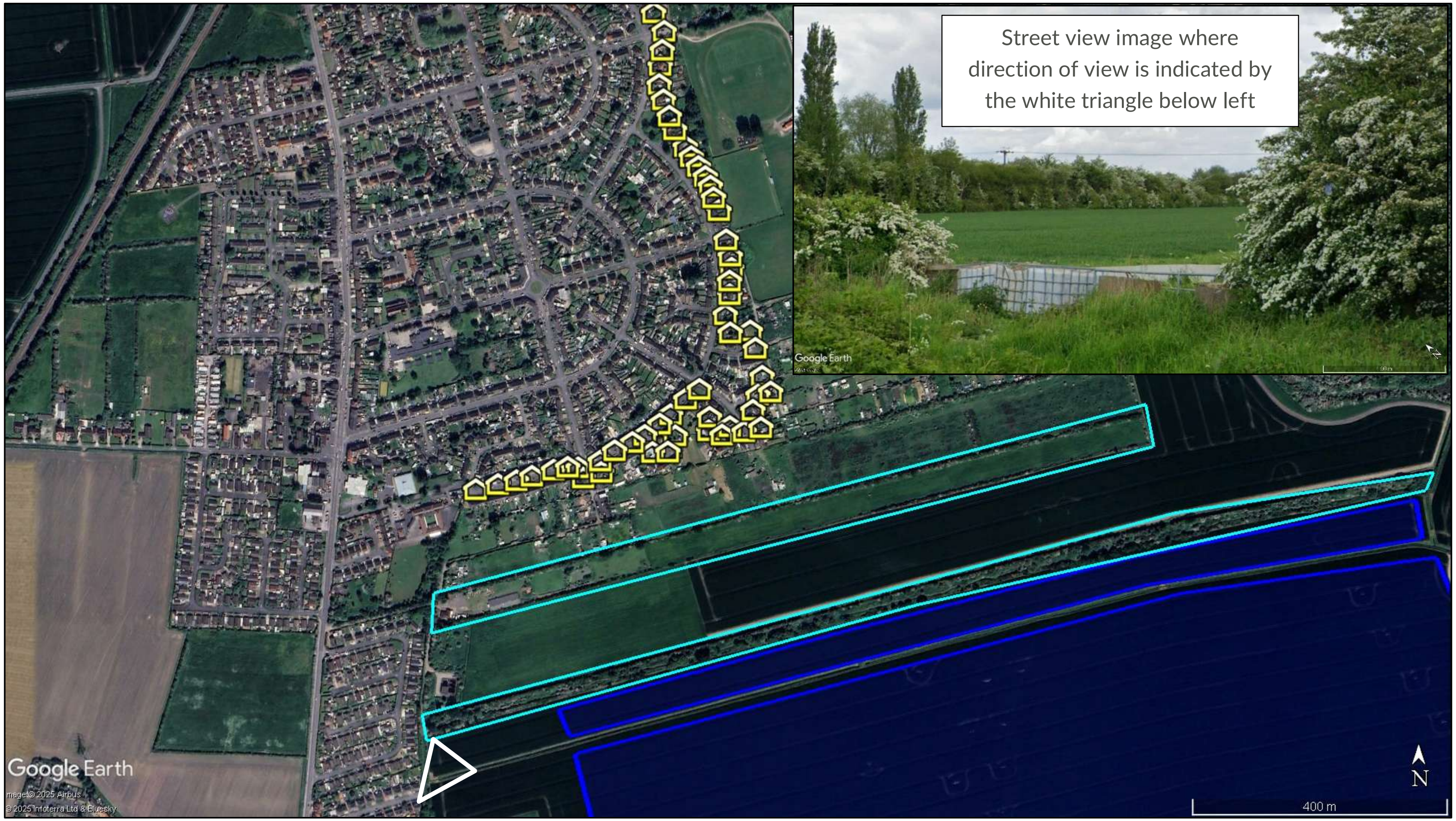
Significant screening for dwelling receptors 75 to 80

Significant screening for dwelling receptor 284



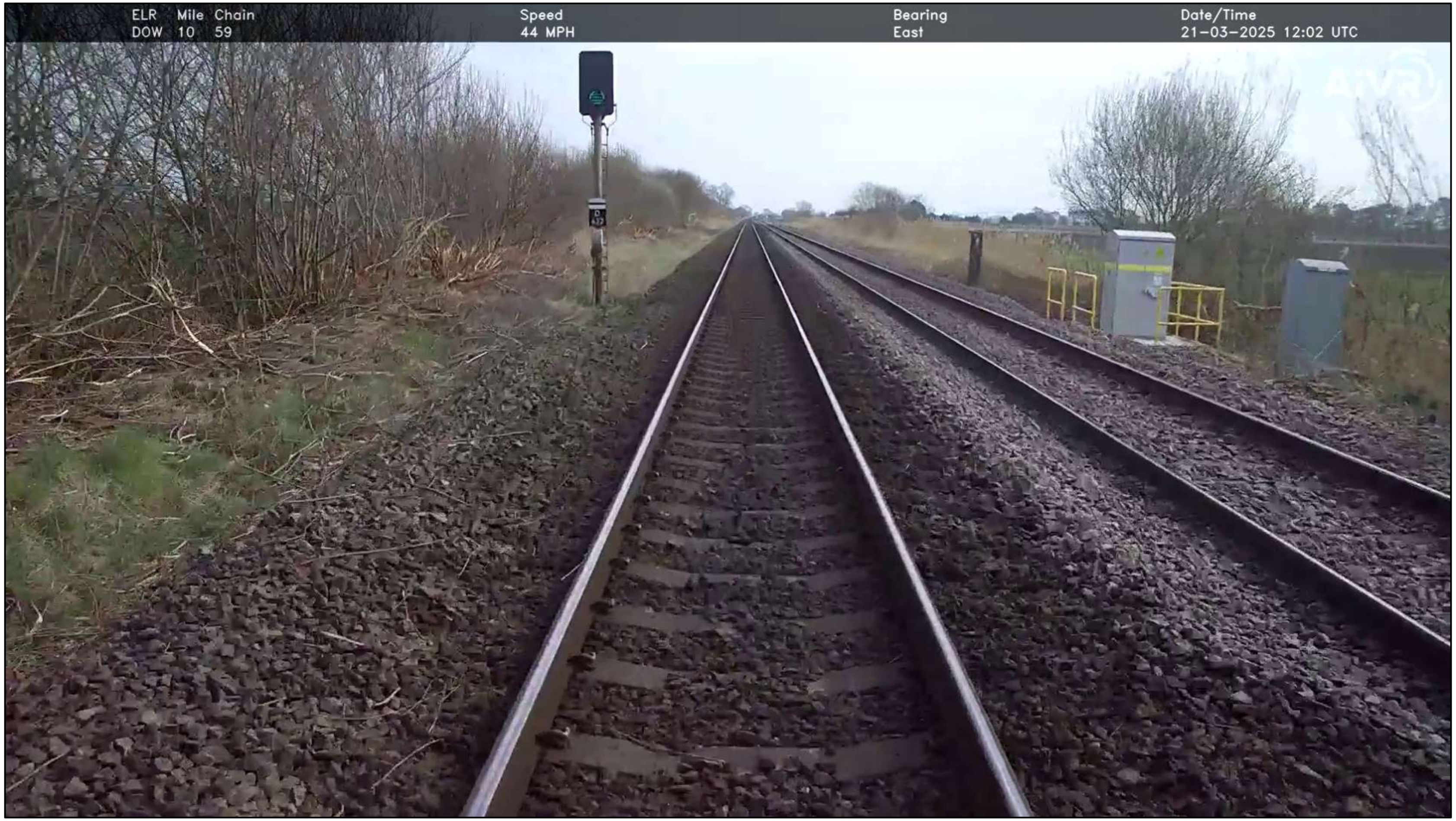
Significant screening for dwelling receptor 363

Significant screening for dwelling receptors 395 to 397



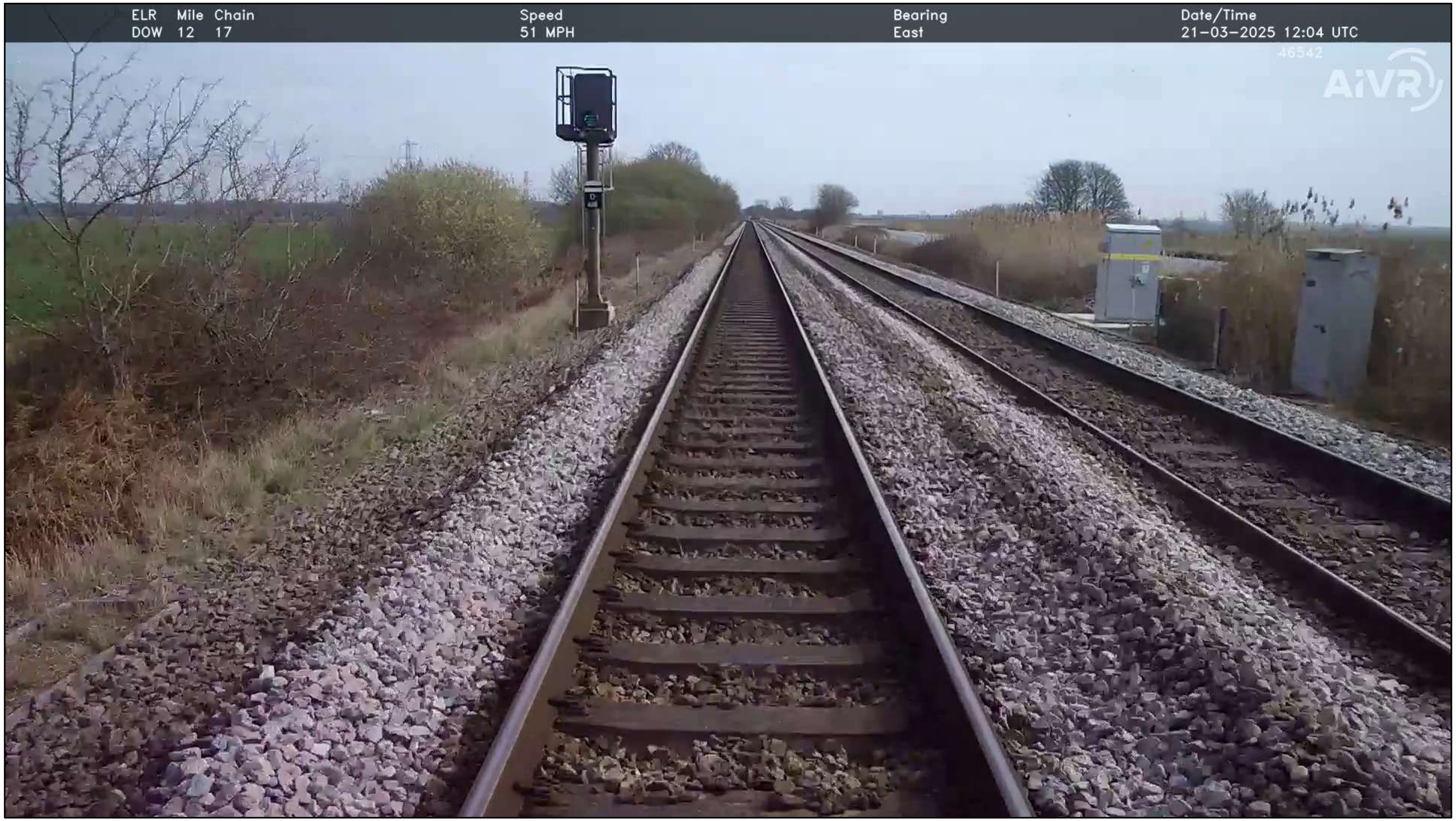
Significant vegetation screening for dwelling receptors 406-459 (inset street-view image shows the height and depth of some of the vegetation screening)

Railway Signals



AIVR imagery of S1 travelling east

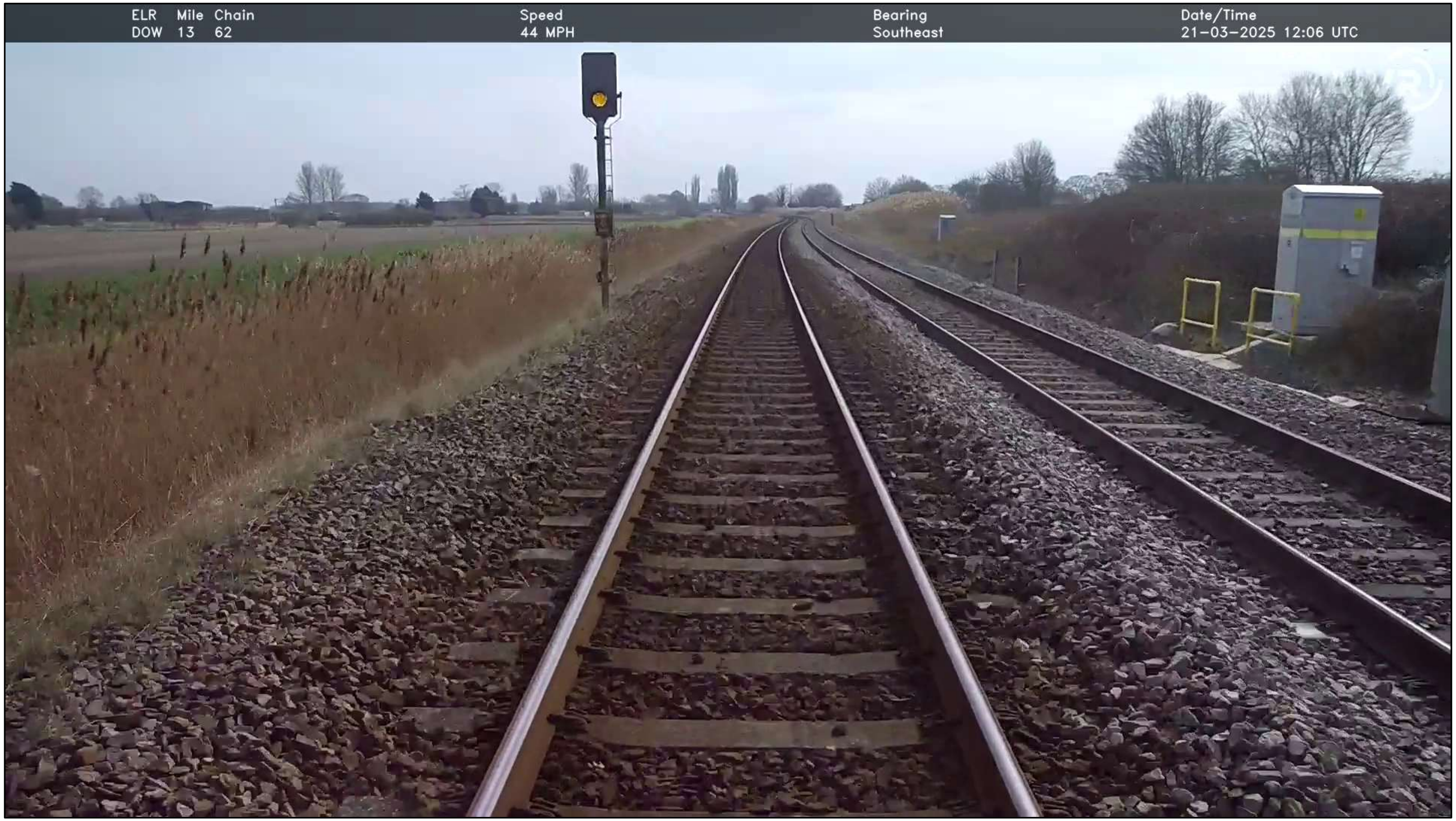
AIVR imagery of S2 travelling east



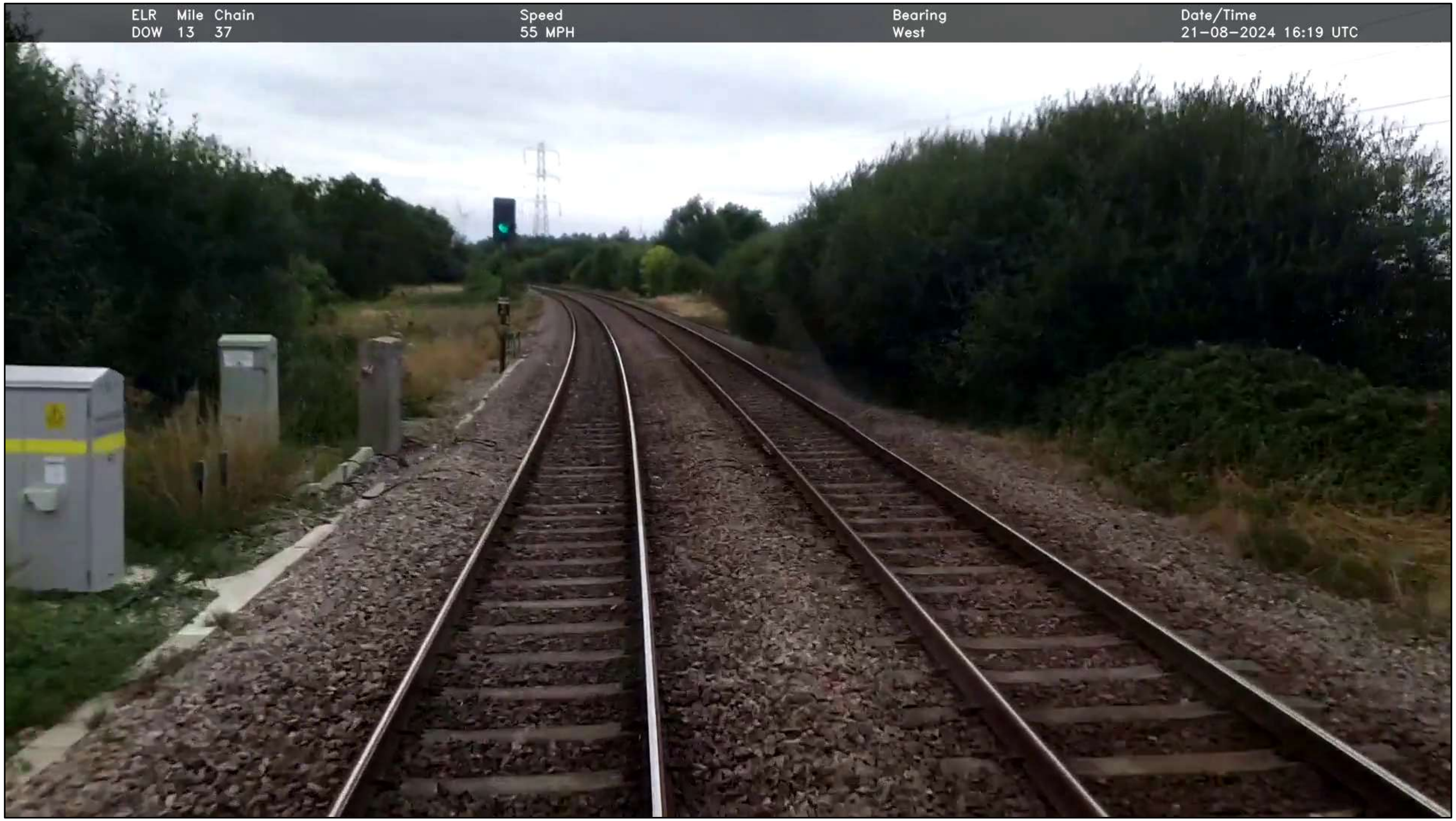
AIVR imagery of S3 travelling east

AIVR imagery of S4 travelling east

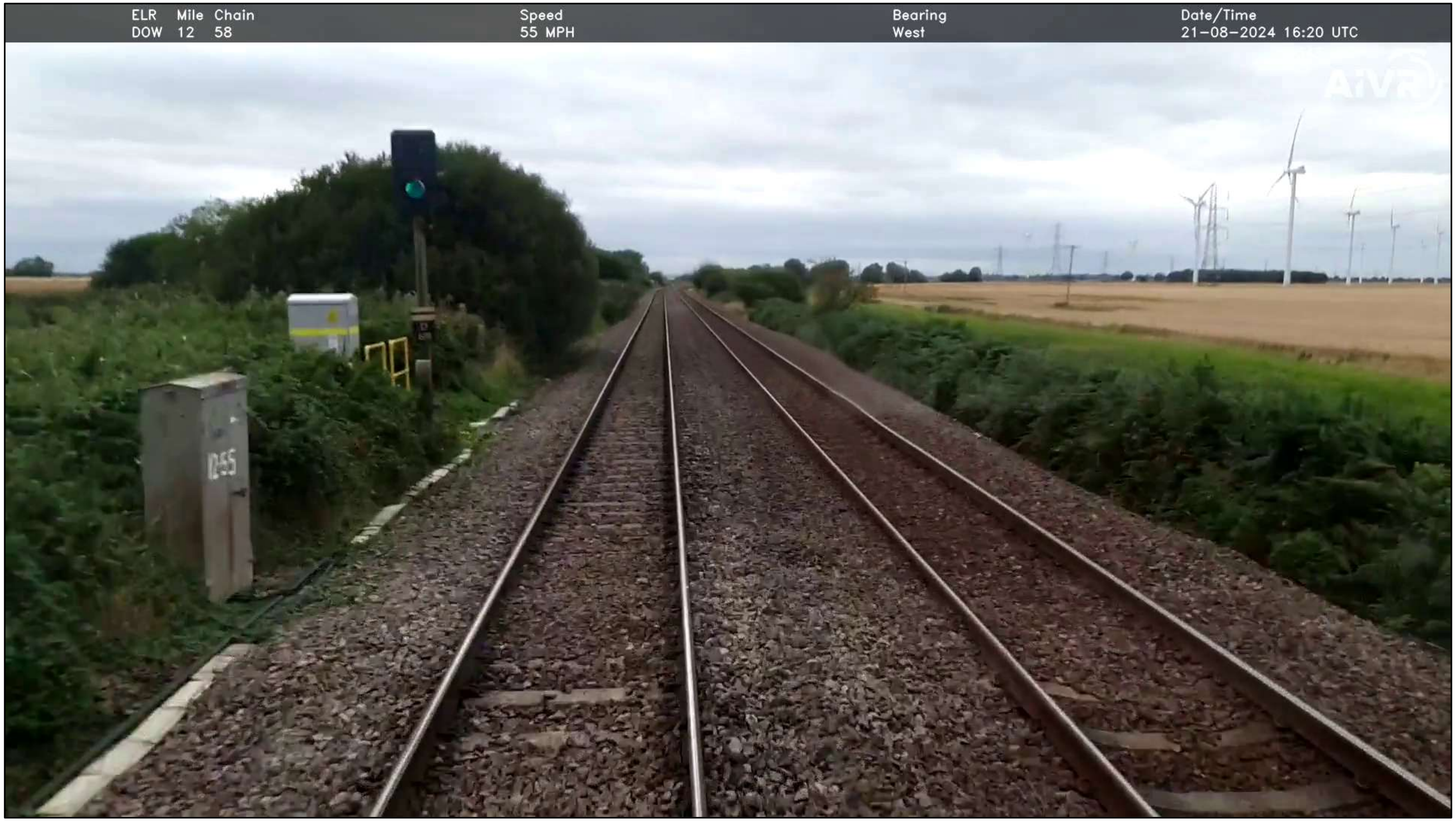
AIVR imagery of S4 travelling east



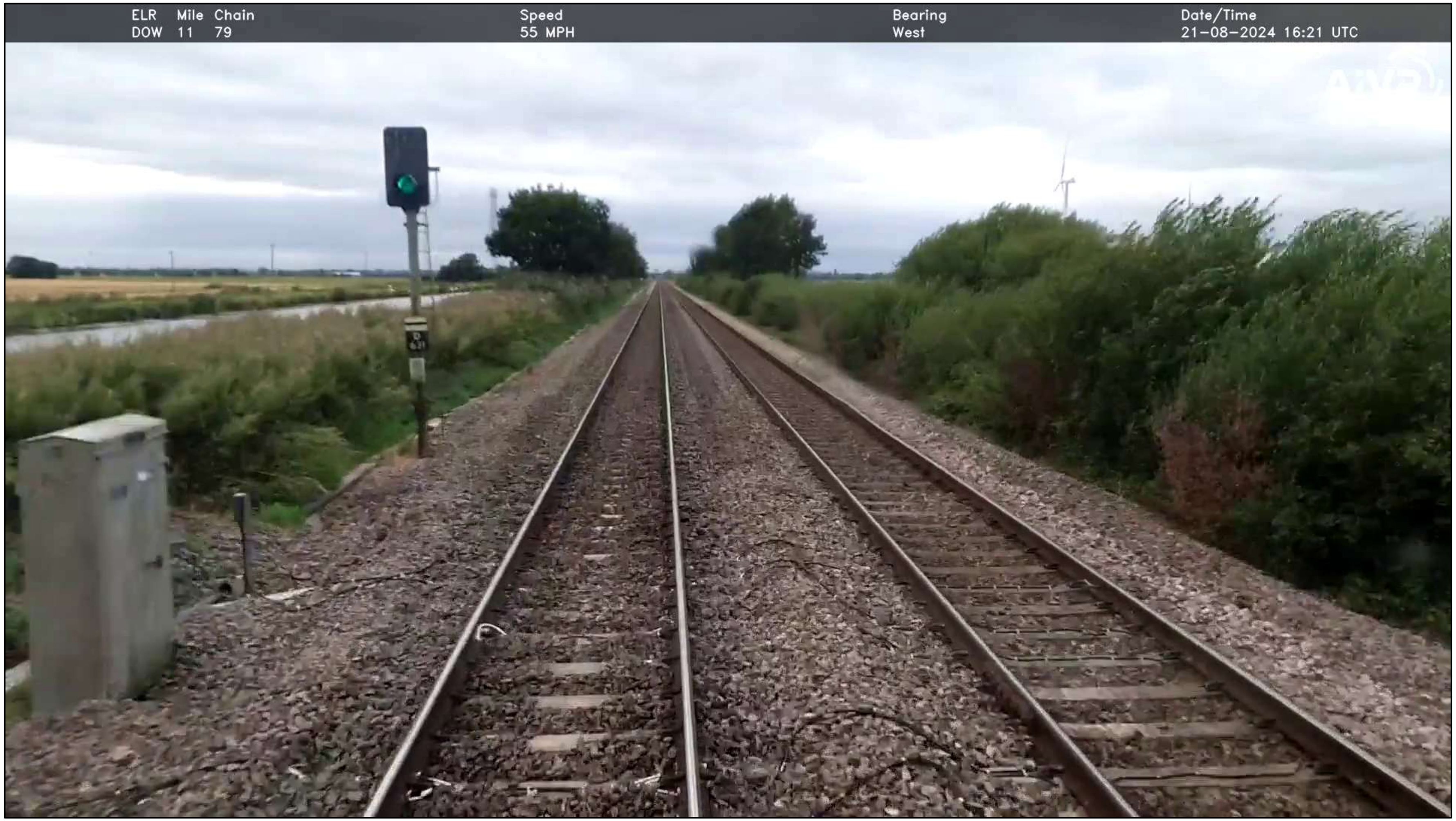
AIVR imagery of S5 travelling east



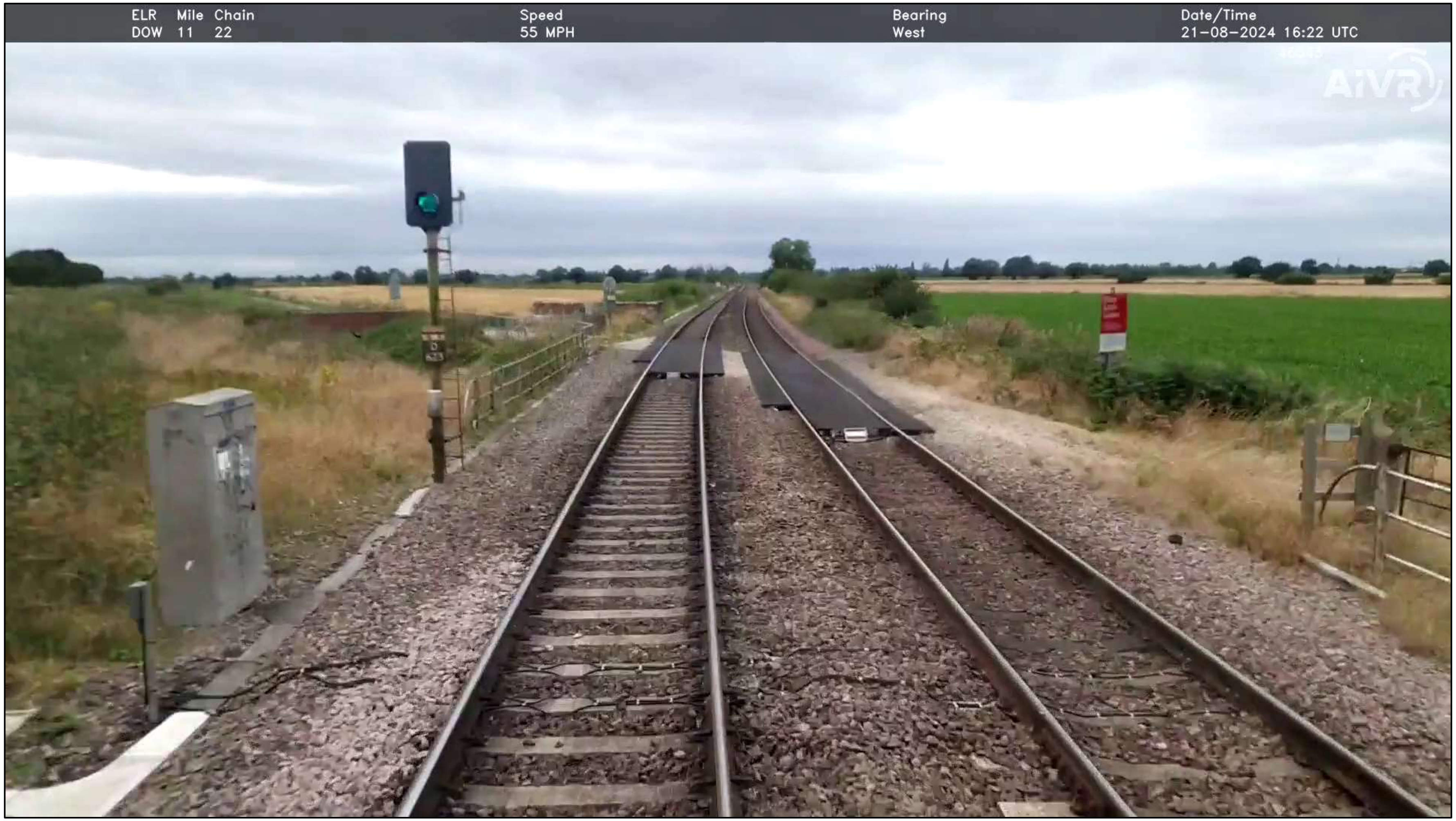
AIVR imagery of S6 travelling west



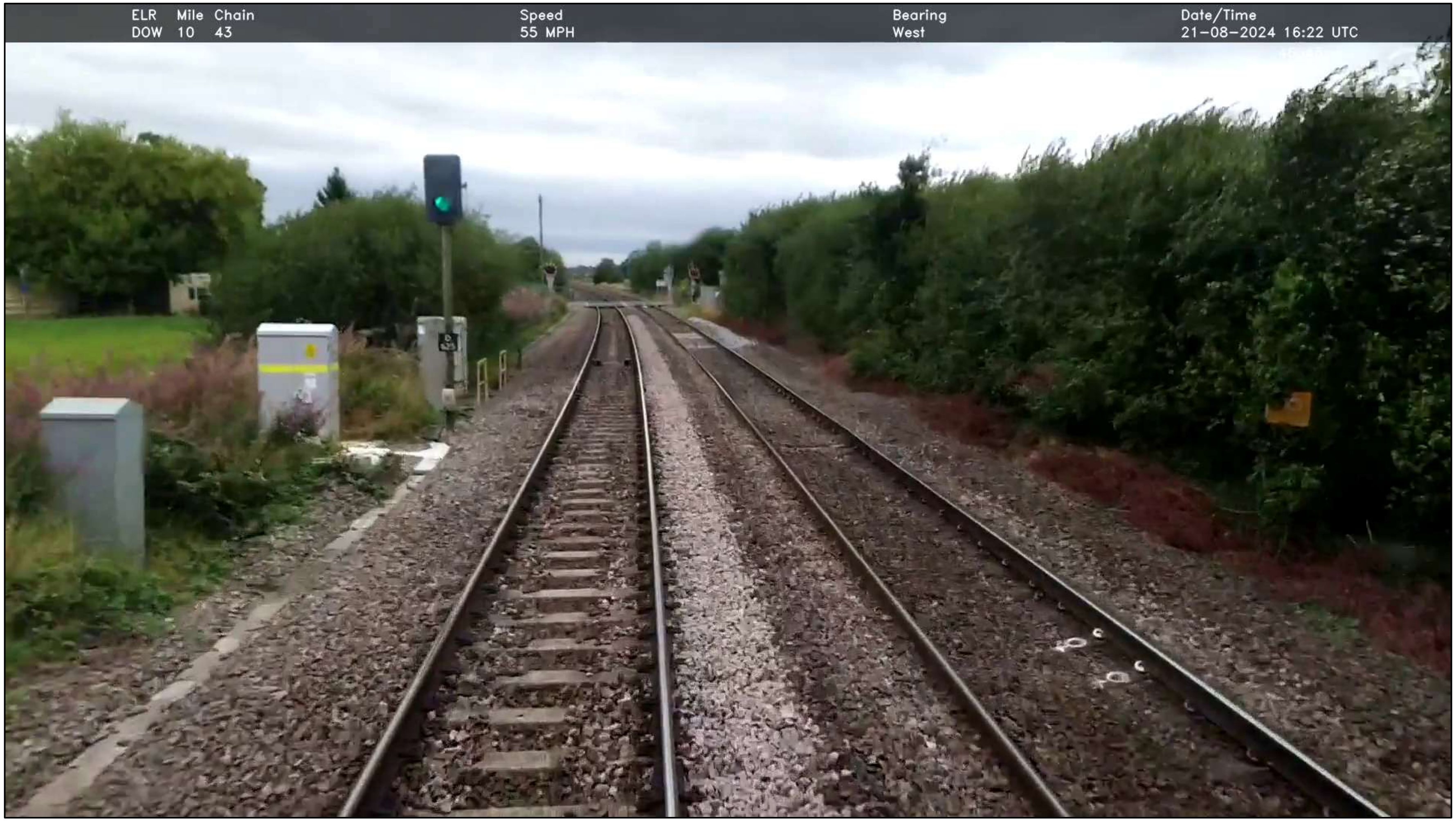
AIVR imagery of S7 travelling west



AIVR imagery of S8 travelling west



AIVR imagery of S9 travelling west

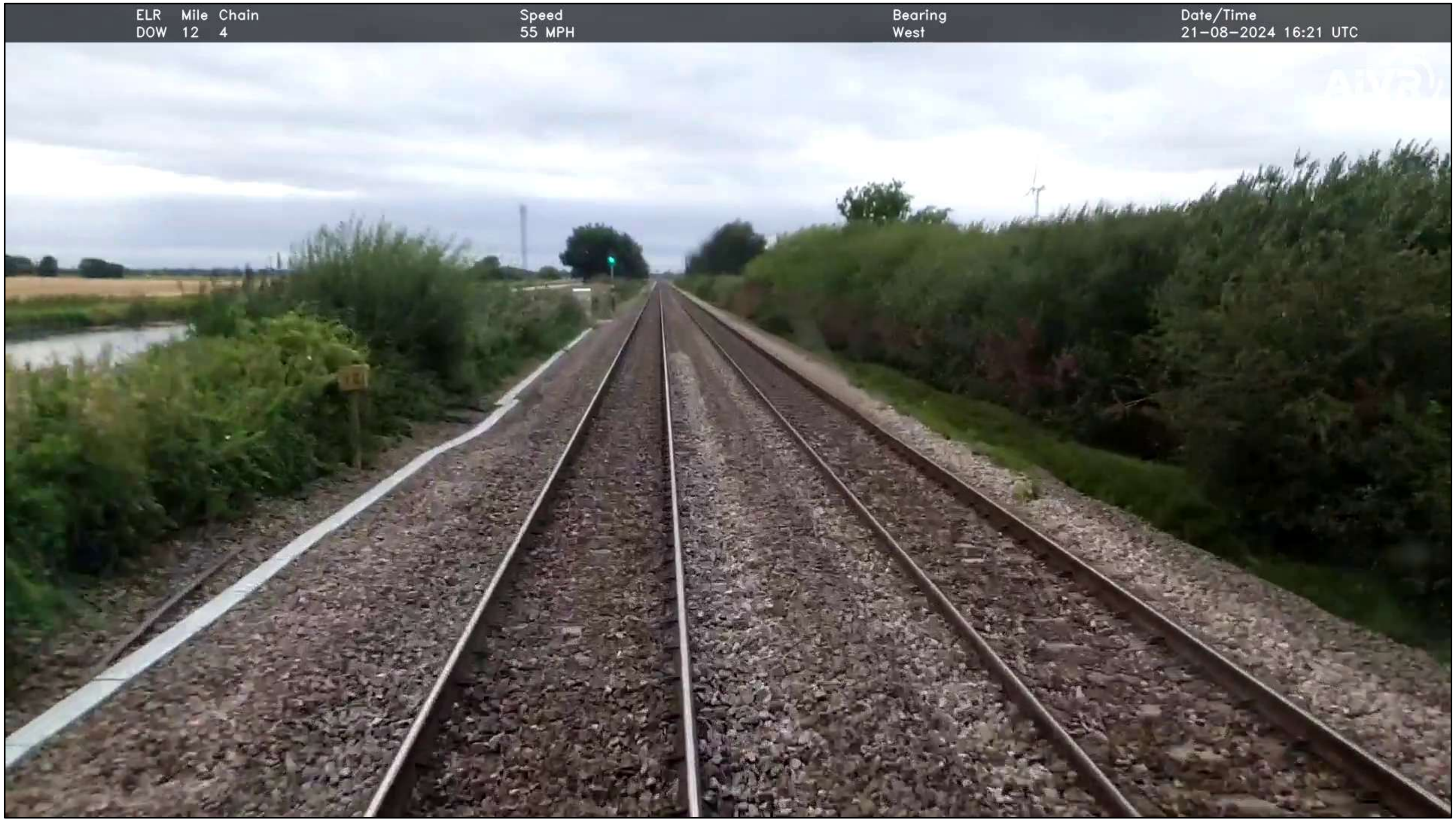


AIVR imagery of S10 travelling west

Railway Line

The following images detail a selection of some of the significant screening for the assessed railway receptors. Pink polygons are used to represent screening.

Significant screening at train driver receptor A7



Significant screening at train driver receptor A32

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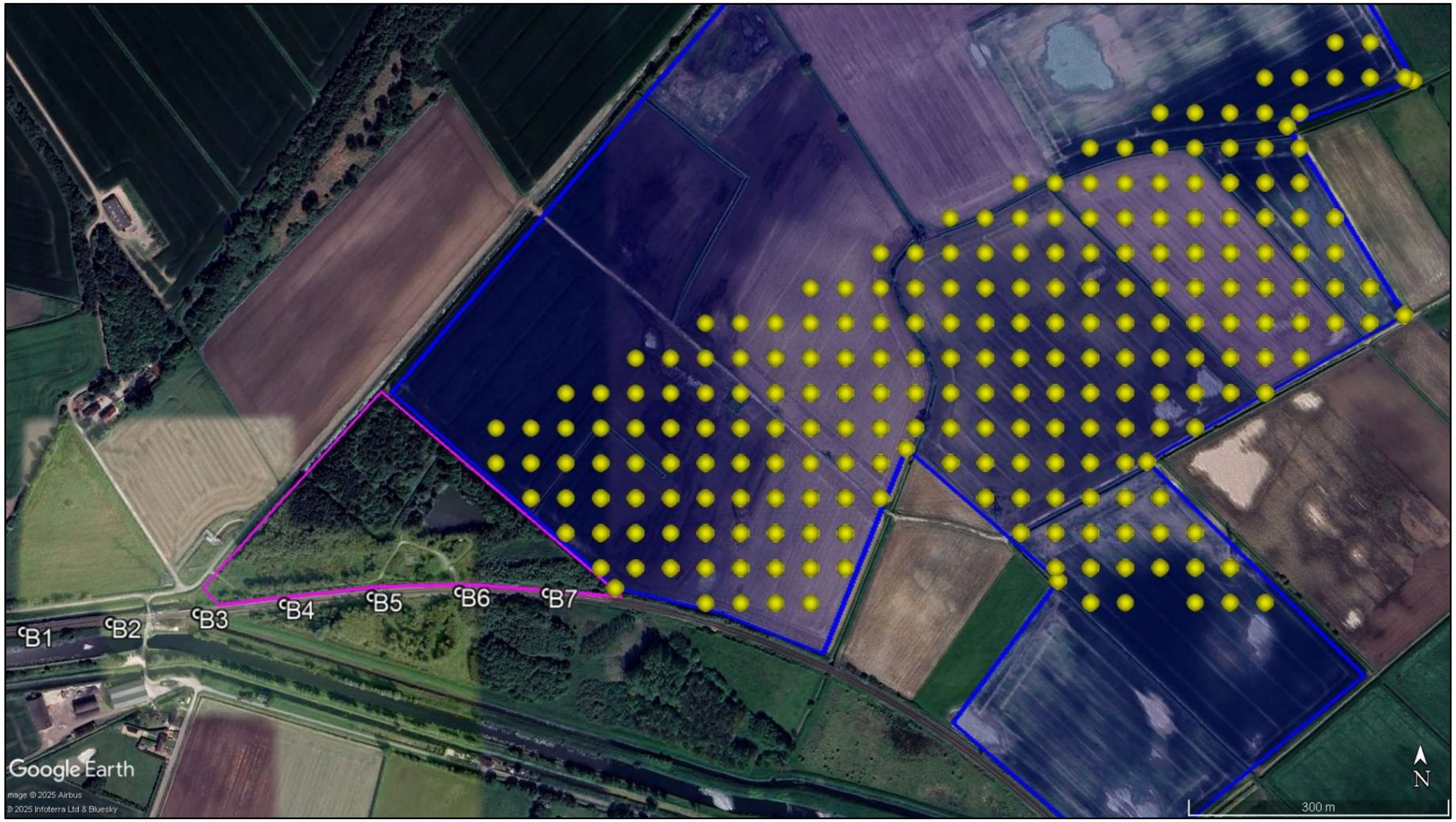

Significant screening for railway line section B1 to B7

Significant screening at train driver receptor B7

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