Botley West Solar Farm

Environmental Statement

Volume 3

Appendix 4.4: Glint and Glare Study inc. Technical Aerodrome Safeguarding Report

November 2024

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Solar Photovoltaic Glint and Glare Study

RPS Group Plc

Botley West Solar Farm

July 2023





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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from a fixed ground-mounted solar photovoltaic development, located near Oxford, Oxfordshire, UK. This assessment pertains to the potential impact upon road safety, residential amenity, railway infrastructure and operations, and aviation activity associated with Oxford Airport, Oaklands Airfield, Enstone Airfield, RAF Weston-on-the-Green, RAF Abingdon, and RAF Brize Norton.

Overall Conclusions

A moderate impact is predicted upon road safety at two sections of the B4027 for which mitigation is recommended (see Section 7.6.1).

A moderate impact is predicted upon residential amenity for seven dwellings for which mitigation is recommended (see Section 7.6.2).

No significant impacts are predicted upon aviation activity or railway infrastructure and operations, and no mitigation is required.

Guidance and Studies

Guidelines exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. The UK CAA guidance is relatively high-level and does not prescribe a formal methodology.

A national policy for determining the impact of glint and glare on road safety, residential amenity and railway infrastructure and operations has not been produced to date. Therefore, in the absence of this, Pager Power reviewed more general existing planning guidelines and the available studies in the process of defining its own glint and glare assessment guidance and methodology[1]. This methodology defines the process for determining the impact upon road safety, residential amenity, railway infrastructure and operations, and aviation activity.

Pager Power's approach is to undertake geometric reflection calculations and, where a solar reflection is predicted, consider the screening (existing and/or proposed) between the receptor and the reflecting solar panels. The scenario in which a solar reflection can occur for all receptors is then identified and discussed, and a comparison is made against the available solar panel reflection studies to determine the overall impact.

The available studies have measured the intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. The results show that the reflections produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel[2]. Reflections from solar panels are less intense than those from

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

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

glass or steel because solar panels are designed in order to absorb light, rather than reflect it, as panels are more efficient when they reflect less light.

Assessment Conclusions – Oxford Airport

Solar reflections are geometrically possible towards the ATC Tower, however existing vegetation and buildings are predicted to partially screen views of the panels. The closest reflecting panel area is also at least 1.6km from the ATC Tower, and reflections are predicted to coincide with direct solar radiance. A low impact is predicted and no mitigation is required.

The analysis has shown that solar reflections are predicted towards the approach paths for runways 01 and 19. Solar reflections towards both approach paths will be outside of a pilot's primary field-of-view. This is deemed acceptable in line with the associated guidance and industry standards; a low impact is predicted, and mitigation is not required.

Overall, a low impact is predicted towards Oxford Airport, and no mitigation is required.

Assessment Conclusions – Roads

Solar reflections are geometrically possible towards 381 of the 417 assessed road receptors.

No relevant screening or other mitigating factors have been identified for separate 0.3km and 0.1km sections of the B4027, where reflections are within a road user's primary field-of-view. A moderate impact is predicted and mitigation is recommended (see Section 7.6.1).

For the remaining sections of road, screening in the form of existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels. No significant impacts are predicted, and no mitigation is recommended.

Assessment Conclusions – Dwellings

Solar reflections are geometrically possible towards 632 of the 699 assessed dwellings.

For seven dwellings, no significant relevant screening or other mitigating factors has been identified. A moderate impact is predicted and mitigation is recommended (see Section 7.6.2).

For the remaining 625 dwellings, screening in the form of existing and proposed vegetation is predicted to obstruct views of reflecting panels. No significant impacts are predicted, and no mitigation is recommended.

Assessment Conclusions – Railway

Solar reflections are geometrically possible towards all 48 of the assessed railway receptors.

For separate 0.2km and 0.1km sections of railway, partial vegetation screening would restrict solar reflections to fleeting views of the reflecting panels over vegetation, and reflections would coincide with direct solar radiance. A low impact is predicted and no mitigation is recommended.

For the remaining sections of railway, screening in the form of existing vegetation is predicted to significantly obstruct views of reflecting panels. No impact is predicted, and no mitigation is required.

High-Level Conclusions – Aviation

Enstone Aerodrome

Any solar reflections towards Enstone Aerodrome are predicted to be acceptable in accordance with the associated guidance and industry best practice. Any possible solar reflections towards runway 08 would have an intensity no greater than 'low potential for temporary after-image'. Solar reflections would be outside a pilot's primary field-of-view (50 degrees either side of the approach bearing) for pilots on approach to runway 26. Therefore, no significant impacts are predicted upon aviation activity at Enstone Aerodrome and detailed modelling is not recommended.

RAF Weston-on-the-Green

Any solar reflections towards RAF Weston-on-the-Green are predicted to be acceptable in accordance with the associated guidance and industry best practice. Any possible solar reflections towards runways 19, 23 and 28 would have an intensity no greater than 'low potential for temporary after-image'. Solar reflections would be outside a pilot's primary field-of-view for pilots on approach to runways 01, 05 and 10. Therefore, no significant impacts are predicted upon aviation activity at RAF Weston-on-the-Green and detailed modelling is not recommended.

Oaklands Farm Airfield

Any solar reflections towards Oaklands Farm Airfield are predicted to be acceptable in accordance with the associated guidance and industry best practice. Any possible solar reflections towards runway 11 would have an intensity no greater than 'low potential for temporary after-image'. Solar reflections would be outside a pilot's primary field-of-view for pilots on approach to runway 29. Therefore, no significant impacts are predicted upon aviation activity at Oaklands Farm Airfield and detailed modelling is not recommended.

RAF Abingdon

Any solar reflections towards RAF Abingdon are predicted to be acceptable in accordance with the associated guidance and industry best practice. Any possible solar reflections towards runway 36 would have an intensity no greater than 'low potential for temporary after-image'. Solar reflections would be outside a pilot's primary field-of-view for pilots on approach to runways 08, 18 and 26. Therefore, no significant impacts are predicted upon aviation activity at RAF Abingdon and detailed modelling is not recommended.

RAF Brize Norton

Any solar reflections towards RAF Brize Norton are predicted to be acceptable in accordance with the associated guidance and industry best practice. Any possible solar reflections towards runway 07 would have an intensity no greater than 'low potential for temporary after-image'. Solar reflections would be outside a pilot's primary field-of-view for pilots on approach to runway 25. The ATC tower is also predicted not to experience solar reflections based upon the tower height and distance to the proposed development.

Therefore, no significant impacts are predicted upon aviation activity at RAF Brize Norton and detailed modelling is not recommended.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 58 countries within Europe, Africa, America, Asia and Australasia.

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

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

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

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

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

1 INTRODUCTION

1.1 Overview

Pager Power has been retained to assess the possible effects of glint and glare from a fixed ground-mounted solar photovoltaic development, located near Oxford, Oxfordshire, UK. This assessment pertains to the potential impact upon road safety, residential amenity, railway infrastructure and operations, and aviation activity associated with Oxford Airport, Oaklands Airfield, Enstone Airfield, RAF Weston-on-the-Green, RAF Abingdon, and RAF Brize Norton.

This report contains the following:

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

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

1.2 Pager Power's Experience

Pager Power has undertaken over 1,000 Glint and Glare assessments in the UK and internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Glint and Glare Definition

The definition[3] of glint and glare is as follows:

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

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

[3] These definitions are aligned with those of the Draft National Policy Statement for Renewable Energy Infrastructure (EN-3) – published by the Department for Energy Security & Net Zero in March 2023, and the Federal Aviation Administration (FAA) in the United States of America.

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Site Layout

Figures 1 to 3, below and on the following page, show the site layout for the proposed development, with the blue areas showing the proposed panel layouts.

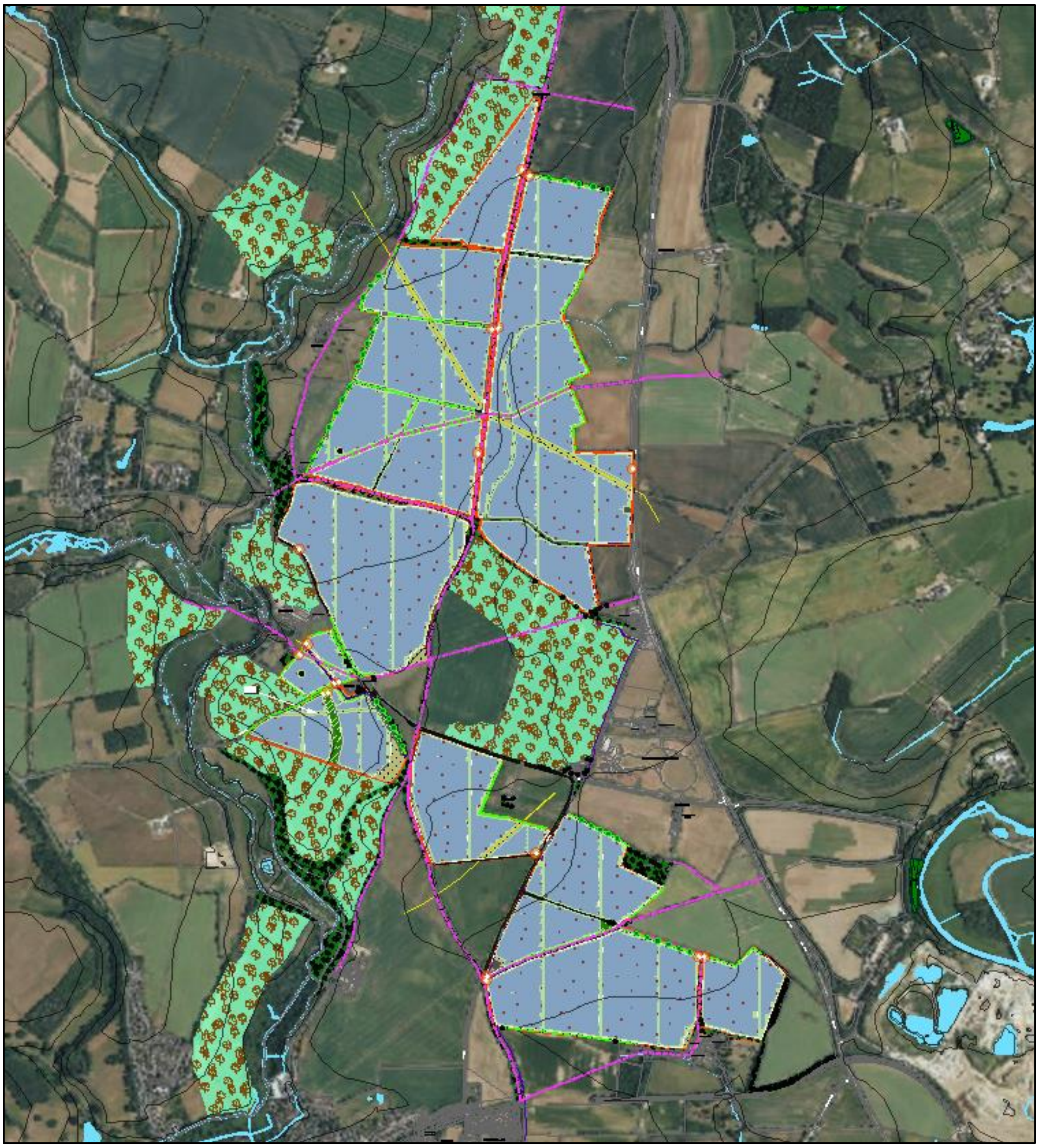

Figure 1 *Proposed development site layout (North)*

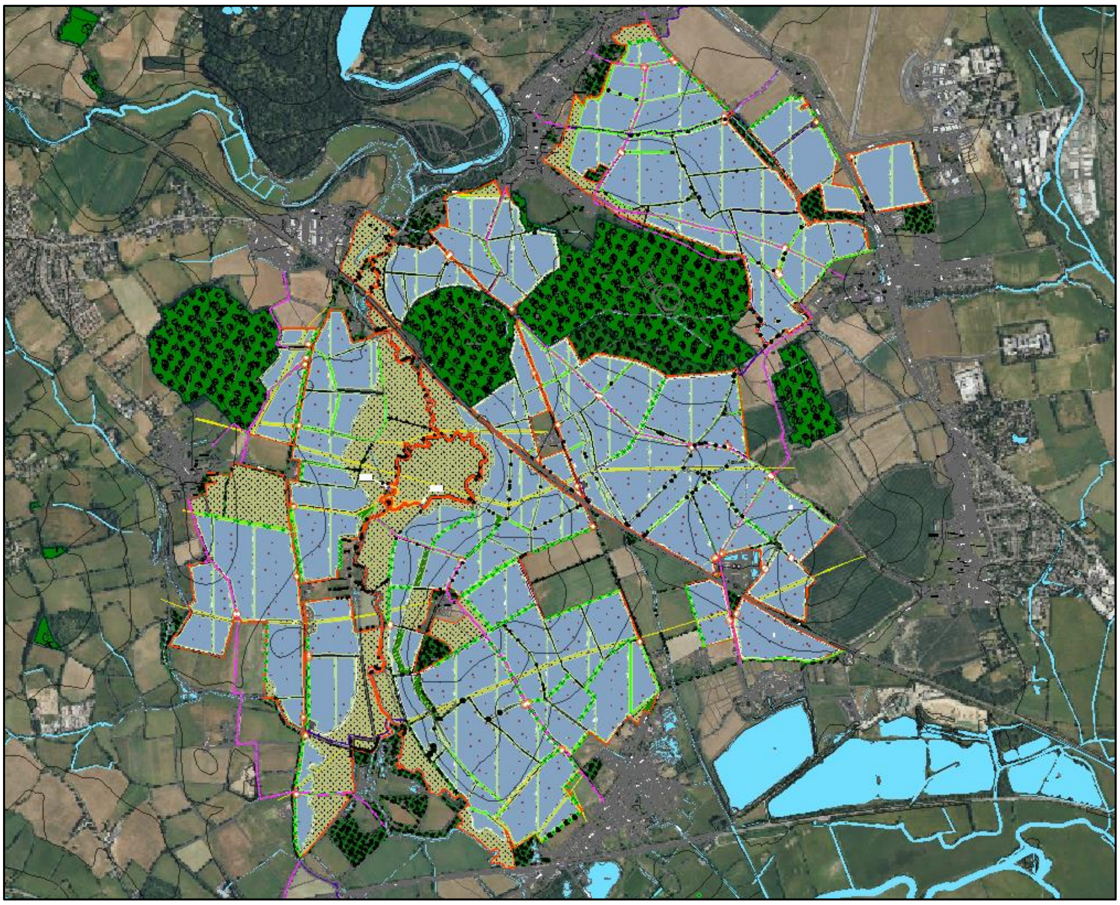

Figure 2 *Proposed development site layout (Middle)*

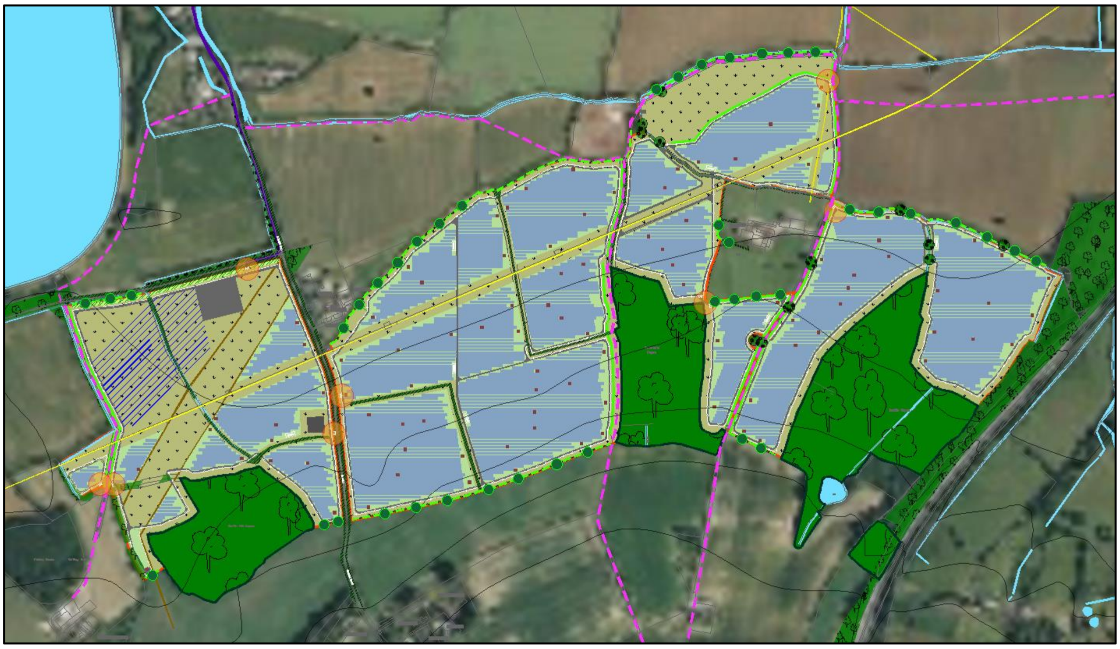

Figure 3 *Proposed development site layout (South)*

Figure 4 below shows the proposed panel areas overlaid onto aerial imagery as the blue areas.

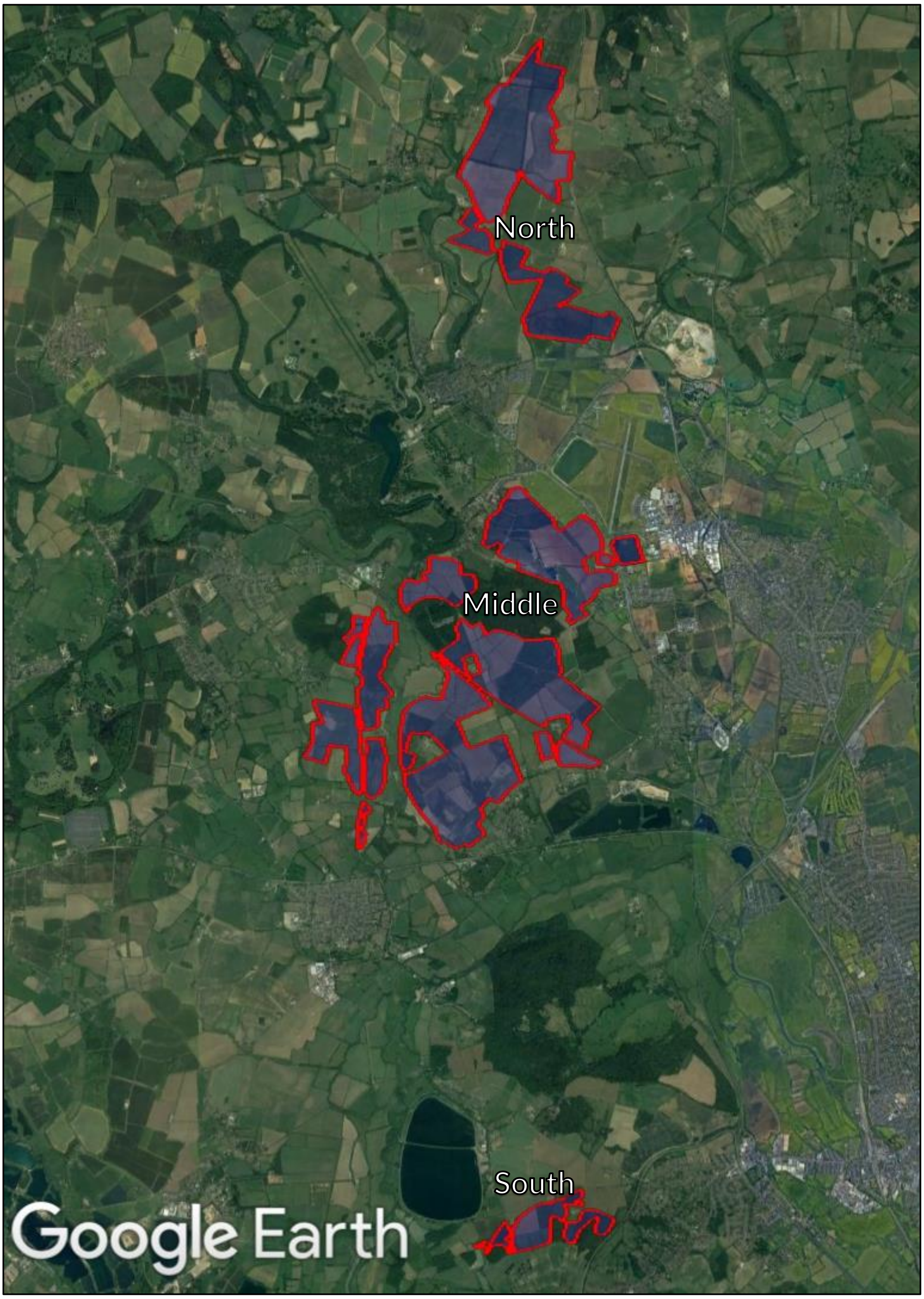

Figure 4 *Solar panel areas for the proposed development*

2.2 Solar Panel Technical Information

Table 1 below summarises the technical information of the modelled solar panels used in the assessment.

Panel Information	
Azimuth angle[4]	180° (south-facing)
Elevation angle[5]	15°
Assessed centre height[6]	1.965m agl[7]

Table 1 *Solar panel technical information*

[4] Relative to true north
[5] Inclination above the horizontal
[6] This is the midpoint of 1.4m and 2.53m
[7] Above ground level

3 RAILWAYS AND GLINT AND GLARE

3.1 Overview

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

3.2 Glint and Glare Definition

As well as the glint and glare definition presented in Section 1.3, glare can also be categorised as causing visual discomfort whereby an observer would instinctively look away, or cause disability whereby objects become difficult to see. The guidance produced by the Commission Internationale de L'Eclairage (CIE)[8] describes disability glare as:

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

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

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

3.3 Common Concerns and Signal Overview

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

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

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

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

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

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

'Light emitted from a Signal lens assembly that has originated from an external source (usually the sun) and has been internally reflected within the Signal Head in such a way that the lens assembly gives the appearance of being lit.[9]'

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

4 GLINT AND GLARE ASSESSMENT METHODOLOGY

4.1 Guidance and Studies

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

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

4.2 Background

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

4.3 Methodology

4.3.1 Pager Power's Methodology

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

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

4.3.2 Sandia National Laboratories' Methodology

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

4.4 Assessment Methodology and Limitations

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

5 IDENTIFICATION OF RECEPTORS

5.1 Aviation Receptors

Oxford Airport is a Civil Aviation Authority (CAA) licenced airport, situated approximately 200m north-east of the proposed solar development. It has an ATC Tower and one operational runway, the details[10] of which are presented below:

- 01/19 measuring 1,552m by 30m (asphalt).

This runway has two associated approach paths, one for each bearing. 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.

A geometric glint and glare assessment has been undertaken for the approach paths for runways 01/19. The Pager Power 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 two miles. The height of the aircraft is determined by using a 3-degree descent path. The receptor details for each runway approach are presented in Appendix G.

Figure 5 below shows the aviation receptors, relative to the proposed solar development.

Figure 5 *Aviation receptors at Oxford Airport, relative to the proposed solar development*

[10] NATS AIP

Figure 6 below shows the aerodrome chart for Oxford Airport[11].

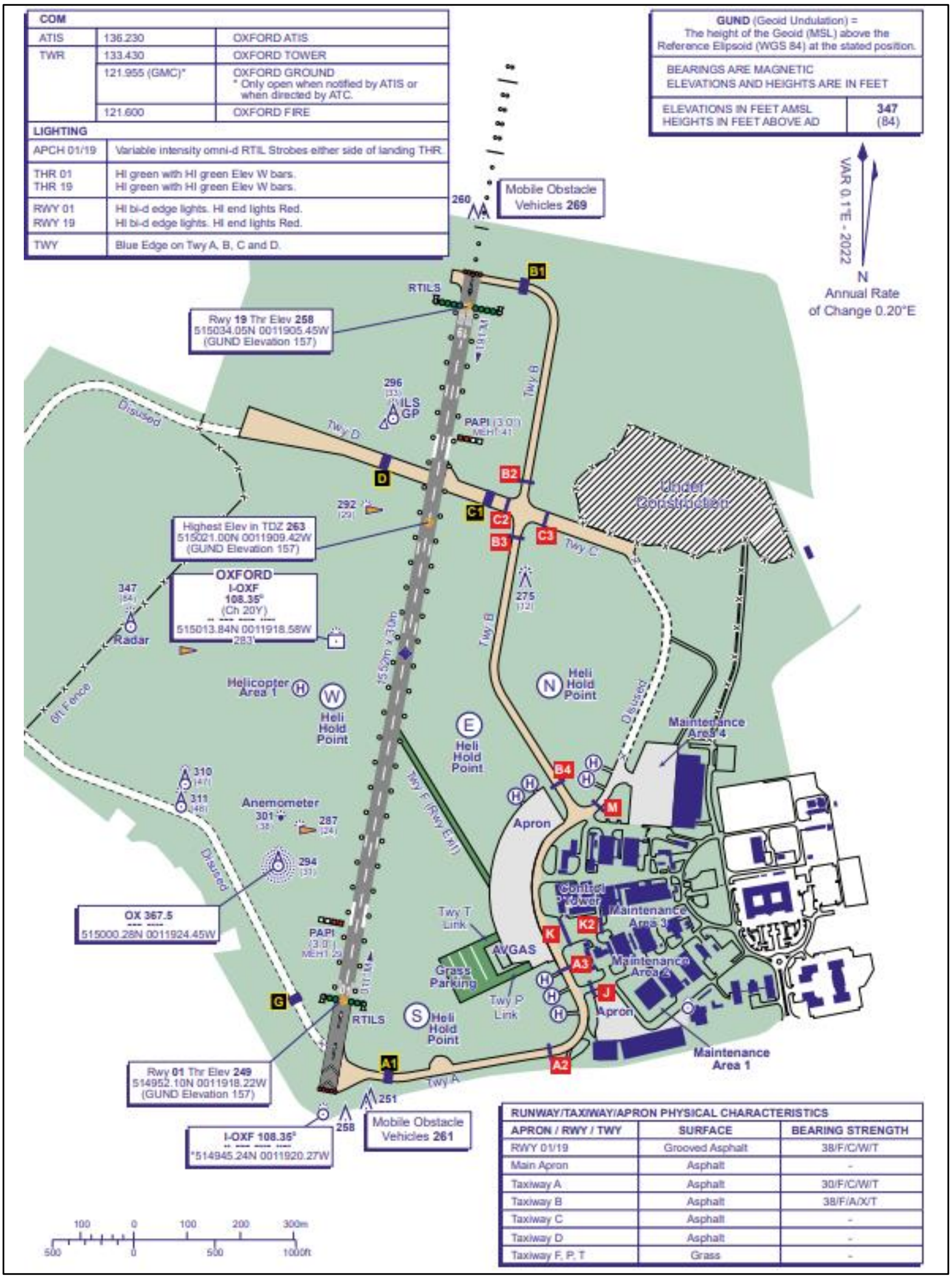

Figure 6 *Aerodrome Chart for Oxford Airport*

[redacted]

5.1.1 ATC Tower

Oxford Airport has one ATC Tower, which is 10m tall and situated approximately 0.44km north-east of the runway 01 threshold. The location of the ATC Tower is shown in Figure 7 below, and Figure 8 below shows a ground-based view of the ATC Tower.

Figure 7 *Location of the ATC Tower within Oxford Airport*

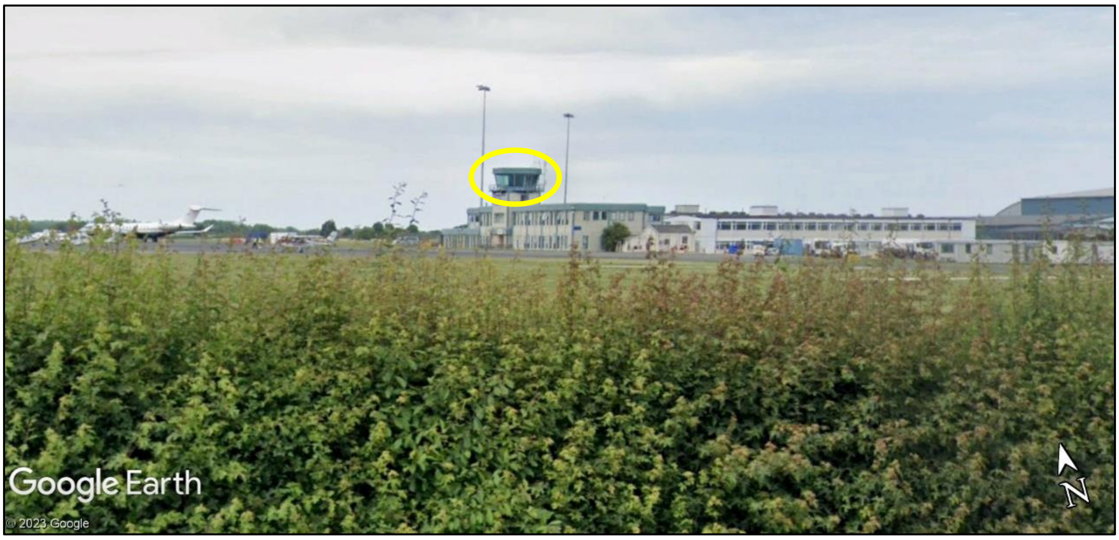

Figure 8 *Ground-based view of the ATC Tower (the visual control room is circled)*

5.2 Ground-Based Receptors Overview

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

A 1km assessment area is considered appropriate for glint and glare effects on ground-based receptors. Receptors within this distance are identified based on mapping and aerial photography of the region. Due to the separation between panels, three separate assessment areas have been produced, and are bounded by the orange outlines in Figures 9 to 11 below and on the following pages. Receptors to the north of the development are not included because solar reflections would not be geometrically possible towards the north when the azimuth angle is considered[12].

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

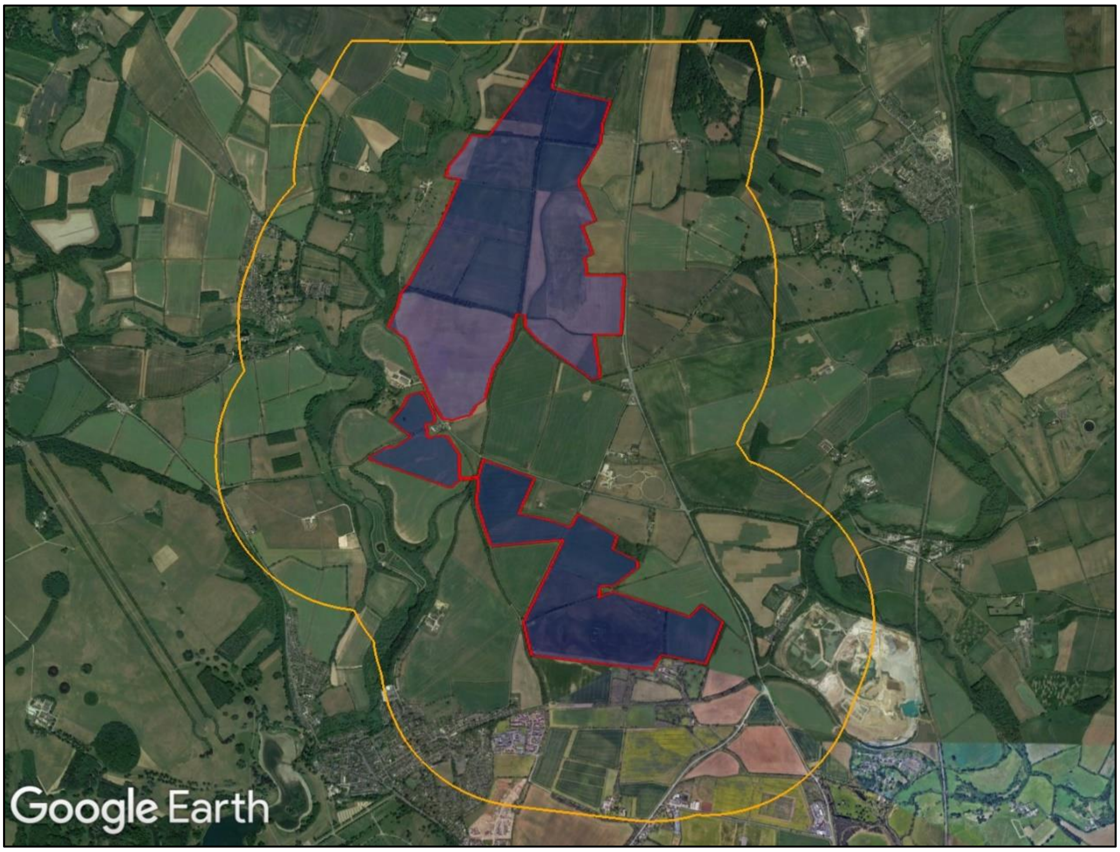

Figure 9 *Assessment area (North)*

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

[13] Digital Terrain Model

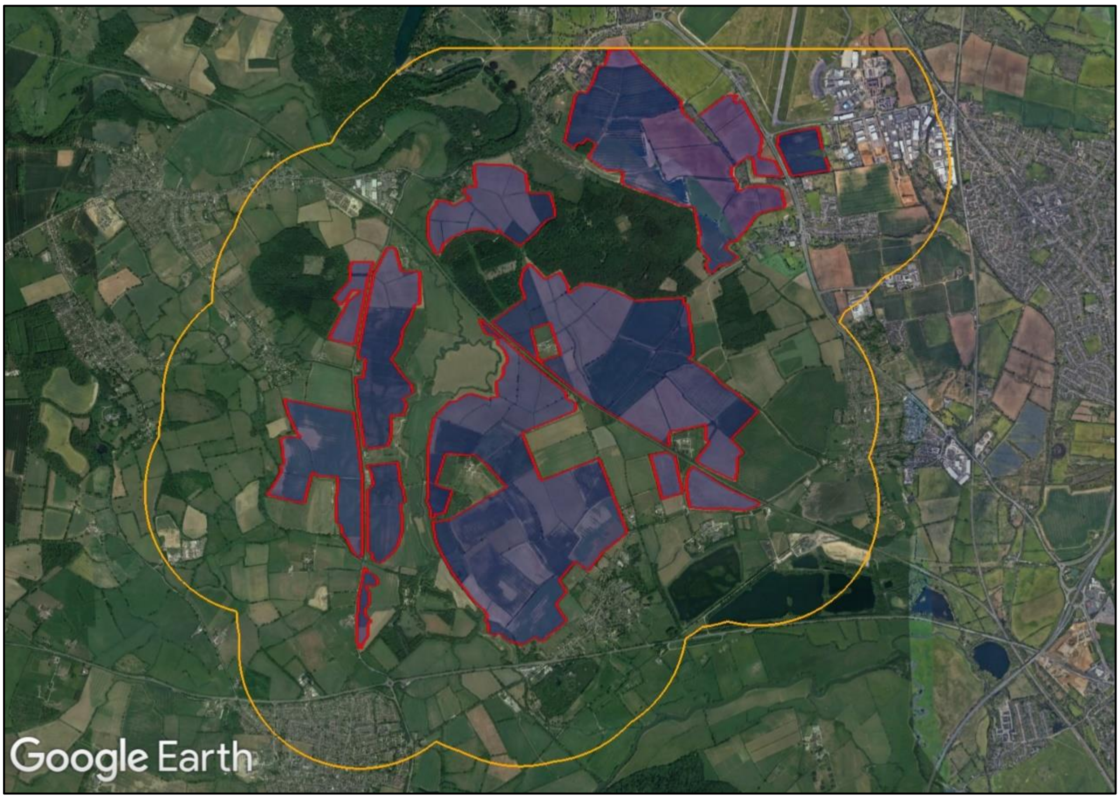

Figure 10 *Assessment area (Middle)*

Figure 11 *Assessment area (South)*

5.3 Road Receptors

5.3.1 Road Receptors Overview

Road types can generally be categorised as:

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

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

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

5.3.2 Identified Road Receptors

Table 2 below shows a summary of the roads identified within the 1km assessment areas. Receptors are placed circa 100m apart and a height of 1.5 metres above ground level has been taken as the typical eye level of a road user[14]. Figures 12 to 14, on the following pages, show the assessed road receptors.

Road	Receptors
A4260	N1 – N52
A4095	N53 – N77
B4027	N78 – N125
A44	N126 – N132
Langford Lane	M1 – M16

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

Road	Receptors
A44	M17 – M48
A4095	M49 – M82
Lower Road	M83 – M128
B4449	M129 – M136
Witney Road	M137 – M140
A40	M141 – M178
Yarnton Road / Cassington Road	M179 – M213
A420	S1 – S21
B4017	S22 – S44
Glebe Road / Oxford Road	S45 – S52
Cumnor Road	S53 – S72

Table 2 *Summary of identified road receptors*

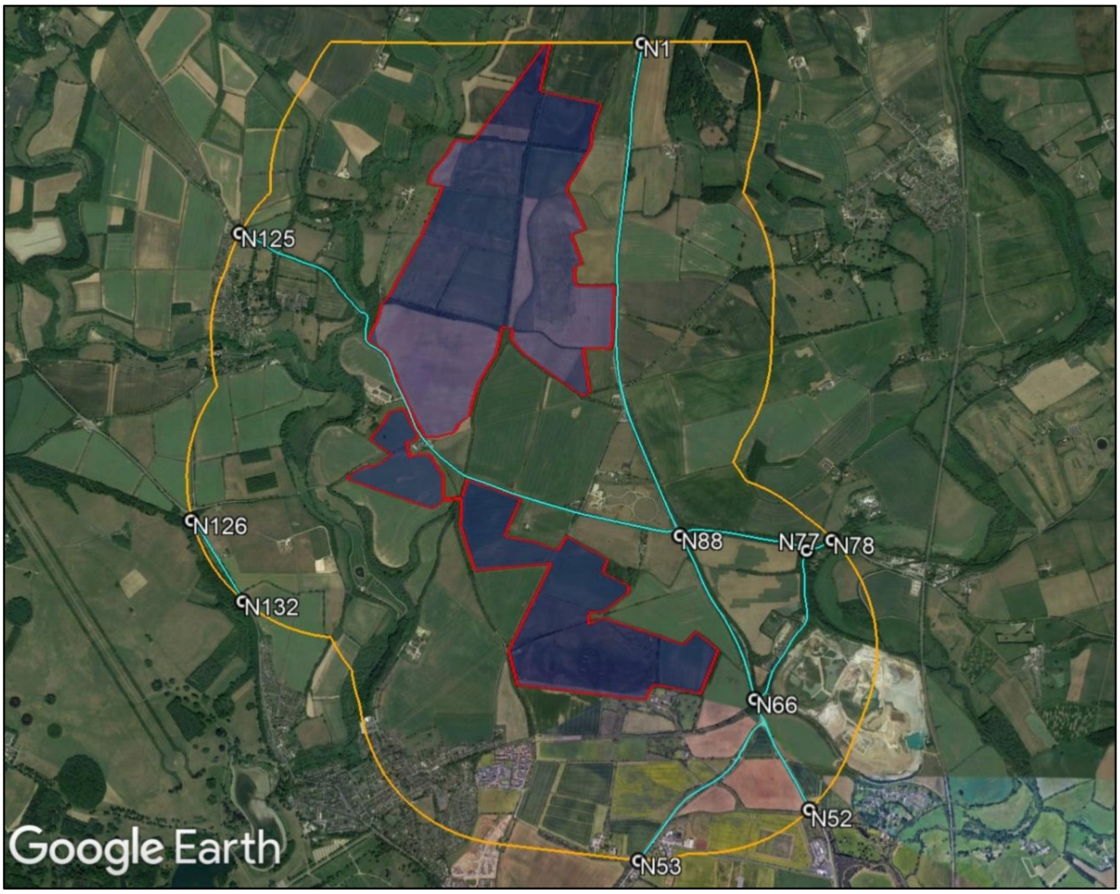

Figure 12 *Road Receptors (North)*

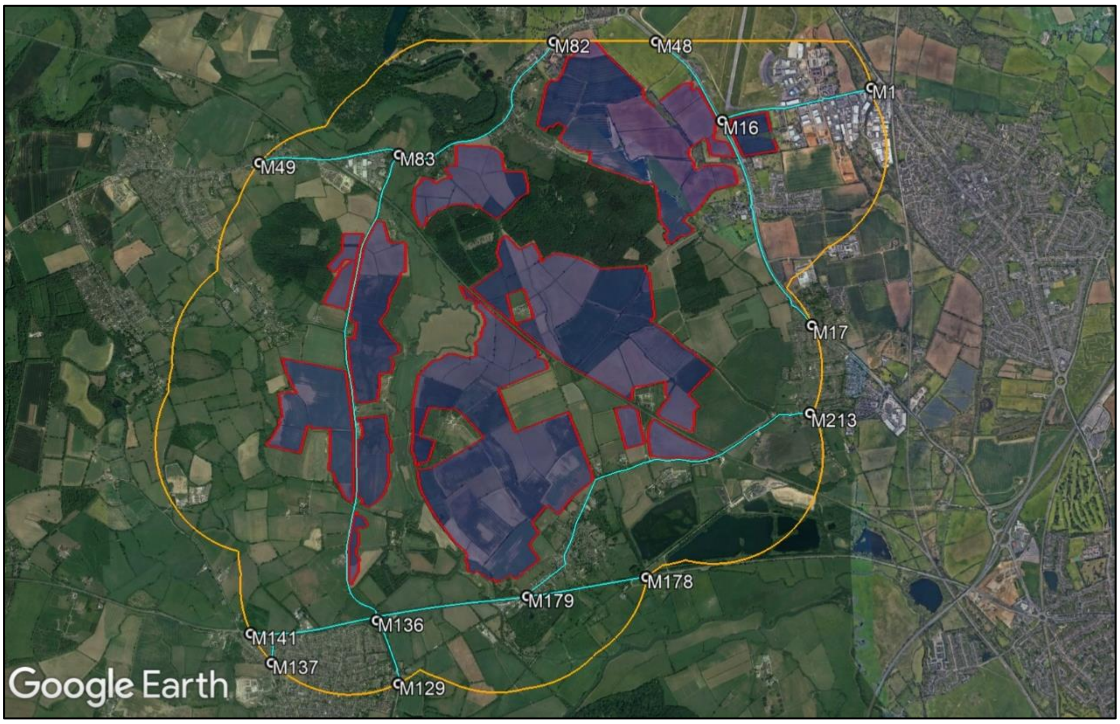

Figure 13 *Road Receptors (Middle)*

Figure 14 *Road Receptors (South)*

5.4 Dwelling Receptors

5.4.1 Dwelling Receptors Overview

The analysis has considered dwellings that:

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

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

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

5.4.2 Identified Dwelling Receptors

The assessed dwelling receptors are shown in Figures 15 to 84, on the following pages. In total, 699 dwellings have been assessed. An additional 1.8m height above ground is used in the modelling to simulate the typical viewing height of an observer on the ground floor[15].

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

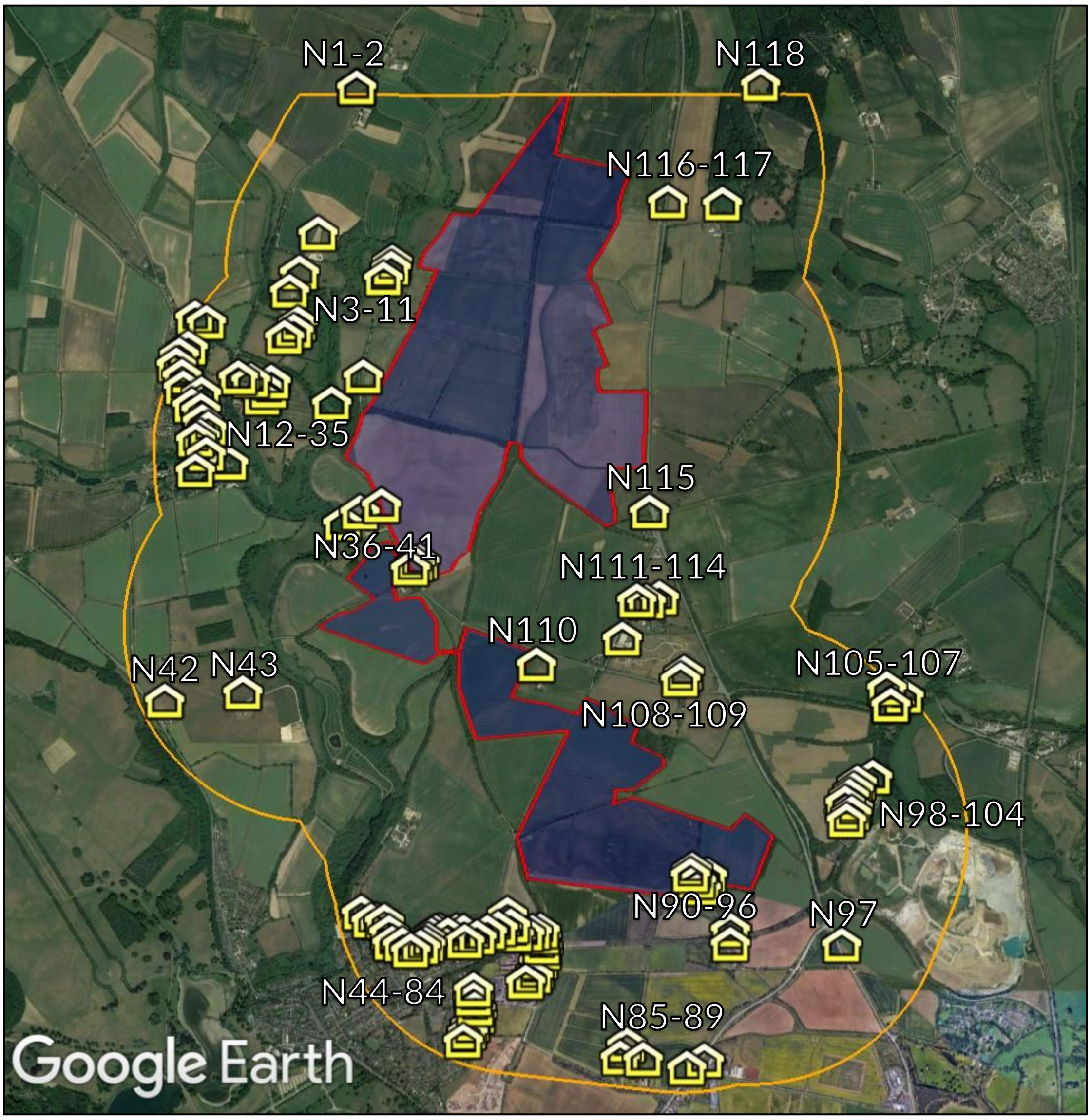

Figure 15 *Overview of Dwellings (North)*

Figure 16 *Dwellings N1 and N2*

Figure 17 *Dwellings N3 to N8*

Figure 18 *Dwellings N9 to N35*

Figure 19 *Dwellings N36 to N41*

Figure 20 *Dwellings N42 and N43*

Figure 21 *Dwellings N44 to N61*

Figure 22 *Dwellings N62 to N77*

Figure 23 *Dwellings N78 to N89*

Figure 24 *Dwellings N90 to N97*

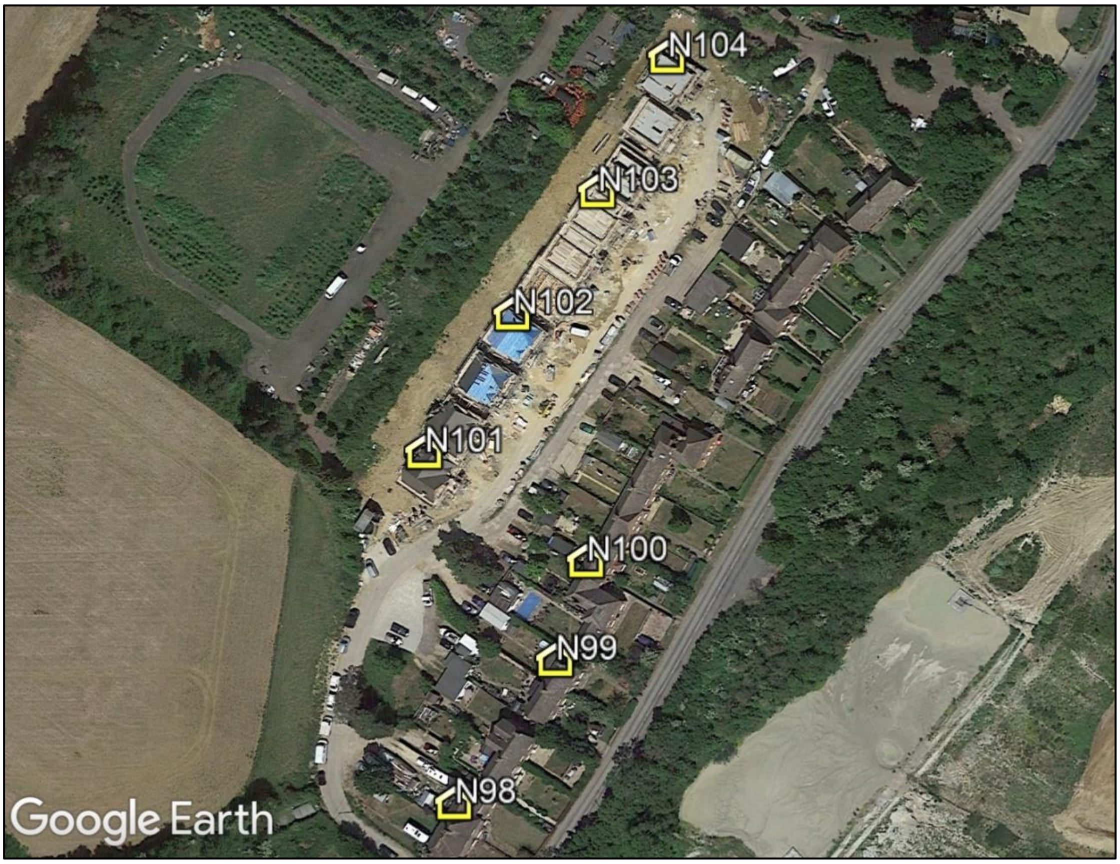

Figure 25 *Dwellings N98 to N104*

Figure 26 *Dwellings N105 to N107*

Figure 27 *Dwellings N108 to N114*

Figure 28 *Dwelling N115*

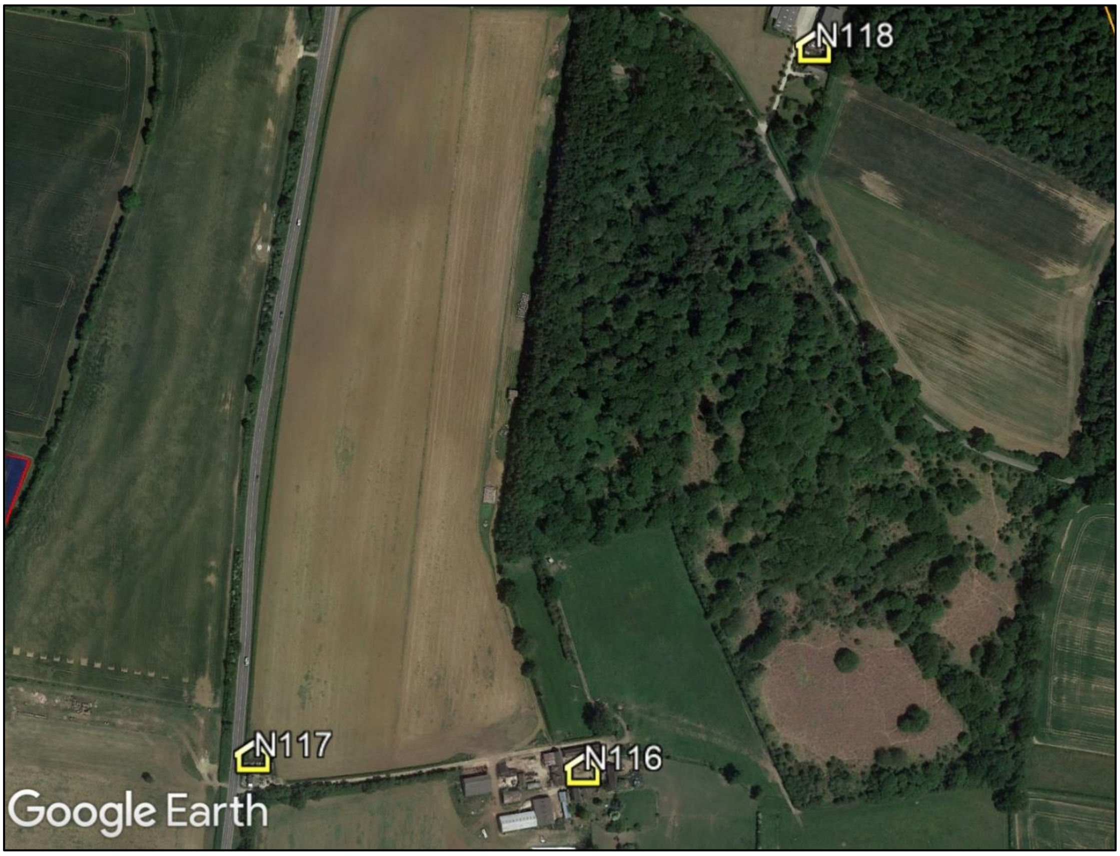

Figure 29 *Dwellings N116 to N118*

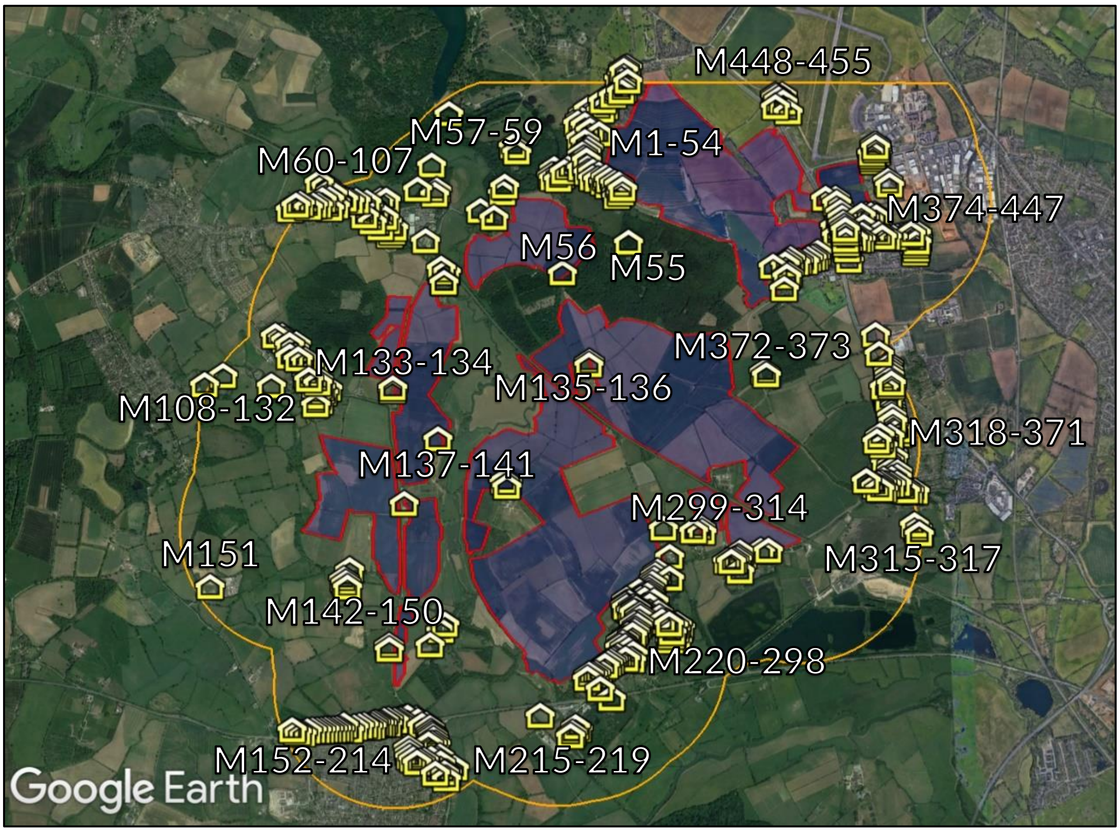

Figure 30 *Overview of Dwellings (Middle)*

Figure 31 *Dwellings M1 to M9*

Figure 32 *Dwellings M10 to M21*

Figure 33 *Dwellings M22 to M54*

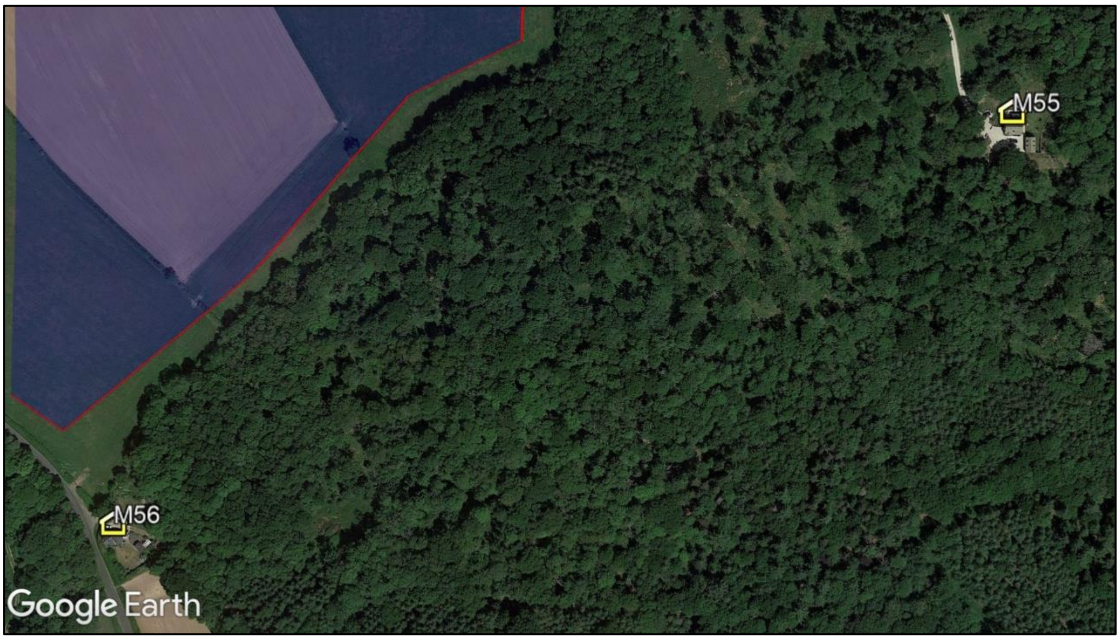

Figure 34 *Dwellings M55 and M56*

Figure 35 *Dwellings M57 to M59*

Figure 36 *Dwellings M60 to M67*

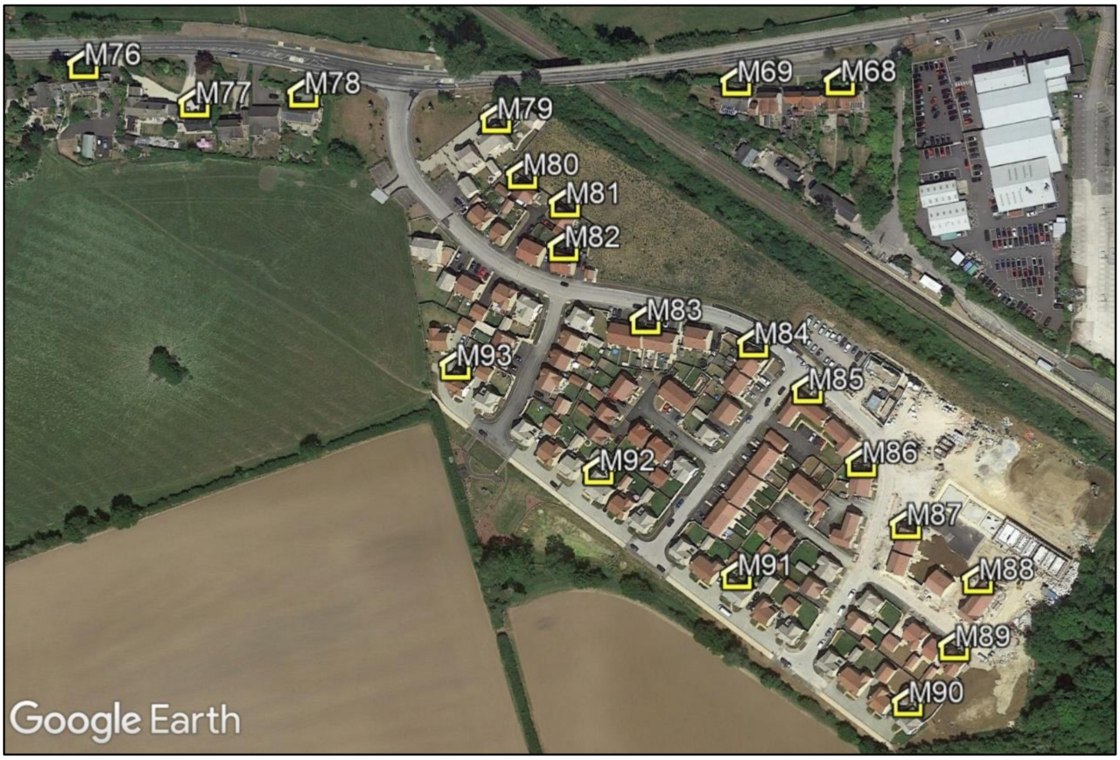

Figure 37 *Dwellings M68 to M69 and M76 to M93*

Figure 38 *Dwellings M70 to M75 and M94 to M102*

Figure 39 *Dwellings M103 to M107*

Figure 40 *Dwellings M108 to M118*

Figure 41 *Dwellings M119 to M129*

Figure 42 *Dwellings M130 to M132*

Figure 43 *Dwellings M133 to M134 and M140*

Figure 44 *Dwellings M135 to M136*

Figure 45 *Dwellings M137 to M139*

Figure 46 *Dwelling M141*

Figure 47 *Dwellings M142 to M146*

Figure 48 *Dwellings M147 to M150*

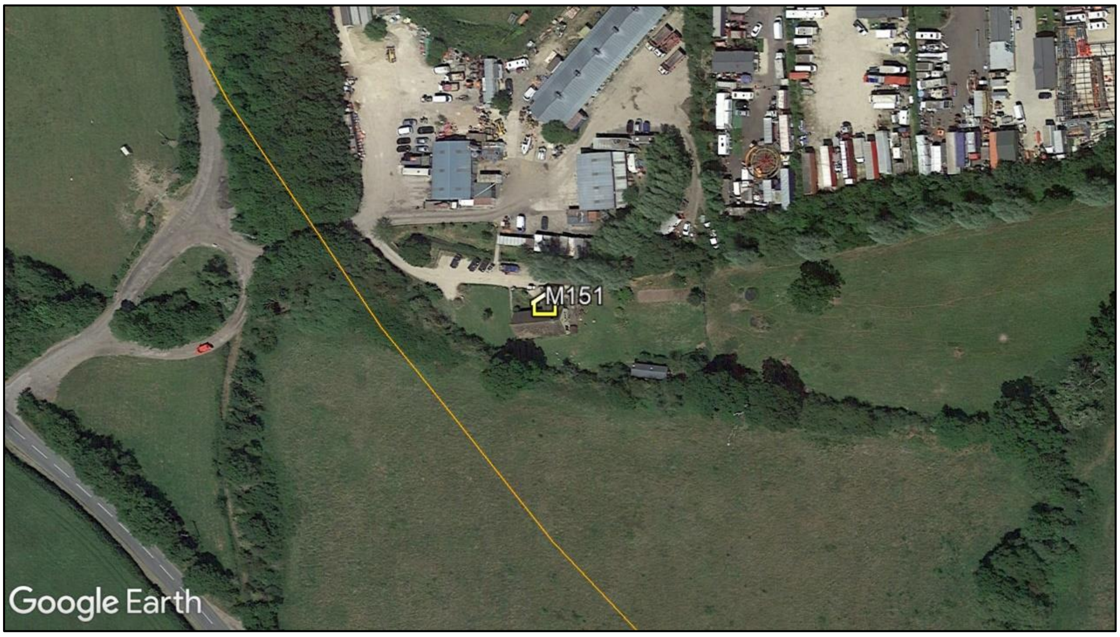

Figure 49 *Dwelling M151*

Figure 50 *Dwellings M152 to M163*

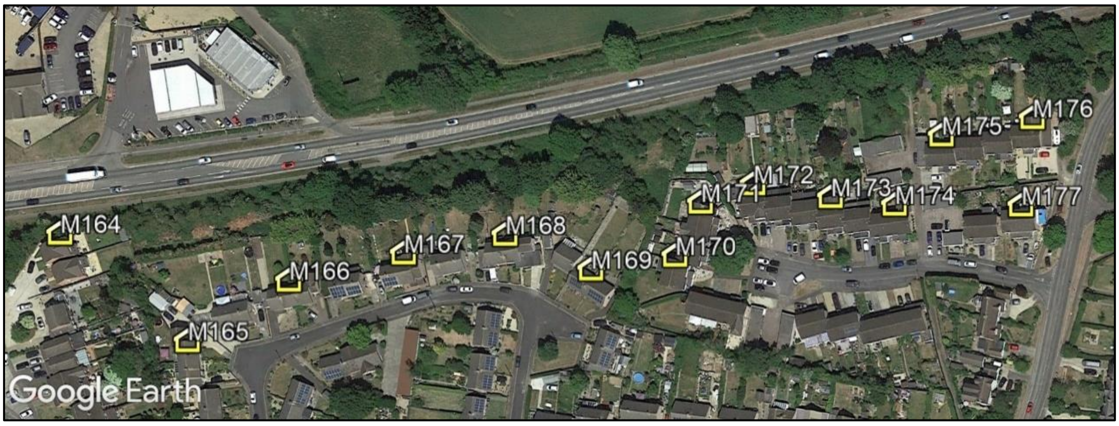

Figure 51 *Dwellings M164 to M177*

Figure 52 *Dwellings M178 to M197*

Figure 53 *Dwellings M198 to M214*

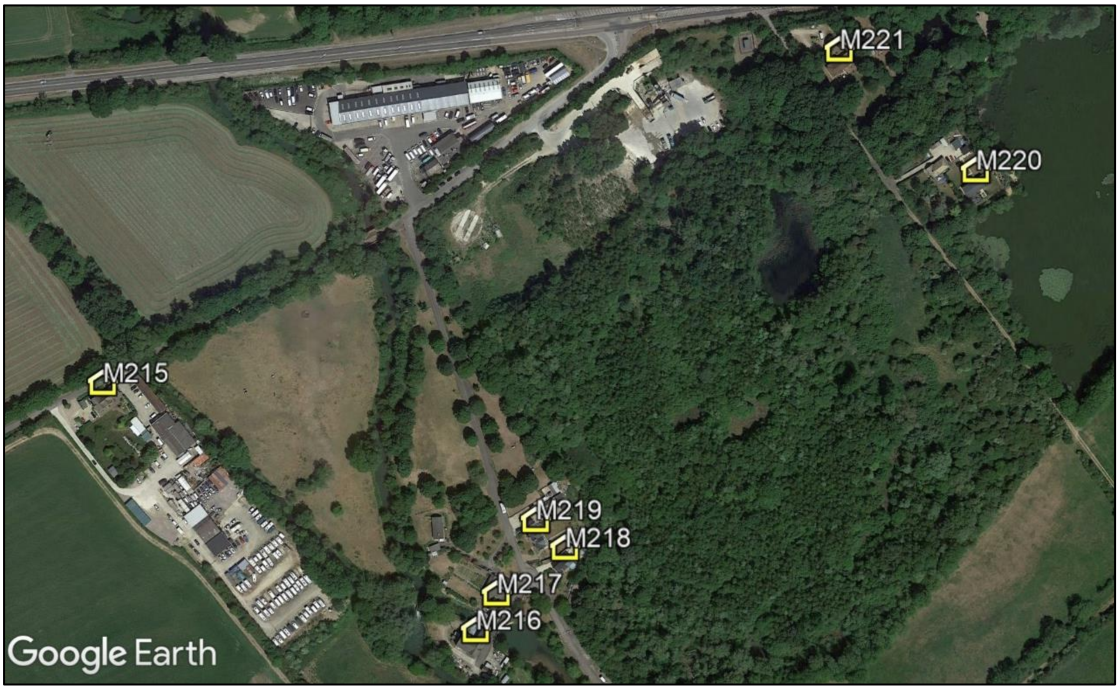

Figure 54 *Dwellings M215 to M221*

Figure 55 *Dwellings M222 to M237*

Figure 56 *Dwellings M238 to M250 and M288 to M298*

Figure 57 *Dwellings M251 to M272 and M284 to M287*

Figure 58 *Dwellings M273 to M283*

Figure 59 *Dwellings M299 to M303*

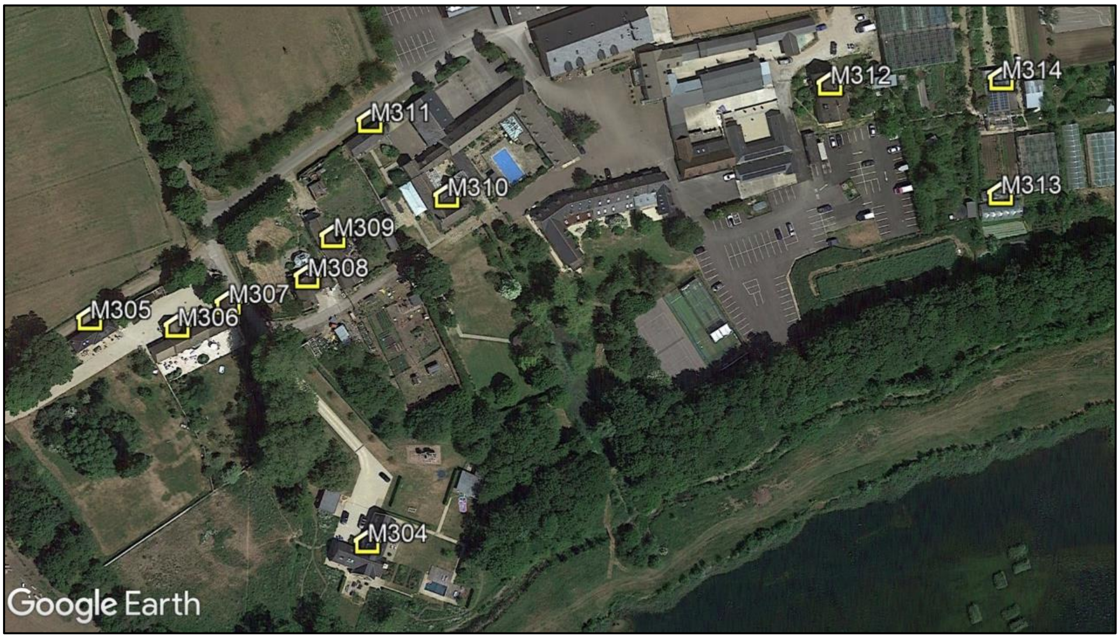

Figure 60 *Dwellings M304 to M314*

Figure 61 *Dwellings M315 to M317*

Figure 62 *Dwellings M318 to M339*

Figure 63 *Dwellings M340 to M357*

Figure 64 *Dwellings M358 to M369*

Figure 65 *Dwellings M370 to M373*

Figure 66 *Dwellings M374 to M376*

Figure 67 *Dwellings M377 to M387*

Figure 68 *Dwellings M388 to M394, M405 to M409, and M424*

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Figure 69 *Dwellings M395 to M404 and M410 to M423*

Figure 70 *Dwellings M425 to M437*

Figure 71 *Dwellings M438 to M447*

Figure 72 *Dwellings M448 to M455*

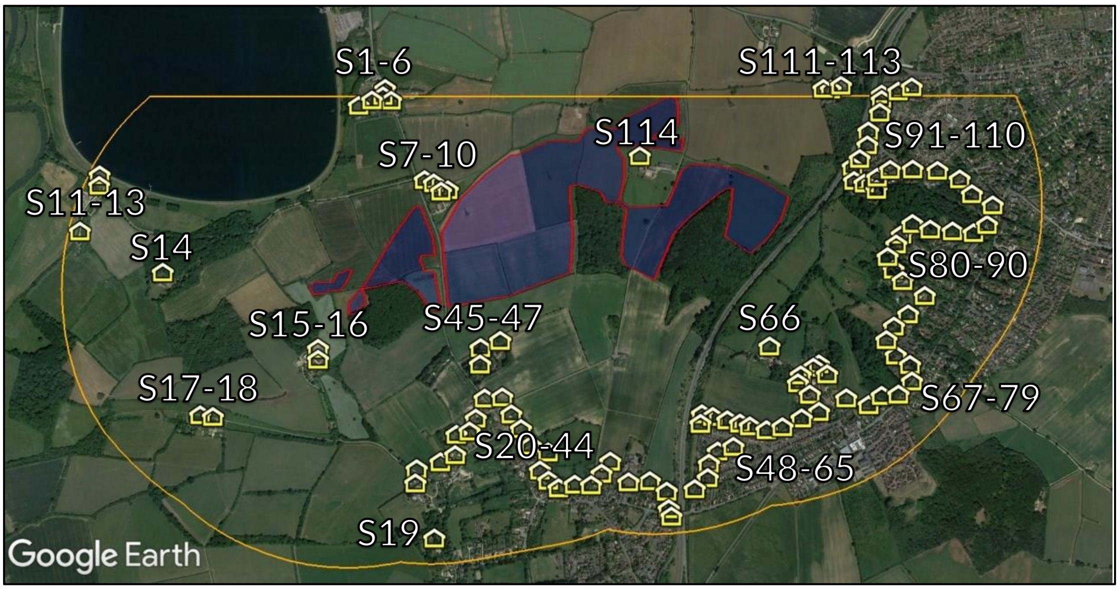

Figure 73 *Overview of Dwellings (South)*

Figure 74 *Dwellings S1 to S6*

Figure 75 *Dwellings S7 to S10*

Figure 76 *Dwellings S11 to S14*

Figure 77 *Dwellings S15 to S18*

Figure 78 *Dwellings S19 to S44*

Figure 79 *Dwellings S45 to S47*

Figure 80 *Dwellings S48 to S62*

Figure 81 *Dwellings S63 to S79*

Figure 82 *Dwellings S80 to S91*

Figure 83 *Dwellings S92 to S113*

Figure 84 *Dwelling S114*

5.5 Railway Receptors

5.5.1 Railway Receptors Overview

The analysis has considered railway receptors, in the context of train drivers, that:

- Are within 500 metres of the proposed development; and
- Have a potential view of the panels.

5.5.2 Identified Railway Receptors

An approximate 4.7km section of railway operates within the assessment area and has therefore been assessed, as part of the HS1 Line between Oxford and Hanborough. In total, 48 receptors have been placed circa 100m along the railway line, as shown in Figure 85 below.

Based on previous consultation[16], an additional 2.75m height above ground is used in the modelling as the typical viewing height of a train operator[17].

Figure 85 *Railway receptors 1 to 48*

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

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

6 ASSESSED REFLECTOR AREAS

6.1 Reflector Areas

The bounding coordinates for the proposed development have been extrapolated from the site plans. The data can be found in Appendix G.

The Pager Power model has used a resolution of 20m for this assessment. This means that a geometric calculation is undertaken for each identified receptor every 20m from within the defined areas. This resolution is sufficiently high to maximise the accuracy of the results – increasing the resolution further would not significantly change the modelling output. If a reflection is experienced from an assessed panel location, then it is likely that a reflection will be viewable from similarly located panels within the proposed solar development.

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Overview

The following sub-section presents the results of the assessment and the significance of any predicted impact in the context of existing screening and the relevant criteria set out in each sub-section. The criteria are determined by the assessment process for each receptor, which are set out in Appendix D.

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

7.2 Aviation Results

7.2.1 Glare Intensity Categorisation

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

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

Table 3 *Glare intensity designation*

This coding has been used in the table where a reflection has been calculated and is in accordance with Sandia National Laboratories' methodology.

In addition, the intensity model allows for assessment of a variety of solar panel surface materials. In the first instance, a surface material of 'smooth glass without an anti-reflective coating' is assessed. This is the most reflective surface and allows for a 'worst case' assessment. Other surfaces that could be modelled include:

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

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

7.2.2 Impact Significance Determination

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

- Whether a reflection is predicted to be experienced in practice.
- The location of glare relative to a pilot's primary field-of-view (50 degrees either side of the approach bearing).
- The intensity of glare for the solar reflections:
  - Glare with 'low potential for temporary after-image' (green glare);
  - Glare with 'potential for temporary after-image' (yellow glare);
  - Glare with 'potential for permanent eye damage' (red glare).
- Whether a reflection is predicted to be operationally significant in practice or not.

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

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

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[18] 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[19], where solar reflections are of an intensity no greater than 'low potential for temporary after-image' expert assessment of the following relevant factors is required to determine the impact significance[20]:

- The likely traffic volumes and level of safeguarding at the aerodrome. Licensed aerodromes typically have higher traffic volumes and are formally safeguarded. 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 short durations throughout the year is less likely to be experienced than glare that occurs for longer durations throughout a year.

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

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

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

- 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.
- 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.

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

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

The tables in the following subsections summarise the results of the assessment. The predicted glare times are based solely on bare-earth terrain i.e. without consideration of screening from buildings and vegetation. The final column summarises the predicted impact considering the level of predicted screening based on a desk-based review of the available imagery. The significance of any predicted impact is discussed in the subsequent report sections.

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

7.2.3 Results Discussion – Oxford Airport

The results of the geometric calculation for aviation receptors at Oxford Airport are presented in Table 4 below.

Receptor/Runway	Geometric Modelling Result	Glare Intensity	Comment	Impact Classification	Mitigation Recommended?
ATC Tower	Solar reflections are geometrically possible		The reflecting panel area is partially screened by existing vegetation and at least 1.30km from the ATC Tower Any solar reflections would be close to the horizon and are predicted to coincide with direct sunlight	Low impact	No
Runway 01 Approach Path	Solar reflections are geometrically possible between the threshold and 1-miles from the threshold		Any solar reflections would be outside of a pilot's primary field-of-view	Low impact	No
Runway 19 Approach Path	Solar reflections are geometrically possible between 0.4-miles from the threshold and 2-miles from the threshold		Any solar reflections would be outside of a pilot's primary field-of-view	Low impact	No

Table 4 *Geometric analysis results – Oxford Airport*

Figure 86 below shows the point-of-view from the ATC Tower towards the reflecting panel area, which can be seen close to the horizon, behind the nearby dwellings and vegetation. The figure shows the sun position at 18:20 on April 1st, when reflections are predicted.

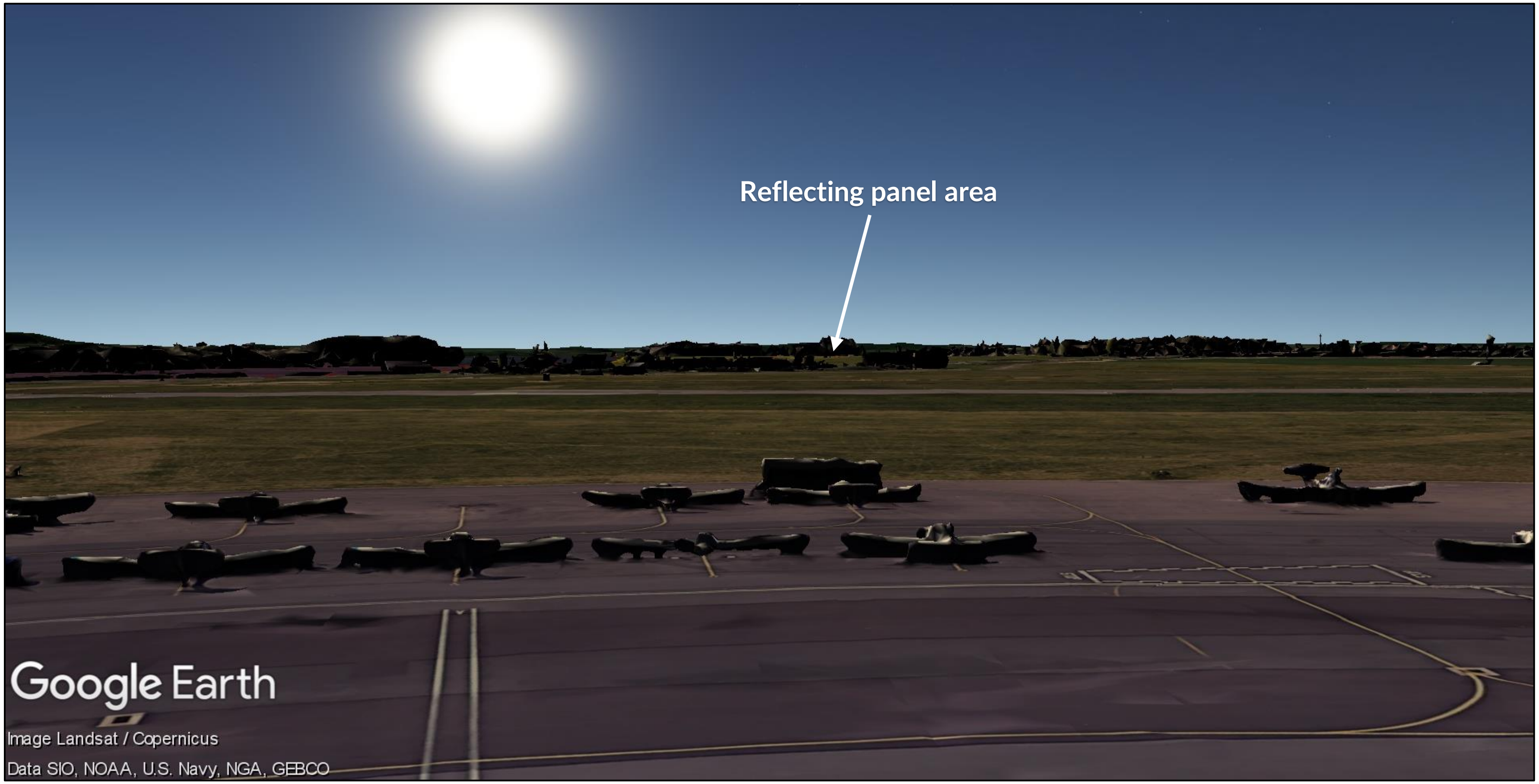

Figure 86 *Point-of-view from the ATC Tower at Oxford Airport*

7.3 Road Results

7.3.1 Impact Significance Determination

The process for quantifying the impact significance concerning road safety is outlined in Appendix D. The key considerations for road users along major national, national, and regional roads are:

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

Where reflections are geometrically possible but expected to be screened, no impact is predicted, and mitigation is not required.

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

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

- Whether visibility is likely for elevated drivers (relevant to dual carriageways and motorways[21]);
- Whether the solar reflection originates from directly in front of a road user. Solar reflections that are directly in front of a road user are more hazardous;
- The separation distance to the reflecting panel area. Larger separation distances reduce the proportion of an observer's field-of-view that is affected by glare;
- The position of the Sun. Effects that coincide with direct sunlight appear less prominent than those that do not. The Sun is a far more significant source of light.

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

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

7.3.2 Results Discussion

The modelling has shown that solar reflections are geometrically possible towards 381 of the 417 assessed receptors. Tables 5 to 7, below and on the following pages, summarise the predicted impact at these receptors. Results where mitigation is recommended are shown in red.

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
N1 – N2	No solar reflections geometrically possible	N/A	N/A	No impact	No
N3 – N10, N13 – N22	Solar reflections geometrically possible from **outside** a road user's primary field-of-view[22]	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
N11 – N12	Solar reflections geometrically possible from **outside** a road user's primary field-of-view	Proposed vegetation is predicted to partially obstruct views of reflecting panels	N/A	Low impact	No
N23 – N52	Solar reflections geometrically possible from **inside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No

[22] 50 degrees either side of the direction of travel

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
N53 – N59	No solar reflections geometrically possible	N/A	N/A	No impact	No
N60 – N64, N67 – N77, N114 – N115, N126 – N132	Solar reflections geometrically possible from **outside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
N65 – N66, N78 – N98, N103 – N108, N116 – N125	Solar reflections geometrically possible from **inside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
N99 – N102, N113	Solar reflections geometrically possible from **inside** a road user's primary field-of-view	No significant relevant screening identified	N/A	Moderate impact	Yes
N109 – N112	Solar reflections geometrically possible from **outside** a road user's primary field-of-view	No significant relevant screening identified	N/A	Low impact	No

Table 5 *Impact Classification – Road Receptors (North)*

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
M1 – M26, M31 – M47	Solar reflections geometrically possible from **inside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
M27 – M30	Solar reflections geometrically possible from **outside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
M48	No solar reflections geometrically possible	N/A	N/A	No impact	No
M49 – M73, M76 – M81	Solar reflections geometrically possible from **inside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
M74 – M75	Solar reflections geometrically possible from **outside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
M82	No solar reflections geometrically possible	N/A	N/A	No impact	No

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
M83 – M89, M125 – M128	Solar reflections geometrically possible from **inside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
M90 – M92	Solar reflections geometrically possible from **inside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to partially obstruct views of reflecting panels	Solar reflections will be fleeting and coincide with direct solar radiance	Low impact	No
M93 – M99, M101 – M102	Solar reflections geometrically possible from **outside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to partially obstruct views of reflecting panels	N/A	Low impact	No
M100, M103 – M124	Solar reflections geometrically possible from **outside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
M129 – M133	No solar reflections geometrically possible	N/A	N/A	No impact	No

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
M134 – M140, M184 – M191	Solar reflections geometrically possible from **outside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
M141 – M183, M192 – M213	Solar reflections geometrically possible from **inside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No

Table 6 *Impact Classification – Road Receptors (Middle)*

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
S1 – S4, S12 – S18	Solar reflections geometrically possible from **outside** a road user's primary field-of-view[23]	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No

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

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
S5 – S11	Solar reflections geometrically possible from **inside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
S19 – S22	No solar reflections geometrically possible	N/A	N/A	No impact	No
S23 – S26, S31, S34	Solar reflections geometrically possible from **outside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
S27 – S30	Solar reflections geometrically possible from **outside** a road user's primary field-of-view	No significant relevant screening identified	N/A	Low impact	No
S32 – S33	Solar reflections geometrically possible from **inside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
S35 – S49	No solar reflections geometrically possible	N/A	N/A	No impact	No

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
S50 – S52	Solar reflections geometrically possible from **inside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
S53	No solar reflections geometrically possible	N/A	N/A	No impact	No
S54 – S55, S60 – S71	Solar reflections geometrically possible from **outside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
S56 – S59, S72	Solar reflections geometrically possible from **inside** a road user's primary field-of-view	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No

Table 7 *Impact Classification – Road Receptors (South)*

7.4 Dwelling Results

7.4.1 Impact Significance Determination

The process for quantifying the impact significance concerning residential amenity is outlined in Appendix D. The key considerations for residential dwellings are:

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

Where reflections are geometrically possible but expected to be screened, no impact is predicted, and mitigation is not required.

Where effects occur for less than 3 months per year and less than 60 minutes on any given day, or the closest reflecting panel is over 1km from the dwelling, the impact significance is low, and mitigation is not recommended.

Where reflections are predicted to be experienced for more than 3 months per year **and/or** for more than 60 minutes on any given day, expert assessment of the following relevant factors is required to determine the impact significance and mitigation requirement:

- The separation distance to the reflecting panel area[24]. Larger separation distances reduce the proportion of an observer's field-of-view that is affected by glare;
- The position of the Sun. Effects that coincide with direct sunlight appear less prominent than those that do not. The Sun is a far more significant source of light;
- Whether solar reflections will be experienced from all storeys. The ground floor is typically considered the main living space and therefore has a greater significance with respect to residential amenity;
- Whether the dwelling appears to have windows facing the reflecting areas. An observer may need to look at an acute angle to observe the reflecting areas.

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

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

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[24] Which is often greater than the nearest panel boundary, because not all areas of the site cause specular reflections towards particular receptor locations.

7.4.2 Results Discussion

The modelling has shown that solar reflections are geometrically possible towards 632 of the 699 assessed dwellings. Tables 8 to 10, below and on the following pages, summarises the predicted impact at these receptors.

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
N1 – N2	No solar reflections geometrically possible	N/A	N/A	No impact	No
N3 – N35, N38 – N70	Solar reflections geometrically possible for **more** than 3 months per year but **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
N36 – N37	Solar reflections geometrically possible for **more** than 3 months per year but **less** than 60 minutes on any given day	No significant relevant screening identified	N/A	Moderate impact	Yes
N71 – N75	Solar reflections geometrically possible for **less** than 3 months per year and **less** than 60 minutes on any given day	Existing vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
N76 – N77	No solar reflections geometrically possible	N/A	N/A	No impact	No

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
N78 – N79	Solar reflections geometrically possible for **less** than 3 months per year and **less** than 60 minutes on any given day	Existing vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
N80 – N89	No solar reflections geometrically possible	N/A	N/A	No impact	No
N90 – N91	Solar reflections geometrically possible for **less** than 3 months per year and **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
N92, N97 – N110, N115 – N117	Solar reflections geometrically possible for **more** than 3 months per year but **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
N93 – N96	Solar reflections geometrically possible for **more** than 3 months per year but **less** than 60 minutes on any given day	No significant relevant screening identified	N/A	Moderate impact	Yes

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
N111 – N114	Solar reflections geometrically possible for **more** than 3 months per year but **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to partially obstruct views of reflecting panels	Partial screening is predicted to reduce the duration of effects to less than 3 months per year	Low impact	No
N118	No solar reflections geometrically possible	N/A	N/A	No impact	No

Table 8 *Impact Classification – Dwelling Receptors (North)*

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
M1 – M2	No solar reflections geometrically possible	N/A	N/A	No impact	No
M3 – M6, M59, M186 – M192	Solar reflections geometrically possible for **less** than 3 months per year and **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
M7 – M58, M60 – M134, M137 – M138, M142 – M185	Solar reflections geometrically possible for **more** than 3 months per year but **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
M135 – M136, M139 – M141	Solar reflections geometrically possible for **more** than 3 months per year but **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to partially obstruct views of reflecting panels	Partial screening is predicted to reduce the duration of effects to less than 3 months per year	Low impact	No
M193 – M214	No solar reflections geometrically possible	N/A	N/A	No impact	No
M215 – M218, M450 – M455	Solar reflections geometrically possible for **less** than 3 months per year and **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
M219 – M280, M282 – M376, M378 – M449	Solar reflections geometrically possible for **more** than 3 months per year but **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
M281	Solar reflections geometrically possible for **more** than 3 months per year but **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to partially obstruct views of reflecting panels	Partial screening is predicted to reduce the duration of effects to less than 3 months per year	Low impact	No

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
M377	Solar reflections geometrically possible for **more** than 3 months per year but **less** than 60 minutes on any given day	No significant relevant screening identified	N/A	Moderate impact	Yes

Table 9 *Impact Classification – Dwelling Receptors (Middle)*

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
S1 – S6, S11 – S13	Solar reflections geometrically possible for **less** than 3 months per year and **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
S7 – S10, S14 – S18	Solar reflections geometrically possible for **more** than 3 months per year but **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
S19 – S44	No solar reflections geometrically possible	N/A	N/A	No impact	No

Dwelling Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Relevant Factors	Impact Classification	Mitigation Recommended?
S45 – S47	Solar reflections geometrically possible for **less** than 3 months per year and **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
S48 – S49	No solar reflections geometrically possible	N/A	N/A	No impact	No
S50 – S59, S104 – S113	Solar reflections geometrically possible for **less** than 3 months per year and **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
S60 – S103, S114	Solar reflections geometrically possible for **more** than 3 months per year but **less** than 60 minutes on any given day	Existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No

Table 10 *Impact Classification – Dwelling Receptors (South)*

7.5 Railway Results

7.5.1 Impact Significance Determination

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

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

Where reflections are geometrically possible but expected to be screened, no impact is predicted, and mitigation is not required.

Where reflections originate from outside of a train driver's primary horizontal field-of-view (30 degrees either side of the direction of travel), or the closest reflecting panel is over 500m from the railway user, the impact significance is low, and mitigation is not recommended.

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

- Whether the solar reflection originates from directly in front of a train driver. Solar reflections that are directly in front of a train driver are more hazardous;
- The separation distance to the reflecting panel area. Larger separation distances reduce the proportion of an observer's field-of-view that is affected by glare;
- The position of the Sun. Effects that coincide with direct sunlight appear less prominent than those that do not. The Sun is a far more significant source of light;
- Whether a signal, station, level crossing, or switching point is located within the reflection zone.

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

7.5.2 Results Discussion

The modelling has shown that solar reflections are geometrically possible towards all 48 of the assessed receptors. Table 11 below summarises the predicted impact at these receptors.

Railway Receptor	Geometric Modelling Results (screening not considered)	Identified Screening (desk-based review)	Mitigating Factors	Impact Classification	Mitigation Recommended?
1 – 16, 20 – 48	Solar reflections geometrically possible from **inside** a train driver's primary field-of-view[25]	Existing vegetation is predicted to significantly obstruct views of reflecting panels	N/A	No impact	No
17 – 19	Solar reflections geometrically possible from **inside** a train driver's primary field-of-view	Existing vegetation is predicted to partially obstruct views of reflecting panels	Any remaining solar reflections will be fleeting and coincide with direct solar radiance	Low impact	No

Table 11 *Impact classification – railway receptors*

[25] 30 degrees either side of the direction of travel

7.6 Mitigation Strategy

7.6.1 Road Mitigation

A moderate impact has been predicted upon separate 0.3km and 0.1km sections of the B4027.

The locations identified for proposed mitigation and/or gap-filling are shown as the purple lines in Figures 87 and 88 below. Screening may be provided in the form of vegetation or a fence; if vegetation is used, it should be ensured that it sufficiently screens solar reflections for a typical road user between mid-March and late-September, when reflections are geometrically possible.

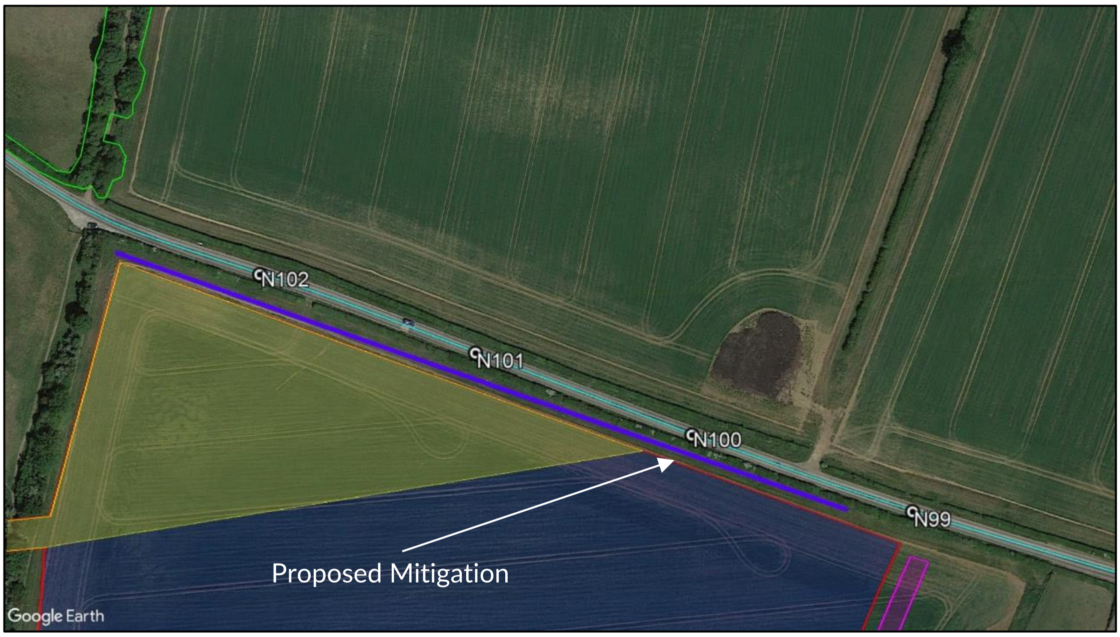

Figure 87 *Reflective panel area and proposed mitigation for road receptors N99 to N102*

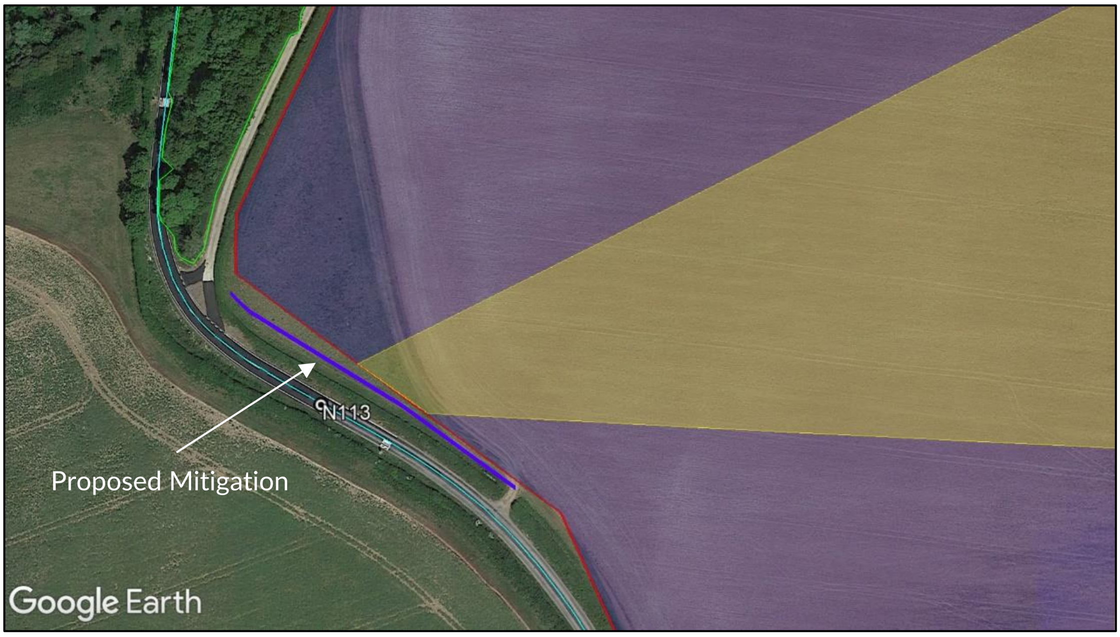

Figure 88 *Reflective panel area and proposed mitigation for road receptor N113*

7.6.2 Dwelling Mitigation

A moderate impact has been predicted upon seven dwellings.

The locations identified for proposed mitigation and/or gap-filling are shown as the purple lines in Figures 89 to 91 below and on the following page. Screening may be provided in the form of vegetation or a fence; if vegetation is used, it should be ensured that it sufficiently screens solar reflections towards at least the ground floor of the dwellings between mid-March and late-September, when reflections are geometrically possible.

Figure 89 *Reflective panel area and proposed mitigation for dwellings N36 and N37*

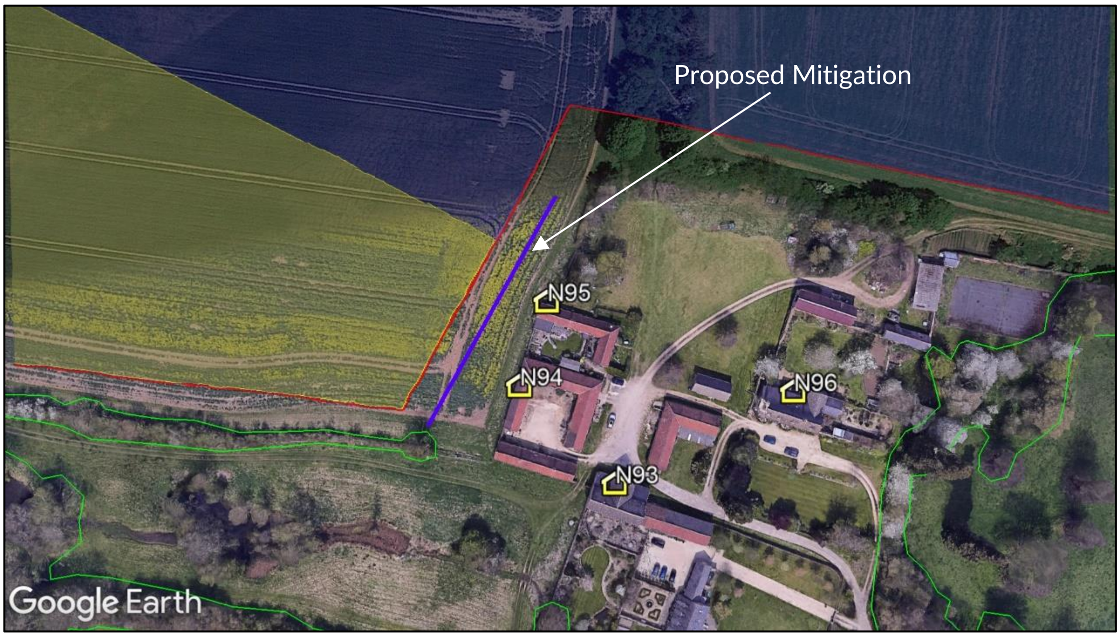

Figure 90 *Reflective panel area and proposed mitigation for dwellings N93 to N96*

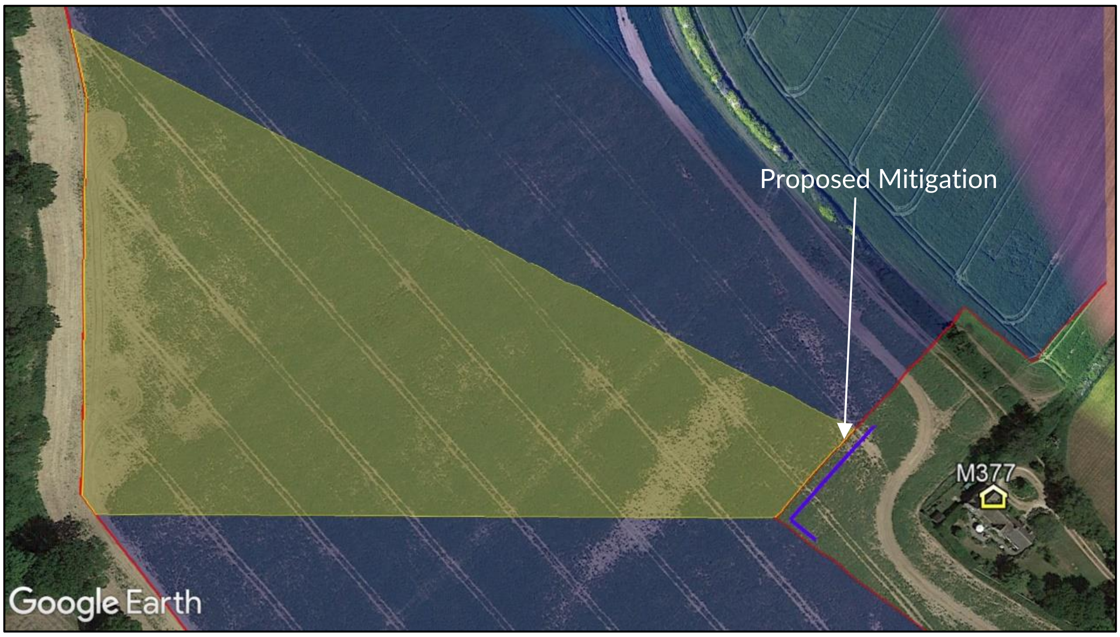

Figure 91 *Reflective panel area and proposed mitigation for dwelling M377*

8 HIGH-LEVEL AVIATION CONSIDERATIONS

8.1 Overview

The following section presents an overview of the possible effects of glint and glare concerning aviation activity at a high-level.

The locations of the airfields relative to the proposed development are shown in Figures 92 and 93 on pages 98 and 99, and summarised below:

- Enstone Aerodrome: approximately 7.8km north-west of the proposed development;
- RAF Weston-on-the-Green: approximately 6.7km east of the proposed development;
- Oaklands Farm Airfield: approximately 5.4km west of the proposed development;
- RAF Abingdon: approximately 5.4km south of the proposed development.

8.2 Aerodrome Details

8.2.1 Enstone Aerodrome Information

Enstone Aerodrome is an unlicensed aerodrome and is not understood to have an Air Traffic Control (ATC) Tower. It has three operational runways, the details[26] of which are presented below:

- 08/26 measuring 800m by 18m (asphalt);
- 08/26 measuring 565m by 25m (grass southside);
- 08/26 measuring 820m by 18m (grass northside).

8.2.2 RAF Weston-on-the-Green Information

RAF Weston-on-the-Green is a licensed military aerodrome and is not understood to have an ATC Tower. It has three operational runways, the details[26] of which are presented below:

- 01/19 measuring 978m by 13m (grass);
- 05/23 measuring 1,060m by 13m (grass);
- 10/28 measuring 1,219m by 13m (grass).

8.2.3 Oaklands Farm Airfield Information

Oaklands Farm Airfield is an unlicensed aerodrome and is not understood to have an ATC Tower. It has one operational runway, the details[27] of which are presented below:

- 11/29 measuring 380m by 18m (grass).

8.2.4 RAF Abingdon Information

RAF Abingdon is a licensed military aerodrome and is not understood to have an ATC Tower. It has two operational runways, the details[9] of which are presented below:

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[26] Pooleys Flight Guide, 61st Edition
[27] As determined by available aerial imagery

- 08/26 measuring 1,067m by 40m (asphalt);
- 18/36 measuring 1,802m by 45m (asphalt).

8.2.5 RAF Brize Norton Information

RAF Brize Norton is a licensed military aerodrome with an ATC Tower. It has one operational runway, the details[28] of which are presented below:

- 07/25 measuring 3,050m by 56m (asphalt).

[28] UK Mil AIP, effective 07/09/23

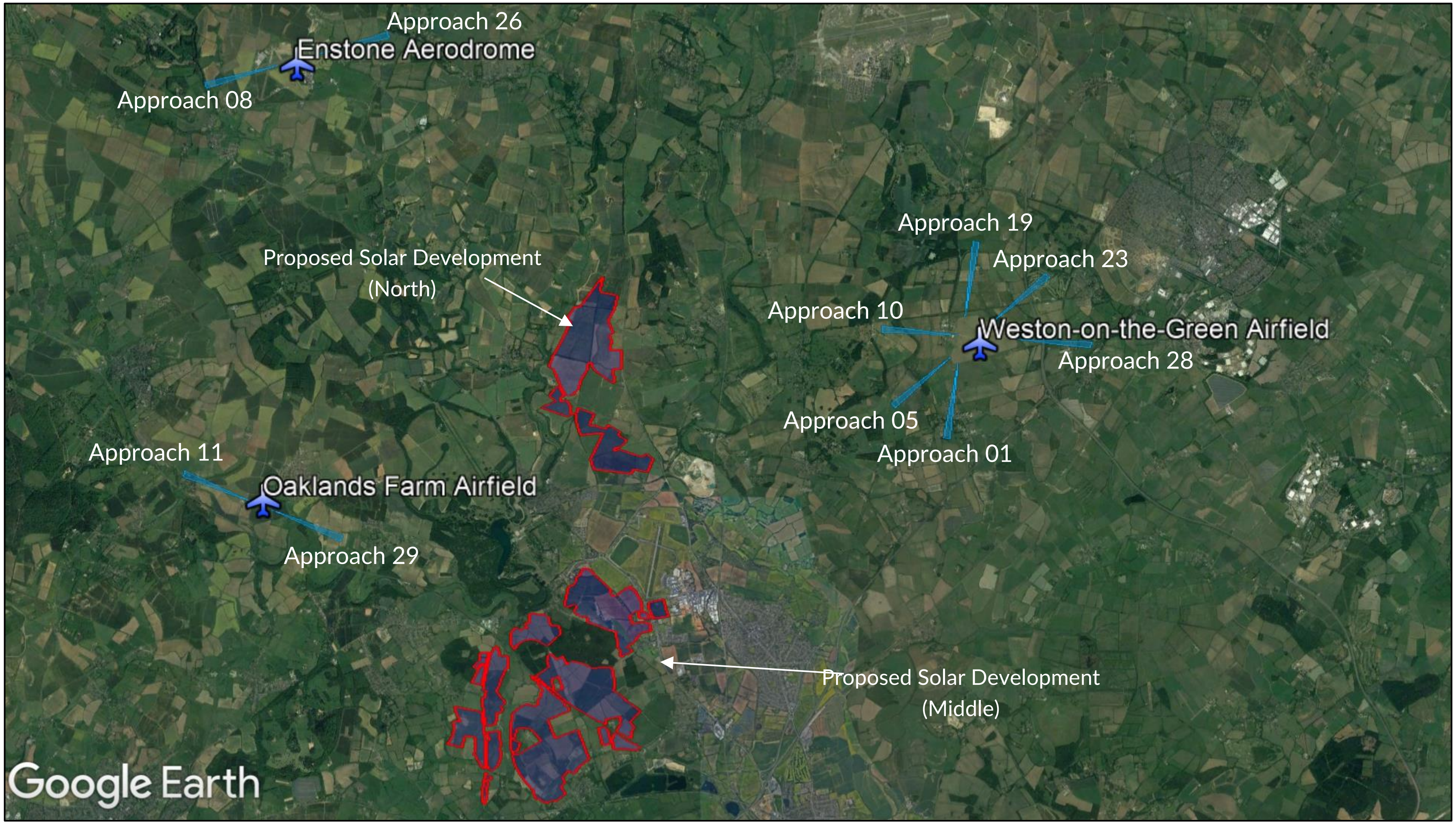

Figure 92 *Locations of Enstone Aerodrome, Weston-on-the-Green Airfield and Oaklands Farm Airfield relative to the proposed solar development*

Figure 93 *Locations of RAF Abingdon and RAF Brize Norton relative to the proposed solar development*

8.3 High-Level Assessment Conclusions

Considerations of the proposed development size, distance between the aerodrome and proposed development, and previous project experience are made during the assessment.

Reference to a pilot's primary field-of-view is made when determining the predicted impact significance, which is defined as 50 degrees either side of the 2-mile approach path, relative to the runway threshold.

8.3.1 Enstone Aerodrome

For aviation activity associated with Enstone Aerodrome, the following can be concluded:

- Any solar reflections towards pilots approaching runway threshold 26 will be outside a pilot's primary field-of-view. This level of glare is acceptable in accordance with the associated guidance and industry best practice;
- It is also predicted that any solar reflections towards pilots approaching runway threshold 07 would have intensities no greater than 'low potential for temporary after-image'. Based upon site size, distance, and previous project experience, this level of glare is acceptable in accordance with the associated guidance and industry best practice.

As a result, no significant impacts are predicted upon aviation activity at Enstone Aerodrome and detailed modelling is not recommended.

8.3.2 RAF Weston-on-the-Green

For aviation activity associated with RAF Weston-on-the-Green, the following can be concluded:

- Any solar reflections towards pilots approaching runway thresholds 01, 05 and 10 will be outside a pilot's primary field-of-view. This level of glare is acceptable in accordance with the associated guidance and industry best practice;
- It is also predicted that any solar reflections towards pilots approaching runway thresholds 19, 23 and 28 would have intensities no greater than 'low potential for temporary after-image'. Based upon site size, distance, and previous project experience, this level of glare is acceptable in accordance with the associated guidance and industry best practice.

As a result, no significant impacts are predicted upon aviation activity at RAF Weston-on-the Green and detailed modelling is not recommended.

8.3.3 Oaklands Farm Airfield

For aviation activity associated with Oaklands Farm Airfield, the following can be concluded:

- Any solar reflections towards pilots approaching runway threshold 29 will be outside a pilot's primary field-of-view. This level of glare is acceptable in accordance with the associated guidance and industry best practice;
- It is also predicted that any solar reflections towards pilots approaching runway threshold 11 would have intensities no greater than 'low potential for temporary after-image'. Based upon site size, distance, and previous project experience, this level of glare is acceptable in accordance with the associated guidance and industry best practice.

As a result, no significant impacts are predicted upon aviation activity at Oaklands Farm Airfield and detailed modelling is not recommended.

8.3.4 RAF Abingdon

For aviation activity associated with RAF Abingdon, the following can be concluded:

- Any solar reflections towards pilots approaching runway thresholds 08, 18 and 26 will be outside a pilot's primary field-of-view. This level of glare is acceptable in accordance with the associated guidance and industry best practice;
- It is also predicted that any solar reflections towards pilots approaching runway threshold 36 would have intensities no greater than 'low potential for temporary after-image'. Based upon site size, distance, and previous project experience, this level of glare is acceptable in accordance with the associated guidance and industry best practice.

As a result, no significant impacts are predicted upon aviation activity at RAF Abingdon and detailed modelling is not recommended.

8.3.5 RAF Brize Norton

For aviation activity associated with RAF Brize Norton, the following can be concluded:

- Any solar reflections towards pilots approaching runway threshold 25 will be outside a pilot's primary field-of-view. This level of glare is acceptable in accordance with the associated guidance and industry best practice;
- It is also predicted that any solar reflections towards pilots approaching runway threshold 07 would have intensities no greater than 'low potential for temporary after-image'. Based upon site size, distance, and previous project experience, this level of glare is acceptable in accordance with the associated guidance and industry best practice;
- It can be reliably predicted that personnel within the ATC tower will not experience solar reflections. This is based upon ATC Tower height, the distance to the proposed development, and previous project experience.

As a result, no significant impacts are predicted upon aviation activity at RAF Brize Norton and detailed modelling is not recommended.

9 OVERALL CONCLUSIONS

9.1 Assessment Conclusions – Oxford Airport

Solar reflections are geometrically possible towards the ATC Tower, however existing vegetation and buildings are predicted to partially screen views of the panels. The closest reflecting panel area is also at least 1.6km from the ATC Tower, and reflections are predicted to coincide with direct solar radiance. A low impact is predicted and no mitigation is required.

The analysis has shown that solar reflections are predicted towards the approach paths for runways 01 and 19. Solar reflections towards both approach paths will be outside of a pilot's primary field-of-view. This is deemed acceptable in line with the associated guidance and industry standards; a low impact is predicted, and mitigation is not required.

Overall, a low impact is predicted towards Oxford Airport, and no mitigation is required.

9.2 Assessment Conclusions – Roads

Solar reflections are geometrically possible towards 381 of the 417 assessed road receptors.

No relevant screening or other mitigating factors have been identified for separate 0.3km and 0.1km sections of the B4027, where reflections are within a road user's primary field-of-view. A moderate impact is predicted and mitigation is recommended (see Section 7.6.1).

For the remaining sections of road, screening in the form of existing and/or proposed vegetation is predicted to significantly obstruct views of reflecting panels. No significant impacts are predicted, and no mitigation is recommended.

9.3 Assessment Conclusions – Dwellings

Solar reflections are geometrically possible towards 632 of the 699 assessed dwellings.

For seven dwellings, no significant relevant screening or other mitigating factors has been identified. A moderate impact is predicted and mitigation is recommended (see Section 7.6.2).

For the remaining 625 dwellings, screening in the form of existing and proposed vegetation is predicted to obstruct views of reflecting panels. No significant impacts are predicted, and no mitigation is recommended.

9.4 Assessment Conclusions – Railway

Solar reflections are geometrically possible towards all 48 of the assessed railway receptors.

For separate 0.2km and 0.1km sections of railway, partial vegetation screening would restrict solar reflections to fleeting views of the reflecting panels over vegetation, and reflections would coincide with direct solar radiance. A low impact is predicted and no mitigation is recommended.

For the remaining sections of railway, screening in the form of existing vegetation is predicted to significantly obstruct views of reflecting panels. No impact is predicted, and no mitigation is required.

9.5 High-Level Conclusions – Aviation

9.5.1 Enstone Aerodrome

Any solar reflections towards Enstone Aerodrome are predicted to be acceptable in accordance with the associated guidance and industry best practice. Any possible solar reflections towards runway 08 would have an intensity no greater than 'low potential for temporary after-image'. Solar reflections would be outside a pilot's primary field-of-view (50 degrees either side of the approach bearing) for pilots on approach to runway 26. Therefore, no significant impacts are predicted upon aviation activity at Enstone Aerodrome and detailed modelling is not recommended.

9.5.2 RAF Weston-on-the-Green

Any solar reflections towards RAF Weston-on-the-Green are predicted to be acceptable in accordance with the associated guidance and industry best practice. Any possible solar reflections towards runways 19, 23 and 28 would have an intensity no greater than 'low potential for temporary after-image'. Solar reflections would be outside a pilot's primary field-of-view for pilots on approach to runways 01, 05 and 10. Therefore, no significant impacts are predicted upon aviation activity at RAF Weston-on-the-Green and detailed modelling is not recommended.

9.5.3 Oaklands Farm Airfield

Any solar reflections towards Oaklands Farm Airfield are predicted to be acceptable in accordance with the associated guidance and industry best practice. Any possible solar reflections towards runway 11 would have an intensity no greater than 'low potential for temporary after-image'. Solar reflections would be outside a pilot's primary field-of-view for pilots on approach to runway 29. Therefore, no significant impacts are predicted upon aviation activity at Oaklands Farm Airfield and detailed modelling is not recommended.

9.5.4 RAF Abingdon

Any solar reflections towards RAF Abingdon are predicted to be acceptable in accordance with the associated guidance and industry best practice. Any possible solar reflections towards runway 36 would have an intensity no greater than 'low potential for temporary after-image'. Solar reflections would be outside a pilot's primary field-of-view for pilots on approach to runways 08, 18 and 26. Therefore, no significant impacts are predicted upon aviation activity at RAF Abingdon and detailed modelling is not recommended.

9.5.5 RAF Brize Norton

Any solar reflections towards RAF Brize Norton are predicted to be acceptable in accordance with the associated guidance and industry best practice. Any possible solar reflections towards runway 07 would have an intensity no greater than 'low potential for temporary after-image'. Solar reflections would be outside a pilot's primary field-of-view for pilots on approach to runway 25. The ATC tower is also predicted not to experience solar reflections based upon the tower height and distance to the proposed development.

Therefore, no significant impacts are predicted upon aviation activity at RAF Brize Norton and detailed modelling is not recommended.

9.6 Overall Conclusions

A moderate impact is predicted upon road safety at two sections of the B4027 for which mitigation is recommended (see Section 7.6.1).

A moderate impact is predicted upon residential amenity for seven dwellings for which mitigation is recommended (see Section 7.6.2).

No significant impacts are predicted upon aviation activity or railway infrastructure and operations, and no mitigation is required.

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

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

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

UK Planning Policy

Renewable and Low Carbon Energy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[29] (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.'

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

Draft National Policy Statement for Renewable Energy Infrastructure

The Draft National Policy Statement for Renewable Energy Infrastructure (EN-3)[30] sets out the primary policy for decisions by the Secretary of State for nationally significant renewable energy infrastructure. Sections 3.10.93-97 state:

'3.10.93 Solar panels are specifically designed to absorb, not reflect, irradiation.[31] 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.

3.10.94 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.

3.10.95 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.

3.10.96 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.

3.10.97 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 3.10.125-127 state:

3.10.125 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.

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

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[30] Draft National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Energy Security & Net Zero, date: March 2023, accessed on: 05/04/2023.

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

3.10.127 *Applicants may consider adjusting the azimuth alignment of or changing the elevation tilt angle of a solar panel, within the economically viable range, to alter the angle of incidence. In practice this is unlikely to remove the potential impact altogether but in marginal cases may contribute to a mitigation strategy*.

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

Sections 3.10.149-150 state:

3.10.149 *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).*

3.10.150 *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 latest version of the draft EN-3 goes some way in referencing that the issue is more complex than presented in the previous issue; 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 impact upon aviation safety. It is possible that the final issue of the policy will change in light of further consultation responses from aviation stakeholders.

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 is provided for 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[32] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

[32] Pager Power Glint and Glare Guidance, Fourth Edition (4.0), August 2022.

Assessment Process – Railways

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

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

Railway Assessment Guidelines

The following section provides an overview of the relevant railway guidance with respect to the siting of signals on railway lines. Network Rail is the stakeholder of the UK's railway infrastructure.

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

Reflections and glare

Rationale

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

Guidance

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

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

The extent to which excessive illumination could make an asset appear to show a different signal aspect or indication to the one being presented can be influenced by the product being used.

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

Requirements for assessing the phantom display performance of signalling products are set out in GKRT0057 section 4.1.

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

a) *Disability glare, caused by scattering of light in the eye, can make it difficult to read a lit display.*
b) *Discomfort glare, which is often associated with disability glare. While being unpleasant, it does not affect the signal reading time directly, but may lead to distraction and fatigue.*

Examples of the adverse effect of disability glare include:

a) *When a colour light signal presenting a lit yellow aspect is viewed at night but the driver is unable to determine whether the aspect is a single yellow or a double yellow.*
b) *Where a colour light signal is positioned beneath a platform roof painted white and the light reflecting off the roof can make the signal difficult to read.*

Options for militating against A5 include:

a) *Using a product that is specified to achieve high light source: phantom ratio values.*
b) *Alteration to the features causing the glare or reflection.*
c) *Provision of screening.*

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

Determining the Field of Focus

The extract below is taken from Appendix F - Guidance on Field of Vision (pages 98-101) of the 'Signal Sighting Assessment Requirements'[34] which details the visibility of signals, train drivers' field of vision and the implications with regard to signal positioning.

Asset visibility

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

a) *Position in the observer's visual field.*
b) *Contrast with its background.*
c) *Luminance properties.*
d) *The observer's adaptation to the illumination level of the environment.*

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

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

Field of vision

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

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

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

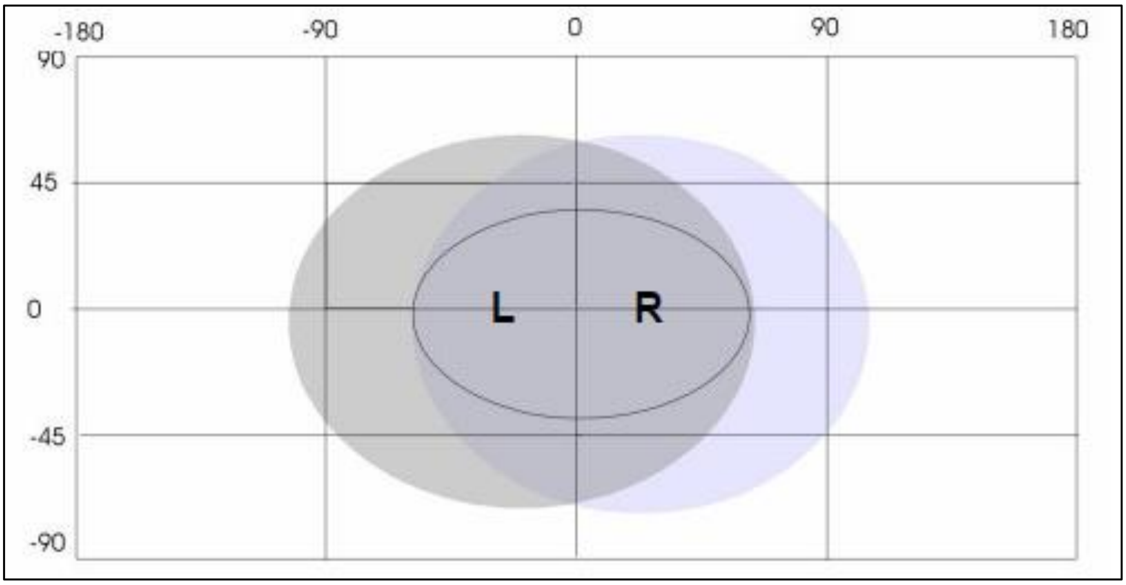

Figure G 21 - Field-of-view

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

Research has shown that drivers search for signs or signals towards the centre of the field of vision. Signals, indicators and signs should be positioned at a height and distance from the running line that permits them to be viewed towards the centre of the field of vision. This is because:

a) As train speed increases, drivers become increasingly dependent on central vision for asset detection. At high speeds, drivers demonstrate a tunnel vision effect and focus only on objects in a field of + 8^o from the direction of travel.

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

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

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

a) A co-acting signal.

b) A miniature banner repeater indicator.

c) A right away indicator.

d) A sign to remind the driver to check the signal aspect.

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

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

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

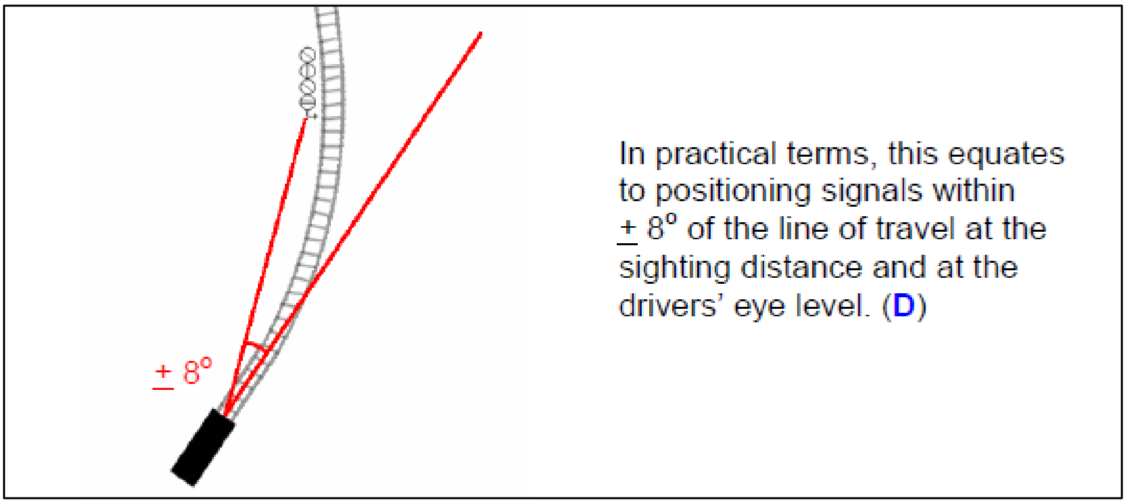

Figure G 22 - Signal positioning

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

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

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

Determining the Assessed Minimum Reading Time

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

'B5.2.2 Determining the assessed minimum reading time

GE/RT8037

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

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

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

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

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

Signal Design and Lighting System

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

- An LED railway signal produces a more intense light making them more visible to approaching trains when compared to the traditional filament bulb technology[35];

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

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

Many LED signal manufacturers[36,37,38] claim that LED signal lights significantly reduce or completely remove the likelihood of a phantom aspect illumination occurring.

Aviation Assessment Guidance

The UK Civil Aviation Authority (CAA) issued interim guidance relating to Solar Photovoltaic Systems (SPV) on 17 December 2010 and was subject to a CAA information alert 2010/53. The formal policy was cancelled on September 7th, 2012[39] however the advice is still applicable[40] 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

[36] Source: [redacted] Last accessed 21.02.18).
[37] Source: [redacted] (Last accessed 21.02.18).
[38] Source: Siemens, Sigmaguard LED Tri-Colour L Signal – LED Signal Technology at Incandescent Prices. Datasheet 1A-23. (Last accessed 22.02.18).
[39] Archived at Pager Power
[40] Reference email from the CAA dated 19/05/2014.

is the responsibility of the ALH[41], as part of a condition of a CAA Aerodrome Licence, the ALH is required to obtain prior consent from CAA Aerodrome Standards Department before any work is begun or approval to the developer or LPA is granted, in accordance with the procedures set out in CAP 791 Procedures for Changes to Aerodrome Infrastructure.

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

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

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

FAA Guidance

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

The 2010 document is entitled 'Technical Guidance for Evaluating Selected Solar Technologies on Airports'[42], the 2013 update is entitled 'Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'[43], and the 2021 final policy is entitled 'Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports'[44].

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.

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[41] Aerodrome Licence Holder.

[42] Archived at Pager Power

[43] Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports, Department of Transportation, Federal Aviation Administration (FAA), date: 10/2013, accessed on: 08/12/2021.

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

The 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.

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’[45]. 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[46].

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

[46] 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.

- 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[47], flat, smooth surfaces reflect a more concentrated amount of sunlight back to the receiver, which is referred to as specular reflection. The more a surface is polished, the more it shines. Rough or uneven surfaces reflect light in a diffused or scattered manner and, therefore, the light will not be received as bright.
- Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:
    - A qualitative analysis of potential impact in consultation with the Control Tower, pilots and airport officials;
    - A demonstration field test with solar panels at the proposed site in coordination with FAA Tower personnel;
    - A geometric analysis to determine days and times when an impact is predicted.
- The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and system design.
- **1. Assessing Baseline Reflectivity Conditions** – Reflection in the form of glare is present in current aviation operations. The existing sources of glare come from glass windows, auto surface parking, rooftops, and water bodies. At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing. Operators also wear polarized eye wear. Potential glare from solar panels should be viewed in this context. Any airport considering a solar PV project should first review existing sources of glare at the airport and the effectiveness of measures used to mitigate that glare.
- **2. Tests in the Field** – Potential glare from solar panels can easily be viewed at the airport through a field test. A few airports have coordinated these tests with FAA Air Traffic Controllers to assess the significance of glare impacts. To conduct such a test, a sponsor can take a solar panel out to proposed location of the solar project, and tilt the panel in different directions to evaluate the potential for glare onto the air traffic control tower. For the two known cases where a field test was conducted, tower personnel determined the glare was not significant. If there is a significant glare impact, the project can be modified by ensuring panels are not directed in that direction.
- **3. Geometric Analysis** – Geometric studies are the most technical approach for reflectivity issues. They are conducted when glare is difficult to assess through other methods. Studies of glare can employ geometry and the known path of the sun to

[47] First figure in Appendix B.

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[48] 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[49] with regard to safeguarding. Key points from the document are presented below.

Lights liable to endanger

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

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

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

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

(a) to extinguish or screen the light; and

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[48] 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.
[49] The Air Navigation Order 2016. [online] Available at: [redacted] [Accessed 4 February 2022].

(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 Order 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

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

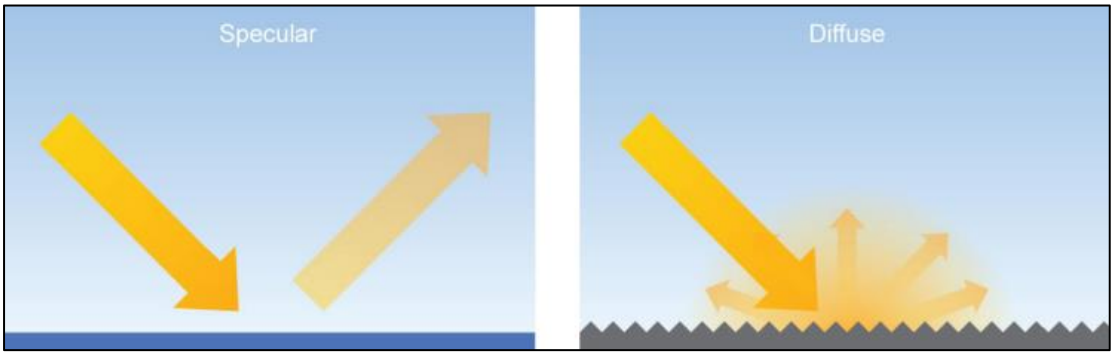
Overview

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[50], 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

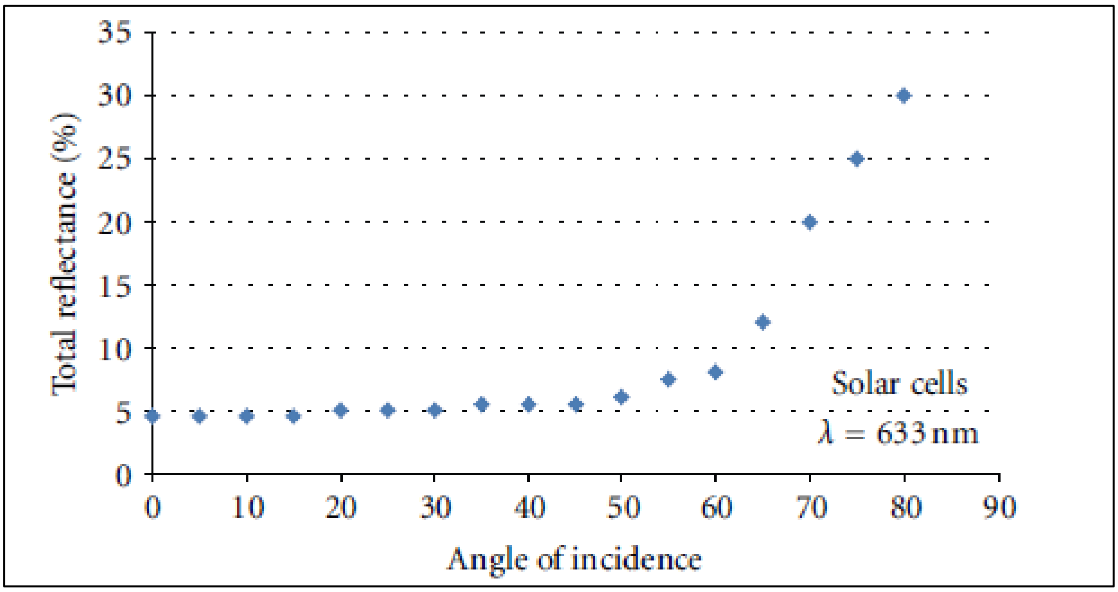
[50] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

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[51]". They researched the potential glare that a pilot could experience from a 25 degree fixed tilt PV system located outside of Las Vegas, Nevada. The theoretical glare was estimated using published ocular safety metrics which quantify the potential for a postflash glare after-image. This was then compared to the postflash glare after-image caused by smooth water. The study demonstrated that the reflectance of the solar cell varied with angle of incidence, with maximum values occurring at angles close to 90 degrees. The reflectance values varied from approximately 5% to 30%. This is shown on the figure below.



Total reflectance % when compared to angle of incidence

The conclusions of the research study were:

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

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

FAA Guidance – "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[52]

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

Surface	Approximate Percentage of Light Reflected[53]
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.

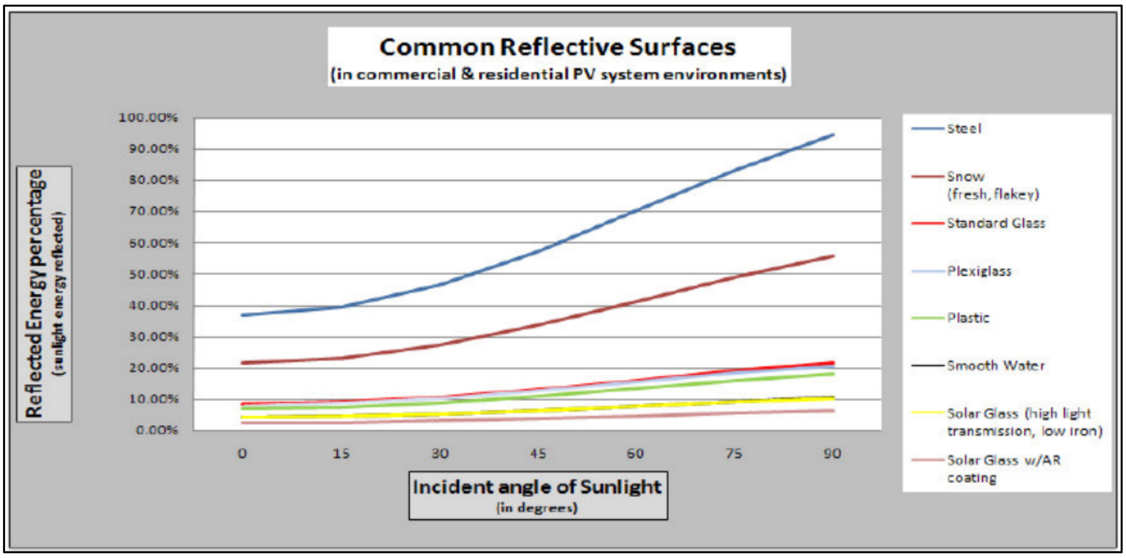
SunPower Technical Notification (2009)

[52] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

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

SunPower published a technical notification[54] to 'increase awareness concerning the possible glare and reflectance impact of PV Systems on their surrounding environment'.

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



Common reflective surfaces

The results, similarly to those from Riley and Olsen study (2011) and the FAA (2010), show that solar panels produce a reflection that is less intense than those of 'standard glass and other common reflective surfaces'.

With respect to aviation and solar reflections observed from the air, SunPower has developed several large installations near airports or on Air Force bases. It is stated that these developments have all passed FAA or Air Force standards with all developments considered "No Hazard to Air Navigation". The note suggests that developers discuss any possible concerns with stakeholders near proposed solar farms.

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

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

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

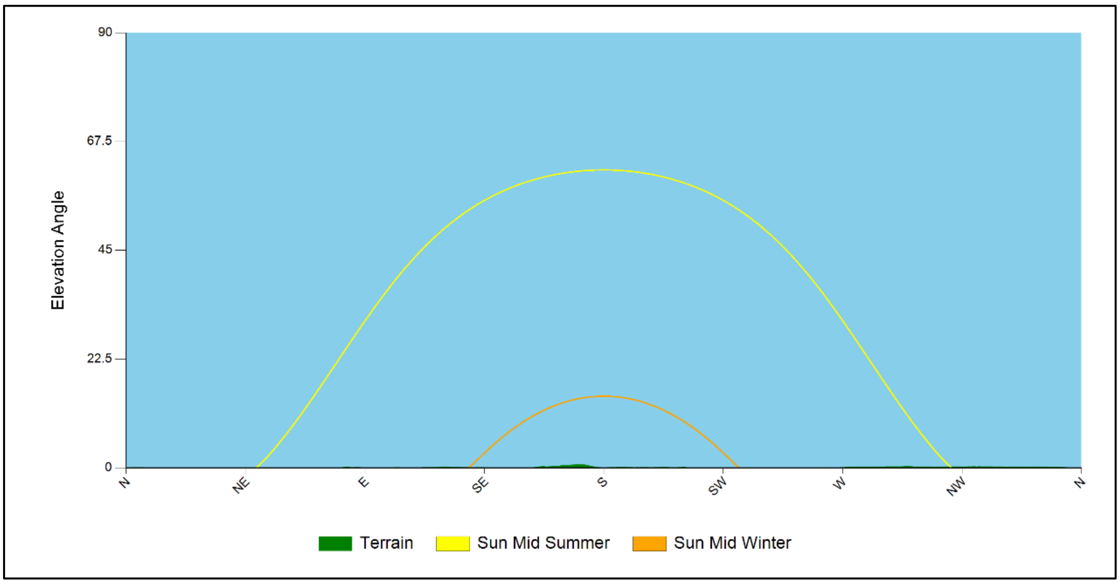
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

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

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

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

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



Sunrise and sunset curves

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact Significance Definition

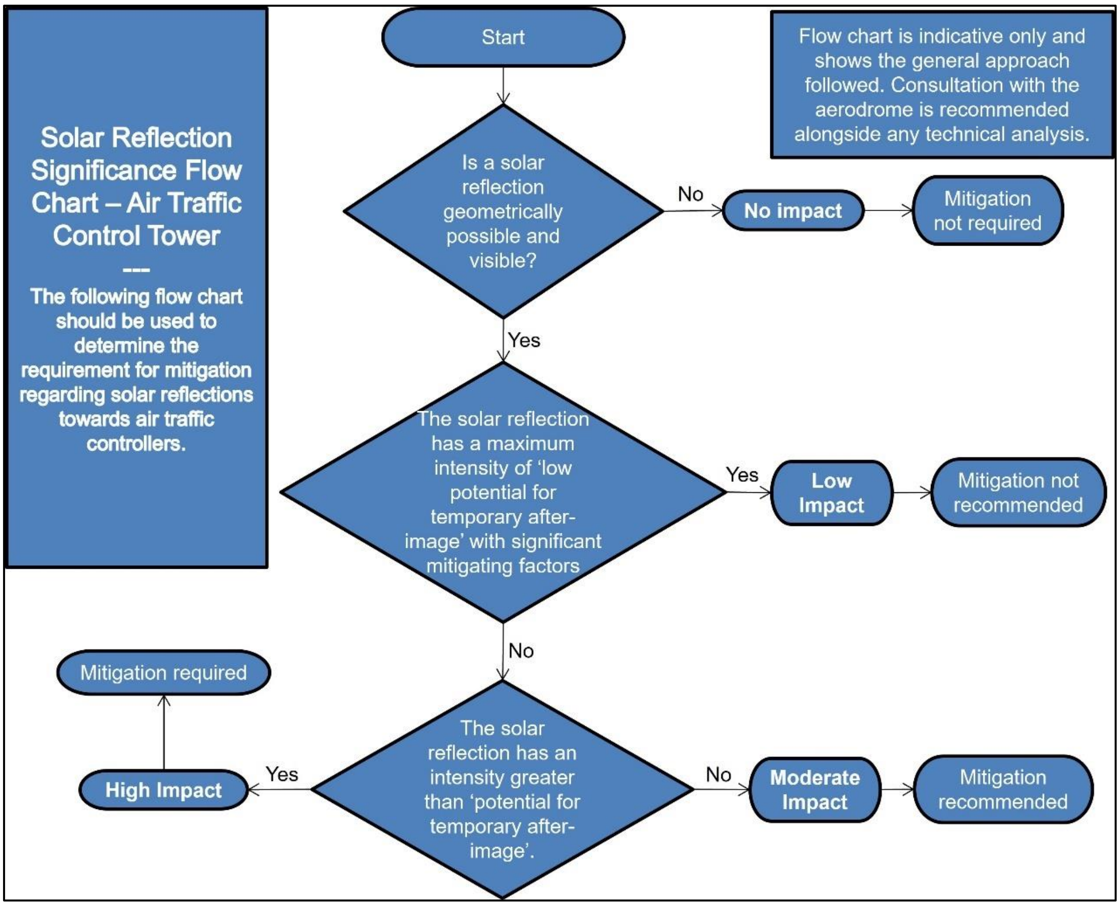
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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

Impact significance definition

Impact Significance Determination for ATC Towers

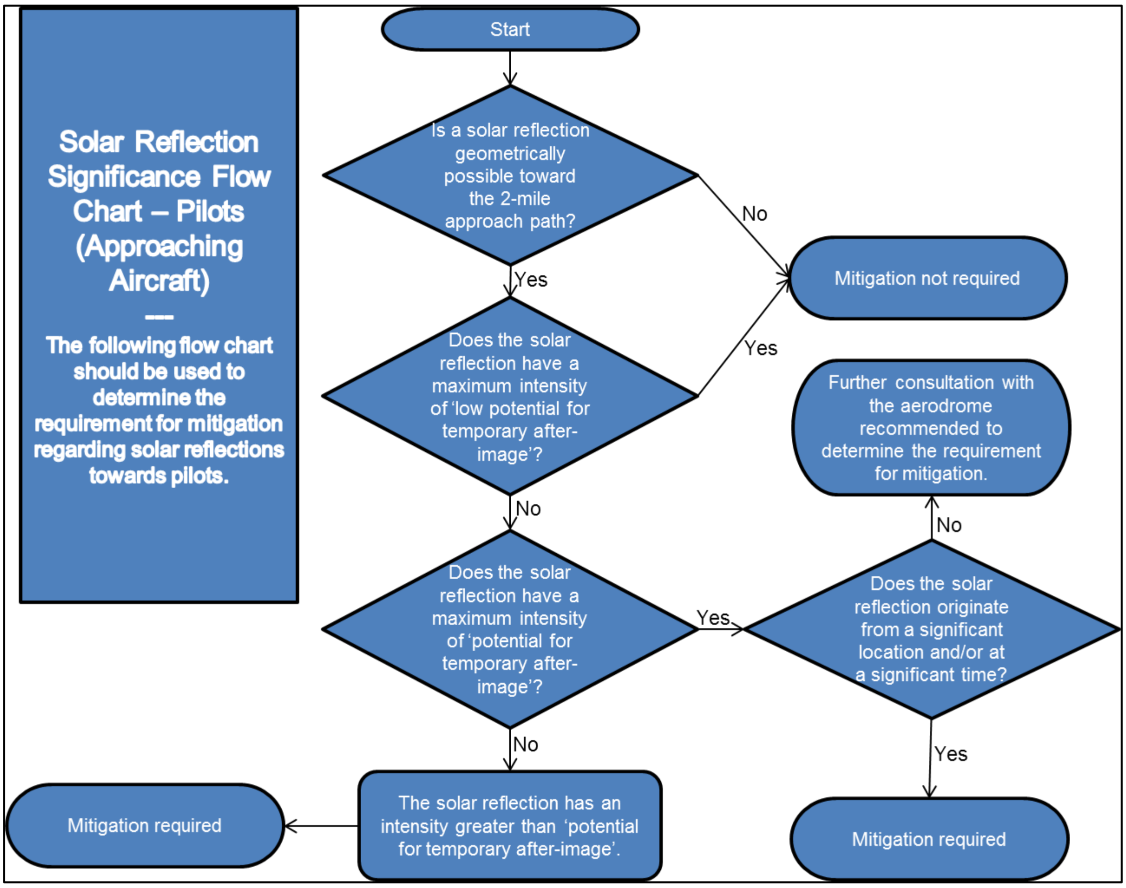
The flow chart presented below has been followed when determining the mitigation requirement for ATC Towers.



ATC Tower receptor mitigation requirement flow chart

Impact Significance Determination for Approaching Aircraft

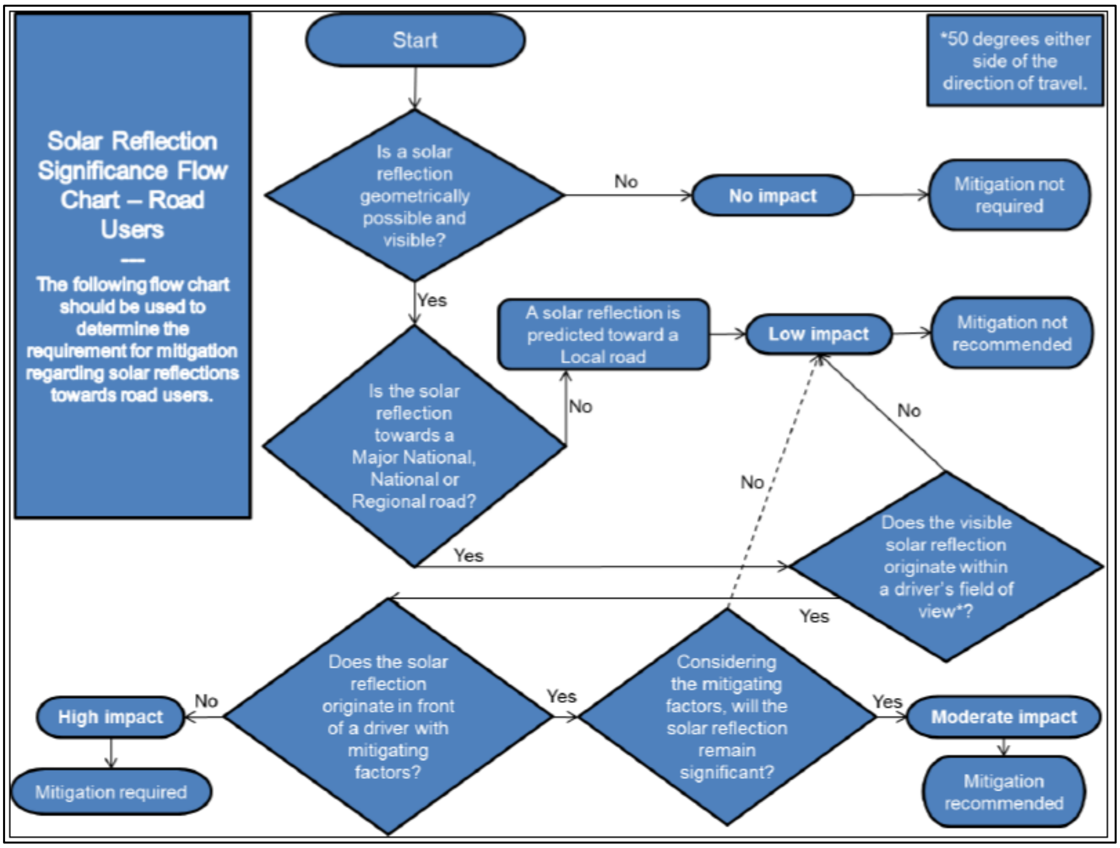
The flow chart presented below has been followed when determining the mitigation requirement for approaching aircraft.



Approaching aircraft receptor impact significance flow chart

Impact Significance Determination for Road Receptors

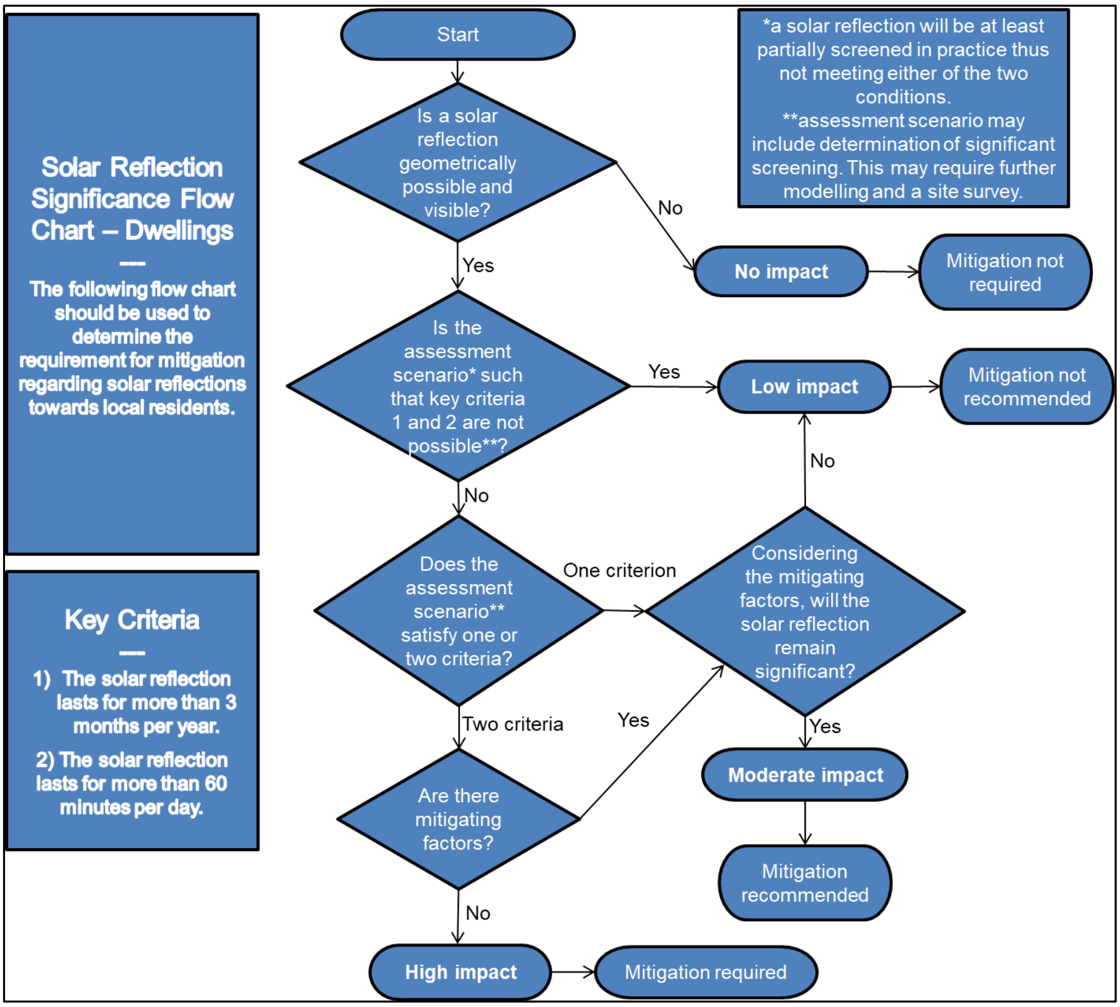
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road receptor impact significance flow chart

Impact Significance Determination for Dwelling Receptors

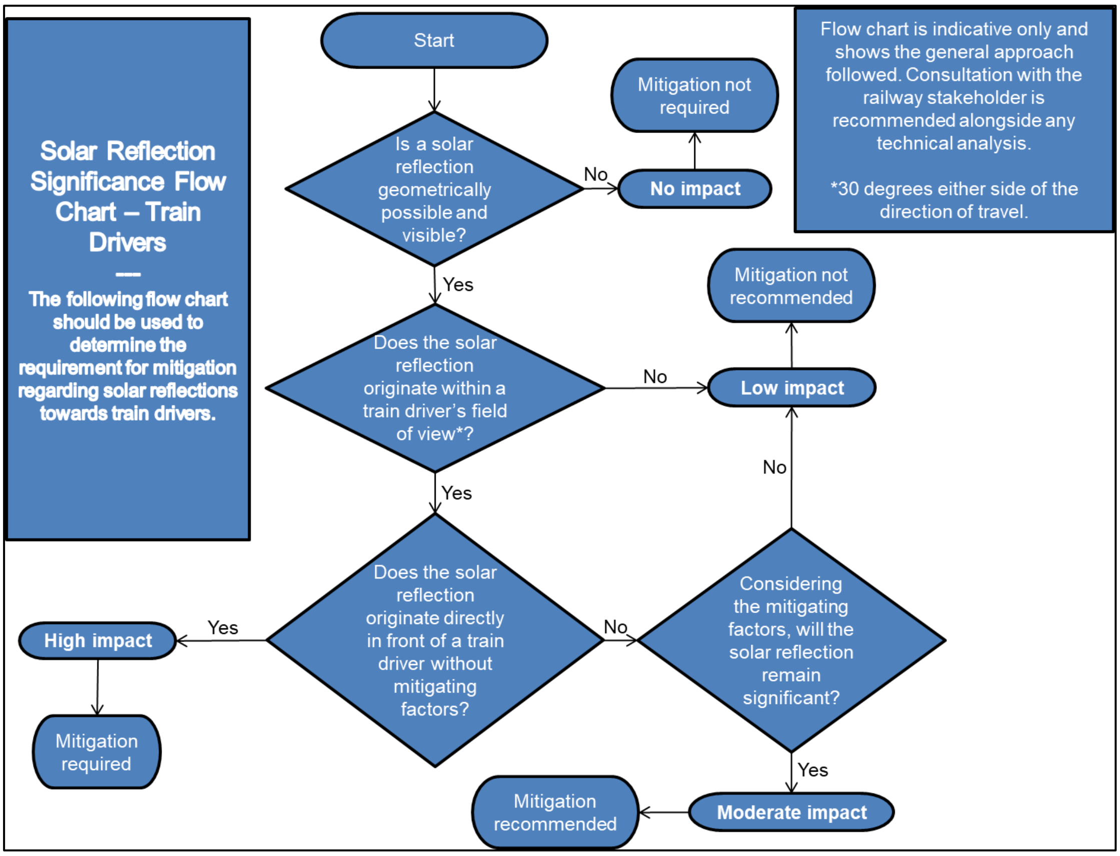
The flow chart presented below has been followed when determining the mitigation requirement for dwelling receptors.



Dwelling receptor impact significance flow chart

Impact Significance Determination for Railway Receptors

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



Train driver impact significance flow chart

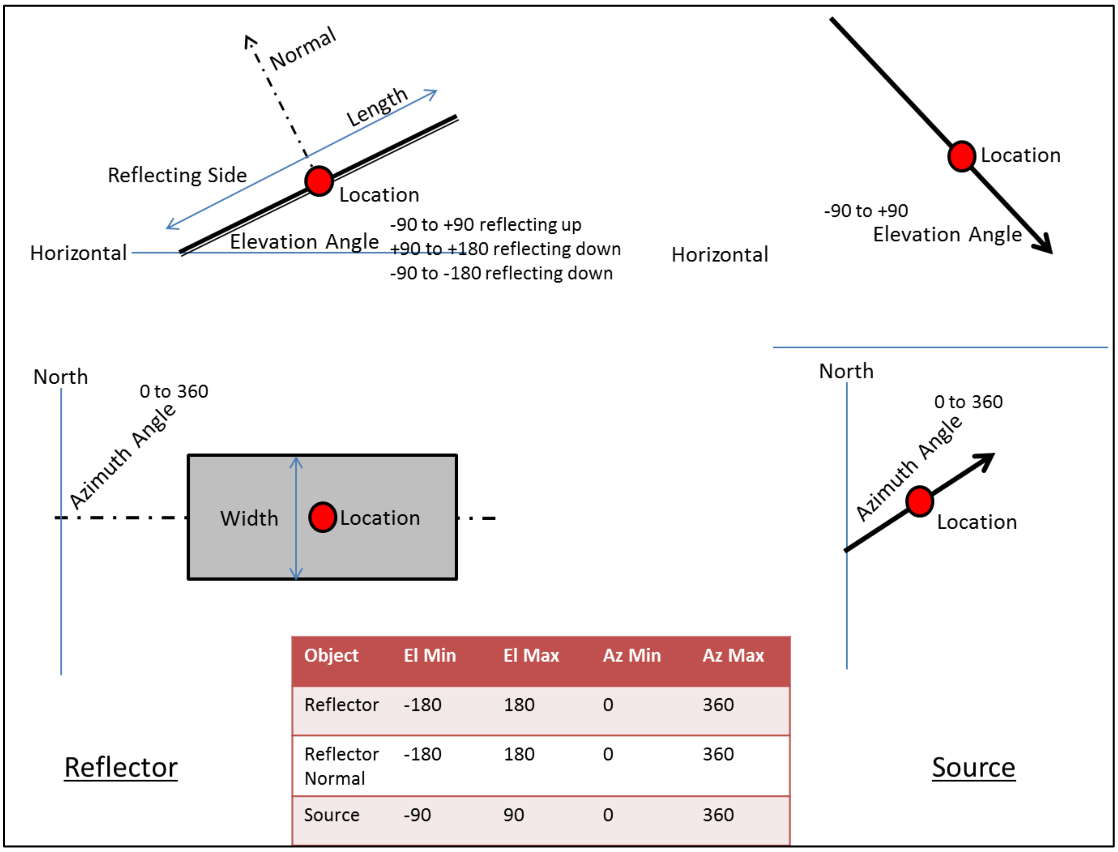
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Pager Power Methodology

The calculations are three dimensional and complex, accounting for:

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

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



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

Reflection calculation process

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

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

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Pager Power's Model

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

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

The model considers terrain between the reflecting solar panels and the visible horizon (where the sun may be obstructed from view of the panels)[55].

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

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

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

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

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

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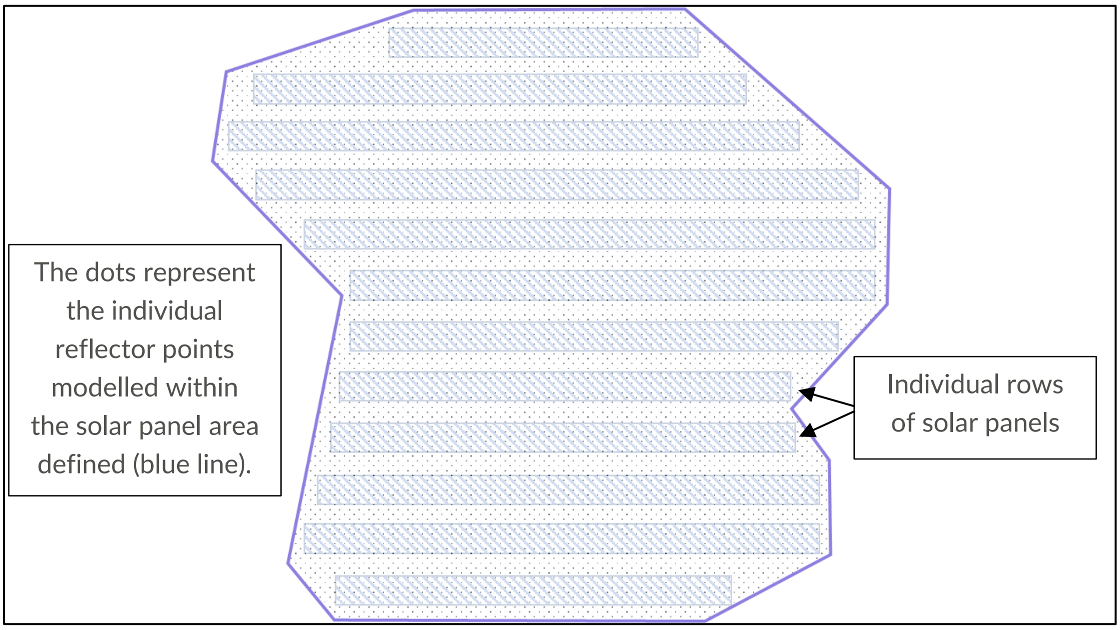
[55] UK only.



Solar panel area modelling overview

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

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

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

Forge's Sandia National Laboratories' (SGHAT) Model

The following text is taken from Forge[56] and is presented for reference.

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

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

[56] Source: [redacted]

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Aerodrome Details

The table below presents the data for the assessed airfields, including runway details. The receptor locations are based on the methodology set out in Section 5.1.

Aerodrome	Threshold	Longitude (°)	Latitude (°)	Threshold Height (m) (amsl)
Oxford Airport	01	-1.32173	51.83114	91.10
	19	-1.31818	51.84279	93.97

Assessed aerodrome information

Road Receptor Data

The road receptor data is presented in the tables 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 amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
N1	-1.32702	51.89042	112.50	N67	-1.31565	51.85394	81.50
N2	-1.32724	51.88953	113.50	N68	-1.31524	51.85480	83.76
N3	-1.32749	51.88865	113.50	N69	-1.31449	51.85557	86.90
N4	-1.32775	51.88776	112.50	N70	-1.31371	51.85632	88.65
N5	-1.32797	51.88687	112.50	N71	-1.31290	51.85707	91.50
N6	-1.32806	51.88597	112.50	N72	-1.31206	51.85780	89.19
N7	-1.32814	51.88508	112.50	N73	-1.31209	51.85869	84.10
N8	-1.32829	51.88418	112.24	N74	-1.31226	51.85958	85.17
N9	-1.32845	51.88329	111.22	N75	-1.31227	51.86048	86.44
N10	-1.32862	51.88239	110.50	N76	-1.31227	51.86137	90.78
N11	-1.32878	51.88150	109.50	N77	-1.31195	51.86178	90.30

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
N12	-1.32895	51.88060	109.33	N78	-1.30966	51.86236	75.14
N13	-1.32912	51.87971	108.50	N79	-1.31091	51.86190	84.05
N14	-1.32928	51.87882	108.30	N80	-1.31233	51.86189	91.50
N15	-1.32934	51.87792	107.50	N81	-1.31373	51.86214	92.45
N16	-1.32933	51.87702	107.50	N82	-1.31517	51.86229	93.84
N17	-1.32932	51.87612	107.50	N83	-1.31660	51.86244	94.25
N18	-1.32934	51.87522	106.50	N84	-1.31803	51.86261	94.58
N19	-1.32939	51.87432	106.50	N85	-1.31947	51.86276	95.23
N20	-1.32940	51.87342	106.50	N86	-1.32092	51.86286	95.98
N21	-1.32933	51.87252	106.38	N87	-1.32237	51.86291	97.85
N22	-1.32918	51.87163	105.86	N88	-1.32351	51.86263	98.79
N23	-1.32891	51.87074	105.50	N89	-1.32393	51.86295	99.50
N24	-1.32853	51.86987	104.94	N90	-1.32533	51.86284	100.79
N25	-1.32807	51.86902	104.50	N91	-1.32676	51.86302	101.34
N26	-1.32752	51.86819	104.37	N92	-1.32818	51.86320	101.50
N27	-1.32696	51.86736	104.13	N93	-1.32961	51.86339	102.11
N28	-1.32639	51.86653	104.93	N94	-1.33103	51.86359	102.50
N29	-1.32582	51.86570	103.38	N95	-1.33245	51.86378	103.50
N30	-1.32524	51.86487	102.50	N96	-1.33386	51.86402	101.78
N31	-1.32466	51.86405	101.50	N97	-1.33526	51.86428	101.50
N32	-1.32406	51.86323	99.50	N98	-1.33665	51.86453	101.41

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
N33	-1.32340	51.86242	98.50	N99	-1.33805	51.86479	100.93
N34	-1.32273	51.86163	97.50	N100	-1.33943	51.86508	100.24
N35	-1.32210	51.86081	96.37	N101	-1.34079	51.86540	97.71
N36	-1.32155	51.85998	95.23	N102	-1.34216	51.86571	92.19
N37	-1.32089	51.85918	92.20	N103	-1.34351	51.86604	89.30
N38	-1.32012	51.85842	91.50	N104	-1.34467	51.86658	90.06
N39	-1.31933	51.85766	91.32	N105	-1.34579	51.86716	90.73
N40	-1.31865	51.85686	90.50	N106	-1.34679	51.86781	91.87
N41	-1.31805	51.85604	88.86	N107	-1.34764	51.86854	92.50
N42	-1.31757	51.85520	86.98	N108	-1.34822	51.86937	95.45
N43	-1.31718	51.85433	83.78	N109	-1.34879	51.87019	94.98
N44	-1.31682	51.85346	81.50	N110	-1.34943	51.87100	99.22
N45	-1.31635	51.85261	81.50	N111	-1.34992	51.87185	102.56
N46	-1.31572	51.85180	81.50	N112	-1.35049	51.87267	104.40
N47	-1.31515	51.85097	81.50	N113	-1.35162	51.87323	104.26
N48	-1.31445	51.85018	81.50	N114	-1.35239	51.87391	96.62
N49	-1.31371	51.84940	81.50	N115	-1.35219	51.87480	88.88
N50	-1.31299	51.84862	78.13	N116	-1.35315	51.87536	88.22
N51	-1.31233	51.84782	73.74	N117	-1.35411	51.87603	94.67
N52	-1.31172	51.84717	71.50	N118	-1.35504	51.87673	93.95
N53	-1.32730	51.84435	87.76	N119	-1.35594	51.87743	96.73

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
N54	-1.32644	51.84508	87.50	N120	-1.35724	51.87782	103.50
N55	-1.32558	51.84581	87.50	N121	-1.35861	51.87813	104.50
N56	-1.32472	51.84653	86.50	N122	-1.35998	51.87843	105.77
N57	-1.32384	51.84725	84.01	N123	-1.36126	51.87885	107.03
N58	-1.32281	51.84788	82.50	N124	-1.36251	51.87931	103.83
N59	-1.32156	51.84835	81.76	N125	-1.36381	51.87969	105.45
N60	-1.32031	51.84880	80.79	N126	-1.36805	51.86349	109.22
N61	-1.31919	51.84937	81.50	N127	-1.36720	51.86276	107.17
N62	-1.31831	51.85009	81.50	N128	-1.36644	51.86199	105.40
N63	-1.31762	51.85088	82.50	N129	-1.36567	51.86123	103.87
N64	-1.31685	51.85164	81.50	N130	-1.36491	51.86046	103.14
N65	-1.31596	51.85201	81.50	N131	-1.36414	51.85970	102.36
N66	-1.31672	51.85340	81.50	N132	-1.36337	51.85893	100.93

Road Receptor Data (North)

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M1	-1.30275	51.83165	65.73	M108	-1.37143	51.80449	70.62
M2	-1.30408	51.83131	65.50	M109	-1.37127	51.80359	71.49
M3	-1.30551	51.83113	67.45	M110	-1.37120	51.80269	71.50
M4	-1.30693	51.83092	68.50	M111	-1.37123	51.80179	71.50
M5	-1.30834	51.83072	69.50	M112	-1.37122	51.80090	69.55

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M6	-1.30970	51.83050	70.50	M113	-1.37117	51.80000	68.50
M7	-1.31112	51.83033	71.50	M114	-1.37114	51.79910	68.50
M8	-1.31255	51.83013	71.50	M115	-1.37120	51.79820	67.50
M9	-1.31396	51.82993	72.22	M116	-1.37140	51.79731	66.50
M10	-1.31541	51.82987	72.66	M117	-1.37171	51.79643	66.50
M11	-1.31687	51.82982	73.64	M118	-1.37197	51.79554	66.50
M12	-1.31831	51.82969	74.21	M119	-1.37224	51.79466	66.50
M13	-1.31973	51.82951	74.50	M120	-1.37247	51.79377	66.13
M14	-1.32114	51.82928	74.79	M121	-1.37247	51.79287	66.81
M15	-1.32248	51.82894	75.39	M122	-1.37245	51.79197	66.91
M16	-1.32259	51.82891	75.37	M123	-1.37237	51.79107	66.50
M17	-1.31072	51.81208	69.50	M124	-1.37198	51.79021	67.24
M18	-1.31172	51.81273	69.55	M125	-1.37111	51.78950	67.20
M19	-1.31272	51.81338	70.72	M126	-1.36985	51.78906	66.50
M20	-1.31360	51.81401	71.50	M127	-1.36860	51.78863	66.50
M21	-1.31446	51.81474	71.50	M128	-1.36857	51.78837	66.50
M22	-1.31534	51.81545	71.40	M129	-1.36550	51.78276	66.09
M23	-1.31612	51.81621	70.65	M130	-1.36575	51.78362	66.50
M24	-1.31678	51.81702	70.83	M131	-1.36606	51.78448	66.55
M25	-1.31732	51.81785	71.17	M132	-1.36656	51.78533	65.50
M26	-1.31776	51.81871	70.67	M133	-1.36706	51.78617	65.50

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M27	-1.31812	51.81958	70.50	M134	-1.36759	51.78701	66.11
M28	-1.31842	51.82046	70.50	M135	-1.36821	51.78782	66.50
M29	-1.31864	51.82135	70.50	M136	-1.36835	51.78792	66.50
M30	-1.31883	51.82221	70.50	M137	-1.38219	51.78449	72.50
M31	-1.31903	51.82310	71.50	M138	-1.38215	51.78538	72.97
M32	-1.31940	51.82397	71.50	M139	-1.38212	51.78628	73.79
M33	-1.31988	51.82482	71.50	M140	-1.38234	51.78672	74.50
M34	-1.32042	51.82566	71.50	M141	-1.38495	51.78689	77.78
M35	-1.32103	51.82648	71.50	M142	-1.38350	51.78682	76.48
M36	-1.32168	51.82728	72.81	M143	-1.38204	51.78680	74.30
M37	-1.32237	51.82808	74.50	M144	-1.38059	51.78684	72.76
M38	-1.32307	51.82886	75.50	M145	-1.37914	51.78690	71.50
M39	-1.32377	51.82965	76.50	M146	-1.37770	51.78701	71.50
M40	-1.32446	51.83044	77.50	M147	-1.37626	51.78714	71.07
M41	-1.32515	51.83124	78.54	M148	-1.37483	51.78732	70.25
M42	-1.32584	51.83203	79.56	M149	-1.37341	51.78752	69.50
M43	-1.32663	51.83278	80.50	M150	-1.37199	51.78771	68.50
M44	-1.32757	51.83347	80.60	M151	-1.37057	51.78789	67.50
M45	-1.32865	51.83408	80.50	M152	-1.36914	51.78808	66.92
M46	-1.32979	51.83464	81.50	M153	-1.36784	51.78828	66.48
M47	-1.33093	51.83519	82.37	M154	-1.36640	51.78839	65.50

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M48	-1.33140	51.83542	82.50	M155	-1.36497	51.78854	64.50
M49	-1.38398	51.82540	94.50	M156	-1.36353	51.78868	63.50
M50	-1.38257	51.82564	93.64	M157	-1.36209	51.78882	63.26
M51	-1.38113	51.82577	93.33	M158	-1.36065	51.78895	62.50
M52	-1.37968	51.82573	92.68	M159	-1.35921	51.78907	62.50
M53	-1.37823	51.82573	91.50	M160	-1.35777	51.78918	62.50
M54	-1.37678	51.82568	88.42	M161	-1.35632	51.78929	62.50
M55	-1.37533	51.82563	87.50	M162	-1.35488	51.78938	62.50
M56	-1.37389	51.82572	84.02	M163	-1.35343	51.78947	62.50
M57	-1.37245	51.82587	82.24	M164	-1.35198	51.78956	64.51
M58	-1.37103	51.82606	75.47	M165	-1.35054	51.78966	63.75
M59	-1.36959	51.82621	73.72	M166	-1.34909	51.78978	64.08
M60	-1.36817	51.82639	72.67	M167	-1.34765	51.78991	64.50
M61	-1.36673	51.82649	72.59	M168	-1.34621	51.79003	65.50
M62	-1.36541	51.82611	70.79	M169	-1.34477	51.79016	65.50
M63	-1.36408	51.82575	68.45	M170	-1.34334	51.79031	64.50
M64	-1.36264	51.82568	67.50	M171	-1.34190	51.79046	63.50
M65	-1.36124	51.82591	70.68	M172	-1.34047	51.79061	62.50
M66	-1.36002	51.82640	71.52	M173	-1.33904	51.79077	62.50
M67	-1.35880	51.82689	72.23	M174	-1.33760	51.79092	61.83
M68	-1.35740	51.82714	71.82	M175	-1.33617	51.79107	61.50

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M69	-1.35596	51.82725	72.34	M176	-1.33474	51.79123	61.50
M70	-1.35460	51.82756	73.65	M177	-1.33330	51.79138	61.50
M71	-1.35335	51.82803	74.04	M178	-1.33273	51.79144	61.50
M72	-1.35218	51.82856	76.17	M179	-1.34849	51.78990	64.50
M73	-1.35127	51.82925	76.86	M180	-1.34756	51.79052	64.72
M74	-1.35063	51.83005	78.43	M181	-1.34640	51.79106	64.98
M75	-1.35071	51.83095	77.50	M182	-1.34524	51.79161	65.33
M76	-1.35022	51.83179	78.62	M183	-1.34409	51.79216	65.50
M77	-1.34940	51.83253	80.05	M184	-1.34368	51.79288	65.50
M78	-1.34833	51.83314	81.50	M185	-1.34326	51.79373	65.50
M79	-1.34723	51.83373	81.50	M186	-1.34269	51.79455	66.12
M80	-1.34621	51.83437	81.50	M187	-1.34229	51.79542	66.50
M81	-1.34532	51.83508	81.50	M188	-1.34176	51.79625	66.50
M82	-1.34500	51.83543	81.50	M189	-1.34115	51.79707	67.30
M83	-1.36558	51.82612	70.80	M190	-1.34058	51.79790	67.50
M84	-1.36643	51.82539	71.50	M191	-1.34000	51.79872	67.50
M85	-1.36685	51.82453	71.17	M192	-1.33924	51.79946	67.78
M86	-1.36738	51.82370	70.50	M193	-1.33786	51.79975	67.50
M87	-1.36792	51.82286	71.50	M194	-1.33649	51.80005	67.50
M88	-1.36821	51.82198	72.43	M195	-1.33508	51.80025	67.46
M89	-1.36849	51.82110	73.02	M196	-1.33374	51.80061	67.35

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M90	-1.36913	51.82030	73.88	M197	-1.33236	51.80088	67.42
M91	-1.36979	51.81950	74.50	M198	-1.33094	51.80100	68.28
M92	-1.37044	51.81869	73.50	M199	-1.32949	51.80096	68.09
M93	-1.37076	51.81781	73.03	M200	-1.32804	51.80100	68.17
M94	-1.37104	51.81693	72.50	M201	-1.32661	51.80086	68.32
M95	-1.37133	51.81605	72.50	M202	-1.32516	51.80096	68.85
M96	-1.37161	51.81517	71.50	M203	-1.32378	51.80123	70.60
M97	-1.37190	51.81428	70.50	M204	-1.32247	51.80161	72.81
M98	-1.37217	51.81340	72.23	M205	-1.32125	51.80211	71.87
M99	-1.37244	51.81251	73.50	M206	-1.32004	51.80261	72.36
M100	-1.37270	51.81163	74.42	M207	-1.31948	51.80288	72.05
M101	-1.37268	51.81073	74.50	M208	-1.31770	51.80360	71.31
M102	-1.37261	51.80983	74.50	M209	-1.31648	51.80408	70.67
M103	-1.37248	51.80894	74.50	M210	-1.31535	51.80464	69.54
M104	-1.37220	51.80805	73.88	M211	-1.31393	51.80466	67.50
M105	-1.37192	51.80717	73.50	M212	-1.31250	51.80479	64.97
M106	-1.37174	51.80628	73.50	M213	-1.31101	51.80487	62.50
M107	-1.37160	51.80538	71.25				

Road Receptor Data (Middle)

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
S1	-1.31645	51.74898	69.50	S37	-1.33726	51.73659	114.98
S2	-1.31684	51.74811	70.25	S38	-1.33655	51.73581	114.29
S3	-1.31732	51.74726	72.07	S39	-1.33556	51.73517	111.50
S4	-1.31795	51.74645	74.88	S40	-1.33442	51.73467	111.67
S5	-1.31871	51.74568	76.68	S41	-1.33301	51.73449	117.65
S6	-1.31962	51.74498	76.56	S42	-1.33156	51.73448	120.68
S7	-1.32060	51.74432	76.69	S43	-1.33014	51.73431	122.50
S8	-1.32158	51.74366	78.13	S44	-1.32971	51.73423	123.50
S9	-1.32257	51.74300	80.93	S45	-1.33068	51.73342	122.93
S10	-1.32356	51.74233	86.69	S46	-1.32977	51.73410	123.25
S11	-1.32448	51.74164	89.98	S47	-1.32838	51.73410	124.50
S12	-1.32530	51.74090	98.65	S48	-1.32693	51.73416	124.65
S13	-1.32600	51.74011	107.88	S49	-1.32554	51.73440	125.50
S14	-1.32674	51.73935	116.88	S50	-1.32419	51.73474	126.50
S15	-1.32719	51.73850	122.76	S51	-1.32285	51.73509	126.50
S16	-1.32752	51.73762	124.50	S52	-1.32217	51.73526	126.50
S17	-1.32772	51.73673	124.02	S53	-1.32357	51.73411	125.60
S18	-1.32780	51.73583	124.50	S54	-1.32272	51.73484	126.50
S19	-1.32781	51.73493	124.50	S55	-1.32167	51.73545	126.59
S20	-1.32784	51.73403	124.36	S56	-1.32043	51.73592	126.50
S21	-1.32782	51.73343	123.50	S57	-1.31917	51.73638	126.30

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
S22	-1.34456	51.74899	66.50	S58	-1.31792	51.73684	126.11
S23	-1.34416	51.74813	66.50	S59	-1.31670	51.73733	125.16
S24	-1.34370	51.74728	66.50	S60	-1.31565	51.73794	122.23
S25	-1.34330	51.74641	67.50	S61	-1.31466	51.73860	120.62
S26	-1.34286	51.74555	68.20	S62	-1.31378	51.73932	119.42
S27	-1.34232	51.74472	69.50	S63	-1.31296	51.74006	110.45
S28	-1.34179	51.74388	70.92	S64	-1.31218	51.74082	120.31
S29	-1.34159	51.74299	75.66	S65	-1.31142	51.74159	120.68
S30	-1.34145	51.74209	82.31	S66	-1.31070	51.74237	117.41
S31	-1.34133	51.74120	87.17	S67	-1.30999	51.74316	114.03
S32	-1.34129	51.74031	95.83	S68	-1.30951	51.74400	107.81
S33	-1.34070	51.73950	103.66	S69	-1.30923	51.74488	106.92
S34	-1.33984	51.73877	110.77	S70	-1.30872	51.74572	101.62
S35	-1.33897	51.73805	113.85	S71	-1.30795	51.74649	98.41
S36	-1.33809	51.73733	116.45	S72	-1.30721	51.74707	94.83

Road Receptor Data (South)

Dwelling Receptor Data

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

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
N1	-1.35133	51.88977	116.70	N60	-1.34319	51.85076	96.80
N2	-1.35133	51.88977	116.70	N61	-1.34310	51.85032	96.80
N3	-1.35423	51.88302	105.73	N62	-1.34219	51.85050	97.80
N4	-1.34865	51.88170	104.23	N63	-1.34142	51.85075	97.80
N5	-1.34872	51.88142	104.86	N64	-1.34061	51.85092	97.80
N6	-1.34931	51.88093	104.80	N65	-1.33993	51.85158	97.80
N7	-1.35563	51.88122	101.23	N66	-1.33968	51.85105	97.80
N8	-1.35641	51.88037	89.11	N67	-1.33943	51.85065	97.80
N9	-1.35575	51.87887	95.07	N68	-1.33860	51.85068	96.80
N10	-1.35604	51.87850	98.59	N69	-1.33806	51.85076	96.80
N11	-1.35671	51.87823	102.47	N70	-1.33745	51.85083	96.24
N12	-1.36253	51.87891	107.80	N71	-1.33736	51.85055	96.71
N13	-1.36338	51.87912	107.85	N72	-1.33731	51.85009	96.80
N14	-1.36387	51.87771	111.68	N73	-1.33728	51.84983	96.80
N15	-1.36451	51.87739	110.96	N74	-1.33752	51.84941	96.80
N16	-1.36475	51.87694	109.60	N75	-1.33776	51.84897	96.80
N17	-1.36433	51.87641	107.86	N76	-1.33798	51.84872	96.80
N18	-1.36424	51.87589	106.65	N77	-1.33853	51.84846	96.80
N19	-1.36288	51.87559	104.98	N78	-1.34243	51.84811	96.19

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
N20	-1.36359	51.87506	103.81	N79	-1.34242	51.84769	95.80
N21	-1.36294	51.87484	101.76	N80	-1.34230	51.84724	95.80
N22	-1.36289	51.87434	96.08	N81	-1.34220	51.84689	95.55
N23	-1.36249	51.87400	89.05	N82	-1.34258	51.84652	94.80
N24	-1.36307	51.87364	87.01	N83	-1.34283	51.84617	94.80
N25	-1.36341	51.87347	86.44	N84	-1.34316	51.84575	94.80
N26	-1.36259	51.87281	90.07	N85	-1.33149	51.84497	91.80
N27	-1.36334	51.87204	103.02	N86	-1.33100	51.84557	90.80
N28	-1.36089	51.87239	99.58	N87	-1.32978	51.84490	90.42
N29	-1.36013	51.87635	105.76	N88	-1.32653	51.84449	87.40
N30	-1.35920	51.87622	104.80	N89	-1.32523	51.84483	86.19
N31	-1.35768	51.87615	104.80	N90	-1.32329	51.85017	81.80
N32	-1.35783	51.87572	104.49	N91	-1.32329	51.85083	81.80
N33	-1.35834	51.87540	103.67	N92	-1.32549	51.85275	86.68
N34	-1.35079	51.87639	103.80	N93	-1.32583	51.85308	87.18
N35	-1.35323	51.87517	89.38	N94	-1.32628	51.85336	88.04
N36	-1.34942	51.87044	96.79	N95	-1.32615	51.85360	88.65
N37	-1.35103	51.87012	93.32	N96	-1.32500	51.85334	87.05
N38	-1.35235	51.86961	91.44	N97	-1.31497	51.85014	81.80
N39	-1.34726	51.86752	93.24	N98	-1.31461	51.85588	87.88
N40	-1.34692	51.86774	92.80	N99	-1.31423	51.85621	88.53

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
N41	-1.34657	51.86784	91.80	N100	-1.31411	51.85644	89.15
N42	-1.36551	51.86141	104.61	N101	-1.31472	51.85669	89.74
N43	-1.35969	51.86181	104.80	N102	-1.31439	51.85701	89.80
N44	-1.35086	51.85164	82.11	N103	-1.31407	51.85730	90.80
N45	-1.35013	51.85125	81.80	N104	-1.31381	51.85761	90.80
N46	-1.34972	51.85126	84.80	N105	-1.31130	51.86119	74.90
N47	-1.34913	51.85124	86.57	N106	-1.31266	51.85788	91.80
N48	-1.34879	51.85074	90.22	N107	-1.31130	51.86119	74.90
N49	-1.34854	51.85025	92.38	N108	-1.31032	51.86160	68.19
N50	-1.34775	51.85018	92.91	N109	-1.31160	51.86198	91.10
N51	-1.34714	51.84991	94.39	N110	-1.32701	51.86239	100.80
N52	-1.34639	51.85006	94.94	N111	-1.33777	51.86308	101.96
N53	-1.34600	51.85019	94.76	N112	-1.33135	51.86426	103.33
N54	-1.34583	51.85038	94.37	N113	-1.33027	51.86603	105.26
N55	-1.34559	51.85061	94.84	N114	-1.32957	51.86598	105.13
N56	-1.34526	51.85074	95.60	N115	-1.32858	51.86616	105.09
N57	-1.34495	51.85079	95.43	N116	-1.32934	51.87014	105.80
N58	-1.34436	51.85063	95.80	N117	-1.32799	51.88448	112.80
N59	-1.34373	51.85078	96.80	N118	-1.32103	51.88990	121.80

Dwelling Receptor Data (North)

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M1	-1.34445	51.83538	81.80	M229	-1.34667	51.79132	65.80
M2	-1.34445	51.83538	81.80	M230	-1.34636	51.79145	65.46
M3	-1.34484	51.83516	81.80	M231	-1.34610	51.79157	65.53
M4	-1.34502	51.83492	81.80	M232	-1.34587	51.79164	65.63
M5	-1.34542	51.83455	81.80	M233	-1.34553	51.79182	66.02
M6	-1.34437	51.83435	81.94	M234	-1.34460	51.79163	65.71
M7	-1.34487	51.83378	82.22	M235	-1.34388	51.79155	65.48
M8	-1.34514	51.83359	82.09	M236	-1.34397	51.79184	65.80
M9	-1.34609	51.83331	81.80	M237	-1.34368	51.79203	65.80
M10	-1.34732	51.83291	81.58	M238	-1.34420	51.79230	65.97
M11	-1.34708	51.83246	81.28	M239	-1.34463	51.79252	66.68
M12	-1.34754	51.83221	81.80	M240	-1.34528	51.79253	66.80
M13	-1.34909	51.83232	80.80	M241	-1.34492	51.79280	66.80
M14	-1.34968	51.83199	79.27	M242	-1.34513	51.79298	66.80
M15	-1.35003	51.83160	78.80	M243	-1.34479	51.79311	66.80
M16	-1.35036	51.83126	77.80	M244	-1.34436	51.79341	66.80
M17	-1.34950	51.83113	80.18	M245	-1.34376	51.79342	66.66
M18	-1.34886	51.83071	82.99	M246	-1.34352	51.79364	66.34
M19	-1.34779	51.83044	84.73	M247	-1.34343	51.79380	66.25
M20	-1.34999	51.83014	81.80	M248	-1.34316	51.79408	65.93
M21	-1.34948	51.82987	82.15	M249	-1.34355	51.79422	66.60

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M22	-1.34906	51.82935	83.14	M250	-1.34298	51.79429	66.55
M23	-1.34935	51.82911	83.65	M251	-1.34283	51.79467	66.60
M24	-1.34981	51.82894	82.04	M252	-1.34290	51.79488	66.80
M25	-1.34961	51.82861	83.92	M253	-1.34328	51.79502	66.80
M26	-1.34930	51.82849	85.30	M254	-1.34358	51.79510	67.30
M27	-1.34960	51.82815	85.39	M255	-1.34387	51.79520	67.63
M28	-1.34914	51.82793	87.35	M256	-1.34416	51.79531	67.67
M29	-1.34853	51.82765	90.00	M257	-1.34448	51.79545	67.80
M30	-1.34780	51.82743	91.53	M258	-1.34462	51.79560	67.80
M31	-1.34697	51.82722	91.88	M259	-1.34448	51.79574	67.80
M32	-1.34652	51.82701	92.97	M260	-1.34449	51.79601	67.80
M33	-1.34590	51.82680	93.67	M261	-1.34415	51.79577	67.80
M34	-1.34538	51.82669	93.80	M262	-1.34385	51.79565	67.80
M35	-1.34496	51.82635	94.80	M263	-1.34366	51.79544	67.80
M36	-1.34514	51.82604	95.03	M264	-1.34335	51.79534	66.80
M37	-1.34563	51.82578	94.80	M265	-1.34312	51.79521	66.80
M38	-1.34560	51.82610	94.44	M266	-1.34281	51.79513	66.80
M39	-1.34578	51.82646	93.80	M267	-1.34213	51.79501	66.55
M40	-1.34663	51.82659	93.04	M268	-1.34212	51.79519	66.66
M41	-1.34720	51.82683	92.69	M269	-1.34200	51.79538	66.80
M42	-1.34793	51.82706	91.80	M270	-1.34171	51.79555	66.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M43	-1.34854	51.82716	91.80	M271	-1.34280	51.79606	67.17
M44	-1.34911	51.82758	88.04	M272	-1.34233	51.79600	66.80
M45	-1.34989	51.82791	85.41	M273	-1.34241	51.79634	66.80
M46	-1.35063	51.82812	82.96	M274	-1.34301	51.79662	67.80
M47	-1.35091	51.82798	83.27	M275	-1.34198	51.79634	66.80
M48	-1.35150	51.82788	83.14	M276	-1.34178	51.79642	66.80
M49	-1.35195	51.82763	82.94	M277	-1.34183	51.79662	66.80
M50	-1.35233	51.82735	83.06	M278	-1.34173	51.79686	67.17
M51	-1.35266	51.82707	83.66	M279	-1.34142	51.79720	67.80
M52	-1.35326	51.82718	82.75	M280	-1.34118	51.79750	67.80
M53	-1.35345	51.82738	81.28	M281	-1.34106	51.79782	67.80
M54	-1.35318	51.82788	77.26	M282	-1.34078	51.79809	67.80
M55	-1.34423	51.82237	103.84	M283	-1.33936	51.79757	67.66
M56	-1.35215	51.82014	91.76	M284	-1.34120	51.79589	66.80
M57	-1.35764	51.82910	79.23	M285	-1.34108	51.79529	66.68
M58	-1.35808	51.82954	84.63	M286	-1.34069	51.79505	66.18
M59	-1.36577	51.83194	83.71	M287	-1.34056	51.79470	66.31
M60	-1.36787	51.82816	70.27	M288	-1.34025	51.79440	66.78
M61	-1.35911	51.82658	72.45	M289	-1.33963	51.79434	65.88
M62	-1.35938	51.82610	72.80	M290	-1.33940	51.79421	65.80
M63	-1.36202	51.82478	70.72	M291	-1.33889	51.79409	65.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M64	-1.36038	51.82425	74.75	M292	-1.33844	51.79418	65.59
M65	-1.36724	51.82628	73.20	M293	-1.33809	51.79399	64.90
M66	-1.36748	51.82597	73.67	M294	-1.33865	51.79381	65.62
M67	-1.36954	51.82636	73.22	M295	-1.33907	51.79358	65.09
M68	-1.37328	51.82553	86.63	M296	-1.33914	51.79332	64.62
M69	-1.37398	51.82553	84.94	M297	-1.33925	51.79296	64.23
M70	-1.38124	51.82682	96.12	M298	-1.33844	51.79294	63.80
M71	-1.38053	51.82659	95.65	M299	-1.33934	51.79918	67.80
M72	-1.37987	51.82619	93.80	M300	-1.34009	51.80128	68.80
M73	-1.37957	51.82597	93.61	M301	-1.33648	51.80107	68.80
M74	-1.37997	51.82559	92.80	M302	-1.33562	51.80130	68.16
M75	-1.37925	51.82536	92.24	M303	-1.33549	51.80099	67.80
M76	-1.37829	51.82559	91.80	M304	-1.33096	51.79809	61.80
M77	-1.37757	51.82543	90.80	M305	-1.33243	51.79884	64.43
M78	-1.37686	51.82548	89.06	M306	-1.33197	51.79881	63.80
M79	-1.37559	51.82538	88.01	M307	-1.33169	51.79889	64.34
M80	-1.37541	51.82515	87.66	M308	-1.33127	51.79898	64.20
M81	-1.37513	51.82503	87.18	M309	-1.33113	51.79911	64.49
M82	-1.37514	51.82485	86.33	M310	-1.33053	51.79924	64.68
M83	-1.37459	51.82454	83.12	M311	-1.33094	51.79949	65.27
M84	-1.37387	51.82445	82.41	M312	-1.32847	51.79961	63.65

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M85	-1.37350	51.82426	82.18	M313	-1.30953	51.80084	61.80
M86	-1.37314	51.82395	81.80	M314	-1.32755	51.79963	63.73
M87	-1.37284	51.82369	81.01	M315	-1.30953	51.80084	61.80
M88	-1.37236	51.82346	79.91	M316	-1.30973	51.80123	61.80
M89	-1.37252	51.82318	79.80	M317	-1.31009	51.80151	62.40
M90	-1.37283	51.82295	79.80	M318	-1.31003	51.80398	61.37
M91	-1.37398	51.82348	80.95	M319	-1.31073	51.80400	62.34
M92	-1.37491	51.82392	81.52	M320	-1.31117	51.80403	62.80
M93	-1.37587	51.82436	86.16	M321	-1.31133	51.80423	63.19
M94	-1.37929	51.82508	92.14	M322	-1.31218	51.80456	64.45
M95	-1.37998	51.82489	92.46	M323	-1.31292	51.80449	65.78
M96	-1.38084	51.82554	92.96	M324	-1.31345	51.80450	66.59
M97	-1.38132	51.82513	93.54	M325	-1.31382	51.80413	66.87
M98	-1.38191	51.82512	93.80	M326	-1.31424	51.80417	67.38
M99	-1.38250	51.82496	93.80	M327	-1.31471	51.80440	68.45
M100	-1.38347	51.82525	94.80	M328	-1.31587	51.80477	70.56
M101	-1.38398	51.82513	94.80	M329	-1.31442	51.80453	68.24
M102	-1.38466	51.82481	94.80	M330	-1.31400	51.80458	67.80
M103	-1.36858	51.82253	72.80	M331	-1.31380	51.80484	67.80
M104	-1.36670	51.82050	71.80	M332	-1.31281	51.80491	66.05
M105	-1.36636	51.81945	72.34	M333	-1.31248	51.80493	65.71

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M106	-1.36609	51.82022	68.71	M334	-1.31217	51.80506	64.88
M107	-1.36636	51.81945	72.34	M335	-1.31211	51.80542	65.13
M108	-1.38637	51.81548	94.80	M336	-1.31280	51.80556	66.36
M109	-1.38557	51.81545	95.58	M337	-1.31325	51.80594	67.77
M110	-1.38515	51.81516	95.40	M338	-1.31353	51.80617	68.73
M111	-1.38467	51.81482	94.80	M339	-1.31312	51.80625	67.80
M112	-1.38387	51.81487	94.90	M340	-1.31257	51.80650	66.97
M113	-1.38408	51.81453	94.80	M341	-1.31268	51.80680	67.65
M114	-1.38462	51.81396	94.20	M342	-1.31318	51.80715	69.59
M115	-1.38363	51.81377	94.34	M343	-1.31386	51.80737	70.90
M116	-1.38281	51.81368	93.80	M344	-1.31458	51.80769	71.83
M117	-1.38235	51.81323	93.80	M345	-1.31424	51.80786	71.80
M118	-1.38157	51.81295	93.22	M346	-1.31420	51.80813	71.80
M119	-1.38255	51.81257	93.80	M347	-1.31301	51.80803	70.49
M120	-1.38237	51.81226	93.43	M348	-1.31193	51.80820	68.94
M121	-1.38169	51.81225	92.65	M349	-1.31189	51.80852	69.59
M122	-1.38122	51.81225	91.87	M350	-1.31262	51.80868	70.80
M123	-1.38131	51.81200	92.15	M351	-1.31262	51.80892	70.80
M124	-1.38099	51.81165	92.08	M352	-1.31267	51.80916	70.80
M125	-1.38013	51.81159	89.91	M353	-1.31276	51.80936	70.80
M126	-1.38063	51.81127	91.77	M354	-1.31280	51.80956	70.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M127	-1.38140	51.81100	92.80	M355	-1.31285	51.80978	70.80
M128	-1.38108	51.81062	92.80	M356	-1.31291	51.81003	70.99
M129	-1.38153	51.81039	92.80	M357	-1.31299	51.81035	71.66
M130	-1.38691	51.81179	86.47	M358	-1.31316	51.81076	71.80
M131	-1.39259	51.81253	101.80	M359	-1.31324	51.81098	71.64
M132	-1.39474	51.81186	103.42	M360	-1.31335	51.81119	71.09
M133	-1.37242	51.81164	74.69	M361	-1.31343	51.81140	71.36
M134	-1.37244	51.81145	74.80	M362	-1.31367	51.81170	71.80
M135	-1.34893	51.81357	82.24	M363	-1.31279	51.81177	71.26
M136	-1.34898	51.81334	82.27	M364	-1.31283	51.81198	71.38
M137	-1.35907	51.80475	91.95	M365	-1.31306	51.81222	71.80
M138	-1.35867	51.80468	92.60	M366	-1.31307	51.81259	71.80
M139	-1.35873	51.80436	92.79	M367	-1.31315	51.81289	71.80
M140	-1.36704	51.80787	65.80	M368	-1.31330	51.81318	71.64
M141	-1.37104	51.80309	71.80	M369	-1.31316	51.81335	71.32
M142	-1.36616	51.79419	63.80	M370	-1.31430	51.81417	71.80
M143	-1.36663	51.79374	63.80	M371	-1.31472	51.81558	70.80
M144	-1.36791	51.79267	63.80	M372	-1.32779	51.81259	94.40
M145	-1.37278	51.79234	67.80	M373	-1.32803	51.81283	94.22
M146	-1.37280	51.79262	67.80	M374	-1.32564	51.81896	84.96
M147	-1.37777	51.79693	71.80	M375	-1.32532	51.81989	80.81

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M148	-1.37797	51.79726	71.80	M376	-1.32511	51.82004	80.53
M149	-1.37820	51.79752	71.80	M377	-1.32697	51.82062	81.38
M150	-1.37753	51.79821	71.47	M378	-1.32552	51.82080	78.08
M151	-1.39412	51.79697	79.69	M379	-1.32525	51.82097	77.53
M152	-1.38426	51.78644	76.47	M380	-1.32488	51.82119	76.08
M153	-1.38365	51.78627	76.21	M381	-1.32426	51.82091	75.75
M154	-1.38309	51.78616	74.80	M382	-1.32393	51.82099	75.17
M155	-1.38246	51.78635	74.46	M383	-1.32319	51.82099	73.17
M156	-1.38189	51.78639	73.80	M384	-1.32276	51.82119	72.09
M157	-1.38132	51.78639	73.80	M385	-1.32228	51.82126	71.80
M158	-1.38085	51.78640	73.80	M386	-1.32194	51.82130	70.93
M159	-1.38037	51.78644	72.80	M387	-1.32163	51.82166	70.80
M160	-1.37994	51.78644	72.45	M388	-1.31787	51.82108	70.80
M161	-1.37943	51.78645	71.80	M389	-1.31807	51.82186	70.80
M162	-1.37899	51.78649	71.80	M390	-1.31814	51.82210	70.80
M163	-1.37860	51.78646	71.80	M391	-1.31819	51.82232	71.07
M164	-1.37814	51.78678	71.80	M392	-1.31826	51.82261	71.65
M165	-1.37745	51.78642	71.80	M393	-1.31937	51.82295	71.80
M166	-1.37691	51.78662	71.80	M394	-1.31826	51.82312	71.80
M167	-1.37628	51.78671	71.61	M395	-1.31830	51.82336	71.80
M168	-1.37573	51.78677	71.25	M396	-1.31840	51.82356	71.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M169	-1.37527	51.78665	70.80	M397	-1.31955	51.82362	71.80
M170	-1.37481	51.78669	70.80	M398	-1.31856	51.82384	71.80
M171	-1.37467	51.78687	70.80	M399	-1.31871	51.82427	71.80
M172	-1.37438	51.78693	70.78	M400	-1.31892	51.82466	71.80
M173	-1.37396	51.78689	70.80	M401	-1.31912	51.82504	71.80
M174	-1.37361	51.78686	70.80	M402	-1.31935	51.82535	71.80
M175	-1.37336	51.78710	70.13	M403	-1.31949	51.82567	71.80
M176	-1.37286	51.78716	69.80	M404	-1.32067	51.82567	71.80
M177	-1.37292	51.78686	69.80	M405	-1.31773	51.82300	71.80
M178	-1.37212	51.78709	69.47	M406	-1.31733	51.82269	71.80
M179	-1.37179	51.78708	69.05	M407	-1.31683	51.82261	71.80
M180	-1.37143	51.78714	68.80	M408	-1.31643	51.82263	71.80
M181	-1.37128	51.78724	68.80	M409	-1.31629	51.82299	71.69
M182	-1.37089	51.78730	68.80	M410	-1.31617	51.82328	71.80
M183	-1.37056	51.78735	68.68	M411	-1.31607	51.82357	71.80
M184	-1.37031	51.78725	68.19	M412	-1.31621	51.82389	71.80
M185	-1.36952	51.78722	67.80	M413	-1.31641	51.82423	71.80
M186	-1.36933	51.78707	67.80	M414	-1.31639	51.82441	71.80
M187	-1.36959	51.78684	67.92	M415	-1.31585	51.82443	71.80
M188	-1.36883	51.78674	66.80	M416	-1.31525	51.82443	71.80
M189	-1.36836	51.78682	66.80	M417	-1.31460	51.82429	71.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M190	-1.36791	51.78658	66.80	M418	-1.31480	51.82445	71.80
M191	-1.36777	51.78625	66.80	M419	-1.31460	51.82429	71.80
M192	-1.36764	51.78611	66.80	M420	-1.31459	51.82405	71.80
M193	-1.36752	51.78597	66.30	M421	-1.31459	51.82378	71.80
M194	-1.36747	51.78572	66.23	M422	-1.31447	51.82357	71.80
M195	-1.36720	51.78539	66.19	M423	-1.31457	51.82335	71.53
M196	-1.36764	51.78539	67.22	M424	-1.31432	51.82305	70.86
M197	-1.36807	51.78537	67.25	M425	-1.31388	51.82280	70.80
M198	-1.37045	51.78510	69.33	M426	-1.31330	51.82278	70.52
M199	-1.37033	51.78477	69.15	M427	-1.31257	51.82277	70.02
M200	-1.37027	51.78446	68.80	M428	-1.31208	51.82282	69.80
M201	-1.36986	51.78427	68.80	M429	-1.31154	51.82289	69.80
M202	-1.36940	51.78403	67.80	M430	-1.31102	51.82293	69.55
M203	-1.36903	51.78409	67.35	M431	-1.31040	51.82306	69.61
M204	-1.36859	51.78417	66.80	M432	-1.30977	51.82311	69.55
M205	-1.36775	51.78430	66.97	M433	-1.30972	51.82276	69.05
M206	-1.36711	51.78424	65.84	M434	-1.30973	51.82243	68.80
M207	-1.36671	51.78447	66.02	M435	-1.30985	51.82222	68.80
M208	-1.36662	51.78398	65.80	M436	-1.30980	51.82190	68.60
M209	-1.36616	51.78324	66.22	M437	-1.30994	51.82162	68.67
M210	-1.36724	51.78322	65.80	M438	-1.31300	51.82666	71.80

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
M211	-1.36616	51.78324	66.22	M439	-1.31321	51.82698	71.80
M212	-1.36588	51.78326	66.80	M440	-1.31490	51.82841	72.80
M213	-1.36594	51.78281	66.64	M441	-1.31498	51.82864	72.80
M214	-1.36498	51.78361	65.80	M442	-1.31503	51.82883	72.80
M215	-1.35477	51.78747	62.80	M443	-1.31509	51.82903	72.80
M216	-1.35114	51.78597	62.80	M444	-1.31451	51.82909	72.80
M217	-1.35094	51.78619	62.80	M445	-1.31458	51.82930	72.80
M218	-1.35027	51.78647	62.80	M446	-1.31465	51.82950	72.80
M219	-1.35055	51.78664	62.80	M447	-1.31471	51.82968	72.80
M220	-1.34628	51.78873	64.80	M448	-1.32515	51.83208	79.81
M221	-1.34760	51.78945	64.80	M449	-1.32667	51.83246	80.73
M222	-1.34914	51.79020	64.80	M450	-1.32576	51.83281	80.80
M223	-1.34893	51.79050	64.91	M451	-1.32591	51.83295	80.84
M224	-1.34852	51.79048	65.05	M452	-1.32627	51.83304	81.08
M225	-1.34818	51.79056	65.06	M453	-1.32658	51.83322	81.37
M226	-1.34780	51.79075	65.50	M454	-1.32670	51.83333	81.65
M227	-1.34743	51.79098	65.80	M455	-1.32589	51.83333	81.70
M228	-1.34705	51.79114	65.80				

Dwelling Receptor Data (Middle)

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
S1	-1.34492	51.74885	66.80	S58	-1.32386	51.73677	125.80
S2	-1.34492	51.74885	66.80	S59	-1.32291	51.73663	125.80
S3	-1.34457	51.74843	66.80	S60	-1.32200	51.73674	125.66
S4	-1.34504	51.74859	66.80	S61	-1.32089	51.73705	124.05
S5	-1.34569	51.74843	66.80	S62	-1.31989	51.73727	123.43
S6	-1.34646	51.74824	66.80	S63	-1.32040	51.73788	119.68
S7	-1.34260	51.74555	68.51	S64	-1.32106	51.73828	116.64
S8	-1.34207	51.74543	68.82	S65	-1.32089	51.73856	113.79
S9	-1.34124	51.74518	69.33	S66	-1.32265	51.73958	108.36
S10	-1.34164	51.74513	69.54	S67	-1.32015	51.73882	111.35
S11	-1.36156	51.74573	65.80	S68	-1.31983	51.73894	109.59
S12	-1.36159	51.74535	66.42	S69	-1.31937	51.73859	114.23
S13	-1.36270	51.74370	67.81	S70	-1.31831	51.73775	121.05
S14	-1.35781	51.74222	73.46	S71	-1.31704	51.73751	124.13
S15	-1.34871	51.73949	87.12	S72	-1.31629	51.73784	122.40
S16	-1.34870	51.73910	89.09	S73	-1.31534	51.73788	123.63
S17	-1.35552	51.73712	85.00	S74	-1.31455	51.73835	122.76
S18	-1.35478	51.73706	85.80	S75	-1.31465	51.73893	119.67
S19	-1.34193	51.73278	111.80	S76	-1.31544	51.73926	111.15
S20	-1.34301	51.73474	112.53	S77	-1.31595	51.73981	104.63
S21	-1.34294	51.73524	112.66	S78	-1.31548	51.74028	102.43

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
S22	-1.34157	51.73548	113.80	S79	-1.31464	51.74072	100.61
S23	-1.34073	51.73574	114.80	S80	-1.31375	51.74137	111.79
S24	-1.34066	51.73646	114.80	S81	-1.31497	51.74190	105.30
S25	-1.33991	51.73657	115.36	S82	-1.31547	51.74231	101.80
S26	-1.33955	51.73703	115.55	S83	-1.31579	51.74276	99.88
S27	-1.33904	51.73774	114.81	S84	-1.31529	51.74321	97.33
S28	-1.33803	51.73778	115.68	S85	-1.31498	51.74356	98.80
S29	-1.33751	51.73718	115.80	S86	-1.31435	51.74394	101.47
S30	-1.33696	51.73666	115.80	S87	-1.31335	51.74374	102.32
S31	-1.33639	51.73607	114.14	S88	-1.31204	51.74368	97.37
S32	-1.33540	51.73583	115.18	S89	-1.31083	51.74361	99.70
S33	-1.33587	51.73519	111.80	S90	-1.31007	51.74390	103.07
S34	-1.33538	51.73483	111.80	S91	-1.30976	51.74460	105.08
S35	-1.33480	51.73456	112.06	S92	-1.31091	51.74500	95.72
S36	-1.33387	51.73469	114.95	S93	-1.31157	51.74554	91.43
S37	-1.33294	51.73467	117.80	S94	-1.31280	51.74586	81.80
S38	-1.33234	51.73508	119.80	S95	-1.31422	51.74591	80.03
S39	-1.33184	51.73551	121.80	S96	-1.31552	51.74590	80.09
S40	-1.33080	51.73479	121.80	S97	-1.31627	51.74562	79.03
S41	-1.32958	51.73484	123.80	S98	-1.31633	51.74518	81.29
S42	-1.32862	51.73446	124.80	S99	-1.31702	51.74541	79.62

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
S43	-1.32850	51.73384	124.29	S100	-1.31762	51.74550	77.79
S44	-1.32835	51.73358	123.80	S101	-1.31768	51.74601	76.13
S45	-1.33931	51.73895	112.19	S102	-1.31727	51.74630	75.93
S46	-1.33928	51.73953	110.46	S103	-1.31682	51.74679	74.08
S47	-1.33815	51.73979	110.99	S104	-1.31675	51.74729	72.66
S48	-1.32702	51.73455	125.14	S105	-1.31596	51.74843	71.04
S49	-1.32628	51.73495	125.80	S106	-1.31607	51.74797	71.79
S50	-1.32621	51.73545	125.80	S107	-1.31596	51.74843	71.04
S51	-1.32570	51.73588	125.80	S108	-1.31595	51.74862	70.34
S52	-1.32480	51.73605	126.80	S109	-1.31499	51.74873	71.11
S53	-1.32668	51.73685	125.69	S110	-1.31420	51.74889	70.80
S54	-1.32659	51.73719	124.82	S111	-1.31832	51.74895	68.80
S55	-1.32597	51.73710	125.80	S112	-1.31892	51.74881	69.00
S56	-1.32515	51.73698	125.80	S113	-1.31934	51.74884	68.93
S57	-1.32442	51.73687	125.80	S114	-1.33005	51.74641	71.05

Dwelling Receptor Data (South)

Railway Receptor Data

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

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
1	-1.37220	51.82449	83.23	25	-1.34659	51.81001	81.75
2	-1.37099	51.82400	79.26	26	-1.34540	51.80951	81.22
3	-1.36979	51.82351	75.99	27	-1.34414	51.80899	78.75
4	-1.36861	51.82300	73.75	28	-1.34292	51.80853	76.00
5	-1.36742	51.82243	71.78	29	-1.34168	51.80807	73.75
6	-1.36633	51.82184	70.31	30	-1.34038	51.80760	73.96
7	-1.36528	51.82124	68.75	31	-1.33919	51.80718	74.75
8	-1.36428	51.82059	68.75	32	-1.33789	51.80671	76.12
9	-1.36333	51.81992	69.01	33	-1.33671	51.80628	77.37
10	-1.36242	51.81923	68.74	34	-1.33541	51.80580	78.02
11	-1.36152	51.81854	68.75	35	-1.33417	51.80535	77.40
12	-1.36055	51.81782	69.45	36	-1.33293	51.80489	76.45
13	-1.35961	51.81714	71.08	37	-1.33163	51.80442	76.45
14	-1.35860	51.81645	70.61	38	-1.33039	51.80397	77.94
15	-1.35760	51.81581	71.74	39	-1.32915	51.80352	79.98
16	-1.35657	51.81519	71.77	40	-1.32790	51.80308	81.02
17	-1.35552	51.81458	72.18	41	-1.32664	51.80265	79.22
18	-1.35443	51.81400	73.10	42	-1.32536	51.80224	76.54
19	-1.35333	51.81342	76.42	43	-1.32407	51.80185	73.28

No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)	No.	Longitude (°)	Latitude (°)	Assessed Height (m amsl)
20	-1.35224	51.81284	80.67	44	-1.32269	51.80146	73.73
21	-1.35115	51.81226	83.69	45	-1.32137	51.80112	70.92
22	-1.35000	51.81165	84.75	46	-1.32004	51.80078	68.18
23	-1.34888	51.81109	82.75	47	-1.31871	51.80044	66.39
24	-1.34775	51.81054	81.94	48	-1.31738	51.80010	65.27

Railway receptor data

Modelled Reflector Areas

The modelled reflector areas are presented in the tables below and on the following pages.

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.33644	51.88767	26	-1.34040	51.87286
2	-1.33541	51.89042	27	-1.34005	51.87391
3	-1.33578	51.89042	28	-1.33984	51.87438
4	-1.34253	51.88482	29	-1.33902	51.87424
5	-1.34415	51.88491	30	-1.33905	51.87364
6	-1.34488	51.88412	31	-1.33785	51.87282
7	-1.34629	51.88307	32	-1.33257	51.87046
8	-1.34660	51.88244	33	-1.33183	51.87064
9	-1.34526	51.88230	34	-1.33243	51.87313
10	-1.34718	51.87954	35	-1.32981	51.87313
11	-1.35016	51.87612	36	-1.32955	51.87664
12	-1.35089	51.87557	37	-1.33313	51.87665
13	-1.35126	51.87475	38	-1.33329	51.87772
14	-1.35201	51.87377	39	-1.33253	51.87791

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
15	-1.35202	51.87360	40	-1.33357	51.87956
16	-1.35052	51.87293	41	-1.33228	51.87985
17	-1.34955	51.87162	42	-1.33348	51.88162
18	-1.34942	51.87122	43	-1.33393	51.88189
19	-1.34786	51.86916	44	-1.33383	51.88240
20	-1.34694	51.86813	45	-1.33305	51.88313
21	-1.34599	51.86810	46	-1.33179	51.88450
22	-1.34428	51.86839	47	-1.33158	51.88567
23	-1.34373	51.86897	48	-1.33082	51.88691
24	-1.34296	51.86925	49	-1.33644	51.88767
25	-1.34211	51.87110			

Panel Area (North A)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.34653	51.86716	25	-1.32682	51.85333
2	-1.34741	51.86716	26	-1.32604	51.85420
3	-1.34829	51.86700	27	-1.32174	51.85367
4	-1.34861	51.86787	28	-1.32013	51.85613
5	-1.34772	51.86791	29	-1.32216	51.85715
6	-1.34769	51.86834	30	-1.32326	51.85644
7	-1.34887	51.86977	31	-1.33061	51.85794
8	-1.35020	51.86953	32	-1.33200	51.85760
9	-1.35083	51.86881	33	-1.33181	51.85830
10	-1.35192	51.86804	34	-1.33061	51.85827
11	-1.34990	51.86710	35	-1.32825	51.85941

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
12	-1.35146	51.86649	36	-1.32822	51.85973
13	-1.35238	51.86647	37	-1.33066	51.86048
14	-1.35380	51.86592	38	-1.33020	51.86123
15	-1.35400	51.86578	39	-1.33395	51.86254
16	-1.34619	51.86408	40	-1.33470	51.86175
17	-1.34527	51.86454	41	-1.33695	51.86224
18	-1.34353	51.86464	42	-1.33963	51.86255
19	-1.34364	51.86317	43	-1.33813	51.86466
20	-1.34299	51.86191	44	-1.34307	51.86575
21	-1.34229	51.86065	45	-1.34350	51.86476
22	-1.33533	51.86102	46	-1.34530	51.86465
23	-1.33919	51.85613	47	-1.34531	51.86600
24	-1.33842	51.85418	48	-1.34653	51.86716

Panel Area (North B)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.37094	51.81845	9	-1.37288	51.81745
2	-1.37028	51.81953	10	-1.37181	51.81738
3	-1.37295	51.81957	11	-1.37337	51.81659
4	-1.37316	51.81897	12	-1.37567	51.81384
5	-1.37315	51.81816	13	-1.37260	51.81335
6	-1.37507	51.81686	14	-1.37159	51.81631
7	-1.37431	51.81635	15	-1.37094	51.81845
8	-1.37349	51.81681			

Panel Area (Middle A)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.36692	51.81882	16	-1.36672	51.80813
2	-1.36769	51.82055	17	-1.36634	51.80880
3	-1.36868	51.82057	18	-1.36638	51.80908
4	-1.37024	51.81864	19	-1.36688	51.80934
5	-1.37167	51.81433	20	-1.36556	51.80982
6	-1.37222	51.81241	21	-1.36569	51.81042
7	-1.37120	51.81230	22	-1.36659	51.81094
8	-1.37153	51.81092	23	-1.36819	51.81229
9	-1.37246	51.81096	24	-1.36706	51.81338
10	-1.37214	51.80892	25	-1.36685	51.81436
11	-1.37139	51.80583	26	-1.36583	51.81548
12	-1.37071	51.80567	27	-1.36530	51.81640
13	-1.36856	51.80585	28	-1.36474	51.81641
14	-1.36825	51.80648	29	-1.36470	51.81885
15	-1.36820	51.80814	30	-1.36692	51.81882

Panel Area (Middle B)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.37270	51.80830	17	-1.37730	51.80381
2	-1.38097	51.80932	18	-1.37709	51.80359
3	-1.38045	51.80821	19	-1.37461	51.80354
4	-1.37943	51.80682	20	-1.37480	51.80018
5	-1.37896	51.80647	21	-1.37429	51.80002
6	-1.38024	51.80654	22	-1.37406	51.79959
7	-1.38145	51.80639	23	-1.37409	51.79932

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
8	-1.38125	51.80592	24	-1.37347	51.79889
9	-1.38121	51.80528	25	-1.37284	51.79802
10	-1.38097	51.80452	26	-1.37215	51.79761
11	-1.38150	51.80431	27	-1.37172	51.79761
12	-1.38128	51.80401	28	-1.37155	51.79837
13	-1.38251	51.80269	29	-1.37163	51.80336
14	-1.38320	51.80224	30	-1.37205	51.80572
15	-1.37867	51.80156	31	-1.37270	51.80830
16	-1.37771	51.80382			

Panel Area (Middle C)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.37103	51.79796	11	-1.36666	51.80257
2	-1.37037	51.79781	12	-1.36707	51.80304
3	-1.37051	51.79738	13	-1.36737	51.80462
4	-1.36955	51.79715	14	-1.37120	51.80438
5	-1.36886	51.79738	15	-1.37059	51.80399
6	-1.36801	51.79786	16	-1.37033	51.80306
7	-1.36734	51.79847	17	-1.37048	51.80273
8	-1.36688	51.79947	18	-1.37102	51.80262
9	-1.36696	51.80152	19	-1.37103	51.79796
10	-1.36655	51.80164			

Panel Area (Middle D)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.37206	51.79080	13	-1.37097	51.79553
2	-1.37170	51.79081	14	-1.37021	51.79538
3	-1.37173	51.79094	15	-1.36977	51.79560
4	-1.37093	51.79179	16	-1.36987	51.79591
5	-1.37093	51.79266	17	-1.37027	51.79630
6	-1.37068	51.79267	18	-1.37106	51.79650
7	-1.37066	51.79285	19	-1.37109	51.79672
8	-1.37125	51.79325	20	-1.37140	51.79673
9	-1.37127	51.79370	21	-1.37207	51.79457
10	-1.37086	51.79401	22	-1.37220	51.79375
11	-1.37084	51.79502	23	-1.37222	51.79121
12	-1.37119	51.79526	24	-1.37206	51.79080

Panel Area (Middle E)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.35721	51.81523	39	-1.36318	51.80018
2	-1.35757	51.81524	40	-1.36275	51.79867
3	-1.35676	51.81420	41	-1.36196	51.79766
4	-1.35592	51.81413	42	-1.36085	51.79645
5	-1.35542	51.81389	43	-1.35975	51.79552
6	-1.35538	51.81344	44	-1.35807	51.79421
7	-1.35466	51.81309	45	-1.35700	51.79366
8	-1.35422	51.81246	46	-1.35651	51.79318
9	-1.35425	51.81201	47	-1.35683	51.79283
10	-1.35460	51.81176	48	-1.35644	51.79257

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
11	-1.35472	51.81112	49	-1.35638	51.79192
12	-1.35507	51.81081	50	-1.35577	51.79172
13	-1.35548	51.81067	51	-1.35515	51.79189
14	-1.35538	51.80953	52	-1.35361	51.79119
15	-1.35655	51.80936	53	-1.35298	51.79129
16	-1.35848	51.80972	54	-1.35262	51.79096
17	-1.35911	51.80968	55	-1.35080	51.79162
18	-1.35959	51.80954	56	-1.35013	51.79125
19	-1.36019	51.80921	57	-1.34703	51.79284
20	-1.36110	51.80915	58	-1.34833	51.79406
21	-1.36303	51.80796	59	-1.34708	51.79501
22	-1.36370	51.80577	60	-1.34794	51.79587
23	-1.36381	51.80167	61	-1.34603	51.79728
24	-1.36345	51.80112	62	-1.34443	51.79656
25	-1.36345	51.80072	63	-1.34253	51.79801
26	-1.36331	51.80050	64	-1.33989	51.79933
27	-1.36294	51.80050	65	-1.33991	51.79970
28	-1.36299	51.80077	66	-1.34314	51.80494
29	-1.36166	51.80089	67	-1.35006	51.80330
30	-1.36076	51.80255	68	-1.35238	51.80683
31	-1.36226	51.80285	69	-1.34591	51.80848
32	-1.36286	51.80296	70	-1.34596	51.80901
33	-1.36159	51.80531	71	-1.34624	51.80920
34	-1.35870	51.80516	72	-1.34715	51.80937

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
35	-1.35822	51.80527	73	-1.34716	51.80989
36	-1.35680	51.80458	74	-1.35219	51.81247
37	-1.35423	51.80284	75	-1.35721	51.81523
38	-1.36104	51.80037			

Panel Area (Middle F)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.35262	51.82072	21	-1.36106	51.82401
2	-1.35093	51.82161	22	-1.36264	51.82415
3	-1.34951	51.82258	23	-1.36281	51.82377
4	-1.34850	51.82288	24	-1.36354	51.82331
5	-1.34848	51.82354	25	-1.36368	51.82289
6	-1.34907	51.82467	26	-1.36373	51.82192
7	-1.35163	51.82467	27	-1.36370	51.82131
8	-1.35196	51.82609	28	-1.36284	51.82019
9	-1.35301	51.82652	29	-1.36237	51.82019
10	-1.35381	51.82672	30	-1.36206	51.82045
11	-1.35713	51.82681	31	-1.36188	51.82097
12	-1.35814	51.82680	32	-1.36146	51.82098
13	-1.35803	51.82511	33	-1.36093	51.82135
14	-1.35883	51.82514	34	-1.35913	51.82184
15	-1.35947	51.82495	35	-1.35742	51.82201
16	-1.35949	51.82482	36	-1.35620	51.82185
17	-1.35854	51.82414	37	-1.35561	51.82167
18	-1.35934	51.82416	38	-1.35525	51.82195

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
19	-1.36051	51.82376	39	-1.35470	51.82160
20	-1.36101	51.82377	40	-1.35262	51.82072

Panel Area (Middle G)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.33491	51.80589	29	-1.33297	51.81635
2	-1.33463	51.80593	30	-1.33297	51.81683
3	-1.33475	51.80667	31	-1.33878	51.81664
4	-1.33441	51.80699	32	-1.34153	51.81748
5	-1.33342	51.80703	33	-1.34335	51.81774
6	-1.33031	51.80746	34	-1.34498	51.81791
7	-1.33032	51.80630	35	-1.34682	51.81719
8	-1.32974	51.80619	36	-1.34686	51.81780
9	-1.33135	51.80486	37	-1.34779	51.81878
10	-1.33126	51.80468	38	-1.34962	51.81824
11	-1.33017	51.80425	39	-1.35131	51.81936
12	-1.32703	51.80335	40	-1.35165	51.81935
13	-1.32662	51.80335	41	-1.35190	51.81898
14	-1.32646	51.80502	42	-1.35220	51.81898
15	-1.32584	51.80538	43	-1.35261	51.81794
16	-1.32636	51.80581	44	-1.35199	51.81684
17	-1.32726	51.80635	45	-1.35601	51.81507
18	-1.32398	51.80846	46	-1.35347	51.81370
19	-1.32629	51.80959	47	-1.35032	51.81212
20	-1.32636	51.80975	48	-1.35130	51.81453

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
21	-1.32799	51.81027	49	-1.34905	51.81503
22	-1.32932	51.81111	50	-1.34772	51.81266
23	-1.33039	51.81162	51	-1.35002	51.81218
24	-1.33221	51.81229	52	-1.35001	51.81197
25	-1.33217	51.81260	53	-1.34710	51.81047
26	-1.33178	51.81260	54	-1.34413	51.80912
27	-1.33175	51.81296	55	-1.33491	51.80589
28	-1.33244	51.81634			

Panel Area (Middle H)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.33399	51.80508	4	-1.33550	51.80191
2	-1.33492	51.80539	5	-1.33306	51.80234
3	-1.33696	51.80518	6	-1.33399	51.80508

Panel Area (Middle I)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.33244	51.80380	7	-1.32392	51.80147
2	-1.33261	51.80291	8	-1.32392	51.80166
3	-1.33222	51.80131	9	-1.32778	51.80275
4	-1.33029	51.80116	10	-1.33166	51.80429
5	-1.32803	51.80122	11	-1.33197	51.80431
6	-1.32554	51.80106	12	-1.33244	51.80380

Panel Area (Middle J)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.32956	51.81870	38	-1.32656	51.83196

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
2	-1.32824	51.81940	39	-1.32735	51.83196
3	-1.32759	51.81937	40	-1.32791	51.83189
4	-1.32665	51.81969	41	-1.33197	51.83002
5	-1.32654	51.81995	42	-1.33316	51.83075
6	-1.32796	51.82060	43	-1.33323	51.83152
7	-1.32709	51.82118	44	-1.33798	51.83420
8	-1.32677	51.82102	45	-1.33955	51.83542
9	-1.32541	51.82195	46	-1.34192	51.83526
10	-1.32421	51.82308	47	-1.34245	51.83413
11	-1.32334	51.82329	48	-1.34320	51.83411
12	-1.32070	51.82366	49	-1.34396	51.83277
13	-1.32117	51.82492	50	-1.34464	51.83212
14	-1.32229	51.82517	51	-1.34553	51.83216
15	-1.32407	51.82520	52	-1.34604	51.83178
16	-1.32543	51.82509	53	-1.34724	51.82850
17	-1.32590	51.82490	54	-1.34618	51.82799
18	-1.32651	51.82488	55	-1.34559	51.82841
19	-1.32655	51.82547	56	-1.34513	51.82826
20	-1.32710	51.82594	57	-1.34457	51.82869
21	-1.32712	51.82655	58	-1.34345	51.82831
22	-1.32505	51.82745	59	-1.34441	51.82729
23	-1.32467	51.82730	60	-1.34278	51.82650
24	-1.32431	51.82603	61	-1.34197	51.82629
25	-1.32143	51.82587	62	-1.34090	51.82632

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
26	-1.32109	51.82602	63	-1.34015	51.82621
27	-1.32197	51.82707	64	-1.34041	51.82535
28	-1.32390	51.82729	65	-1.33398	51.82391
29	-1.32348	51.82887	66	-1.33349	51.82373
30	-1.32585	51.83150	67	-1.33172	51.82364
31	-1.32611	51.83148	68	-1.33103	51.82176
32	-1.32656	51.83135	69	-1.33106	51.82067
33	-1.32685	51.83156	70	-1.32978	51.81968
34	-1.32702	51.83155	71	-1.33037	51.81935
35	-1.32702	51.83170	72	-1.32984	51.81870
36	-1.32678	51.83170	73	-1.32956	51.81870
37	-1.32656	51.83184			

Panel Area (Middle K)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.32151	51.82895	5	-1.31618	51.82776
2	-1.32168	51.82823	6	-1.31683	51.82956
3	-1.31996	51.82596	7	-1.31943	51.82930
4	-1.31532	51.82640	8	-1.32151	51.82895

Panel Area (Middle L)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.34875	51.74185	8	-1.34760	51.74262
2	-1.34811	51.74198	9	-1.34792	51.74229
3	-1.34752	51.74198	10	-1.34847	51.74228
4	-1.34715	51.74225	11	-1.34884	51.74229
5	-1.34680	51.74272	12	-1.34928	51.74213

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
6	-1.34717	51.74274	13	-1.34903	51.74183
7	-1.34730	51.74262	14	-1.34875	51.74185

Panel Area (South A)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.34170	51.74129	12	-1.34444	51.74391
2	-1.34167	51.74157	13	-1.34606	51.74219
3	-1.34203	51.74266	14	-1.34696	51.74157
4	-1.34267	51.74269	15	-1.34697	51.74113
5	-1.34270	51.74297	16	-1.34660	51.74114
6	-1.34286	51.74300	17	-1.34599	51.74154
7	-1.34277	51.74325	18	-1.34617	51.74204
8	-1.34198	51.74324	19	-1.34386	51.74233
9	-1.34213	51.74391	20	-1.34289	51.74192
10	-1.34283	51.74501	21	-1.34221	51.74128
11	-1.34318	51.74502	22	-1.34170	51.74129

Panel Area (South B)

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.33094	51.74669	29	-1.33206	51.74515
2	-1.33137	51.74707	30	-1.33138	51.74516
3	-1.33124	51.74737	31	-1.33083	51.74487
4	-1.33048	51.74722	32	-1.33102	51.74416
5	-1.32762	51.74702	33	-1.33115	51.74326
6	-1.32750	51.74745	34	-1.33094	51.74292
7	-1.32956	51.74747	35	-1.32927	51.74235
8	-1.32781	51.74795	36	-1.32809	51.74404

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
9	-1.32787	51.74889	37	-1.32719	51.74461
10	-1.32828	51.74899	38	-1.32549	51.74546
11	-1.33088	51.74822	39	-1.32495	51.74566
12	-1.33134	51.74783	40	-1.32464	51.74565
13	-1.33312	51.74783	41	-1.32484	51.74458
14	-1.33367	51.74736	42	-1.32514	51.74393
15	-1.33533	51.74739	43	-1.32368	51.74332
16	-1.33722	51.74688	44	-1.32262	51.74387
17	-1.33758	51.74686	45	-1.32188	51.74451
18	-1.33904	51.74616	46	-1.32139	51.74535
19	-1.34048	51.74530	47	-1.32325	51.74604
20	-1.34159	51.74406	48	-1.32463	51.74635
21	-1.34148	51.74323	49	-1.32544	51.74648
22	-1.34119	51.74140	50	-1.32702	51.74653
23	-1.33773	51.74178	51	-1.32760	51.74631
24	-1.33413	51.74262	52	-1.32848	51.74504
25	-1.33398	51.74382	53	-1.33065	51.74497
26	-1.33414	51.74576	54	-1.33130	51.74524
27	-1.33363	51.74579	55	-1.33102	51.74574
28	-1.33234	51.74552	56	-1.33094	51.74669

Panel Area (South C)

APPENDIX H – DETAILLED MODELLING RESULTS

Overview

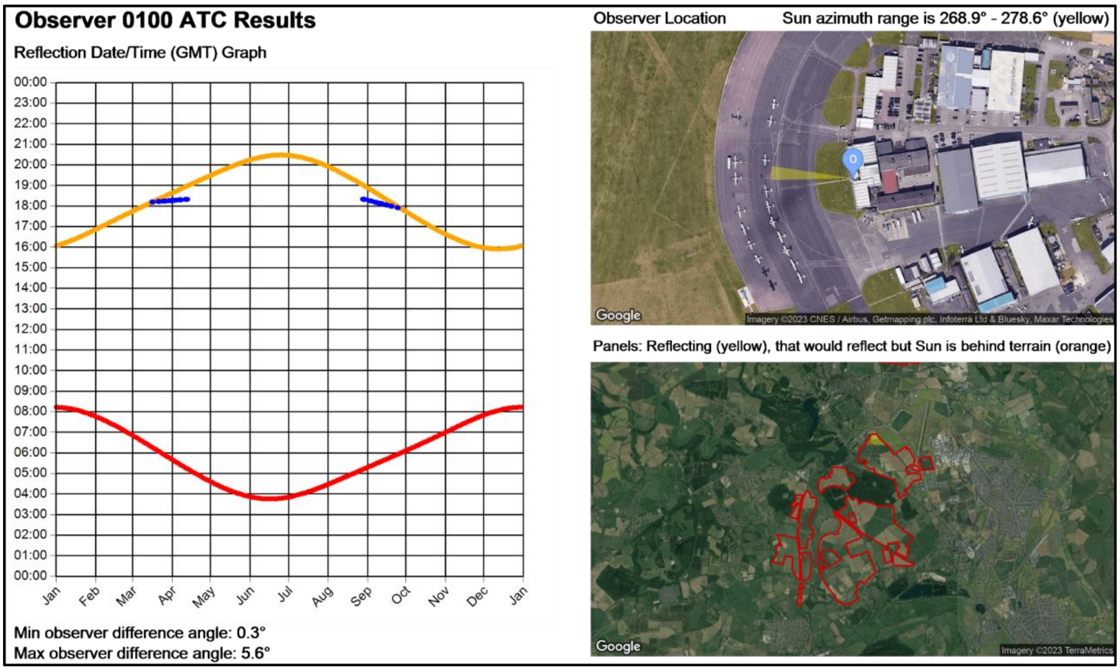
The Pager Power charts for receptors are shown on the following pages. Further modelling charts can be provided upon request. Each chart shows:

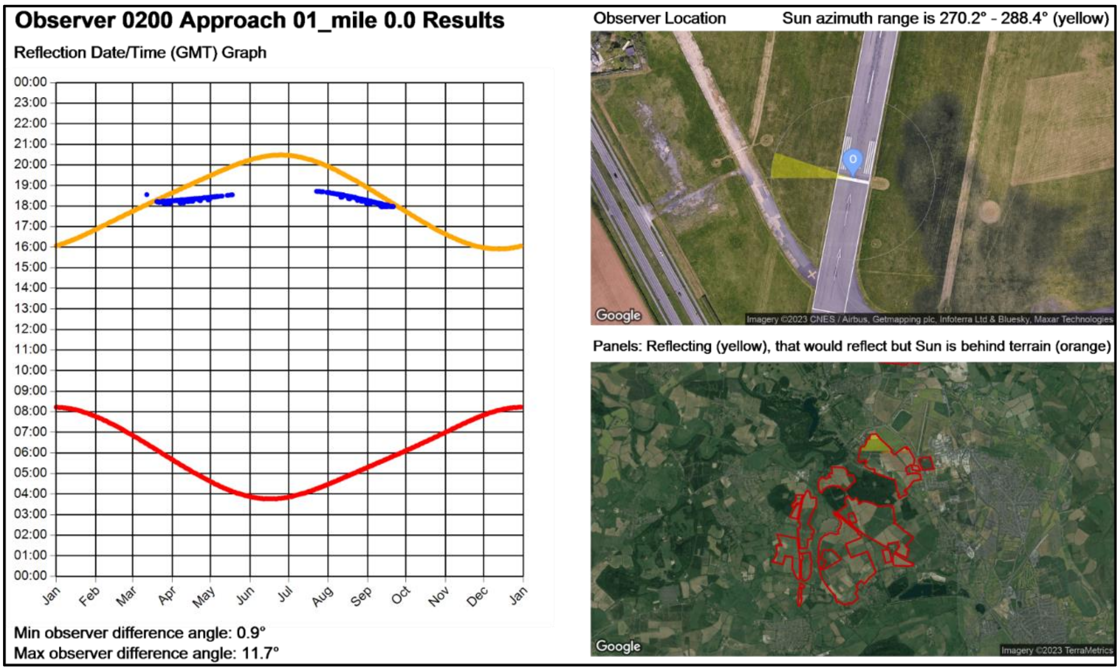
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of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

Full modelling results can be provided upon request.

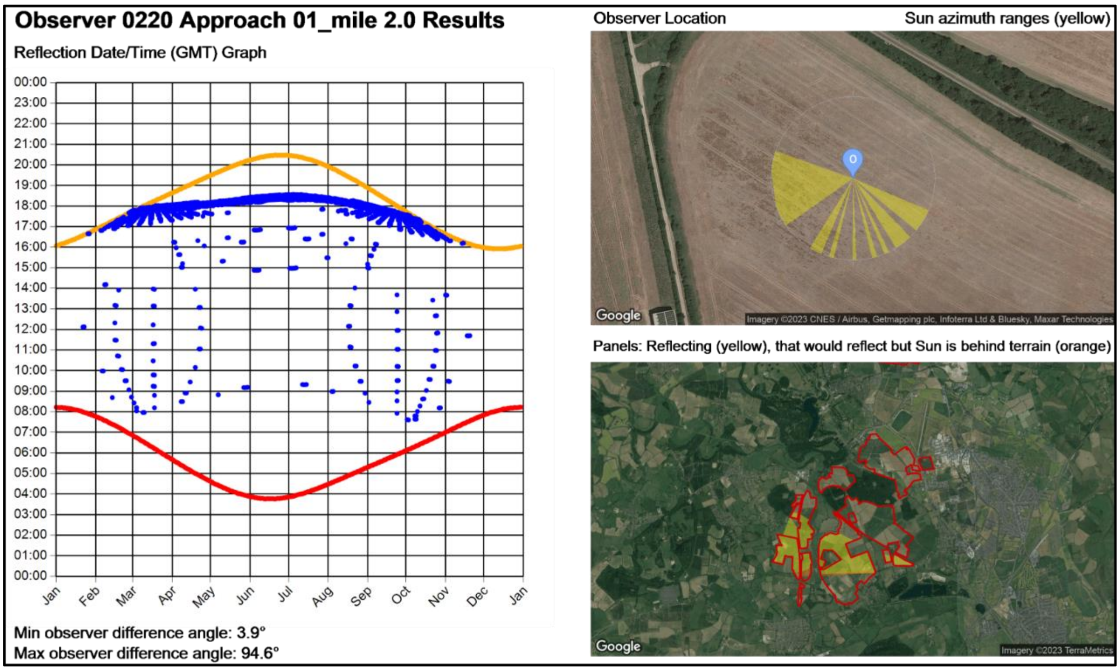
Aviation Receptors

Selected results have been included to show a range of representative results.

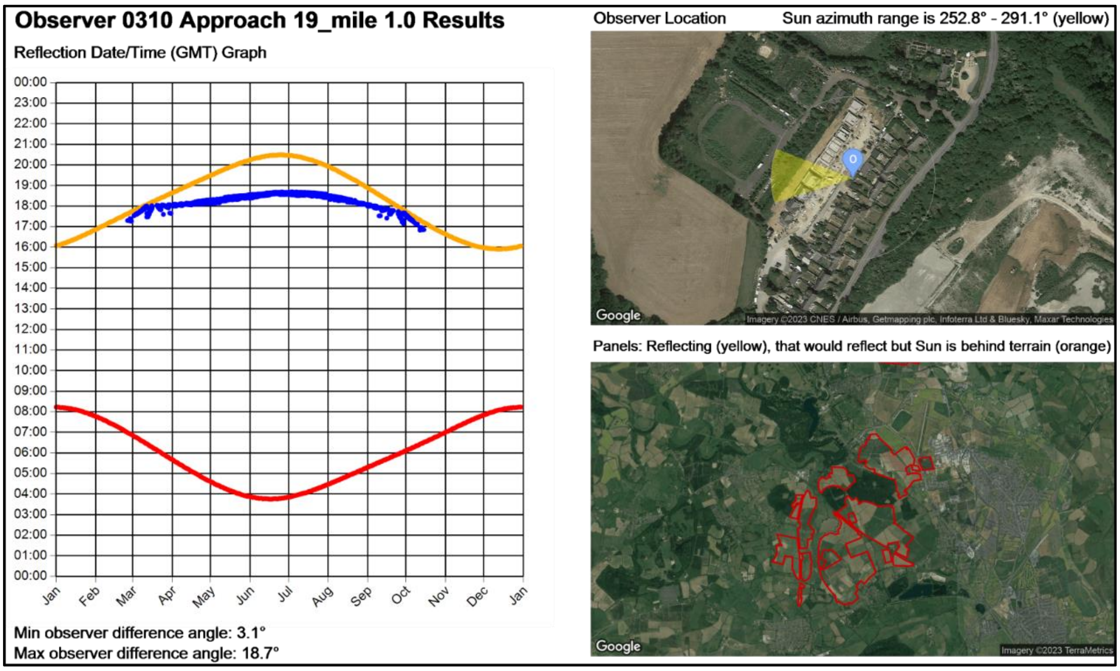


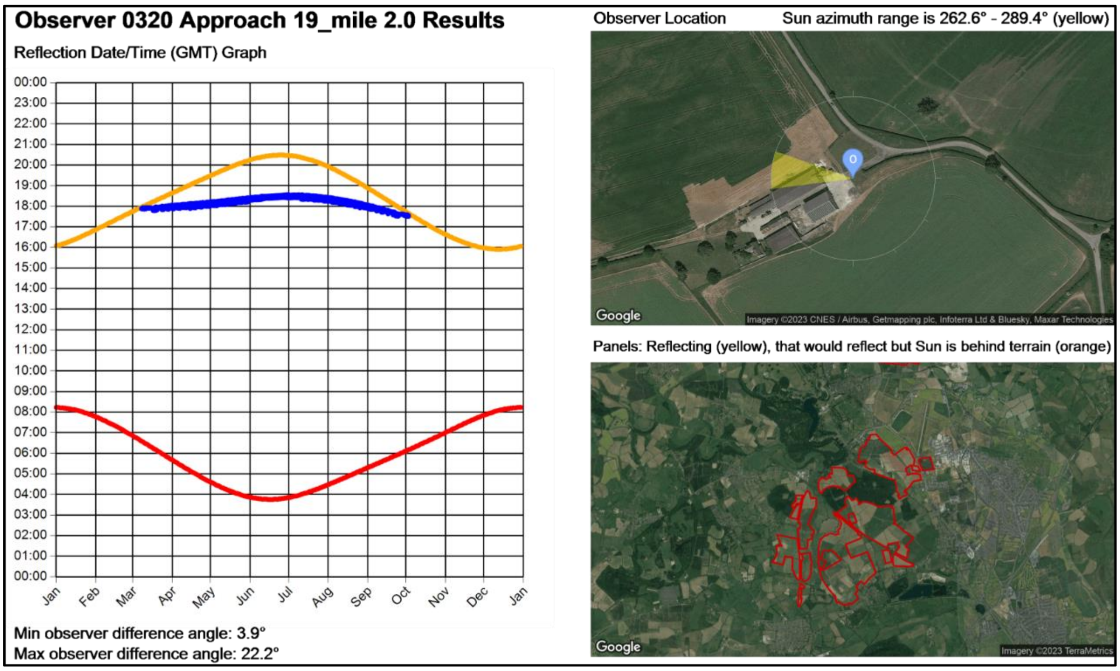


Observer 0200 Approach 01_mile 0.0 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.9°
Max observer difference angle: 11.7°
Observer Location
Sun azimuth range is 270.2° - 288.4° (yellow)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2023 TerraMetrics



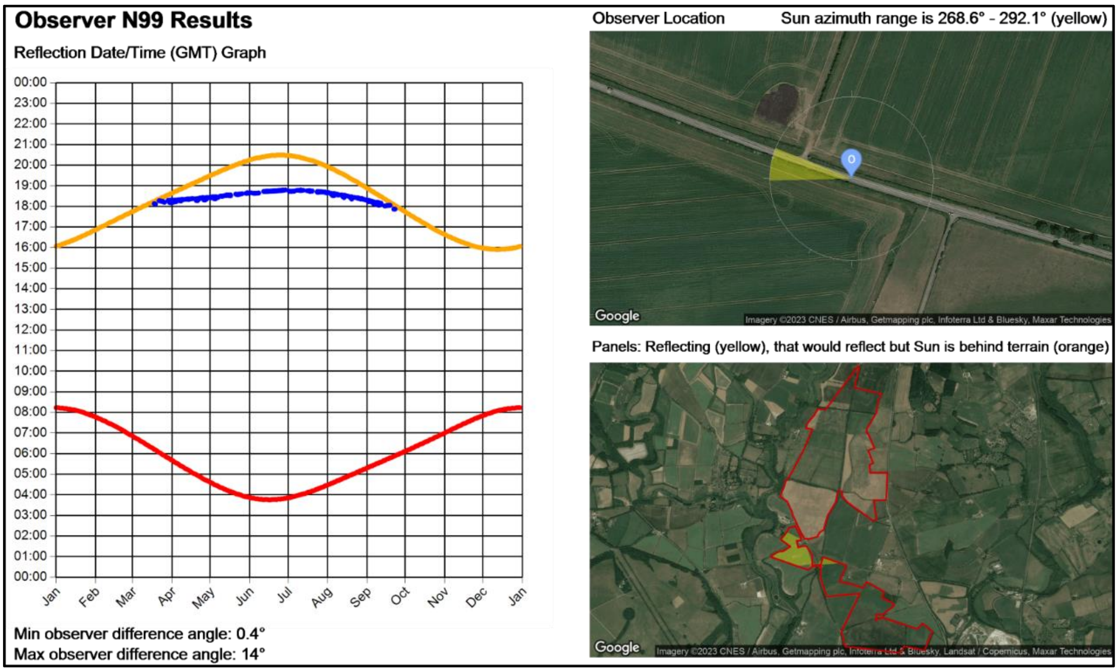
Observer 0220 Approach 01_mile 2.0 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 3.9°
Max observer difference angle: 94.6°
Observer Location
Sun azimuth ranges (yellow)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2023 TerraMetrics

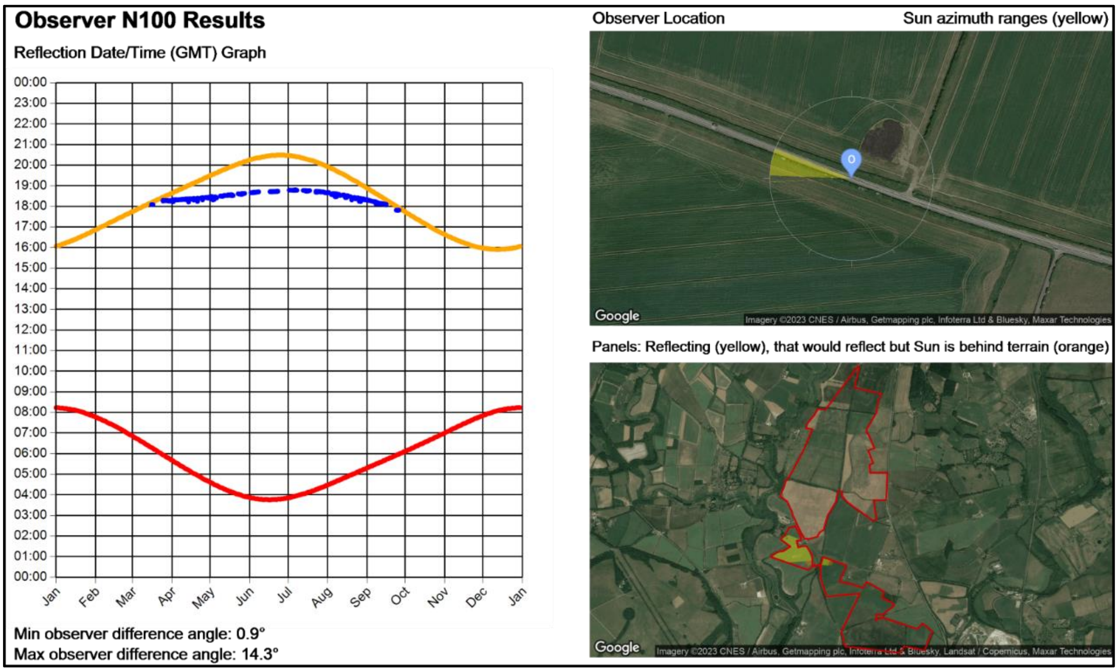

Observer 0310 Approach 19_mile 1.0 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 3.1°
Max observer difference angle: 18.7°
Observer Location
Sun azimuth range is 252.8° - 291.1° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2023 TerraMetrics

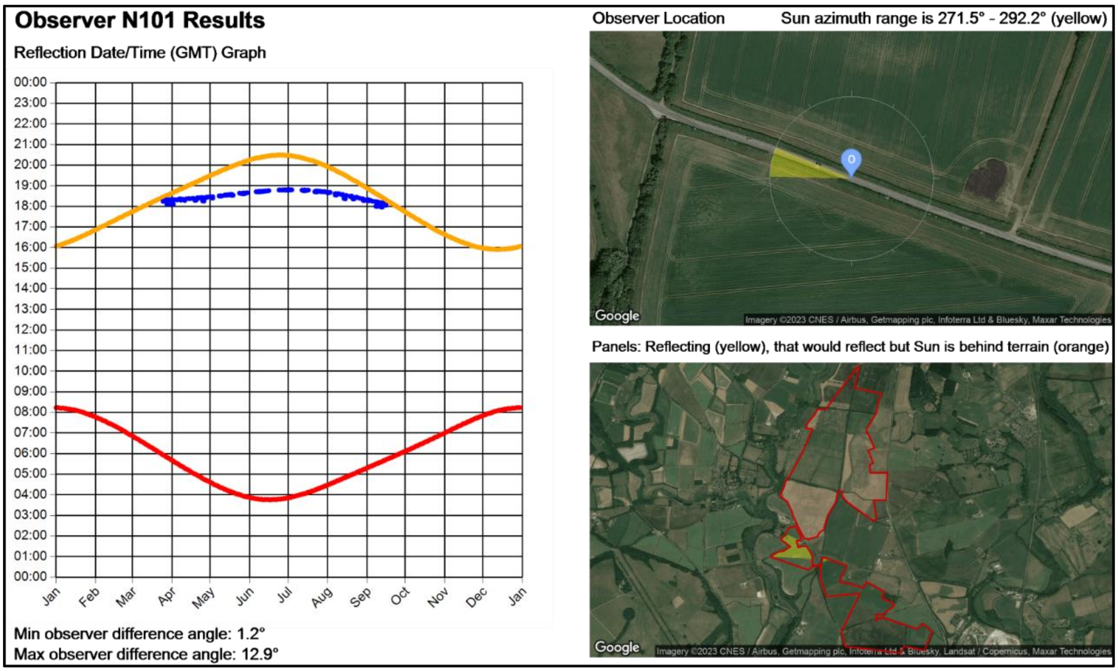

Observer 0320 Approach 19_mile 2.0 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 3.9°
Max observer difference angle: 22.2°
Observer Location
Sun azimuth range is 262.6° - 289.4° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2023 TerraMetrics

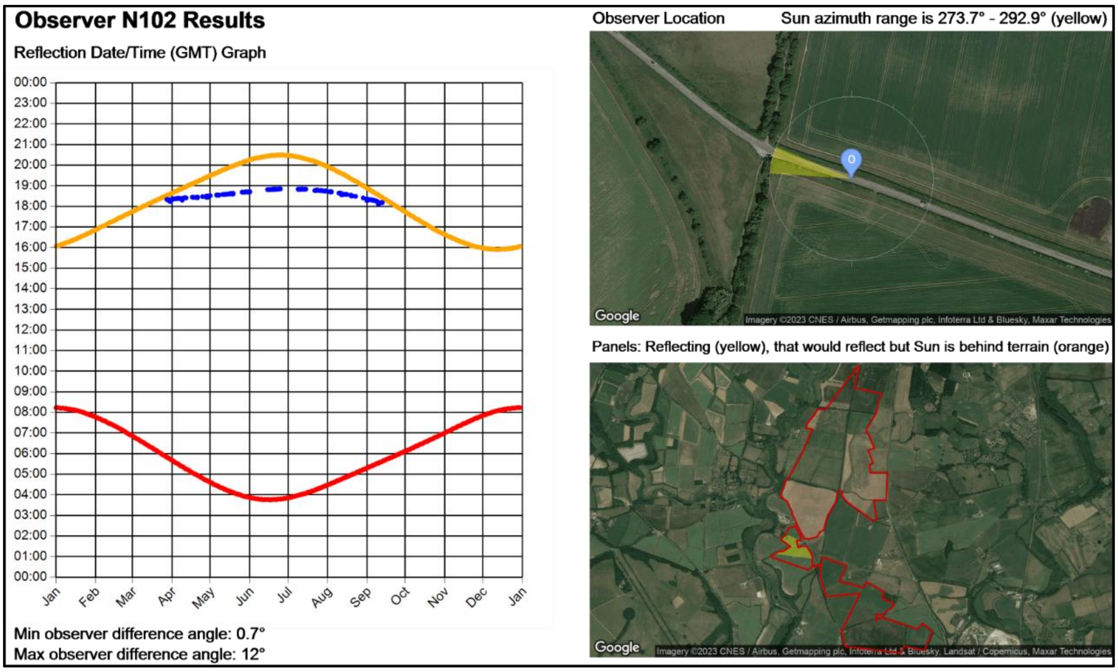
Road Receptors

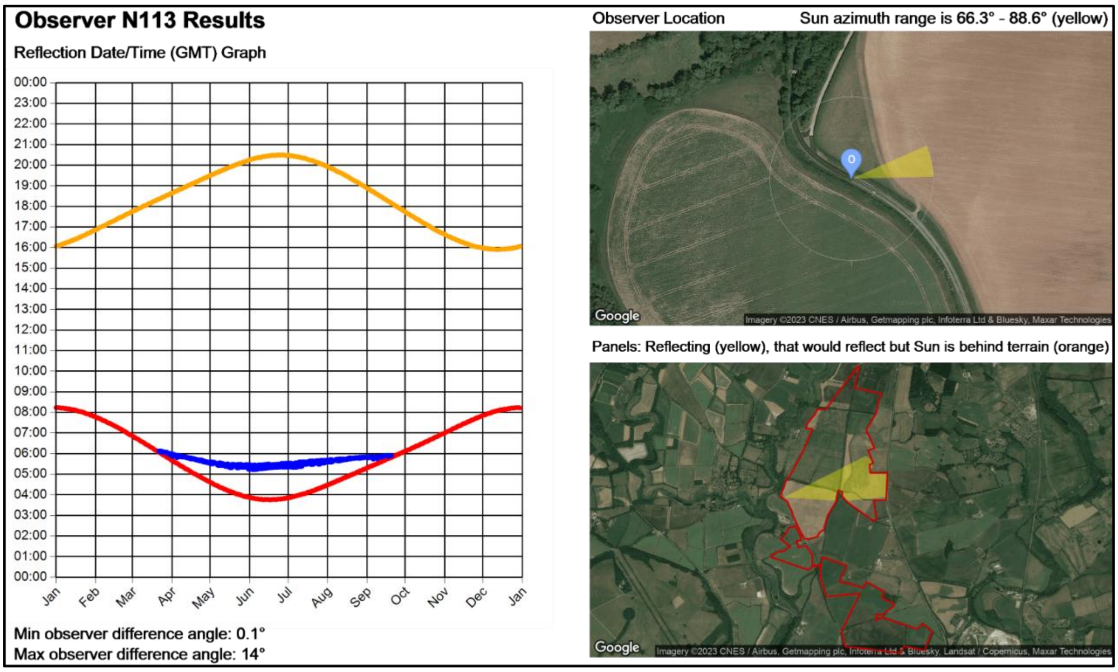
Results have been included where mitigation has been recommended.





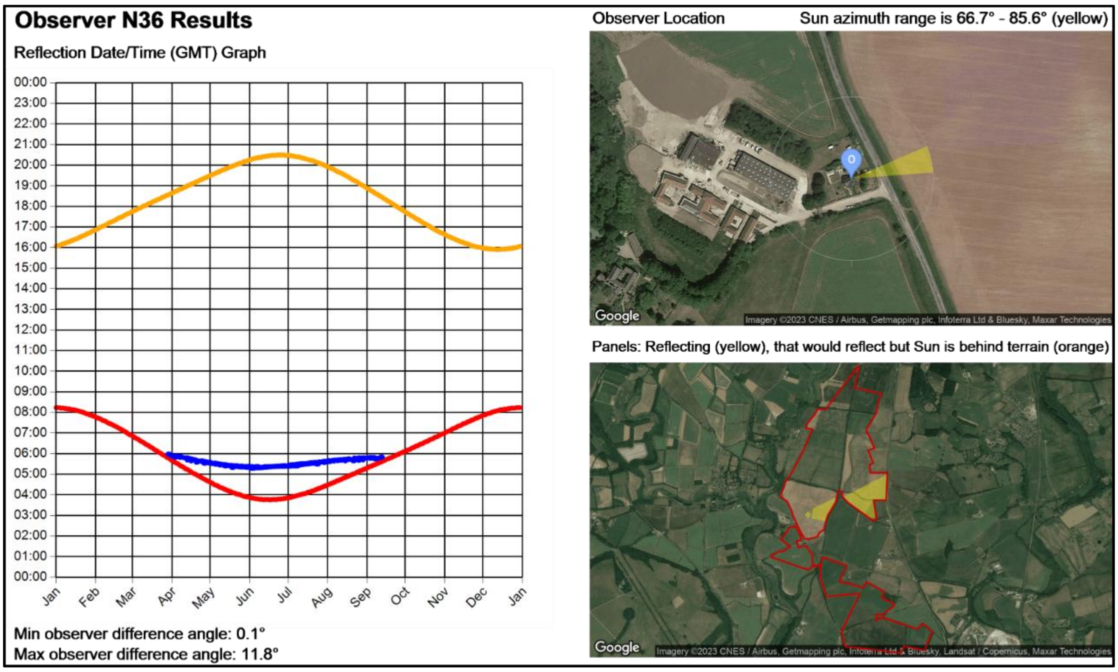

Observer N101 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 1.2°
Max observer difference angle: 12.9°
Observer Location
Sun azimuth range is 271.5° - 292.2° (yellow)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Landsat / Copernicus, Maxar Technologies

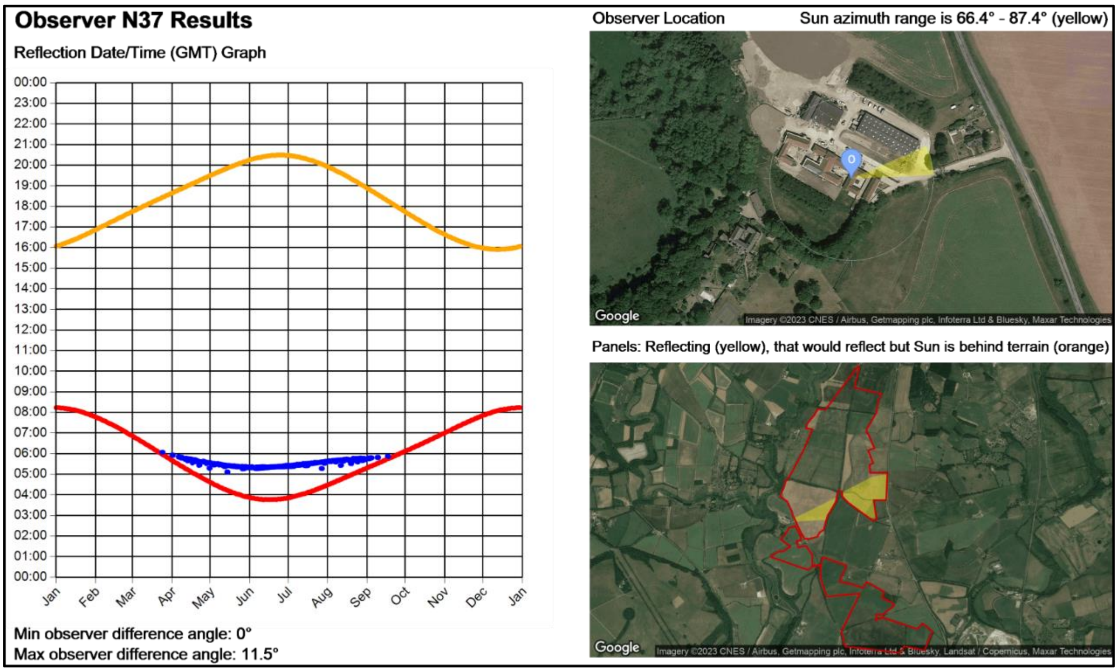

Observer N102 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.7°
Max observer difference angle: 12°
Observer Location
Sun azimuth range is 273.7° - 292.9° (yellow)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Landsat / Copernicus, Maxar Technologies

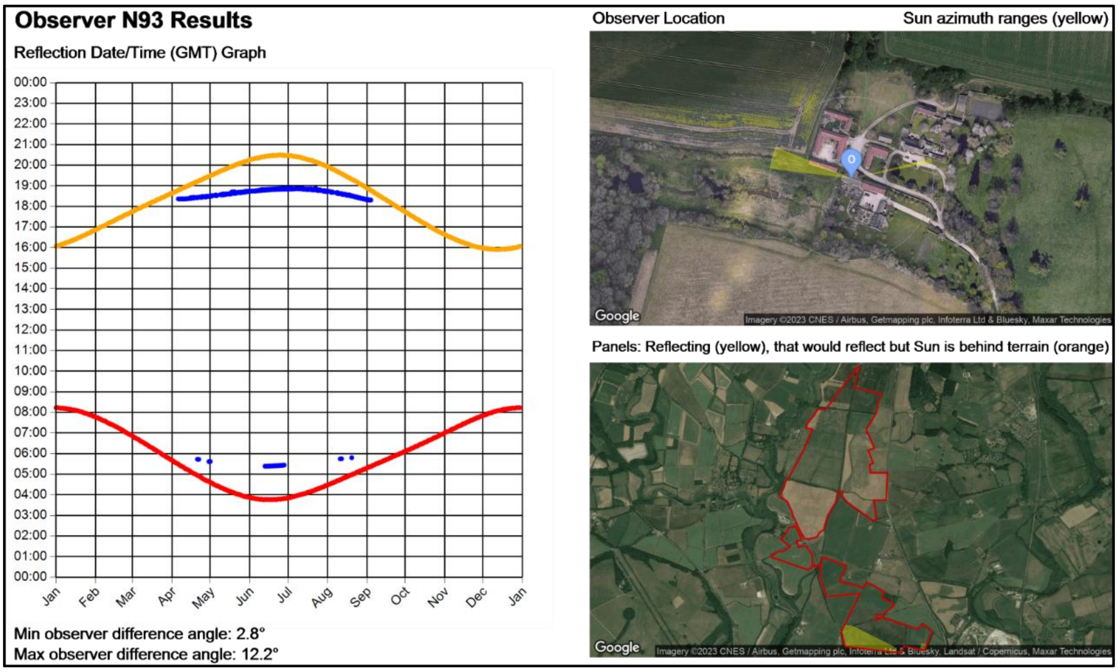


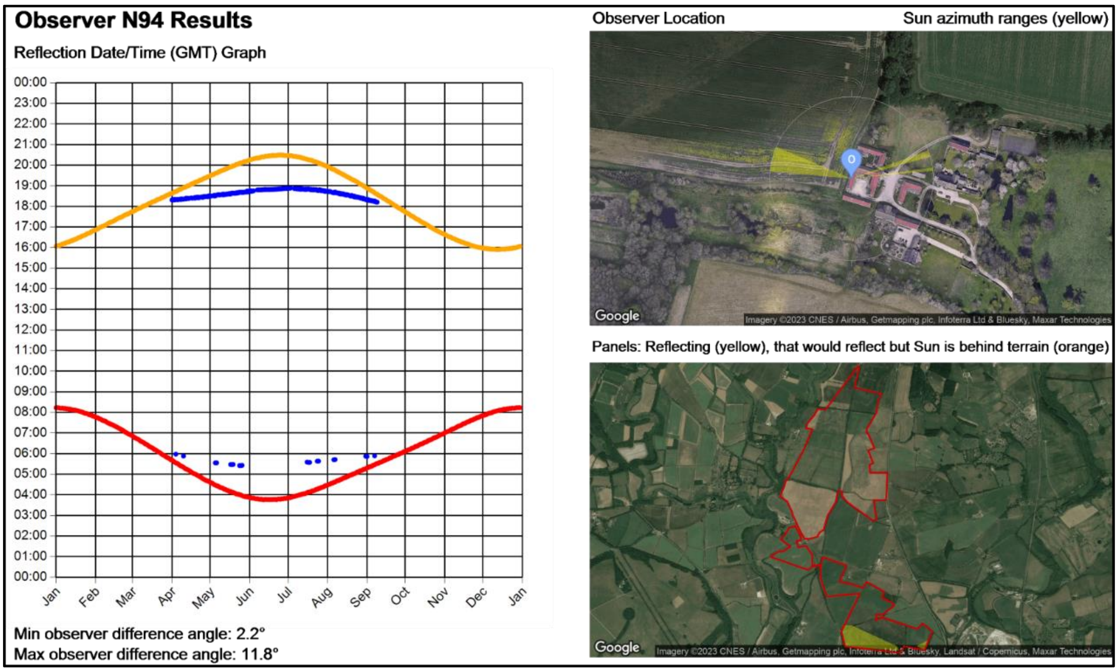
Dwelling Receptors

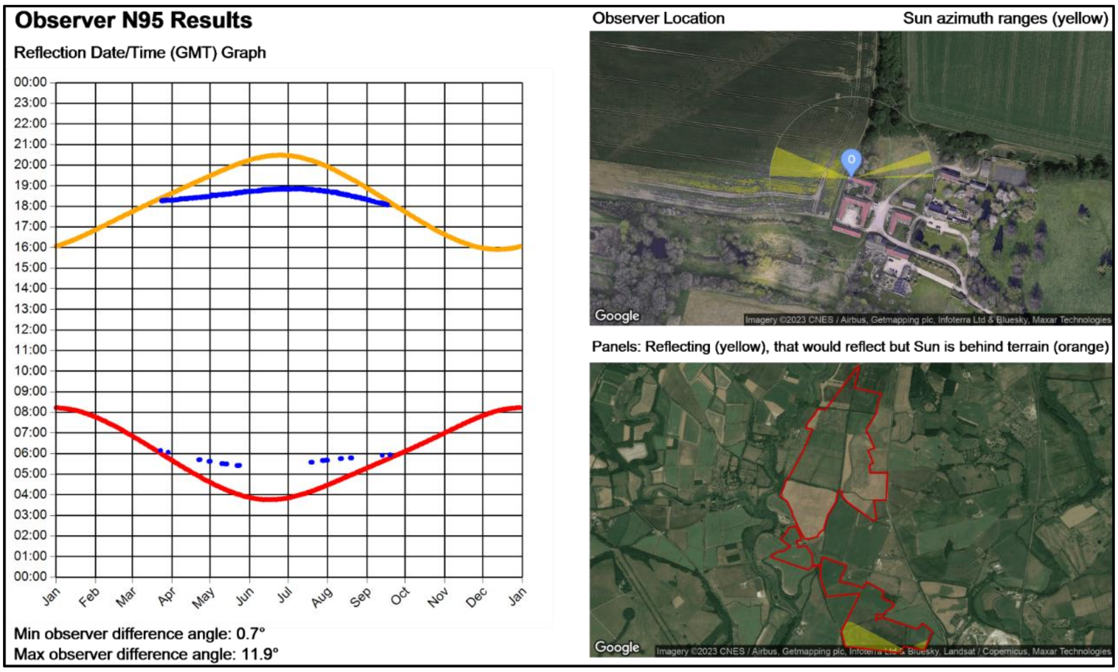
Results have been included where mitigation has been recommended.

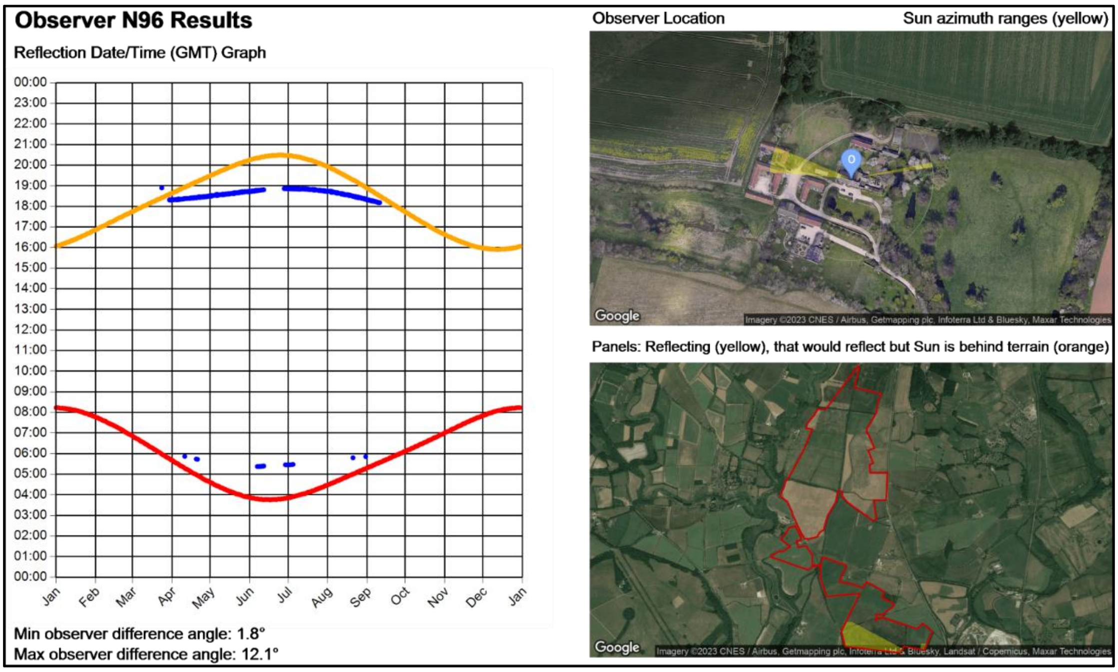


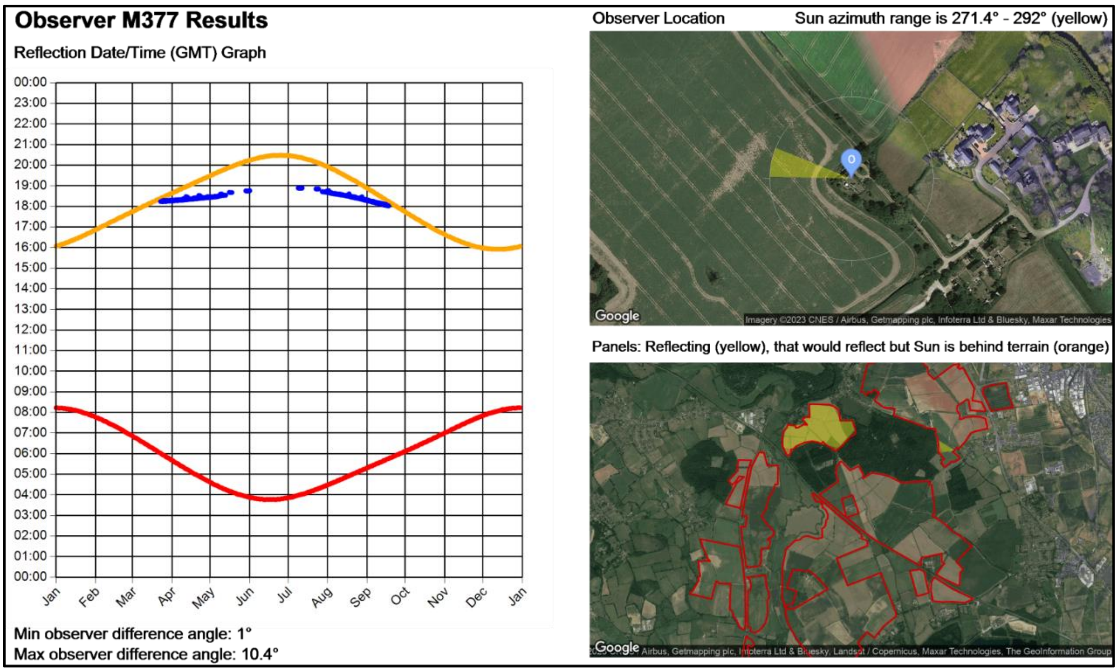

Observer N37 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0°
Max observer difference angle: 11.5°
Observer Location
Sun azimuth range is 66.4° - 87.4° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer N93 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 2.8°
Max observer difference angle: 12.2°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer N94 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 2.2°
Max observer difference angle: 11.8°
Observer Location
Sun azimuth ranges (yellow)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

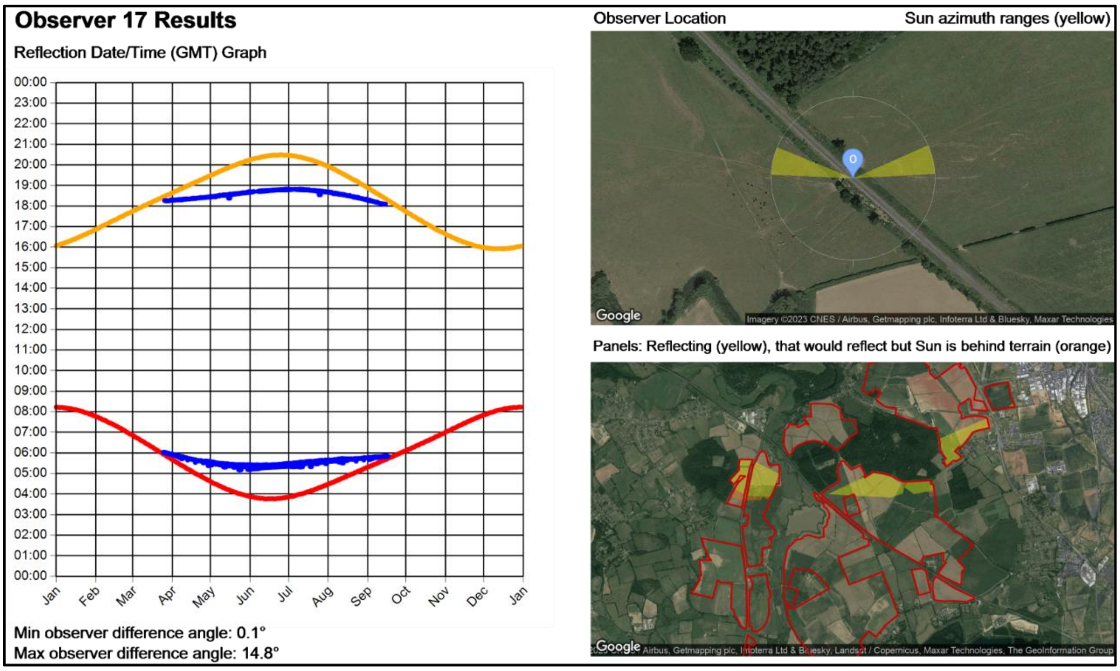

Observer N95 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.7°
Max observer difference angle: 11.9°
Observer Location
Sun azimuth ranges (yellow)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

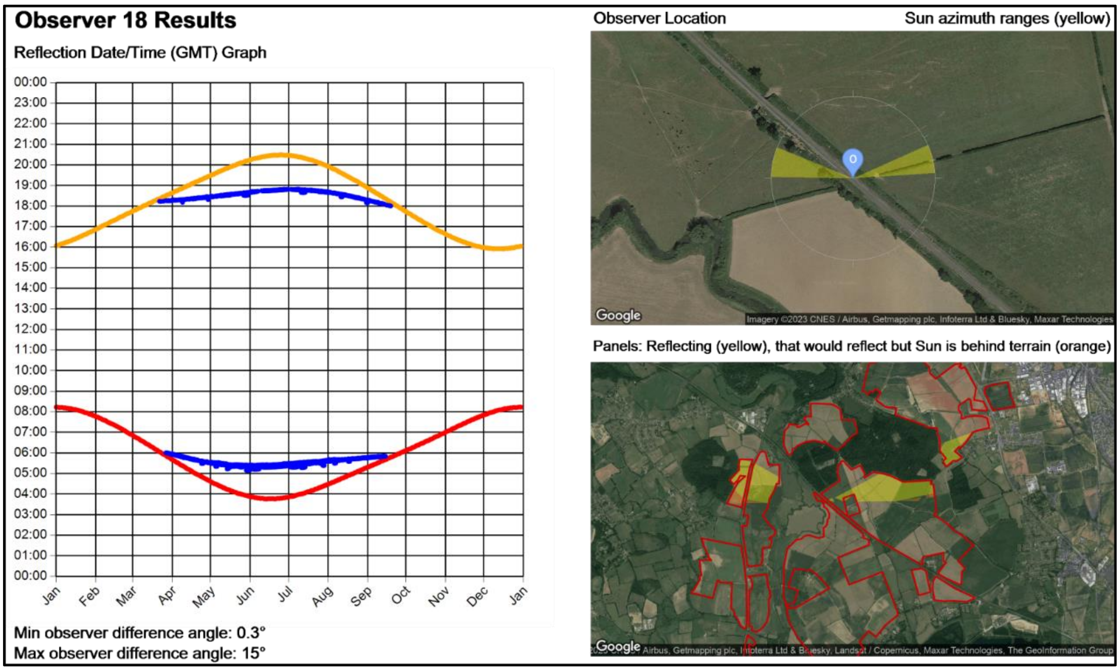

Observer N96 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 1.8°
Max observer difference angle: 12.1°
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

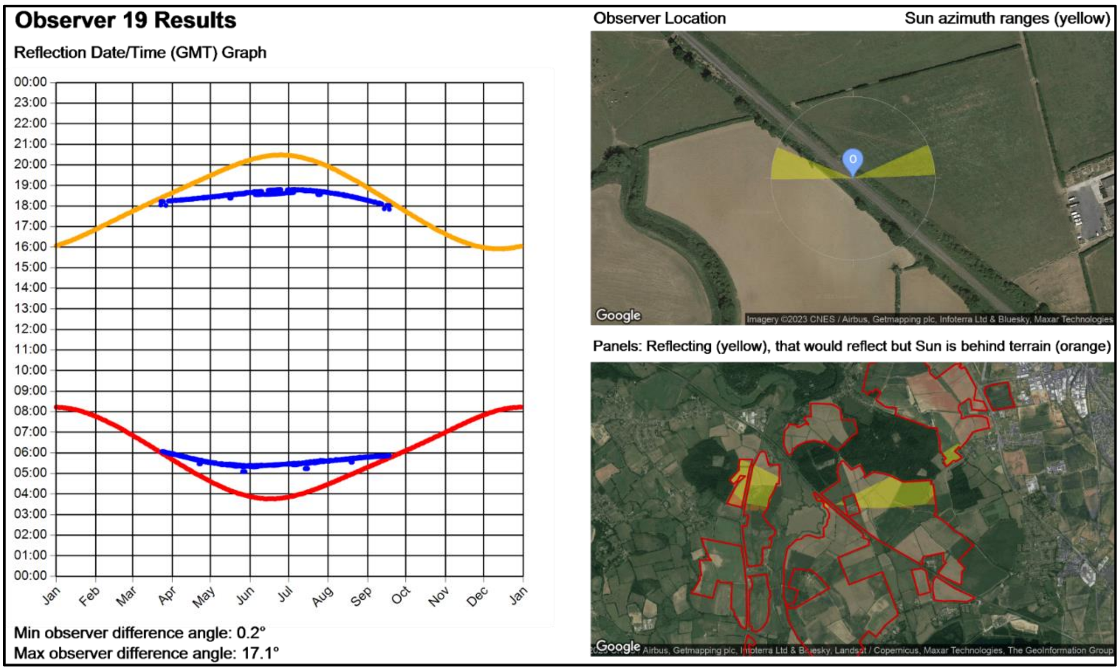

Observer M377 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 1°
Max observer difference angle: 10.4°
Observer Location
Sun azimuth range is 271.4° - 292° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

Railway Receptors

Results have been included where a low impact is predicted.







Observer 19 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.2°
Max observer difference angle: 17.1°
Observer Location
Sun azimuth ranges (yellow)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

APPENDIX I – DESK-BASED ANALYSIS

Overview

Representative desk-based analysis for receptors is shown on the following pages, including the identification of relevant screening and reflecting panel areas. Further images can be provided upon request. Each chart shows:

- The receptor (observer) location(s);
- The reflecting panels (shaded in yellow);
- Identified existing vegetation (outlined in green) and proposed vegetation (pink areas).

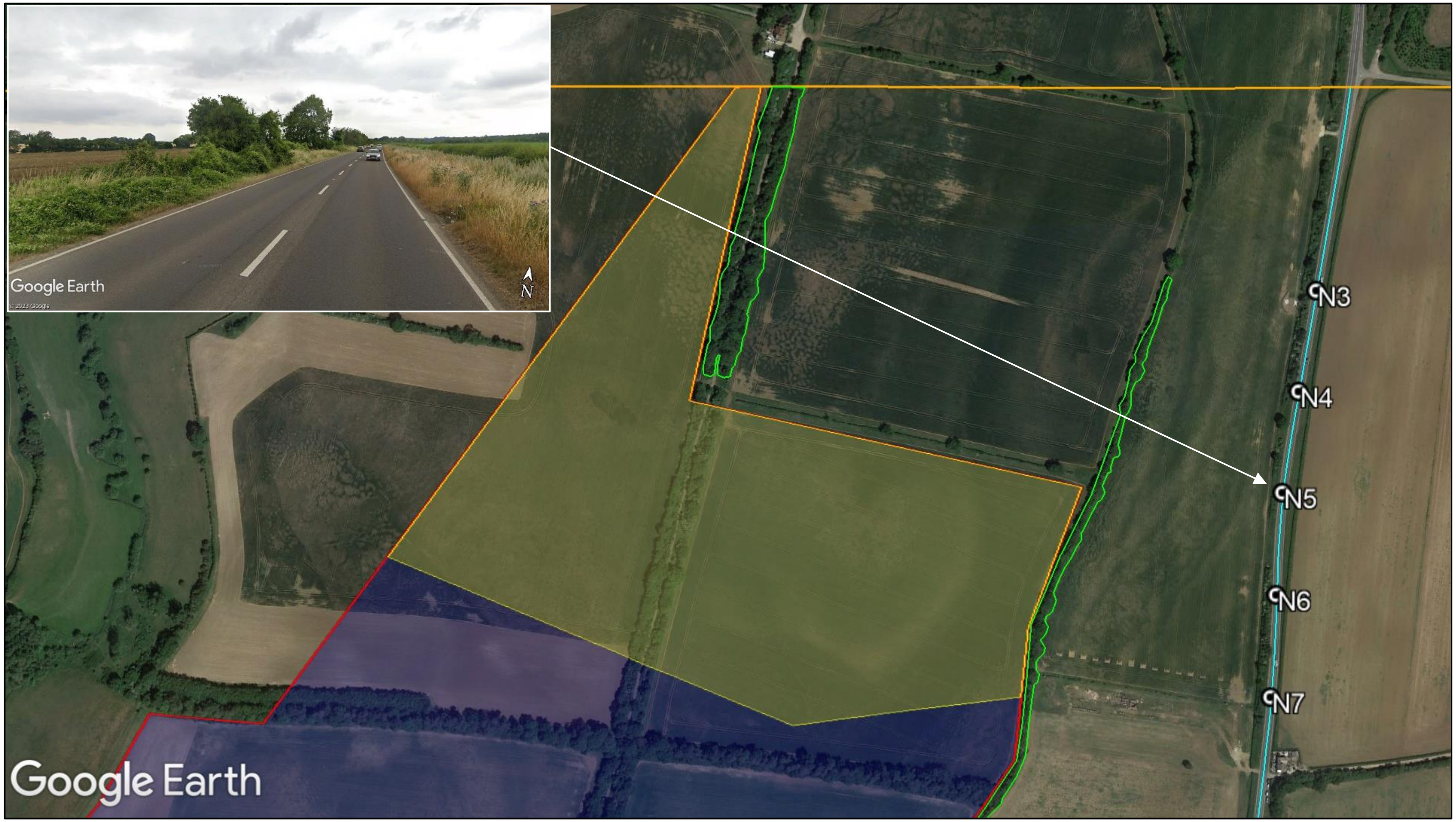


Figure 94 *Reflective panel areas and screening for road receptors N3 to N8*

Figure 95 *Reflective panel areas and screening for road receptors N8 to N12*

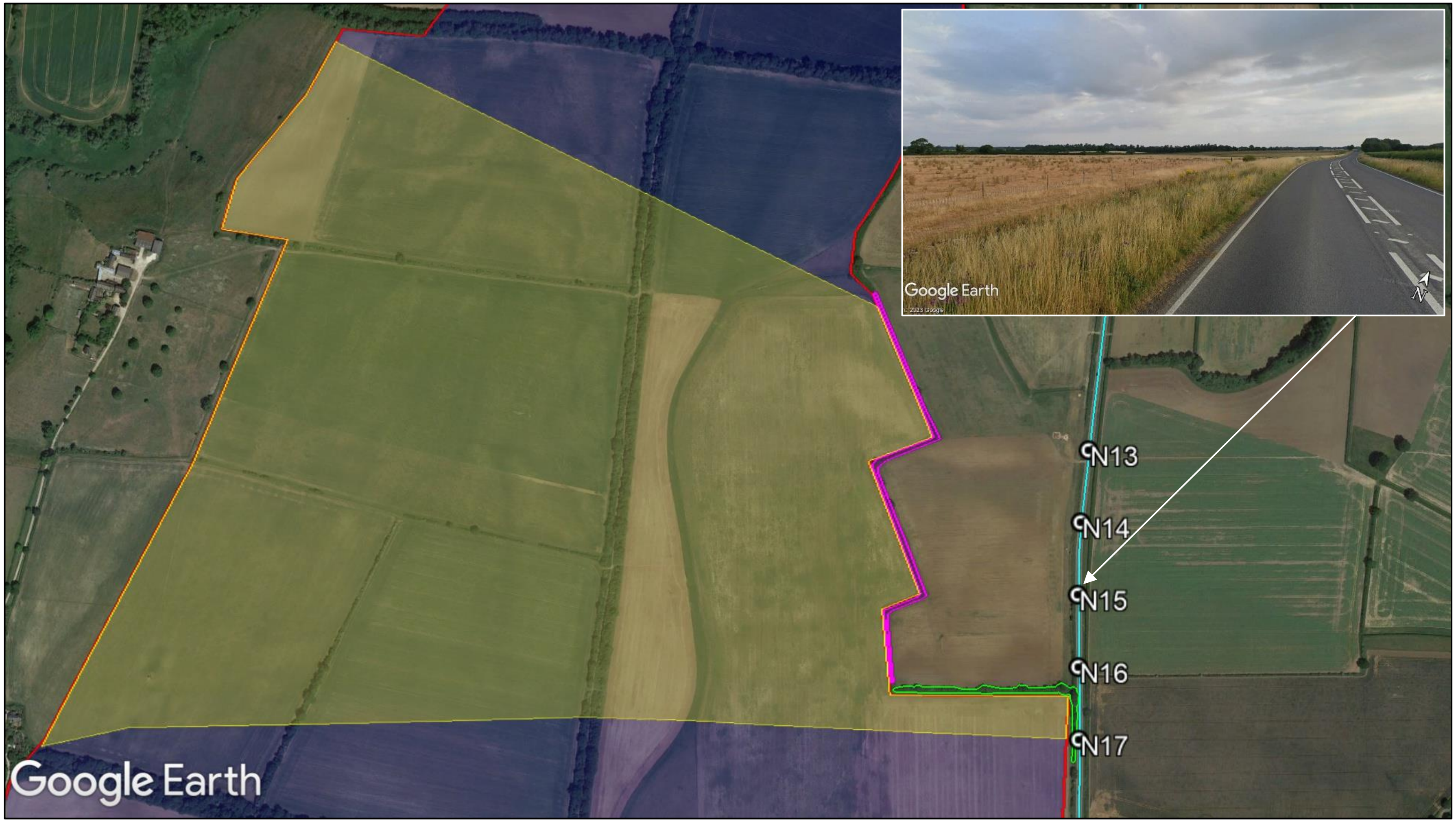


Figure 96 *Reflective panel areas and screening for road receptors N13 to N17*

Figure 97 *Reflective panel areas and screening for road receptor N18 to N22*

Figure 98 *Reflective panel areas and screening for road receptors N23 to N27*

Figure 99 *Reflective panel areas and screening for road receptors N28 to N32*

Figure 100 *Reflective panel areas and screening for road receptors N33 to N37*

Figure 101 *Reflective panel areas and screening for road receptors N38 to N42*

Figure 102 *Reflective panel areas and screening for road receptors N43 to N47*

Figure 103 *Reflective panel areas and screening for road receptors N48 to N52*

Figure 104 *Reflective panel areas and screening for road receptors N60 to N65*

Figure 105 *Reflective panel areas and screening for road receptors N66 to N71*

Figure 106 *Reflective panel areas and screening for road receptors N72 to N77*

Figure 107 *Reflective panel areas and screening for road receptors N78 to N83*

Figure 108 *Reflective panel areas and screening for road receptors N84 to N88*

Figure 109 *Reflective panel areas and screening for road receptors N89 to N93*

Figure 110 *Reflective panel areas and screening for road receptors N94 to N98*

Figure 111 *Reflective panel areas and screening for road receptors N103 to N108*

Figure 112 *Reflective panel areas and screening for road receptors N114 to N119*

Figure 113 *Reflective panel areas and screening for road receptors N120 to N125*

Figure 114 *Reflective panel areas and screening for road receptors N126 to N132*

Figure 115 *Reflective panel areas and screening for dwellings N3 to N13*

Figure 116 *Reflective panel areas and screening for dwellings N14 to N35*

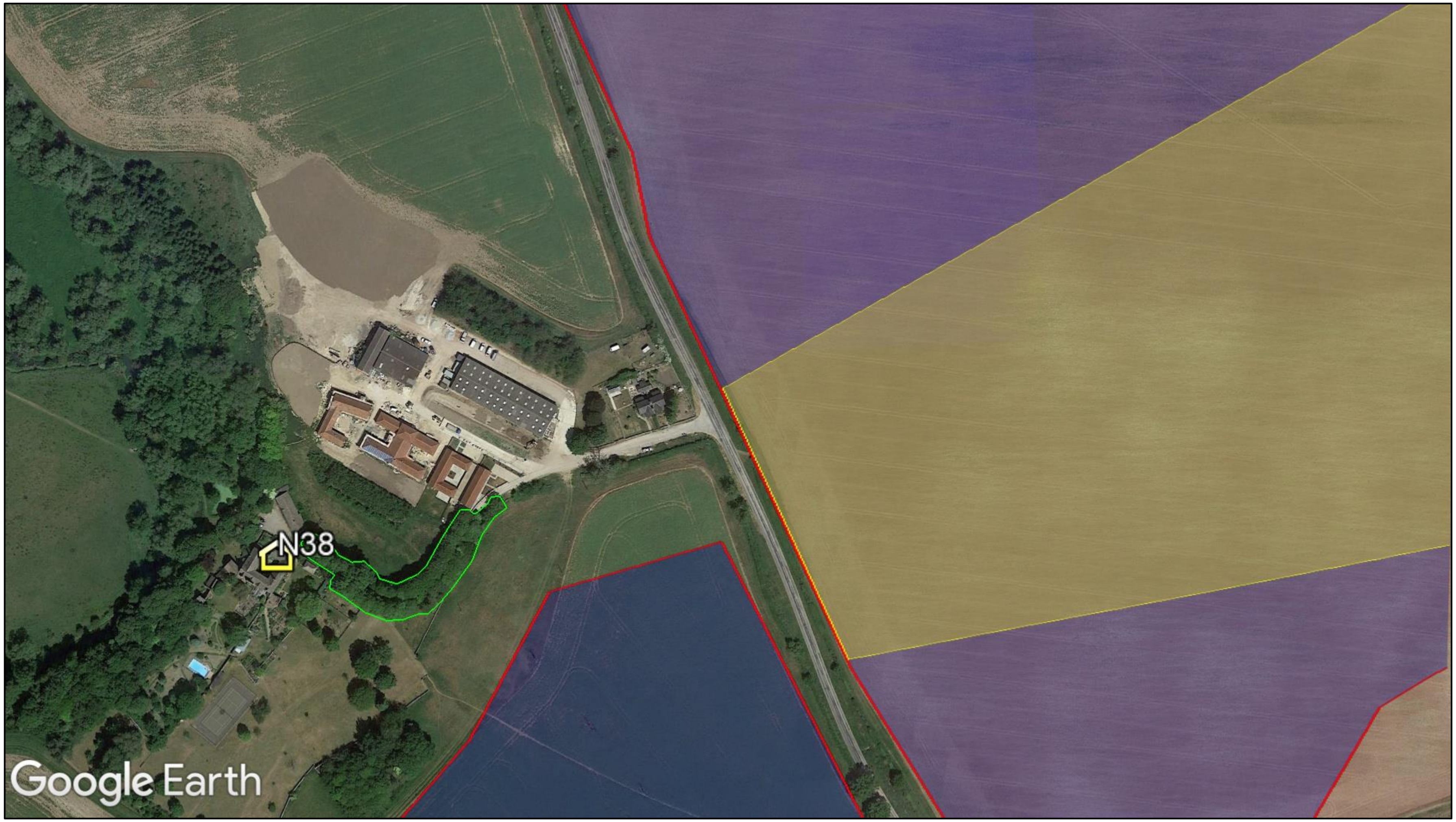


Figure 117 *Reflective panel areas and screening for dwelling N38*

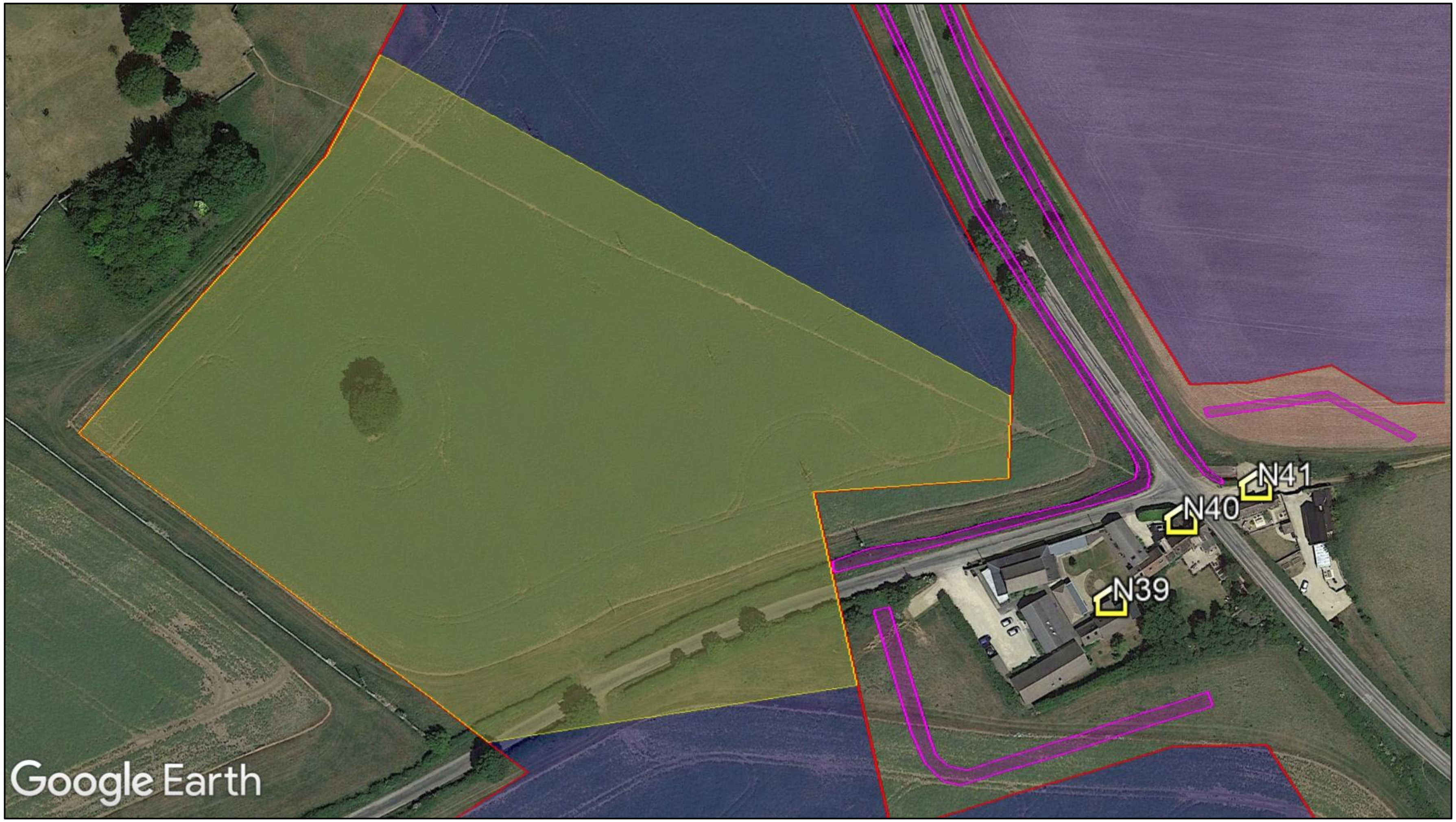


Figure 118 *Reflective panel areas and screening for dwellings N39 to N41*

Figure 119 *Reflective panel areas and screening for dwellings N42 and N43*

Figure 120 *Reflective panel areas and screening for dwellings N44 to N79*

Figure 121 *Reflective panel areas and screening for dwellings N90 to N92*

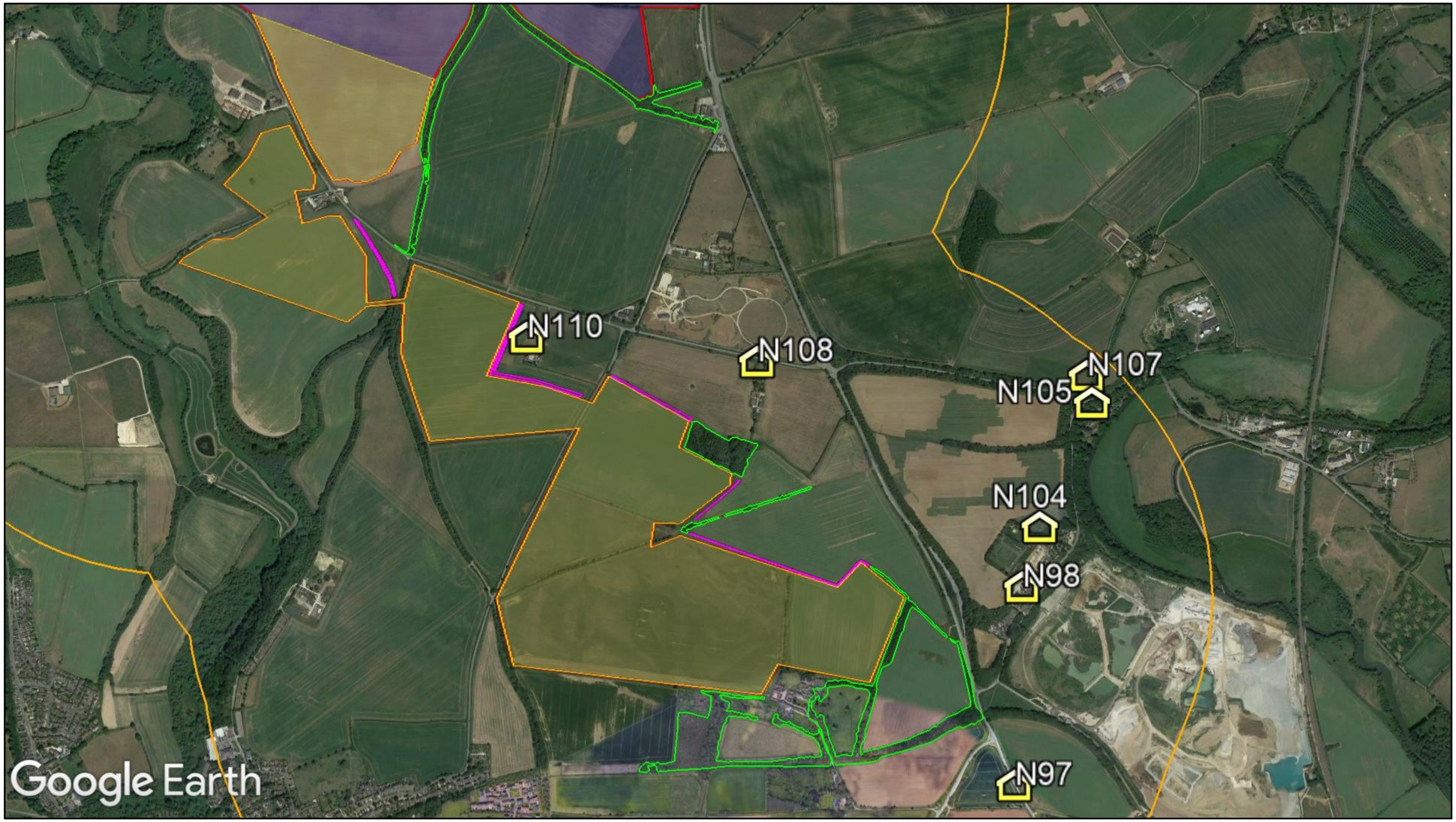


Figure 122 *Reflective panel areas and screening for dwellings N97 to N110*

Figure 123 *Reflective panel areas and partial screening for dwellings N111 to N114*

Figure 124 *Reflective panel areas and screening for dwelling N115*

Figure 125 *Reflective panel areas and screening for dwellings N116 and N117*

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Technical Aerodrome Safeguarding Report

RPS Group

Botley West Solar Farm

September 2024

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ADMINISTRATION PAGE

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Issue	Date	Detail of Changes
1	August 2024	Initial issue
2	September 2024	Minor updates

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EXECUTIVE SUMMARY

Purpose of this Technical Note

Pager Power has been retained to comment on the consultation response of Oxford Airport dated 17th July 2024. This Technical Aerodrome Safeguarding Report specifically relates to the concerns raised over the presence of the proposed solar development and possible impacts upon radio interference and emergency landing procedures.

Background

The proposed development is a ground-mounted solar development, with fixed panels planned to produce approximately 840MW of capacity. Oxford Airfield is a licensed airfield with a single asphalt runway (01/19), which is 1,526m in length.

Figure 1 below shows the location of the proposed development relative to Oxford Airport.

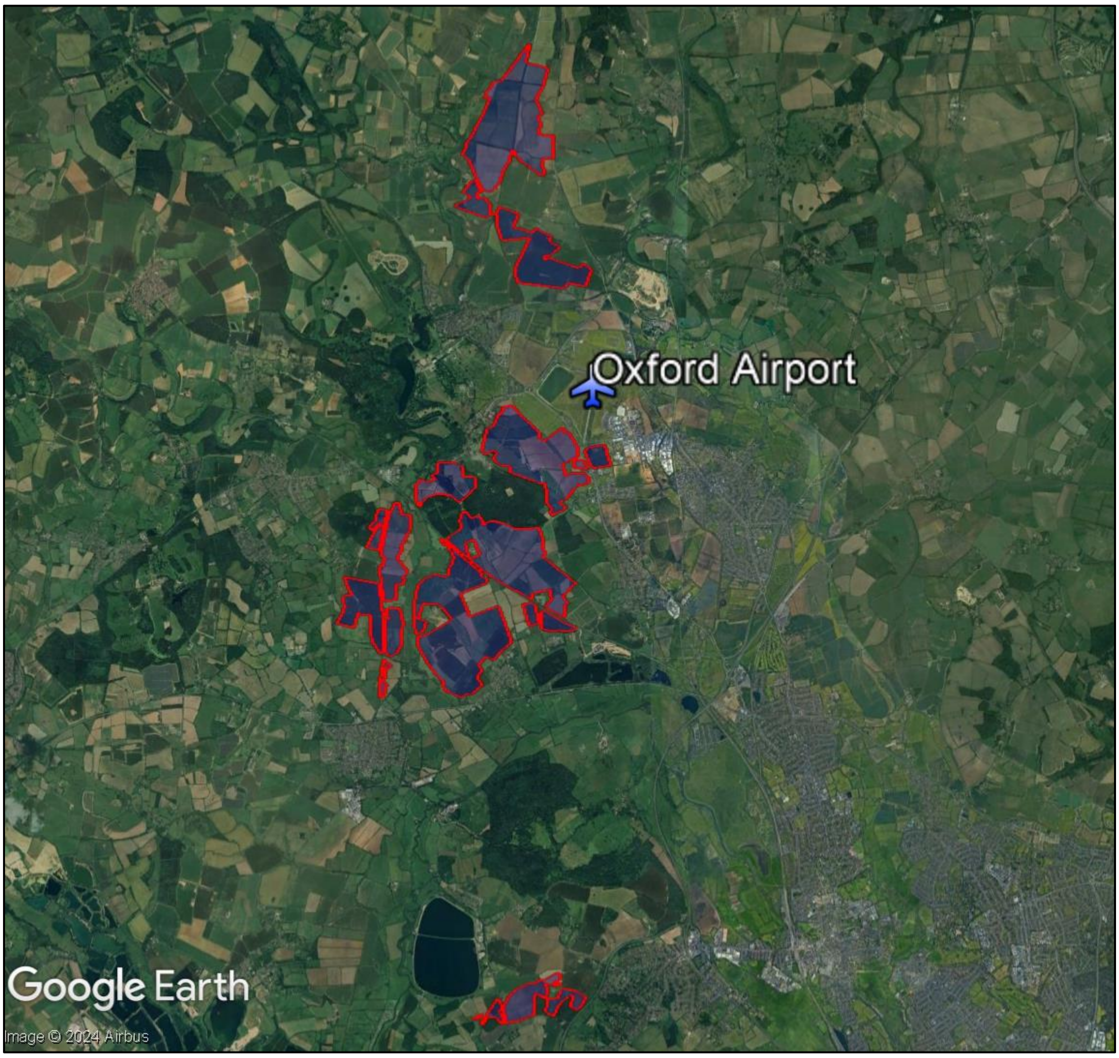

Figure 1 *Proposed development site location relative to Oxford Airport*

Figure 2 below shows a closer view of the proposed development located south-west of Oxford Airport.

Figure 2 *Proposed development site layout near Oxford Airport*

Conclusions

Obstacle Limitation Surfaces

The OLS is infringed by a maximum of 1.15m, with panels sited nearest to the runway 01 threshold breaching the Inner Horizontal Surface (IHS) and the Take-Off Climb Surface (TOCS). It is expected that this small breach to the OLS may be operationally accommodatable given the low profile of the solar panels and the existing breaches from road infrastructure and vegetation which is located much closer to the threshold.

Electromagnetic Interference

The results of the assessment indicate that the panels nearest to the Communication, Navigation & Surveillance (CNS) equipment do not infringe upon the Building Restricted Areas, but panel areas to the south-west are likely to infringe upon the radar and ILS LLZ due to increased ground heights of the terrain. In these areas, the terrain already infringes the building restricted areas, and the extra 2.53m height would not be expected to significantly increase the risk upon radio communications, especially as panels, which could infringe, would be over 1km from the relevant navigation aid.

Pager Power is aware of studies relating to the effect of electromagnetic interference from solar panels upon radio communications equipment, in which it was determined that significant impacts may be possible within a distance of 10m from the solar panels. It is therefore expected that the current setback between the solar panels and any radio communications infrastructure will be sufficient to mitigate any impact upon the CNS equipment at Oxford Airport.

Emergency Procedures and EFATO

The risk of Engine Failure After Take-Off (EFATO) could require a designated EFATO-safeguarded zone to be established. This would take the form of an obstruction-free corridor through the solar development, which would be available for aircraft to use in the event of an EFATO incident. Two potential options are presented in the report, and it is recommended that further consultation is undertaken with Oxford Airport in order to ascertain their preference and any further comments they may have.

Public Safety Zones (PSZ) are not strictly related to EFATO, but it is not expected that the proposed development would increase the number of people congregating within the zone on a permanent basis and therefore there would be no increased risk in accordance with the relevant guidance.[1] It is however recommended that site offices and emergency assembly points etc., designated during construction and decommissioning be located outside of this zone in order to minimise risk.

Windshear and Heat-Induced Turbulence

Windshear turbulence from the solar arrays is not expected to be significant due to the low vertical profile of the panels and the horizontal distances between the PV arrays and the runway.

With regard to heat-induced turbulence, there is the potential that the proposed solar development could result in thermal updrafts under the approach path to runway 01, but it is expected that these would result in turbulence no more severe than is currently likely to occur from the nearby infrastructure. Many UK aerodromes have infrastructure sited underneath their approach paths that could potentially cause heat-induced turbulence; this is therefore a common occurrence which pilots should be expected to be aware of and navigate.

Glint and Glare

Solar reflections are geometrically possible towards the ATC Tower, however existing vegetation and buildings are predicted to partially screen views of the panels. The closest reflecting panel area is also at least 1.6km from the ATC Tower, and reflections are predicted to coincide with direct solar radiance. A low impact is predicted and no mitigation is recommended.

The analysis has shown that solar reflections are predicted towards the approach paths for runways 01 and 19. Solar reflections towards both approach paths will be outside of a pilot's primary field-of-view. This is deemed acceptable in line with the associated guidance and industry standards; a low impact is predicted, and mitigation is not required.

Overall, a low impact is predicted towards Oxford Airport, and no mitigation is recommended.

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[1] Department for Transport, "Control of development in airport public safety zones" (8th October 2021)

OBSTACLE LIMITATION SURFACES

Overview

Obstacle Limitation Surfaces (OLS) are imaginary planes defined in three dimensions for physical safeguarding purposes (i.e. ensuring that physical structures do not present a safety hazard at an airfield) and are defined around licensed airfields. The dimensions and geometry of the surfaces are constructed based on detailed rules defined in the UK Civil Aviation Authority's Civil Aviation Publication 168. The size of the surfaces is dependent on the number of runways, their dimensions and the procedures carried out at the airfield.

Though OLS were not mentioned in Oxford Airport's consultation response, modelling is presented in the below section to provide context to the proposed development.

Oxford Airport Obstacle Limitation Surfaces

The OLS for Oxford Airport are presented in Figure 3 below. The proposed development boundaries for the fields closest to Oxford Airport are shown by the red polygons on the chart.

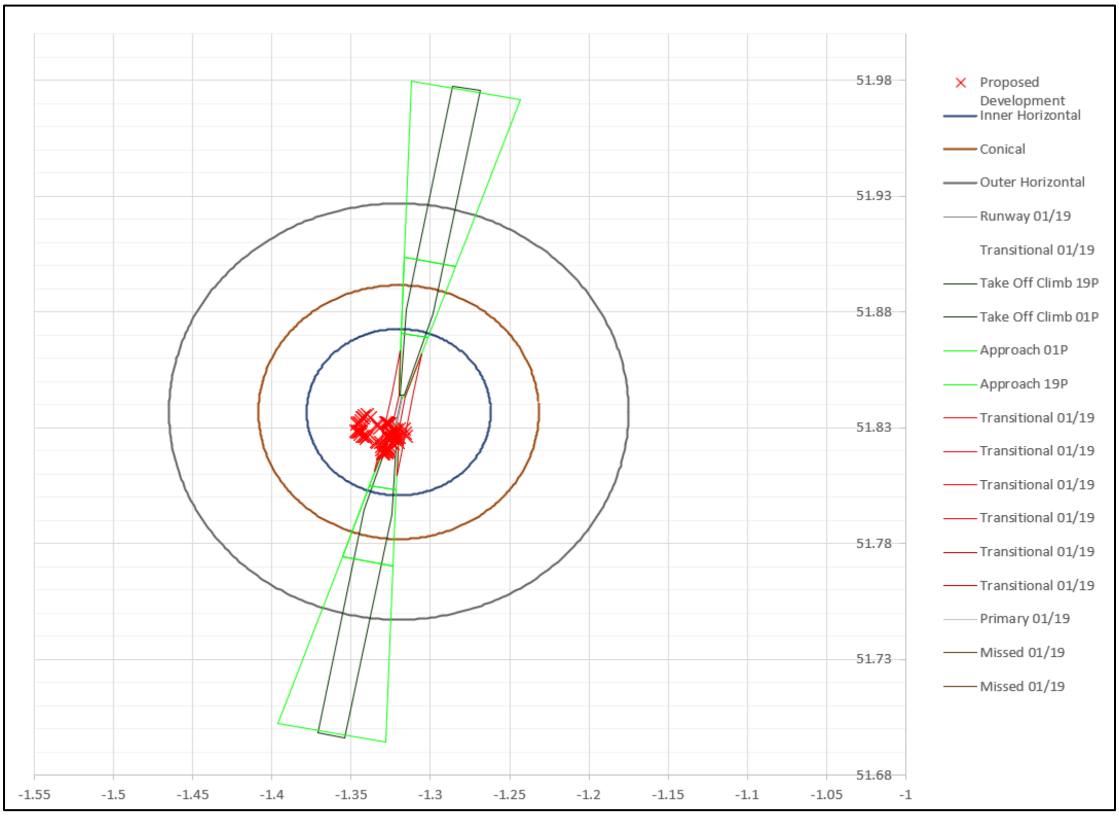

Figure 3 *Oxford Airport Obstacle Limitation Surfaces chart*

The OLS is infringed by a maximum of 1.15m, with panels sited nearest to the runway 01 threshold breaching the Inner Horizontal Surface (IHS) and the Take-Off Climb Surface (TOCS).

Figure 4 below shows a view of the road intersection directly south of the runway threshold, viewed facing away from the runway threshold. This shows a large volume of road infrastructure present in the area, which would also be expected to breach the OLS at Oxford Airport. In addition, there is a hedgerow running along this road which is of a height similar to that of the solar panels. It is therefore expected that the small breach to the OLS may be operationally accommodatable given the low profile of the solar panels and the existing breaches which are located much closer to the threshold.

Figure 4 *View of the road intersection directly south of the runway 01 threshold*

ELECTROMAGNETIC INTERFERENCE

Overview

Oxford Airport's consultation response requested:

> *A study of potential electrical interference to ground based or airborne radios, radio aids, compasses and electrical systems that might arise as a result of the proposed development*

The following sections will consider the impact of the proposed solar development upon radio communications equipment as physical obstructions and sources of electromagnetic interference.

Radio Navigational Aids

The following radio navigational aids are located at Oxford Airport and have been considered within this assessment:

- Primary Surveillance Radar (PSR);
- Distance Measuring Equipment (DME);
- Non-Directional Beacon (NDB);
- Instrument Landing System (ILS) [localiser and glide path].

The Oxford Airport radio navigational aid details[2] are presented in Table 1 on the following page.

[2] Navigational aid details found from NATS AIP data. Ground heights calculated based on OSGB data.

Facility Type	Facility	Longitude	Latitude	Distance from Proposed Development (km)	Base of Antenna at Ground Level (m amsl)
Radar	Oxford – PSR/SSR	0011938.7W	515014.84N	0.61	80.20
ILS Localiser	ILS/LLZ RWY 19 – IOXF	0011920.3W	514945.2N	0.06	74.13
ILS Glide Path	ILS/GP – IOXF	0011912.8W	515027.3N	1.08	80.81
DME	DME RWY 19 – IOXF	0011918.6W	515013.8N	0.66	80.52
NDB	NDB – OX	0011924.5W	515000.3N	0.27	79.91

Table 1 *All identified radio navigation aids at Oxford Airport*

Building Restricted Areas Assessment

The navigation aids identified in the above subsection have been assessed in accordance with the BRAs defined within ICAO EUR DOC 015 - European Guidance Material on Managing Building Restricted Areas.

The results of the assessment indicate that the panels nearest to the navigation aids do not infringe upon the building restricted areas, but areas to the south-west are likely to infringe due to increased ground heights of the terrain. In these areas, the terrain already infringes the building restricted areas, and the extra 2.53m height would not be expected to significantly increase the risk upon radio communications, especially as panels which could infringe would be over 1km from the relevant navigation aid.

Further Analysis

Pager Power is aware of studies relating to the effect of electromagnetic interference from solar panels upon radio communications equipment, in which it was determined that significant impacts may be possible within a distance of 10m from the solar panels. It is therefore recommended that the current setback between the solar panels and any radio communications infrastructure will be sufficient to mitigate any impact towards Oxford Airport.

EMERGENCY PROCEDURES AND EFATO

Overview

Oxford Airport's consultation response requested:

> *An alteration to the proposed layout sufficient to safeguard and area of land under the approach and departure route south of the airport in order to allow for the safe emergency landing of an aircraft afflicted by insurmountable technical issues and for the airport Rescue and Fire Fighting Service to access then land in order to deliver its Obligated Response.*

The following sections of this report consider the relevant emergency procedures and Engine Failure After Take-Off (EFATO) to suggest a suitable alteration to the solar layout that would provide sufficient area for emergency landings whilst retaining solar arrays where possible.

Engine Failure After Take-Off (EFATO)

Overview

In the event of catastrophic engine failure shortly after take-off, it is recommended that pilots attempt to land in the most appropriate area within 45° each side of the nose.[3] It is important to note that many airports do not have a suitable EFATO zone due to other constraints, and the most suitable landing zone is likely to change based on ground conditions and development in the area surrounding the aerodrome.

Analysis

The Combined Aerodrome Safeguarding Team (CAST) published an advice note in February 2024[4], which includes reference to EFATO considerations for solar farms. In this document it is stated that "the safeguarding of [EFATO zones] must be considered reasonably and pragmatically by both an aerodrome operator and a solar developer"[5]. It is further stated that if a designated EFATO safeguarded area is to be implemented, it should be located along the extended runway centreline.

With regard to the proposed development, the developer has already agreed to not site any panels in the field directly south of the runway 01 threshold. This means that the first solar panels would be sited 450m away from the runway threshold, along the extended runway centreline. This may be considered to be a suitably safeguarded zone without any extension of the zone, as this zone will already serve to provide a clear landing zone for aircraft that experience EFATO close to the ground, and therefore have less response time than those who may already have achieved significant altitude.

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[3] Many flight training organisations recommend a smaller zone than this, such as 30° either side of the nose
[4] Combined Aerodrome Safeguarding Team, Advice Note 5 – Renewable Energy Developments
[5] Ibid, pg. 4

If it is considered that an extended safeguarded zone is required, this would most likely be achieved through an extension of this panel-free zone running along the extended runway centreline. Figure 5 below shows an example of this, with the safeguarded zone extending to the treeline, offering an unobstructed emergency landing strip extending to a distance 590m from the runway threshold. This could also assist with allowing emergency response vehicles to access a striken aircraft quickly in the event of an incident.

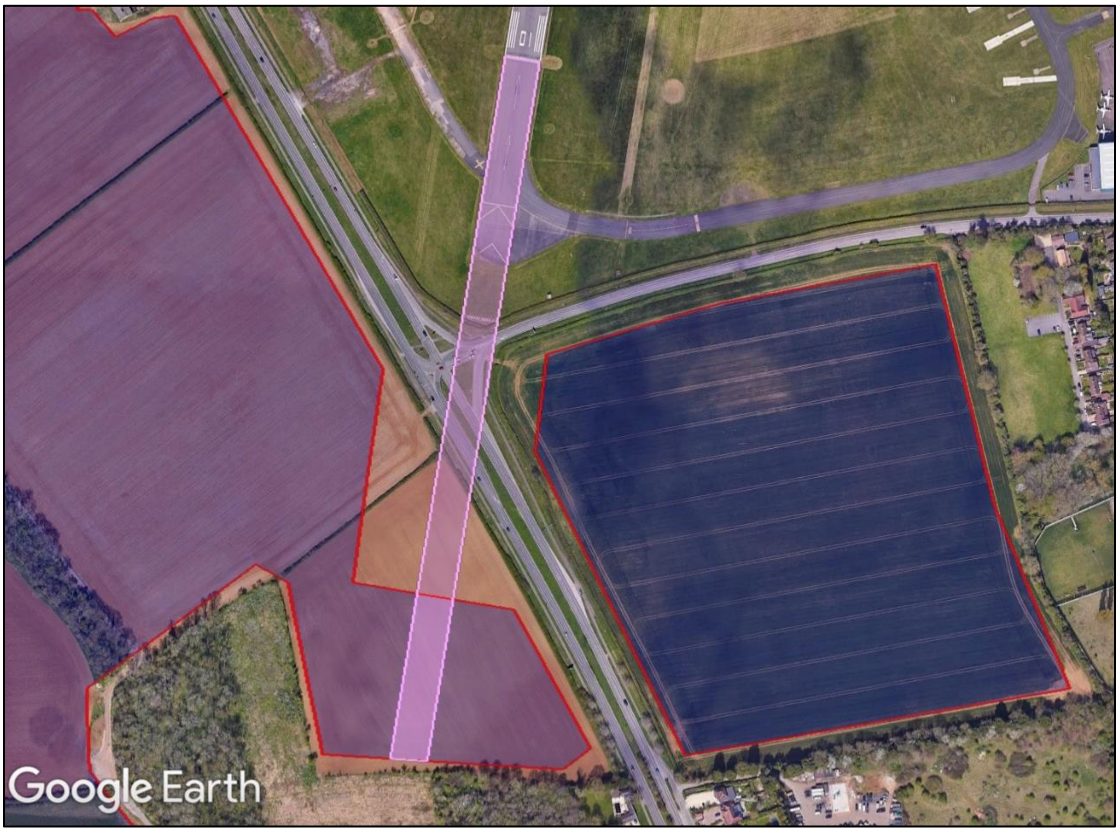

Figure 5 *The suggested designated EFATO safeguarded zone, running along the extended runway centreline*

Public Safety Zones

Public Safety Zones (PSZ) are intended to restrict the number of people congregating within areas directly adjoining runway thresholds, in order to reduce the number of people at risk in the event of an accident during take-off or landing. It is important to note that PSZs do not relate to obstruction risk and are not blanket 'no build zones'.

Developments are permitted within PSZs if they "involve a very low density of people coming and going"[6]. A solar farm such as the proposed development would be expected to meet this requirement, as once operational, regular access will only be required for maintenance purposes.

It is recommended that during the construction phase, site offices and evacuation assembly points are situated outside of the PSZ in order to comply with the policy.

[6] Department for Transport, "Control of development in airport public safety zones" (8th October 2021)

WINDSHEAR AND HEAT-INDUCED TURBULENCE

Background

Oxford Airport's consultation response requested:

> *A study of the effect of heat radiation from the proposed solar panels which might create air turbulence adversely affecting safety or comfort of flight.*

The following section of this report considers (at a high-level) potential windshear and heat-induced turbulence from the solar development.

Analysis

Windshear Turbulence

Windshear turbulence is unlikely to significantly impact aviation operations at Oxford Airport, due to the low vertical profile of the solar panels relative to the surrounding terrain.

Typically, effects of windshear turbulence may be possible within a horizontal radius of ten times the obstruction height[7]. Nearby buildings and infrastructure near Oxford Airport would be far more likely to result in windshear turbulence, and it is not considered that the proposed solar development will increase the risk of windshear turbulence.

Heat-induced Turbulence

Solar panels are designed to absorb light from the sun and typically operate most efficiently at a temperature of approximately 25°C. The panels are therefore designed to remain cool in direct sunlight, and it is not anticipated that panels would reach temperatures significantly greater than the surrounding ground.

There are currently many ground surfaces surrounding Oxford Airport which would be expected to have greater thermal conductivity and diffusivity than bare earth, such as asphalt on the runway and taxiways at Oxford Airport, the neighbouring business park and the A44 road. These surfaces all have the potential to create thermal updrafts which pilots on approach to Oxford Airport would likely already be routinely navigating.

Overall, there is the potential that the proposed solar development could result in thermal updrafts under the approach path to runway 01, but it is expected that these would result in turbulence no more severe than is currently likely to occur from the nearby infrastructure. Many UK aerodromes have infrastructure sited underneath their approach paths which could potentially cause heat-induced turbulence; this is therefore a common occurrence which pilots should be expected to be aware of and navigate.

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[7] The maximum height of solar panels will be 2.53m above ground level

GLINT AND GLARE

Background

A Glint and Glare Assessment was previously produced by Pager Power for Botley West Solar Farm and an associated PIER Chapter has also been produced. The full document, reference 11216B, is available as part of the DCO documentation and a summary of the results relevant to Oxford Airport are presented below.

Results Summary

The results of the geometric calculation for aviation receptors at Oxford Airport are presented in Table 2 on the following page.

Conclusions

Solar reflections are geometrically possible towards the ATC Tower, however existing vegetation and buildings are predicted to partially screen views of the panels. The closest reflecting panel area is also at least 1.6km from the ATC Tower, and reflections are predicted to coincide with direct solar radiance. A low impact is predicted and no mitigation is recommended.

The analysis has shown that solar reflections are predicted towards the approach paths for runways 01 and 19. Solar reflections towards both approach paths will be outside of a pilot's primary field-of-view. This is deemed acceptable in line with the associated guidance and industry standards; a low impact is predicted, and mitigation is not required.

Overall, a low impact is predicted towards Oxford Airport, and no mitigation is recommended.

Receptor/ Runway	Geometric Modelling Result	Glare Intensity	Comment	Impact Classification	Mitigation Recommended?
ATC Tower	Solar reflections are geometrically possible		The reflecting panel area is partially screened by existing vegetation and at least 1.30km from the ATC Tower Any solar reflections would be close to the horizon and are predicted to coincide with direct sunlight	Low impact	No
Runway 01 Approach Path	Solar reflections are geometrically possible between the threshold and 1-miles from the threshold		Any solar reflections would be outside of a pilot's primary field-of-view	Low impact	No
Runway 19 Approach Path	Solar reflections are geometrically possible between 0.4-miles from the threshold and 2-miles from the threshold		Any solar reflections would be outside of a pilot's primary field-of-view	Low impact	No

Table 2 *Geometric analysis results – Oxford Airport*

EXAMPLES OF SOLAR FARMS AND AIRPORTS COEXISTING

Overview

The following section shows a number of UK civil and military aerodromes which coexist with solar farms. Whilst the scale of the solar farms and the distances between the airfield and the solar farm differ, all of these aerodromes would have needed to consider similar safeguarding concerns and continue to operate successfully in the presence of these developments.

Figures 6 to 26 on the following pages show examples of solar farms in the vicinity of UK aerodromes.

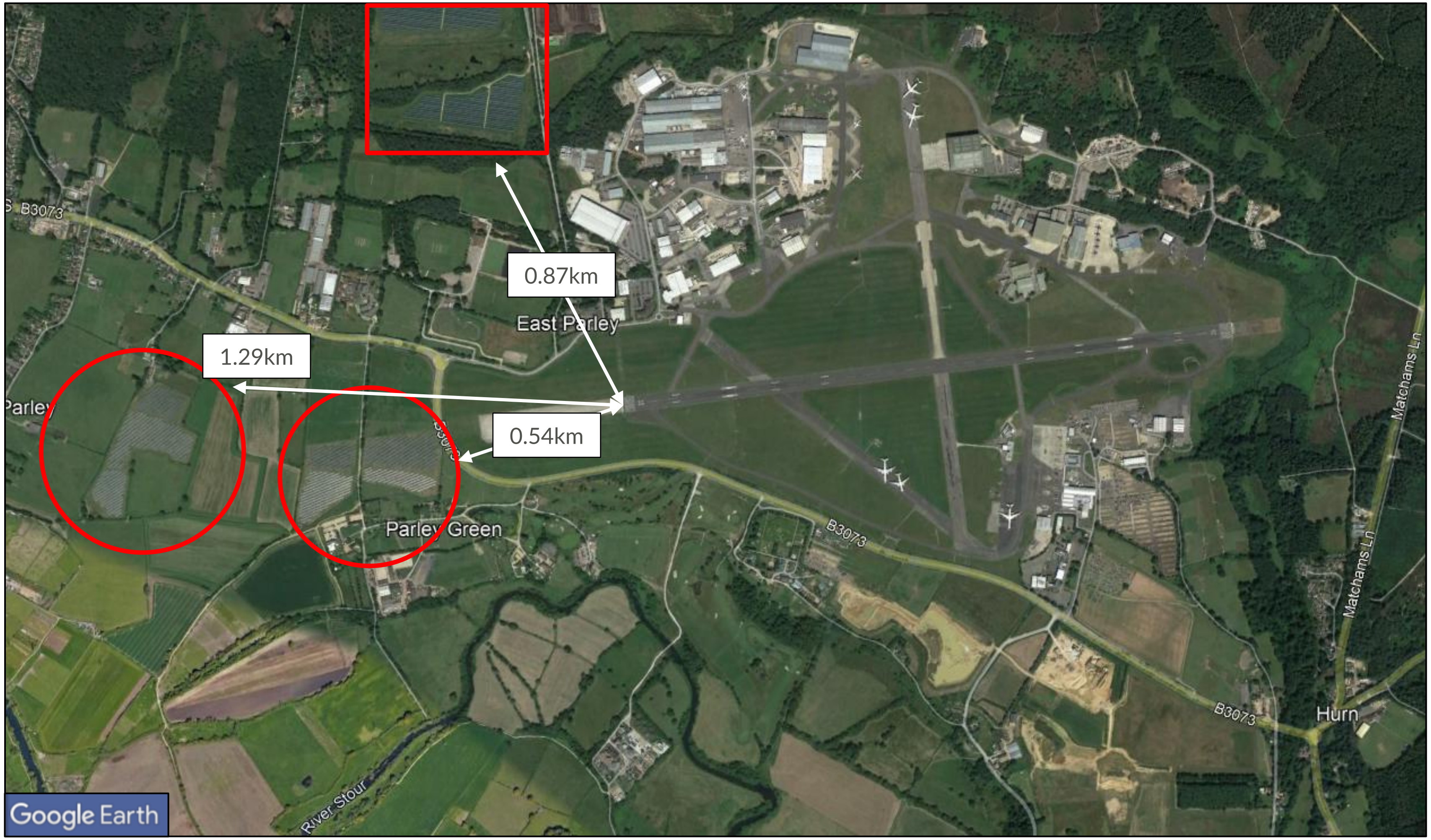

Figure 6 *Existing solar PV development on the approach to Bournemouth Airport*

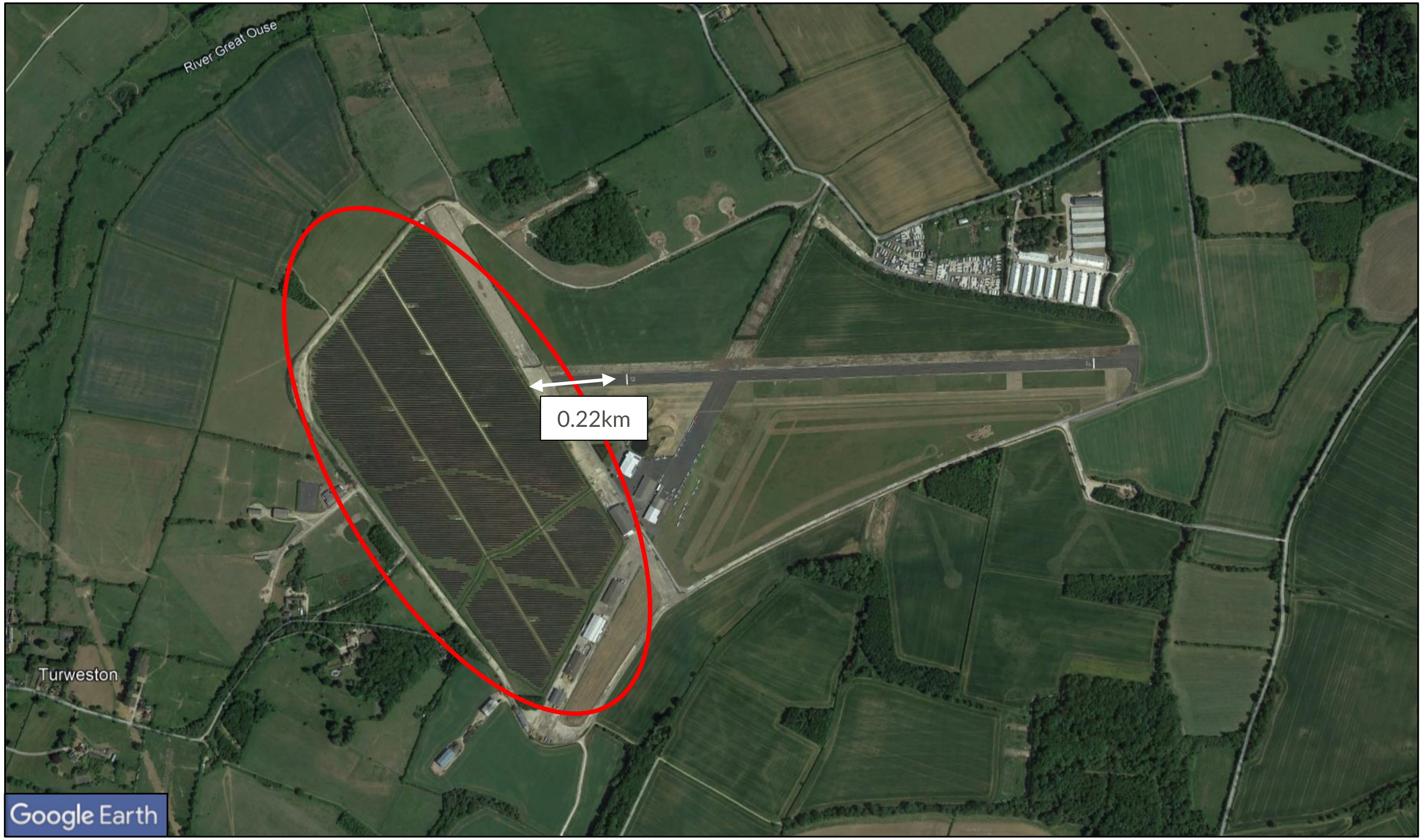

Figure 7 *Existing solar PV development on the approach to Turweston Airport*

Figure 8 *Existing solar PV development on the approach to Haverfordwest Airport*

Figure 9 *Existing solar PV development on the approach to RNAS Yeovilton*

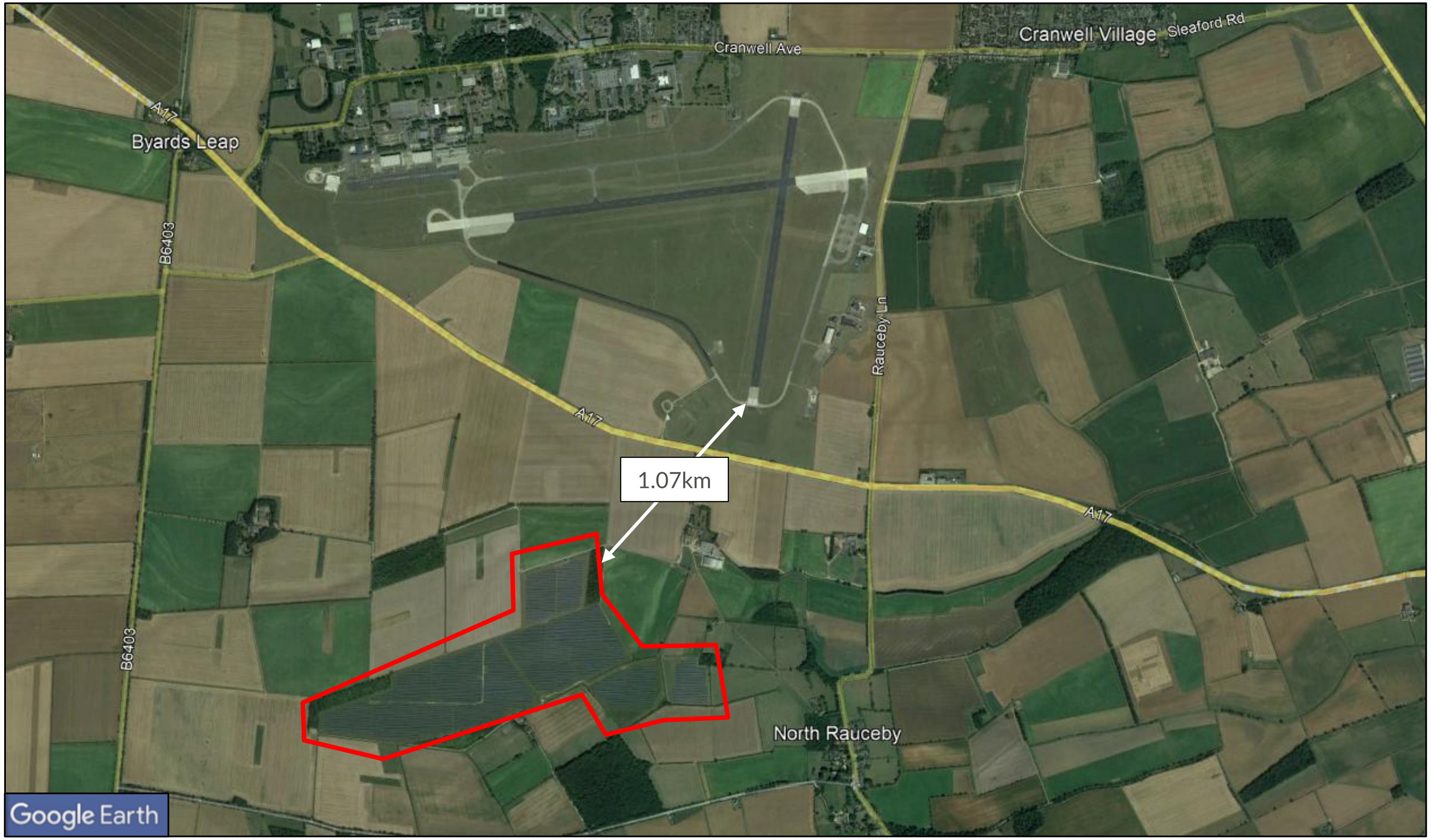

Figure 10 *Existing solar PV development on the approach to RAF Cranwell*

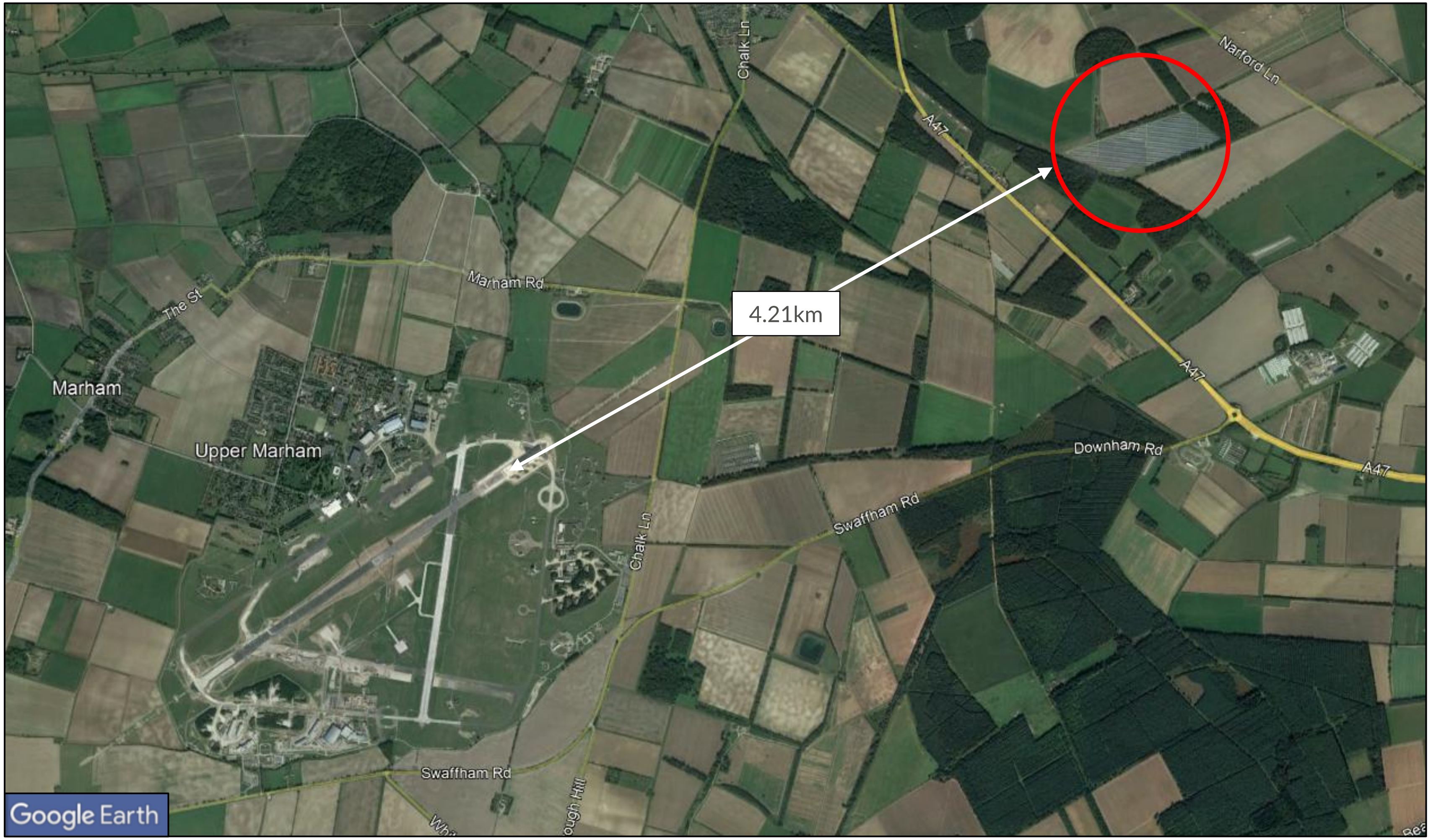

Figure 11 *Existing solar PV development on the approach to RAF Marham*

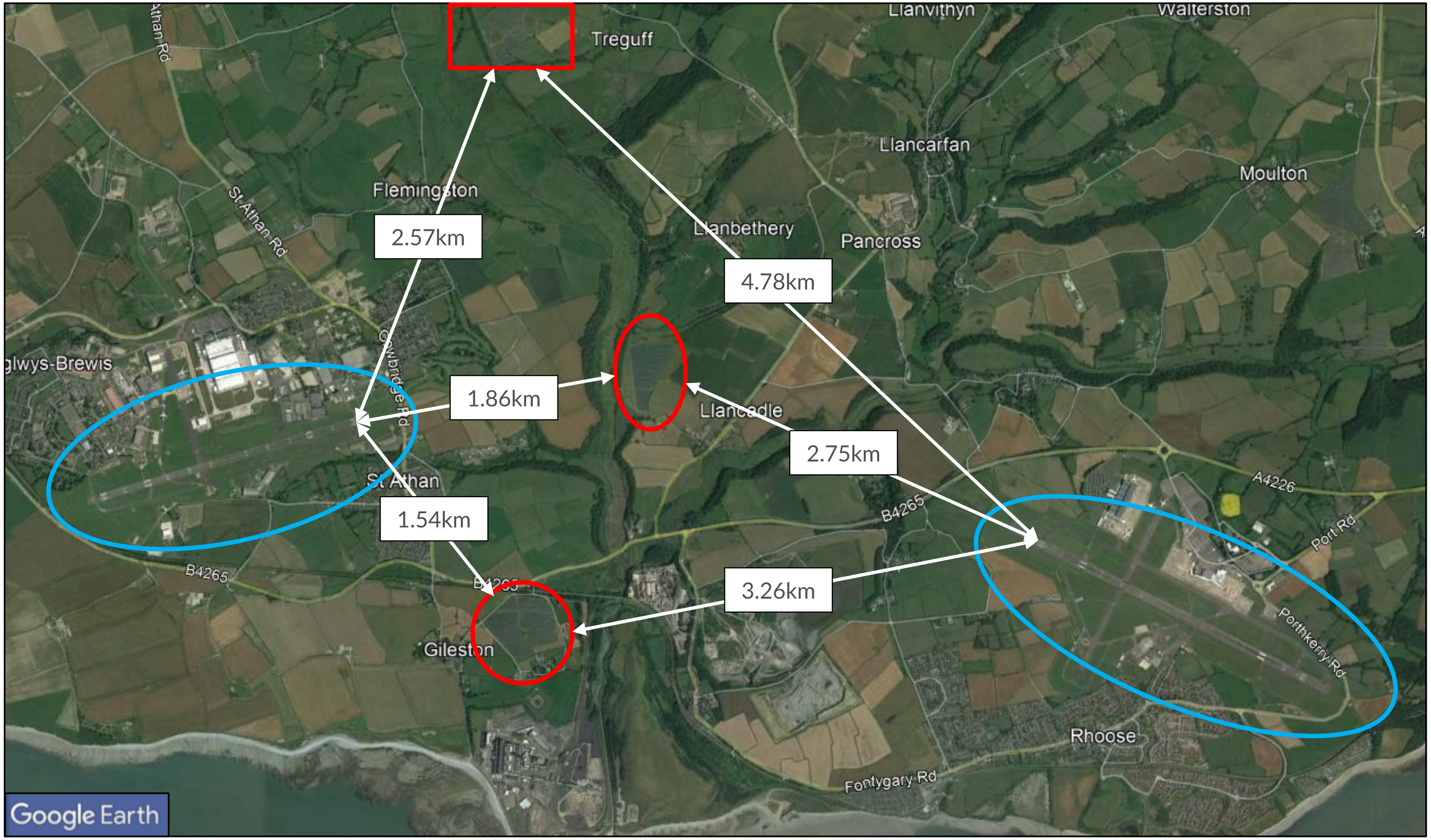

Figure 12 *Existing solar PV development on the approach to MOD St Athan and Cardiff Airport*

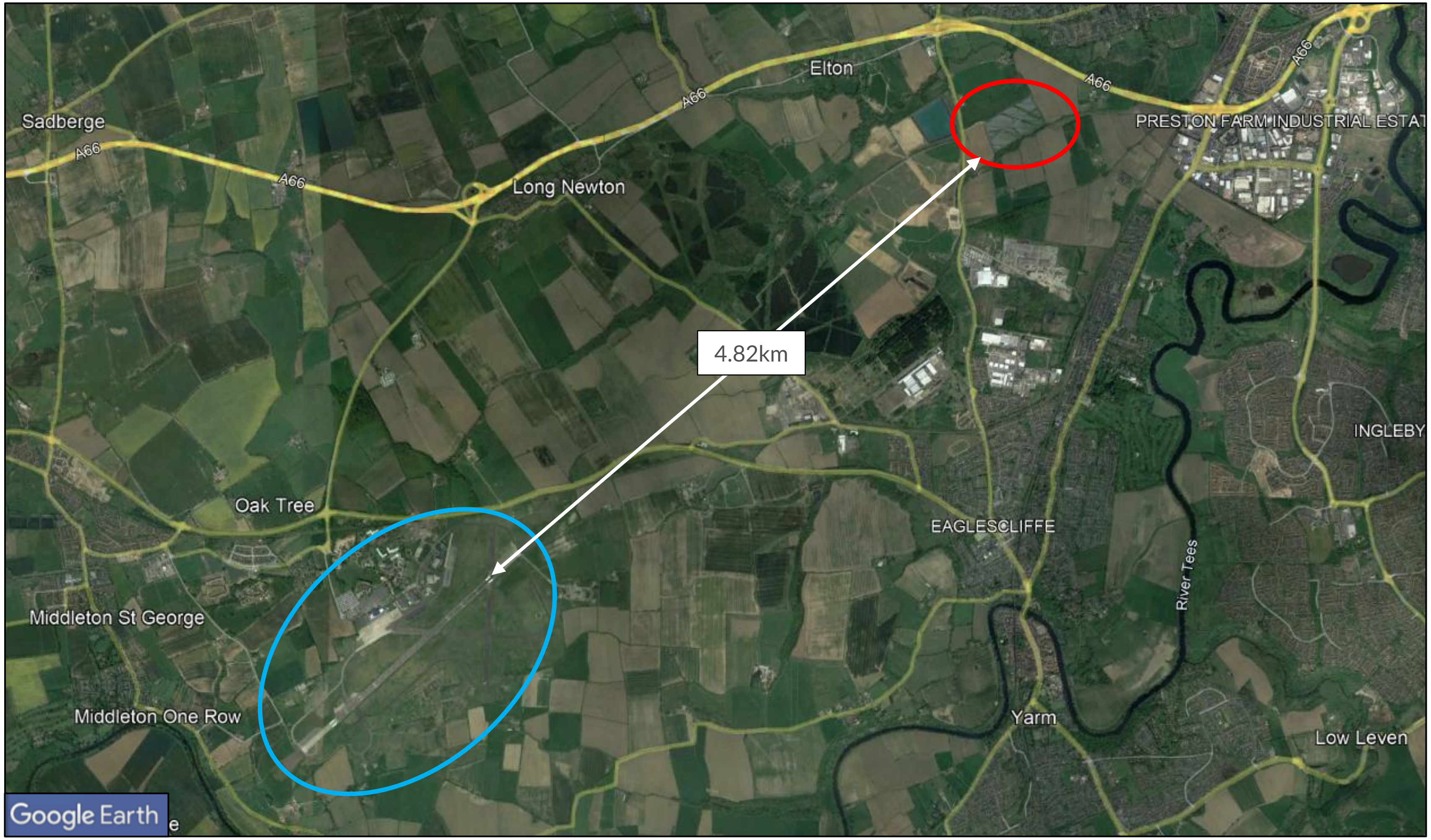

Figure 13 *Existing solar PV development on the approach to Teesside International Airport*

Figure 14 *Existing solar PV development on the approach to Barrow/Walney Island Airport*

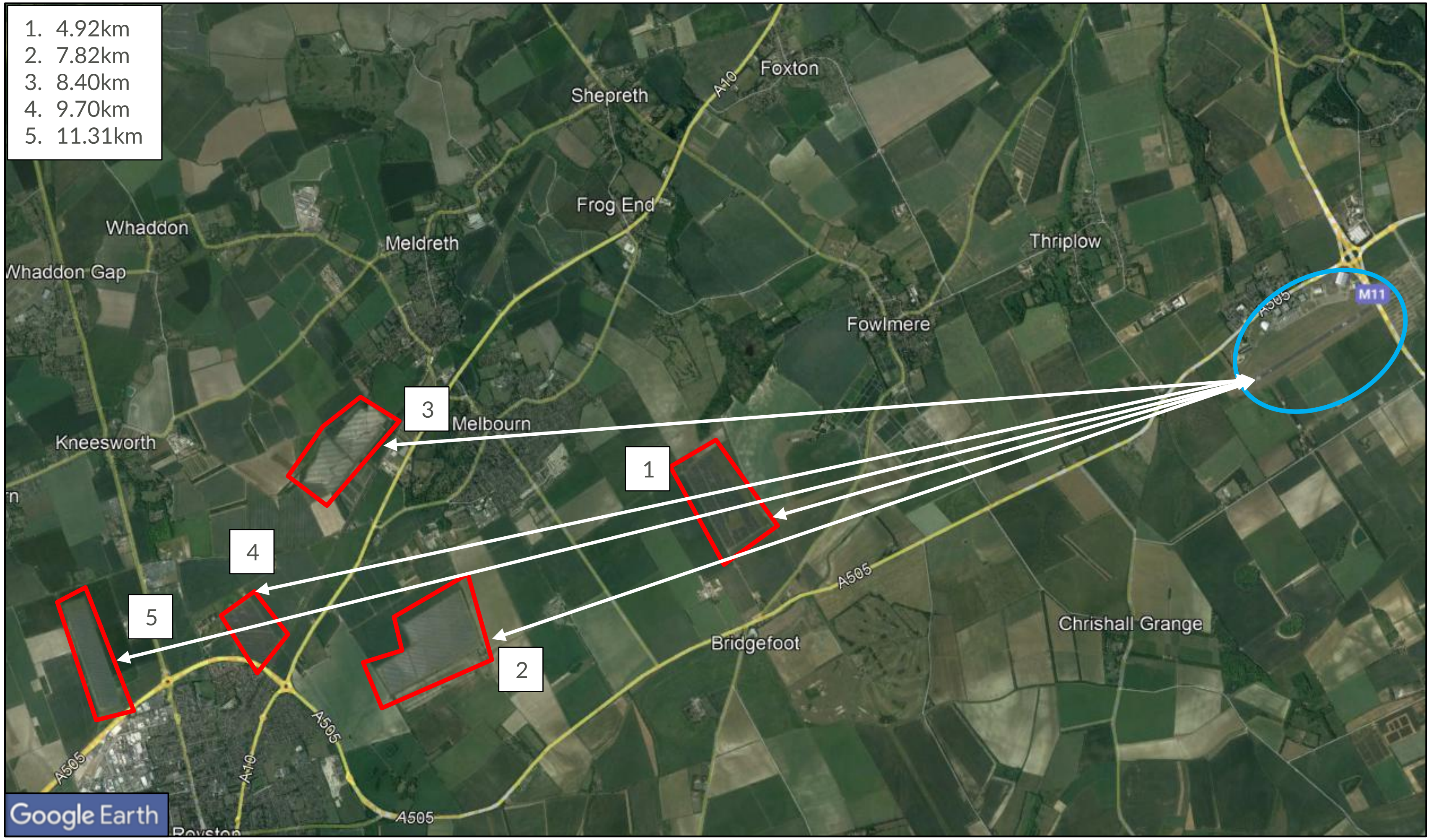

Figure 15 *Existing solar PV development close to the approach to Duxford*

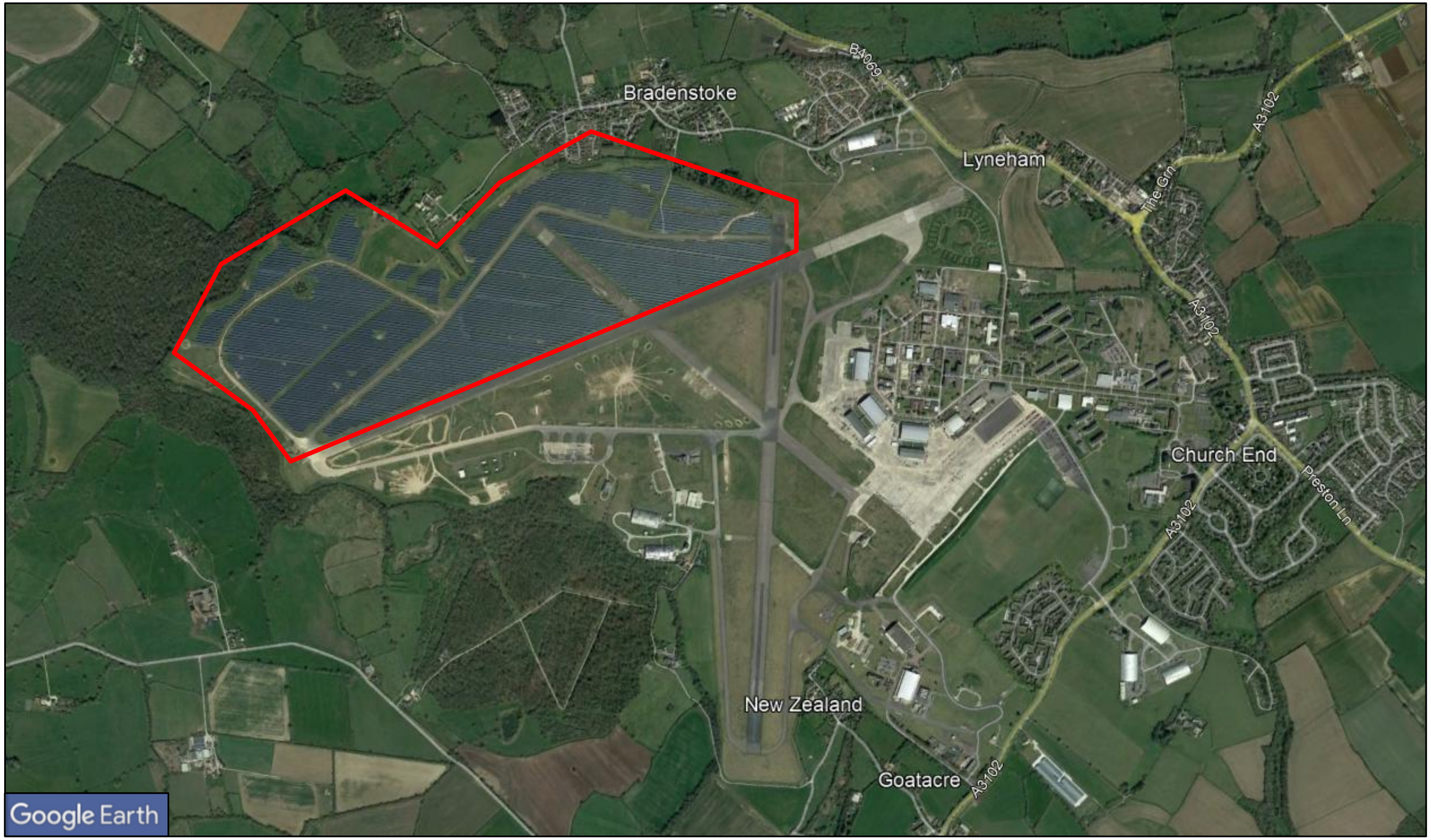

Figure 16 *Existing solar PV development in close proximity to MOD Lyneham/Cotswold Airport*

Figure 17 *Existing solar PV development in close proximity to MOD Boscombe Down*

Figure 18 *Existing solar PV development in close proximity to Dunsfold Aerodrome*

Figure 19 *Existing solar PV development in close proximity to Cranfield Airport*

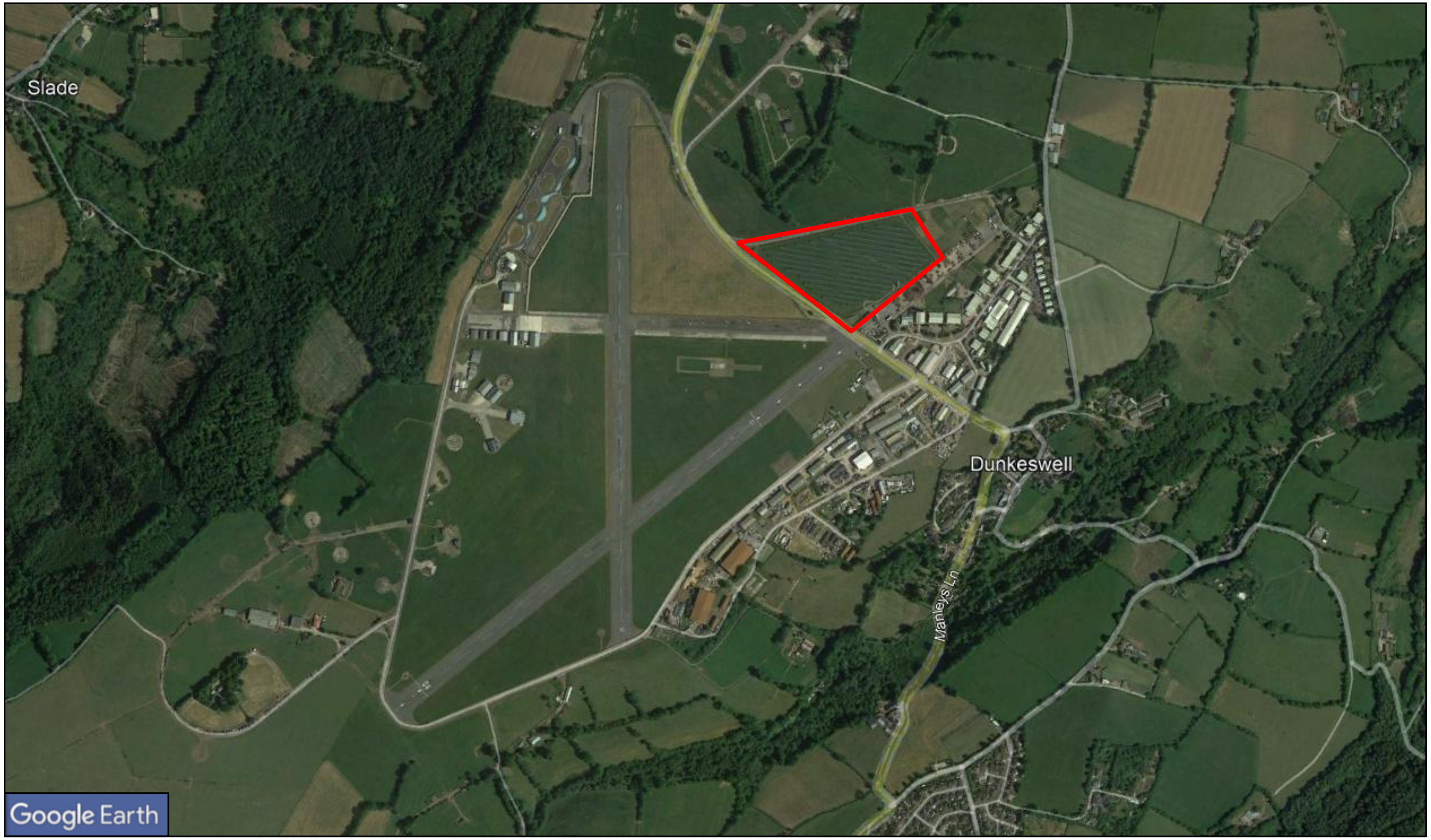

Figure 20 *Existing solar PV development in close proximity to Dunkeswell Aerodrome*

Figure 21 *Existing solar PV development in close proximity to London Southend Airport*

Figure 22 *Existing solar PV development in close proximity to RAF Honnington*

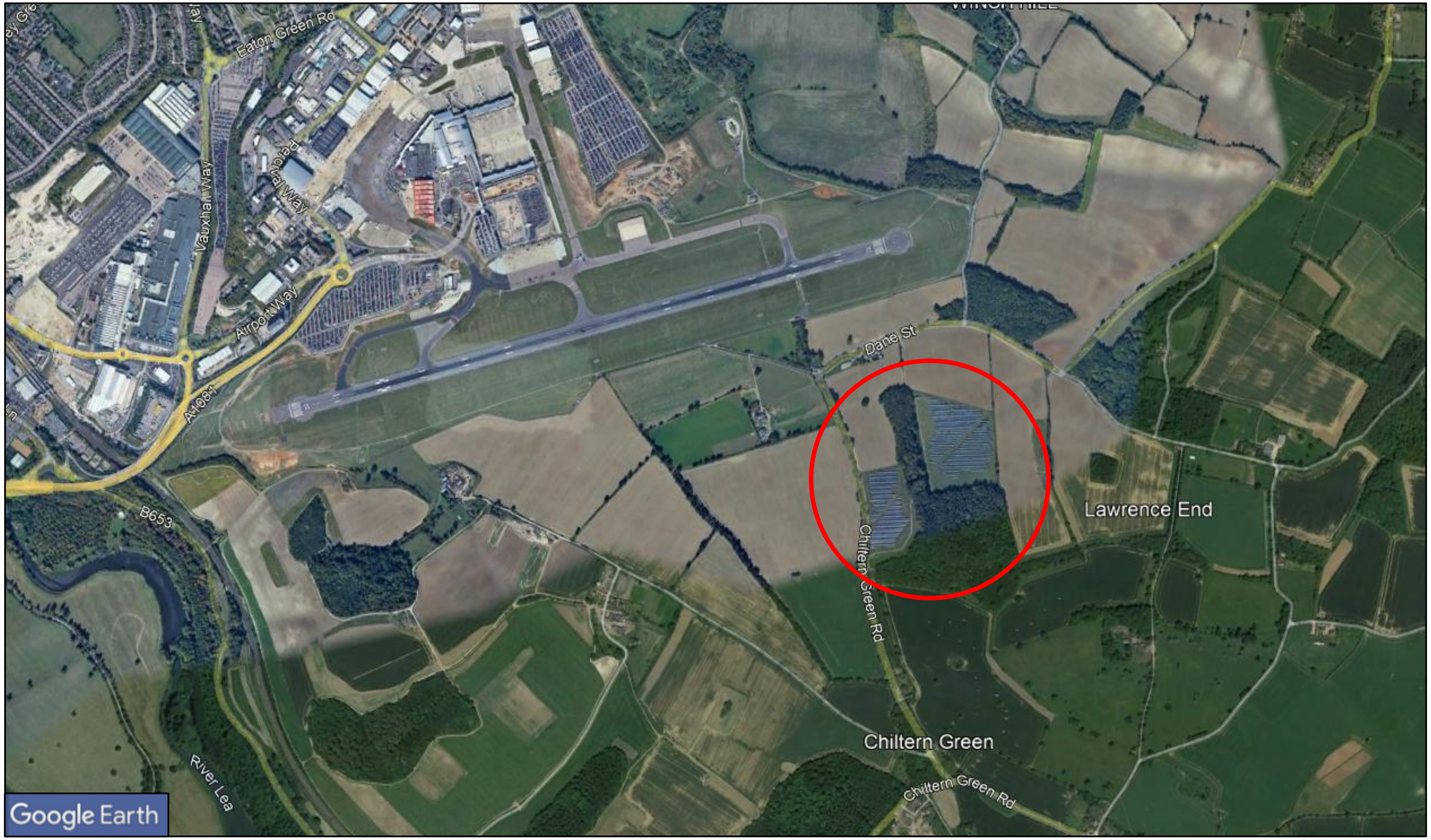

Figure 23 *Existing solar PV development in close proximity to Luton Airport*

Figure 24 *Existing solar PV development in close proximity to Nottingham Airport*

Figure 25 *Existing solar PV development in close proximity to Belfast International Airport*

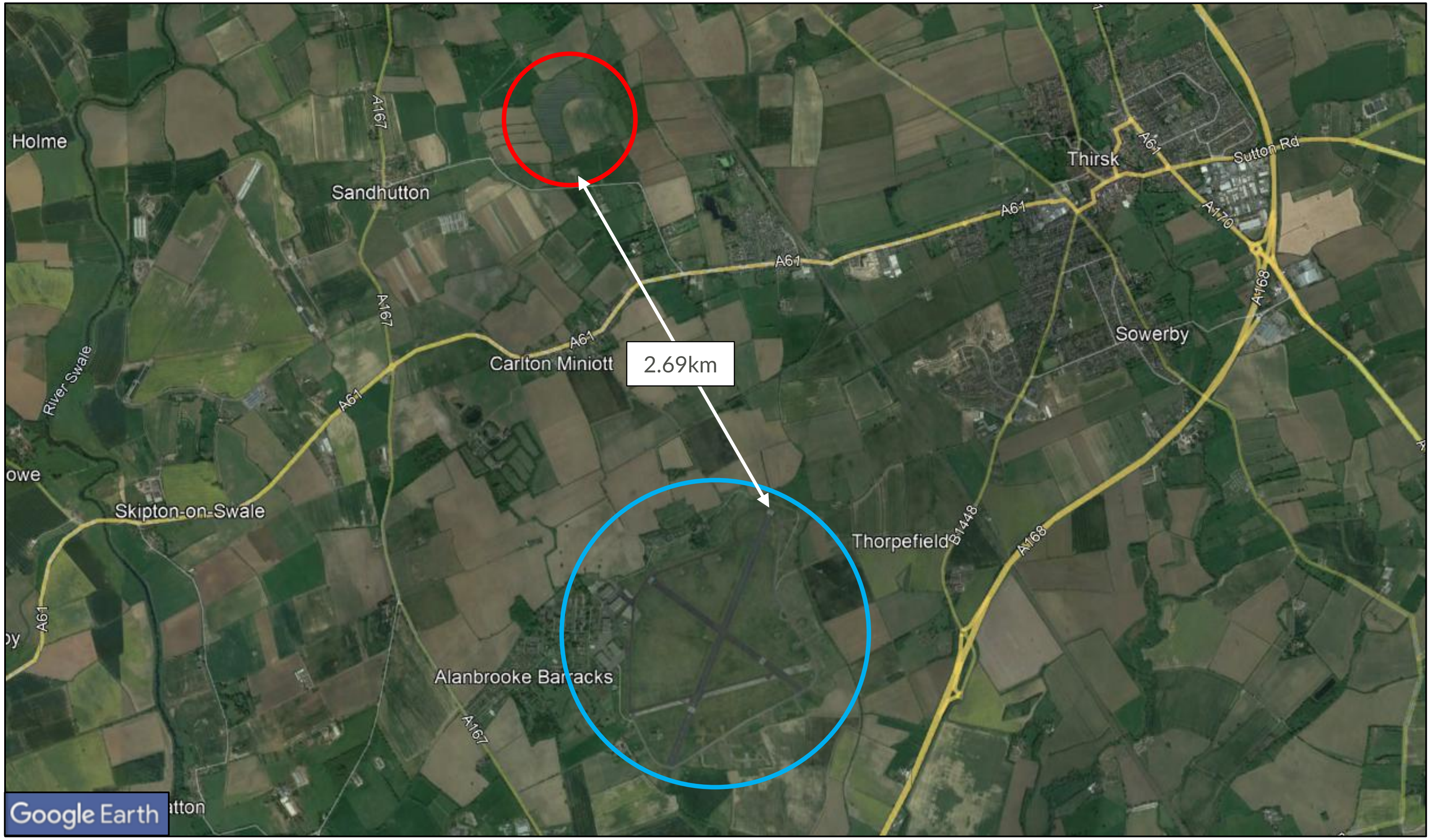

Figure 26 *Existing solar PV development in proximity to RAF Topcliffe*

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