PDAS Appendix J – Glint and Glare Assessment

PAGERPOWER

Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Grove Farm Solar

Axis

June 2023

PLANNING SOLUTIONS FOR:

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ADMINISTRATION PAGE

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from solar photovoltaic (PV) development located south of Ipswich, Suffolk. The assessment pertains to the possible impact upon surrounding residential amenity, road safety, and railway operations and infrastructure.

Conclusions

No significant impacts are predicted upon railway operations and infrastructure, road users travelling along the nearby roads and residential amenity for nearby dwellings. No mitigation is recommended.

Guidance and Studies

Pager Power has reviewed existing guidelines and the available studies in the process of defining its own glint and glare assessment guidance document and methodology[1]. This methodology defines a comprehensive process for determining the impact upon railway operations and infrastructure.

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].

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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).

Assessment Results – Railway Signals

Following a review of the available imagery, no trackside railway signals were identified. This report can be updated if further railway signals are identified by Network Rail.

Assessment Results – Train Drivers

The results of the modelling indicate that solar reflections are geometrically possible towards a section of the railway line of circa 0.9km.

Visibility of the reflective area is predicted to be significantly obstructed by existing vegetation and terrain for train drivers travelling along 0.8km of this section of railway line. For the remaining 0.1km section the solar reflective area is predicted to be visible. However, it will be outside a train driver's primary field of view. Overall, the predicted impact upon train drivers is low, and no mitigation is recommended.

Assessment Results – Road Users

The results of the modelling indicate that solar reflections are geometrically possible towards an approximately 1.1km section of the A137. Existing screening is predicted to sufficiently obstruct the visibility of the reflecting area. Therefore, no impact is predicted, and no mitigation is required.

Assessment Results – Road Users

The results of the modelling indicate that solar reflections are geometrically possible towards 54 of the 139 assessed dwellings. Existing screening is predicted to significantly obstruct the visibility of the reflective area for all 54 affected dwellings receptors. Therefore, no impact is predicted, and no mitigation is required.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 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 solar photovoltaic (PV) development located south of Ipswich, Suffolk. The assessment pertains to the possible impact upon surrounding residential amenity, road safety, and railway operations and infrastructure.

This report contains the following:

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

1.2 Pager Power's Experience

Pager Power has undertaken over 1,000 glint and glare assessments in the UK, Europe and internationally. The company's own glint and glare guidance is based on industry experience and extensive consultation with industry stakeholders including airports and aviation regulators.

1.3 Glint and Glare Definition

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

- 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 presented within the Draft National Policy Statement for Renewable Energy Infrastructure (EN-3) – published by the Department for Energy Security and Net Zero in March 2023 and the Federal Aviation Administration in the USA.

2 PROPOSED DEVELOPMENT LOCATION AND CHARACTERISTICS

2.1 Proposed Development Site Layout

Figure 1[4] below shows the proposed development site layout.

Figure 1 – Proposed development site layout

2.2 Panel Information

The information for the modelled solar panels in this assessment is shown in Table 1 below.

Panel Information	
Azimuth angle	150°
Tilt angle[5]	17.5°
Assessed height above ground level (agl) [6]	1.9m

Table 1 – Panel information

[4] Source: GENERAL ARRANGEMENT, GROVE FARM SOLAR ARRAY, Axis, date: 04/23 drawing number: 3223-01

[5] The client has provided a tilt range between 15° and 20°. The average value of 17.5° was used in the modelling assessment. Minimal changes to the tilt are not predicted to significantly affect the results of the modelling and therefore the conclusion of the report.

[6] The middle height of the panel has been considered for the assessment. This height is calculated using the minimum height 0.8m and the maximum height 3.0m: 0.8+((3.0-0.8)/2). Minimal changes to the height are not predicted to significantly affect the results of the modelling and therefore the conclusion of the report.

3 RAILWAYS AND GLINT AND GLARE

3.1 Overview

A railway stakeholder 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[7]). 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

[7] For Network Rail in the UK.
[8] CIE 146:2002 & CIE 147:2002 Collection on glare (2002).

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

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

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

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

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 assessments 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.

4.4 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 Overview

The following section presents the relevant receptors assessed within this report.

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.

Railway receptors within close proximity (typically within 100m to 200m) to a solar development are often required for assessment. When required, a 500m assessment area is considered appropriate.

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

Terrain elevation heights have been interpolated based on OSGB terrain data. Receptor details can be found in Appendix G.

5.3 Railway Signals

5.3.1 Railway Signal Overview

The analysis has considered railway signal receptors that are within the 500m assessment area.

Typical heights[10] above ground level (agl) for a signal are[11]:

- Gantry signals – 3.35m.
- Trackside signals – 2.25m.

5.3.2 Identified Railway Signals

Following a review of the available imagery, no trackside railway signals were identified. This report can be updated if further railway signals or assests are identified by Network Rail.

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

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

5.4 Train Driver Receptors

5.4.1 Train Driver Receptors Overview

The analysis has considered train driver receptors that:

- Are within the 500m assessment area.
- Have a potential view of the panels.

5.4.2 Identified Train Driver Receptors

The assessed train driver receptor points are shown in Figure 2 below. In total, 12 receptor locations have been assessed along circa 1.1km of railway line located to the east of the proposed development and orientated north/south. The distance between train driver receptors is circa 100m positioned along the yellow line. Visibility and direction of travel is considered in the assessment for all receptors. Based on previous consultation[12] the driver's eye level is assumed to be 2.75m above ground level[13]. This height has therefore been added to the ground height at each receptor location[14].

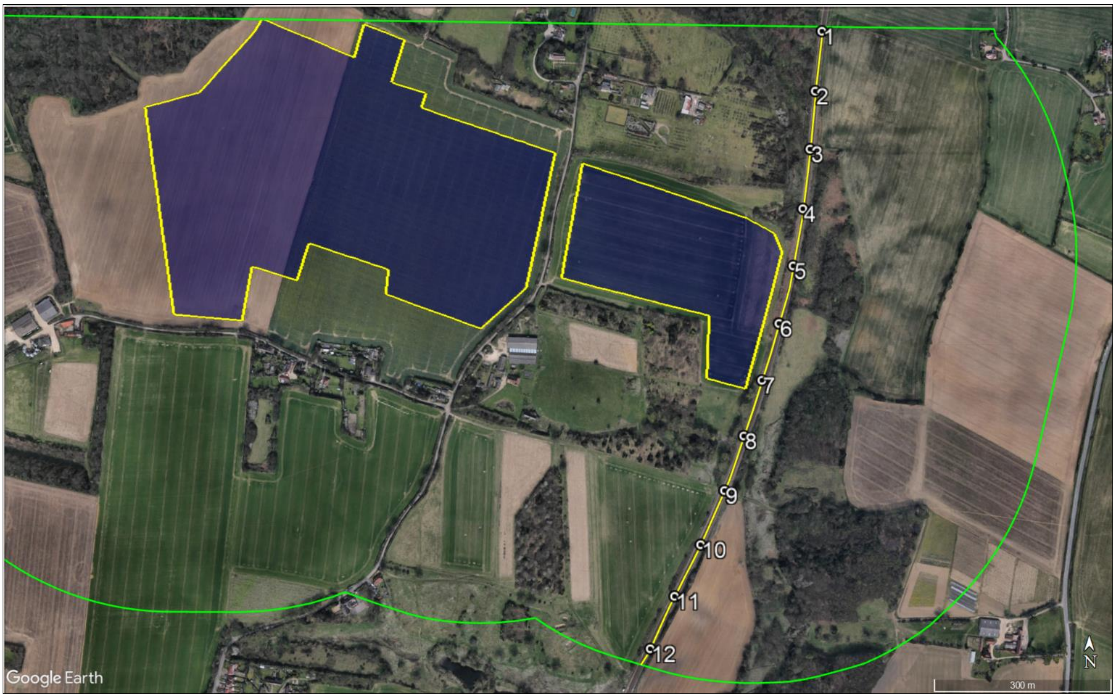

Figure 2 – Assessed train driver receptors

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

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

[14] This fixed height for the train driver receptors is for modelling purposes. Changes to the modelling height by a few metres is not expected to significantly change the modelling results.

5.5 Road Receptors

5.5.1 Overview

Road types can generally be categorised as:

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

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

The analysis has also considered major national, national, and regional roads that:

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

5.5.2 Identified Road Receptors

A 1.5km section of the A137 (16 receptors) has been identified within the assessment area with potential views of the reflecting panel area.

Figure 3 on the following page shows the road receptors modelled. The receptors are placed approximately 100m apart along these roads. A height of 1.5 metres above ground level has been taken as the typical eye-level of a road user[15].

[15] This height is used for modelling purposes. Small changes to this height are not significant, and views for elevated drivers are also considered where appropriate

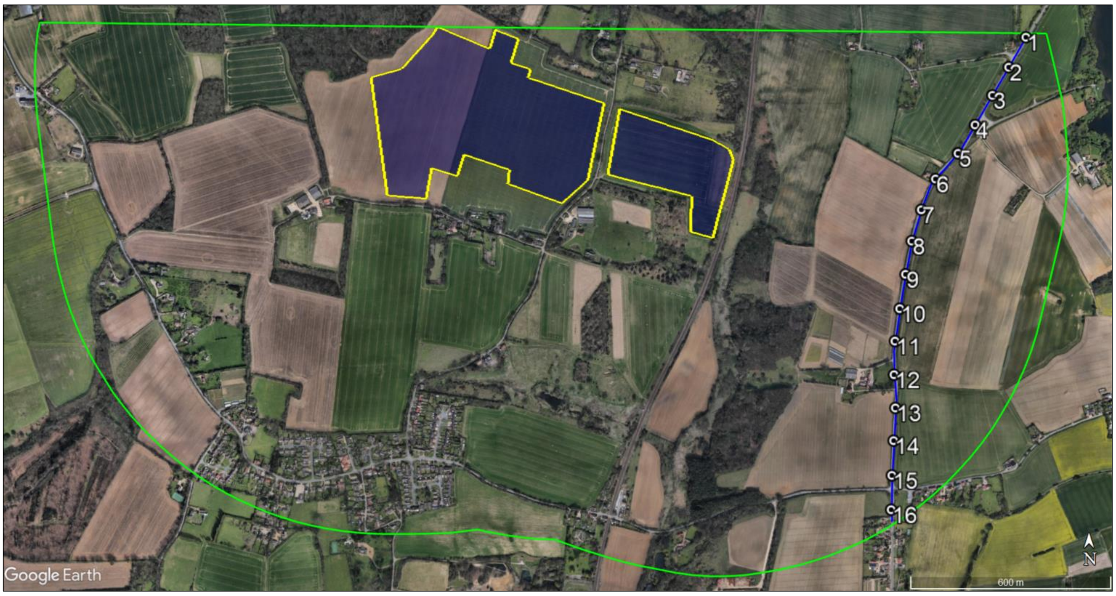

Figure 3 – Assessed A137 road receptors

5.6 Dwelling Receptors

5.6.1 Overview

The analysis has considered dwellings that:

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

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

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.

5.6.2 Identified Dwelling Receptors

The assessed dwelling receptors are shown in Figure 4 to Figure 10 on the following pages. In total, 139 dwelling receptors have been assessed. A 1.8m height above ground level is used in the modelling to simulate the typical viewing height of an observer on the ground floor[16].

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

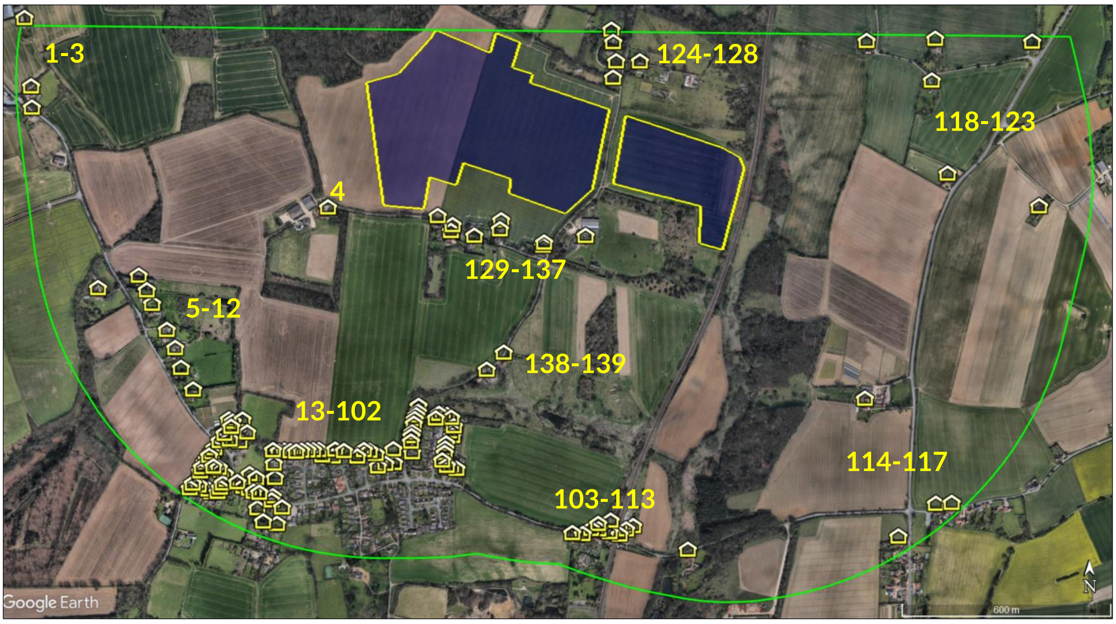

Figure 4 – Assessed dwelling receptors 1 to 139

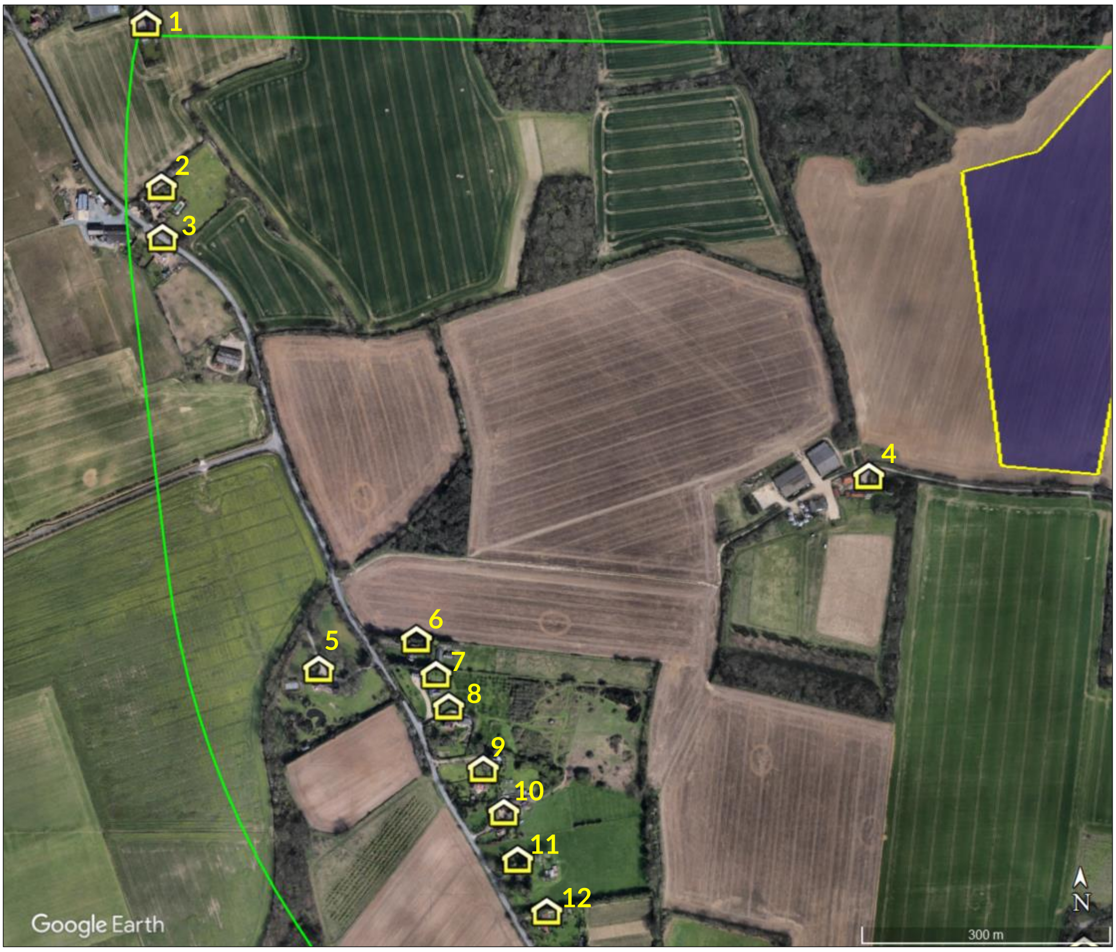

Figure 5 – Assessed dwelling receptors 1 to 12

Figure 6 – Assessed dwelling receptors 13 to 78

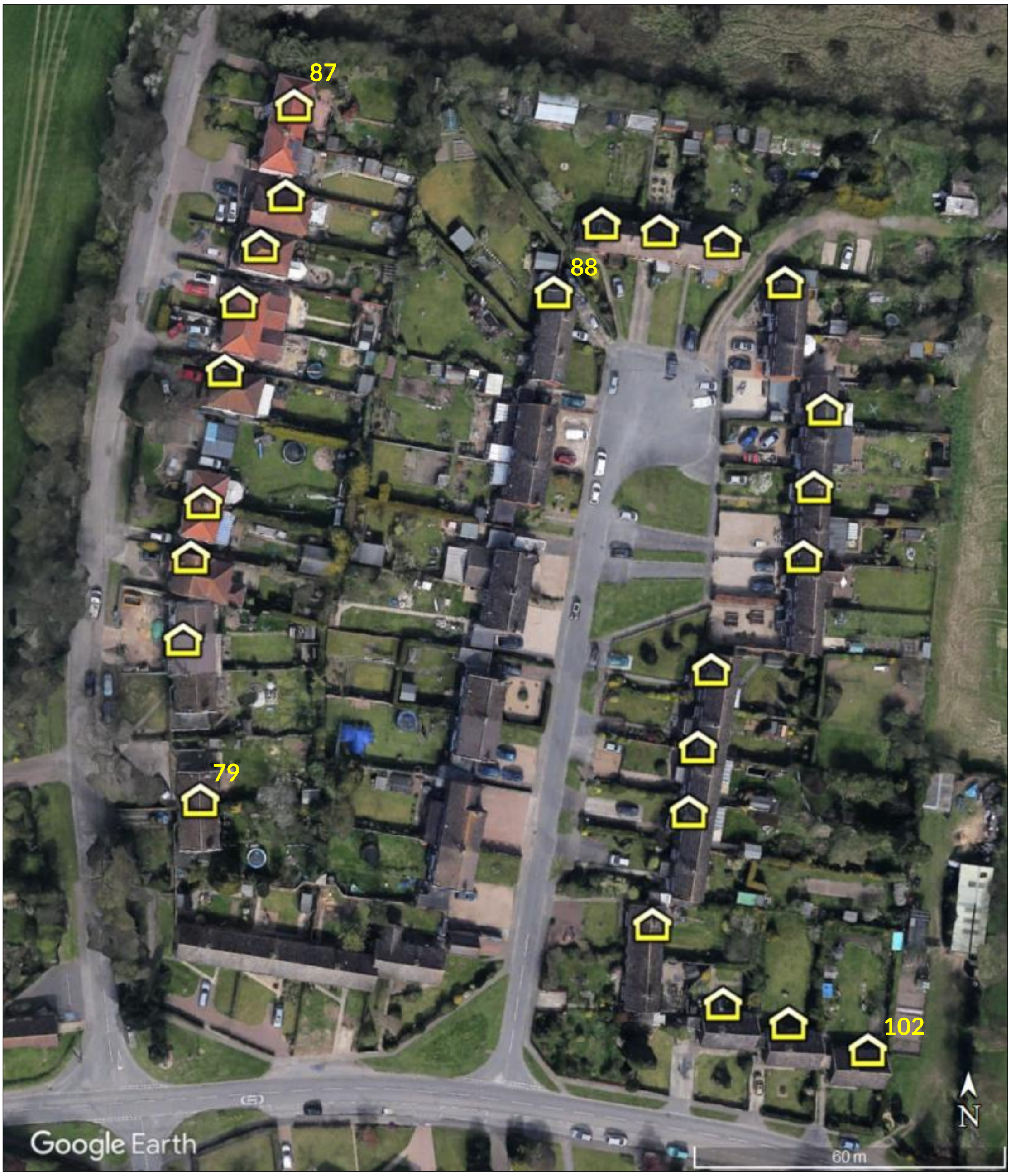

Figure 7 – Assessed dwelling receptors 79 to 102

Figure 8 – Assessed dwelling receptors 103 to 117

Figure 9 – Assessed dwelling receptors 118 to 128

Figure 10 – Assessed dwelling receptors 129 to 139

6 ASSESSED REFLECTOR AREAS AND SOLAR PANEL DETAILS

6.1 Reflector Areas

A resolution of 10m has been chosen for this assessment. This means that a geometric calculation is undertaken for each identified receptor from a point every 10m from within the defined areas. This resolution is sufficiently high to maximise the accuracy of the results, increasing the resolution further would not significantly change the modelling output. The number of modelled reflector points is determined by the size of the reflector areas and the assessment resolution. The bounding co-ordinates for the proposed solar development have been extrapolated from the site plans. The data can be found in Appendix G.

The assessed reflector areas are shown in Figure 11 below.

Figure 11 – Assessed reflector areas

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Overview

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

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

7.2 Geometric Calculation Results Overview – Railway Receptors

The results of the geometric calculations for the identified railway receptors are presented in Table 2 below and discussed further in Section 7.3 at page 43.

Receptor	Predicted reflection times towards railway receptors (GMT)		Comment
	am	pm	
1	None.	None.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
2	None.	Between 18:06 and 18:09 from late March to early April. Between 17:53 and 18:06 from early September to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
3	None.	Between 18:07 and 18:14 from late March to the end of April. Between 17:54 and 18:21 from mid-August to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
4	None.	Between 18:07 and 18:24 from late March to late May. Between 17:55 and 18:33 from mid- July to mid- September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
5	None.	Between 17:55 and 18:35 from late March to mid-September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards railway receptors (GMT)		Comment
	am	pm	
6	None.	Between 17:55 and 18:35 from late March to mid-September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
7	None.	Between 18:05 and 18:42 from early April to early September.	Solar reflections are geometrically possible. While some screening has been identified, views of the reflecting surface are deemed possible. However, the reflective area is predicted to be outside a train driver's primary field of view (30° either side considering the direction of travel). Therefore, low impact is predicted, and no mitigation is recommended.
8	None.	Between 18:13 and 18:36 from mid- April to late August.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
9	None.	Between 18:17 and 18:34 from early May to early August.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
10	None.	Between 18:25 and 18:33 from the beginning of June to mid- July.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards railway receptors (GMT)		Comment
	am	pm	
11 – 12	None.	None.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.

Table 2 – Railway receptors: geometric analysis results

7.1 Geometric Calculation Results Overview – Roads

7.1.1 A137

The results of the geometric calculations for road users travelling along the assessed stretch of A137 are presented in Table 3 below. Discussed in Section 7.4.2 on page 46.

Receptor	Predicted reflection times towards road users (GMT)		Comment
	am	pm	
1	None.	None.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
2	None.	Between 18:05 and 18:07 during late March. Between 17:51 and 17:57 during mid- September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards road users (GMT)		Comment
	am	pm	
3	None.	Between 18:05 and 18:08 from late March to early April. Between 17:51 and 18:04 from early September to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
4	None.	Between 18:04 and 18:09 from late March to mid-April. Between 17:49 and 18:11 from late August to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
5	None.	Between 18:03 and 18:12 from mid- March to late April. Between 17:47 and 18:18 from mid- August to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
6	None.	Between 18:02 and 18:15 from mid- March to mid- May. Between 17:46 and 18:25 from the beginning of August to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
7	None.	Between 18:02 and 18:22 from mid- March to the end of May. Between 17:46 and 18:30 from mid-July to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
8	None.	Between 17:47 and 18:31 from late March to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards road users (GMT)		Comment
	am	pm	
9	None.	Between 18:06 and 18:31 from mid- April to the beginning of September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
10	None.	Between 18:10 and 18:31 from late April to late August.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
11	None.	Between 18:12 and 18:31 from the beginning of May to mid- August.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
12	None.	Between 18:16 and 18:31 from mid- May to the end of July.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
13	None.	Between 18:21 and 18:31 from late May to mid-July.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
14 – 16	None.	None.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.

Table 3 – Geometric analysis results for A137

7.2 Geometric Calculation Results Overview – Dwellings

The results of the geometric calculations for observers located within the identified dwelling are presented in Table 4 below. Discussed in Section 7.5 on page 47.

Receptor	Predicted reflection times towards dwelling receptors (GMT)		Comment
	am	pm	
1	None.	None.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
2	Between 05:45 and 06:03 from mid- March to mid- April. Between 05:45 and 05:48 from the end of August to late September.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
3	Between 05:40 and 06:04 from mid- March to late April. Between 05:44 and 05:48 from late August to late September.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
4	Between 05:22 and 06:06 from mid- March to the end of September.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards dwelling receptors (GMT)		Comment
	am	pm	
5	Between 05:22 and 05:54 from the beginning of April to mid- September.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
6	Between 05:24 and 05:57 from the end of March to mid- September.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
7	Between 05:24 and 05:54 from the beginning of April to mid- September.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
8	Between 05:24 and 05:51 from early April to early September.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
9	Between 05:25 and 05:46 from mid- April to the beginning of September.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
10	Between 05:25 and 05:46 from mid- April to late August.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards dwelling receptors (GMT)		Comment
	am	pm	
11	Between 05:25 and 05:44 from late April to mid- August.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
12	Between 05:25 and 05:43 from the beginning of May to mid- August.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
13	Between 05:26 and 05:40 from mid- May to the end of July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
14	Between 05:26 and 05:39 from mid- May to late July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
15	Between 05:26 and 05:39 from mid- May to late July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
16	Between 05:26 and 05:38 from late May to late July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards dwelling receptors (GMT)		Comment
	am	pm	
17	Between 05:26 and 05:37 from late May to mid- July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
18	Between 05:26 and 05:39 from late May to late July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
19	Between 05:26 and 05:37 from late May to mid- July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
20	Between 05:26 and 05:35 from the end of May to mid-July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
21	Between 05:26 and 05:37 from late May to mid- July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
22	Between 05:26 and 05:36 from late May to mid- July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards dwelling receptors (GMT)		Comment
	am	pm	
23	Between 05:25 and 05:35 from the end of May to mid-July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
24	Between 05:26 and 05:35 from the end of May to mid-July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
25	Between 05:26 and 05:34 from the end of May to mid-July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
26	Between 05:26 and 05:34 from the beginning of June to mid- July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
27	Between 05:26 and 05:33 from early June to early July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
28	Between 05:26 and 05:32 from early June to early July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards dwelling receptors (GMT)		Comment
	am	pm	
29	Between 05:27 and 05:32 from early June to early July.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
30	Between 05:27 and 05:31 from mid- June to the end of June.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
31	Between 05:28 and 05:29 during late June.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
32 – 40	None.	None.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
41	At circa 05:28 during late June.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
42 – 116	None.	None.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards dwelling receptors (GMT)		Comment
	am	pm	
117	None.	Between 18:22 and 18:31 from the end of May to mid-July.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
118	None.	Between 18:02 and 18:15 from mid- March to early May. Between 17:45 and 18:24 from early August to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
119	None.	Between 18:04 and 18:15 from late March to mid-May. Between 17:49 and 18:25 from the beginning of August to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
120	None.	Between 18:05 and 18:06 during late March. Between 17:51 and 17:54 during late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards dwelling receptors (GMT)		Comment
	am	pm	
121	None.	Between 18:05 and 18:07 from late March to early April. Between 17:50 and 18:04 from early September to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
122	None.	Between 18:05 and 18:06 during late March. Between 17:51 and 17:53 during late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
123	None.	Between 18:05 and 18:06 during late March. Between 17:51 and 17:55 during mid-September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
124	None.	Between 18:07 and 18:13 from late March to late April. Between 17:54 and 18:19 from mid- August to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards dwelling receptors (GMT)		Comment
	am	pm	
125	None.	Between 18:06 and 18:07 during late March. Between 17:55 and 17:56 during mid-September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
126	None.	Between 18:06 and 18:09 from late March to mid-April. Between 17:53 and 18:08 from the beginning of September to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
127	None.	Between 18:06 and 18:15 from late March to early May. Between 17:53 and 18:24 from early August to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
128	None.	Between 17:53 and 18:32 from late March to late September.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards dwelling receptors (GMT)		Comment
	am	pm	
129	Between 05:27 and 06:07 from late March to the end of September.	Between 18:11 and 18:32 from mid- April to late August.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
130	Between 05:27 and 06:05 from late March to late September.	Between 18:13 and 18:32 from the beginning of May to mid- August.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
131	Between 05:27 and 06:01 from the end of March to mid- September.	Between 18:14 and 18:32 from early May to early August.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
132	Between 05:27 and 06:10 from mid- March to the beginning of October.	Between 18:09 and 18:31 from mid- April to late August.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
133	Between 05:28 and 06:10 from mid- March to the beginning of October.	Between 18:12 and 18:31 from the beginning of May to early August.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards dwelling receptors (GMT)		Comment
	am	pm	
134	Between 05:25 and 06:08 from mid- March to the end of September.	Between 18:17 and 18:25 from mid- May to early June. Between 18:27 and 18:31 from early July to the end of July.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
135	Between 05:26 and 06:09 from mid- March to the beginning of October.	At circa 18:21 during the end of May. At circa 18:26 during mid- June. At circa 18:30 during the beginning of July.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
136	Between 05:26 and 06:08 from mid- March to the end of September.	None.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.
137	Between 05:27 and 06:07 from mid- March to late September.	At circa 18:23 during the beginning of June. Between 18:28 and 18:29 during late June. At circa 18:30 during mid- July.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly screen of the reflecting panel area. Therefore, no impact is predicted, and no mitigation is required.

Receptor	Predicted reflection times towards dwelling receptors (GMT)		Comment
	am	pm	
138 – 139	None.	None.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.

Table 4 – Geometric analysis results for dwellings receptors

7.3 Train Driver Receptors

7.3.1 Key Considerations

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

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

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

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

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 mitigating factors, the impact significance is high, and mitigation is required.

7.3.2 Geometric Modelling Results Overview

The results of the modelling indicate that solar reflections are geometrically possible towards nine of the 12 assessed train driver receptors equivalent to 0.9km section of railway line. The sections of railway line where solar reflections are geometrically possible are shown by the orange lines in Figure 12 on the following page.

For train drivers travelling between 1 and 6 and 8 and 10 solar reflections are predicted to be sufficiently screened by the existing vegetation and terrain (see Figure 12 and Figure 13 below). Therefore, for a train driver travelling along this stretch of railway, no impact is predicted and no mitigation is required.

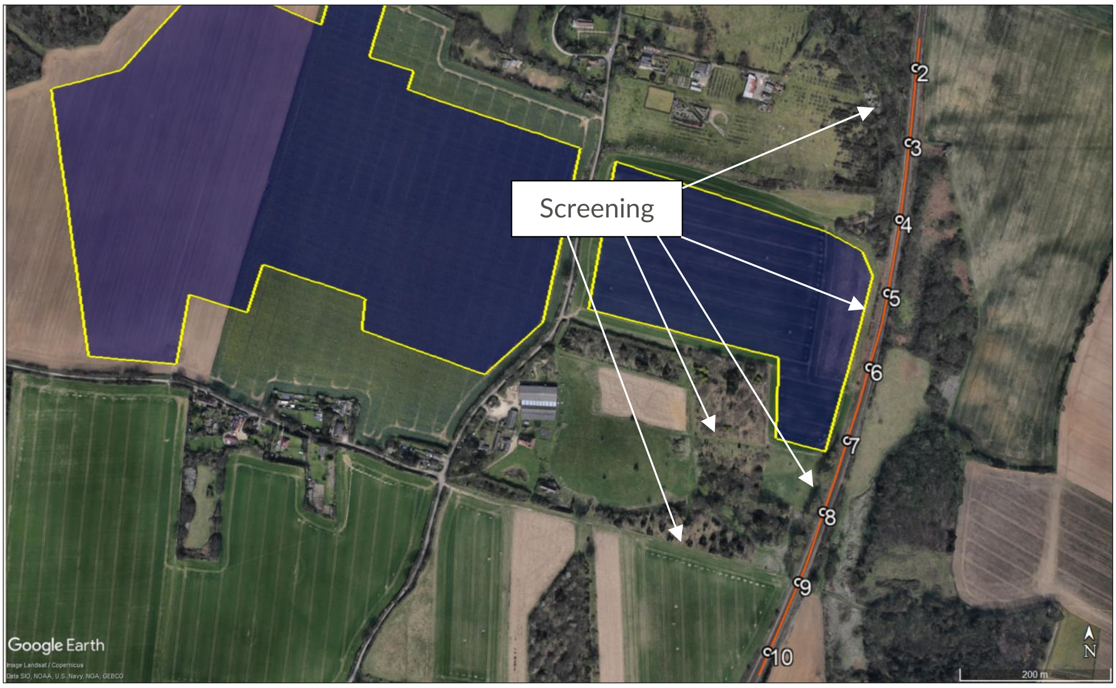

Figure 12 – Section of railway line where solar reflections are geometrically possible and relevant screening

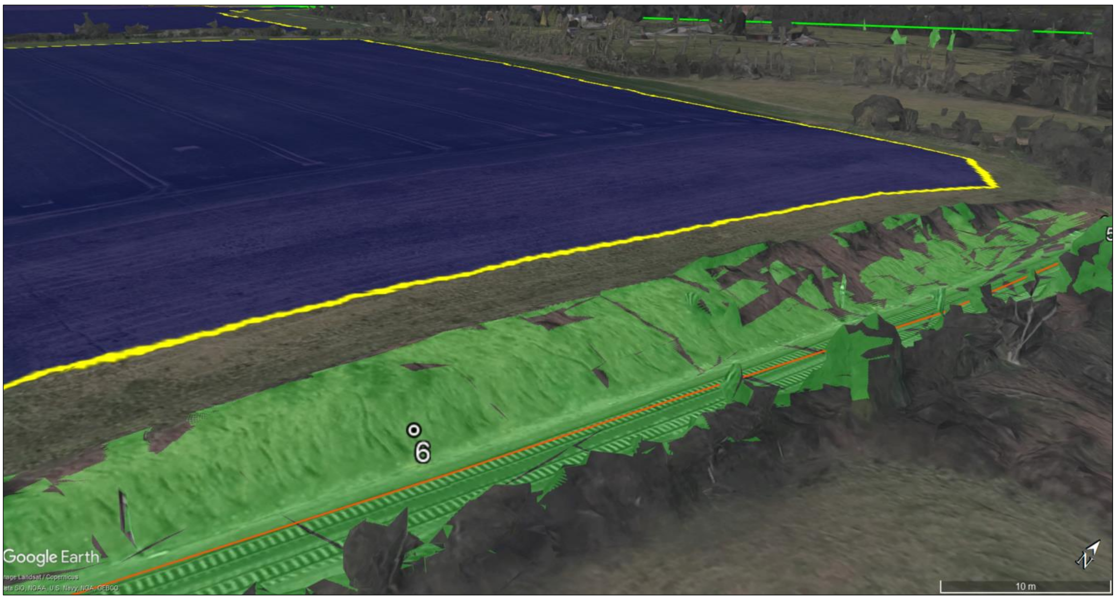

Figure 13 – Zones of theoretical visibility (green areas) from receptor 6 and existing screening in the form of terrain

For train drivers travelling across receptor 7 the solar reflective area is predicted to be outside a train driver's primary field of view (see Figure 14 below). Therefore, a low impact is predicted towards train drivers and mitigation is not recommended.

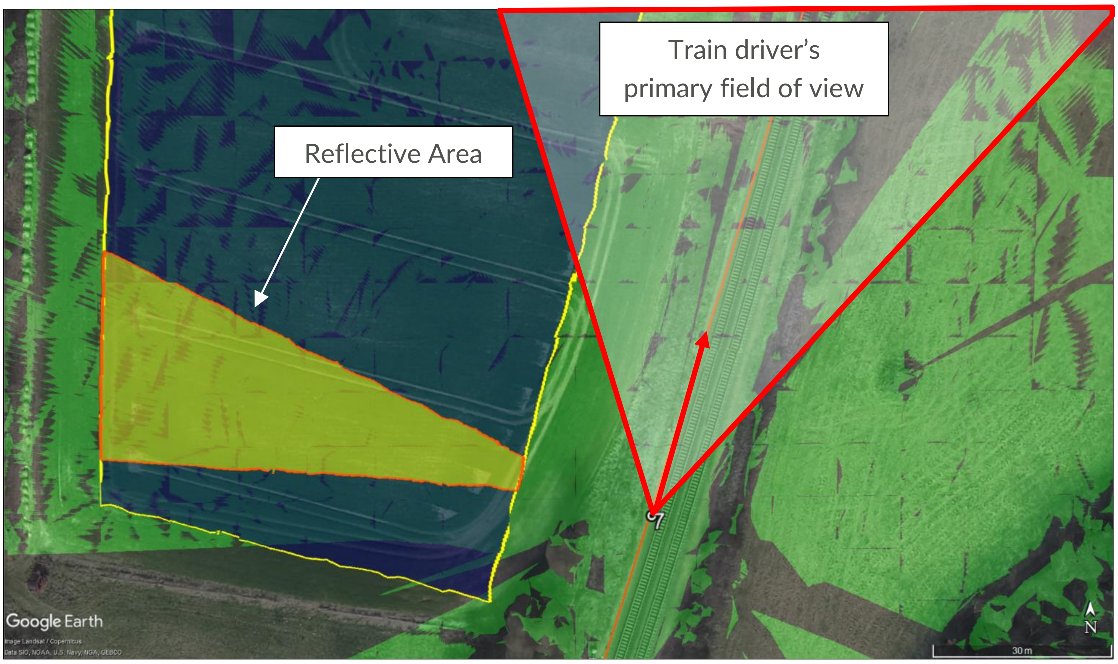

Figure 14 – Reflective area for receptor 7 and train driver's primary field of view (zones of theoretical visibility (green areas))

Overall, the impact upon train drivers travelling along the identified section of railway line is predicted to be maximum low, for which no mitigation is recommended.

7.4 Geometric Assessment Results – Road Receptors

7.4.1 Overview

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

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

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

- Whether the solar reflection originates from directly in front of a road user – a solar reflection that is directly in front of a road user is more hazardous than a solar reflection to one side;

- Whether visibility is likely for elevated drivers (relevant to dual carriageways and motorways[17]);
- The separation distance to the panel area – larger separation distances reduce the proportion of an observer's field of view that is affected by glare;
- Whether a solar reflection is fleeting in nature – a momentary reflection is less significant than a sustained source of glare;
- The position of the Sun – effects that coincide with direct sunlight appear less prominent than those that do not, as the Sun is a far more significant source of light.

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

7.4.2 Geometric Results and Discussion – A137

The results of the modelling indicate that solar reflections are geometrically possible towards 12 of the 16 assessed road receptors equivalent to 1.1km section of A137. The section of road where solar reflections are geometrically possible is shown by the orange lines in Figure 15 below. Existing screening is predicted to significantly screen the reflecting area. Therefore, no impact is predicted and no mitigation is required.

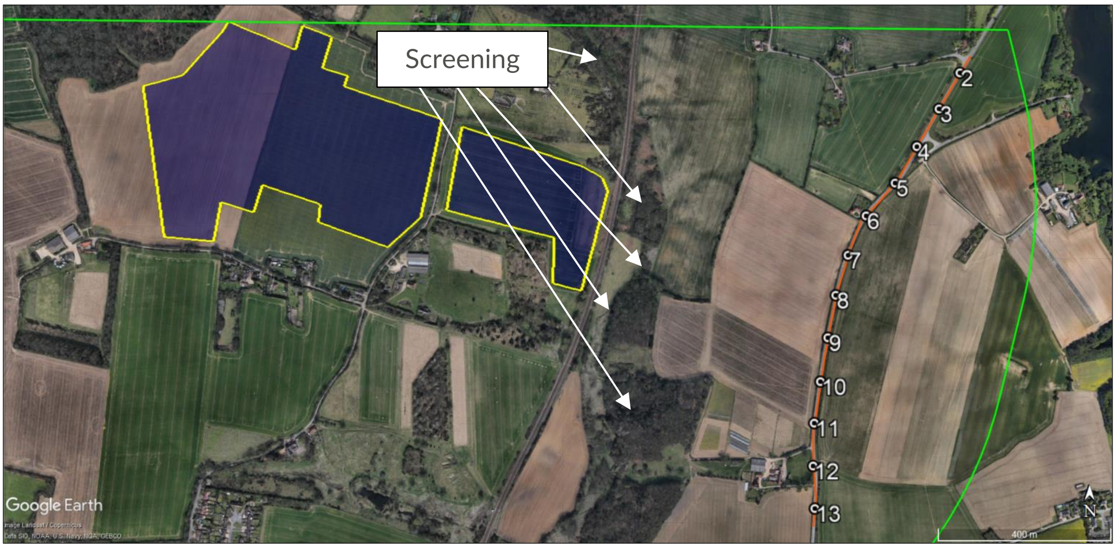

Figure 15 – Section of A137 where solar reflections are geometrically possible and relevant screening

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

7.5 Geometric Assessment Results – Dwelling Receptors

7.5.1 Overview

The key considerations for residential dwellings are:

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

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

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

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

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

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

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

7.5.2 Geometric Results and Discussion

The results of the modelling indicate that solar reflections are geometrically possible towards 54 of the 139 assessed dwellings (see Figure 16 on the following page). Existing screening is predicted to significantly reduce the visibility of the reflective area for all 54 dwellings receptors. Therefore, no impact is predicted and no mitigation is required.

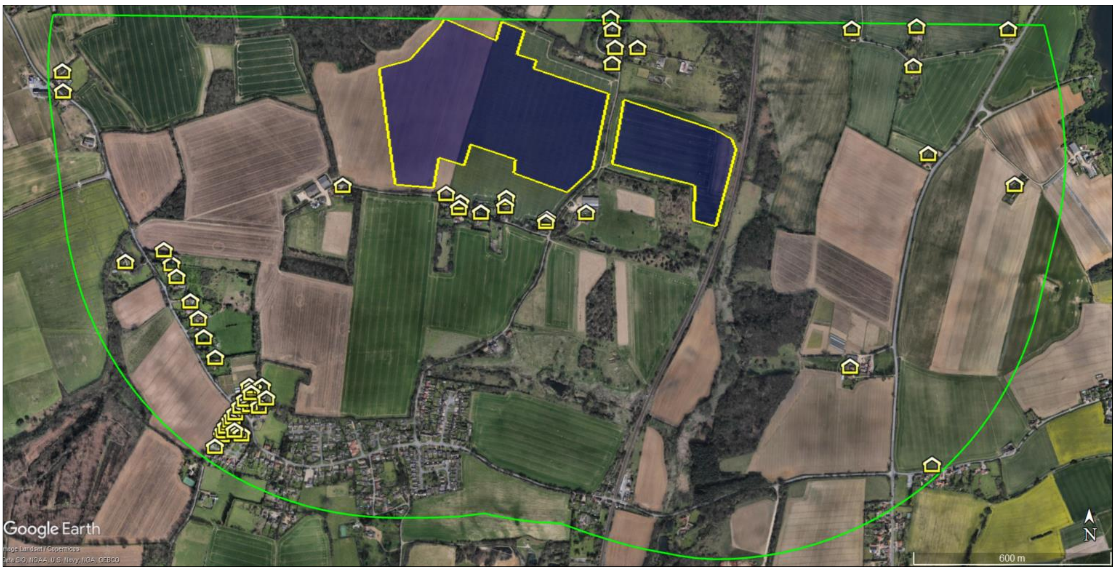

Figure 16 – Dwellings where solar reflections are predicted to be geometrically possible

Figure 17 – Existing screening nearby receptors 4

Figure 18 – Existing screening nearby receptors 124 to 128

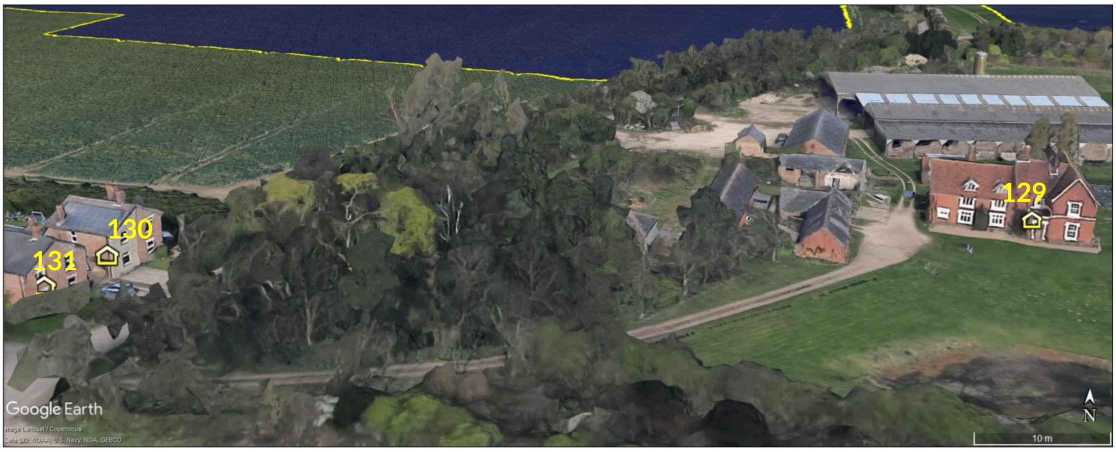

Figure 19 – Existing screening nearby receptors 129 to 131

Figure 20 – Existing screening nearby receptors 132[18] to 137

[18] Dwelling 132: while visibility of the solar development located directly north of the dwelling is possible, visibility of the solar reflective area (located east and west) will be sufficiently screened.

8 OVERALL CONCLUSIONS

8.1 Assessment Results – Railway Signals

Following a review of the available imagery, no trackside railway signals were identified. This report can be updated if further railway signals are identified by Network Rail.

8.2 Assessment Results – Train Drivers

The results of the modelling indicate that solar reflections are geometrically possible towards a section of the railway line of circa 0.9km.

Visibility of the reflective area is predicted to be significantly obstructed by existing vegetation and terrain for train drivers travelling along 0.8km of this section of railway line. For the remaining 0.1km section the solar reflective area is predicted to be visible. However, it will be outside a train driver's primary field of view. Overall, the predicted impact upon train drivers is low, and no mitigation is recommended.

8.3 Assessment Results – Road Users

The results of the modelling indicate that solar reflections are geometrically possible towards an approximately 1.1km section of the A137. Existing screening is predicted to sufficiently obstruct the visibility of the reflecting area. Therefore, no impact is predicted, and no mitigation is required.

8.4 Assessment Results – Road Users

The results of the modelling indicate that solar reflections are geometrically possible towards 54 of the 139 assessed dwellings. Existing screening is predicted to significantly obstruct the visibility of the reflective area for all 54 affected dwellings receptors. Therefore, no impact is predicted, 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.

UK Planning Policy

Renewable and Low Carbon Energy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[19] (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.'

[19] 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)[20] 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.[21] 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.

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.

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

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

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

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

Sections 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

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

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

Railway Assessment Guidelines

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

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

1. The development producing solar glare that affects train drivers; and

2. The development producing solar reflections that affect railway signals and create a risk of a phantom aspect signal.

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

Reflections and Glare

The extract below is taken from Section A5 – Reflections and glare (pages 64-65) of the 'Signal Sighting Assessment Requirements'22 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. 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.
c) 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.

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

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

Asset visibility

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

a) Position in the observer's visual field.

b) Contrast with its background.

c) Luminance properties.

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

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

Field of vision

The field of vision, or visual field, is the area of the visual environment that is registered by the eyes when both eyes and head are held still. The normal extent of the visual field is approximately 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.

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

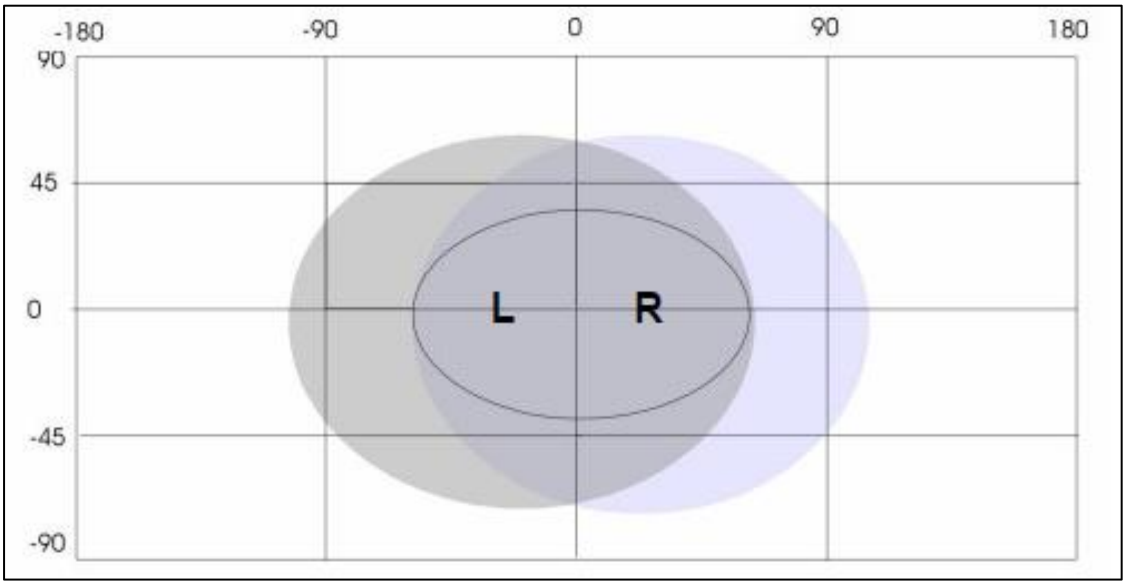

Figure G 21 - Field of view

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

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

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

a) *A co-acting signal.*
b) *A miniature banner repeater indicator.*
c) *A right away indicator.*

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

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

'Car stop' signs should be positioned so that the relevant platform starting signals and / or indicators can be seen in the driver's central field of vision.
If possible, clutter and non-signal lights in a driver's field of view should be screened off or removed so that they do not cause distraction.

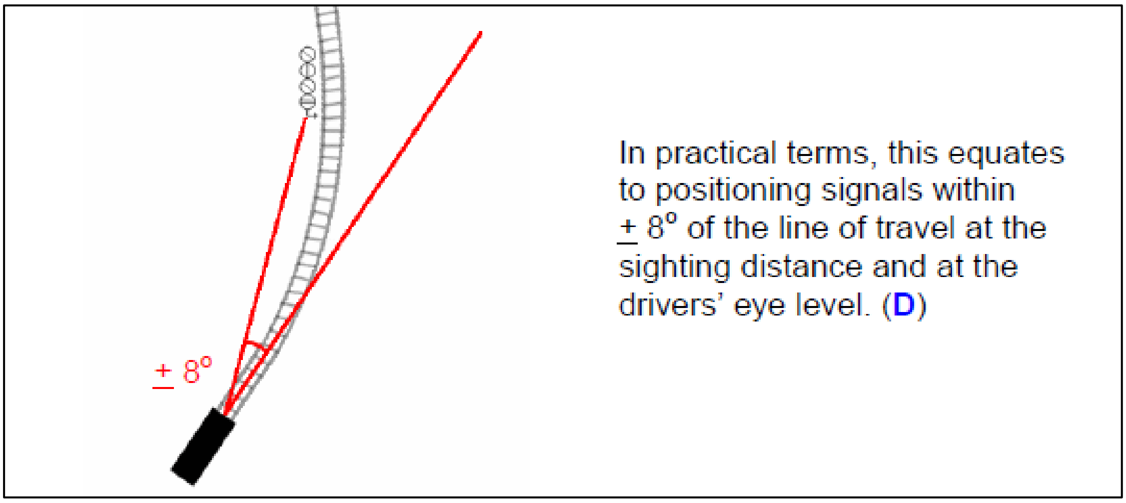

Figure G 22 - Signal positioning

'A' (m)	'B' (m)	Typical display positions
5	0.70	-
6	0.84	-
7	0.98	-
8	1.12	-
9	1.26	-
10	1.41	-
11	1.55	-
12	1.69	-
13	1.83	-
14	1.97	-

15	*2.11*	*A stop aspect positioned 3.3 m above rail level and 2.1 m from the left hand rail is within the 8º cone at 15.44 m in front of the driver*
16	*2.25*	-
17	*2.39*	-
18	*2.53*	*A stop aspect positioned 5.1 m above rail level and 0.9 m from the left hand rail is within the 8º cone at 17.93 m in front of the driver*
19	*2.67*	-
20	*2.81*	-
21	*2.95*	-
22	*3.09*	-
23	*3.23*	-
24	*3.37*	-
25	*3.51*	*A stop aspect positioned 3.3 m above rail level and 2.1 m from the right hand rail is within the 8º cone at 25.46 m in front of the driver*

Table G 5 – 8º 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[24];
- 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[25,26,27] claim that LED signal lights significantly reduce or completely remove the likelihood of a phantom aspect illumination occurring.

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[24] Source: Wayside LED Signals – Why it's Harder than it Looks, Bill Petit.
[25] Source: http://www.unipartdorman.co.uk/assets/unipart_dorman_rail_brochure.pdf. (Last accessed 21.02.18).
[26] Source: http://www.vmstech.co.uk/downloads/Rail.pdf. (Last accessed 21.02.18).
[27] Source: Siemens, Sigmaguard LED Tri-Colour L Signal – LED Signal Technology at Incandescent Prices. Datasheet 1A-23. (Last accessed 22.02.18).

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

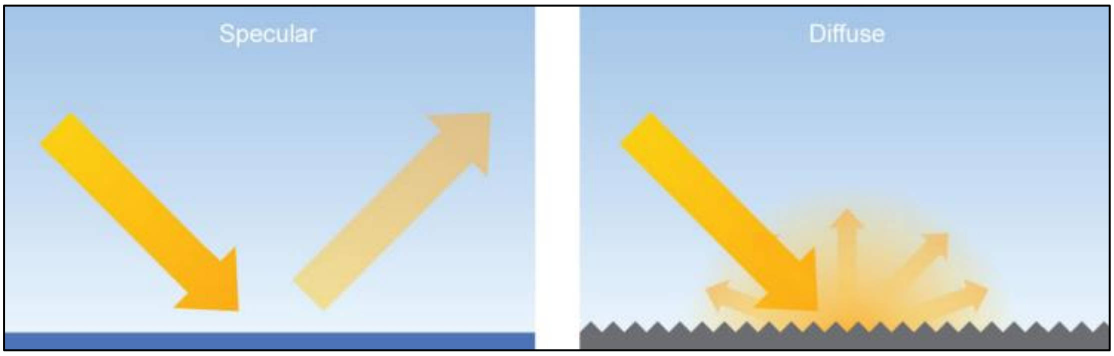
Overview

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[28], 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

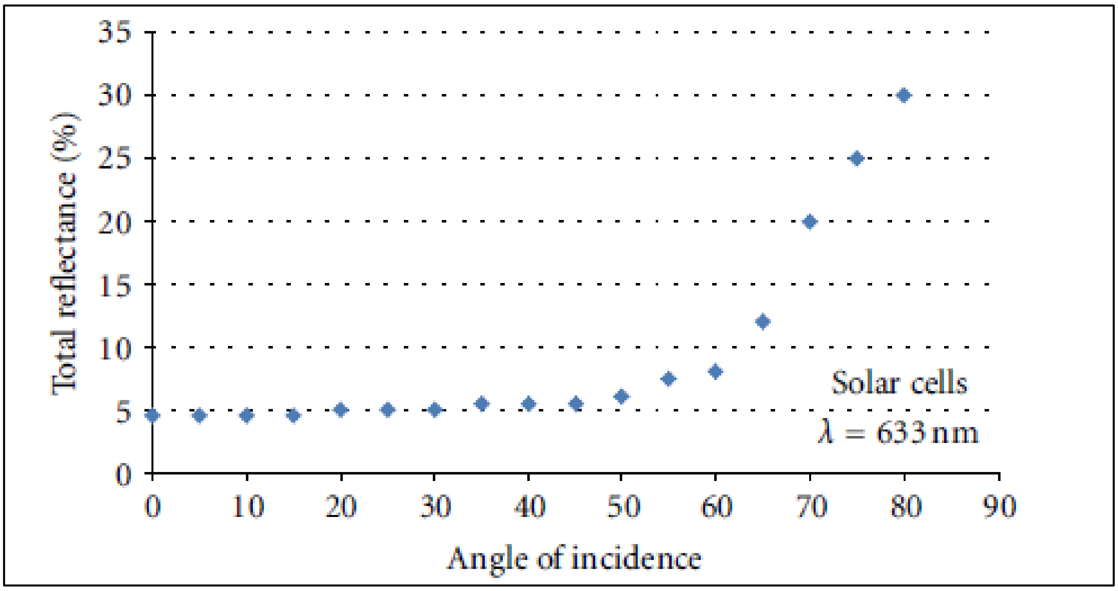
[28] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

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



Total reflectance % when compared to angle of incidence

The conclusions of the research study were:

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

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[29] 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"[30]

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[31]
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.

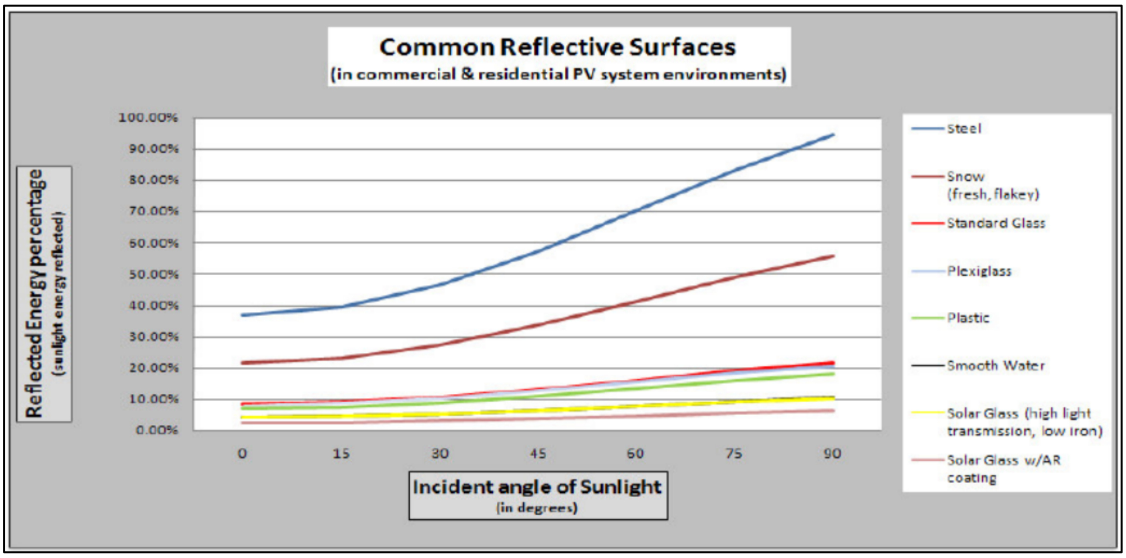
[30] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

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

SunPower Technical Notification (2009)

SunPower published a technical notification[32] 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.

[32] 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).

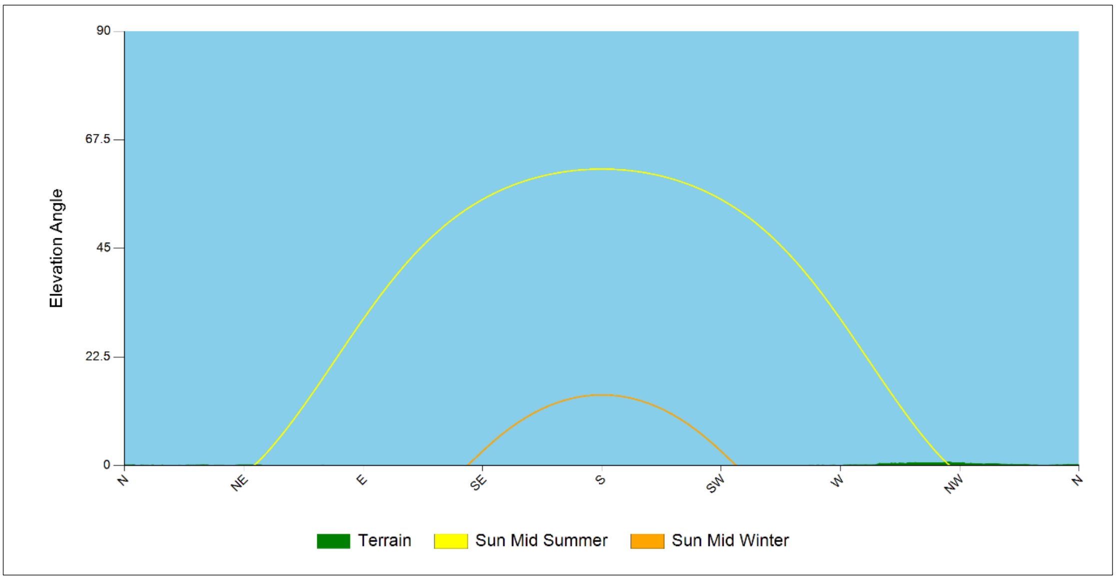
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

- 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 22 December, the maximum elevation reached by the Sun is at its lowest (shortest day).

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



APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact Significance Definition

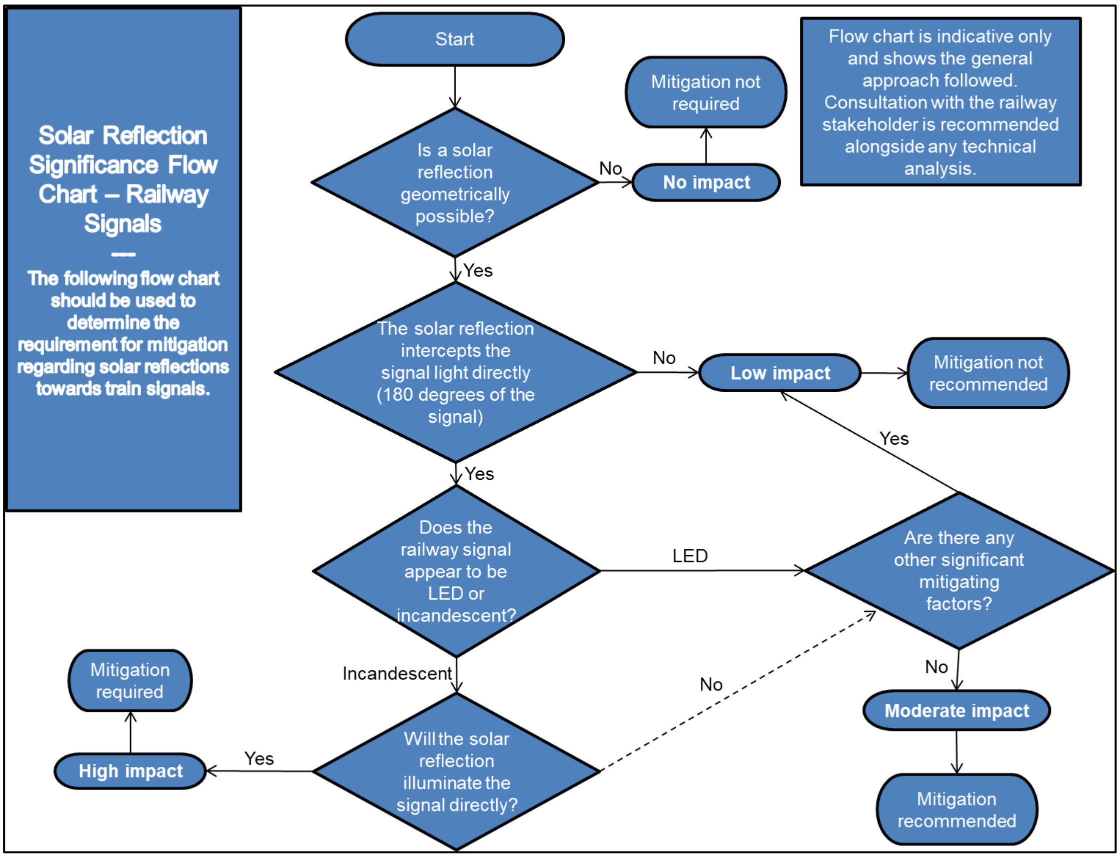
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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

Impact significance definition

Assessment Process for Railway Signals

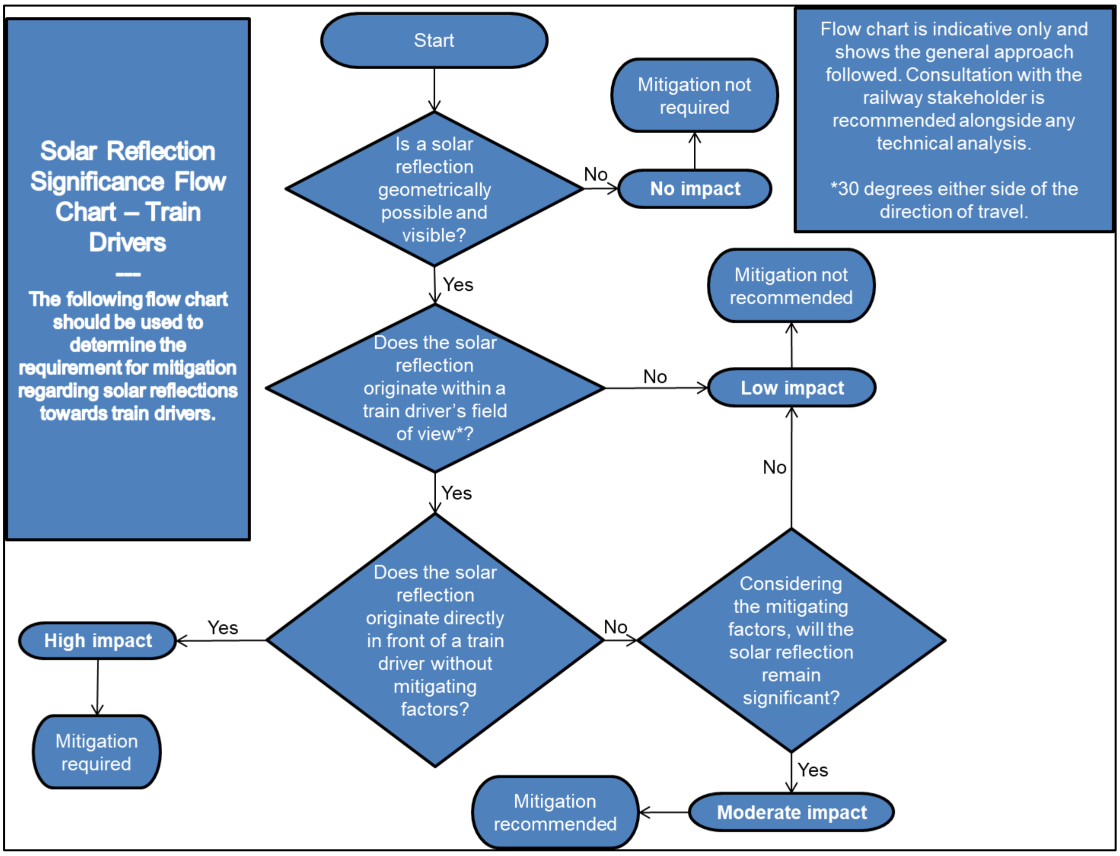
The flow chart presented below has been followed when determining the impact significance and mitigation recommendation/requirement for railway signals.



Railway signal impact significance flow chart

Assessment Process for Train Driver Receptors

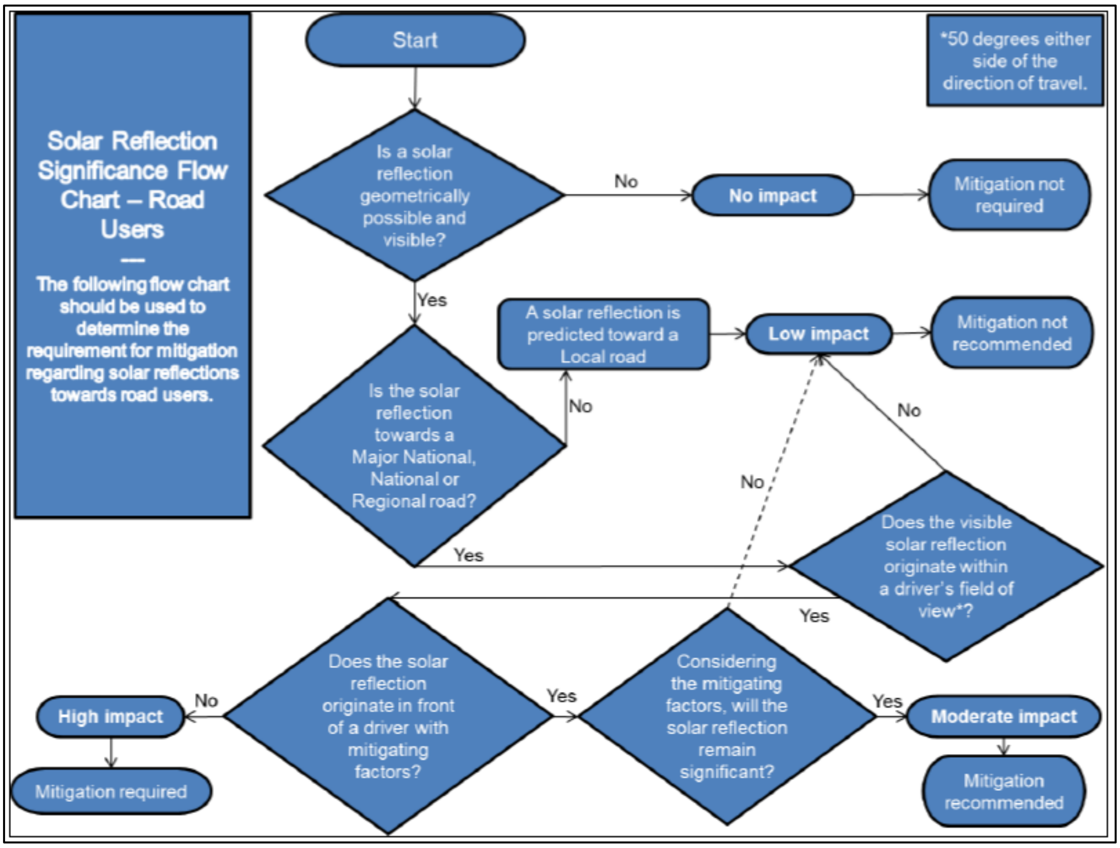
The flow chart presented below has been followed when determining the impact significance and mitigation recommendation/requirement for train driver receptors.



Train driver impact significance flow chart

Impact Significance Determination for Road Receptors

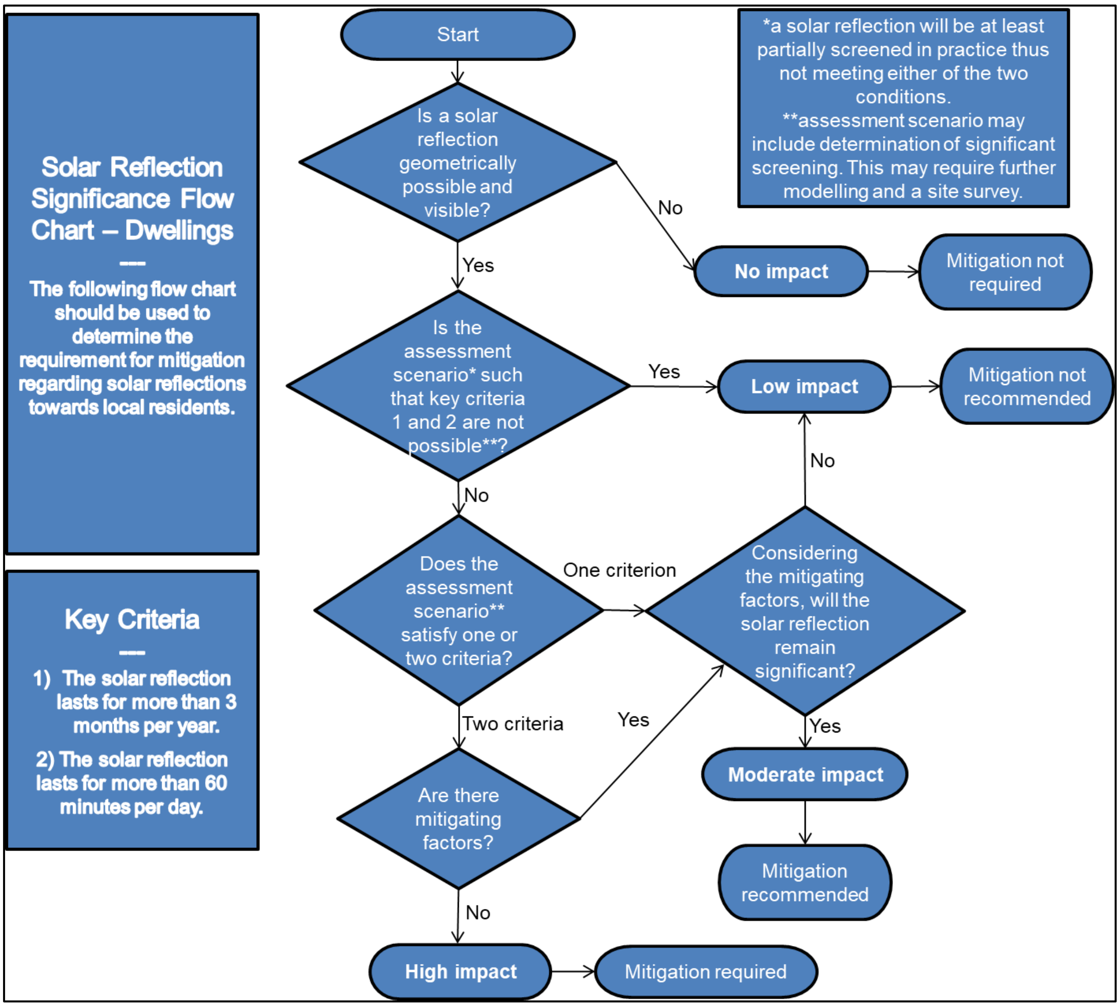
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road receptor mitigation requirement 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 mitigation requirement flow chart

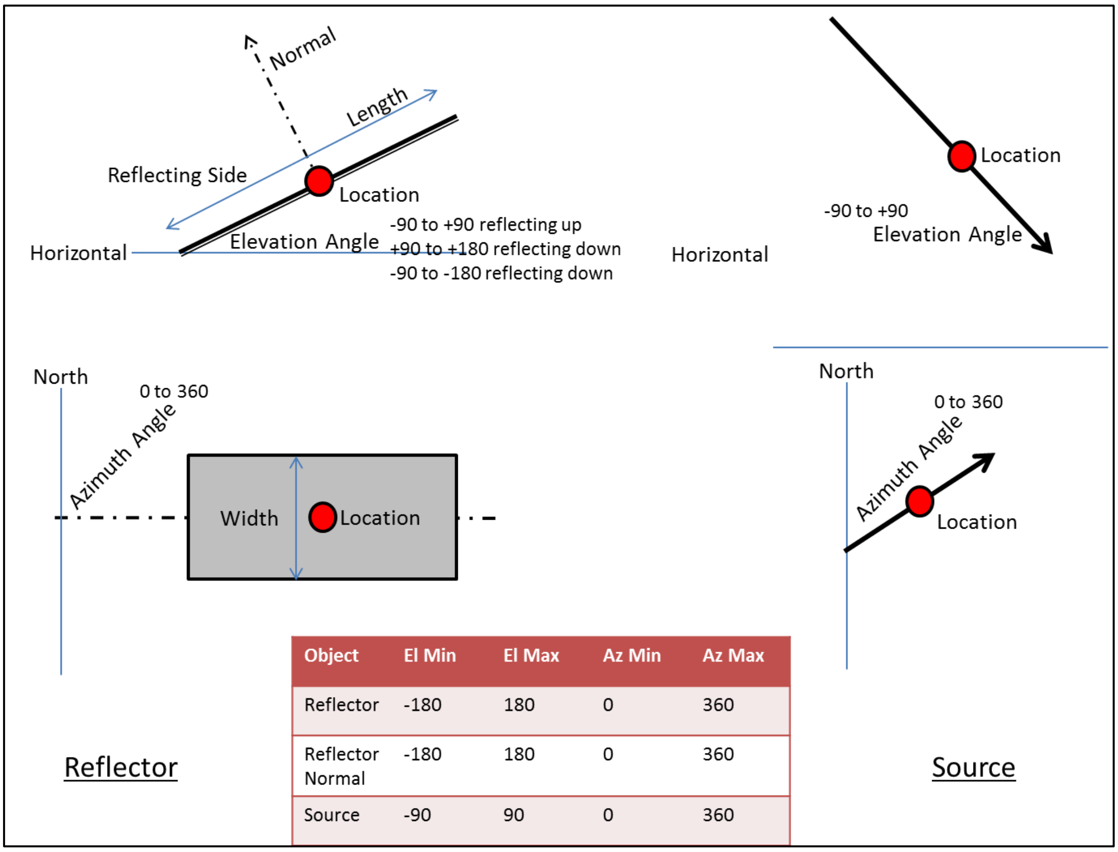
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Pager Power Methodology

The calculations are three dimensional and complex, accounting for:

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

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



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

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

- Use the Latitude and Longitude of reflector as the reference for calculation purposes;
- Calculate the Azimuth and Elevation of the normal to the reflector;

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

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)[33].

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

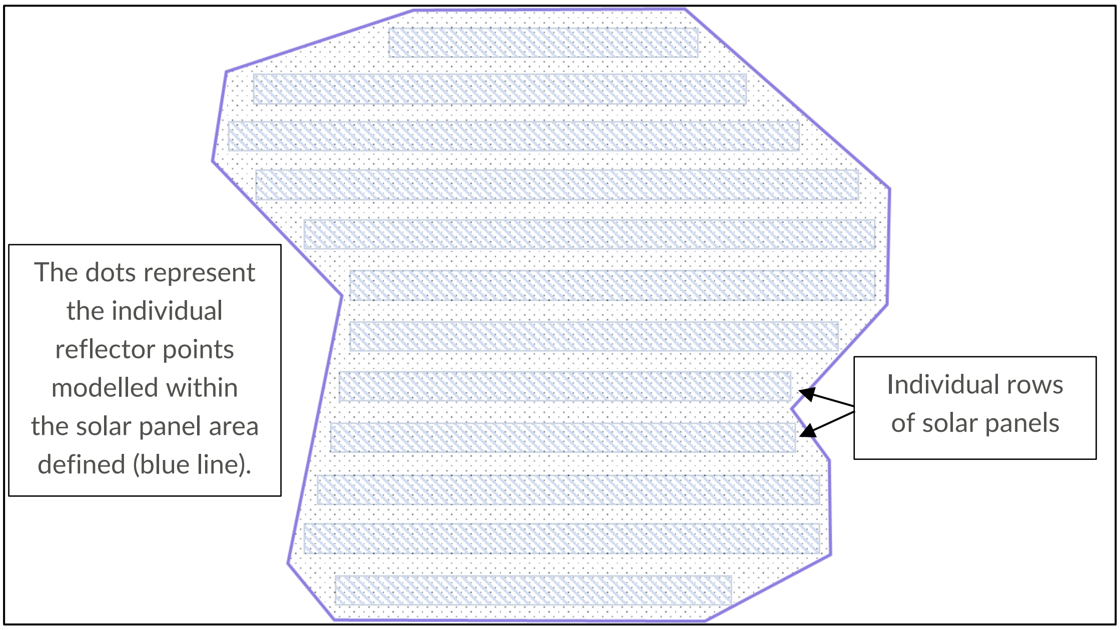
It is assumed that the panel azimuth angle assessed represents the azimuth angle for all of the panels within each solar panel area defined.

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

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

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

[33] 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.

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Terrain Data

Terrain elevation heights have been interpolated based on OSGB terrain data.

Train Driver Receptor Data

An additional height of 2.75m has been added to the ground height, this has been taken as typical eye level for a train driver.

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	1.09154	52.00169	7	1.09007	51.99638
2	1.09138	52.00078	8	1.08963	51.99553
3	1.09125	51.99990	9	1.08915	51.99470
4	1.09108	51.99900	10	1.08856	51.99388
5	1.09084	51.99813	11	1.08791	51.99309
6	1.09049	51.99725	12	1.08731	51.99229

Train Driver Receptor Data

Road Receptor Data

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

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	1.10323	52.00160	25	1.09799	51.99529
2	1.10247	52.00080	26	1.09774	51.99438
3	1.10176	52.00005	27	1.09753	51.99352
4	1.10101	51.99926	28	1.09750	51.99262
5	1.10027	51.99851	29	1.09755	51.99174
6	1.09928	51.99782	30	1.09748	51.99087
7	1.09867	51.99701	31	1.09740	51.98994

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
8	1.09826	51.99617	32	1.09737	51.98903

Road receptor data

Dwelling Receptor Data

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

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	1.06075	52.00189	71	1.07448	51.99073
2	1.06101	52.00016	72	1.07475	51.99089
3	1.06103	51.99962	73	1.07499	51.99087
4	1.07326	51.99708	74	1.07525	51.99079
5	1.06373	51.99502	75	1.07534	51.99047
6	1.06542	51.99534	76	1.07565	51.99054
7	1.06576	51.99497	77	1.07600	51.99056
8	1.06598	51.99462	78	1.07597	51.99091
9	1.06658	51.99396	79	1.07675	51.99083
10	1.06694	51.99349	80	1.07670	51.99110
11	1.06717	51.99299	81	1.07673	51.99124
12	1.06768	51.99244	82	1.07676	51.99134
13	1.06916	51.99167	83	1.07682	51.99156
14	1.06973	51.99167	84	1.07686	51.99168
15	1.06932	51.99162	85	1.07692	51.99177
16	1.06926	51.99149	86	1.07699	51.99186

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
17	1.06992	51.99134	87	1.07701	51.99201
18	1.06898	51.99131	88	1.07773	51.99169
19	1.06920	51.99116	89	1.07786	51.99181
20	1.06959	51.99112	90	1.07802	51.99180
21	1.06878	51.99112	91	1.07820	51.99178
22	1.06856	51.99094	92	1.07837	51.99171
23	1.06845	51.99083	93	1.07848	51.99149
24	1.06834	51.99074	94	1.07845	51.99136
25	1.06825	51.99066	95	1.07842	51.99124
26	1.06815	51.99058	96	1.07816	51.99105
27	1.06804	51.99045	97	1.07812	51.99092
28	1.06798	51.99035	98	1.07810	51.99081
29	1.06853	51.99047	99	1.07800	51.99062
30	1.06874	51.99044	100	1.07819	51.99049
31	1.06883	51.99037	101	1.07837	51.99045
32	1.06899	51.99028	102	1.07859	51.99041
33	1.06905	51.99013	103	1.08339	51.98875
34	1.06891	51.99004	104	1.08383	51.98872
35	1.06879	51.98993	105	1.08418	51.98885
36	1.06870	51.98982	106	1.08449	51.98883
37	1.06842	51.98982	107	1.08447	51.98897

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
38	1.06831	51.98989	108	1.08495	51.98876
39	1.06808	51.98991	109	1.08499	51.98905
40	1.06791	51.98999	110	1.08537	51.98869
41	1.06766	51.99003	111	1.08564	51.98882
42	1.06754	51.98992	112	1.08593	51.98891
43	1.06951	51.99007	113	1.08821	51.98830
44	1.06975	51.98996	114	1.09692	51.98867
45	1.07002	51.99028	115	1.09847	51.98951
46	1.07029	51.99017	116	1.09912	51.98953
47	1.06999	51.98991	117	1.09553	51.99219
48	1.07019	51.98983	118	1.09896	51.99794
49	1.07042	51.98980	119	1.10276	51.99710
50	1.07034	51.98941	120	1.10249	52.00131
51	1.07058	51.98907	121	1.09831	52.00031
52	1.07094	51.98961	122	1.09846	52.00138
53	1.07098	51.98971	123	1.09560	52.00133
54	1.07115	51.98901	124	1.08620	52.00081
55	1.07136	51.98943	125	1.08502	52.00162
56	1.07107	51.99018	126	1.08509	52.00130
57	1.07103	51.99055	127	1.08522	52.00081
58	1.07099	51.99089	128	1.08509	52.00039

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
59	1.07123	51.99085	129	1.08395	51.99635
60	1.07146	51.99087	130	1.08223	51.99618
61	1.07171	51.99086	131	1.08218	51.99611
62	1.07195	51.99085	132	1.08045	51.99675
63	1.07217	51.99087	133	1.08039	51.99652
64	1.07242	51.99088	134	1.07782	51.99686
65	1.07265	51.99088	135	1.07843	51.99663
66	1.07289	51.99089	136	1.07836	51.99648
67	1.07303	51.99076	137	1.07933	51.99636
68	1.07348	51.99073	138	1.08055	51.99337
69	1.07357	51.99090	139	1.07984	51.99294
70	1.07393	51.99087			

Dwelling receptor data

Modelled Reflector Data

Site West

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	1.07724	51.99728	11	1.08176	52.00072
2	1.07748	51.99809	12	1.08091	52.00088
3	1.07859	51.99788	13	1.08123	52.00153
4	1.07888	51.99845	14	1.08023	52.00176
5	1.08083	51.99805	15	1.07999	52.00126
6	1.08077	51.99767	16	1.07773	52.00185
7	1.08311	51.99716	17	1.07753	52.00164

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
8	1.08422	51.99777	18	1.07619	52.00073
9	1.08494	51.99982	19	1.07486	52.00050
10	1.08164	52.00050	20	1.07556	51.99737

Modelled Reflector Data – Site West

Site East

Location	Longitude (°)	Latitude (°)	Location	Longitude (°)	Latitude (°)
1	1.08872	51.99735	5	1.09035	51.99861
2	1.08867	51.99640	6	1.08964	51.99885
3	1.08964	51.99624	7	1.08561	51.99967
4	1.09054	51.99832	8	1.08509	51.99792

Modelled Reflector Data – Site East

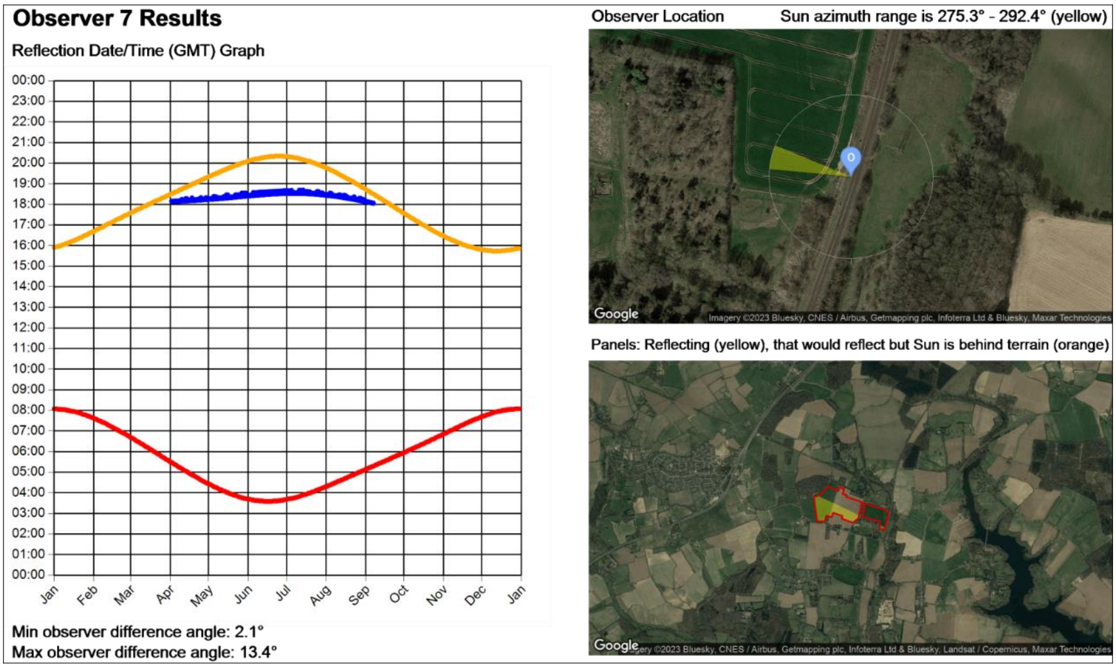
APPENDIX H – DETAILLED MODELLING RESULTS

Overview

The modelling results are shown in the figures on the following pages. Only charts where solar reflections are predicted to be visible are shown. Full modelling can be provided upon request. The charts show:

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

Train Driver Receptors



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