West Burton Solar Project

Environmental Statement

Appendix 16.1: Solar Photovoltaic Glint and Glare Study

Prepared by: Pager Power
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PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

West Burton Solar Project

West Burton Solar Project Limited

March 2023

ADMINISTRATION PAGE

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1	December 2022	Initial Issue
2	January 2023	Second Issue – Minor amendments
3	7th February 2023	Third Issue – Minor amendments
4	17th February 2023	Fourth Issue – Minor amendments
5	March 2023	Fifth Issue – Legal review

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to identify the potential receptors associated with the proposed solar development West Burton to be located near Lincoln, Lincolnshire, England. This glint and glare assessment pertains to the possible impact upon surrounding road safety, residential amenity, railway operation and infrastructure and aviation operations[1].

Pager Power

Pager Power has undertaken over 950 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

Guidelines exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. The UK CAA guidance is relatively high-level and does not prescribe a formal methodology. Pager Power has reviewed existing guidelines and the available studies in the process of defining its own glint and glare assessment guidance document and methodology[2]. This methodology defines a comprehensive process for determining the impact upon roads, dwellings, railway operation and infrastructure and aviation activity.

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

The available studies have measured the intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. The results show that the reflections produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel[3].

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[1] Public Rights of Way (PRoW) have not been included within this assessment because they are receptors with "low" sensitivity which means the receptor is tolerant of change without detrimental effect, is of low or local importance.

[2] Pager Power Glint and Glare Guidance, Fourth Edition (4), April 2022.

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

Aviation Receptors – Consultation

Pager Power has consulted with the safeguarding teams at Sturgate Airfield, RAF Scampton and Doncaster-Sheffield Airport with regard to the effect of the proposed development upon aviation activity. The results of the glint and glare were presented and the safeguarding teams have concluded that the proposed development sites West Burton 1, 2 and 3 are not predicted to pose a significant risk upon their operations. The safeguarding teams have not submitted an objection towards the proposed development as part of the pre-application consultation process.

High-Level Assessment of Waterways

Pager Power has reviewed the available imagery to identify if any waterway[4-5] exists within 1km of the proposed development. No waterway of a size sufficiently large to accommodate navigation has been identified and therefore glint and glare impacts towards waterway users are not considered possible.

High-level Assessment of Public Rights of Way

In Pager Power's experience, significant impacts upon pedestrians/observers along PRoWs from glint and glare are not possible. This is because:

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

Furthermore, any effect will have a low magnitude because:

- It is likely that the existing and the proposed screening would fully remove the visibility of the proposed development for certain PRoW users;
- If effects are possible and unscreened they would typically coincide with direct sunlight. The Sun is a far more significant source of light.
- The reflection intensity is similar for solar panels and still water (and significantly less than reflections from glass and steel[6]) which is frequently a feature of the outdoor environment surrounding public rights of way. Therefore, the reflections are likely to be

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[4] A navigable body of water, such as a river, channel, or canal.

[5] River Till is a small river located nearby West Burton sites 1 and 2. This river is too small for navigation and it is not considered within the assessment. The river Trent is circa 1.2km west of the West Burton Solar Development (at its closest point). Therefore, if geometrically possible and unscreened, any glint and glare effects will not have a significant impact due to the large separation distance.

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

comparable to those from common outdoor sources whilst navigating the natural and built environment on a regular basis.

Therefore, since no significant impacts are predicted, no full modelling is required.

Dwelling Receptors

The results of the analysis have shown that reflections from the proposed development are geometrically possible towards some of the identified dwelling receptors. Under the baseline scenario a significant (moderate adverse) impact is predicted for one dwelling at West Burton 3 if a fixed mounting system is implemented and two dwellings if a tracking mounting system is implemented.

Within the landscaping plan, the developer has proposed mitigation in the form of vegetation. It is predicted that the proposed mitigation solution will reduce the impact to acceptable levels (the proposed screening is predicted to significantly reduce the visibility[7] of the reflective area from observers located at the ground floor[8]). If necessary, the developer will implement additional mitigation measures (opaque fencing) before planting is established. Therefore, low impact is predicted at worst upon the identified dwelling receptors, and no further mitigation is recommended.

Road Receptors

The results of the analysis have shown that solar reflections from the proposed development are geometrically possible towards some of the identified road receptors. Under the baseline scenario a significant (moderate adverse) impact (from West Burton 2 only) is predicted for road users travelling along a 300m stretch of Sturton Road, for both a fixed or tracking mounting system.

However, the proposed screening is predicted to significantly reduce the visibility of the reflective area for road users travelling along Sturton Road. The height of the screening will be sufficient to significantly reduce visibility[7] of reflecting solar panel for typical road users' drivers. If necessary, the developer will implement additional mitigation measures (opaque fencing) before planting is established. Therefore, a low impact is predicted at worst upon the identified road receptors, and no further mitigation is recommended.

Network Rail Receptors

Railway Signal Receptors

No potential signal locations were identified along the assessed section of railway line using available imagery and have therefore not been assessed. Network Rail has been contacted to confirm the location of any signals at these locations; however, no response has been received to date.

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[7] Vegetation may provide varying levels of cover, immediately after planting, during winter, and after maintenance (e.g. pruning). The developer will also implement instant screening where required.

[8] The ground floor is typically considered the main living space and has a greater significance with respect to residential amenity and views from the first floor have been considered within the results discussion where appropriate.

Train Driver Receptors

The results of the analysis have shown that reflections from the proposed development are geometrically possible towards train drivers. Under the baseline scenario, no significant impacts are predicted along the assessed railway track at West Burton 3.

The developer has also proposed screening along the boundary of the proposed development to further obstruct views of the reflecting panel area to a train driver using any section of the identified railway track, in the event any trackside vegetation is removed.

Cumulative Assessment of Nearby Solar NSIP Projects

The cumulative glint and glare effect of Cottam Solar Project and Gate Burton Energy Park has been considered. Gate Burton Energy Park and Cottam 1 are sufficiently close to the proposed development to share multiple receptors.

The shared receptors are as follows:

- Cottam 1, West Burton 1, 2 and 3 and Gate Burton Energy Park:
  - A section of the A156 and A1500 (specifically road receptor 1 to 12 ad 65 to 79).
  - Dwellings near and within Marton Village (specifically dwelling receptors 1 to 4 and 28-59).
  - A section of Till Bridge Lane north of West Burton 1 (specifically road receptors 1-6).

However, under the baseline conditions, shared receptors are unlikely to concurrently have visibility of multiple areas due to existing and proposed screening. Therefore, no significant cumulative effects are possible.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 55 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 identify the potential receptors associated with the proposed solar development West Burton to be located near Lincoln, Lincolnshire, England. This glint and glare assessment pertains to the possible impact upon surrounding road safety, residential amenity, railway operation and infrastructure and aviation operations[9]. A report has therefore been produced that contains the following:

- Presentation of indicative solar development areas;
- Explanation of glint and glare;
- Overview of relevant guidance;
- Overview of relevant studies;
- Identification of receptors:
    - Road receptors;
    - Dwelling receptors;
    - Railway receptors (train driver locations and railway signals);
    - Licensed and unlicensed aerodromes (ATC Towers and approach paths).
- Assessment methodology and process;
- Stakeholders where consultation is required.

1.2 Glint and Glare Definition

The definition of glint and glare is as follows[10-11]:

- 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.

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[9] Public Rights of Way (PRoW) have not been included within this assessment because they are receptors with "low" sensitivity which means the receptor is tolerant of change without detrimental effect, is of low or local importance

[10] "These definitions are aligned with those presented within the Draft National Policy Statement for Renewable Energy Infrastructure (EN-3) – published by the Department for Business, Energy & Industrial Strategy in September 2021 and the Federal Aviation Administration in the USA."

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

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Site Layouts

Overview

Figures 1-3[12] below and on the following page show the proposed site layout plans which demonstrate the worst-case scenario for the purposes of this assessment. The blue areas denote the proposed solar panel locations.

West Burton 1 - Broxholme

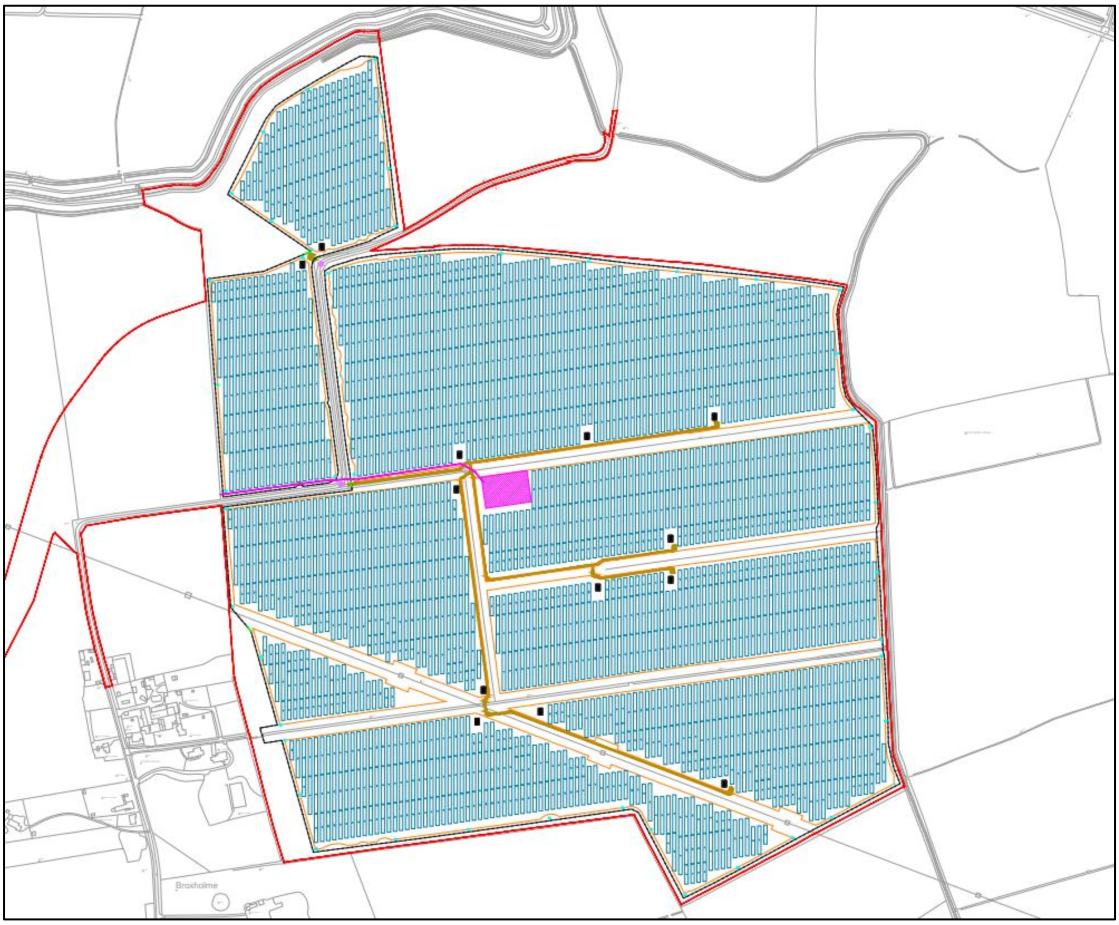

Figure 1 *West Burton 1 site layout*

[12] Provided to Pager Power by the developer, IGP Ltd.

West Burton 2 - Ingleby

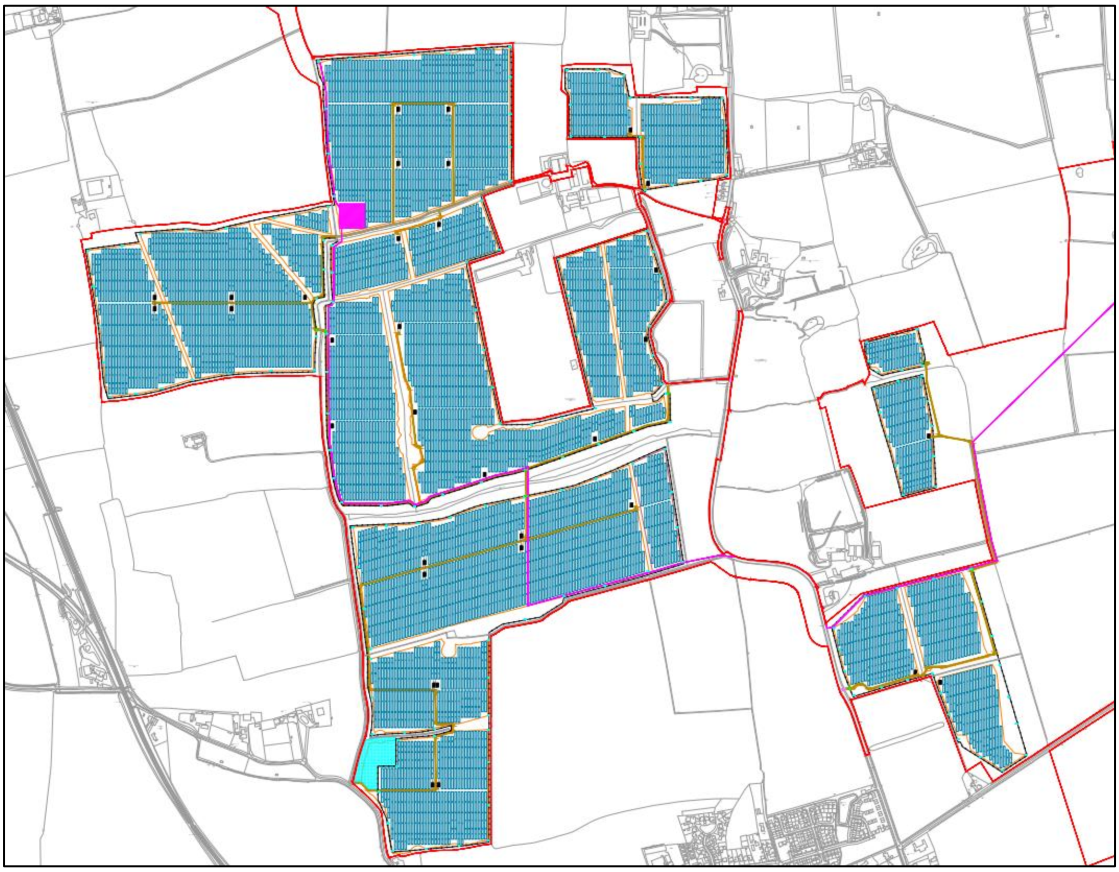

Figure 2 *West Burton 2 site layout*

West Burton 3 – Bellwood Brampton

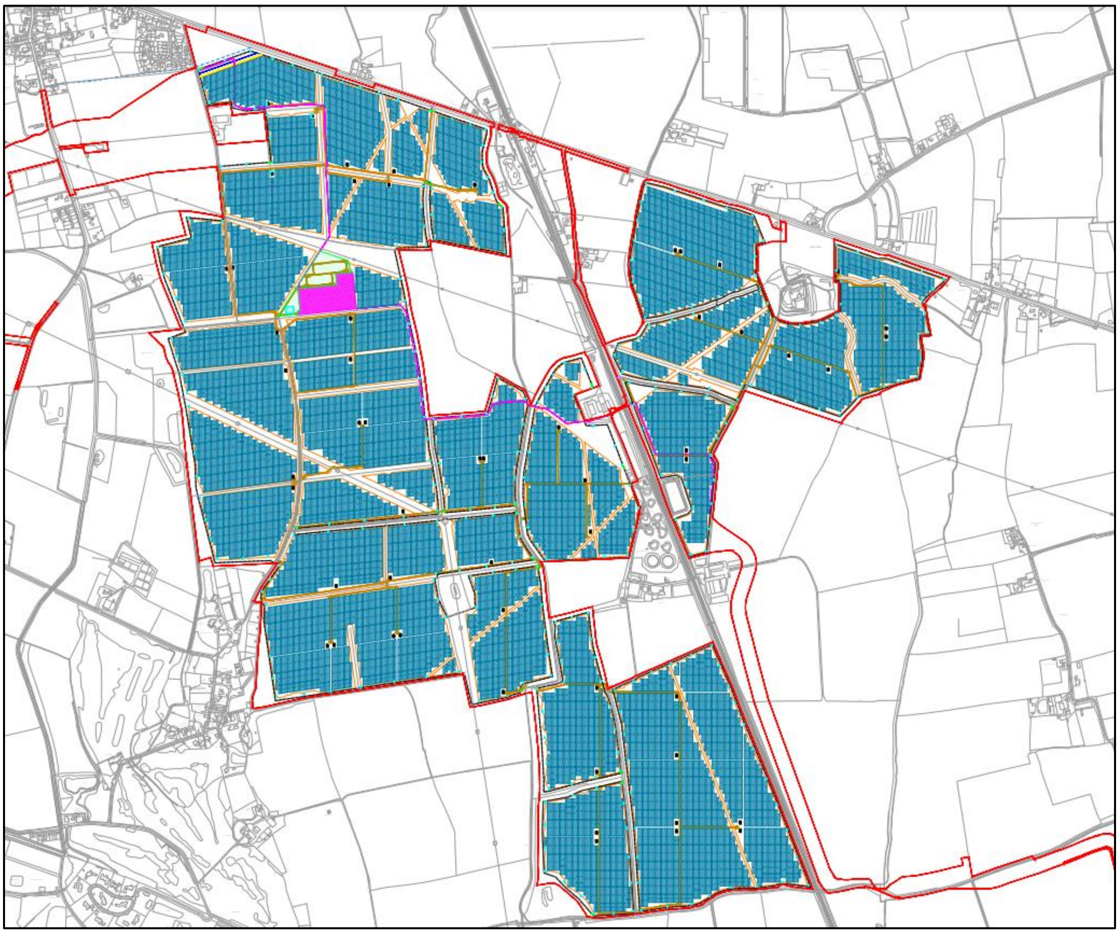

Figure 3 *West Burton 3 site layout*

2.2 Proposed Development Location – Aerial Image

Figure 4 below shows the panel areas (blue outlined polygons).

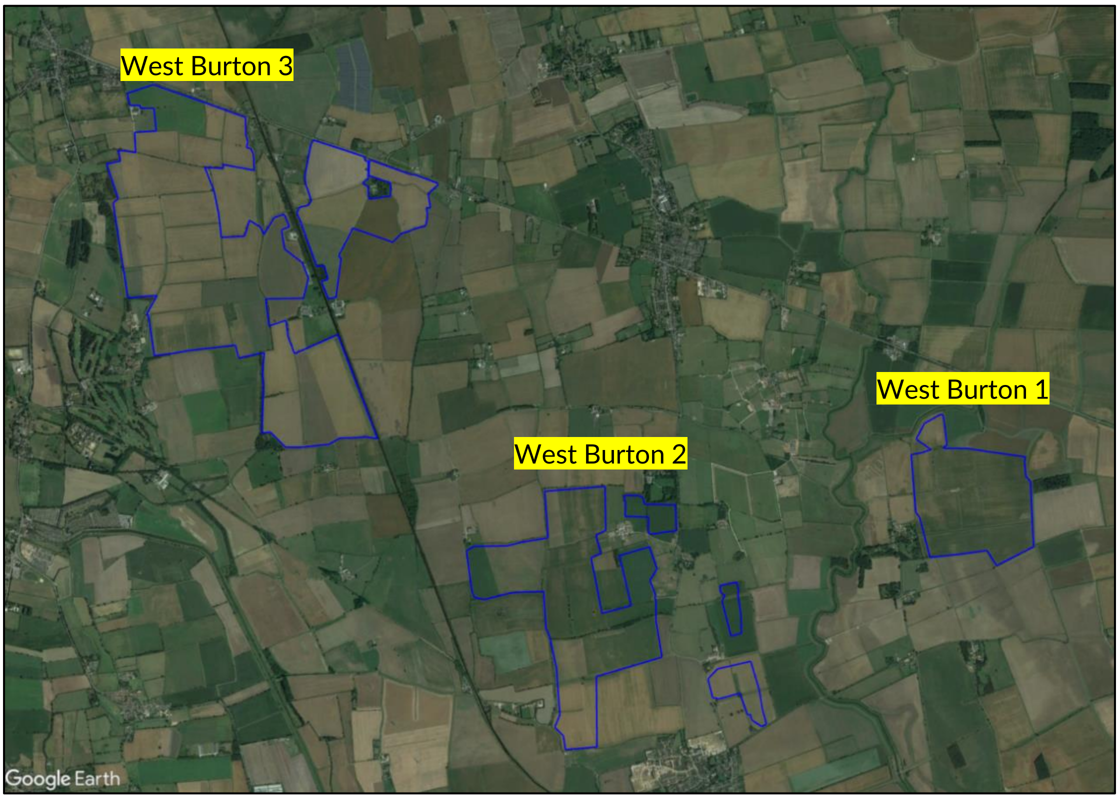

Figure 4 *Proposed development location – aerial image*

2.3 Solar Panel Technical Information

The Applicant has requested to model the sites considering two mounting options: fixed and tracking. The characteristics used in the modelling are shown in the sections below.

Fixed System

Solar Panel Technical Information	
Assessed centre-height[13-14] (m)	2.65 agl (above ground level)
Tilt[14] (°)	25
Orientation (°)	180 (due south)

Table 1 *Fixed panel system: solar panel technical information*

Solar Panel Backtracking

The technical information used for the modelling are presented in Table 2 below.

Solar Panel Technical Information	
Assessed centre-height (m)	2.5 agl (above ground level)
Tracking	Horizontal Single Axis tracks Sun East to West
Tilt of tracking axis (°)	0
Orientation of tracking axis (°)	180
Offset angle of module (°)	0
Tracker Range of Motion (°)	±60
Resting angle (°)	0
Surface material	Smooth glass without an ARC (anti-reflective coating)

Table 2 *Tracking panel system: solar panel technical information*

Shading considerations dictate the panel tilt. This is affected by:

- The elevation angle of the Sun;
- The vertical tilt of the panels;
- The spacing between the panel rows.

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[13] The middle of the solar panel has been used as the assessed height in metres above ground level (agl), which has been chosen as it represents the smallest possible variation in height from the bottom and top of the solar panels. The small variation in panel height will not change the conclusions of the report because the modelling results are unlikely to be meaningfully affected. When the visibility of the solar panels for ground-based receptors is discussed, the maximum height of the panel is considered since it will be the most visible part of the panel.

[14] This value has been provided to Pager Power by IGP.

This means that early in the morning and late in the evening, the panels will not be directed exactly towards the Sun, as the loss from shading of the panels (caused by facing the sun directly when the Sun is low in the horizon), would be greater than the loss from lowering the panels to a less direct angle in order to avoid the shading Figure 5 below illustrates this.

The graphics in Figure 5 show two lines illustrating the paths of light from the Sun towards the solar panels. In reality, the lines from the Sun to each panel would be effectively parallel due to the large separation distance. The figure is for illustrative purposes only.

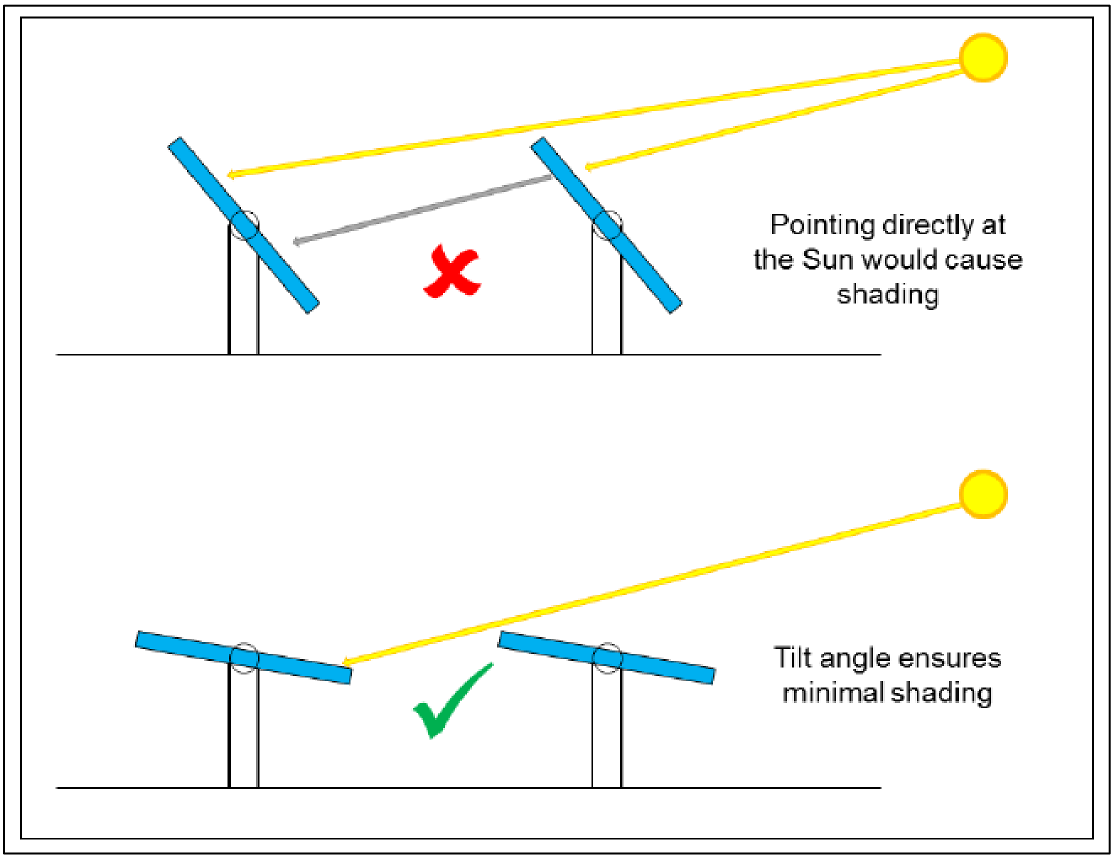

Figure 5 *Shading Considerations*

Later in the day, the panels can be directed towards the Sun without any shading issues. This is illustrated in Figure 6 below.

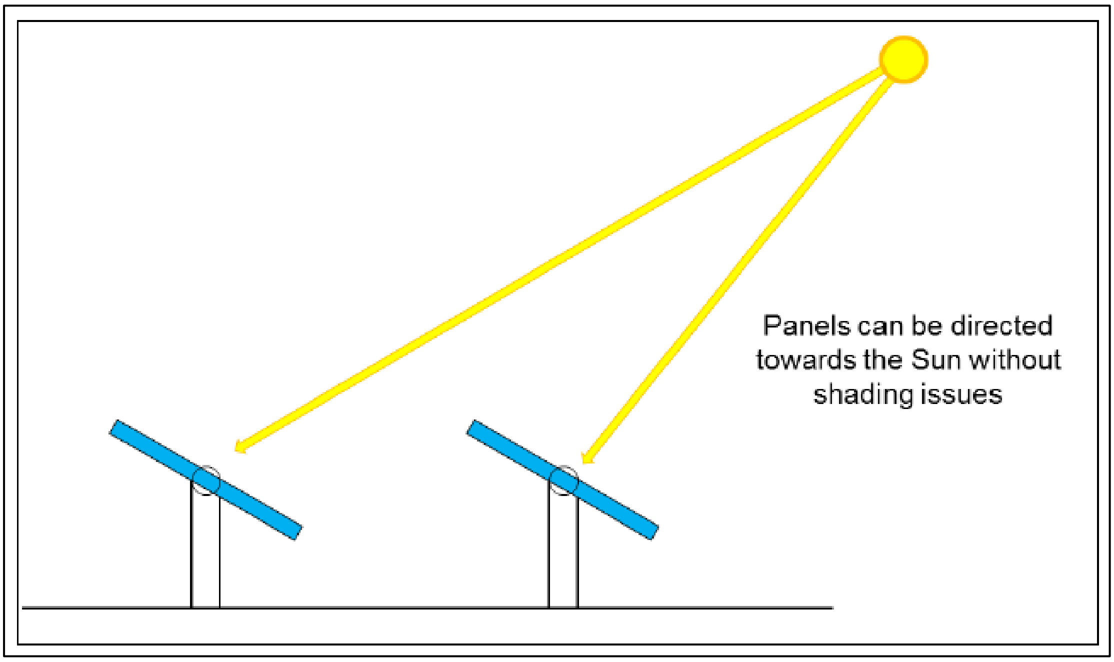

Figure 6 *Panel alignment at high solar angles*

The solar panels backtrack (where the panel angle gradually declines to prevent shading) by reverting to 0 degrees (flat) once the maximum elevation angle of the panels (60 degrees) becomes ineffective due to the low height of the Sun above the horizon and to avoid shading.

Back Tracking Solar Panel Model

Back tracking systems are sensitive to panel length, row spacing, topography and the level of shading which varies throughout the year. The Forge Solar model used in this assessment is a widely accepted model within this area. The model approximates a backtracking system by assuming the panels instantaneously revert to its resting angle of 0 degrees whenever the sun is outside the rotation range (60 degrees in this instance). Panels with a maximum tracking angle of 60 degrees and resting angle of 0 degrees would therefore lie horizontally from sunrise until the Sun enters the rotation range, and immediately after the sun leaves the rotation range until sunset daily. This definition is taken from Forge and by rotation range it is assumed the panels remain at 0 degrees until the Sun reaches 30 degrees above the horizon – when the Sun is at right angles to the panels at 60 degrees. It is understood that this option was created specifically to account for backtracking to the extent possible.

Whilst this model simplifies the backtracking process to be used by the solar panels within the solar development, panels that revert to their resting angle immediately in many cases present a worst-case scenario for reflectors. This is because flatter panels can produce solar reflections in a much greater range of azimuth angles at ground level. The results would in most cases be more conservative than modelling a detailed back tracking system.

3 HIGH-LEVEL ASSESSMENT OF AVIATION RECEPTORS AND CONSULTATION

3.1 Overview of Aviation Receptors

Three active aerodromes have been identified for assessment, these are:

1. Sturgate Airfield: 3.2km south of West Burton 2, two approaches 09/27;
2. RAF Scampton: 4.2km south-east of West Burton 1, two approaches 04/24;
3. Doncaster Sheffield Airport: 24km north-west of West Burton 3, two approaches 02/20.

Their locations (including runway approach paths) relative to the proposed developments are shown in Figure 7 below. Receptor details can be found in Appendix G.

3.2 Aviation Receptors – Consultation

Pager Power has consulted with the safeguarding teams at Sturgate, RAF Scampton and Doncaster Sheffield Airport with regard to the effect of the proposed development upon aviation operation at the two airfields. The safeguarding teams have responded with no objections to West Burton sites 1, 2 and 3.

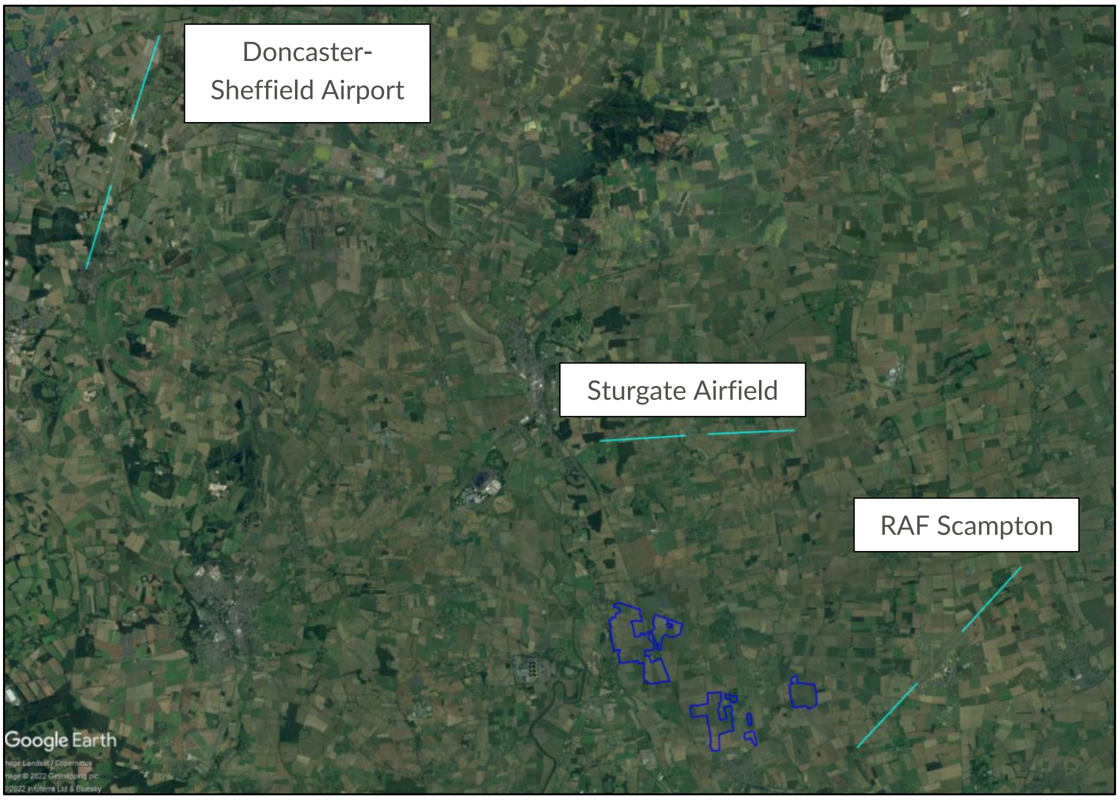

Figure 7 *Licenced and unlicensed airfield locations relative to the proposed developments*

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[15] 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 (i.e. bare aluminium, water or snow).

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 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.

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.

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[15] See Appendix B

5 IDENTIFICATION OF RECEPTORS

5.1 Ground-Based Receptors

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

The above parameters and extensive experience over a significant number of glint and glare assessments undertaken, show that a 1km assessment area from the proposed panel area is appropriate for glint and glare effects on ground-based receptors (road users and dwellings), and a 500m[16] assessment area is appropriate for railway receptors. Receptors have been modelled with the panel areas respective to their 1km assessment area; however, a cumulative assessment area has been presented in the following figures.

Potential receptors within the 1km 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 Ordnance Survey of Great Britain (OSGB) 50m Panorama data. Receptor details can be found in Appendix G.

5.2 Dwelling Receptors

Overview

The analysis has considered dwellings that:

- Are within the 1km assessment area; and
- Have a potential view of the panels.

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[17].

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.

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[16] This smaller study area has been identified during consultation with Network Rail.

[17] This height is used for modelling purposes and all floors are considered in the results discussion where appropriate.

Some of the identified dwellings 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.

West Burton 1

In total, 35 dwelling receptors points have been identified for the assessment of this area. The assessed dwellings are shown in Figure 8 below.

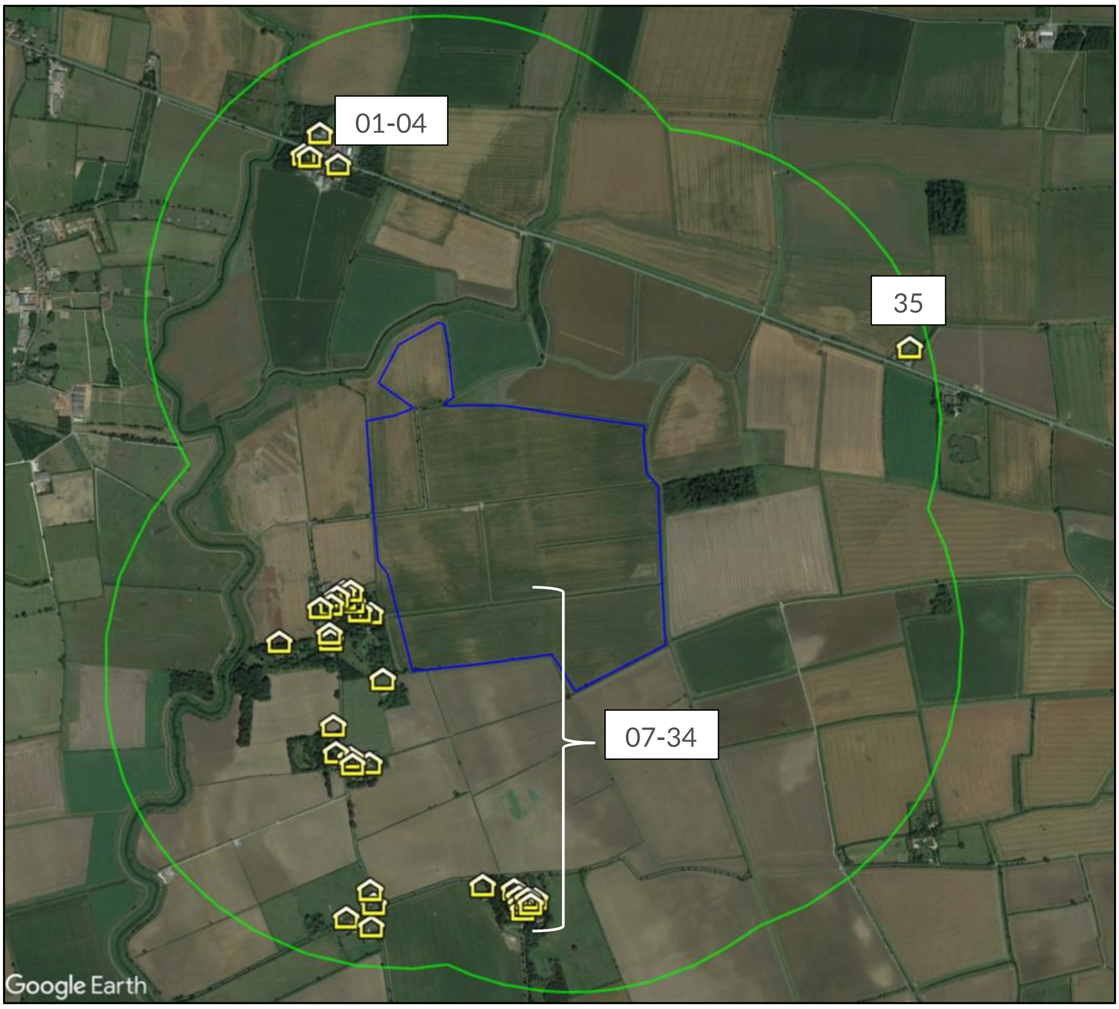

Figure 8 *West Burton 1: all dwellings 1 to 35*

West Burton 2

In total, 83 dwelling receptors points have been identified for the assessment of this area. The assessed dwellings are shown in Figure 9 below.

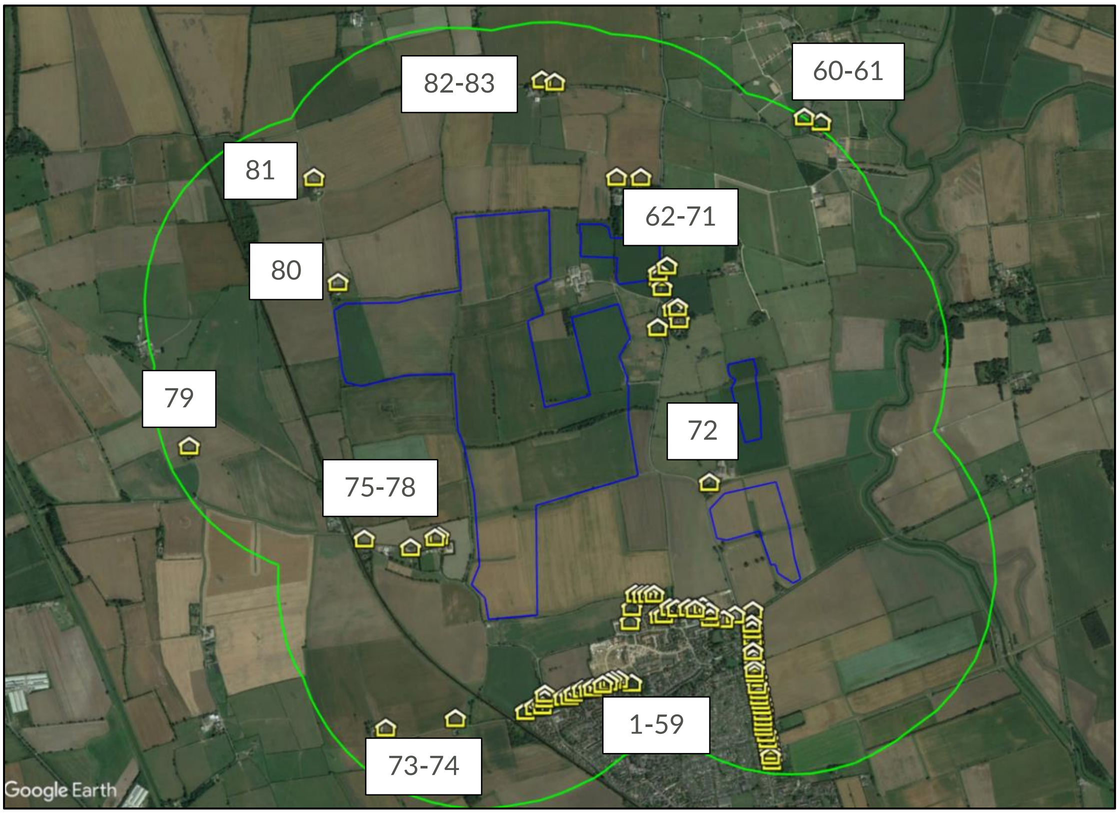

Figure 9 *West Burton 2: all dwellings 1 to 83*

West Burton 3

In total, 100 dwelling receptors points have been identified for the assessment of this area. The assessed dwellings are shown in Figure 10 below.

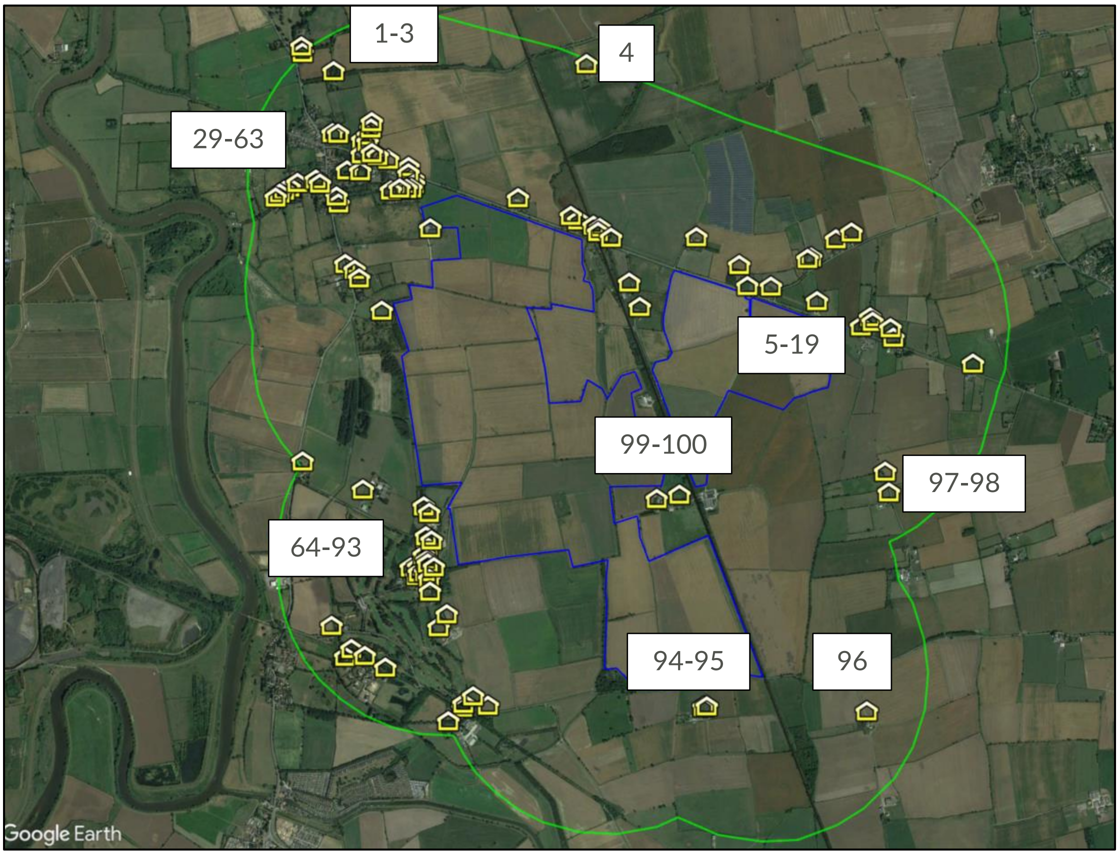

Figure 10 *West Burton 3: all dwelling locations 1 to 100*

5.3 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.

Major National, National and Regional are predicted to have higher level of traffic compared to local roads and have higher sensitivity. Therefore, these roads are taken forwards for the technical modelling.

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

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

- Are within the 1km assessment areas.
- Have a potential view of the panels.

West Burton 1

One road has been identified for the assessment (Till Bridge Lane) which is shown in Figure 11 on the following page. In total, 26 road receptor points have been identified for the assessment of this area.

Figure 11 *West Burton 1 – Till Bridge Lane*

West Burton 2

In total, 53 road receptor points have been identified for the assessment of this area over two roads: Sturton road and Church Road, shown in Figure 12 below.

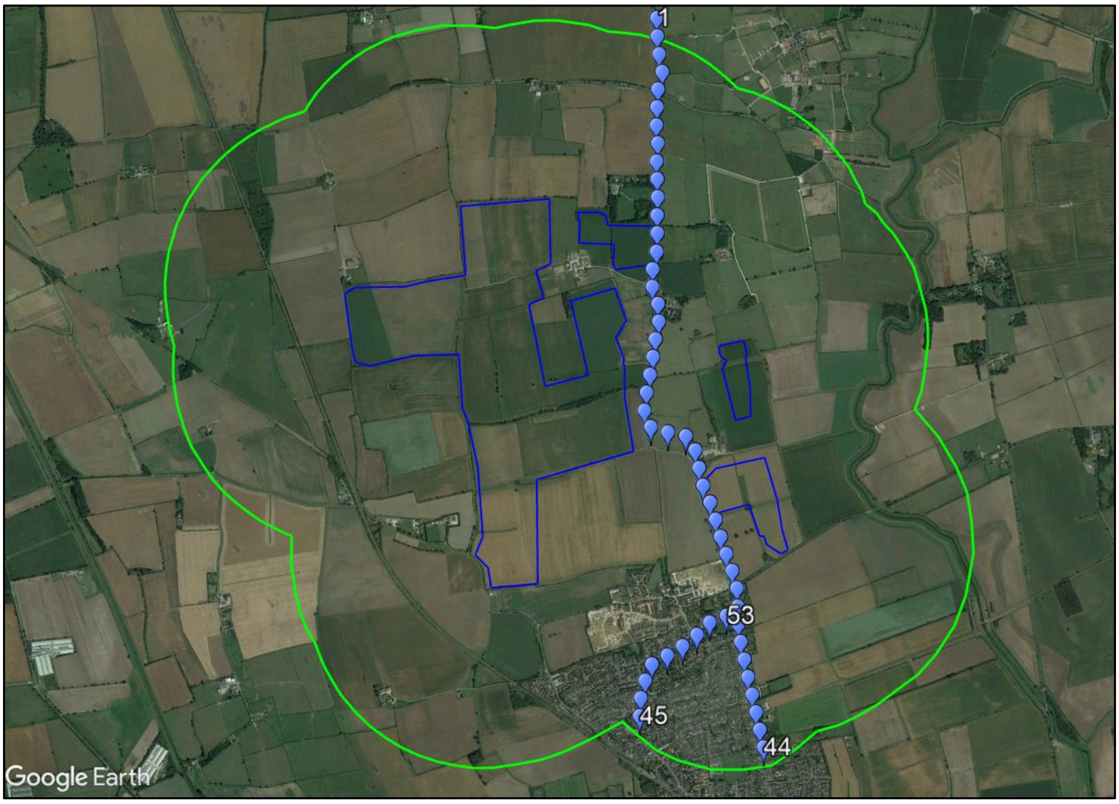

Figure 12 *West Burton 2- Sturton road and Church Road*

West Burton 3

In total, 79 road receptor points have been identified for the assessment of this area over two roads: A156 and A1500, shown in Figure 13 below.

Figure 13 *West Burton 3 - A156 and A1500*

5.4 Railway Receptors

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 that affect railway signals.

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

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.[18]'

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) describes disability glare as[19]:

'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.'

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[18] Source: Glossary of Signalling Terms, Railway Group Guidance Note GK/GN0802. Issue One. Date April 2004.
[19] CIE 146:2002 & CIE 147:2002 Collection on glare (2002).

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).

5.4.1 Railway Signal Receptors

The analysis has considered railway signal receptors that:

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

The impact of solar reflections upon railway signals has been assessed by considering the height and location of any identified signals. No potential signal locations were identified along the assessed section of railway line using available imagery and have therefore not been assessed. Network Rail has been contacted to confirm the location of any signals at these locations; however, no response has been received to date. Once a response has been received, the report can be updated.

5.4.2 Train Driver Receptors

Sections of railway line within close proximity (typically within 100-200m) of the proposed development are often required for assessment. When required, a 500m assessment area is considered appropriate.

The analysis has, therefore, considered train driver receptors that:

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

The identified train driver receptor points along the assessed section of railway line are shown in Figure 14 on the following page, for West Burton 3. Based on previous UK-based consultation with Network Rail, a train driver's eye level is typically 2.75m above rail level.

Figure 14 *West Burton 3 - train driver receptors*

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[20]. The flowcharts setting out the impact characterisation are presented in Appendix D[21]. 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.

6.2 Summary of Results

The tables in the following subsections summarise the results of the assessment. The predicted glare times are based solely on bare-earth terrain i.e. without consideration of screening from buildings and vegetation.

The significance of any predicted impact is discussed in the subsequent report sections. The modelling output showing the precise predicted times and the reflecting panel area is shown in Appendix H.

[20] Solar Photovoltaic Development – Glint and Glare Guidance Issue 4.0, August 2022.

[21] 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.

6.3 Geometric Calculation Results – Dwelling Receptors

Refer to Section 7.1 for a discussion of the following results. The results for a tracking mounted system are found within Section 6.3.2.

Fixed System

6.3.1.1 West Burton 1

Dwelling Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-4	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
5-18	Yes.	No.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly reduce the visibility of the reflective area. Therefore, no impact is predicted, and mitigation is not required.
19-22	Yes.	No.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly reduce the visibility of the reflective area. Therefore, no impact is predicted, and mitigation is not required.
23-34	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
35	No.	Yes.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly reduce the visibility of the reflective area. Therefore, no impact is predicted, and mitigation is not required.

Table 3 *Geometric analysis results for dwelling receptors (West Burton 1)*

6.3.1.2 West Burton 2

Dwelling Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-16	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
17-29	Yes.	Yes.	Solar reflections geometrically possible. However, screening in the form of existing vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
30-53	No.	Yes.	Solar reflections geometrically possible. However, screening in the form of existing vegetation and other buildings has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
54-71	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
72	Yes.	Yes.	Solar reflections geometrically possible. However, screening in the form of existing vegetation and other buildings has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
73-79	Yes.	No.	Solar reflections geometrically possible. However, screening in the form of existing vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
80	Yes.	No.	Solar reflections geometrically possible. However, low impact is predicted due to a combination of existing mitigating factors and further mitigation is not judged a requirement.
81-83	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.

Table 4 Geometric analysis results for dwelling receptors (West Burton 2)

6.3.1.3 West Burton 3

Dwelling Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-4	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
5-8	No.	Yes.	Solar reflections geometrically possible. However, screening in the form of existing vegetation and other buildings has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
9-17	No.	Yes.	Solar reflections geometrically possible. However, screening in the form of existing vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
18-25	No.	Yes.	Solar reflections geometrically possible. However, screening in the form of existing vegetation and other buildings has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
26-27	Yes.	Yes.	Solar reflections geometrically possible. However, screening in the form of existing vegetation and other buildings has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
28	No.	Yes.	Solar reflections geometrically possible. However, screening in the form of existing vegetation and other buildings has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
29-31	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.

Dwelling Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
32-36	Yes.	No.	Solar reflections geometrically possible. However, screening in the form of existing vegetation and other buildings has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
37-49	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
50-51	Yes.	No.	Solar reflections geometrically possible. However, screening in the form of existing vegetation and other buildings has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
52-55	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
56-58	Yes.	No.	Solar reflections geometrically possible. However, screening in the form of existing vegetation and other buildings has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
59	Yes.	No.	Solar reflections are geometrically possible. However, proposed screening is predicted to significantly reduce views of the proposed development from an observer located at the ground floor. Therefore, low impact is predicted, and no further mitigation is required.
60-93	Yes.	No.	Solar reflections geometrically possible. However, screening in the form of existing vegetation and other buildings has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
94	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.

Dwelling Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
95	No.	Yes.	Solar reflections geometrically possible. However, screening in the form of existing vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
96-100	No.	Yes.	Solar reflections geometrically possible. However, screening in the form of existing vegetation and other buildings has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.

Table 5 *Geometric analysis results for dwelling receptors (West Burton 3)*

Tracking System

6.3.1.4 West Burton 1

Dwelling Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-4	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
5-24	Yes.	No.	Solar reflections geometrically possible. However, screening in the form of existing vegetation and other buildings has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
25	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
26	Yes.	No.	Solar reflections geometrically possible. However, screening in the form of existing vegetation and other buildings has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.

Dwelling Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
27-34	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
35	No.	Yes.	Solar reflections geometrically possible. However, screening in the form of existing vegetation and other buildings has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.

Table 6 *Geometric analysis results for dwelling receptors (West Burton 1)*

6.3.1.5 West Burton 2

Dwelling Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-8	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
9	No.	Yes.	Solar reflections geometrically possible. However, screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
10-34	Yes.	Yes.	Solar reflections geometrically possible. However, screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
35-40	No.	Yes.	Solar reflections geometrically possible. However, screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
41-63	No.	Yes.	Solar reflections geometrically possible. However, screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.

Dwelling Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
64-66	Yes.	Yes.	Solar reflections geometrically possible. However, screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
67-68	No.	Yes.	Solar reflections geometrically possible. However, screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
69-72	Yes.	Yes.	Solar reflections geometrically possible. However, screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
73	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
74-81	Yes.	No.	Solar reflections geometrically possible. However, screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
82-83	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.

Table 7 *Geometric analysis results for dwelling receptors (West Burton 2)*

6.3.1.6 West Burton 3

Dwelling Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-3	Yes.	Yes.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.

Dwelling Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
4	Yes.	Yes.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.
5-14	No.	Yes.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.
15	Yes.	Yes.	Solar reflections are geometrically possible. However, proposed screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.
16	Yes.	Yes.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.
17	Yes.	Yes.	The model output shows that solar reflections are possible. However, proposed screening is predicted to significantly reduce views of the proposed development from an observer located at the ground floor. Therefore, low impact is predicted, and no further mitigation is required.
18-28	Yes.	Yes.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.
29-40	Yes.	No.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.
41-58	Yes.	No.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.

Dwelling Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
59	Yes.	Yes.	The model output shows that solar reflections are possible. However, proposed screening is predicted to significantly reduce views of the proposed development from an observer located at the ground floor. Therefore, low impact is predicted, and no further mitigation is required.
60-63	Yes.	No.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.
64-93	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
94-95	No.	Yes.	Solar reflections are geometrically possible. However, proposed screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.
96	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
97-100	No.	Yes.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.

Table 8 *Geometric analysis results for dwelling receptors (West Burton 3)*

6.4 Geometric Calculation Results – Road Receptors

Refer to Section 7.2 for a discussion of the following results. The results for a tracking mounted system are found within Section 6.4.2.

Fixed System

6.4.1.1 West Burton 1

Road Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-22	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
23-26	No.	Yes.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly reduce the visibility of the reflective area. Therefore, no impact is predicted, and mitigation is not required.

Table 9 *Geometric analysis results for road receptors (Till Bridge Lane)*

6.4.1.2 West Burton 2

Road Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-10	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
11-18	No.	Yes.	Solar reflections geometrically possible. However, existing and other mitigating factors are predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
19-23	Yes.	Yes.	Solar reflections geometrically possible. However, existing and other mitigating factors are predicted to significantly reduce the visibility of the proposed development. No impact is predicted.

Road Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
24-25	Yes.	Yes.	Solar reflections geometrically possible. However, proposed screening is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
26	No.	Yes.	Solar reflections geometrically possible. However, proposed screening is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
27	Yes.	Yes.	Solar reflections geometrically possible. However, proposed screening is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
28-33	Yes.	Yes.	Solar reflections geometrically possible. However, existing and other mitigating factors are predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
34-40	No.	Yes.	Solar reflections geometrically possible. However, existing screening is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
41-49	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
50-53	No.	Yes.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.

Table 10 *Geometric analysis results for road receptors (Sturton road and Church Road)*

6.4.1.3 West Burton 3

Road Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-9	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
10-17	Yes.	No.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
18-36	Yes.	No.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
37-70	No.	Yes.	Solar reflections are geometrically possible. However, existing screening is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
71-79	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.

Table 11 *Geometric analysis results for road receptors (A156 and A1500)*

Tracking System

6.4.1.4 West Burton 1

Road Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-26	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.

Table 12 *Geometric analysis results for road receptors (Till Bridge Lane)*

6.4.1.5 West Burton 2

Road Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-6	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
7-10	No.	Yes.	Solar reflections geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
11	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
12-13	No.	Yes.	Solar reflections geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
14	Yes.	Yes.	Solar reflections geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
15	No.	Yes.	Solar reflections geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
16-23	Yes.	Yes.	Solar reflections geometrically possible. However, existing and other mitigating factors are predicted to significantly reduce the visibility of the proposed development. No impact is predicted.

Road Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
24-27	Yes.	Yes.	Solar reflections geometrically possible. However, proposed screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
28	Yes.	Yes.	Solar reflections are geometrically possible. However, the reflecting panel area is outside the road user's primary field of view. Therefore, a low impact is predicted and mitigation is not recommended.
29	No.	Yes.	Solar reflections geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
30-33	Yes.	Yes.	Solar reflections geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
34-44	No.	Yes	Solar reflections geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.
45	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
46-53	No.	Yes.	Solar reflections geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the proposed development. No impact is predicted.

Table 13 *Geometric analysis results for road receptors (Sturton road and Church Road)*

6.4.1.6 West Burton 3

Road Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-15	Yes.	No.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.
16-24	Yes.	No.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.
25-36	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
37-40	No.	Yes.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.
41-79	Yes.	Yes.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.

Table 14 *Geometric analysis results for road receptors (A156 and A1500)*

6.5 Geometric Calculation Results – Train Driver Receptors

Refer to Section 7.3 for a discussion of the following results. The results for a tracking mounted system are found within Section 6.5.2.

Fixed System

Railway Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-4	No.	No.	Solar reflections are not geometrically possible. Therefore, no impact is predicted, and no mitigation is required.
5-10	No.	Yes.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.
11-23	Yes.	Yes.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.
24-40	No.	Yes.	Solar reflections are geometrically possible. However, existing screening in the form of vegetation has been identified which is predicted to significantly reduce the visibility of the reflective area. No impact is predicted.

Table 15 *Geometric analysis results for train driver receptors (West Burton 3)*

Tracking System

Railway Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-13	Yes.	Yes.	Solar reflections geometrically possible. However, existing screening in the form of vegetation has been identified. No impact is predicted.

Railway Receptor	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
14-40	No.	Yes.	Solar reflections geometrically possible. However, existing screening in the form of vegetation has been identified. No impact is predicted.

Table 16 *Geometric analysis results for train driver receptors (West Burton 3)*

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Dwelling Results

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

- Whether a significant reflection is predicted to be experienced in practice.
- The duration of the predicted effects, relative to thresholds[22] of:
  - 3 months per year.
  - 60 minutes per day.

Where reflections are predicted to be experienced for less than 3 months per year and less than 60 minutes per day or where the separation distance to the nearest visible reflecting panel is over 1km, the impact significance is low, and mitigation is not required.

Where reflections are predicted to be experienced for more than 3 months per year or for more than 60 minutes per day, the impact significance is moderate and expert assessment of the following mitigating factors is required to determine the 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. The Sun is a far more significant source of light.
- Whether solar reflections will be experienced from all storeys. The ground floor is typically considered the main living space[23] and therefore has a greater significance with respect to residential amenity.
- Whether the dwelling appears to have windows facing the reflecting areas. An observer may need to look at an acute angle to observe the reflecting areas.

Where reflections are predicted to be experienced for more than 3 months per year and more than 60 minutes per day, the impact significance is high, and mitigation is required.

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.

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[22] This threshold was identified by Pager Power and implemented within its Glint and Glare guidance. The threshold is derived from the shadow flicker guidance which states that effects for more than 30 minutes per day, over 30 hours of the year are significant and requires mitigation. Since effects of glint and glare less significant than shadow flicker, the duration beyond which mitigation should be required for glint and glare is longer than for shadow flicker.

[23] This is true for most dwellings however it does not apply to apartment blocks where the main living area is located on each floor and visibility from each floor is considered.

Fixed System

7.1.1.1 West Burton 1

Solar reflections are geometrically possible for 19 out of the 35 identified dwelling receptors. Under the baseline scenario, no impacts are predicted towards these dwellings due to the presence of existing screening in the form of vegetation, terrain or buildings that will significantly reduce the visibility of the reflective area from an observer located within the dwelling. Therefore, mitigation is not required. It should be noted, in accordance with the landscape plan, the existing screening will be maintained and infilled.

Figure 15 below shows the dwellings where solar reflections are geometrically possible, for completeness.

Figure 15 *Dwellings where reflections are geometrically possible - West Burton 1*

7.1.1.2 West Burton 2

Solar reflections are geometrically possible for 46 out of the 83 identified dwelling receptors. Under the baseline scenario, no significant impacts are predicted towards the dwellings due to:

- Existing screening in the form of vegetation, terrain or building will significantly reduce the visibility of the reflective area from an observer located within the dwelling (no impact);
- If visibility of the reflective area is possible one or more of the following mitigating factors have been identified (low impact) (dwelling 80):
  - The distance between the dwellings and the reflective area is sufficiently large to reduce the glint and glare significance;
  - The reflective area is not visible to observers located at the ground floor;

- Sun light and reflective area are predicted to originate from the same point in space (the Sun is a much brighter source of light).

Figure 16 below shows the dwellings where solar reflections are geometrically possible, for completeness.

Figure 16 *Dwellings where reflections are geometrically possible - West Burton 2*

The proposed screening will remove the views of the reflecting panel area for dwelling 80 where a low impact is predicted. Therefore, no impacts will be predicted towards any of the identified dwellings, after the implementation of the proposed screening.

7.1.1.3 West burton 3

Solar reflections are geometrically possible for 75 out of the 100 identified dwelling receptors. Under the baseline scenario, significant (moderate adverse) impacts are predicted towards one dwelling (59). The remaining dwellings are predicted to experience no significant impacts due to:

- Existing screening in the form of vegetation, terrain or building will significantly reduce the visibility of the reflective area from an observer located within the dwelling (no impact);
- If visibility of the reflective area is possible one or more of the following mitigating factors have been identified (low impact) (dwelling 80):
  - The distance between the dwellings and the reflective area is sufficiently large to reduce the glint and glare significance;
  - The reflective area is not visible to observers located at the ground floor;

- Sun light and reflective area are predicted to originate from the same point in space (the Sun is a much brighter source of light);
- The duration of effects is significantly low – less than 3 months per year and 60 minutes per day.

Figure 17 below shows the dwellings where solar reflections are geometrically possible, for completeness.

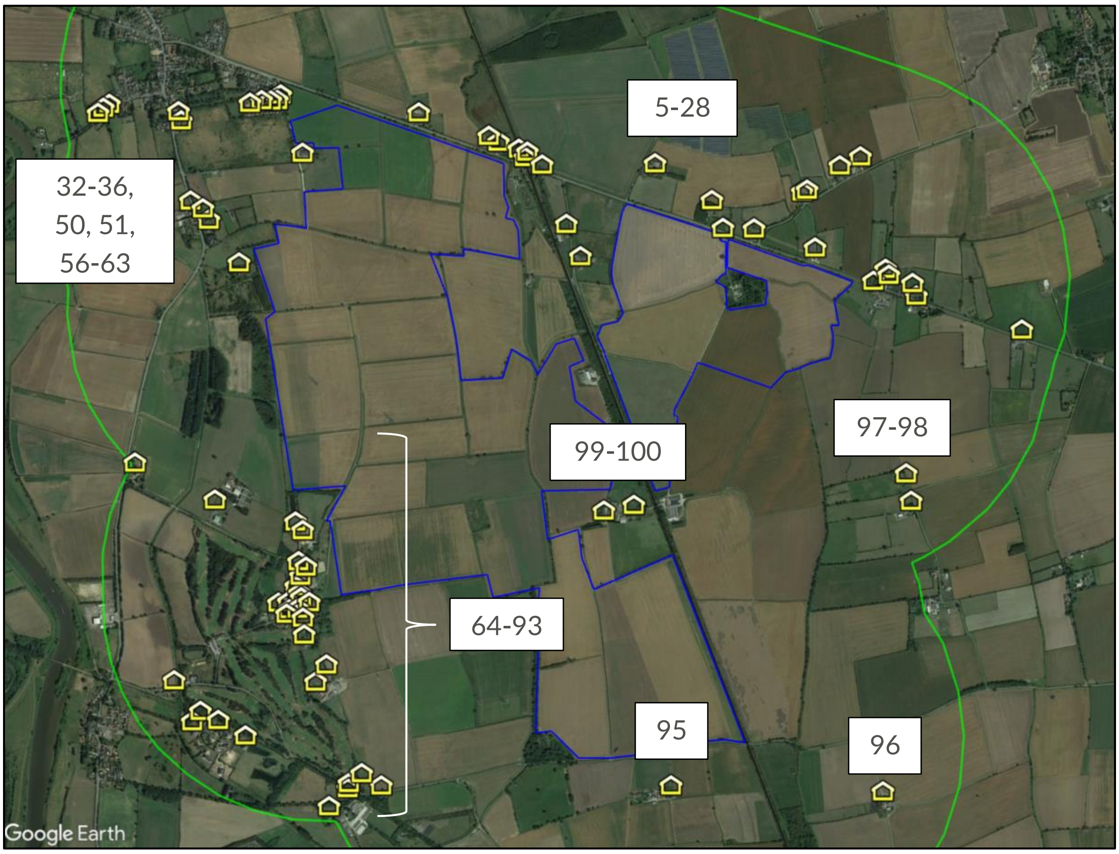

Figure 17 *Dwellings where reflections are geometrically possible - West Burton 3*

In order to reduce the impact, the developer has proposed screening in the form of vegetation. The proposed screening for dwelling 59 is shown in Figure 18 on the following page (the reflective areas are represented by the yellow areas). It is predicted that the proposed screening will significantly reduce the views of the reflective area from an observer located at the ground floor. If necessary, the developer will implement an interim mitigation measure (opaque fencing) before the screening in the form of vegetation is established. Therefore, a maximum low impact is predicted, and no further mitigation is recommended.

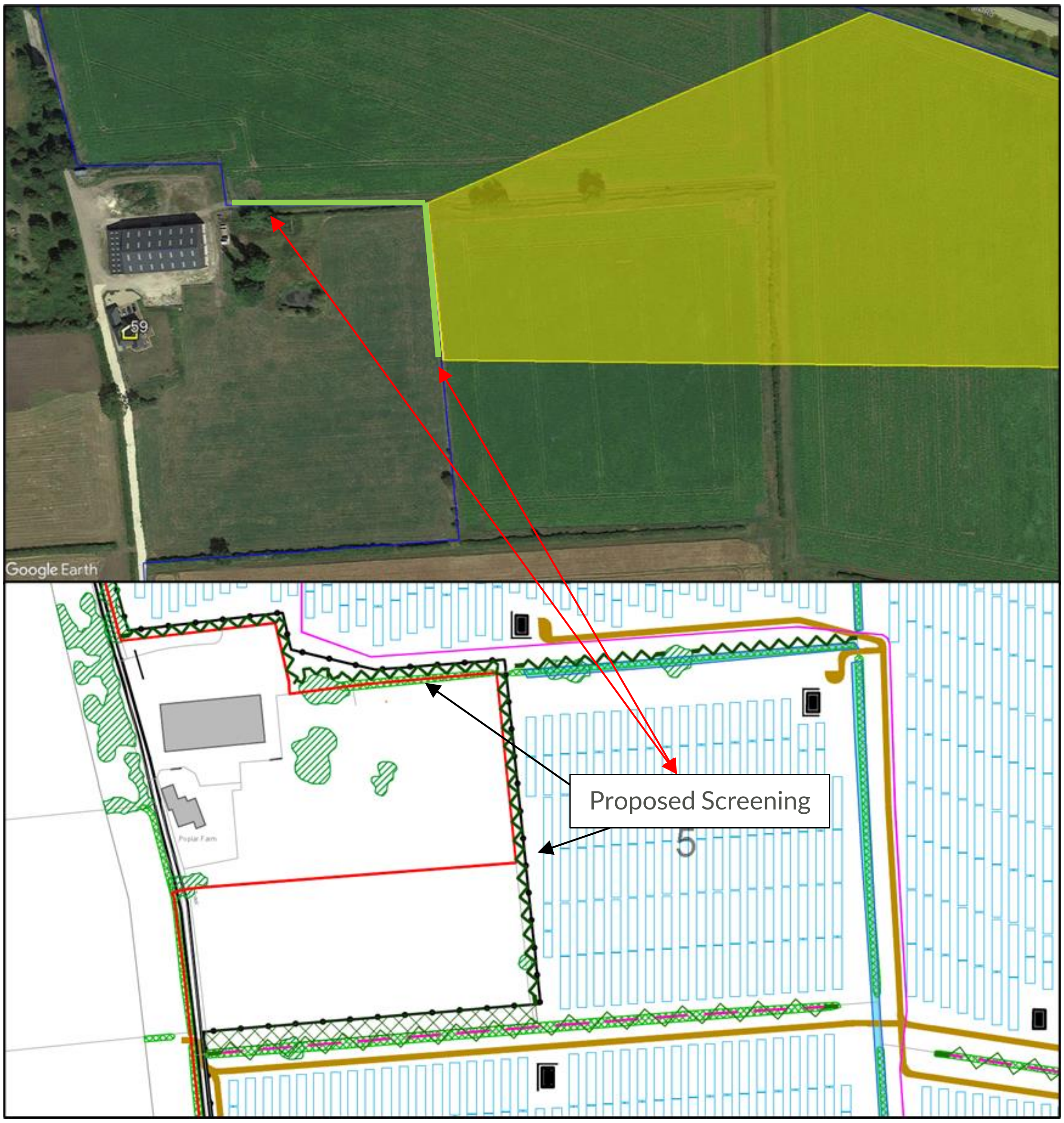

Figure 18 *Reflecting area and proposed screening for dwelling 59*

Tracking System

7.1.1.4 West Burton 1

Solar reflections are geometrically possible for 22 out of the 35 identified dwelling receptors. Under the baseline scenario, no impacts are predicted towards these dwellings due to the presence of existing and proposed screening in the form of vegetation, terrain or building that will significantly reduce the visibility of the reflective area from an observer located within the dwelling. Therefore, mitigation is not required. Figure 19 on the following page shows the dwellings where solar reflections are geometrically possible, for completeness.

Figure 19 *Dwellings where reflections are geometrically possible - West Burton 1*

7.1.1.5 West Burton 2

Solar reflections are geometrically possible for 72 out of the 83 identified dwelling receptors. Under the baseline conditions, no significant impacts are predicted towards these dwellings due to:

- Existing screening in the form of vegetation, terrain or building will significantly reduce the visibility of the reflective area from an observer located within the dwelling (no impact);
- If visibility of the reflective area is possible one or more of the following mitigating factors have been identified (low impact) (dwelling 80):
  - The distance between the dwellings and the reflective area is sufficiently large to reduce the glint and glare significance;
  - The reflective area is not visible to observers located at the ground floor;
  - Sun light and reflective area are predicted to originate from the same point in space (the Sun is a much brighter source of light);
  - The duration of effects is significantly low – less than 3 months per year and 60 minutes per day.

Figure 20 on the following page shows the dwellings where solar reflections are geometrically possible, for completeness.

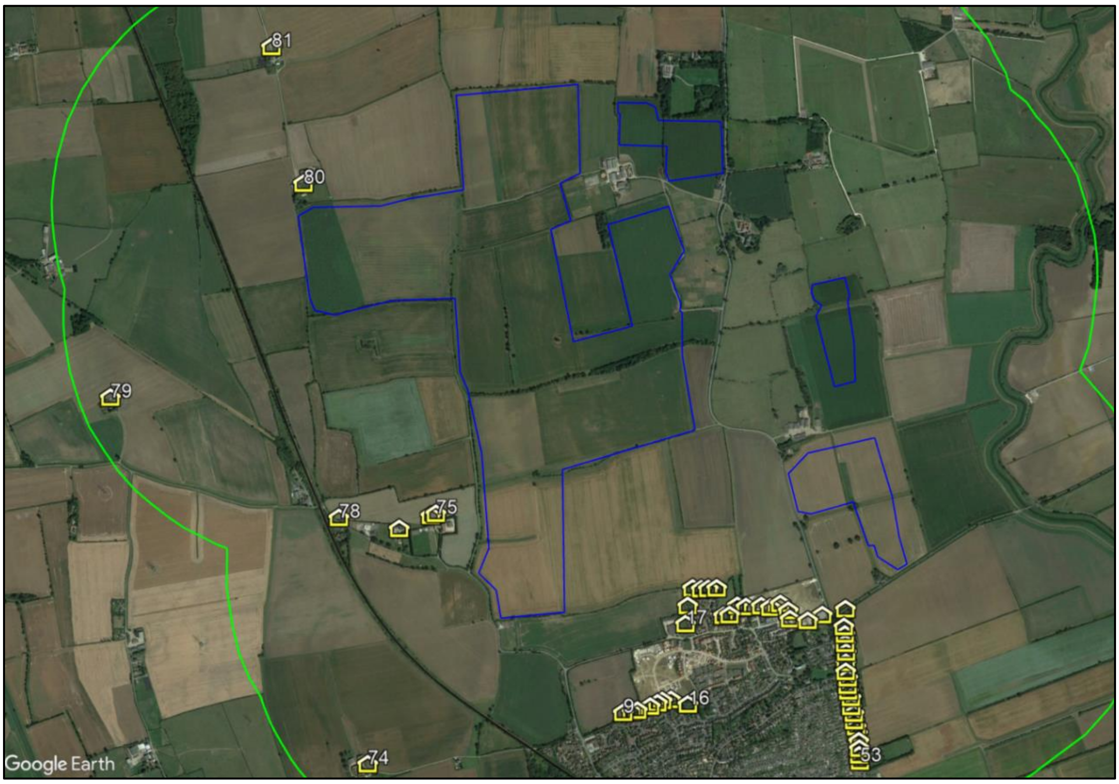

Figure 20 *Dwellings where reflections are geometrically possible - West Burton 2*

7.1.1.6 West Burton 3

Solar reflections are geometrically possible for 69 out of the 100 dwelling receptors. Under the baseline conditions, a significant (moderate adverse) impact is predicted towards two dwellings (17 and 59). For the remaining dwellings, no impacts are predicted towards these dwellings due to the presence of existing and proposed screening in the form of vegetation, terrain or building that will significantly reduce the visibility of the reflective area from an observer located within the dwelling. Therefore, mitigation is not required.

Figure 21 on the following page shows the dwellings where solar reflections are geometrically possible, for completeness.

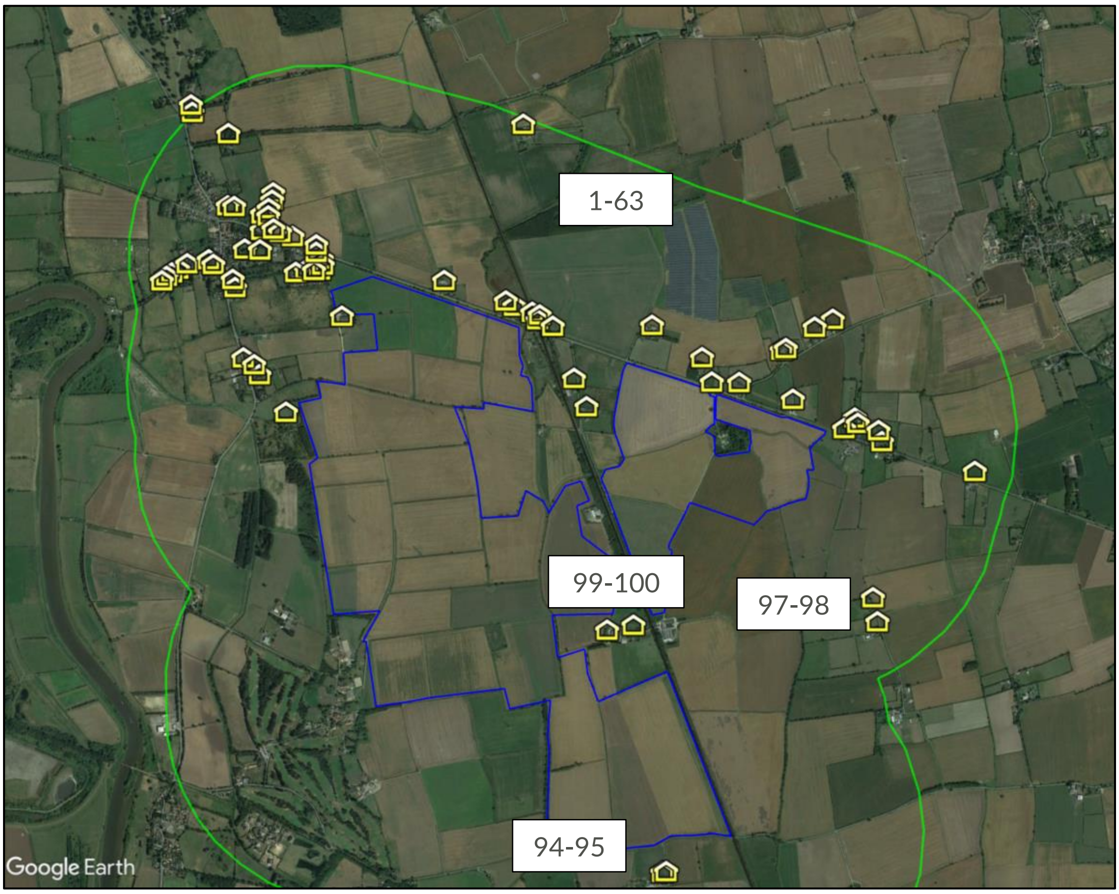

Figure 21 *Dwellings where reflections are geometrically possible - West Burton 3*

In order to reduce the impact, the developer has proposed screening in the form of vegetation. The proposed screening for dwellings 17 and 59 is shown in Figures 22 and 23 on the following page (the reflective areas are represented by the yellow areas). It is predicted that the proposed screening will significantly reduce the views of the reflective area from an observer located at the ground floor. If necessary, the developer will implement an interim mitigation measure (opaque fencing) before the screening in the form of vegetation is established. Therefore, a maximum low impact is predicted, and no further mitigation is recommended.

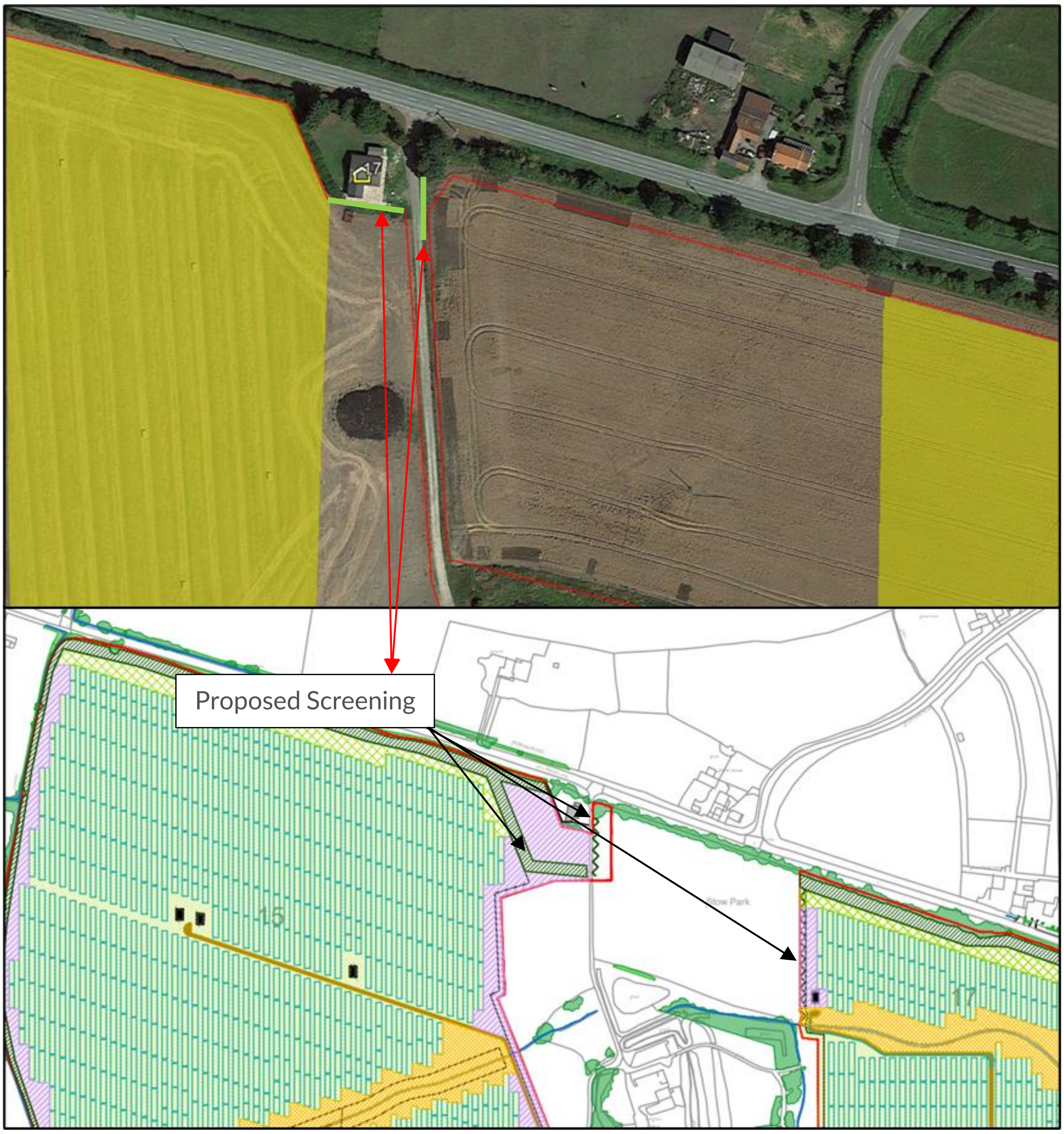

Figure 22 *Reflecting area and proposed screening for dwelling 17*

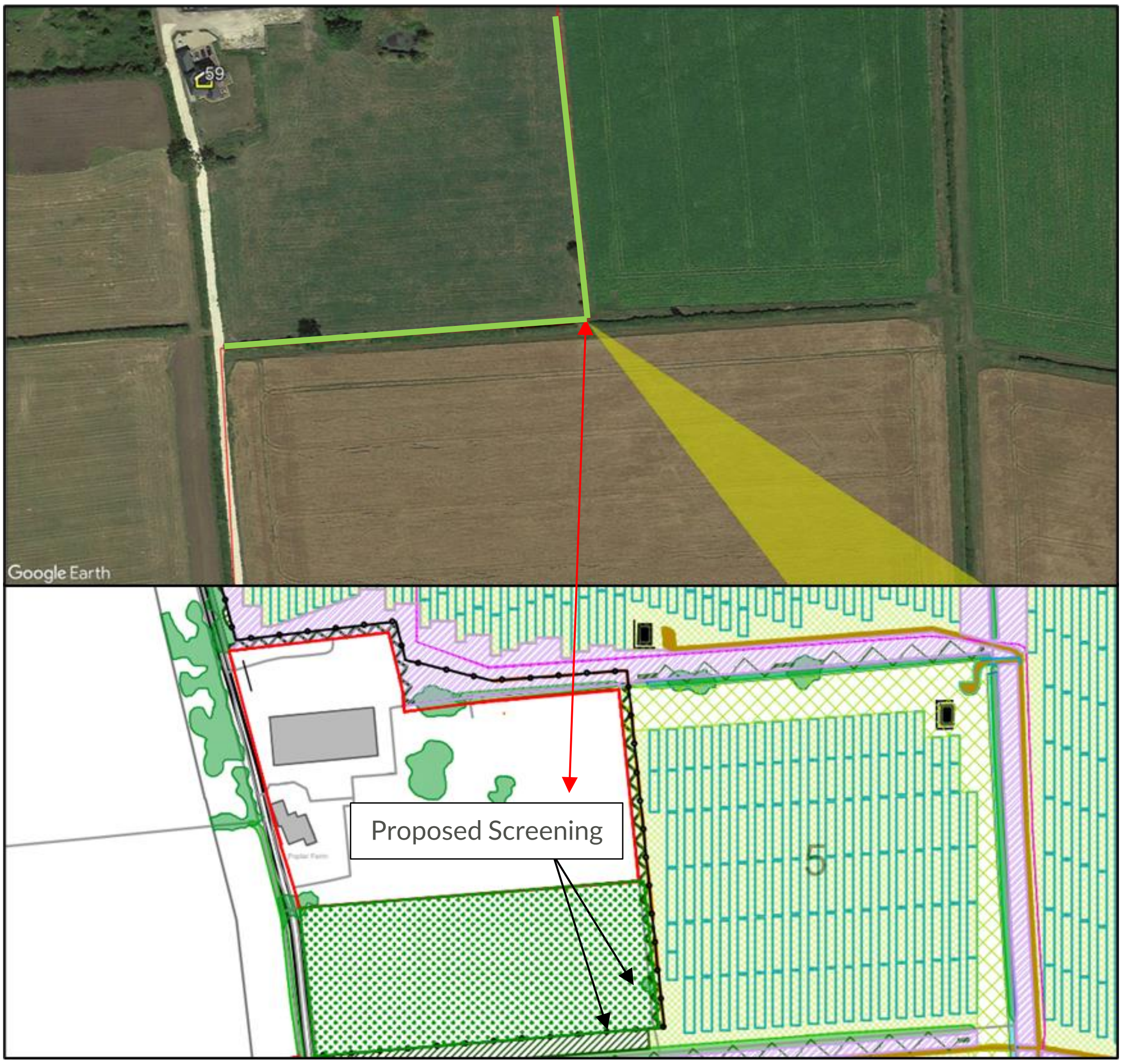

Figure 23 *Reflecting area and proposed screening for dwelling 59*

7.1.1.7 Cumulative Effects - West Burton 2 and 3

One dwelling (receptor 81) is predicted to be within the 1km boundary of both West Burton 2 and 3 and can experience glare from both sites. The dwelling is shown in Figure 24 below.

Figure 24 *Dwelling receptors within West Burton 2 and 3 1km boundary*

Existing screening will significantly reduce views of both sites, furthermore the developer has proposed screening along the site boundary of the reflecting panel area, which will further remove any visibility.

Overall cumulative effects from both sites are not predicted to result in a significant impact upon the identified dwelling. Therefore, no significant cumulative impacts are predicted upon the dwelling located within 1km from West Burton 2 and 3.

7.2 Road Results

For road users along major national, national and regional roads, the key considerations are:

- Whether a reflection is predicted to be experienced in practice.
- 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).

Where reflections are predicted to be experienced from outside of a road user's field of view (50 degrees either side of the direction of travel), the impact significance is low, and mitigation is not required.

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

- Whether visibility is likely for elevated drivers (applicable to dual carriageways and motorways only) – there is typically a higher density of elevated drivers (such as HGVs) along dual carriageways and motorways compared to other types of road;
- 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;
- 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.

Where reflections predicted to be experienced originate from directly in front of a road user and there are no further mitigating circumstances, the impact significance is high, and mitigation is required.

Fixed System

7.2.1.1 West Burton 1

The results of the analysis have shown that solar reflections are geometrically possible along approximately 300m of Till Bridge Lane. Existing screening in the form of vegetation is predicted to significantly reduce the visibility of the proposed development, therefore no impacts are predicted and mitigation is not required.

7.2.1.2 West Burton 2

The results of the analysis have shown that solar reflections are geometrically possible along 3.2km of Sturton Road and 300m of Church Road. Under the baseline scenario, a significant (moderate adverse) impact is predicted along approximately 300m of Sturton Road, between receptors 24-27. However, for the remaining receptors, due to a combination of existing screening and mitigating factors such as the solar reflective area being outside of the road user's primary field of view (50° either side of the direction of travel), further mitigation is not recommended and no significant impacts are predicted.

It is predicted that the proposed screening will significantly reduce views of the reflective area for road users travelling along the 300m section of Sturton Road. The height of the screening will be sufficient to significantly reduce the visibility of the reflecting solar panel from typical road users' drivers. If necessary, the developer will implement an interim mitigation measure (opaque fence) before the screening in the form of vegetation is established.

Figure 25 below shows the affected locations and the proposed screening location.

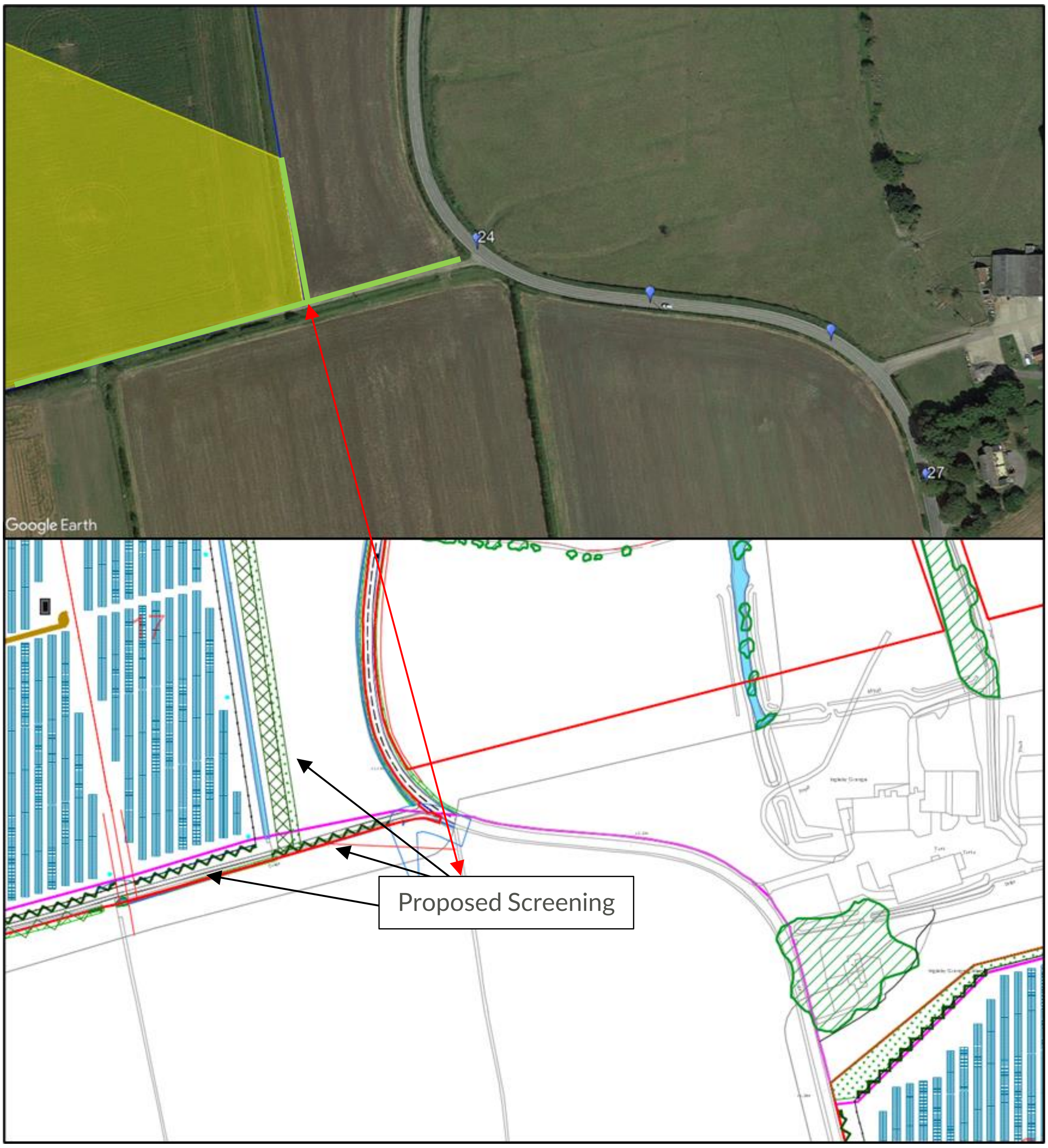

Figure 25 *Reflecting area and proposed screening for receptors 24-27*

7.2.1.3 West Burton 3

The results of the analysis have shown that solar reflections are geometrically possible for along approximately 2.5km of the A156 and 3.4km of the A1500. However, screening in the form of existing and proposed vegetation, as well as buildings will significantly reduce views of the proposed development. Therefore, no impacts are predicted and further mitigation is not required.

Tracking System

7.2.1.4 West Burton 1

The results of the analysis have shown that solar reflections are not geometrically possible for road users travelling along all Till Bridge Lane. Therefore, no impacts are predicted and mitigation is not required.

7.2.1.5 West Burton 2

The results of the analysis have shown that solar reflections are geometrically possible along approximately 3.6km of Sturton Road and 600m of Church Road. Under the baseline scenario, a significant (moderate adverse) impact is predicted along approximately 300m of Sturton Road, between receptors 24-27. However, for the remaining receptors, due to a combination of existing screening and mitigating factors such as the solar reflective area being outside of the road user's primary field of view (50° either side of the direction of travel), further mitigation is not recommended and no significant impacts are predicted.

It is predicted that the proposed screening will significantly reduce views of the reflective area for road users travelling along the 300m section of Sturton Road. The height of the screening will be sufficient to significantly reduce the visibility of the reflecting solar panel from typical road users' drivers. If necessary, the developer will implement an interim mitigation measure (opaque fence) before the screening in the form of vegetation is established.

Figure 26 on the following page shows the affected locations and the proposed screening location.

Figure 26 *Reflecting area and proposed screening for receptors 24-27*

7.2.1.6 West Burton 3

The results of the analysis have shown that reflections are geometrically possible towards 67 of the 79 assessed road receptors along the A156 and the A1500; however, existing screening will remove views of the reflecting panel area. Therefore, no impact is predicted and mitigation is not required.

7.2.1.7 Cumulative Effects - West Burton 2 and 3

No roads have been identified within the 1km boundaries for both West burton 2 and 3. Therefore, no cumulative effects from both sites are predicted, and further mitigation is not required.

7.3 Railway Results

The key considerations for quantifying impact significance for train driver receptors are:

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

Where reflections originate from outside of a train driver's field of view (30 degrees either side of the direction of travel), the impact significance is low, and mitigation is not required.

Where reflections originate from inside of a train driver's field of view but there are mitigating circumstances, the impact significance is low and mitigation is not recommended.

Where reflections originate from inside of a train driver's field of view and there is a lack of sufficient mitigating factors, a moderate impact is predicted and mitigation is recommended.

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

Fixed System

The results of the analysis have shown that solar reflections are geometrically possible for train drivers travelling along approximately 3.6km of assessed railway line. However, under the baseline scenario, existing vegetation significantly screens the reflecting panel area where reflections occur within the train drivers' primary field of vision (30 degrees either side of the direction of travel).

The developer has also proposed screening along the boundary of the proposed development to further obstruct views of the reflecting panel area to a train driver using any section of the identified railway track, in the event any trackside vegetation is removed.

Therefore, no impacts are predicted and further mitigation is not required.

Tracking System

The results of the modelling indicate that solar reflections are geometrically possible towards all of the assessed train driver receptors, along the 4km section of railway track. However, existing vegetation significantly screens the reflecting panel area where reflections occur within the train drivers' primary field of vision (30 degrees either side of the direction of travel).

The developer has also proposed screening along the boundary of the proposed development to further obstruct views of the reflecting panel area to a train driver using any section of the identified railway track, in the event any trackside vegetation is removed.

Therefore, no impacts are predicted and further mitigation is not required.

8 CUMULATIVE ASSESSMENT OF NEARBY NSIPS

8.1 Introduction

Overview

The Applicant has requested Pager Power to consider the cumulative glint and glare effect of other known solar NSIP projects (Cottam Solar Project and Gate Burton Energy Park[24]). These sites are located in the proximity of the proposed development, see Figure 27 below.

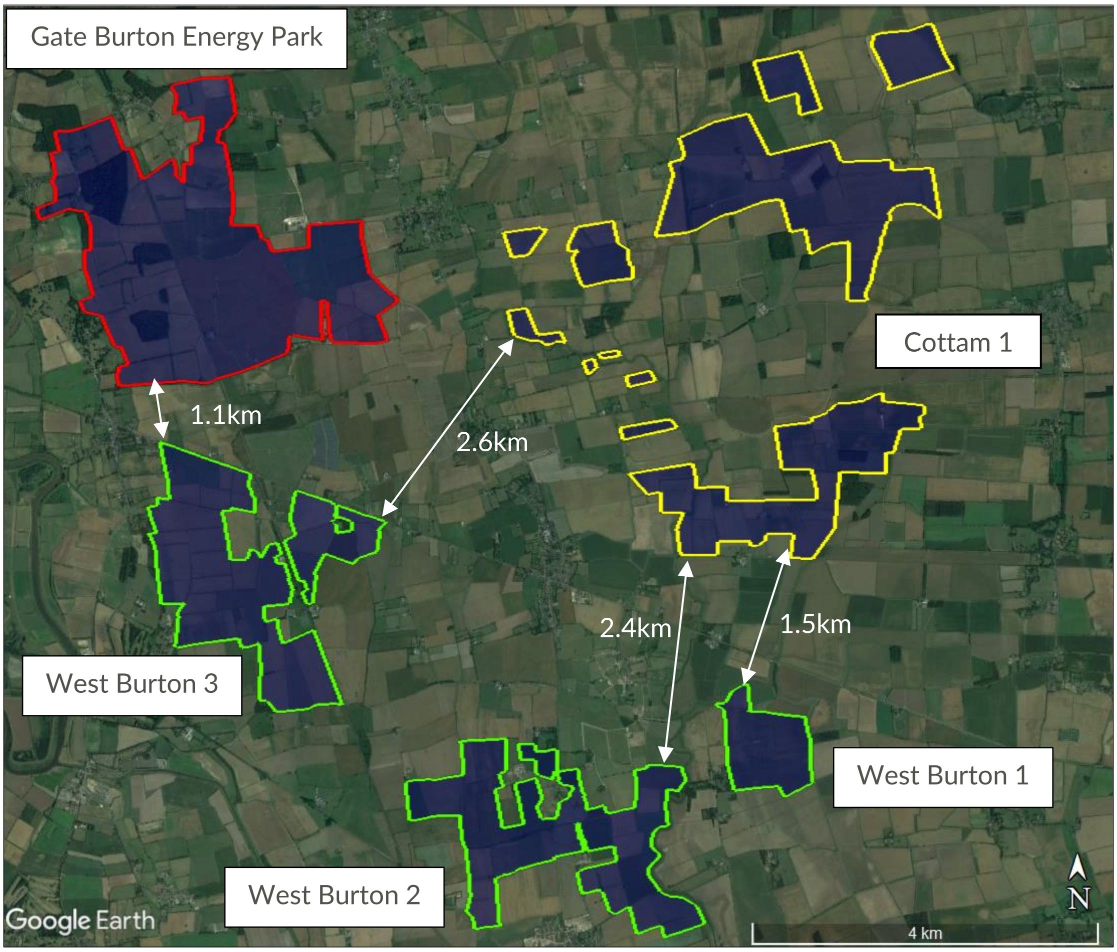

Figure 27 *Location of West Burton 1,2 and 3 relative to Cottam 1 and Gate Burton Energy Park*

Cumulative assessment

The significance of effects reduces to acceptable levels beyond 1km, therefore significant cumulative effects are only possible for receptors sited between West Burton 1 and Cottam 1 and for receptors sited between West Burton 3 and Gate Burton Energy Park.

[24] Only NSIP projects were considered, as requested and identified by The Applicant.

The receptors located within 1km from both West Burton 3 and Gate Burton Energy Park and 1km from both West Burton 1 and Cottam 1 are shown in Figure 28 and Figure 29 below and on the following page. The review of the available imagery showed that due to existing screening (other dwellings, vegetation or terrain) visibility of both sites is not predicted for the dwellings and road receptors located within the white area. Therefore, under the baseline conditions, shared receptors are not predicted to have concurrent visibility of multiple areas. Therefore, significant cumulative effects are not considered likely.

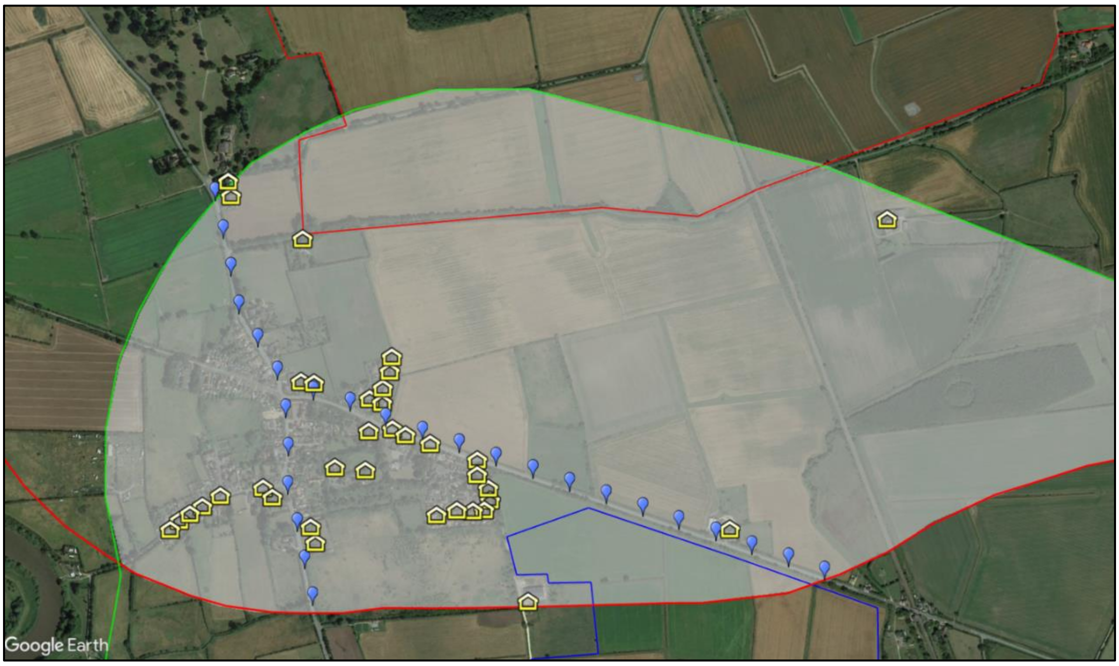

Figure 28 *Shared dwelling and road receptors between West Burton 3 and Gate Burton Energy Park (section of A156 and A1500, road receptors 1 to 12, 65-79, and dwelling receptors 1-4 and 28-59)*

Figure 29 *Shared dwelling and road receptors between West Burton 1 and Cottam 1 (section of Till Bridge Lane, specifically road receptors 1-6 of West Burton 1)*

9 OVERALL CONCLUSIONS

9.1 Aviation Receptors – Consultation

Pager Power has consulted with the safeguarding teams at Sturgate Airfield, RAF Scampton and Doncaster-Sheffield Airport with regard to the effect of the proposed development upon aviation activity. The results of the glint and glare were presented and the safeguarding teams have concluded that the proposed development sites West Burton 1, 2 and 3 are not predicted to pose a significant risk upon their operations. The safeguarding teams have not submitted an objection towards the proposed development as part of the pre-application consultation process.

9.2 High-Level Assessment of Waterways

Pager Power has reviewed the available imagery to identify if any waterway[25-26] exists within 1km of the proposed development. No waterway of a size sufficiently large to accommodate navigation has been identified and therefore glint and glare impacts towards waterway users are not considered possible.

9.3 High-level Assessment of Public Rights of Way

In Pager Power's experience, significant impacts upon pedestrians/observers along PRoWs from glint and glare are not possible. This is because:

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

Furthermore, any effect will have a low magnitude because:

- It is likely that the existing and the proposed screening is predicted fully remove the visibility of the proposed development for certain PRoW users;
- If effects are possible and unscreened they would typically coincide with direct sunlight. The Sun is a far more significant source of light.

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[25] A navigable body of water, such as a river, channel, or canal.

[26] River Till is a small river located nearby West Burton sites 1 and 2. This river is too small for navigation and it is not considered within the assessment. The river Trent is circa 1.2km west of the West Burton Solar Development (at its closest point). Therefore, if geometrically possible and unscreened, any glint and glare effects will not have a significant impact due to the large separation distance

- The reflection intensity is similar for solar panels and still water (and significantly less than reflections from glass and steel[27]) which is frequently a feature of the outdoor environment surrounding public rights of way. Therefore, the reflections are likely to be comparable to those from common outdoor sources whilst navigating the natural and built environment on a regular basis.

Therefore, since no significant impacts are predicted, no full modelling is required.

9.4 Dwelling Receptors

The results of the analysis have shown that reflections from the proposed development are geometrically possible towards some of the identified dwelling receptors. Under the baseline scenario a significant (moderate adverse) impact is predicted for one dwelling at West Burton 3 if a fixed mounting system is implemented and two dwellings at West Burton 3 if a tracking mounting system is implemented.

Within the landscaping plan, the developer has proposed mitigation in the form of vegetation. It is predicted that the proposed mitigation solution will reduce the impact to acceptable levels (the proposed screening is predicted to significantly reduce the visibility[28] of the reflective area from observers located at the ground floor[29]). If necessary, the developer will implement an interim mitigation measure (opaque fencing) before planting is established. Therefore, low impact is predicted at worst upon the identified dwelling receptors, and no further mitigation is recommended.

9.5 Road Receptors

The results of the analysis have shown that solar reflections from the proposed development are geometrically possible towards some of the identified road receptors. Under the baseline scenario a significant (moderate adverse) impact (from West Burton 2 only) is predicted for road users travelling along a 300m stretch of Sturton Road, for both a fixed or tracking mounting system.

However, the proposed screening is predicted to significantly reduce the visibility of the reflective area for road users travelling along Sturton Road. The height of the screening will be sufficient to significantly reduce visibility[7] of reflecting solar panel for typical road users' drivers. If necessary, the developer will implement an interim mitigation measure (opaque fencing) before planting is established. Therefore, a low impact is predicted at worst upon the identified road receptors, and no further mitigation is recommended.

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[27] SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy, 2010).
[28] Vegetation may provide varying levels of cover, immediately after planting, during winter, and after maintenance (e.g. pruning). The developer will also implement instant screening.
[29] The ground floor is typically considered the main living space and has a greater significance with respect to residential amenity and views from the first floor have been considered within the results discussion where appropriate.

9.6 Network Rail Receptors

Railway Signal Receptors

No potential signal locations were identified along the assessed section of railway line using available imagery and have therefore not been assessed. Network Rail has been contacted to confirm the location of any signals at these locations; however, no response has been received to date.

Train Driver Receptors

The results of the analysis have shown that reflections from the proposed development are geometrically possible towards train drivers. Under the baseline scenario, no significant impacts are predicted along the assessed railway track at West Burton 3.

The developer has also proposed screening along the boundary of the proposed development to further obstruct views of the reflecting panel area to a train driver using any section of the identified railway track, in the event any trackside vegetation is removed.

9.7 Cumulative Assessment of Nearby Solar NSIP Projects

The cumulative glint and glare effect of Cottam Solar Project and Gate Burton Energy Park. Gate Burton Energy Park and Cottam 1 are sufficiently close to the proposed development to share multiple receptors.

The shared receptors are as follows:

- Cottam 1, West Burton 1, 2 and 3 and Gate Burton Energy Park:
    - A section of the A156 and A1500 (specifically road receptor 1 to 12 and 65 to 79).
    - Dwellings near and within Marton Village (specifically dwelling receptors 1 to 4 and 28-59).
    - A section of Till Bridge Lane north of West Burton 1 (specifically road receptors 1-6).

However, under the baseline conditions, shared receptors are unlikely to concurrently have visibility of multiple areas due to existing and proposed screening. Therefore, no significant cumulative effects are possible.

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[30] (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.'

Draft National Policy Statement for Renewable Energy Infrastructure

The Draft National Policy Statement for Renewable Energy Infrastructure (EN-3)[31] sets out the primary policy for decisions by the Secretary of State for nationally significant renewable energy infrastructure. Section 2.52 states:

'2.52.1 Solar panels may reflect the sun's rays, 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

[30] Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 18 June 2015, accessed on: 08/12/2022.
[31] Draft National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Business, Energy & Industrial Strategy, date: September 2021, accessed on: 08/12/2022.

a continuous source of excessive brightness experienced by a stationary observer located in the path of reflected sunlight from the face of the panel. The effect occurs when the solar panel is stationed between or at an angle of the sun and the receptor.

2.52.2 In some instances, it may be necessary to seek a glint and glare assessment as part of the application. This may need to account for 'tracking' panels if they are proposed as these may cause differential diurnal and/or seasonal impacts. The potential for solar PV panels, frames and supports to have a combined reflective quality should be assessed. This assessment needs to consider the likely reflective capacity of all of the materials used[32] *in the construction of the solar PV farm.*

2.52.3 Applicants should consider using, and in some cases the Secretary of State may require, solar panels to be of a non-glare/ non-reflective type and the front face of the panels to comprise of (or be covered) with a non-reflective coating for the lifetime of the permission.

2.52.4 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 and motorists.

2.52.5 There is no evidence that glint and glare from solar farms interferes in any way with aviation navigation or pilot and aircraft visibility or safety. Therefore, the Secretary of State is unlikely to have to give any weight to claims of aviation interference as a result of glint and glare from solar farms.'

Consultation to determine whether EN-3 provides a suitable framework to support decision making for nationally significant energy infrastructure ended in November 2021. Pager Power is aware that aviation stakeholders were not consulted prior to the publication of the draft policy and understands that they will still request a glint and glare assessment on the basis that glare may lead to impact upon aviation safety. As a result, aviation stakeholders were consulted with respect to the Scheme, prior to the completion of the technical appendix.

It is possible that the draft policy will change in light of the consultation responses from aviation stakeholders.

Assessment Process – Ground-Based Receptors

No process for determining and contextualising the effects of glint and glare is provided for assessing the impact of solar reflections upon surrounding roads and dwellings. Therefore, the Pager Power approach is to determine whether a reflection from the proposed solar development is geometrically possible and then to compare the results against the relevant guidance/studies to determine whether the reflection is significant.

The Pager Power approach has been informed by the policy presented above, current studies (presented in Appendix B) and stakeholder consultation. Further information can be found in Pager Power's Glint and Glare Guidance document[33] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

[32] In Pager Power's experience, the solar panels themselves are the overriding source of specular reflections which have the potential to cause significant impacts upon safety or amenity.
[33] Pager Power Glint and Glare Guidance, Fourth Edition (4.0), April 2022.

Aviation Assessment Guidance

The UK Civil Aviation Authority (CAA) issued interim guidance relating to Solar Photovoltaic Systems (SPV) on 17 December 2010 and was subject to a CAA information alert 2010/53. The formal policy was cancelled on September 7th, 2012[34] however the advice is still applicable[35] until a formal policy is developed. The relevant aviation guidance from the CAA is presented in the section below.

CAA Interim Guidance

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

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

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

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

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

12. If an installation of SPV systems is planned on-aerodrome (i.e. within its licensed boundary) then it is recommended that data on the reflectivity of the solar panel material should be included in any assessment before installation approval can be granted. Although approval for installation is the responsibility of the ALH[36], as part of a condition of a CAA Aerodrome Licence, the ALH is required to obtain prior consent from CAA Aerodrome Standards Department before any work is begun or approval to the developer or LPA is granted, in accordance with the procedures set out in CAP 791 Procedures for Changes to Aerodrome Infrastructure.

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

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

[34] Archived at Pager Power

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

[36] Aerodrome Licence Holder.

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

FAA Guidance

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

The 2010 document is entitled '*Technical Guidance for Evaluating Selected Solar Technologies on Airports'*[37], the 2013 update is entitled '*Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'*[38], and the 2021 final policy is entitled '*Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports'*[39].

Key excerpts from the final policy are presented below:

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

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

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

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[37] Archived at Pager Power

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

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

The excerpt above states where a solar PV development is to be located on a federally obligated aerodrome with an ATC Tower, it will require a glint and glare assessment to accompany its application. It states that pilots on approach are no longer a specific assessment requirement due to effects from solar energy systems being similar to glint and glare pilots routinely experience from water bodies, glass-façade buildings, parking lots, and similar features. Ultimately it comes down to the specific aerodrome to ensure it is adequately safeguarded, and it is on this basis that glint and glare assessments are routinely still requested.

The policy also states that several different tools and methodologies can be used to assess the impacts of glint and glare, which was previously required to be undertaken by the Solar Glare Hazard Analysis Tool (SGHAT) using the Sandia National Laboratories methodology.

In 2018, the FAA released the latest version (Version 1.1) of the '*Technical Guidance for Evaluating Selected Solar Technologies on Airports*'[40]. Whilst the 2021 final policy also supersedes this guidance, many of the points are still relevant because aerodromes are still safeguarding against glint and glare irrespective of the FAA guidance. The key points are presented below for reference:

- *Reflectivity refers to light that is reflected off surfaces. The potential effects of reflectivity are glint (a momentary flash of bright light) and glare (a continuous source of bright light). These two effects are referred to hereinafter as "glare," which can cause a brief loss of vision, also known as flash blindness*[41].
- *The amount of light reflected off a solar panel surface depends on the amount of sunlight hitting the surface, its surface reflectivity, geographic location, time of year, cloud cover, and solar panel orientation.*
- *As illustrated on Figure 16*[42], *flat, smooth surfaces reflect a more concentrated amount of sunlight back to the receiver, which is referred to as specular reflection. The more a surface is polished, the more it shines. Rough or uneven surfaces reflect light in a diffused or scattered manner and, therefore, the light will not be received as bright.*
- *Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:*
    - *A qualitative analysis of potential impact in consultation with the Control Tower, pilots and airport officials;*
    - *A demonstration field test with solar panels at the proposed site in coordination with FAA Tower personnel;*
    - *A geometric analysis to determine days and times when an impact is predicted.*

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

[41] Flash Blindness, as described in the FAA guidelines, can be described as a temporary visual interference effect that persists after the source of illumination has ceased. This occurs from many reflective materials in the ambient environment.

[42] First figure in Appendix B.

- *The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and system design.*
- ***1. Assessing Baseline Reflectivity Conditions** – Reflection in the form of glare is present in current aviation operations. The existing sources of glare come from glass windows, auto surface parking, rooftops, and water bodies. At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing. Operators also wear polarized eye wear. Potential glare from solar panels should be viewed in this context. Any airport considering a solar PV project should first review existing sources of glare at the airport and the effectiveness of measures used to mitigate that glare.*
- ***2. Tests in the Field** – Potential glare from solar panels can easily be viewed at the airport through a field test. A few airports have coordinated these tests with FAA Air Traffic Controllers to assess the significance of glare impacts. To conduct such a test, a sponsor can take a solar panel out to proposed location of the solar project, and tilt the panel in different directions to evaluate the potential for glare onto the air traffic control tower. For the two known cases where a field test was conducted, tower personnel determined the glare was not significant. If there is a significant glare impact, the project can be modified by ensuring panels are not directed in that direction.*
- ***3. Geometric Analysis** – Geometric studies are the most technical approach for reflectivity issues. They are conducted when glare is difficult to assess through other methods. Studies of glare can employ geometry and the known path of the sun to predict when sunlight will reflect off of a fixed surface (like a solar panel) and contact a fixed receptor (e.g., control tower). At any given site, the sun moves across the sky every day and its path in the sky changes throughout year. This in turn alters the destination of the resultant reflections since the angle of reflection for the solar panels will be the same as the angle at which the sun hits the panels. The larger the reflective surface, the greater the likelihood of glare impacts.*
- *Facilities placed in remote locations, like the desert, will be far from receptors and therefore potential impacts are limited to passing aircraft. Because the intensity of the light reflected from the solar panel decreases with increasing distance, an appropriate question is how far you need to be from a solar reflected surface to avoid flash blindness. It is known that this distance is directly proportional to the size of the array in question*[43] *but still requires further research to definitively answer.*
- ***Experiences of Existing Airport Solar Projects** – Solar installations are presently operating at a number of airports, including megawatt-sized solar facilities covering multiple acres. Air traffic control towers have expressed concern about glint and glare from a small number of solar installations. These were often instances when solar installations were sited between the tower and airfield, or for installations with inadequate or no reflectivity analysis. Adequate reflectivity analysis and alternative siting addressed initial issues at those installations.*

[43] Ho, Clifford, Cheryl Ghanbari, and Richard Diver. 2009. Hazard Analysis of Glint and Glare From Concentrating Solar Power Plants. SolarPACES 2009, Berlin Germany. Sandia National Laboratories.

Air Navigation Order (ANO) 2016

In some instances, an aviation stakeholder can refer to the ANO 2016[44] with regard to safeguarding. Key points from the document are presented below.

Lights liable to endanger

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

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

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

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

(a) to extinguish or screen the light; and

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

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

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

Lights which dazzle or distract

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

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

Endangering safety of an aircraft

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

Endangering safety of any person or property

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

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.

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

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'[45] 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.
b) Where a colour light signal is positioned beneath a platform roof painted white and the light reflecting off the roof can make the signal difficult to read.

Options for militating against A5 include:

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

[45] Source: Signal Sighting Assessment Requirements, June 2016. Railway Group Guidance Note. Last accessed 12/12/2022.

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

c) *Provision of screening.*

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

Determining the Field of Focus

The extract below is taken from Appendix F - Guidance on Field of Vision (pages 98-101) of the 'Signal Sighting Assessment Requirements'[46] 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.

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

Field of vision

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

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

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

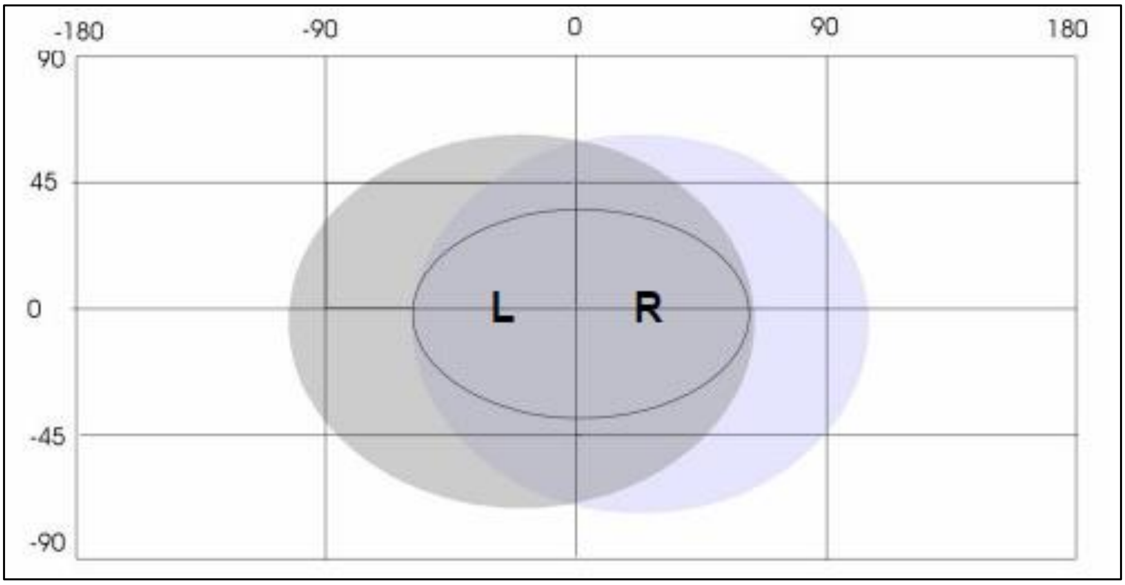


Figure G 21 - Field of view

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

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

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

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

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

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

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

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

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

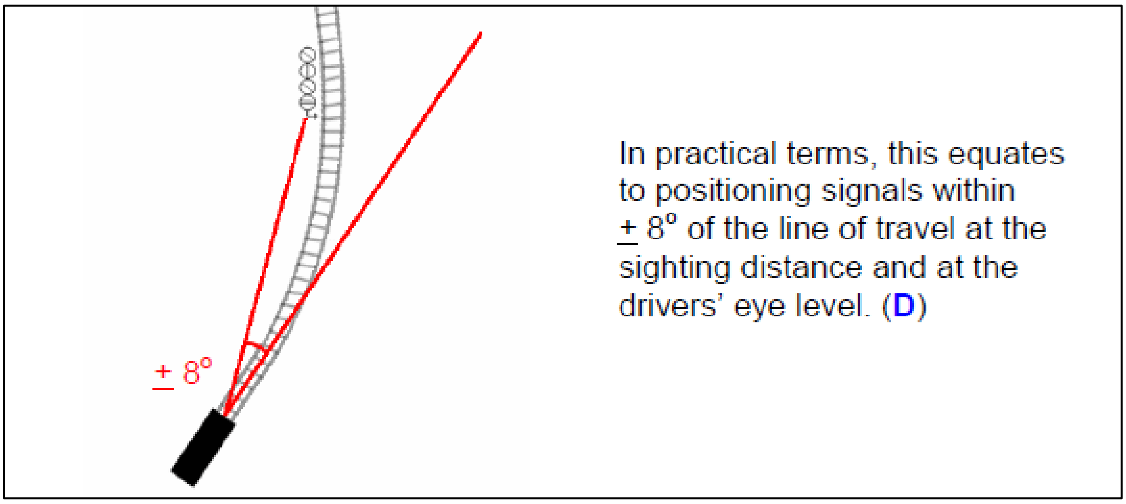


Figure G 22 - Signal positioning

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

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

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

Determining the Assessed Minimum Reading Time

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

'B5.2.2 Determining the assessed minimum reading time

GE/RT8037

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

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

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

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

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

Signal Design and Lighting System

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

- An LED railway signal produces a more intense light making them more visible to approaching trains when compared to the traditional filament bulb technology[47];

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

- No reflective mirror is present within the LED signal itself unlike a filament bulb. The presence of the reflective surfaces greatly increases the likelihood of incoming light being reflecting out making the signal appear illuminated.
- Many LED signal manufacturers[48] claim that LED signal lights significantly reduce or completely remove the likelihood of a phantom aspect illumination occurring.

[48] Source: Sun phantom LED traffic signal, Patrick Martineau, Siemens, date: 16/05/2002, Patent No.: US 2002/0186143 A1, (Last accessed 07.12.22).

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

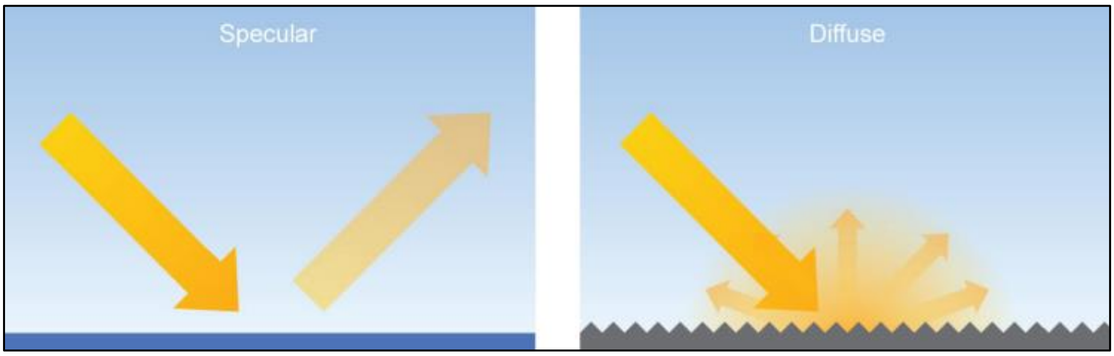
Overview

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 reflection will reflect the incoming light and scatter it in many directions. The figure below, taken from the FAA guidance[49], 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

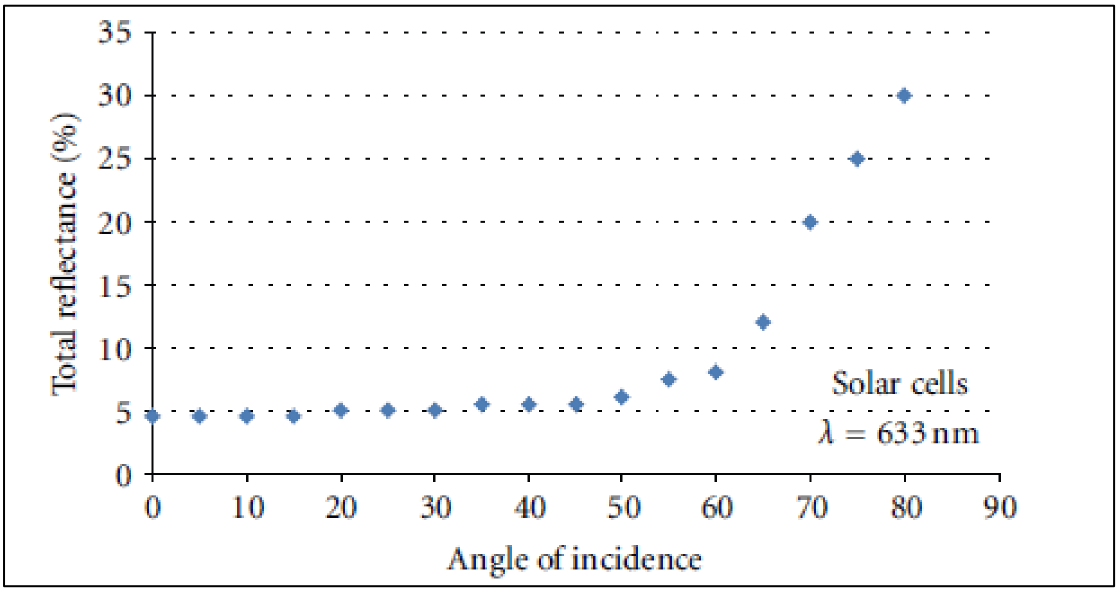
[49] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

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*[50]". 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.

FAA Guidance – "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[51]

[50] 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

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

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[52]
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).

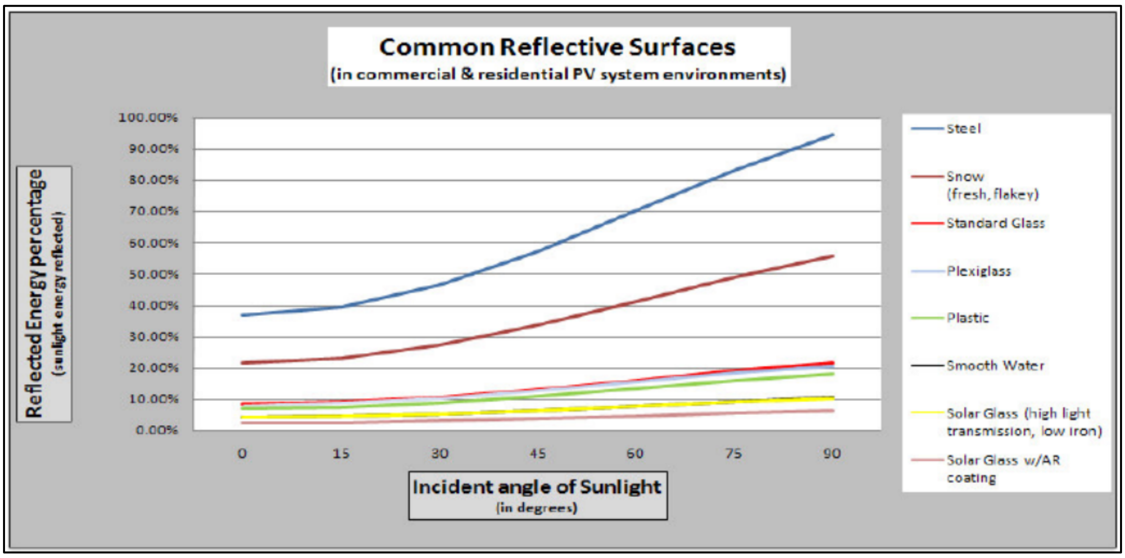
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

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

SunPower Technical Notification (2009)

SunPower published a technical notification[53] 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.

[53] 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.

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.

Receptor Sensitivity Definition

The table below presents the recommended definition of 'receptor sensitivity' in glint and glare terms and the type of receptor based on the sensitivity.

Sensitivity	Definition	Receptor
High	The receptor or resource has little ability to absorb the change without fundamentally altering its present character or it is of international or national importance.	None
Medium	The receptor or resource has moderate capacity to absorb the change without significantly altering its present character or is of high and more than local (but not national or international) importance.	Aviation Receptors (ATC Tower and Approach Paths), Railway Receptors (Train Drivers and Railway Signals), Roads (no local roads) and Dwellings.
Low	The receptor or resource is tolerant of change without detrimental effect, is of low or local importance.	Local Roads and Public Rights of Way

Receptors sensitivity definition

Impact Significance Definition

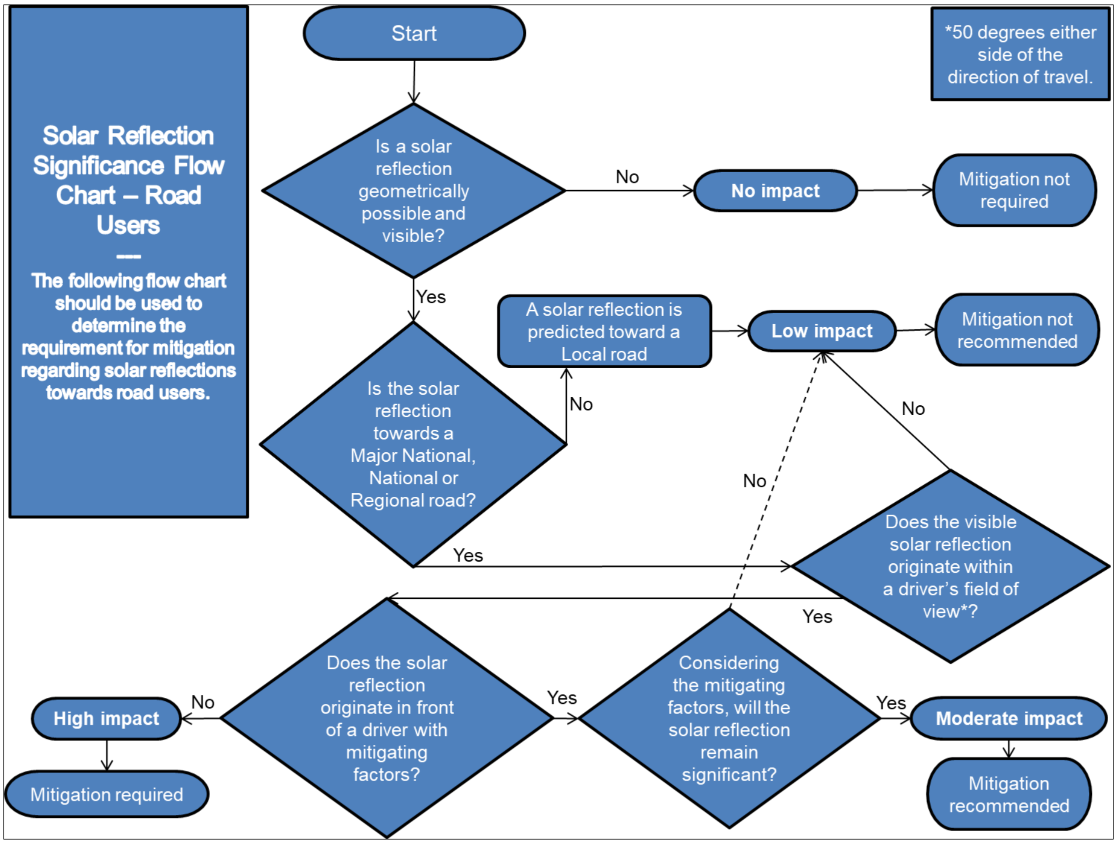
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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 significantly.	No mitigation recommended.
Moderate	A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case given individual receptor criteria.	Mitigation recommended.
High	A solar reflection is geometrically possible and visible under worst-case conditions that will produce a significant impact given individual receptor criteria	Mitigation will be required if the proposed development is to proceed.

Impact significance definition

Impact Significance Determination for Road Receptors

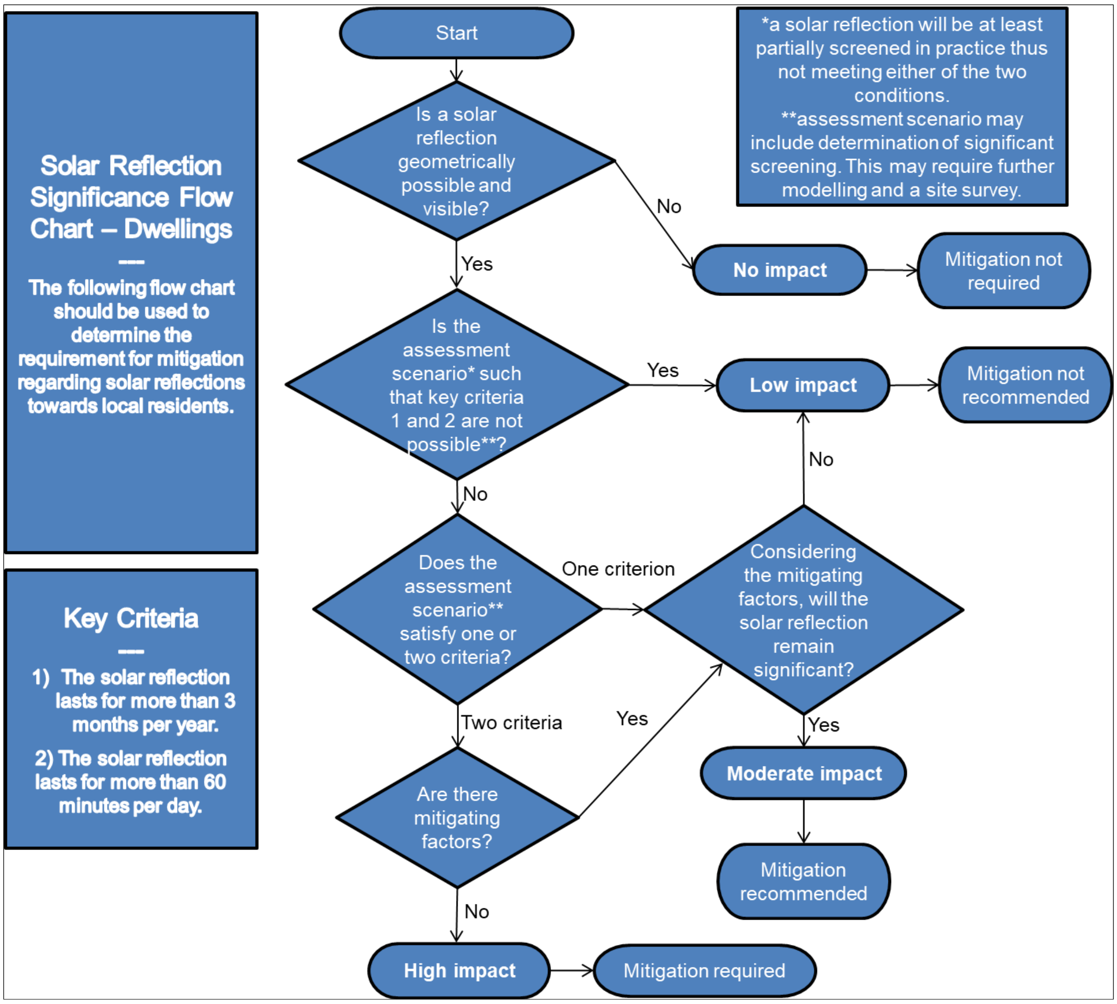
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road user impact significance flow chart

Impact Significance Determination for Dwelling Receptors

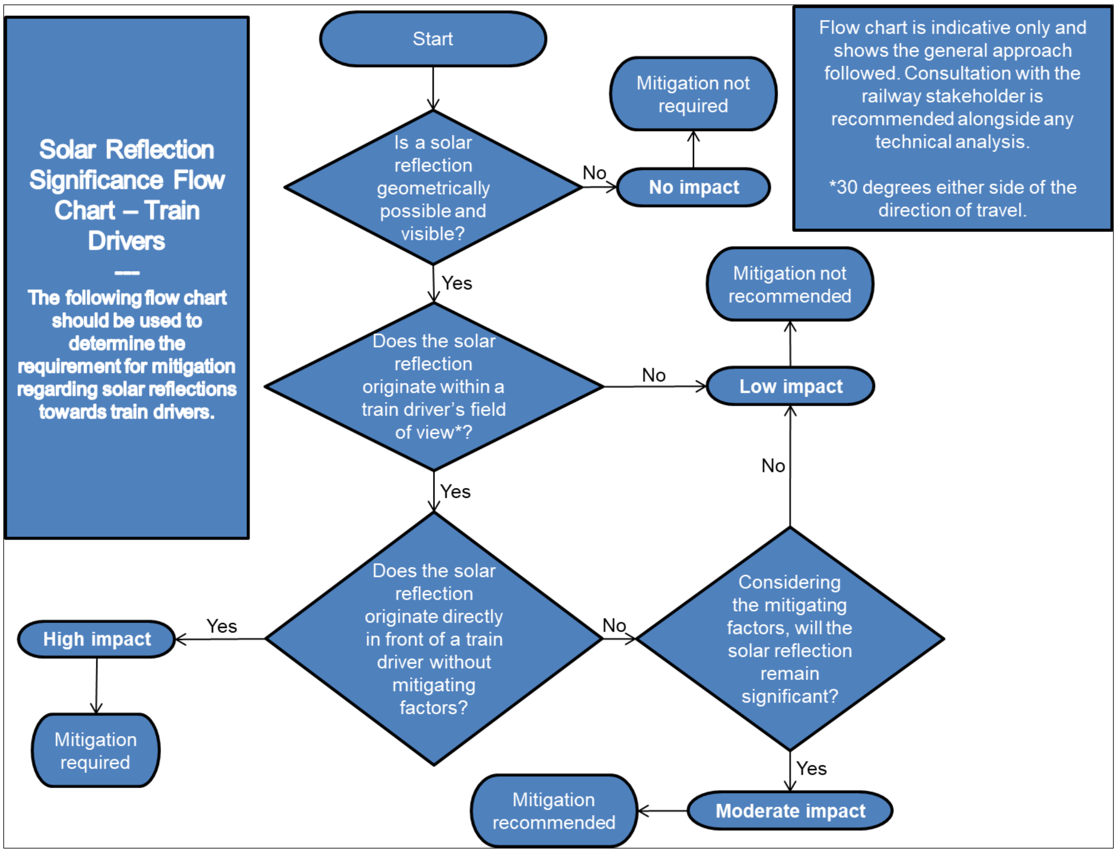
The flow chart presented below has been followed when determining the mitigation requirement for dwelling receptors.



Dwelling impact significance flow chart

Impact Significance Determination for Railway Receptors – Train Drivers

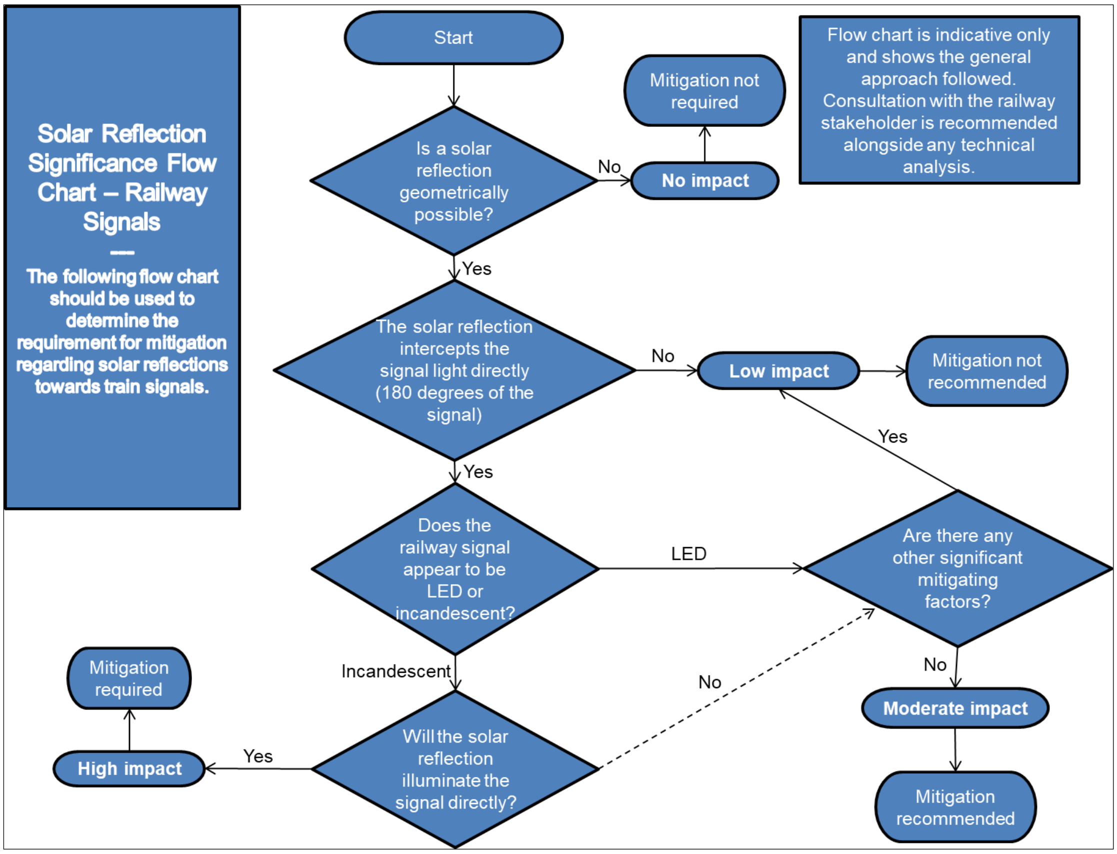
The flow chart presented below has been followed when determining the mitigation requirement for train drivers.



Train driver impact significance flow chart

Impact Significance Determination for Railway Receptors – Railway Signals

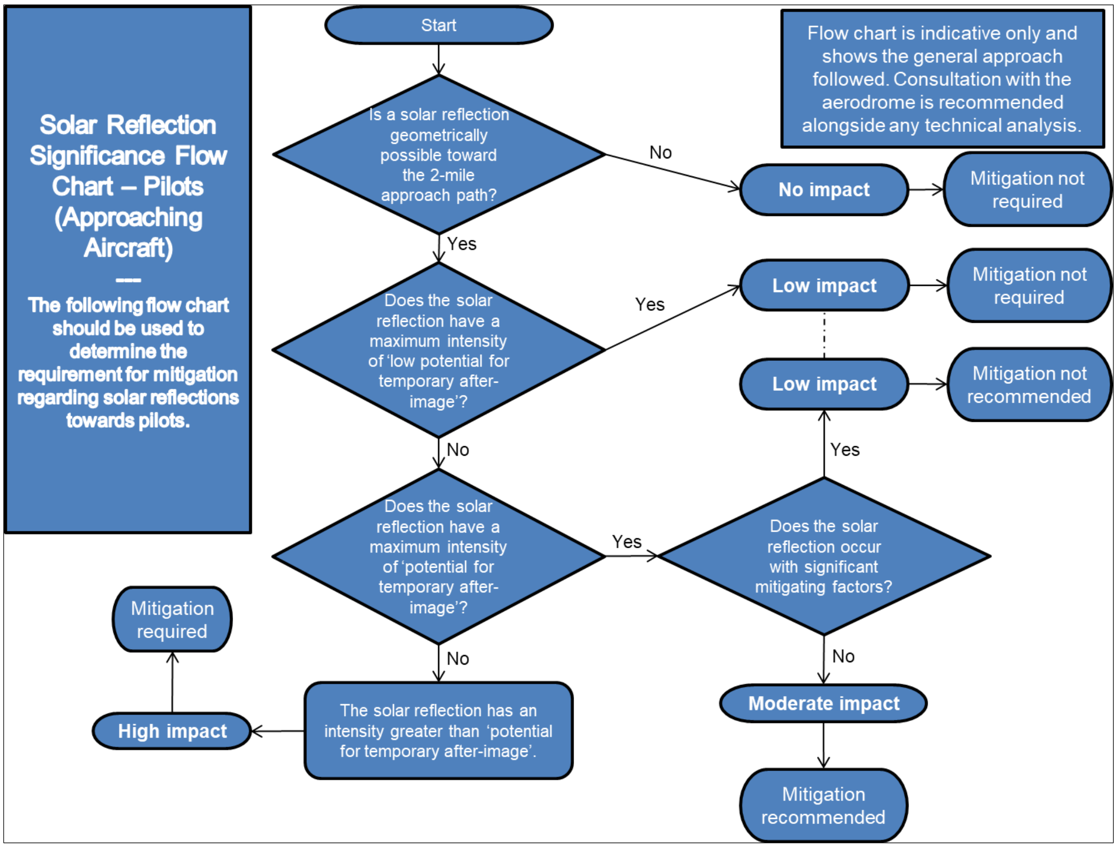
The flow chart presented below has been followed when determining the mitigation requirement for railway signals.



Railway signals impact significance flow chart

Impact Significance Determination for Aviation Receptors – Approaching Aircrafts

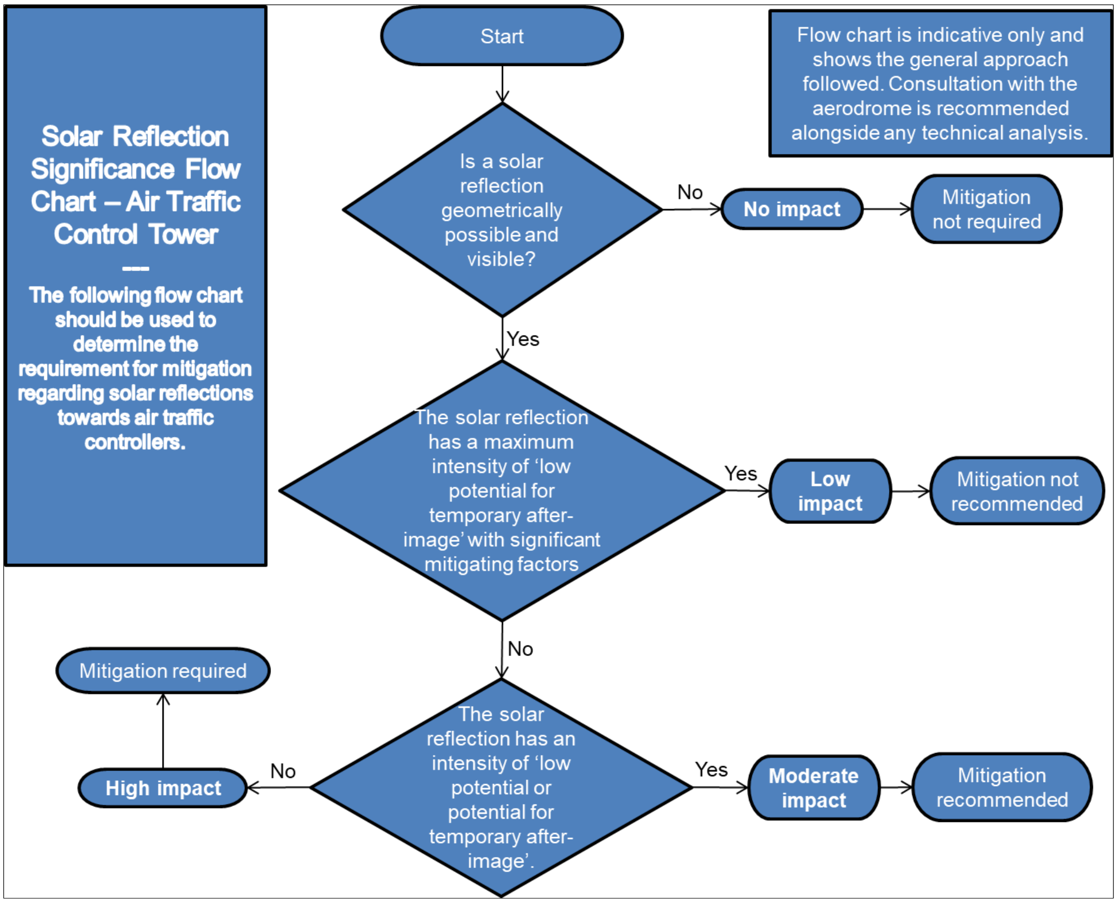
The flow chart presented below has been followed when determining the mitigation requirement for approaching aircrafts.



Approaching Aircrafts impact significance flow chart

Impact Significance Determination for Aviation Receptors – ATC Tower

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



ATC Tower impact significance flow chart

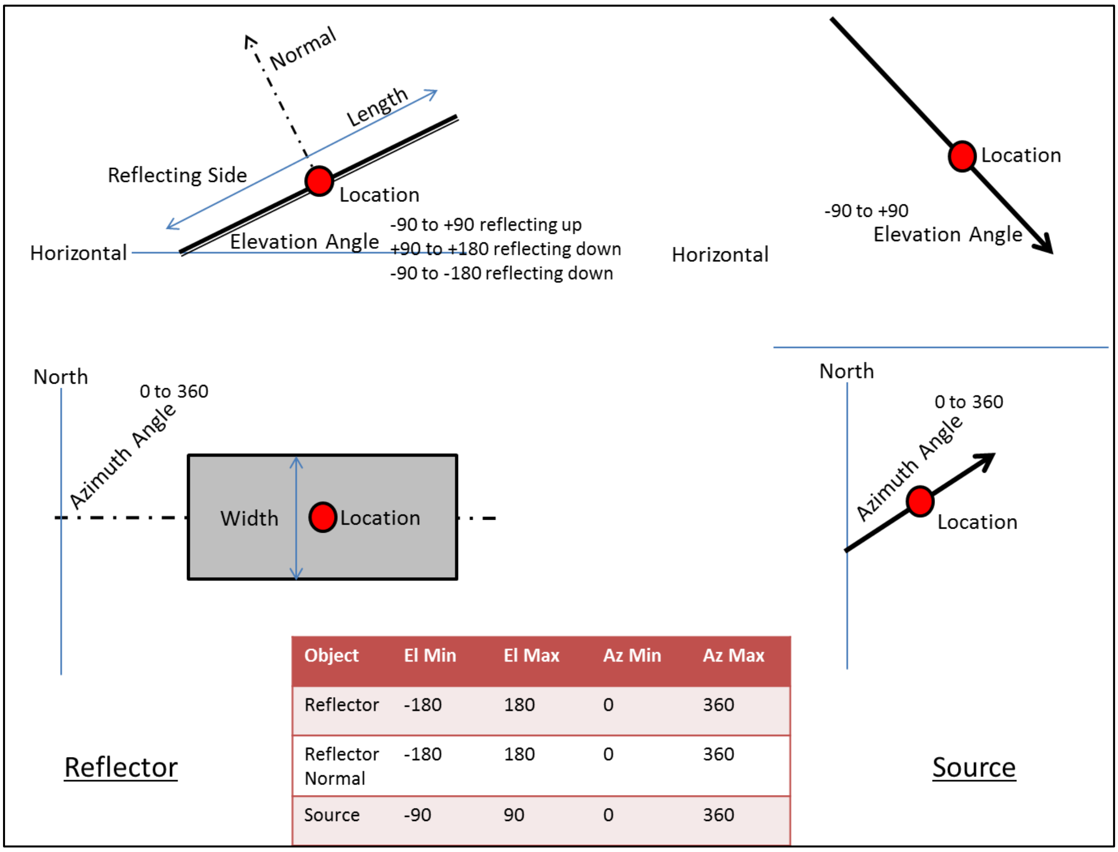
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Pager Power Methodology

The calculations are three dimensional and complex, accounting for:

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

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



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

Reflection calculation process

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

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

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

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)[54].

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

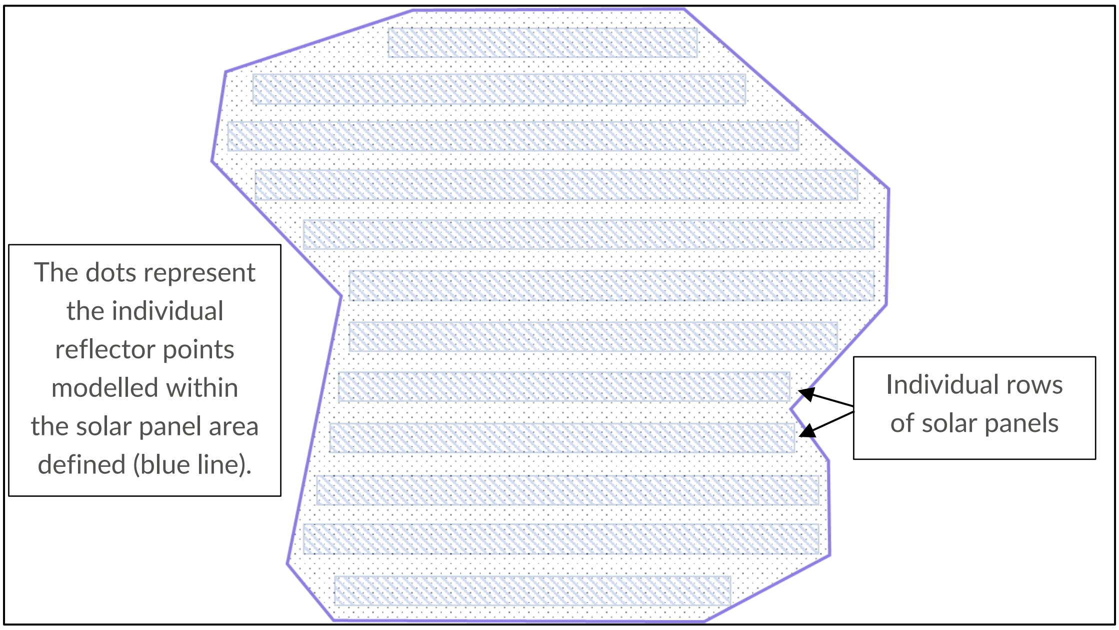
It is assumed that the panel azimuth angle assessed represents the azimuth angle for all of the panels within each solar panel area defined.

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

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

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

[54] 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.

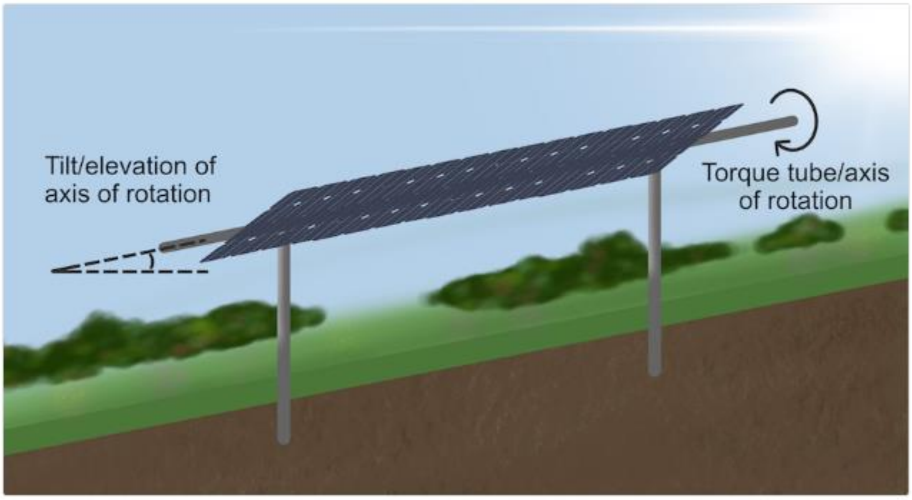
APPENDIX F – REFLECTION CALCULATIONS METHODOLOGY

Forge Reflection Calculations Methodology

Extracts taken from the Forge Solar Model.

Tracking System Parameters

Single-axis module tracking systems are described by a unique set of parameters. These angular inputs model the tracking axis, rotation range and backtracking behavior. Dual-axis module tracking systems are assumed to track the sun at all times.



Single-axis tracking system with torque tube tilted due to geography

Tilt of tracking axis (°)
Tilt above flat ground of axis over which panels rotate (e.g. torque tube). System on flat, level ground would have axis tilt of 0°.

Orientation of tracking axis (°)
Azimuthal angle of axis over which panels rotate. Angle represents the facing of the axis and system. For example. typical tracking system in northern hemisphere has tracking axis oriented north-south with an orientation of 180°, allowing panels to rotate east-west with potential south-facing tilt. Typical tracking system in southern hemisphere runs south-north with axis orientation of 0°, yielding east-west rotation with potential north-facing tilt.

Offset angle of module (°)
Additional tilt angle of PV module elevated above tracking axis/torque tube. Offset angle is measured from the torque tube.

Maximum tracking angle (°)
Maximum angle of rotation of tracking system in one direction. For example, a typical system with a 120° range of rotation has a *max tracking angle* of 60° (east/west).

Resting angle (°)
Angle of rotation of panels when sun is outside tracking range. Used to model backtracking. Panels will revert to the position described by this rotation angle at all times when the sun is outside the rotation range. Setting this equal to the *maximum tracking angle* implies the panels do not backtrack.

ForgeSolar utilizes a simplified model of backtracking which assumes panels instantaneously revert to the *resting angle* whenever the sun is outside the rotation range. For example, panels with *max tracking angle* of 60° and *resting angle* of 0° would lie flat from sunrise until the sun enters the rotation range, and immediately after the sun leaves the rotation range until sunset daily.

Tracking System Parameters

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Dwelling Receptor Details

The dwelling receptors details are presented in the tables below.

West Burton 1

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.63777	53.30611	19	-0.63617	53.28795
2	-0.63747	53.30605	20	-0.63543	53.28780
3	-0.63602	53.30582	21	-0.63532	53.28760
4	-0.63695	53.30676	22	-0.63447	53.28763
5	-0.63695	53.29234	23	-0.63444	53.28377
6	-0.63640	53.29244	24	-0.63426	53.28335
7	-0.63610	53.29269	25	-0.63439	53.28267
8	-0.63577	53.29284	26	-0.63567	53.28293
9	-0.63541	53.29285	27	-0.62873	53.28391
10	-0.63531	53.29252	28	-0.62714	53.28379
11	-0.63573	53.29262	29	-0.62689	53.28357
12	-0.63497	53.29224	30	-0.62679	53.28336
13	-0.63441	53.29218	31	-0.62669	53.28318
14	-0.63648	53.29156	32	-0.62645	53.28351
15	-0.63643	53.29138	33	-0.62629	53.28334
16	-0.63905	53.29131	34	-0.62605	53.28350
17	-0.63380	53.29017	35	-0.60698	53.30022
18	-0.63629	53.28877			

West Burton 1: receptor (dwellings) locations

West Burton 2

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.67450	53.27171	43	-0.65622	53.27352
2	-0.67378	53.27193	44	-0.65606	53.27328
3	-0.67315	53.27197	45	-0.65604	53.27295
4	-0.67299	53.27230	46	-0.65589	53.27270
5	-0.67295	53.27254	47	-0.65587	53.27243
6	-0.67147	53.27237	48	-0.65575	53.27220
7	-0.67098	53.27242	49	-0.65566	53.27197
8	-0.67065	53.27258	50	-0.65559	53.27169
9	-0.66998	53.27276	51	-0.65556	53.27141
10	-0.66945	53.27280	52	-0.65557	53.27117
11	-0.66912	53.27285	53	-0.65552	53.27095
12	-0.66833	53.27300	54	-0.65533	53.27066
13	-0.66789	53.27311	55	-0.65519	53.27038
14	-0.66760	53.27320	56	-0.65512	53.27007
15	-0.66707	53.27323	57	-0.65504	53.26980
16	-0.66602	53.27306	58	-0.65498	53.26958
17	-0.66615	53.27600	59	-0.65487	53.26933
18	-0.66601	53.27666	60	-0.65088	53.29976
19	-0.66571	53.27730	61	-0.65221	53.30001
20	-0.66518	53.27727	62	-0.66525	53.29713
21	-0.66475	53.27728	63	-0.66718	53.29714
22	-0.66424	53.27730	64	-0.66317	53.29292
23	-0.66382	53.27630	65	-0.66386	53.29262
24	-0.66346	53.27632	66	-0.66390	53.29238

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
25	-0.66298	53.27666	67	-0.66357	53.29190
26	-0.66245	53.27661	68	-0.66273	53.29091
27	-0.66151	53.27664	69	-0.66233	53.29094
28	-0.66096	53.27658	70	-0.66221	53.29036
29	-0.66035	53.27672	71	-0.66393	53.28999
30	-0.65987	53.27646	72	-0.65981	53.28261
31	-0.65977	53.27616	73	-0.68009	53.27137
32	-0.65868	53.27610	74	-0.68563	53.27093
33	-0.65779	53.27630	75	-0.68140	53.28007
34	-0.65637	53.27651	76	-0.68171	53.27999
35	-0.65647	53.27587	77	-0.68365	53.27952
36	-0.65641	53.27559	78	-0.68734	53.27993
37	-0.65639	53.27525	79	-0.70130	53.28437
38	-0.65634	53.27493	80	-0.68939	53.29215
39	-0.65636	53.27456	81	-0.69128	53.29714
40	-0.65637	53.27423	82	-0.67312	53.30178
41	-0.65625	53.27400	83	-0.67210	53.30167
42	-0.65626	53.27372			

West Burton 2: receptor (dwellings) locations

West Burton 3

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.74264	53.33328	51	-0.73931	53.32477
2	-0.74254	53.33293	52	-0.74100	53.32584
3	-0.73968	53.33191	53	-0.74136	53.32606
4	-0.71673	53.33233	54	-0.74305	53.32588

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
5	-0.69263	53.32316	55	-0.74376	53.32563
6	-0.69405	53.32279	56	-0.74425	53.32546
7	-0.69630	53.32180	57	-0.74467	53.32530
8	-0.69663	53.32173	58	-0.74503	53.32509
9	-0.68160	53.31603	59	-0.73092	53.32339
10	-0.68884	53.31744	60	-0.73870	53.32148
11	-0.68910	53.31796	61	-0.73785	53.32115
12	-0.69072	53.31830	62	-0.73744	53.32069
13	-0.69095	53.31854	63	-0.73537	53.31893
14	-0.69178	53.31806	64	-0.74260	53.31073
15	-0.69577	53.31943	65	-0.73711	53.30920
16	-0.69996	53.32023	66	-0.73106	53.30794
17	-0.70209	53.32026	67	-0.73156	53.30829
18	-0.70284	53.32140	68	-0.73136	53.30666
19	-0.70674	53.32292	69	-0.73085	53.30644
20	-0.71450	53.32290	70	-0.73123	53.30607
21	-0.71568	53.32321	71	-0.73157	53.30564
22	-0.71552	53.32343	72	-0.73130	53.30535
23	-0.71610	53.32355	73	-0.73119	53.30518
24	-0.71751	53.32384	74	-0.73063	53.30498
25	-0.71816	53.32409	75	-0.73143	53.30471
26	-0.71286	53.32046	76	-0.73107	53.30434
27	-0.71189	53.31913	77	-0.73099	53.30365
28	-0.72297	53.32505	78	-0.73201	53.30469
29	-0.73289	53.32672	79	-0.73220	53.30451

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
30	-0.73289	53.32638	80	-0.73208	53.30500
31	-0.73246	53.32606	81	-0.73276	53.30496
32	-0.73239	53.32578	82	-0.72946	53.30242
33	-0.73262	53.32555	83	-0.73021	53.30172
34	-0.73306	53.32553	84	-0.73996	53.30179
35	-0.73369	53.32555	85	-0.73872	53.30011
36	-0.73449	53.32544	86	-0.73815	53.30053
37	-0.73473	53.32711	87	-0.73693	53.30016
38	-0.73569	53.32731	88	-0.73506	53.29952
39	-0.73620	53.32746	89	-0.72933	53.29660
40	-0.73713	53.32741	90	-0.72803	53.29735
41	-0.73660	53.32807	91	-0.72795	53.29756
42	-0.73657	53.32842	92	-0.72707	53.29796
43	-0.73630	53.32881	93	-0.72572	53.29745
44	-0.73621	53.32915	94	-0.70610	53.29739
45	-0.73709	53.32817	95	-0.70582	53.29742
46	-0.73930	53.32853	96	-0.69129	53.29715
47	-0.73982	53.32857	97	-0.68926	53.30904
48	-0.73727	53.32649	98	-0.68960	53.31017
49	-0.73850	53.32655	99	-0.71035	53.30869
50	-0.73949	53.32514	100	-0.70829	53.30892

West Burton 3: receptor (dwellings) locations

Road Receptor Details

The road receptors details are presented in the tables below.

West Burton 1

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.64212	53.30771	14	-0.62370	53.30366
2	-0.64070	53.30740	15	-0.62230	53.30335
3	-0.63927	53.30711	16	-0.62088	53.30304
4	-0.63785	53.30680	17	-0.61946	53.30272
5	-0.63647	53.30643	18	-0.61804	53.30242
6	-0.63506	53.30611	19	-0.61663	53.30212
7	-0.63364	53.30582	20	-0.61521	53.30180
8	-0.63223	53.30549	21	-0.61379	53.30149
9	-0.63082	53.30515	22	-0.61240	53.30117
10	-0.62942	53.30482	23	-0.61097	53.30086
11	-0.62803	53.30448	24	-0.60955	53.30056
12	-0.62661	53.30420	25	-0.60814	53.30025
13	-0.62516	53.30394	26	-0.60672	53.29992

West Burton 1: Assessed road receptor locations

West Burton 2

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.66357	53.30423	28	-0.66002	53.28169
2	-0.66353	53.30332	29	-0.65968	53.28081
3	-0.66337	53.30243	30	-0.65910	53.27996
4	-0.66311	53.30153	31	-0.65863	53.27910
5	-0.66347	53.30066	32	-0.65821	53.27824
6	-0.66356	53.29977	33	-0.65775	53.27739
7	-0.66360	53.29886	34	-0.65724	53.27654
8	-0.66349	53.29796	35	-0.65685	53.27567

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
9	-0.66359	53.29705	36	-0.65678	53.27476
10	-0.66354	53.29616	37	-0.65673	53.27388
11	-0.66349	53.29526	38	-0.65653	53.27298
12	-0.66354	53.29435	39	-0.65623	53.27210
13	-0.66353	53.29345	40	-0.65592	53.27122
14	-0.66358	53.29253	41	-0.65556	53.27034
15	-0.66391	53.29165	42	-0.65525	53.26946
16	-0.66393	53.29077	43	-0.65493	53.26857
17	-0.66347	53.28991	44	-0.65460	53.26769
18	-0.66340	53.28902	45	-0.66499	53.26925
19	-0.66369	53.28815	46	-0.66491	53.27015
20	-0.66389	53.28725	47	-0.66454	53.27103
21	-0.66414	53.28636	48	-0.66398	53.27185
22	-0.66443	53.28547	49	-0.66269	53.27230
23	-0.66460	53.28457	50	-0.66140	53.27278
24	-0.66407	53.28375	51	-0.66021	53.27334
25	-0.66264	53.28348	52	-0.65913	53.27396
26	-0.66114	53.28329	53	-0.65773	53.27429
27	-0.66035	53.28258			

West Burton 2: Assessed road receptor locations

West Burton 3

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.74317	53.33306	41	-0.68479	53.31685
2	-0.74287	53.33218	42	-0.68623	53.31714
3	-0.74258	53.33129	43	-0.68766	53.31746
4	-0.74227	53.33041	44	-0.68909	53.31774

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
5	-0.74152	53.32962	45	-0.69053	53.31805
6	-0.74076	53.32885	46	-0.69194	53.31838
7	-0.74044	53.32796	47	-0.69338	53.31869
8	-0.74035	53.32706	48	-0.69478	53.31903
9	-0.74038	53.32615	49	-0.69621	53.31933
10	-0.74001	53.32528	50	-0.69765	53.31962
11	-0.73974	53.32440	51	-0.69908	53.31992
12	-0.73943	53.32353	52	-0.70050	53.32025
13	-0.73901	53.32267	53	-0.70194	53.32054
14	-0.73857	53.32180	54	-0.70339	53.32083
15	-0.73811	53.32094	55	-0.70483	53.32110
16	-0.73777	53.32006	56	-0.70628	53.32140
17	-0.73821	53.31919	57	-0.70772	53.32165
18	-0.73905	53.31845	58	-0.70915	53.32195
19	-0.74000	53.31775	59	-0.71059	53.32226
20	-0.74072	53.31697	60	-0.71204	53.32256
21	-0.74119	53.31611	61	-0.71349	53.32288
22	-0.74164	53.31525	62	-0.71491	53.32318
23	-0.74198	53.31437	63	-0.71633	53.32347
24	-0.74233	53.31349	64	-0.71780	53.32377
25	-0.74263	53.31260	65	-0.71924	53.32409
26	-0.74291	53.31172	66	-0.72065	53.32440
27	-0.74320	53.31085	67	-0.72210	53.32469
28	-0.74346	53.30997	68	-0.72352	53.32503
29	-0.74373	53.30908	69	-0.72498	53.32530
30	-0.74387	53.30817	70	-0.72639	53.32561
31	-0.74385	53.30727	71	-0.72783	53.32592

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
32	-0.74379	53.30639	72	-0.72927	53.32621
33	-0.74373	53.30548	73	-0.73071	53.32652
34	-0.74363	53.30459	74	-0.73215	53.32682
35	-0.74362	53.30369	75	-0.73359	53.32714
36	-0.74393	53.30281	76	-0.73503	53.32743
37	-0.67911	53.31564	77	-0.73646	53.32776
38	-0.68053	53.31595	78	-0.73786	53.32812
39	-0.68197	53.31623	79	-0.73933	53.32838
40	-0.68338	53.31654			

West Burton 3: Assessed road receptor locations

Modelled Reflector Data – PV Areas

West Burton 1

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.63316	53.29862	15	-0.62054	53.29791
2	-0.63460	53.29846	16	-0.62047	53.29829
3	-0.63458	53.29821	17	-0.62418	53.29860
4	-0.63404	53.29419	18	-0.62752	53.29890
5	-0.63356	53.29382	19	-0.62925	53.29893
6	-0.63228	53.29086	20	-0.63041	53.29889
7	-0.62873	53.29107	21	-0.63064	53.29898
8	-0.62521	53.29136	22	-0.63018	53.29915
9	-0.62402	53.29023	23	-0.63047	53.30076
10	-0.61943	53.29164	24	-0.63066	53.30140
11	-0.61959	53.29346	25	-0.63098	53.30143
12	-0.61971	53.29504	26	-0.63296	53.30077
13	-0.61979	53.29646	27	-0.63399	53.29961

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
14	-0.62037	53.29685	28	-0.63219	53.29885

West Burton 1: Modelled Reflector Data

West Burton 2 – Western area

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.68292	53.29199	28	-0.66931	53.28730
2	-0.68466	53.29172	29	-0.67293	53.28673
3	-0.68882	53.29168	30	-0.67428	53.29084
4	-0.68972	53.29136	31	-0.67304	53.29115
5	-0.68904	53.28837	32	-0.67370	53.29252
6	-0.68874	53.28792	33	-0.67246	53.29287
7	-0.68750	53.28775	34	-0.67256	53.29612
8	-0.68402	53.28826	35	-0.68004	53.29576
9	-0.68017	53.28834	36	-0.67960	53.29230
10	-0.67987	53.28562	37	0.00000	53.32111
11	-0.67942	53.28500	38	-0.71702	53.32119
12	-0.67858	53.28268	39	-0.71684	53.32163
13	-0.67816	53.27919	40	-0.71712	53.32211
14	-0.67879	53.27828	41	-0.71714	53.32343
15	-0.67772	53.27764	42	-0.72284	53.32465
16	-0.67745	53.27663	43	-0.72853	53.32583
17	-0.67355	53.27683	44	-0.73173	53.32517
18	-0.67363	53.28206	45	-0.73136	53.32427
19	-0.66550	53.28348	46	-0.73016	53.32428
20	-0.66626	53.28621	47	-0.73011	53.32407
21	-0.66626	53.28776	48	-0.72844	53.32408
22	-0.66639	53.28787	49	-0.72817	53.32240

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
23	-0.66634	53.28812	50	-0.73081	53.32229
24	-0.66700	53.28916	51	-0.73066	53.32079
25	-0.66613	53.29001	52	-0.73178	53.32089
26	-0.66704	53.29166	53	-0.73284	53.32096
27	-0.67077	53.29100			

West Burton 2: Modelled Reflector Data – western area

West Burton 2 – North-eastern area

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.67001	53.29504	24	-0.67256	53.29612
2	-0.67006	53.29391	25	-0.68004	53.29576
3	-0.66714	53.29384	26	-0.67960	53.29230
4	-0.66722	53.29288	27	0.00000	53.32111
5	-0.66703	53.29258	28	-0.71702	53.32119
6	-0.66373	53.29285	29	-0.71684	53.32163
7	-0.66379	53.29432	30	-0.71712	53.32211
8	-0.66384	53.29475	31	-0.71714	53.32343
9	-0.66472	53.29476	32	-0.72284	53.32465
10	-0.66767	53.29480	33	-0.72853	53.32583
11	-0.66784	53.29528	34	-0.73173	53.32517
12	-0.66837	53.29544	35	-0.73136	53.32427
13	-0.67013	53.29545	36	-0.73016	53.32428
14	-0.67013	53.29504	37	-0.73011	53.32407
15	0.00000	53.28787	38	-0.72844	53.32408
16	-0.66634	53.28812	39	-0.72817	53.32240
17	-0.66700	53.28916	40	-0.73081	53.32229
18	-0.66613	53.29001	41	-0.73066	53.32079

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
19	-0.66704	53.29166	42	-0.73178	53.32089
20	-0.67077	53.29100	43	-0.73284	53.32096
21	-0.66931	53.28730	44	-0.67256	53.29612
22	-0.67293	53.28673	45	-0.68004	53.29576
23	-0.67428	53.29084	46	-0.67960	53.29230

West Burton 2: Modelled Reflector Data – north eastern area

West Burton 2 – Mid-eastern area

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.65818	53.28822	21	-0.67256	53.29612
2	-0.65770	53.28802	22	-0.68004	53.29576
3	-0.65806	53.28764	23	-0.67960	53.29230
4	-0.65695	53.28504	24	0.00000	53.32111
5	-0.65567	53.28523	25	-0.71702	53.32119
6	-0.65574	53.28668	26	-0.71684	53.32163
7	-0.65606	53.28793	27	-0.71712	53.32211
8	-0.65611	53.28817	28	-0.71714	53.32343
9	-0.65600	53.28838	29	-0.72284	53.32465
10	-0.65628	53.28903	30	-0.72853	53.32583
11	-0.65830	53.28877	31	-0.73173	53.32517
12	-0.65832	53.28848	32	-0.73136	53.32427
13	0.00000	53.29166	33	-0.73016	53.32428
14	-0.67077	53.29100	34	-0.73011	53.32407
15	-0.66931	53.28730	35	-0.72844	53.32408
16	-0.67293	53.28673	36	-0.72817	53.32240
17	-0.67428	53.29084	37	-0.73081	53.32229
18	-0.67304	53.29115	38	-0.73066	53.32079

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
19	-0.67370	53.29252	39	-0.73178	53.32089
20	-0.67246	53.29287	40	-0.73284	53.32096

West Burton 2: Modelled Reflector Data – mid eastern area

West Burton 2 – South-eastern area

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.65844	53.28039	8	-0.65303	53.27953
2	-0.65585	53.28082	9	-0.65345	53.28103
3	-0.65492	53.27922	10	-0.65450	53.28316
4	-0.65457	53.27923	11	-0.65861	53.28262
5	-0.65435	53.27881	12	-0.65980	53.28187
6	-0.65313	53.27834	13	-0.65922	53.28048
7	-0.65255	53.27853			

West Burton 2: Modelled Reflector Data – south-eastern area

West Burton 3 – Eastern Area

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.70965	53.31843	45	-0.69445	53.31770
2	-0.70948	53.31818	46	-0.69413	53.31794
3	-0.70897	53.31726	47	-0.69375	53.31814
4	-0.70934	53.31693	48	-0.69336	53.31835
5	-0.71044	53.31677	49	-0.69322	53.31847
6	-0.71077	53.31635	50	-0.69327	53.31853
7	-0.71049	53.31596	51	-0.69419	53.31875
8	-0.71026	53.31566	52	-0.69615	53.31917
9	-0.71025	53.31557	53	-0.69632	53.31919
10	-0.70825	53.31237	54	-0.69657	53.31918
11	-0.70734	53.31246	55	-0.69672	53.31920

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
12	-0.70718	53.31209	56	-0.70163	53.32026
13	-0.70686	53.31144	57	-0.70177	53.32016
14	-0.70706	53.31141	58	-0.70181	53.31915
15	-0.70767	53.31128	59	-0.70180	53.31911
16	-0.70765	53.31120	60	-0.69912	53.31857
17	-0.70681	53.30999	61	-0.69905	53.31802
18	-0.70586	53.31011	62	-0.69916	53.31784
19	-0.70525	53.31300	63	-0.69916	53.31770
20	-0.70540	53.31304	64	-0.69916	53.31759
21	-0.70549	53.31309	65	-0.70116	53.31742
22	-0.70552	53.31318	66	-0.70157	53.31738
23	-0.70547	53.31330	67	-0.70184	53.31744
24	-0.70529	53.31350	68	-0.70188	53.31791
25	-0.70445	53.31445	69	-0.70190	53.31826
26	-0.70420	53.31474	70	-0.70208	53.31837
27	-0.70384	53.31523	71	-0.70256	53.31851
28	-0.70375	53.31521	72	-0.70243	53.31864
29	-0.69882	53.31417	73	-0.70224	53.31878
30	-0.69875	53.31424	74	-0.70188	53.31887
31	-0.69843	53.31443	75	-0.70188	53.31897
32	-0.69803	53.31468	76	-0.70191	53.31904
33	-0.69785	53.31480	77	-0.70188	53.32017
34	-0.69685	53.31497	78	-0.70227	53.32022
35	-0.69658	53.31506	79	-0.70243	53.32052
36	-0.69628	53.31513	80	-0.70288	53.32060
37	-0.69574	53.31523	81	-0.70484	53.32100

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
38	-0.69522	53.31532	82	-0.70867	53.32174
39	-0.69478	53.31537	83	-0.70884	53.32163
40	-0.69461	53.31581	84	-0.70901	53.32140
41	-0.69455	53.31605	85	-0.70921	53.32084
42	-0.69456	53.31633	86	-0.70966	53.31946
43	-0.69469	53.31671	87	-0.70972	53.31923
44	-0.69416	53.31673	88	-0.70976	53.31888

West Burton 3: Modelled Reflector Data – Eastern panel area

West Burton 3 – Western Area

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-0.73257	53.32018	37	-0.71229	53.31368
2	-0.73432	53.31996	38	-0.71268	53.31510
3	-0.73289	53.31739	39	-0.71170	53.31533
4	-0.73355	53.31709	40	-0.71235	53.31626
5	-0.73171	53.31006	41	-0.71358	53.31602
6	-0.72808	53.31023	42	-0.71486	53.31477
7	-0.72940	53.30879	43	-0.71529	53.31531
8	-0.72915	53.30880	44	-0.71665	53.31581
9	-0.72841	53.30577	45	-0.71728	53.31463
10	-0.72607	53.30597	46	-0.72015	53.31454
11	-0.72416	53.30617	47	-0.72033	53.31559
12	-0.71839	53.30657	48	-0.72051	53.31641
13	-0.71799	53.30562	49	-0.72104	53.31794
14	-0.71481	53.30602	50	-0.72220	53.31974
15	-0.71504	53.30438	51	-0.71991	53.31964
16	-0.71490	53.30358	52	-0.71994	53.31993

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
17	-0.71495	53.30281	53	-0.71608	53.31952
18	-0.71511	53.30006	54	-0.71617	53.32070
19	-0.71403	53.30013	55	-0.71648	53.32111
20	-0.71309	53.29958	56	-0.71702	53.32119
21	-0.71217	53.29902	57	-0.71684	53.32163
22	-0.70993	53.29902	58	-0.71712	53.32211
23	-0.70674	53.29924	59	-0.71714	53.32343
24	-0.70542	53.29969	60	-0.72284	53.32465
25	-0.70370	53.29971	61	-0.72853	53.32583
26	-0.70216	53.29978	62	-0.73173	53.32517
27	-0.70071	53.29965	63	-0.73136	53.32427
28	-0.70566	53.30735	64	-0.73016	53.32428
29	-0.71107	53.30594	65	-0.73011	53.32407
30	-0.71189	53.30724	66	-0.72844	53.32408
31	-0.71212	53.30840	67	-0.72817	53.32240
32	-0.71423	53.30799	68	-0.73081	53.32229
33	-0.71464	53.30999	69	-0.73066	53.32079
34	-0.70991	53.31004	70	-0.73178	53.32089
35	-0.70933	53.31154	71	-0.73284	53.32096
36	-0.71008	53.31267			

West Burton 3: Modelled Reflector Data – Western panel area

APPENDIX H – DETAILED MODELLING RESULTS

Model Output Charts

Each Forge chart shows:

- The reflection date/time graph – top left image. The chart shows the time at which glare at the corresponding intensities can occur;
- Duration of glare – top right image. The chart shows the duration for the corresponding glare intensities;
- The reflecting areas – bottom left image. Indicative only;
- Glare intensity graph – bottom right image. Shows you the intensity of glare produced and the categorisation it falls within.

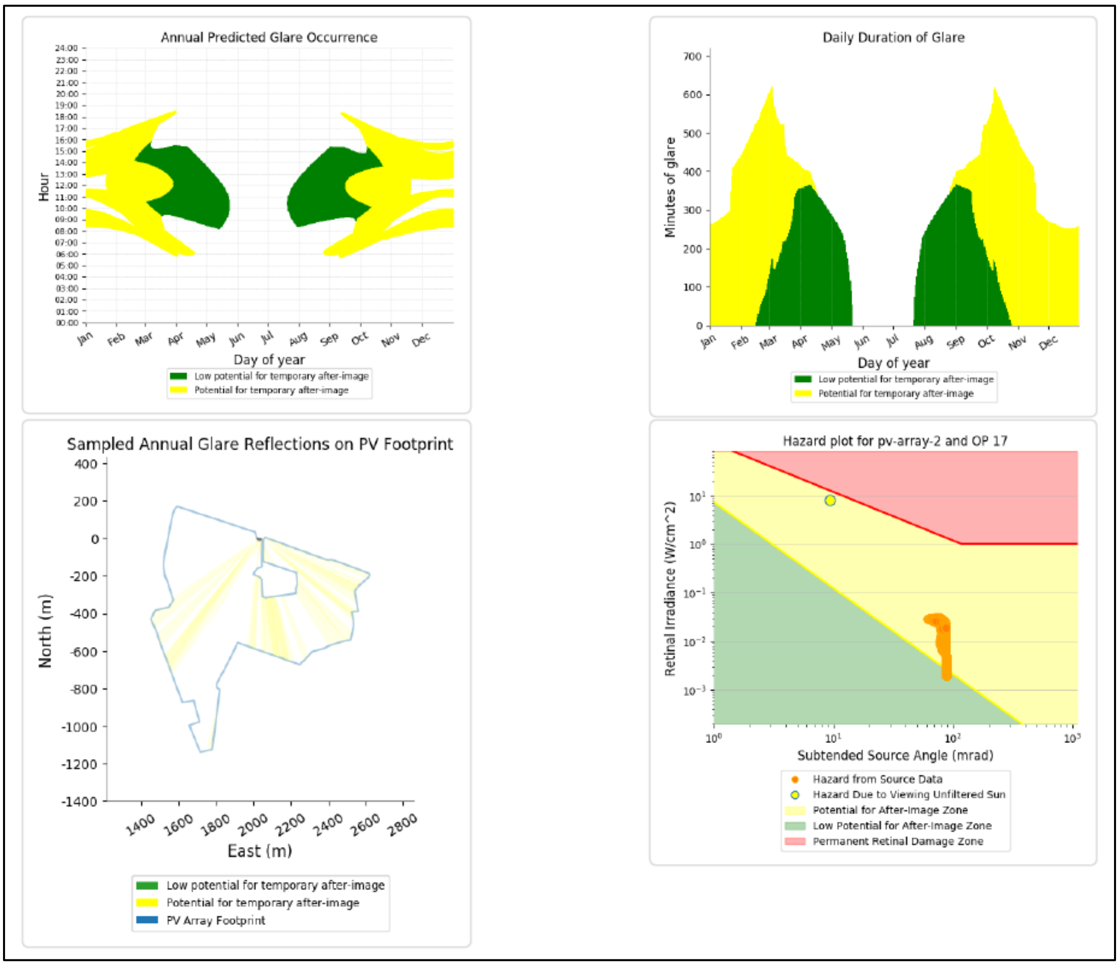
The Pager Power charts for the receptors are shown on the following pages. Each chart shows:

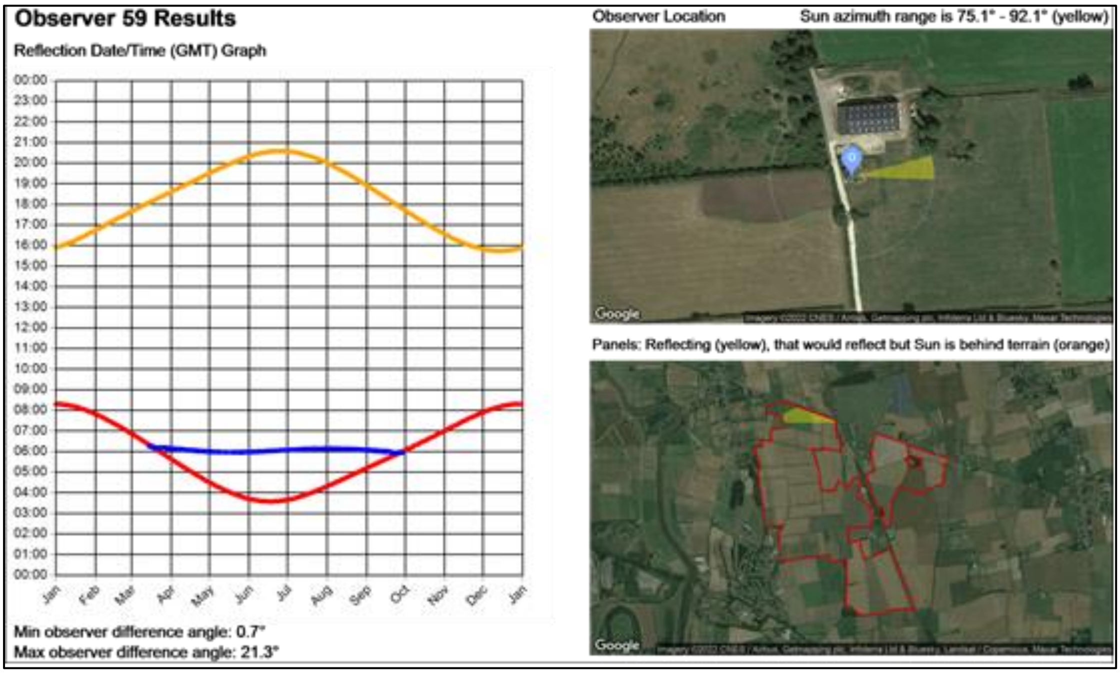
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of the report;
- The reflecting areas – 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 reflector area 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 only.

The remaining modelling outputs can be provided upon request.

Dwellings

The charts on the following page relate to dwellings 17 and 59, where a significant impact, prior to the implementation of proposed mitigation, is predicted.

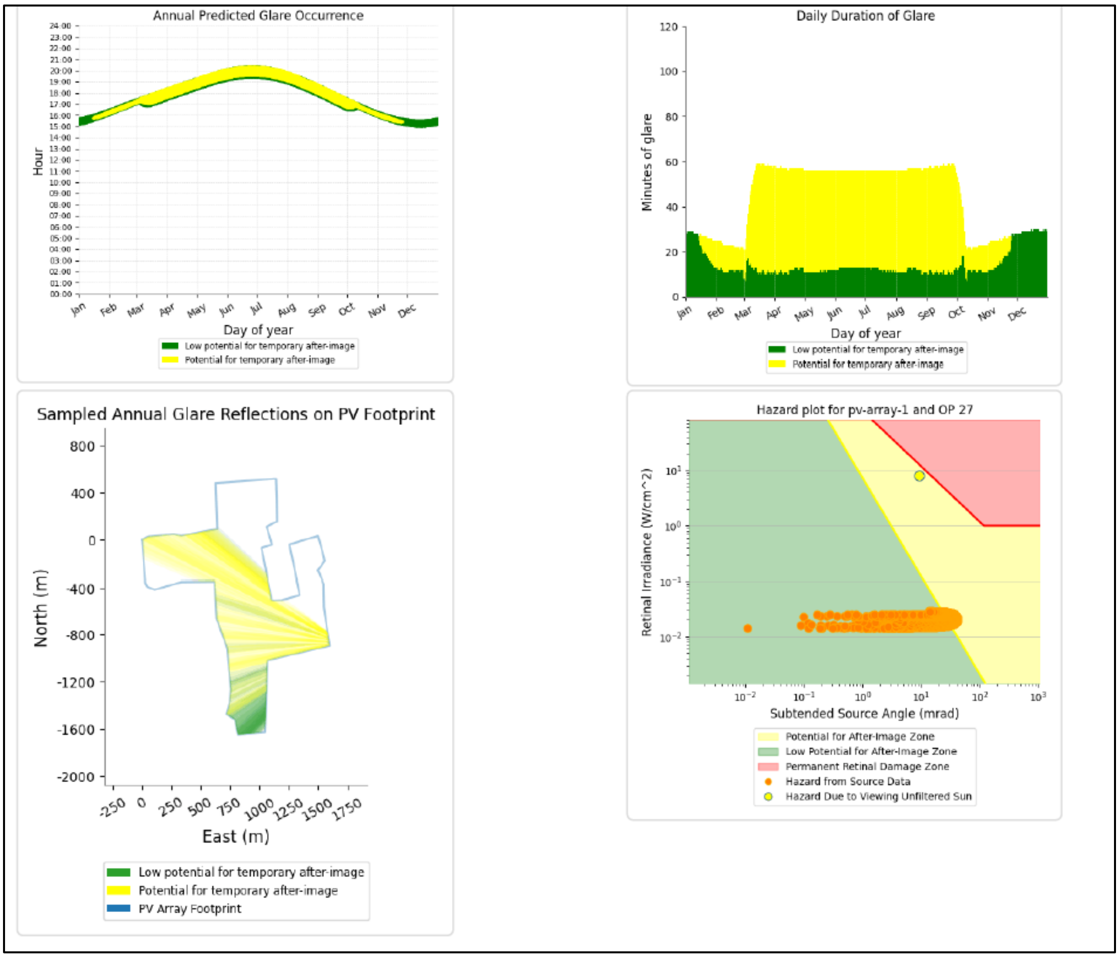

Annual Predicted Glare Occurrence
Hour
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Daily Duration of Glare
Minutes of glare
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Sampled Annual Glare Reflections on PV Footprint
North (m)
East (m)
Low potential for temporary after-image
Potential for temporary after-image
PV Array Footprint
Hazard plot for pv-array-2 and OP 17
Retinal Irradiance (W/cm^2)
Subtended Source Angle (mrad)
Hazard from Source Data
Hazard Due to Viewing Unfiltered Sun
Potential for After-Image Zone
Low Potential for After-Image Zone
Permanent Retinal Damage Zone

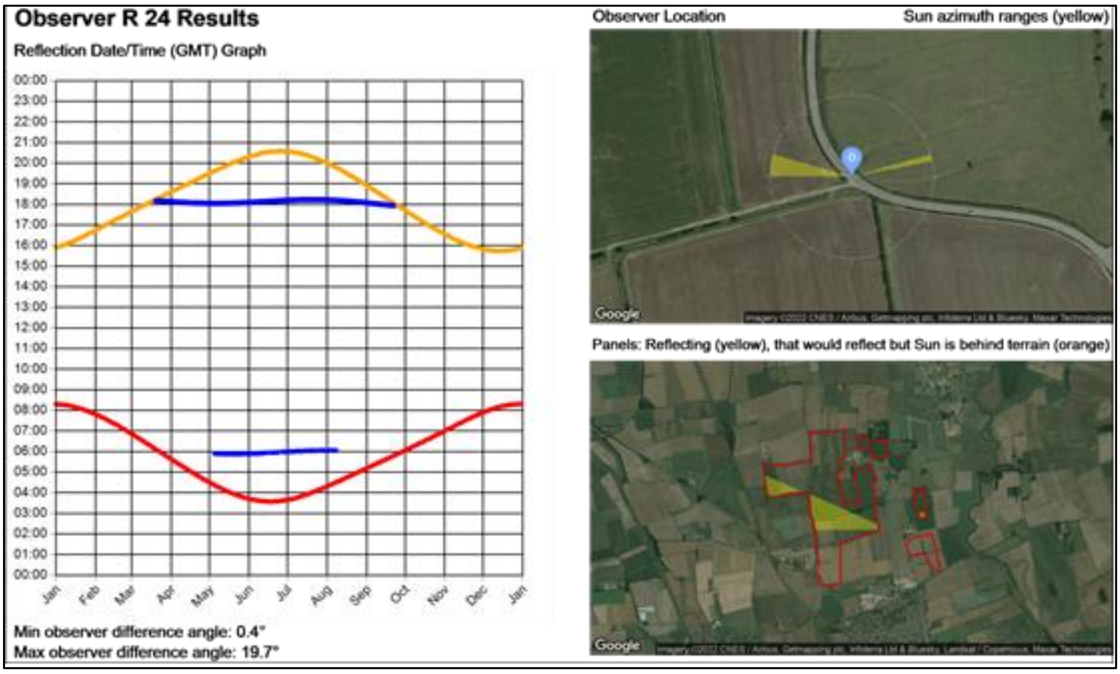

Observer 59 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.7°
Max observer difference angle: 21.3°
Observer Location
Sun azimuth range is 75.1° - 92.1° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

Roads

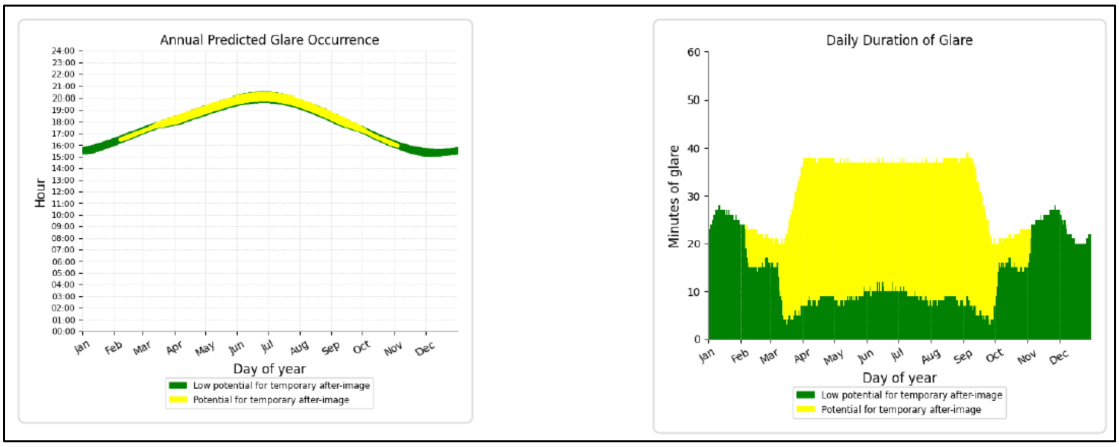
The charts below and on the following pages relate to receptors 24-27, where a significant impact, prior to the implementation of proposed mitigation, is predicted.

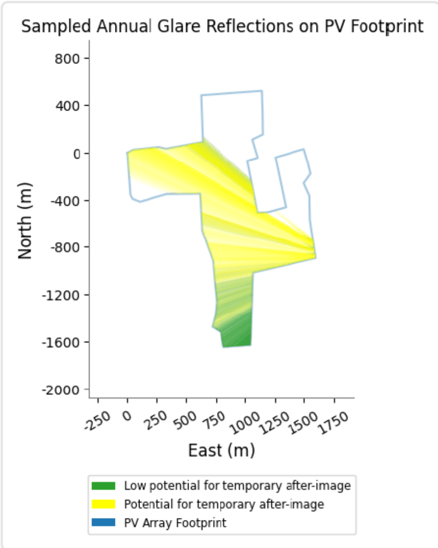
24

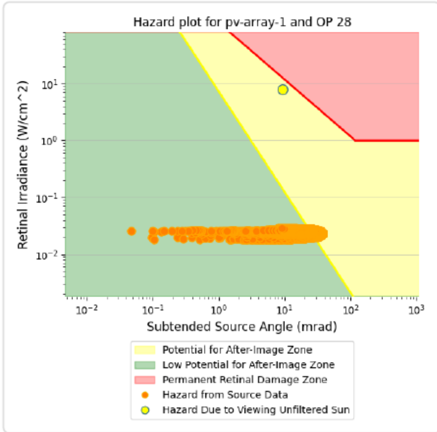


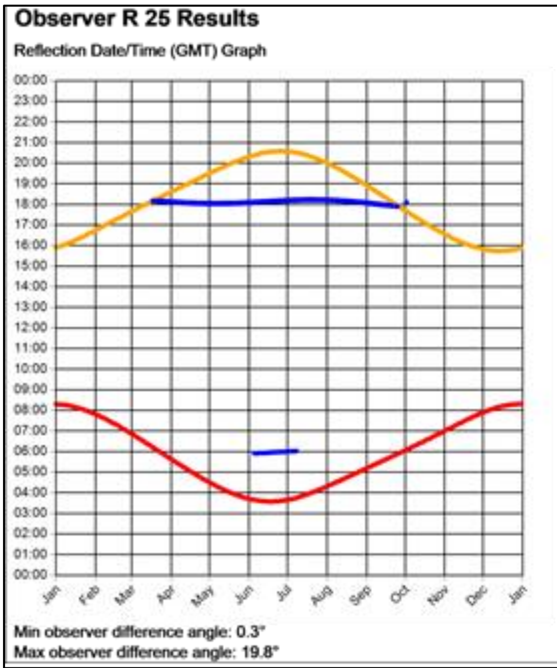

Observer R 24 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 0.4°
Max observer difference angle: 19.7°

25


Annual Predicted Glare Occurrence
Hour
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Daily Duration of Glare
Minutes of glare
Day of year
Low potential for temporary after-image
Potential for temporary after-image

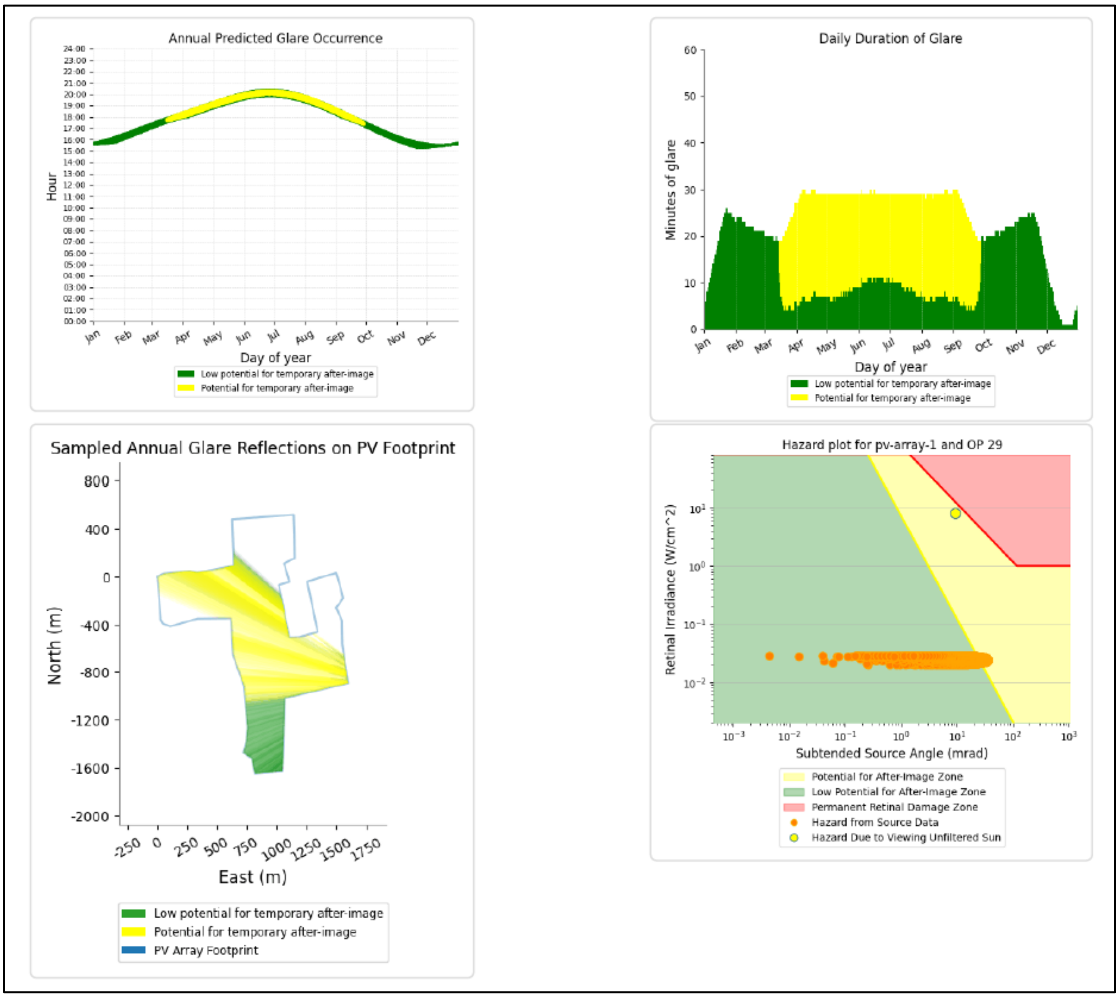

Sampled Annual Glare Reflections on PV Footprint
North (m)
East (m)
Low potential for temporary after-image
Potential for temporary after-image
PV Array Footprint

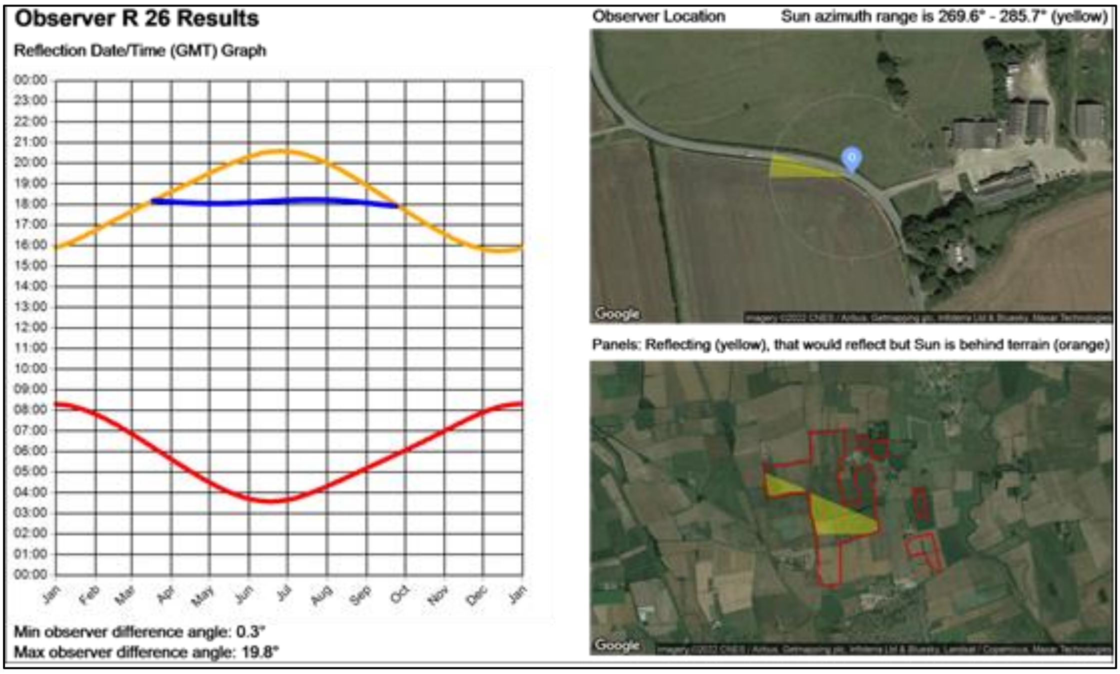

Hazard plot for pv-array-1 and OP 28
Retinal Irradiance (W/cm^2)
Subtended Source Angle (mrad)
Potential for After-Image Zone
Low Potential for After-Image Zone
Permanent Retinal Damage Zone
Hazard from Source Data
Hazard Due to Viewing Unfiltered Sun


Observer R 25 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.3°
Max observer difference angle: 19.8°

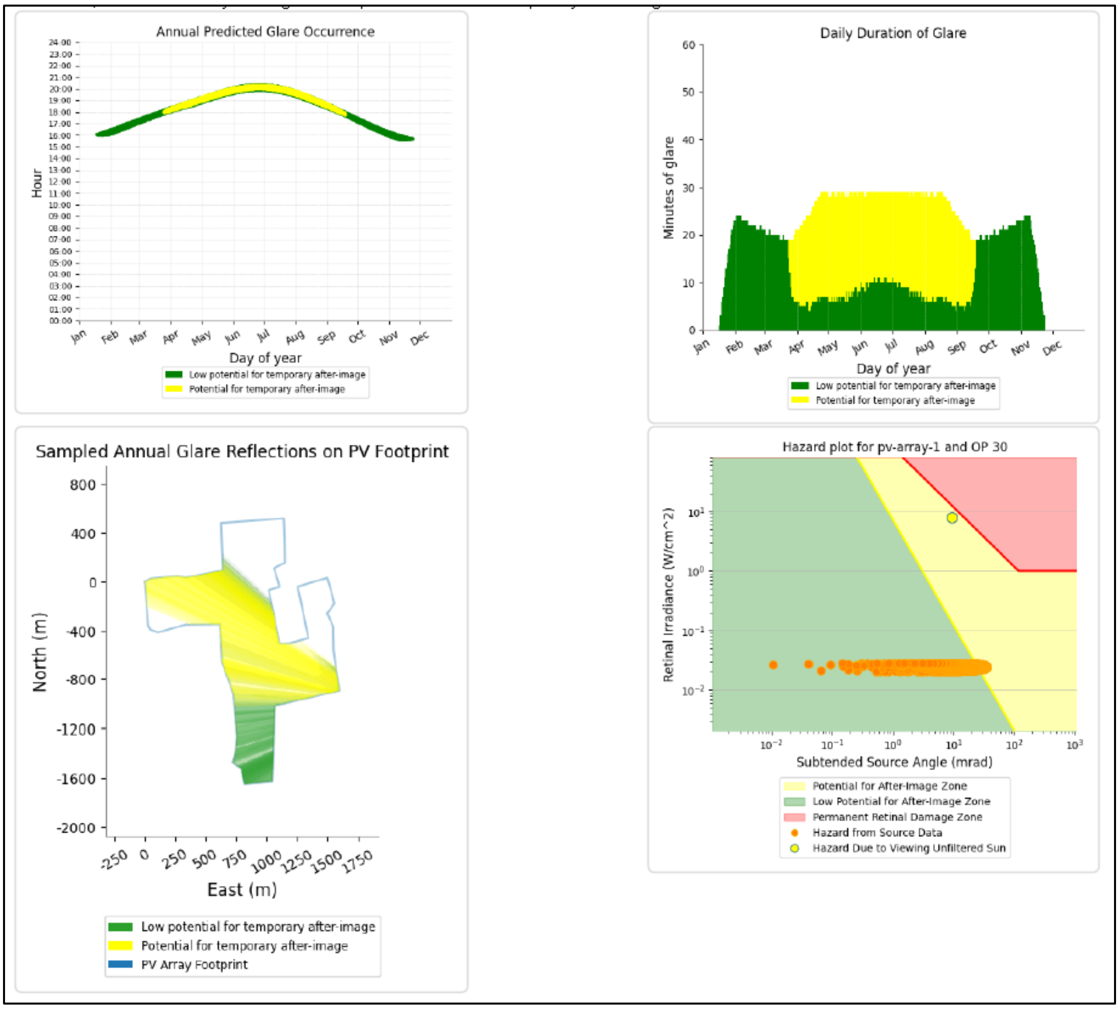

Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

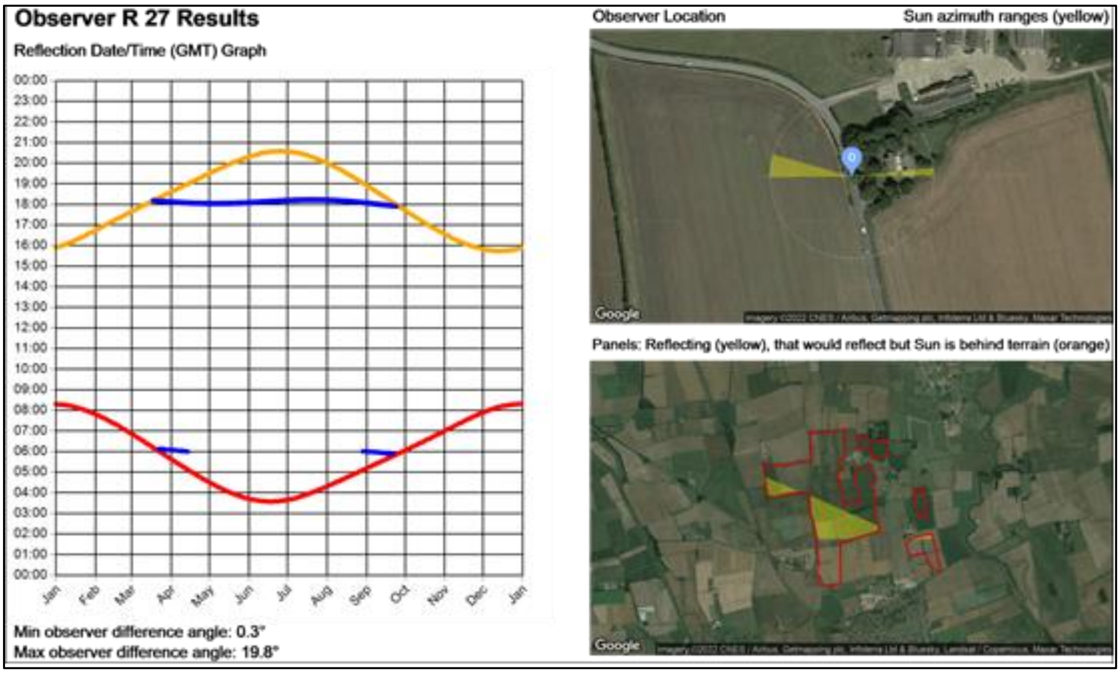
26


Annual Predicted Glare Occurrence
Hour
Day of year
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Low potential for temporary after-image
Potential for temporary after-image
Daily Duration of Glare
Minutes of glare
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Sampled Annual Glare Reflections on PV Footprint
North (m)
East (m)
Low potential for temporary after-image
Potential for temporary after-image
PV Array Footprint
Hazard plot for pv-array-1 and OP 29
Retinal Irradiance (W/cm^2)
Subtended Source Angle (mrad)
Potential for After-Image Zone
Low Potential for After-Image Zone
Permanent Retinal Damage Zone
Hazard from Source Data
Hazard Due to Viewing Unfiltered Sun


Observer R 26 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.3°
Max observer difference angle: 19.8°
Observer Location
Sun azimuth range is 269.6° - 285.7° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

27


Annual Predicted Glare Occurrence
Hour
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Daily Duration of Glare
Minutes of glare
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Sampled Annual Glare Reflections on PV Footprint
North (m)
East (m)
Low potential for temporary after-image
Potential for temporary after-image
PV Array Footprint
Hazard plot for pv-array-1 and OP 30
Retinal Irradiance (W/cm^2)
Subtended Source Angle (mrad)
Potential for After-Image Zone
Low Potential for After-Image Zone
Permanent Retinal Damage Zone
Hazard from Source Data
Hazard Due to Viewing Unfiltered Sun


Observer R 27 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 0.3°
Max observer difference angle: 19.8°
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Google

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