Appendix G: Glint & Glare Assessment

PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Priory Farm Solar Array

October 2021

PLANNING SOLUTIONS FOR:

- Solar
- Telecoms
- Railways
- Defence
- Buildings
- Wind
- Airports
- Radar
- Mitigation

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ADMINISTRATION PAGE

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1	September 2021	Initial issue
2	October 2021	Report update

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from a solar photovoltaic (PV) development located on land at Great Wymondley, Hertfordshire, UK. The assessment pertains to the possible impact upon surrounding road users and dwellings in accordance with industry best practice.

Pager Power

Pager Power has undertaken over 700 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.

Guidance and Studies

Pager Power's approach to assessing glint and glare is based on its published guidance document[1], now in its third edition. This was published following a literature review, stakeholder consultation and engagement with solar developers. Broadly, the process 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 intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. 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].

Conclusions

Where solar reflections are geometrically possible towards 76 dwellings, they are acceptable due to their limited duration, proximity to the reflector area, the existing screening, and the proposed screening (see Section 7.1).

Solar reflections that are predicted for the north section of the A1(M), Graveley Lane, Graveley Road, Arch Road and a section of Stevenage Road are acceptable due to the existing screening present, proposed screening and/or the position of the reflection outside of the driver's primary field of vision (see Section 7.2).

In addition, no significant impact upon aviation activity associated with London Luton and Hitchin Airfield are predicted and no further detailed assessment is recommended (see Section 8).

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[1] Solar Photovoltaic Development – Glint and Glare Guidance Issue 3.1, April 2021 (can be downloaded here).

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

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 51 countries within Europe, Africa, America, Asia and Australasia.

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

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

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

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

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

1 INTRODUCTION

1.1 Overview

Pager Power has been retained to assess the possible effects of glint and glare from a solar photovoltaic (PV) development located on land at Great Wymondley, Hertfordshire, UK. The assessment pertains to the possible impact upon surrounding road users and dwellings in accordance with industry best practice.

This report contains the following:

- Solar development details.
- Explanation of glint and glare.
- Overview of relevant guidance.
- Overview of relevant 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 700 Glint and Glare assessments in the UK and internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Glint and Glare Definition

The definition of glint and glare can vary however, the definition used by Pager Power 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 of the Federal Aviation Administration (FAA) in the United States of America.

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development

Figure 1 below[4] shows the site location plan. The horizontal blue lines depict the solar panels and the proposed mitigation is labelled.

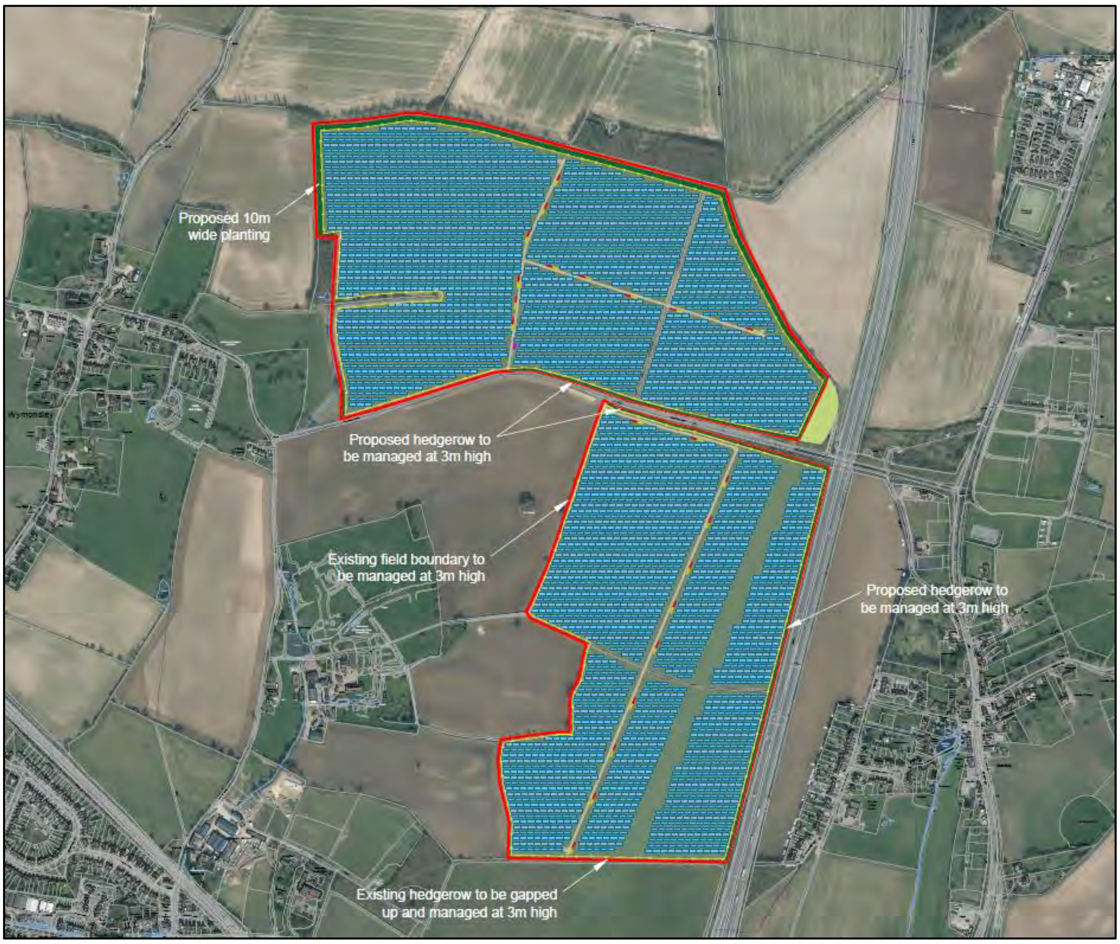

Figure 1 *Proposed development location*

[4] Provided to Pager Power by the developer, Axis

2.2 Proposed Development Location – Aerial Image

Figure 2 below[5] shows the panel area overlaid onto aerial imagery (blue polygons).

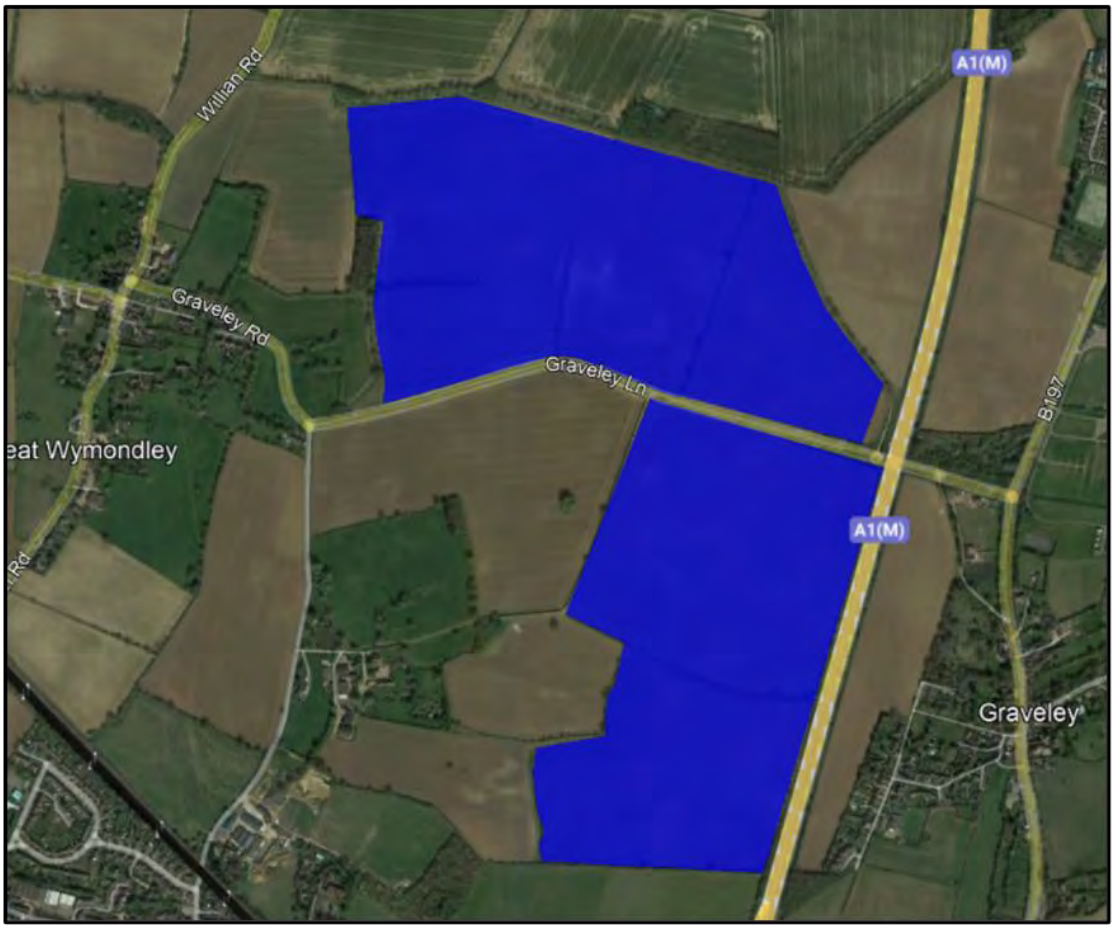

Figure 2 *Proposed development location – aerial image*

[5] Copyright © 2021 Google.

2.3 Photovoltaic Panel Mounting Arrangements and Orientation

The proposed solar development will have fixed solar panels, the assessed centre height is 1.9m above ground level (agl). The azimuth angle of the panels is 180 degrees (south-facing) and the vertical tilt angle will be 20 degrees.

Figure 3[6] below shows a profile view of the panels.

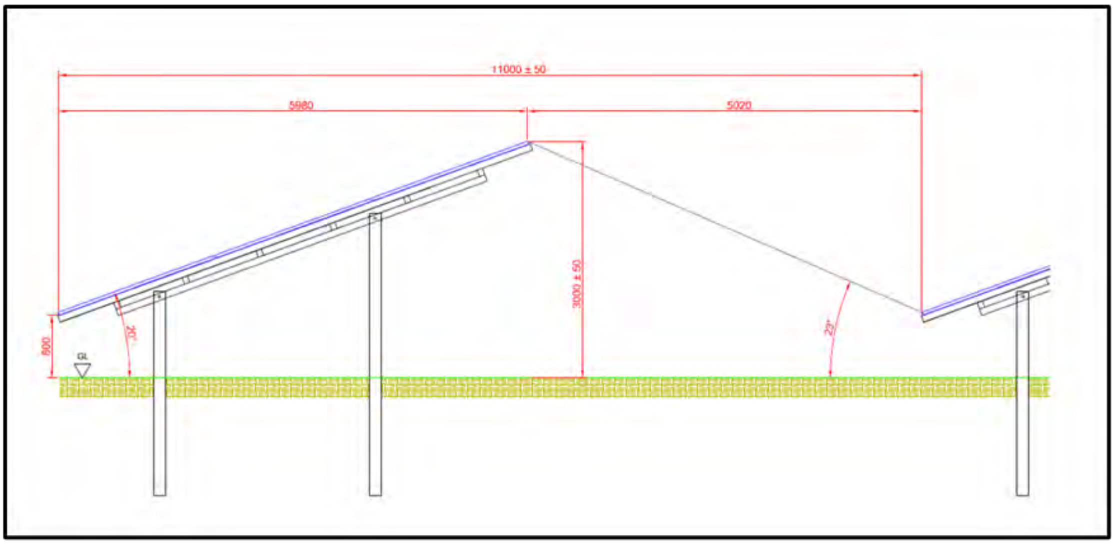

Figure 3 *Panel profile*

[6] Provided to Pager Power by the developer, Axis

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 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.

3.2 Background

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

3.3 Pager Power's Methodology

The glint and glare assessment methodology has been derived from the information provided to Pager Power through consultation with stakeholders and by reviewing the available guidance and studies. The methodology for a 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.
- Determine whether a significant detrimental impact is expected in line with the process presented in Appendix D.

3.4 Assessment Methodology and Limitations

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

4 GROUND-BASED RECEPTORS

4.1 Ground-Based Receptors – Overview

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

The above parameters and extensive experience over a significant number of glint and glare assessments undertaken, shows that a 1km assessment area from the proposed panel area is appropriate for glint and glare effects on ground-based receptors.

Potential receptors within the 1km assessment area are identified based on mapping and aerial photography of the region. The initial judgement is made based on high-level consideration of aerial photography and mapping i.e. receptors are excluded if it is clear from the outset that no visibility would be possible. A more detailed assessment is made if the modelling reveals a reflection would be geometrically possible.

Terrain elevation heights have been interpolated based on Ordnance Survey of Great Britain 50m Panorama data. Receptor details can be found in Appendix G.

Figure 4 below[5] shows the 1 km assessment area as a green polygon. This zone is based on a combined 1 km area around each vertex of the extrapolated panel area, it is therefore an irregular shape.

Figure 4 *Ground-based receptor assessment area (1 km)*

4.2 Dwelling Receptors

The analysis has considered dwellings that:

- Are within, or close to one kilometre of the proposed development; and
- Have a potential view of the panels.

Dwellings that are further north than the panels have been excluded from assessment because reflections towards ground-based receptors further north than the panels are not likely at this latitude[7].

The assessed dwelling receptors are shown in Figure 5[5] below. A total of 88 dwelling locations have been assessed.

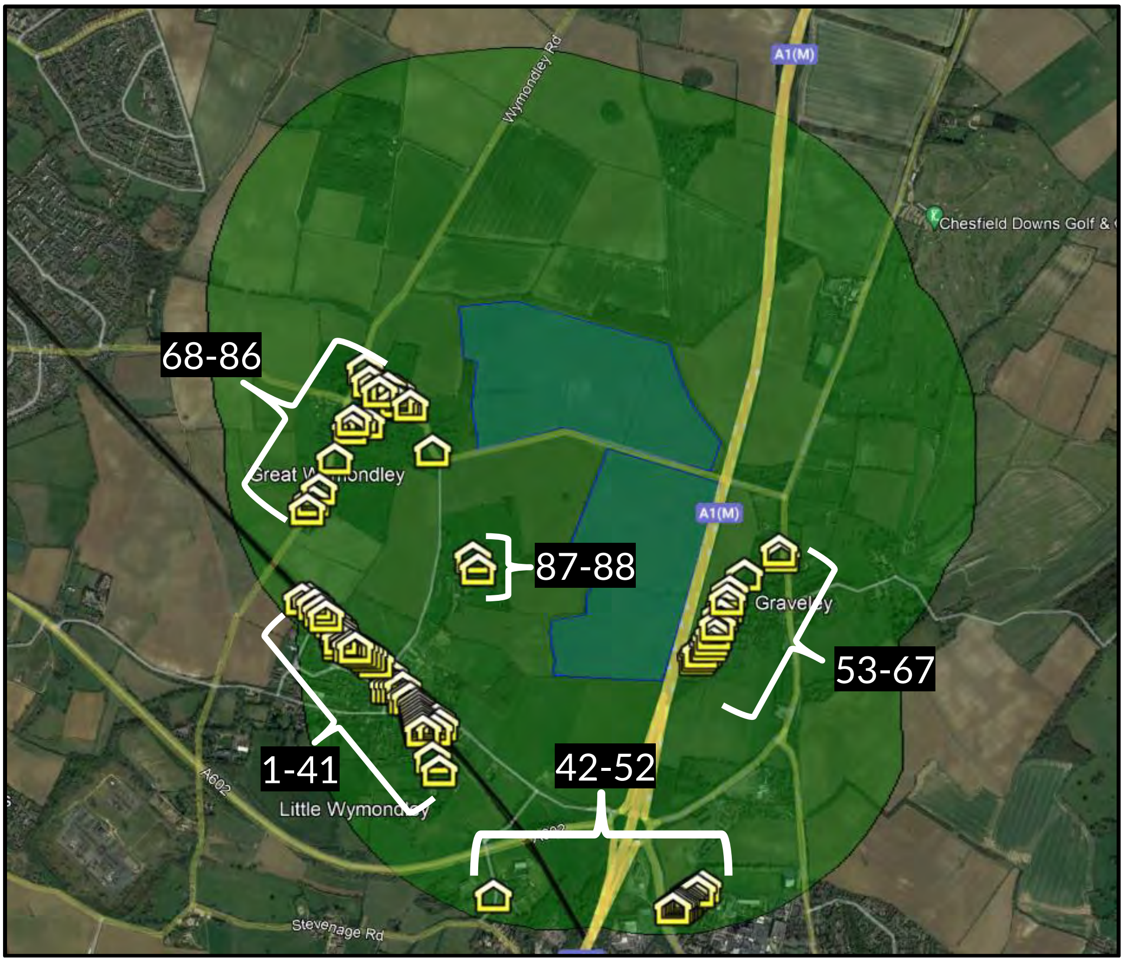

Figure 5 *Assessed dwelling receptors*

The dwellings, presented in the above area, comprise a mix of one-storey houses and two-storey buildings that are likely divided into multiple addresses. Modelling output has not been generated for every individual address independently. The sampling resolution is sufficiently high to capture the level of effect for all potentially affected dwellings.

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[7] For south-facing fixed panels like the ones proposed in this case.

For the dwellings, a height of 1.8 metres above ground level has been taken as typical eye level for an observer on the ground floor of the dwelling. In practice, the modelling output will be similar for each storey.

The remaining residential dwellings in the area are either outside the buffer distance or lie north of the panels, such that reflections would not be geometrically possible towards them[8].

Close-up images to illustrate the dwelling receptors are presented[5] in Figures 6-16 below and on the following pages.

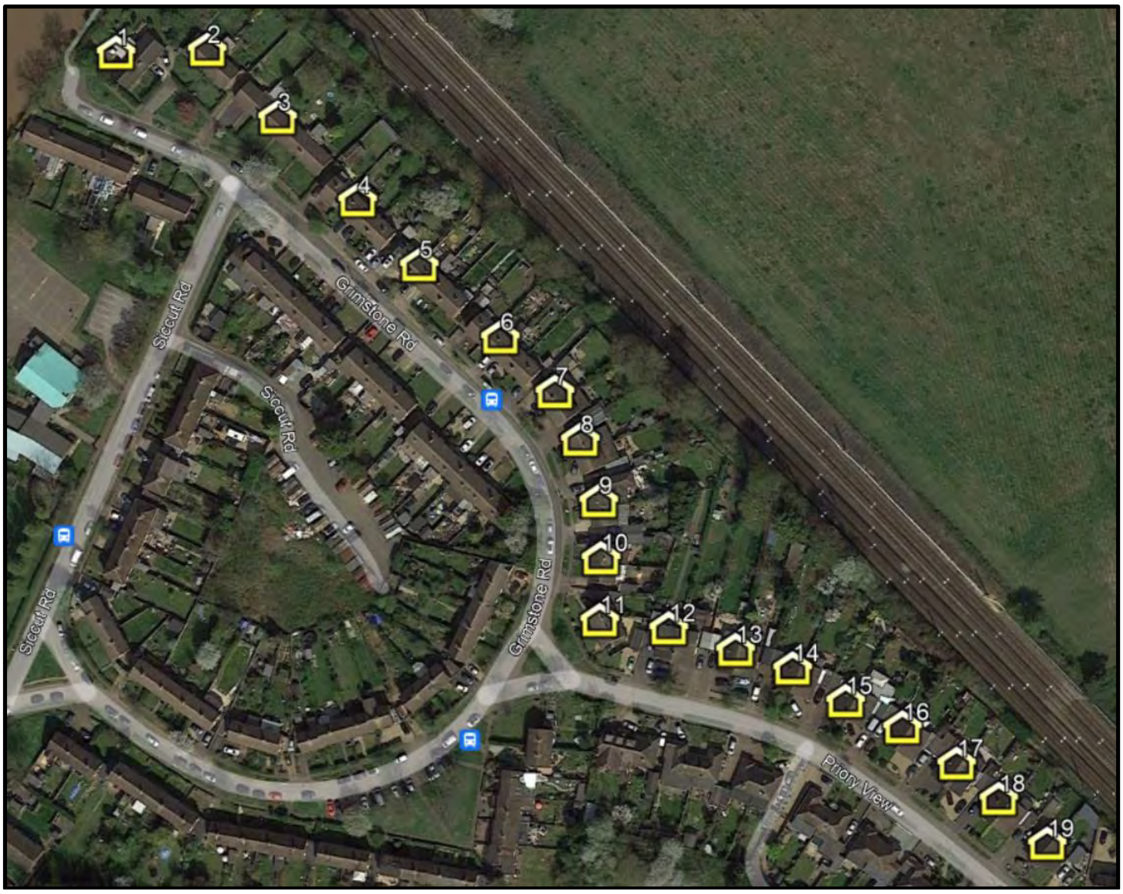

Figure 6 *Dwellings 01-19*

[8] There is also a caravan park within 1 km of the site. Visibility of the panels is not predicted from this location, and there is no guidance for assessment of caravan parks. Modelling is therefore not a requirement in this context.

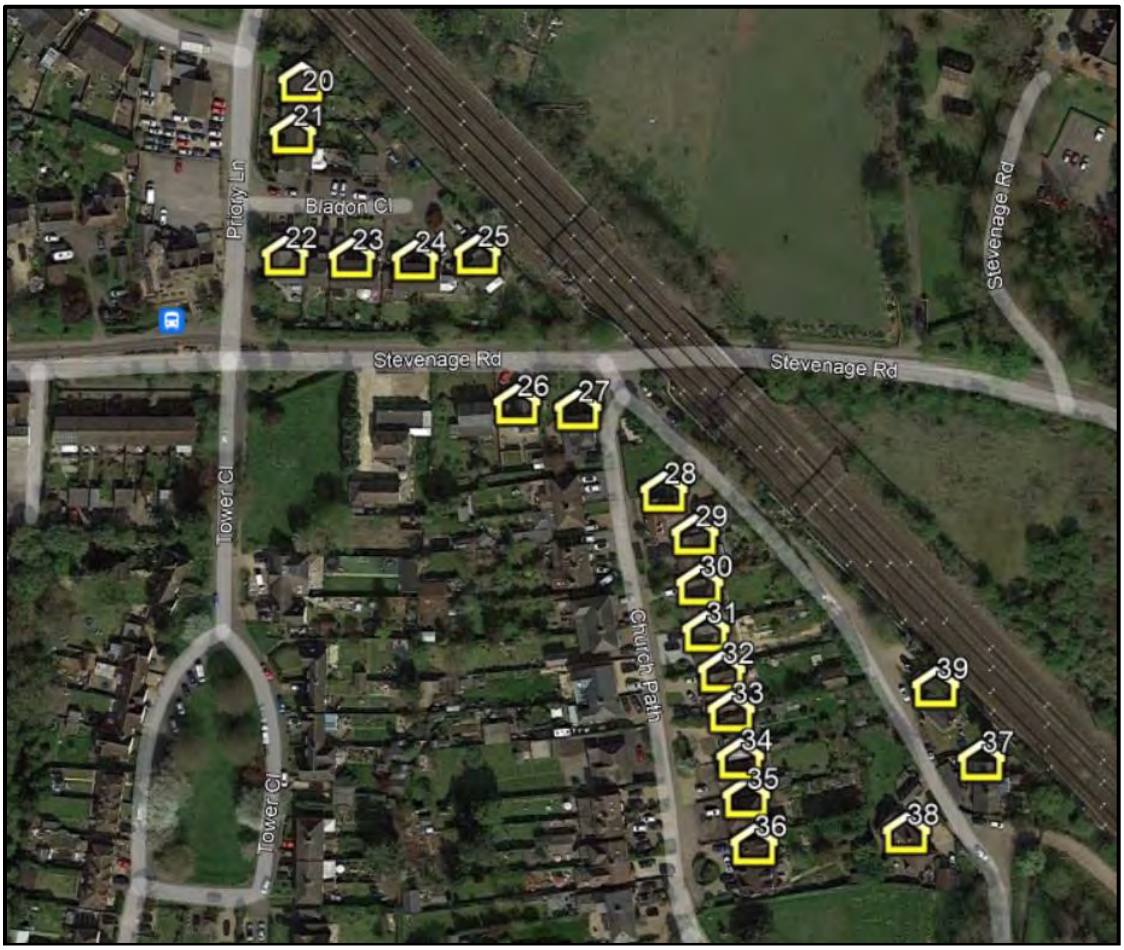

Figure 7 *Dwellings 20-39*

Figure 8 *Dwellings – 40, 41*

Figure 9 *Dwelling 42*

Figure 10 *Dwellings 43-52*

Figure 11 *Dwellings 53-64*

Figure 12 *Dwellings 65-67*

Figure 13 *Dwellings – 68-77*

Figure 14 *Dwellings 78*

Figure 15 *Dwellings 79-86*

Figure 16 *Dwellings 87-88*

4.3 Road Receptors

Road types can generally be categorised as:

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

Technical modelling is not recommended for local roads, where traffic volumes and/or speeds are likely to be relatively low, as any solar reflections from the proposed development that are experienced by a road user would be considered low impact in the worst case.

Following this, any local roads have been excluded when considering the placement of receptors and the major national, national and regional roads are shown in the aerial image in Figure 17, on the following page[5]. The blue polygon shows the panel area, the green zone shows the combined 1 km assessment area and the blue icons show the assessed road locations. A height of 1.5 metres above ground level has been modelled, this is a typical eye level for a road user.

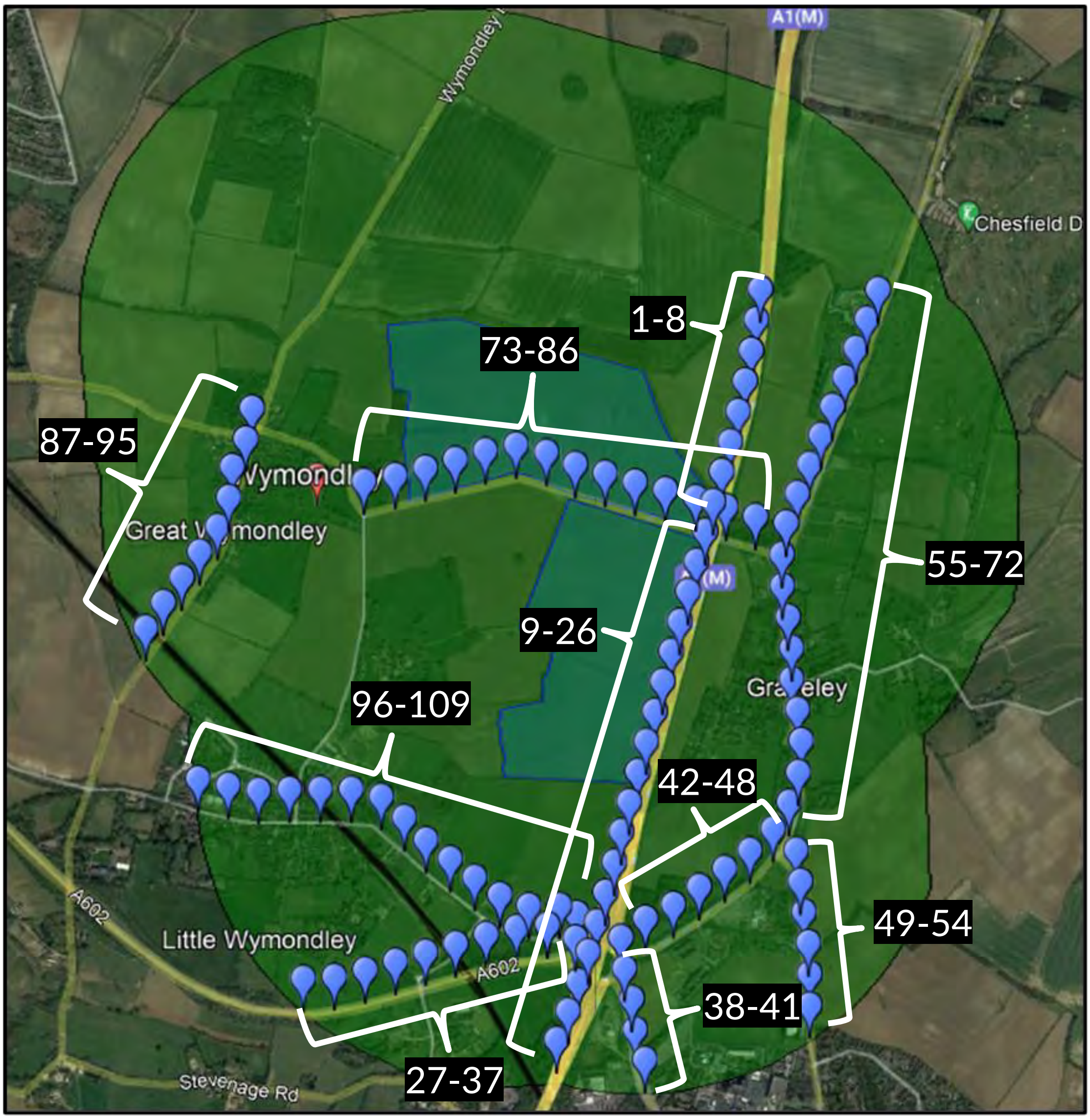

Figure 17 *Main roads surrounding panel area*

Other roads within the 1 km buffer have not been modelled because they meet one or more of the following criteria:

- They are local roads where traffic volumes/speeds are generally low (e.g. Priory Lane).
- They are north of the panels where effects are not geometrically possible (e.g. Wymondley Road).

5 ASSESSED REFLECTORS

5.1 Reflector Area

A number of representative panel locations are selected within the proposed area. The bounding coordinates for the proposed solar development have been extrapolated from the application plans. Ground heights have been based on OSGB terrain data.

The coordinate data can be found in Appendix G. The assessed panel areas are shown in Section 2 of this report.

The assessment resolution within each panel area was 15 metres, which results in over 3000 panel locations on which the calculations are based. This resolution is sufficiently high to maximise the accuracy of the results. Increasing the resolution further would not make the results more meaningful.

6 GLINT AND GLARE ASSESSMENT – TECHNICAL RESULTS

6.1 Evaluation of Effects

The tables in the following subsections present the results of the technical analysis. The final column summarises the predicted impact considering the level of identified screening based on a desk-based review of the available imagery.

The significance of the predicted effects has been evaluated in accordance with Pager Power's published guidance document[9].

The flowcharts setting out the impact characterisation and presented in Appendix D[10]. The list of assumptions and limitations are presented in Appendix F. The modelling output for key receptors can be found in Appendix H.

When evaluating visibility in the context of glint and glare, it is only the *reflecting* panel area that must be considered. For example, if the western half of the development is visible, but reflections would only be possible from the eastern half, it can be concluded that the reflecting area is not visible and no impacts are predicted. This is why there can be instances where visibility of the development is predicted, but glint and glare issues are screened.

Receptors are included within the assessment based on the potential visibility of the development as a whole, among other factors. Once the modelling output has been generated, the assessment can be refined to evaluate the visibility of the reflecting area specifically.

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[9] Solar Photovoltaic Development – Glint and Glare Guidance Issue 3.1, April 2021.

[10] There is no standard methodology for evaluating effects on ground-based receptors beyond a kilometre. These receptors have been considered based on first principles and the general methodology for ground-based receptors, keeping in mind the relative safety/amenity implications for differing receptor types.

6.2 Dwellings

Dwelling(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
01-21	Between 05:30 and 06:00 for parts of March-September.	None.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate; however existing and proposed screening remove visibility of solar reflections and no impact is predicted.
22-25	Between 05:30 and 06:00 for parts of April-September.	None.	
26-27	Between 05:30 and 05:50 for parts of April-September.	None.	
28-33	Between 05:30 and 05:50 for parts of April-August.	None.	
34	Between 05:00 and 05:50 for parts of April-August.	None.	
35	Between 05:30 and 05:50 for parts of April-August.	None.	
36-38	Between 05:30 and 05:50 for parts of May-August.	None.	
39	Between 05:30 and 05:50 for parts of April-August.	None.	
40	Between 05:30 and 05:50 for parts of late May-mid July.	None.	The model output shows potential effects that would last for less than three months per year and less than 60 minutes per day. The worst-case impact is low, which is acceptable without further mitigation (see section 7.1).

<table>
<tr><th rowspan="2">Dwelling(s)</th><th colspan="2">Approximate predicted reflection times (GMT)</th><th rowspan="2">Comment</th></tr>
<tr><th>am</th><th>pm</th></tr>
<tr><td>41-52</td><td>None.</td><td>None.</td><td>No solar reflections predicted.
No impact predicted.</td></tr>
<tr><td>53-59</td><td>None.</td><td>Between 17:50 and 18:20 for parts of March-September.</td><td rowspan="9">The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day.
The worst-case impact is moderate; however existing and proposed screening remove visibility of solar reflections and no impact is predicted.</td></tr>
<tr><td>60</td><td>None.</td><td>Between 17:55 and 18:50 for parts of March-September.</td></tr>
<tr><td>61-65</td><td>None.</td><td>Between17:55 and 18:30 for parts of March-September.</td></tr>
<tr><td>66-67</td><td>None.</td><td>Between17:55 and 18:50 for parts of March-September.</td></tr>
<tr><td>68-71</td><td>Between 05:40 and 06:05 for parts of March-September.</td><td>None.</td></tr>
<tr><td>72</td><td>Between 5:20 and 06:05 for parts of March-September.</td><td>None.</td></tr>
<tr><td>73-77</td><td>Between 05:40 and 06:05 for parts of March-September.</td><td>None.</td></tr>
<tr><td>78-80</td><td>Between 05:30 and 06:05 for parts of March-September.</td><td>None.</td></tr>
<tr><td>81</td><td>Between 05:10 and 06:05 for parts of March-September.</td><td>None.</td></tr>
</table>

<table>
<tr><th rowspan="2">Dwelling(s)</th><th colspan="2">Approximate predicted reflection times (GMT)</th><th rowspan="2">Comment</th></tr>
<tr><th>am</th><th>pm</th></tr>
<tr><td>82-87</td><td>Between 05:40 and 06:05 for parts of March-September.</td><td>None.</td><td rowspan="2">The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day.
The worst-case impact is moderate; however existing and proposed screening remove visibility of solar reflections and no impact is predicted.</td></tr>
<tr><td>88</td><td>Between 05:05 and 06:00 for parts of March-September.</td><td>None.</td></tr>
</table>

Table 1 *Results – dwelling receptors*

6.3 Roads

Road Receptor(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
1	None.	Between 17:55 and 18:05 for parts of March and September.	Reflections would originate significantly outside a driver's primary field of view when facing the direction of travel. The worst-case impact is low, which is acceptable without further mitigation (see section 7.2).
2	None.	Between 17:55 and 18:05 for parts of March, early April and September.	
3	None.	Between 17:55 and 18:05 for parts of March, April, late August and September.	
4-6	None.	Between 17:55 and 18:20 for parts of March-September.	
7-13	None.	Between 17:55 and 18:20 for parts of March-October.	
14-16	None.	Between 17:55 and 18:20 for parts of March-September.	
17	None.	Between 18:00 and 18:20 for parts of April-August.	

Road Receptor(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
18-46	None.	None.	No solar reflections predicted. No impact predicted.
47	None.	Between 18:10 and 18:30 for parts of June-early July.	Reflections would originate significantly outside a driver's primary field of view when facing the direction of travel. The worst-case impact is low, which is acceptable without further mitigation (see section 7.2).
48	None.	Between 18:05 and 18:20 for parts of May-August.	
49	None.	Between 18:05 and 18:20 for parts of May-July.	
50-54	None.	None.	No solar reflections predicted. No impact predicted.
55	None.	Between 18:05 and 18:20 for parts of April-August.	Reflections would originate significantly outside a driver's primary field of view when facing the direction of travel. The worst-case impact is low, which is acceptable without further mitigation (see section 7.2).
56	None.	Between 18:00 and 18:20 for parts of April-September.	
57-67	None.	Between 17:55 and 18:20 for parts of March-September.	

Road Receptor(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
68	None.	Between 17:55 and 18:20 for parts of mid March-May and late July-September.	
69-70	None.	Between 17:55 and 18:05 for parts of March-April and August-September.	Reflections would originate significantly outside a driver's primary field of view when facing the direction of travel. The worst-case impact is low, which is acceptable without further mitigation (see section 7.2).
71-72	None.	Between 17:55 and 18:05 for parts of March and September.	
73-75	None.	Between 17:55 and 18:20 for parts of March and September.	Reflections would originate within the driver's primary field of vision when facing the direction of travel. The worst-case impact is moderate; however, proposed screening will remove visibility of solar reflections and no impact is predicted.
76-79	Between 05:30 and 05:55 for parts of April-September.	Between 17:50 and 18:20 for parts of March-September.	
80-83	Between 05:30 and 06:00 for parts of March-September.	Between 17:50 and 18:20 for parts of March-September.	
84	Between 05:30 and 06:00 for parts of March-September.	Between 18:05 and 18:20 for parts of April, May and August.	

Road Receptor(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
85-86	Between 05:30 and 06:00 for parts of March-September.	None.	
87-90	Between 05:30 and 6:00 for parts of March-September.	None.	Reflections would originate significantly outside a driver's primary field of view when facing the direction of travel. The worst-case impact is low, which is acceptable without further mitigation (see section 7.2).
91-95	Between 05:30 and 06:00 for parts of March-September.	None.	Reflections would originate within the driver's primary field of vision when facing the direction of travel. The worst-case impact is moderate; however existing screening removes visibility of solar reflections and no impact is predicted.
96	Between 05:30 and 06:00 for parts of March-September.	None.	
97-100	Between 05:30 and 06:00 for parts of April-September.	None.	
101	Between 05:30 and 05:55 for parts of April-September.	None.	
102	Between 05:30 and 05:55 for parts of April-August.	None.	Reflections would originate outside a driver's primary field of view when facing the direction of travel. The worst-case impact is low, which is acceptable without further mitigation (see section 7.2).
103	Between 05:30 and 05:55 for parts of May-August.	None.	

Road Receptor(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
104	Between 05:30 and 05:50 for parts of June-July.	None.	Reflections would originate outside a driver's primary field of view when facing the direction of travel. The worst-case impact is low, which is acceptable without further mitigation (see section 7.2).
105-109	None.	None.	No solar reflections predicted. No impact predicted.

Table 2 *Results – road receptors*

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Dwelling Results

The process for quantifying impact significance is defined in the report appendices. For dwelling receptors, the key considerations are:

- Whether a significant reflection is predicted in practice.
- The duration of the predicted effects, relative to thresholds of:
    - 3 months per year.
    - 60 minutes per day.

Where effects occur for less than 3 months per year and less than 60 minutes per day, the worst-case impact significance is low and mitigation is not required.

Where effects last for more than 3 months per year and less than 60 minutes per day[11], the worst-case impact significance is moderate and expert assessment of any mitigating factors is required to determine the mitigation requirement (if any). Of particular relevance is the level of likely screening, the separation distance between the reflecting panels and the receptor location[12] and the extent to which effects coincide with direct sunlight.

Where effects last for more than 3 months per year and more than 60 minutes per day, the worst-case impact is high, and mitigation is required. In this case, there are no instances of high impact, even under worst-case conditions.

A conservative review of the available imagery has been undertaken within the desk-based assessment, whereby it is assumed views of the panels are possible if it cannot be reliably determined that existing screening will remove effects.

Moderate impacts have been predicted for dwellings 1-39 and 53-88. In all cases, this is due to worst-case effects potentially lasting for more than 3 months per year and less than 60 minutes on any one day. However, existing and proposed screening will remove visibility of the solar reflections, resulting in no predicted impact from the reflecting area.

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[11] Or if effects last for less than 3 months per year but more than 60 minutes per day, which is a scenario that is almost never seen in practice but could occur in theory.

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

The dwellings that could experience moderate impacts in the absence of screening are shown in Figure 18 below[5].

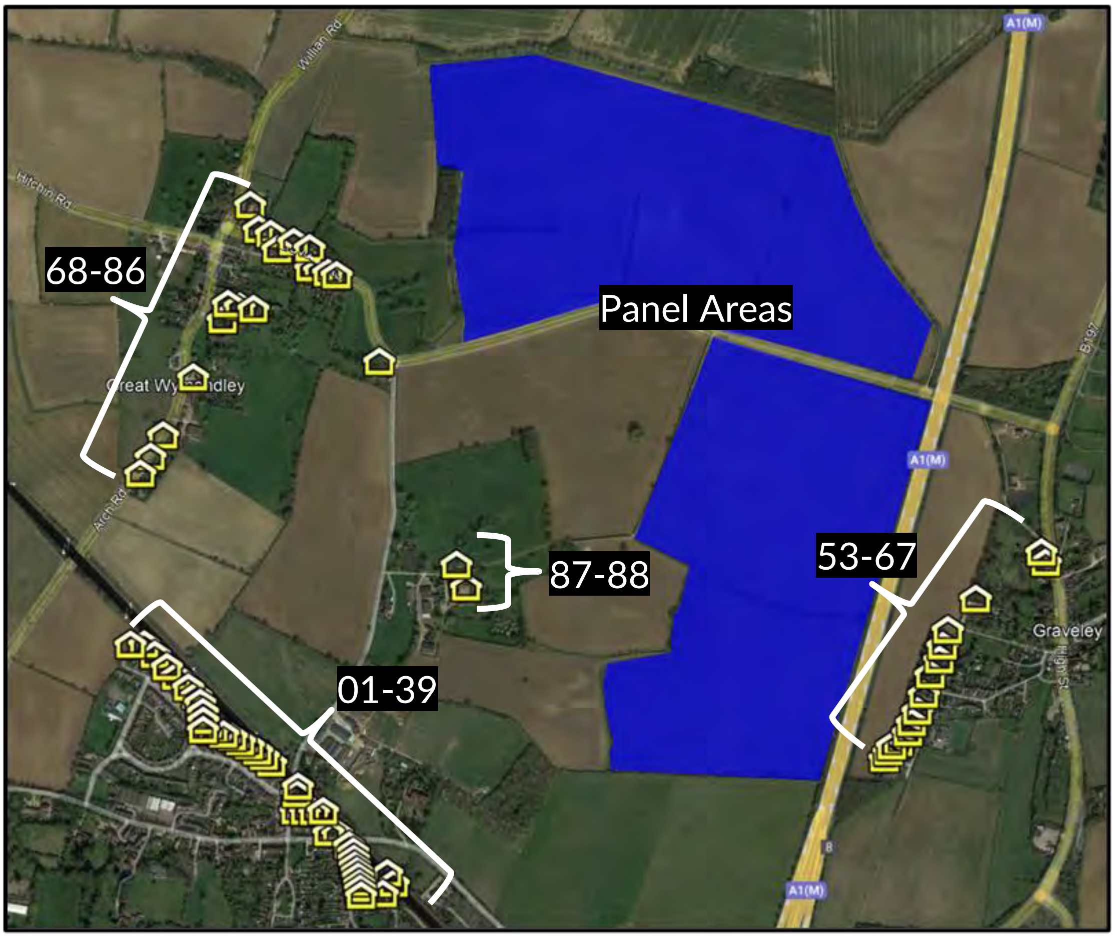

Figure 18 *Dwellings that could experience moderate impacts*

Figure 19[55], on the following page, depicts the reflector area in relation to dwelling 20; this is representative of the reflector areas for dwellings 1-39. The entire area would not reflect all at once, this is the total area accounting for potential reflections throughout April-September.

Figure 19 *Aerial image depicting dwelling 20, in relation to the reflector area*

The figures above relate specifically to dwelling 20; however, the results are representative of those for the stretch of potentially affected dwellings (1-39) in terms of the relative position of the reflecting area and the overall timing/duration of effects[13]. Since the impacts are moderate, specific consideration of the project-specific parameters is required. In terms of mitigating factors, the following statements apply:

- It is likely that visibility will be obstructed as a result of the existing screening backing onto the properties and the existing screening surrounding the proposed development area. Any partial screening will reduce the overall duration of effects throughout the year. In reality, there will be cloud cover for some of the times that glare is predicted, further reducing the likely duration.
- The separation distance between each receptor and the corresponding reflecting area exceeds 300 metres. Increasing the separation distance reduces the perceived level of effect because the proportion of an observer's view that is affected also decreases.
- Any effects, from the reflections, would coincide with direct sunlight as the Sun would be relatively low in the sky beyond the panels. The intensity of direct sunlight is significantly greater than the intensity of a reflection.

Overall, based on the specific parameters and mitigating factors, mitigation measures are not required beyond those already proposed by the developer.

Dwellings 53-88 are also deemed to have moderate impact based on the model output prior to the consideration of further screening; however, the views of the reflecting area for these locations will be screened by existing vegetation and the proposed screening. In addition, after assessing the ZTV imagery provided by Axis, it can be concluded that dwellings 53-67 and 77-86 will have negligible views of the proposed site. Furthermore, dwellings 53-67 sit lower than

[13] The more detailed breakdown of effect times/dates is presented in Section 6 and in Appendix H.

the proposed development and the land rises towards the bund meaning solar reflections are not visible.

Figures 20[5]-22 below and on the following page present the reflector area for these dwellings and highlights the proposed mitigation that removes visibility of the solar reflections.

Figure 20 *Aerial image depicting dwellings 53-67, in relation to the reflector area*

Figure 21 *Aerial image depicting dwellings 68-77 and 83-86, in relation to the reflector area*

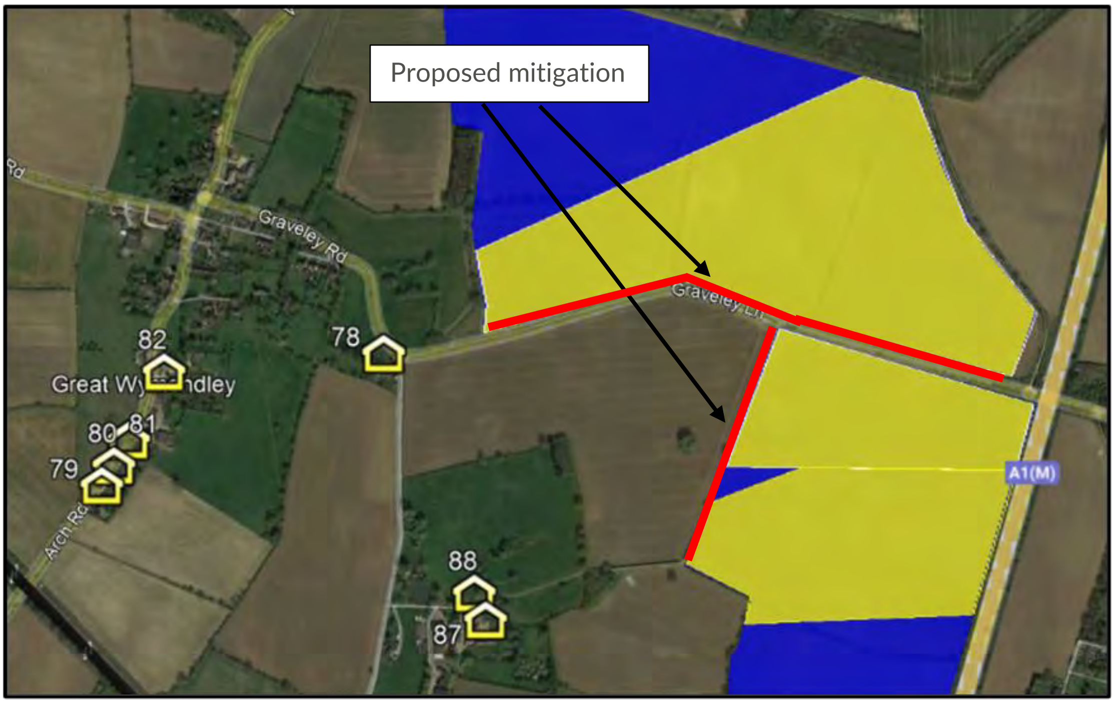

Figure 22 Location where screening is required to remove glint and glare for dwellings 78-82 and 87-88

The solar reflections towards dwellings 87 and 88 are not entirely visible. There is existing screening present that removes the reflections seen at the base of the yellow reflecting area in Figure 22 and the proposed screening removes any other possible reflections.

7.1.1 Dwelling Assessment Conclusions

Overall, solar reflections are deemed possible and visible towards receptor locations 1-39 and 53-88, for more than 3 months of the year and less than 60 minutes per day. The worst-case impact is moderate due to the duration of effects. However, following a review of the available imagery and the proposed screening it has been concluded that no visibility of the reflecting panel areas is considered possible. Therefore, no impact is predicted, and no further mitigation is required.

Dwelling 40 could experience solar reflections for less than 3 months of the year and less than 60 minutes. In accordance with the methodology set out in Section 3 and Appendix D, the worst-case resulting impact significance is low and, subsequently, no mitigation is required.

The remaining dwellings are expected to experience no impact, where no reflections are geometrically possible (dwellings 41-52), therefore no mitigation is required.

7.2 Road Results

For road users, the key considerations are:

- Whether a reflection is predicted in practice.
- The type of road (and associated likely traffic levels/speeds).
- The location of the reflecting panels relative to a road user's direction of travel (a reflection directly in front of a driver is more hazardous than a reflection from a location off to one side).

The results of the analysis have shown that solar reflections from the proposed development towards the assessed surrounding roads are geometrically possible at some of the assessed road locations. These results are presented in Appendix H.

Reflections towards receptors 1-17, 47-49, 55-72, 87-90 and 102-104 are not significant because they would occur from a bearing that is outside a driver's primary field of focus (50 degrees either side of straight ahead) when facing the direction of travel. Furthermore, the reflecting area is likely to be partially or entirely screened by intervening terrain at locations where reflections would be geometrically possible. Impacts on road users are low at worst and mitigation measures are not required. Figures[5] 23, 24, 25 and 26 present street view images from receptor locations 10, 57, 88 and 103 respectively and show the view towards the reflecting solar panel area. This is representative of the screening for the remaining receptor locations discussed above.

Figure 23 *Street view image from location 10 showing the solar panel area*

The above figure shows that the solar panels are visible along the A1(M); however, the reflections are to the east of the panel area and are not seen in the driver's primary field of vision (refer to Figure 27), thus mitigation is not needed to screen from the reflections.

Figure 24 *Street view image from location 57, towards the reflecting solar panel area*

Figure 25 *Street view image from location 88, towards the reflecting solar panel area*

Figure 26 *Street view image from location 103, towards the reflecting solar panel area*

Figures[5] 27-30 show the bearing between the direction of travel and the reflecting solar panel area for the locations depicted above. This is relevant for determining whether the solar reflections would occur outside of the road user's field of vision. The red arrow shows the shallowest angle of reflection towards the road user, the orange line shows the line to the reflecting solar panel area, and the yellow area is the reflecting solar panel area for that location.

Figure 27 *Aerial image showing the bearing from location 10 towards the reflecting solar panel area*

Figure 28 *Aerial image showing the bearing from location 57 towards the reflecting solar panel area*

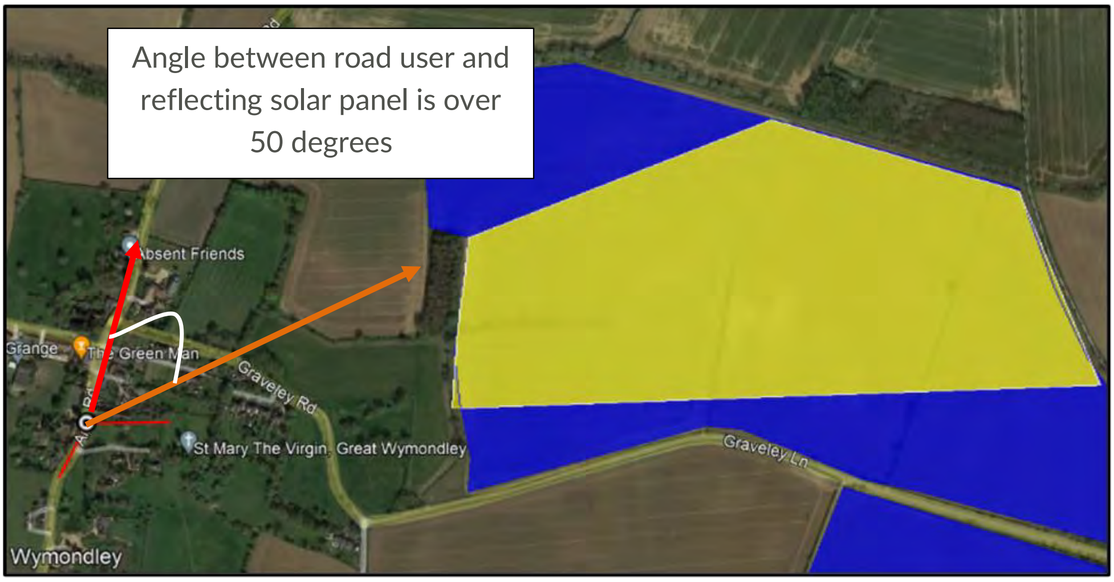

Figure 29 *Aerial image showing the bearing from location 88 towards the reflecting solar panel area*

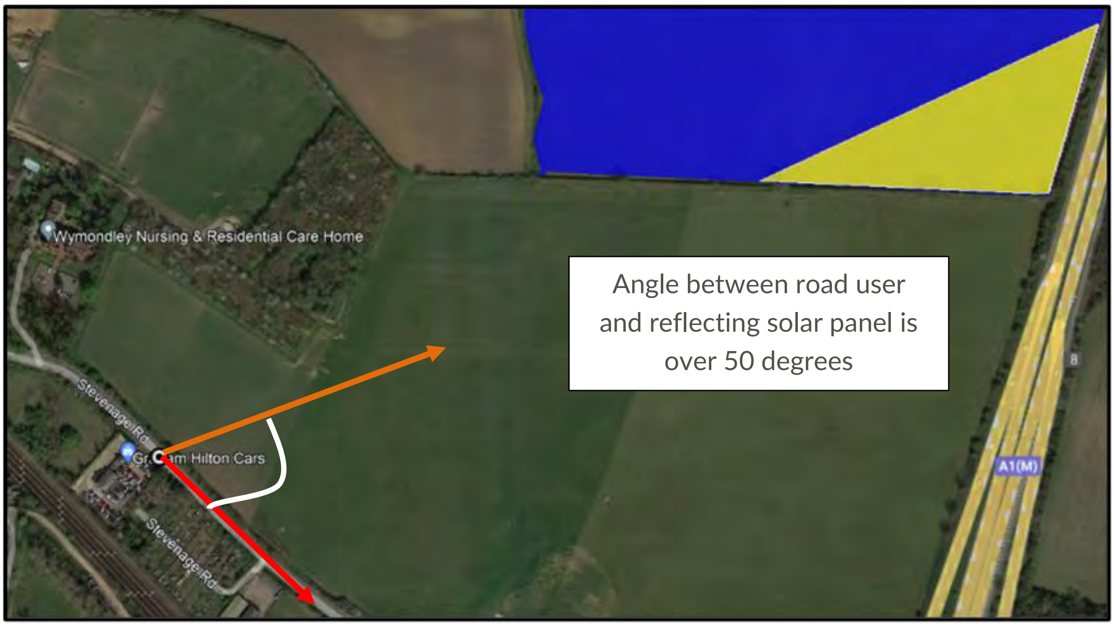

Figure 30 *Aerial image showing the bearing from location 88 towards the reflecting solar panel area*

At road locations 18-46, 50-54 and 105-109, no solar reflections are geometrically possible, and no impact is possible. Therefore, no impact upon road users at any of these locations is predicted.

At road locations 73-86 and 91-101, reflections are found to be geometrically possible; however, the proposed screening and any existing screening will remove views of the reflecting solar panel areas. Therefore, no impact upon road users at these locations are predicted.

Figures 31-32 highlight the proposed screening relative to the reflector areas for receptors 76-86 and 91-95; however, the effects of the proposed screening are representative for dwellings 73-86 and 91-101.

Figure 31 *Aerial image for road receptors 76-86 relative to the reflecting solar panel area*

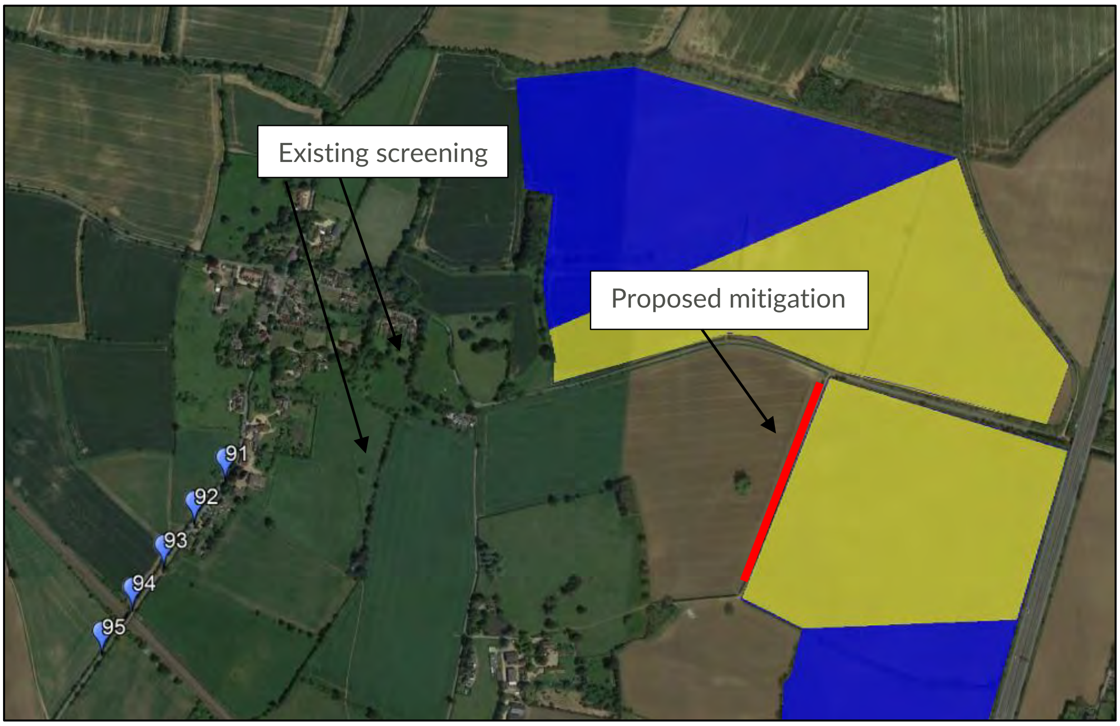

Figure 32 *Aerial image for road receptors 91-95 relative to the reflecting solar panel area*

7.2.1 Road Assessment Conclusions

Overall, the results of the assessment suggest that solar reflections are deemed possible, within the driver's primary field of vision, between road locations 73-86 and 91-101. After a review of the available imagery, it is evident that these reflections will be removed by the proposed screening; thus, in accordance with the methodology set out in Section 3 and Appendix D, no further mitigation is required.

Along the north section of the A1(M), Graveley Road, Arch Road and a section of Stevenage Road, solar reflections are deemed possible and visible under baseline conditions; however, the reflections would occur outside the driver's field of vision. In accordance with the methodology set out in Section 3 and Appendix D, the resulting impact significance is low and no mitigation is required.

At the remaining road receptor locations 18-46, 50-54 and 105-109, no solar reflections are deemed possible and no impact is predicted to a road user.

8 AVIATION CONSIDERATIONS (HIGH-LEVEL)

8.1 Overview

The following section presents the results of the high-level aviation assessment with respect to the nearest relevant aerodrome.

8.2 High-Level Assessment

Solar developments can cause adverse glint and glare effects towards nearby aerodromes. It is industry best-practice to consider reflections towards pilots on the last two miles of final approach and personnel in air traffic control towers for developments in close proximity to large aerodromes.

The nearest main airport is London Luton, which is approximately 11 km southwest of the development, shown in Figure 33[5] below. London Luton has a single asphalt runway that is aligned west-southwest to east-northeast.

Figure 33 Aerial image showing London Luton in relation to the proposed development

Based on the separation distance and relative position of the airport to the solar development, reflections towards the air traffic control tower at London Luton are considered unlikely. Furthermore, any such reflections are highly unlikely to be visible to a controller at this range.

Pilots on approach to Runway 26 (i.e. from the east) would be directed away from the solar development, such that any reflections towards their aircraft would not be significant.

Reflections towards approaching pilots are only significant if they occur within 50 degrees of the aircraft heading (as per the most applicable guidance and industry-best practice).

Pilots approaching Runway 08 would be facing the general direction of the solar development. However, based on the separation distance it is likely that any reflections towards a pilot would be of an acceptably low intensity.

The nearest unlicensed airfield is located at Hitchin. The airfield has a single grass runway approximately 3.7 km southwest of the nearest panel area. The runway is understood to be a 16/34 runway which means it is orientated north-northwest to south-southeast. There is no air traffic control tower at the airfield.

Aircraft approaching Hitchin from the north would not experience reflections from within 50 degrees of the aircraft heading. Aircraft approaching from the southeast may not experience reflections at all because the receptor locations would be directly south of the development. Furthermore, reflections would not occur from directly in front of the pilot and it is likely that any reflections are likely to have an acceptably low intensity.

8.3 High-Level Assessment Conclusions

Overall, significant impacts are not predicted for surrounding aerodromes and technical modelling is not recommended.

9 OVERALL CONCLUSIONS

9.1 Dwelling Receptors

The result of the analysis has shown that reflections from the proposed development are geometrically possible towards 76 out of 88 identified dwelling receptors. Of these 76 dwelling receptors, 75 are predicted to experience glare for more than 3 months per year and less than 60 minutes per day. However, the proposed screening (grown and maintained to 3m) will block the views of the proposed development's reflective areas. Therefore, no impact is predicted and further mitigation is not required. The remaining dwelling will experience glare for less than 3 months per year and less than 60 minutes a day, therefore a 'low' impact is predicted and no further mitigation is required.

9.2 Road Receptors

The results of the analysis have shown that reflections from the proposed development are geometrically possible towards 70 out of 109 identified road receptors. However, the proposed screening will remove solar reflections. Therefore further mitigation is not required.

9.3 High-Level Aviation

No significant impact upon aviation activity associated with London Luton and Hitchin Airfield are predicted and no further detailed assessment is recommended.

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

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

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

UK Planning Policy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[14] (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.'

[14] Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 18 June 2015, accessed on: 17/06/2020

Assessment Process – Ground-Based Receptors

No process for determining and contextualising the effects of glint and glare are, however, provided for assessing the impact of solar reflections upon surrounding roads and dwellings. Therefore, the Pager Power approach is to determine whether a reflection from the proposed solar development is geometrically possible and then to compare the results against the relevant guidance/studies to determine whether the reflection is significant. The Pager Power approach has been informed by the policy presented above, current studies (presented in Appendix B) and stakeholder consultation. Further information can be found in Pager Power's Glint and Glare Guidance document[15] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

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[15] Solar Photovoltaic Development – Glint and Glare Guidance, Edition 3.1, April 2021. Pager Power.

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

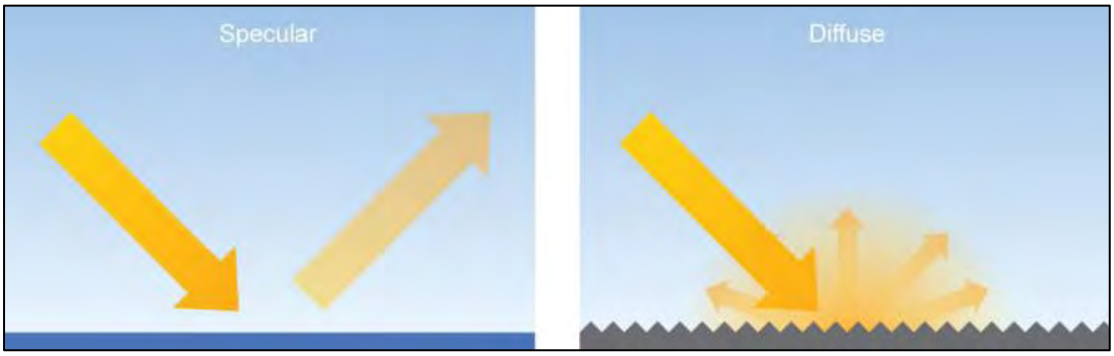
Overview

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[16], 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

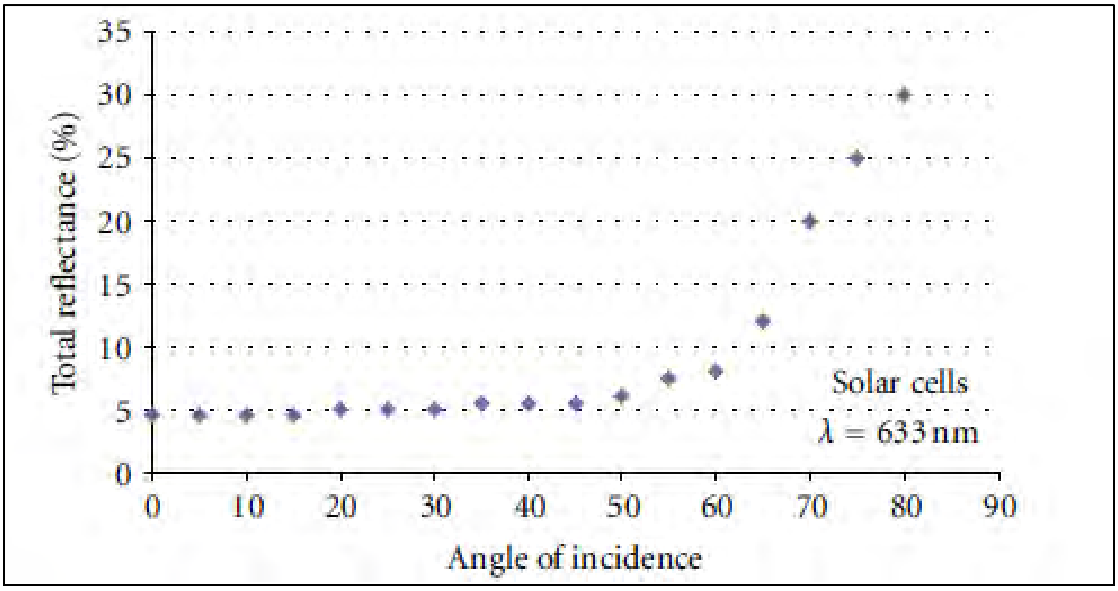
[16] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

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*[17]". 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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[17] 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"[18]

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[19]
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).

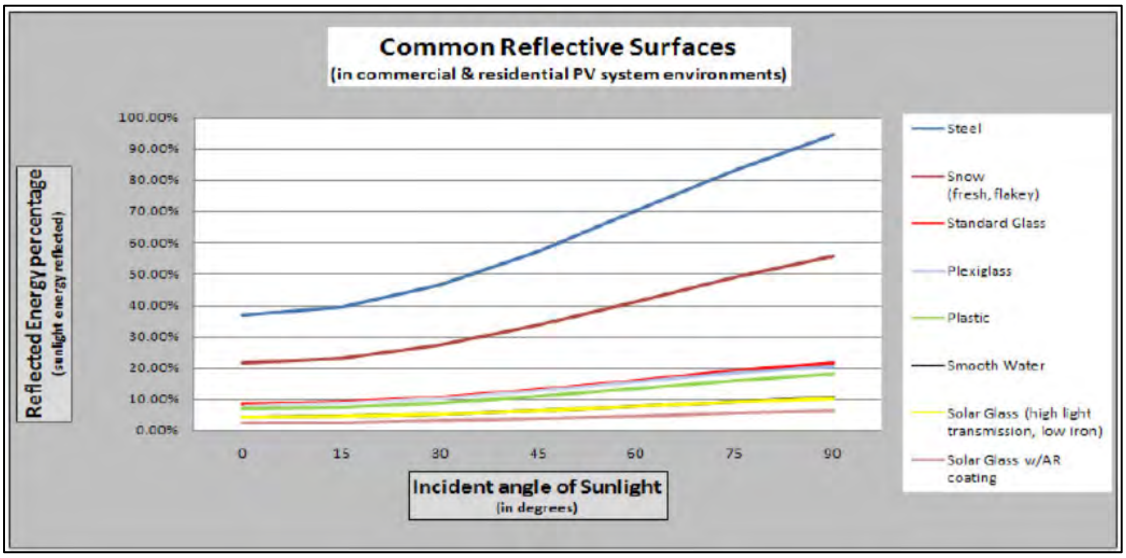
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

[18] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.
[19] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification[20] 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.

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

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

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

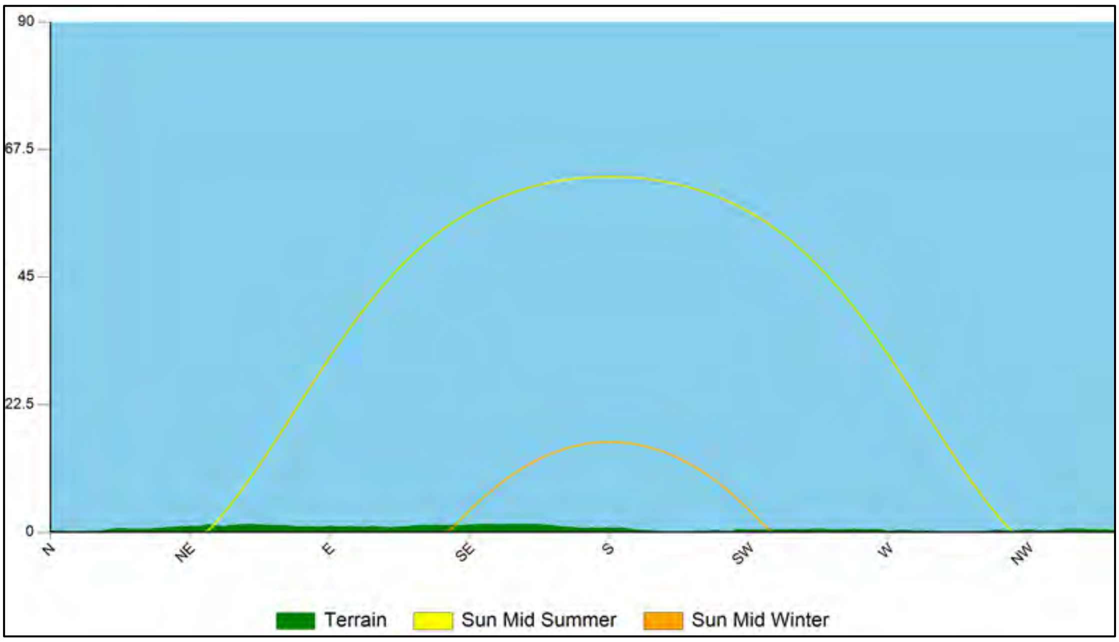
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

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

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

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

The combination of the Sun's azimuth angle and vertical elevation will affect the direction and angle of the reflection from a reflector. The figure below shows terrain at the horizon as well as the sunrise and sunset curves throughout the year. This is based on the location longitude: - 0.222787 and latitude: 51.939555.



Terrain at the visible horizon and Sun paths

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact Significance Definition

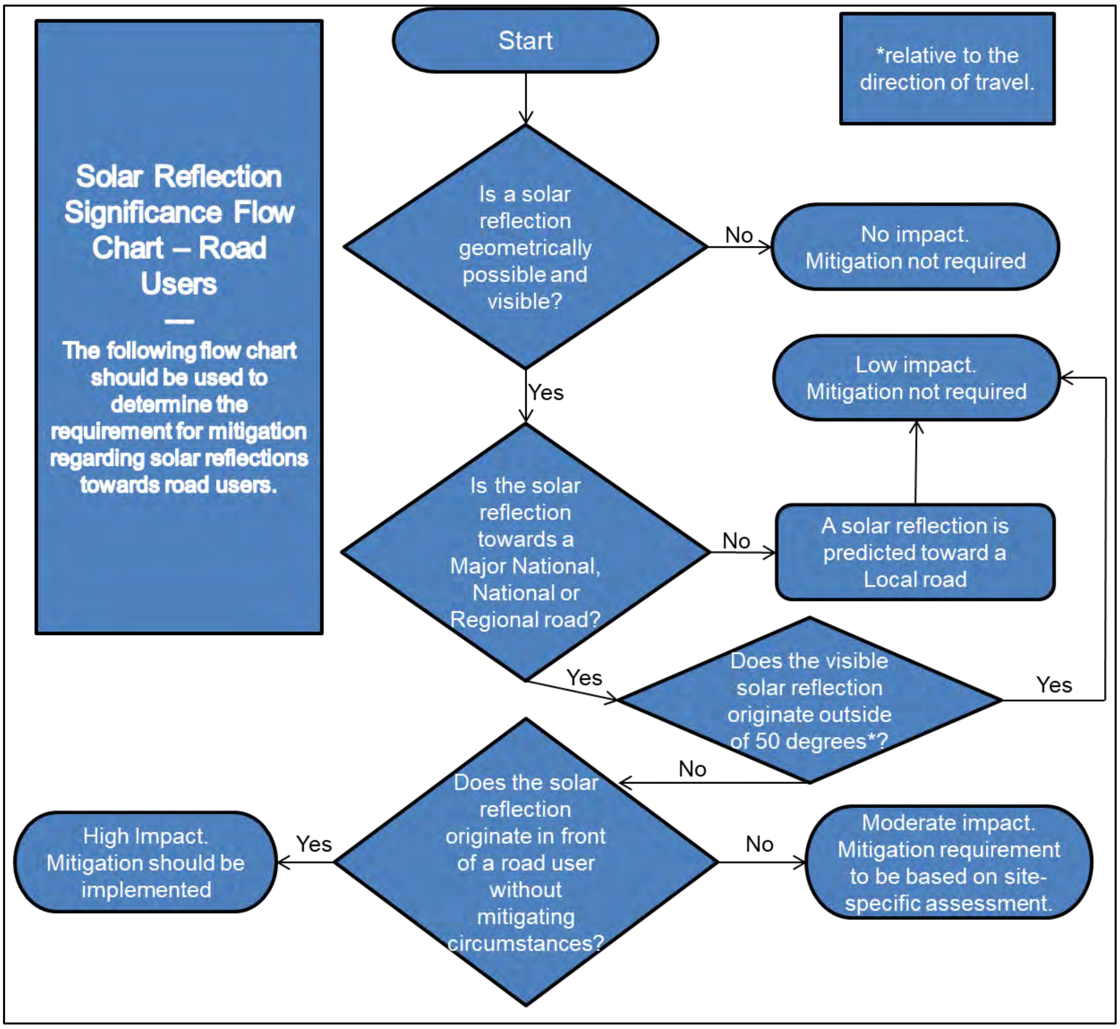
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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

Impact significance definition

Assessment Process for Road Receptors

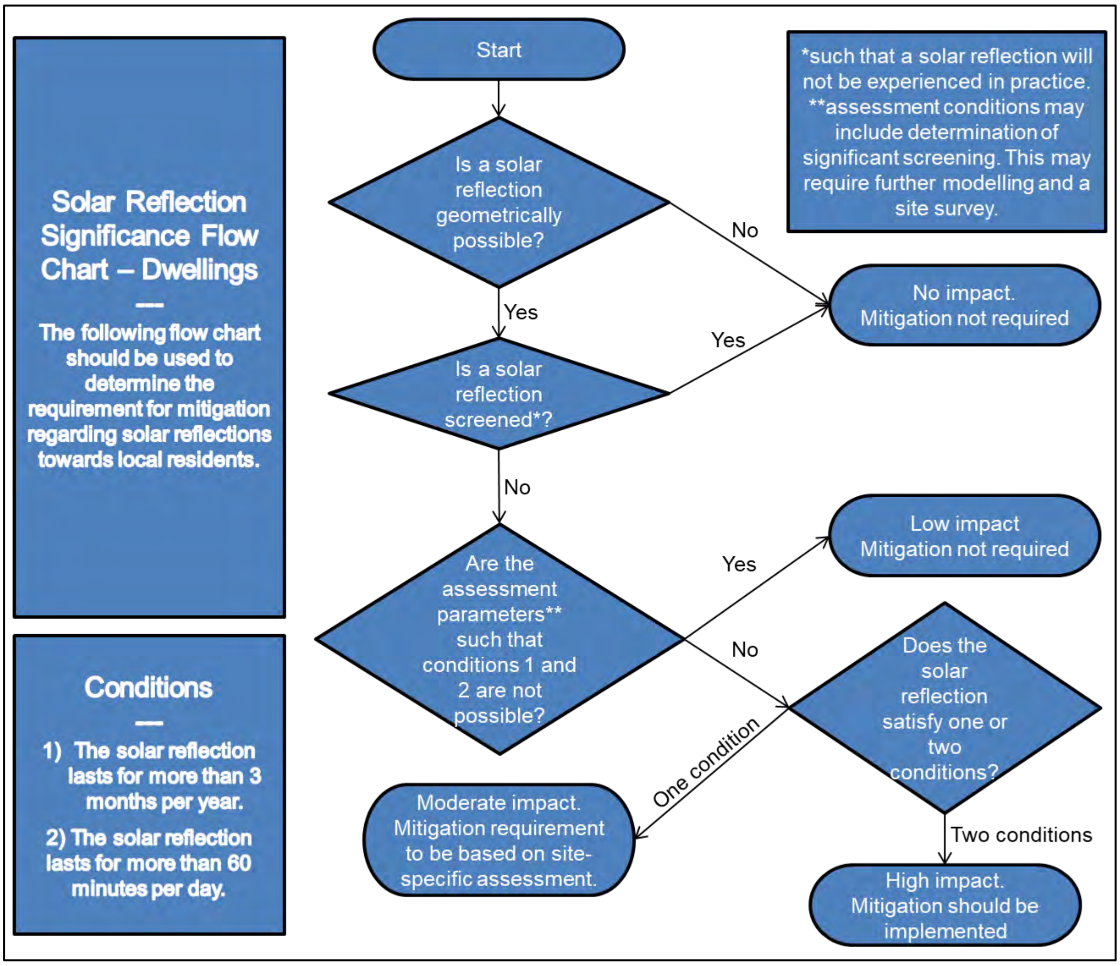
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road receptor mitigation requirement flow chart

Assessment Process for Dwelling Receptors

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



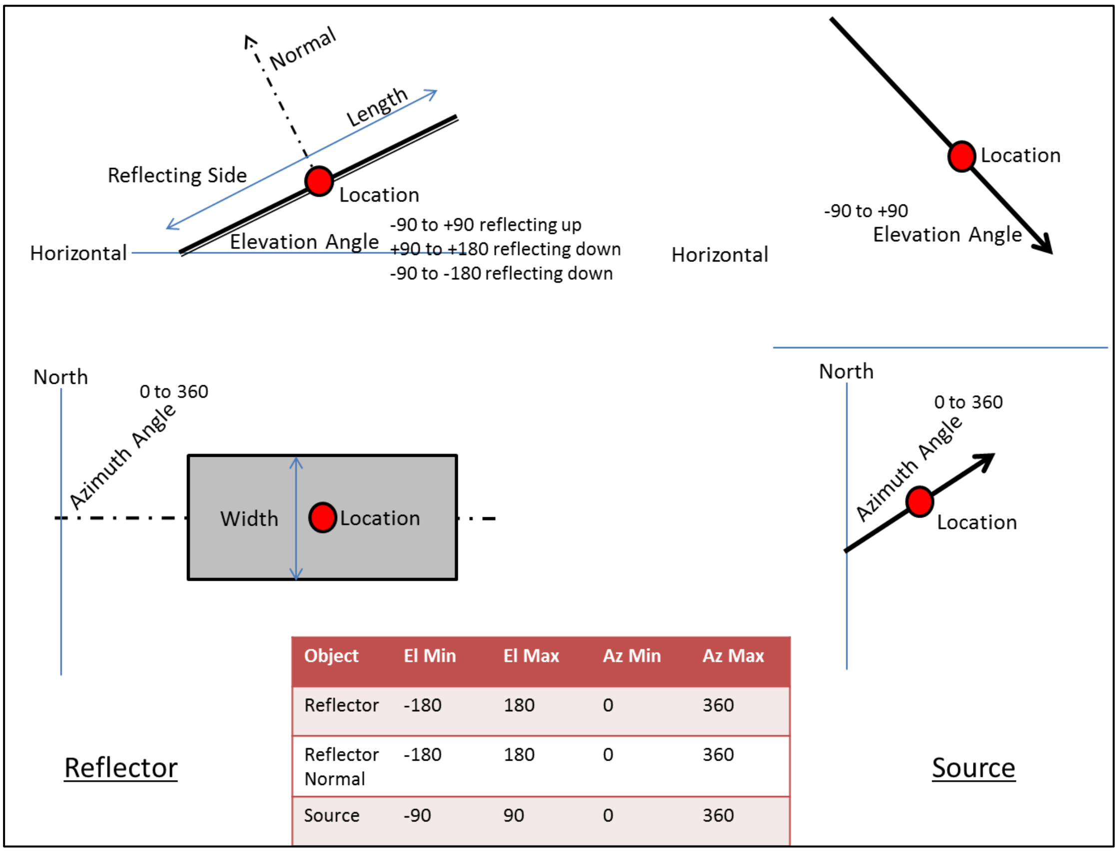
Dwelling receptor mitigation requirement flow chart

APPENDIX E – PAGER POWER'S REFLECTION CALCULATIONS METHODOLOGY

The calculations are three dimensional and complex, accounting for:

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

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



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

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

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

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

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Pager Power's Model

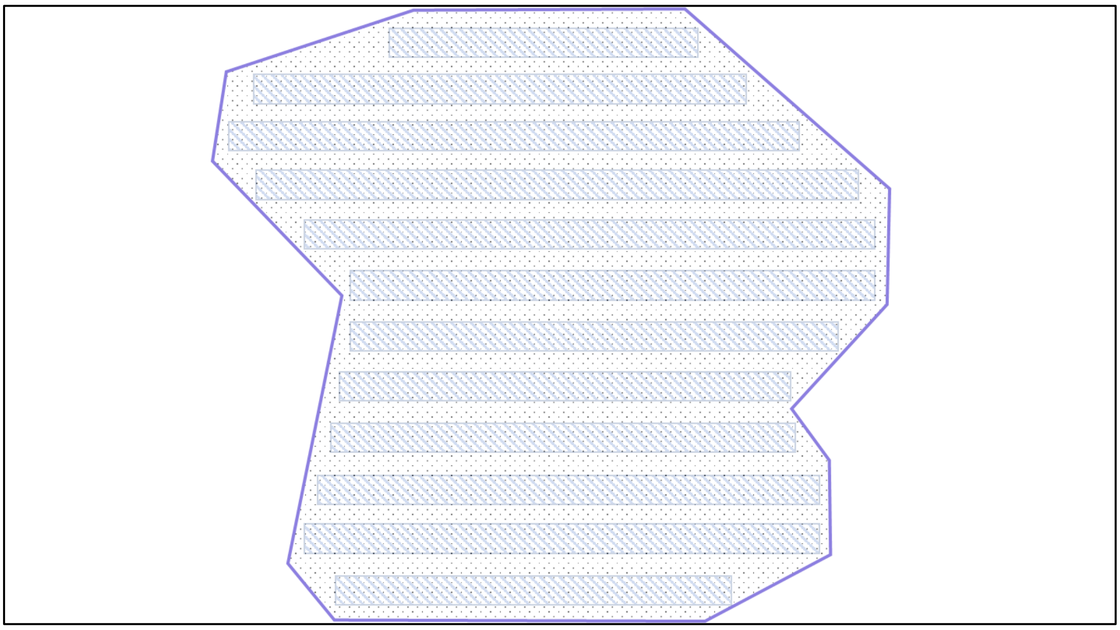
It is assumed that the panel elevation angle provided by the developer represents the elevation angle for all of the panels within each solar panel area defined.

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

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

The model assumes that a receptor can view the face of every panel within the proposed 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 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.



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 Height

All ground heights are interpolated based on OSGB data.

Dwelling Data

The table below presents the coordinate data for assessed dwelling receptors.

Dwelling	Longitude (°)	Latitude (°)	Dwelling	Longitude (°)	Latitude (°)
1	51.935433	-0.238557	45	51.924611	-0.216954
2	51.93544	-0.238141	46	51.924645	-0.21682
3	51.935249	-0.237818	47	51.924708	-0.21671
4	51.935018	-0.237456	48	51.924757	-0.216564
5	51.934838	-0.237179	49	51.92484	-0.216464
6	51.934636	-0.236811	50	51.924998	-0.216244
7	51.934484	-0.236563	51	51.925111	-0.215813
8	51.934351	-0.236448	52	51.925275	-0.215506
9	51.93418	-0.236365	53	51.93335	-0.215847

Dwelling	Longitude (°)	Latitude (°)	Dwelling	Longitude (°)	Latitude (°)
10	51.934021	-0.236354	54	51.933471	-0.215724
11	51.933849	-0.23636	55	51.933575	-0.215626
12	51.933827	-0.236048	56	51.93364	-0.215435
13	51.933766	-0.235747	57	51.933829	-0.215148
14	51.933714	-0.235489	58	51.934013	-0.215034
15	51.933622	-0.235248	59	51.934222	-0.214864
16	51.933547	-0.234987	60	51.934537	-0.214673
17	51.933444	-0.234738	61	51.9349	-0.214478
18	51.933344	-0.234545	62	51.935176	-0.21421
19	51.933219	-0.234326	63	51.935433	-0.214114
20	51.932776	-0.233532	64	51.935728	-0.213957
21	51.932639	-0.233572	65	51.936305	-0.213119
22	51.932315	-0.233606	66	51.936974	-0.211001
23	51.932309	-0.233317	67	51.937164	-0.211135
24	51.932304	-0.233044	68	51.943622	-0.23493
25	51.932317	-0.232774	69	51.943161	-0.234668
26	51.931919	-0.232603	70	51.943081	-0.234306
27	51.931904	-0.23234	71	51.942794	-0.234103
28	51.931687	-0.231972	72	51.942929	-0.233613
29	51.931575	-0.23184	73	51.942813	-0.233131
30	51.931443	-0.23182	74	51.942443	-0.233105
31	51.931321	-0.231795	75	51.942406	-0.232849

Dwelling	Longitude (°)	Latitude (°)	Dwelling	Longitude (°)	Latitude (°)
32	51.931216	-0.231728	76	51.942354	-0.232574
33	51.931112	-0.231688	77	51.942311	-0.232314
34	51.93099	-0.23165	78	51.940706	-0.231045
35	51.930889	-0.231625	79	51.938621	-0.238268
36	51.930765	-0.231592	80	51.938935	-0.237963
37	51.930981	-0.230619	81	51.939336	-0.237589
38	51.930794	-0.230943	82	51.940417	-0.236682
39	51.931174	-0.230813	83	51.941486	-0.235774
40	51.929491	-0.230914	84	51.941781	-0.235606
41	51.929361	-0.230656	85	51.941735	-0.235253
42	51.924943	-0.227533	86	51.941686	-0.234835
43	51.924482	-0.217214	87	51.936501	-0.228437
44	51.924552	-0.217058	88	51.936924	-0.228727

Dwelling data

Road Data

The table below presents the coordinate data for assessed road receptors.

Road	Longitude (°)	Latitude (°)	Road	Longitude (°)	Latitude (°)
1	51.946582	-0.212006	56	51.93261	-0.210222
2	51.945689	-0.212199	57	51.933527	-0.210082
3	51.944804	-0.212438	58	51.934424	-0.210251
4	51.94392	-0.212731	59	51.935303	-0.210533
5	51.943041	-0.213053	60	51.936205	-0.210524
6	51.942166	-0.213421	61	51.937102	-0.2107
7	51.941306	-0.213825	62	51.938005	-0.210972

Road	Longitude (°)	Latitude (°)	Road	Longitude (°)	Latitude (°)
8	51.940443	-0.214219	63	51.93891	-0.210988
9	51.939577	-0.214588	64	51.939823	-0.210796
10	51.938715	-0.215008	65	51.940671	-0.210279
11	51.937842	-0.215399	66	51.941511	-0.209715
12	51.936976	-0.215786	67	51.942346	-0.209185
13	51.936114	-0.216187	68	51.943183	-0.208648
14	51.935248	-0.21659	69	51.944007	-0.208063
15	51.934376	-0.216954	70	51.944853	-0.207552
16	51.933508	-0.217357	71	51.945695	-0.207034
17	51.932633	-0.217759	72	51.946542	-0.206511
18	51.931765	-0.218158	73	51.940009	-0.212232
19	51.930897	-0.218525	74	51.940287	-0.213623
20	51.930011	-0.218856	75	51.940548	-0.215033
21	51.929139	-0.219269	76	51.940776	-0.216454
22	51.928278	-0.219676	77	51.941004	-0.217879
23	51.927414	-0.220079	78	51.941259	-0.219284
24	51.926553	-0.220551	79	51.941519	-0.220682
25	51.925703	-0.221026	80	51.94187	-0.222041
26	51.924869	-0.221557	81	51.942085	-0.223466
27	51.926645	-0.233452	82	51.941918	-0.224912
28	51.92669	-0.231995	83	51.941665	-0.226325
29	51.926888	-0.23055	84	51.94142	-0.227736
30	51.927132	-0.229131	85	51.941201	-0.229158
31	51.927389	-0.227721	86	51.941033	-0.230627
32	51.927636	-0.226304	87	51.943152	-0.235894

Road	Longitude (°)	Latitude (°)	Road	Longitude (°)	Latitude (°)
33	51.927896	-0.224881	88	51.94226	-0.236186
34	51.928098	-0.223452	89	51.941464	-0.236833
35	51.928187	-0.221995	90	51.940566	-0.237007
36	51.928516	-0.220626	91	51.939721	-0.237535
37	51.9278	-0.220679	92	51.93899	-0.238376
38	51.924281	-0.217417	93	51.938249	-0.239209
39	51.925147	-0.217877	94	51.937522	-0.240078
40	51.926047	-0.218031	95	51.936783	-0.2409
41	51.926925	-0.218378	96	51.932401	-0.238465
42	51.927821	-0.218543	97	51.932212	-0.23704
43	51.928381	-0.217393	98	51.932067	-0.235608
44	51.928783	-0.216078	99	51.932096	-0.234152
45	51.929299	-0.214868	100	51.932108	-0.232698
46	51.929823	-0.213672	101	51.932105	-0.231241
47	51.930351	-0.212484	102	51.931891	-0.229827
48	51.93097	-0.211401	103	51.931281	-0.22874
49	51.930364	-0.210321	104	51.930635	-0.22772
50	51.929469	-0.210129	105	51.930082	-0.226581
51	51.928578	-0.209961	106	51.929545	-0.225428
52	51.927683	-0.209748	107	51.929044	-0.224238
53	51.92678	-0.20969	108	51.928737	-0.222877
54	51.925884	-0.209695	109	51.928748	-0.221429
55	51.931744	-0.210654			

Road data

Modelled Reflector Data

The table below presents the coordinate data for modelled reflector area used in the assessment.

South Area:

Vertex number	Longitude (°)	Latitude (°)	Vertex number	Longitude (°)	Latitude (°)
01	-0.22398	51.93344	09	-0.22195	51.93649
02	-0.22408	51.93370	10	-0.22168	51.93724
03	-0.22396	51.93398	11	-0.22331	51.93774
04	-0.22419	51.93448	12	-0.22332	51.93774
05	-0.22426	51.93500	13	-0.22094	51.94148
06	-0.22415	51.93540	14	-0.21462	51.94019
07	-0.22223	51.93563	15	-0.21782	51.93326
08	-0.22217	51.93631			

Modelled reflector area

North Area:

Vertex number	Longitude (°)	Latitude (°)	Vertex number	Longitude (°)	Latitude (°)
01	-0.21447	51.94158	09	-0.22842	51.94181
02	-0.21614	51.94306	10	-0.22851	51.94140
03	-0.21747	51.94517	11	-0.22375	51.94223
04	-0.22622	51.94670	12	-0.22295	51.94220
05	-0.22949	51.94652	13	-0.22225	51.94199
06	-0.22925	51.94471	14	-0.22060	51.94156
07	-0.22845	51.94456	15	-0.21489	51.94070
08	-0.22874	51.94304			

Modelled reflector area

APPENDIX H – DETAILLED MODELLING RESULTS

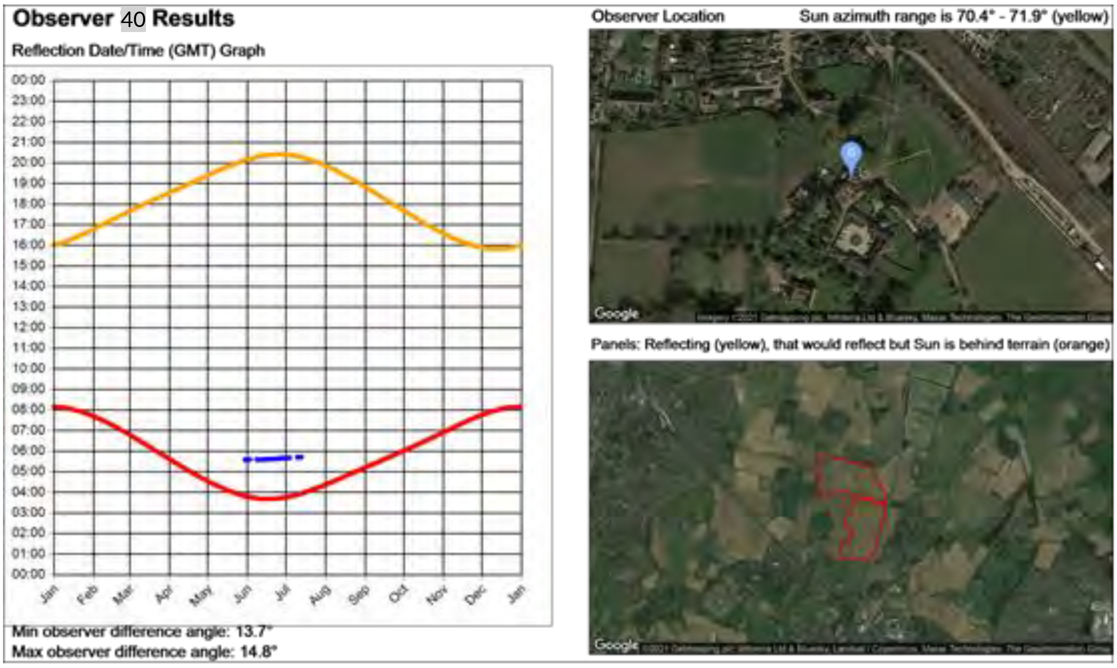
Model Output Charts

The charts for the potentially affected receptors are shown on the following pages. Each chart shows:

- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of the report.
- The reflecting panels – bottom right image. The reflecting area is shown in yellow. The orange areas denote panel locations that will not produce glare due to terrain screening at the horizon. 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).

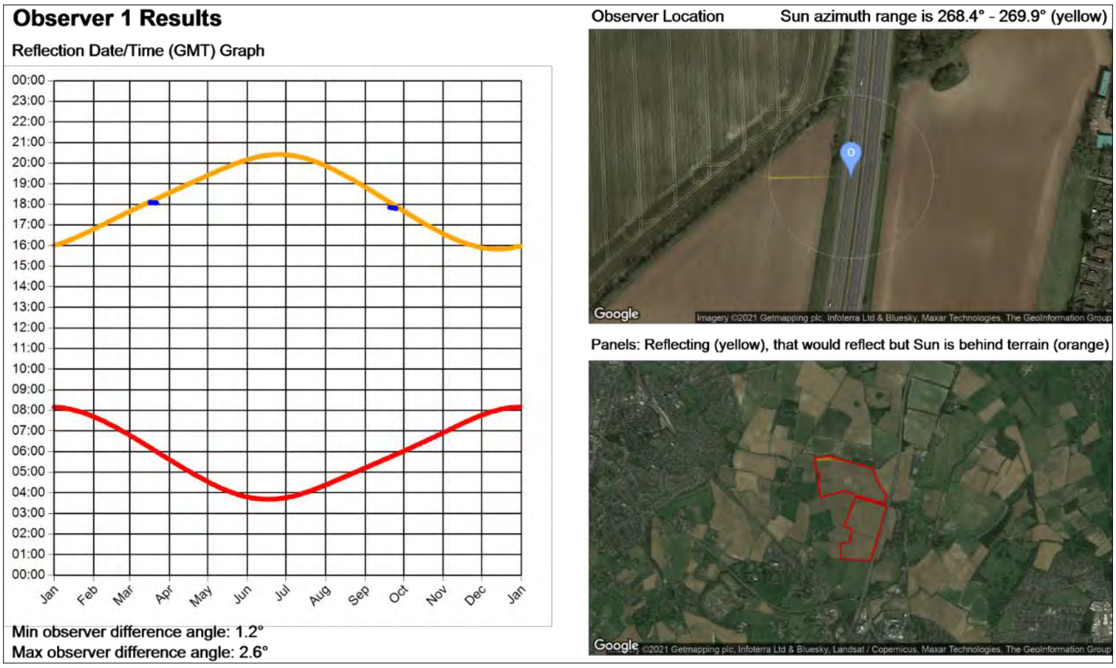
Dwelling Receptors

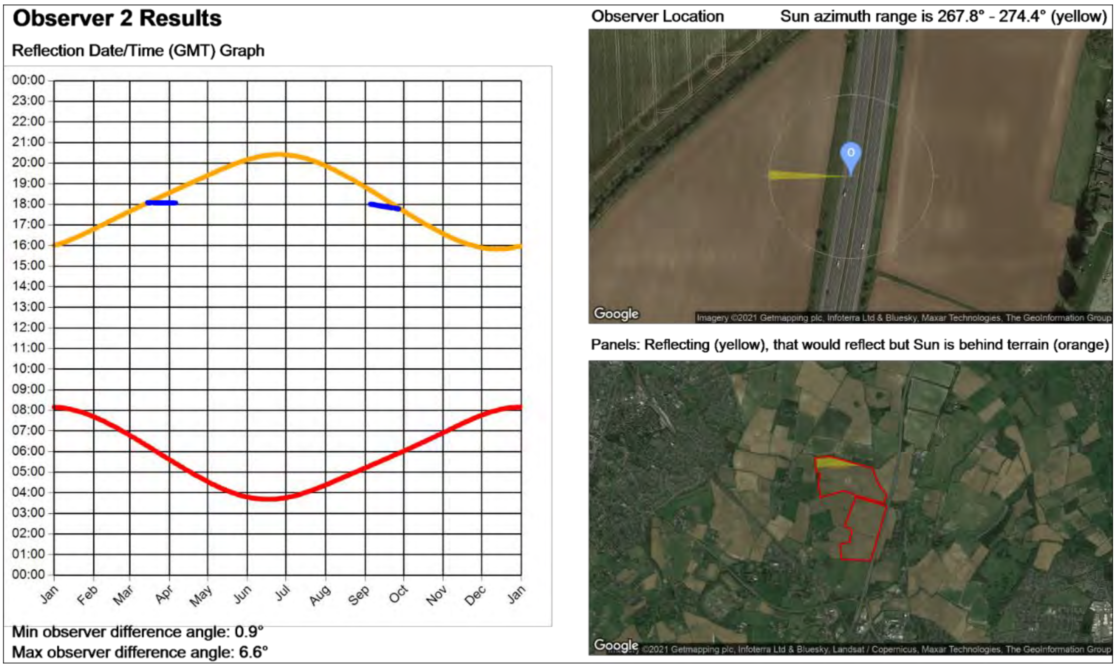
The charts below relate to the dwelling receptors where low impacts have been predicted. Modelling output for the remaining receptors can be provided on request.



Road Receptors

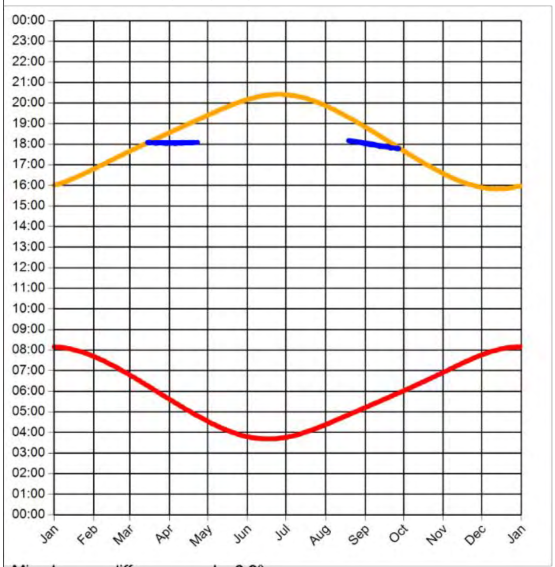
The charts below relate to the road receptors where low impacts have been predicted. Modelling output for the remaining receptors can be provided on request.





Observer 3 Results

Reflection Date/Time (GMT) Graph



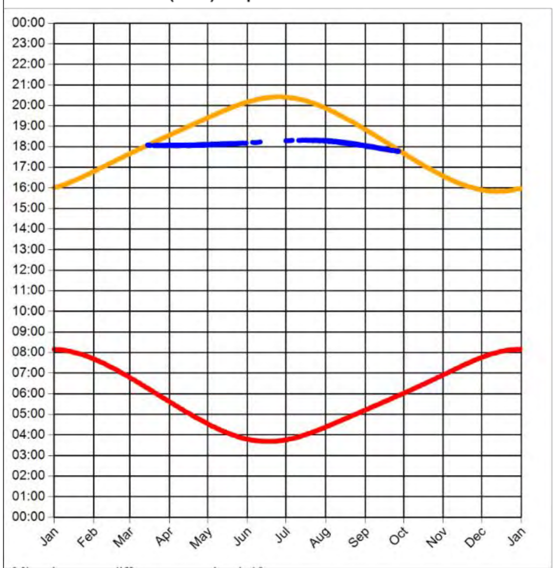
Min observer difference angle: 0.9°
Max observer difference angle: 10.6°

Observer Location — Sun azimuth range is 267.9° - 279.2° (yellow)

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

Observer 4 Results

Reflection Date/Time (GMT) Graph



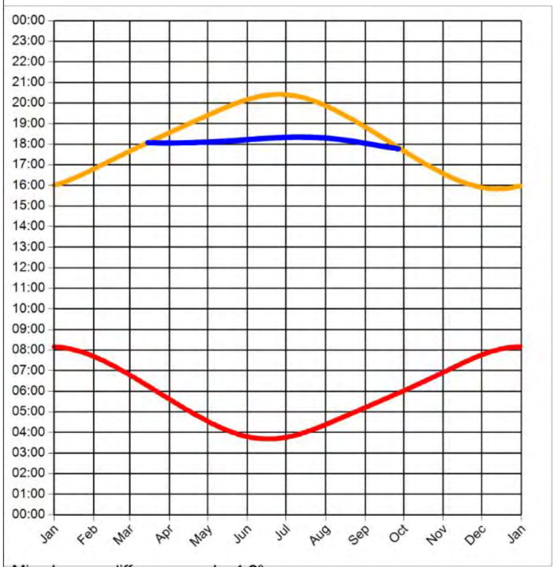
Min observer difference angle: 1.1°
Max observer difference angle: 18.7°

Observer Location — Sun azimuth range is 267.8° - 287.2° (yellow)

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

Observer 5 Results

Reflection Date/Time (GMT) Graph



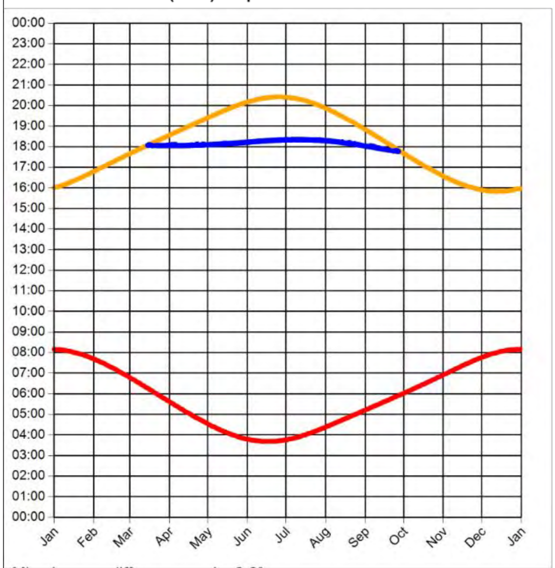
Min observer difference angle: 1.2°
Max observer difference angle: 18.3°

Observer Location — Sun azimuth range is 267.8° - 288° (yellow)

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

Observer 6 Results

Reflection Date/Time (GMT) Graph



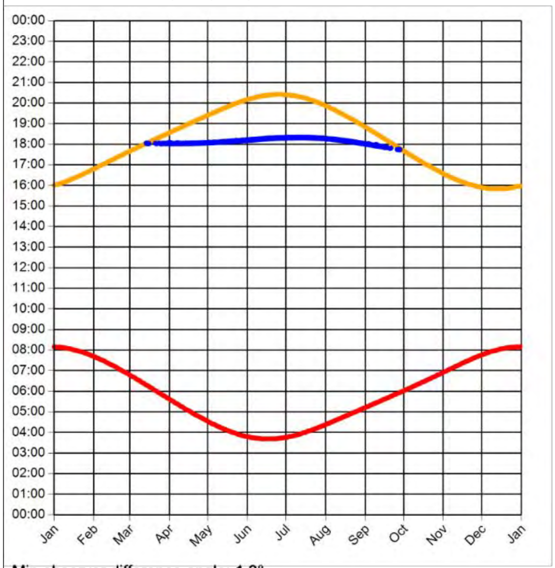
Min observer difference angle: 0.6°
Max observer difference angle: 18.2°

Observer Location — Sun azimuth range is 267.7° - 288.1° (yellow)

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

Observer 7 Results

Reflection Date/Time (GMT) Graph



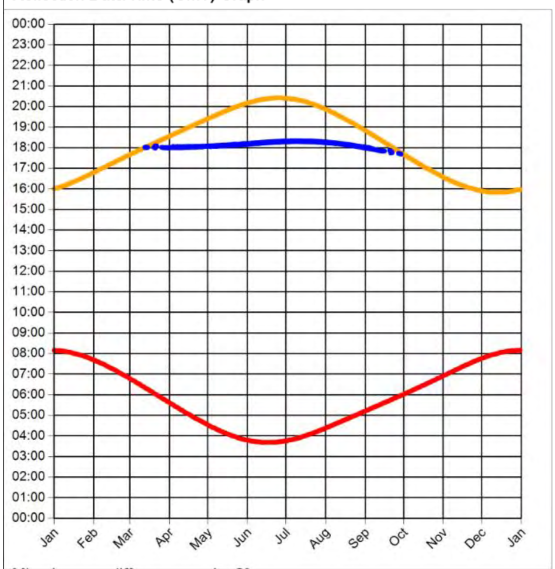
Min observer difference angle: 1.3°
Max observer difference angle: 18.8°

Observer Location — Sun azimuth range is 267° - 287.9° (yellow)

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

Observer 8 Results

Reflection Date/Time (GMT) Graph



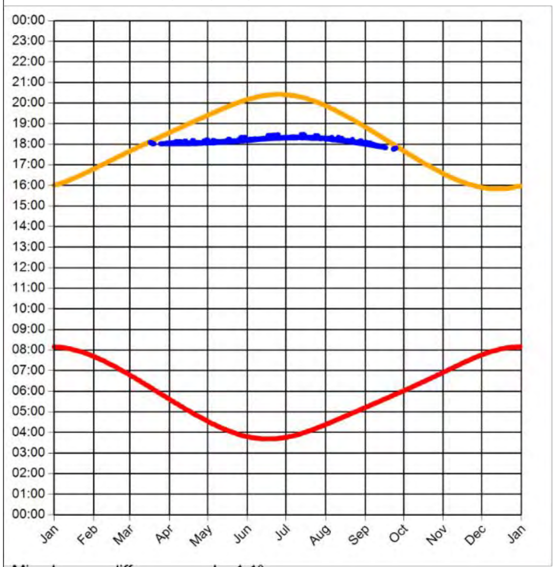
Min observer difference angle: 2°
Max observer difference angle: 19.1°

Observer Location — Sun azimuth range is 266.5° - 287.8° (yellow)

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

Observer 9 Results

Reflection Date/Time (GMT) Graph



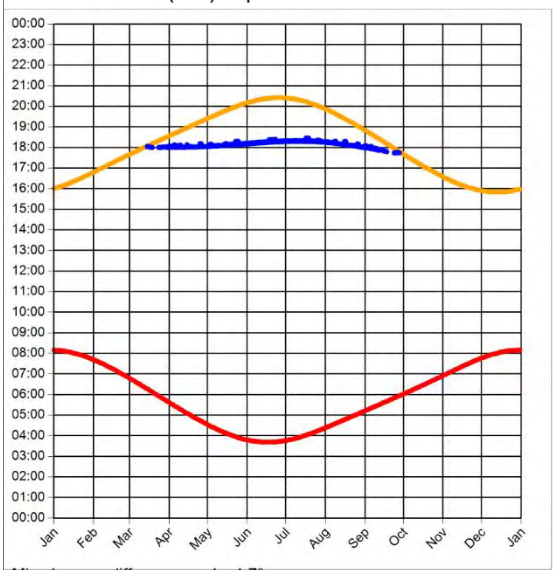
Min observer difference angle: 1.1°
Max observer difference angle: 18.7°

Observer Location — Sun azimuth range is 268.3° - 289.4° (yellow)

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

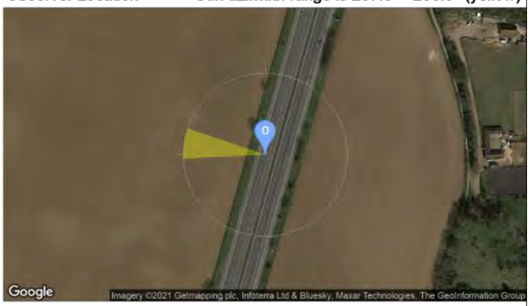
Observer 10 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 1.7°
Max observer difference angle: 19.1°

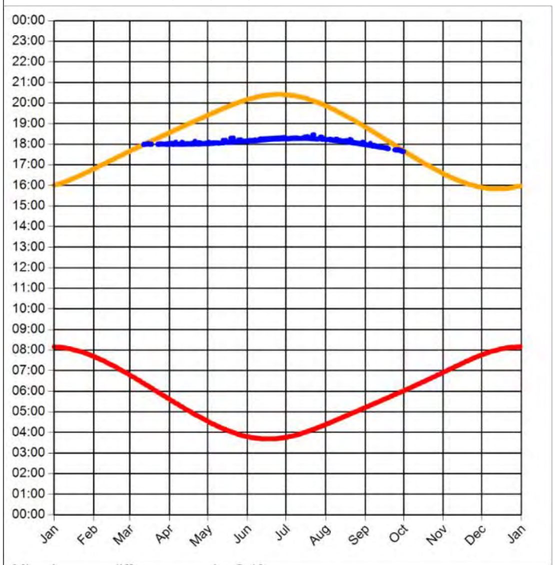
Observer Location — Sun azimuth range is 267.3° - 288.8° (yellow)



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

Observer 11 Results

Reflection Date/Time (GMT) Graph



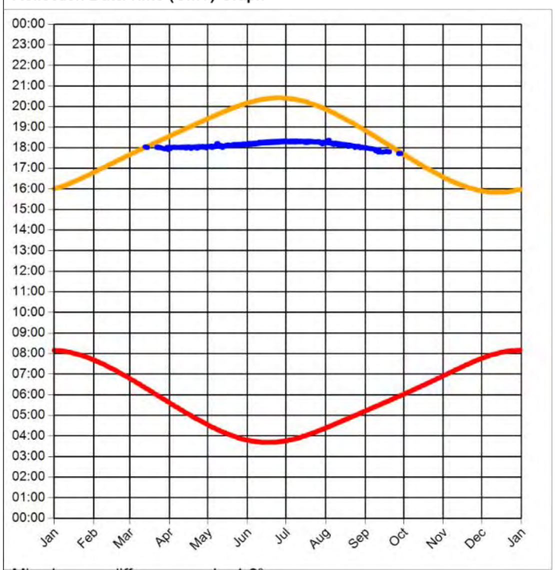
Min observer difference angle: 2.1°
Max observer difference angle: 19.5°

Observer Location Sun azimuth range is 265.7° - 287.7° (yellow)

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

Observer 12 Results

Reflection Date/Time (GMT) Graph



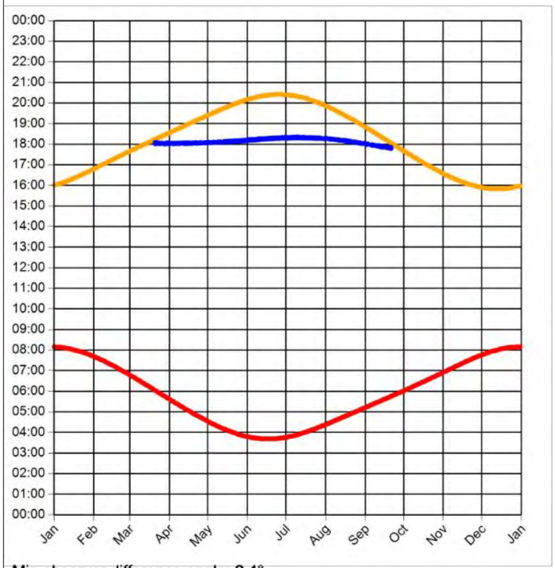
Min observer difference angle: 1.6°
Max observer difference angle: 19.3°

Observer Location Sun azimuth range is 266.8° - 287.8° (yellow)

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

Observer 13 Results

Reflection Date/Time (GMT) Graph



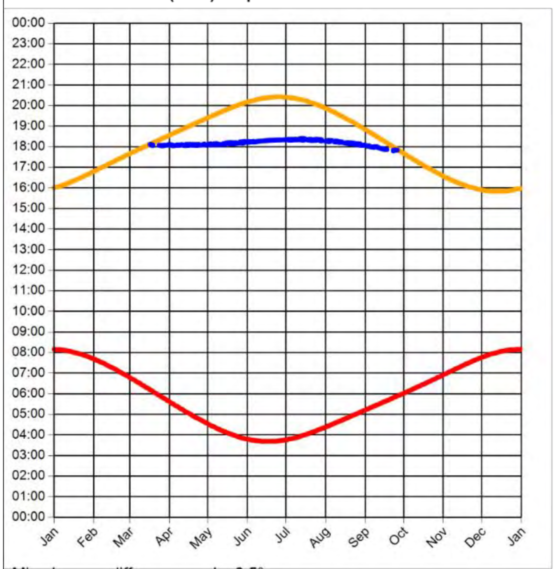
Min observer difference angle: 2.4°
Max observer difference angle: 18.9°

Observer Location | Sun azimuth range is 269° - 287.8° (yellow)

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

Observer 14 Results

Reflection Date/Time (GMT) Graph



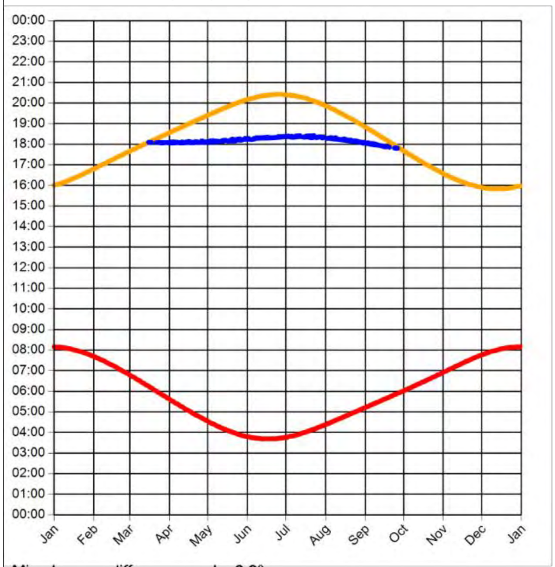
Min observer difference angle: 0.5°
Max observer difference angle: 18°

Observer Location | Sun azimuth range is 268.7° - 288.1° (yellow)

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

Observer 15 Results

Reflection Date/Time (GMT) Graph



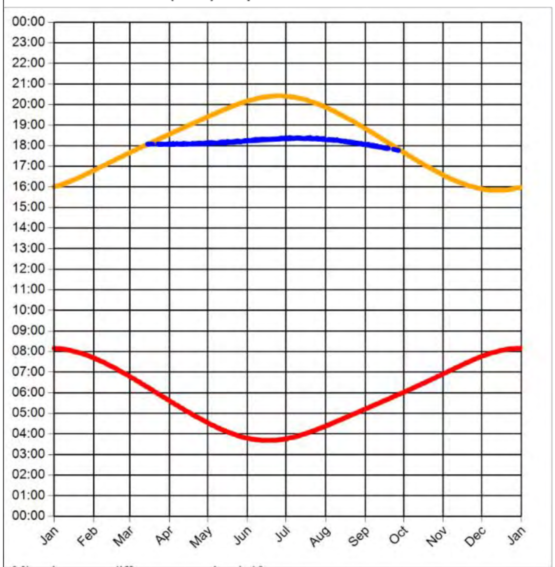
Min observer difference angle: 0.9°
Max observer difference angle: 17.6°

Observer Location — Sun azimuth range is 268.3° - 288.5° (yellow)

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

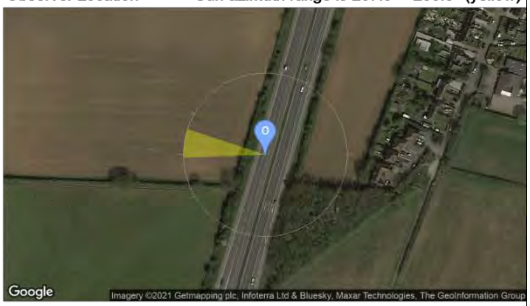
Observer 16 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 1.1°
Max observer difference angle: 17.9°

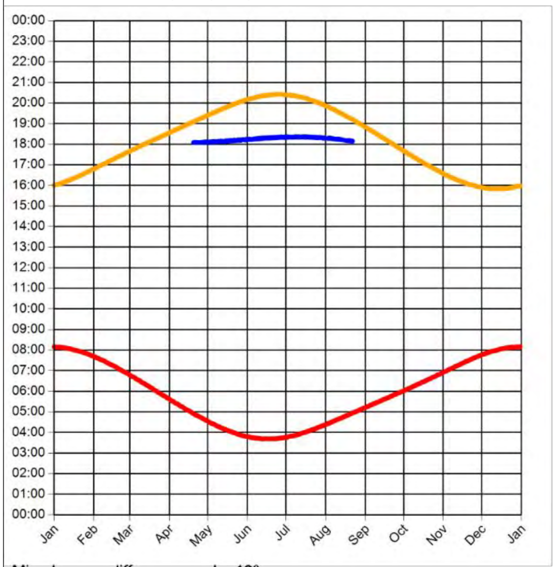
Observer Location — Sun azimuth range is 267.9° - 288.3° (yellow)



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

Observer 17 Results

Reflection Date/Time (GMT) Graph



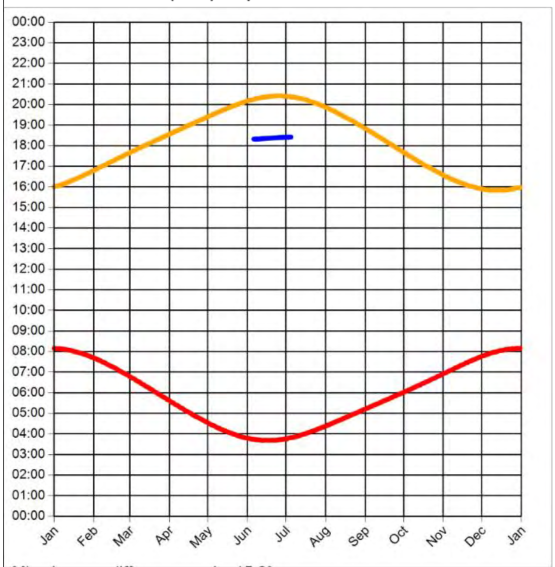
Min observer difference angle: 10°
Max observer difference angle: 17.9°

Observer Location Sun azimuth range is 278.3° - 288.1° (yellow)

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

Observer 47 Results

Reflection Date/Time (GMT) Graph



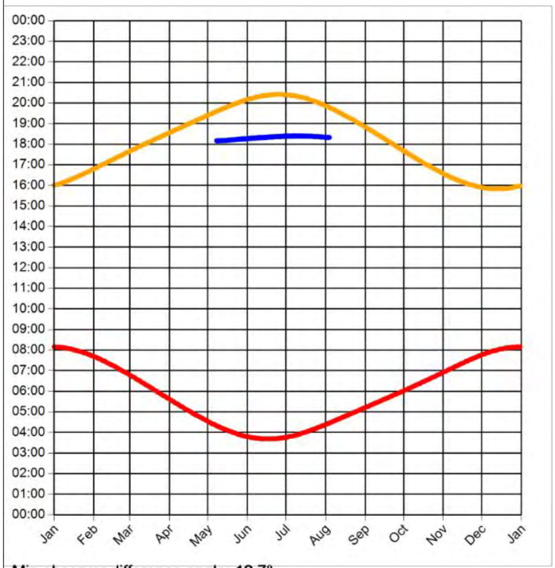
Min observer difference angle: 15.8°
Max observer difference angle: 16.3°

Observer Location Sun azimuth range is 288.1° - 288.7° (yellow)

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

Observer 48 Results

Reflection Date/Time (GMT) Graph



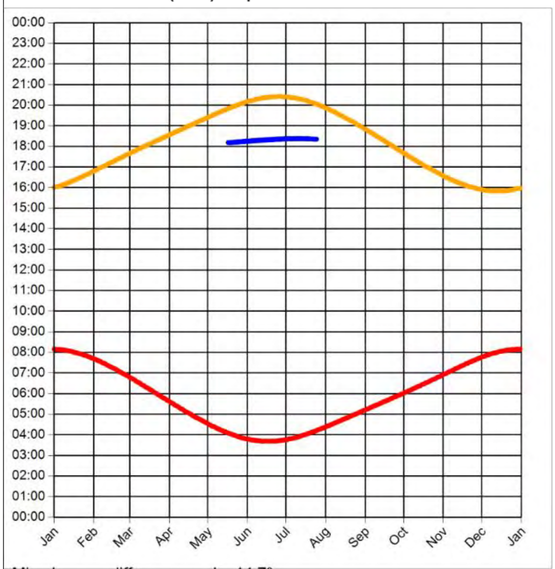
Min observer difference angle: 12.7°
Max observer difference angle: 16.8°

Observer Location — Sun azimuth range is 283.2° - 288.6° (yellow)

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

Observer 49 Results

Reflection Date/Time (GMT) Graph



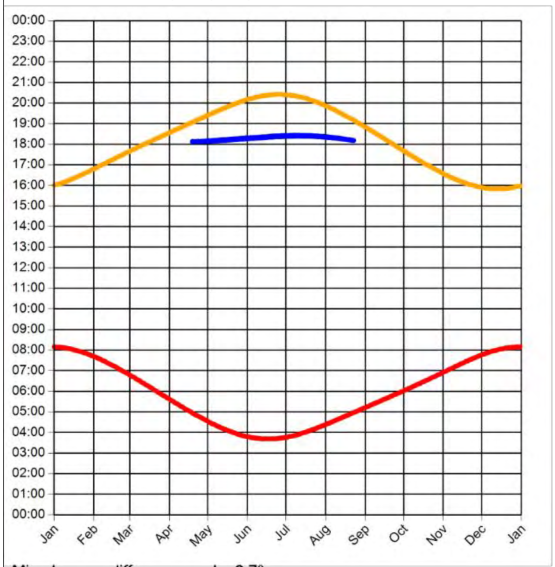
Min observer difference angle: 14.7°
Max observer difference angle: 17.3°

Observer Location — Sun azimuth range is 284.9° - 288.3° (yellow)

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

Observer 55 Results

Reflection Date/Time (GMT) Graph



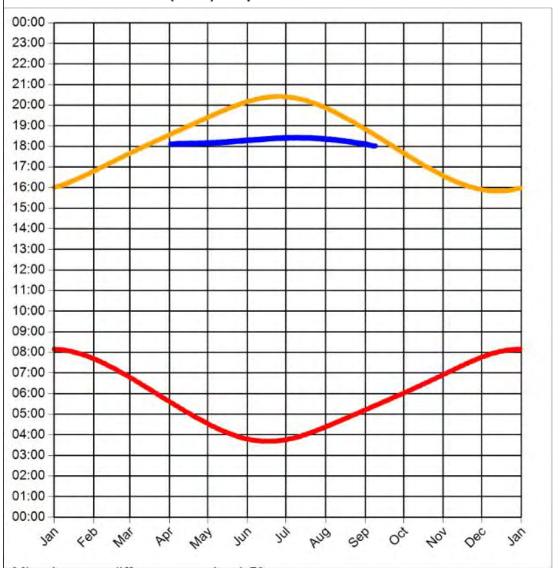
Min observer difference angle: 8.7°
Max observer difference angle: 16.9°

Observer Location Sun azimuth range is 278.5° - 288.9° (yellow)

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

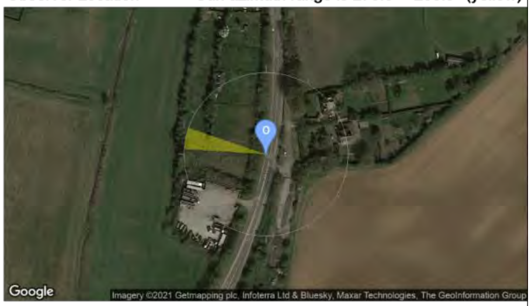
Observer 56 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 4.5°
Max observer difference angle: 16.7°

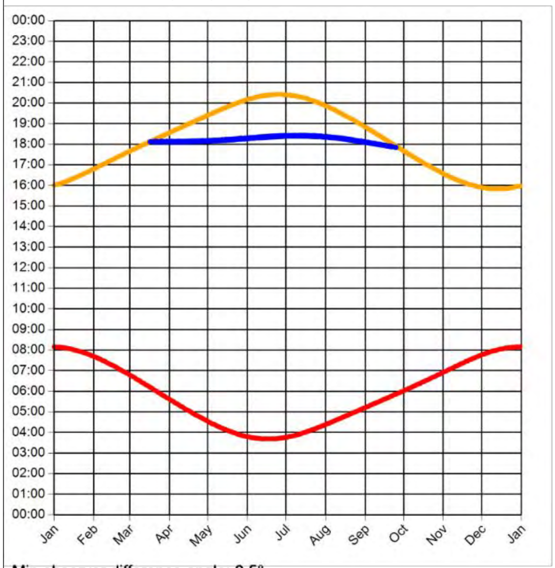
Observer Location Sun azimuth range is 273.8° - 288.9° (yellow)



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

Observer 57 Results

Reflection Date/Time (GMT) Graph



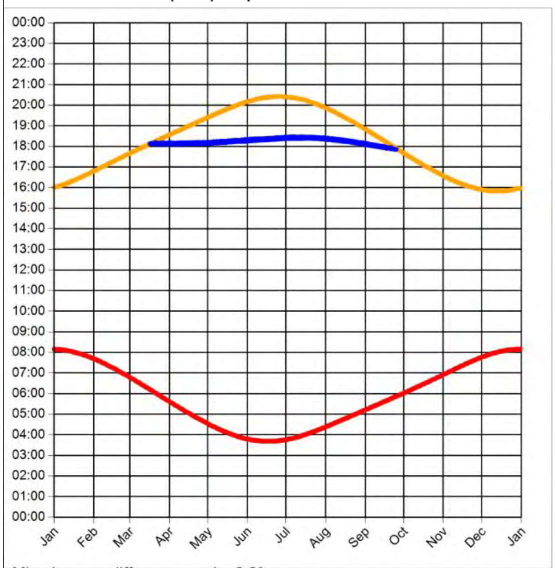
Min observer difference angle: 0.5°
Max observer difference angle: 16.9°

Observer Location | Sun azimuth range is 268.9° - 289° (yellow)

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

Observer 58 Results

Reflection Date/Time (GMT) Graph



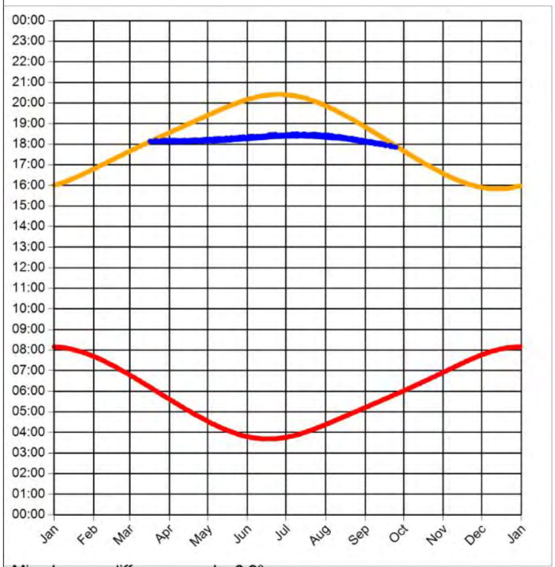
Min observer difference angle: 0.3°
Max observer difference angle: 17.1°

Observer Location | Sun azimuth range is 269.1° - 289° (yellow)

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

Observer 59 Results

Reflection Date/Time (GMT) Graph



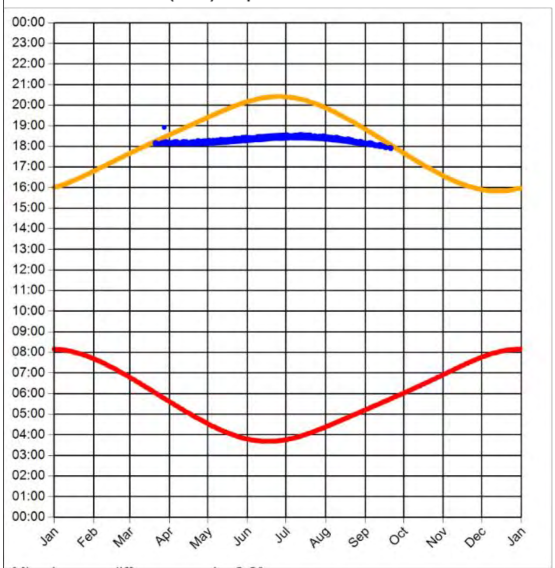
Min observer difference angle: 0.3°
Max observer difference angle: 16.6°

Observer Location — Sun azimuth range is 269.2° - 289.7° (yellow)

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

Observer 60 Results

Reflection Date/Time (GMT) Graph



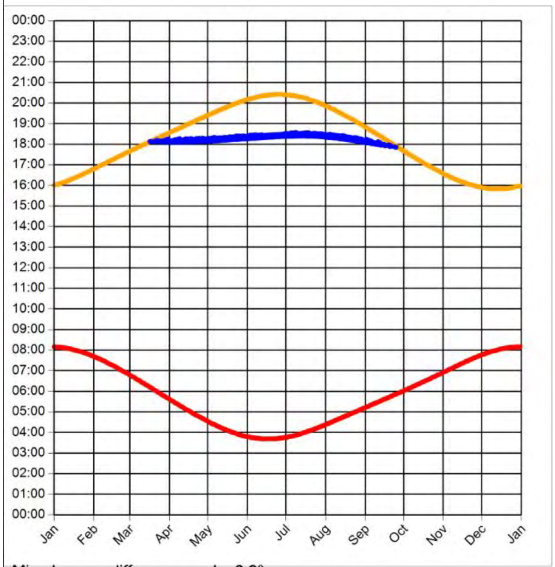
Min observer difference angle: 0.3°
Max observer difference angle: 16.4°

Observer Location — Sun azimuth range is 270.2° - 290.3° (yellow)

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

Observer 61 Results

Reflection Date/Time (GMT) Graph



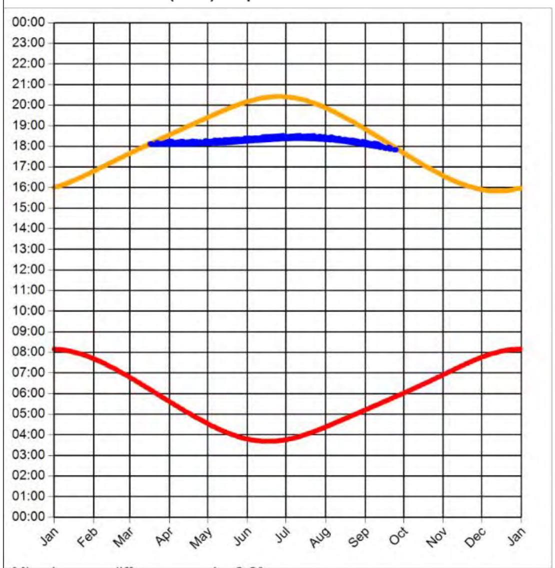
Min observer difference angle: 0.3°
Max observer difference angle: 16.9°

Observer Location — Sun azimuth range is 269.1° - 289.7° (yellow)

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

Observer 62 Results

Reflection Date/Time (GMT) Graph



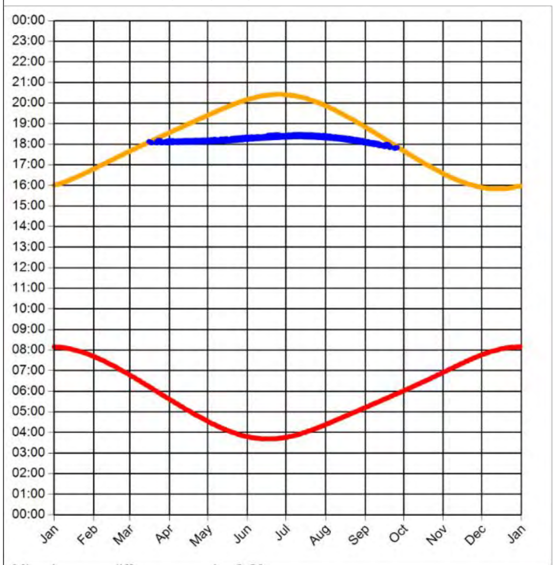
Min observer difference angle: 0.3°
Max observer difference angle: 17.1°

Observer Location — Sun azimuth range is 268.9° - 290° (yellow)

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

Observer 63 Results

Reflection Date/Time (GMT) Graph



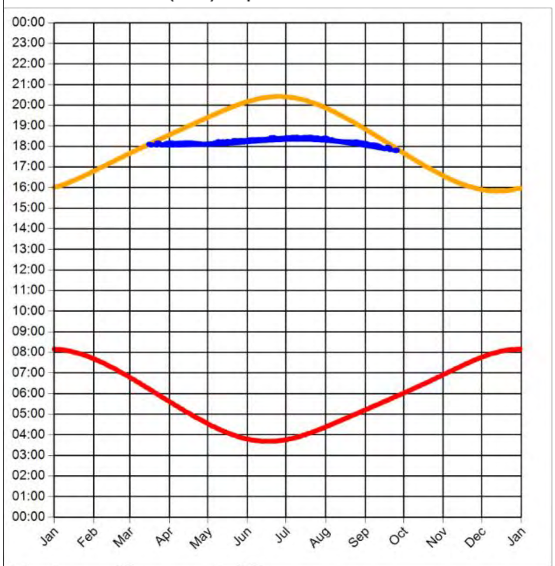
Min observer difference angle: 0.3°
Max observer difference angle: 17.6°

Observer Location Sun azimuth range is 268.6° - 289.5° (yellow)

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

Observer 64 Results

Reflection Date/Time (GMT) Graph



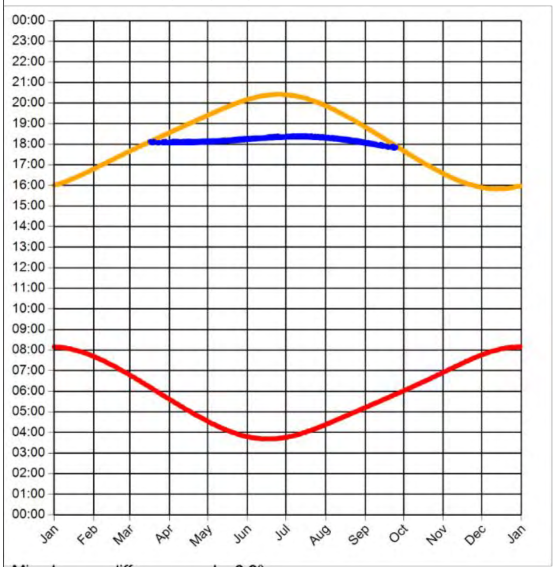
Min observer difference angle: 0.8°
Max observer difference angle: 17.7°

Observer Location Sun azimuth range is 268.4° - 289.2° (yellow)

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

Observer 65 Results

Reflection Date/Time (GMT) Graph



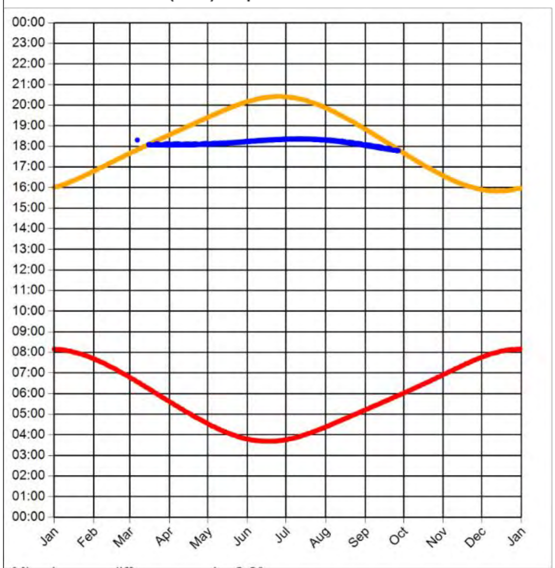
Min observer difference angle: 0.3°
Max observer difference angle: 17.8°

Observer Location — Sun azimuth range is 268.7° - 288.7° (yellow)

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

Observer 66 Results

Reflection Date/Time (GMT) Graph



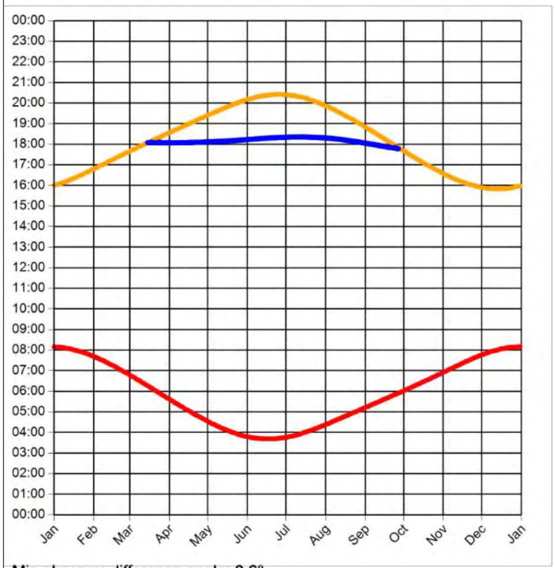
Min observer difference angle: 0.9°
Max observer difference angle: 17.8°

Observer Location — Sun azimuth range is 268.1° - 288.2° (yellow)

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

Observer 67 Results

Reflection Date/Time (GMT) Graph



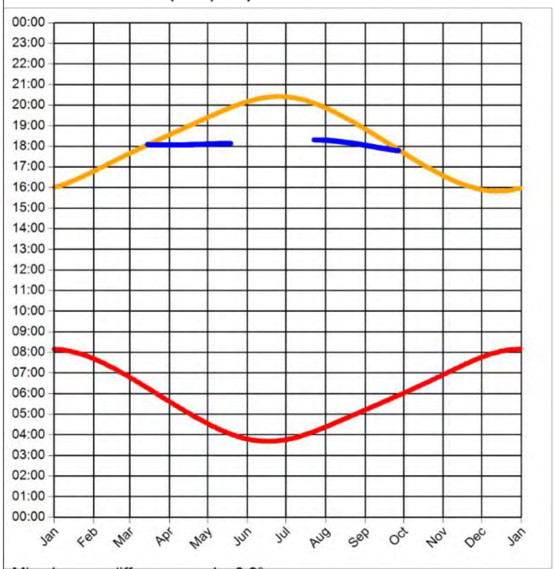
Min observer difference angle: 0.6°
Max observer difference angle: 17.9°

Observer Location — Sun azimuth range is 267.9° - 288.1° (yellow)

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

Observer 68 Results

Reflection Date/Time (GMT) Graph



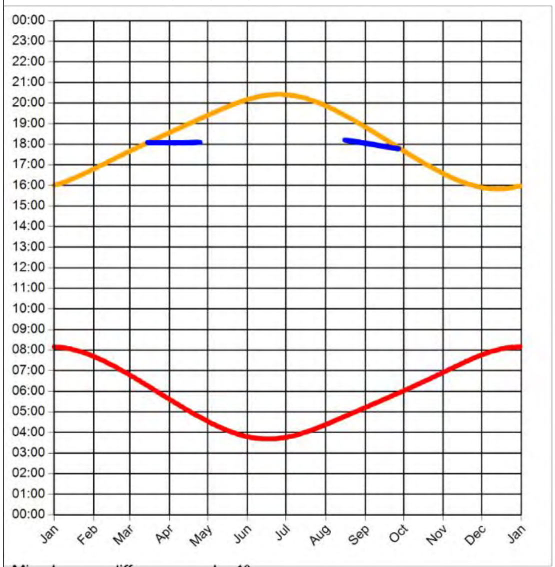
Min observer difference angle: 0.8°
Max observer difference angle: 16°

Observer Location — Sun azimuth range is 267.9° - 284.8° (yellow)

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

Observer 69 Results

Reflection Date/Time (GMT) Graph



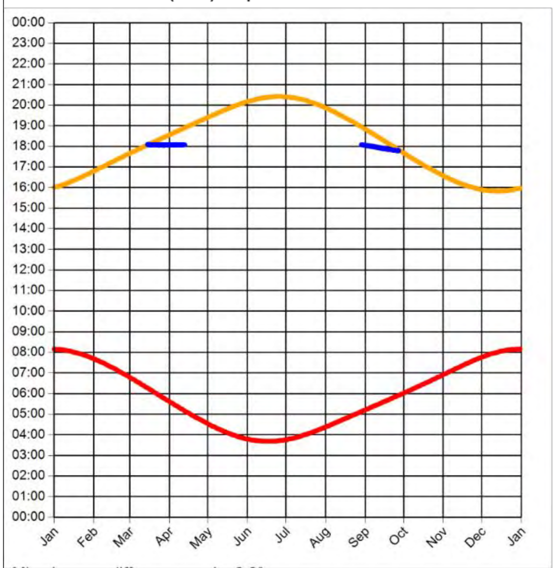
Min observer difference angle: 1°
Max observer difference angle: 11.2°

Observer Location Sun azimuth range is 267.9° - 279.9° (yellow)

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

Observer 70 Results

Reflection Date/Time (GMT) Graph



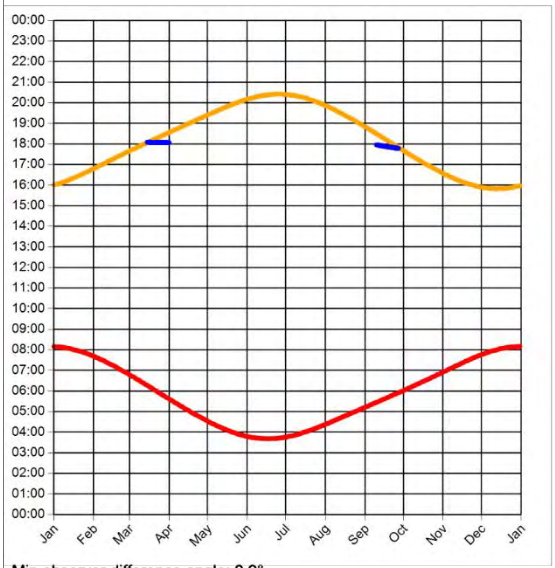
Min observer difference angle: 0.8°
Max observer difference angle: 8.2°

Observer Location Sun azimuth range is 267.9° - 276.4° (yellow)

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

Observer 71 Results

Reflection Date/Time (GMT) Graph



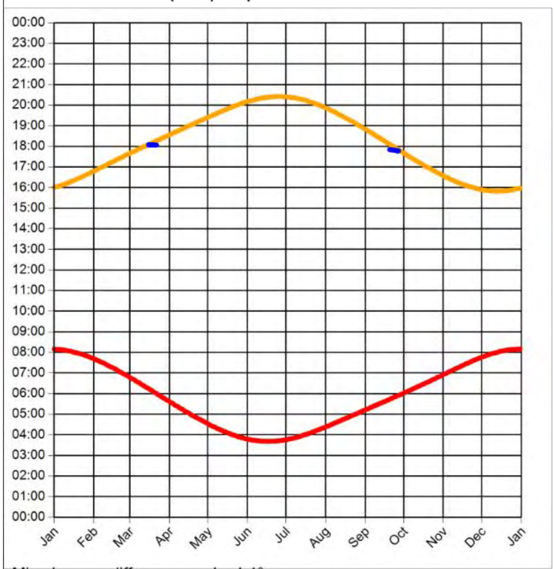
Min observer difference angle: 0.9°
Max observer difference angle: 5.3°

Observer Location | Sun azimuth range is 268° - 272.9° (yellow)

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

Observer 72 Results

Reflection Date/Time (GMT) Graph



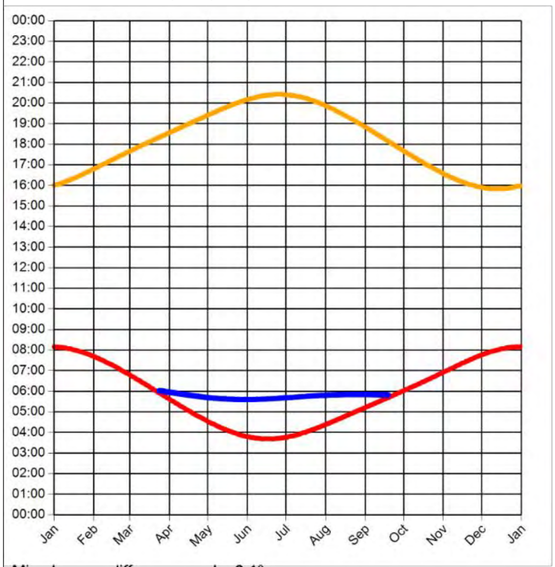
Min observer difference angle: 1.1°
Max observer difference angle: 2.8°

Observer Location | Sun azimuth range is 267.9° - 269.9° (yellow)

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

Observer 87 Results

Reflection Date/Time (GMT) Graph



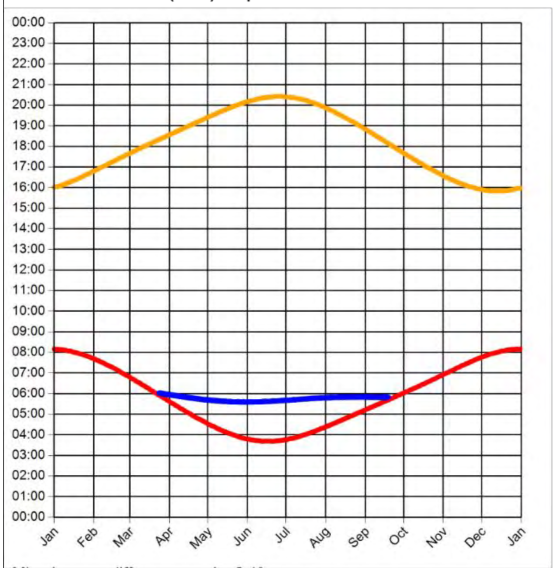
Min observer difference angle: 0.1°
Max observer difference angle: 15.3°

Observer Location — Sun azimuth range is 70.6° - 88.2° (yellow)

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

Observer 88 Results

Reflection Date/Time (GMT) Graph



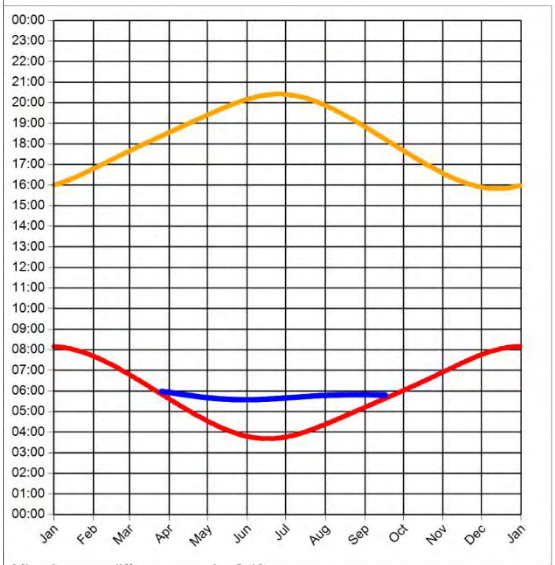
Min observer difference angle: 0.1°
Max observer difference angle: 15.2°

Observer Location — Sun azimuth range is 70.4° - 88.2° (yellow)

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

Observer 89 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 14.9°

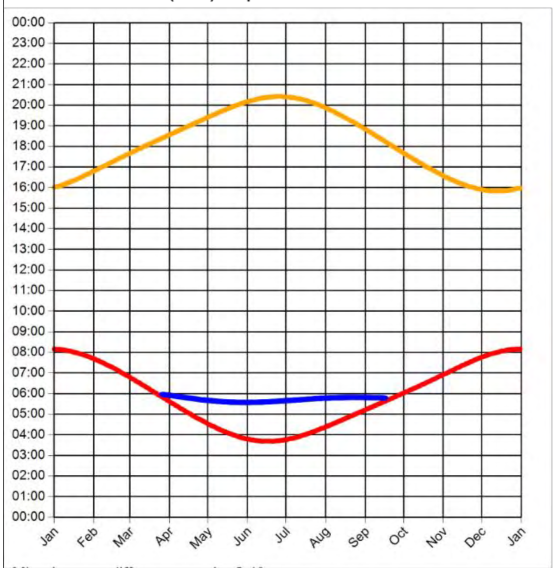
Observer Location

Sun azimuth range is 70.3° - 87.4° (yellow)

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

Observer 90 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.1°
Max observer difference angle: 14.8°

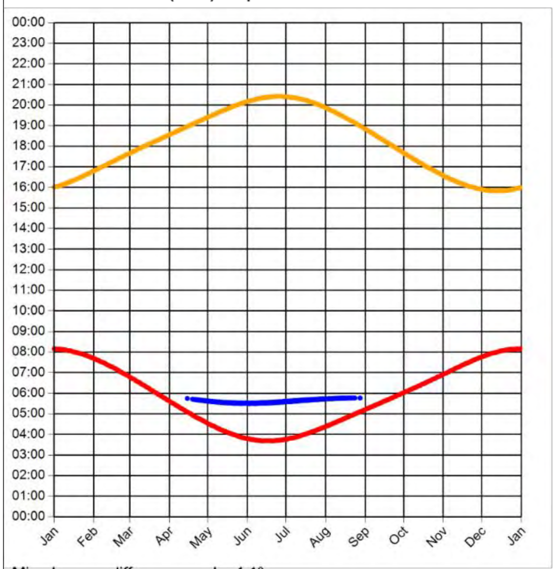
Observer Location

Sun azimuth range is 70.2° - 87° (yellow)

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

Observer 102 Results

Reflection Date/Time (GMT) Graph



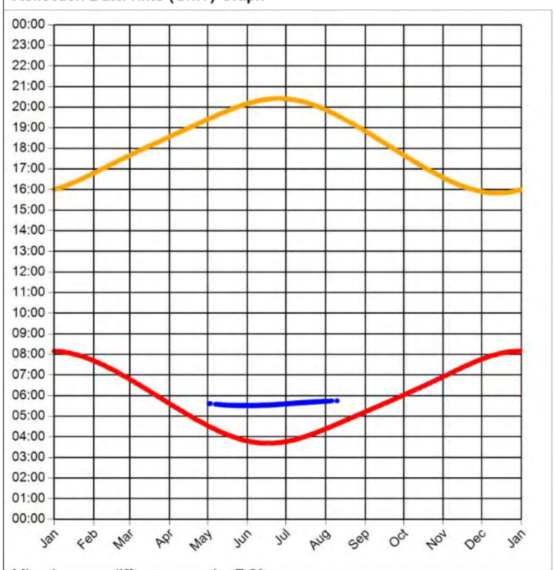
Min observer difference angle: 4.1°
Max observer difference angle: 13.4°

Observer Location — Sun azimuth range is 69.5° - 80.9° (yellow)

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

Observer 103 Results

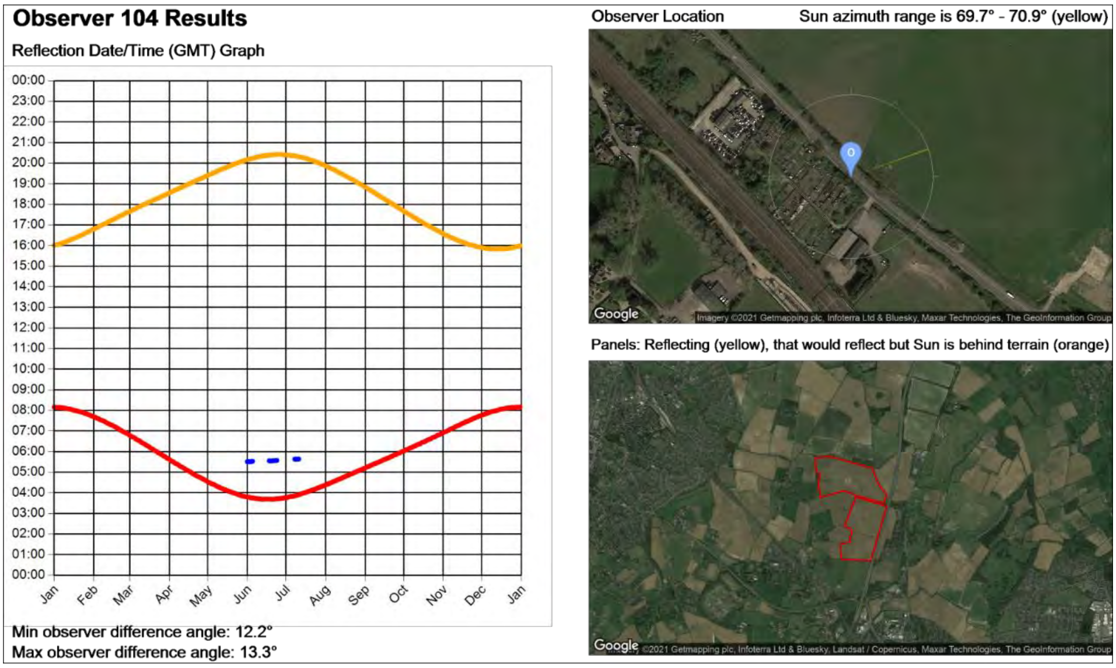
Reflection Date/Time (GMT) Graph



Min observer difference angle: 7.9°
Max observer difference angle: 13.4°

Observer Location — Sun azimuth range is 69.6° - 76.3° (yellow)

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


Observer 104 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 12.2°
Max observer difference angle: 13.3°
Observer Location
Sun azimuth range is 69.7° - 70.9° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
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