Glint and Glare Assessment

Six Oaks Renewable Energy Park

10/11/2022

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1. EXECUTIVE SUMMARY

1.1. This assessment considers the potential impacts on ground-based receptors such as roads, rail and residential dwellings as well as aviation assets. A 1km study area around the Application Site is considered adequate for the assessment of ground-based receptors, whilst a 30km study area is chosen for aviation receptors. Within 1km of the Application Site, there are 22 residential receptors, 40 road receptors and 28 bridleway Receptors which were considered. Following an initial assessment, rail receptors were scoped out as assets that will be impacted upon from the Proposed Development as no rail receptors fell within the 1km study area. As per the methodology section, where there are a number of residential receptors within close proximity, a representative dwelling or dwellings is/are chosen for full assessment as the impacts will not vary to any significant degree. Where small groups of receptors have been evident, the receptors on either end of the group have been assessed in detail. Seven residential receptors, 20 road receptors and three bridleway receptors were dismissed as they are located within the no reflection zones. 15 aerodromes are located within the 30km study area; Two of which, Cambridge City Airport and Duxford Airfield, required an assessment due to the Proposed Development falling within their respective safeguarding buffer zones, which are outlined in **paragraph 4.26**.

1.2. Geometric analysis was conducted at 15 individual residential receptors and 20 road receptors as well as four runway approach paths and an air traffic control tower at Cambridge City Airport and four runway approach paths and an air traffic control tower at Duxford Airfield.

1.3. Following an initial assessment, rail receptors were scoped out as assets that will be impacted upon from the Proposed Development as no rail receptors fell within the 1km study area. The assessment concludes that:

- Glare is theoretically possible at 10 of the 15 residential receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **High** at 10 receptors and **None** at the remaining five receptors. Upon reviewing the actual visibility of the receptor, glint and glare impacts reduce **Low** at two receptors and to **None** at all remaining receptors.

- Glare is theoretically possible at 12 of the 20 road receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **High** at 12 receptors and **None** at the remaining eight receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts remain **High** at three receptors and reduce to **None** at all remaining receptors. Once mitigation measures were considered, impacts reduce to **None** at all receptors.

- Glare is theoretically possible at 17 of the 25 bridleway receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **High** at 17 receptors and **None** at the remaining eight receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduce to **Low** at 15 receptors and reduce to **None** at all remaining receptors.
- **No impact** on train drivers or railway infrastructure is predicted.
- Only green glare is predicted to impact upon Runways 05 and 05G and the air traffic control tower at Cambridge City Airport. Green glare is described as 'Low Potential for After Image' which is an **acceptable impact** when pilots are approaching runways/helipads, according to the FAA guidance. The predicted green glare impacts upon the control tower occur outside the operational hours of Cambridge City Airport and are therefore deemed as **not significant**. There were no glare impacts predicted upon Duxford Airfield. Therefore, impacts upon aviation assets are **not significant**.

1.4. Mitigation is required to ensure the **High** impact views from Road Receptors 8, 9 and 10 into the Proposed Development are screened. This includes native hedgerows to be planted/infilled up along the northeast and northwest boundaries of the Proposed Development and maintained to a height of at least 2.5m.

1.5. The effects of glint and glare and their impact on local receptors has been analysed in detail and once mitigation measures have been introduced there is predicted to be **Low** and **None** impacts, and therefore **No Significant Effects**.

2. INTRODUCTION

BACKGROUND

2.1. Neo Environmental Ltd has been appointed by Engena, on behalf of Six Oaks Renewable Energy Park Ltd (the "Applicant") to undertake a Glint and Glare Assessment for a proposed energy park consisting of solar arrays, battery storage and associated infrastructure (the "Proposed Development") on lands c. 1.9km east of Bottisham (the "Application Site").

PROPOSED DEVELOPMENT DESCRIPTION

2.2. The Proposed Development will consist of the construction of PV panels mounted on metal frames, substation and battery storage area, compound area, DNO, customer cabin, customer substation, power station, access tracks, perimeter fence, access gate and all ancillary grid infrastructure and associated works.

SITE DESCRIPTION

2.3. The Application Site is located c. 1.9km to the east of the village of Bottisham. Centred at approximate Grid Reference N259288 E557142, the Application Site covers a total area of c. 76.9 hectares. The Application Site comprises one site consisting of four fields and the Proposed Development will be accessed via existing farm tracks from Wilbraham Road.

SCOPE OF REPORT

2.4. Although there may be small amounts of glint and glare from the metal structures associated with the solar farm, the main source of glint and glare will be from the panels themselves and this will be the focus of this assessment.

2.5. Solar panels are designed to absorb as much light as possible and not to reflect it. However, glint can be produced as a reflection of the sun from the surface of the solar PV panel. This can also be described as a momentary flash. This may be an issue due to visual impact and viewer distraction on ground-based receptors and on aviation.

2.6. Glare is significantly less intense in comparison to glint and can be described as a continuous source of bright light, relative to diffused lighting. This is not a direct reflection of the sun, but a reflection of the sky around the sun.

2.7. This report will concentrate on the effects of glint and glare and its impact on local receptors and will be supported with the following Figures and Appendices.

- Appendix A: Figures
  - Figure 1: Residential Based Receptors
  - Figure 2: Road Based Receptors
  - Figure 3: Bridleway Based Receptors
  - Figure 4: Site Layout
  - Figure 5: Cambridge City Airport Aerodrome Chart
  - Figure 6: Duxford Airfield Aerodrome Chart
- Appendix B: Residential Receptor Glare Results
- Appendix C: Road Receptor Glare Results
- Appendix D: Bridleway Receptor Glare Results
- Appendix E: Aviation Receptor Glare Results
- Appendix F: Visibility Evidence Assessment
- Appendix G: Solar Module Glare and Reflectance Technical Memo[1]

STATEMENT OF AUTHORITY

2.8. This Glint and Glare Assessment has been produced by Tom Saddington, Michael McGhee and David Thomson of Neo Environmental. Having completed a civil engineering degree in 2012, Michael has produced Glint and Glare assessments for over 1GW of solar farm developments across the UK and Ireland. Tom has an undergraduate degree in Bioengineering and graduated with an MSc in Environmental and Energy Engineering in January 2020. He has been working on various technical assessments including glint and glare reports for numerous solar farms in Ireland and the UK. David has an undergraduate degree in physics, as well as a MSc in sensor design and a MSc in nanoscience. He is an Environmental Engineer currently being trained in Glint and Glare assessments.

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1 Sunpower Corporation (September 2009), T09014 Solar Module Glare and Reflectance Technical Memo

DEFINITIONS

2.9. This study examined the potential hazard and nuisance effects of glint and glare in relation to ground-based receptors, this includes the occupants of surrounding dwellings as well as road users. The Federal Aviation Authority (FAA) in their "*Technical Guidance for Evaluating Selected Solar Technologies on Airports*"[2] have defined the terms 'Glint' and 'Glare' as meaning;

- Glint – "*A momentary flash of bright light*"
- Glare – "*A continuous source of bright light*"

2.10. Glint and glare are essentially the unwanted reflection of sunlight from reflective surfaces. This study used a multi-step process of elimination to determine which receptors have the potential to experience the effects of glint and glare. It then examined, using a computer-generated geometric model, the times of the year and the times of the day such effects could occur. This is based on the relative angles between the sun, the panels, and the receptor throughout the year.

General Nature of Reflectance from Photovoltaic Panels

2.11. In terms of reflectance, photovoltaic solar panels are by no means a highly reflective surface. They are designed to absorb sunlight and not to reflect it. Nonetheless, photovoltaic panels have a flat polished surface, which omits 'specular' reflectance rather than a 'diffuse' reflectance, which would occur from a rough surface. Several studies have shown that photovoltaic panels (as opposed to Concentrated Solar Power) have less reflectance characteristics to water, which is much lower than the likes of glass, steel, snow and white concrete by comparison (**See Appendix G**). Similar levels of reflectance can be found in rural environments from the likes of shed roofs and the lines of plastic mulch used in cropping. In terms of the potential for reflectance from photovoltaic panels to cause hazard and/ or nuisance effects, there have been a number of studies undertaken in respect of schemes in close proximity to airports. The most recent of these was compiled by the Solar Trade Association (STA) in April 2016 and used a number of case studies and expert opinions, including that from Neo. The summary of this report states that "*the STA does not believe that there is cause for concern in relation to the impact of glint and glare from solar PV on aviation and airports…*"[3].

2 Harris, Miller, Miller & Hanson Inc. (November 2010). Technical Guidance for Evaluating Selected Solar Technologies on Airports; 3.1.2 Reflectivity. Technical Guidance for Evaluating Selected Solar Technologies on Airports. Available at:

https://www.faa.gov/airports/environmental/policy_guidance/media/airport-solar-guide.pdf

3 Solar Trade Association. (April 2016). Summary of evidence compiled by the Solar Trade Association to help inform the debate around permitted development for non - domestic solar PV in Scotland. Impact of solar PV on aviation and airports. Available at: http://www.solar-trade.org.uk/wp-content/uploads/2016/04/STA-glint-and-glare-briefing-April-2016-v3.pdf

Time Zones / Datum's

2.12. Locations in this report are given in Eastings and Northings using the 'British National Grid' grid reference system unless otherwise stated.

2.13. England uses British Summer Time (BST, UTC + 01:00) in the summer months and Greenwich Mean Time (UTC+0) in the winter period. For the purposes of this report all time references are in GMT.

3. LEGISLATION AND GUIDANCE

NATIONAL PLANNING POLICY GUIDANCE (NPPG) ON RENEWABLE AND LOW CARBON ENERGY (UK) [4]

3.1. Paragraph 013 (Reference ID: 5-013-20150327) sets out planning considerations that relate to large scale ground-mounted solar PV farms. This determines that 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. Considerations to be taken into account by local planning authorities are;

- *"the proposal's visual impact, the effect on landscape of glint and glare 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 potential to mitigate landscape and visual impacts through, for example, screening with native hedges"*

PLANNING GUIDANCE FOR THE DEVELOPMENT OF LARGE-SCALE GROUND MOUNTED SOLAR PV SYSTEMS

3.2. As outlined within the BRE document 'Planning Guidance for the Development of Large-Scale Ground Mounted Solar PV Systems'[5]

"Glint may be produced as a direct reflection of the sun in the surface of the solar PV panel. It may be the source of the visual issues regarding viewer distraction. Glare is a continuous source of brightness, relative to diffused lighting. This is not a direct reflection of the sun, but rather a reflection of the bright sky around the sun. Glare is significantly less intense than glint.

[4] NPPG Renewable and Low Carbon Energy. Available at: http://planningguidance.communities.gov.uk/blog/guidance/renewable-and-low-carbon-energy/particular-planning-considerations-for-hydropower-active-solar-technology-solar-farms-and-wind-turbines/#paragraph_012

[5] BRE (2013) *Planning Guidance for the Development of Large Scale Ground Mounted Solar PV Systems*. Available at: https://www.bre.co.uk/filelibrary/pdf/other_pdfs/KN5524_Planning_Guidance_reduced.pdf

Solar PV panels are designed to absorb, not reflect, irradiation. However, the sensitivities associated with glint and glare, and the landscape/ visual impact and the potential impact on aircraft safety, should be a consideration. In some instances, it may be necessary to seek a glint and glare assessment as part of a planning application. This may be particularly important if 'tracking' panels 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 in the construction of the solar PV farm."

Interim CAA Guidance – Solar Photovoltaic Systems (2010)

3.3. There is little guidance on the assessment of glint and glare from solar farms with regards to aviation safety. The Civil Aviation Authority (CAA) has published interim guidance on 'Solar Photovoltaic Systems[6]', they also intend to undertake a review of the potential impacts of solar PV developments upon aviation, however this is yet to be published.

3.4. The interim guidance identifies the key safety issues with regards to aviation, including *"glare, dazzling pilots leading them to confuse reflections with aeronautical lights."* It is outlined that solar farm developers should be aware of the requirements to comply with the Air Navigation Order (ANO), published in 2016 and amended in 2022. In particular, developers should be cognisant of the following articles of the ANO[7], including:

- ***Article 240*** *– Endangering safety of an aircraft – "A person must not recklessly or negligently act in a manner likely to endanger an aircraft, or any person in an aircraft."*
- ***Article 224*** *- Lights liable to endanger – "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 or from landing at an aerodrome; or*

– *b) by reason of its liability to be mistaken for an aeronautical ground light liable to endanger aircraft"*

[6] *CAA (2010) Interim CAA Guidance – Solar Photovoltaic Systems. Available at: https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&appid=11&mode=detail&id=4370*

[7] CAA (2016) Air Navigation: The Order and Regulations. Available at: https://www.caa.co.uk/media/1a2cigrq/air-navigation-order-2016-amended-april-2022-version.pdf

- ***Article 225*** *– Lights which dazzle or distract – "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."*

3.5. Relevant studies generally agree that there is potential for glint and glare from photovoltaic panels to cause a hazard or nuisance for surrounding receptors, but that the intensity of such reflections is similar to that emanating from still water. This is considerably lower than for other manmade materials such as glass, steel or white concrete (SunPower – 2009).

3.6. These Articles are considered within the assessment of glint and glare of the Proposed Development.

CAA – CAP738: Safeguarding of Aerodromes 3rd Edition[8]

3.7. In 2003 the CAA first introduced the CAP738 document to help provide advice and guidance to ensure aerodrome safeguarding. Subsequently, there have been two updates to this document in 2006 and 2020.

3.8. Within the latest edition of CAP738, it outlines that the purpose of the document is to protect an aerodrome and to ensure safe operation. Specifically stating:

"Its purpose is to protect:

Aircraft from the risk of glint and glare e.g. solar panels."

3.9. Within the section named as "Appendix C – Solar Photovoltaic Cells", the following is stated:

"Policy

1. In 2010 the CAA published interim guidance on Solar Photovoltaic Cells (SPCs). At that time, it was agreed that we would review our policy based on research carried out by the Federal Aviation Authorities (FAA) in the United States, in addition to reviewing guidance issued by other National Aviation Authorities. New information and field experience, particularly with respect to compatibility and glare, has resulted in the FAA reviewing its original document 'Technical Guidance for Evaluating Selected Solar Technologies on Airports', which is likely to be subject to change, see link; https://www.federalregister.gov/documents/2013/10/23/2013-24729/interimpolicy-faa-review-of-solar-energy-system-projects-on-federally-obligated-airports

2. In the United Kingdom there has been a further increase in SPV cells, including some located close to aerodrome boundaries; to date the CAA has not received any detrimental comments

[8] Civil Avaition Authority (2020). CAP738 – Safeguarding of Aerodromes 3rd Edition. Available at: https://publicapps.caa.co.uk/docs/33/CAP738%20Issue%203.pdf

or issues of glare at these established sites. Whilst this early indication is encouraging, those responsible for safeguarding should remain vigilant to the possibility."

3.10. The above is stating that to date, there has not been any complications on airfields due to glare originating from solar farms across the UK.

US Federal Aviation Administration Policy

3.11. The US Federal Aviation Administration (FAA) in their Solar Guide (Federal Aviation Authority, 2010)[9] incorporates a chapter on the impact and assessment of glint from solar panels. It concludes that (although subject to revision):

"…evidence suggests that either significant glare is not occurring during times of operation or if glare is occurring, it is not a negative effect and is a minor part of the landscape to which pilots and tower personnel are exposed."

3.12. The interim policy (Federal Register, 2013)[10] demands that an ocular impact assessment must be assessed at 1-minute intervals from when the sun rises above the horizon until the sun sets below the horizon. Specifically, the developer must use the 'Solar Glare Hazard Analysis Tool' (SGHAT) tool specifically and reference its results as this was developed by the FAA and Sandia National Laboratories as a standard and approved methodology for assessing potential impacts on aviation interests, although it notes other assessment methods may be considered. The SGHAT tool has since been licensed to a private organisation who were also involved in its development and it is the software model used in this assessment.

3.13. Crucially, the policy provides a quantitative threshold which is lacking in the English guidance. This outlines that a solar development will not automatically receive an objection on glint grounds if low intensity glint is visible to pilots on final approach. In other words, low intensity glint with a low potential to form a temporary after-image (Green Glare) would be considered acceptable under US guidance. Due to the lack of legislation and guidance within England, this US document has been utilised as guidance for this report.

3.14. The FAA guidance states that for a solar PV development to obtain FAA approval or to receive no objection, the following two criteria must be met:

- No potential for glint or glare in the existing or planned Air Traffic Control Tower (ATCT); and

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[9] FAA (2010), Technical Guidance for Evaluating Selected Solar Technologies on Airports. Available at https://www.faa.gov/airports/environmental/policy_guidance/media/airport-solar-guide-print.pdf

[10] FAA (2013), Interim Policy, *FAA Review of Solar Energy System Projects on Federally Obligated Airports*. Available at https://www.federalregister.gov/documents/2013/10/23/2013-24729/interim-policy-faa-review-of-solar-energy-system-projects-on-federally-obligated-airports

- No potential for glare (glint) or "low potential for after-image" (Green Glare) along the final approach path for any existing or future runway landing thresholds (including planned or interim phases), as shown by the approved layout plan (ALP). The final approach path is defined as 2 miles from 50 feet above the landing threshold using a standard 3-degree glide path.

3.15. The geometric analysis included later in this report, which defines the extent and time at which glint may occur, is required by the FAA as the methodology to be used when assessing glint and glare impacts on aviation receptors. This report follows the methodology required by the FAA as it offers the most robust assessment method currently available.

FAA Policy: Review of Solar Energy Systems Projects on Federally - Obligated Airports[11]

3.16. The FAA updated their Interim Policy from 2013 as part of their commitment to "*update policies and procedures as part of an iterative process as new information and technologies become available."* The main development regarding Glint and Glare since the Interim Policy is the following:

> *"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."*

3.17. This is outlining that solar panels are similar to nuisances that are already caused by other existing infrastructure, such as; car parks, glass buildings and water bodies. Furthermore, the ATCT has been outlined as the key receptor to be assessed when determining Glint and Glare impacts from a solar farm.

[11] FAA (2021). FAA Policy: Review of Solar Energy Systems Projects on Federally – Obligated Airports. Available at: https://www.federalregister.gov/documents/2021/05/11/2021-09862/federal-aviation-administration-policy-review-of-solar-energy-system-projects-on-federally-obligated

REVIEW OF LOCAL PLAN

East Cambridgeshire District Council Local Plan

3.18. The East Cambridgeshire Local Plan 2015[12] was adopted by the Council on 21 April 2015.

3.19. The Plan states in **Policy ENV 6: Renewable energy development** that:

'Proposals for renewable energy and associated infrastructure will be supported, unless their wider environmental, social and economic benefits would be outweighed by significant adverse effects that cannot be remediated and made acceptable in relation to:

- *Residential amenity.*
- *Safeguarding areas for nearby airfields'*

[12] East Cambridgeshire Local Plan 2015, available at: https://www.eastcambs.gov.uk/local-development-framework/east-cambridgeshire-local-plan-2015

4. METHODOLOGY

4.1. A desk-based assessment was undertaken to identify when and where glint and glare may be visible at receptors within the vicinity of the Proposed Development, throughout the day and the year.

SUN POSITION AND REFLECTION MODEL

Sun Data Model

4.2. The calculations in the solar position calculator are based on equations from Astronomical Algorithms[13]. The sunrise and sunset results are theoretically accurate to within a minute for locations between +/- 72° latitude, and within 10 minutes outside of those latitudes. However, due to variations in atmospheric composition, temperature, pressure and conditions, observed values may vary from calculations.

Solar Reflection Model

4.3. The position of the sun is calculated at one-minute intervals of a typical year, in this instance the year being assessed was 2022.

4.4. In order to determine if glint and glare will reach a receptor the following variables are required:

- Sun position;
- Observer location, and;
- Tilt, orientation, and extent of the modules in the solar array.

4.5. The model assumes that the azimuth and horizontal angle of the sun is the same across the whole solar farm. This is considered acceptable due to the distance of the sun from the Proposed Development and the miniscule differences in location of the sun over the Proposed Development.

4.6. Once the position of the sun is known for each time interval, a vector reflection equation determines the reflected sun vector, based on the normal vector of the solar array panels. This assumes that the angle of reflection is equal to the angle of incidence reflected across a normal plane. In this instance, the plane being the vector which the solar panels are facing.

[13] Jean Meeus, Astronomical Algorithms (Second Edition), 1999

4.7. On knowing the vector of the glare, the azimuth is calculated and the horizontal reflection from multiple points within the solar farm. These are then compared with the azimuth and horizontal angle of the receptor from the solar farm to determine if it is within range to receive solar reflections.

4.8. The glare in the model is considered to be specular as a worst-case scenario. In practice the light from the sun will not be fully reflected as solar panels are designed to absorb light rather than reflect it. The text above and Appendix G outlines the reflective properties of solar glass and compares it to other reflective surfaces. Although the exact figures in this report could be argued, it is included as a visual guide and it agrees with most other reports, in that solar glass has less reflective properties than other types of glass, bodies of water and snow, and that the amount of reflective energy drops as the angle of incidence decreases.

4.9. Most modern panels have a slight surface texture which should have a small effect on diffusing the solar radiation further. Although, this has not been modelled to conform with the worst-case scenario assessment.

4.10. The panel reflectivity has been modelled to assume an anti-reflective coating (ARC) which is the industry standard for photo-voltaic panels and further reduces the reflective properties of the PV panels.

Determination of Ocular Impact

4.11. The software used for this assessment is based on the Sandia Laboratories Solar Glare Hazard Analysis Tool (SGHAT). This tool is specifically mentioned in the FAA guidance as the software which should be used in this type of assessment.

4.12. Determination of the ocular impact requires knowledge of the direct normal irradiance, PV module reflectance, size and orientation of the array, optical properties of the PV module, and ocular parameters. These values are used to determine the retinal irradiance and subtended source angle used in the ocular hazard plot.

4.13. The ocular impact[14] of viewed glare can be classified into three levels based on the retinal irradiance and subtended source angle: low potential for after-image (green), potential for after-image (yellow), and potential for permanent eye damage (red).

4.14. Green glare can be ignored when looking at ground based and some aviation receptors. Green glare does not cause temporary flash blindness and happens at an instant with very slight disturbance. As per FAA guidelines mitigation is only required for green glare when affecting an Air Traffic Control Tower, but not for when affecting pilots. Therefore, it can be assumed that green glare is acceptable for ground-based receptors.

[14] Ho, C.K., C.M. Ghanbari, and R.B. Diver, 2011, Methodology to Assess Potential Glint and Glare Hazards From Concentrating Solar Power Plants: Analytical Models and Experimental Validation, Journal of Solar Energy Engineering-Transactions of the Asme, 133(3).

4.15. The subtended source angle represents the size of the glare viewed by an observer, while the retinal irradiance determines the amount of energy impacting the retina of the observer. Larger source angles can result in glare of high intensity, even if the retinal irradiance is low.

4.16. The modelling software outputs a hazard plot for each receptor predicted to be impacted by glare from the photovoltaic (PV) array. An orange dot is plotted for each minute of glare indicating the irradiance (power density) of the reflected solar light. A yellow dot is plotted to show the irradiance of the Sun when it is viewed directly. The hazard plot shows that the irradiance of the Sun is approximately three orders of magnitude greater than the reflected irradiance, i.e., the power density of solar reflections from photovoltaic panels are approximately 0.1% that of viewing the Sun. Due to the disparity in irradiance, whenever the Sun is observed in the same frame as solar reflections from a PV array, the Sun will be main source of glare impacts upon the observer. In such a case, the impact is deemed to be **Low** as a worst-case scenario.

Relevant Parameters of the Proposed Development

4.17. The photovoltaic panels are oriented in a southwards direction to maximise solar gain and will remain in a fixed position throughout the day and during the year (i.e. they will not rotate to track the movement of the sun). The panels will face southwards and will be inclined at an angle of 25 degrees.

4.18. The height of the panels above ground level is a maximum of 3m and points at the top of the panels are used to determine the potential for glint and glare generation.

Identification of Receptors

Ground Based Receptors

4.19. Glint is most likely to impact upon a ground-based receptor close to dusk and dawn, when the sun is at its lowest in the sky. Therefore, any effect would likely occur early in the day or late in the day, reflected to the west at dawn and east at dusk.

4.20. A 1km study area from the panels was deemed appropriate for the assessment of ground-based receptors as this seemed to contain a good spread of residential and road receptors in most directions from the Proposed Development. The further distance a receptor is from a solar farm, the less chance it has of being affected by glint and glare due to scattering of the reflected beam and atmospheric attenuation, in addition to obstructions from ground sources, such as any intervening vegetation or buildings.

4.21. An observer height of 2m was utilised for residential receptors, as this is a typical height for a ground-floor window. With regards to road users, a receptor height of 1.5m was employed as this is typical of eye level. For horse riders on a bridleway, a receptor height of 2.7m is used.

Rail driver's eye level was assumed to be 2.75m above the rail for signal signing purposes and therefore this is the height used for assessment purposes.

4.22. An assessment was undertaken to determine zones where solar reflections will never be directed near ground level.

4.23. Where there are several residential receptors within close proximity, a representative dwelling or dwellings is/are chosen for full assessment as the impacts will not vary to any significant degree. Where small groups of receptors have been evident, the receptors on either end of the group have been analysed in detail with the worst-case impacts attributed to that receptor.

Aviation

4.24. Glint is only considered to be an issue with regards to aviation safety when the solar farm lies within close proximity to the ATCT, runway, particularly when the aircraft is descending to land. En-route activities are not considered an issue as the flight will most likely be at a higher altitude than the glare.

4.25. Should a solar farm be proposed within the safeguarded zone of an aerodrome then a full geometric study may be required which would determine if there is potential for glint and glare at key locations, most likely on the descent to land.

4.26. Buffer zones to identify aviation assets vary depending on the safeguarding criteria of that asset. All aerodromes within 30km will be identified, however generally the detailed assessments are only required within: 20km for large international aerodromes, 10km for military aerodromes and 5km for small aerodromes.

Magnitude of Impact

Static Receptors

4.27. Although there is no specific guidance set out to identify the magnitude of impact from solar reflections, the following criteria has been set out for the purposes of this report:

- High - Glare impacts of over 30 hours per year or over 30 minutes per day
- Medium - Glare impacts between 20 and 30 hours per year or between 20 minutes and 30 minutes per day
- Low - Glare impacts between 0 and 20 hours per year or between 0 minutes and 20 minutes per day

- **None -** Effects not geometrically possible or no visibility of reflective surfaces likely due to high levels of intervening screening

Moving Receptors (Road and Rail)

4.28. Again, no specific guidance is available to identify the magnitude of impact from solar reflections on moving receptors except in aviation, however it is thought that a similar approach should be applied to moving receptors as aviation, based on the ocular impact and the potential for after-image.

4.29. The FAA guidance states that for a solar PV development to obtain FAA approval or to receive no objection the following criteria must be met:

- No potential for glare (glint) or "*low potential for after-image*" along the final approach path for any existing or future runway landing thresholds (including planned or interim phases), as shown by the approved layout plan (ALP).

4.30. The FAA produced an evaluation of glare as a hazard and concluded in their report[15] that:

"The more forward the glare is and the longer the glare duration, the greater the impairment to the pilots' ability to see their instruments and to fly the aircraft. These results taken together suggest that any sources of glare at an airport may be potentially mitigated if the angle of the glare is greater than 25 deg from the direction that the pilot is looking in. We therefore recommend that the design of any solar installation at an airport consider the approach of pilots and ensure that any solar installation that is developed is placed such that they will not have to face glare that is straight ahead of them or within 25 deg of straight ahead during final approach."

4.31. It is reasonable to assume that although this report was assessing pilots vision impairment that it can be also used to drivers of other vehicles. Therefore, the driver's field of view will also be analysed where required and if the glare is out with 25 degrees either side of their line of sight then any impacts will reduce to **None**.

Moving Receptors (Aviation)

Approach Paths

4.32. Each final approach path which has the potential to receive glint is assessed using the SGHAT model. The model assumes an approach bearing on the runway centreline, a 3-degree glide path with the origin 50ft (15.24m) above the runway threshold.

[15] Federal Aviation Authority, Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach (2015), Available at https://libraryonline.erau.edu/online-full-text/faa-aviation-medicine-reports/AM15-12.pdf

4.33. The computer model considers the pilots field of view. The azimuthal field of view (AFOV) or horizontal field of view (HFOV) as it is sometimes referred, refers to the extents of the pilot's horizontal field of view measured in degrees left and right from directly in front of the cockpit. The vertical field of view (VFOV) refers to the extents of the pilot's vertical field of view measured in degrees from directly in front of the cockpit. The HFOV is modelled at 50 degrees left and right from the front of the cockpit whilst the VFOV is modelled at 30 degrees.

4.34. The FAA guidance states that there should be no potential for glare or '*low potential for after-image*' at any existing or future planned runway landing thresholds for the Proposed Development to be acceptable.

Air Traffic Control Tower (ATCT)

4.35. An air traffic controller uses the visual control room to monitor and direct aircraft on the ground, approaching and departing the aerodrome. It is essential that air traffic controllers have a clear unobstructed view of the aviation activity. The key areas on an aerodrome are the views towards the runway thresholds, taxiways, and aircraft bays.

4.36. The FAA guidance states that no glare towards the ATCT should be produced by a proposed solar development, however this should be assessed on a site by site case and will depend on the operations at a particular aerodrome.

4.37. In order to determine the impact on the ATCT, the location and height of the tower will need to be fed into the SGHAT model and where there is a potential for 'low potential for After-Image' or more, then mitigation measures will be required.

Assessment Limitations

4.38. Below is a list of assumptions and limitations of the model and methods used within this report:

- The model does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc;
- The model does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results;
- Due to variations in atmospheric composition, temperature, pressure and conditions, observed values may vary slightly from calculated positions;
- The model does not account for the effects of diffraction; however, buffers are applied as a factor of safety; and

- The model assumes clear skies at all times and does not account for meteorological effects such as cloud cover, fog, or any other weather event which may screen the sun.

4.39. Due to these assumptions and limitations the model overestimates the number of minutes of glint and glare which are possible at each receptor and presents the worst-case scenario. Where glint and glare are predicted a visibility assessment is carried out to determine a more accurate, real-world prediction of the impacts.

4.40. The approach outlined in the Methodology above has been developed following feedback over time from councils across the UK and Ireland where Glint and Glare Assessments have been completed for up to 2GW in solar projects. We believe this Methodology to be the most robust and will continue to update this as we complete more Glint and Glare Assessments.

5. BASELINE CONDITIONS

GROUND BASED RECEPTORS REFLECTION ZONES

5.1. Based on the relatively flat topography in the area, solar reflections between five degrees below the horizontal plane to five degrees above it are described as near horizontal. Reflections from the proposed solar farm within this arc have the potential to be seen by receptors at or near ground level.

5.2. Further analysis showed that this will only occur between the azimuth of 238.15 degrees and 298.73 degrees in the western direction (late day reflections) and 64.76 degrees and 129.14 degrees in the eastern direction (morning reflections) and therefore any ground-based receptor outside these arcs will not have any impact from solar reflections.

5.3. **Figure 1 and 2 of Appendix A** show the respective study areas whilst also subtracting from this the areas where solar reflections will not impact on ground-based receptors due to the reasons set out in **paragraphs 5.1 to 5.2.**

Residential Receptors

5.4. Residential receptors located within 1km of the Application Site have been identified (**Table 5 - 1**). Glint was assumed to be possible if the receptor is located within the ground-based receptor zones outlined previously.

5.5. There are seven residential receptors (Receptors 16 - 22) which are within the no-reflection zones and are clearly identifiable in **Figure 1: Appendix A.** The process of how these are calculated is explained in **paragraphs 5.1 to 5.2** of this report.

Table 5 - 1: Residential Based Receptors

Receptor	Easting	Northing	Glint and Glare Theoretically Possible
1	555714	259910	Yes
2	556034	260016	Yes
3	556059	260003	Yes
4	556611	259816	Yes
5	556658	259790	Yes
6	558125	259434	Yes
7	558145	259453	Yes

8	558282	259416	Yes
9	558317	259258	Yes
10	558247	259044	Yes
11	558337	258936	Yes
12	558337	258891	Yes
13	558362	258875	Yes
14	558357	258867	Yes
15	558352	258861	Yes
16	557939	257948	No
17	557798	258022	No
18	557677	258107	No
19	556767	260019	No
20	556929	260491	No
21	556796	260500	No
22	556840	260713	No

Road / Rail Receptors

5.6. There are three roads within the 1km study area that require a detailed Glint and Glare Assessment; The A1303, the A14 and the A11. There are some minor roads which serve dwellings; however, these have been dismissed as vehicle users of these roads will likely be travelling at low speeds and therefore, there is a negligible risk of safety impacts resulting from glint and glare of the Proposed Development.

5.7. The ground receptor no-reflection zones are clearly identifiable on **Figure 2: Appendix A** and the process of how these are calculated is explained in **paragraphs 5.1 to 5.2** of this report.

5.8. **Table 5 - 2** shows a list of receptor points within the study area which are 200m apart.

Table 5 - 2: Road Based Receptors

Receptor	Easting	Northing	Glint and Glare Theoretically Possible
1	555679	259939	Yes
2	555878	259961	Yes

3	556076	259979	Yes
4	556276	259967	Yes
5	555633	259578	Yes
6	555833	259577	Yes
7	556033	259585	Yes
8	556232	259602	Yes
9	556429	259633	Yes
10	556626	259672	Yes
11	556819	259723	Yes
12	558023	260049	Yes
13	557954	260025	Yes
14	557875	259841	Yes
15	557809	259652	Yes
16	557749	259461	Yes
17	557699	259267	Yes
18	557663	259071	Yes
19	557630	258873	Yes
20	557597	258676	Yes
21	557565	258478	No
22	557536	258281	No
23	557506	258083	No
24	557472	257886	No
25	557439	257688	No
26	556474	259992	No
27	556674	259996	No
28	556872	260018	No
29	557070	260039	No
30	557269	260048	No

31	557452	260126	No
32	557646	260168	No
33	557835	260110	No
34	557010	259784	No
35	557197	259853	No
36	557382	259929	No
37	557564	260014	No
38	557742	260103	No
39	557916	260202	No
40	558051	260199	No

5.9. There are no railway lines within the 1km study area which require a detailed assessment.

Bridleway Receptors

5.10. Bridleway receptors located within 1km of the Application Site have been identified (**Figure 3; Appendix A**). Glint was assumed to be possible if the receptor is located within the ground-based receptor zones outlined previously.

5.11. There are three bridleway receptors (Receptors 26 - 28) which are within the no-reflection zones and are clearly identifiable in **Figure 3: Appendix A.** The process of how these are calculated is explained in **paragraphs 5.1 to 5.2** of this report.

5.12. **Table 5 - 3** shows a list of receptor points within the study area which are 200m apart.

Table 5 - 3: Bridleway Based Receptors

Receptor	Easting	Northing	Glint and Glare Theoretically Possible
1	555670	259907	Yes
2	555767	259755	Yes
3	555815	259562	Yes
4	555891	259359	Yes
5	556065	259255	Yes
6	556253	259185	Yes

7	556456	259119	Yes
8	556641	259041	Yes
9	556811	258933	Yes
10	556987	258835	Yes
11	557165	258744	Yes
12	557346	258648	Yes
13	557520	258577	Yes
14	557708	258491	Yes
15	557891	258406	Yes
16	558072	258322	Yes
17	558249	258240	Yes
18	558428	258159	Yes
19	557189	258608	Yes
20	557028	258499	Yes
21	556875	258391	Yes
22	556708	258282	Yes
23	556544	258250	Yes
24	556402	258152	Yes
25	556211	259977	Yes
26	556252	260169	No
27	556297	260355	No
28	556344	260535	No

Aviation Receptors

5.13. Aerodromes within 30km of the Proposed Development can be found in **Table 5 - 4.**

Table 5 - 4: Airfields within close proximity

Airfield	Distance	Use
Cambridge City Airport	7.29km	Licensed airport
Little Shelford Airfield	13.87km	Small grass strip
Duxford Airfield	16.39km	Licensed aerodrome
Willingham Airfield	20.04km	Small grass strip
RAF Mildenhall	20.05km	Military
Fowlmere Airfield	20.88km	Unlicensed small grass strip
Audley End Airfield	22.11km	Unlicensed small grass strip
Bourn Airfield	22.43km	Unlicensed small concrete strip
Ridgwell Airfield	24.46km	Small grass strip
Sutton Meadows Airfield	24.83km	Unlicensed small grass strip
Main Hall Farm	25.17km	Small grass strip
RAF Lakenheath	26.94km	Military
Gransden Lodge	27.48km	Small grass strip
Top Farm	29.09km	Small grass strip
Waits Farm	29.55km	Unlicensed small grass strip

5.14. There are two aerodromes, Cambridge Airport and Duxford Airport, which require detailed assessments due to these airfields being within their respective safeguarding buffer zones outlined in **paragraph 4.26.**

Cambridge City Airport

5.15. Cambridge City Airport (ICAO code EGSC) is designated as an IFR/VFR aerodrome. It is located approximately 1.5NM (2.78km) east of Cambridge.

5.16. The elevation of the aerodrome at the Aerodrome Reference Point (ARP) is 48ft (14.63m). It has one grooved asphalt runway and one grass strip runway (**Figure 5: Appendix A**), the details of which are given in **Table 5 - 5.**

Table 5 - 5: Runways at Cambridge City Airport

Runway Designation	True Bearing (°)	Length (m)	Width (m)
05	049.87	1965	45
23	229.89	1965	45
05G	049.91	899	35
23G	229.92	899	35

5.17. The threshold locations and heights of the runways at Cambridge City Airport are given in **Table 5 - 6**.

Table 5 - 6: Runway Threshold Locations and Heights

Runway Designation	Threshold Latitude	Threshold Longitude	Height AOD (m)
05	52° 12' 02.23" N	000° 09' 59.41" E	13
23	52° 12' 35.57" N	000° 11' 03.78" E	16
05G	52° 12' 11.07" N	000° 10' 32.24" E	15
23G	52° 12' 29.77" N	000° 11' 89.39" E	11

5.18. The Airport Reference Point (ARP) is located at the centre of runway 05/23. The actual location of the ARP is given in **Table 5 - 7**. The height of the air traffic control tower (ATCT) is estimated to be 26m based off a Google Earth 3D ground level image.

Table 5 - 7: Cambridge City Airport Reference Point

	Latitude	Longitude	Eastings	Northings
ARP	52° 12' 17.39" N	000° 10' 29.04" E	548706	258523
ATCT	52° 12' 29.14" N	000° 10' 21.93" E	548570	258875

Duxford Airfield

5.19. Duxford Airfield (ICAO code EGSU) is designated as a VFR only aerodrome. It is located approximately 8NM (14.82km) south of Cambridge.

5.20. The elevation of the aerodrome at the Aerodrome Reference Point (ARP) is 126ft (38.4m). It has one asphalt runway and one grass strip runway (**Figure 6: Appendix A**), the details of which are given in **Table 5 - 8.**

Table 5 - 8: Runways at Duxford Airfield

Runway Designation	True Bearing (°)	Length (m)	Width (m)
06L	058.02	880	25
24R	238.03	880	25
06R	058.02	1503	32
24L	238.04	1503	32

5.21. The threshold locations and heights of the runways at Duxford Airfield are given in **Table 5 - 9**.

Table 5 - 9: Runway Threshold Locations and Heights

Runway Designation	Threshold Latitude	Threshold Longitude	Height AOD (m)
06L	52° 05' 21.40" N	000° 07' 27.14" E	38
24R	52° 05' 36.50" N	000° 08' 06.51" E	34
06R	52° 05' 13.44" N	000° 07' 21.43" E	39
24L	52° 05' 36.45" N	000° 08' 21.07" E	33

5.22. The Airport Reference Point (ARP) is located at the centre of runway 06R/24L. The actual location of the ARP is given in **Table 5 - 10**. The height of the air traffic control tower (ATCT) is estimated to be 8m based off a photograph from Historic England.

Table 5 - 10: Duxford Airfield Reference Point

	Latitude	Longitude	Eastings	Northings
ARP	52° 05' 25.64" N	000° 07' 53.07" E	546117	245712
ATCT	52° 05' 38.60" N	000° 07' 52.92" E	546104	246113

6. IMPACT ASSESSMENT

6.1. Following the methodology outlined earlier in this report, geometrical analysis comparing the azimuth and horizontal angle of the receptors from the Proposed Development and the solar reflection was conducted. Although this assessment did not take into account obstructions such as vegetation and buildings, discussion on the potentially impacted receptors is provided where necessary.

GROUND BASED RECEPTORS

Residential Receptors

6.2. **Table 6 - 1** identifies the receptors that will experience solar reflections based on solar reflection modelling and whether the reflections will be experienced in the morning (AM), evening (PM), or both.

6.3. The seven receptors which were within the no-reflection zones outlined previously have been excluded from the detailed modelling as they will never receive any glint and glare impacts from the Proposed Development.

6.4. **Appendix B** shows the analysis with the solar panels at a tilt angle of 25 degrees. **Table 6 - 1** shows the worst-case impact at each receptor with the assumption of no intervening screening.

Table 6 - 1: Potential for Unmitigated Glint and Glare impact on Residential Receptors

Receptor	Glint Theoretically Possible from Site		Potential Theoretical Glare Impact (per year)		Magnitude of Theoretical Impact
	AM	PM	Minutes	Hours	
1	No	No	0	0	None
2	No	No	0	0	None
3	No	No	0	0	None
4	No	No	0	0	None
5	No	No	0	0	None
6	No	Yes	2572	42.87	High
7	No	Yes	2362	39.37	High
8	No	Yes	2254	37.57	High

9	No	Yes	3693	61.55	**High**
10	No	Yes	3847	64.12	**High**
11	No	Yes	3493	58.22	**High**
12	No	Yes	3360	56.00	**High**
13	No	Yes	3220	53.67	**High**
14	No	Yes	3259	54.32	**High**
15	No	Yes	3240	54.00	**High**

6.5. As can be seen in **Table 6 - 1,** there is potential for a **High** impact at 10 receptors and **None** impact at the remaining five receptors. **Appendix B** shows detailed analysis of when the glare impacts are possible, whilst also showing which parts of the solar farm the solar glare is reflected from.

6.6. **Appendix F** shows Google Earth images that give an insight into how each receptor will be impacted by glint and glare from the Proposed Development. There is a mixture of images used, which include aerial, ground level and street level. The aerial images show the location of the receptor with the solar farm drawn as a white polygon and it can be seen on the images when the solar farm is theoretically visible. The area of the solar farm from where reflections may be possible has been drawn as a yellow polygon. The ground level terrain is based on the height data of the surrounding land showing no intervening vegetation or buildings. The white and yellow polygons can be seen in this view also. The street view gives a good indication as to whether the area of the solar farm where reflections are theoretically possible will be visible from the receptor point.

Receptors 6, 8 and 9

6.7. The 'Glare Reflections on PV Footprint' chart in **Appendix B** shows that reflections from the northern half of the Proposed Development can potentially impact on the receptors.

6.8. The first image in **Appendix F** is an aerial image showing the position of the receptors (yellow pins) in relation to the Proposed Development, and the location from which the second image was taken (red pin). This image shows dense vegetation between the receptors and the Proposed Development. The second image is a street view image with a view towards the receptors. This image confirms that the vegetation is sufficient to screen all views of the Proposed Development where glint and glare is possible. Therefore, the theoretical impact reduces to **None**.

Receptor 7

6.9. The 'Glare Reflections on PV Footprint' chart in **Appendix B** shows that reflections from a northern section of the Proposed Development can potentially impact on the receptor.

6.10. The first image in **Appendix F** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development. This image shows vegetation between the receptor and the Proposed Development. The second image is a ground level image taken from the position of the receptor with a view towards the Proposed Development showing the position of the Sun at 17:45 on March 15th and May 15th respectively. However, the impacts occur when the Sun is low in the sky and behind the solar array at the time of glare impacts. Hence, the Sun's reflections will be far greater than those reflections from the solar array, as outlined in **paragraph 4.16**. These images confirm that the sun will be the main source of solar reflection at the receptor. Therefore, the theoretical impact reduces to **Low**.

Receptor 10

6.11. The 'Glare Reflections on PV Footprint' chart in **Appendix B** shows that reflections from most of the Proposed Development, except a northeast section and a southern section, can potentially impact on the receptor.

6.12. The first image in **Appendix F** is an aerial image showing the position of the receptor (yellow pin) in relation to the Proposed Development, and the location from which the second image was taken (red pin). This image shows vegetation between the receptor and the Proposed Development. The second image is a street view image taken with a view towards the receptor. This image confirms that the vegetation will screen most views of the Proposed Development where glint and glare is possible. Therefore, the theoretical impact reduces to **Low**.

Receptors 11 - 15

6.13. The 'Glare Reflections on PV Footprint' chart in **Appendix B** shows that reflections from most of the Proposed Development, except a northeast section and a southeast section can potentially impact on the receptors.

6.14. The first image in **Appendix F** is an aerial image showing the position of the receptors (yellow pins) in relation to the Proposed Development, and the location from which the second image was taken (red pin). This image shows dense vegetation between the receptors and the Proposed Development. The second image is a street view image with a view towards the receptors. This image confirms that the vegetation is sufficient to screen views of the Proposed Development where glint and glare is possible. Therefore, the theoretical impact reduces to **None**.

Road Receptors

6.15. **Table 6 - 2** shows a summary of the modelling results for each of the Road Receptor Points whilst the detailed results and ocular impact charts can be viewed in **Appendix C**.

6.16. The 20 receptors within the no-reflection zones outlined previously have been excluded from the detailed modelling as they will never receive glint and glare impacts from the Proposed Development.

Table 6 - 2: Potential for Glint and Glare impact on Road Receptors

Receptor	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)	Magnitude of Theoretical Impact
1	0	0	0	None
2	0	0	0	None
3	0	0	0	None
4	0	0	0	None
5	0	514	0	High
6	0	539	0	High
7	0	0	0	None
8	0	136	0	High
9	0	144	0	High
10	0	109	0	High
11	0	22	0	High
12	0	0	0	None
13	0	0	0	None
14	0	64	0	High
15	0	1073	0	High
16	0	3007	0	High
17	0	2906	0	High
18	0	6489	0	High
19	0	6199	0	High
20	0	2189	0	High

6.17. As can be seen in **Table 6 - 2**, there are 13 receptor points which have potential glare impacts with the “potential for after-image” (yellow glare), which is a **High** impact. **Appendix C** shows detailed analysis of when the glint and glare impacts are possible, whilst also showing from which parts of the solar farm the solar glare is reflected from.

6.18. **Appendix F** shows Google Earth images that give an insight into how each receptor will be impacted by glint and glare from the Proposed Development. There is a mixture of images used, which include aerial, ground level and street level. The aerial images show the location of the receptor with the solar farm drawn as a white polygon and can be seen on the images when the solar farm is theoretically visible. The area of the solar farm from where reflections may be possible has been drawn as a yellow polygon. The ground level terrain is based on the height data of the surrounding land showing no intervening vegetation or buildings. The white and yellow polygons can be seen in this view also. The street view gives a good indication as to whether the area of the solar farm where reflections are theoretically possible will be visible from the receptor point.

6.19. As can be seen in **Appendix F**, views of the Proposed Development from all receptors, except receptors 8, 9, 10, 16 and 17, are blocked by a mixture of intervening vegetation, topography and buildings. Therefore, impacts upon these receptors reduce to **None**. Theoretical impacts upon Road Receptors 8, 9 and 10 remain **High**.

6.20. For Road Receptors 16 and 17 the image is an aerial image which shows the receptor at the purple point, with the driver's field of view (50-degrees) shown between the two red lines for each direction. This image shows the glare to be occurring outside the driver's field of view. Therefore, the impact is reduced to **None**, in line with **paragraph 4.31**.

Bridleway Receptors

6.21. **Table 6 - 3** shows a summary of the modelling results for each of the Road Receptor Points whilst the detailed results and ocular impact charts can be viewed in **Appendix D**.

6.22. The three receptors within the no-reflection zones outlined previously have been excluded from the detailed modelling as they will never receive glint and glare impacts from the Proposed Development.

Table 6 - 3: Potential for Glint and Glare impact on Bridleway Receptors

Receptor	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)	Magnitude of Theoretical Impact
1	0	0	0	None
2	0	105	0	High
3	0	665	0	High
4	0	1013	0	High
5	0	0	0	None
6	0	2127	0	High

7	0	2232	0	High
8	0	4997	0	High
9	0	6716	0	High
10	0	5183	0	High
11	0	4665	0	High
12	0	2615	0	High
13	0	3670	0	High
14	0	0	0	None
15	0	0	0	None
16	0	0	0	None
17	0	0	0	None
18	0	0	0	None
19	0	2274	0	High
20	0	2574	0	High
21	0	2289	0	High
22	0	922	0	High
23	0	1146	0	High
24	0	1050	0	High
25	0	0	0	None

6.23. As can be seen in **Table 6 - 3**, there are 17 receptor points which have potential glare impacts with the "potential for after-image" (yellow glare), which is a **High** impact. **Appendix D** shows detailed analysis of when the glint and glare impacts are possible, whilst also showing from which parts of the solar farm the solar glare is reflected from.

6.24. **Appendix F** shows Google Earth images that give an insight into how each receptor will be impacted by glint and glare from the Proposed Development. There is a mixture of images used, which include aerial, ground level and street level. The aerial images show the location of the receptor with the solar farm drawn as a white polygon and can be seen on the images when the solar farm is theoretically visible. The area of the solar farm from where reflections may be possible has been drawn as a yellow polygon. The ground level terrain is based on the height data of the surrounding land showing no intervening vegetation or buildings. The white and yellow polygons can be seen in this view also. The street view gives a good indication as to whether the area of the solar farm where reflections are theoretically possible will be visible from the receptor point.

6.25. As can be seen in **Appendix F**, views of the Proposed Development from all receptors, except receptors 4, 6 – 13 and 19 - 24, are blocked by a mixture of intervening vegetation, topography and buildings. Therefore, impacts upon these receptors reduce to **None**. The theoretical impacts upon Bridleway Receptors 4, 6 – 13 and 19 – 24 occur when the Sun is low in the sky and behind the solar array at the time of glare impacts. Hence, the Sun's reflections will be far greater than those reflections from the solar array, as outlined in **paragraph 4.16**. Therefore, the impact upon these receptors reduces to **Low**.

Aviation Receptors

6.26. **Table 6 - 4** shows a summary of the modelling results for each of the runway approach paths, whilst the detailed results and ocular impact charts can be viewed in **Appendix E.**

Table 6 - 4: Summary of Glare Results

Component	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)
Cambridge City Airport			
Runway 05	1968	0	0
Runway 23	0	0	0
Runway 05G	2065	0	0
Runway 23G	0	0	0
ATCT	622	0	0
Duxford Airfield			
Runway 06L	0	0	0
Runway 24R	0	0	0
Runway 06R	0	0	0
Runway 24L	0	0	0
ATCT	0	0	0

6.27. As can be seen in **Table 6 - 4**, only green glare is predicted to impact upon Runways 05 and 05G, and the air traffic control tower (ATCT) at Cambridge City Airport. Green glare is described as 'Low Potential for After Image' which is an **acceptable impact** when pilots are approaching runways/helipads, according to the FAA guidance. The theoretical impact on approach at these runways is therefore deemed as **Not Significant** and the theoretical impact on the ATCT has been investigated further below.

6.28. As can be seen in **Table 6 - 4**, there is no Glint and Glare predicted at Duxford Airfield. Therefore, the impact on all aviation receptors at Duxford Airfield is **None.**

6.29. As shown in **Appendix F**, the impacts occur when the Sun is low in the sky and behind the solar array at the time of glare impacts. Hence, the Sun's reflections will be far greater than those reflections from the solar array, as outlined in **paragraph 4.16**. These images confirm that the sun will be the main source of solar reflection at the ATCT, therefore any impact because of the Proposed Development can be deemed as **Low**. As can be seen in **Appendix F**, green glare is only predicted to impact upon the ATCT at Cambridge City Airport between the hours of 05:45 UTC and 06:30 UTC in the months of March, April and September. The operational hours[16] of Cambridge City Airport are between 07:00 and 17:00 on Monday – Friday. The glare impacts are predicted to occur outside the operational hours of the airport, as stated above. Therefore, the theoretical impact on the ATCT at Cambridge City Airport is deemed as **Not Significant**.

[16] Cambridge City Airport Information, available at: https://cambridgeairport.com/airport-information/

7. GROUND BASED RECEPTOR MITIGATION

7.1. Mitigation is only required for those receptors that have **High** or **Medium** theoretical impacts. Notwithstanding this, the landscape enhancement proposals identified as part of this planning application, also supports the reduction of glint and glare impacts across all affected properties and road receptors.

7.2. Mitigation is required to ensure the **High** theoretical impact views from Road Receptors 8, 9, 10 into the Proposed Development are screened. This includes:

- Native hedgerows to be planted/infilled up along the northeast and northwest boundaries of the Proposed Development and maintained to a height of at least 2.5m. This will screen views from Road Receptors 8, 9 and 10. Therefore, reducing the **High** impact to **None.**

7.3. **Table 7 – 1, 7 – 2 and 7 – 3** show the impacts at each stage of the glint and glare analysis, with the final residual impacts considered once the mitigation is in place.

Table 7 - 1: Potential Residual Glint and Glare Impacts on Residential Receptors

	Magnitude of Impact		
Receptor	After Geometric Analysis	After Visibility Analysis	Residual Impacts
1	None	None	None
2	None	None	None
3	None	None	None
4	None	None	None
5	None	None	None
6	High	None	None
7	High	Low	Low
8	High	None	None
9	High	None	None
10	High	Low	Low
11	High	None	None
12	High	None	None

13	High	None	None
14	High	None	None
15	High	None	None

Table 7 - 2: Potential Residual Glint and Glare Impacts on Road Receptors

	Magnitude of Impact		
Receptor	After Geometric Analysis	After Visibility Analysis	Residual Impacts
1	None	None	None
2	None	None	None
3	None	None	None
4	None	None	None
5	High	None	None
6	High	None	None
7	None	None	None
8	None	High	None
9	High	High	None
10	High	High	None
11	High	None	None
12	None	None	None
13	None	None	None
14	High	None	None
15	High	None	None
16	High	None	None
17	High	None	None
18	High	None	None
19	High	None	None
20	High	None	None

Table 7 - 3: Potential Residual Glint and Glare Impacts on Bridleway Receptors

	Magnitude of Impact		
Receptor	After Geometric Analysis	After Visibility Analysis	Residual Impacts
1	None	None	None
2	High	None	None
3	High	None	None
4	High	Low	Low
5	None	None	None
6	High	Low	Low
7	High	Low	Low
8	High	Low	Low
9	High	Low	Low
10	High	Low	Low
11	High	Low	Low
12	High	Low	Low
13	High	Low	Low
14	None	None	None
15	None	None	None
16	None	None	None
17	None	None	None
18	None	None	None
19	High	Low	Low
20	High	Low	Low
21	High	Low	Low
22	High	Low	Low
23	High	Low	Low
24	High	Low	Low

25	None	None	**None**

7.4. **Table 7 - 4, 7 - 5 and 7 - 6** show the overall impacts for all residential and road receptors.

Table 7 - 4: Solar Reflections: Residential Receptors

Magnitude	Theoretical Visibility	Actual Visibility (No Mitigation)	Actual Visibility with Mitigation
High	10	0	0
Medium	0	0	0
Low	0	2	2
None	5	13	13

- **High –** Glare impacts of over 30 hours per year or over 30 minutes per day
- **Medium -** Glare impacts between 20 and 30 hours per year or between 20 minutes and 30 minutes per day
- **Low -** Glare impacts up to 20 hours per year or up to 20 minutes per day
- **None -** Effects not geometrically possible or no visibility of reflective surfaces likely due to high levels of intervening screening

Table 7 - 5: Solar Reflections: Road Receptors

Magnitude	Theoretical Visibility	Actual Visibility (No Mitigation)	Actual Visibility with Mitigation
High	13	3	0
Medium	0	0	0
Low	0	0	0
None	7	15	20

- **High –** Glare impacts of over 30 hours per year or over 30 minutes per day
- **Medium -** Glare impacts between 20 and 30 hours per year or between 20 minutes and 30 minutes per day
- **Low -** Glare impacts up to 20 hours per year or up to 20 minutes per day
- **None -** Effects not geometrically possible or no visibility of reflective surfaces likely due to high levels of intervening screening

Table 7 - 6: Solar Reflections: Bridleway Receptors

Magnitude	Theoretical Visibility	Actual Visibility (No Mitigation)	Actual Visibility with Mitigation
High	17	0	0
Medium	0	0	0
Low	0	15	15
None	8	10	10

- High – Glare impacts of over 30 hours per year or over 30 minutes per day
- Medium - Glare impacts between 20 and 30 hours per year or between 20 minutes and 30 minutes per day
- Low - Glare impacts up to 20 hours per year or up to 20 minutes per day
- None - Effects not geometrically possible or no visibility of reflective surfaces likely due to high levels of intervening screening

8. SUMMARY

8.1. This assessment considers the potential impacts on ground-based receptors such as roads, rail and residential dwellings as well as aviation assets. A 1km study area around the Application Site is considered adequate for the assessment of ground-based receptors, whilst a 30km study area is chosen for aviation receptors. Within 1km of the Application Site, there are 22 residential receptors, 40 road receptors and 28 bridleway Receptors which were considered. Following an initial assessment, rail receptors were scoped out as assets that will be impacted upon from the Proposed Development as no rail receptors fell within the 1km study area. As per the methodology section, where there are a number of residential receptors within close proximity, a representative dwelling or dwellings is/are chosen for full assessment as the impacts will not vary to any significant degree. Where small groups of receptors have been evident, the receptors on either end of the group have been assessed in detail. Seven residential receptors, 20 road receptors and three bridleway receptors were dismissed as they are located within the no reflection zones. 15 aerodromes are located within the 30km study area; Two of which, Cambridge City Airport and Duxford Airfield, required an assessment due to the Proposed Development falling within their respective safeguarding buffer zones, which are outlined in **paragraph 4.26**.

8.2. Geometric analysis was conducted at 15 individual residential receptors and 20 road receptors as well as four runway approach paths and an air traffic control tower at Cambridge City Airport and four runway approach paths and an air traffic control tower at Duxford Airfield.

8.3. Following an initial assessment, rail receptors were scoped out as assets that will be impacted upon from the Proposed Development as no rail receptors fell within the 1km study area. The assessment concludes that:

- Glare is theoretically possible at 10 of the 15 residential receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **High** at 10 receptors and **None** at the remaining five receptors. Upon reviewing the actual visibility of the receptor, glint and glare impacts reduce **Low** at two receptors and to **None** at all remaining receptors.

- Glare is theoretically possible at 12 of the 20 road receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **High** at 12 receptors and **None** at the remaining eight receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts remain **High** at three receptors and reduce to **None** at all remaining receptors. Once mitigation measures were considered, impacts reduce to **None** at all receptors.

- Glare is theoretically possible at 17 of the 25 bridleway receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **High** at 17 receptors and **None** at the remaining eight receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduce to **Low** at 15 receptors and reduce to **None** at all remaining receptors.

- **No impact** on train drivers or railway infrastructure is predicted.

- Only green glare is predicted to impact upon Runways 05 and 05G and the air traffic control tower at Cambridge City Airport. Green glare is described as 'Low Potential for After Image' which is an **acceptable impact** when pilots are approaching runways/helipads, according to the FAA guidance. The predicted green glare impacts upon the control tower occur outside the operational hours of Cambridge City Airport and are therefore deemed as **not significant**. There were no glare impacts predicted upon Duxford Airfield. Therefore, impacts upon aviation assets are **not significant**.

8.4. Mitigation is required to ensure the **High** impact views from Road Receptors 8, 9 and 10 into the Proposed Development are screened. This includes native hedgerows to be planted/infilled up along the northeast and northwest boundaries of the Proposed Development and maintained to a height of at least 2.5m.

8.5. The effects of glint and glare and their impact on local receptors has been analysed in detail and once mitigation measures have been introduced there is predicted to be **Low** and **None** impacts, and therefore **No Significant Effects**.

9. APPENDICES

Appendix A: Figures

- Figure 1: Residential Based Receptors
- Figure 2: Road Based Receptors
- Figure 3: Bridleway Based Receptors
- Figure 4: Site Layout
- Figure 5: Cambridge City Airport Aerodrome Chart
- Figure 6: Duxford Airfield Aerodrome Chart

Appendix B: Residential Receptor Glare Results

Appendix C: Road Receptor Glare Results

Appendix D: Bridleway Receptor Glare Results

Appendix E: Aviation Receptor Glare Results

Appendix F: Visibility Assessment Evidence

Appendix G: Solar Module Glare and Reflectance Technical Memo[17]

17 Sunpower Corporation (September 2009), T09014 Solar Module Glare and Reflectance Technical Memo

GLASGOW - HEAD OFFICE

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Crab Lane, Fearnhead
Warrington
Cheshire
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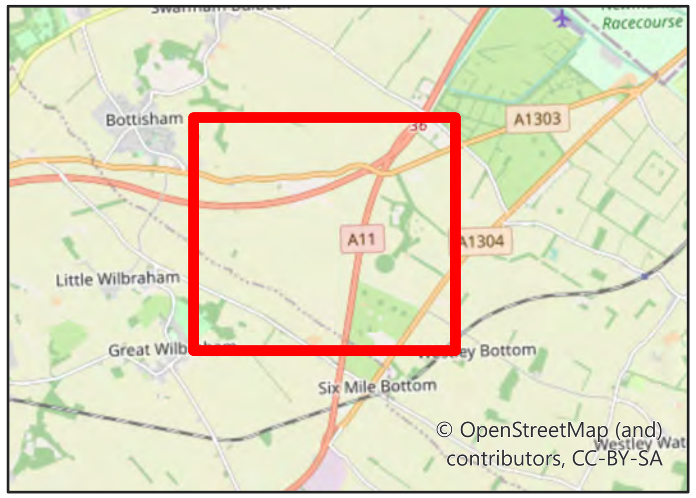
0 0.25 0.5 1 Kilometers

Six Oaks Solar Farm
Residential Based Receptors
Figure 1

Key

- Development Boundary
- Panel Boundary
- 1km Study Area
- Glare Not Possible at Receptor
- Glare Possible at Receptor
- Non-Reflection Zones

Neo Office Address:
Wright Business Centre, 1 Lonmay Road, Glasgow, G33 4EL



Date: 02/09/2022
Drawn By: Scott Griffin
Scale (A3): 1:12,500
Drawing No: NEO01098/001I/A

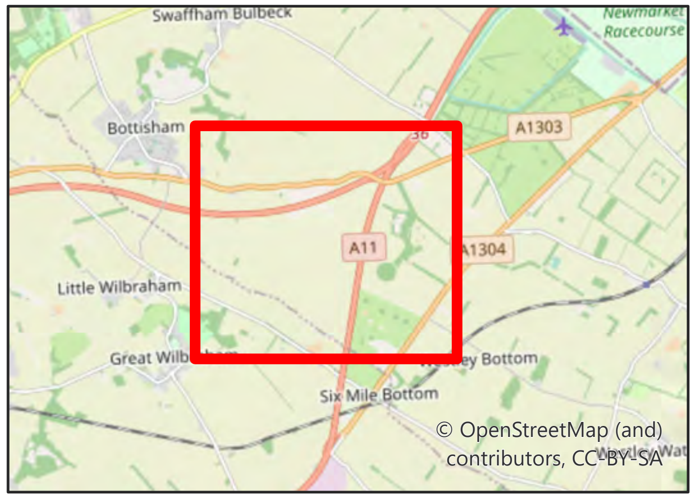
ENVIRONMENTAL

Six Oaks Solar Farm
Road Based Receptors
Figure 2

Key

- Development Boundary
- Panel Boundary
- 1km Study Area
- Glare Not Possible at Receptor
- Glare Possible at Receptor
- Non-Reflection Zones

Neo Office Address:
Wright Business Centre, 1 Lonmay Road, Glasgow, G33 4EL



Date: 02/09/2022
Drawn By: Scott Griffin
Scale (A3): 1:12,500
Drawing No: NEO01098/002I/A

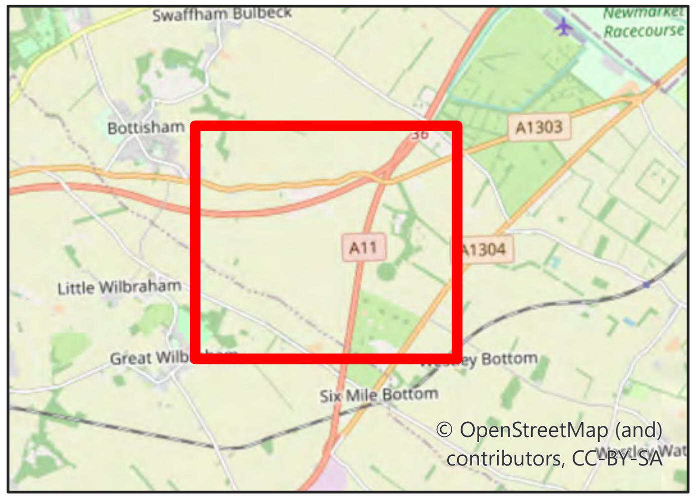
NEO ENVIRONMENTAL

Six Oaks Renewable Energy Park
Bridleway Based Receptors
Figure 3

Key

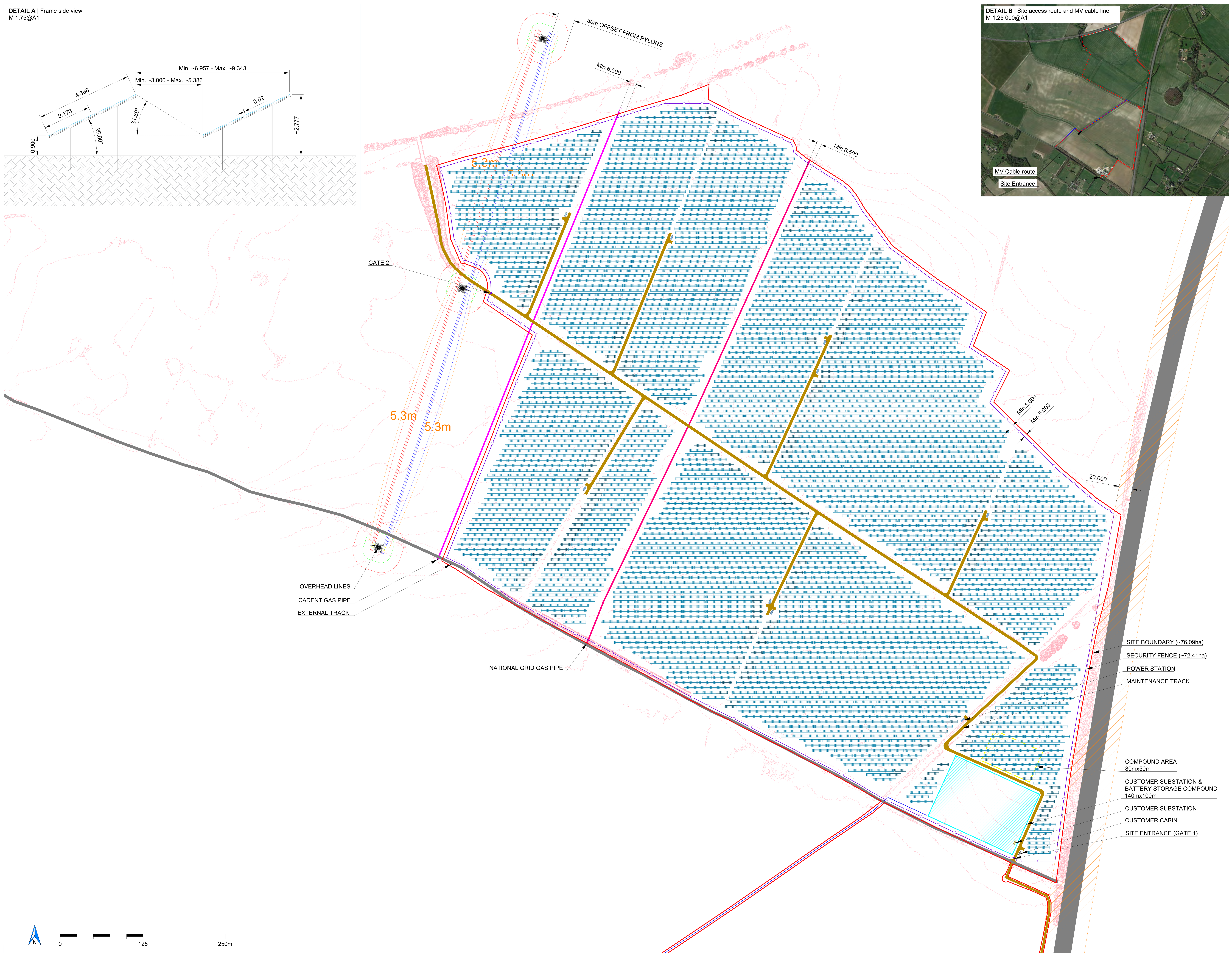
- Development Boundary
- Panel Boundary
- 1km Study Area
- Glare Not Possible at Receptor
- Glare Possible at Receptor
- Non-Reflection Zones

Neo Office Address:
Wright Business Centre, 1 Lonmay Road, Glasgow, G33 4EL



Date: 04/11/2022
Drawn By: David Thomson
Scale (A3): 1:12,500
Drawing No: NEO01098/003I/B

NEO ENVIRONMENTAL



Proposal only

Notes:

1. All dimensions to be confirmed on site prior to installation.
2. All dimensions are indicative only and in m unless otherwise specified.
3. Drawing based on satellite data:
   Imagery date: 22/04/2021

Reference drawings

Drawing name	Rev	Date
Six Oaks Boundary and Layout 07072022	--	03/08/22
ENGN1010-100	A	21/03/22

Legend:

- Site boundary
- Perimeter fence (~3 628 m)
- Maintenance track
- External track
- Cadent gas pipe
- National grid gas pipe
- Customer substation & Battery storage area
- Compound area
- Road restriction area
- CUSTOMER CABIN — Customer cabin
- DNO — DNO
- 20ft. Customer Substation
- 20ft. Power Station (9x 6 000 kVA)
- Table of 2P26 modules (2 185 pcs.)
- Table of 2P13 modules (232 pcs.)
- Gate

System description:

DC Power kWp:	70594.68
AC Power kVA:	49880 (@Pmax) / 46400 (@Pnom)
No. of modules:	119652
Module type:	Canadian Solar CS7L-590MB
Dimensions:	2173x1305x35
Substructure type:	2 modules in portrait
Modules per string:	26
Number of strings:	4 562
Tilt angle:	25°
Shading angle:	~31.59°
Azimuth from South:	0°
Inverter model:	Huawei SUN2000-215KTL-H1
Inverter power, kVA:	215 (@Pmax) / 200 (@Pnom)
No. of inverters:	232
DC / AC ratio:	1.52 (@Pnom)

Proposed location:

Revisions:

Rev	Date	Comments	Drawn	Approve
0	04/08/22	First issue	MC	UZ
0	10/08/22	Frames added over compound area	UZ	UZ

Project:	Six Oaks		
Location:	Wilbraham Road, Six Mile Bottom,New Market, CB8 0UW,UK 52.209753°, 0.297069°		
Title:	PV Layout		
Drawn:	Detra Solar / MC	Checked:	RB
Scale:	1:2500@A1	Date:	04/08/22
Drawing No:	RCE1002-100	Rev:	A

Ridge Clean Energy
Noah's Ark, Market Street Charlbury,
OX7 3PL Oxforshire
energy@ridgecleanenergy.com

Detra Solar
Lvovo str. 25-104,
LT-09320 Vilnius
www.detrasolar.com

AERODROME CHART - ICAO

ARP 521218N 0001030E

AD ELEV 48FT

CAMBRIDGE
EGSC

COM		
ATIS	134.605	CAMBRIDGE INFO
TWR	125.905	CAMBRIDGE TOWER
	121.600	CAMBRIDGE FIRE

LIGHTING	
APCH 05 APCH 23	420m HI C/L with 1 bar. 900m HI coded C/L with 5 bars.
THR 05	Elev HI W bars.
THR 23	Elev HI W bars. Flush green threshold bar.
RWY 05/23	Elev HI bi-d with LI omni-d component. Flush HI bi-d red end lights. End turn pads blue elevated edge.
TWY	Green C/L bi-d to/from main runway holding points. Blue elevated edge lights on Charlie and Delta. Blue reflective markers on Alpha, Bravo and Foxtrot.

GUND (Geoid Undulation) = The height of the Geoid (MSL) above the Reference Elipsoid (WGS 84) at the stated position.

BEARINGS ARE MAGNETIC
ELEVATIONS AND HEIGHTS ARE IN FEET

ELEVATIONS IN FEET AMSL HEIGHTS IN FEET ABOVE AD	**178** (131)

RUNWAY/TAXIWAY/APRON PHYSICAL CHARACTERISTICS

APRON / RWY / TWY	SURFACE	BEARING STRENGTH	ELEVATION
Rwy 05/23	Asphalt (Grooved)	50/F/C/W/T	-
Rwy 05G/23G	Grass	-	-
Apron 2	Concrete/Asphalt	22/R/C/W/T	-
Apron 12	Concrete/Asphalt	8/R/C/W/T	-
Apron 16	Concrete	23/R/C/W/T	49ft amsl
Apron 17	Concrete/Asphalt	50/R/C/W/T	-
Apron (Customs North)	Concrete	17/R/C/W/T	-
Apron (Customs South)	Asphalt	23/R/C/X/T	-
Eastern Apron	Concrete	14/R/C/X/T	-
Twy A (from Rwy to B)	Concrete	42/R/C/X/T	-
Twy A (from B)	Concrete	14/R/C/X/T	-
Twy B	Asphalt	15/R/C/X/T	-
Twy C	Asphalt	24/F/C/X/U	-
Twy D	Concrete	50/R/C/W/T	-
Twy E	Concrete	11/R/C/W/T	-
Twy F	Concrete	39/R/C/X/T	-
Twy L and N	Grass	-	-

CHANGE (7/21): VDF POSITION.

AERODROME CHART - ICAO

ARP 520526N 0000753E

AD ELEV 126FT

DUXFORD EGSU

RUNWAY/TAXIWAY/APRON PHYSICAL CHARACTERISTICS			
APRON / RWY / TWY	SURFACE	BEARING STRENGTH	ELEVATION
RWY 06R/24L	Asphalt	27/F/C/W/T	-
RWY 06L/24R	Grass	-	-
Main Apron	Concrete	-	-
Main Taxiway	Asphalt	-	-

BEARINGS ARE MAGNETIC
ELEVATIONS AND HEIGHTS ARE IN FEET

ELEVATIONS IN FEET AMSL HEIGHTS IN FEET ABOVE AD	134 (9)

COM		
AFIS	122.080	DUXFORD INFORMATION
TWR	121.600	DUXFORD FIRE

CHANGE (7/20): GRASS PARKING EXTENDED. HOLDS A24 & D AMENDED ORIENTATION.

ForgeSolar

Six Oaks Solar Farm

Six Oaks Solar Farm Residential

Created Sept. 6, 2022
Updated Sept. 22, 2022
Time-step 1 minute
Timezone offset UTC0
Site ID 75309.13311

Project type Advanced
Project status: active
Category 10 MW to 100 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodology: **Version 2**
Enhanced subtended angle calculation: **Off**

Summary of Results

Glare with potential for temporary after-image predicted

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	25.0	180.0	0	31,300	-

Component Data

PV Array(s)

Total PV footprint area: 660,016 m^2

Name: PV array 1
Footprint area: 660,016 m^2
Axis tracking: Fixed (no rotation)
Tilt: 25.0 deg
Orientation: 180.0 deg

Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	52.212724	0.291343	19.50	3.00	22.50
2	52.213552	0.296836	25.15	3.00	28.15
3	52.213368	0.297523	25.82	3.00	28.82
4	52.212934	0.298338	26.67	3.00	29.67
5	52.212777	0.298681	26.73	3.00	29.73
6	52.212474	0.299132	26.48	3.00	29.48
7	52.212224	0.299948	26.95	3.00	29.95
8	52.211672	0.300398	26.24	3.00	29.24
9	52.210541	0.302587	27.79	3.00	30.79
10	52.210121	0.302265	27.20	3.00	30.20
11	52.209753	0.303037	28.40	3.00	31.40
12	52.209305	0.302673	29.16	3.00	32.16
13	52.207728	0.305462	35.68	3.00	38.68
14	52.206939	0.305248	36.22	3.00	39.22
15	52.206044	0.303853	36.17	3.00	39.17
16	52.205847	0.304325	36.92	3.00	39.92
17	52.205755	0.304861	37.84	3.00	40.84
18	52.202941	0.304024	35.08	3.00	38.08
19	52.203072	0.303617	35.46	3.00	38.46
20	52.203927	0.303896	37.48	3.00	40.48
21	52.204506	0.302222	37.05	3.00	40.05
22	52.203888	0.301342	35.28	3.00	38.28
23	52.206807	0.292802	27.78	3.00	30.78
24	52.207228	0.291879	26.13	3.00	29.13
25	52.207636	0.290914	25.52	3.00	28.52
26	52.210528	0.293575	20.00	3.00	23.00
27	52.211067	0.292287	21.00	3.00	24.00
28	52.211343	0.292394	20.72	3.00	23.72
29	52.211567	0.292094	20.39	3.00	23.39
30	52.211672	0.291536	19.83	3.00	22.83

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	52.215413	0.277894	15.80	2.00	17.80
OP 2	52.216454	0.282726	16.82	2.00	18.82
OP 3	52.216160	0.282987	16.29	2.00	18.29
OP 4	52.214365	0.290958	19.08	2.00	21.08
OP 5	52.214279	0.291870	19.07	2.00	21.07
OP 6	52.210461	0.312918	57.16	2.00	59.16
OP 7	52.210632	0.313245	58.19	2.00	60.19
OP 8	52.210267	0.315214	59.27	2.00	61.27
OP 9	52.208850	0.315680	61.48	2.00	63.48
OP 10	52.206958	0.314594	58.34	2.00	60.34
OP 11	52.205909	0.315796	55.84	2.00	57.84
OP 12	52.205528	0.315748	53.20	2.00	55.20
OP 13	52.205383	0.316086	52.66	2.00	54.66
OP 14	52.205317	0.316032	52.28	2.00	54.28
OP 15	52.205228	0.315957	51.69	2.00	53.69

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	25.0	180.0	0	31,300	-	-

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	0	0	0	0	0	0	0	0	0	0	0	0
pv-array-1 (yellow)	0	0	318	602	603	600	611	609	532	2	0	0

PV & Receptor Analysis Results

Results for each PV array and receptor

PV array 1 potential temporary after-image

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	2572
OP: OP 7	0	2362
OP: OP 8	0	2254
OP: OP 9	0	3693
OP: OP 10	0	3847
OP: OP 11	0	3493
OP: OP 12	0	3360
OP: OP 13	0	3220
OP: OP 14	0	3259
OP: OP 15	0	3240

PV array 1 - OP Receptor (OP 1)

No glare found

PV array 1 - OP Receptor (OP 2)

No glare found

PV array 1 - OP Receptor (OP 3)

No glare found

PV array 1 - OP Receptor (OP 4)

No glare found

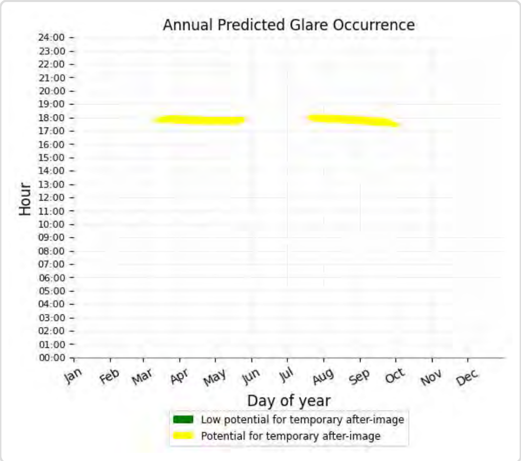
PV array 1 - OP Receptor (OP 5)

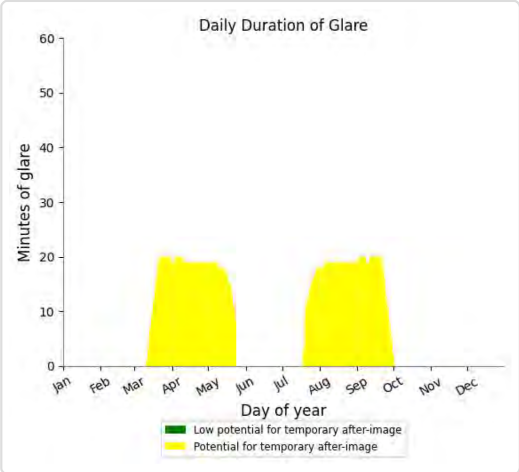
No glare found

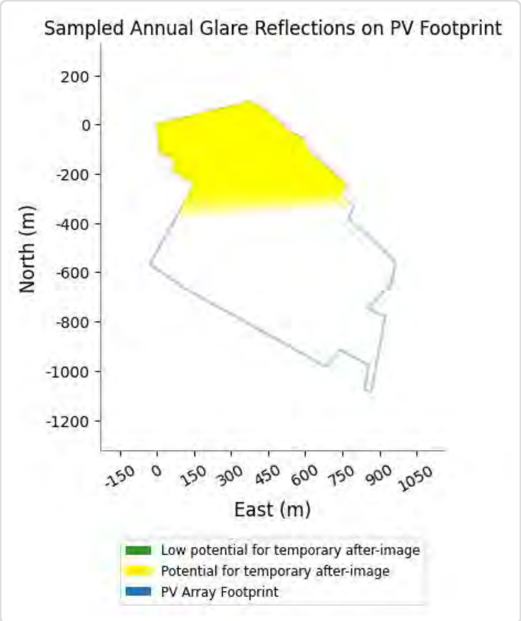
PV array 1 - OP Receptor (OP 6)

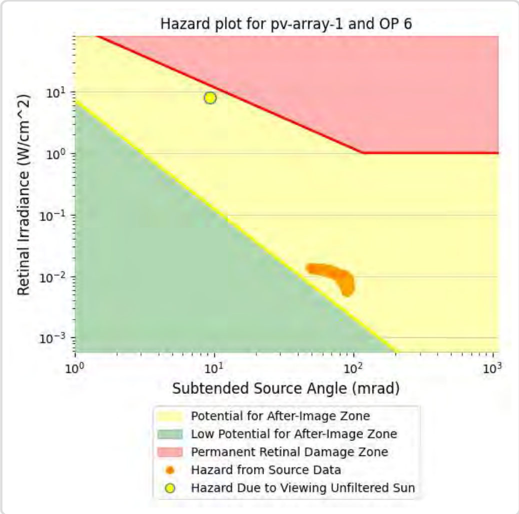
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,572 minutes of "yellow" glare with potential to cause temporary after-image.





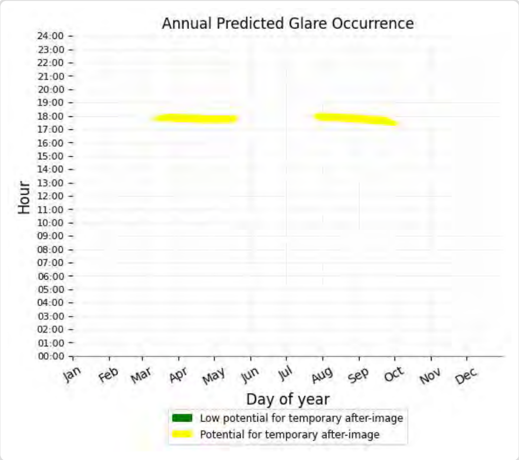


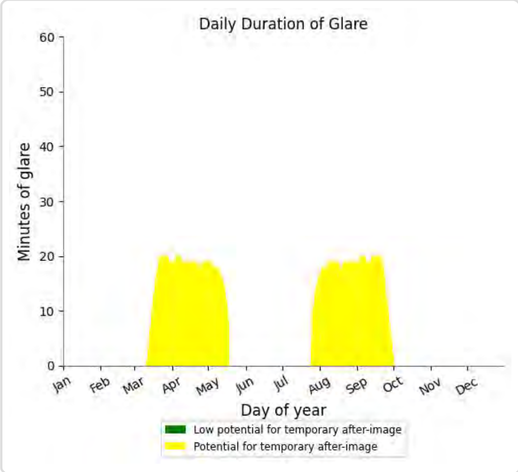


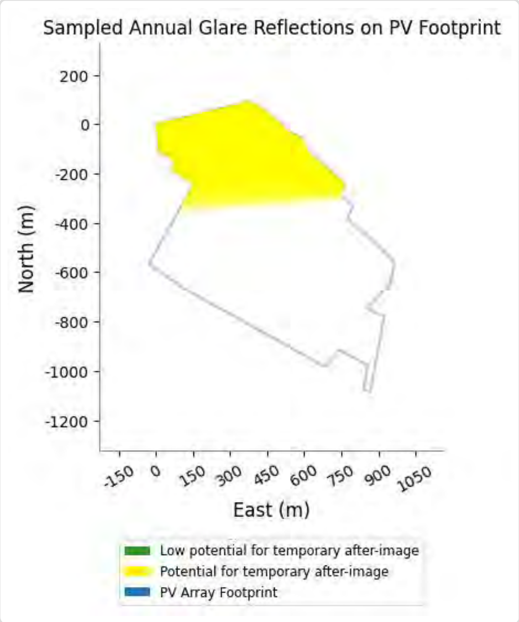
PV array 1 - OP Receptor (OP 7)

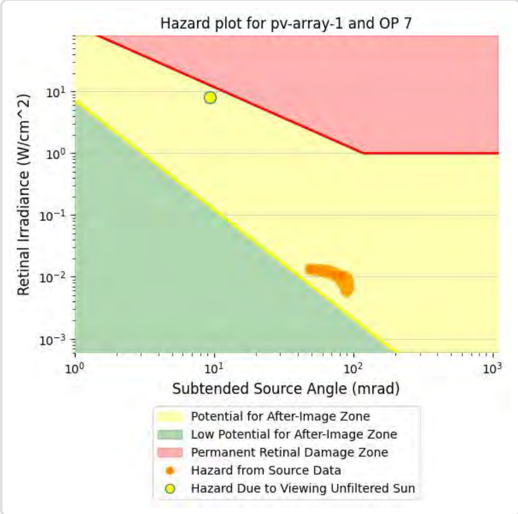
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,362 minutes of "yellow" glare with potential to cause temporary after-image.





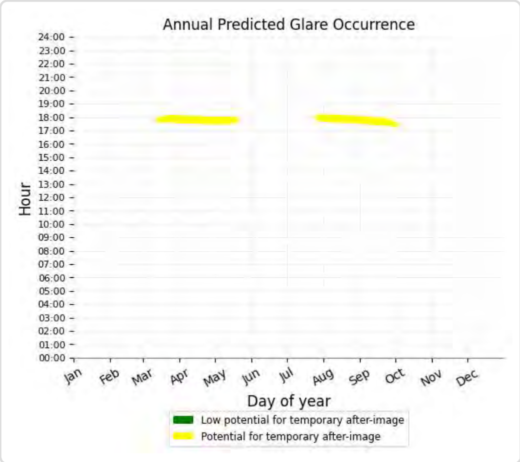


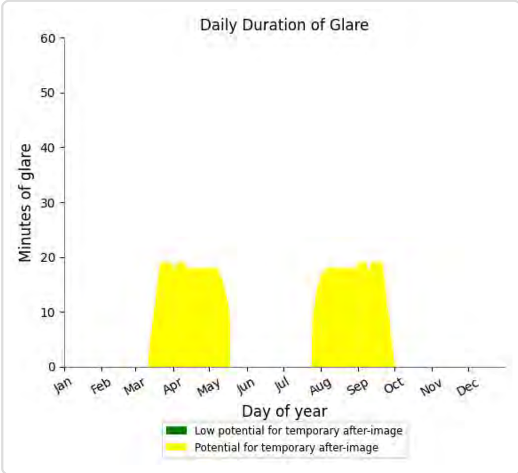


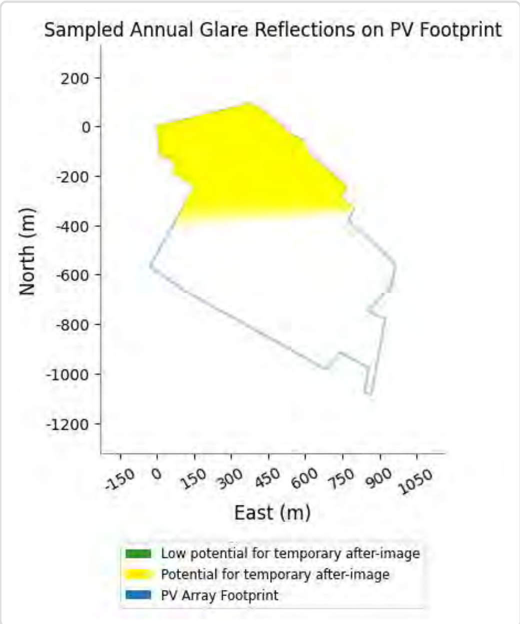
PV array 1 - OP Receptor (OP 8)

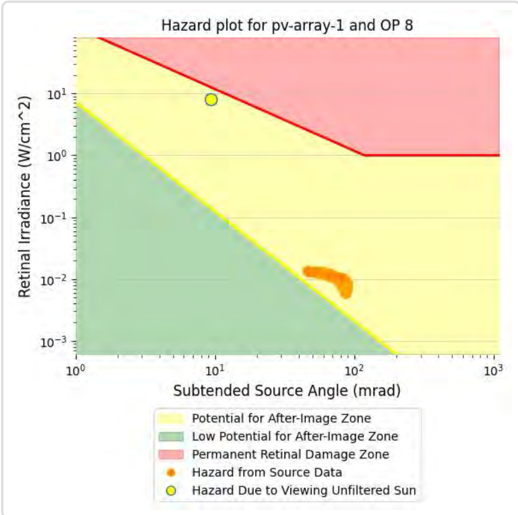
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,254 minutes of "yellow" glare with potential to cause temporary after-image.





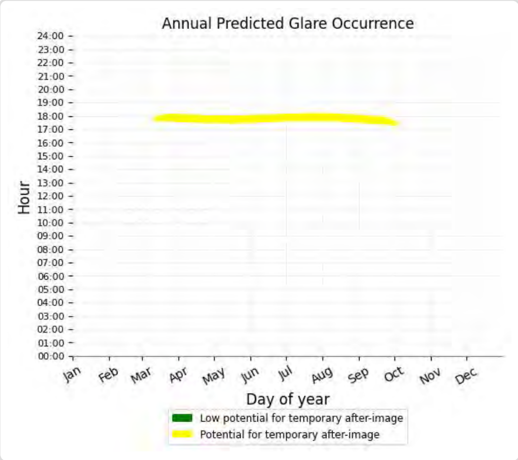


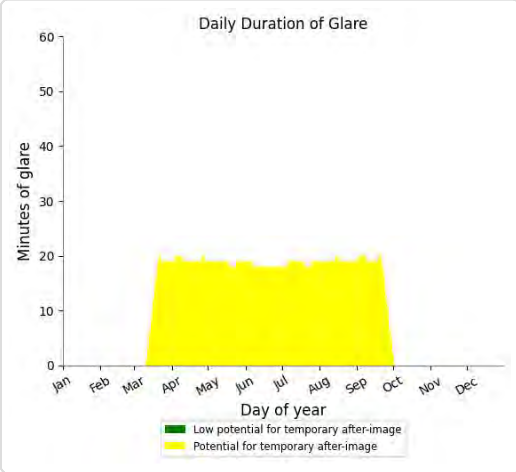


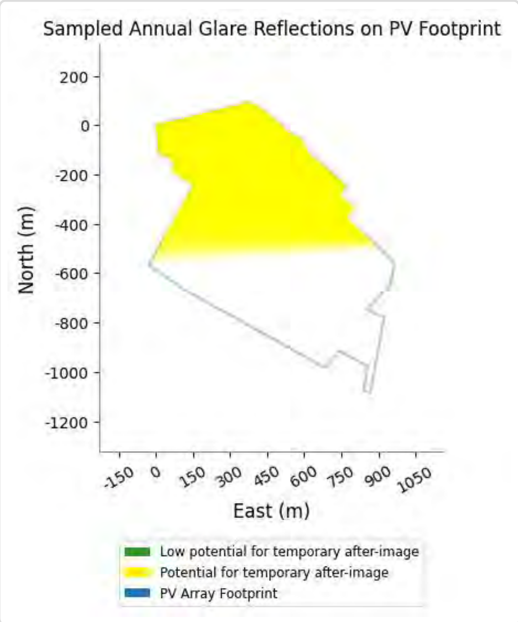
PV array 1 - OP Receptor (OP 9)

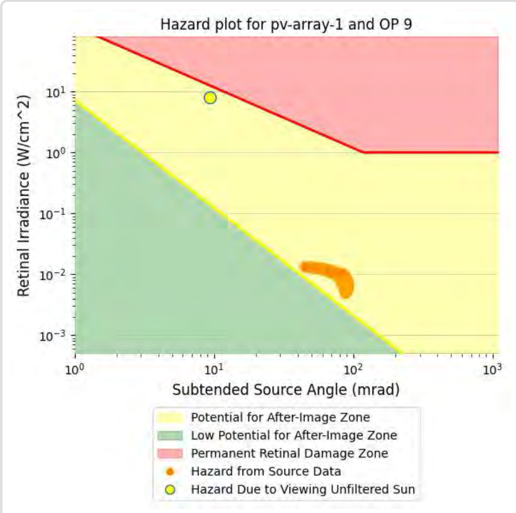
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,693 minutes of "yellow" glare with potential to cause temporary after-image.





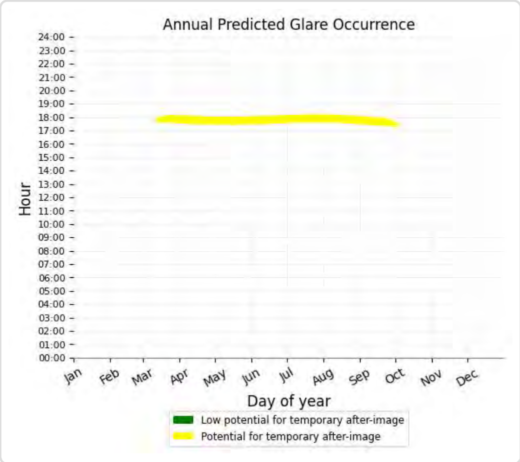


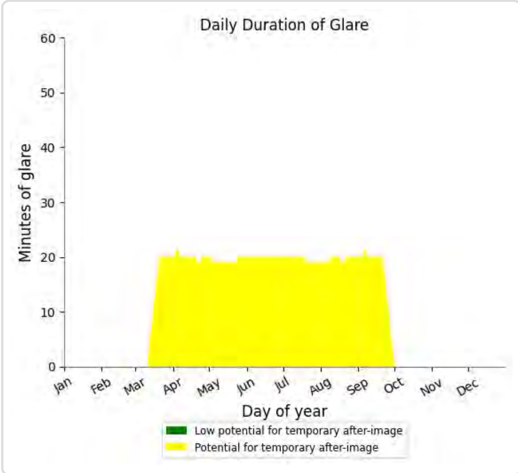


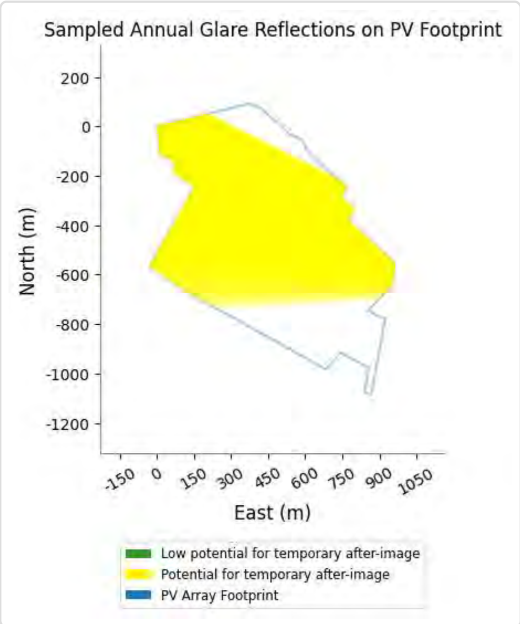
PV array 1 - OP Receptor (OP 10)

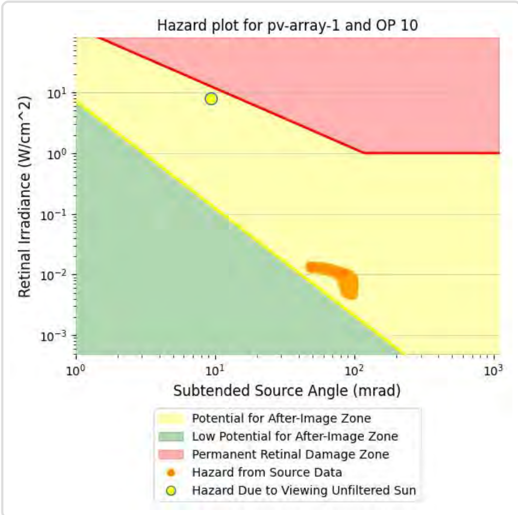
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,847 minutes of "yellow" glare with potential to cause temporary after-image.





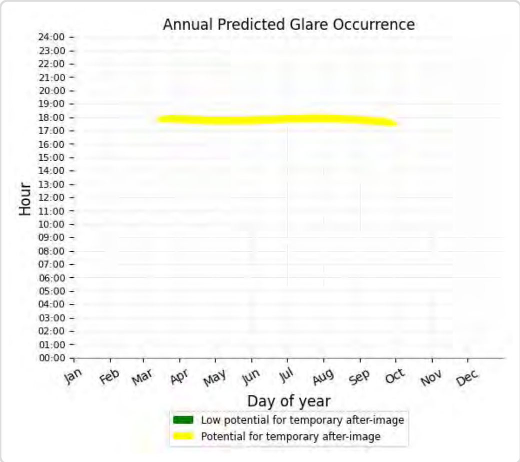


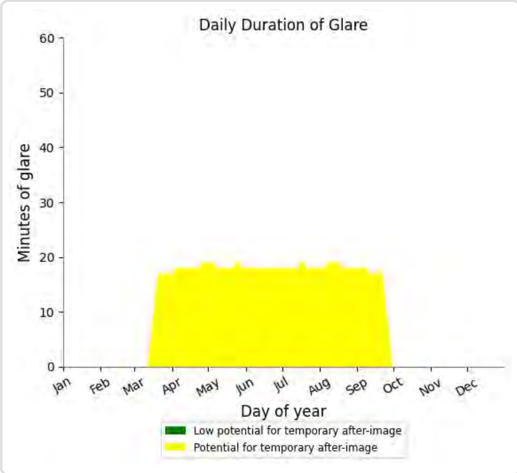


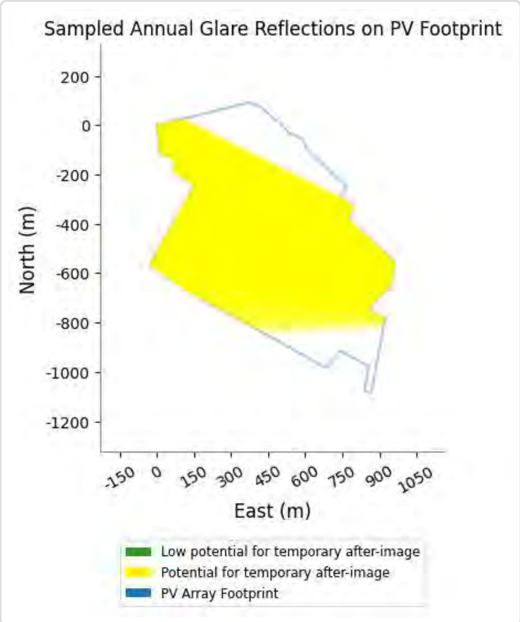
PV array 1 - OP Receptor (OP 11)

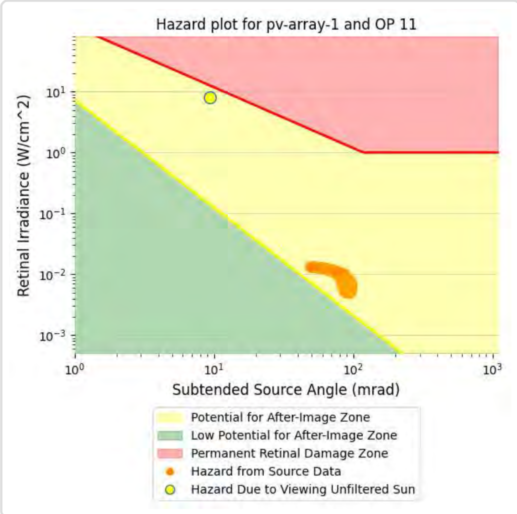
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,493 minutes of "yellow" glare with potential to cause temporary after-image.





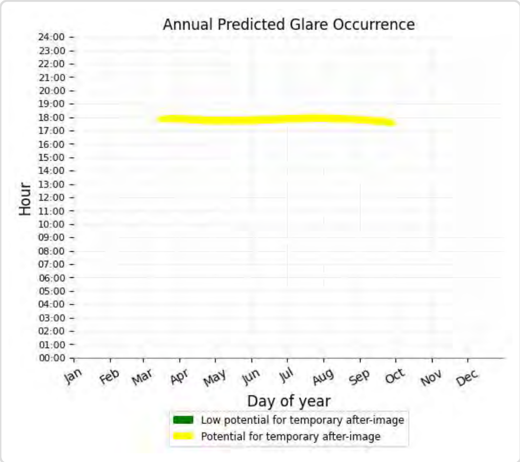


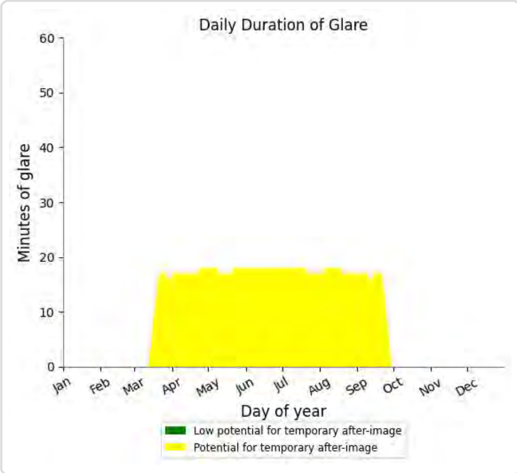


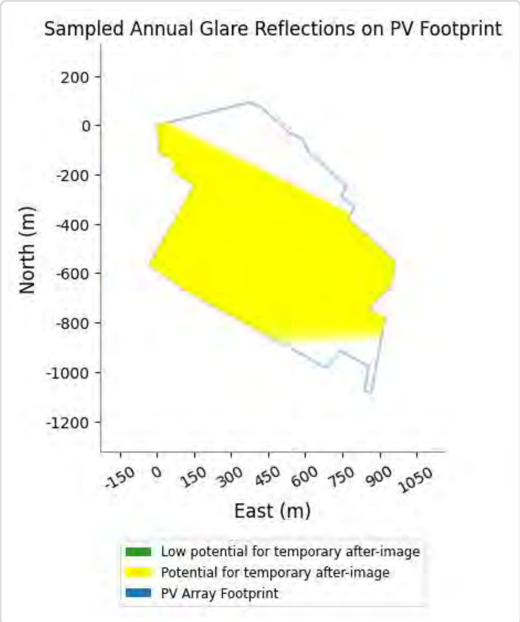
PV array 1 - OP Receptor (OP 12)

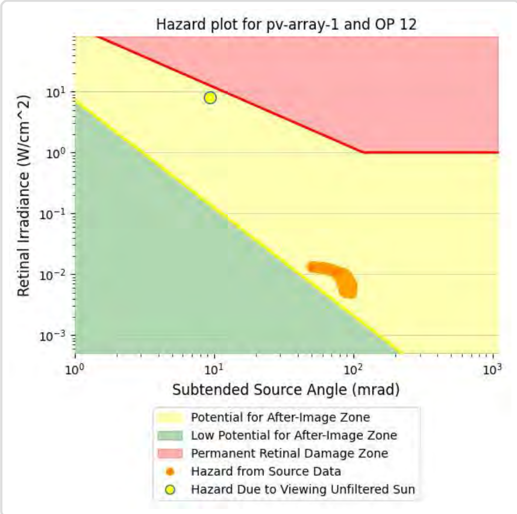
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,360 minutes of "yellow" glare with potential to cause temporary after-image.





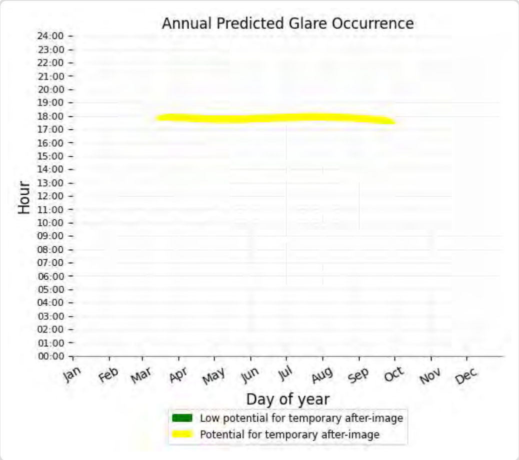


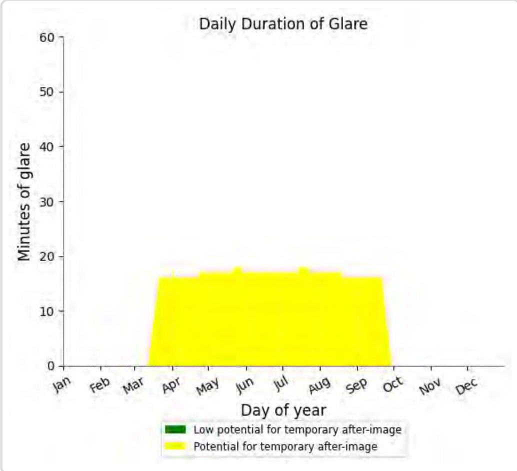


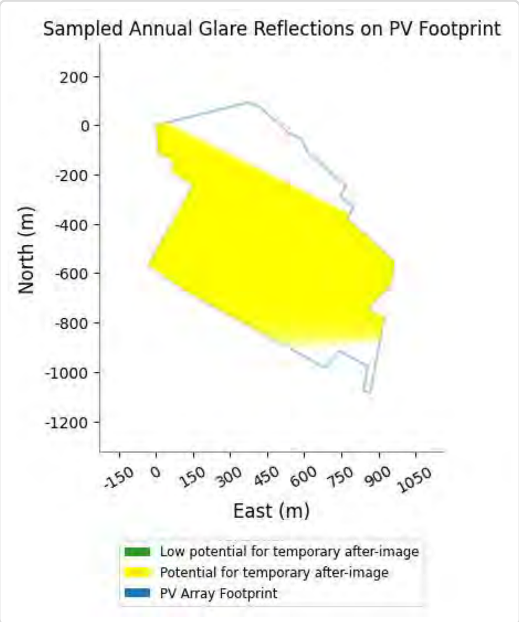
PV array 1 - OP Receptor (OP 13)

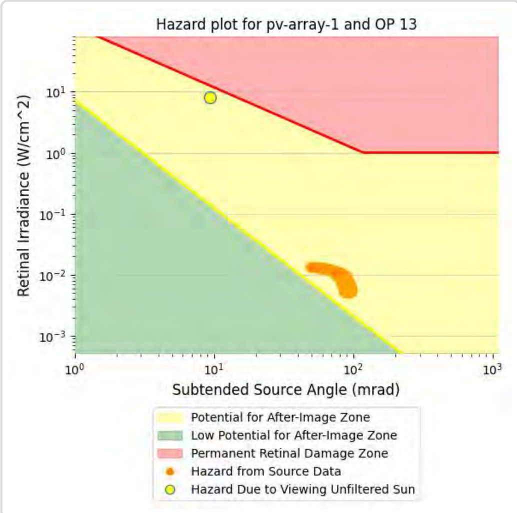
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,220 minutes of "yellow" glare with potential to cause temporary after-image.





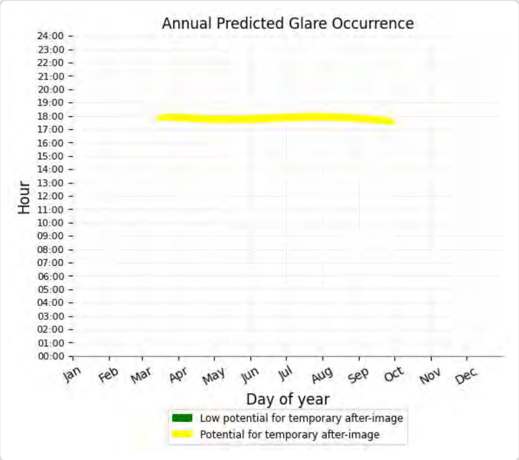


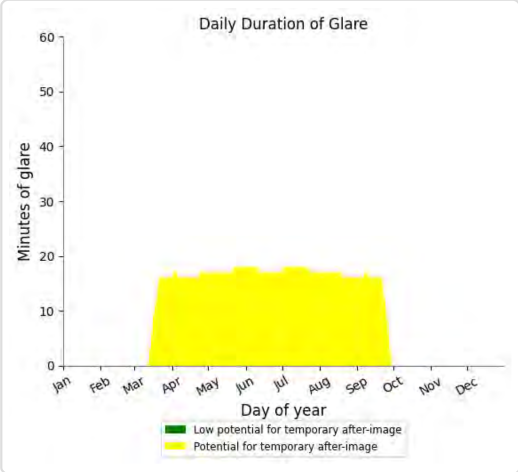


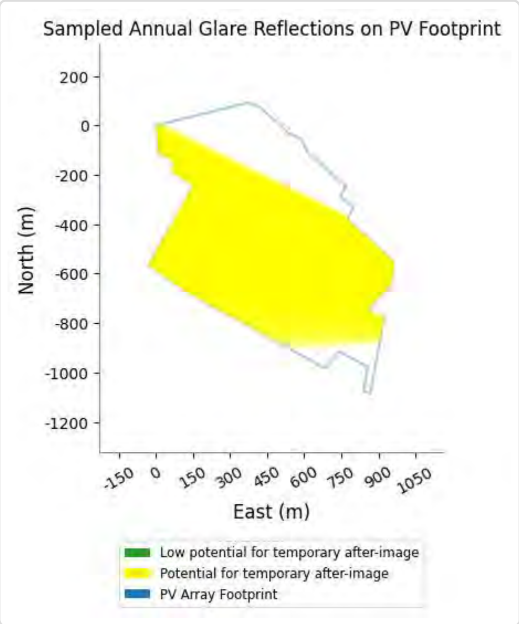
PV array 1 - OP Receptor (OP 14)

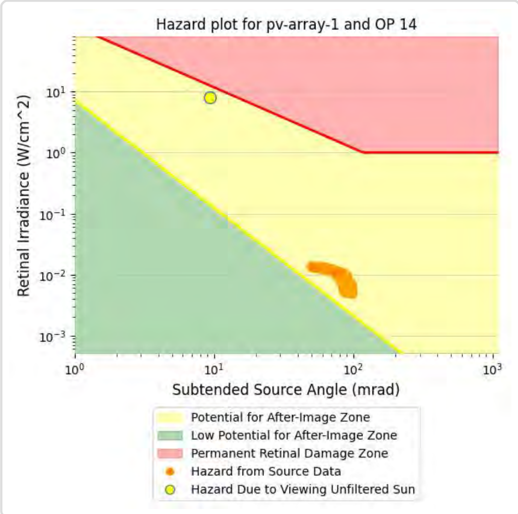
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,259 minutes of "yellow" glare with potential to cause temporary after-image.





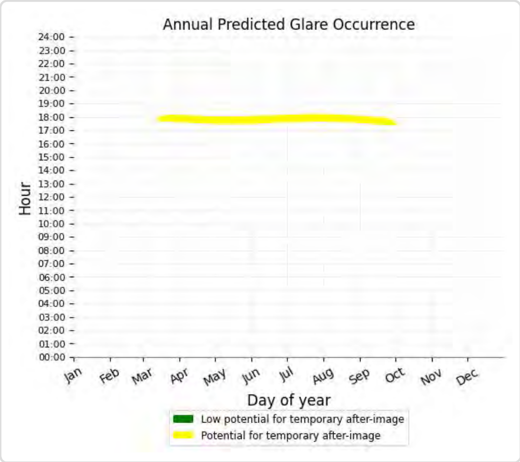


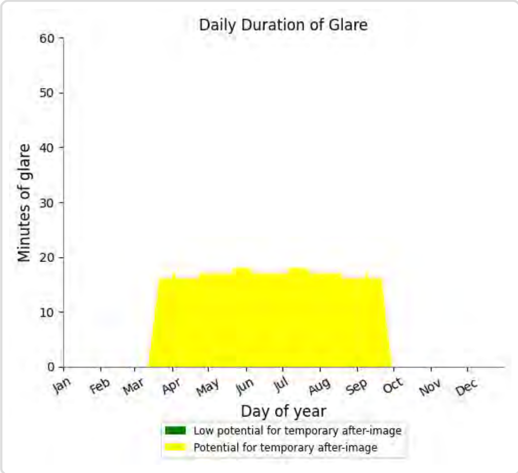


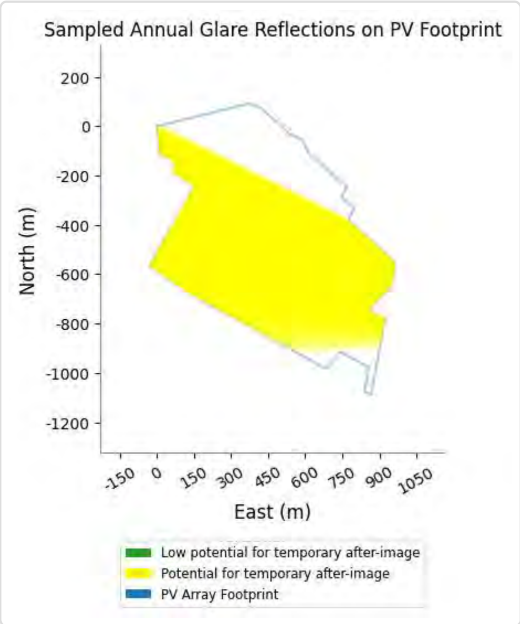
PV array 1 - OP Receptor (OP 15)

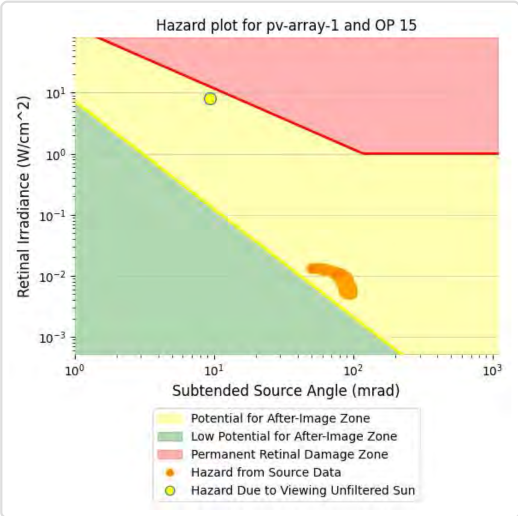
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,240 minutes of "yellow" glare with potential to cause temporary after-image.









Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not automatically account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results fc large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

ForgeSolar

Six Oaks Solar Farm

Six Oaks Solar Farm Road

Created Sept. 6, 2022
Updated Sept. 22, 2022
Time-step 1 minute
Timezone offset UTC0
Site ID 75315.13311

Project type Advanced
Project status: active
Category 10 MW to 100 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodology: **Version 2**
Enhanced subtended angle calculation: **Off**

Summary of Results

Glare with potential for temporary after-image predicted

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	25.0	180.0	0	23,391	-

Component Data

PV Array(s)

Total PV footprint area: 660,016 m^2

Name: PV array 1
Footprint area: 660,016 m^2
Axis tracking: Fixed (no rotation)
Tilt: 25.0 deg
Orientation: 180.0 deg

Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	52.212724	0.291343	19.50	3.00	22.50
2	52.213552	0.296836	25.15	3.00	28.15
3	52.213368	0.297523	25.82	3.00	28.82
4	52.212934	0.298338	26.67	3.00	29.67
5	52.212777	0.298681	26.73	3.00	29.73
6	52.212474	0.299132	26.48	3.00	29.48
7	52.212224	0.299948	26.95	3.00	29.95
8	52.211672	0.300398	26.24	3.00	29.24
9	52.210541	0.302587	27.79	3.00	30.79
10	52.210121	0.302265	27.20	3.00	30.20
11	52.209753	0.303037	28.40	3.00	31.40
12	52.209305	0.302673	29.16	3.00	32.16
13	52.207728	0.305462	35.68	3.00	38.68
14	52.206939	0.305248	36.22	3.00	39.22
15	52.206044	0.303853	36.17	3.00	39.17
16	52.205847	0.304325	36.92	3.00	39.92
17	52.205755	0.304861	37.84	3.00	40.84
18	52.202941	0.304024	35.08	3.00	38.08
19	52.203072	0.303617	35.46	3.00	38.46
20	52.203927	0.303896	37.48	3.00	40.48
21	52.204506	0.302222	37.05	3.00	40.05
22	52.203888	0.301342	35.28	3.00	38.28
23	52.206807	0.292802	27.78	3.00	30.78
24	52.207228	0.291879	26.13	3.00	29.13
25	52.207636	0.290914	25.52	3.00	28.52
26	52.210528	0.293575	20.00	3.00	23.00
27	52.211067	0.292287	21.00	3.00	24.00
28	52.211343	0.292394	20.72	3.00	23.72
29	52.211567	0.292094	20.39	3.00	23.39
30	52.211672	0.291536	19.83	3.00	22.83

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	52.215728	0.277004	15.33	1.50	16.83
OP 2	52.215859	0.280137	16.00	1.50	17.50
OP 3	52.215951	0.283291	15.99	1.50	17.49
OP 4	52.215807	0.285716	16.70	1.50	18.20
OP 5	52.212480	0.276597	17.84	1.50	19.34
OP 6	52.212415	0.279365	18.00	1.50	19.50
OP 7	52.212415	0.282111	16.00	1.50	17.50
OP 8	52.212520	0.285115	17.00	1.50	18.50
OP 9	52.212743	0.287948	18.36	1.50	19.86
OP 10	52.213059	0.290930	19.22	1.50	20.72
OP 11	52.213493	0.294385	21.74	1.50	23.24
OP 12	52.216043	0.311551	50.79	1.50	52.29
OP 13	52.215872	0.310779	51.00	1.50	52.50
OP 14	52.214190	0.309534	50.21	1.50	51.71
OP 15	52.212609	0.308464	41.83	1.50	43.33
OP 16	52.210611	0.307326	35.88	1.50	37.38
OP 17	52.209204	0.306640	35.00	1.50	36.50
OP 18	52.207403	0.305975	37.39	1.50	38.89
OP 19	52.205522	0.305417	38.80	1.50	40.30
OP 20	52.203707	0.304880	37.17	1.50	38.67

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	25.0	180.0	0	23,391	-	-

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	0	0	0	0	0	0	0	0	0	0	0	0
pv-array-1 (yellow)	0	0	727	1246	1015	1020	1039	1077	1220	40	0	0

PV & Receptor Analysis Results

Results for each PV array and receptor

PV array 1 potential temporary after-image

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	514
OP: OP 6	0	539
OP: OP 7	0	0
OP: OP 8	0	136
OP: OP 9	0	144
OP: OP 10	0	109
OP: OP 11	0	22
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	64
OP: OP 15	0	1073
OP: OP 16	0	3007
OP: OP 17	0	2906
OP: OP 18	0	6489
OP: OP 19	0	6199
OP: OP 20	0	2189

PV array 1 - OP Receptor (OP 1)

No glare found

PV array 1 - OP Receptor (OP 2)

No glare found

PV array 1 - OP Receptor (OP 3)

No glare found

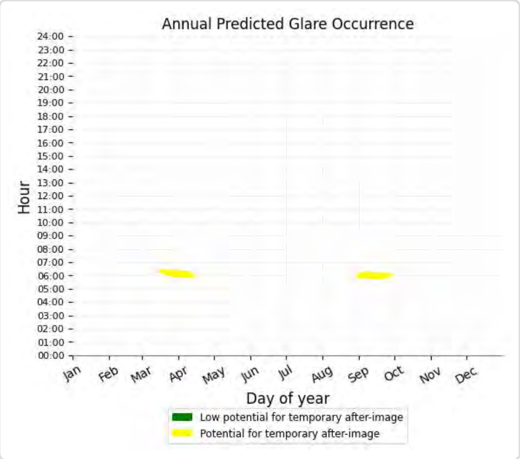
PV array 1 - OP Receptor (OP 4)

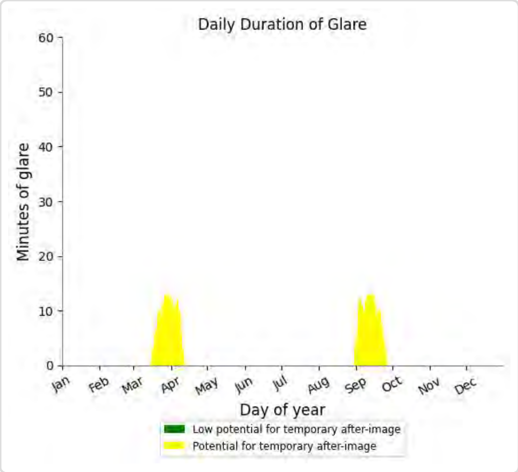
No glare found

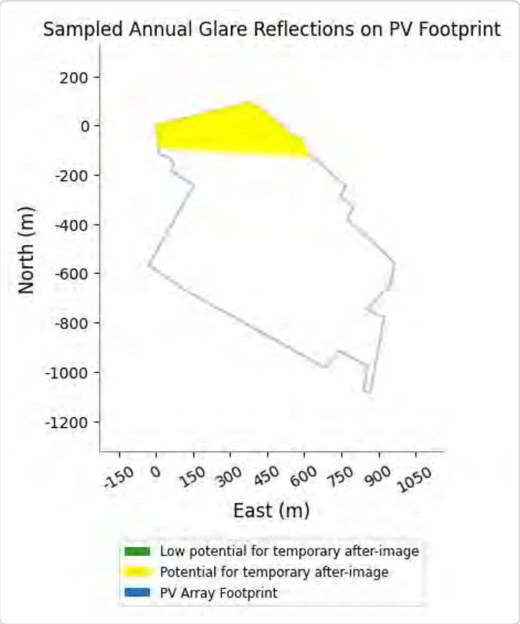
PV array 1 - OP Receptor (OP 5)

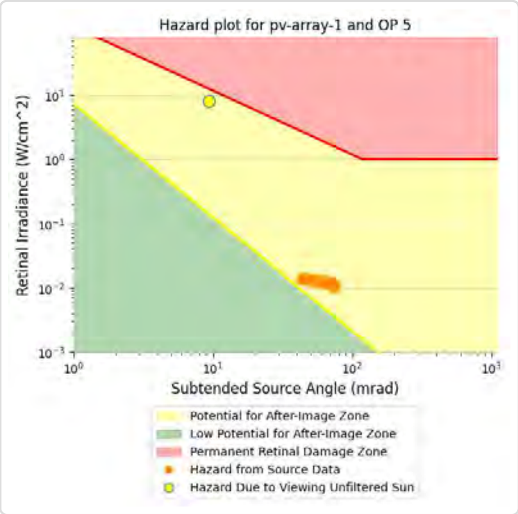
PV array is expected to produce the following glare for receptors at this location:

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





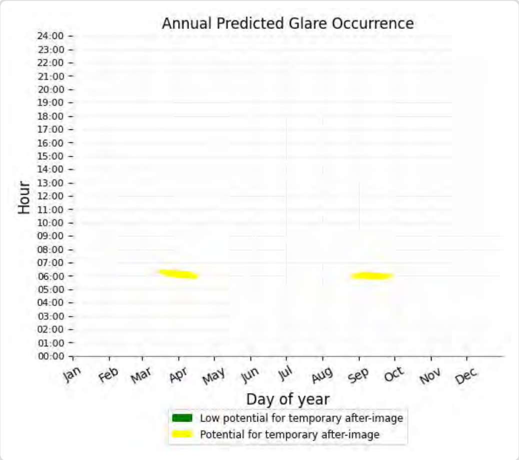


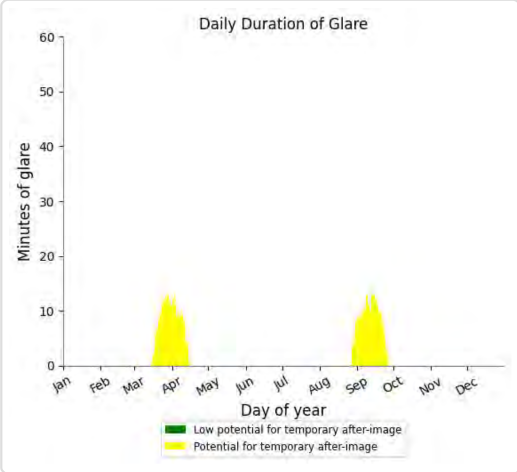


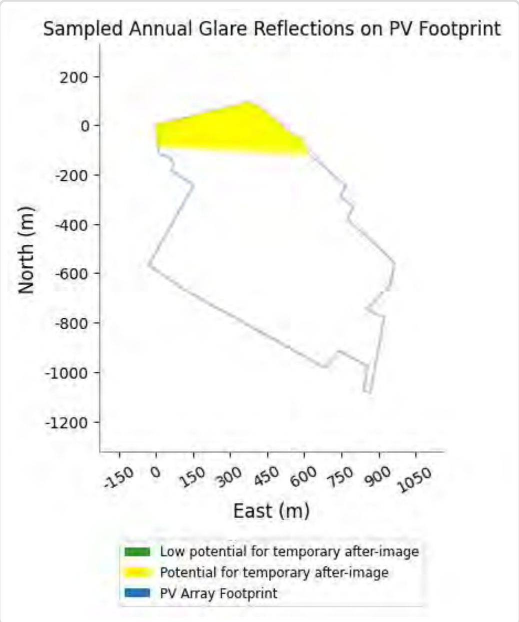
PV array 1 - OP Receptor (OP 6)

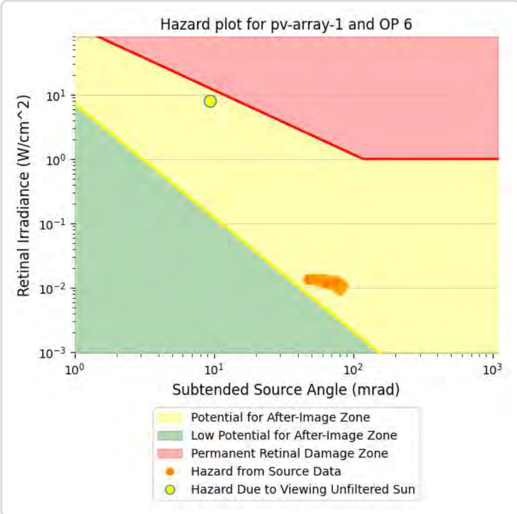
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 539 minutes of "yellow" glare with potential to cause temporary after-image.









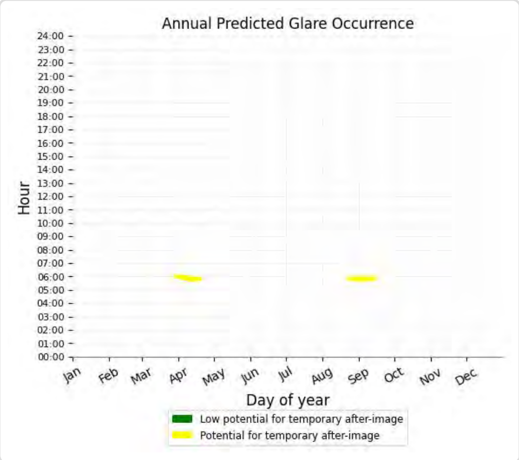
PV array 1 - OP Receptor (OP 7)

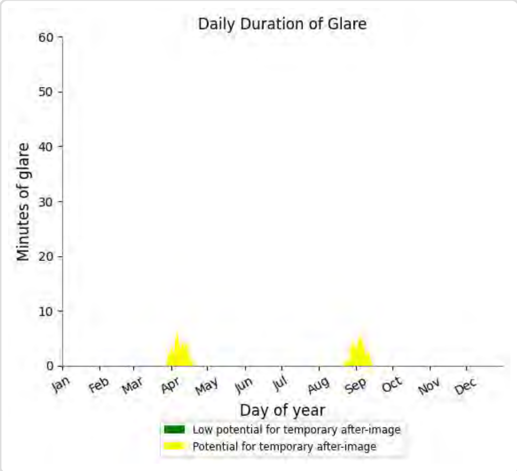
No glare found

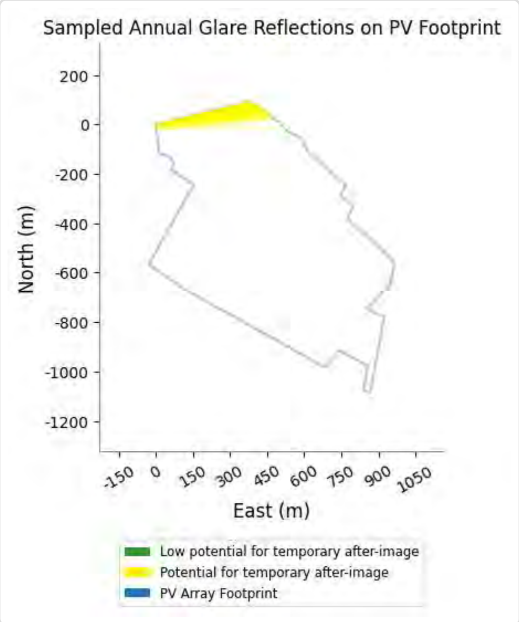
PV array 1 - OP Receptor (OP 8)

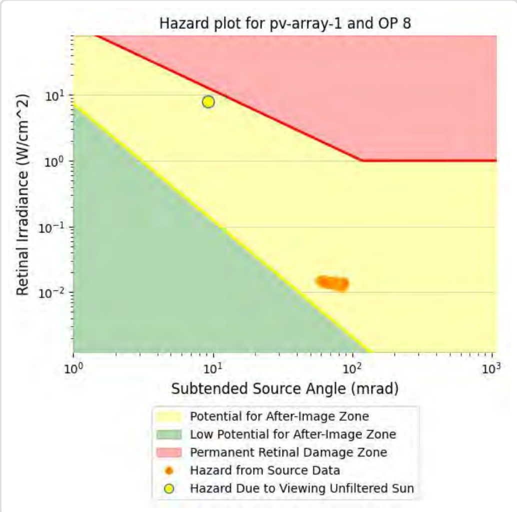
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 136 minutes of "yellow" glare with potential to cause temporary after-image.





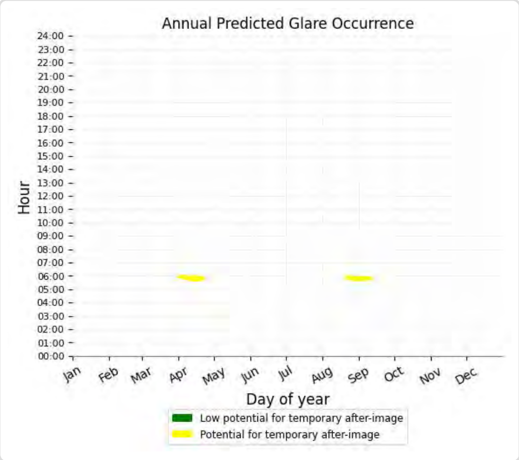


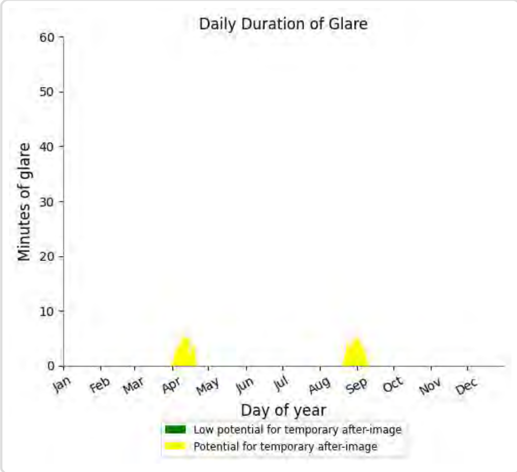


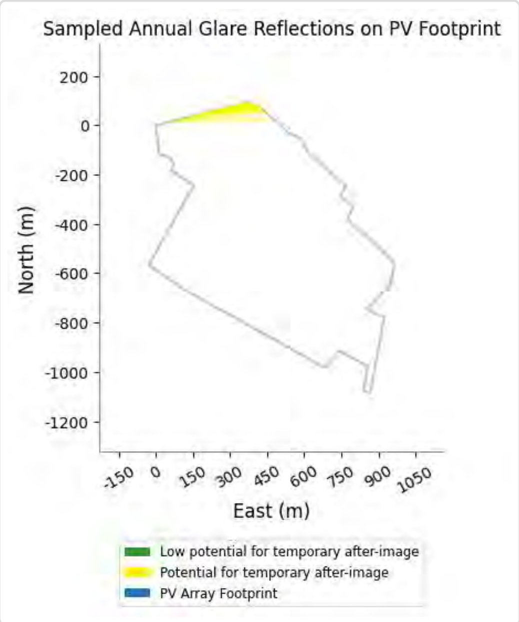
PV array 1 - OP Receptor (OP 9)

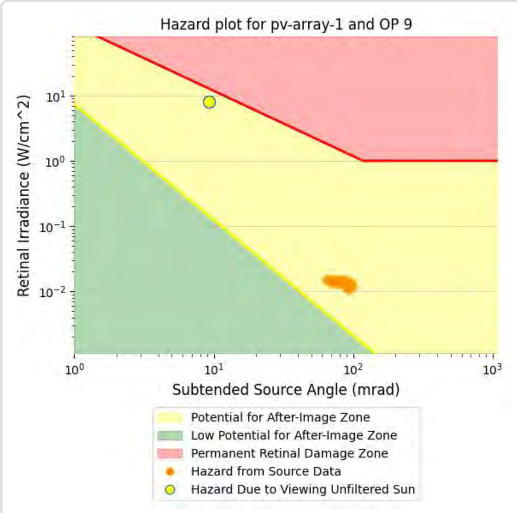
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 144 minutes of "yellow" glare with potential to cause temporary after-image.









PV array 1 - OP Receptor (OP 10)

PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 109 minutes of "yellow" glare with potential to cause temporary after-image.