# GLINT AND GLARE ASSESSMENT

BURSTEAD SOLAR FARM AND BATTERY STORAGE 'FREE GO'

LAND SOUTH AND EAST OF GREAT BURSTEAD, BILLERICAY, ESSEX

NOVEMBER 2023

# Glint and Glare Assessment

## Burstead Solar Farm Free Go

20/11/2023

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NEO ENVIRONMENTAL

# 1. EXECUTIVE SUMMARY

1.1. This Glint and Glare Assessment is prepared to support a 'Free Go' planning application known as Burstead Solar Farm.

1.2. This assessment considers the potential impacts on ground-based receptors such as roads, rail and residential dwellings as well as aviation assets. A 1km survey 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 38 residential receptors, including 10 residential areas, and 33 road receptors which were considered. 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 the glint and glare analysis 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 included in the glint and glare analysis with some context to all receptors given in the visual analysis. 10 residential receptors, including two residential areas, and 11 road receptors were dismissed as they are located within the no reflection zones and therefore, will not be impacted upon by the Proposed Development. 14 aerodromes are located within 30km of the Proposed Development; Two of which, Laindon Airstrip and Southend Airport, required detailed assessments due to the Proposed Development falling within their respective safeguarding buffer zones, which is outlined in **paragraph 4.25**.

1.3. The solar panels will face south and will be inclined at an angle of between 15 and 30 degrees. The maximum above ground level height of the panels is 3m and points at the top of the panels are used to determine the potential for glint and glare.

1.4. Geometric analysis was conducted for 28 individual residential receptors, including eight residential areas, and 22 road receptors. Geometric analysis was also conducted at two runway approach paths at Laindon Airstrip and two runway approach paths and an air traffic control tower at Southend.

1.5. 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:

Solar reflections are possible at nine of the 28 residential receptors assessed within the 1km study area. Initial impacts were **Medium** at two receptors, **Low** at seven receptors and **None** at the remaining 19 receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduce to **None** at all receptors.

Solar reflections are possible at 16 of the 22 road receptors assessed within the 1km study area. Initial impacts were **High** at eight receptors, **Low** at eight receptors and

**None** at the remaining six receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduce to **None** at all receptors.

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

**No impact** was found at the runway approach paths assessed at Stapleford Airport. Yellow glare and green glare were predicted at Runway 25 at Laindon Airstrip which are **unacceptable impacts**. The position of the sun and standard mitigation methods available to pilots, such as sunglasses and darkened sun visors, reduce the impacts to **acceptable** and therefore **not significant**. Only green glare was predicted at Runway 23 at Southend Airport which are **acceptable impacts** and therefore **not significant**. Only green glare was predicted at the Southend Airport air traffic control tower which is a **not acceptable** impact. All views of the Proposed Development from the air traffic control tower at Southend Airport are blocked by intervening terrain reducing the impacts to **None**. Therefore, impacts on aviation receptors are **not significant**.

1.6. Mitigation is not required due to all impacts upon ground-based receptors being **None**.

1.7. The effects of glint and glare and their impact on local receptors has been analysed in detail and there is predicted to be only **Low** and **None** impacts, and therefore **No Significant Effects**.

# 2. INTRODUCTION

## BACKGROUND

2.1. Neo Environmental Ltd has been appointed by Enso Green Holdings J Ltd (the "Applicant") to undertake a Glint and Glare Assessment ("G&G") for a proposed solar farm and battery storage development (the "Proposed Development") on south and east of Great Burstead, Billericay, Essex (the "Application Site"). This application forms a 'Free Go' submission following a previous refusal.

## DEVELOPMENT DESCRIPTION

2.2. The Proposed Development will consist of the construction of PV panels mounted on metal frames, new access tracks, underground cabling, transformers, perimeter fencing with access gates, a substation, control room, spare parts containers, battery storage and all ancillary grid infrastructure and associated works. Only the eastern parcel is proposed to be developed as part of the scheme.

## SITE DESCRIPTION

2.3. The area of the Application Site comprises of approximately 119.5 ha of land (including the grid connection route). The field boundaries consist of a mixture of trees and hedgerows. Ground levels within the Application Site vary from approximately 56m AOD at the western boundary to 15m AOD at the eastern boundary.

2.4. The Application Site is accessed from Granites Chase.

2.5. The western section of the Application Site is centred at approximate grid reference E568902, N192116. The wider landscape contains the town of Billericay, which is located approximately 2.8km to the north of the Application Site.

## SCOPE OF REPORT

2.6. 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.

2.7. 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.

2.8. 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.

2.9. 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 Receptor Map

Figure 2: Road Receptor Map

Figure 3: Southend Airport Aerodrome Chart

Appendix B: Residential Receptor Glare Results (15 degrees)

Appendix C: Residential Receptor Glare Results (30 degrees)

Appendix D: Road Receptor Glare Results (15 degrees)

Appendix E: Road Receptor Glare Results (30 degrees)

Appendix F: Aviation Receptor Glare Results (15 degrees)

Appendix G: Aviation Receptor Glare Results (30 degrees)

Appendix H: Visibility Assessment Evidence

Appendix I: Ground Elevation Profile

Appendix J: Solar Module Glare and Reflectance Technical Memo[1]

## Statement of Authority

2.10. 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

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

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, a MSc in nanoscience and a Diploma in acoustics and noise control. He is an Environmental Engineer and has produced numerous glint and glare reports for solar farms across the UK and Ireland.

## DEFINITIONS

2.11. 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 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*"

2.12. 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

2.13. 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 similar reflectance characteristics to water, which is much lower than the likes of glass, steel, snow and white concrete by comparison (**See Appendix J**). 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

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

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].

## Time Zones / Datum's

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

2.15. 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 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

# 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."*

## 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.*
>
> *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*

[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

*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."*

## Draft National Policy Statement for Renewable Energy Infrastructure (EN-3)

3.3. The draft NPS EN3 notes "*There is no evidence that glint and glare from solar farms interferes in any way with aviation navigation or pilot and aircraft visibility or safety*"[6].

## Interim CAA Guidance – Solar Photovoltaic Systems (2010)

3.4. 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[7]', they also intend to undertake a review of the potential impacts of solar PV developments upon aviation, however this is yet to be published.

3.5. 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[8], 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:*

[6] Draft National Policy Statement for Renewable Energy (EN – 3) (2021). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1015236/en-3-draft-for-consultation.pdf

[7] *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*

[8] 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

*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"*

***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."*

3.6. 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).

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

## CAA – CAP738: Safeguarding of Aerodromes 3rd Edition[9]

3.8. 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.

3.9. 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."*

3.10. 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;*

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

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

3.11. 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

3.12. The US Federal Aviation Administration (FAA) in their Solar Guide (Federal Aviation Authority, 2018)[10] incorporates a chapter on the impact and assessment of glint from solar panels. It concludes that (although subject to revision):

*"Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:*

*(1) A qualitative analysis of potential impact in consultation with the Air Traffic Control Tower, pilots, and airport officials*

*(2) A demonstration field test with solar panels at the proposed site in coordination with Air Traffic Control Tower personnel*

*(3) A geometric analysis to determine days and times when there may be an ocular impact."*

3.13. The interim policy (Federal Register, 2013)[11] 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.

3.14. 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

[10] FAA (2018), Technical Guidance for Evaluating Selected Solar Technologies on Airports. Available at https://www.faa.gov/sites/faa.gov/files/airports/environmental/FAA-Airport-Solar-Guide-2018.pdf

[11] 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

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.

3.15. 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

No potential for glare 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.

3.16. 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[12]

3.17. 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."*

3.18. 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

[12] 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

ATCT has been outlined as the key receptor to be assessed when determining Glint and Glare impacts from a solar farm.

## REVIEW OF LOCAL PLAN

### Basildon Council

3.19. The remaining 'saved' policies of the Local Plan 1998[13] form the development plan for the application. The Revised Publication Local Plan was submitted to the Secretary of State on the 28th of March 2019 for the Examination in Public but has since been withdrawn by the Council.

3.20. The plan had stated in **Policy CC7: Renewable Energy Infrastructure** that:

*'Proposals for renewable and low carbon energy schemes, including schemes which apply EcoIndustrial Park (EIP) principles, will be positively considered provided they are in a sustainable and accessible location and comply with all other relevant policies within this plan.'*

3.21. There are no policies contained within the remaining saved polices of the Local Plan 1998 or now withdrawn emerging Local Plan which are of relevance to this Glint and Glare Assessment.

### Rochford District Council

3.22. The Rochford District Core Strategy[14] was formally adopted by the Council on 13 December 2011 following the Planning Inspectorate's decision that the Plan was sound and legally compliant.

3.23. There are no policies contained within the Core Strategy which are of relevance to this Glint and Glare Assessment.

3.24. The Council is in the process of preparing a new Local Plan[15]. Once adopted the new Local Plan will replace a number of the adopted policy documents. The time table for preparing the new Local Plan is set out in the Council's Local Development Scheme (LDS), the latest update to this was adopted on 7 September 2023. A public consultation for the Preferred Options Document is due to take place in Winter 2023/24.

[13] Basildon Council, Basildon District Local Plan Saved Policies 2007, available at: https://www.basildon.gov.uk/adoptedplan

[14] Rochford District Council, Core Strategy, available at: https://www.rochford.gov.uk/core-strategy

[15] Rochford District Council, New Local Plan, available at: https://www.rochford.gov.uk/new-local-plan

# 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[16]. 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 2023.

4.4. In order to determine if a solar reflection 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.

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

4.7. On knowing the vector of the solar reflection, 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 solar reflection 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 J** 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[17] 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.

[17] 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.

## Relevant Parameters of the Proposed Development

4.16. 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 south and will be inclined at an angle of between 15 and 30 degrees.

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

# IDENTIFICATION OF RECEPTORS

## Ground Based Receptors

4.18. 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.

4.19. 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.

4.20. 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. 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.

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

4.22. 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

4.23. Glint is only considered to be an issue with regards to aviation safety when the solar farm lies within close proximity to a 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 solar reflection.

4.24. 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

4.25. 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

4.26. 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 - Solar reflections impacts of over 30 hours per year or over 30 minutes per day

Medium - Solar reflections impacts between 20 and 30 hours per year or between 20 minutes and 30 minutes per day

Low - Solar reflections 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)

4.27. 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.

4.28. 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).

4.29. The following criteria has been set out for the purposes of this report:

High - Solar reflections impacts consisting of any amount of yellow glare.

Low - Solar reflections impacts consisting of any amount of only green glare.

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

4.30. The FAA produced an evaluation of glare as a hazard and concluded in their report[18] 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.

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 90 degrees left and right from the front of the cockpit whilst the VFOV is modelled at 30 degrees.

[18] 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

4.34. 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 solar reflection 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.

4.38. Based on the above, the following criteria has been set out for the purpose of this report:

High – Any Glare impacts upon the receptors.

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

## Assessment Limitations

4.39. 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.

4.40. 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.

# 5. BASELINE CONDITIONS

## GROUND BASED RECEPTORS REFLECTION ZONES

5.1. Based on the 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**). The number in brackets indicates which residential area the receptor belongs. Glint was assumed to be possible if the receptor is located within the ground-based receptor zones outlined previously.

5.5. There are 10 residential receptors (Receptors –29 - 38) 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 Possible |
|---|---|---|---|
| 1 | 569453 | 193542 | Yes |
| 2 | 569428 | 193436 | Yes |
| 3 | 569274 | 193406 | Yes |
| 4 | 569505 | 193256 | Yes |
| 5 | 569477 | 193244 | Yes |
| 6 | 569328 | 193277 | Yes |

| Receptor | Easting | Northing | Glint and Glare Possible |
|---|---|---|---|
| 7 | 569191 | 193195 | Yes |
| 8 | 569116 | 193112 | Yes |
| 9 | 568722 | 193615 | Yes |
| 10 | 568701 | 193490 | Yes |
| 11 | 568630 | 193364 | Yes |
| 12 | 568683 | 193287 | Yes |
| 13 | 568769 | 193115 | Yes |
| 14 | 568983 | 193023 | Yes |
| 15 | 569060 | 192646 | Yes |
| 16 | 568839 | 192731 | Yes |
| 17 | 569474 | 192081 | Yes |
| 18 | 569370 | 192002 | Yes |
| 19 | 569420 | 191949 | Yes |
| 20 | 570817 | 193284 | Yes |
| 21 | 570895 | 193159 | Yes |
| 22 | 570782 | 193037 | Yes |
| 23 | 570935 | 192975 | Yes |
| 24 | 570916 | 192775 | Yes |
| 25 | 570872 | 191936 | Yes |
| 26 | 570983 | 192112 | Yes |
| 27 | 571148 | 192204 | Yes |
| 28 | 571204 | 192306 | Yes |
| 29 | 569120 | 193959 | No |
| 30 | 569420 | 194062 | No |
| 31 | 569336 | 193895 | No |
| 32 | 569413 | 193771 | No |

| Receptor | Easting | Northing | Glint and Glare Possible |
|---|---|---|---|
| 33 | 569460 | 193661 | No |
| 34 | 570555 | 191816 | No |
| 35 | 570646 | 191824 | No |
| 36 | 570554 | 191578 | No |
| 37 | 570680 | 191598 | No |
| 38 | 570936 | 191649 | No |

## Road / Rail Receptors

5.6. There are no railway lines within the 1km study area around the site which require assessment and therefore the impact on railway infrastructure is **None**.

5.7. There are five roads within the 1km study area that require detailed glint and glare analysis, which are the Southend Road (A129), Outwood Farm Road, Coxes Farm Road and Barleylands Road. 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.

5.8. 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.

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

Table 5 - 2: Road Based Receptors

| Receptor | Easting | Northing | Glint and Glare Possible |
|---|---|---|---|
| 1 | 568643 | 193284 | Yes |
| 2 | 568778 | 193137 | Yes |
| 3 | 568910 | 192987 | Yes |
| 4 | 569015 | 192817 | Yes |
| 5 | 569088 | 192631 | Yes |
| 6 | 569137 | 192443 | Yes |
| 7 | 569261 | 192286 | Yes |
| 8 | 569409 | 192167 | Yes |

| Receptor | Easting | Northing | Glint and Glare Possible |
|---|---|---|---|
| 9 | 569608 | 192165 | Yes |
| 10 | 569799 | 192105 | Yes |
| 11 | 570865 | 191966 | Yes |
| 12 | 571018 | 192082 | Yes |
| 13 | 571189 | 192178 | Yes |
| 14 | 571362 | 192274 | Yes |
| 15 | 569084 | 193076 | Yes |
| 16 | 569232 | 193207 | Yes |
| 17 | 569374 | 193348 | Yes |
| 18 | 569437 | 193516 | Yes |
| 19 | 568906 | 192800 | Yes |
| 20 | 568730 | 192708 | Yes |
| 21 | 569405 | 192014 | Yes |
| 22 | 569487 | 191845 | Yes |
| 23 | 569397 | 193712 | No |
| 24 | 569360 | 193908 | No |
| 25 | 569385 | 194086 | No |
| 26 | 569466 | 194254 | No |
| 27 | 569195 | 194024 | No |
| 28 | 569000 | 193982 | No |
| 29 | 569979 | 192021 | No |
| 30 | 570147 | 191913 | No |
| 31 | 570318 | 191808 | No |
| 32 | 570512 | 191779 | No |
| 33 | 570688 | 191871 | No |

## Aviation Receptors

5.10. Aerodromes within 30km of the Proposed Development can be found in **Table 5 - 3.**

Table 5 - 3: Airfields within close proximity

| Airfield | Distance | Use |
|---|---|---|
| Laindon Airstrip | 1.37km | Small grass strip |
| Napps Field Airstrip | 5.14km | Small grass strip |
| West Horndon Airfield | 8.26km | Small grass strip |
| Thurrock Airfield | 9.45km | Small concrete strip |
| Stow Maries Airfield | 13.72km | Unlicensed small grass strip |
| Southend Airport | 16.08km | Licensed airport |
| Damyns Hall Airfield | 16.52km | Unlicensed small grass strip |
| Gerpins Farm | 17.32km | Small grass strip |
| Stapleford Airport | 20.42km | Licensed aerodrome |
| High Easter Airfield | 22.79km | Small grass strip |
| North Weald Airfield | 23.54km | Unlicensed small concrete strip |
| Rochester Airport | 27.85km | Licensed small grass strip |
| London City Airport | 29.45km | Licensed airport |

5.11. There are two aerodromes, Laindon Airstrip, and Southend Airport, which require detailed assessments due to these airfields being within their respective safeguarding buffer zones outlined in **paragraph 4.25.**

### Laindon Airstrip

5.12. Laindon Airstrip (ICAO code GB-0788) is a visual flight rules (VFR) only aerodrome. It is located approximately 1.5NM (6.11km) northwest of Basildon.

5.13. The elevation of the aerodrome is 82ft (25m). It has one grass strip runway, details of which are given in **Table 5 - 4**.

Table 5 - 4: Runways at Laindon Airstrip

| Runway Designation | True Bearing (°) | Length (m) | Width (m) |
|---|---|---|---|
| 07 | 071 | 500 | 20 |
| 25 | 251 | 500 | 20 |

5.14. The threshold location and height of the runway at Laindon Airstrip are given in **Table 5 - 5**.

Table 5 - 5: Runway Threshold Locations and Heights

| Runway Designation | Threshold Latitude | Threshold Longitude | Height AOD (m) |
|---|---|---|---|
| 07 | 51° 35′ 34.90″ N | 000° 26′ 28.54″ E | 29 |
| 25 | 51° 35′ 40.02″ N | 000° 26′ 52.61″ E | 21 |

5.15. There is no ARP or air traffic control tower (ATCT) at Laindon Airstrip.

## Southend Airport

5.16. Southend Airport (ICAO code EGMC) is an instrument flight rules/visual flight rules (IFR/VFR) aerodrome. It is located approximately 1.5NM (2.78km) north of Southend-on-Sea.

5.17. The elevation of the aerodrome is 55ft (16.76m). It has one asphalt (grooved) runway and one, details of which are given in **Table 5 - 6**.

Table 5 - 6: Runways at Southend Airport

| Runway Designation | True Bearing (°) | Length (m) | Width (m) |
|---|---|---|---|
| 05 | 054.16 | 1856 | 36 |
| 23 | 234.16 | 1856 | 36 |

5.18. The threshold location and height of the runway at Southend Airport are given in **Table 5 - 7**.

Table 5 - 7: Runway Threshold Locations and Heights

| Runway Designation | Threshold Latitude | Threshold Longitude | Height AOD (m) |
|---|---|---|---|
| 05 | 51° 33′ 57.29″ N | 000° 40′ 59.97″ E | 16 |
| 23 | 51° 34′ 27.79″ N | 000° 42′ 07.62″ E | 11 |

5.19. The ARP is located at the midpoint of Runway 05/23. The actual location of the ARP and ATCT is given in **Table 5 - 8**. The height of the ATCT is 32m.

Table 5 - 8: Southend Airport Reference Point

| | Latitude | Longitude | Eastings | Northings |
|---|---|---|---|---|
| ARP | 51° 34' 13.61'' N | 000° 41' 36.16'' E | 586752 | 189169 |
| ATCT | 51° 34' 16.67'' N | 000° 42' 15.42'' E | 587498 | 189291 |

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

6.4. **Appendix B and C** shows the analysis with the solar panels at a tilt angle of between 15 and 30 degrees and a height of 3m. **Table 6 - 1** shows the worst-case impact at each receptor.

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

| Receptor | Glint Possible from Site | | Potential Glare Impact (per year) | | Magnitude of Impact | Worst Case Tilt |
|---|---|---|---|---|---|---|
| | AM | PM | Minutes | Hours | | |
| 1 | No | No | 0 | 0 | None | N/A |
| 2 | No | No | 0 | 0 | None | N/A |
| 3 | No | No | 0 | 0 | None | N/A |
| 4 | Yes | No | 1216 | 20.27 | Medium | 15 |
| 5 | Yes | No | 1153 | 19.22 | Low | 15 |
| 6 | No | No | 0 | 0 | None | N/A |
| 7 | Yes | No | 116 | 1.93 | Low | 30 |
| 8 | Yes | No | 216 | 3.60 | Low | 30 |

| Receptor | Glint Possible from Site | | Potential Glare Impact (per year) | | Magnitude of Impact | Worst Case Tilt |
|---|---|---|---|---|---|---|
| | AM | PM | Minutes | Hours | | |
| 9 | No | No | 0 | 0 | None | N/A |
| 10 | No | No | 0 | 0 | None | N/A |
| 11 | No | No | 0 | 0 | None | N/A |
| 12 | No | No | 0 | 0 | None | N/A |
| 13 | No | No | 0 | 0 | None | N/A |
| 14 | No | No | 0 | 0 | None | N/A |
| 15 | No | No | 0 | 0 | None | N/A |
| 16 | No | No | 0 | 0 | None | N/A |
| 17 | No | No | 0 | 0 | None | N/A |
| 18 | No | No | 0 | 0 | None | N/A |
| 19 | No | No | 0 | 0 | None | N/A |
| 20 | No | No | 0 | 0 | None | N/A |
| 21 | No | No | 0 | 0 | None | N/A |
| 22 | No | Yes | 51 | 0.85 | Low | 30 |
| 23 | No | Yes | 9 | 0.15 | Low | 30 |
| 24 | No | Yes | 103 | 1.72 | Low | 15 |
| 25 | No | No | 0 | 0 | None | N/A |
| 26 | No | No | 0 | 0 | None | N/A |
| 27 | No | Yes | 379 | 6.32 | Low | 15 |
| 28 | No | Yes | 1435 | 23.92 | Medium | 15 |

6.5. As can be seen in **Table 6 - 1,** there is a, **Medium** impact at two receptors, including one residential area, **Low** impact at seven receptors, including three residential areas, and **None** impact for the remaining 19 receptors. **Appendix B and C** 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 H** 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.

### Receptors 4, 5, 7 and 8

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

6.8. The first image in **Appendix H** is an aerial image showing the position of the receptors (yellow pins) in relation to the Proposed, and the location from which the second image was taken (red dot). The second image is a photo taken from within the Proposed Development a view towards the Receptors. This image confirms that no windows are visible and the vegetation is sufficient to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

### Receptor 22

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

6.10. The first image in **Appendix H** is an aerial image showing the position of the receptors (yellow pins) in relation to the Proposed, and the location from which the second image was taken (red dot). The second image is a photo taken from within the Proposed Development a view towards the Receptor. This image confirms that the vegetation is sufficient to screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

### Receptor 23

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

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

### Receptor 24

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

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

### Receptors 27 and 28

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

6.16. The first image in **Appendix H** is an aerial image showing the position of the receptors (yellow pin) in relation to the Proposed, and the location from which the second image was taken (red dot). The second image is a photo taken from with the Proposed Development 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 impact reduces to **None**.

### Residential Area 1 (Coxes Farm Road)

6.17. This encompasses a number of residential receptors including those at Receptors 1 and 2 (assessed previously) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity of each other, so the worst-case scenario is assumed for the impact of glint and glare. All receptors were considered within the visibility analysis, and it was concluded their impacts were similar. As per the assessment of these two receptors, the impacts on the other receptors within this area are assessed as being **None (worst case scenario).**

### Residential Area 2 (No. 4 to No. 5 Coxes Farm Road)

6.18. This encompasses a number of residential receptors including those at Receptors 6 and 7 (assessed previously) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity of each other, so the worst-case scenario is assumed for the impact of glint and glare. All receptors were considered within the visibility analysis, and it was concluded their impacts were similar. As per the assessment of these two receptors, the impacts on the other receptors within this area are assessed as being **None (worst case scenario).**

## Residential Area 3 (Highfield Road and The Rowans)

6.19. This encompasses a number of residential receptors including those at Receptors –9 - 11 (assessed previously) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity of each other, so the worst-case scenario is assumed for the impact of glint and glare. All receptors were considered within the visibility analysis, and it was concluded their impacts were similar. As per the assessment of these three receptors, the impacts on the other receptors within this area are assessed as being **None (worst case scenario).**

## Residential Area 4 (Southend Road (A129) and Mill Road)

6.20. This encompasses a number of residential receptors including those at Receptors 12 - 16 (assessed previously) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity of each other, so the worst-case scenario is assumed for the impact of glint and glare. All receptors were considered within the visibility analysis, and it was concluded their impacts were similar. As per the assessments of these five receptors, the impacts on the other receptors within this area are assessed as being **None (worst case scenario).**

## Residential Area 5 (Barleylands Road)

6.21. This encompasses a number of residential receptors including those at Receptors –18 and 19 (assessed previously) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity of each other, so the worst-case scenario is assumed for the impact of glint and glare. All receptors were considered within the visibility analysis, and it was concluded their impacts were similar. As per the assessments of these two receptors, the impacts on the other receptors within this area are assessed as being **Low (worst case scenario).**

## Residential Area 6 (Church Lane)

6.22. This encompasses a number of residential receptors including those at Receptors 20 and 21 (assessed previously) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity of each other, so the worst-case scenario is assumed for the impact of glint and glare. All receptors were considered within the visibility analysis, and it was concluded their impacts were similar. As per the assessments of these two receptors, the impacts on the other receptors within this area are assessed as being **None (worst case scenario).**

## Residential Area 7 (Church Lane)

6.23. This encompasses a number of residential receptors including those at Receptor 24 (assessed previously) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity of each other, so the worst-case scenario is assumed for the impact of glint and glare. All receptors were considered within the visibility analysis, and it was concluded their impacts were similar. As per the assessments of this receptor, the impacts on the other receptors within this area are assessed as being **None (worst case scenario).**

### Residential Area 8 (Southend Road (A129) and Staceys Mount)

6.24. This encompasses a number of residential receptors including those at Receptors 25 - 28 (assessed previously) (See **Figure 1: Appendix A**). Each receptor assessed represents multiple receptors as they are in close proximity of each other, so the worst-case scenario is assumed for the impact of glint and glare. All receptors were considered within the visibility analysis, and it was concluded their impacts were similar. As per the assessments of these four receptors, the impacts on the other receptors within this area are assessed as being **Low (worst case scenario).**

## Road Receptors

6.25. **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 D and** E.

6.26. The 12 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 Impact | Worst Case Tilt |
|---|---|---|---|---|---|
| 1 | 233 | 0 | 0 | Low | 15 |
| 2 | 555 | 0 | 0 | Low | 15 |
| 3 | 1003 | 35 | 0 | High | 30 |
| 4 | 1600 | 239 | 0 | High | 30 |
| 5 | 0 | 0 | 0 | None | N/A |
| 6 | 2037 | 8 | 0 | High | 30 |
| 7 | 2357 | 0 | 0 | Low | 15 |
| 8 | 1570 | 0 | 0 | Low | 15 |
| 9 | 1224 | 0 | 0 | Low | 15 |
| 10 | 99 | 0 | 0 | Low | 15 |

| Receptor | Green Glare (mins) | Yellow Glare (mins) | Red Glare (mins) | Magnitude of Impact | Worst Case Tilt |
|---|---|---|---|---|---|
| 11 | 0 | 0 | 0 | None | N/A |
| 12 | 0 | 0 | 0 | None | N/A |
| 13 | 2177 | 259 | 0 | High | 15 |
| 14 | 2357 | 1163 | 0 | High | 15 |
| 15 | 0 | 0 | 0 | None | N/A |
| 16 | 1093 | 116 | 0 | High | 30 |
| 17 | 754 | 0 | 0 | Low | 15 |
| 18 | 0 | 0 | 0 | None | N/A |
| 19 | 1686 | 139 | 0 | High | 30 |
| 20 | 1836 | 37 | 0 | High | 15 |
| 21 | 414 | 0 | 0 | Low | 15 |
| 22 | 0 | 0 | 0 | None | N/A |

6.27. As can be seen in **Table 6 – 2**, there are eight receptor points which have potential glare impacts with the "potential for after-image" (yellow glare), which is a **High** impact and eight receptor points which have potential glare impacts with "low potential for after-image" (green glare) which is a **Low** impact. **Appendix D and E** show 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.

6.28. **Appendix H** 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.

6.29. As can be seen in **Appendix H**, views of the Proposed Development from all receptors are blocked by a mixture of intervening vegetation, topography and buildings. Therefore, impacts upon these receptors reduce to **None**.

## Aviation Receptors

6.30. **Table 6 - 3** 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 F and G.**

Table 6 - 3: Summary of Glare Results

| Component | Green Glare (mins) | Yellow Glare (mins) | Red Glare (mins) | Worse Case Tilt |
|---|---|---|---|---|
| Laindon Airstrip | | | | |
| Runway 07 | 0 | 0 | 0 | N/A |
| Runway 25 | 3293 | 3465 | 0 | 15 |
| Southend Airport | | | | |
| Runway 05 | 0 | 0 | 0 | N/A |
| Runway 23 | 1425 | 0 | 0 | 30 |
| ATCT | 845 | 0 | 0 | 30 |

6.31. As can be seen in **Table 6 - 3**, yellow glare and green glare are expected to Runway 25 at Laindon Airstrip. Yellow glare is described as 'Potential for After Image' which is an **unacceptable impact** when pilots are approaching runways/helipads and 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. Therefore, the impact is deemed as **significant**.

6.32. As can be seen in **Table 6 - 3**, only green glare is expected to Runway 23 at Southend 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. Therefore, the impact is deemed as **not significant**.

6.33. As can be seen in **Table 6 - 3**, only green glare is expected to impact the air traffic control tower (ATCT) at Southend Airport. Green glare is described 'Low Potential for After Image' which is a **not acceptable impact** on the ATCT, according to the FAA guidance. Therefore, the impact is deemed as **significant**.

6.34. As can be seen in **Appendix H**, the first and second images are Google Earth ground level images with a view towards Laindon Airstrip showing the Runway 25 approach path (red line) and the position of the sun at 17:45 UTC on April 1st and 18:00 UTC on July 1st respectively. Pilots use mitigation methods to reduce the impact of the sun when landing in the direction of the sun. These mitigation measures include: sunglasses, darkened cockpit and land in the opposite direction (if the wind allows). Therefore, as these images confirm that the sun is the main source of solar reflection on the approach path to Runway 25, any mitigation measures that the pilot will use when landing in the direction of the sun will also mitigate those Yellow Glare impacts from the Proposed Development. Resulting in the impacts reducing to **not significant**.

6.35. As can be seen in **Appendix I** the terrain between the Proposed Development and the ATCT at Southend Airport provides a blocking feature, a hill c. 11km from the Proposed Development with a height of 65m, which will screen all views of the Proposed Development where glint and glare is possible. Therefore, the impact reduces to **None**.

# 7. GROUND BASED RECEPTOR MITIGATION

7.1. Mitigation is not required due to all impacts upon ground-based receptors being None.

7.2. **Table 7 - 1 and Table 7 - 2** 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

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

| Receptor | Magnitude of Impact | | |
|---|---|---|---|
| | After Geometric Analysis | After Visibility Analysis | Residual Impacts |
| 20 | None | None | None |
| 21 | None | None | None |
| 22 | Low | None | None |
| 23 | Low | None | None |
| 24 | Low | None | None |
| 25 | None | None | None |
| 26 | None | None | None |
| 27 | Low | None | None |
| 28 | Medium | None | None |

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

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

| Receptor | Magnitude of Impact | | |
|---|---|---|---|
| | After Geometric Analysis | After Visibility Analysis | Residual Impacts |
| 13 | High | None | None |
| 14 | High | None | None |
| 15 | None | None | None |
| 16 | High | None | None |
| 17 | Low | None | None |
| 18 | None | None | None |
| 19 | High | None | None |
| 20 | High | None | None |
| 21 | Low | None | None |
| 22 | None | None | None |

7.3. **Table 7 - 3 and Table 7 - 4** show the overall impacts for all residential and road receptors.

Table 7 - 3: Solar Reflections: Residential Receptors

| Magnitude | Theoretical Visibility | Actual Visibility (No Mitigation) | Actual Visibility with Mitigation |
|---|---|---|---|
| High | 0 | 0 | 0 |
| Medium | 2 | 0 | 0 |
| Low | 7 | 0 | 0 |
| None | 19 | 28 | 28 |
| **High** – Solar reflections impacts of over 30 hours per year or over 30 minutes per day<br>**Medium** - Solar reflections impacts between 20 and 30 hours per year or between 20 minutes and 30 minutes per day<br>**Low** - Solar reflections impacts between 0 and 20 hours per year or between 0 minutes and 20 minutes per day<br>**None** - Effects not geometrically possible or no visibility of reflective surfaces likely due to high levels of intervening screening | | | |

Table 7 - 4: Solar Reflections: Road Receptors

| Magnitude | Theoretical Visibility | Actual Visibility (No Mitigation) | Actual Visibility with Mitigation |
|---|---|---|---|
| High | 8 | 0 | 0 |
| Low | 8 | 0 | 0 |
| None | 6 | 28 | 28 |

**High -** Solar reflections impacts with yellow glare (potential for after-image).
**Low -** Solar reflections impacts with only green glare (low potential for after-image)
**None -** Effects not geometrically possible or no visibility of reflective surfaces likely due to high levels of intervening screening or being outside the drivers field of view

7.4. Aviation mitigation has been detailed in paragraph 6.97, above.

# 8. CUMULATIVE ASSESSMENT

8.1. The Proposed Development is adjacent to an existing solar farm, Outwood Farm, which is northeast of the Proposed Development and a proposed solar farm at Crays Hall Farm (planning ref: **21/01671/SCREEN**) to the east of the Proposed Development. Impacts are currently **not significant** impacts upon the Runway 25 approach path at Laindon Airstrip and the Runway 23 approach path at Southend Airport. However, these impacts will remain **Low** when taking into account the existing solar farm development. Therefore, it is **anticipated that there will not be any cumulative glint and glare effects** on aviation receptors as a result of the construction of the Proposed Development.

8.2. Impacts are **None** for all ground-based receptors, so a cumulative assessment is not required. Therefore, it is **anticipated that there will not be any cumulative glint and glare effects** on ground-based receptors as a result of the construction of the Proposed Development.

# 9. SUMMARY

9.1. This Glint and Glare Assessment is prepared to support a 'Free Go' planning application known as Burstead Solar Farm.

9.2. There is little guidance or policy available in the UK at present in relation to the assessment of glint and glare from Proposed Development developments. However, it is recognised as a potential impact which needs to be considered for a Proposed Development, therefore this assessment considers the potential impacts on ground-based receptors such as roads, rail, and residential dwellings as well as aviation assets.

9.3. This assessment considers the potential impacts on ground-based receptors such as roads, rail and residential dwellings as well as aviation assets. A 1km survey 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 38 residential receptors, including 10 residential areas, and 33 road receptors which were considered. 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 the glint and glare analysis 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 included in the glint and glare analysis with some context to all receptors given in the visual analysis. 10 residential receptors, including two residential areas, and 11 road receptors were dismissed as they are located within the no reflection zones and therefore, will not be impacted upon by the Proposed Development. 14 aerodromes are located within 30km of the Proposed Development; Two of which, Laindon Airstrip and Southend Airport, required detailed assessments due to the Proposed Development falling within their respective safeguarding buffer zones, which is outlined in **paragraph 4.25**.

9.4. The solar panels will face south and will be inclined at an angle of between 15 and 30 degrees. The maximum above ground level height of the panels is 3m and points at the top of the panels are used to determine the potential for glint and glare.

9.5. Geometric analysis was conducted for 28 individual residential receptors, including eight residential areas, and 22 road receptors. Geometric analysis was also conducted at two runway approach paths at Laindon Airstrip and two runway approach paths and an air traffic control tower at Southend.

9.6. 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:

Solar reflections are possible at nine of the 28 residential receptors assessed within the 1km study area. Initial impacts were **Medium** at two receptors, **Low** at seven receptors and **None** at the remaining 19 receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduce to **None** at all receptors.

Solar reflections are possible at 16 of the 22 road receptors assessed within the 1km study area. Initial impacts were **High** at eight receptors, **Low** at eight receptors and **None** at the remaining six receptors. Upon reviewing the actual visibility of the receptors, glint and glare impacts reduce to **None** at all receptors.

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

**No impact** was found at the runway approach paths assessed at Stapleford Airport. Yellow glare and green glare were predicted at Runway 25 at Laindon Airstrip which are **unacceptable impacts**. The position of the sun and standard mitigation methods available to pilots, such as sunglasses and darkened sun visors, reduce the impacts to **acceptable** and therefore **not significant**. Only green glare was predicted at Runway 23 at Southend Airport which are **acceptable impacts** and therefore **not significant**. Only green glare was predicted at the Southend Airport air traffic control tower which is a **not acceptable** impact. All views of the Proposed Development from the air traffic control tower at Southend Airport are blocked by intervening terrain reducing the impacts to **None**. Therefore, impacts on aviation receptors are **not significant**.

9.7. Mitigation is not required due to all impacts upon ground-based receptors being **None**.

9.8. The effects of glint and glare and their impact on local receptors has been analysed in detail and there is predicted to be only **Low** and **None** impacts, and therefore **No Significant Effects**.

# 10. APPENDICES

## Appendix A: Figures

Figure 1: Residential Receptor Map

Figure 2: Road Receptor Map

Figure 3: Southend Airport Aerodrome Chart

## Appendix B: Residential Receptor Glare Results (15 degrees)

## Appendix C: Residential Receptor Glare Results (30 degrees)

## Appendix D: Road Receptor Glare Results (15 degrees)

## Appendix E: Road Receptor Glare Results (30 degrees)

## Appendix F: Aviation Receptor Glare Results (15 degrees)

## Appendix G: Aviation Receptor Glare Results (30 degrees)

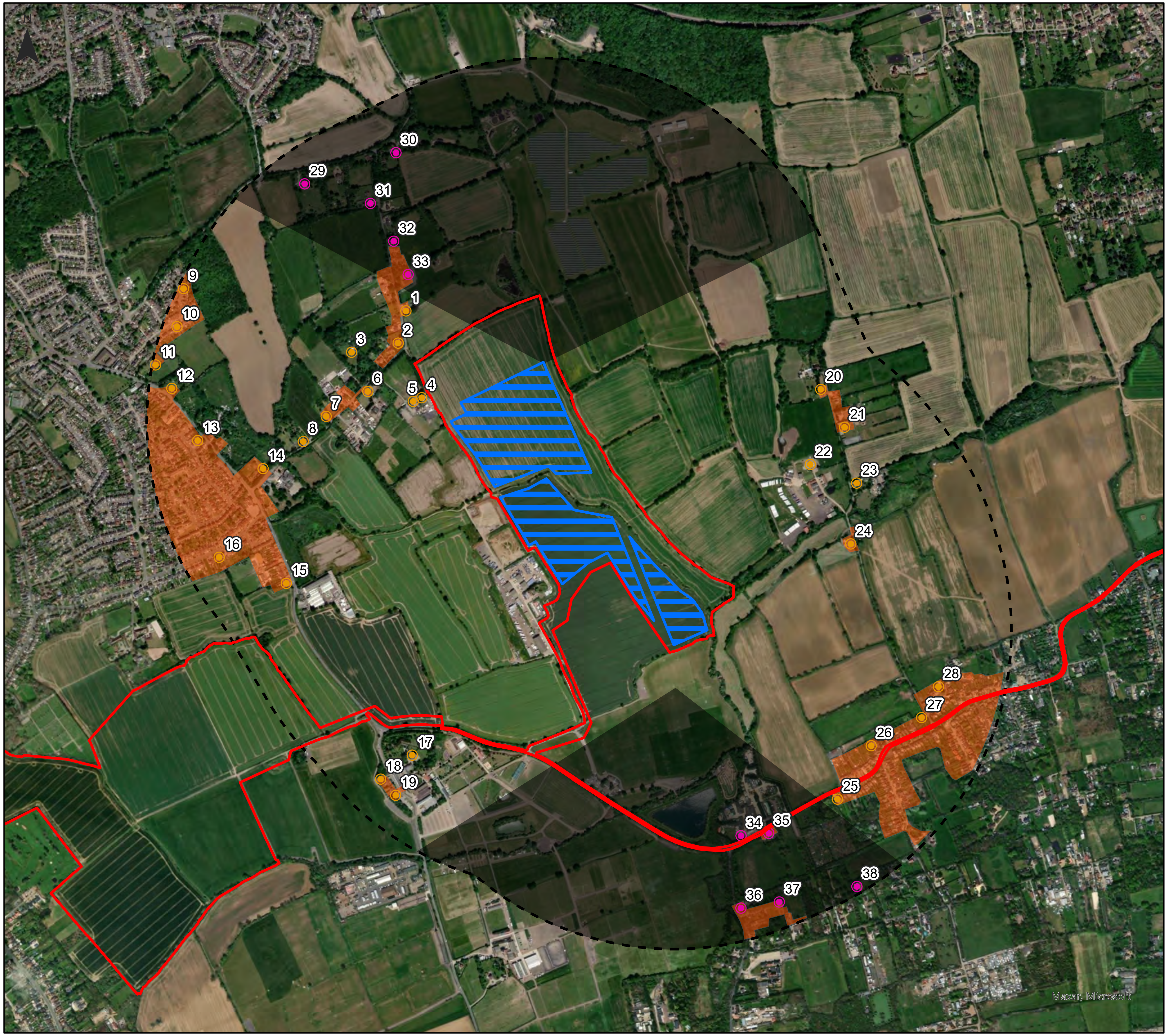
## Appendix H: Visibility Assessment Evidence

## Appendix I: Ground Elevation Profile

# Appendix J: Solar Module Glare and Reflectance Technical Memo[19]

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

# Burstead Solar Farm
# Residential Based Receptors
# Figure 1




0 0.25 0.5 1 Kilometers

Key

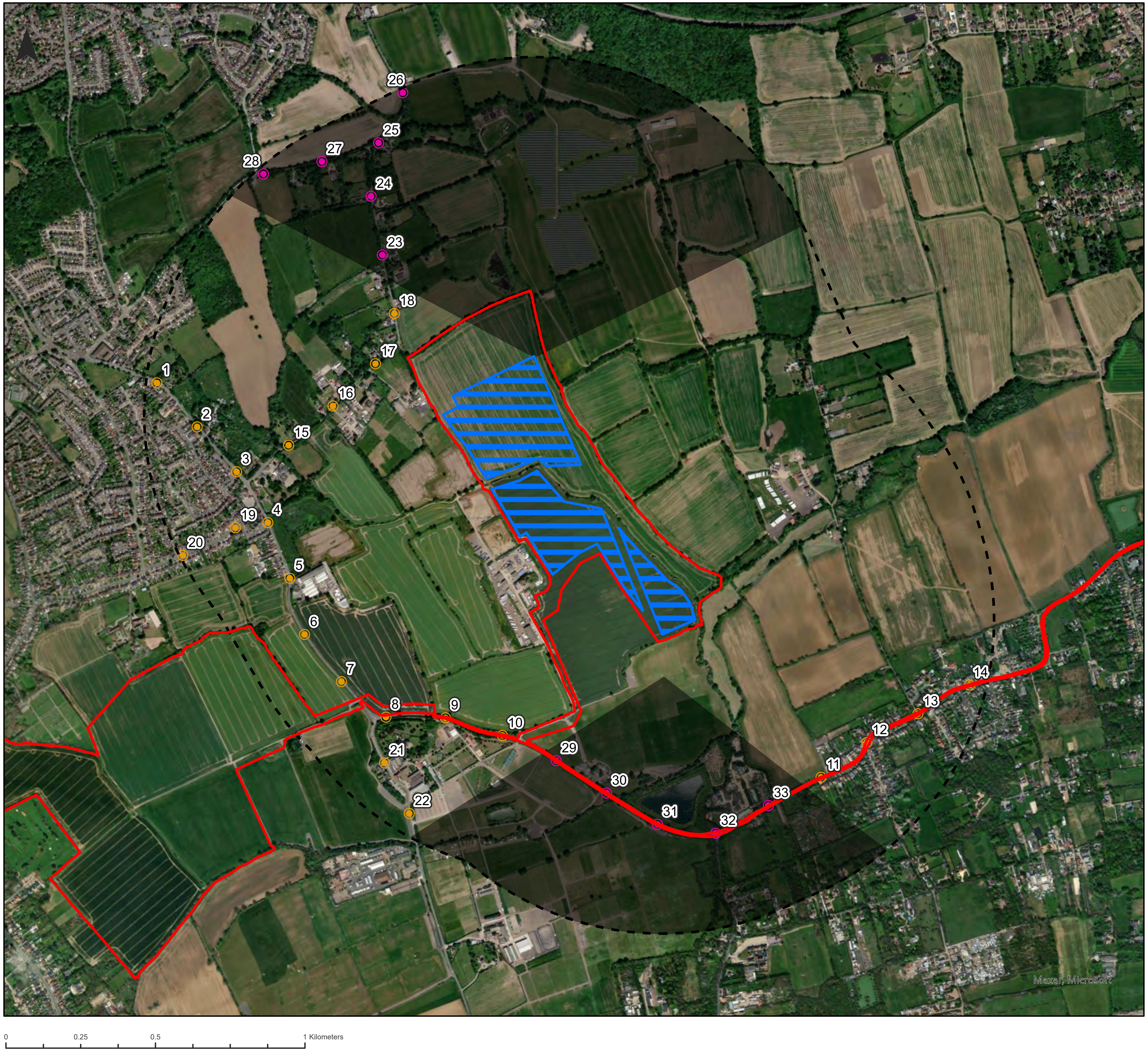
- Development Boundary
- Panel Boundary
- 1km Study Area
- Glare Not Possible at Receptor
- Glare Possible at Receptor
- Residential Area
- Non-Reflection Zones

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


Date: 20/10/2023
Drawn By: David Thomson
Scale (A3): 1:12,500
Drawing No: NEO00947/001I/B

NEO ENVIRONMENTAL

# Burstead 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: 20/10/2023
Drawn By: David Thomson
Scale (A3): 1:12,500
Drawing No: NEO00947/002I/B

neo ENVIRONMENTAL

# AERODROME CHART - ICAO

**ARP 513413N 0004136E** **AD ELEV 55FT**

# SOUTHEND
## EGMC

| COM | | |
|---|---|---|
| ATIS | 136.055 | SOUTHEND INFORMATION |
| TWR | 127.730 | SOUTHEND TOWER |
| | 121.600 | SOUTHEND FIRE |

| LIGHTING | |
|---|---|
| THR 05/23 | HI Green with W bars. |
| RWY 05 | HI elev edge bi-d with omni-d component. HI C/L. End lights red. Red flush C/L beyond end of LDA/TORA. Blue starter extension edge. |
| RWY 23 | HI Uni-directional C/L with four crossbars 583m. End lights red. Red pre-threshold edge. |
| TWYs | Green C/L from C1 to A1. Elev blue edge on TWY A, B, C, D & Z. |

**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 | **114** |
| HEIGHTS IN FEET ABOVE AD | (59) |

**Hot Spot**
**HS1**
Potential conflict with airside vehicles operating without ATC clearance to access hangars via Taxiway D and a vehicle road located north of Holding Point D.


| RUNWAY/TAXIWAY/APRON PHYSICAL CHARACTERISTICS | | | |
|---|---|---|---|
| APRON / RWY / TWY | SURFACE | BEARING STRENGTH | ELEVATION |
| RWY 05/23 | Asphalt (Grooved) | 65/F/B/W/T | - |
| North Apron | Concrete | 47/R/D/X/U | 37ft amsl |
| South Apron | Concrete | 47/R/D/X/U | 37ft amsl |
| Terminal Apron | Concrete | 47/R/D/X/T | - |
| Taxiway A | Asphalt | 47/F/D/X/T | - |
| Taxiway B | Concrete/Asphalt | 47/R/D/X/U | - |
| Taxiway C | Concrete/Asphalt | 47/F/D/X/U | - |
| Taxiways D & F | Asphalt | 26/F/B/X/T | - |
| Link Taxiway Z | Asphalt | 47/F/D/X/U | - |

**CHANGE (8/20):** MAG VAR. MAG HEADING. LLZ, DME & NDB COORDINATES. ROP ADDED. RWY 05 LIGHTING DESCRIPTION. OBSTACLES. SURVEY EDITORIAL.

ForgeSolar

# Burstead Solar Farm

## Burstead Solar Farm Residential 15 Degrees

**Created** Oct 20, 2023
**Updated** Oct 20, 2023
**Time-step** 1 minute
**Timezone offset** UTC0
**Minimum sun altitude** 0.0 deg
**Site ID** 103458.18016

**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**

PV Analysis Methodology: **Version 2**
Enhanced subtended angle calculation: **On**

## 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 | 15.0 | 180.0 | 21,502 | 4,464 | - |

# Component Data

## PV Array(s)

**Total PV footprint area:** 220,193 m^2

**Name**: PV array 1
**Footprint area**: 220,193 m^2
**Axis tracking**: Fixed (no rotation)
**Tilt**: 15.0 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 | 51.611806 | 0.448259 | 29.96 | 3.00 | 32.96 |
| 2 | 51.610833 | 0.449353 | 26.41 | 3.00 | 29.41 |
| 3 | 51.608141 | 0.451606 | 23.67 | 3.00 | 26.67 |
| 4 | 51.608181 | 0.451971 | 22.69 | 3.00 | 25.69 |
| 5 | 51.606928 | 0.452980 | 23.79 | 3.00 | 26.79 |
| 6 | 51.607475 | 0.454374 | 22.13 | 3.00 | 25.13 |
| 7 | 51.607741 | 0.455383 | 20.73 | 3.00 | 23.73 |
| 8 | 51.604998 | 0.458297 | 15.50 | 3.00 | 18.50 |
| 9 | 51.605438 | 0.459906 | 15.15 | 3.00 | 18.15 |
| 10 | 51.605958 | 0.459670 | 15.42 | 3.00 | 18.42 |
| 11 | 51.606504 | 0.459069 | 16.49 | 3.00 | 19.49 |
| 12 | 51.607330 | 0.457632 | 18.55 | 3.00 | 21.55 |
| 13 | 51.608876 | 0.455464 | 19.69 | 3.00 | 22.69 |
| 14 | 51.609142 | 0.453791 | 20.55 | 3.00 | 23.55 |
| 15 | 51.610142 | 0.452546 | 21.17 | 3.00 | 24.17 |
| 16 | 51.610395 | 0.453125 | 21.93 | 3.00 | 24.93 |
| 17 | 51.610515 | 0.454520 | 22.13 | 3.00 | 25.13 |
| 18 | 51.613580 | 0.452525 | 32.38 | 3.00 | 35.38 |
| 19 | 51.612394 | 0.448898 | 32.57 | 3.00 | 35.57 |
| 20 | 51.612047 | 0.449156 | 30.87 | 3.00 | 33.87 |

## Discrete Observation Receptors

| Number | Latitude | Longitude | Ground elevation | Height above ground | Total Elevation |
|---|---|---|---|---|---|
| | deg | deg | m | m | m |
| OP 1 | 51.615180 | 0.446178 | 49.32 | 2.00 | 51.32 |
| OP 2 | 51.614268 | 0.445802 | 46.60 | 2.00 | 48.60 |
| OP 3 | 51.614154 | 0.443506 | 49.38 | 2.00 | 51.38 |
| OP 4 | 51.612622 | 0.446822 | 41.71 | 2.00 | 43.71 |
| OP 5 | 51.612529 | 0.446382 | 41.68 | 2.00 | 43.68 |
| OP 6 | 51.612869 | 0.444220 | 41.35 | 2.00 | 43.35 |
| OP 7 | 51.612156 | 0.442213 | 39.60 | 2.00 | 41.60 |
| OP 8 | 51.611470 | 0.441098 | 38.17 | 2.00 | 40.17 |
| OP 9 | 51.616080 | 0.435615 | 54.40 | 2.00 | 56.40 |
| OP 10 | 51.614961 | 0.435250 | 49.56 | 2.00 | 51.56 |
| OP 11 | 51.613861 | 0.434167 | 44.79 | 2.00 | 46.79 |
| OP 12 | 51.613152 | 0.434918 | 42.87 | 2.00 | 44.87 |
| OP 13 | 51.611583 | 0.436071 | 42.12 | 2.00 | 44.12 |
| OP 14 | 51.610690 | 0.439129 | 37.58 | 2.00 | 39.58 |
| OP 15 | 51.607257 | 0.440036 | 34.17 | 2.00 | 36.17 |
| OP 16 | 51.608080 | 0.436718 | 35.19 | 2.00 | 37.19 |
| OP 17 | 51.602064 | 0.445677 | 27.70 | 2.00 | 29.70 |
| OP 18 | 51.601397 | 0.444228 | 27.88 | 2.00 | 29.88 |
| OP 19 | 51.600891 | 0.444939 | 27.59 | 2.00 | 29.59 |
| OP 20 | 51.613159 | 0.465511 | 24.88 | 2.00 | 26.88 |
| OP 21 | 51.611344 | 0.466764 | 22.71 | 2.00 | 24.71 |
| OP 22 | 51.610138 | 0.465262 | 19.51 | 2.00 | 21.51 |
| OP 23 | 51.609685 | 0.467268 | 16.76 | 2.00 | 18.76 |
| OP 24 | 51.607779 | 0.466914 | 16.71 | 2.00 | 18.71 |
| OP 25 | 51.600371 | 0.465818 | 22.47 | 2.00 | 24.47 |
| OP 26 | 51.601898 | 0.467486 | 26.86 | 2.00 | 28.86 |
| OP 27 | 51.602641 | 0.469932 | 41.72 | 2.00 | 43.72 |
| OP 28 | 51.603557 | 0.470796 | 46.76 | 2.00 | 48.76 |

# 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 | 15.0 | 180.0 | 21,502 | 4,464 | - | - |

## 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 | 3 | 625 | 1219 | 1000 | 723 | 739 | 1411 | 857 | 116 | 0 | 0 |
| pv-array-1 (yellow) | 0 | 0 | 28 | 22 | 318 | 580 | 538 | 7 | 42 | 0 | 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 | 1792 | 1216 |
| OP: OP 5 | 1698 | 1153 |
| OP: OP 6 | 1274 | 0 |
| OP: OP 7 | 1453 | 15 |
| OP: OP 8 | 1423 | 163 |
| OP: OP 9 | 0 | 0 |
| OP: OP 10 | 0 | 0 |
| OP: OP 11 | 29 | 0 |
| OP: OP 12 | 0 | 0 |
| OP: OP 13 | 878 | 0 |
| OP: OP 14 | 23 | 0 |
| OP: OP 15 | 0 | 0 |
| OP: OP 16 | 0 | 0 |
| OP: OP 17 | 965 | 0 |
| OP: OP 18 | 609 | 0 |
| OP: OP 19 | 222 | 0 |
| OP: OP 20 | 191 | 0 |
| OP: OP 21 | 1228 | 0 |
| OP: OP 22 | 1855 | 0 |
| OP: OP 23 | 1146 | 0 |
| OP: OP 24 | 2031 | 103 |
| OP: OP 25 | 0 | 0 |
| OP: OP 26 | 66 | 0 |
| OP: OP 27 | 2277 | 379 |
| OP: OP 28 | 2342 | 1435 |

## PV array 1: OP 1

*No glare found*

## PV array 1: OP 2

*No glare found*

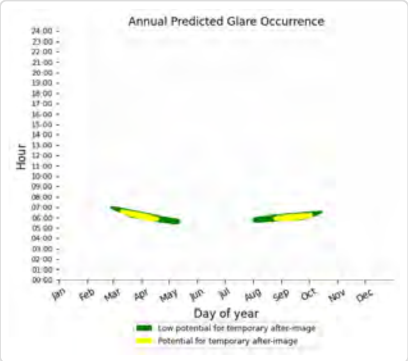
## PV array 1: OP 3

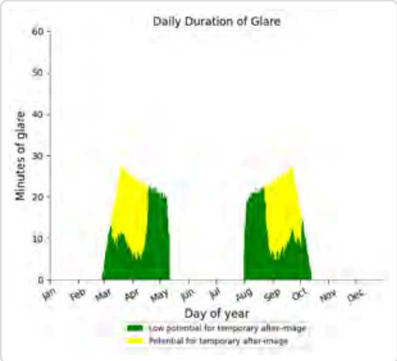
*No glare found*

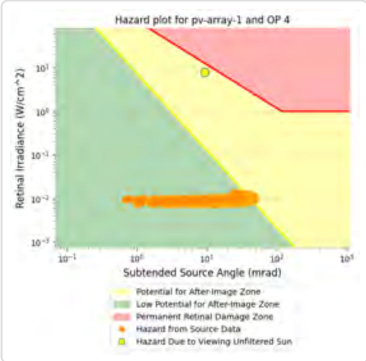
## PV array 1: OP 4

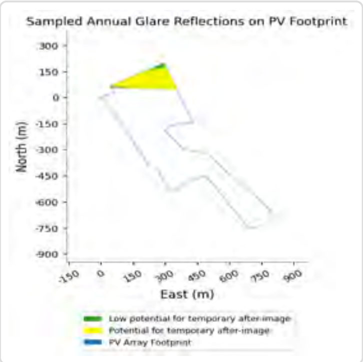
PV array is expected to produce the following glare for this receptor:

- 1,792 minutes of "green" glare with low potential to cause temporary after-image.
- 1,216 minutes of "yellow" glare with potential to cause temporary after-image.



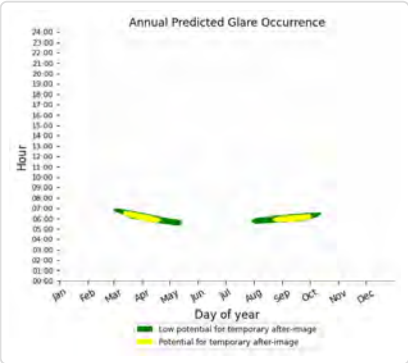



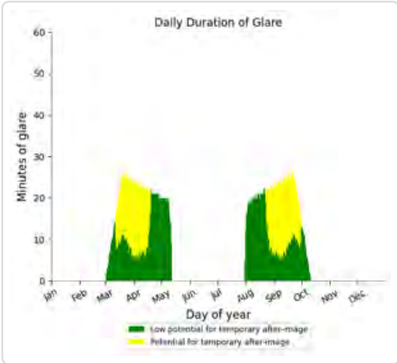



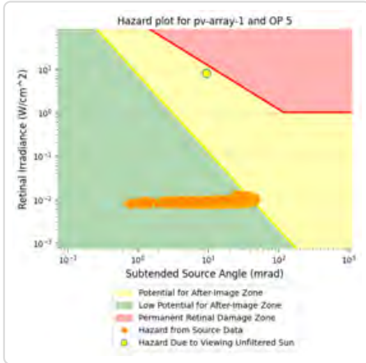
## PV array 1: OP 5

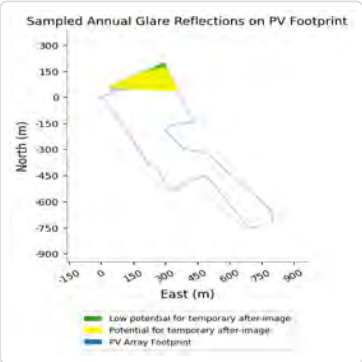
PV array is expected to produce the following glare for this receptor:

- 1,698 minutes of "green" glare with low potential to cause temporary after-image.
- 1,153 minutes of "yellow" glare with potential to cause temporary after-image.



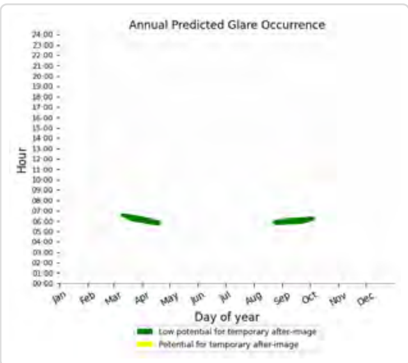



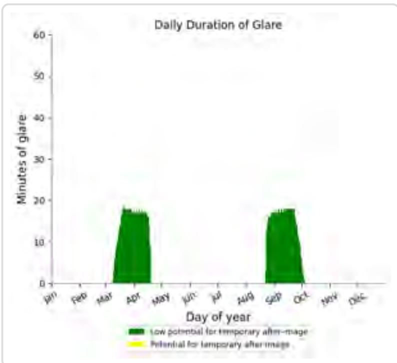



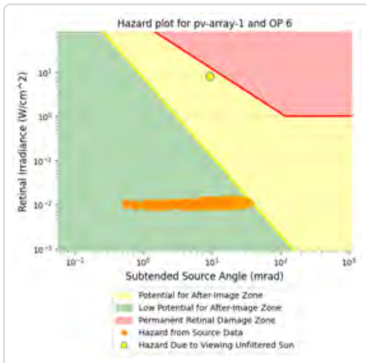

## PV array 1: OP 6

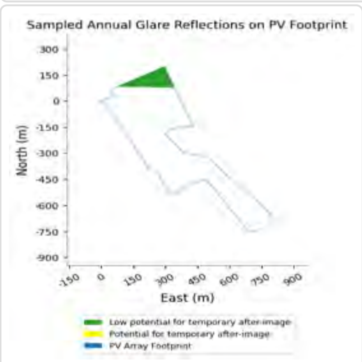
PV array is expected to produce the following glare for this receptor:

- 1,274 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.



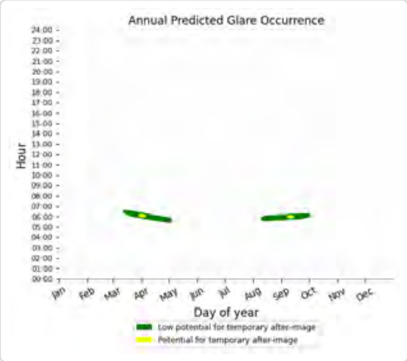



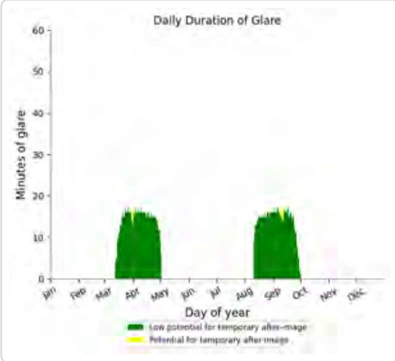



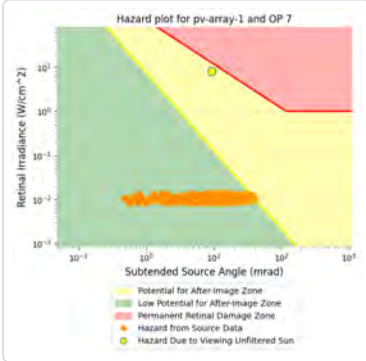
## PV array 1: OP 7

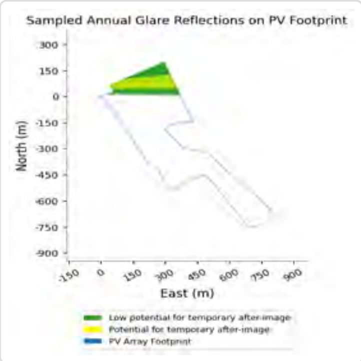
PV array is expected to produce the following glare for this receptor:

- 1,453 minutes of "green" glare with low potential to cause temporary after-image.
- 15 minutes of "yellow" glare with potential to cause temporary after-image.



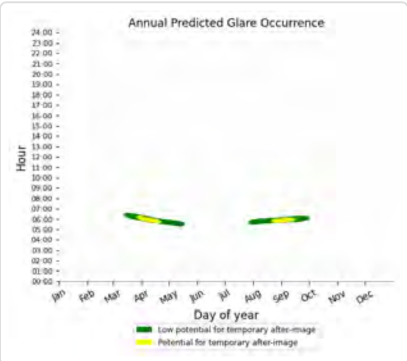



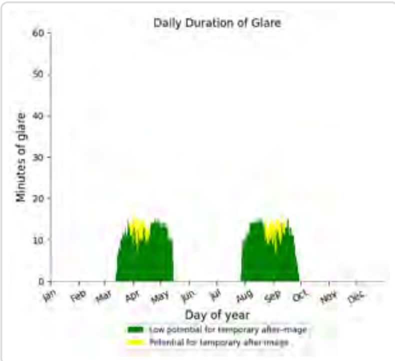



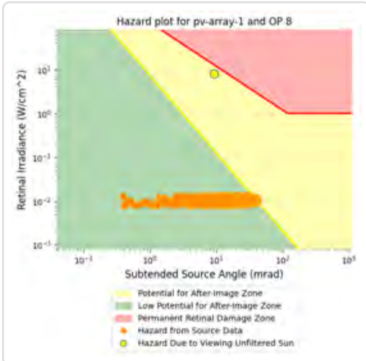

## PV array 1: OP 8

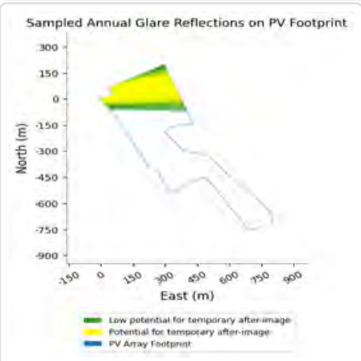
PV array is expected to produce the following glare for this receptor:

- 1,423 minutes of "green" glare with low potential to cause temporary after-image.
- 163 minutes of "yellow" glare with potential to cause temporary after-image.




## PV array 1: OP 9

*No glare found*

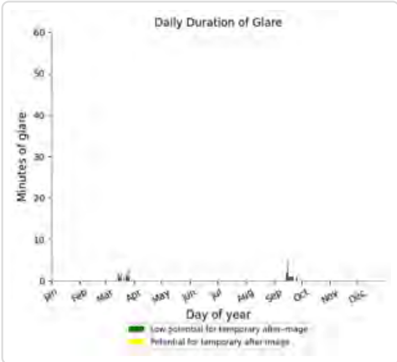
## PV array 1: OP 10

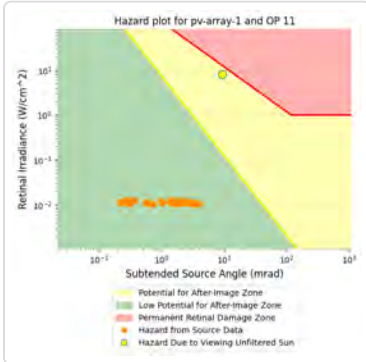
*No glare found*

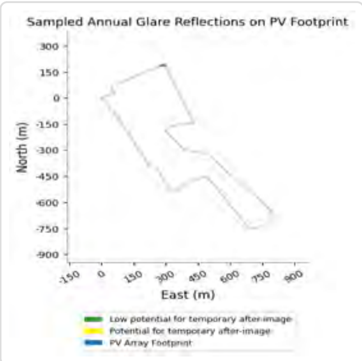
## PV array 1: OP 11

PV array is expected to produce the following glare for this receptor:

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

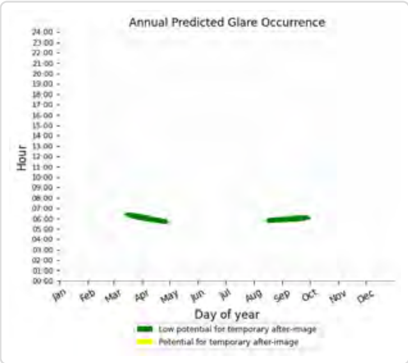

## PV array 1: OP 12

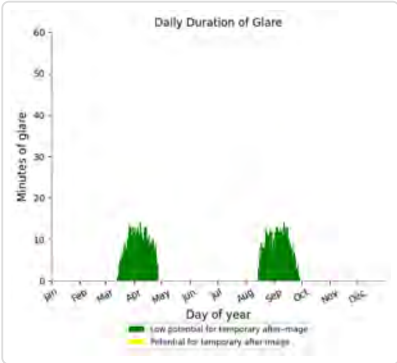
*No glare found*

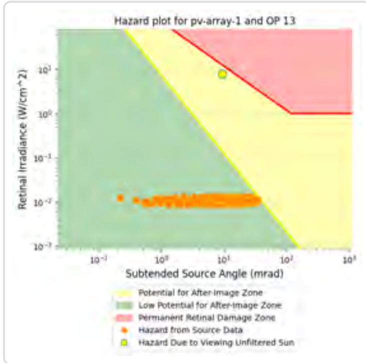
## PV array 1: OP 13

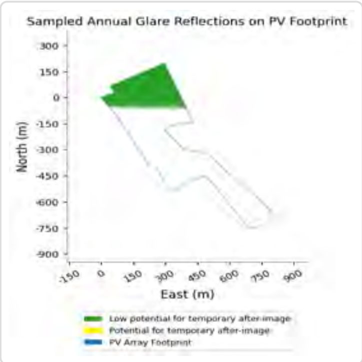
PV array is expected to produce the following glare for this receptor:

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



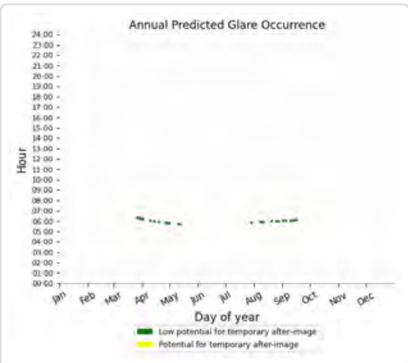



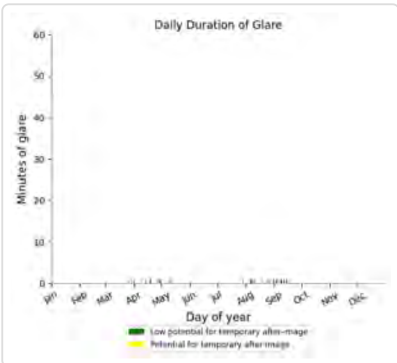



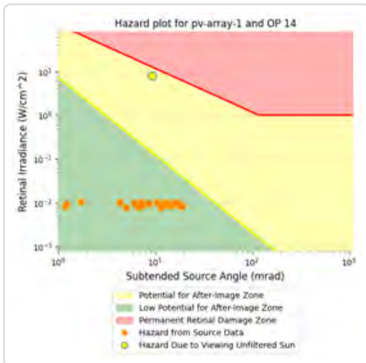

## PV array 1: OP 14

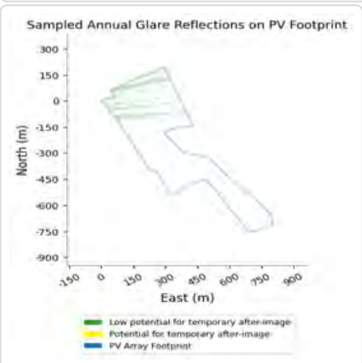
PV array is expected to produce the following glare for this receptor:

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




## PV array 1: OP 15

*No glare found*

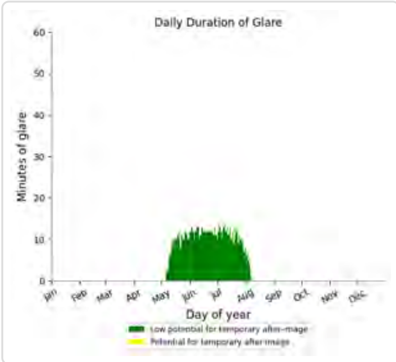
## PV array 1: OP 16

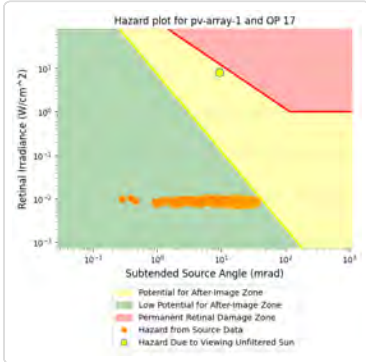
*No glare found*

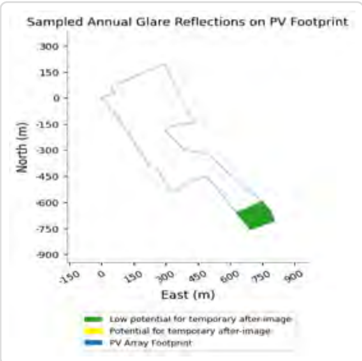
## PV array 1: OP 17

PV array is expected to produce the following glare for this receptor:

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

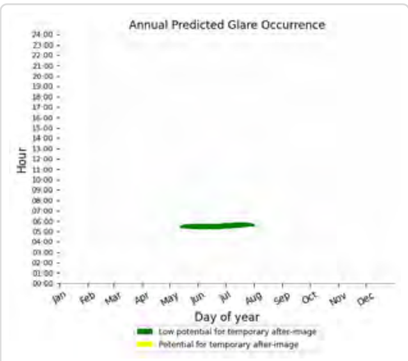



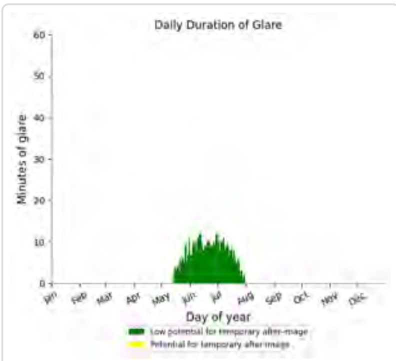



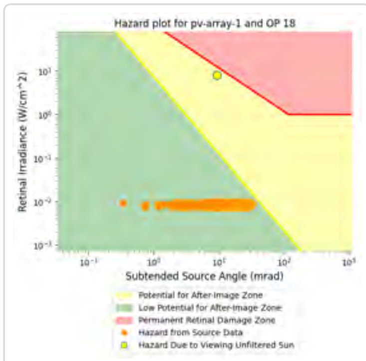

## PV array 1: OP 18

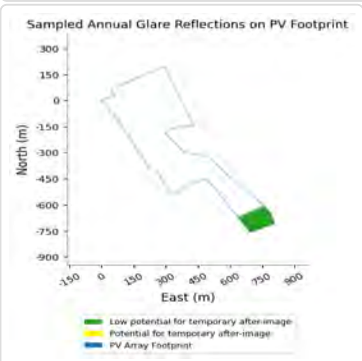
PV array is expected to produce the following glare for this receptor:

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



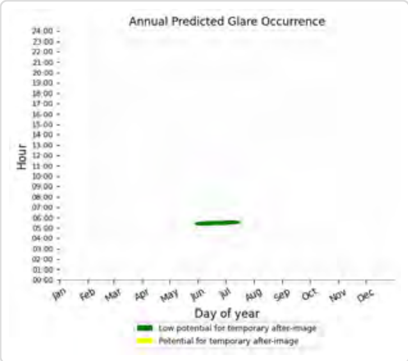



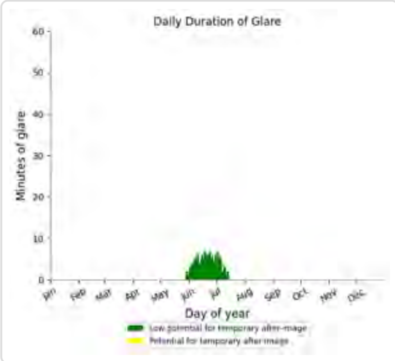



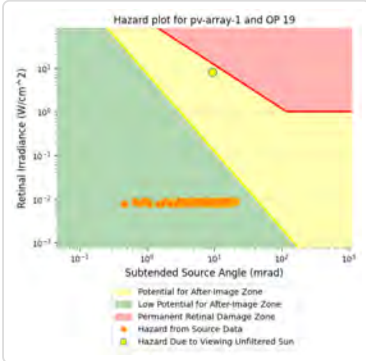
## PV array 1: OP 19

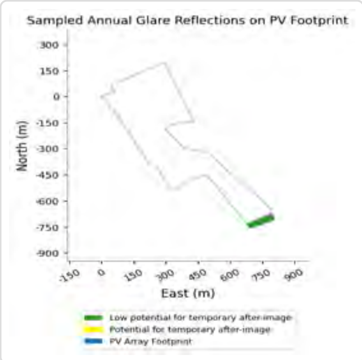
PV array is expected to produce the following glare for this receptor:

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



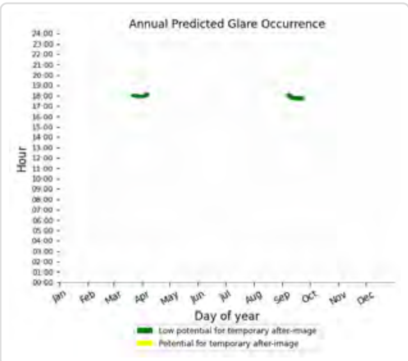



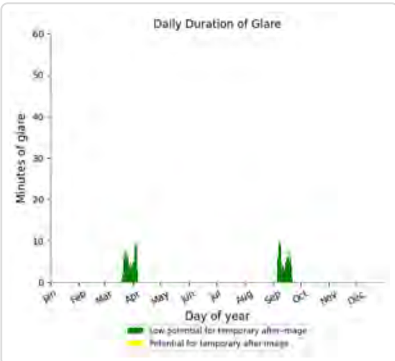



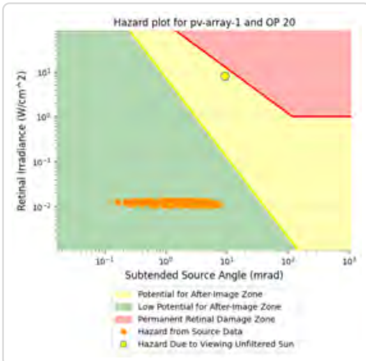

## PV array 1: OP 20

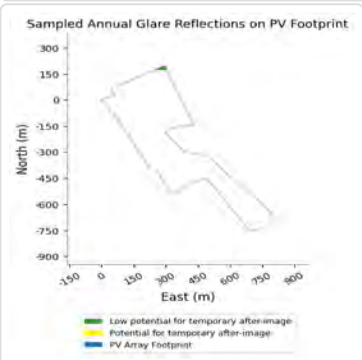
PV array is expected to produce the following glare for this receptor:

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



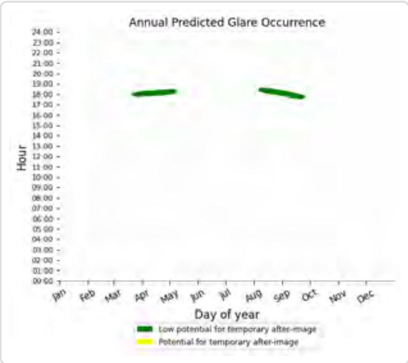



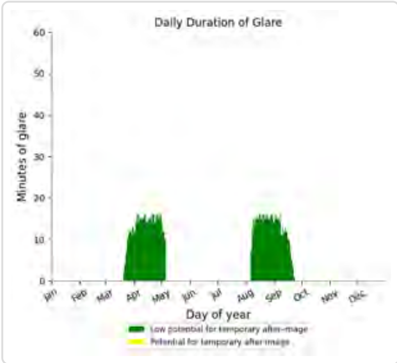



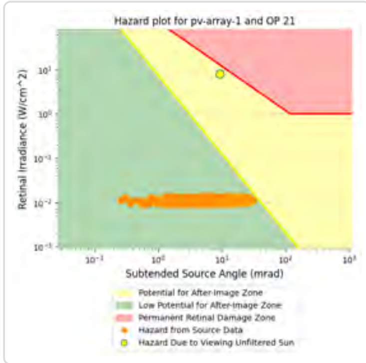
## PV array 1: OP 21

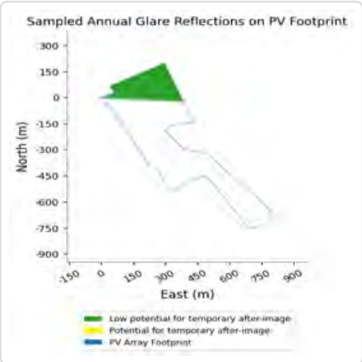
PV array is expected to produce the following glare for this receptor:

- 1,228 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.



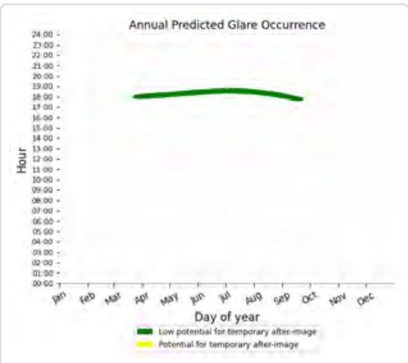



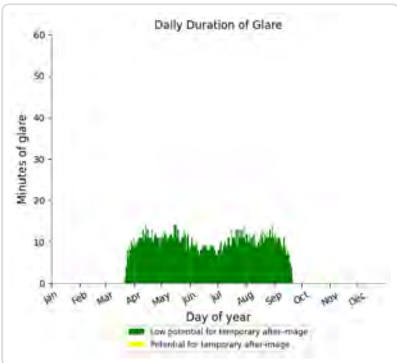



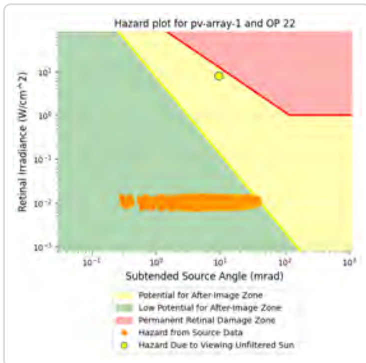

## PV array 1: OP 22

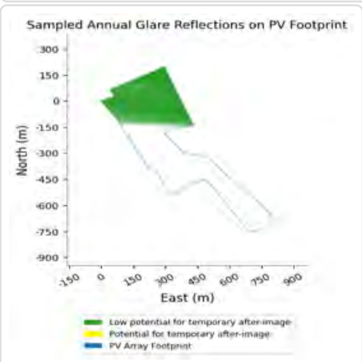
PV array is expected to produce the following glare for this receptor:

- 1,855 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.



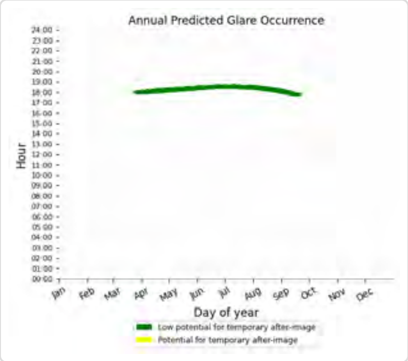



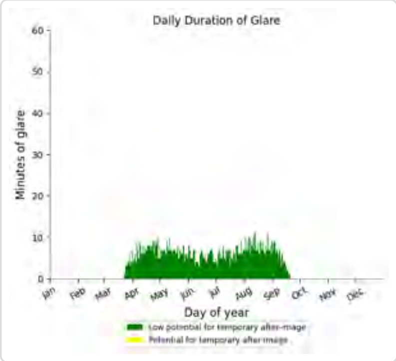



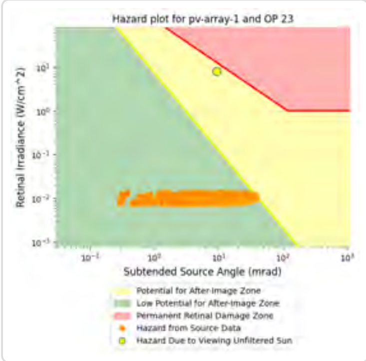
## PV array 1: OP 23

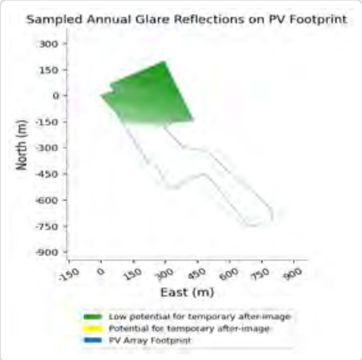
PV array is expected to produce the following glare for this receptor:

- 1,146 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.



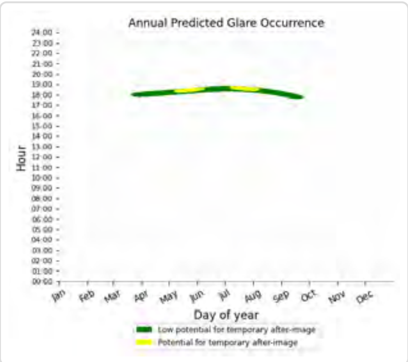



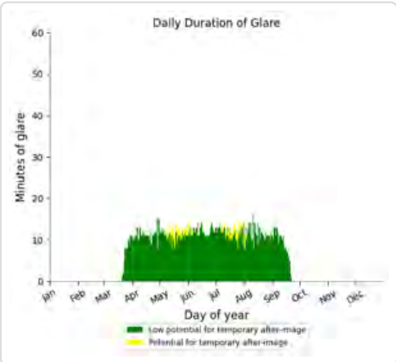



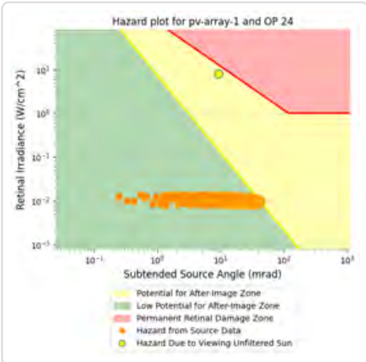

## PV array 1: OP 24

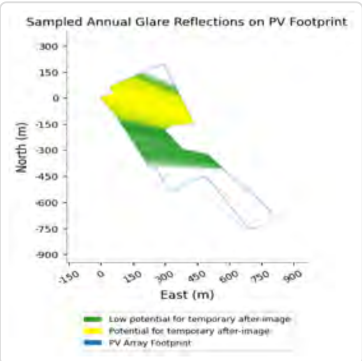
PV array is expected to produce the following glare for this receptor:

- 2,031 minutes of "green" glare with low potential to cause temporary after-image.
- 103 minutes of "yellow" glare with potential to cause temporary after-image.



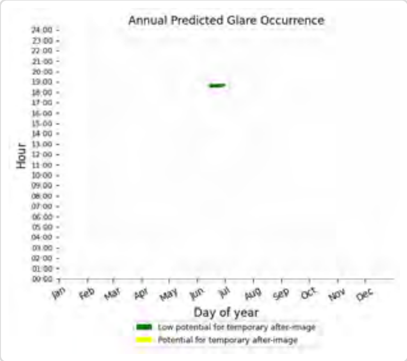

## PV array 1: OP 25

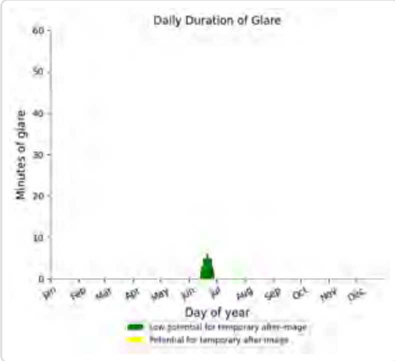
*No glare found*

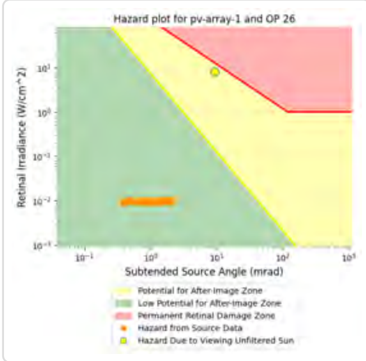
## PV array 1: OP 26

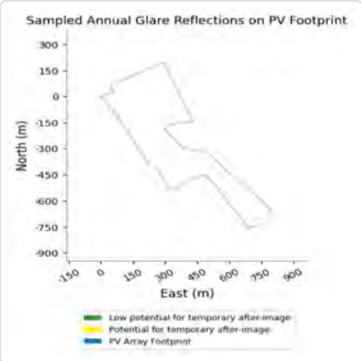
PV array is expected to produce the following glare for this receptor:

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



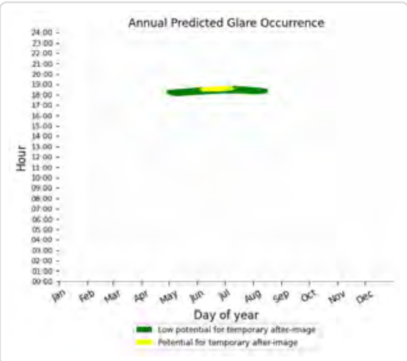



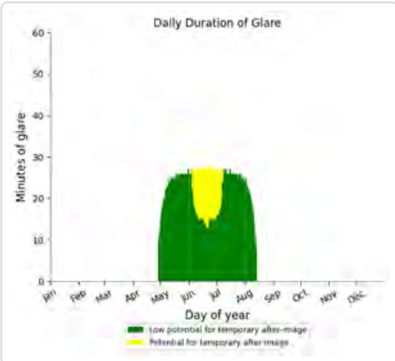



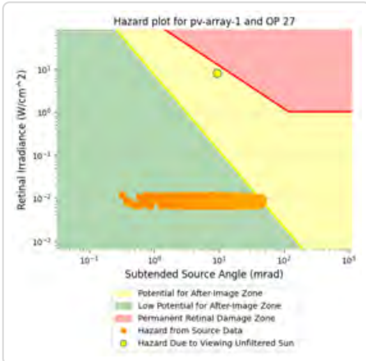

## PV array 1: OP 27

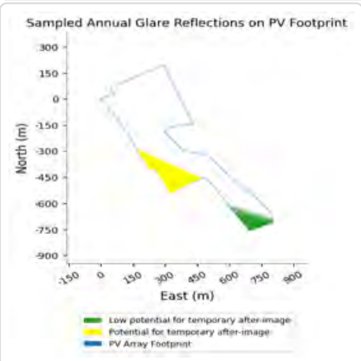
PV array is expected to produce the following glare for this receptor:

- 2,277 minutes of "green" glare with low potential to cause temporary after-image.
- 379 minutes of "yellow" glare with potential to cause temporary after-image.



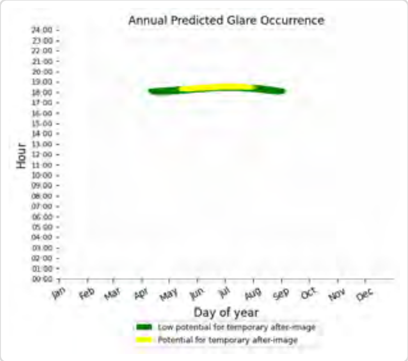



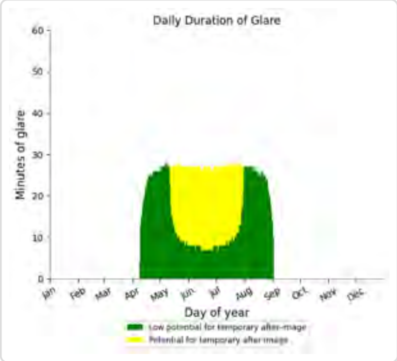



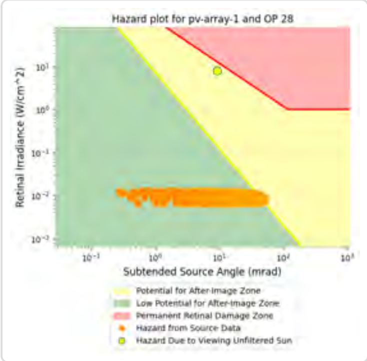
### PV array 1: OP 28

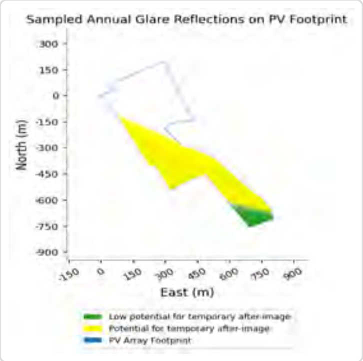
PV array is expected to produce the following glare for this receptor:

- 2,342 minutes of "green" glare with low potential to cause temporary after-image.
- 1,435 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 for 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

# Burstead Solar Farm

## Burstead Solar Farm Residential 30 Degrees

**Created** Oct 20, 2023
**Updated** Oct 20, 2023
**Time-step** 1 minute
**Timezone offset** UTC0
**Minimum sun altitude** 0.0 deg
**Site ID** 103458.18016

**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**

PV Analysis Methodology: **Version 2**
Enhanced subtended angle calculation: **On**

## 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 | 30.0 | 180.0 | 20,405 | 3,044 | - |

# Component Data

## PV Array(s)

**Total PV footprint area:** 220,193 m^2

**Name**: PV array 1
**Footprint area**: 220,193 m^2
**Axis tracking**: Fixed (no rotation)
**Tilt**: 30.0 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 | 51.611806 | 0.448259 | 29.96 | 3.00 | 32.96 |
| 2 | 51.610833 | 0.449353 | 26.41 | 3.00 | 29.41 |
| 3 | 51.608141 | 0.451606 | 23.67 | 3.00 | 26.67 |
| 4 | 51.608181 | 0.451971 | 22.69 | 3.00 | 25.69 |
| 5 | 51.606928 | 0.452980 | 23.79 | 3.00 | 26.79 |
| 6 | 51.607475 | 0.454374 | 22.13 | 3.00 | 25.13 |
| 7 | 51.607741 | 0.455383 | 20.73 | 3.00 | 23.73 |
| 8 | 51.604998 | 0.458297 | 15.50 | 3.00 | 18.50 |
| 9 | 51.605438 | 0.459906 | 15.15 | 3.00 | 18.15 |
| 10 | 51.605958 | 0.459670 | 15.42 | 3.00 | 18.42 |
| 11 | 51.606504 | 0.459069 | 16.49 | 3.00 | 19.49 |
| 12 | 51.607330 | 0.457632 | 18.55 | 3.00 | 21.55 |
| 13 | 51.608876 | 0.455464 | 19.69 | 3.00 | 22.69 |
| 14 | 51.609142 | 0.453791 | 20.55 | 3.00 | 23.55 |
| 15 | 51.610142 | 0.452546 | 21.17 | 3.00 | 24.17 |
| 16 | 51.610395 | 0.453125 | 21.93 | 3.00 | 24.93 |
| 17 | 51.610515 | 0.454520 | 22.13 | 3.00 | 25.13 |
| 18 | 51.613580 | 0.452525 | 32.38 | 3.00 | 35.38 |
| 19 | 51.612394 | 0.448898 | 32.57 | 3.00 | 35.57 |
| 20 | 51.612047 | 0.449156 | 30.87 | 3.00 | 33.87 |

## Discrete Observation Receptors

| Number | Latitude | Longitude | Ground elevation | Height above ground | Total Elevation |
|---|---|---|---|---|---|
| | deg | deg | m | m | m |
| OP 1 | 51.615180 | 0.446178 | 49.32 | 2.00 | 51.32 |
| OP 2 | 51.614268 | 0.445802 | 46.60 | 2.00 | 48.60 |
| OP 3 | 51.614154 | 0.443506 | 49.38 | 2.00 | 51.38 |
| OP 4 | 51.612622 | 0.446822 | 41.71 | 2.00 | 43.71 |
| OP 5 | 51.612529 | 0.446382 | 41.68 | 2.00 | 43.68 |
| OP 6 | 51.612869 | 0.444220 | 41.35 | 2.00 | 43.35 |
| OP 7 | 51.612156 | 0.442213 | 39.60 | 2.00 | 41.60 |
| OP 8 | 51.611470 | 0.441098 | 38.17 | 2.00 | 40.17 |
| OP 9 | 51.616080 | 0.435615 | 54.40 | 2.00 | 56.40 |
| OP 10 | 51.614961 | 0.435250 | 49.56 | 2.00 | 51.56 |
| OP 11 | 51.613861 | 0.434167 | 44.79 | 2.00 | 46.79 |
| OP 12 | 51.613152 | 0.434918 | 42.87 | 2.00 | 44.87 |
| OP 13 | 51.611583 | 0.436071 | 42.12 | 2.00 | 44.12 |
| OP 14 | 51.610690 | 0.439129 | 37.58 | 2.00 | 39.58 |
| OP 15 | 51.607257 | 0.440036 | 34.17 | 2.00 | 36.17 |
| OP 16 | 51.608080 | 0.436718 | 35.19 | 2.00 | 37.19 |
| OP 17 | 51.602064 | 0.445677 | 27.70 | 2.00 | 29.70 |
| OP 18 | 51.601397 | 0.444228 | 27.88 | 2.00 | 29.88 |
| OP 19 | 51.600891 | 0.444939 | 27.59 | 2.00 | 29.59 |
| OP 20 | 51.613159 | 0.465511 | 24.88 | 2.00 | 26.88 |
| OP 21 | 51.611344 | 0.466764 | 22.71 | 2.00 | 24.71 |
| OP 22 | 51.610138 | 0.465262 | 19.51 | 2.00 | 21.51 |
| OP 23 | 51.609685 | 0.467268 | 16.76 | 2.00 | 18.76 |
| OP 24 | 51.607779 | 0.466914 | 16.71 | 2.00 | 18.71 |
| OP 25 | 51.600371 | 0.465818 | 22.47 | 2.00 | 24.47 |
| OP 26 | 51.601898 | 0.467486 | 26.86 | 2.00 | 28.86 |
| OP 27 | 51.602641 | 0.469932 | 41.72 | 2.00 | 43.72 |
| OP 28 | 51.603557 | 0.470796 | 46.76 | 2.00 | 48.76 |

## 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 | 30.0 | 180.0 | 20,405 | 3,044 | - | - |

### 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 | 457 | 1152 | 1067 | 889 | 916 | 1305 | 766 | 6 | 0 | 0 |
| pv-array-1 (yellow) | 0 | 0 | 22 | 26 | 137 | 309 | 260 | 9 | 35 | 0 | 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 | 1364 | 957 |
| OP: OP 5 | 1353 | 918 |
| OP: OP 6 | 994 | 0 |
| OP: OP 7 | 1145 | 116 |
| OP: OP 8 | 1222 | 216 |
| OP: OP 9 | 0 | 0 |
| OP: OP 10 | 0 | 0 |
| OP: OP 11 | 0 | 0 |
| OP: OP 12 | 0 | 0 |
| OP: OP 13 | 763 | 0 |
| OP: OP 14 | 23 | 0 |
| OP: OP 15 | 0 | 0 |
| OP: OP 16 | 23 | 0 |
| OP: OP 17 | 900 | 0 |
| OP: OP 18 | 579 | 0 |
| OP: OP 19 | 173 | 0 |
| OP: OP 20 | 228 | 0 |
| OP: OP 21 | 1272 | 0 |
| OP: OP 22 | 1773 | 51 |
| OP: OP 23 | 1135 | 9 |
| OP: OP 24 | 2022 | 72 |
| OP: OP 25 | 0 | 0 |
| OP: OP 26 | 0 | 0 |
| OP: OP 27 | 2541 | 0 |
| OP: OP 28 | 2895 | 705 |

## PV array 1: OP 1

*No glare found*

## PV array 1: OP 2

*No glare found*

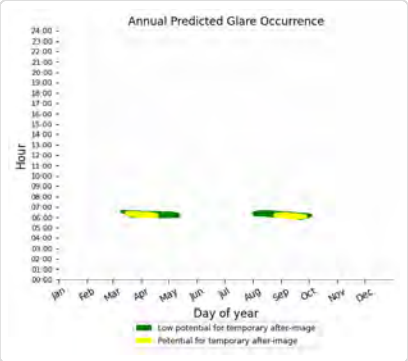
## PV array 1: OP 3

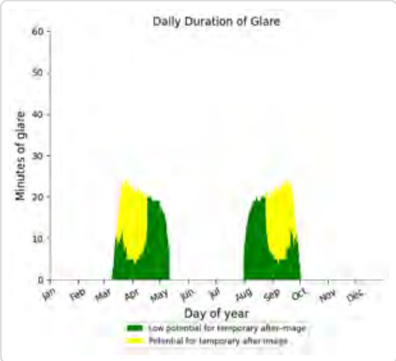
*No glare found*

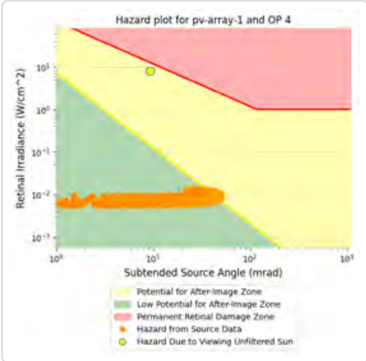
## PV array 1: OP 4

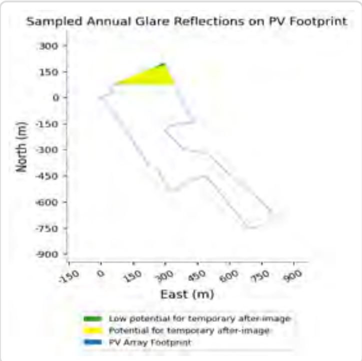
PV array is expected to produce the following glare for this receptor:

- 1,364 minutes of "green" glare with low potential to cause temporary after-image.
- 957 minutes of "yellow" glare with potential to cause temporary after-image.



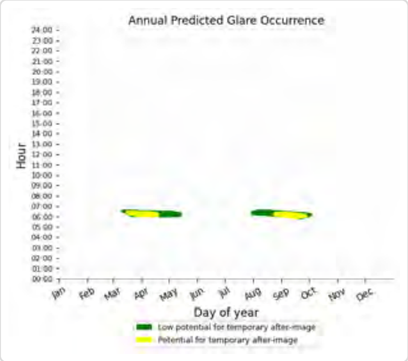



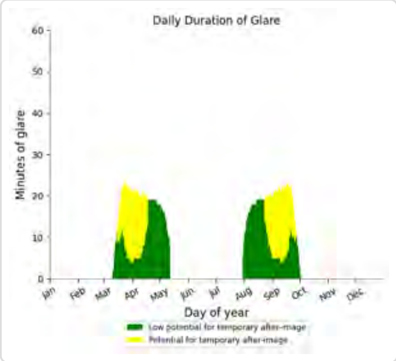



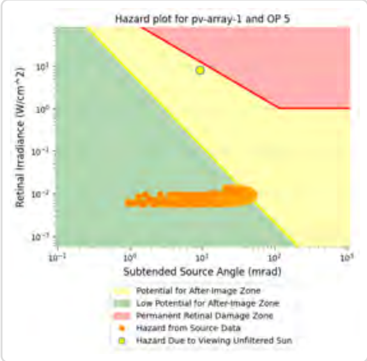
## PV array 1: OP 5

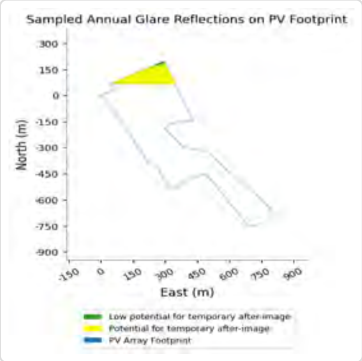
PV array is expected to produce the following glare for this receptor:

- 1,353 minutes of "green" glare with low potential to cause temporary after-image.
- 918 minutes of "yellow" glare with potential to cause temporary after-image.



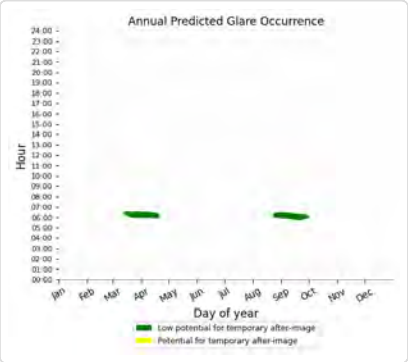



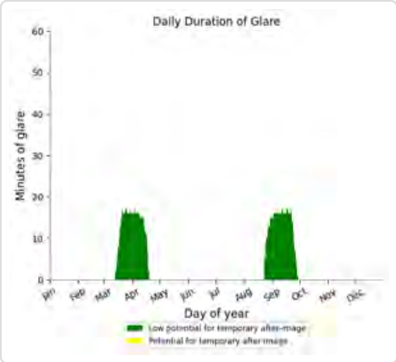



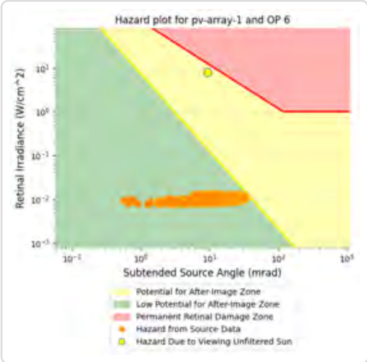

## PV array 1: OP 6

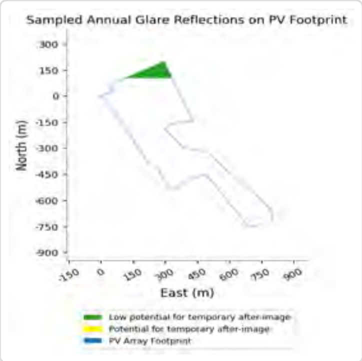
PV array is expected to produce the following glare for this receptor:

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



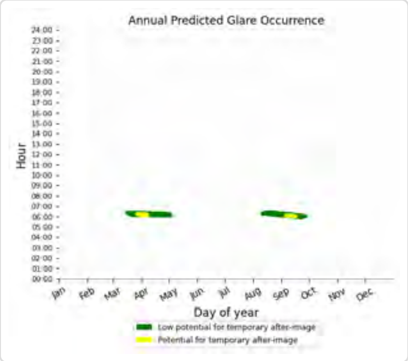



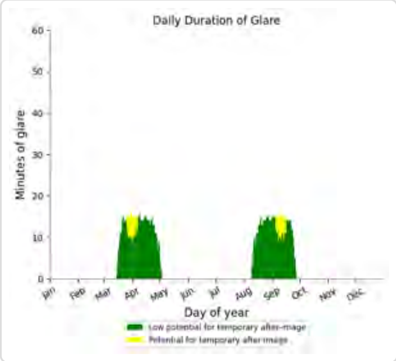



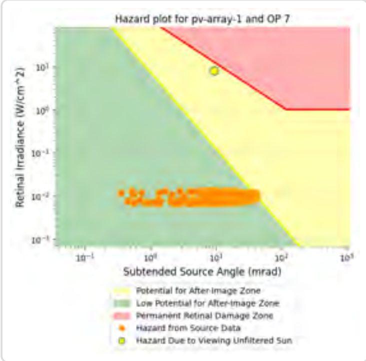
## PV array 1: OP 7

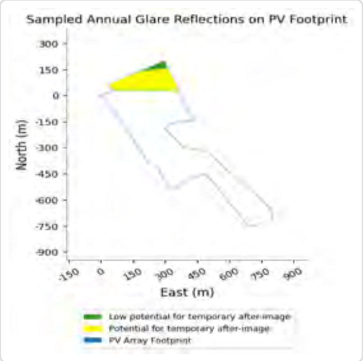
PV array is expected to produce the following glare for this receptor:

- 1,145 minutes of "green" glare with low potential to cause temporary after-image.
- 116 minutes of "yellow" glare with potential to cause temporary after-image.



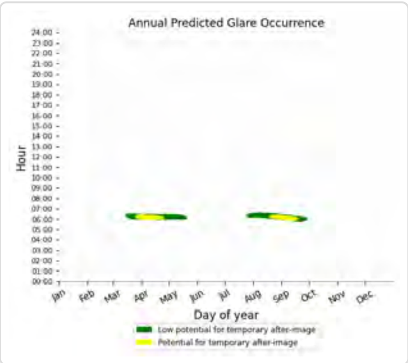



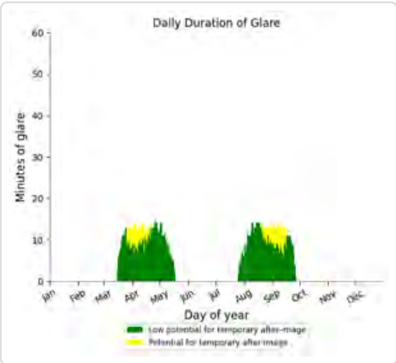



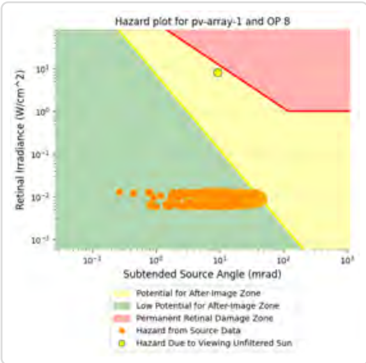

## PV array 1: OP 8

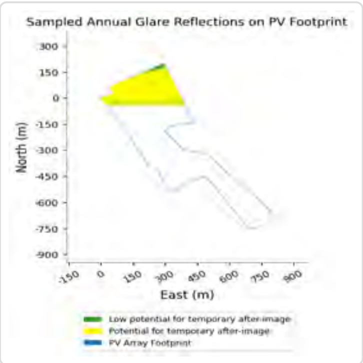
PV array is expected to produce the following glare for this receptor:

- 1,222 minutes of "green" glare with low potential to cause temporary after-image.
- 216 minutes of "yellow" glare with potential to cause temporary after-image.




## PV array 1: OP 9

*No glare found*

## PV array 1: OP 10

*No glare found*

## PV array 1: OP 11

*No glare found*

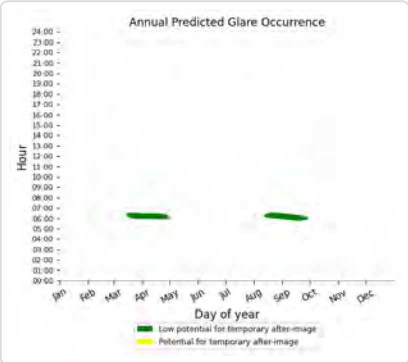
## PV array 1: OP 12

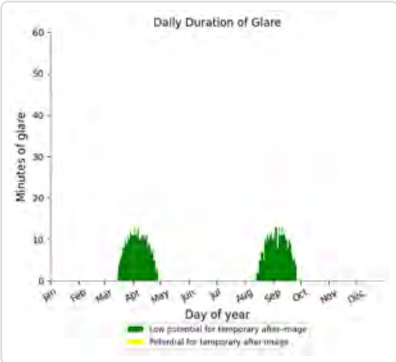
*No glare found*

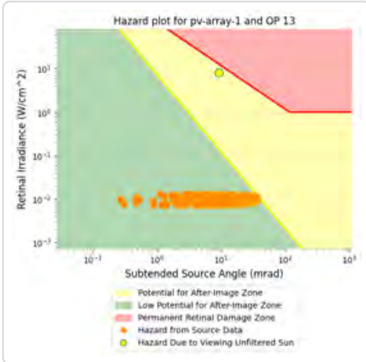
## PV array 1: OP 13

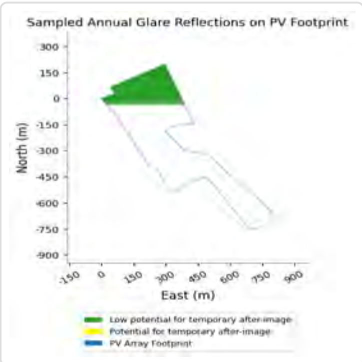
PV array is expected to produce the following glare for this receptor:

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



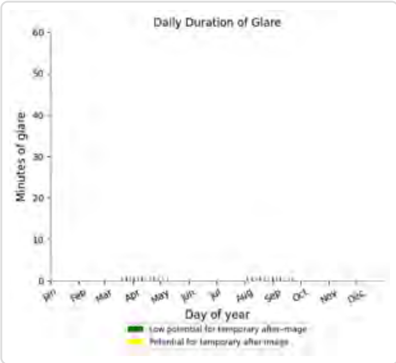



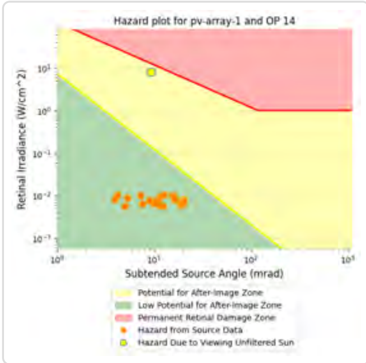



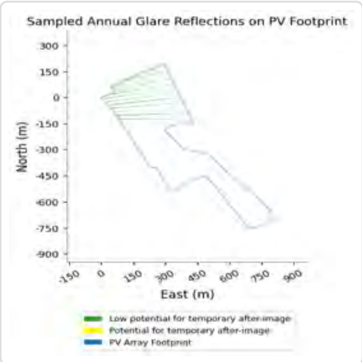
## PV array 1: OP 14

PV array is expected to produce the following glare for this receptor:

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

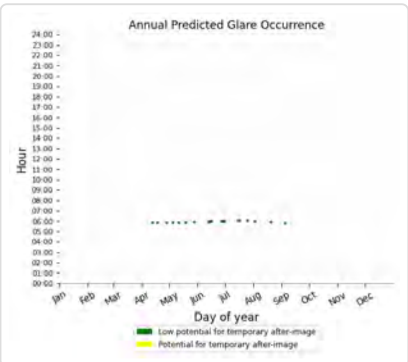

## PV array 1: OP 15

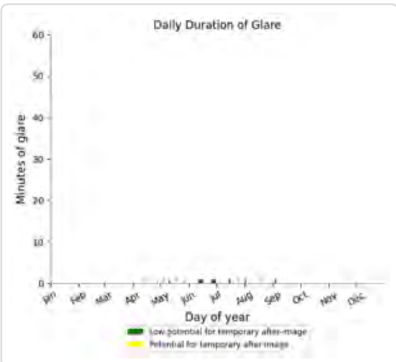
*No glare found*

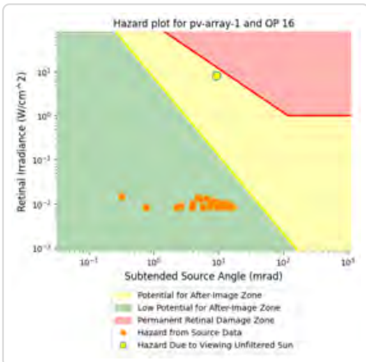
## PV array 1: OP 16

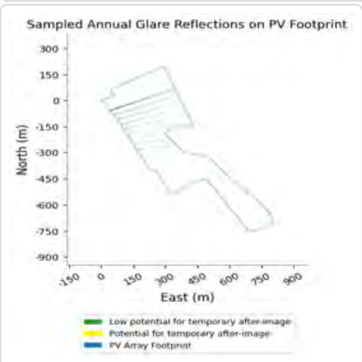
PV array is expected to produce the following glare for this receptor:

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



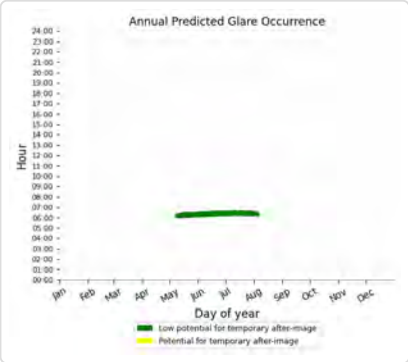



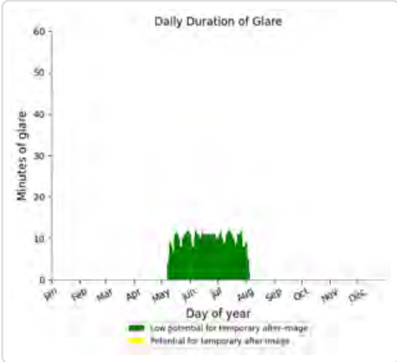



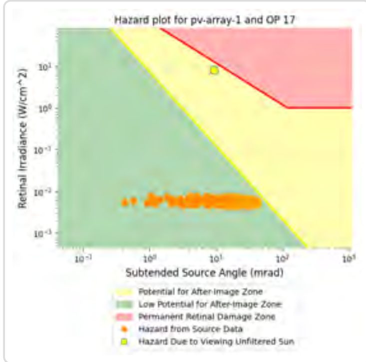
## PV array 1: OP 17

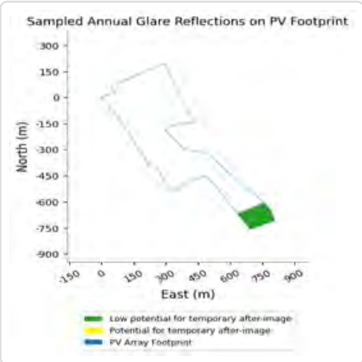
PV array is expected to produce the following glare for this receptor:

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



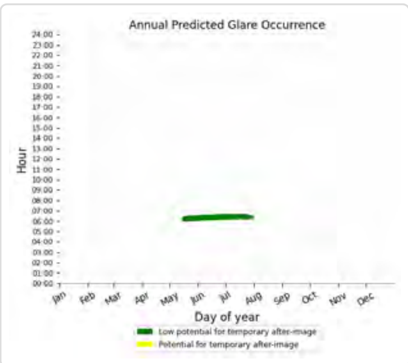



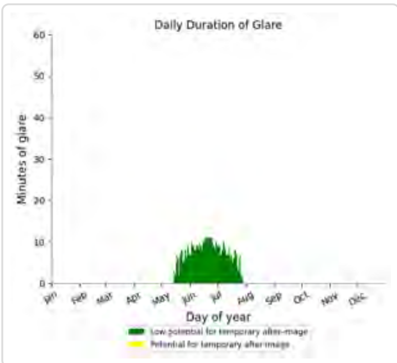



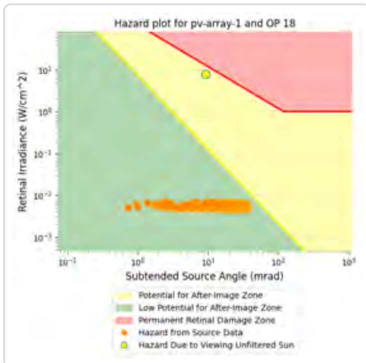

## PV array 1: OP 18

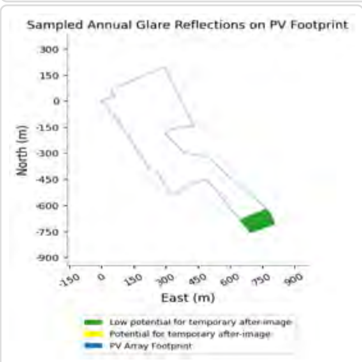
PV array is expected to produce the following glare for this receptor:

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



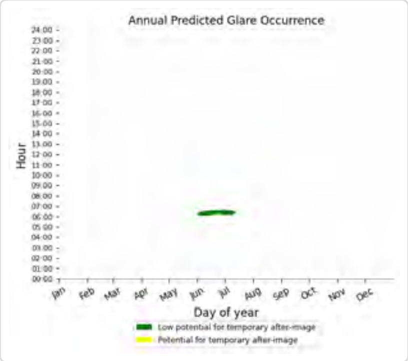



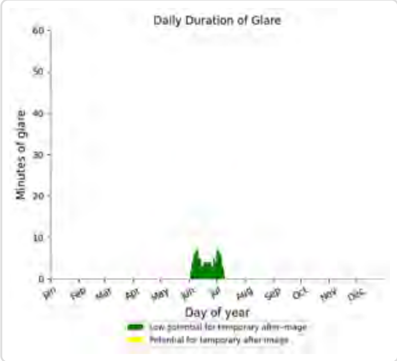



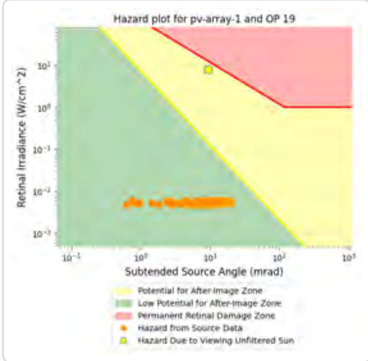
## PV array 1: OP 19

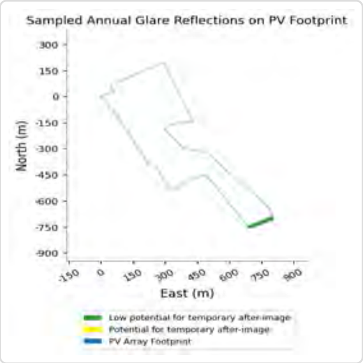
PV array is expected to produce the following glare for this receptor:

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



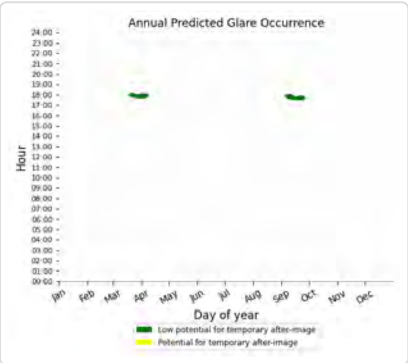



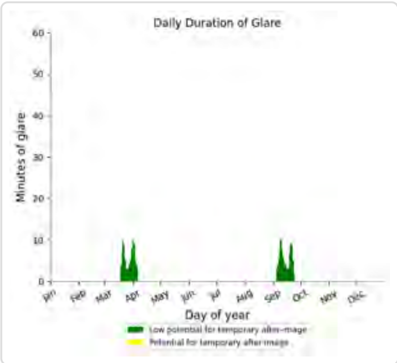



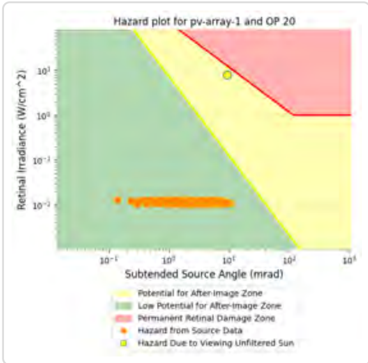

## PV array 1: OP 20

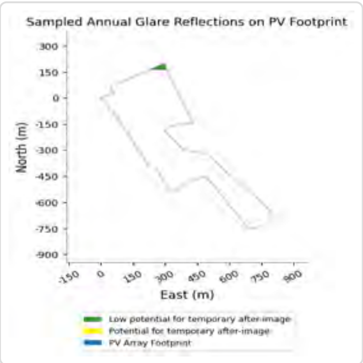
PV array is expected to produce the following glare for this receptor:

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



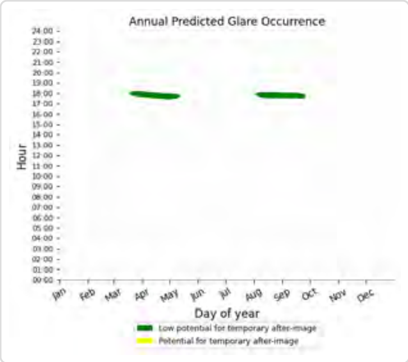



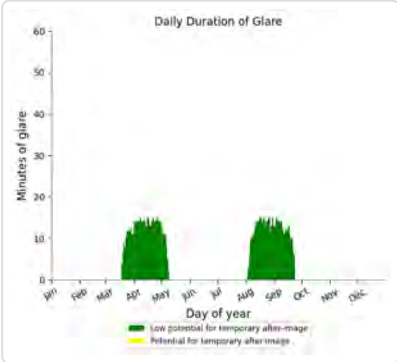



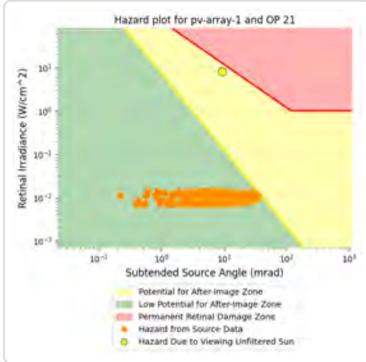
## PV array 1: OP 21

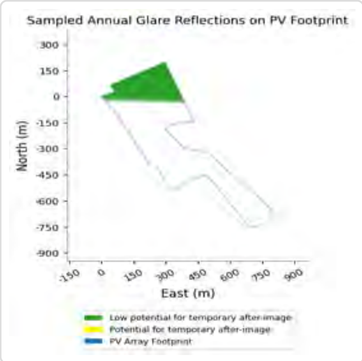
PV array is expected to produce the following glare for this receptor:

- 1,272 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.



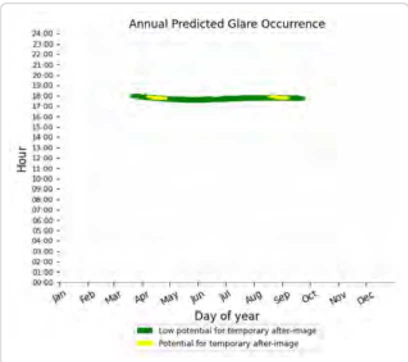



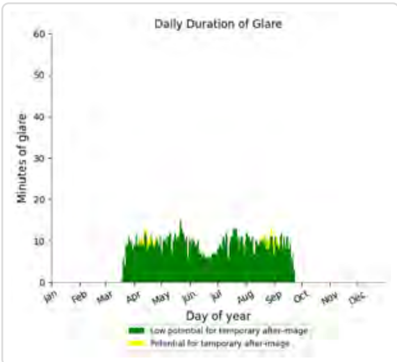



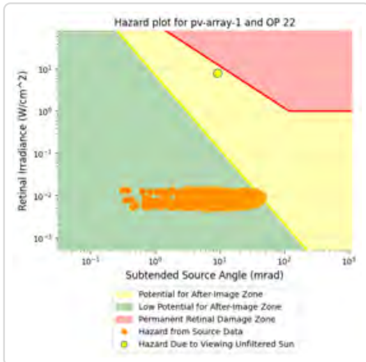

## PV array 1: OP 22

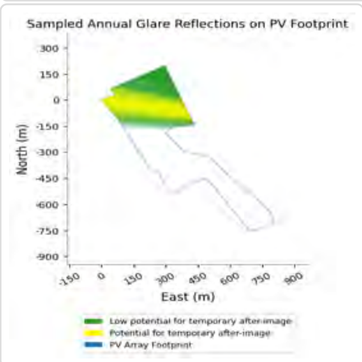
PV array is expected to produce the following glare for this receptor:

- 1,773 minutes of "green" glare with low potential to cause temporary after-image.
- 51 minutes of "yellow" glare with potential to cause temporary after-image.



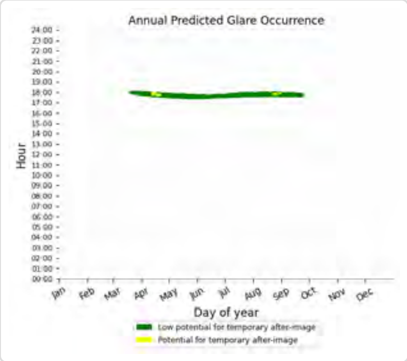



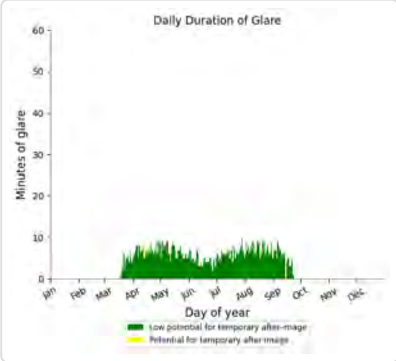



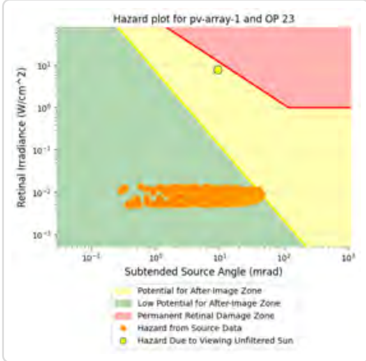
## PV array 1: OP 23

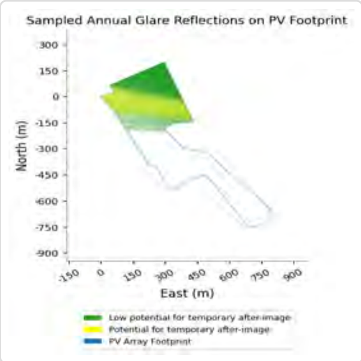
PV array is expected to produce the following glare for this receptor:

- 1,135 minutes of "green" glare with low potential to cause temporary after-image.
- 9 minutes of "yellow" glare with potential to cause temporary after-image.



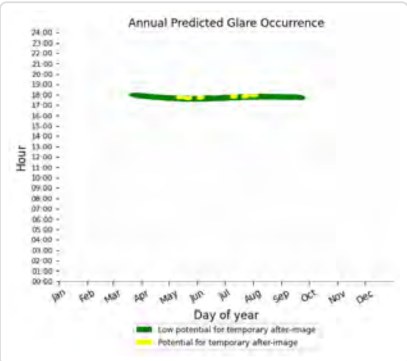



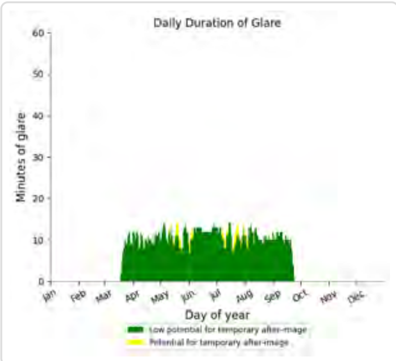



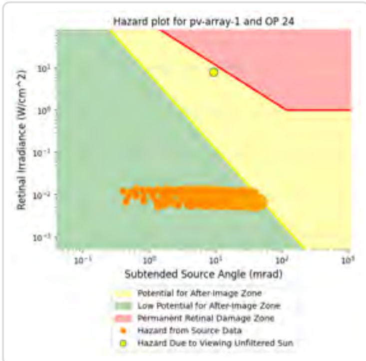

## PV array 1: OP 24

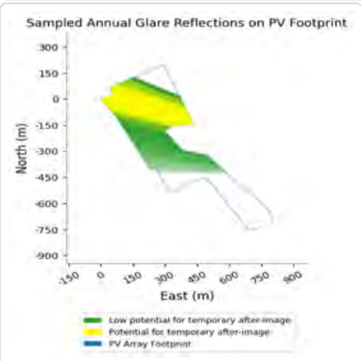
PV array is expected to produce the following glare for this receptor:

- 2,022 minutes of "green" glare with low potential to cause temporary after-image.
- 72 minutes of "yellow" glare with potential to cause temporary after-image.




## PV array 1: OP 25

*No glare found*

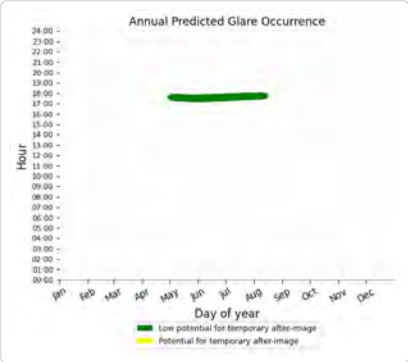
## PV array 1: OP 26

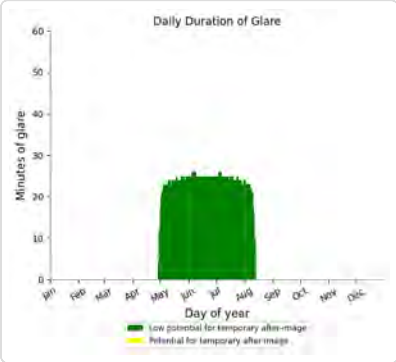
*No glare found*

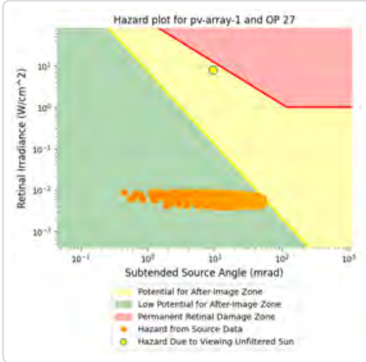
## PV array 1: OP 27

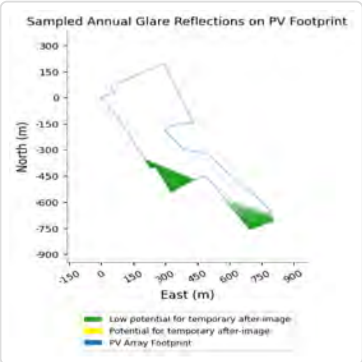
PV array is expected to produce the following glare for this receptor:

- 2,541 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.



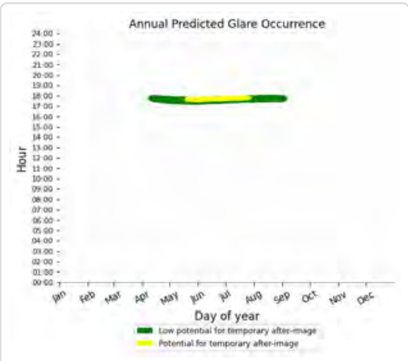



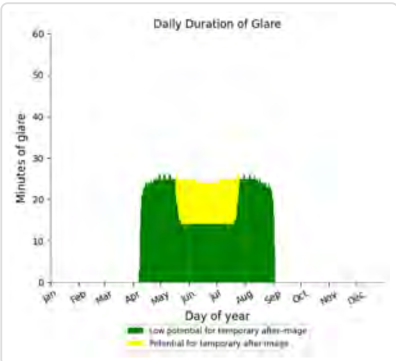



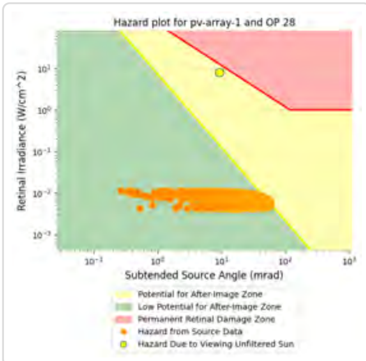

## PV array 1: OP 28

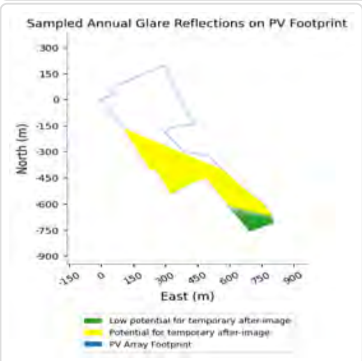
PV array is expected to produce the following glare for this receptor:

- 2,895 minutes of "green" glare with low potential to cause temporary after-image.
- 705 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 for 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

# Burstead Solar Farm

## Burstead Solar Farm Road 15 Degrees

**Created** Oct 20, 2023
**Updated** Oct 20, 2023
**Time-step** 1 minute
**Timezone offset** UTC0
**Minimum sun altitude** 0.0 deg
**Site ID** 103459.18016

**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**

PV Analysis Methodology: **Version 2**
Enhanced subtended angle calculation: **On**

## 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 | 15.0 | 180.0 | 21,528 | 1,766 | - |

# Component Data

## PV Array(s)

**Total PV footprint area:** 220,193 m^2

**Name**: PV array 1
**Footprint area**: 220,193 m^2
**Axis tracking**: Fixed (no rotation)
**Tilt**: 15.0 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 deg | Longitude deg | Ground elevation m | Height above ground m | Total elevation m |
|---|---|---|---|---|---|
| 1 | 51.611806 | 0.448259 | 29.96 | 3.00 | 32.96 |
| 2 | 51.610833 | 0.449353 | 26.41 | 3.00 | 29.41 |
| 3 | 51.608141 | 0.451606 | 23.67 | 3.00 | 26.67 |
| 4 | 51.608181 | 0.451971 | 22.69 | 3.00 | 25.69 |
| 5 | 51.606928 | 0.452980 | 23.79 | 3.00 | 26.79 |
| 6 | 51.607475 | 0.454374 | 22.13 | 3.00 | 25.13 |
| 7 | 51.607741 | 0.455383 | 20.73 | 3.00 | 23.73 |
| 8 | 51.604998 | 0.458297 | 15.50 | 3.00 | 18.50 |
| 9 | 51.605438 | 0.459906 | 15.15 | 3.00 | 18.15 |
| 10 | 51.605958 | 0.459670 | 15.42 | 3.00 | 18.42 |
| 11 | 51.606504 | 0.459069 | 16.49 | 3.00 | 19.49 |
| 12 | 51.607330 | 0.457632 | 18.55 | 3.00 | 21.55 |
| 13 | 51.608876 | 0.455464 | 19.69 | 3.00 | 22.69 |
| 14 | 51.609142 | 0.453791 | 20.55 | 3.00 | 23.55 |
| 15 | 51.610142 | 0.452546 | 21.17 | 3.00 | 24.17 |
| 16 | 51.610395 | 0.453125 | 21.93 | 3.00 | 24.93 |
| 17 | 51.610515 | 0.454520 | 22.13 | 3.00 | 25.13 |
| 18 | 51.613580 | 0.452525 | 32.38 | 3.00 | 35.38 |
| 19 | 51.612394 | 0.448898 | 32.57 | 3.00 | 35.57 |
| 20 | 51.612047 | 0.449156 | 30.87 | 3.00 | 33.87 |

## Discrete Observation Receptors

| Number | Latitude deg | Longitude deg | Ground elevation m | Height above ground m | Total Elevation m |
|---|---|---|---|---|---|
| OP 1 | 51.613122 | 0.434387 | 44.35 | 1.50 | 45.85 |
| OP 2 | 51.611796 | 0.436168 | 42.32 | 1.50 | 43.82 |
| OP 3 | 51.610410 | 0.438035 | 38.97 | 1.50 | 40.47 |
| OP 4 | 51.608838 | 0.439494 | 33.49 | 1.50 | 34.99 |
| OP 5 | 51.607159 | 0.440449 | 33.69 | 1.50 | 35.19 |
| OP 6 | 51.605485 | 0.441019 | 28.38 | 1.50 | 29.88 |
| OP 7 | 51.604149 | 0.442596 | 24.25 | 1.50 | 25.75 |
| OP 8 | 51.602856 | 0.444924 | 24.18 | 1.50 | 25.68 |
| OP 9 | 51.602789 | 0.447831 | 22.66 | 1.50 | 24.16 |
| OP 10 | 51.602203 | 0.450417 | 19.67 | 1.50 | 21.17 |
| OP 11 | 51.600607 | 0.465732 | 20.39 | 1.50 | 21.89 |
| OP 12 | 51.601527 | 0.467964 | 24.71 | 1.50 | 26.21 |
| OP 13 | 51.602433 | 0.470491 | 39.45 | 1.50 | 40.95 |
| OP 14 | 51.603258 | 0.473120 | 47.35 | 1.50 | 48.85 |
| OP 15 | 51.611130 | 0.440591 | 35.86 | 1.50 | 37.36 |
| OP 16 | 51.612236 | 0.442812 | 38.88 | 1.50 | 40.38 |
| OP 17 | 51.613475 | 0.444893 | 43.69 | 1.50 | 45.19 |
| OP 18 | 51.614961 | 0.445966 | 47.71 | 1.50 | 49.21 |
| OP 19 | 51.608696 | 0.437852 | 34.05 | 1.50 | 35.55 |
| OP 20 | 51.607949 | 0.435266 | 34.65 | 1.50 | 36.15 |
| OP 21 | 51.601508 | 0.444707 | 26.73 | 1.50 | 28.23 |
| OP 22 | 51.600028 | 0.445812 | 23.92 | 1.50 | 25.42 |

## 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 | 15.0 | 180.0 | 21,528 | 1,766 | - | - |

### 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 | 350 | 1269 | 1232 | 985 | 1035 | 1572 | 597 | 17 | 0 | 0 |
| pv-array-1 (yellow) | 0 | 0 | 0 | 1 | 283 | 455 | 475 | 2 | 1 | 0 | 0 | 0 |

## PV & Receptor Analysis Results

*Results for each PV array and receptor*

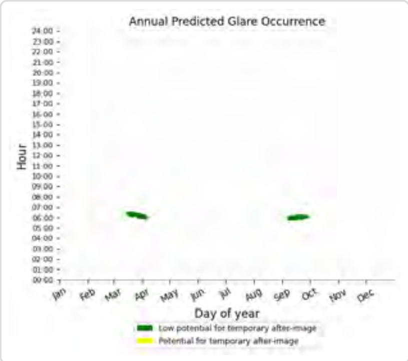
### PV array 1 potential temporary after-image

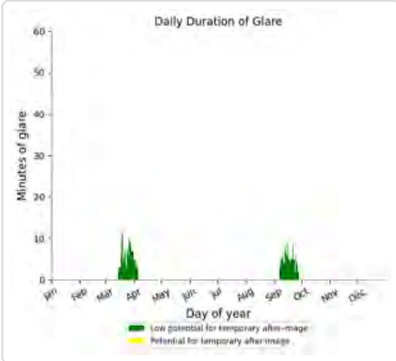
| Component | Green glare (min) | Yellow glare (min) |
|---|---|---|
| OP: OP 1 | 233 | 0 |
| OP: OP 2 | 555 | 0 |
| OP: OP 3 | 1103 | 27 |
| OP: OP 4 | 1713 | 142 |
| OP: OP 5 | 0 | 0 |
| OP: OP 6 | 2090 | 0 |
| OP: OP 7 | 2357 | 0 |
| OP: OP 8 | 1570 | 0 |
| OP: OP 9 | 1224 | 0 |
| OP: OP 10 | 99 | 0 |
| OP: OP 11 | 0 | 0 |
| OP: OP 12 | 0 | 0 |
| OP: OP 13 | 2177 | 259 |
| OP: OP 14 | 2357 | 1163 |
| OP: OP 15 | 0 | 0 |
| OP: OP 16 | 1371 | 32 |
| OP: OP 17 | 754 | 0 |
| OP: OP 18 | 0 | 0 |
| OP: OP 19 | 1675 | 106 |
| OP: OP 20 | 1836 | 37 |
| OP: OP 21 | 414 | 0 |
| OP: OP 22 | 0 | 0 |

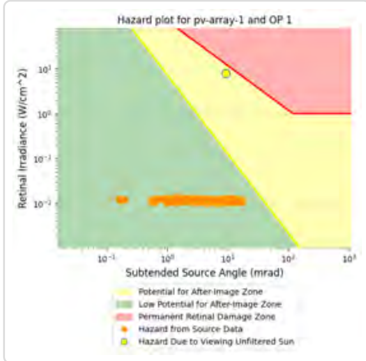
## PV array 1: OP 1

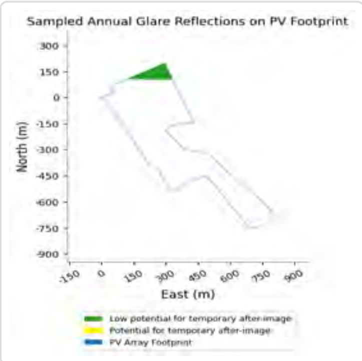
PV array is expected to produce the following glare for this receptor:

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



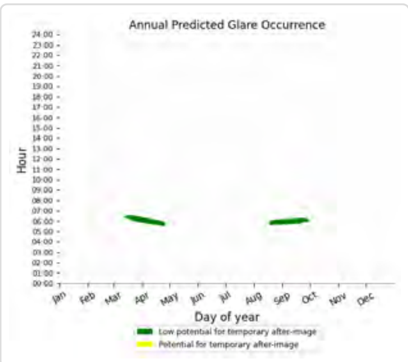



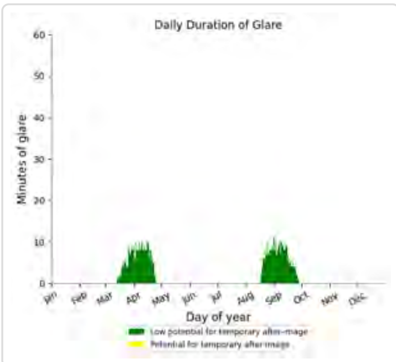



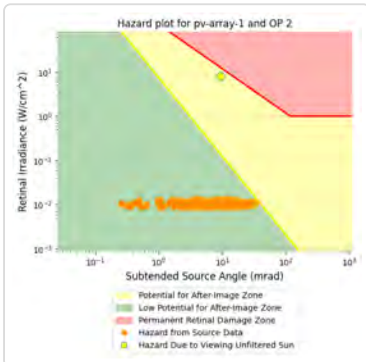

## PV array 1: OP 2

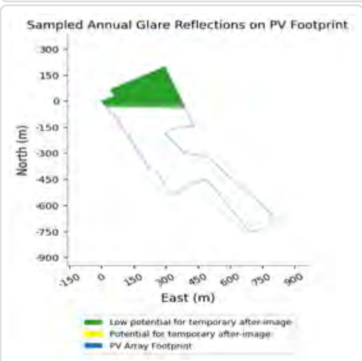
PV array is expected to produce the following glare for this receptor:

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



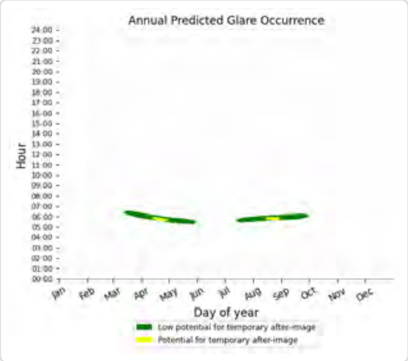



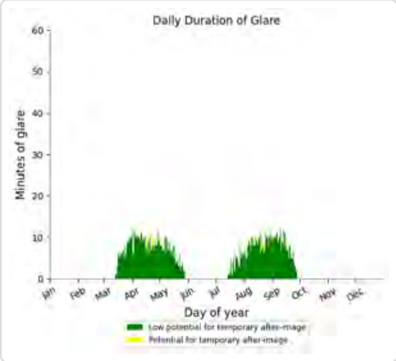



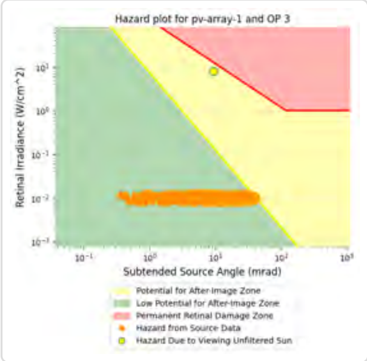
## PV array 1: OP 3

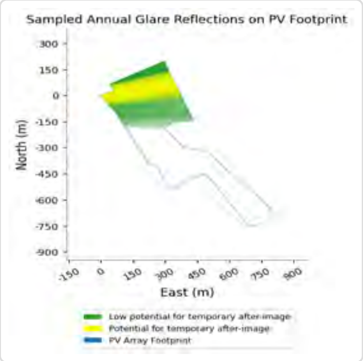
PV array is expected to produce the following glare for this receptor:

- 1,103 minutes of "green" glare with low potential to cause temporary after-image.
- 27 minutes of "yellow" glare with potential to cause temporary after-image.



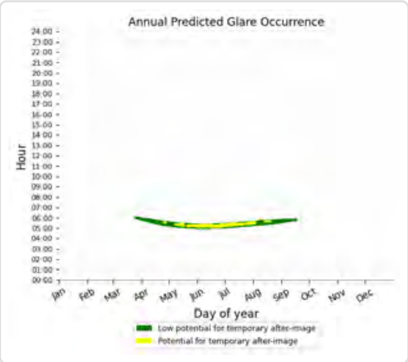



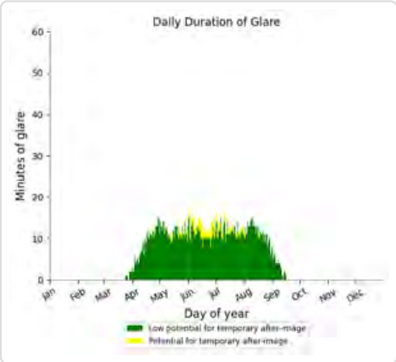



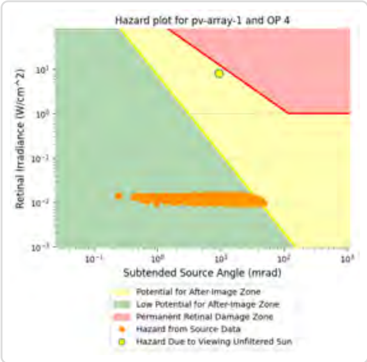

## PV array 1: OP 4

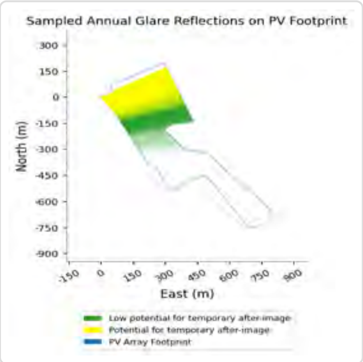
PV array is expected to produce the following glare for this receptor:

- 1,713 minutes of "green" glare with low potential to cause temporary after-image.
- 142 minutes of "yellow" glare with potential to cause temporary after-image.



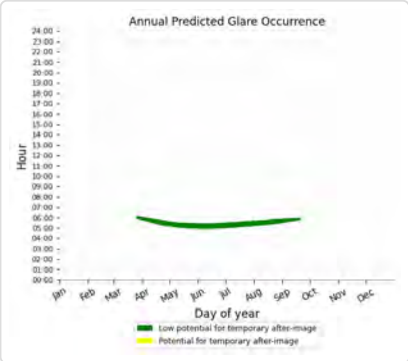

## PV array 1: OP 5

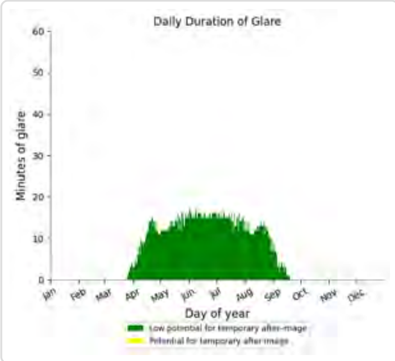
*No glare found*

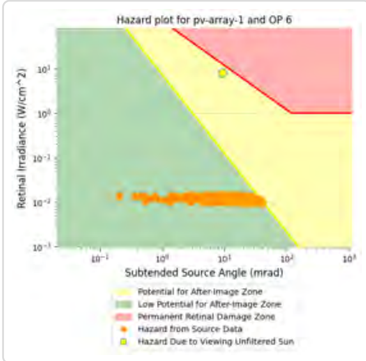
## PV array 1: OP 6

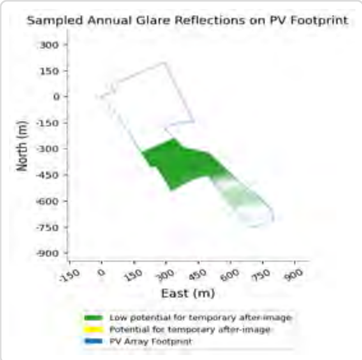
PV array is expected to produce the following glare for this receptor:

- 2,090 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.



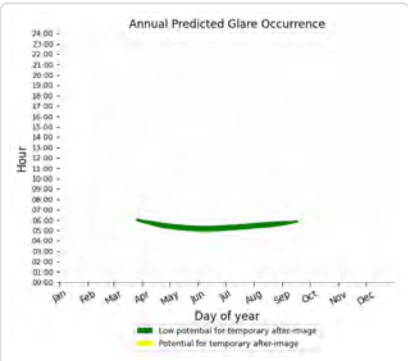



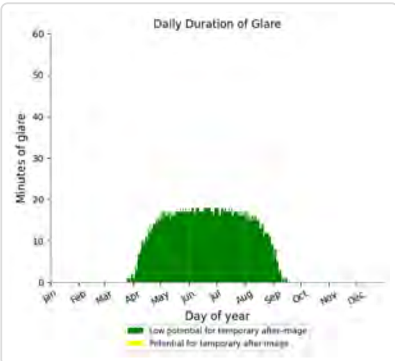



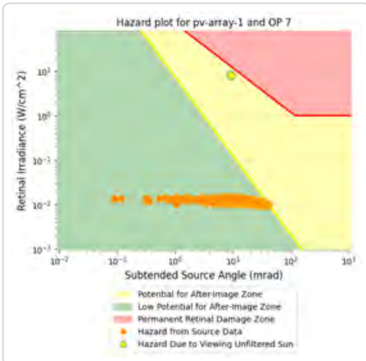

## PV array 1: OP 7

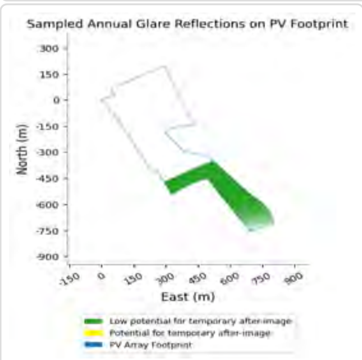
PV array is expected to produce the following glare for this receptor:

- 2,357 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.



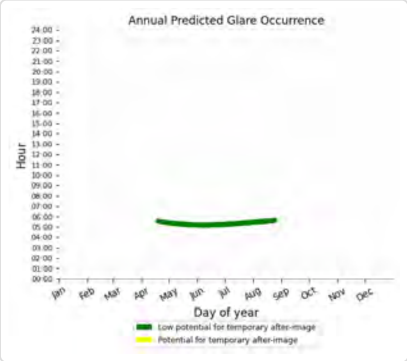



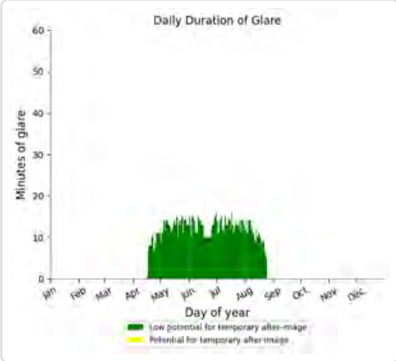



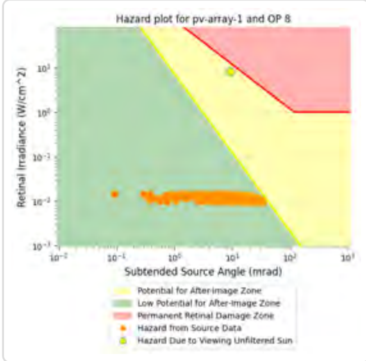
## PV array 1: OP 8

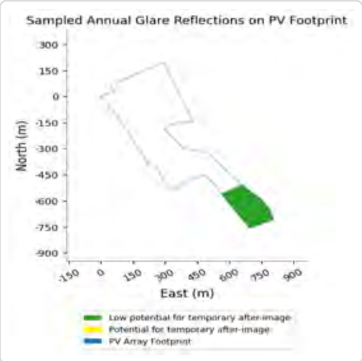
PV array is expected to produce the following glare for this receptor:

- 1,570 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.



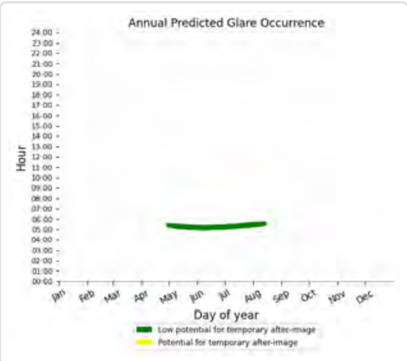



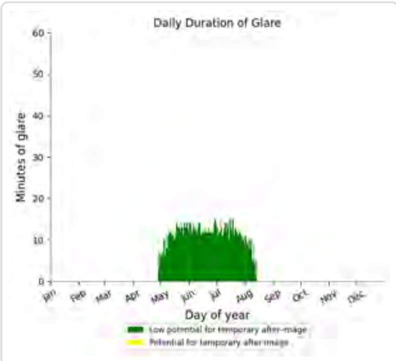



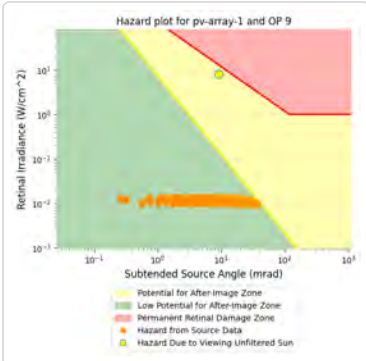

## PV array 1: OP 9

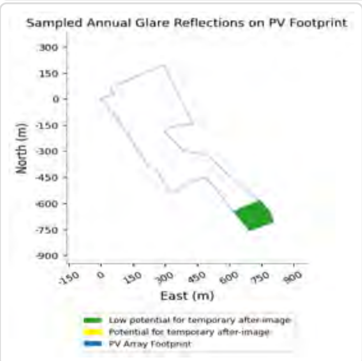
PV array is expected to produce the following glare for this receptor:

- 1,224 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.



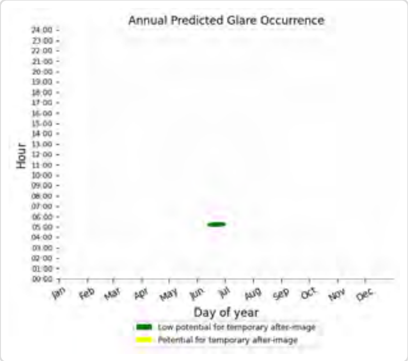



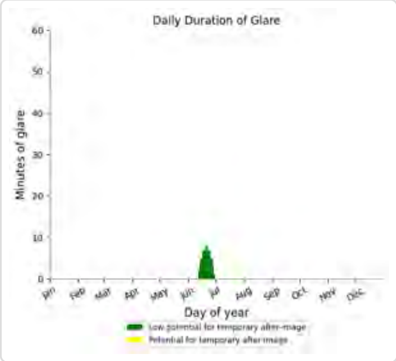



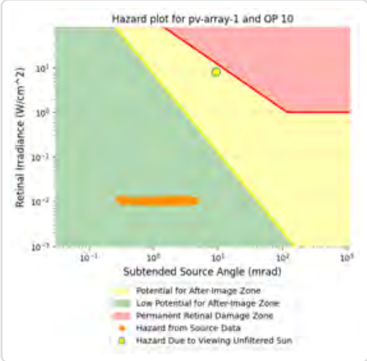
## PV array 1: OP 10

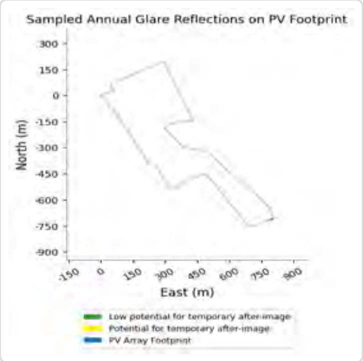
PV array is expected to produce the following glare for this receptor:

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




## PV array 1: OP 11

*No glare found*

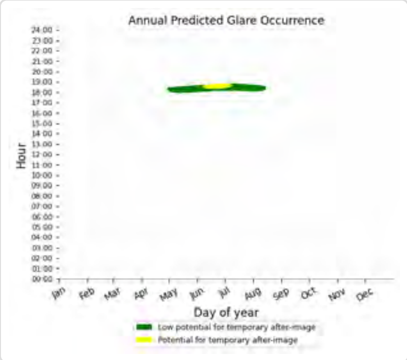
## PV array 1: OP 12

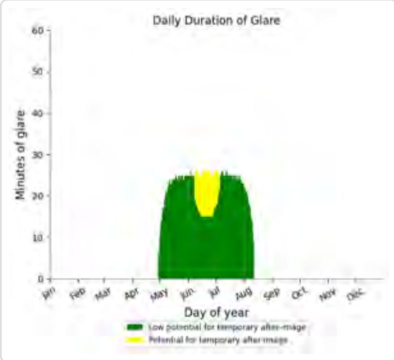
*No glare found*

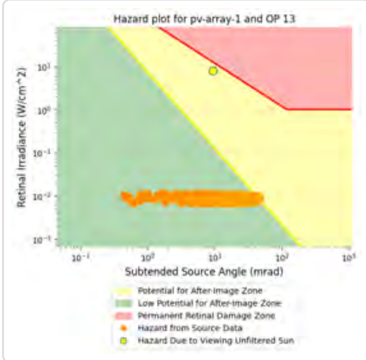
## PV array 1: OP 13

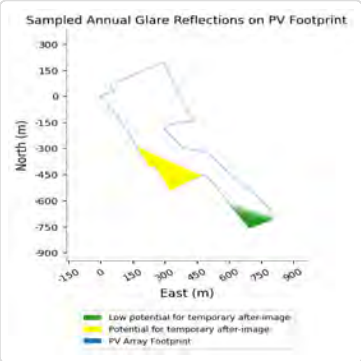
PV array is expected to produce the following glare for this receptor:

- 2,177 minutes of "green" glare with low potential to cause temporary after-image.
- 259 minutes of "yellow" glare with potential to cause temporary after-image.



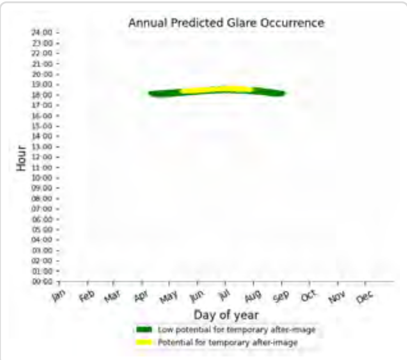



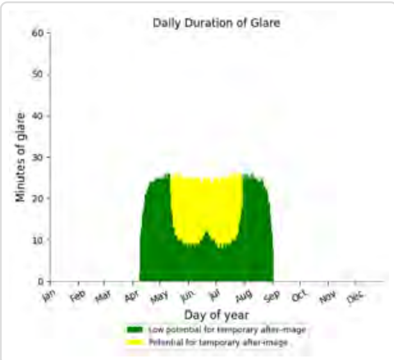



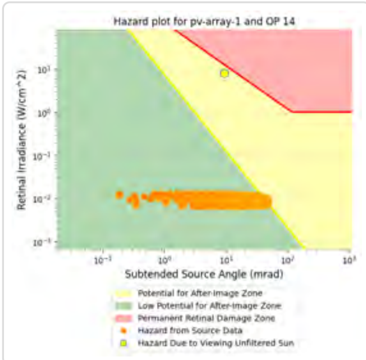

## PV array 1: OP 14

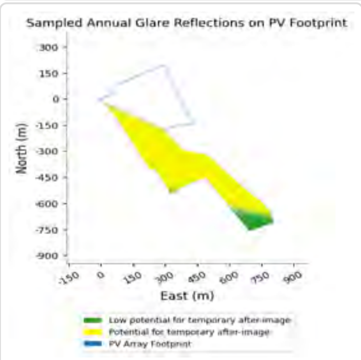
PV array is expected to produce the following glare for this receptor:

- 2,357 minutes of "green" glare with low potential to cause temporary after-image.
- 1,163 minutes of "yellow" glare with potential to cause temporary after-image.



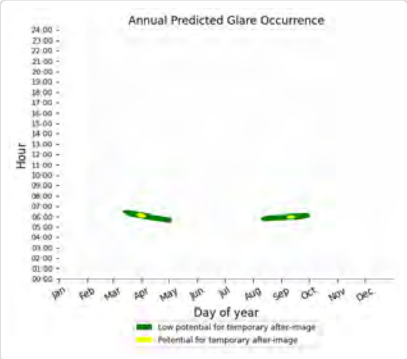

## PV array 1: OP 15

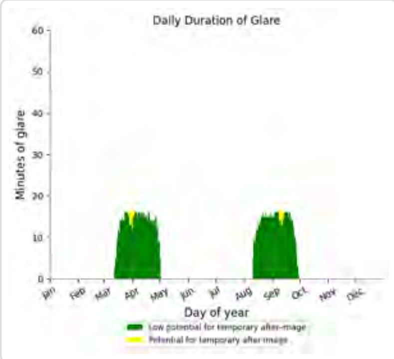
*No glare found*

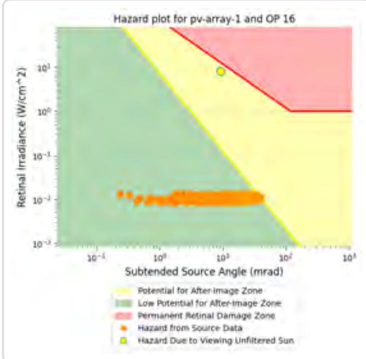
## PV array 1: OP 16

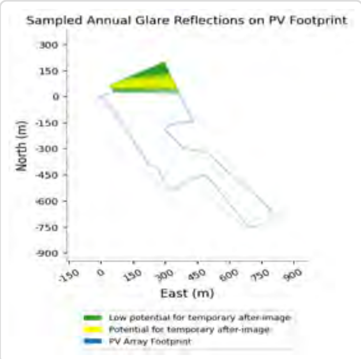
PV array is expected to produce the following glare for this receptor:

- 1,371 minutes of "green" glare with low potential to cause temporary after-image.
- 32 minutes of "yellow" glare with potential to cause temporary after-image.



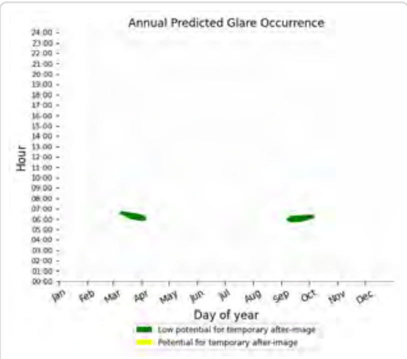



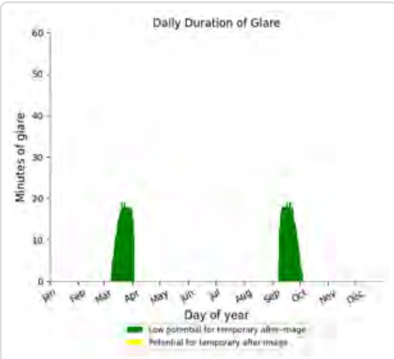



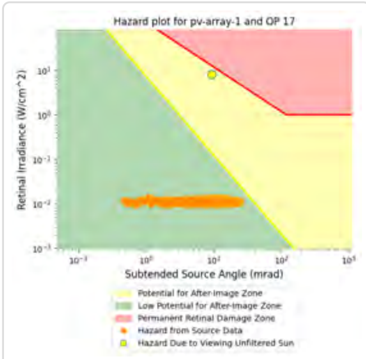

## PV array 1: OP 17

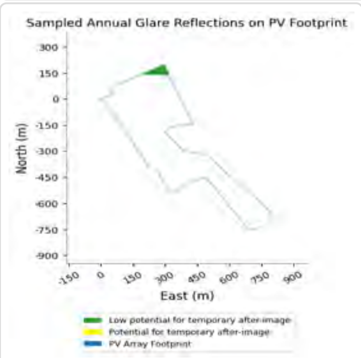
PV array is expected to produce the following glare for this receptor:

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



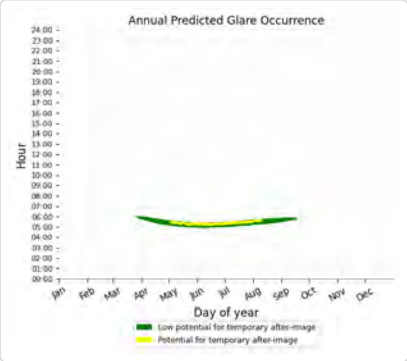

## PV array 1: OP 18

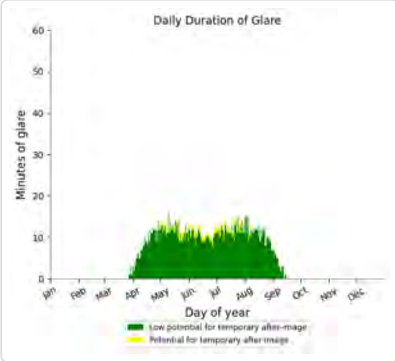
*No glare found*

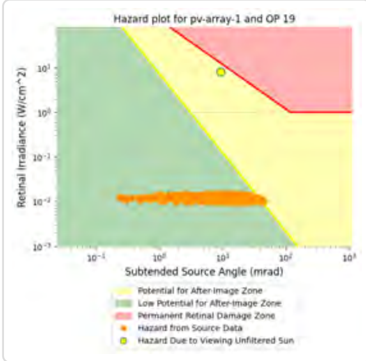
## PV array 1: OP 19

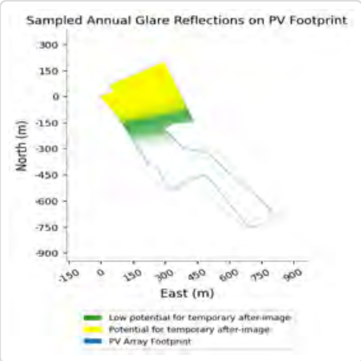
PV array is expected to produce the following glare for this receptor:

- 1,675 minutes of "green" glare with low potential to cause temporary after-image.
- 106 minutes of "yellow" glare with potential to cause temporary after-image.



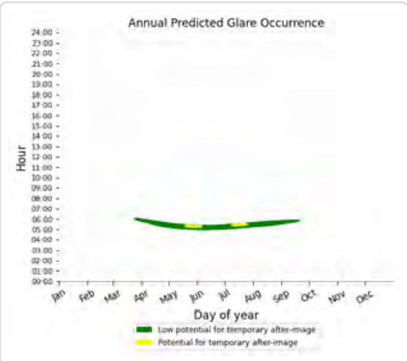



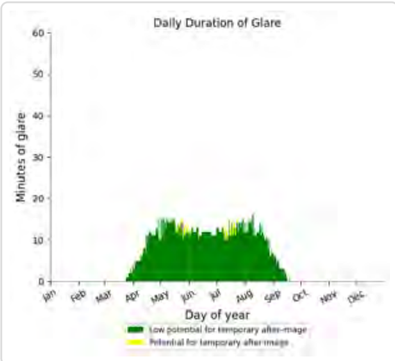



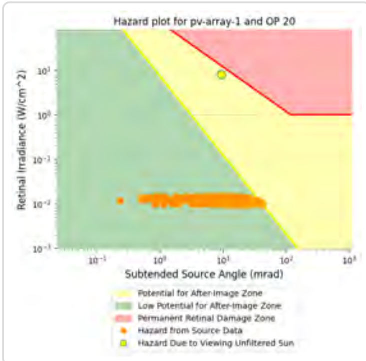

## PV array 1: OP 20

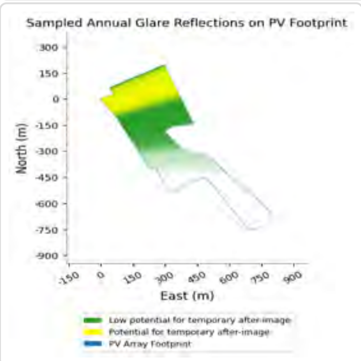
PV array is expected to produce the following glare for this receptor:

- 1,836 minutes of "green" glare with low potential to cause temporary after-image.
- 37 minutes of "yellow" glare with potential to cause temporary after-image.



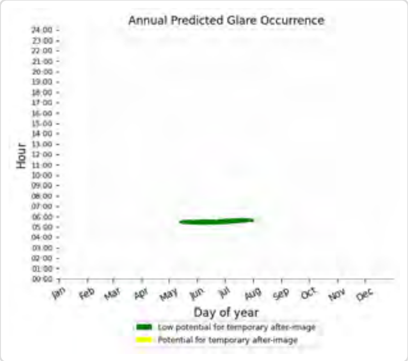



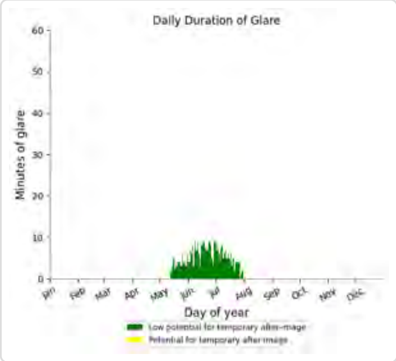



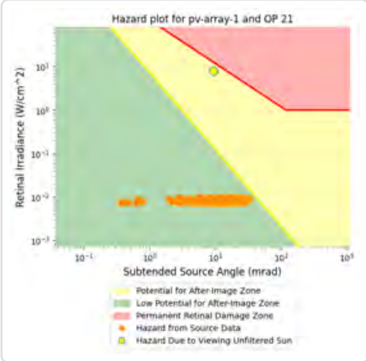
### PV array 1: OP 21

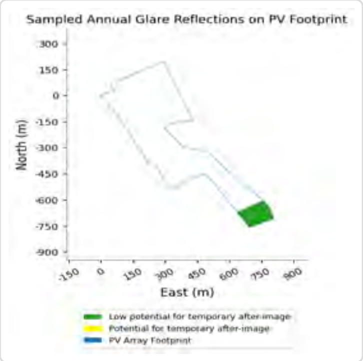
PV array is expected to produce the following glare for this receptor:

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




### PV array 1: OP 22

*No glare found*

## 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 for 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

# Burstead Solar Farm

## Burstead Solar Farm Road 30 Degrees

**Created** Oct 20, 2023
**Updated** Oct 20, 2023
**Time-step** 1 minute
**Timezone offset** UTC0
**Minimum sun altitude** 0.0 deg
**Site ID** 103459.18016

**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**

PV Analysis Methodology: **Version 2**
Enhanced subtended angle calculation: **On**

## 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 | 30.0 | 180.0 | 20,840 | 831 | - |

# Component Data

## PV Array(s)

**Total PV footprint area:** 220,193 m^2

**Name**: PV array 1
**Footprint area**: 220,193 m^2
**Axis tracking**: Fixed (no rotation)
**Tilt**: 30.0 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<br>deg | Longitude<br>deg | Ground elevation<br>m | Height above ground<br>m | Total elevation<br>m |
|---|---|---|---|---|---|
| 1 | 51.611806 | 0.448259 | 29.96 | 3.00 | 32.96 |
| 2 | 51.610833 | 0.449353 | 26.41 | 3.00 | 29.41 |
| 3 | 51.608141 | 0.451606 | 23.67 | 3.00 | 26.67 |
| 4 | 51.608181 | 0.451971 | 22.69 | 3.00 | 25.69 |
| 5 | 51.606928 | 0.452980 | 23.79 | 3.00 | 26.79 |
| 6 | 51.607475 | 0.454374 | 22.13 | 3.00 | 25.13 |
| 7 | 51.607741 | 0.455383 | 20.73 | 3.00 | 23.73 |
| 8 | 51.604998 | 0.458297 | 15.50 | 3.00 | 18.50 |
| 9 | 51.605438 | 0.459906 | 15.15 | 3.00 | 18.15 |
| 10 | 51.605958 | 0.459670 | 15.42 | 3.00 | 18.42 |
| 11 | 51.606504 | 0.459069 | 16.49 | 3.00 | 19.49 |
| 12 | 51.607330 | 0.457632 | 18.55 | 3.00 | 21.55 |
| 13 | 51.608876 | 0.455464 | 19.69 | 3.00 | 22.69 |
| 14 | 51.609142 | 0.453791 | 20.55 | 3.00 | 23.55 |
| 15 | 51.610142 | 0.452546 | 21.17 | 3.00 | 24.17 |
| 16 | 51.610395 | 0.453125 | 21.93 | 3.00 | 24.93 |
| 17 | 51.610515 | 0.454520 | 22.13 | 3.00 | 25.13 |
| 18 | 51.613580 | 0.452525 | 32.38 | 3.00 | 35.38 |
| 19 | 51.612394 | 0.448898 | 32.57 | 3.00 | 35.57 |
| 20 | 51.612047 | 0.449156 | 30.87 | 3.00 | 33.87 |

## Discrete Observation Receptors

| Number | Latitude<br>deg | Longitude<br>deg | Ground elevation<br>m | Height above ground<br>m | Total Elevation<br>m |
|---|---|---|---|---|---|
| OP 1 | 51.613122 | 0.434387 | 44.35 | 1.50 | 45.85 |
| OP 2 | 51.611796 | 0.436168 | 42.32 | 1.50 | 43.82 |
| OP 3 | 51.610410 | 0.438035 | 38.97 | 1.50 | 40.47 |
| OP 4 | 51.608838 | 0.439494 | 33.49 | 1.50 | 34.99 |
| OP 5 | 51.607159 | 0.440449 | 33.69 | 1.50 | 35.19 |
| OP 6 | 51.605485 | 0.441019 | 28.38 | 1.50 | 29.88 |
| OP 7 | 51.604149 | 0.442596 | 24.25 | 1.50 | 25.75 |
| OP 8 | 51.602856 | 0.444924 | 24.18 | 1.50 | 25.68 |
| OP 9 | 51.602789 | 0.447831 | 22.66 | 1.50 | 24.16 |
| OP 10 | 51.602203 | 0.450417 | 19.67 | 1.50 | 21.17 |
| OP 11 | 51.600607 | 0.465732 | 20.39 | 1.50 | 21.89 |
| OP 12 | 51.601527 | 0.467964 | 24.71 | 1.50 | 26.21 |
| OP 13 | 51.602433 | 0.470491 | 39.45 | 1.50 | 40.95 |
| OP 14 | 51.603258 | 0.473120 | 47.35 | 1.50 | 48.85 |
| OP 15 | 51.611130 | 0.440591 | 35.86 | 1.50 | 37.36 |
| OP 16 | 51.612236 | 0.442812 | 38.88 | 1.50 | 40.38 |
| OP 17 | 51.613475 | 0.444893 | 43.69 | 1.50 | 45.19 |
| OP 18 | 51.614961 | 0.445966 | 47.71 | 1.50 | 49.21 |
| OP 19 | 51.608696 | 0.437852 | 34.05 | 1.50 | 35.55 |
| OP 20 | 51.607949 | 0.435266 | 34.65 | 1.50 | 36.15 |
| OP 21 | 51.601508 | 0.444707 | 26.73 | 1.50 | 28.23 |
| OP 22 | 51.600028 | 0.445812 | 23.92 | 1.50 | 25.42 |

## 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 | 30.0 | 180.0 | 20,840 | 831 | - | - |

### 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 | 238 | 1270 | 1315 | 1277 | 1231 | 1519 | 531 | 0 | 0 | 0 |
| pv-array-1 (yellow) | 0 | 0 | 0 | 25 | 78 | 86 | 145 | 7 | 22 | 0 | 0 | 0 |

## PV & Receptor Analysis Results

*Results for each PV array and receptor*

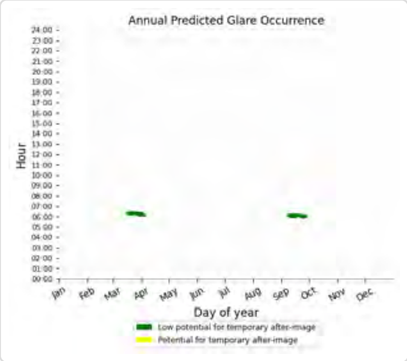
### PV array 1 potential temporary after-image

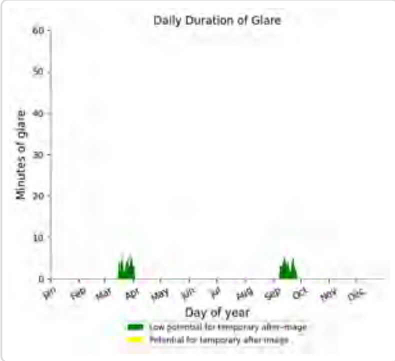
| Component | Green glare (min) | Yellow glare (min) |
|---|---|---|
| OP: OP 1 | 129 | 0 |
| OP: OP 2 | 495 | 0 |
| OP: OP 3 | 1003 | 35 |
| OP: OP 4 | 1600 | 239 |
| OP: OP 5 | 0 | 0 |
| OP: OP 6 | 2037 | 8 |
| OP: OP 7 | 2305 | 0 |
| OP: OP 8 | 1382 | 0 |
| OP: OP 9 | 959 | 0 |
| OP: OP 10 | 0 | 0 |
| OP: OP 11 | 0 | 0 |
| OP: OP 12 | 0 | 0 |
| OP: OP 13 | 2326 | 0 |
| OP: OP 14 | 3054 | 294 |
| OP: OP 15 | 0 | 0 |
| OP: OP 16 | 1093 | 116 |
| OP: OP 17 | 439 | 0 |
| OP: OP 18 | 0 | 0 |
| OP: OP 19 | 1686 | 139 |
| OP: OP 20 | 1930 | 0 |
| OP: OP 21 | 402 | 0 |
| OP: OP 22 | 0 | 0 |

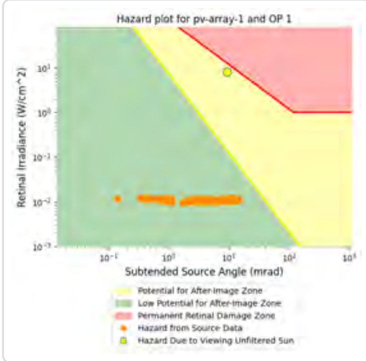
## PV array 1: OP 1

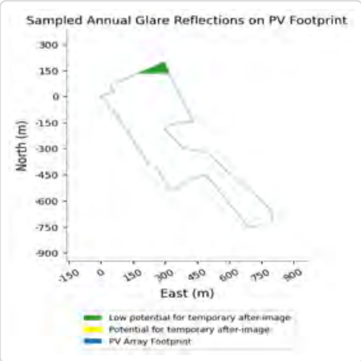
PV array is expected to produce the following glare for this receptor:

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



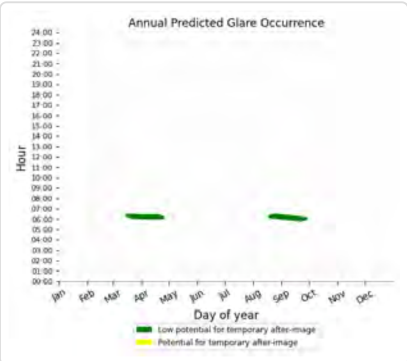



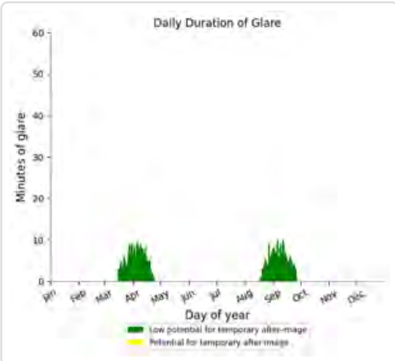



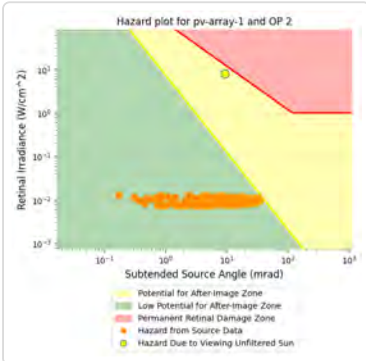

## PV array 1: OP 2

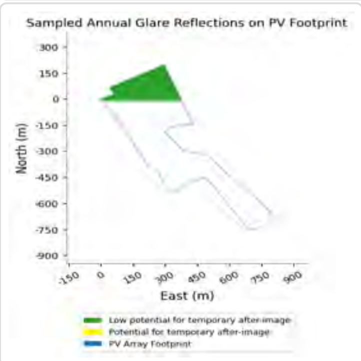
PV array is expected to produce the following glare for this receptor:

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



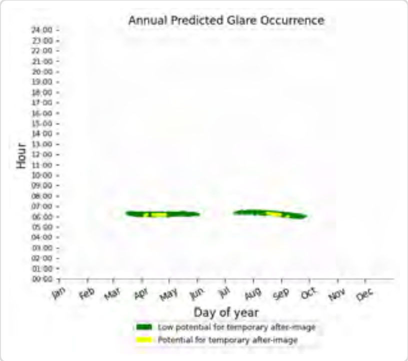



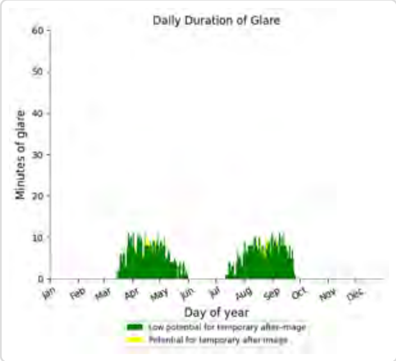



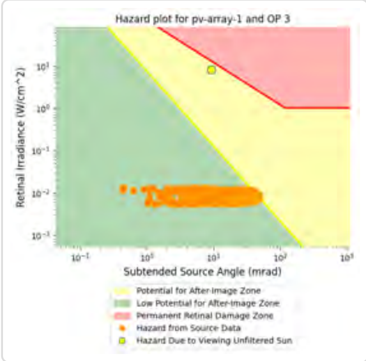
## PV array 1: OP 3

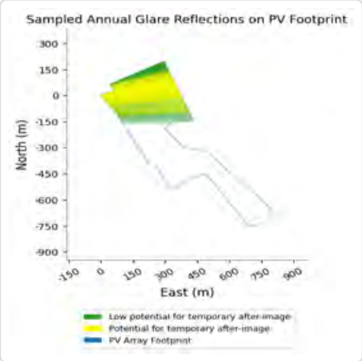
PV array is expected to produce the following glare for this receptor:

- 1,003 minutes of "green" glare with low potential to cause temporary after-image.
- 35 minutes of "yellow" glare with potential to cause temporary after-image.



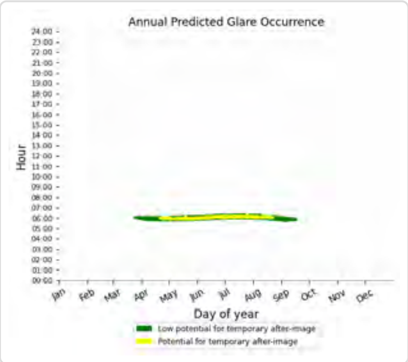



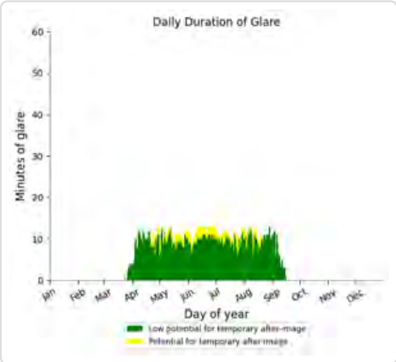



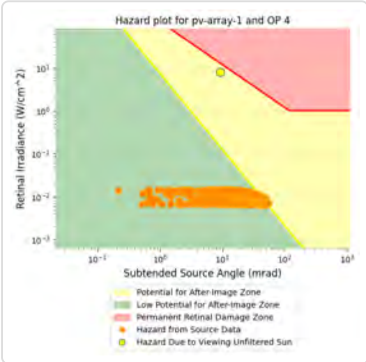

## PV array 1: OP 4

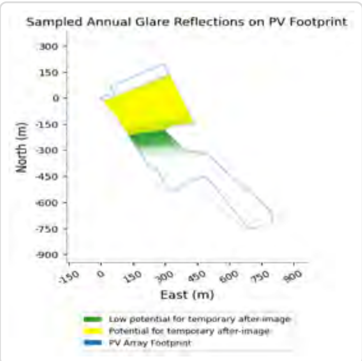
PV array is expected to produce the following glare for this receptor:

- 1,600 minutes of "green" glare with low potential to cause temporary after-image.
- 239 minutes of "yellow" glare with potential to cause temporary after-image.



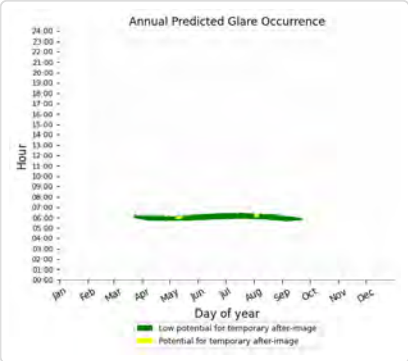

## PV array 1: OP 5

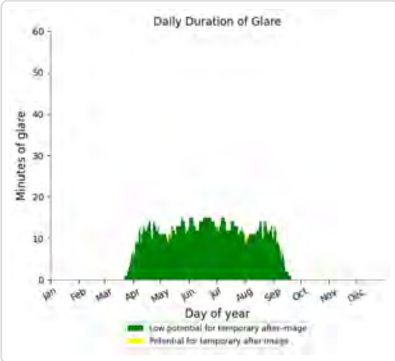
*No glare found*

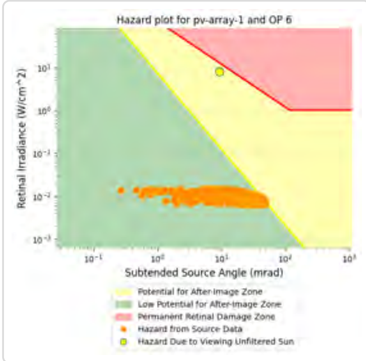
## PV array 1: OP 6

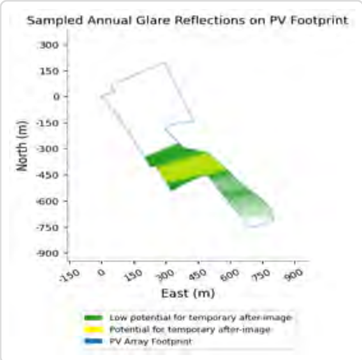
PV array is expected to produce the following glare for this receptor:

- 2,037 minutes of "green" glare with low potential to cause temporary after-image.
- 8 minutes of "yellow" glare with potential to cause temporary after-image.



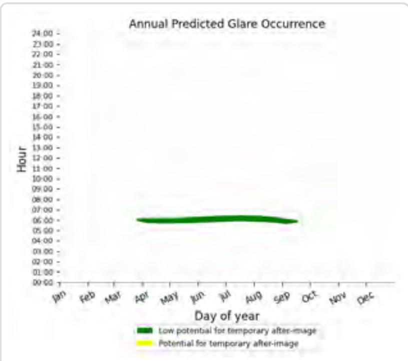



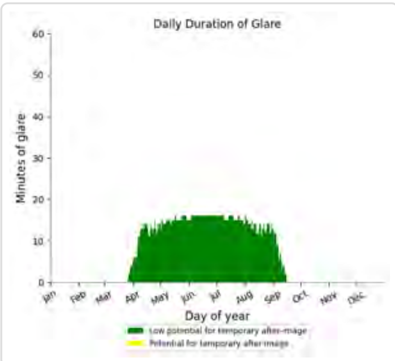



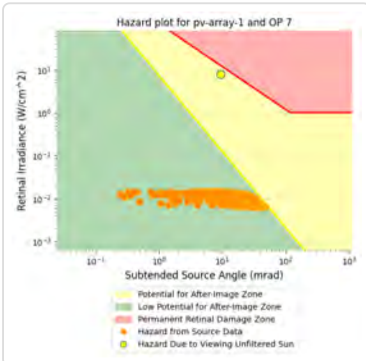

## PV array 1: OP 7

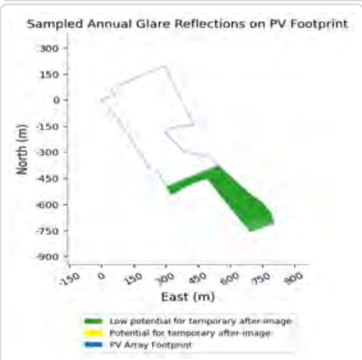
PV array is expected to produce the following glare for this receptor:

- 2,305 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.



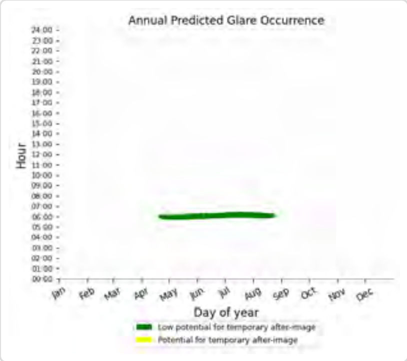



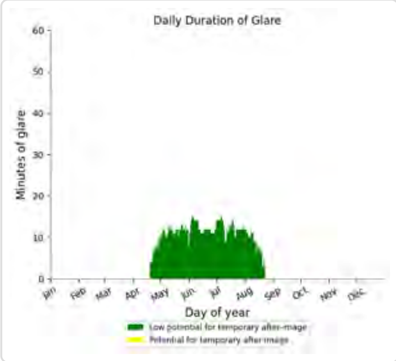



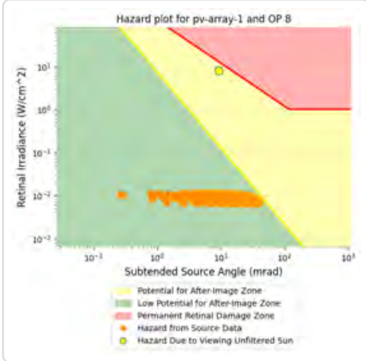
## PV array 1: OP 8

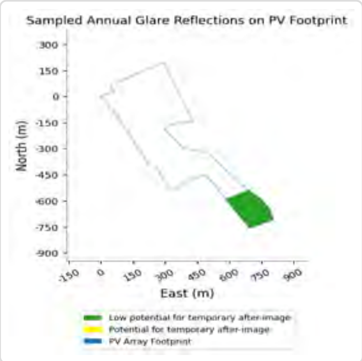
PV array is expected to produce the following glare for this receptor:

- 1,382 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.



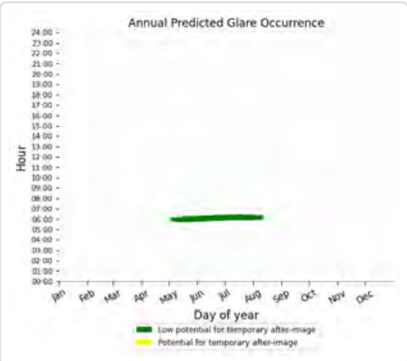



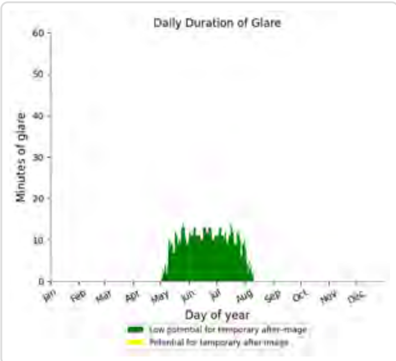



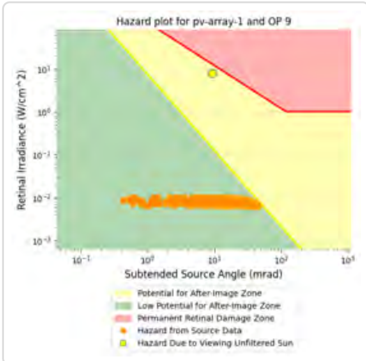

## PV array 1: OP 9

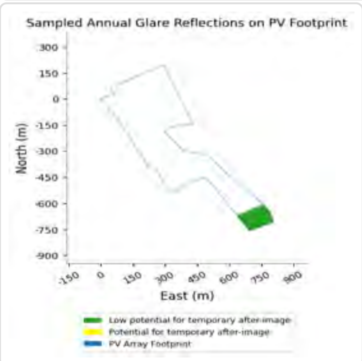
PV array is expected to produce the following glare for this receptor:

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




## PV array 1: OP 10

*No glare found*

## PV array 1: OP 11

*No glare found*

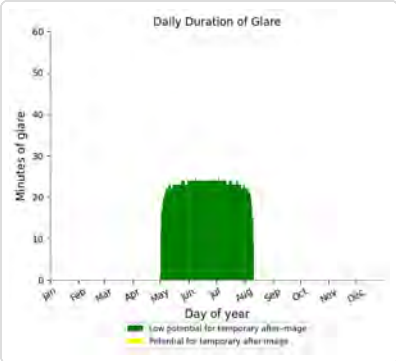
## PV array 1: OP 12

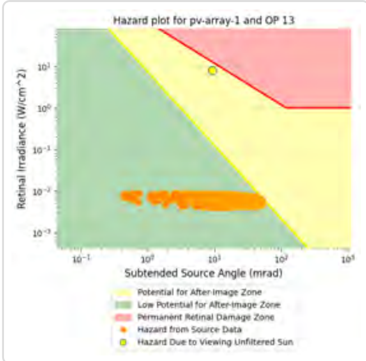
*No glare found*

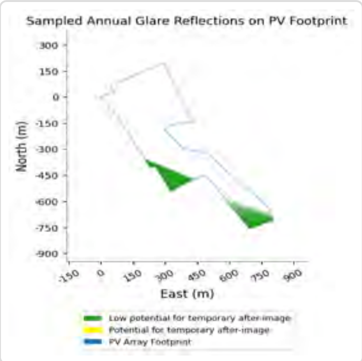
## PV array 1: OP 13

PV array is expected to produce the following glare for this receptor:

- 2,326 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

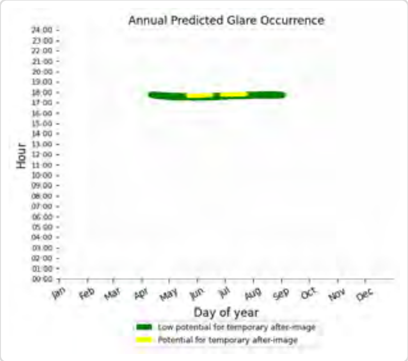



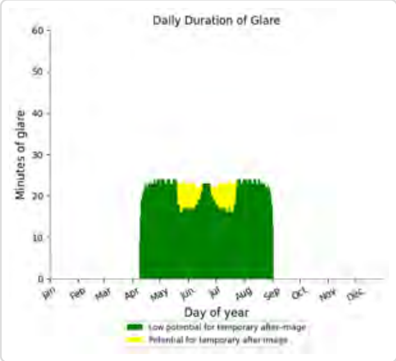



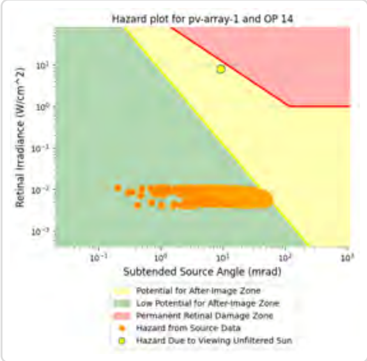
## PV array 1: OP 14

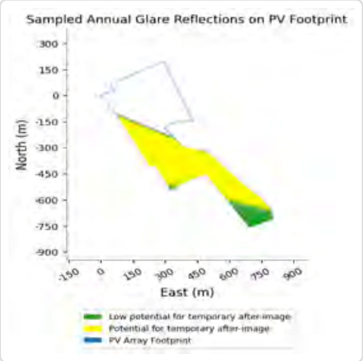
PV array is expected to produce the following glare for this receptor:

- 3,054 minutes of "green" glare with low potential to cause temporary after-image.
- 294 minutes of "yellow" glare with potential to cause temporary after-image.



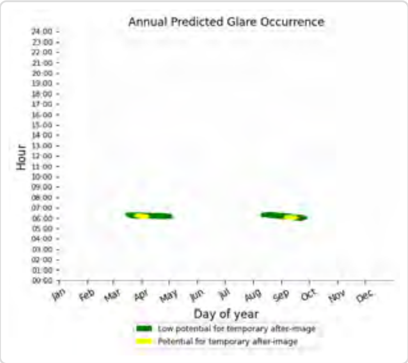

## PV array 1: OP 15

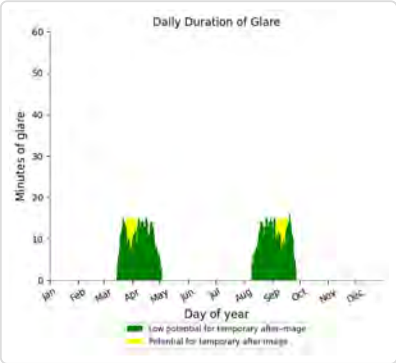
*No glare found*

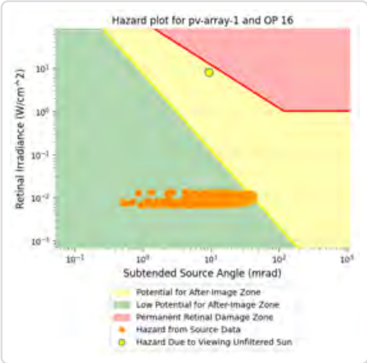
## PV array 1: OP 16

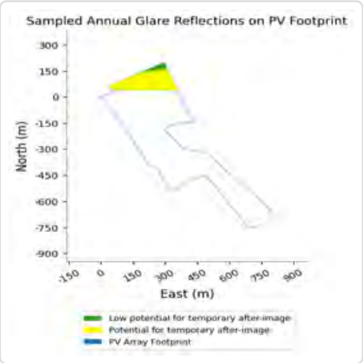
PV array is expected to produce the following glare for this receptor:

- 1,093 minutes of "green" glare with low potential to cause temporary after-image.
- 116 minutes of "yellow" glare with potential to cause temporary after-image.



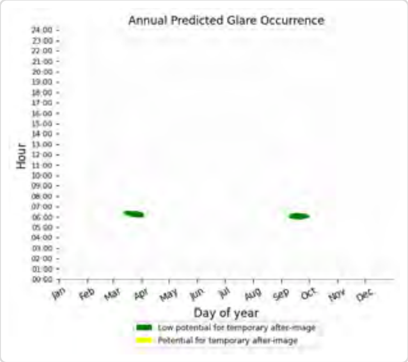



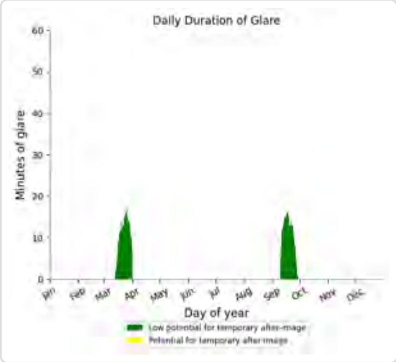



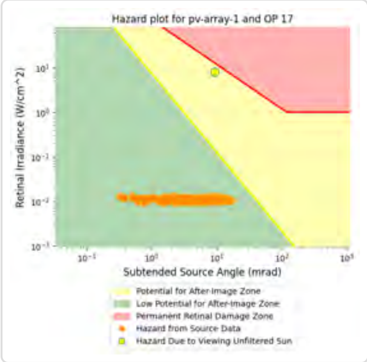
## PV array 1: OP 17

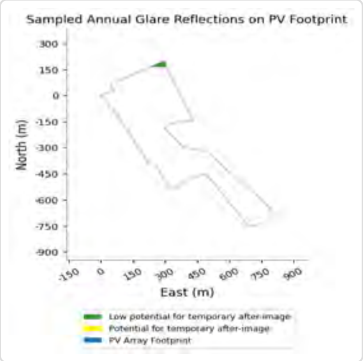
PV array is expected to produce the following glare for this receptor:

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



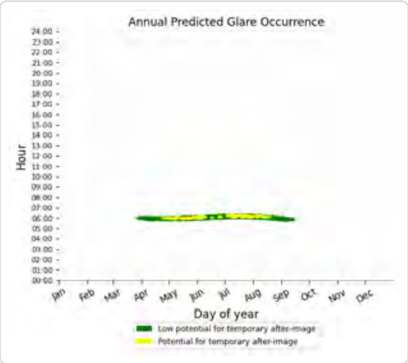

## PV array 1: OP 18

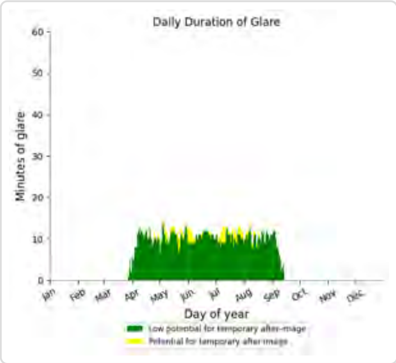
*No glare found*

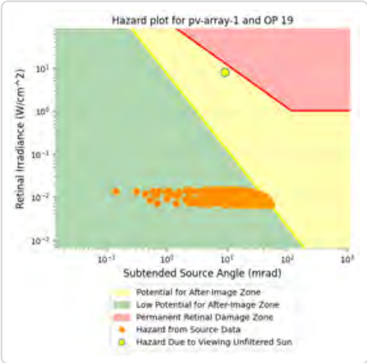
## PV array 1: OP 19

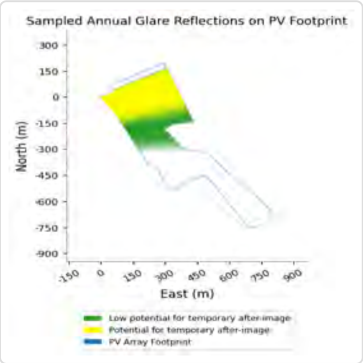
PV array is expected to produce the following glare for this receptor:

- 1,686 minutes of "green" glare with low potential to cause temporary after-image.
- 139 minutes of "yellow" glare with potential to cause temporary after-image.



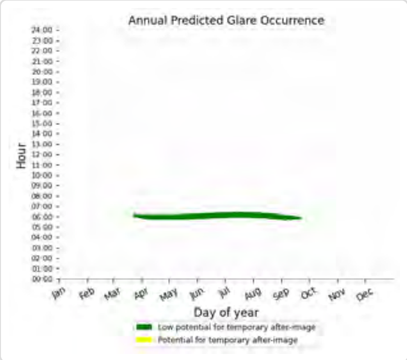



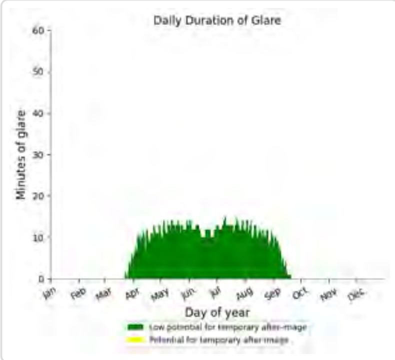



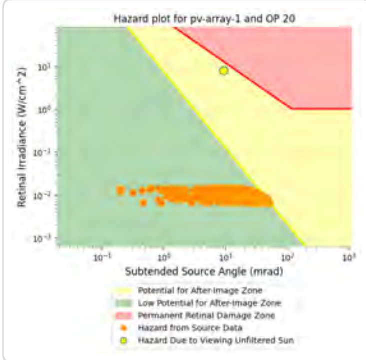
## PV array 1: OP 20

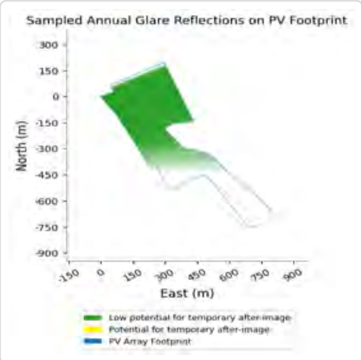
PV array is expected to produce the following glare for this receptor:

- 1,930 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.



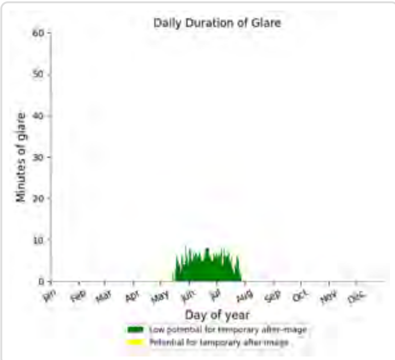



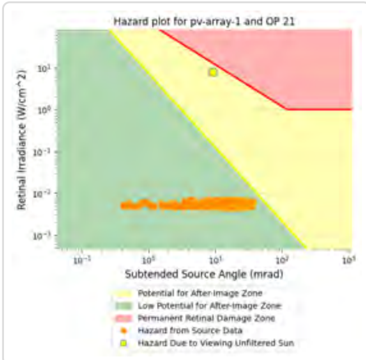



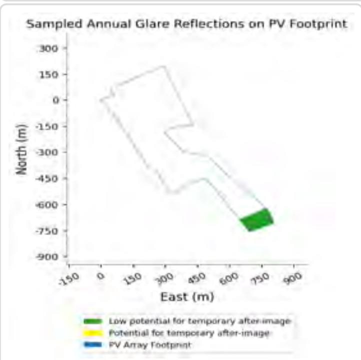

## PV array 1: OP 21

PV array is expected to produce the following glare for this receptor:

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


## PV array 1: OP 22

*No glare found*

# 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 for 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

# Burstead Solar Farm

## Burstead Solar Farm Aviation 15 Degrees

**Created** Oct 20, 2023
**Updated** Oct 20, 2023
**Time-step** 1 minute
**Timezone offset** UTC0
**Minimum sun altitude** 0.0 deg
**Site ID** 103460.18016

**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**

PV Analysis Methodology: **Version 2**
Enhanced subtended angle calculation: **On**

## 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 | 15.0 | 180.0 | 5,533 | 3,465 | - |

# Component Data

## PV Array(s)

**Total PV footprint area:** 220,193 m^2

**Name**: PV array 1
**Footprint area**: 220,193 m^2
**Axis tracking**: Fixed (no rotation)
**Tilt**: 15.0 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<br>deg | Longitude<br>deg | Ground elevation<br>m | Height above ground<br>m | Total elevation<br>m |
|---|---|---|---|---|---|
| 1 | 51.611806 | 0.448259 | 29.96 | 3.00 | 32.96 |
| 2 | 51.610833 | 0.449353 | 26.41 | 3.00 | 29.41 |
| 3 | 51.608141 | 0.451606 | 23.67 | 3.00 | 26.67 |
| 4 | 51.608181 | 0.451971 | 22.69 | 3.00 | 25.69 |
| 5 | 51.606928 | 0.452980 | 23.79 | 3.00 | 26.79 |
| 6 | 51.607475 | 0.454374 | 22.13 | 3.00 | 25.13 |
| 7 | 51.607741 | 0.455383 | 20.73 | 3.00 | 23.73 |
| 8 | 51.604998 | 0.458297 | 15.50 | 3.00 | 18.50 |
| 9 | 51.605438 | 0.459906 | 15.15 | 3.00 | 18.15 |
| 10 | 51.605958 | 0.459670 | 15.42 | 3.00 | 18.42 |
| 11 | 51.606504 | 0.459069 | 16.49 | 3.00 | 19.49 |
| 12 | 51.607330 | 0.457632 | 18.55 | 3.00 | 21.55 |
| 13 | 51.608876 | 0.455464 | 19.69 | 3.00 | 22.69 |
| 14 | 51.609142 | 0.453791 | 20.55 | 3.00 | 23.55 |
| 15 | 51.610142 | 0.452546 | 21.17 | 3.00 | 24.17 |
| 16 | 51.610395 | 0.453125 | 21.93 | 3.00 | 24.93 |
| 17 | 51.610515 | 0.454520 | 22.13 | 3.00 | 25.13 |
| 18 | 51.613580 | 0.452525 | 32.38 | 3.00 | 35.38 |
| 19 | 51.612394 | 0.448898 | 32.57 | 3.00 | 35.57 |
| 20 | 51.612047 | 0.449156 | 30.87 | 3.00 | 33.87 |

## 2-Mile Flight Path Receptor(s)

**Name**: Laindon RWY 07
**Description**:
**Threshold height** : 15 m
**Direction**: 71.0 deg
**Glide slope**: 3.0 deg
**Pilot view restricted?** Yes
**Vertical view restriction**: 30.0 deg
**Azimuthal view restriction**: 50.0 deg

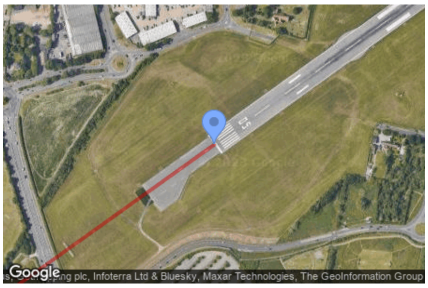
| Point | Latitude deg | Longitude deg | Ground elevation m | Height above ground m | Total elevation m |
|---|---|---|---|---|---|
| Threshold | 51.593019 | 0.441230 | 28.71 | 15.24 | 43.95 |
| 2-mile point | 51.583606 | 0.397174 | 34.07 | 178.56 | 212.64 |


**Name**: Laindon RWY 25
**Description**:
**Threshold height** : 15 m
**Direction**: 251.0 deg
**Glide slope**: 3.0 deg
**Pilot view restricted?** Yes
**Vertical view restriction**: 30.0 deg
**Azimuthal view restriction**: 50.0 deg

| Point | Latitude deg | Longitude deg | Ground elevation m | Height above ground m | Total elevation m |
|---|---|---|---|---|---|
| Threshold | 51.594454 | 0.447935 | 20.76 | 15.24 | 36.00 |
| 2-mile point | 51.603867 | 0.491992 | 37.20 | 167.49 | 204.69 |

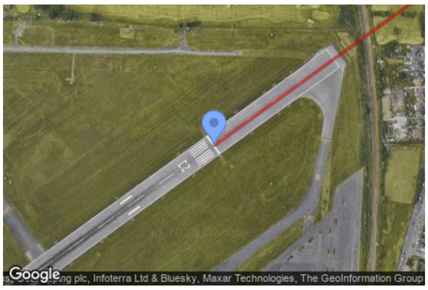

**Name**: Southend RWY 05
**Description**:
**Threshold height** : 15 m
**Direction**: 54.2 deg
**Glide slope**: 3.0 deg
**Pilot view restricted?** Yes
**Vertical view restriction**: 30.0 deg
**Azimuthal view restriction**: 50.0 deg

| Point | Latitude deg | Longitude deg | Ground elevation m | Height above ground m | Total elevation m |
|---|---|---|---|---|---|
| Threshold | 51.565916 | 0.683270 | 16.57 | 15.24 | 31.81 |
| 2-mile point | 51.549003 | 0.645502 | 44.41 | 156.08 | 200.49 |



**Name**: Southend RWY 23
**Description**:
**Threshold height** : 15 m
**Direction**: 234.2 deg
**Glide slope**: 3.0 deg
**Pilot view restricted?** Yes
**Vertical view restriction**: 30.0 deg
**Azimuthal view restriction**: 50.0 deg

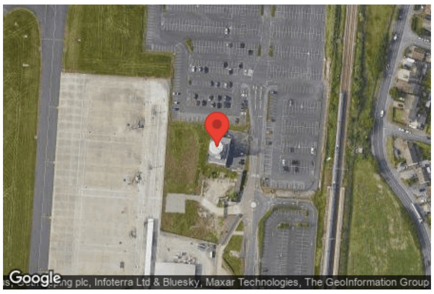
| Point | Latitude<br>deg | Longitude<br>deg | Ground elevation<br>m | Height above ground<br>m | Total elevation<br>m |
|---|---|---|---|---|---|
| Threshold | 51.574381 | 0.702123 | 11.11 | 15.24 | 26.35 |
| 2-mile point | 51.591310 | 0.739879 | 4.98 | 190.06 | 195.04 |



## Discrete Observation Receptors

| Number | Latitude<br>deg | Longitude<br>deg | Ground elevation<br>m | Height above ground<br>m | Total Elevation<br>m |
|---|---|---|---|---|---|
| 1-ATCT | 51.571344 | 0.704161 | 8.08 | 32.00 | 40.08 |

*1-ATCT map image*



# 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 | 15.0 | 180.0 | 5,533 | 3,465 | - | - |

## 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 | 163 | 1016 | 361 | 353 | 356 | 771 | 545 | 0 | 0 | 0 |
| pv-array-1 (yellow) | 0 | 0 | 0 | 81 | 876 | 965 | 974 | 347 | 0 | 0 | 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) |
|---|---|---|
| FP: Laindon RWY 07 | 0 | 0 |
| FP: Laindon RWY 25 | 3293 | 3465 |
| FP: Southend RWY 05 | 0 | 0 |
| FP: Southend RWY 23 | 1405 | 0 |
| OP: 1-ATCT | 835 | 0 |

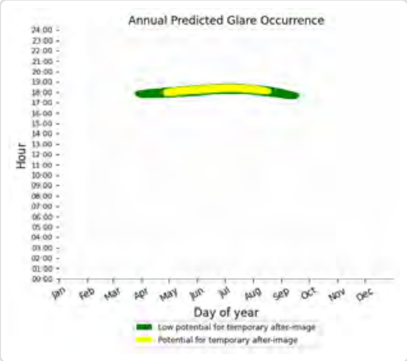
### PV array 1: Laindon RWY 07

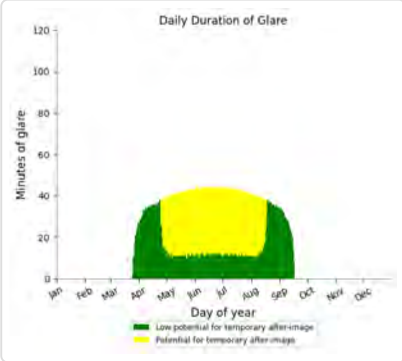
*No glare found*

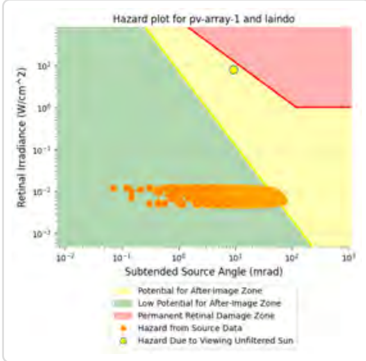
## PV array 1: Laindon RWY 25

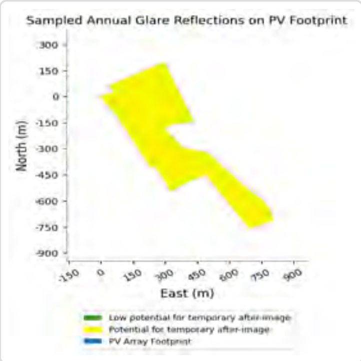
PV array is expected to produce the following glare for this receptor:

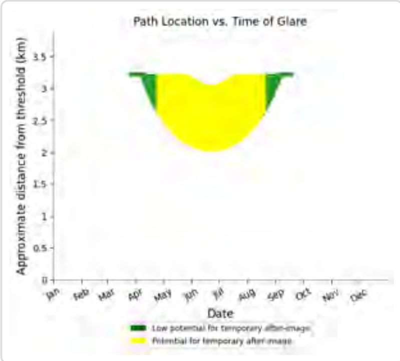
- 3,293 minutes of "green" glare with low potential to cause temporary after-image.
- 3,465 minutes of "yellow" glare with potential to cause temporary after-image.

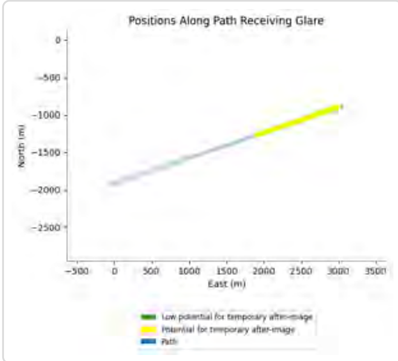


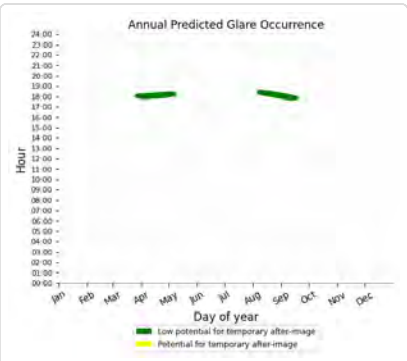

## PV array 1: Southend RWY 05

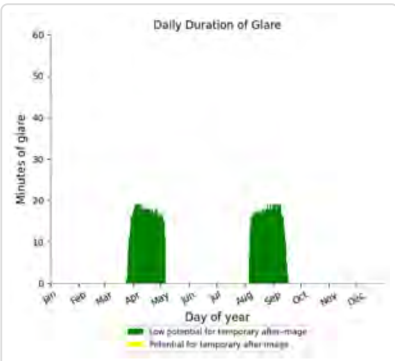
*No glare found*

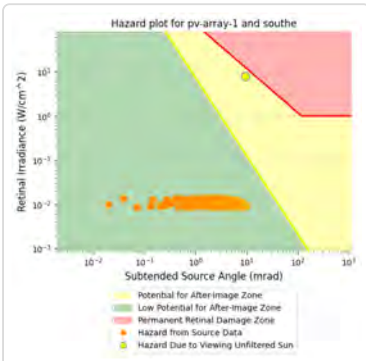
## PV array 1: Southend RWY 23

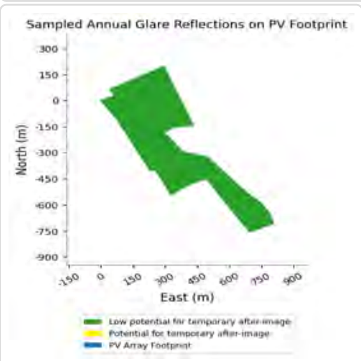
PV array is expected to produce the following glare for this receptor:

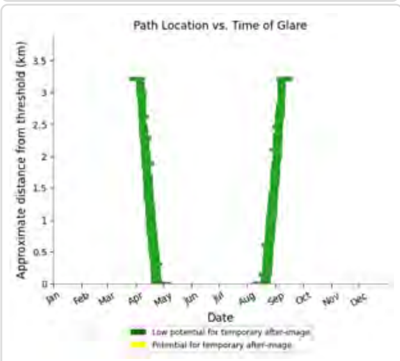
- 1,405 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

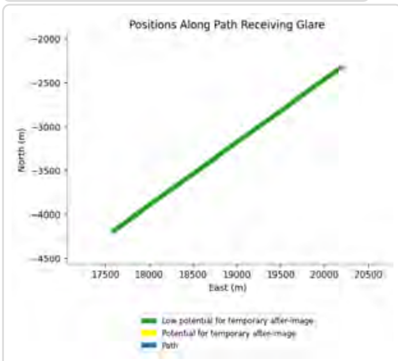


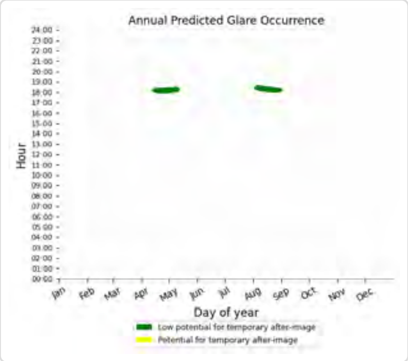



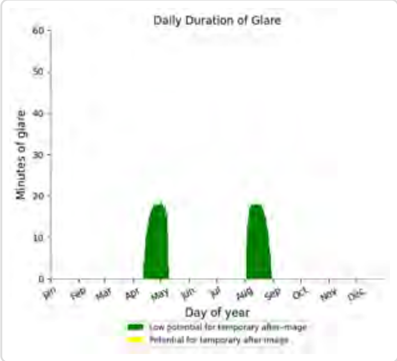



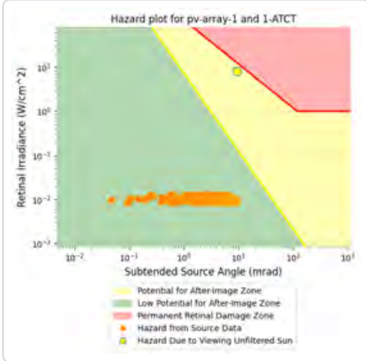



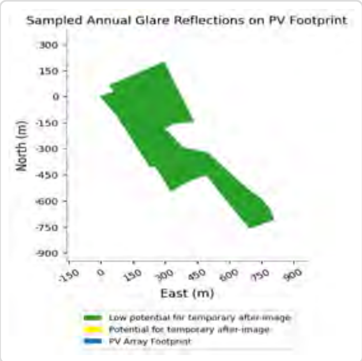
### PV array 1: 1-ATCT

PV array is expected to produce the following glare for this receptor:
- 835 minutes of "green" glare with low potential to cause temporary after-image.
- 0 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 for 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

# Burstead Solar Farm

## Burstead Solar Farm Aviation 30 Degrees

**Created** Oct 20, 2023
**Updated** Oct 20, 2023
**Time-step** 1 minute
**Timezone offset** UTC0
**Minimum sun altitude** 0.0 deg
**Site ID** 103460.18016

**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**

PV Analysis Methodology: **Version 2**
Enhanced subtended angle calculation: **On**

## 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 | 30.0 | 180.0 | 5,897 | 3,185 | - |

# Component Data

## PV Array(s)

**Total PV footprint area:** 220,193 m^2

**Name**: PV array 1
**Footprint area**: 220,193 m^2
**Axis tracking**: Fixed (no rotation)
**Tilt**: 30.0 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 | 51.611806 | 0.448259 | 29.96 | 3.00 | 32.96 |
| 2 | 51.610833 | 0.449353 | 26.41 | 3.00 | 29.41 |
| 3 | 51.608141 | 0.451606 | 23.67 | 3.00 | 26.67 |
| 4 | 51.608181 | 0.451971 | 22.69 | 3.00 | 25.69 |
| 5 | 51.606928 | 0.452980 | 23.79 | 3.00 | 26.79 |
| 6 | 51.607475 | 0.454374 | 22.13 | 3.00 | 25.13 |
| 7 | 51.607741 | 0.455383 | 20.73 | 3.00 | 23.73 |
| 8 | 51.604998 | 0.458297 | 15.50 | 3.00 | 18.50 |
| 9 | 51.605438 | 0.459906 | 15.15 | 3.00 | 18.15 |
| 10 | 51.605958 | 0.459670 | 15.42 | 3.00 | 18.42 |
| 11 | 51.606504 | 0.459069 | 16.49 | 3.00 | 19.49 |
| 12 | 51.607330 | 0.457632 | 18.55 | 3.00 | 21.55 |
| 13 | 51.608876 | 0.455464 | 19.69 | 3.00 | 22.69 |
| 14 | 51.609142 | 0.453791 | 20.55 | 3.00 | 23.55 |
| 15 | 51.610142 | 0.452546 | 21.17 | 3.00 | 24.17 |
| 16 | 51.610395 | 0.453125 | 21.93 | 3.00 | 24.93 |
| 17 | 51.610515 | 0.454520 | 22.13 | 3.00 | 25.13 |
| 18 | 51.613580 | 0.452525 | 32.38 | 3.00 | 35.38 |
| 19 | 51.612394 | 0.448898 | 32.57 | 3.00 | 35.57 |
| 20 | 51.612047 | 0.449156 | 30.87 | 3.00 | 33.87 |

## 2-Mile Flight Path Receptor(s)

**Name**: Laindon RWY 07
**Description**:
**Threshold height** : 15 m
**Direction**: 71.0 deg
**Glide slope**: 3.0 deg
**Pilot view restricted?** Yes
**Vertical view restriction**: 30.0 deg
**Azimuthal view restriction**: 50.0 deg

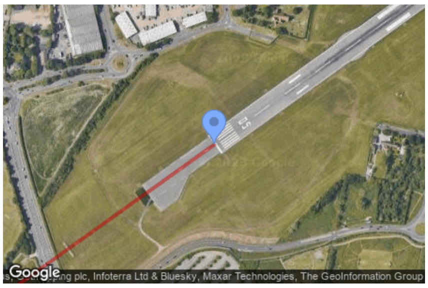
| Point | Latitude<br>deg | Longitude<br>deg | Ground elevation<br>m | Height above ground<br>m | Total elevation<br>m |
|---|---|---|---|---|---|
| Threshold | 51.593019 | 0.441230 | 28.71 | 15.24 | 43.95 |
| 2-mile point | 51.583606 | 0.397174 | 34.07 | 178.56 | 212.64 |


**Name**: Laindon RWY 25
**Description**:
**Threshold height** : 15 m
**Direction**: 251.0 deg
**Glide slope**: 3.0 deg
**Pilot view restricted?** Yes
**Vertical view restriction**: 30.0 deg
**Azimuthal view restriction**: 50.0 deg

| Point | Latitude<br>deg | Longitude<br>deg | Ground elevation<br>m | Height above ground<br>m | Total elevation<br>m |
|---|---|---|---|---|---|
| Threshold | 51.594454 | 0.447935 | 20.76 | 15.24 | 36.00 |
| 2-mile point | 51.603867 | 0.491992 | 37.20 | 167.49 | 204.69 |

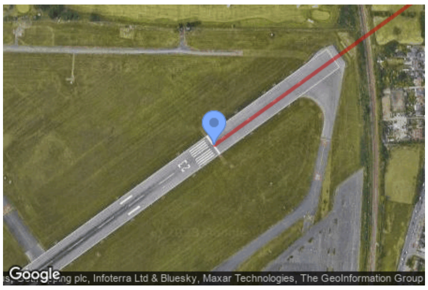

**Name**: Southend RWY 05
**Description**:
**Threshold height** : 15 m
**Direction**: 54.2 deg
**Glide slope**: 3.0 deg
**Pilot view restricted?** Yes
**Vertical view restriction**: 30.0 deg
**Azimuthal view restriction**: 50.0 deg

| Point | Latitude<br>deg | Longitude<br>deg | Ground elevation<br>m | Height above ground<br>m | Total elevation<br>m |
|---|---|---|---|---|---|
| Threshold | 51.565916 | 0.683270 | 16.57 | 15.24 | 31.81 |
| 2-mile point | 51.549003 | 0.645502 | 44.41 | 156.08 | 200.49 |



**Name**: Southend RWY 23
**Description**:
**Threshold height** : 15 m
**Direction**: 234.2 deg
**Glide slope**: 3.0 deg
**Pilot view restricted?** Yes
**Vertical view restriction**: 30.0 deg
**Azimuthal view restriction**: 50.0 deg

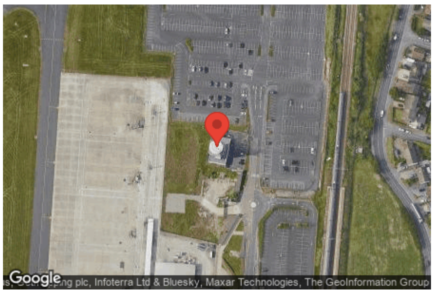
| Point | Latitude deg | Longitude deg | Ground elevation m | Height above ground m | Total elevation m |
|---|---|---|---|---|---|
| Threshold | 51.574381 | 0.702123 | 11.11 | 15.24 | 26.35 |
| 2-mile point | 51.591310 | 0.739879 | 4.98 | 190.06 | 195.04 |




## Discrete Observation Receptors

| Number | Latitude deg | Longitude deg | Ground elevation m | Height above ground m | Total Elevation m |
|---|---|---|---|---|---|
| 1-ATCT | 51.571344 | 0.704161 | 8.08 | 32.00 | 40.08 |

*1-ATCT map image*



# 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 | 30.0 | 180.0 | 5,897 | 3,185 | - | - |

## 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 | 323 | 944 | 405 | 426 | 407 | 726 | 692 | 0 | 0 | 0 |
| pv-array-1 (yellow) | 0 | 0 | 0 | 116 | 782 | 840 | 865 | 353 | 0 | 0 | 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) |
|---|---|---|
| FP: Laindon RWY 07 | 0 | 0 |
| FP: Laindon RWY 25 | 3627 | 3185 |
| FP: Southend RWY 05 | 0 | 0 |
| FP: Southend RWY 23 | 1425 | 0 |
| OP: 1-ATCT | 845 | 0 |

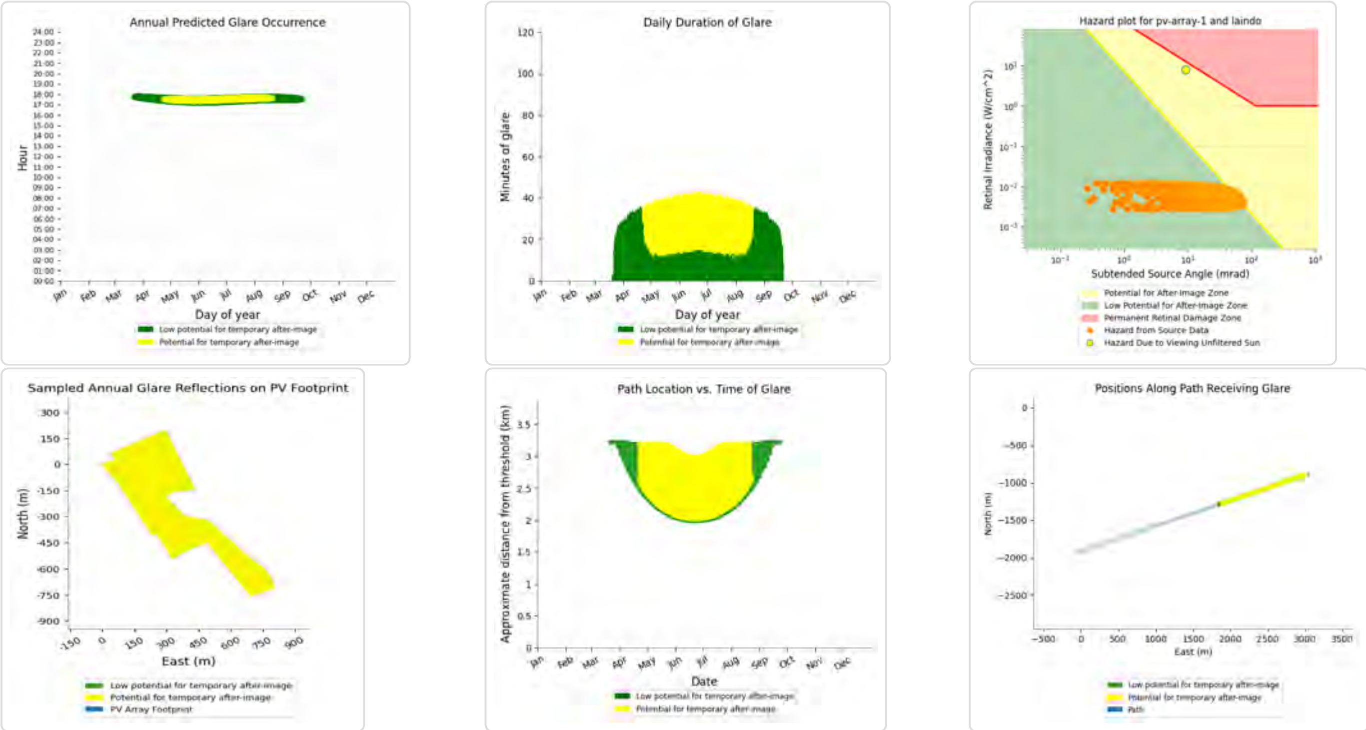
### PV array 1: Laindon RWY 07

*No glare found*

## PV array 1: Laindon RWY 25

PV array is expected to produce the following glare for this receptor:

- 3,627 minutes of "green" glare with low potential to cause temporary after-image.
- 3,185 minutes of "yellow" glare with potential to cause temporary after-image.



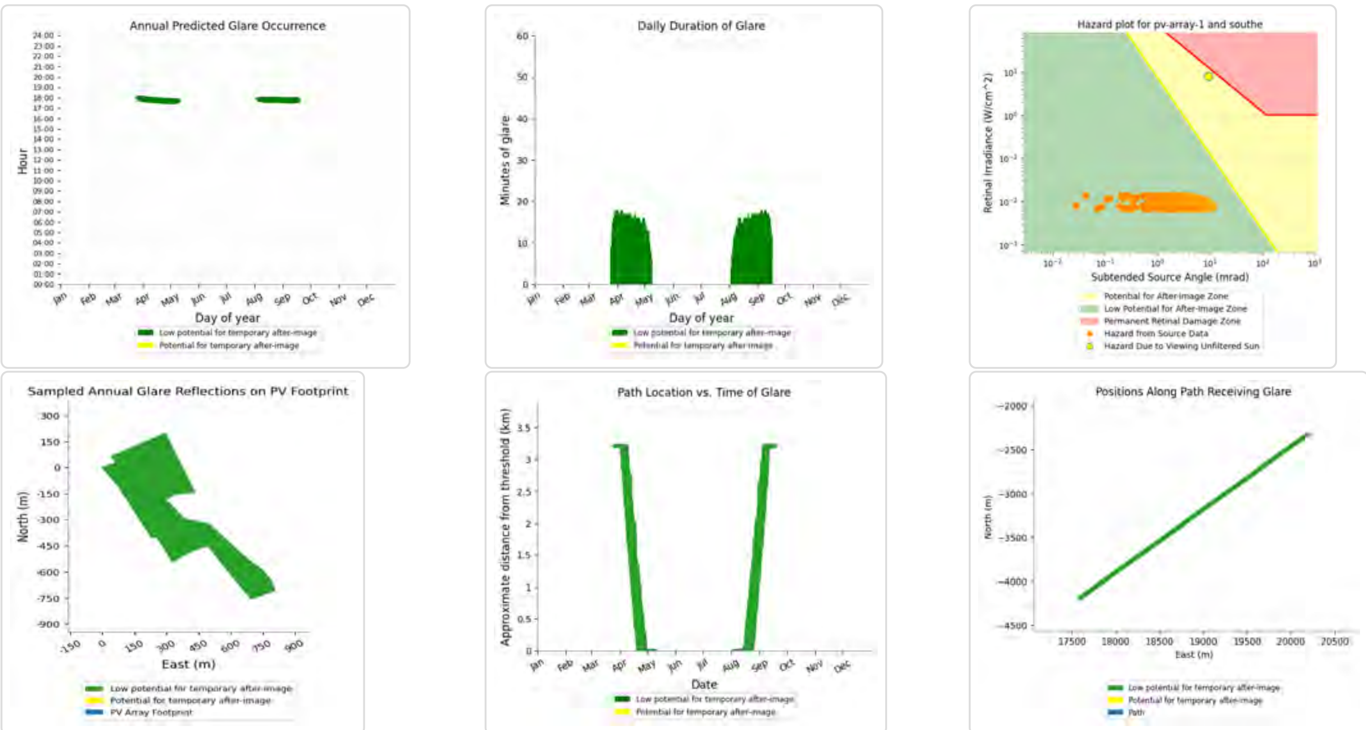

## PV array 1: Southend RWY 05

*No glare found*

## PV array 1: Southend RWY 23

PV array is expected to produce the following glare for this receptor:

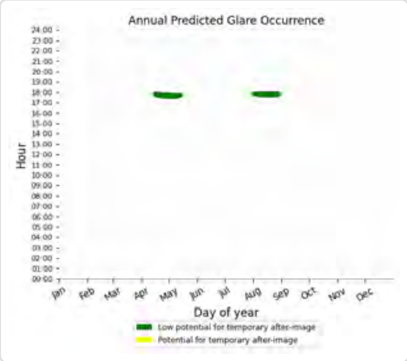
- 1,425 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

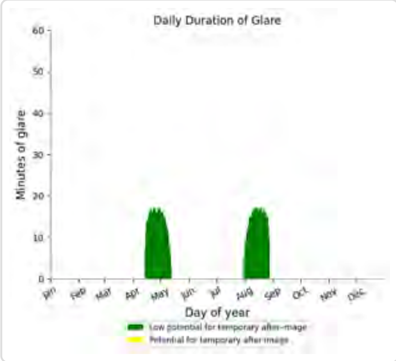


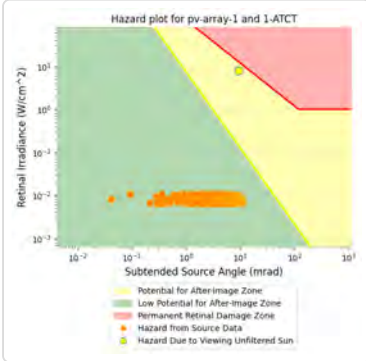
### PV array 1: 1-ATCT

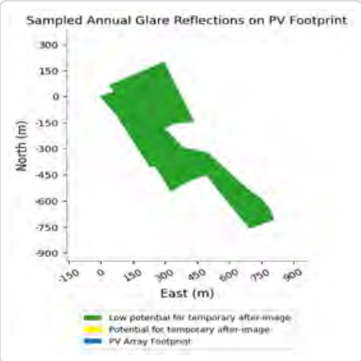
PV array is expected to produce the following glare for this receptor:

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

# Appendix H: Visibility Assessment Evidence

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# Residential Receptors

## Receptors 4, 5, 7 and 8


## Receptor 22


## Receptor 23

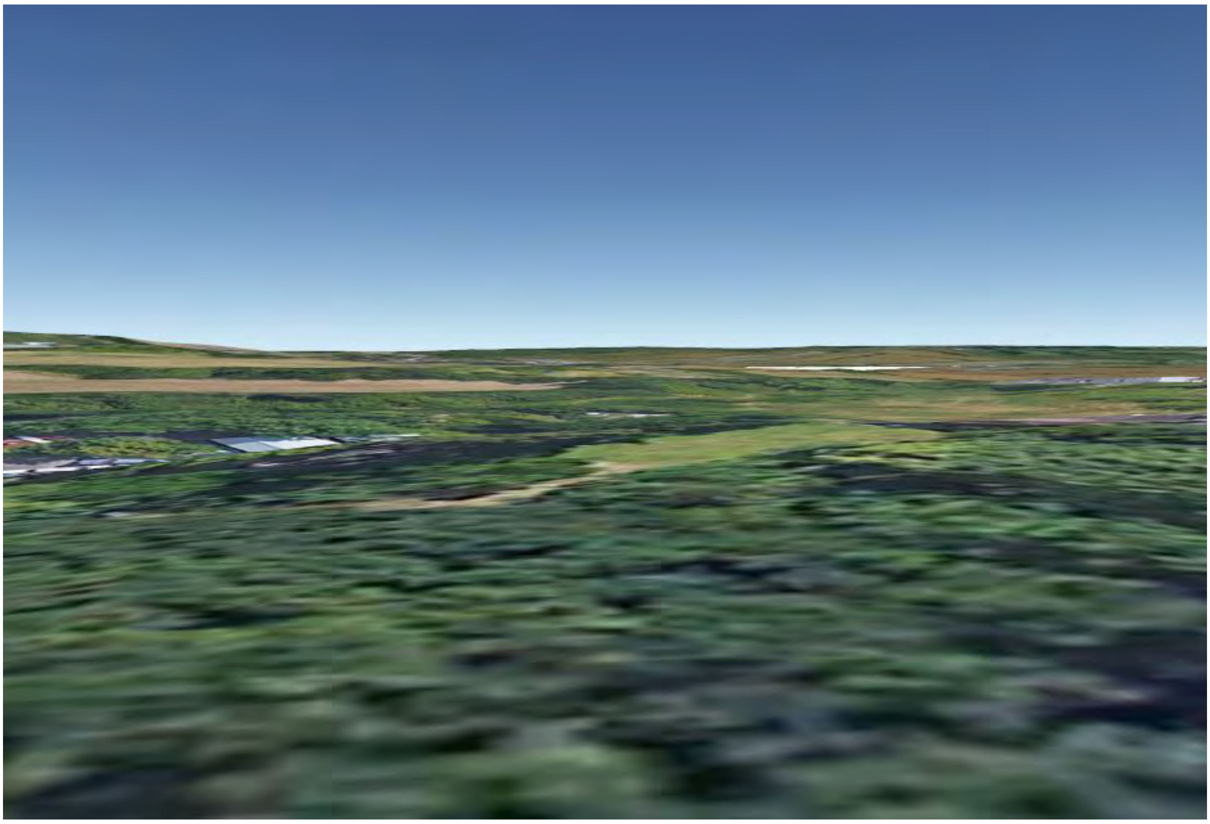

## Receptor 24


## Receptors 27 and 28

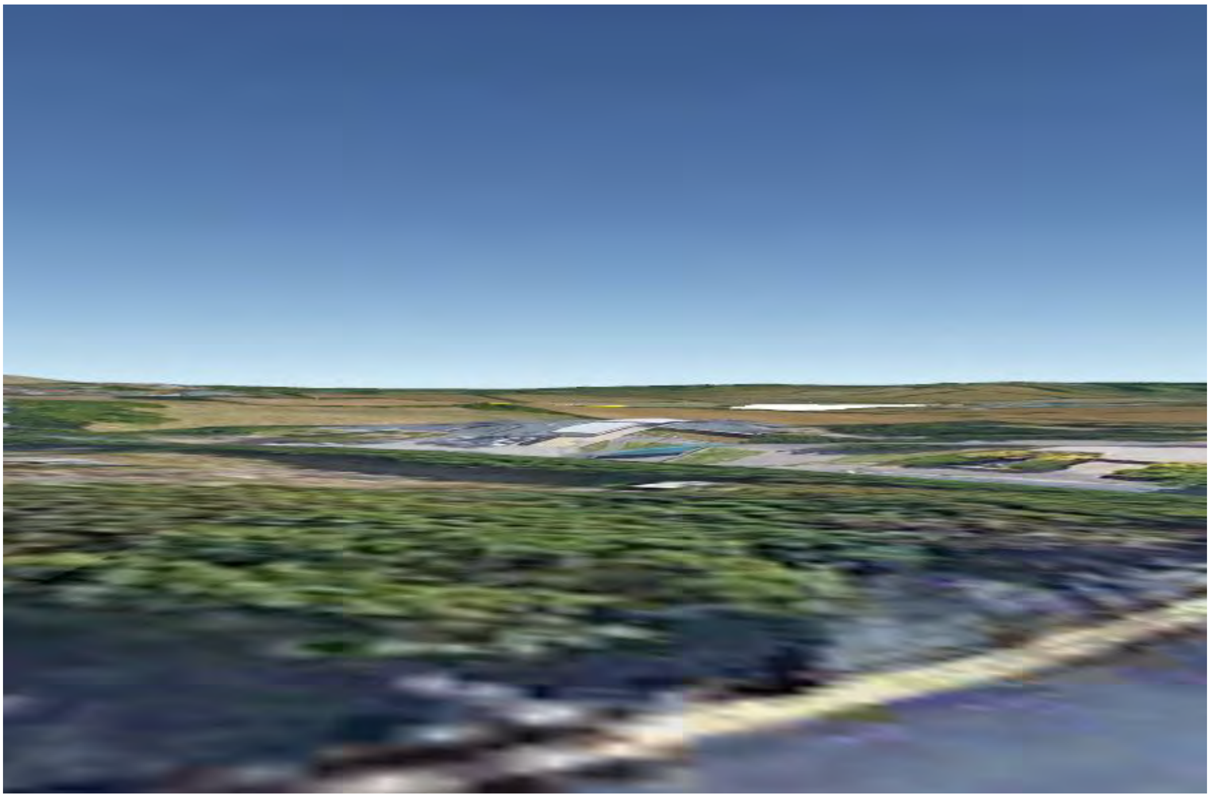

## Road Receptors

### Receptor 1

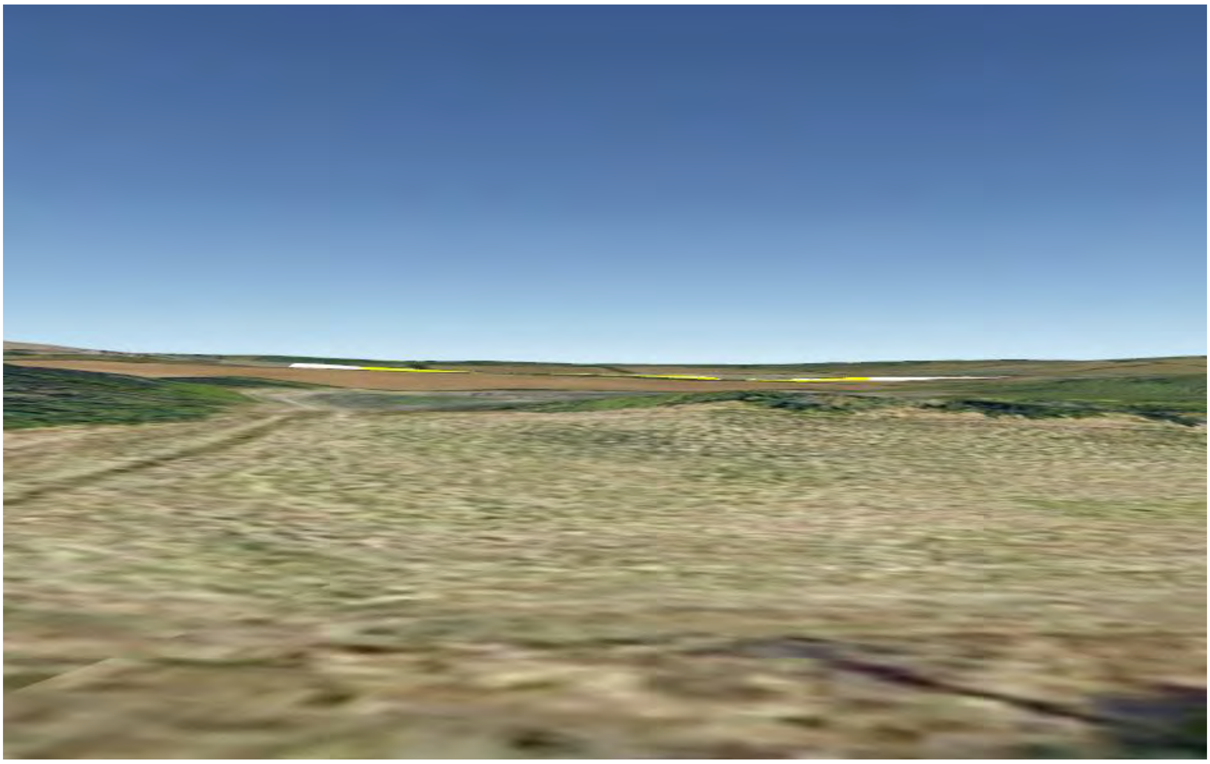
## Receptor 2



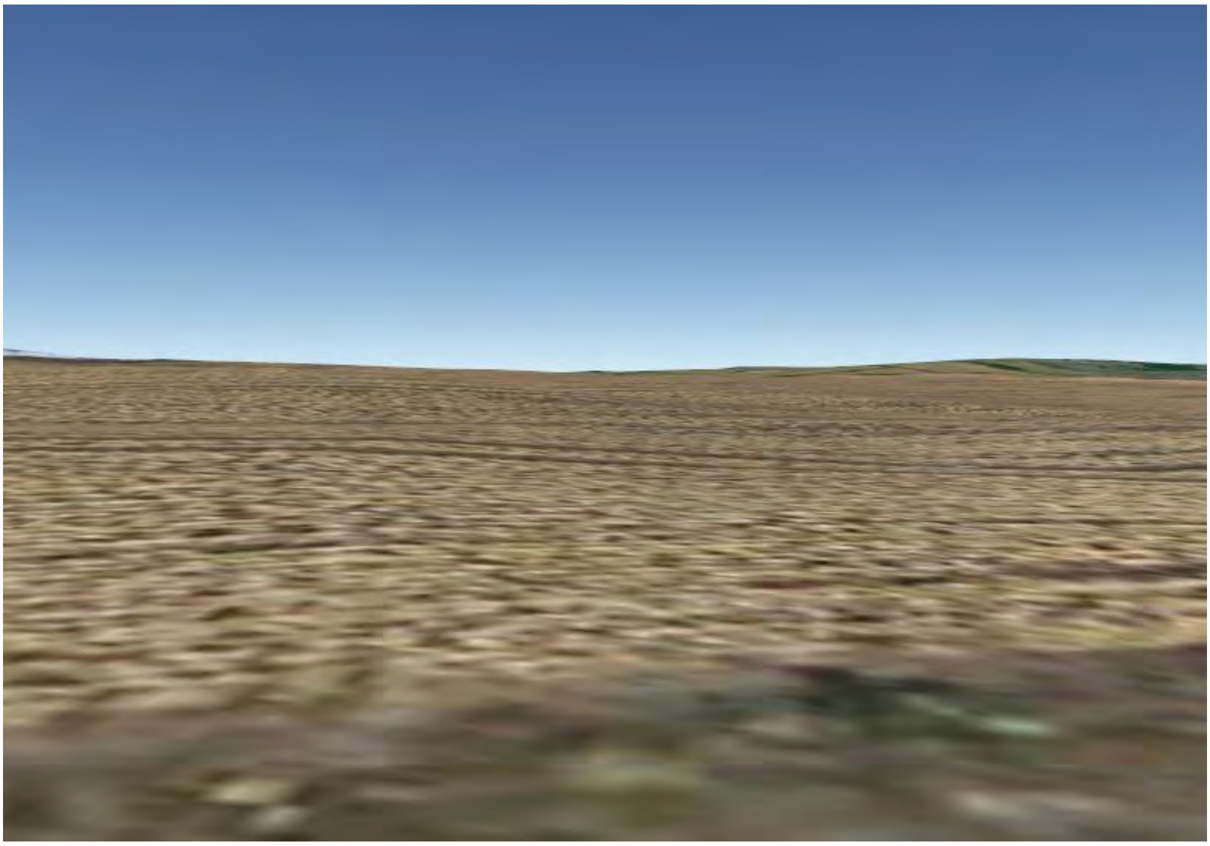
## Receptor 3



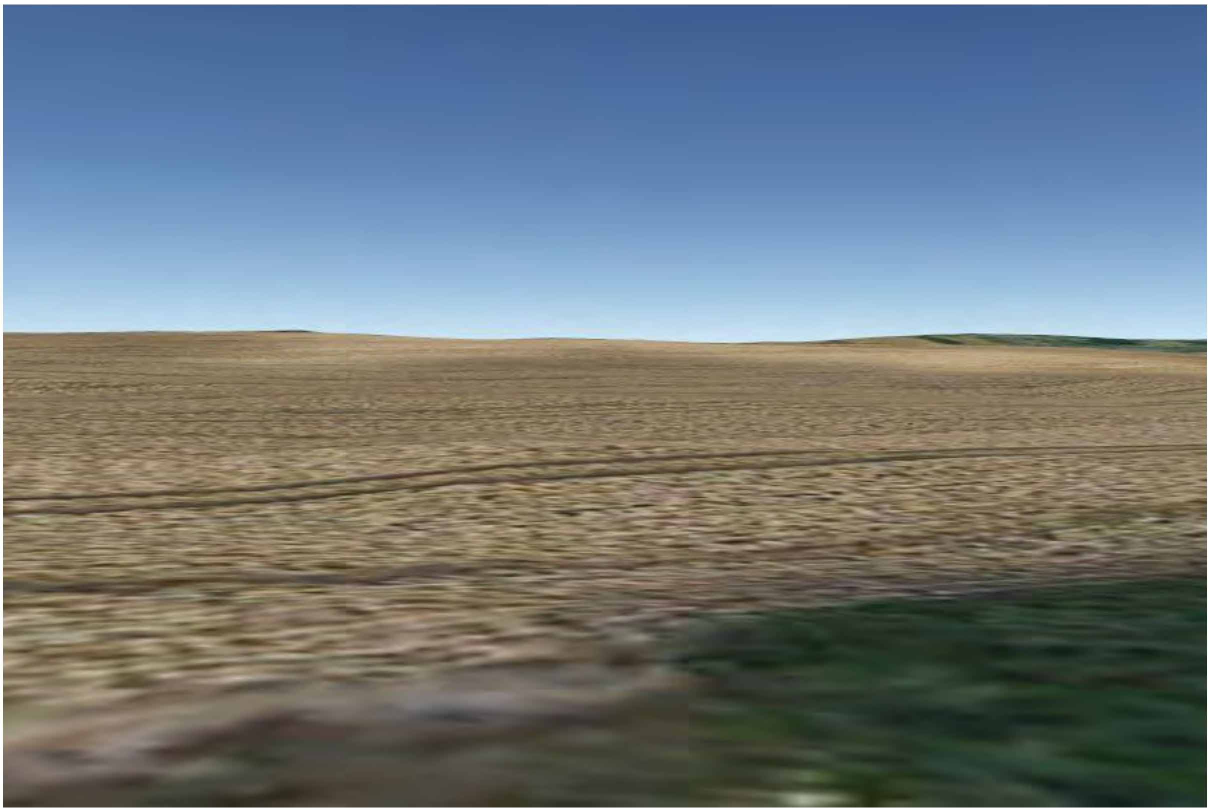
## Receptor 4



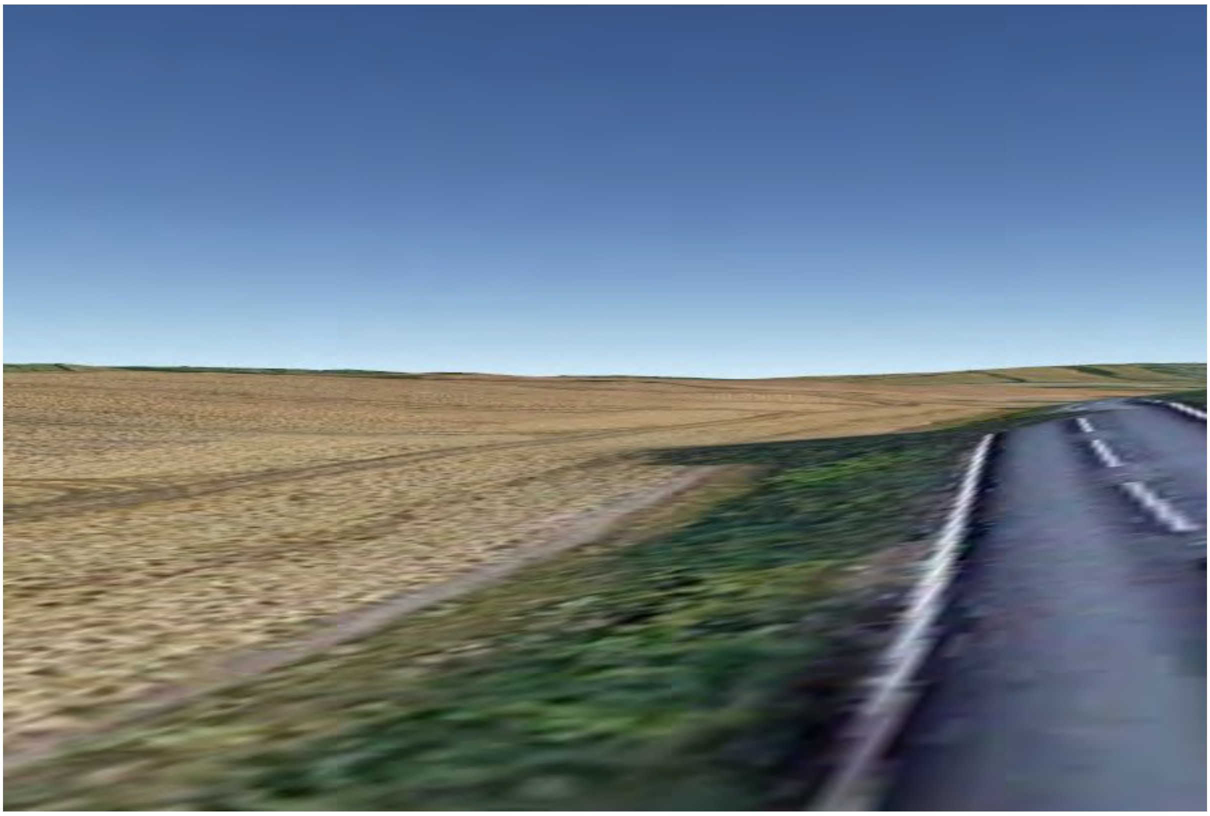
## Receptor 6



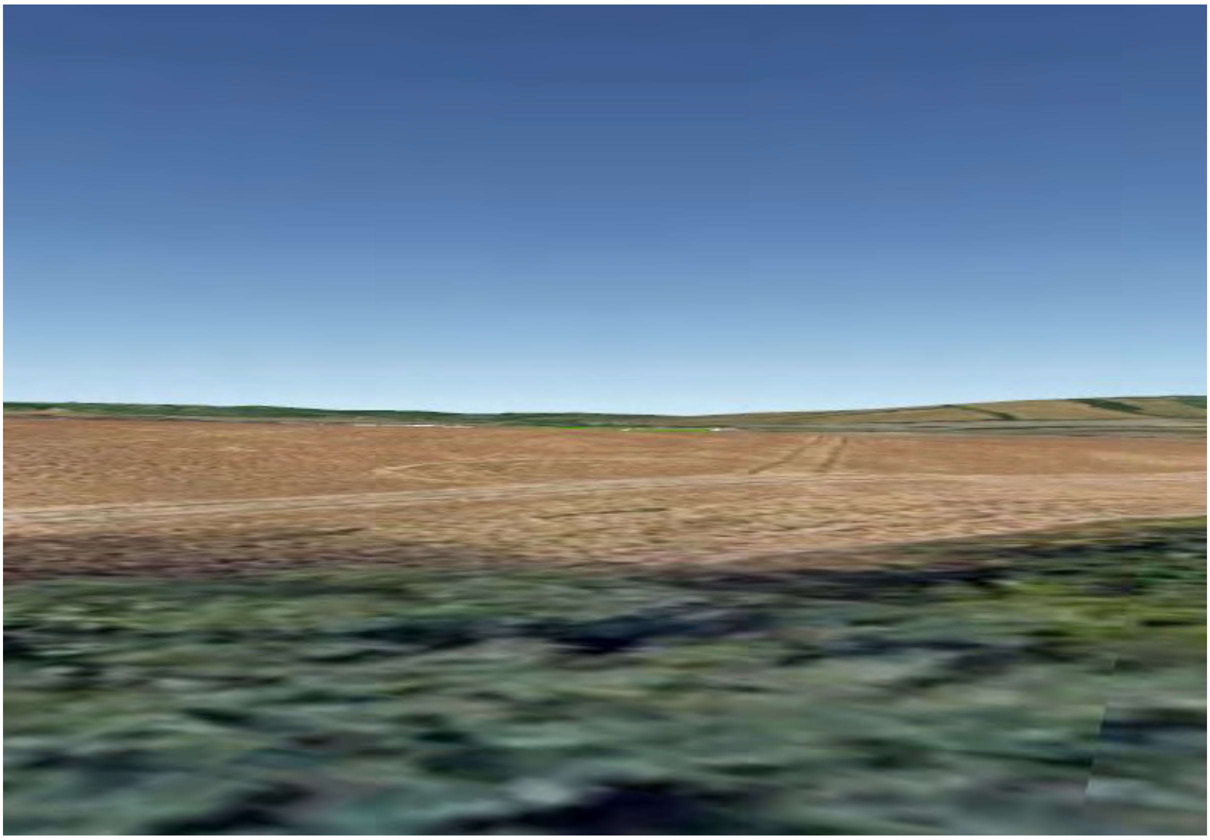
## Receptor 7



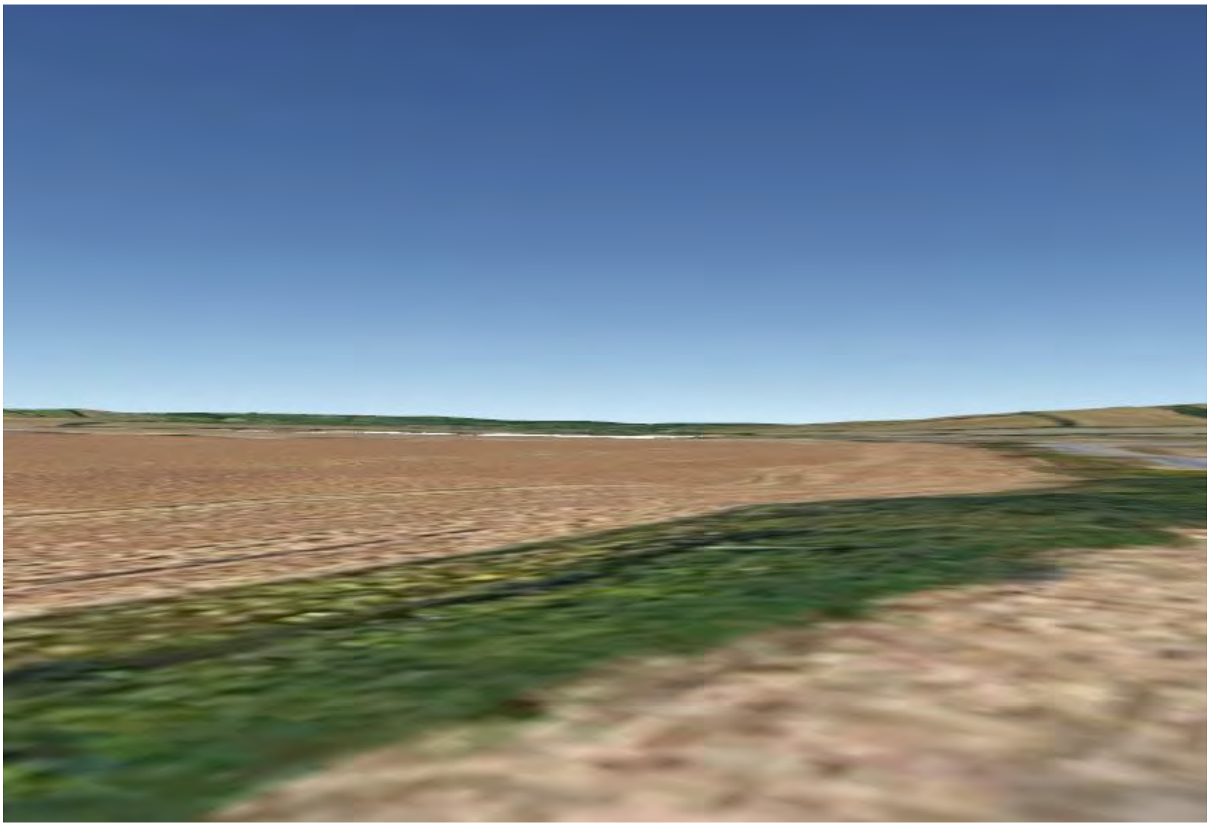
## Receptor 8



## Receptor 9

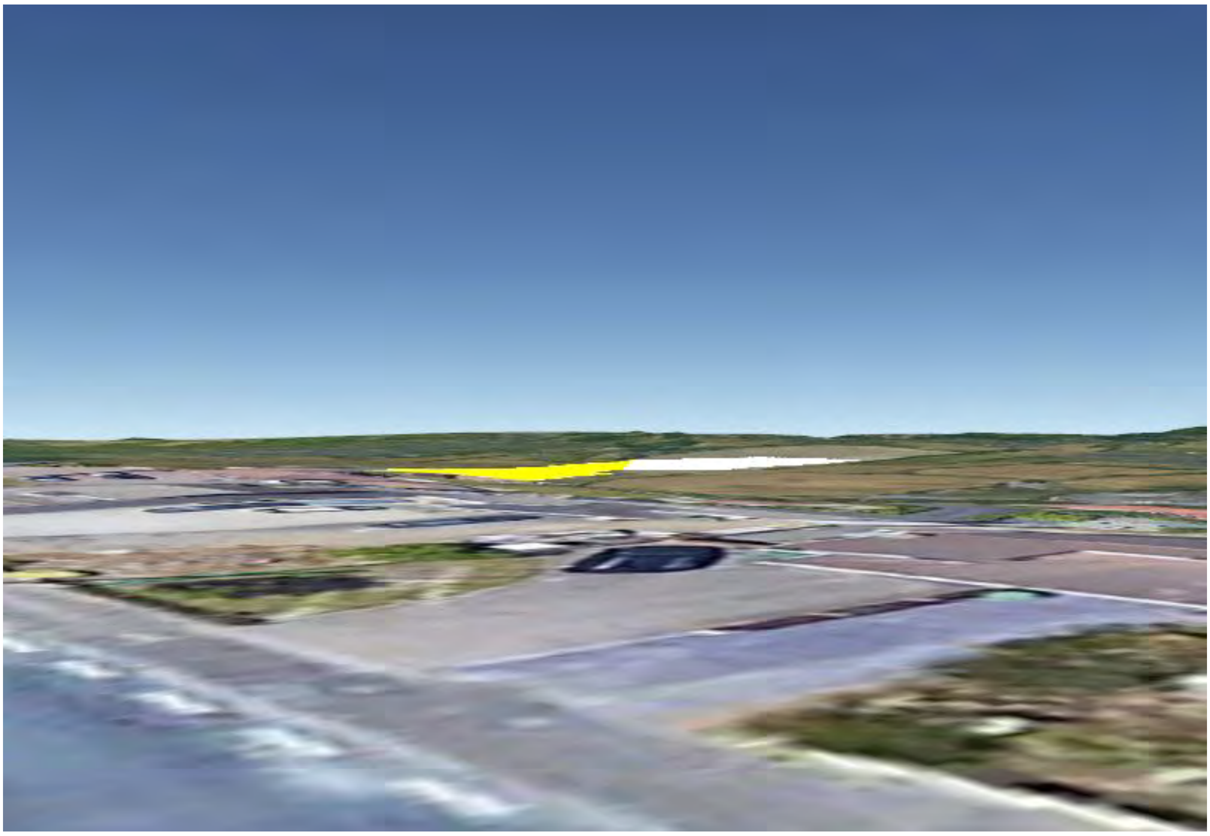


## Receptor 10

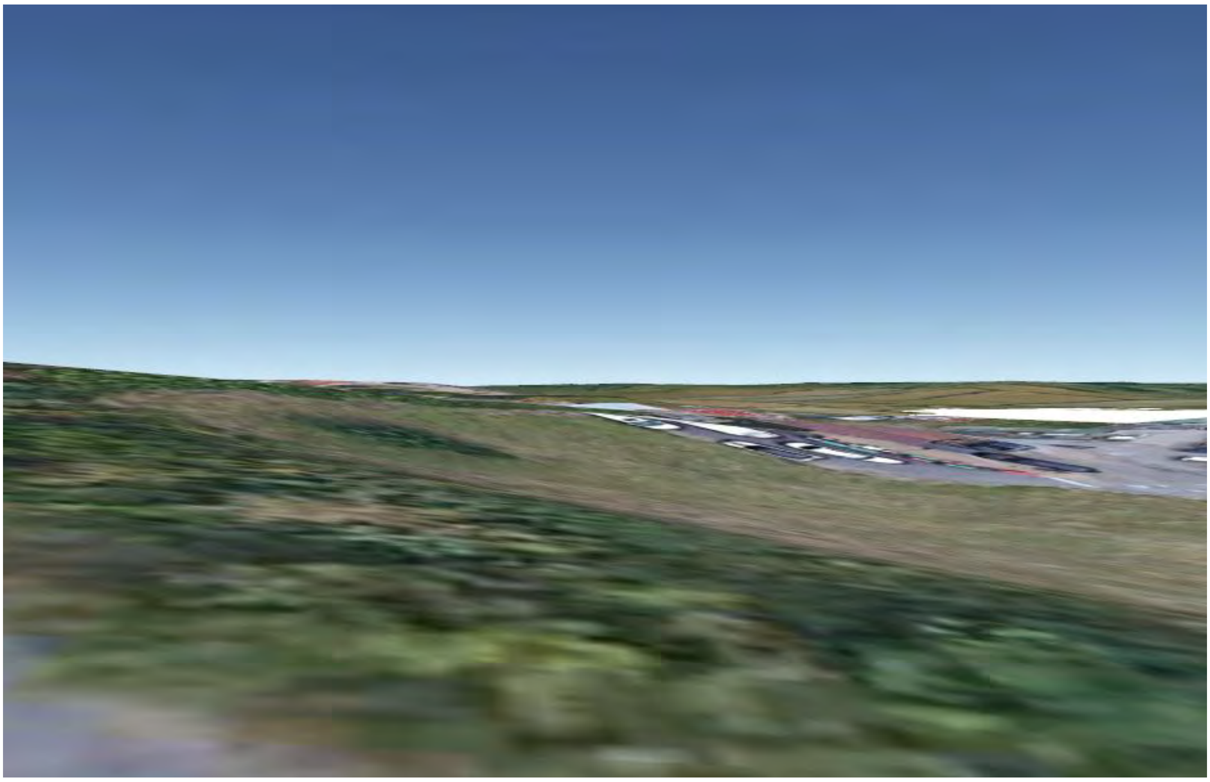


## Receptor 13

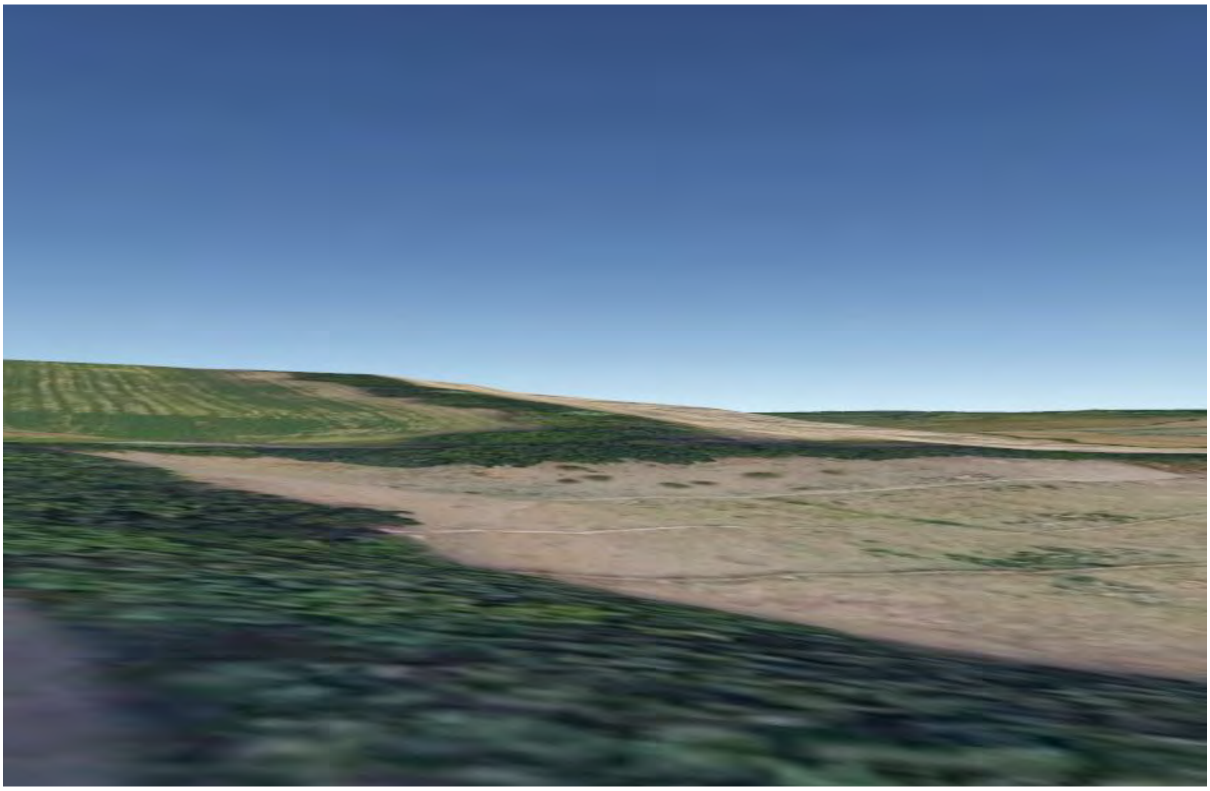
## Receptor 14



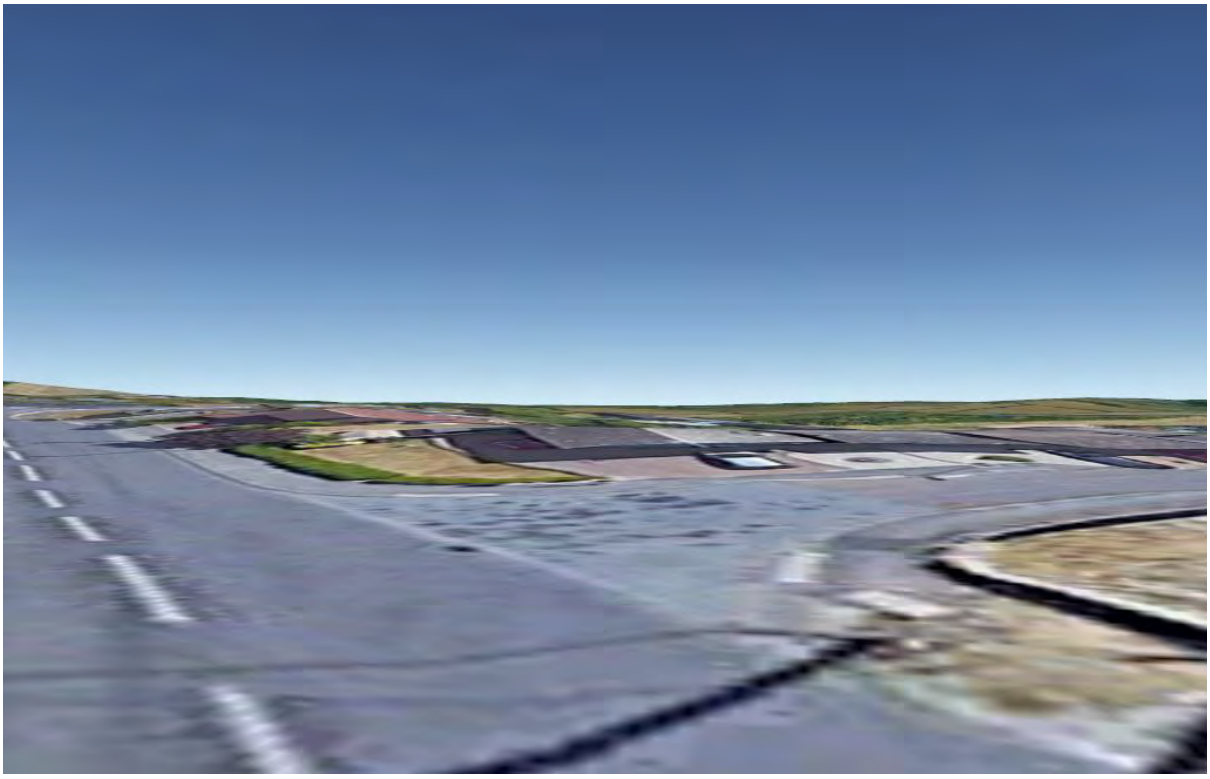
## Receptor 16



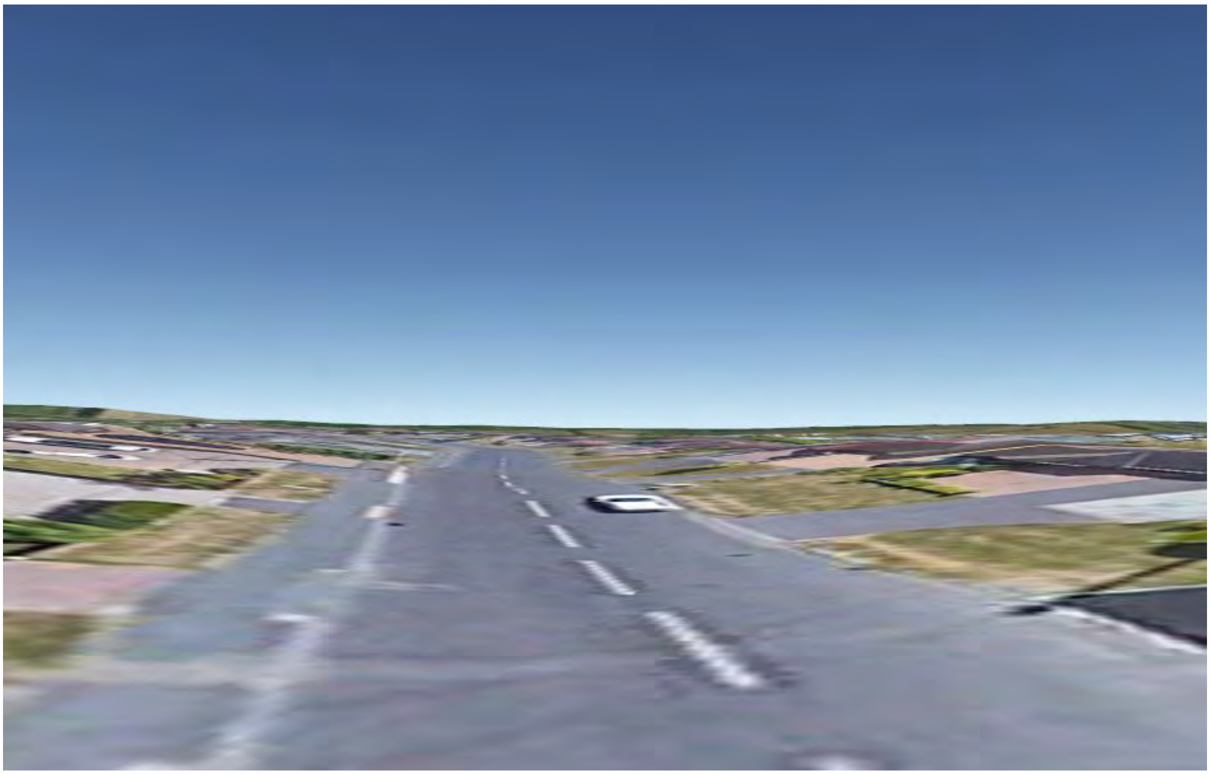
## Receptor 17



## Receptor 19



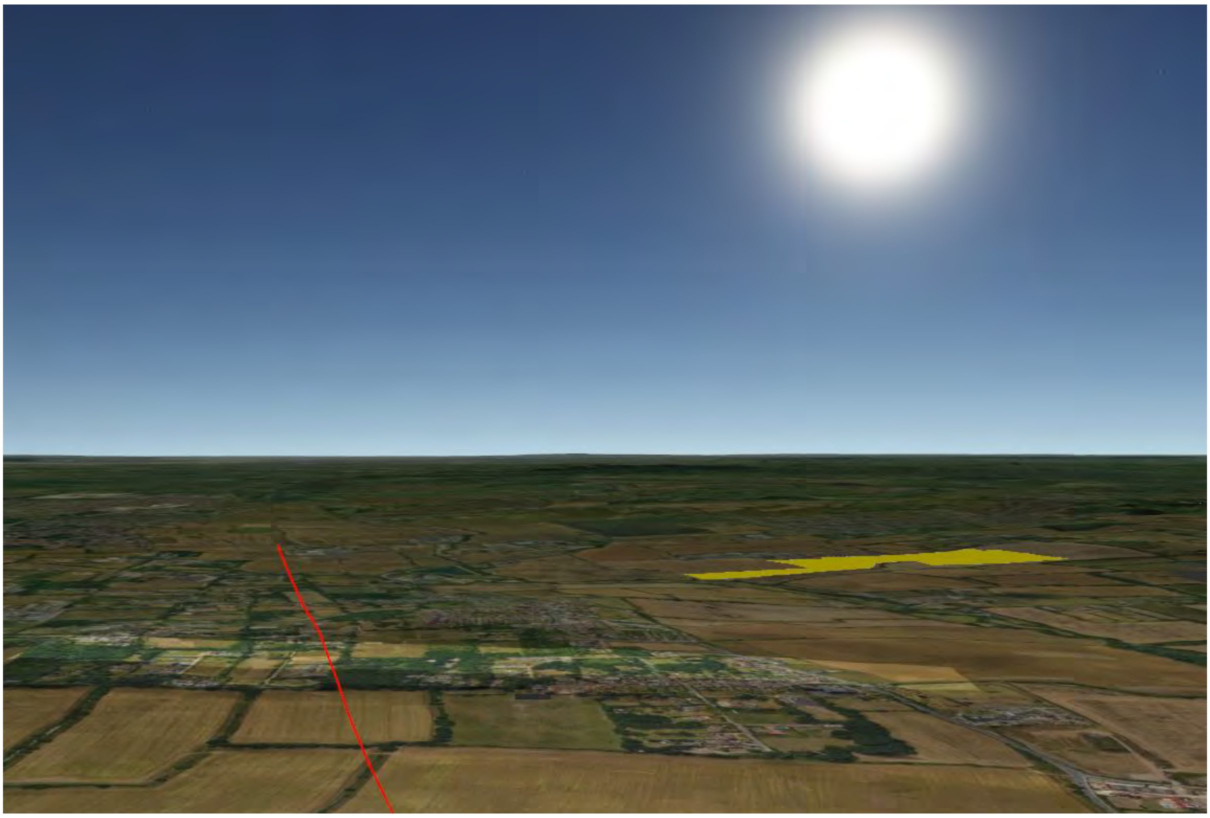
## Receptor 20



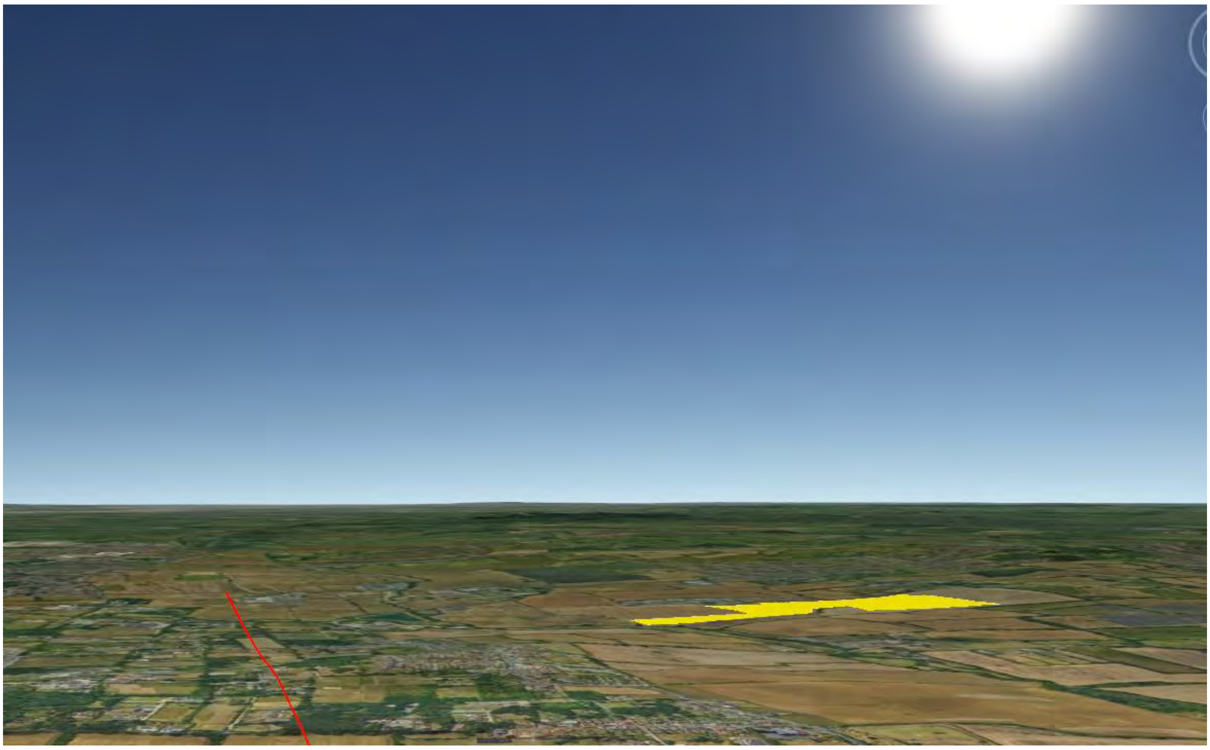
## Receptor 21

## Aviation

### April 25th 17:45 UTC



### July 1st 18:00 UTC



# Appendix I: Ground Elevation Profile


Proposed Development

Southend Airport ATCT

Appendix J

# Solar Module Glare and Reflectance Technical Memo

SUNPOWER

# Technical Notification

TITLE: SunPower Solar Module Glare and Reflectance
AUTHORS: Technical Support
APPLICATION: Residential/ Commercial
SCOPE: SunPower Modules

## SUMMARY:

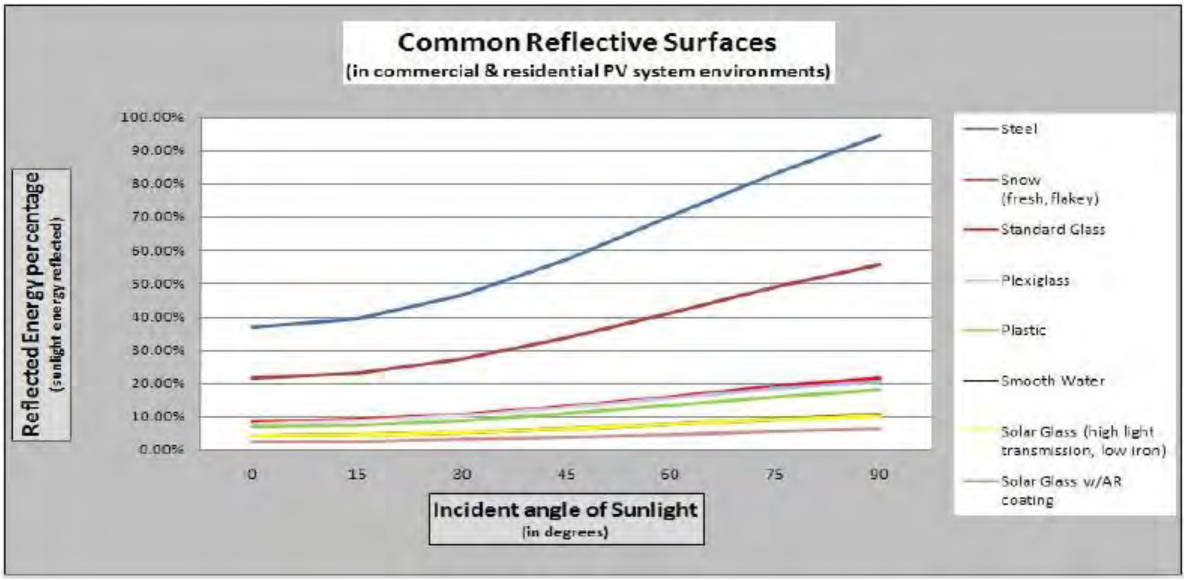
The objective of this document is to increase awareness concerning the possible glare and reflectance impact of PV Systems on their surrounding environment.

The glare and reflectance levels from a given PV system are decisively lower than the glare andreflectance generated by the standard glass and other common reflective surfaces in the environments surrounding the given PV system. Concerning random glare and reflectance observed from the air: SunPower has several large projects installed near airports or on air force bases. Each of these large projects has passed FAA or Air Force standards and all projects have been determined as "No Hazard toAir Navigation". Although the possible glare and reflectance from PV systems are at safe levels and are usually decisively lower than other standard residential and commercial reflective surfaces, SunPower suggests that customers and installers discuss any possible concerns with the neighbors/cohabitants near the planned PV system installation.

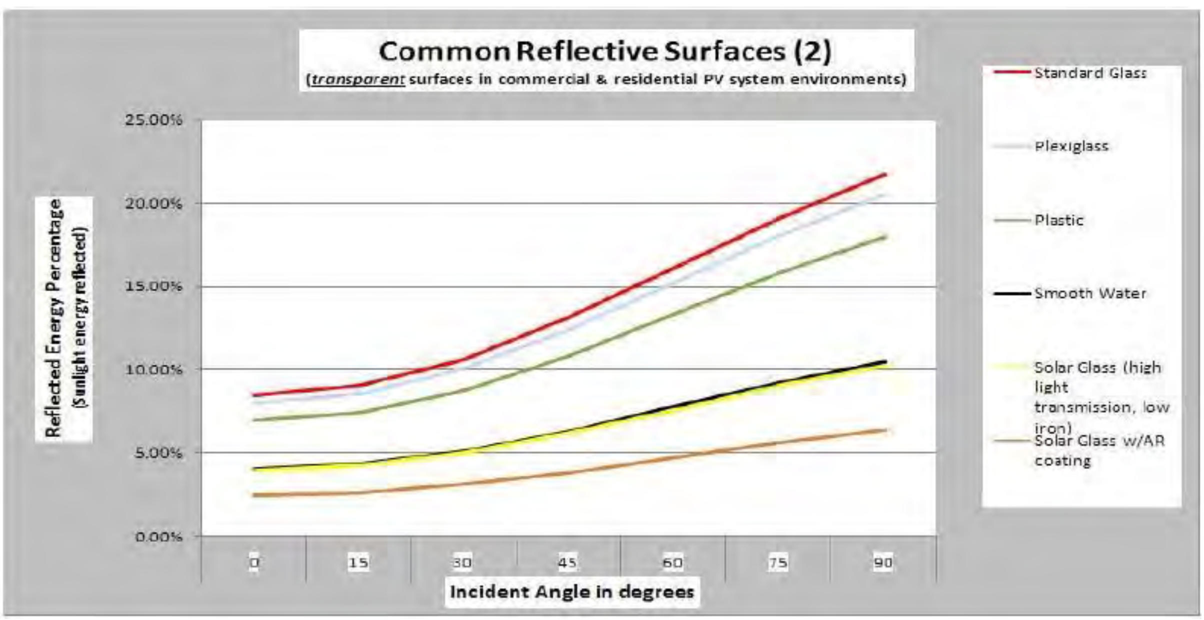
## DETAILED EXPLANATION:

In general, since the whole concept of efficient solar power is to absorb as much light as possible while reflecting as little light as possible, standard solar module produces less glare and reflectance than standard window glass. This is pointed out very well in US Patent #6359212 which explains the differences in the refraction and reflection of solar module glass versus standard window glass. Solar modules use "high-transmission, low iron glass" which absorbs more light, producing small amounts of glare and reflectance than normal glass.

In the graph below, we show the reflected energy percentages of sunlight, of some common residential and commercial surfaces. The legend and the graph lists the items from top to bottom in order of the highest percentage of reflected energy.




It should be noted that the reflected energy percentage of Solar Glass is far below that of a standard glass and more on the level of smooth water. Also, below are the ratios of the common reflective surfaces:




Light beam physics resolves that the least amount of light is reflected when the beam is the normal, in other words, least light energy is reflected when the beam is at 0 degrees to the normal. The chart below is a result of light beam physics calculations:

| Common Reflective Surfaces (in surrounding environments for PV systems) | | Incident angle in degrees | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 15 | 30 | 45 | 60 | 75 | 90 |
| Material Reflectivity (percent of incident light reflected) | Steel | 36.73% | 39.22% | 46.34% | 57.11% | 70.02% | 83.15% | 94.40% |
| | Snow (fresh, flakey) | 21.63% | 23.09% | 27.29% | 33.63% | 41.23% | 48.96% | 55.59% |
| | Standard Glass | 8.44% | 9.01% | 10.65% | 13.12% | 16.09% | 19.10% | 21.69% |
| | Plexiglass | 8.00% | 8.54% | 10.09% | 12.44% | 15.25% | 18.11% | 20.56% |
| | Plastic | 6.99% | 7.46% | 8.82% | 10.87% | 13.33% | 15.83% | 17.97% |
| | Smooth Water | 4.07% | 4.35% | 5.14% | 6.33% | 7.76% | 9.22% | 10.47% |
| | Solar Glass (high light transmission, low iron) | 3.99% | 4.26% | 5.03% | 6.20% | 7.61% | 9.03% | 10.26% |
| | Solar Glass w/AR coating | 2.47% | 2.64% | 3.12% | 3.84% | 4.71% | 5.59% | 6.35% |

(Note: Index of refraction values may vary slightly depending on suppliers and reference documentation. The values for the above calculations are averages or single values obtained from the list of references for this document).

Important reference – "Stipples glass": In addition to the superior refractive/reflective properties of solar glass versus standard glass, SunPower uses stippled solar glass for our modules. Stippled glass is used with high powered telescopes and powerful beacons and lights. The basic concept behind stippling is for the surfaces of the glass to be textured with small types of indentations. As a result, stippling allows more light energy to be channeled/ transmitted through the glass while diffusing the reflected lightenergy. This concept is why the reflection of off a SunPower solar module will look hazy and less-defined than the reflection from standard glass, this occurs because the stippled SunPower glass is transmitting a larger percentage of light to the solar cell while breaking up the intensity of the reflected light energy.

## SUMMARY/ACTION REQUIRED:

The studies, data and light beam physics behind the charts and graphs prove beyond a reasonable doubt that solar glass has less glare and reflectance than standard glass. The figures also make it clear that the difference is very decisive between solar glass and other common residential/commercial glasses. In addition, not to be lost in the standard light/glass equations and calculations, the SunPower solar glass is stippled and has a very photon-absorbent solar cell attached to the back side, contributing two additional factors which results in even less light energy being reflected.

## REGIONAL CONTACTS:

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

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