Springwell Solar Farm

Environmental Statement
Appendix 5.4 Glint and Glare Study

Volume 3

APFP Regulation 5(2)(a)

Planning Act 2008

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

EN010149/APP/6.3
November 2024
Springwell Energyfarm Ltd

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Executive Summary

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from a ground-mounted solar photovoltaic development, located in North Kesteven, Lincolnshire, UK. This assessment pertains to the possible impact upon road safety, residential amenity, railway infrastructure and operations, and aviation activity.

Overall Conclusions

Solar reflections towards four aerodromes are considered to be operationally accommodatable, and a low impact is predicted.

No significant impact is predicted upon road safety, residential amenity, and railway operations and infrastructure.

Guidance, Policy and Studies

Guidelines exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. The UK CAA guidance is relatively high-level and does not prescribe a formal methodology. There is railway guidance with respect to signal sighting; however, no guidance with respect to glint and glare from solar developments upon railway operations and infrastructure has been specifically produced. Pager Power has, however, produced guidance[1] for glint and glare and solar photovoltaic developments which was published in early 2017, with the fourth edition published in 2022. This methodology defines a comprehensive process for determining the impact upon railway infrastructure and operations, and aviation activity.

The associated relevant national planning policy that has effect for the determination of the DCO Application in relation to glint and glare is outlined in the National Policy Statement for Renewable Energy Infrastructure (EN-3). Further details are presented in **Appendix A**.

Pager Power's approach is to identify receptors, undertake geometric reflection calculations and, where a solar reflection is predicted, consider the screening (existing and/or proposed) between the receptor and the reflecting solar panels, whilst comparing the results against available solar reflection studies. For aviation activity, where a solar reflection is predicted, solar intensity calculations are undertaken where appropriate in line with the Sandia National Laboratories' FAA

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

methodology[2]. The scenario in which a solar reflection can occur for all receptors is then identified and discussed, and a comparison is made against the available solar panel reflection studies to determine the overall impact. Previous consultation with Network Rail and completing glint and glare assessment for railway infrastructure has been used to produce an overall methodology.

Studies have measured the intensity of solar reflections from various naturally occurring and man-made surfaces. The results show that the intensity of solar reflections from solar panels are slightly higher than those from still water but significantly less than those from steel[3].

Assessment Conclusions – Aviation Activity

Conclusions consider and are made in accordance with and consider the relevant guidance policy (National Policy Statement for Renewable Energy Infrastructure EN-3, paragraph 2.10.159, presented in **Appendix A**), associated methodology (**Appendix D**), Pager Power's industry experience and industry best practice.

RAF Cranwell

Solar reflections are geometrically possible towards the 2-mile approach path for threshold 19 and occur outside a pilot's primary field-of-view (FOV), and so are therefore not considered significant in accordance with the associated guidance (**Appendix D**) and industry best practice. No significant impact is predicted in accordance with the associated guidance (**Appendix A)** and methodology (**Appendix D**). Mitigation is not required.

Solar reflections with intensities 'potential for temporary after-image' ('yellow' glare) are predicted towards sections of the circuit for runway 01/19. There are mitigating factors (presented in Section 6.2.4) that decrease the level of impact, including that instances of 'yellow' glare occur outside the aerodrome's published hours of flying. It is therefore considered that instances of 'yellow' glare would be operationally accommodated. A low impact is predicted in accordance with the relevant guidance set out in **Appendix A**, and mitigation is not required.

Solar reflections are not geometrically possible towards the Air Traffic Control (ATC) Tower, or 2-mile approach paths for threshold 10, 08 and 26. No impact is predicted, and mitigation is not required.

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

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

The Applicant has engaged with the Ministry of Defence on the results of its Glint and Glare Assessment. The Applicant is in ongoing engagement with the MOD regarding the outcomes noted at RAF Cranwell. While the potential for yellow glare occurs outside of its published hours of flying, the Applicant shared the results of its Glint and Glare Assessment and continues to welcome further engagement to discuss the assessment in more detail.

RAF Waddington

Solar reflections are geometrically possible towards the 2-mile approach path for threshold 02 and occur outside a pilot's primary FOV, therefore not considered significant in accordance with the associated methodology (**Appendix D**) and industry best practice. A low impact is predicted, and mitigation is not required.

Solar reflections with intensities of 'low potential for temporary after-image' ('green' glare) are predicted towards sections of the circuit for runway 02/20. The glare intensity is considered acceptable and not significant in accordance with the associated methodology (**Appendix D**) and industry best practice. A low impact is predicted in accordance with the relevant guidance (**Appendix A**), and mitigation is not required.

Solar reflections are not geometrically possible towards the ATC Tower and 2-mile approach paths for threshold 20. No impact is predicted, and mitigation is not required.

The Applicant has engaged with the Ministry of Defence on the results of its Glint and Glare Assessment. The Applicant is in ongoing engagement with the MOD regarding the outcomes noted at RAF Waddington and continues to welcome further engagement to discuss the assessment in more detail.

Temple Bruer (Griffins Farm) Airfield

Solar reflections are geometrically possible towards the 1-mile splayed approach path for threshold 26 occur outside a pilot's primary FOV, and so are therefore not considered significant in accordance with the associated guidance (**Appendix D**) and industry best practice. No significant impact is predicted, and mitigation is not required.

Solar reflections with intensities of 'yellow' glare are predicted towards sections of the splayed approach path for threshold 08 and final sections of the visual circuits for runway 08/26. There are mitigating factors that decrease the level of impact (Section 6.2.4). The Applicant considers that instances of 'yellow' glare to be operationally accommodatable. No significant impact is predicted in accordance with the relevant guidance (**Appendix A**) and associated methodology (**Appendix D**). Mitigation is not required.

The Applicant considers that the potential for yellow glare is operationally accommodatable. Engagement has been sought to understand their operations and discuss the results of the assessment. The Applicant will continue to engage with Temple Bruer Airfield following submission of the Application.

Cottage Farm Airfield

Solar reflections are geometrically possible towards the 1-mile splayed approach path for threshold 09 and occur outside a pilot's primary FOV, and so are therefore not considered significant in accordance with the relevant guidance (**Appendix A**) and associated methodology (**Appendix D**). Mitigation is not required. No significant impact is predicted, and mitigation is not required.

Solar reflections with intensities of 'yellow' glare are predicted towards sections of the splayed approach path for threshold 27 and final sections of the visual circuits for runway 09/27. There are mitigating factors that decrease the level of impact (**Section 6.2.4**). The Applicant considers the instances of 'yellow' glare to be operationally accommodatable. No significant impact is predicted in accordance with the relevant guidance (Appendix A) and associated methodology (**Appendix D**). Mitigation is not required. Mitigation is not required.

The Applicant considers that the potential for yellow glare is operationally accommodatable. Engagement has been sought to understand their operations and discuss the results of the assessment. The Applicant will continue to engage with Cottage Farm Airfield following submission of the Application.

Old Manor Farm Airfield

Solar reflections are geometrically possible towards the 1-mile splayed approach path for thresholds 06 and 24, and occur outside a pilot's primary FOV, therefore not considered significant in accordance relevant guidance (**Appendix A**) and associated methodology (**Appendix D**). No significant impact is predicted, and mitigation is not required.

Solar reflections with intensities of 'green' glare are predicted towards the final sections of the visual circuits for runway 06/24. The glare intensity is considered acceptable for approach paths in accordance with the associated methodology (**Appendix D**) and industry best practice, and therefore considered acceptable for these receptors. No significant impact is predicted in accordance with the relevant guidance (**Appendix A**) and associated methodology (**Appendix D**). Mitigation is not required.

Hill Top Farm Airfield

Solar reflections with intensities of 'yellow' glare are geometrically possible towards the 1-mile splayed approach paths for thresholds 09 and 27, normal circuit, and bad weather circuit for runway 09/27. There are mitigating factors that decrease the level of impact (**Section 6.2.4**). The instances of 'yellow' glare are considered to be operationally accommodatable. No significant impact is predicted in accordance with the relevant guidance (**Appendix A**) and associated methodology (**Appendix D**). Mitigation is not required. Mitigation is not required.

The Applicant considers that the potential for yellow glare is operationally accommodatable. Engagement has been undertaken with Hill top Farm Airfield and the Civil Aviation Authority to understand their operations and discuss the results of the assessment.

High-Level Assessment Conclusions – Aviation Activity

The following conclusions consider aviation activity at RAF Barkston Heath, RAF Conningsby, Hanbeck Farm Airfield, and Millfield Farm Airfield.

Solar reflections towards approach paths and final sections of visual circuits are predicted to be of an acceptable glare intensity or will occur outside a pilot's primary FOV and therefore not considered significant in accordance with the associated methodology (**Appendix D**).

Solar reflections towards the ATC Tower at RAF Barkston Heath will be obstructed by existing vegetation, buildings and intervening terrain and therefore not experienced by personnel.

No significant impacts are predicted in accordance with the relevant guidance (Appendix A) and associated methodology (**Appendix D**). Mitigation is not required.

Assessment Results – Railway Operations and Infrastructure

Solar reflections are geometrically possible towards a 1.5km-section of railway track and occur outside a train driver's main FOV (30 degrees either side of the direction of travel). Screening in the form of existing vegetation is predicted to significantly obstruct views of reflecting panels, such that a solar reflection will not be experienced. No impact is predicted, and mitigation is not required.

Solar reflections are geometrically possible towards one trackside signal. Screening in the form of existing vegetation is predicted to significantly obstruct views of reflecting panels, such that a solar reflection will not be experienced. No impact is predicted, and mitigation is not required.

Assessment Results – Road Safety

Solar reflections are geometrically possible towards:

- A 4.0km section of the A15
- Separate 3.0km and 1.4km sections of the B1911;
- Separate 2.4km and 1.1km sections of the B1188;
- Separate 300m, 400m and 400m sections of Main Street/Scopwick / Kirby Green) and Timberland Road.

Screening in the form of existing and proposed vegetation, buildings and/or intervening terrain is predicted to significantly obstruct views of reflecting panels, such that solar reflections will not be experienced. Temporary mitigation will be implemented during the interim for proposed vegetation to reach a sufficient height and density to mitigate impacts (see Section 2.2).

Assessment Results

Solar reflections are geometrically possible towards 103 dwellings. Screening in the form of existing and proposed vegetation, buildings and/or intervening terrain is predicted to significantly obstruct views of reflecting panels for 99 dwellings, such that solar reflections will not be experienced. Any impacts during the interim for proposed vegetation to reach a sufficient height and density to mitigate impacts are considered to be low due to the duration of the effects considering the existing screening present. No significant impact is predicted, and mitigation is not required.

For the remaining four dwellings, marginal views from above ground floor levels are considered possible. The duration of effects are predicted to be experienced for less than three months per year and less than 60 minutes on any given day. Therefore, a low impact is predicted for these four dwellings and not considered significant in accordance with the associated methodology (**Appendix D**). No mitigation is required.

1. Introduction

1.1. Overview

1.1.1. Pager Power has been retained to assess the possible effects of glint and glare from a ground-mounted solar photovoltaic development ('the Proposed Development'), located in North Kesteven, Lincolnshire, UK. This assessment pertains to the possible impact upon road safety, residential amenity, railway infrastructure and operations, and aviation activity.

1.1.2. This report contains the following;

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

1.2. Pager Power's Experience

1.2.1. Pager Power has undertaken over 1,400 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

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

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

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

1.4. Guidance and Policy

1.4.1. The associated relevant policy in relation to glint and glare is outlined in the National Policy Statement for Renewable Energy Infrastructure (EN-3). Further details are presented in **Appendix A**.

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

2. Proposed Development Location and Details

2.1.1. The Proposed Development layout is illustrated in **ES Volume 2, Figure 3.1: Zonal Masterplan [EN010149/APP/6.2]** and full description provided in **ES Volume 1, Chapter 3: Proposed Development Description [EN010149/APP/6.1]**.

2.1.2. The Green Infrastructure that is proposed as part of the Proposed Development is illustrated in **ES Volume 2, Figure 3.3: Green Infrastructure Parameters [EN010149/APP/6.2]** and secured in **Appendix 1: Green Infrastructure Parameters** of the **Outline Landscape and Ecology Management Plan [EN010149/APP/7.9].** This has been considered as embedded mitigation within the assessment.

2.1.3. **Figure 1** on the following page shows the site layout[5] for the Proposed Development.

2.1.4. The Applicant is committed to advanced planting (prior to installation of solar panels) as part of the Proposed Development for a 700m section of the A15 to mitigate glint and glare impacts upon road users. The assumptions and details of the advanced planting are outlined below:

- Advanced planting would be implemented in Winter 2024/2025 during planting season.
- Trees would be planted as young transplants or 'whips'.
- Vegetation will need to be established to a height of 3m to provide effective mitigation of the glint and glare impacts.
- The Proposed Development currently has phased grid connection dates of 2028 and 2030. It is currently anticipated that construction works will commence at the earliest in Q1 2027 and run to Q4 2030.
- It is assumed that some parts of the Proposed Development (Springwell West) will become operational from 2029.
- Advanced planting undertaken in Winter 2024/2025 is therefore anticipated to have at least 3 seasons growth before construction commences and more than this in some parts of the Site.
- It is anticipated that the planting would be at least 1.8m high at the start of construction and 2.6m at the start of operation of the Proposed Development.

2.1.5. Based on the assumption that in year 1 that the planting stock would typically be at approximately 0.6m to 0.8m high and contained with tree protected tubes and would not put on much growth during the first planning season and then put on an average of 0.4m growth each subsequent year. It is anticipated a temporary mitigation would be required for approximately 3 years following the construction phase.

2.1.6. A 700m section of the A15 at the south of Springwell West requires mitigation to reduce glint and glare impacts upon roads users. This includes hedgerows to be infilled and maintained to a height of at least 3m. Until the advance planting (to be planted in Winter 2024/25) in this area has grown to sufficient density and height of 3m to mitigate impacts of glint and glare, temporary mitigation will be implemented to mitigate impacts. This temporary mitigation may include temporary screening or suitable alternative mitigation to be confirmed in the detailed LEMP. This would be removed once the hedgerows are of sufficient height. It is anticipated that a temporary hoarding or suitable alternative would be required for approximately 3 years following the construction phase. The landscape planting proposals are secured within the **Outline Landscape and Ecology Management Plan [EN010149/APP/7.9]**. The full green infrastructure has been considered within the glint and glare assessment.

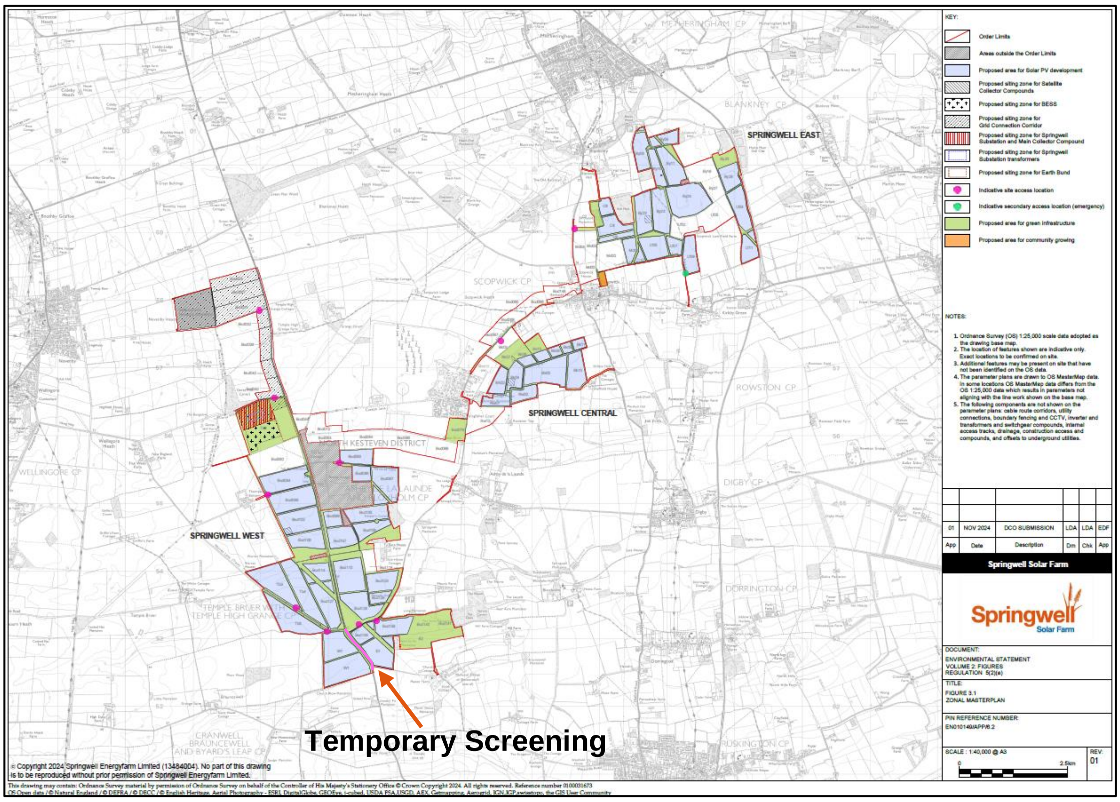

Figure 1 Proposed planting and temporary screening (illustrated by a pink line) along the A15

2.2. Reflector Areas

2.2.1. The bounding coordinates for the Proposed Development have been extrapolated from **ES Volume 1, Figure 3.1: Zonal Masterplan [EN010149/APP/6.2]**. The data can be found in **Appendix G**. **Figure 2** below shows the assessed reflector areas that have been used for modelling purposes on to aerial imagery.

Figure 2 Assessed reflector areas

2.2.2. The Pager Power model has used a resolution of 5m for this assessment. This means that a geometric calculation is undertaken for each identified receptor every 5m from within the defined areas. This resolution is sufficiently high to maximise the accuracy of the results – increasing the resolution further would not significantly change the modelling output. If a reflection is experienced from an assessed panel location, then it is likely that a reflection will be viewable from similarly located panels within the proposed solar development.

2.3. Solar Panel Technical Information

2.3.1. For the purposes of this assessment, the below technical assumptions have been used. Small changes to these parameters are not expected to significantly affect the modelling results and would be comparable to the parameters modelled:

- Azimuth angle: 180°

- Elevation angle[6]: 13°
- Assessed centre height[7]: 1.90m above ground level
- This assessment has modelled solar panels with a surface material of ‘smooth glass with an anti-reflective/anti-glare coating’.

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

[6] Pitch above horizontal. Small changes to the assessed tilt are not considered significant to change the geometric result.

[7] Relative to the lowest (0.80m) and highest (3.00m) points above ground level. Small changes to the assessed height are not considered significant to change the geometric result.

3. Glint and Glare Assessment Methodology

3.1. Guidance and Studies

3.1.1. Guidelines exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. The UK CAA guidance is relatively high-level and does not prescribe a formal methodology. There is railway guidance with respect to signal sighting; however, no guidance with respect to glint and glare from solar developments and railway infrastructure has been specifically produced. Pager Power has however produced guidance for glint and glare and solar photovoltaic developments, which was published in early 2017, with the fourth edition[8] published in 2022. This methodology defines a comprehensive process for determining the impact upon railway infrastructure and operations, and aviation activity.

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

3.1.3. **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.

3.1.4. 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[9].

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

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

3.2. Background

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

3.3. Methodology

3.3.1. Information regarding Pager Power's and Sandia National Laboratories' methodology is presented in the following sub-sections respectively.

Pager Power's Methodology

3.3.2. The glint and glare assessment methodology has been derived from the information provided to Pager Power through consultation with stakeholders and by reviewing the available guidance, studies and Pager Power's practical experience. The methodology for this glint and glare assessment is as follows:

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

3.3.3. 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.

Sandia National Laboratories' Methodology

3.3.4. Sandia National Laboratories developed the Solar Glare Hazard Analysis Tool (SGHAT) which is no longer freely available however it is now developed by Forge Solar. Pager Power uses this model where required for aviation receptors. Whilst strictly applicable in the USA and to solar photovoltaic developments only, the methodology is widely used by aviation stakeholders internationally.

3.4. Assessment Methodology and Limitations

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

4. Railways Assessment Methodology

4.1. Overview

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

4.2. Disability Glare for Railway Considerations

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

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

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

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

4.3. Common Concerns and Signals Overview

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

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

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

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

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

'Light emitted from a Signal lens assembly that has originated from an external source (usually the sun) and has been internally reflected within the Signal Head in such a way that the lens assembly gives the appearance of being lit.[10]'

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

An LED railway signal produces a more intense light making them more visible to approaching trains when compared to the traditional filament bulb technology[11].

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

4.4. Methodology and Consultation

4.4.1. The railway glint and glare assessment methodology, including study area and modelled heights for signals, has been based on Pager Power's

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

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

experience within the UK following previous consultation with Network Rail.

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

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

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

4.5. Railway Specific Criteria

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

- Whether the solar reflection originates within a train driver's main field-of-view, defined as 30 degrees either side of the railway line with respect to the direction of travel
- The contrast of sensitivity, considering a low sensitivity is where disability glare is more likely to occur
- The reflecting area compared to the façade as a whole, with a significant area considered more than 50%

- Solar reflections occurring towards a significant section of railway line, for example:
    - A point of multiple lines with switch points;
    - At a station;
    - Signals being present;
    - Road or pedestrian crossings being present.
- The duration of the solar reflection
- If the development is in keeping with those around it and near to the assessed railway line.

4.6. Assumptions and Limitations

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

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

4.6.2. Further assumptions and limitations are presented in **Appendix E**.

5. Identification of Receptors

5.1. Overview

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

5.2. Aviation Receptors

Identified Aerodrome Receptors

5.2.1. **Table 1** on the following page summarises the assessed aerodromes for this proposed development.

Table 1 Identified aerodromes

Aerodrome	Type	ATC Tower	Operational Runway(s)	Distance from Proposed Development
RAF Cranwell	Military	One	08/26 01/19	3.3km
RAF Waddington	Military	One	02/20	9.6km
RAF Barkston Heath	Military	One	06/24 10/28 18/36	12.0km
RAF Conningsby	Military	One	07/25	13.6km
Temple Bruer (Griffin's Farm) Airfield	General Aviation	N/A	08/26	2.0km

Cottage Farm Airfield	General Aviation	N/A	09/27	1.7km
Old Manor Farm Airfield	General Aviation	N/A	06/24	8.0km
Hanbeck Farm Airfield	General Aviation	N/A	06/24	9.1km
Millfield Farm Airfield	General Aviation	N/A	08/26	12.3km
Hill Top Farm Airfield	General Aviation	N/A	09/27	320m

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

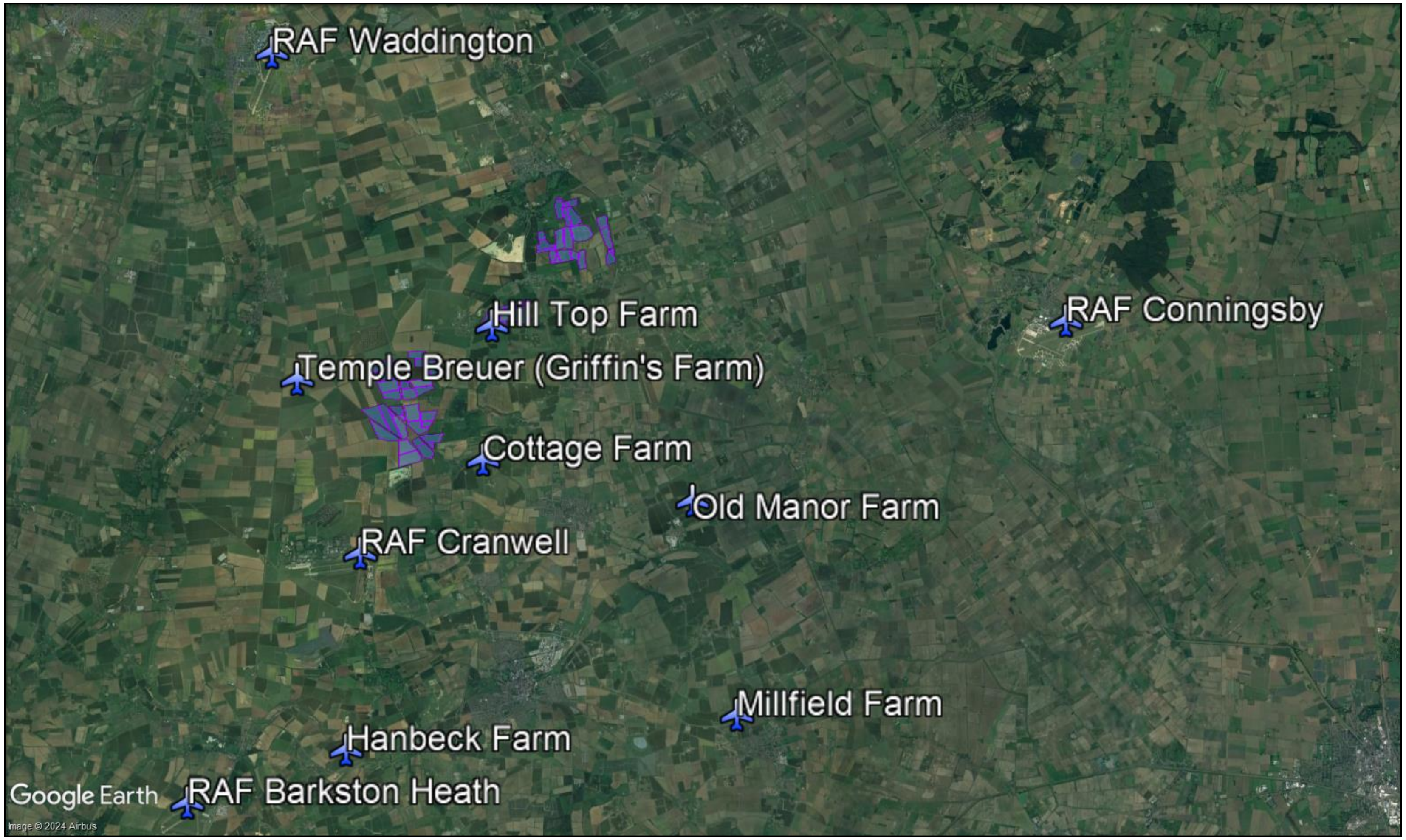

Figure 3 Identified aerodromes relative to Proposed Development

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

5.2.4. This assessment has considered all aerodromes within 15km of the Proposed Development. Aerodromes within 10km have been geometrically modelled with the receptors outlined in the following subsections. Aerodromes beyond 10km have been assessed at a high-level (Section 7). The following subsections present the receptors for aerodromes geometrically modelled for. **Section 7** presents high-level assessments for the remaining aerodromes.

ATC Tower for RAF Airfields

5.2.5. It is standard practice to determine whether a solar reflection can be experienced by personnel within the ATC Tower. Receptors at RAF Cranwell and RAF Waddington have been used to model the eye-level of air traffic controllers within Visual Control Room at each aerodrome respectively.

5.2.6. The receptors for the ATC Towers at RAF Cranwell and RAF Waddington are shown in **Figure 4** below.

Figure 4 ATC Tower receptors for RAF Airfields

5.2.7. It is Pager Power's methodology to assess whether a solar reflection can be experienced on the approach paths for the associated runways. This is considered to be the most critical stage of the flight.

5.2.8. RAF Cranwell has an associated approach path for each runway threshold: 02 and 20. This totals two approach paths for RAF Cranwell. RAF Waddington has four approach paths for each runway threshold: 01, 08, 19 and 26. Pager Power's approach for determining receptor (aircraft) locations on the approach path is to select locations along the extended runway centre line from 50ft above the runway threshold out to a distance of 2 miles. The height of the aircraft is determined by using a 3-degree descent path relative to the runway threshold height.

5.2.9. The receptors for the approach paths for RAF Cranwell and RAF Waddington are shown in **Figure 5** on the following page.

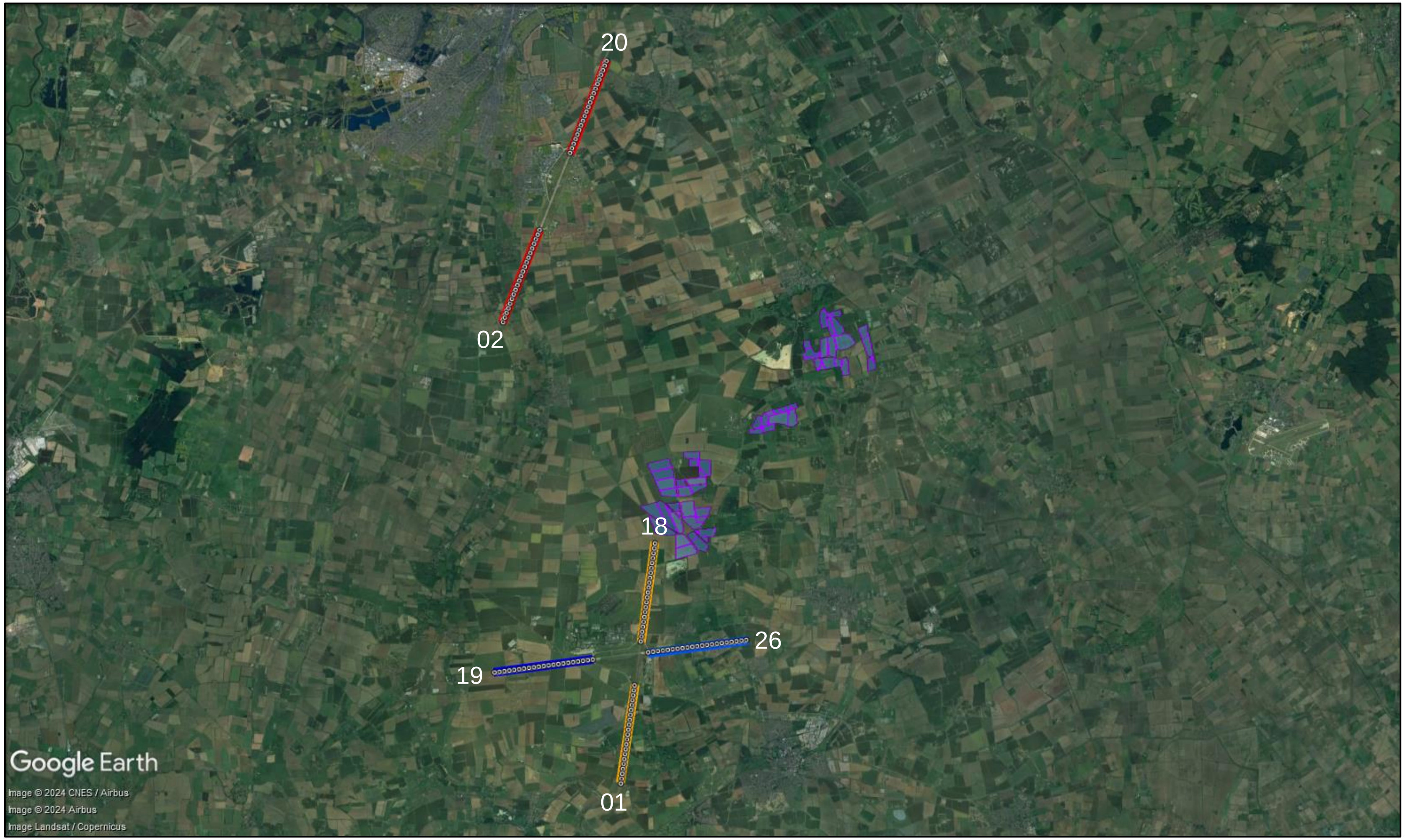

Figure 5 Approach path receptors for RAF Airfields

Circuit Approach Paths for RAF Airfields

5.2.10. When aircraft arrive or depart from an aerodrome they fly in a standard pattern. A typical circuit is shown in **Figure 6** below.

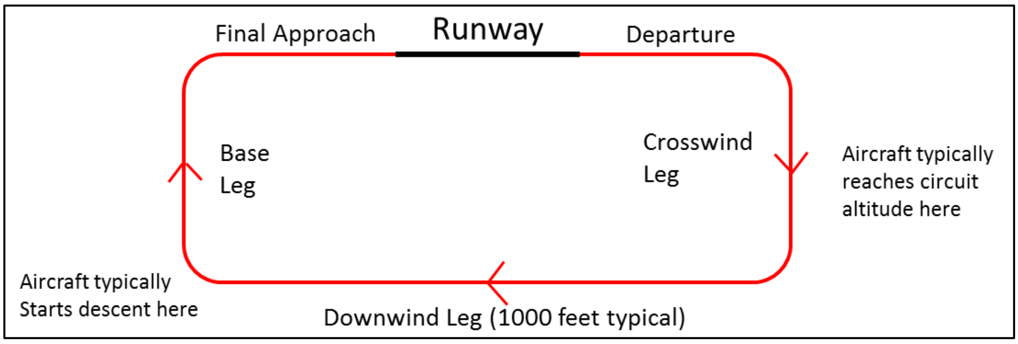

Figure 6 Typical circuit diagram

5.2.11. The way circuits are flown varies from airport to airport, pilot to pilot and aircraft to aircraft.

5.2.12. The assessed circuits for RAF Cranwell and RAR Waddington have the following characteristics:

- Circuit altitude 1,000ft above the aerodrome height;
- Circuit originates and terminates at the runway thresholds;
- The circuit considers an ascent and descent angle of 3°.

It is assumed that aircraft will be at 1,000ft above the aerodrome altitude (above mean sea level) on the base leg. A circuit width of 1 nautical mile (nm) has been modelled for the 1,000ft circuit.

5.2.13. The receptors for the circuits for RAF Cranwell and RAF Waddington are shown in **Figure 7** on the following page.

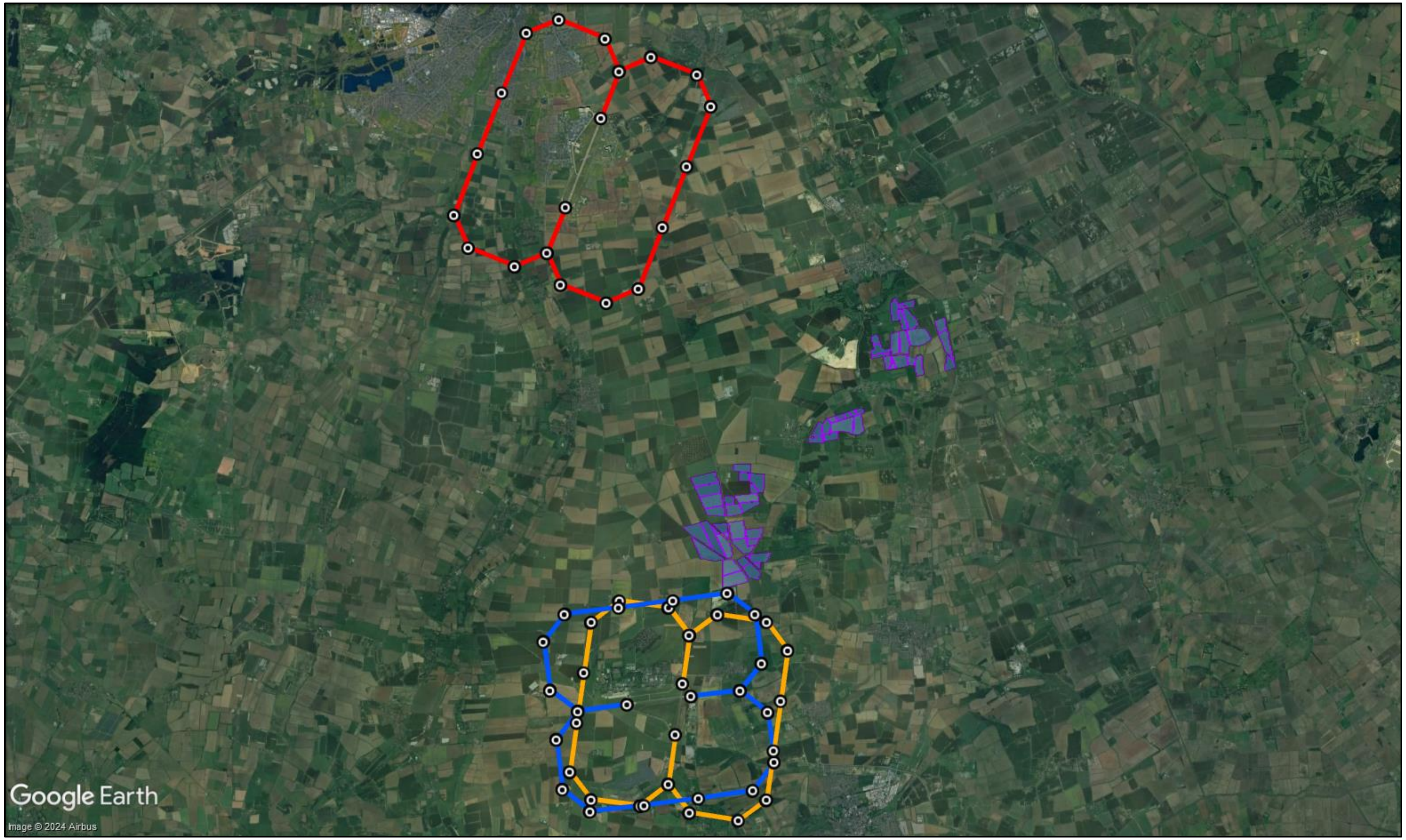

Figure 7 Circuit receptors for RAF airfields

General Aviation Runway Approach Paths and Final Sections of Visual Circuits

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

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

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

5.2.16. **Figure 8** below illustrates the splayed approach and final sections of the visual circuits.

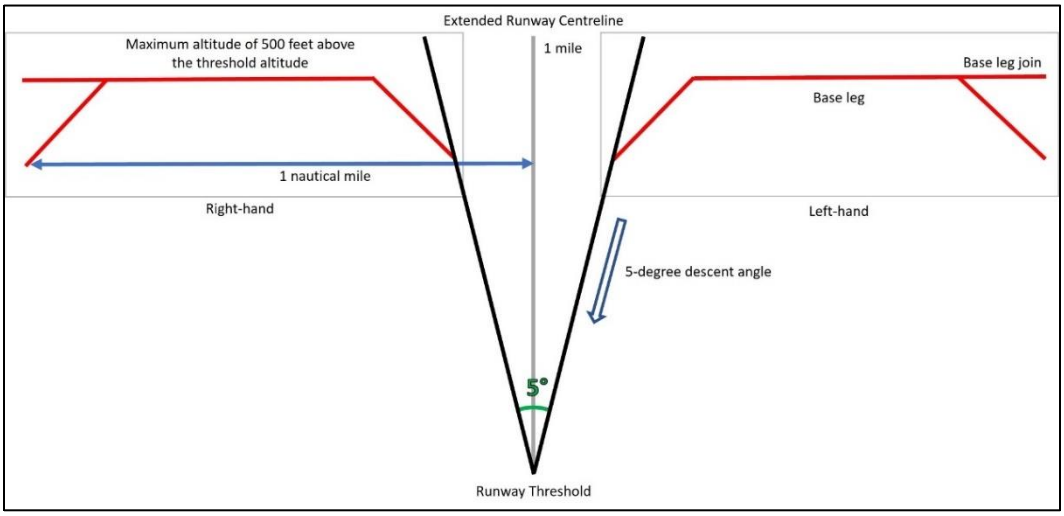

Figure 8 Splayed approach and final sections of visual circuits

5.2.17. **Figure 9** on the following page shows the assessed aircraft receptor points of the splayed approach and final sections of the visual circuits at Cottage Farm Airfield, Temple Bruer Airfield, and Old Manor Farm Airfield.

Figure 9 Assessed receptors for GA airfields

Hill Top Farm Airfield Specific Receptors

5.2.18. Hill Top Farm Airfield is a General Aviation (GA) aerodrome. The following receptors have been modelled as defined by Hill Top Farm following consultation:

- 1-mile splayed approach paths considering a 5-degree and 11.5-degree descent gradient
- Normal Circuit (4,000m × 2,000m at 1,000ft AGL) considering a 5-degree and 11.5-degree slope
- Bad Weather Circuit (2,500m × 500m at 500ft AGL) considering a 5-degree and 11.5-degree slope.

5.2.19. The receptors for Hill Top Farm Airfield are shown in **Figures 10** and **11** and on the following page.

Figure 10 Approach path receptors for Hill Top Farm

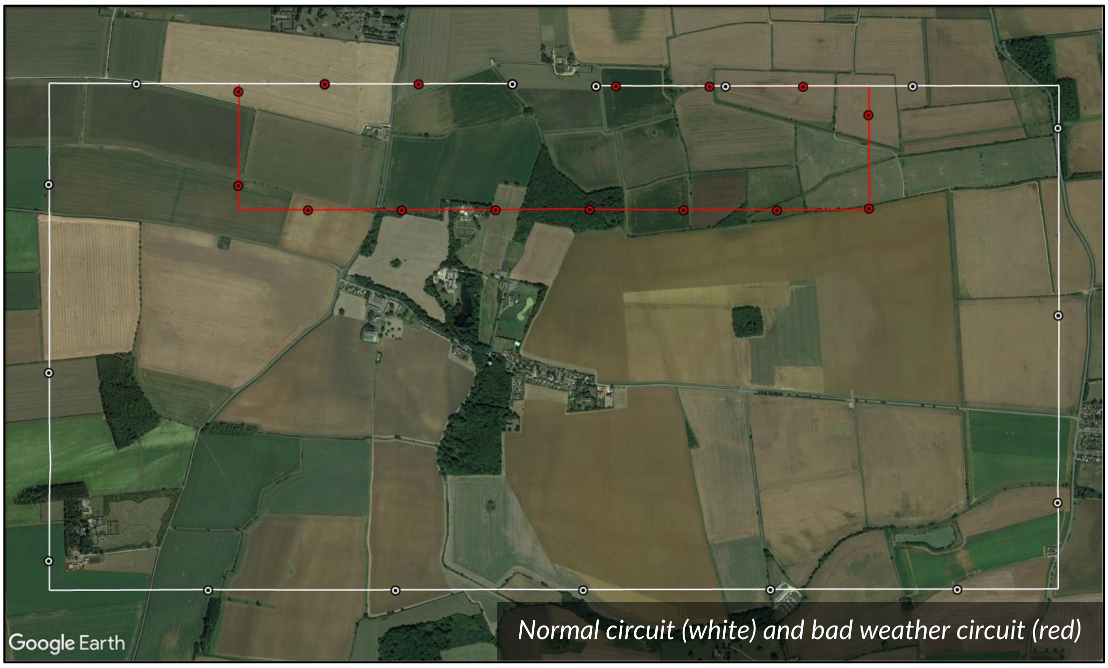

Figure 11 Hill Top Farm circuit receptors

5.3. Railway Receptors

5.3.1. Railway receptors within close proximity (typically within 100m to 200m of a proposed development, based on previous consultation with Network Rail) to a solar development are often required for assessment. When required, a 500m assessment area (outlined white in the following figures) is considered appropriate and has been designed accordingly.

5.3.2. Receptors within the 500m assessment area are identified based on mapping and aerial photography of the region. A more detailed assessment is made if the modelling reveals that a reflection would be geometrically possible. The significance of a reflection decreases with distance because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases.

5.4. Train Driver Receptors

5.4.1. The analysis has considered train driver receptors that:

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

5.4.2. An additional height of 2.75m above rail level is used to model the eye-level of train drivers, based on previous consultation[12].

5.5. Identified Train Driver Receptors

5.5.1. A 2.5km-section of railway is identified within 500m of the proposed development. Receptors 1 to 26 are modelled approximately 100m apart along this section of railway. **Figure 12** on the following page shows the modelled train driver receptors.

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

Figure 12 Assessed train driver receptors

5.6. Railway Signal Receptors

Railway Signals Overview

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

5.6.2. The assessment has considered both gantry and trackside signals within 500m of the development and a line-of-sight of the development. The typical heights above ground level of each signal have been provided by Network Rail[13]. Additional 3.30m and 5.10m heights[14] above ground level are used to model for trackside and gantry signals respectively.

Identified Railway Signals

5.6.3. Three trackside signals and one ground-mounted signal have been assessed in both directions. The ground-mounted signal is estimated to be at a height of 1.5m above ground level.

[13] Consultation undertaken with Network Rail in the UK

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

5.6.4. **Figure 13** on the following page shows the assessed train signal receptors.

Figure 13 Assessed trackside signals

5.7. Ground Based Receptors Overview

5.7.1. 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.

5.7.2. The above parameters and industry experience over a significant number of glint and glare assessments undertaken, shows that a 1km assessment area from the proposed development is considered appropriate for glint and glare effects on road users and dwellings. The assessment area has been designed accordingly as 1km from the proposed development.

5.7.3. Potential receptors within the associated assessment area are identified based on mapping and aerial photography of the region. The initial judgement is made based on high-level consideration of aerial photography and mapping i.e. receptors are excluded if it is clear from the outset that no visibility would be possible. A more detailed assessment is made if the modelling reveals a reflection would be geometrically possible.

5.8. Road Receptors

Road Receptors Overview

5.8.1. Road types can generally be categorised as:

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

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

- Are within the one-kilometre assessment area;
- Have a potential view of the Solar PV modules.

5.8.3. Receptors along each road are placed circa 100m apart. A height of 1.5 metres above ground level has been used to model the typical eye-level[15] of a road user.

Identified Road Receptors

5.8.4. **Table 2** on the following page summarises the identified roads, lengths and specific receptors geometrically modelled in this assessment.

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

Table 2 Identified roads

Road	Total Length Assessed	Receptors
A15	4.90km	1 to 51
B1191	6.70km	52 to 119
B1188	4.70km	120 to 167
Main Street (Scopwick / Kirby Green and Timberland Road)	3.80km	168 to 206

5.8.5. **Figure 14** on the following page shows the assessed road receptors.

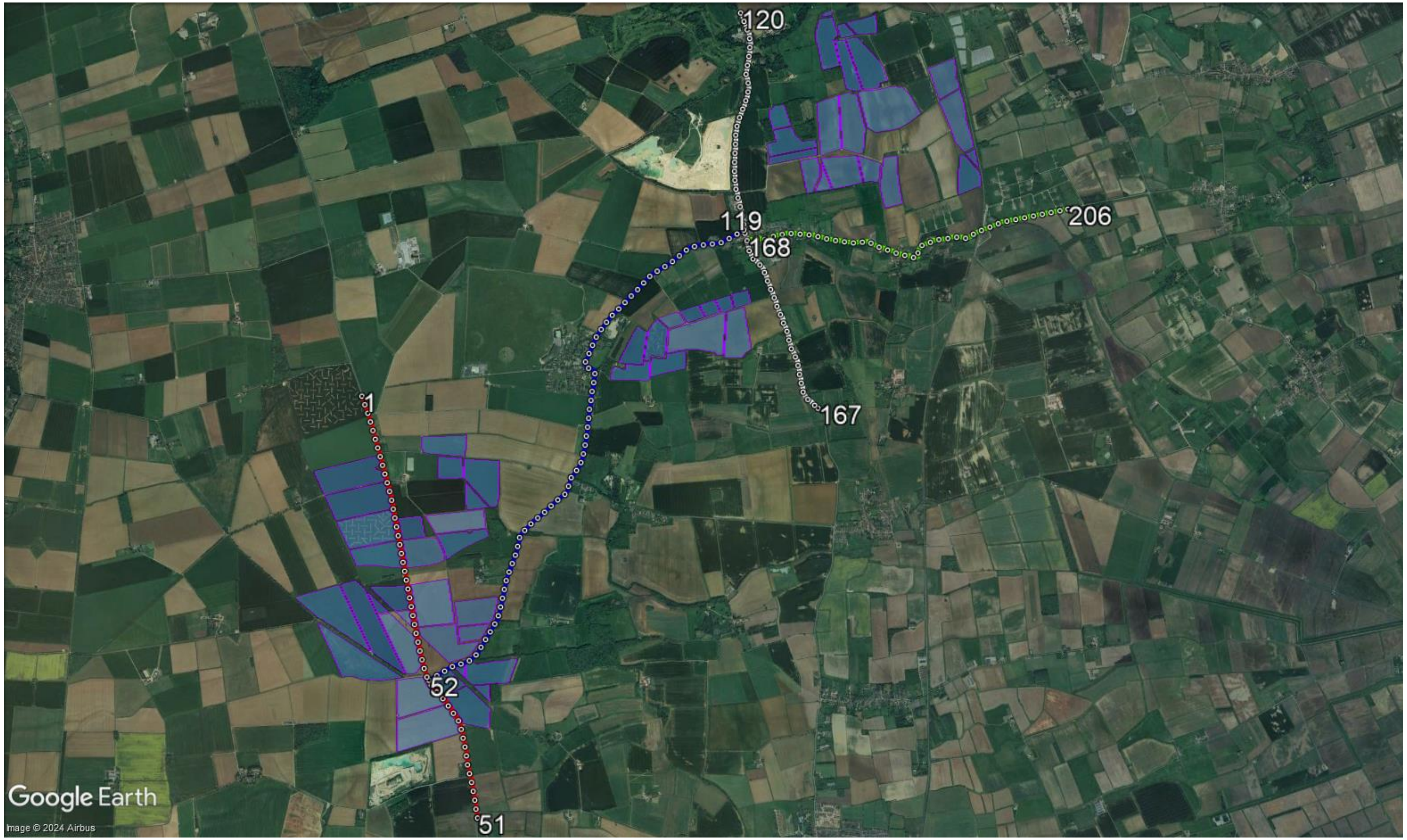

Figure 14 Assessed road receptors

5.9. Dwelling Receptors

Dwelling Receptors Overview

5.9.1. The analysis has considered dwellings that:

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

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

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

5.9.4. A height of 1.8 metres above ground level has been used to model the typical eye-level from the ground floor[16].

Identified Dwelling Receptors

5.9.5. In total, 130 dwelling receptors have been assessed, as shown in **Figure 15** below. Detailed identification of dwelling receptors is presented in **Appendix H.**

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

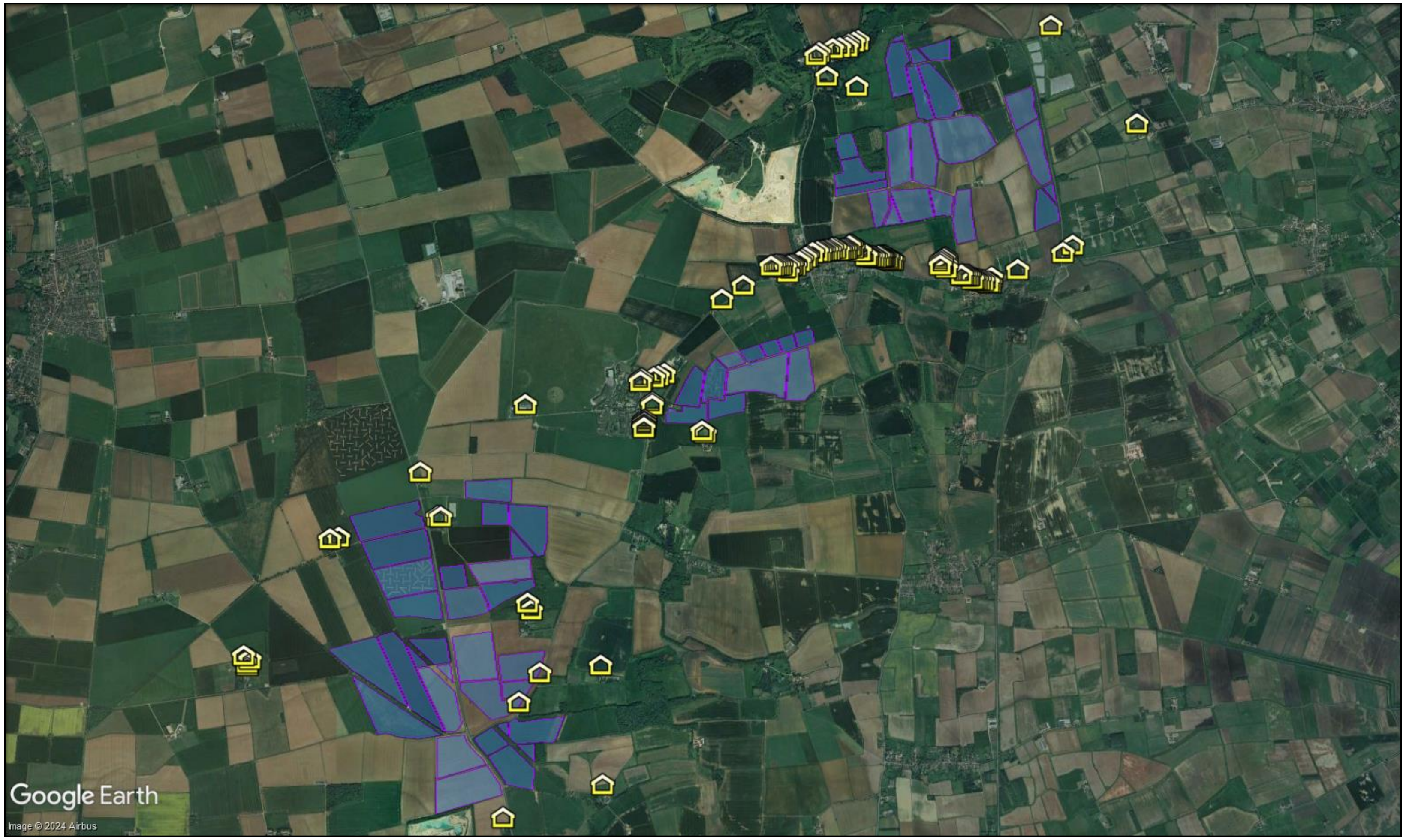

Figure 15 Overview of modelled dwelling receptors

6. Geometric Assessment Results and Discussion

6.1. Overview

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

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

6.2. Assessment Results - Aviation Receptors

Glare Intensity Categorisation

6.2.1. The Pager Power and Forge models have been used to determine whether reflections are possible for aviation receptors. Intensity calculations (Forge Model) in line with the Sandia National Laboratories methodology have been undertaken. These calculations are routinely required for solar photovoltaic developments on or near aerodromes. The intensity model calculates the expected intensity of a reflection with respect to the potential for an after-image (or worse) occurring. The designation used by the model is presented in **Table 3** on the following page along with the associated colour coding. This coding has been used in the table where a reflection has been calculated and is in accordance with Sandia National Laboratories' methodology.

Table 3 Glare intensity designated

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

6.2.2. The intensity model allows for the assessment of a variety of solar panel surface materials. This assessment has modelled solar panels with a surface material of 'smooth glass with an anti-reflective/anti-glare coating'.

Key Considerations – ATC Towers

6.2.3. The process for quantifying impact significance is defined in the report appendices. For an ATC Tower, the key considerations are:

- Whether a reflection is predicted to be experienced in practice.
- The intensity of glare for the solar reflections:
- Whether a reflection is predicted to be operationally significant in practice or not.

6.2.4. Where solar reflections are not geometrically possible, or where solar reflections are predicted to be significantly screened (i.e. not visible), then no impact is predicted, and mitigation is not required.

6.2.5. Glare of any kind towards an ATC Tower was formerly not permissible under the interim guidance provided by the Federal Aviation

Administration in the USA[17] 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 to consider glare towards the ATC Tower in an operational context. As per Pager Power's glint and glare guidance document[18], where solar reflections are of an intensity categorisation of 'low potential for temporary after-image' (green glare), an expert assessment of the following relevant factors is required to determine the impact significance[19]:

- 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. Will the ATC Tower be operational at the time of day at which glare is predicted?
- The duration of any predicted glare. Glare that is experienced for low durations throughout the year is less significant than longer durations.
- Glare location relative to key operational areas. A solar reflection originating near sensitive areas such as the runway threshold will have a higher impact upon ATC personnel.
- The relative size of the reflecting panel area. Does the reflecting area make up a large percentage of an ATC observer's 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. Is the intensity of glare close to the green/yellow glare threshold on the intensity chart?

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

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

[19] 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 glare towards an ATC Tower.

- The level of predicted effect relative to existing sources of glare. A solar reflection is less noticeable by ATC personnel when there are existing reflective surfaces in the surrounding environment.

6.2.6. Following consideration of these mitigating factors, where the solar reflection is deemed not significant, a low impact is predicted, and mitigation is not recommended; however, consultation with the aerodrome is recommended to understand their position along with any feedback or comments regarding the proposed development. Where the solar reflection is deemed significant or where a glare intensity categorisation of ‘potential for temporary after-image’ (yellow glare) is predicted, the impact significance is moderate, and mitigation is recommended.

6.2.7. Where solar reflections are of an intensity greater than ‘potential for temporary after-image’, the impact significance is high, and mitigation is required.

Key Considerations – Runway Approach Paths

6.2.8. The process for quantifying impact significance is defined in the report appendices. 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:
- Whether a reflection is predicted to be operationally significant in practice or not

6.2.9. 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.

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

6.2.11. Glare with ‘potential for a temporary after-image’ (yellow glare) was formerly not permissible under the interim guidance provided by the

Federal Aviation Administration in the USA[20] for on-airfield solar. 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[21], where solar reflections are of an intensity categorisation of 'potential for temporary after-image', an expert assessment of the following relevant factors is required to determine the impact significance[22]:

- 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. Will the aerodrome 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 (50 degrees either side of the approach bearing). Do solar reflections occur directly in front of a pilot?
- The relative size of the reflecting panel area. Does the reflecting area make 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.

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

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

[22] 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.

- The intensity of the predicted glare. Is the intensity of glare close to the green/yellow glare threshold on the intensity chart?
- 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.

6.2.12. Following consideration of these mitigating factors, where the solar reflection is deemed not significant, a low impact is predicted, and mitigation is not recommended; however, the Applicant will continue to engage with the aerodrome operators. Where the solar reflection is deemed significant, the impact significance is moderate, and mitigation is recommended.

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

Assessment Results

6.2.14. **Tables 4 to 9** on the following pages presents the geometric modelling results for receptors associated with each airfield.

Springwell Solar Farm

Table 4 Geometric Modelling Results - RAF Cranwell

Receptor	Geometric Modelling Result	Glare Intensity	Predicted Impact
ATC Tower	Solar reflections are not geometrically possible towards the ATC Tower	N/A	No impact
2-mile Approach Path Runways 01, 08 and 26	Solar reflections are not geometrically possible towards the approach path	N/A	No impact
2-mile Approach Path Runway 19	Solar reflections are geometrically possible towards a 0.7-mile section, between 1.3 miles and 2.0 miles from the threshold	Glare beyond 50°	Solar reflections occur outside a pilot's field-of-view, and therefore not considered significant in accordance with the associated guidance (**Appendix D**) and industry best practice
Circuit Runway 01/19	Solar reflections are geometrically possible towards sections of the circuits	'Yellow'	Operationally accommodatable / low impact See Section 6.2.15
Circuits Runway 08/26	Solar reflections are geometrically possible towards sections of the circuits	'Yellow'	Operationally accommodatable / low impact See Section 6.2.15

Springwell Solar Farm

Table 5 Geometric Modelling Results - RAF Waddington

Receptor	Geometric Modelling Result	Glare Intensity	Predicted Impact
ATC Tower	Solar reflections are not geometrically possible towards the ATC Tower	N/A	No impact
2-mile Approach Path Runway 02	Solar reflections are geometrically possible towards a 0.7-mile section, between 1.3 miles and 2.0 miles from the threshold	Glare beyond 50°	Solar reflections occur outside a pilot's field-of-view, and therefore not considered significant in accordance with the associated guidance (**Appendix D**) and industry best practice
2-mile Approach Path Runway 20	Solar reflections are not geometrically possible towards the approach path	N/A	No impact
Circuit Runway 02/20	Solar reflections are geometrically possible towards sections of the circuits	'Green'	The glare intensity is considered acceptable in accordance with the associated guidance (**Appendix D**) and industry best practice

Table 6 Geometric Modelling Results - Temple Bruer

Receptor	Geometric Modelling Result	Glare Intensity	Predicted Impact
Splayed Approach Runway 08	Solar reflections are geometrically possible towards the entire 1.0-mile splayed approach path	'Yellow'	Operationally accommodatable / low impact See Section 6.2.15
Splayed Approach Runway 26	Solar reflections are geometrically possible towards the entire 1.0-mile splayed approach path	Glare beyond 50°	Solar reflections occur outside a pilot's field-of-view, and therefore not considered significant in accordance with the associated guidance (**Appendix D**) and industry best practice
Final Sections of Visual Circuits 08/26	Solar reflections are geometrically possible towards final sections of visual circuits	'Yellow'	Operationally accommodatable / low impact See Section 6.2.15

Table 7 Geometric Modelling Results - Cottage Farm

Receptor	Geometric Modelling Result	Glare Intensity	Predicted Impact
Splayed Approach Runway 09	Solar reflections are geometrically possible towards the entire 1.0-mile splayed approach path	Glare beyond 50°	Solar reflections occur outside a pilot's field-of-view, and therefore not considered significant in accordance with the associated guidance (**Appendix D**) and industry best practice
Splayed Approach Runway 27	Solar reflections are geometrically possible towards final sections of visual circuits	'Yellow'	Operationally accommodatable / low impact See Section 6.2.15
Final Sections of Visual Circuits 09/27	Solar reflections are geometrically possible towards final sections of visual circuits	'Yellow'	Operationally accommodatable / low impact See Section 6.2.15

Springwell Solar Farm

Table 8 Geometric Modelling Results - Old Manor Farm

Receptor	Geometric Modelling Result	Glare Intensity	Predicted Impact
Splayed Approach Runway 06	Solar reflections are geometrically possible towards the entire 1.0-mile splayed approach path	Glare beyond 50°	Solar reflections occur outside a pilot’s field-of-view, and therefore not considered significant in accordance with the associated guidance (**Appendix D**) and industry best practice
Splayed Approach Runway 24	Solar reflections are geometrically possible towards final sections of visual circuits	Glare beyond 50°	Solar reflections occur outside a pilot’s field-of-view, and therefore not considered significant in accordance with the associated guidance (**Appendix D**) and industry best practice
Final Sections of Visual Circuits 06/24	Solar reflections are geometrically possible towards final sections of visual circuits	‘Green’	The glare intensity is considered acceptable in accordance with the associated guidance (**Appendix D**) and industry best practice

Table 9 Geometric Modelling Results - Hill Top Farm

Receptor	Geometric Modelling Result	Glare Intensity	Predicted Impact
Splayed Approach Runway 06	Solar reflections are geometrically possible towards the entire 1.0-mile splayed approach path	'Yellow'	Operationally accommodatable / low impact See Section 6.2.15
Splayed Approach Runway 24	Solar reflections are geometrically possible towards the entire 1.0-mile splayed approach path	'Yellow'	Operationally accommodatable / low impact See Section 6.2.15
Normal and Bad Weather Circuits	Solar reflections are geometrically possible towards final sections of visual circuits	'Yellow'	Operationally accommodatable / low impact See Section 6.2.15

Further Analysis of 'Yellow' Glare

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

6.2.16. Pager Power therefore recommends a pragmatic approach whereby instances of 'yellow' glare are evaluated in a technical and operational context with consideration to the available guidance and policies including NPS EN-3 (**Appendix A**).

6.2.17. Where solar reflections are of an intensity no greater than 'potential for temporary after-image' expert assessment of the following mitigating factors, with respect to the airfield's specific operations.

6.2.18. **Table 10** on the following page presents the maximum duration of 'yellow' glare annually for each respective aerodrome. The duration is also considered as a percentage relative to average daylight hours[23] in any given year.

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

Table 10 Maximum duration of 'yellow' glare

Aerodrome	Receptor	Annual Duration (mins)	Percentage of Daylight Hours (%)	Time (GMT)
RAF Cranwell	Base leg section of circuit for threshold 19	2,683	1.02	Between 05:00 – 06:00 Published flying hours are between 08:00 – 17:00
Temple Bruer	Base leg section of circuit for threshold 26	8,072	3.07	Between 06:00 – 07:00
Cottage Farm	Base leg section of circuit for threshold 09	10,647	4.05	Between 16:00 – 18:30
Hill Top Farm	0.6 nautical miles along approach path for threshold 09 at 5-degree descent	3,592	1.37	Between 05:00 – 06:00

6.2.19. The following points are also considered for all instanced of ‘yellow’ glare for all aerodromes:

- Solar reflections with ‘yellow’ glare are predicted at times when the Sun is low in the sky beyond the reflecting panels. This means that a pilot will likely have a view of the Sun within the same viewpoint of the reflecting solar. The Sun is a far more significant source of light, and therefore the glare originating from the proposed development will be less significant
- The ‘yellow’ glare only marginally exceeds the ‘yellow’ threshold on the intensity chart. ‘Green’ glare (or glare with ‘low potential for temporary after-image’) is considered an acceptable level of glare intensity for aircrafts on approach. The glare intensity does not border onto a greater level of intensity than ‘yellow’;
- Effects would be fleeting due to their short duration along the visual circuits and the restricted size of the reflecting panel area;
- Instances of ‘yellow’ glare for all aerodromes will not occur for more than 30 minutes on any given day;

- For RAF Cranwell, instances of 'yellow' glare occur outside the aerodrome's published hours of flying[24]. There are no published hours of operation/flying for the GA aerodromes;
- The volume of air traffic at all GA aerodromes is expected to be relatively low compared to licensed aerodromes;
- The weather would have to be clear and sunny at the specific times when the glare was possible to be experienced. A pilot would also have to be on approach/the circuit path at the times when solar reflections are possible.

6.2.20. It is expected that operational measures used by pilots to mitigate the effects of direct sunlight could potentially be used to mitigate the effects of solar glare from the panels.

6.2.21. Based on the result of its technical assessment, the Applicant considers that the potential for yellow glare is operationally accommodatable at the identified airfields. This is in accordance with the associated NPS EN-3 policy (**Appendix A**) and guidance (**Appendix D**), industry experience and industry best practice. Prior to submission of the DCO Application, the Applicant has engaged with the Ministry of Defence and the Civil Aviation Authority on the results of the assessment. This has also involved seeking engagement with three private airfields (of General Aviation use) to understand their operations and discuss the results of the assessment. The Applicant will continue to engage with these airfields following submission of the Application. The Applicant is in ongoing engagement with the MOD regarding the outcomes noted at RAF Cranwell. While the potential for yellow glare occurs outside of its published hours of flying, the Applicant shared the results of its Glint and Glare Assessment and continues to welcome further engagement to discuss the assessment in more detail.

[24] https://www.raf.mod.uk/our-organisation/stations/raf-cranwell/flying-info/#:~:text=A%20usual%20flying%20day%20is,which%20do%20practice%20low%20flying.

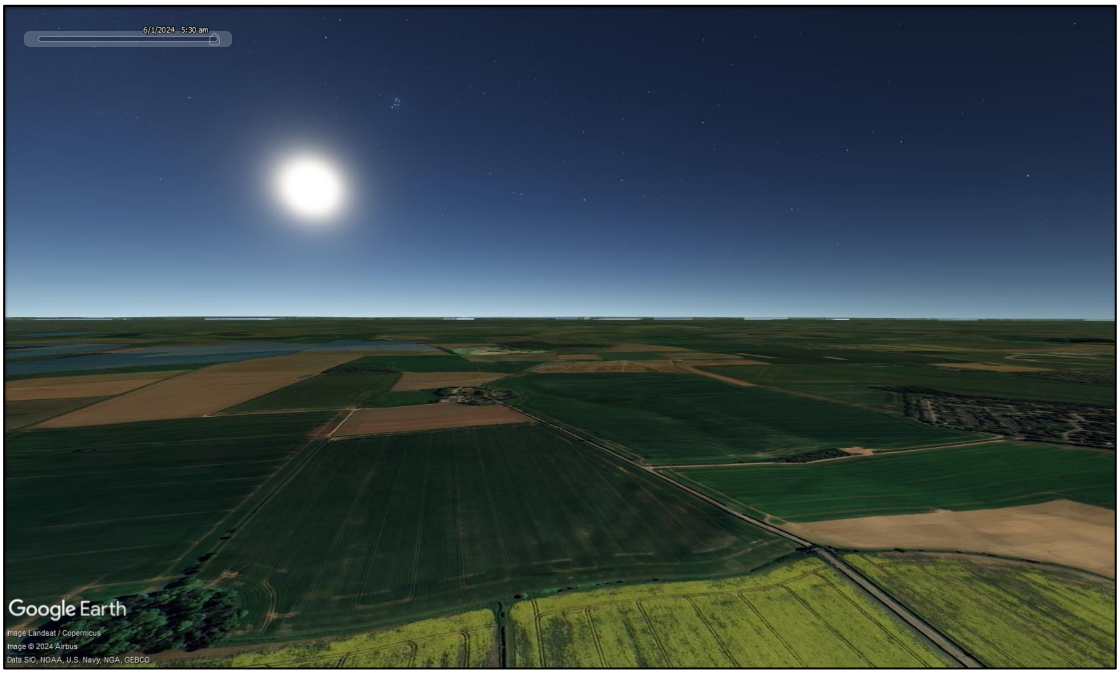

Figure 16 POV of 'yellow' glare – RAF Cranwell

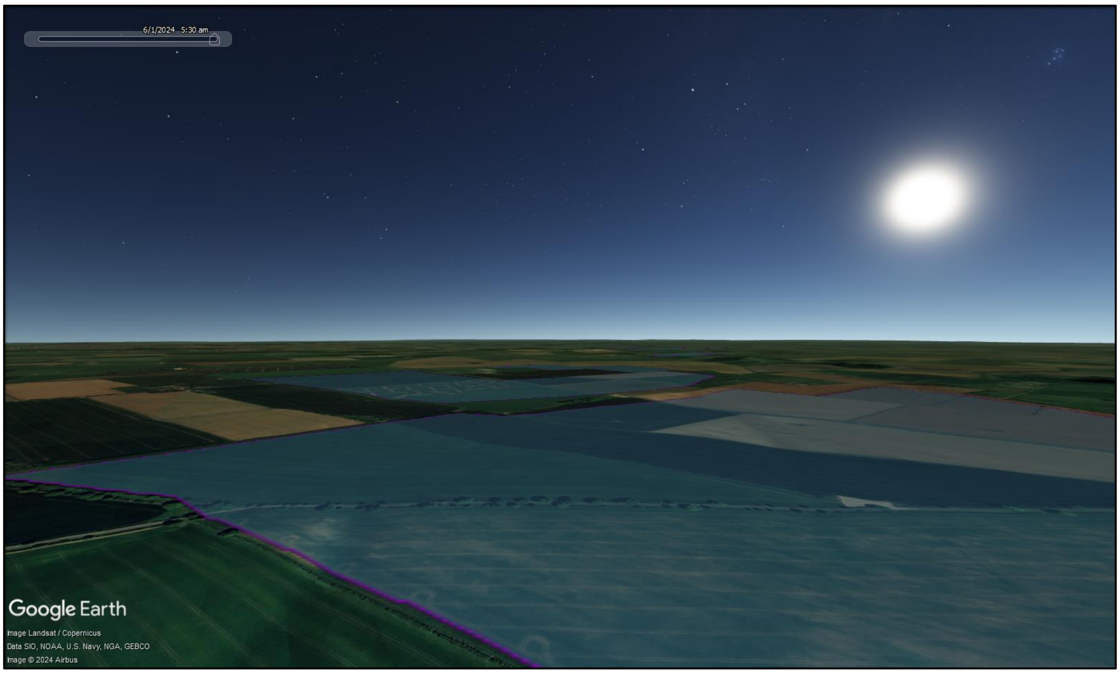

Figure 17 POV of 'yellow' glare – Temple Bruer

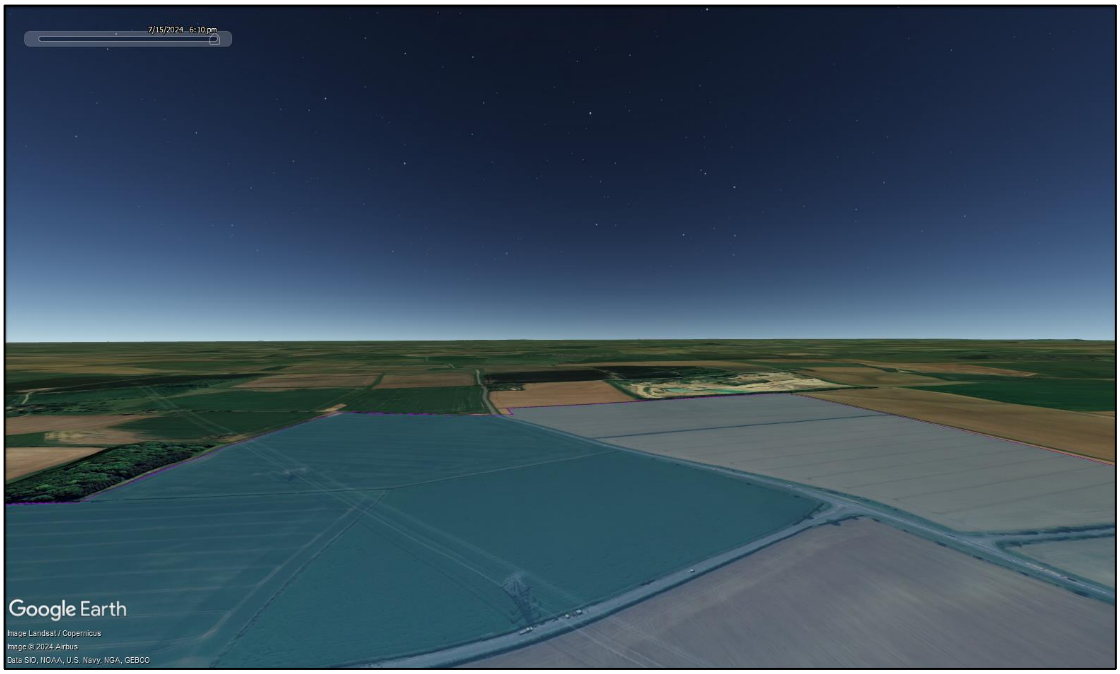

Figure 18 POV of ‘yellow’ glare – Cottage Farm

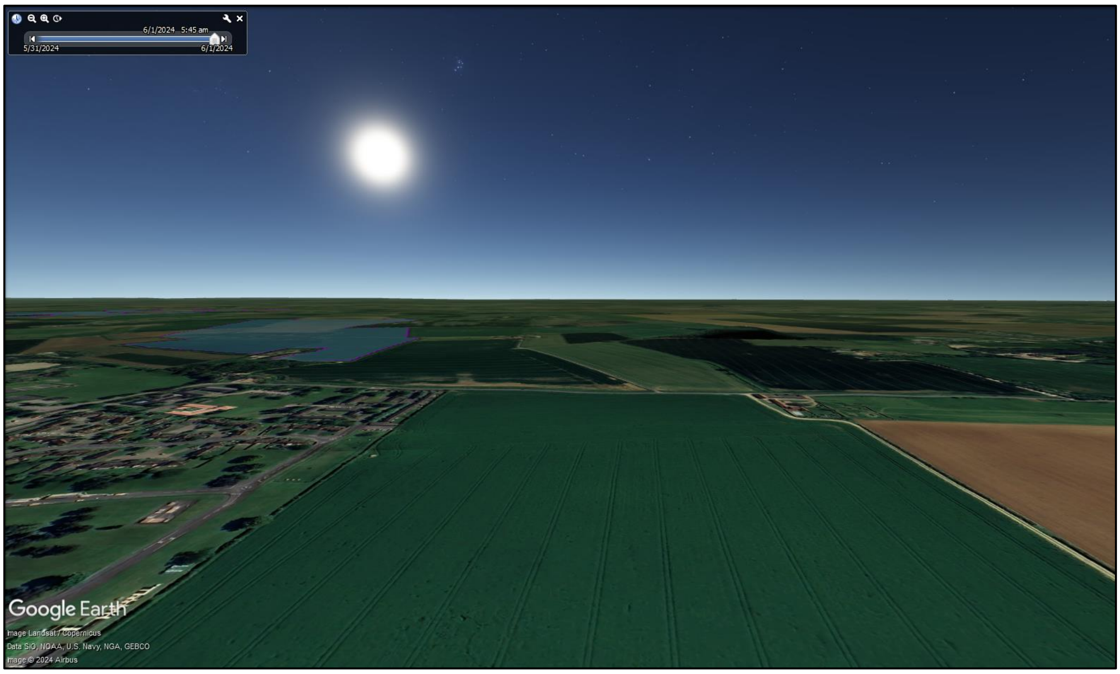

Figure 19 POV of ‘yellow’ glare – Hill Top Farm

6.3. Assessment Results – Railway Receptors

Key Considerations

6.3.1. 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.

6.3.2. 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.

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

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

- Whether the solar reflection originates from directly in front of a train driver. Solar reflections that are directly in front of a road user are more hazardous.
- Whether a solar reflection is fleeting in nature. Small gap/s in screening, e.g. an access point to the site, may not result in a sustained reflection for a train driver.
- The separation distance to the panel area. Larger separation distances reduce the proportion of an observer's field of view that is affected by glare.
- The workload of a train driver experiencing a solar reflection. Is there visibility of a railway signal or level crossing when solar reflections are predicted to be received? Is there a switch in the railway line when solar reflections are predicted to be received?
- The position of the Sun. Effects that coincide with direct sunlight appear less prominent than those that do not. The Sun is a far more significant source of light.

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

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

Geometric Modelling Results and Discussion

6.3.7. **Table 11** on the following pages presents the geometric modelling results and predicted impact significance for the assessed railway receptors. The screening review is presented in **Appendix J**.

Table 11 Geometric modelling results – railway receptors

Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening) [25]	Mitigating Factors	Predicted Impact Classification
1 – 4	Solar reflections are not geometrically possible	N/A	N/A	N/A	None
5 – 20	Solar reflections are geometrically possible outside a train driver's main field-of-view	Existing vegetation is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None
21 – 26	Solar reflections are not geometrically possible	N/A	N/A	N/A	None

[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 three months per year 2) and/or for more than 60 minutes on any given day.

Signal 1, 3 Ground-mounted signal	Solar reflections are not geometrically possible	N/A	N/A	N/A	None
Signal 2	Solar reflections are geometrically possible outside 90° either side of the direction of the signal	Existing vegetation is predicted to significantly obstruct solar reflections of signal	N/A	N/A	None

6.4. Assessment Results – Road Receptors

Key Considerations

6.4.1. 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.

6.4.2. 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.

6.4.3. Where solar reflections originate from outside of a road user's primary horizontal field-of-view (FOV), defined as 50 degrees either side relative to 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.

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

- Whether the solar reflection originates from directly in front of a road user – a solar reflection that is directly in front of a road user is more hazardous than a solar reflection to one side;
- Whether visibility is likely for elevated drivers (relevant to dual carriageways and motorways[26]);
- 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 a solar reflection is fleeting in nature. Small gap/s in screening, e.g. an access point to the site, may not result in a sustained reflection for a road user;
- The 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.

[26] There is typically a higher density of elevated drivers (such as HGVs) along dual carriageways and motorways compared to other types of road.

6.4.5. 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.

6.4.6. 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.

Geometric Modelling Results and Discussion

6.4.7. **Table 12** on the following pages presents the geometric modelling results and predicted impact significance for the assessed road receptors (coordinate data presented in **Appendix G**). The screening review is presented in **Appendix J**.

Table 12 Geometric modelling results – road receptors

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening) [27]	Mitigating Factors	Predicted Impact Classification
1 – 5	Solar reflections are not geometrically possible	N/A	N/A	N/A	None
6 – 7	Solar reflections are geometrically possible outside a road user's FOV	Existing and proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None

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

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening) [27]	Mitigating Factors	Predicted Impact Classification
8 – 12	Solar reflections are geometrically possible inside a road user's FOV	Existing and proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None
13 – 32	Solar reflections are geometrically possible inside a road user's FOV	Proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None
33 – 40	Solar reflections are geometrically possible inside a road user's FOV	Existing and proposed vegetation is predicted to significantly obstruct views of reflecting panels	33 – 40	Solar reflections are geometrically possible inside a road user's FOV	Existing and proposed vegetation is predicted to significantly obstruct views of reflecting panels

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening) [27]	Mitigating Factors	Predicted Impact Classification
41 – 46	Solar reflections are geometrically possible outside a road user's FOV	Existing and proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None
47 – 51	Solar reflections are not geometrically possible	N/A	N/A	N/A	None
52 – 57	Solar reflections are geometrically possible inside a road user's FOV	Existing and proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None
58 – 65	Solar reflections are geometrically	Proposed vegetation is predicted to	N/A	N/A	None

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening) [27]	Mitigating Factors	Predicted Impact Classification
	possible outside a road user's FOV	significantly obstruct views of reflecting panels			
66 – 74	Solar reflections are geometrically possible outside a road user's FOV	Existing and proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None
75 – 82	Solar reflections are geometrically possible outside a road user's FOV	Existing vegetation and intervening terrain is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening) [27]	Mitigating Factors	Predicted Impact Classification
83 – 88	Solar reflections are not geometrically possible	N/A	N/A	N/A	None
89 – 92	Solar reflections are geometrically possible outside a road user's FOV	Existing vegetation and intervening terrain is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None
93 – 94	Solar reflections are geometrically possible inside a road user's FOV	Existing vegetation is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening) [27]	Mitigating Factors	Predicted Impact Classification
95 – 101	Solar reflections are geometrically possible outside a road user's FOV	Existing vegetation and buildings is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None
102 – 103	Solar reflections are geometrically possible outside a road user's FOV	Intervening terrain is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None
104 – 119	Solar reflections are not geometrically possible	N/A	N/A	N/A	None
120 – 130	Solar reflections are geometrically	Existing vegetation is predicted to significantly obstruct	N/A	N/A	None

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening) [27]	Mitigating Factors	Predicted Impact Classification
	possible outside a road user's FOV	views of reflecting panels			
131 – 144	Solar reflections are geometrically possible outside a road user's FOV	Existing and proposed vegetation, and intervening terrain is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None
145 – 152	Solar reflections are not geometrically possible	N/A	N/A	N/A	None
153 – 157	Solar reflections are geometrically possible outside a road user's FOV	Existing vegetation is predicted to significantly obstruct	N/A	N/A	None

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening) [27]	Mitigating Factors	Predicted Impact Classification
		views of reflecting panels			
158 – 164	Solar reflections are geometrically possible outside a road user's FOV	Existing buildings and proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None
165 – 173	Solar reflections are not geometrically possible	N/A	N/A	N/A	None
174 – 177	Solar reflections are geometrically possible outside a road user's FOV	Existing vegetations and buildings is predicted to significantly obstruct	N/A	N/A	None

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening) [27]	Mitigating Factors	Predicted Impact Classification
		views of reflecting panels			
178 – 191	Solar reflections are not geometrically possible	N/A	N/A	N/A	None
192 – 196	Solar reflections are geometrically possible outside a road user's FOV	Intervening terrain is predicted to significantly obstruct views of reflecting panels	N/A	N/A	None
197 – 199	Solar reflections are not geometrically possible	N/A	N/A	N/A	None
200 – 205	Solar reflections are geometrically	Existing vegetation and intervening terrain is predicted	N/A	N/A	None

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening) [27]	Mitigating Factors	Predicted Impact Classification
	possible outside a road user's FOV	to significantly obstruct views of reflecting panels			
206	Solar reflections are not geometrically possible	N/A	N/A	N/A	None

6.5. Assessment Results – Dwelling Receptors

Key Considerations

6.5.1. The key considerations for residential dwellings are:

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

6.5.2. 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.

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

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

- The separation distance to the panel area – larger separation distances reduce the proportion of an observer's field of view that is affected by glare;
- The position of the Sun – effects that coincide with direct sunlight appear less prominent than those that do not;
- Whether visibility is likely from all storeys – the ground floor is typically considered the main living space and has a greater significance with respect to residential amenity;
- Whether the dwelling appears to have windows facing the reflecting area – factors that restrict potential views of a reflecting area reduce the level of impact.

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

6.5.6. If effects last for more than 3 months per year and for more than 60 minutes on any given day, and there are no mitigating factors, the impact significance is high, and mitigation is required.

Geometric Modelling Results and Discussion

6.5.7. **Table 13** on the following pages presents the geometric modelling results and predicted impact significance for the assessed dwelling receptors (coordinate data presented in **Appendix G**). The screening review is presented in **Appendix J**.

Springwell Solar Farm

Table 13 Geometric modelling results - dwelling receptors

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[28]	Mitigating Factors	Predicted Impact Classification
1	Solar reflections are not geometrically possible	N/A	N/A	N/A	None
2 – 5	Solar reflections are geometrically possible for more than three months per year but less than 60 minutes on any given day	Existing vegetation and buildings, and proposed vegetation is predicted to significantly obstruct views of reflecting panels	NA	N/A	None
6 – 9	Solar reflections are geometrically possible for more than three months	Existing vegetation and intervening terrain is predicted to significantly	NA	N/A	None

[28] 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.

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[28]	Mitigating Factors	Predicted Impact Classification
	per year but less than 60 minutes on any given day	obstruct views of reflecting panels			
10 – 12	Solar reflections are geometrically possible for more than three months per year but less than 60 minutes on any given day	Existing and proposed vegetation is predicted to significantly obstruct views of reflecting panels	NA	N/A	None
13	Solar reflections are not geometrically possible	N/A	N/A	N/A	None
14	Solar reflections are geometrically possible for more than three months per year but less	Existing and proposed vegetation is predicted to significantly obstruct views of reflecting panels	NA	N/A	None

Springwell Solar Farm

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[28]	Mitigating Factors	Predicted Impact Classification
	than 60 minutes on any given day				
15 – 28	Solar reflections are geometrically possible for more than three months per year but less than 60 minutes on any given day	Existing and proposed vegetation is predicted to significantly obstruct views of reflecting panels	NA	N/A	None
29 – 30	Solar reflections are geometrically possible for less than three months per year and less than 60 minutes on any given day	Existing and proposed vegetation is predicted to significantly obstruct views of reflecting panels	NA	N/A	None
31 – 39	Solar reflections are not geometrically possible	N/A	N/A	N/A	None

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[28]	Mitigating Factors	Predicted Impact Classification
40 – 81	Solar reflections are geometrically possible for more than three months per year but less than 60 minutes on any given day	Existing vegetation is predicted to significantly obstruct views of reflecting panels	NA	N/A	None
82 – 89	Solar reflections are geometrically possible for less than three months per year and less than 60 minutes on any given day	Existing vegetation is predicted to significantly obstruct views of reflecting panels	NA	N/A	None
90 – 103	Solar reflections are not geometrically possible	N/A	N/A	N/A	None

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[28]	Mitigating Factors	Predicted Impact Classification
104	Solar reflections are geometrically possible for less than three months per year and less than 60 minutes on any given day	Existing vegetation is predicted to significantly obstruct views of reflecting panels	NA	N/A	None
105 – 107	Solar reflections are geometrically possible for more than three months per year but less than 60 minutes on any given day	Existing vegetation and buildings are predicted to significantly obstruct views of reflecting panels	NA	N/A	None
108	Solar reflections are not geometrically possible	N/A	N/A	N/A	None

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[28]	Mitigating Factors	Predicted Impact Classification
109 – 117	Solar reflections are geometrically possible for more than three months per year but less than 60 minutes on any given day	Existing vegetation is predicted to significantly obstruct views of reflecting panels	NA	N/A	None
118	Solar reflections are geometrically possible for more than three months per year but less than 60 minutes on any given day	Existing vegetation is predicted to obstruct views with marginal views above ground floor levels considered possible	Less than three months and less than 60 minutes on any given day	N/A	Low
119	Solar reflections are geometrically possible for less than three months per year and less	Existing vegetation is predicted to significantly obstruct views of reflecting panels	NA	N/A	None

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[28]	Mitigating Factors	Predicted Impact Classification
	than 60 minutes on any given day				
120	Solar reflections are geometrically possible for less than three months per year and less than 60 minutes on any given day	Proposed vegetation is predicted to obstruct views with marginal views above ground floor levels considered possible	Less than three months and less than 60 minutes on any given day	N/A	Low
121	Solar reflections are geometrically possible for more than three months per year but less than 60 minutes on any given day	Existing vegetation is predicted to obstruct views with marginal views above ground floor levels considered possible	Less than three months and less than 60 minutes on any given day	N/A	Low
122	Solar reflections are geometrically possible for more	Existing vegetation is predicted to significantly obstruct	NA	N/A	None

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[28]	Mitigating Factors	Predicted Impact Classification
	than three months per year but less than 60 minutes on any given day	views of reflecting panels			
123	Solar reflections are geometrically possible for less than three months per year and less than 60 minutes on any given day	Intervening terrain is predicted to significantly obstruct views of reflecting panels	NA	N/A	None
124	Solar reflections are not geometrically possible	N/A	N/A	N/A	None
125 - 128	Solar reflections are geometrically possible for more than three months per year but less	Existing vegetation and buildings is predicted to significantly obstruct	NA	N/A	None

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[28]	Mitigating Factors	Predicted Impact Classification
	than 60 minutes on any given day	views of reflecting panels			
129	Solar reflections are geometrically possible for less than three months per year and less than 60 minutes on any given day	Existing vegetation is predicted to significantly obstruct views of reflecting panels	NA	N/A	None
130	Solar reflections are geometrically possible for more than three months per year but less than 60 minutes on any given day	Existing and proposed vegetation is predicted to obstruct views with marginal views above ground floor levels considered possible	Less than three months and less than 60 minutes on any given day	N/A	Low

7. Public Rights of Way

7.1.1. Pedestrians/observers along PRoW have not been assessed in this assessment as no significant effects are predicted.

7.1.2. Based on professional experience, pedestrians/observers along PRoW are low-sensitivity receptors. This is due to the following reasons:

- The typical density of pedestrians on a PRoW is low in a rural environment;
- Any resultant effect is much less serious and has far lesser consequences than, for example, solar reflections experienced towards a road network, whereby the resultant impacts of solar reflect can be serious to safety;
- Glint and glare effects towards receptors on a PRoW are transient and time and location sensitive, where a pedestrian could move beyond the solar reflection zone with ease and little impact upon safety or amenity;
- There is no safety hazard associated with reflections towards an observer on a footpath.

7.1.3. Furthermore, it is determined that any likely effect will have a low magnitude due to the following reasons:

- It is likely that the existing and the proposed screening is predicted to significantly reduce and in some instance remove the visibility of the Proposed Development for PRoW users;
- The reflection intensity is similar for solar panels and still water (and significantly less than reflections from glass and steel) which is frequently a feature of the outdoor environment surrounding PRoW. Therefore, the reflections are likely to be comparable to those from common outdoor sources whilst navigating the natural and built environment on a regular basis.

8. High-Level Aviation Assessments

8.1. Overview

8.1.1. The following sections present high-level assessments and conclusions for aviation concerns at aerodromes RAF Barkston Heath, RAF Conningsby, Hanbeck Farm Airfield, and Millfield Farm Airfield, which have been assessed without being geometrically modelled for due to the distance between the aerodromes and the Proposed Development.

8.1.2. Aerodromes within 15km of the Proposed Development have been considered for completeness.

8.1.3. The proposed development size, distance between the aerodrome and proposed development, geometric results for those aerodromes modelled for in this assessment, and industry experience are considered to determine the potential impact.

8.2. High-Level Assessment of RAF Barkston Heath

8.2.1. RAF Barkston Heath is a military aerodrome approximately 12km southwest of the proposed development and is understood to have an ATC Tower.

8.2.2. The location of RAF Barkston Heath, the ATC Tower and 2-mile approach paths relative to the proposed development is shown in **Figure 20** below.

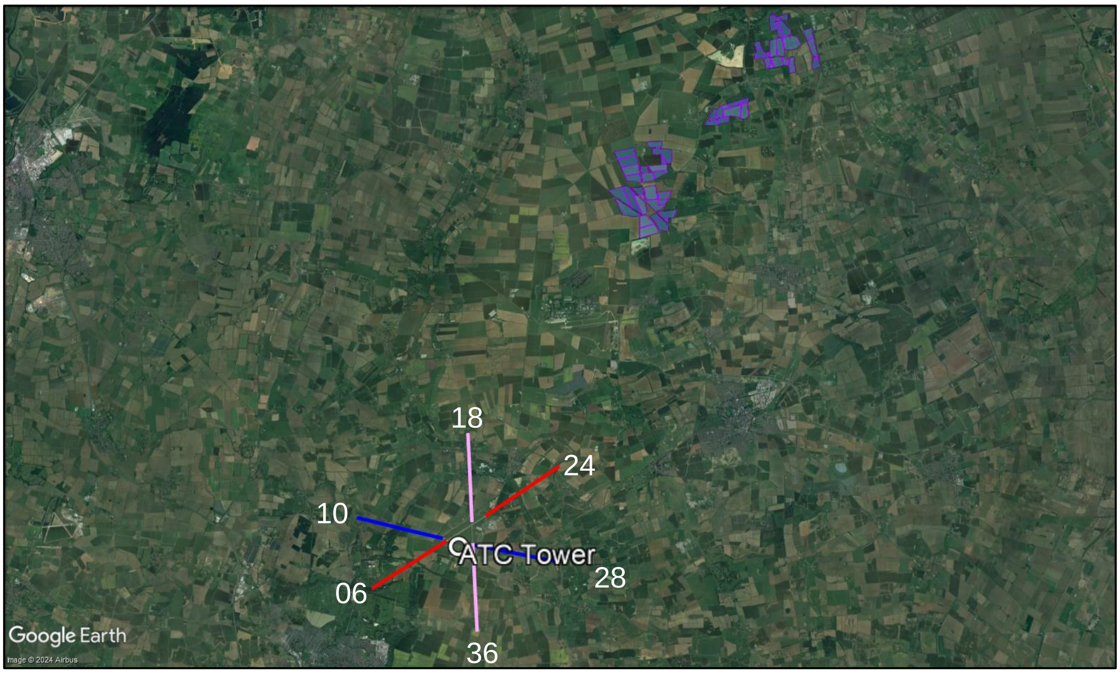

Figure 20 RAF Barkston Heath relative to Proposed Development

Assessment

8.2.3. The following can be concluded for RAF Barkston Heath with regards to the proposed development:

- Solar reflections originating from the proposed development towards the 2-mile approach paths for thresholds 10, 18 24 and 28 will be outside a pilot's primary field-of-view (50 degrees either side relative to the runway threshold bearing), and would therefore not be considered significant considering the associated guidance (**Appendix D**) and industry best practice;
- Solar reflections originating from the proposed development towards the 2-mile approach paths for thresholds 06 and 36 will have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (**Appendix D**) and industry best practice, the glare intensity is considered acceptable;
- Solar reflections towards visual circuits will have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (**Appendix D**) and industry best practice, the glare intensity is considered acceptable;
- Solar reflections towards the ATC Tower will be obstructed and therefore no impact upon personnel is considered possible.

Conclusions

8.2.4. No significant impacts upon aviation activity associated with RAF Barkston Heath are predicted, and mitigation is not required. Detailed modelling is not recommended.

8.3. High-Level Assessment of RAF Conningsby

8.3.1. RAF Conningsby is a military aerodrome approximately 13.6km east of the proposed development and is understood to have an ATC Tower.

8.3.2. The location of RAF Conningsby, the ATC Tower and 2-mile approach paths relative to the proposed development is shown in **Figure 21** on the following page.

Figure 21 RAF Conningsby relative to Proposed Development

Assessment

8.3.3. The following can be concluded for RAF Conningsby with regards to the proposed development:

- Solar reflections originating from the proposed development towards the 2-mile approach path for threshold 07 will be outside a pilot's primary field-of-view (50 degrees either side relative to the runway threshold bearing), and would therefore not be considered significant considering the associated guidance (**Appendix D**) and industry best practice;
- Solar reflections originating from the proposed development towards the 2-mile approach path for threshold 25 will have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (**Appendix D**) and industry best practice, the glare intensity is considered acceptable;
- Solar reflections towards visual circuits will have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (**Appendix D**) and industry best practice, the glare intensity is considered acceptable;
- Solar reflections towards the ATC Tower will be obstructed and therefore no impact upon personnel is considered possible.

Conclusions

8.3.4. No significant impacts upon aviation activity associated with RAF Conningsby are predicted, and mitigation is not required. Detailed modelling is not recommended.

8.4. High-Level Assessment of Hanbeck Farm Airfield

8.4.1. Hanbeck Farm Airfield is a General Aviation (GA) airfield approximately 9.1km south of the proposed development and is understood not to have an ATC Tower.

8.4.2. The location of Hanbeck Farm Airfield and 1-mile splayed approach paths relative to the proposed development is shown in Figure 22 below.

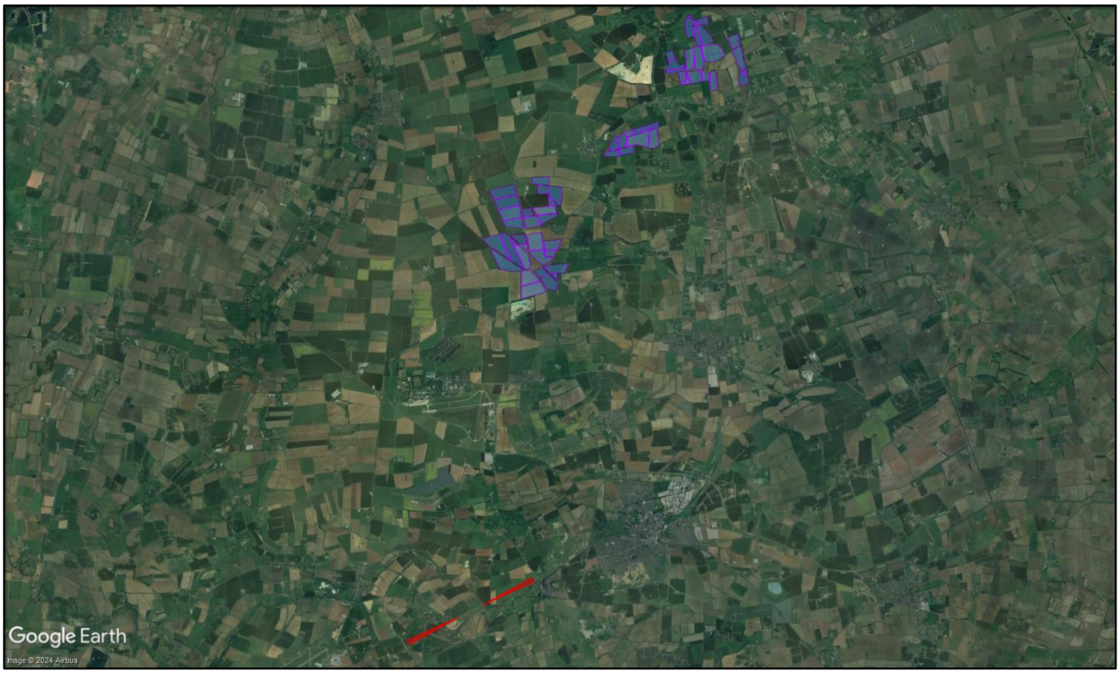

Figure 22 Hanbeck Farm Airfield relative to Proposed Development

Assessment

8.4.3. The following can be concluded for Hanbeck Farm Airfield with regards to the proposed development:

- Solar reflections originating from the proposed development towards the 1-mile splayed approach path for threshold 06 will have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (**Appendix D**) and industry best practice, the glare intensity is considered acceptable;

- Solar reflections originating from the proposed development towards the 1-mile splayed approach path for threshold 24 will be outside a pilot's primary field-of-view (50 degrees either side relative to the runway threshold bearing), and would therefore not be considered significant considering the associated guidance (**Appendix D**) and industry best practice;
- Solar reflections towards the final sections of visual circuits will have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (**Appendix D**) and industry best practice, the glare intensity is considered acceptable.

Conclusions

8.4.4. No significant impacts upon aviation activity associated with Hanbeck Farm Airfield are predicted, and mitigation is not required. Detailed modelling is not recommended.

8.5. High-Level Assessment of Millfield Farm Airfield

8.5.1. Millfield Farm Airfield is a General Aviation (GA) airfield approximately 12.3km southeast of the proposed development and is understood not to have an ATC Tower.

8.5.2. The location of Millfield Farm Airfield and 1-mile splayed approach paths relative to the proposed development is shown in **Figure 23** below.

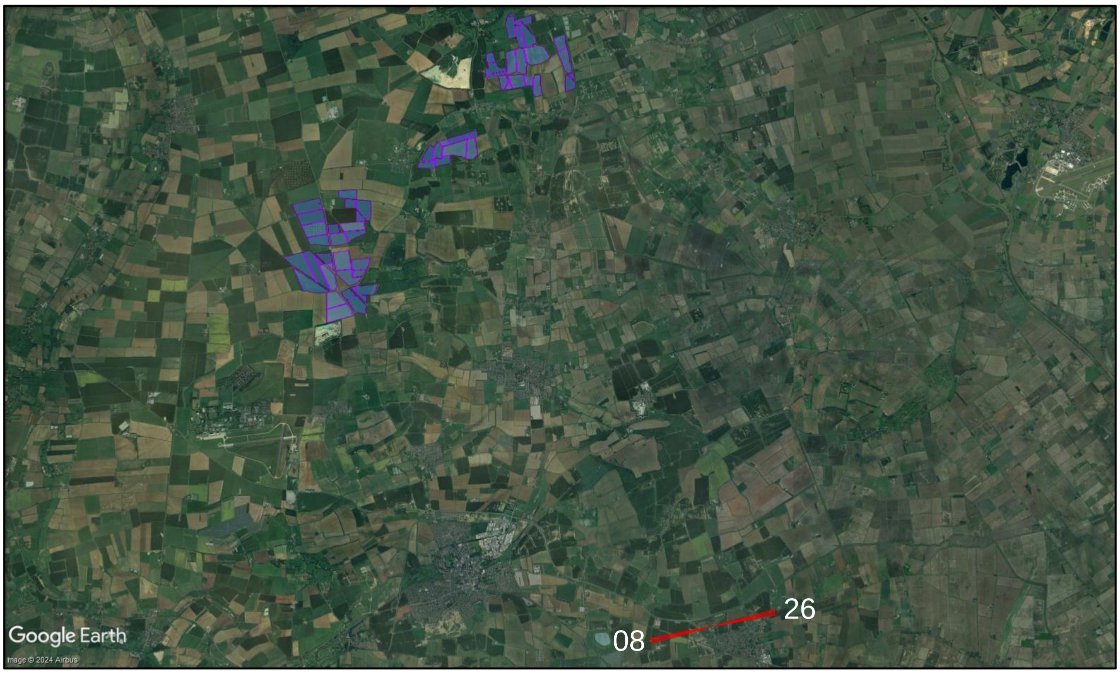

Figure 23 Millfield Farm Airfield relative to Proposed Development

Assessment

8.5.3. The following can be concluded for Millfield Farm Airfield with regards to the proposed development:

- Solar reflections originating from the proposed development towards the 1-mile splayed approach path for threshold 28 will be outside a pilot's primary field-of-view (50 degrees either side relative to the runway threshold bearing), and would therefore not be considered significant considering the associated guidance (**Appendix D**) and industry best practice;
- Solar reflections originating from the proposed development towards the 1-mile splayed approach path for threshold 26 will have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (**Appendix D**) and industry best practice, the glare intensity is considered acceptable;
- Solar reflections towards the final sections of visual circuits will have glare intensities no greater than 'low potential for temporary after-image'. Considering the associated guidance (**Appendix D**) and industry best practice, the glare intensity is considered acceptable.

Conclusions

8.5.4. No significant impacts upon aviation activity associated with Millfield Farm Airfield are predicted, and mitigation is not required. Detailed 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 (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.'

National Policy Statement for Renewable Energy Infrastructure

The National Policy Statement for Renewable Energy Infrastructure (EN-3)[29] sets out the primary policy for decisions by the Secretary of State for nationally significant renewable energy infrastructure. Sections 2.10.102-106 state:

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

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

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

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

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

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

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

Sections 2.10.134-136 state:

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

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

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

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

Railway Assessment Guidelines

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

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' which details the requirement for assessing glare towards railway signals.

Reflections and glare

<u>Rationale</u>

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

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

Guidance

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

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

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

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

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

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

Examples of the adverse effect of disability glare include:

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

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

Options for militating against A5 include:

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

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

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' which details the visibility of signals, train drivers' field of vision and the implications with regard to signal positioning.

Asset visibility

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

a) Position in the observer's visual field.

b) Contrast with its background.

c) Luminance properties.

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

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

Field of vision

The field of vision, or visual field, is the area of the visual environment that is registered by the eyes when both eyes and head are held still. The normal extent of the visual field is approximately 135° in the vertical plane and 200° 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°) to approximately 30° at each eye. The peripheral field extends from 30° 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.

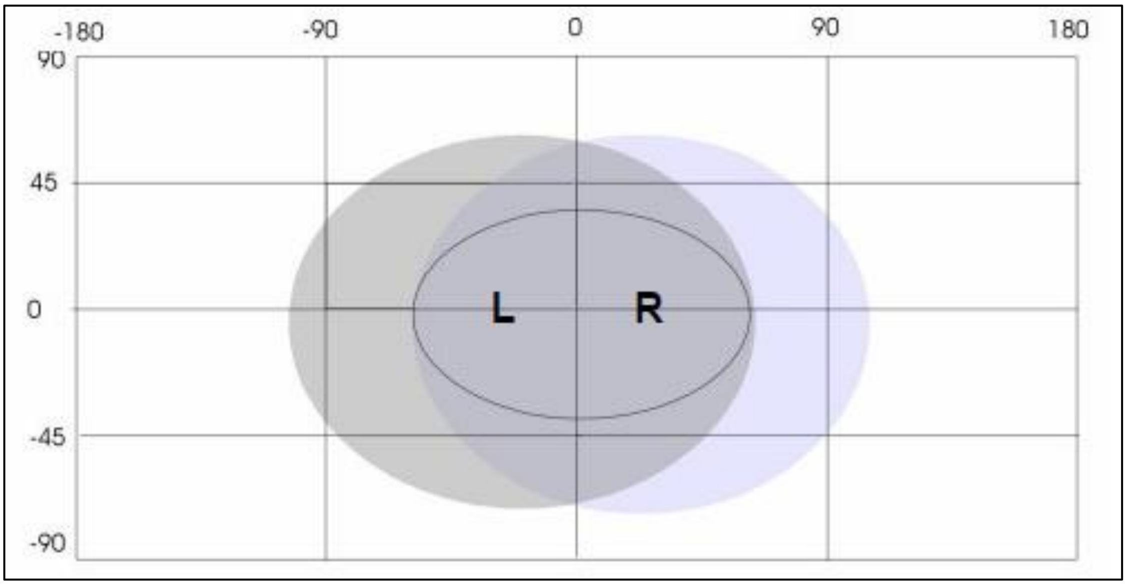

Figure G 21 – field of view

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 + 8o from the direction of travel.

b) Sensitivity to movement in the peripheral field, even minor distractions can reduce the visibility of the asset if it is viewed towards the peripheral field of vision. The presence *of clutter to the sides of the running line can be highly distracting (for example, fence posts, lamp-posts, traffic, or non-signal lights, such as house, compatibility factors or security lights).*

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

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

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

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

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

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

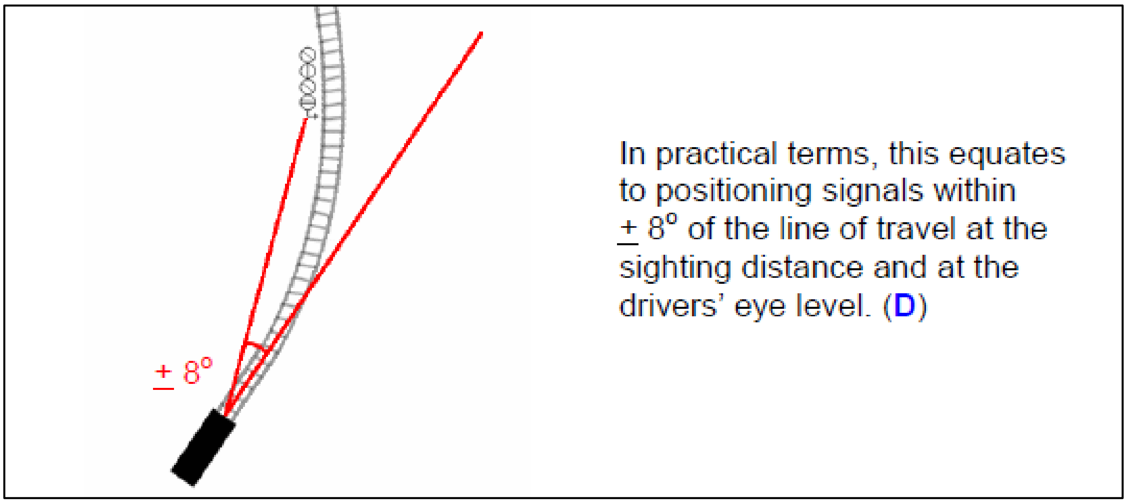

Figure G 22- Signal positioning

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

25	3.51	A stop aspect positioned 3.3 m above rail level and 2.1 m from the right hand rail is within the 8° cone at 25.46 m in front of the driver

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

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

Determining the Assessed Minimum Reading Time

The 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.
b) Interpret the display or display combination
c) Assimilate all of the available information
d) Decide what action to take (if any), and when it needs to be taken
e) Take the action, where necessary, before the train passes the asset.

MRT = BRT + SRT'

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

Aviation Assessment Guidance

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

CAA Interim Guidance

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

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

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

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

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

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

FAA Guidance

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

The 2010 document is entitled '*Technical Guidance for Evaluating Selected Solar Technologies on Airports*'[31], the 2013 update is entitled '*Interim Policy, FAA Review of Solar*

[31] Archived at Pager Power

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

Key excerpts from the final policy are presented below:

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

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

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

[32] [redacted], Department of Transportation, Federal Aviation Administration (FAA), date: 10/2013, accessed on: 08/12/2021.

[33] [redacted], Federal Aviation Administration, date: May 2021, accessed on: 08/12/2021.

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' . 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[34].*
- *The amount of light reflected off a solar panel surface depends on the amount of sunlight hitting the surface, its surface reflectivity, geographic location, time of year, cloud cover, and solar panel orientation.*
- *As illustrated on Figure 16[35], 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.*
- ***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.*

[34] 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.

[35] First figure in Appendix B.

- ***2. Tests in the Field** – Potential glare from solar panels can easily be viewed at the airport through a field test. A few airports have coordinated these tests with FAA Air Traffic Controllers to assess the significance of glare impacts. To conduct such a test, a sponsor can take a solar panel out to proposed location of the solar project, and tilt the panel in different directions to evaluate the potential for glare onto the air traffic control tower. For the two known cases where a field test was conducted, tower personnel determined the glare was not significant. If there is a significant glare impact, the project can be modified by ensuring panels are not directed in that direction.*
- ***3. Geometric Analysis** – Geometric studies are the most technical approach for reflectivity issues. They are conducted when glare is difficult to assess through other methods. Studies of glare can employ geometry and the known path of the sun to predict when sunlight will reflect off of a fixed surface (like a solar panel) and contact a fixed receptor (e.g., control tower). At any given site, the sun moves across the sky every day and its path in the sky changes throughout year. This in turn alters the destination of the resultant reflections since the angle of reflection for the solar panels will be the same as the angle at which the sun hits the panels. The larger the reflective surface, the greater the likelihood of glare impacts.*

- Facilities placed in remote locations, like the desert, will be far from receptors and therefore potential impacts are limited to passing aircraft. Because the intensity of the light reflected from the solar panel decreases with increasing distance, an appropriate question is how far you need to be from a solar reflected surface to avoid flash blindness. It is known that this distance is directly proportional to the size of the array in question[36] 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[37] 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—

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[36] 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.

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

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

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

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

(a) to extinguish or screen the light; and

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

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

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

Lights which dazzle or distract

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

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

Endangering safety of an aircraft

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

Endangering safety of any person or property

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

Civil Aviation Authority consolidation of UK Regulation 139/2014

The Civil Aviation Authority (CAA) published a consolidating document[38] 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.

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

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

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

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

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

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

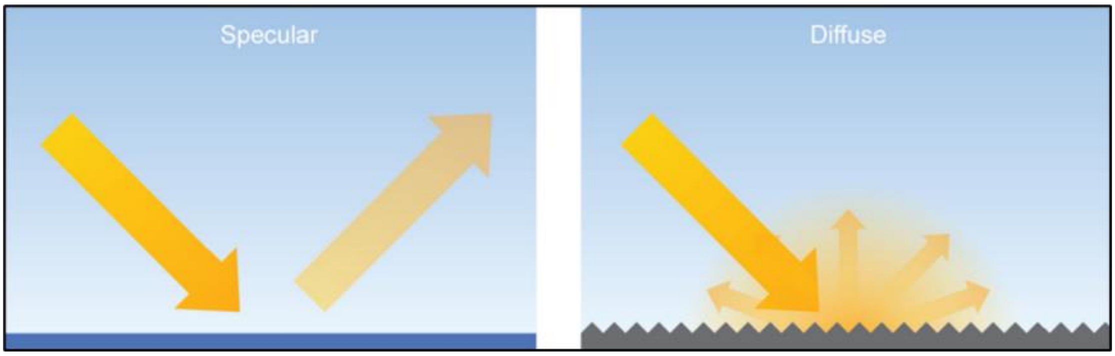
Overview

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[39], 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

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*[40]". 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

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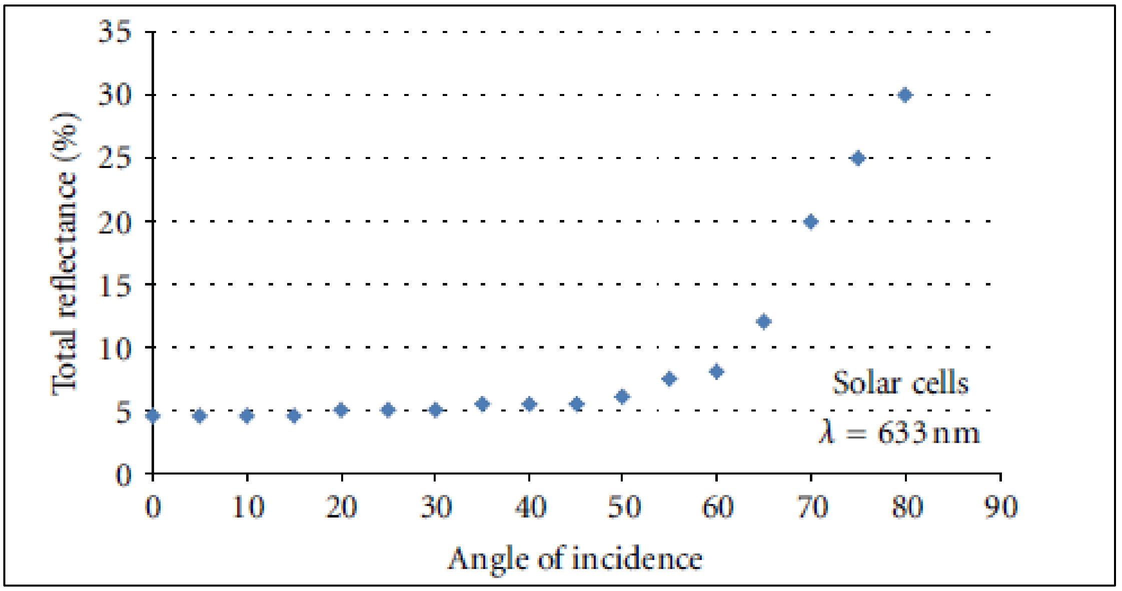
[redacted], Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

[40] 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

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 the angle of incidence

The conclusions of the research study were:

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

FAA Guidance – "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[41]

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 on the following page.

[41] [redacted], Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

Surface	Approximate Percentage of Light Reflected[42]
Snow	80
White Concrete	77
Bare Aluminium	74
Vegetation	50
Bare Soil	30
Wood Shingle	17
Water	5
Solar Panels	5
Black Asphalt	2

Relative reflectivity of various surfaces

Note that the data above does not appear to consider the reflection type (specular or diffuse).

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

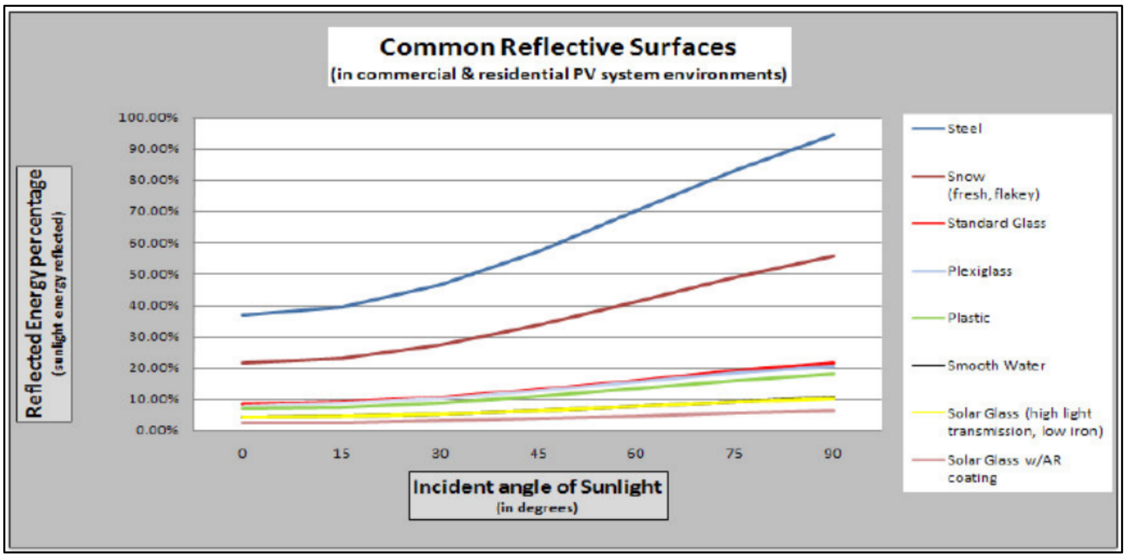
SunPower Technical Notification (2009)

SunPower published a technical notification[43] to '*increase awareness concerning the possible glare and reflectance impact of PV Systems on their surrounding environment'.*

The figure presented on the following page shows the relative reflectivity of solar panels compared to other natural and manmade materials including smooth water, standard glass and steel.

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

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



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.

Appendix C – Overview of Sun Movements and Relative Reflections

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

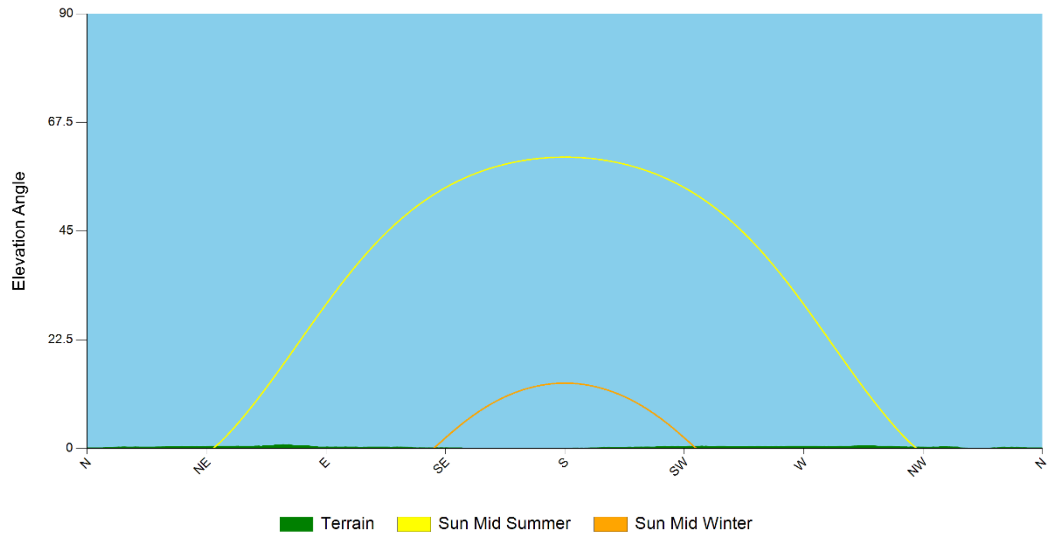
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

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

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

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

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



Terrain at Sun horizon at location of the Proposed Development

Appendix D – Glint and Glare Impact Significance

Overview

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

Impact Significance Definition

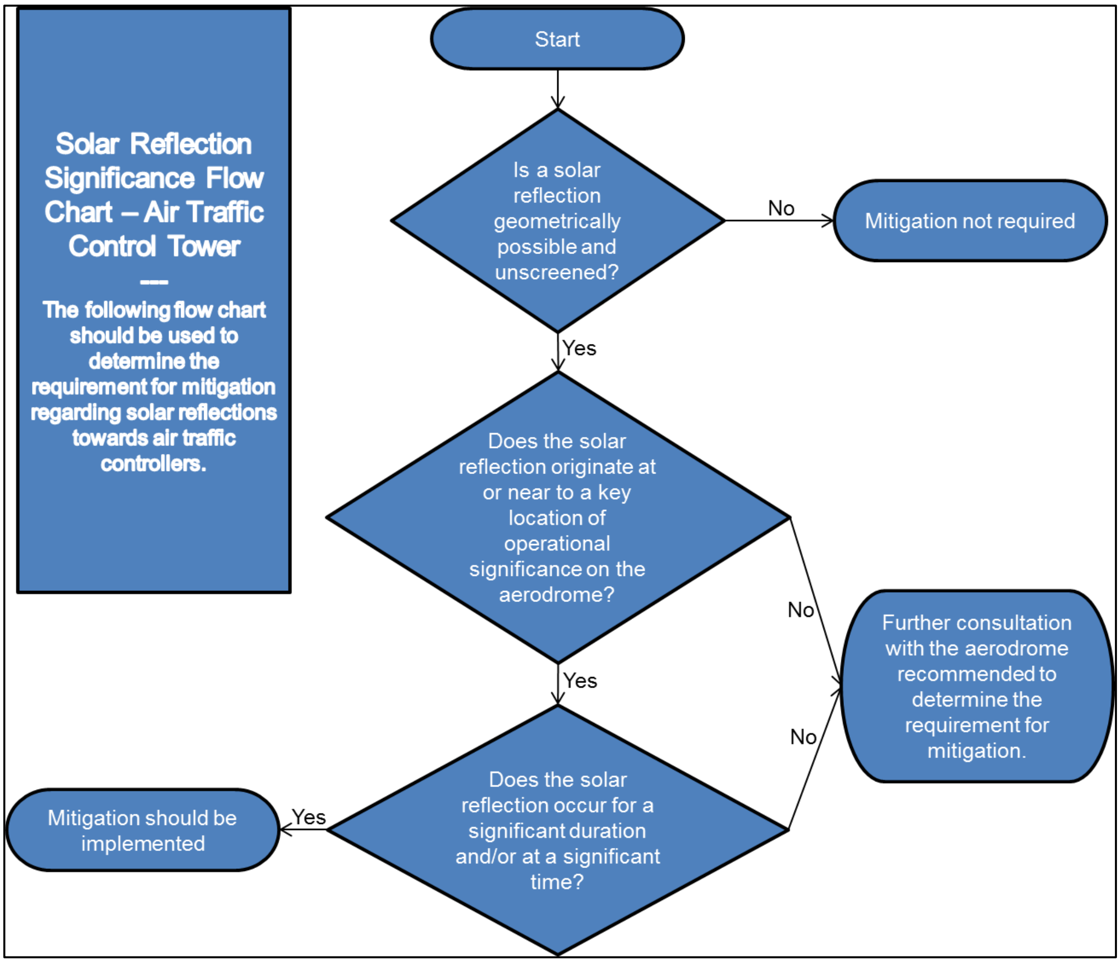
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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

Impact significance definition

Impact Significance Determination for an ATC Tower

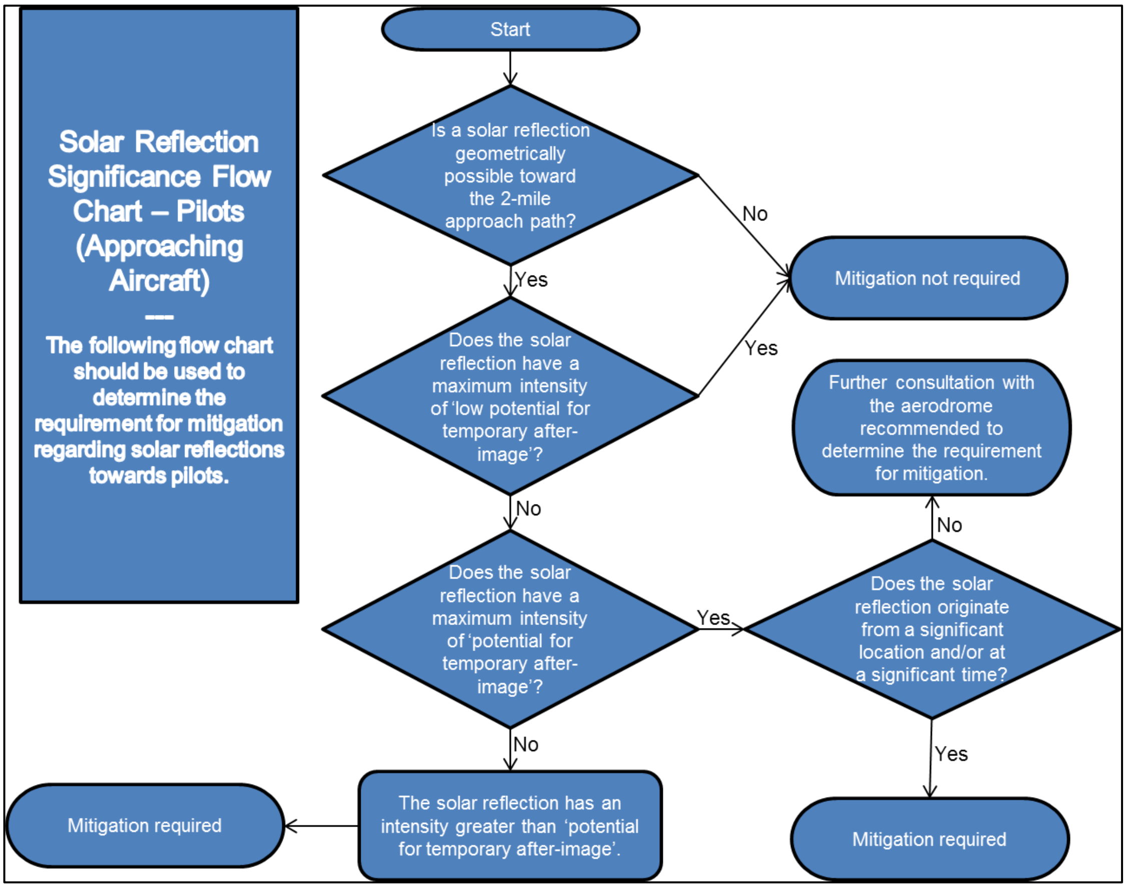
The flow chart presented below has been followed when determining the mitigation requirement for an ATC Tower.



ATC Tower mitigation requirement flow chart

Impact Significance Determination for Approaching Aircraft

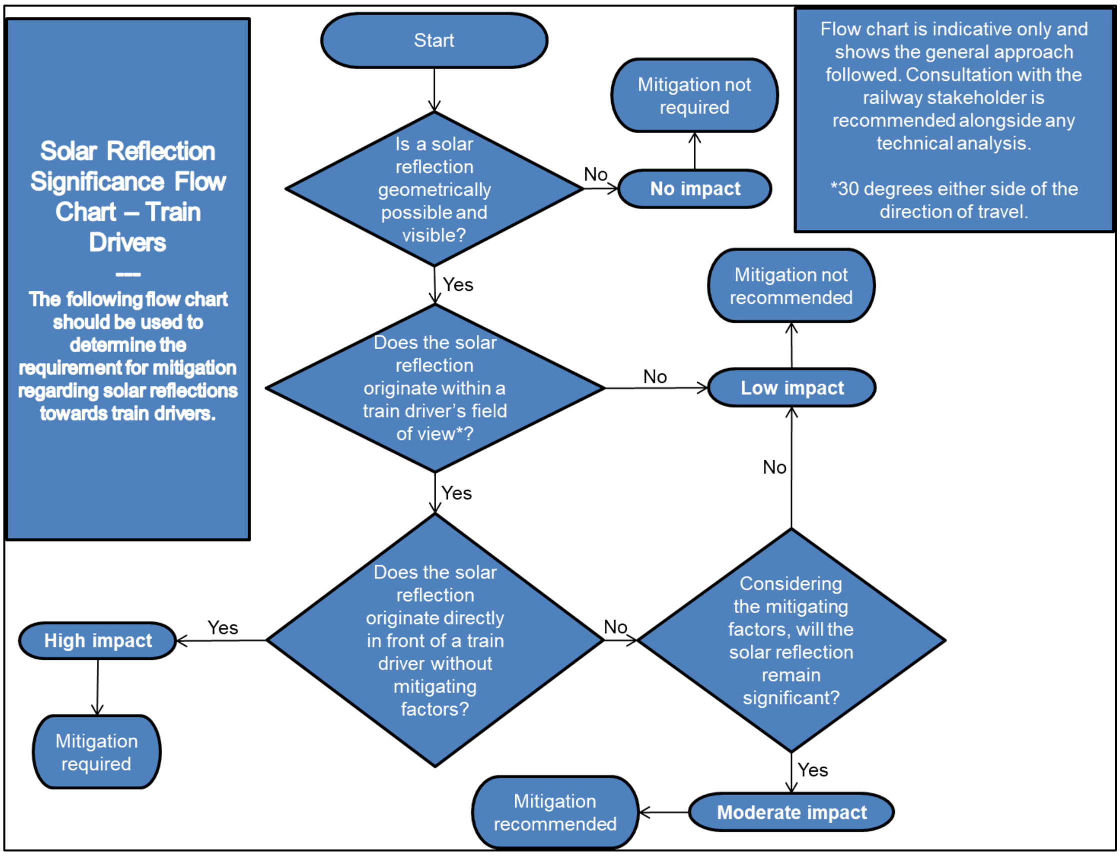
The flow chart presented below has been followed when determining the mitigation requirement for approaching aircraft.



Approaching aircraft receptor mitigation requirement flow chart

Impact Significance Determination for Train Drivers

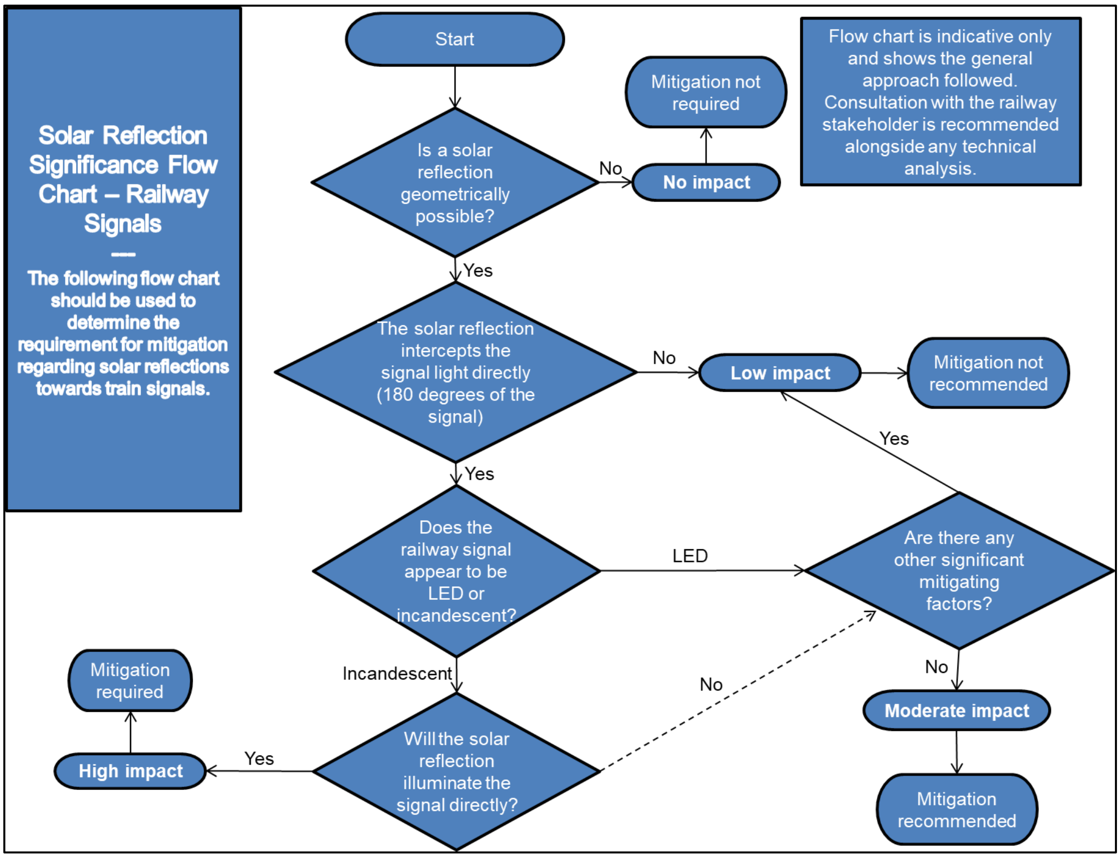
The flow chart presented below has been followed when determining the impact significance and mitigation requirement for train drivers.



Train Driver impact significance flow chart

Impact Significance Determination for Railway Signals

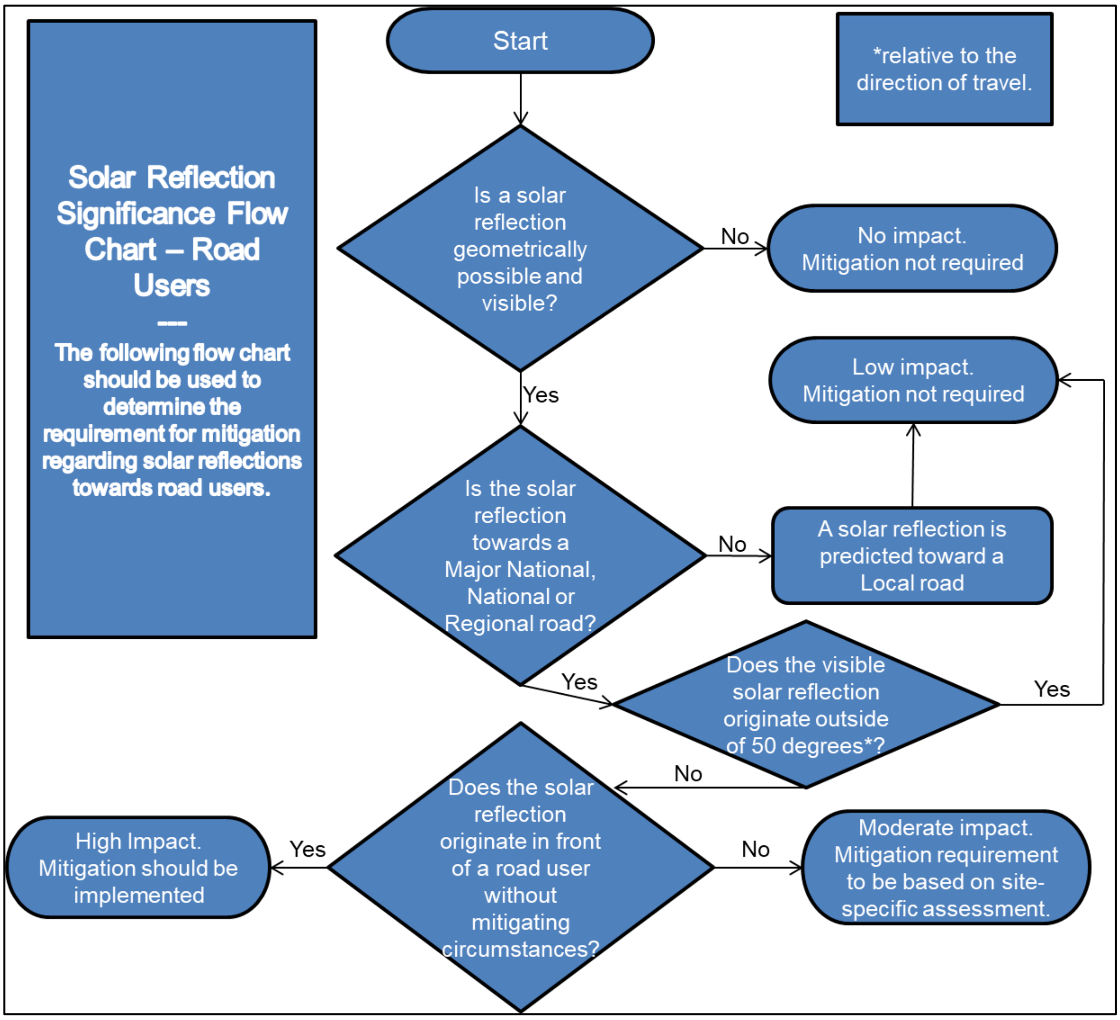
The flow chart presented below has been followed when determining the impact significance mitigation requirement for railway signals.



Railway signal impact significance flow chart

Impact Significance Determination for Road Receptors

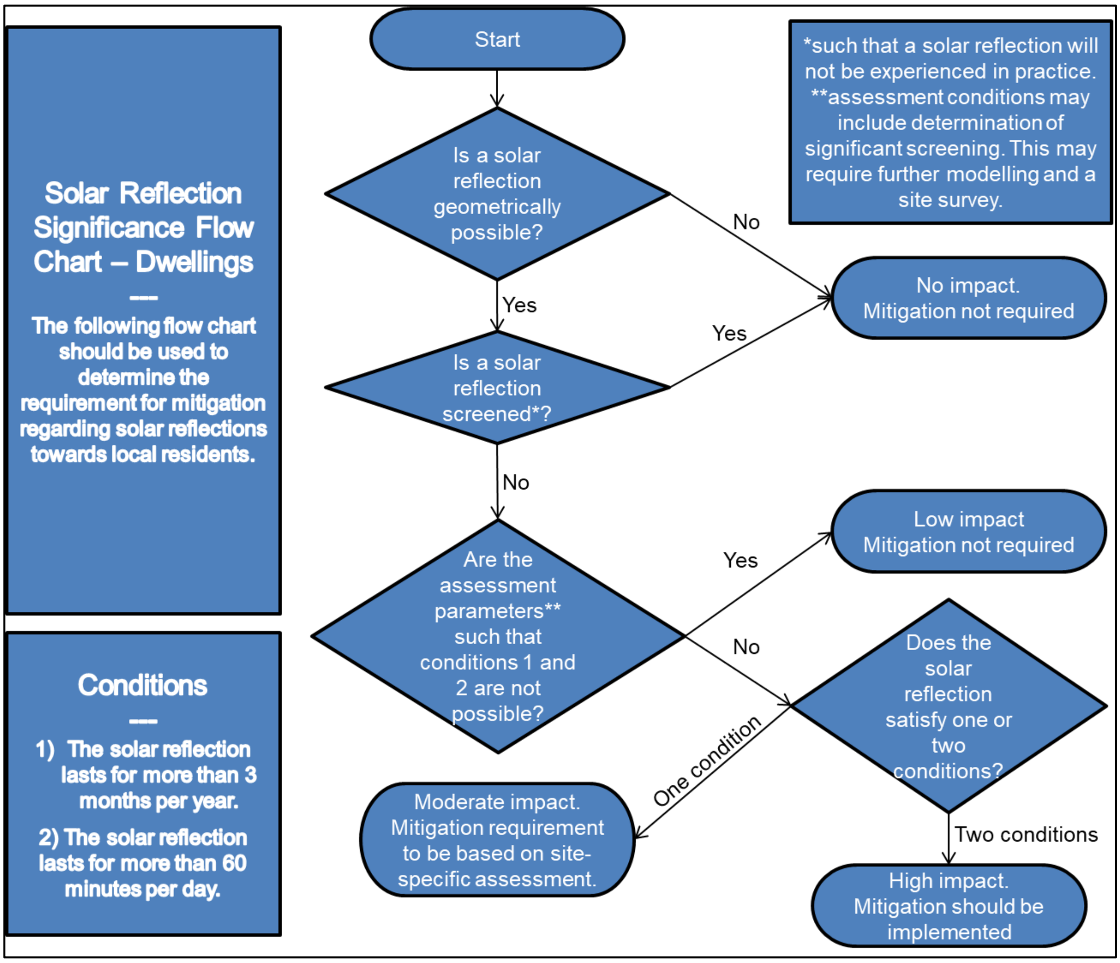
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road user impact significance flow chart

Impact Significance Determination for Dwelling Receptors

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



Dwelling impact significance flow chart

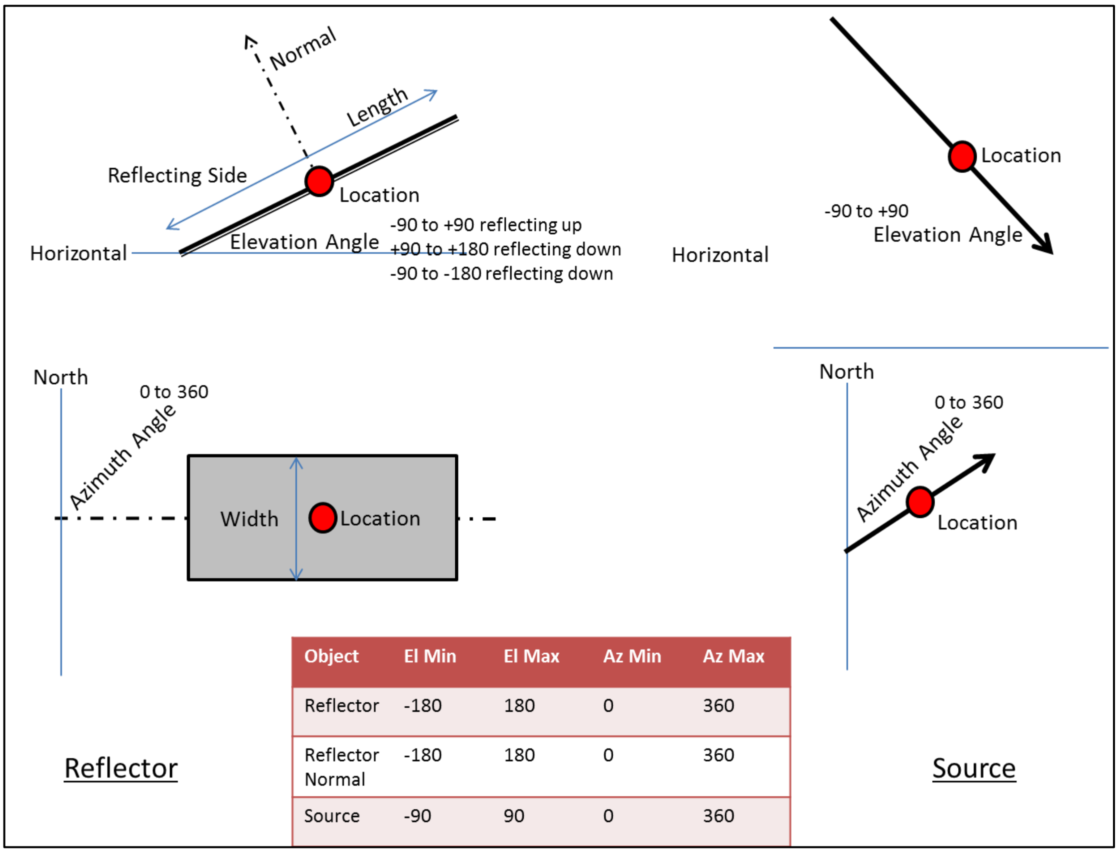
Appendix E – Reflection Calculations Methodology

Pager Power Methodology

The calculations are three dimensional and complex, accounting for:

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

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



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

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

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

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

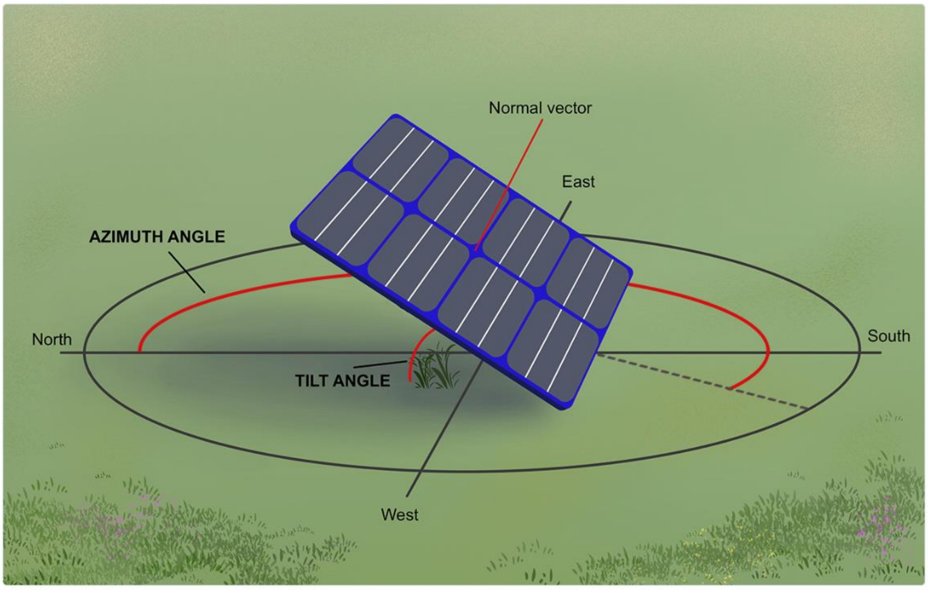
Source, Normal and Reflection are in the same plane.

Forge Reflection Calculations Methodology

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

Fixed-Mount Parameters

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



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

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

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

Fixed System Parameters

Appendix F – Assessment Limitations and Assumptions

Forge's Sandia National Laboratories' (SGHAT) Model[44]

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

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

[redacted]

Appendix G – Receptor and Reflector Area Details

Aviation Receptor Data

Aerodrome	Threshold	Longitude (°)	Latitude (°)	Elevation
RAF Cranwell	ATC Tower	-0.48665	53.03318	65.00
	08	-0.50571	53.02874	81.24
	26	-0.47877	53.03082	70.24
	01	-0.48543	53.02112	69.24
	19	-0.48235	53.03400	69.24
RAF Waddington	ATC Tower	-0.52380	53.17239	81.00
	02	-0.53166	53.15436	84.24
	20	-0.51672	53.17693	82.24
Temple Bruer	08	-0.51588	53.07672	87.24
	26	-0.50755	53.07784	84.24
Cottage Farm	09	-0.42731	53.05530	43.24
	27	-0.42342	53.05523	40.24
Old Manor Farm	06	-0.33760	53.04284	26.24
	24	-0.32806	53.04590	22.24
Hill Top Farm	09	-0.42622	53.09172	47.24
	27	-0.42127	53.09164	43.24

Aviation receptor data

Railway Receptor Data

Train Driver Receptors

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
1	53.10888	-0.36813	10.75	14	53.12035	-0.36948	10.75
2	53.10975	-0.36777	10.75	15	53.12125	-0.36978	10.75

3	53.11063	-0.36750	10.93	16	53.12215	-0.37010	11.75
4	53.11154	-0.36732	11.75	17	53.12298	-0.37038	11.75
5	53.11242	-0.36725	11.75	18	53.12388	-0.37069	11.75
6	53.11333	-0.36732	11.56	19	53.12476	-0.37100	11.75
7	53.11422	-0.36746	9.93	20	53.12564	-0.37130	11.75
8	53.11511	-0.36772	9.75	21	53.12653	-0.37161	11.75
9	53.11598	-0.36801	9.75	22	53.12737	-0.37190	11.75
10	53.11686	-0.36831	9.75	23	53.12825	-0.37230	11.75
11	53.11774	-0.36861	9.75	24	53.12911	-0.37282	11.75
12	53.11857	-0.36889	9.75	25	53.12992	-0.37346	11.75
13	53.11949	-0.36920	9.75	26	53.13064	-0.37414	11.75

Train Signal Receptors

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
1	53.12743	-0.37180	12.30	3	53.11157	-0.36722	12.30
2	53.12400	-0.37062	12.30	4	53.10916	-0.36807	11.30

Road Receptor Data

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

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
1	-0.47095	53.09339	49.50	104	-0.42602	53.10313	25.50
2	-0.47048	53.09254	49.24	105	-0.42495	53.10376	24.50
3	-0.47001	53.09168	49.50	106	-0.42394	53.10442	23.50
4	-0.46957	53.09082	48.66	107	-0.42291	53.10507	23.37
5	-0.46917	53.08995	49.50	108	-0.42167	53.10558	23.50

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
6	-0.46879	53.08908	49.50	109	-0.42038	53.10603	21.57
7	-0.46840	53.08821	49.19	110	-0.41912	53.10652	22.27
8	-0.46800	53.08735	48.50	111	-0.41796	53.10709	21.96
9	-0.46762	53.08648	48.10	112	-0.41679	53.10765	21.88
10	-0.46725	53.08560	46.70	113	-0.41543	53.10800	21.06
11	-0.46687	53.08473	47.50	114	-0.41395	53.10815	19.05
12	-0.46649	53.08386	48.10	115	-0.41246	53.10823	19.70
13	-0.46617	53.08298	47.50	116	-0.41099	53.10836	20.50
14	-0.46591	53.08210	46.50	117	-0.40965	53.10877	20.50
15	-0.46565	53.08121	46.32	118	-0.40834	53.10921	20.50
16	-0.46540	53.08033	44.19	119	-0.40721	53.10961	20.50
17	-0.46513	53.07944	41.50	120	-0.40737	53.13124	23.48
18	-0.46488	53.07855	40.39	121	-0.40683	53.13040	19.29
19	-0.46463	53.07767	36.50	122	-0.40632	53.12956	18.69
20	-0.46437	53.07678	38.56	123	-0.40591	53.12869	18.50
21	-0.46411	53.07589	39.50	124	-0.40590	53.12780	18.50
22	-0.46385	53.07501	37.23	125	-0.40607	53.12691	18.50
23	-0.46360	53.07412	32.83	126	-0.40634	53.12602	19.65
24	-0.46334	53.07323	32.57	127	-0.40657	53.12513	20.94
25	-0.46308	53.07235	34.50	128	-0.40624	53.12426	22.44
26	-0.46282	53.07146	36.49	129	-0.40628	53.12337	22.56
27	-0.46255	53.07057	38.45	130	-0.40666	53.12250	23.92
28	-0.46230	53.06969	40.76	131	-0.40719	53.12165	24.50
29	-0.46201	53.06881	41.50	132	-0.40774	53.12082	26.50

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
30	-0.46169	53.06793	42.38	133	-0.40816	53.11996	28.53
31	-0.46137	53.06705	42.50	134	-0.40839	53.11907	29.50
32	-0.46102	53.06617	42.50	135	-0.40845	53.11817	29.50
33	-0.46058	53.06531	41.50	136	-0.40855	53.11727	29.50
34	-0.45988	53.06452	41.50	137	-0.40863	53.11637	28.50
35	-0.45896	53.06381	41.50	138	-0.40866	53.11547	27.50
36	-0.45795	53.06315	41.50	139	-0.40861	53.11457	26.50
37	-0.45708	53.06242	40.50	140	-0.40845	53.11368	25.24
38	-0.45623	53.06168	38.78	141	-0.40812	53.11280	24.00
39	-0.45541	53.06092	37.35	142	-0.40778	53.11192	22.50
40	-0.45496	53.06007	35.38	143	-0.40746	53.11104	21.50
41	-0.45466	53.05919	33.27	144	-0.40723	53.11016	21.15
42	-0.45437	53.05831	31.33	145	-0.40702	53.10926	20.50
43	-0.45414	53.05742	30.50	146	-0.40672	53.10838	20.50
44	-0.45398	53.05652	31.64	147	-0.40634	53.10751	21.50
45	-0.45366	53.05564	33.51	148	-0.40572	53.10670	21.50
46	-0.45332	53.05477	36.47	149	-0.40459	53.10611	21.50
47	-0.45307	53.05388	39.12	150	-0.40384	53.10533	21.50
48	-0.45282	53.05299	41.40	151	-0.40335	53.10449	21.50
49	-0.45264	53.05210	42.50	152	-0.40284	53.10364	21.50
50	-0.45237	53.05122	43.50	153	-0.40227	53.10281	21.97
51	-0.45237	53.05121	43.50	154	-0.40182	53.10195	22.50
52	-0.46021	53.06498	41.50	155	-0.40124	53.10113	22.50
53	-0.45892	53.06543	40.50	156	-0.40077	53.10028	21.95

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
54	-0.45763	53.06589	40.50	157	-0.40019	53.09945	21.40
55	-0.45633	53.06634	39.50	158	-0.39988	53.09857	20.50
56	-0.45490	53.06659	38.96	159	-0.39950	53.09770	21.32
57	-0.45351	53.06691	37.63	160	-0.39885	53.09689	20.85
58	-0.45237	53.06748	36.50	161	-0.39843	53.09603	20.50
59	-0.45155	53.06824	36.50	162	-0.39818	53.09515	21.50
60	-0.45077	53.06900	35.50	163	-0.39790	53.09426	21.50
61	-0.44998	53.06977	34.50	164	-0.39762	53.09338	21.50
62	-0.44922	53.07054	34.50	165	-0.39684	53.09264	21.50
63	-0.44862	53.07136	33.50	166	-0.39572	53.09204	21.34
64	-0.44824	53.07223	33.50	167	-0.39515	53.09175	21.30
65	-0.44791	53.07311	32.50	168	-0.40667	53.10853	20.50
66	-0.44759	53.07399	32.49	169	-0.40519	53.10867	19.11
67	-0.44725	53.07487	31.50	170	-0.40369	53.10863	18.24
68	-0.44677	53.07572	31.50	171	-0.40230	53.10893	16.50
69	-0.44623	53.07656	31.50	172	-0.40084	53.10911	16.50
70	-0.44569	53.07740	31.50	173	-0.39934	53.10920	15.50
71	-0.44530	53.07827	29.80	174	-0.39785	53.10913	15.50
72	-0.44497	53.07914	29.50	175	-0.39636	53.10905	16.50
73	-0.44410	53.07985	29.50	176	-0.39490	53.10886	16.50
74	-0.44306	53.08050	29.50	177	-0.39345	53.10863	16.50
75	-0.44192	53.08108	28.62	178	-0.39198	53.10846	16.50
76	-0.44076	53.08165	28.75	179	-0.39050	53.10832	16.50
77	-0.43968	53.08227	28.50	180	-0.38901	53.10820	16.50

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
78	-0.43855	53.08286	28.36	181	-0.38752	53.10826	16.50
79	-0.43737	53.08342	28.78	182	-0.38608	53.10816	16.50
80	-0.43676	53.08422	29.50	183	-0.38474	53.10775	16.50
81	-0.43628	53.08506	29.50	184	-0.38332	53.10746	16.50
82	-0.43539	53.08578	30.50	185	-0.38193	53.10714	16.50
83	-0.43465	53.08656	30.11	186	-0.38048	53.10691	15.22
84	-0.43424	53.08743	29.50	187	-0.37903	53.10668	12.50
85	-0.43393	53.08831	29.50	188	-0.37829	53.10713	11.50
86	-0.43371	53.08920	29.50	189	-0.37760	53.10789	11.50
87	-0.43349	53.09009	29.50	190	-0.37619	53.10818	10.63
88	-0.43331	53.09098	29.50	191	-0.37478	53.10844	11.36
89	-0.43316	53.09188	29.50	192	-0.37329	53.10854	10.50
90	-0.43288	53.09276	29.50	193	-0.37182	53.10867	10.50
91	-0.43269	53.09365	29.50	194	-0.37034	53.10855	9.50
92	-0.43239	53.09453	29.50	195	-0.36903	53.10894	9.50
93	-0.43219	53.09542	30.45	196	-0.36768	53.10932	9.50
94	-0.43323	53.09597	29.78	197	-0.36627	53.10964	9.50
95	-0.43374	53.09661	31.05	198	-0.36488	53.10997	8.50
96	-0.43314	53.09743	31.50	199	-0.36345	53.11021	8.50
97	-0.43254	53.09826	31.50	200	-0.36197	53.11037	7.50
98	-0.43190	53.09907	31.21	201	-0.36050	53.11054	7.50
99	-0.43108	53.09982	30.44	202	-0.35902	53.11070	7.50
100	-0.43018	53.10054	29.50	203	-0.35755	53.11086	8.50
101	-0.42921	53.10122	28.50	204	-0.35608	53.11103	9.50

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
102	-0.42812	53.10185	26.89	205	-0.35460	53.11119	10.50
103	-0.42707	53.10249	26.46	206	-0.35327	53.11134	10.96

Dwelling Receptor Data

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

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
1	-0.45167	53.09528	39.29	66	-0.3991	53.10978	15.80
2	-0.48222	53.08263	53.92	67	-0.39815	53.10934	15.80
3	-0.48085	53.08279	53.72	68	-0.39792	53.10933	15.80
4	-0.46542	53.08473	46.87	69	-0.39751	53.10924	15.80
5	-0.46492	53.08471	46.20	70	-0.39704	53.10922	15.88
6	-0.49576	53.07163	51.80	71	-0.39668	53.10917	16.42
7	-0.49476	53.07129	51.80	72	-0.39621	53.10928	16.80
8	-0.49521	53.07093	50.88	73	-0.39594	53.10927	16.80
9	-0.4952	53.0707	50.62	74	-0.39577	53.10925	16.80
10	-0.45131	53.07658	32.80	75	-0.39562	53.10926	16.80
11	-0.45071	53.07594	33.08	76	-0.39546	53.10926	16.80
12	-0.43983	53.07071	31.80	77	-0.39526	53.1093	16.80
13	-0.47134	53.0511	48.99	78	-0.39488	53.10918	16.80
14	-0.43954	53.05943	28.80	79	-0.39468	53.10904	16.80
15	-0.42987	53.09821	29.80	80	-0.39424	53.10897	16.80
16	-0.43083	53.09799	29.80	81	-0.39399	53.1089	16.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
17	-0.43154	53.09781	30.34	82	-0.38648	53.10845	16.80
18	-0.43341	53.09768	31.91	83	-0.38635	53.10867	16.80
19	-0.4336	53.09745	32.21	84	-0.38629	53.10886	16.80
20	-0.43173	53.09545	31.54	85	-0.38593	53.10903	16.80
21	-0.43176	53.09525	31.80	86	-0.38565	53.10911	16.80
22	-0.4329	53.09378	29.80	87	-0.38563	53.10891	16.80
23	-0.43298	53.09362	29.80	88	-0.38561	53.10873	16.80
24	-0.43301	53.09353	29.80	89	-0.3856	53.10851	16.80
25	-0.43301	53.09342	29.80	90	-0.38554	53.10817	16.80
26	-0.43303	53.09331	29.80	91	-0.38318	53.10752	16.80
27	-0.43306	53.09322	29.80	92	-0.38292	53.1075	16.80
28	-0.43307	53.09311	29.80	93	-0.38253	53.10748	16.80
29	-0.42394	53.0928	31.80	94	-0.3822	53.10745	16.80
30	-0.42346	53.09263	31.80	95	-0.38197	53.10744	16.80
31	-0.42084	53.10523	22.15	96	-0.38145	53.10711	16.80
32	-0.41747	53.10654	21.80	97	-0.38118	53.10715	16.80
33	-0.41309	53.10837	20.07	98	-0.38082	53.10705	15.15
34	-0.41269	53.10837	20.37	99	-0.38038	53.10703	14.66
35	-0.41235	53.10844	20.44	100	-0.3798	53.10696	13.80
36	-0.41194	53.10843	20.53	101	-0.37896	53.10683	12.80
37	-0.41158	53.10842	20.62	102	-0.37866	53.10677	11.80
38	-0.41087	53.10826	20.49	103	-0.37842	53.10728	11.80
39	-0.41044	53.10777	20.53	104	-0.37431	53.10803	10.90
40	-0.41038	53.10838	20.56	105	-0.36718	53.10963	9.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
41	-0.40998	53.10843	20.80	106	-0.36563	53.11034	9.80
42	-0.40975	53.10849	20.80	107	-0.35556	53.12179	14.80
43	-0.40932	53.10838	20.80	108	-0.36905	53.13108	10.80
44	-0.40864	53.10879	20.80	109	-0.3994	53.12965	15.80
45	-0.4083	53.10896	20.80	110	-0.40008	53.1295	15.80
46	-0.40769	53.10919	20.80	111	-0.40092	53.1293	15.80
47	-0.40741	53.10927	20.80	112	-0.40112	53.12903	15.30
48	-0.40658	53.10963	20.80	113	-0.40229	53.12898	15.02
49	-0.40583	53.10972	20.80	114	-0.4034	53.12889	15.06
50	-0.40541	53.1097	19.80	115	-0.40556	53.12851	18.21
51	-0.40516	53.10978	19.80	116	-0.40604	53.12822	18.80
52	-0.40485	53.1098	19.32	117	-0.40432	53.12628	18.80
53	-0.40438	53.10984	18.85	118	-0.3996	53.12532	16.80
54	-0.40395	53.10984	17.92	119	53.05632	-0.45517	32.65
55	-0.40357	53.11002	18.22	120	53.08891	-0.46813	49.38
56	-0.40307	53.11004	17.43	121	53.06998	-0.44940	34.80
57	-0.40252	53.10985	17.08	122	53.09701	-0.40564	23.80
58	-0.40222	53.10988	16.91	123	53.09011	-0.43441	29.88
59	-0.40187	53.10993	17.00	124	53.08707	-0.42818	34.26
60	-0.4015	53.10993	16.80	125	53.09572	-0.43139	31.55
61	-0.40126	53.10996	16.80	126	53.10773	-0.40767	21.80
62	-0.40079	53.11027	16.80	127	53.11174	-0.40832	22.80
63	-0.40053	53.11031	16.80	128	53.11720	-0.38053	14.80
64	-0.40023	53.11022	15.80	129	53.13009	-0.37876	10.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m)	No.	Longitude (°)	Latitude (°)	Assessed Height (m)
65	-0.40024	53.11008	16.06				

Modelled Reflector Areas

Panel Area 1

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.47209	53.07646	12	-0.46109	53.08927
2	-0.46486	53.07611	13	-0.46100	53.08770
3	-0.46357	53.07625	14	-0.45844	53.08743
4	-0.45755	53.07688	15	-0.45834	53.08511
5	-0.45015	53.07920	16	-0.45416	53.08511
6	-0.45118	53.08208	17	-0.45385	53.08172
7	-0.44875	53.08224	18	-0.46614	53.08105
8	-0.44837	53.08387	19	-0.46856	53.08735
9	-0.44828	53.08671	20	-0.47911	53.08584
10	-0.45412	53.08701	21	-0.47209	53.07646
11	-0.45371	53.08941			

Panel Area 2

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.47938	53.07171	21	-0.44561	53.06698
2	-0.47469	53.06537	22	-0.44662	53.06699
3	-0.47387	53.06547	23	-0.44720	53.06683
4	-0.47298	53.06543	24	-0.44989	53.06669

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
5	-0.47178	53.06519	25	-0.45202	53.06650
6	-0.46975	53.06505	26	-0.45249	53.06650
7	-0.46847	53.06497	27	-0.45281	53.06659
8	-0.46672	53.06511	28	-0.45311	53.06683
9	-0.46555	53.06523	29	-0.45372	53.06738
10	-0.46567	53.06113	30	-0.45313	53.06766
11	-0.46558	53.05786	31	-0.45196	53.06872
12	-0.45532	53.05964	32	-0.44948	53.07131
13	-0.45561	53.06048	33	-0.44869	53.07315
14	-0.45465	53.06060	34	-0.45640	53.07266
15	-0.45051	53.06010	35	-0.45702	53.07503
16	-0.45021	53.06202	36	-0.46422	53.07442
17	-0.45038	53.06457	37	-0.47116	53.07427
18	-0.44870	53.06464	38	-0.47240	53.07493
19	-0.44869	53.06455	39	-0.48231	53.07328
20	-0.44712	53.06461	40	-0.47938	53.07171

Panel Area 3

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.42608	53.09898	16	-0.41537	53.09773
2	-0.42820	53.09648	17	-0.41222	53.09739
3	-0.42696	53.09641	18	-0.41212	53.09717
4	-0.42699	53.09572	19	-0.41072	53.09703
5	-0.42778	53.09574	20	-0.41073	53.09686

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
6	-0.42818	53.09588	21	-0.40783	53.09683
7	-0.42915	53.09602	22	-0.40625	53.09772
8	-0.42938	53.09558	23	-0.40744	53.10204
9	-0.42962	53.09479	24	-0.40617	53.10228
10	-0.42329	53.09467	25	-0.40678	53.10356
11	-0.42328	53.09497	26	-0.42175	53.10081
12	-0.41737	53.09582	27	-0.42332	53.09957
13	-0.41739	53.09605	28	-0.42361	53.09944
14	-0.41728	53.09612	29	-0.42503	53.10002
15	-0.41735	53.09768	30	-0.42608	53.09898

Panel Area 4

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.39335	53.13114	32	-0.38416	53.11268
2	-0.39398	53.13081	33	-0.38380	53.11163
3	-0.39427	53.13050	34	-0.38085	53.11207
4	-0.39498	53.12902	35	-0.38155	53.11460
5	-0.39477	53.12805	36	-0.38176	53.11680
6	-0.39387	53.12546	37	-0.38384	53.11661
7	-0.39083	53.12594	38	-0.38403	53.11599
8	-0.38979	53.12313	39	-0.38742	53.11668
9	-0.39489	53.12211	40	-0.38691	53.11960
10	-0.39451	53.11850	41	-0.38661	53.11976
11	-0.39744	53.11830	42	-0.38518	53.11919

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
12	-0.39855	53.11890	43	-0.38324	53.11933
13	-0.39920	53.11973	44	-0.38125	53.11959
14	-0.40051	53.12202	45	-0.37935	53.12025
15	-0.40218	53.12184	46	-0.37770	53.12101
16	-0.40225	53.12158	47	-0.37949	53.12285
17	-0.40287	53.12148	48	-0.38071	53.12366
18	-0.40269	53.12059	49	-0.38134	53.12357
19	-0.40168	53.11834	50	-0.38158	53.12373
20	-0.40322	53.11809	51	-0.38289	53.12368
21	-0.40288	53.11672	52	-0.38468	53.12342
22	-0.40297	53.11609	53	-0.38451	53.12410
23	-0.39788	53.11665	54	-0.38318	53.12435
24	-0.39667	53.11318	55	-0.38387	53.12573
25	-0.39265	53.11354	56	-0.38418	53.12602
26	-0.38713	53.11424	57	-0.38852	53.12889
27	-0.38565	53.11434	58	-0.38491	53.12909
28	-0.38552	53.11431	59	-0.38498	53.13088
29	-0.38546	53.11421	60	-0.39180	53.12977
30	-0.38435	53.11433	61	-0.39242	53.13128
31	-0.38438	53.11336	62	-0.39335	53.13114

Panel Area 5

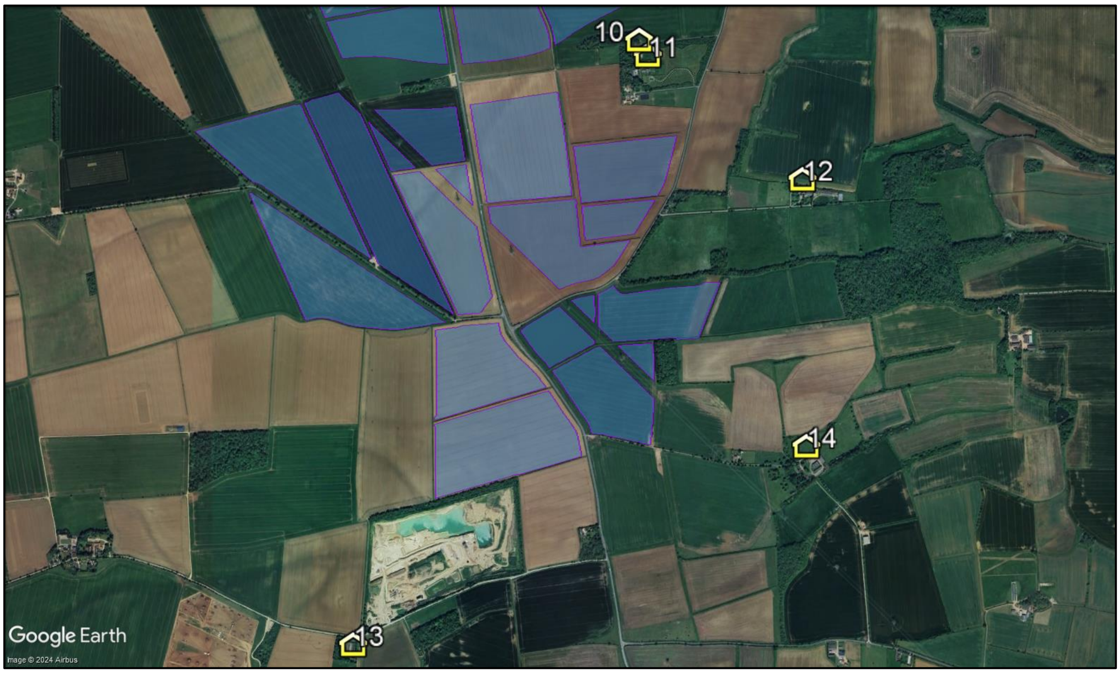
No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.37451	53.12240	10	-0.36950	53.11915

2	-0.37450	53.12212	11	-0.37013	53.12021
3	-0.37254	53.11934	12	-0.37055	53.12223
4	-0.37190	53.11810	13	-0.37187	53.12455
5	-0.37125	53.11665	14	-0.37170	53.12531
6	-0.37151	53.11448	15	-0.37203	53.12642
7	-0.37138	53.11289	16	-0.37627	53.12545
8	-0.36773	53.11379	17	-0.37451	53.12240
9	-0.36825	53.11558			

Appendix H – Detailed Identification of Dwelling Receptors

Dwellings 1 to 5

Dwellings 6 to 9



Dwellings 10 to 14

Dwellings 15 to 21

Dwellings 22 to 28

Dwellings 29 to 30

Dwelling 31 to 32

Dwellings 33 to 48

Dwelling 49 to 66

Dwelling 67 to 81

Dwellings 82 to 95

Dwellings 96 to 104

Dwellings 105 to 108

Dwellings 109 to 118

Dwellings 119 to 121 and 130

Dwellings 122 to 125

Dwellings 126 to 129

Appendix I – Detailed Modelling Results

Overview

The Pager Power charts for the assessed receptors are shown on the following pages. Each chart shows:

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

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

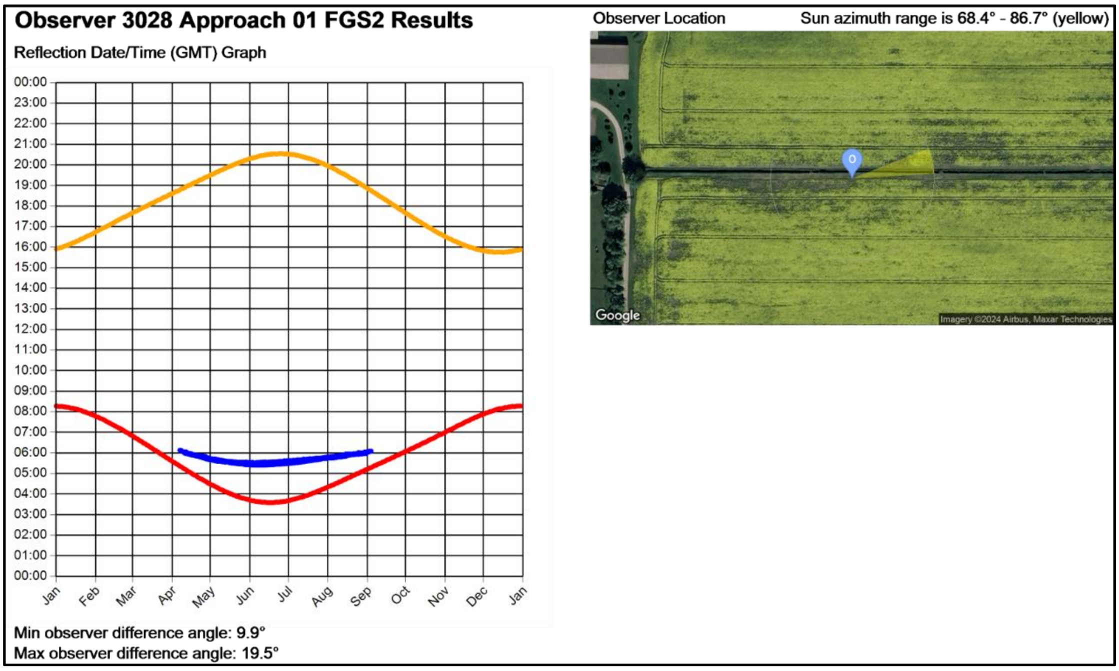
- The annual predicted solar reflections.
- The daily duration of the solar reflections.
- The location of the proposed development where glare will originate.
- The calculated intensity of the predicted solar reflections.

Full modelling results are available upon request.

Aviation Receptors

The modelling results are shown for the receptors where ‘yellow’ glare occurs for the longest duration.

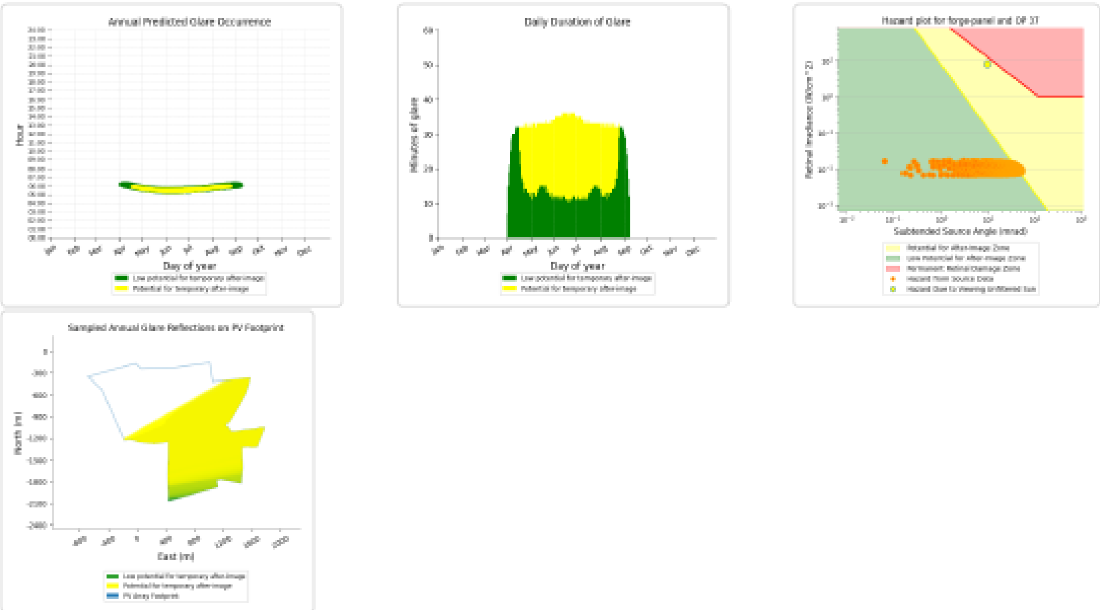
RAF Cranwell



Forge Panel Area 2: OP 37

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

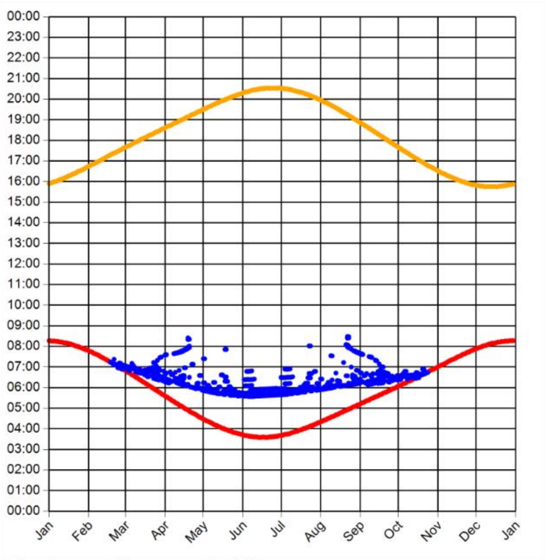
- 2,514 minutes of "green" glare with low potential to cause temporary after-image.
- 2,683 minutes of "yellow" glare with potential to cause temporary after-image.



Temple Bruer

Observer 2072 Approach 26 DES2 Results

Reflection Date/Time (GMT) Graph



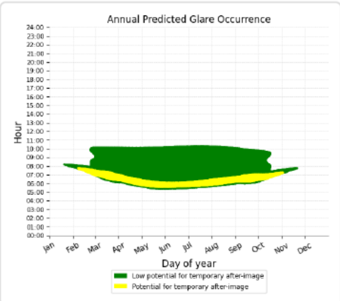
Observer Location — Sun azimuth range is 70.4° - 113.5° (yellow)

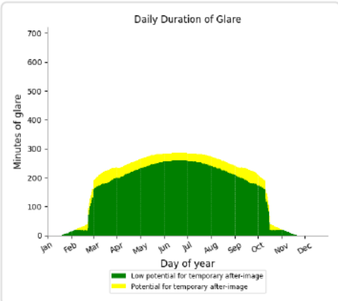
Min observer difference angle: 5.2°
Max observer difference angle: 69.6°

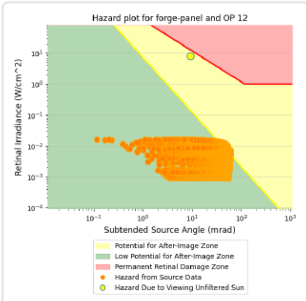
Forge Panel Area 2: OP 12

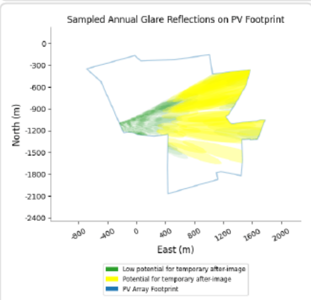
PV array is expected to produce the following glare for this receptor:

- 51,716 minutes of "green" glare with low potential to cause temporary after-image.
- 8,072 minutes of "yellow" glare with potential to cause temporary after-image.





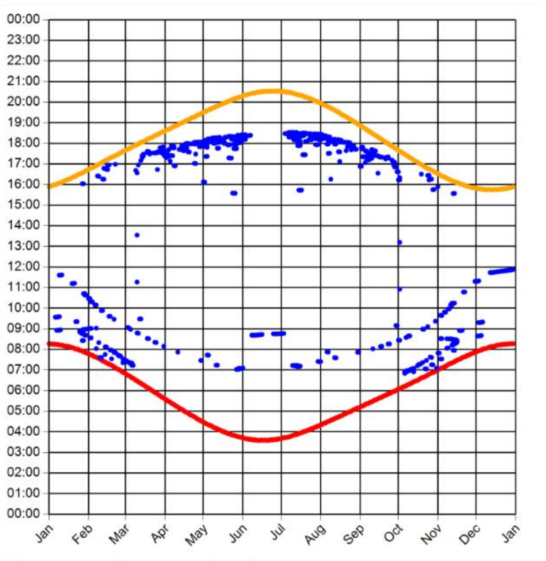




Cottage Farm

Observer 1055 Approach 09 CDS7 Results

Reflection Date/Time (GMT) Graph



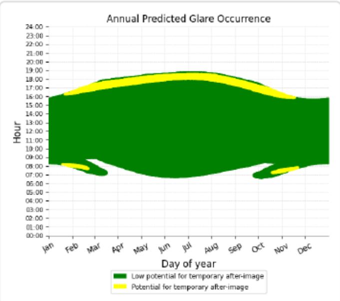
Min observer difference angle: 12°
Max observer difference angle: 90.3°

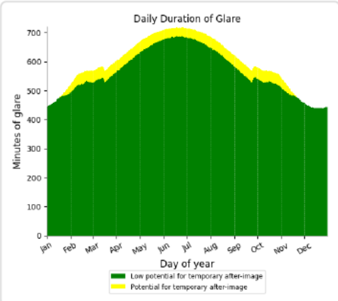
Observer Location | Sun azimuth ranges (yellow)

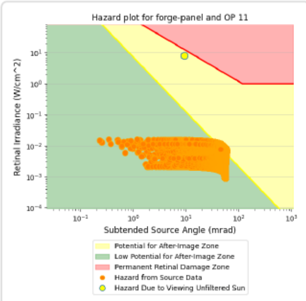
Forge Panel Area 2: OP 11

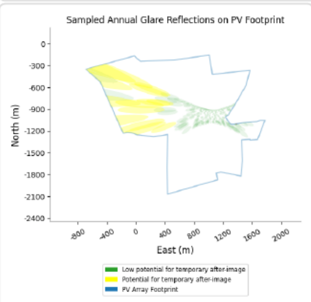
PV array is expected to produce the following glare for this receptor:

- 206,306 minutes of "green" glare with low potential to cause temporary after-image.
- 10,647 minutes of "yellow" glare with potential to cause temporary after-image.





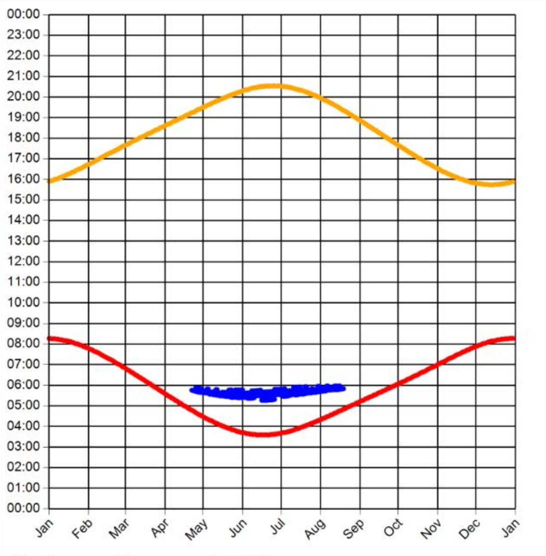




Hill Top Farm

Observer 1027 Approach 09 TSO7 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 10.8°
Max observer difference angle: 23.7°

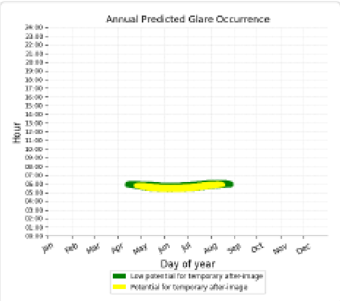
Observer Location

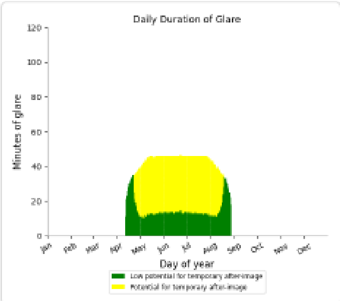
Sun azimuth range is 66.7° - 80.5° (yellow)

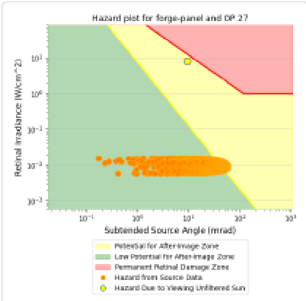
Forge Panel Area 3: OP 27

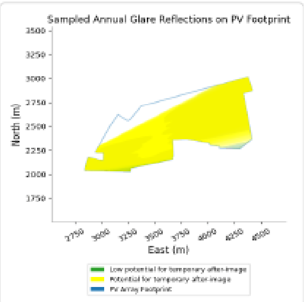
PV array is expected to produce the following glare for this receptor:

- 2,181 minutes of "green" glare with low potential to cause temporary after-image.
- 3,592 minutes of "yellow" glare with potential to cause temporary after-image.









Appendix J – Screening Review

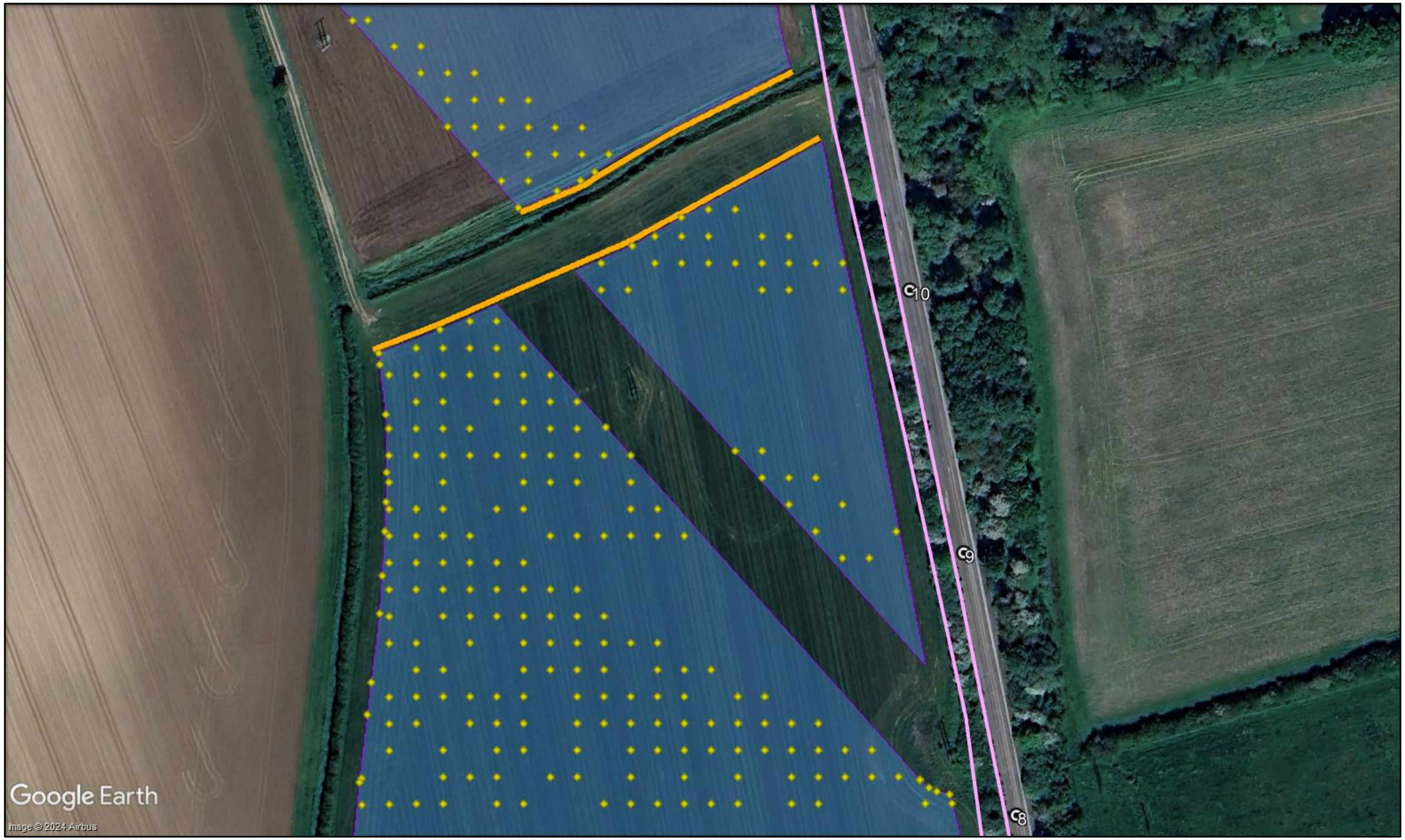
Overview

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

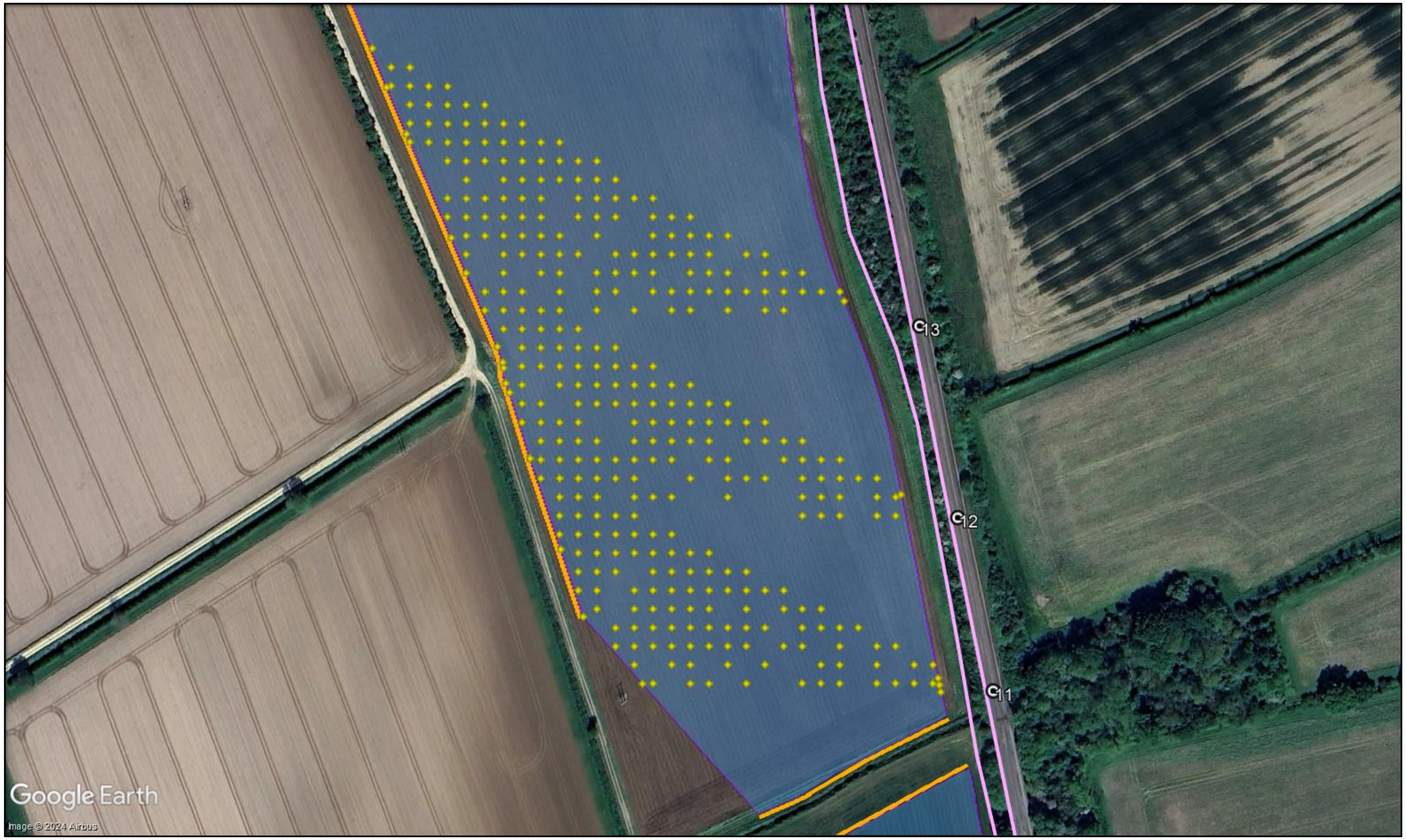
Railway Receptors

The cumulative reflecting panel areas are indicated by regions of yellow within the figures. The identified screening in the form of existing and proposed vegetation is outlined in pink and orange respectively.

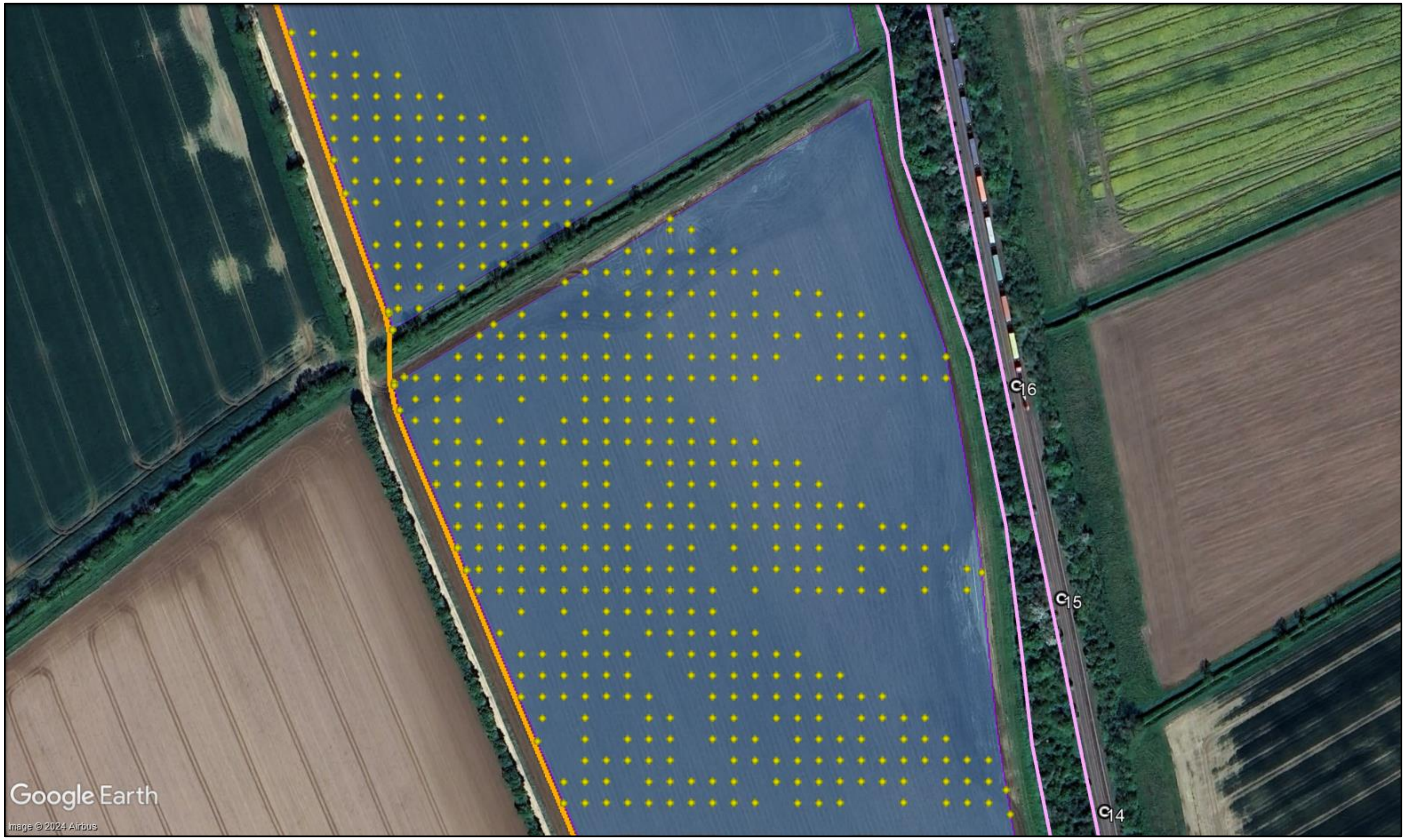
Screening for train driver receptors 5 to 7



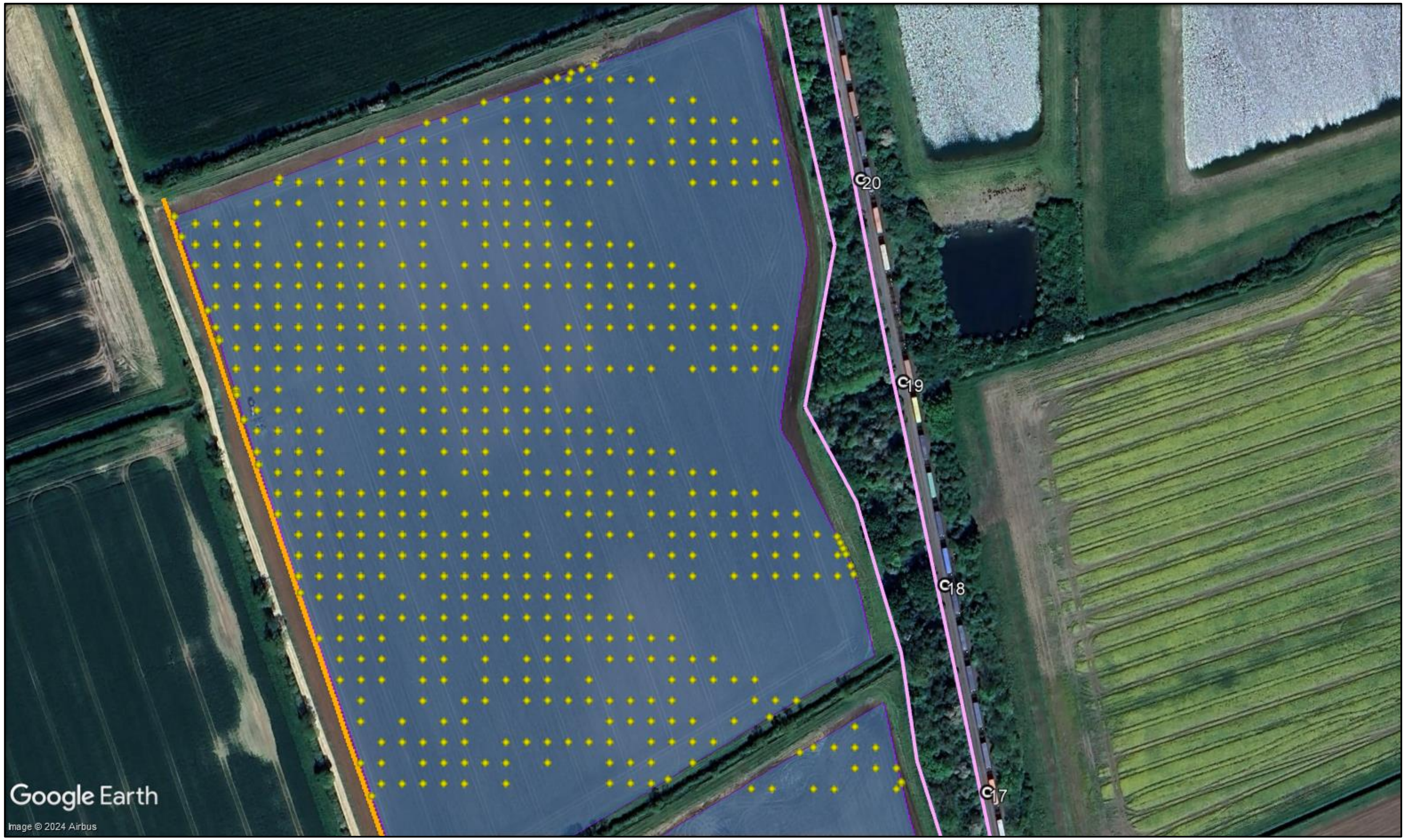
Screening for train driver receptors 8 to 10



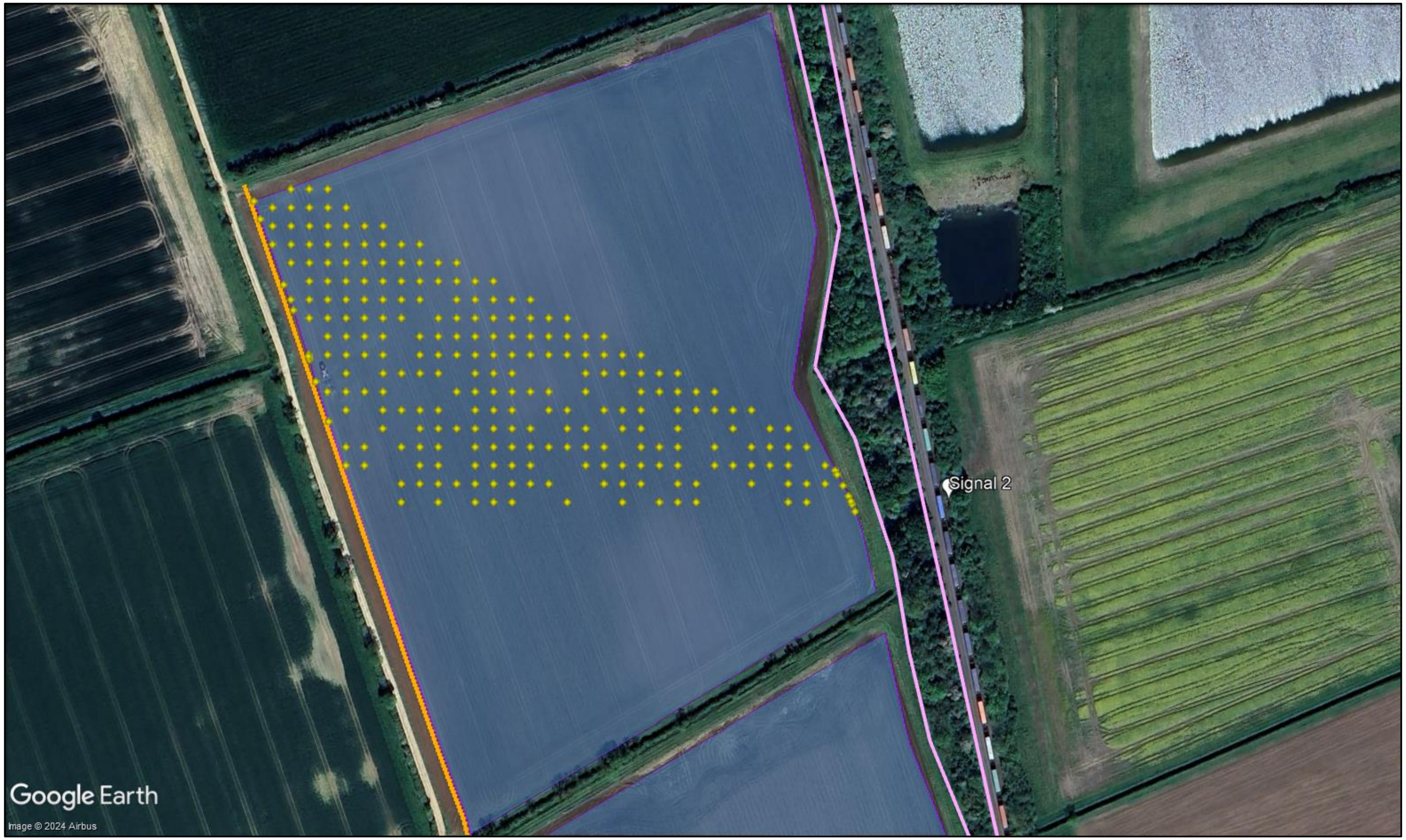
Screening for train driver receptors 11 to 13



Screening for train driver receptors 14 to 16



Screening for train driver receptors 17 to 20

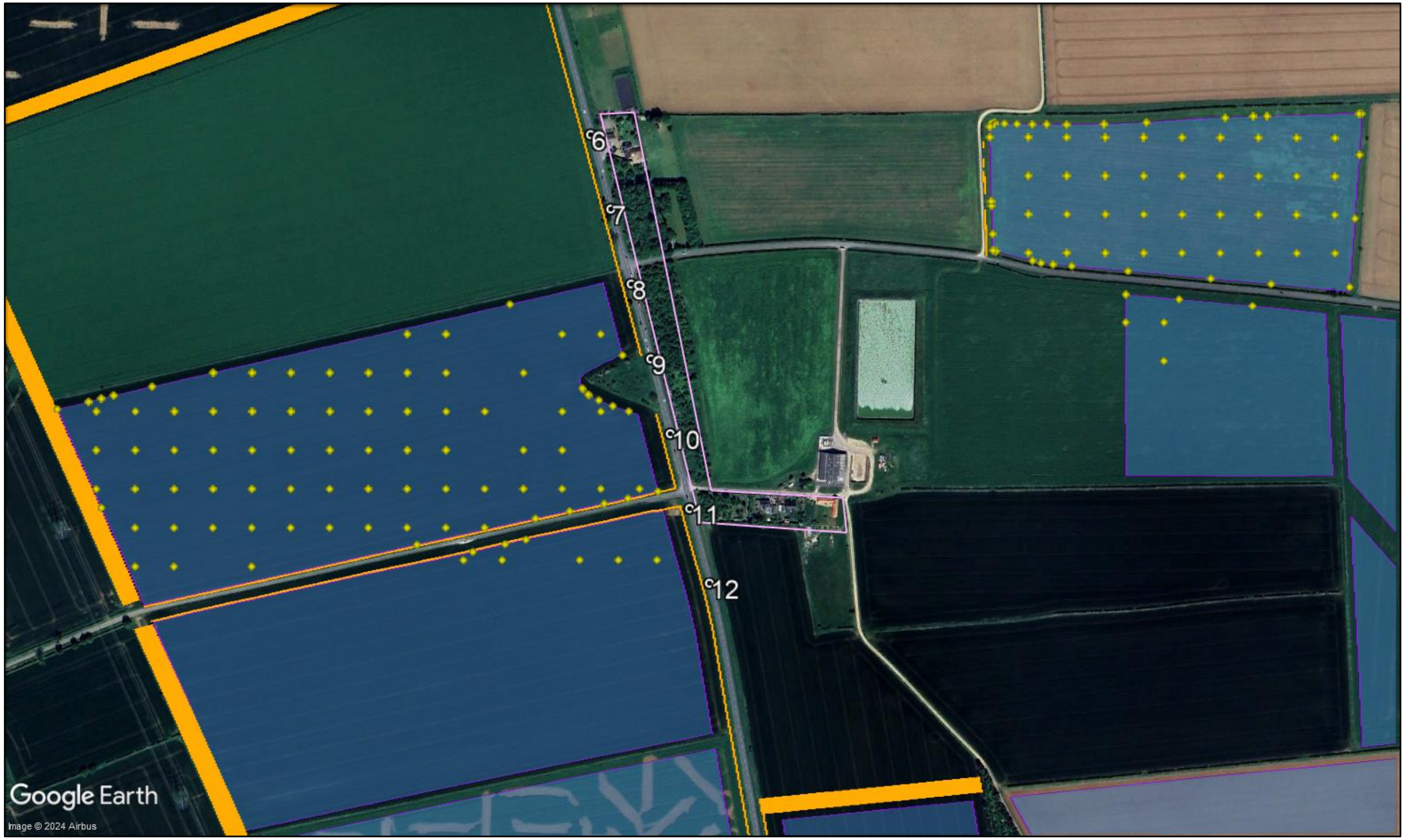


Screening for train signal receptor 2

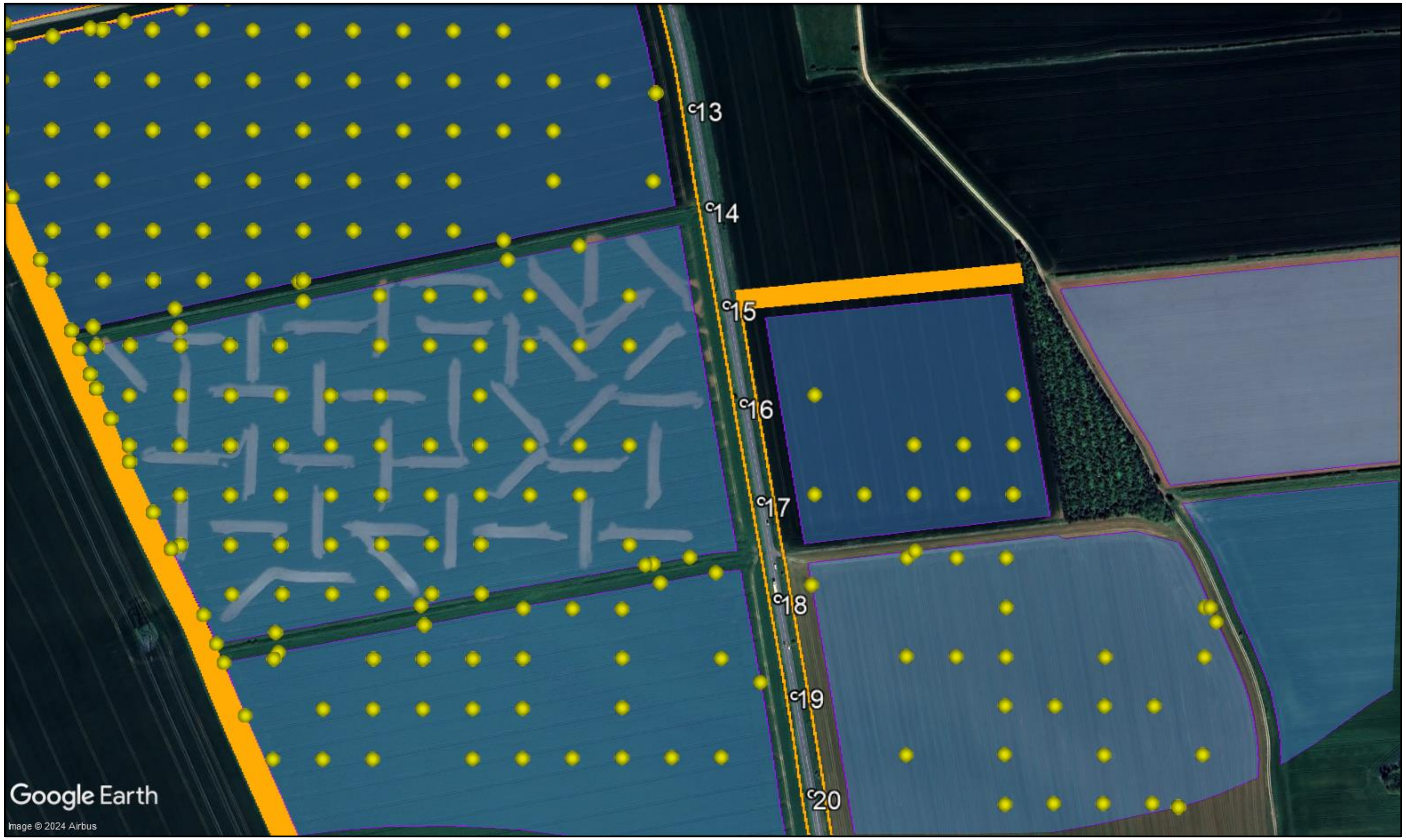
Road Receptors

A desk-based review of the available imagery is presented in the figures (in this subsection) on the following pages. The cumulative reflecting panel areas are indicated by regions of yellow within the figures. The identified screening in the form of existing vegetation, buildings and proposed vegetation is outlined in pink, blue and orange respectively. High-level Zones of Visible Terrain[45] (ZTV) show regions visible from a point and are indicated by shaded regions of green.

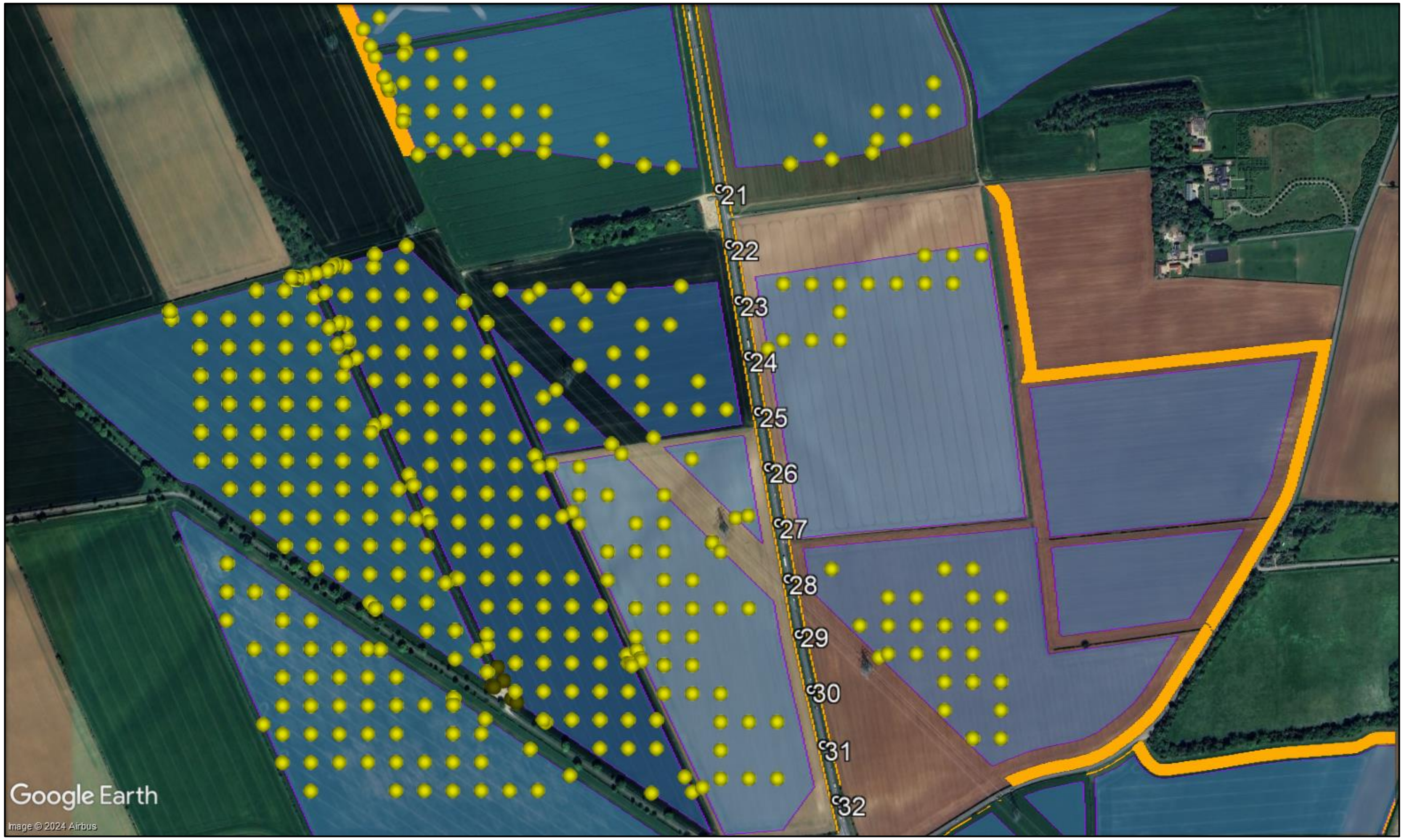
[45] Generated by Google Earth Viewshed at a height of 2.0m above ground level



Screening for road receptors 6 to 12



Screening for road receptors 13 to 20



Screening for road receptors 21 to 32

Screening for road receptors 33 to 40

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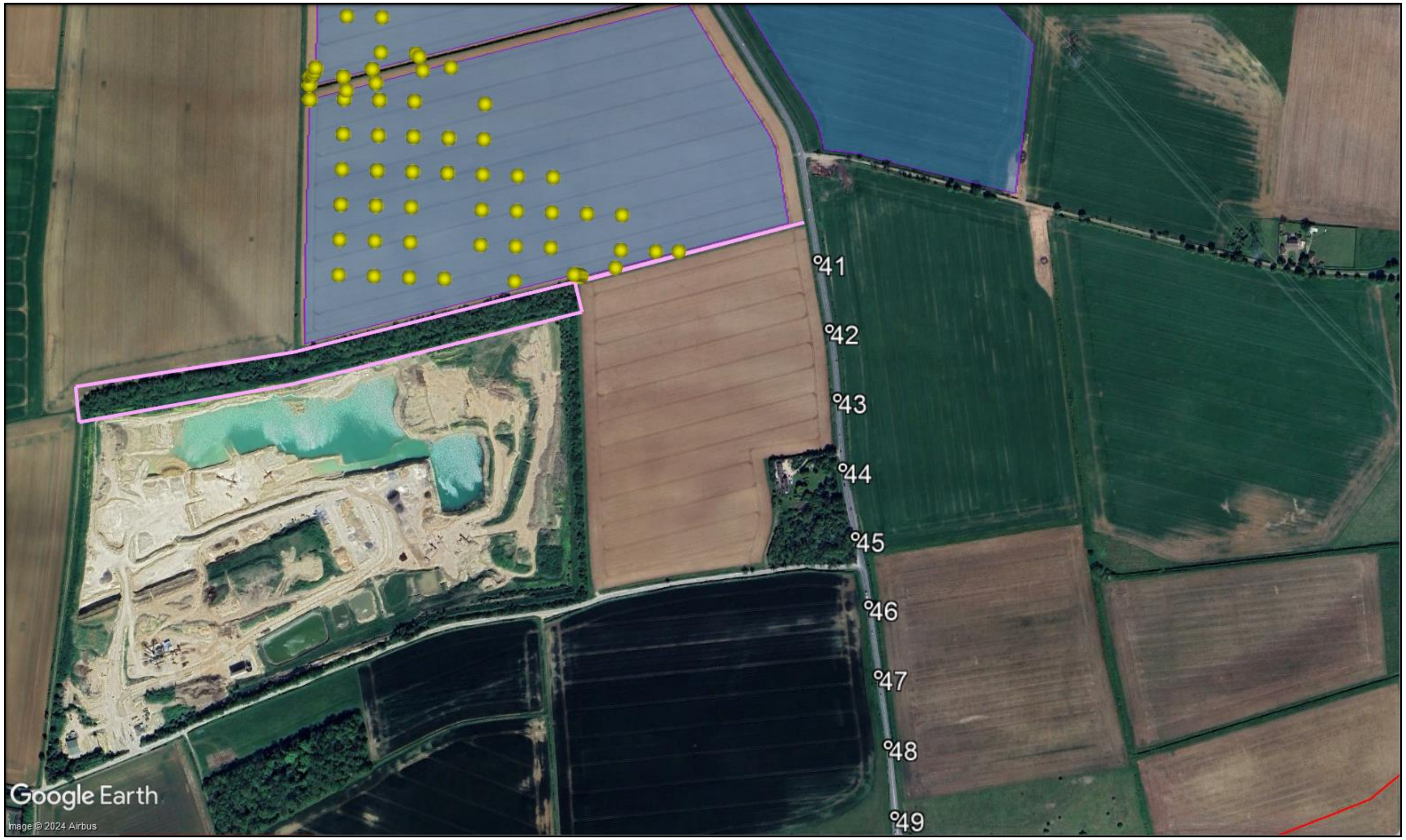
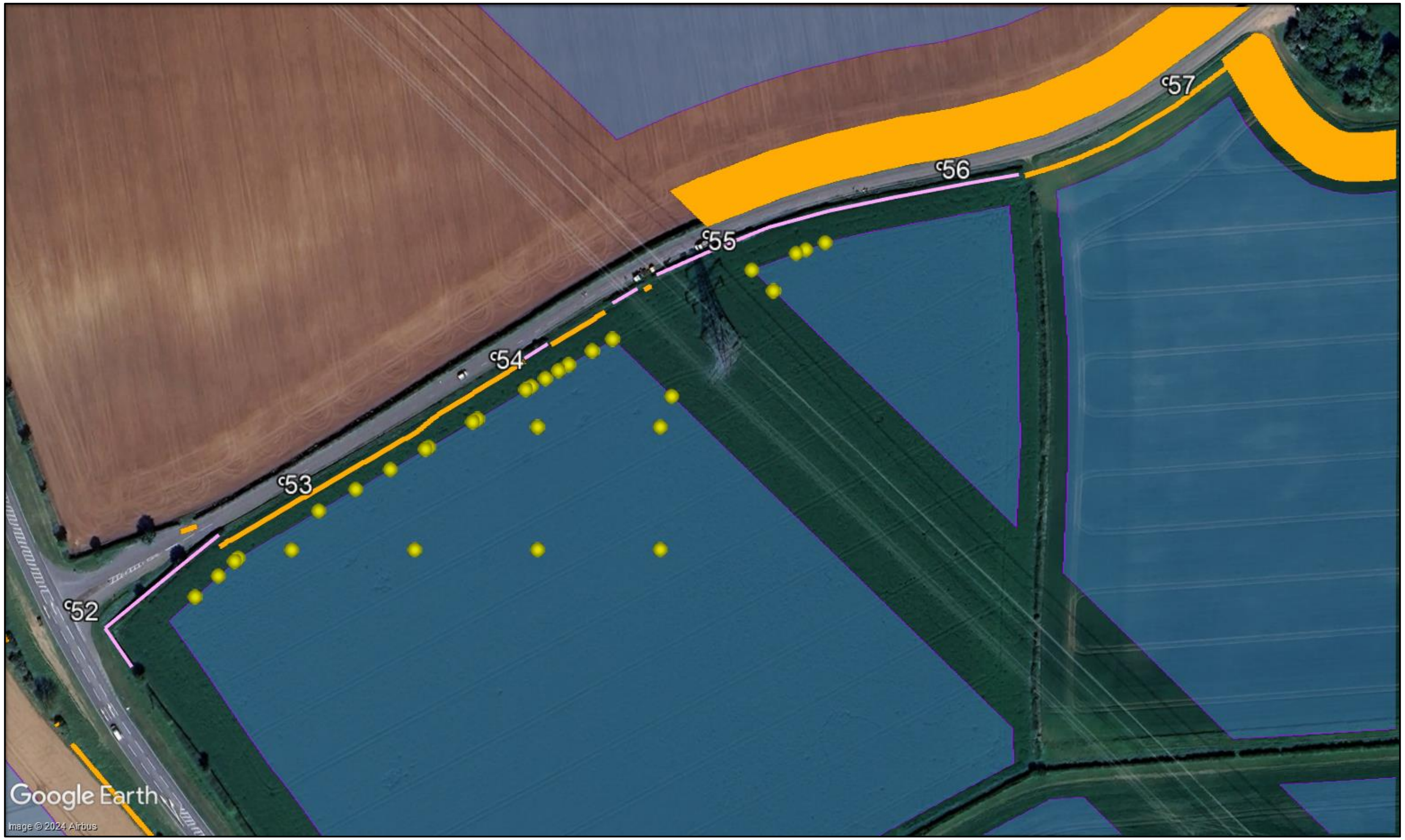
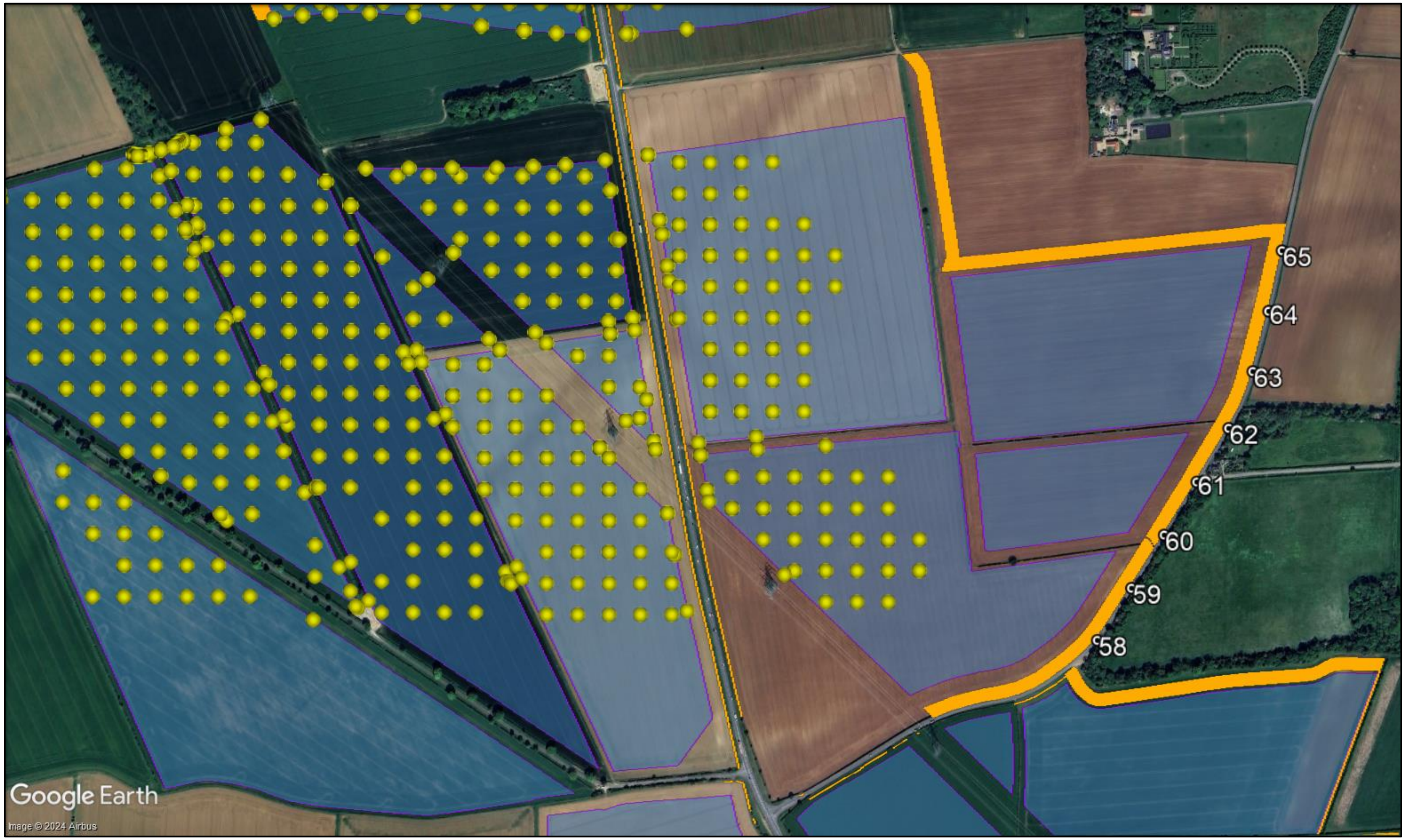


Screening for road receptors 41 to 49



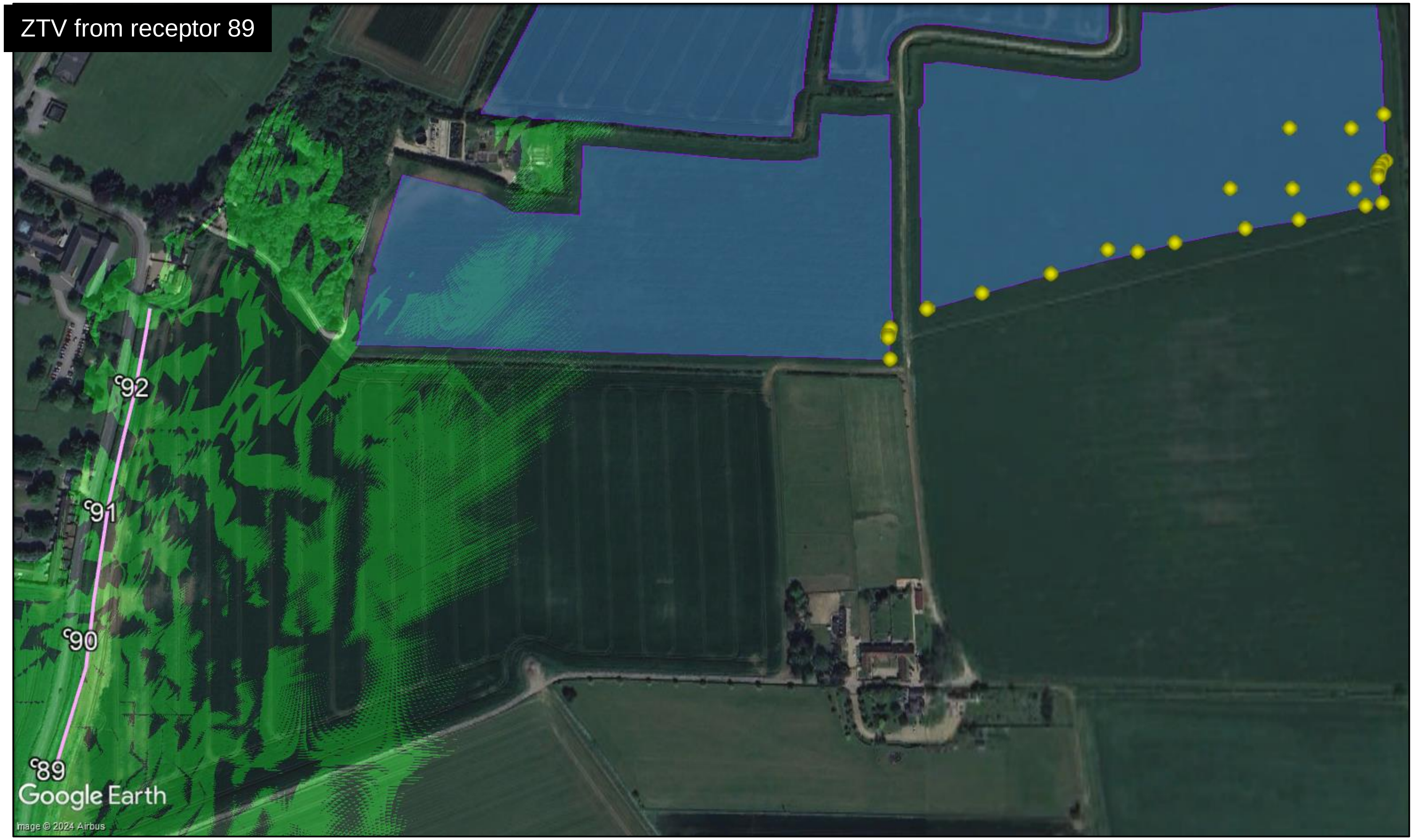
Screening for road receptors 52 to 57



Screening for road receptors 58 to 65

Screening for road receptors 66 to 74

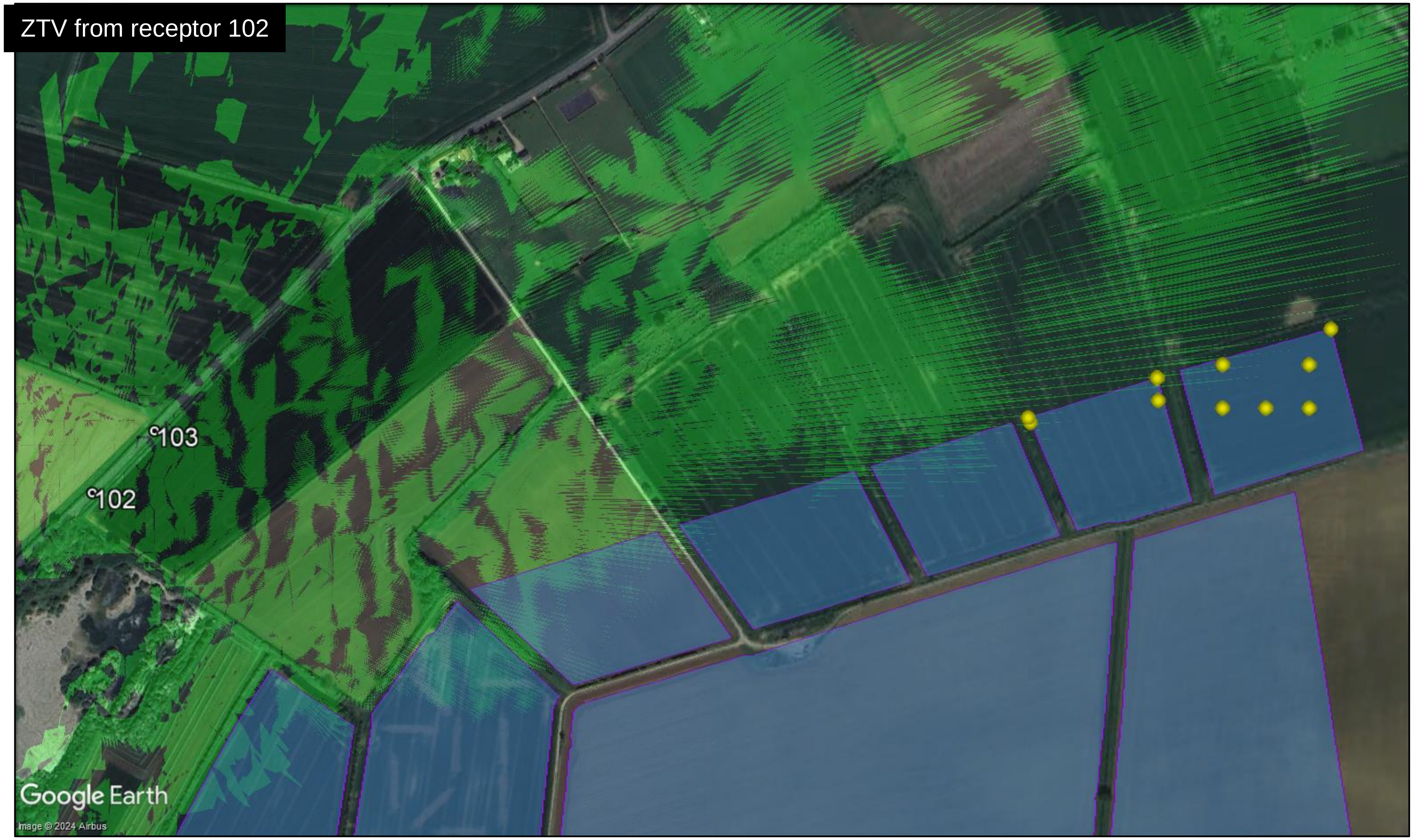
Screening for road receptors 75 to 82



Screening for road receptors 89 to 92

Screening for road receptors 93 to 94

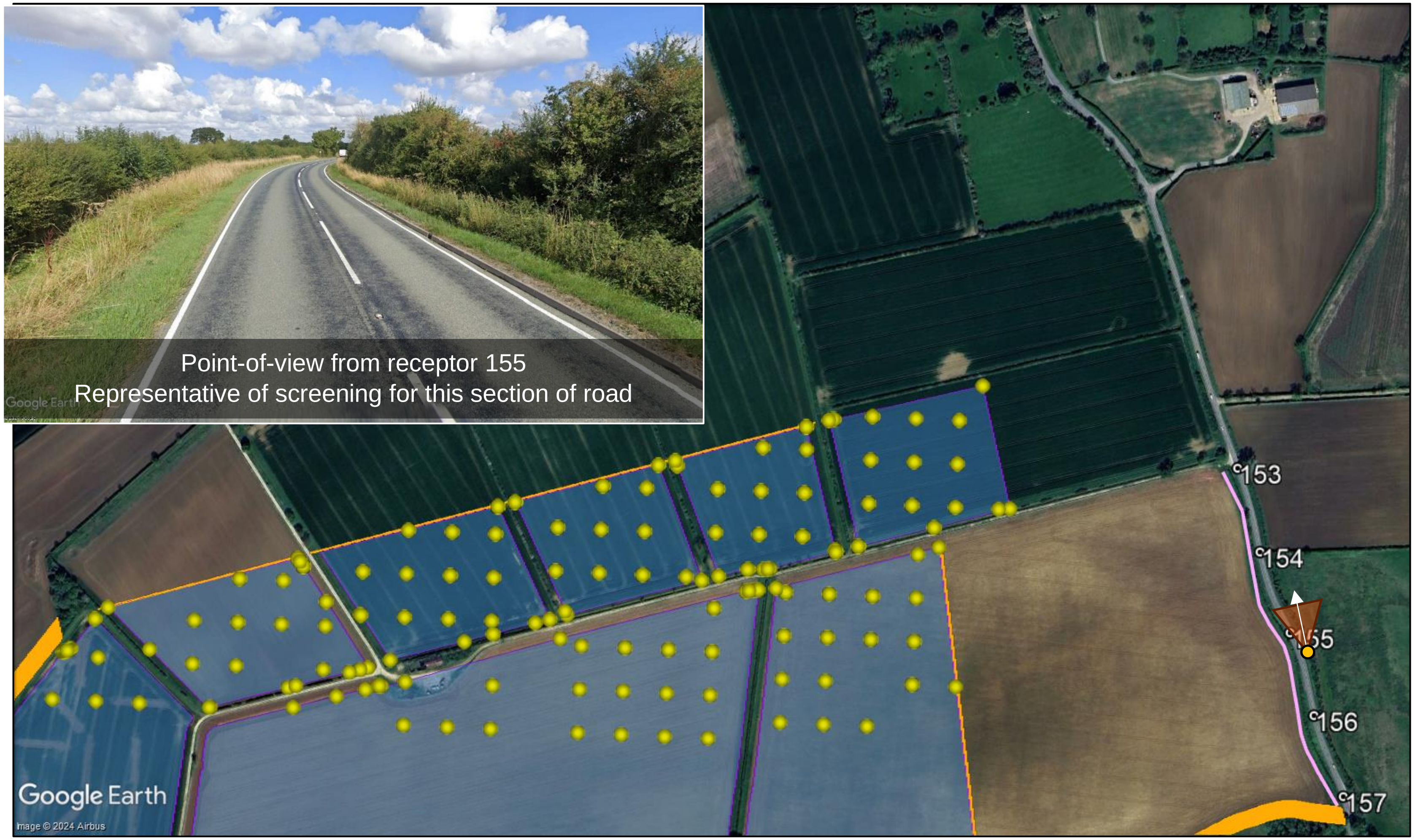
Screening for road receptors 95 to 101



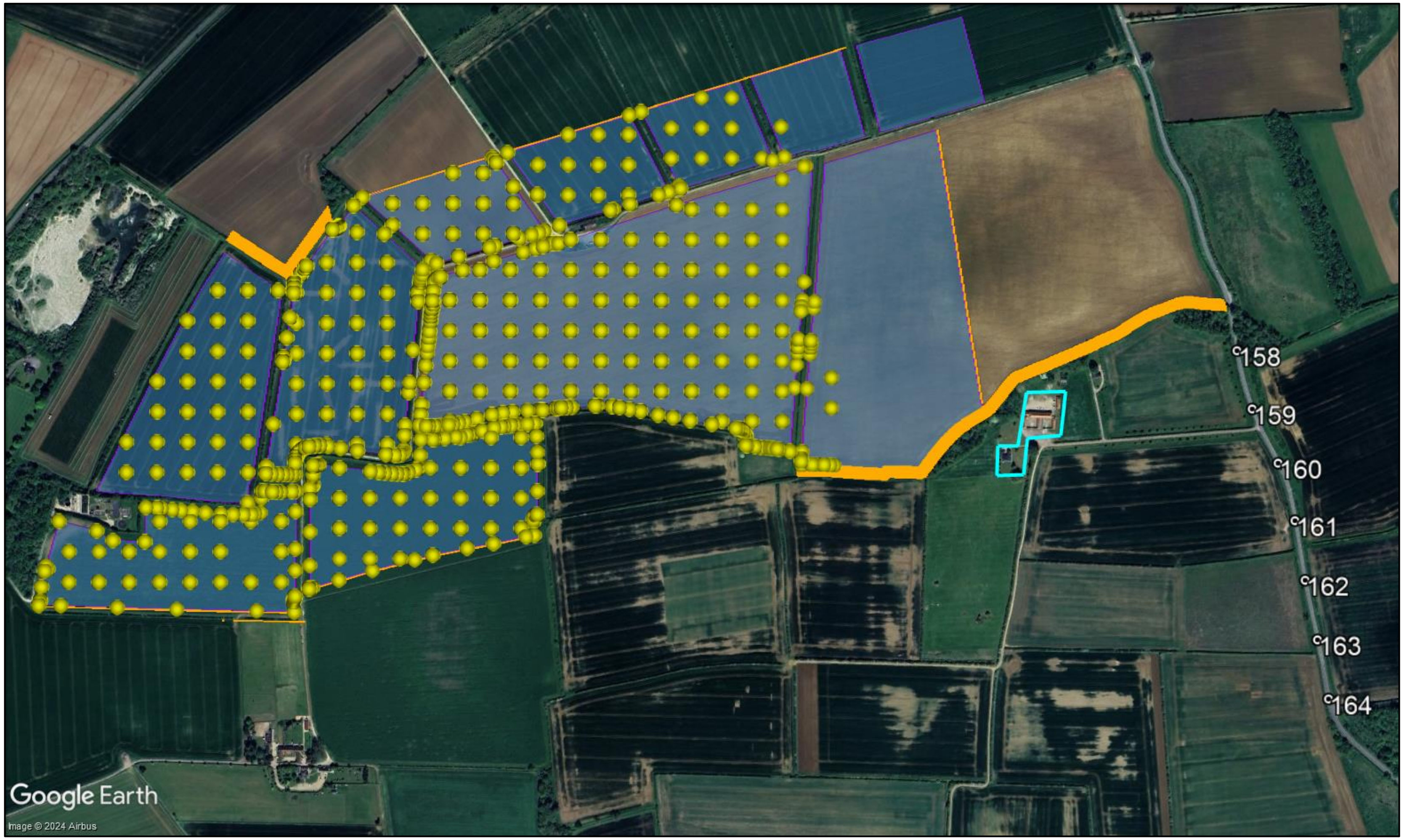
Screening for road receptors 102 to 103

Screening for road receptors 120 to 130

Screening for road receptors 131 to 144



Screening for road receptors 153 to 157



Screening for road receptors 158 to 164

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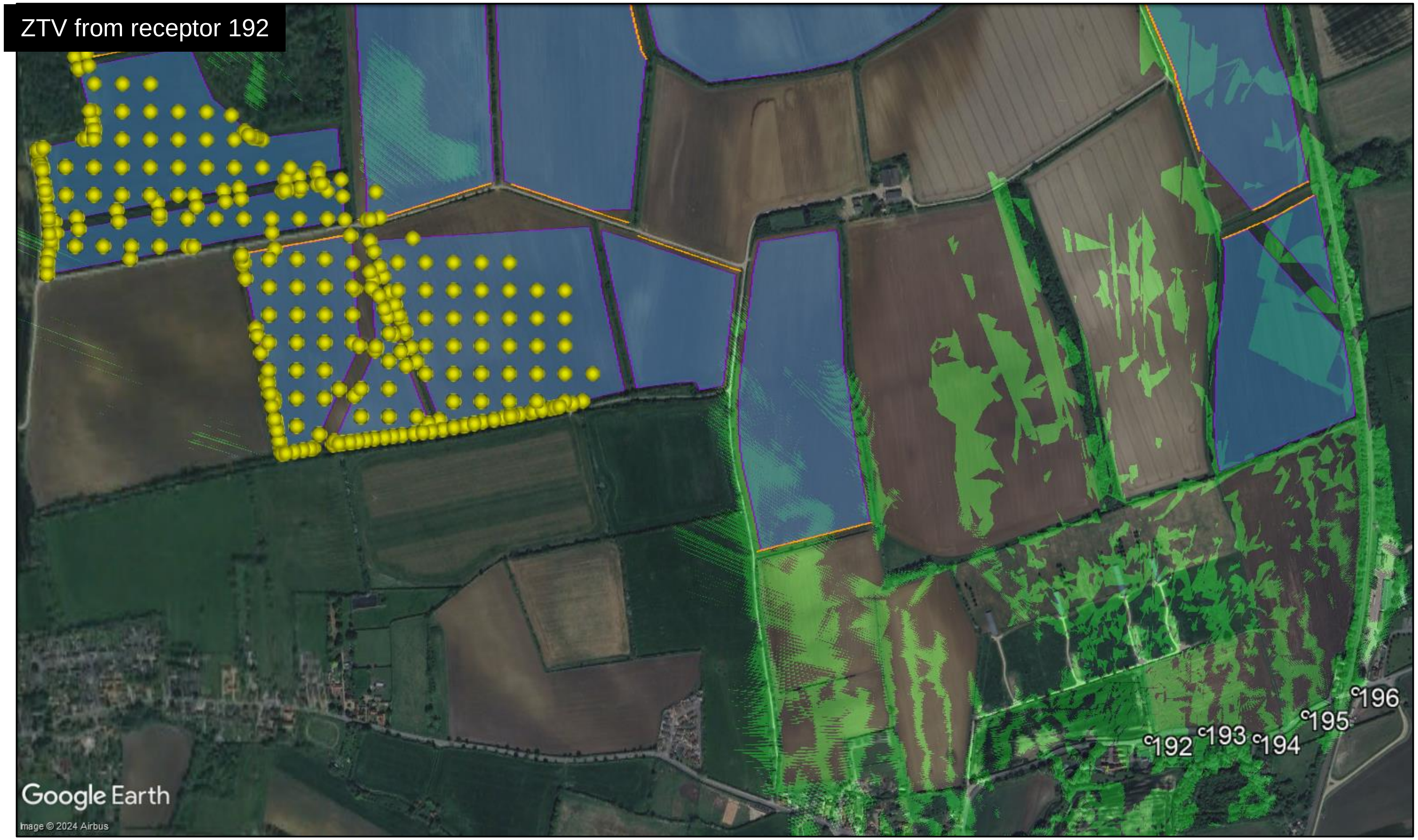
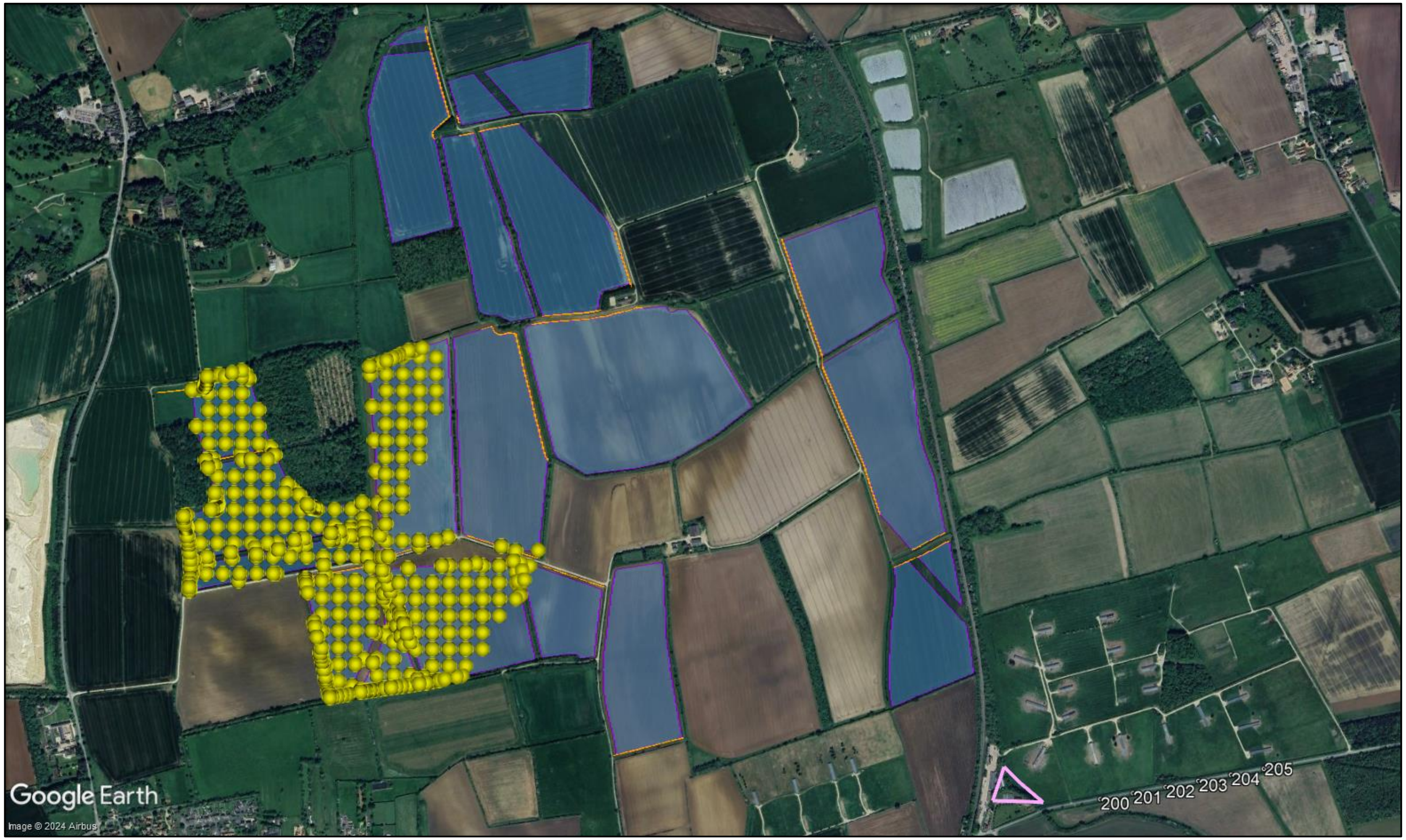
Screening for road receptors 174 to 177



Screening for road receptors 192 to 196



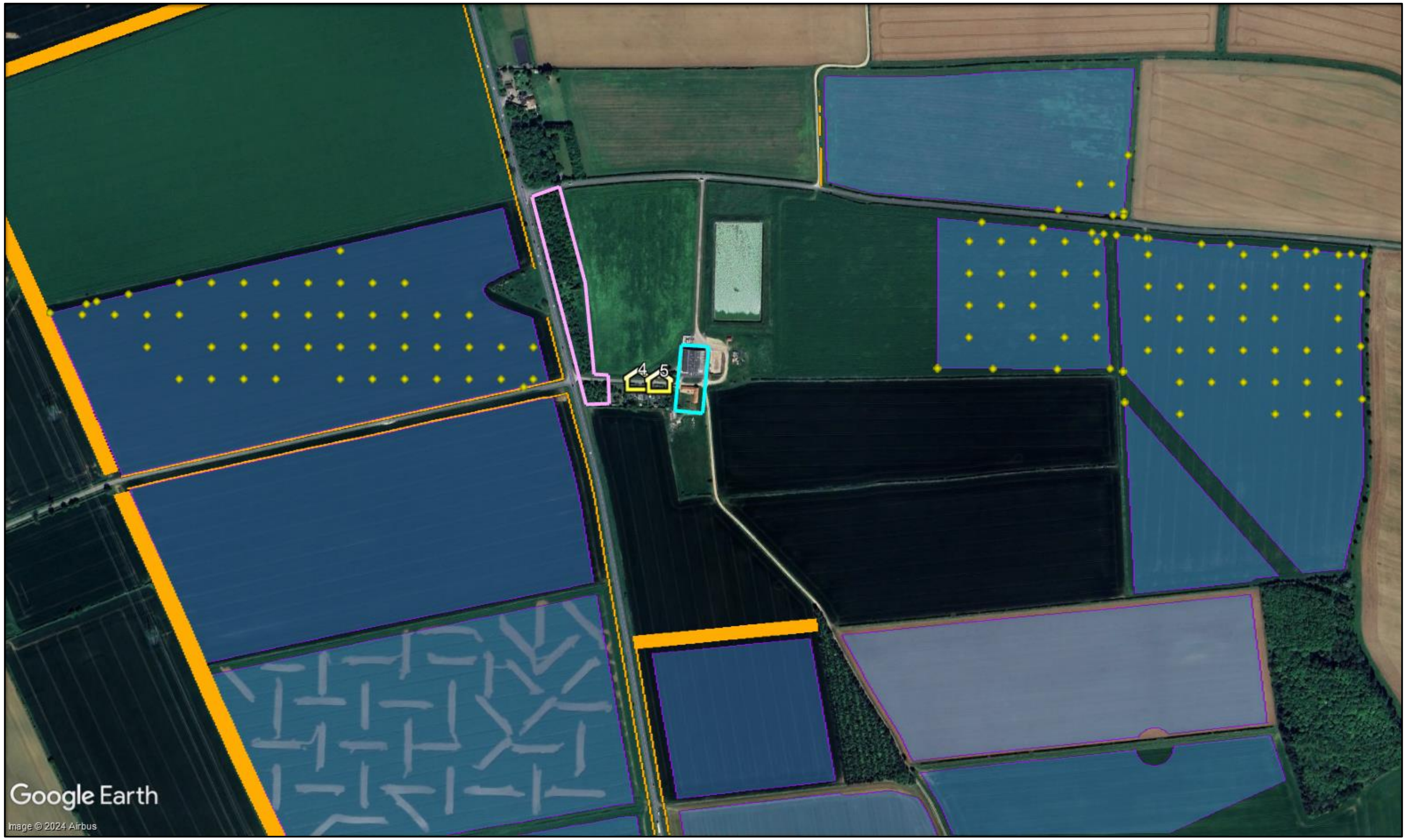
Screening for road receptors 200 to 205

Dwelling Receptors

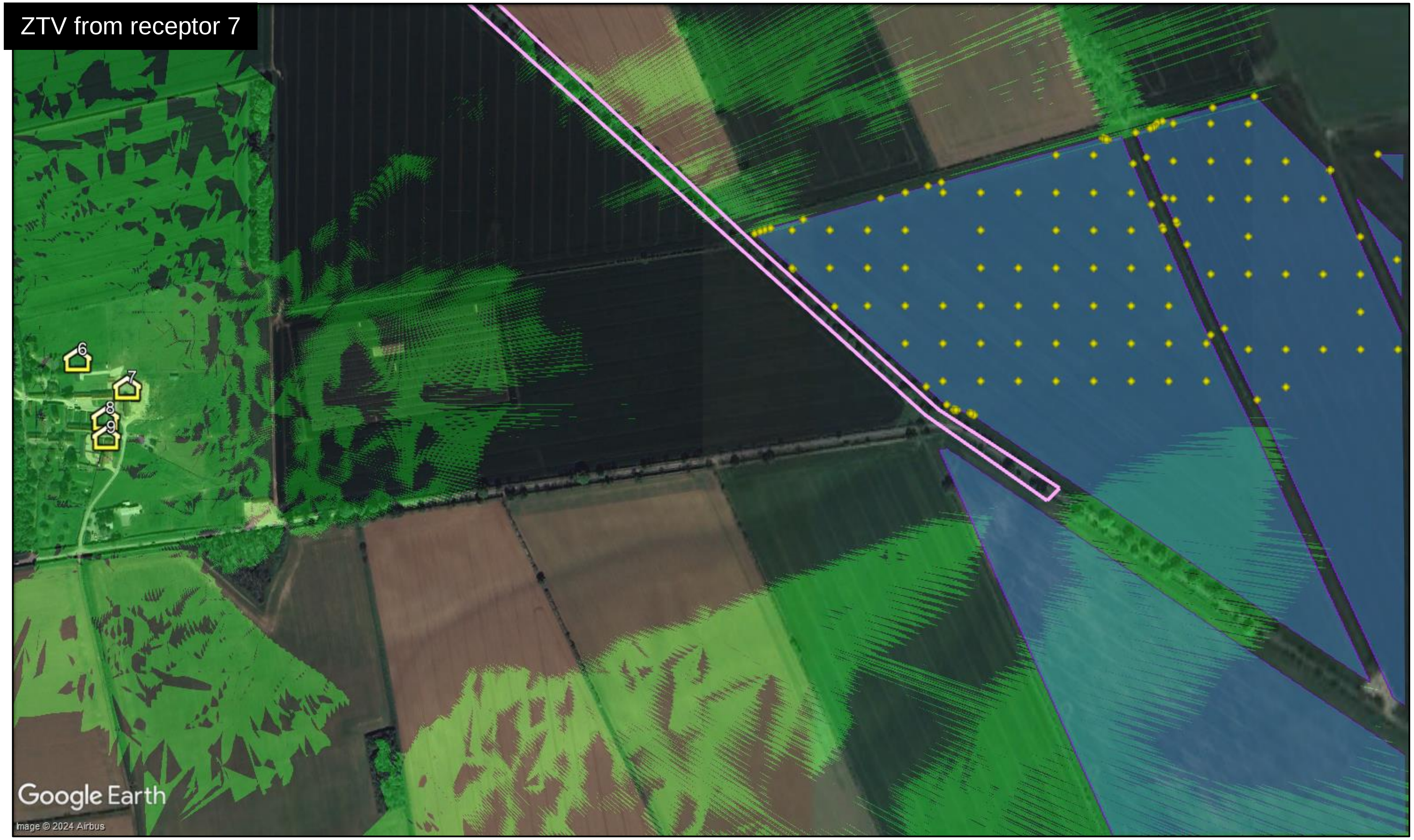
A desk-based review of the available imagery is presented in the figures (in this subsection) on the following pages. The cumulative reflecting panel areas are indicated by regions of yellow within the figures. The identified screening in the form of existing vegetation, buildings and proposed vegetation is outlined in pink, blue and orange respectively. High-level Zones of Visible Terrain[46] (ZTV) show regions visible from a point and are indicated by shaded regions of green.

[46] Generated by Google Earth Viewshed at a height of 5.0m above ground level

Screening for dwelling receptors 2 to 3



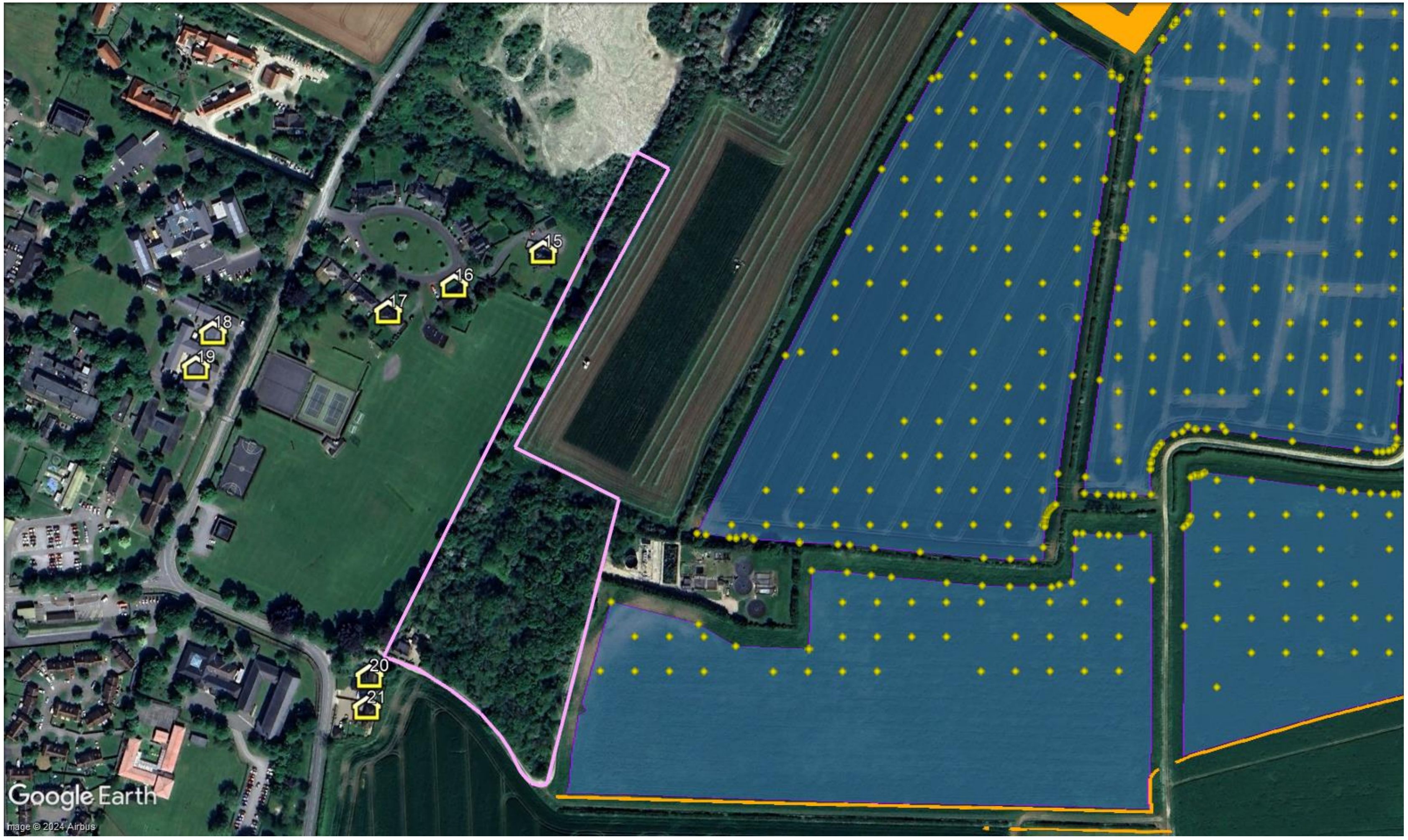
Screening for road receptors 4 to 5



Screening for dwelling receptors 6 to 9

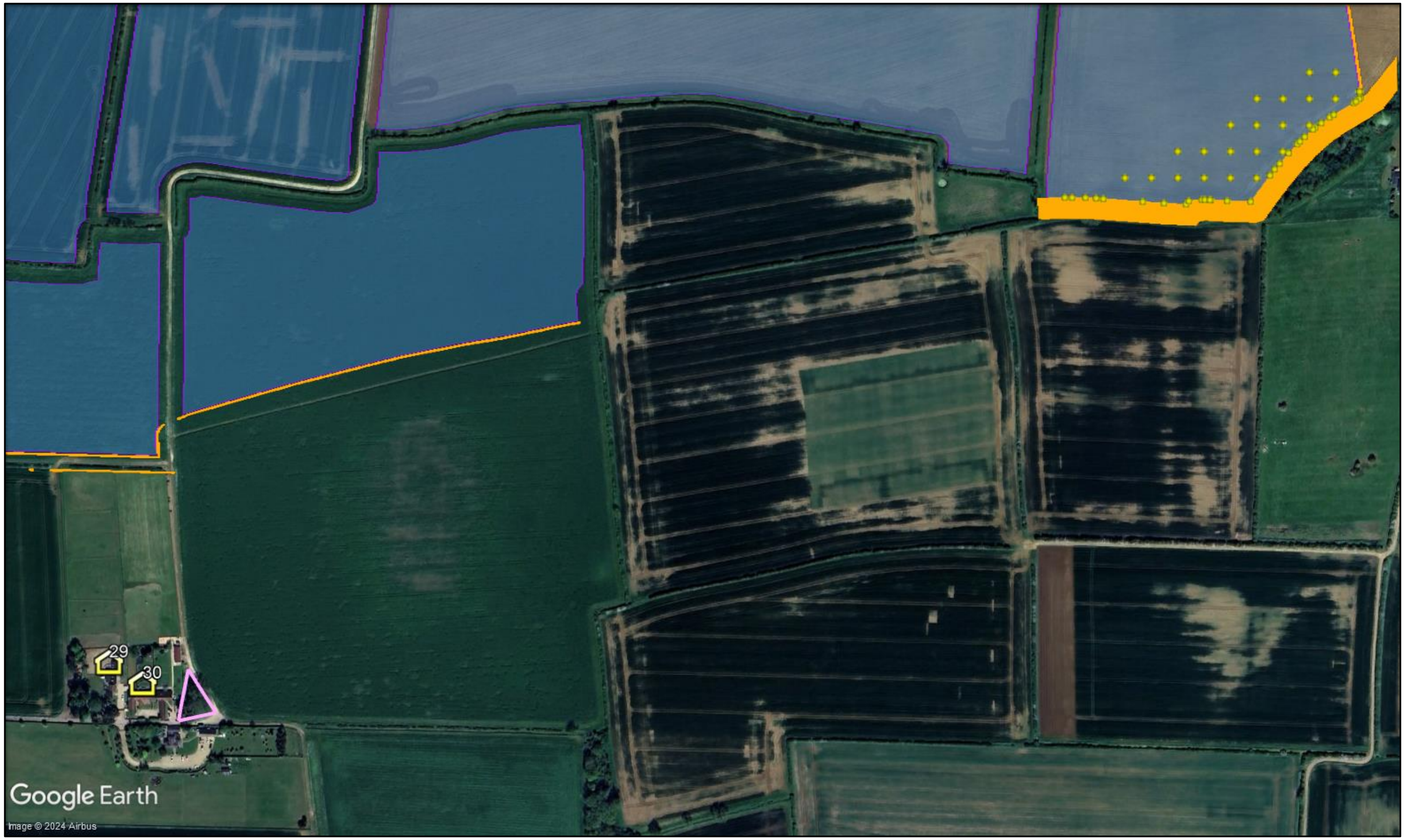
Screening for dwelling receptors 10 to 12

Screening for dwelling receptor 14



Screening for dwelling receptors 15 to 21

Screening for dwelling receptors 22 to 28



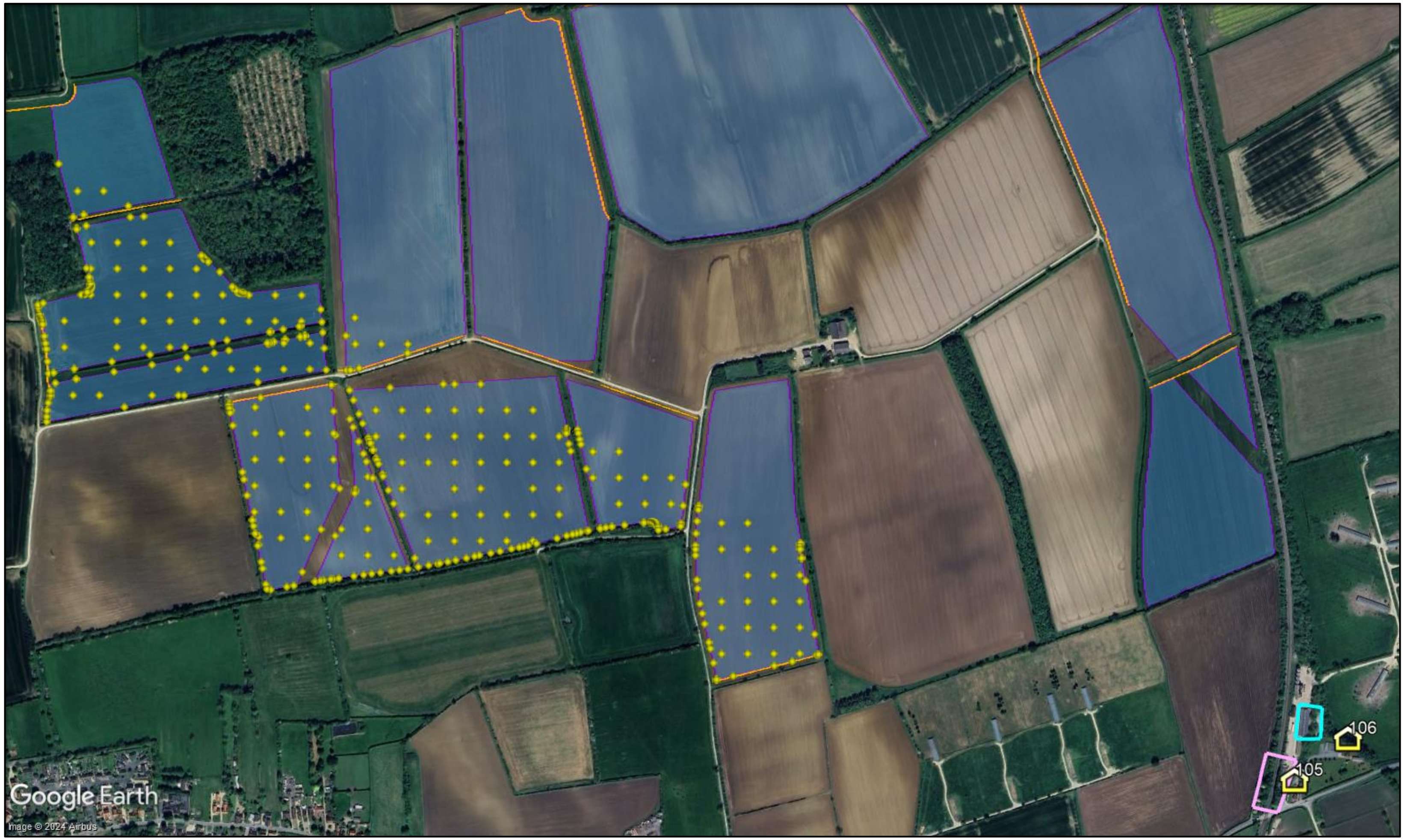
Screening for dwelling receptors 29 to 30

Screening for dwelling receptors 41 to 66

Screening for dwelling receptors 67 to 81

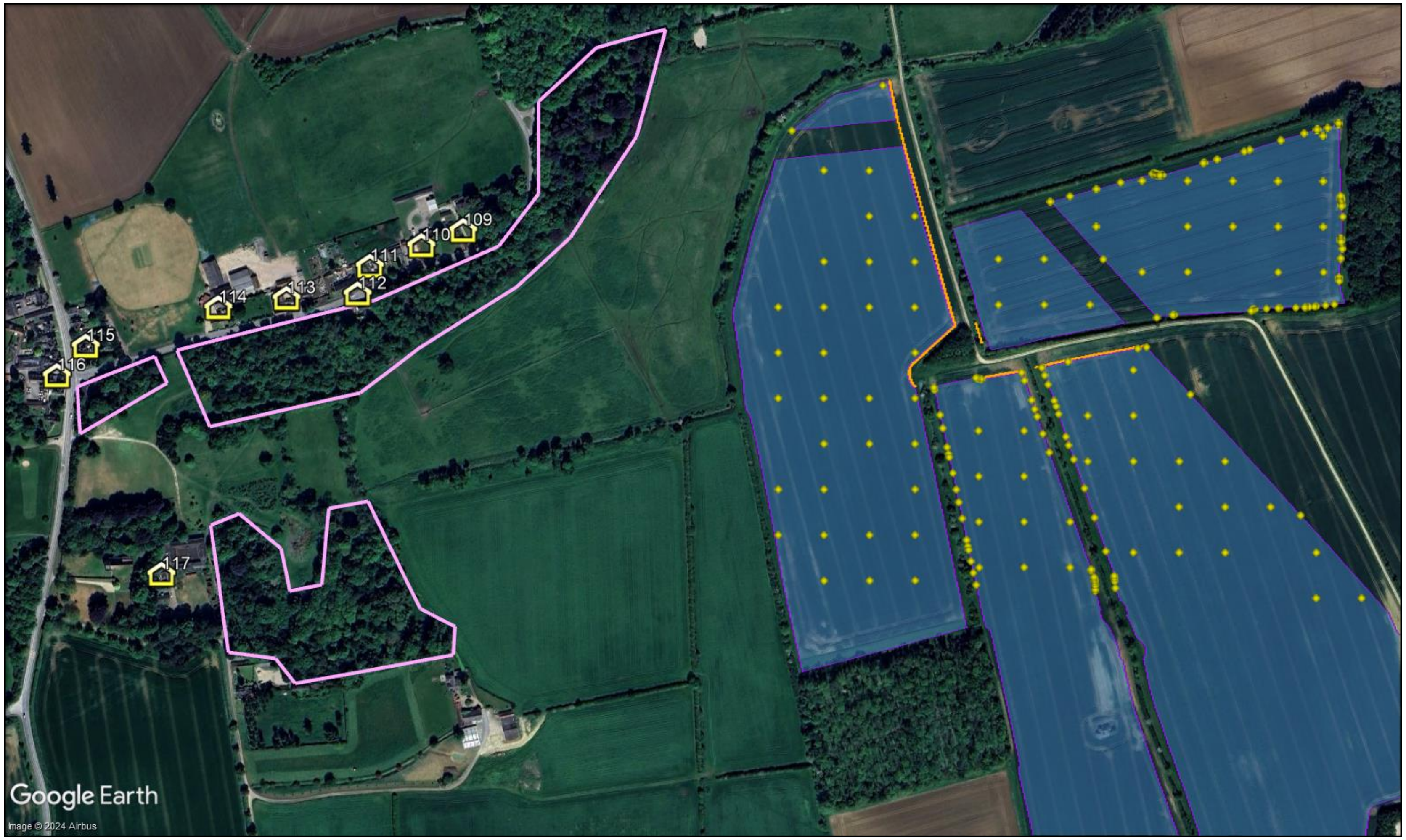
Screening for dwelling receptors 82 to 89

Screening for dwelling receptor 104

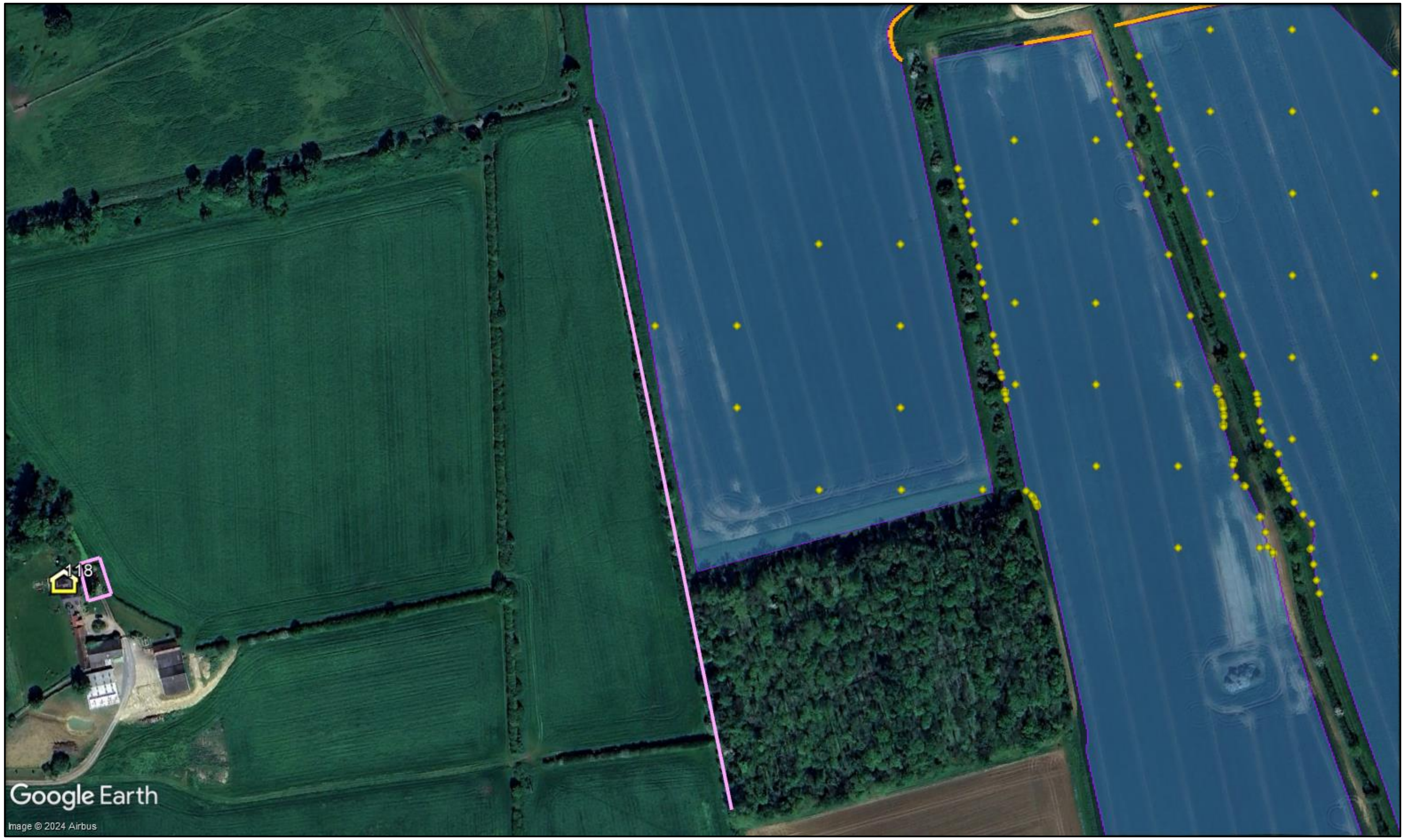


Screening for dwelling receptors 105 to 106

Screening for dwelling receptor 107



Screening for dwelling receptors 109 to 117



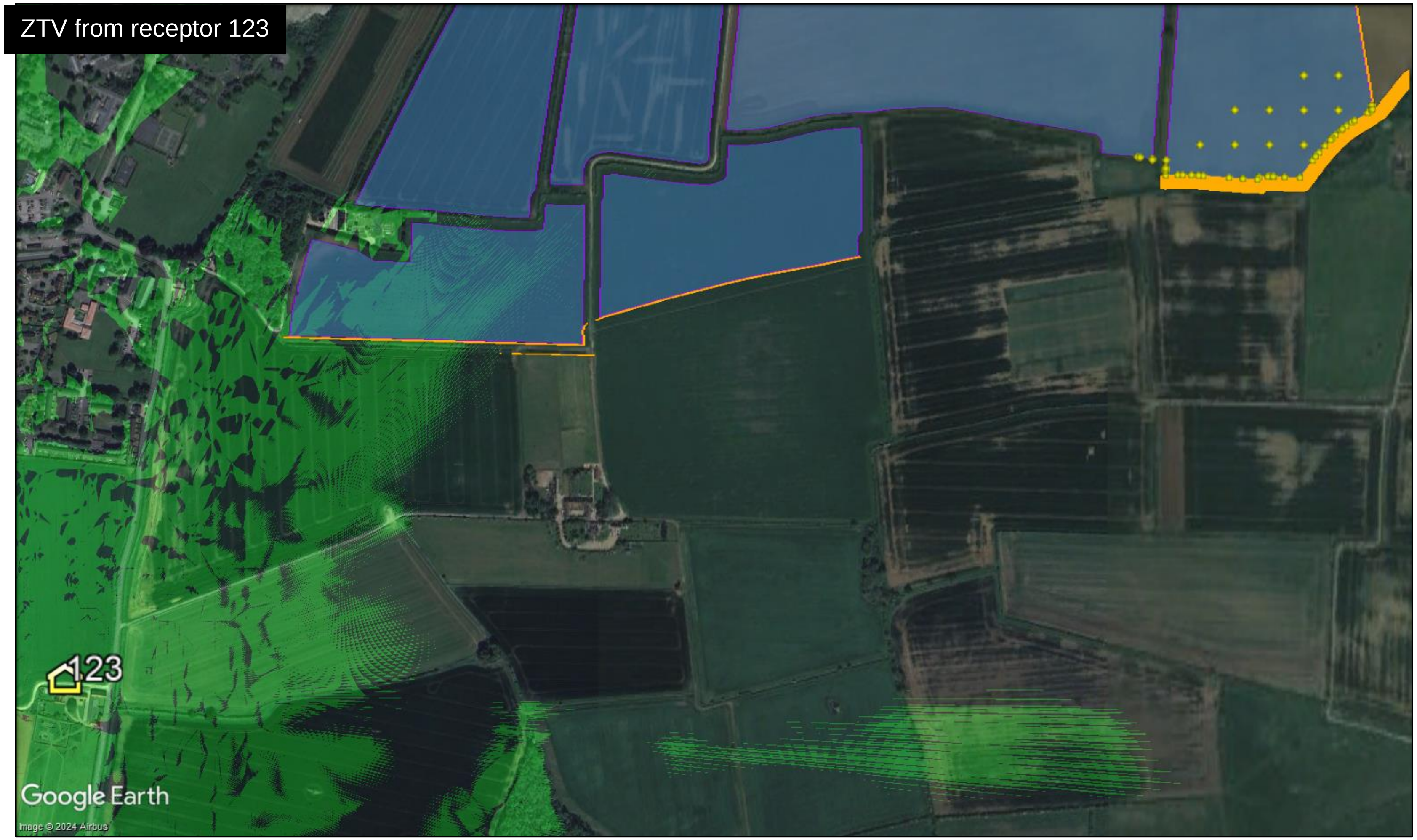
Screening for dwelling receptor 118

Screening for dwelling receptor 119

Screening for dwelling receptor 120

Screening for dwelling receptor 121

Screening for dwelling receptor 122



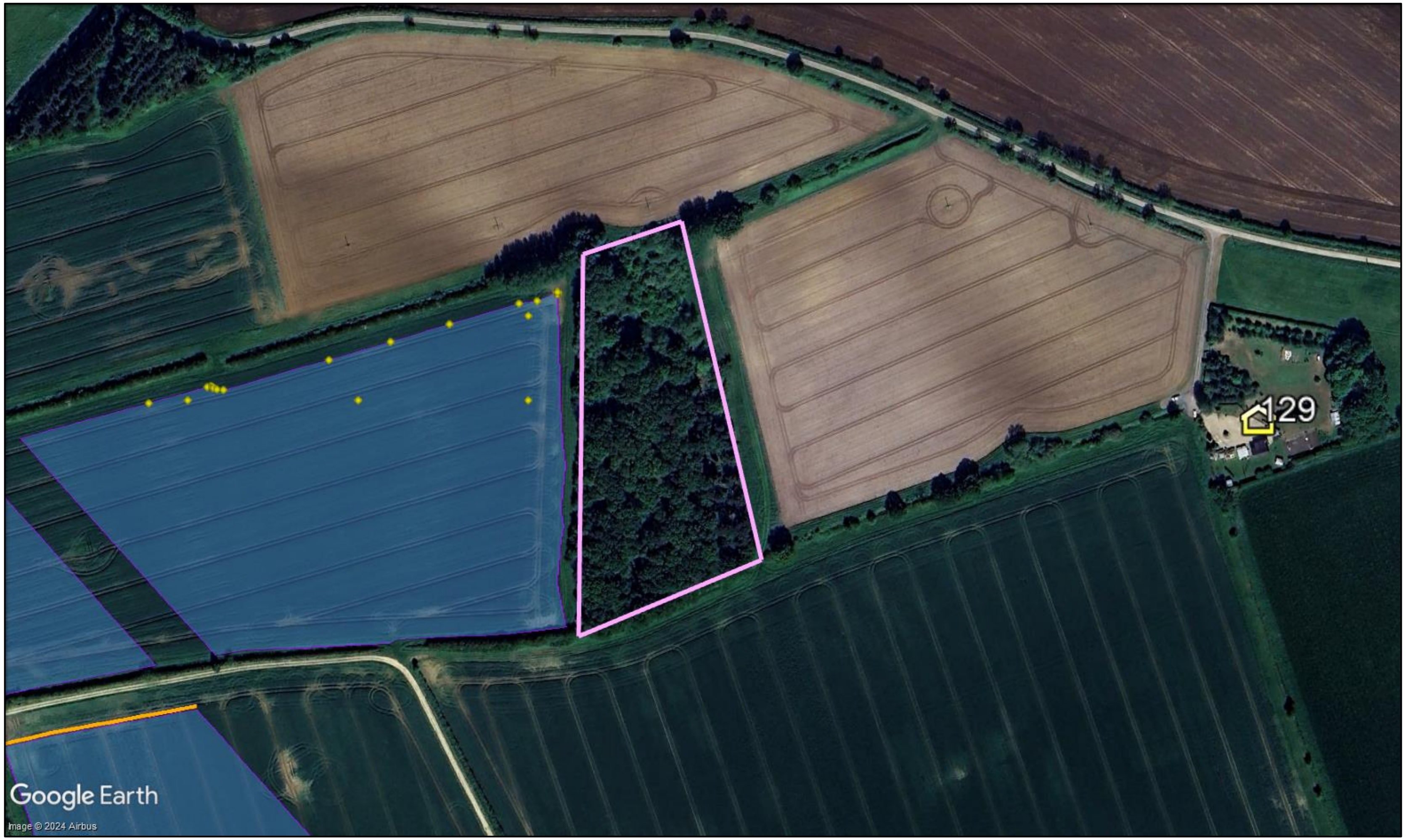
Screening for dwelling receptor 123

Screening for dwelling receptor 125

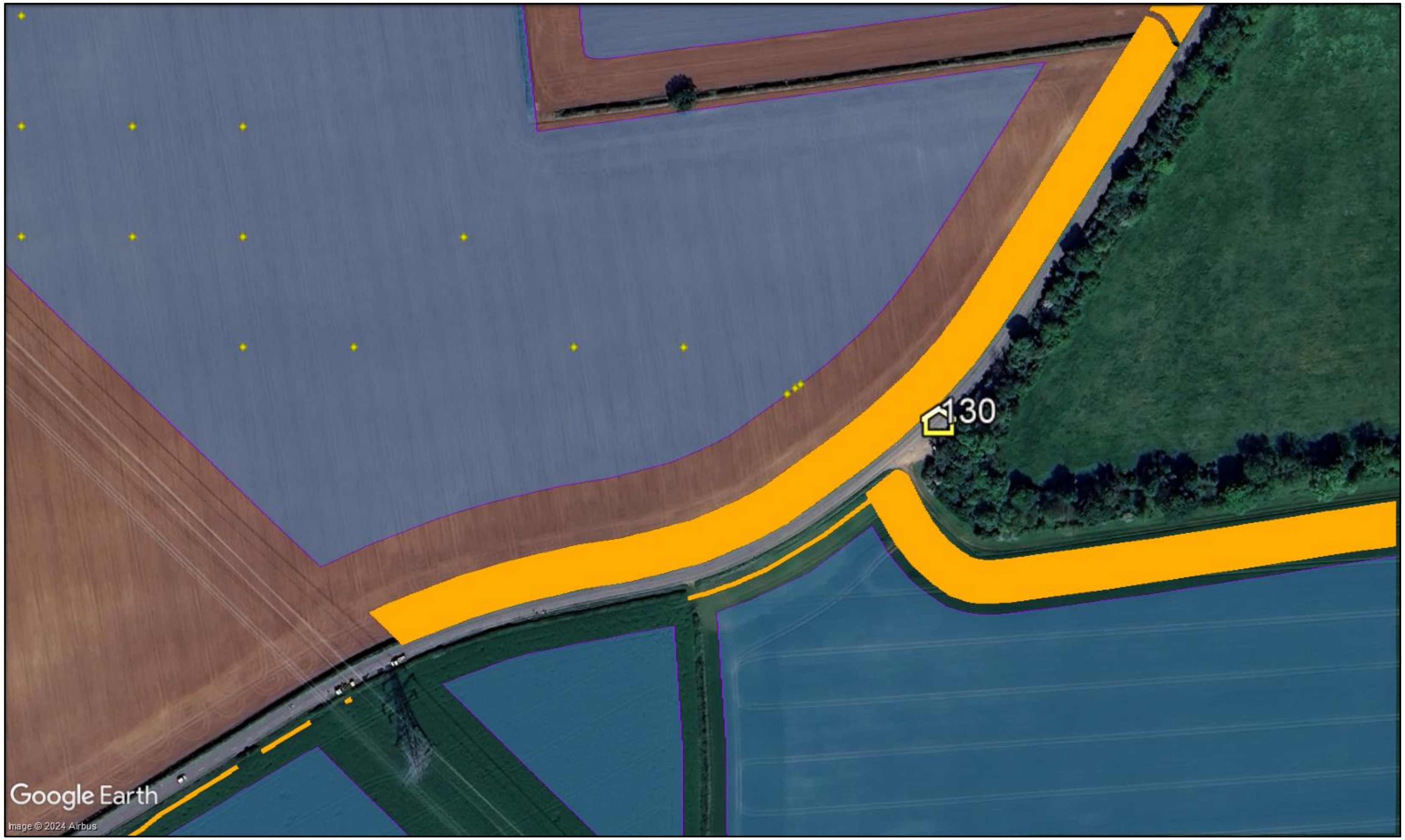
Screening for dwelling receptor 126

Screening for dwelling receptor 127

Screening for dwelling receptor 128



Screening for dwelling receptor 129



Screening for dwelling receptor 130

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Planning Inspectorate Scheme Ref: EN010149