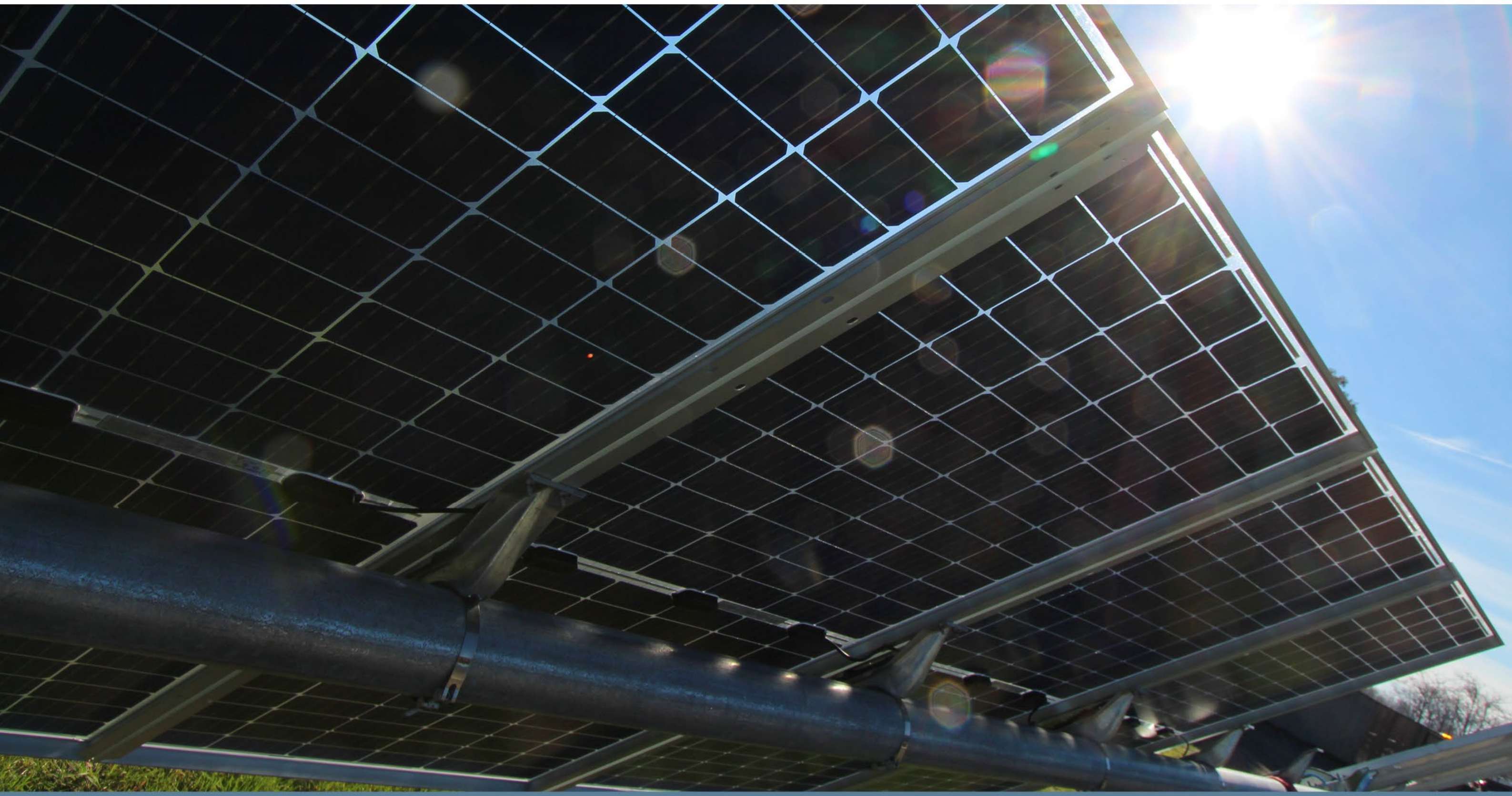
GLINT AND GLARE ASSESSMENT

SOUTHLANDS SOLAR FARM AND BATTERY STORAGE
LAND SOUTH OF RUNWELL ROAD (A132), RUNWELL, WICKFORD
P19-GG OCTOBER 2022



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1. EXECUTIVE SUMMARY

1.1. This assessment considers the potential impacts on ground-based receptors such as roads, rail and residential dwellings as well as aviation assets. A 1km study area around the Application Site is considered adequate for the assessment of ground-based receptors, whilst a 30km study area is chosen for aviation receptors. Within 1km of the Application Site, there are 144 residential receptors, including 12 residential areas, 55 road receptors and 14 rail 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 full assessment as the impacts will not vary to any significant degree. Where small groups of receptors have been evident, the receptors on either end of the group have been assessed in detail. 45 residential receptors, 19 road receptors and five rail receptors were dismissed as they are located within the no reflection zones. 12 aerodromes are located within the 30km study area; One of which, Southend Airport, required an assessment due to the Proposed Development falling within its respective safeguarding buffer zone, which are outlined in **paragraph 4.26**.

1.2. Geometric analysis was conducted at 99 individual residential receptors, including 11 residential areas, 36 road receptors and nine rail receptors, as well as two runway approach paths and an air traffic control tower at Southend Airport.

1.3. The assessment concludes that:

- Solar reflections are possible at none of the 99 residential receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **None** at all receptors.
- Solar reflections are possible at none of the 36 road receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **None** at all receptors.
- Solar reflections are possible at all none of the nine rail receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **None** at all receptors.
- No glare is predicted to impact the runway approach paths or air traffic control tower at Southend Airport. Therefore, the impact on aviation assets is **None**.

1.4. Mitigation is not required due to all impacts being **None**.

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

2. INTRODUCTION

BACKGROUND

2.1. Neo Environmental Ltd has been appointed by Enso Green Holdings J Limited (the "Applicant") to undertake a Glint and Glare Assessment for a proposed solar array development (the "Proposed Development") on lands south of Runwell Road (A132), Runwell, Essex (the "Application Site").

PROPOSED DEVELOPMENT DESCRIPTION

2.2. The Proposed Development will consist of the construction of PV panels mounted on metal frames, substation, transformers, inverters, batteries, spare parts containers, control room, access tracks, perimeter fencing with access gates and all ancillary grid infrastructure and associated works.

SITE DESCRIPTION

2.3. The Application Site is located south of Runwell Road (A132), Runwell, Essex. Centred at approximate Grid Reference N194652 E576740, the Application Site covers a total area of c. 59 hectares. and comprises two areas of land consisting of five fields. The Proposed Development will be accessed via existing roads from Runwell Road (A132).

SCOPE OF REPORT

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

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

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

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

- Appendix A: Figures
  - Figure 1: Residential Based Receptors
  - Figure 2: Road Based Receptors
  - Figure 3: Rail Based Receptors
  - Figure 4: Site Layout
  - Figure 5: Southend Airport Aerodrome Chart
- Appendix B: Residential Receptor Glare Results Group 1 (1 – 50)
- Appendix C: Residential Receptor Glare Results Group 2 (51 – 99)
- Appendix D: Road Receptor Glare Results
- Appendix E: Rail Receptor Glare Results
- Appendix F: Aviation Receptor Glare Results
- Appendix G: Solar Module Glare and Reflectance Technical Memo[1]

STATEMENT OF AUTHORITY

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

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

DEFINITIONS

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

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

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

General Nature of Reflectance from Photovoltaic Panels

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

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

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

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

Time Zones / Datum's

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

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

3. LEGISLATION AND GUIDANCE

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

3.1. Paragraph 013 (Reference ID: 5-013-20150327) sets out planning considerations that relate to large scale ground-mounted solar PV farms. This determines that the deployment of large-scale solar farms can have a negative impact on the rural environment, particularly in undulating landscapes. However, the visual impact of a well-planned and well-screened solar farm can be properly addressed within the landscape if planned sensitively. Considerations to be taken into account by local planning authorities are;

- *"the proposal's visual impact, the effect on landscape of glint and glare and on neighbouring uses and aircraft safety;*
- *the extent to which there may be additional impacts if solar arrays follow the daily movement of the sun."*

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."

INTERIM CAA GUIDANCE – SOLAR PHOTOVOLTAIC SYSTEMS (2010)

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

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

- ***Article 240*** *– Endangering safety of an aircraft – "A person must not recklessly or negligently act in a manner likely to endanger an aircraft, or any person in an aircraft."*
- ***Article 224*** *- Lights liable to endanger – "A person must not exhibit in the United Kingdom any light which:*
  - *a) by reason of its glare is liable to endanger aircraft taking off or from landing at an aerodrome; or*
  - *b) by reason of its liability to be mistaken for an aeronautical ground light liable to endanger aircraft"*
- ***Article 225*** *– Lights which dazzle or distract – "A person must not in the United Kingdom direct or shine any light at any aircraft in flight so as to dazzle or distract the pilot of the aircraft."*

3.5. Relevant studies generally agree that there is potential for glint and glare from photovoltaic panels to cause a hazard or nuisance for surrounding receptors, but that the intensity of such

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

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

reflections is similar to that emanating from still water. This is considerably lower than for other manmade materials such as glass, steel or white concrete (SunPower – 2009).

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

CAA – CAP738: SAFEGUARDING OF AERODROMES 3RD EDITION[8]

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

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

"Its purpose is to protect:

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

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

"Policy

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

2. In the United Kingdom there has been a further increase in SPV cells, including some located close to aerodrome boundaries; to date the CAA has not received any detrimental comments or issues of glare at these established sites. Whilst this early indication is encouraging, those responsible for safeguarding should remain vigilant to the possibility."

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

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

US Federal Aviation Administration Policy

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

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

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

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

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

- No potential for glint or glare in the existing or planned Air Traffic Control Tower (ATCT); and
- No potential for glare (glint) or "low potential for after-image" (Green Glare) along the final approach path for any existing or future runway landing thresholds (including planned or interim phases), as shown by the approved layout plan (ALP). The final

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

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

approach path is defined as 2 miles from 50 feet above the landing threshold using a standard 3-degree glide path.

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

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

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

> *"Initially, FAA believed that solar energy systems could introduce a novel glint and glare effect to pilots on final approach. FAA has subsequently concluded that in most cases, the glint and glare from solar energy systems to pilots on final approach is similar to glint and glare pilots routinely experience from water bodies, glass-façade buildings, parking lots, and similar features. However, FAA has continued to receive reports of potential glint and glare from on-airport solar energy systems on personnel working in ATCT cabs."*

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

Review of Local Plan

Chelmsford City Council Local Plan

3.18. The Chelmsford Local Plan 2013 - 2036[12] was adopted by the Council in May 2020.

3.19. The plan states in **Policy DM19 – Renewable and Low Carbon Energy** that:

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

[12] Chelmsford Local Plan 2013 - 2036, available at: https://www.chelmsford.gov.uk/planning-and-building-control/planning-policy-and-local-plan/adopted-local-plan/

'Planning permission will be granted for renewable or low carbon energy developments provided that they:

v. will not have a detrimental impact on highway safety.'

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. Since the assessment was carried out, an area of PV panels at the west of the Proposed Development has been removed from the design. The results of the assessment represent a worst-case scenario and impacts will be overestimated.

SUN POSITION AND REFLECTION MODEL

Sun Data Model

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

Solar Reflection Model

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

4.4. In order to determine if 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

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

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.

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 G** outlines the reflective properties of solar glass and compares it to other reflective surfaces. Although the exact figures in this report could be argued, it is included as a visual guide and it agrees with most other reports, in that solar glass has less reflective properties than other types of glass, bodies of water and snow, and that the amount of reflective energy drops as the angle of incidence decreases.

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

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

Determination of Ocular Impact

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

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

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

4.14. Green glare can be ignored when looking at ground based and some aviation receptors. Green glare does not cause temporary flash blindness and happens at an instant with very slight disturbance. As per FAA guidelines mitigation is only required for green glare when affecting

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

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.

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

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

Relevant Parameters of the Proposed Development

4.17. The photovoltaic panels will utilise a tracker system to rotate to track the movement of the sun throughout the day and during the year.

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

Identification of Receptors

Ground Based Receptors

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

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

4.21. An observer height of 2m was utilised for residential receptors, as this is a typical height for a ground-floor window. With regards to road users, a receptor height of 1.5m was employed as this is typical of eye level. Rail driver's eye level was assumed to be 2.75m above the rail for signal signing purposes and therefore this is the height used for assessment purposes.

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

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

Aviation

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

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

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

Magnitude of Impact

Static Receptors

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

- High - 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)

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

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

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

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

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

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

Moving Receptors (Aviation)

Approach Paths

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

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

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

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

Air Traffic Control Tower (ATCT)

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

4.36. The FAA guidance states that no 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.

Assessment Limitations

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

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

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

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

5. BASELINE CONDITIONS

GROUND BASED RECEPTORS REFLECTION ZONES

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

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

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

Residential Receptors

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

5.5. There are 45 residential receptors (Receptors 100 - 144) 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 (1)	575343	195356	Yes
2 (1)	575477	195260	Yes
3 (1)	575307	195223	Yes
4 (1)	575347	195155	Yes
5 (1)	575263	195046	Yes
6	575644	195127	Yes
7	575757	195129	Yes

8	575833	195123	Yes
9 (2)	575852	195484	Yes
10	575971	195414	Yes
11 (3)	575977	195304	Yes
12 (3)	576019	195353	Yes
13	576888	195105	Yes
14	576871	195087	Yes
15	576799	195069	Yes
16	576772	195087	Yes
17	576765	195057	Yes
18	576456	194975	Yes
19	576271	194951	Yes
20	576236	194946	Yes
21	576248	194924	Yes
22	576211	194905	Yes
23	576182	194888	Yes
24	576136	194873	Yes
25	576103	194868	Yes
26	576061	194862	Yes
27 (4)	576048	195156	Yes
28 (4)	576036	195056	Yes
29 (4)	576037	194953	Yes
30 (4)	575977	194887	Yes
31 (4)	575854	194848	Yes
32 (4)	575790	194816	Yes
33 (4)	575753	194770	Yes
34	575838	194747	Yes
35	575893	194787	Yes

36	575918	194812	Yes
37 (5)	575980	194786	Yes
38 (5)	576010	194747	Yes
39 (5)	575949	194764	Yes
40 (5)	575977	194732	Yes
41	575884	194690	Yes
42	575724	194653	Yes
43	575610	194592	Yes
44	575577	194567	Yes
45	575533	194591	Yes
46	575515	194563	Yes
47	575469	194548	Yes
48	575397	194581	Yes
49	575274	194850	Yes
50	575213	194895	Yes
51 (6)	575206	194721	Yes
52 (6)	575265	194607	Yes
53 (6)	575302	194536	Yes
54 (6)	575319	194443	Yes
55 (6)	575420	194457	Yes
56 (6)	575365	194405	Yes
57 (6)	575323	194349	Yes
58 (6)	575270	194260	Yes
59 (6)	575248	194100	Yes
60 (7)	575299	193956	Yes
61 (7)	575361	193879	Yes
62 (7)	575465	193982	Yes
63 (7)	575532	194038	Yes

64 (7)	575692	194039	Yes
65 (7)	575805	194070	Yes
66 (7)	575890	194031	Yes
67 (7)	576003	194005	Yes
68 (7)	576095	193951	Yes
69 (7)	576204	193923	Yes
70	576355	194266	Yes
71 (8)	577556	194350	Yes
72 (8)	577549	194381	Yes
73 (8)	577554	194420	Yes
74 (8)	577590	194453	Yes
75	578113	194516	Yes
76	578110	194616	Yes
77 (9)	578069	194583	Yes
78 (9)	577961	194592	Yes
79 (10)	578083	194700	Yes
80 (10)	578107	194758	Yes
81 (10)	578113	194824	Yes
82 (10)	578028	194793	Yes
83 (10)	577989	194706	Yes
84 (10)	577915	194777	Yes
85 (10)	577843	194767	Yes
86	577741	194788	Yes
87	577709	194811	Yes
88	577516	194624	Yes
89	577589	194634	Yes
90	577614	194655	Yes
91	577603	194675	Yes

92	577607	194735	Yes
93	577639	194787	Yes
94	577616	194834	Yes
95	577630	194845	Yes
96 (11)	577516	194896	Yes
97 (11)	577447	194969	Yes
98	577471	195097	Yes
99	577488	195141	Yes
100	577381	195366	No
101	577397	195367	No
102	577409	195375	No
103	577417	195388	No
104	577520	195433	No
105	577542	195442	No
106	577561	195459	No
107	577572	195464	No
108	577615	195506	No
109	577630	195469	No
110	577646	195477	No
111	577647	195504	No
112	577679	195581	No
113	577748	195641	No
114	577797	195666	No
115	577807	195677	No
116	577814	195684	No
117	577833	195690	No
118	577087	196004	No
119	577025	196006	No

120	577050	195988	No
121	577012	195898	No
122 (2)	576288	195850	No
123 (2)	576180	195831	No
124 (2)	576117	195757	No
125 (2)	576062	195723	No
126 (2)	576033	195661	No
127 (2)	575987	195627	No
128 (2)	575811	195652	No
129	576913	195135	No
130 (7)	576339	193917	No
131 (7)	576502	193902	No
132 (7)	576495	193837	No
133 (7)	576431	193803	No
134 (7)	576406	193728	No
135 (7)	576368	193664	No
136 (7)	576380	193573	No
137 (7)	576361	193484	No
138 (7)	576389	193414	No
139 (7)	576461	193349	No
140	576829	193236	No
141 (12)	577071	193305	No
142 (12)	577163	193286	No
143	577067	193486	No
144	576883	193845	No

5.6. The number in brackets indicates to which residential area the receptor belongs.

Road / Rail Receptors

5.7. There are six roads within the 1km study area that require a detailed Glint and Glare Assessment; Church End Lane, Runwell Road (A132), the A130, the A1245, Hawk Hill and Burnham 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	575147	194763	Yes
2	575249	194591	Yes
3	575144	194065	Yes
4	575233	194242	Yes
5	575324	194418	Yes
6	575474	194538	Yes
7	575653	194627	Yes
8	575812	194749	Yes
9	575974	194862	Yes
10	576129	194973	Yes
11	576286	195016	Yes
12	576483	194991	Yes
13	576683	195003	Yes
14	576882	195018	Yes
15	577142	194983	Yes
16	577190	194788	Yes
17	577230	194592	Yes

18	577259	194395	Yes
19	577277	194195	Yes
20	577295	193996	Yes
21	577979	193984	Yes
22	577793	194057	Yes
23	577624	194163	Yes
24	577482	194304	Yes
25	577367	194467	Yes
26	577286	194649	Yes
27	577259	194846	Yes
28	577290	195043	Yes
29	577433	195087	Yes
30	577528	194911	Yes
31	577637	194745	Yes
32	577827	194700	Yes
33	578026	194692	Yes
34	578155	194554	Yes
35	577760	195296	Yes
36	577958	195325	Yes
37	576589	195804	No
38	576718	195651	No
39	576847	195497	No
40	576970	195340	No
41	577045	195129	No
42	577195	195260	No
43	577368	195327	No
44	577562	195281	No
45	577293	195227	No

46	577303	195399	No
47	577314	195598	No
48	577267	195792	No
49	577191	195977	No
50	577516	195468	No
51	577693	195561	No
52	577854	195679	No
53	577312	193797	No
54	577330	193598	No
55	577340	193398	No

5.10. There is one railway line within the 1km study area which require a detailed assessment.

5.11. 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.

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

Table 5 - 3: Rail Based Receptors

Receptor	Easting	Northing	Glint and Glare Possible
1	575147	194763	Yes
2	575249	194591	Yes
3	575144	194065	Yes
4	575233	194242	Yes
5	575324	194418	Yes
6	575474	194538	Yes
7	575653	194627	Yes
8	575812	194749	Yes
9	575974	194862	Yes
10	576129	194973	Yes
11	576286	195016	Yes
12	576483	194991	Yes

13	576683	195003	Yes
14	576882	195018	Yes

Aviation Receptors

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

Table 5 - 4: Airfields within close proximity

Airfield	Distance	Use
Stow Maries	6.83km	Unlicensed small grass strip
Southend	10.64km	Licensed airport
West Horndon	14.28km	small grass strip
Thurrock	14.92km	small grass strip
North Weald	19.03km	Unlicensed concrete strip
Fyyfield	22.43km	small grass strip
Damyns Hall	22.78km	Unlicensed small grass strip
Gerpins Farm	23.63km	small grass strip
High Easter	24.44km	small grass strip
Stapleford	26.59km	Licensed aerodrome
Braintree Rayne	28.93km	small grass strip
Rochester	29.42km	Licensed aerodrome

5.14. There is one aerodrome, Southend Airport, which requires a detailed assessment due to this airfield being within its respective safeguarding buffer zone outlined in **paragraph 4.26.**

Southend Airport

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

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

Table 5 - 5: Runways at Southend Airport

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

5.17. The threshold location and height of the runway at Southend Airport are given in **Table 5 - 6**.

Table 5 - 6: Runway Threshold Locations and Heights

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

5.18. The ARP is located at the midpoint of Runway 05/23. The actual location of the ARP and ATCT is given in **Table 5 - 7**. The height of the ATCT is 32m.

Table 5 - 7: 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. Due to the limitations of the modelling software the residential receptors were split into two groups; Group 1 and Group 2. Group 1 contains residential receptors 1 – 50 and Group 2 contains residential receptors 51 – 99. As such, receptors in Group 2 are numbered as 1 – 49 in **Appendix C**.

6.3. **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.

6.4. The 45 receptors which were within the no-reflection zones outlined previously have been excluded from the detailed modelling as they will never receive any glint and glare impacts from the Proposed Development.

6.5. **Appendix B** and **C** show the analysis with the solar panels utilising a tracker system. **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
	AM	PM	Minutes	Hours	
1 (1)	No	No	0	0	None
2 (1)	No	No	0	0	None
3 (1)	No	No	0	0	None
4 (1)	No	No	0	0	None
5 (1)	No	No	0	0	None

6	No	No	0	0	None
7	No	No	0	0	None
8	No	No	0	0	None
9 (2)	No	No	0	0	None
10	No	No	0	0	None
11 (3)	No	No	0	0	None
12 (3)	No	No	0	0	None
13	No	No	0	0	None
14	No	No	0	0	None
15	No	No	0	0	None
16	No	No	0	0	None
17	No	No	0	0	None
18	No	No	0	0	None
19	No	No	0	0	None
20	No	No	0	0	None
21	No	No	0	0	None
22	No	No	0	0	None
23	No	No	0	0	None
24	No	No	0	0	None
25	No	No	0	0	None
26	No	No	0	0	None
27 (4)	No	No	0	0	None
28 (4)	No	No	0	0	None
29 (4)	No	No	0	0	None
30 (4)	No	No	0	0	None
31 (4)	No	No	0	0	None
32 (4)	No	No	0	0	None
33 (4)	No	No	0	0	None

34	No	No	0	0	None
35	No	No	0	0	None
36	No	No	0	0	None
37 (5)	No	No	0	0	None
38 (5)	No	No	0	0	None
39 (5)	No	No	0	0	None
40 (5)	No	No	0	0	None
41	No	No	0	0	None
42	No	No	0	0	None
43	No	No	0	0	None
44	No	No	0	0	None
45	No	No	0	0	None
46	No	No	0	0	None
47	No	No	0	0	None
48	No	No	0	0	None
49	No	No	0	0	None
50	No	No	0	0	None
51 (6)	No	No	0	0	None
52 (6)	No	No	0	0	None
53 (6)	No	No	0	0	None
54 (6)	No	No	0	0	None
55 (6)	No	No	0	0	None
56 (6)	No	No	0	0	None
57 (6)	No	No	0	0	None
58 (6)	No	No	0	0	None
59 (6)	No	No	0	0	None
60 (7)	No	No	0	0	None
61 (7)	No	No	0	0	None

62 (7)	No	No	0	0	None
63 (7)	No	No	0	0	None
64 (7)	No	No	0	0	None
65 (7)	No	No	0	0	None
66 (7)	No	No	0	0	None
67 (7)	No	No	0	0	None
68 (7)	No	No	0	0	None
69 (7)	No	No	0	0	None
70	No	No	0	0	None
71 (8)	No	No	0	0	None
72 (8)	No	No	0	0	None
73 (8)	No	No	0	0	None
74 (8)	No	No	0	0	None
75	No	No	0	0	None
76	No	No	0	0	None
77 (9)	No	No	0	0	None
78 (9)	No	No	0	0	None
79 (10)	No	No	0	0	None
80 (10)	No	No	0	0	None
81 (10)	No	No	0	0	None
82 (10)	No	No	0	0	None
83 (10)	No	No	0	0	None
84 (10)	No	No	0	0	None
85 (10)	No	No	0	0	None
86	No	No	0	0	None
87	No	No	0	0	None
88	No	No	0	0	None
89	No	No	0	0	None

90	No	No	0	0	None
91	No	No	0	0	None
92	No	No	0	0	None
93	No	No	0	0	None
94	No	No	0	0	None
95	No	No	0	0	None
96 (11)	No	No	0	0	None
97 (11)	No	No	0	0	None
98	No	No	0	0	None
99	No	No	0	0	None

6.6. As can be seen in **Table 6 - 1**, there is a **None** impact at all 99 receptors, including 11 residential areas. The number in brackets indicates to which residential area the receptor belongs. **Appendix B** shows detailed analysis of when the glare impacts are possible, whilst also showing which parts of the solar farm the solar glare is reflected from.

Road Receptors

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

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

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

Receptor	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)	Magnitude of Impact
1	0	0	0	None
2	0	0	0	None
3	0	0	0	None
4	0	0	0	None
5	0	0	0	None
6	0	0	0	None

7	0	0	0	None
8	0	0	0	None
9	0	0	0	None
10	0	0	0	None
11	0	0	0	None
12	0	0	0	None
13	0	0	0	None
14	0	0	0	None
15	0	0	0	None
16	0	0	0	None
17	0	0	0	None
18	0	0	0	None
19	0	0	0	None
20	0	0	0	None
21	0	0	0	None
22	0	0	0	None
23	0	0	0	None
24	0	0	0	None
25	0	0	0	None
26	0	0	0	None
27	0	0	0	None
28	0	0	0	None
29	0	0	0	None
30	0	0	0	None
31	0	0	0	None
32	0	0	0	None
33	0	0	0	None
34	0	0	0	None

35	0	0	0	None
36	0	0	0	None

6.9. As can be seen in **Table 6 - 2**, there are no receptor points which have potential glare impacts. **Appendix C** shows detailed analysis of when the glint and glare impacts are possible, whilst also showing from which parts of the solar farm the solar glare is reflected from.

Rail Receptors

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

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

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

Receptor	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)	Magnitude of Impact
1	0	0	0	None
2	0	0	0	None
3	0	0	0	None
4	0	0	0	None
5	0	0	0	None
6	0	0	0	None
7	0	0	0	None
8	0	0	0	None
9	0	0	0	None

6.12. As can be seen in **Table 6 - 3**, there is a **None** impact at all nine receptors. **Appendix E** 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.

Aviation Receptors

6.13. **Table 6 - 4** shows a summary of the modelling results for the runway approach paths as well as the ATCT whilst the detailed results and ocular impact charts can be viewed in **Appendix F**.

Table 6 - 4: Summary of Glare Results

Component	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)
Southend Airport			
Runway 05	0	0	0
Runway 23	0	0	0
ATCT	0	0	0

6.14. As can be seen in **Table 6 - 4**, no glare impacts are predicted on aviation assets. Therefore, impacts are **None**.

7. GROUND BASED RECEPTOR MITIGATION

7.1. Mitigation is not required due to all impacts being **None**.

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

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

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

20	None	None	None
21	None	None	None
22	None	None	None
23	None	None	None
24	None	None	None
25	None	None	None
26	None	None	None
27 (4)	None	None	None
28 (4)	None	None	None
29 (4)	None	None	None
30 (4)	None	None	None
31 (4)	None	None	None
32 (4)	None	None	None
33 (4)	None	None	None
34	None	None	None
35	None	None	None
36	None	None	None
37 (5)	None	None	None
38 (5)	None	None	None
39 (5)	None	None	None
40 (5)	None	None	None
41	None	None	None
42	None	None	None
43	None	None	None
44	None	None	None
45	None	None	None
46	None	None	None
47	None	None	None

48	None	None	None
49	None	None	None
50	None	None	None
51 (6)	None	None	None
52 (6)	None	None	None
53 (6)	None	None	None
54 (6)	None	None	None
55 (6)	None	None	None
56 (6)	None	None	None
57 (6)	None	None	None
58 (6)	None	None	None
59 (6)	None	None	None
60 (7)	None	None	None
61 (7)	None	None	None
62 (7)	None	None	None
63 (7)	None	None	None
64 (7)	None	None	None
65 (7)	None	None	None
66 (7)	None	None	None
67 (7)	None	None	None
68 (7)	None	None	None
69 (7)	None	None	None
70	None	None	None
71 (8)	None	None	None
72 (8)	None	None	None
73 (8)	None	None	None
74 (8)	None	None	None
75	None	None	None

76	None	None	None
77 (9)	None	None	None
78 (9)	None	None	None
79 (10)	None	None	None
80 (10)	None	None	None
81 (10)	None	None	None
82 (10)	None	None	None
83 (10)	None	None	None
84 (10)	None	None	None
85 (10)	None	None	None
86	None	None	None
87	None	None	None
88	None	None	None
89	None	None	None
90	None	None	None
91	None	None	None
92	None	None	None
93	None	None	None
94	None	None	None
95	None	None	None
96 (11)	None	None	None
97 (11)	None	None	None
98	None	None	None
99	None	None	None

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

	Magnitude of Impact		
Receptor	After Geometric Analysis	After Visibility Analysis	Residual Impacts
1	None	None	None
2	None	None	None
3	None	None	None
4	None	None	None
5	None	None	None
6	None	None	None
7	None	None	None
8	None	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
20	None	None	None
21	None	None	None
22	None	None	None
23	None	None	None
24	None	None	None

25	None	None	None
26	None	None	None
27	None	None	None
28	None	None	None
29	None	None	None
30	None	None	None
31	None	None	None
32	None	None	None
33	None	None	None
34	None	None	None
35	None	None	None
36	None	None	None

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

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

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

Table 7 - 4: Solar Reflections: Residential Receptors

Magnitude	Theoretical Visibility	Actual Visibility (No Mitigation)	Actual Visibility with Mitigation
High	0	0	0
Medium	0	0	0
Low	0	0	0
None	99	99	99

- **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

Table 7 - 5: Solar Reflections: Road Receptors

Magnitude	Theoretical Visibility	Actual Visibility (No Mitigation)	Actual Visibility with Mitigation
High	0	0	0
Medium	0	0	0
Low	0	0	0
None	36	36	36

- **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

Table 7 - 6: Solar Reflections: Rail Receptors

Magnitude	Theoretical Visibility	Actual Visibility (No Mitigation)	Actual Visibility with Mitigation
High	0	0	0
Medium	0	0	0
Low	0	0	0
None	9	9	9

- 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

8. SUMMARY

8.1. This assessment considers the potential impacts on ground-based receptors such as roads, rail and residential dwellings as well as aviation assets. A 1km study area around the Application Site is considered adequate for the assessment of ground-based receptors, whilst a 30km study area is chosen for aviation receptors. Within 1km of the Application Site, there are 144 residential receptors, including 12 residential areas, 55 road receptors and 14 rail 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 full assessment as the impacts will not vary to any significant degree. Where small groups of receptors have been evident, the receptors on either end of the group have been assessed in detail. 45 residential receptors, including one residential area, 19 road receptors and five rail receptors were dismissed as they are located within the no reflection zones. 12 aerodromes are located within the 30km study area; One of which, Southend Airport, required an assessment due to the Proposed Development falling within its respective safeguarding buffer zone, which are outlined in **paragraph 4.26**.

8.2. Geometric analysis was conducted at 99 individual residential receptors, including 11 residential areas, 36 road receptors and nine rail receptors, as well as two runway approach paths and an air traffic control tower at Southend Airport.

8.3. The assessment concludes that:

- Solar reflections are possible at none of the 99 residential receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **None** at all receptors.
- Solar reflections are possible at none of the 36 road receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **None** at all receptors.
- Solar reflections are possible at all none of the nine rail receptors assessed within the 1km study area. The initial bald-earth scenario identified potential impacts as **None** at all receptors.
- No glare is predicted to impact the runway approach paths or air traffic control tower at Southend Airport. Therefore, the impact on aviation assets is **None**.

8.4. Mitigation is not required due to all impacts being **None**.

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

9. APPENDICES

Appendix A: Figures

- Figure 1: Residential Based Receptors
- Figure 2: Road Based Receptors
- Figure 3: Rail Based Receptors
- Figure 4: Site Layout
- Figure 5: Southend Airport Aerodrome Chart

Appendix B: Residential Receptor Glare Results Group 1 (1 -50)

Appendix C: Residential Receptor Glare Results Group 2 (51 – 99)

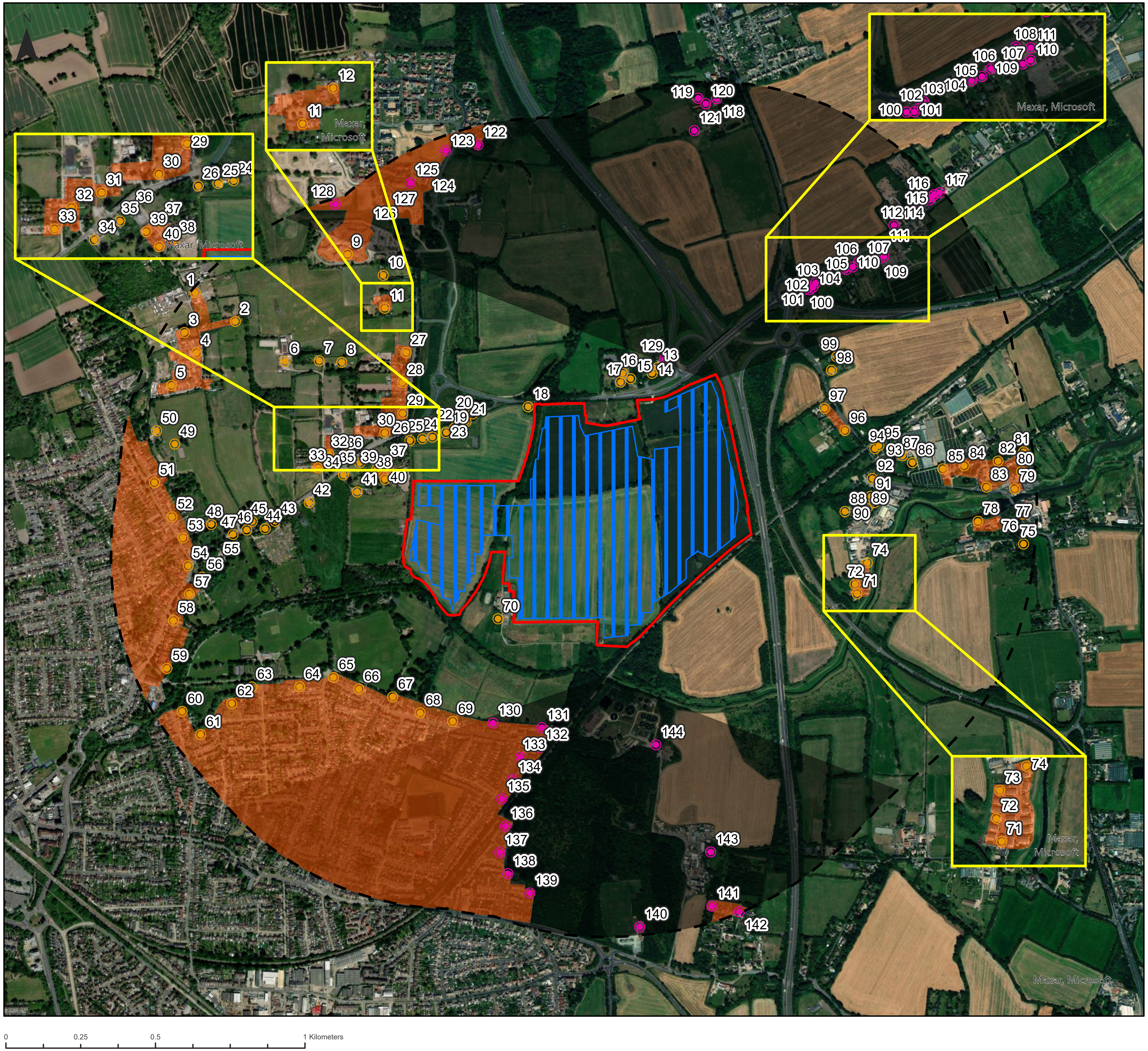
Appendix D: Road Receptor Glare Results

Appendix E: Rail Receptor Glare Results

Appendix F: Aviation Receptor Glare Results

Appendix G: Solar Module Glare and Reflectance Technical Memo[16]

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

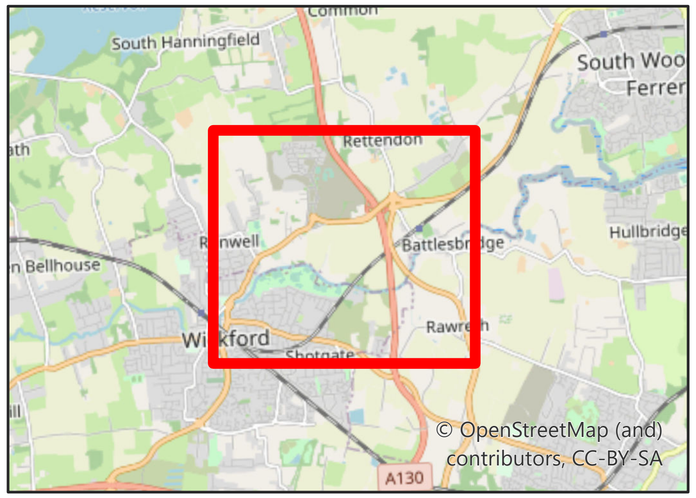


Southlands Solar Farm
Residential Based Receptors
Figure 1

Key

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

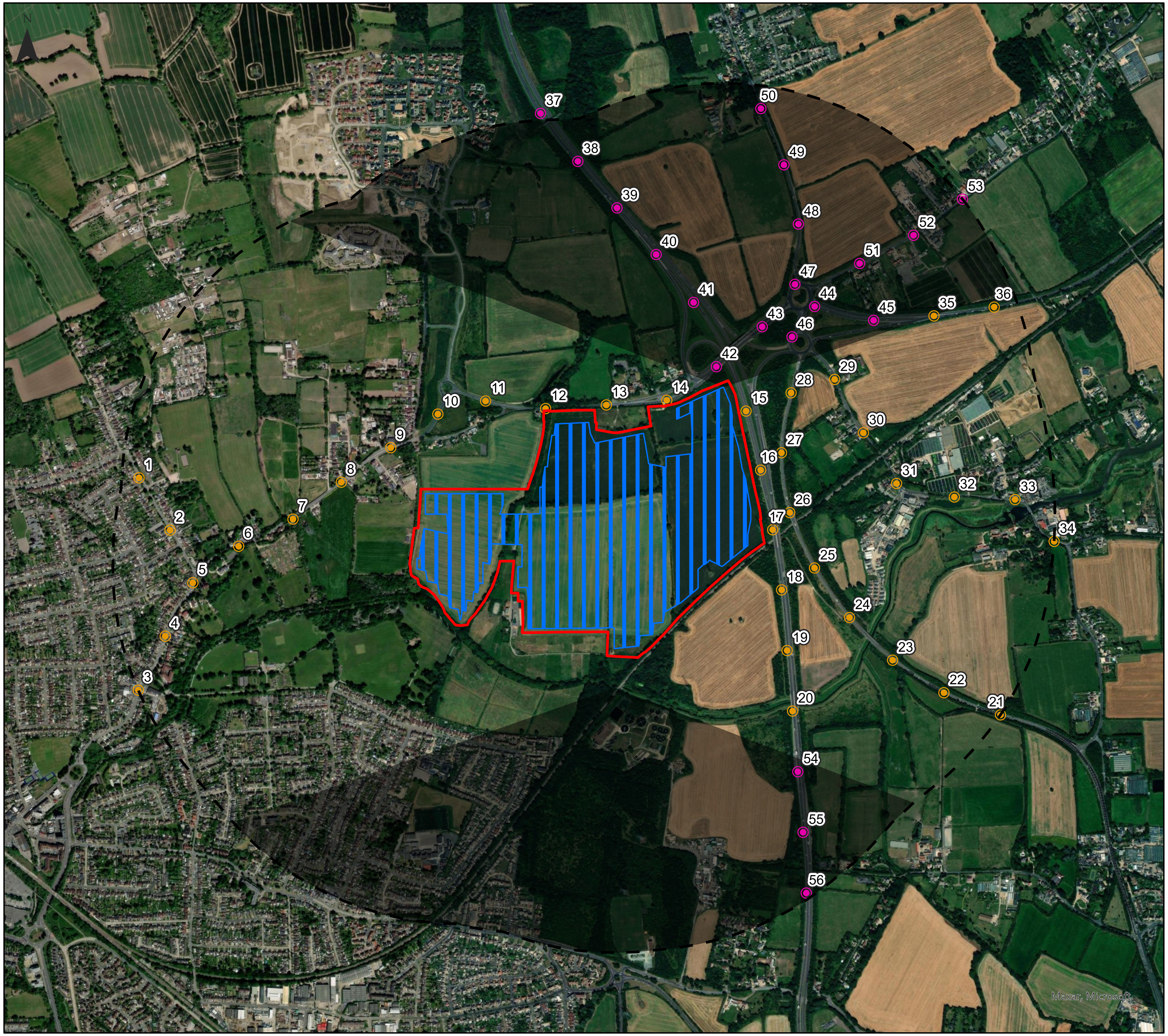
Neo Office Address:
Wright Business Centre, 1 Lonmay Road, Glasgow, G33 4EL



Date: 07/09/2022
Drawn By: Scott Griffin
Scale (A3): 1:12,500
Drawing No: NEO01074/001I/B

NEO ENVIRONMENTAL

Southlands Solar Farm
Road Based Receptors
Figure 2

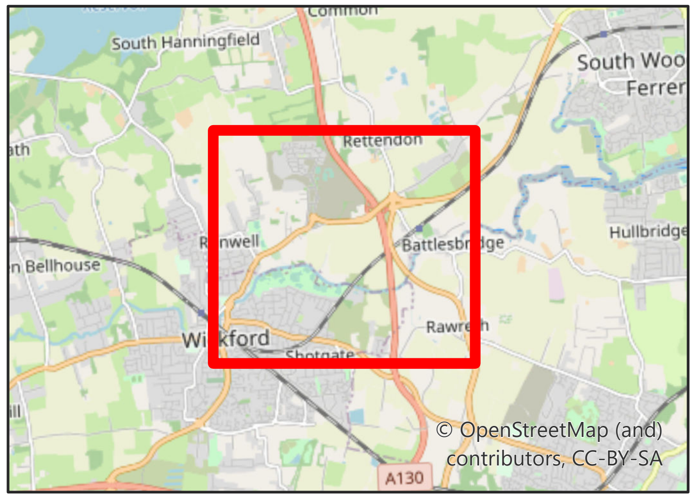


0 0.25 0.5 1 Kilometers

Key

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

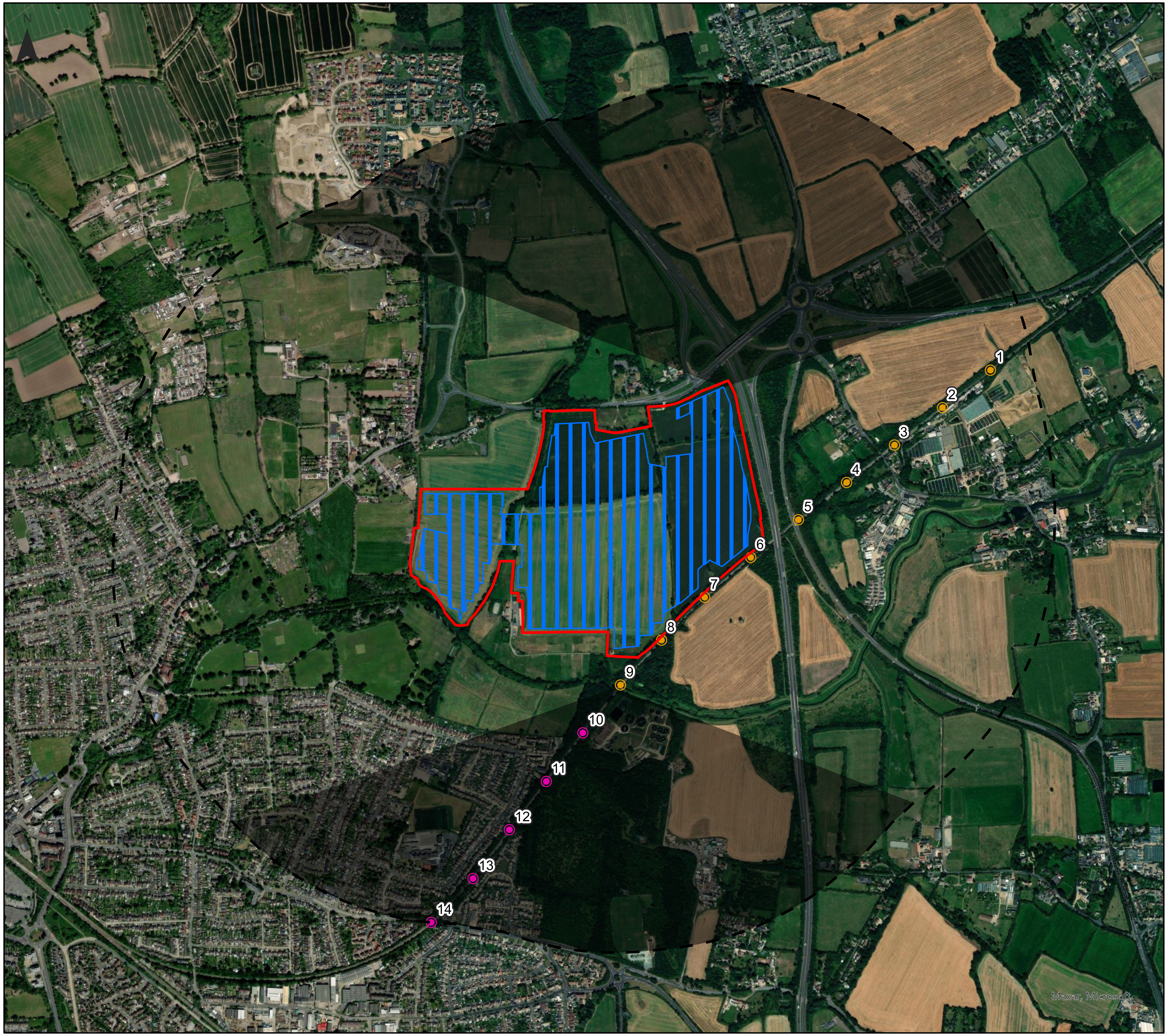
Neo Office Address:
Wright Business Centre, 1 Lonmay Road, Glasgow, G33 4EL



Date: 07/09/2022
Drawn By: Scott Griffin
Scale (A3): 1:12,500
Drawing No: NEO01074/002I/B

NEO ENVIRONMENTAL

Southlands Solar Farm
Rail Based Receptors
Figure 3

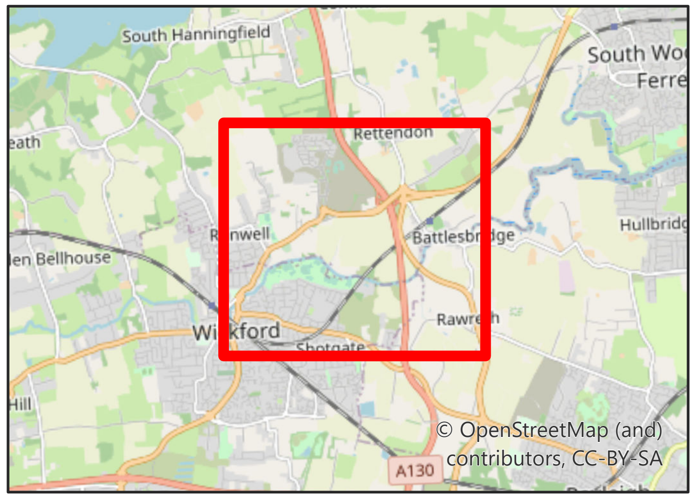


0 0.25 0.5 1 Kilometers

Key

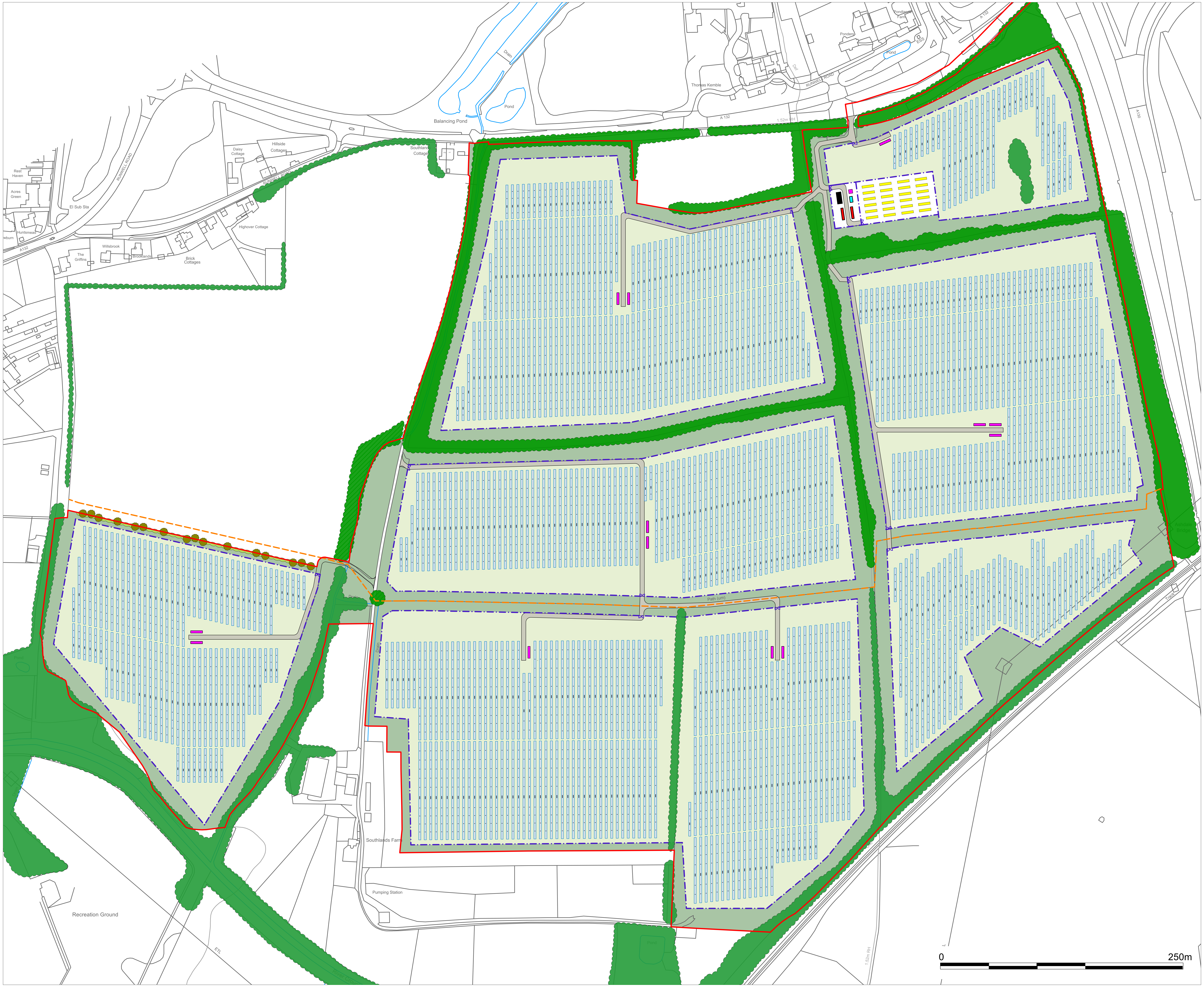
- Development Boundary
- Panel Boundary
- 1km Study Area
- Glare Not Possible at Receptor
- Glare Possible at Receptor
- Non-Reflection Zones

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



Date: 07/09/2022
Drawn By: Scott Griffin
Scale (A3): 1:12,500
Drawing No: NEO01074/003I/B

ENVIRONMENTAL



KEY

- Site Boundary
- Security Fence
- Access Track
- PV Modules
- 33kV Subststion
- Transformer
- Security Gate
- Inverter
- Batteries
- Spare Parts Container
- Control Room
- Existing Vegetation
- Species Rich Grassland
- Field Margin Planting
- Proposed Hedgerow
- Proposed Tree Planting

N

Revisions:
First Issue- 04/08/2022 JS
01 - (06/09/2022 JS) Revised layout and planting added
02 - (04/10/2022 JS Revised layout, boundary and planting

ALL DIMENSIONS TO BE CHECKED ON SITE WORK TO FIGURED DIMENSIONS ONLY REPORT DISCREPANCIES TO THE GFP AT ONCE BEFORE PROCEEDING COPYRIGHT ACT APPLIES.

enso energy

Enso Energy Limited, Unit 1 & 2 Cirencester Office Park, Tetbury Road, Cirencester, GL7 6JJ
Tel: 01452 764685 Email: enquiries@ensoenergy.co.uk

Project Title: Southlands Solar Farm		
Drawing Title: Proposed Site Plan		
DRWG No: RC3-02-P02	Rev: 02	Sht no: -
Drawn by : JS	Checked by: RM	
Scale: 1:2500 @ A2	Date: 04/10/2022	

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

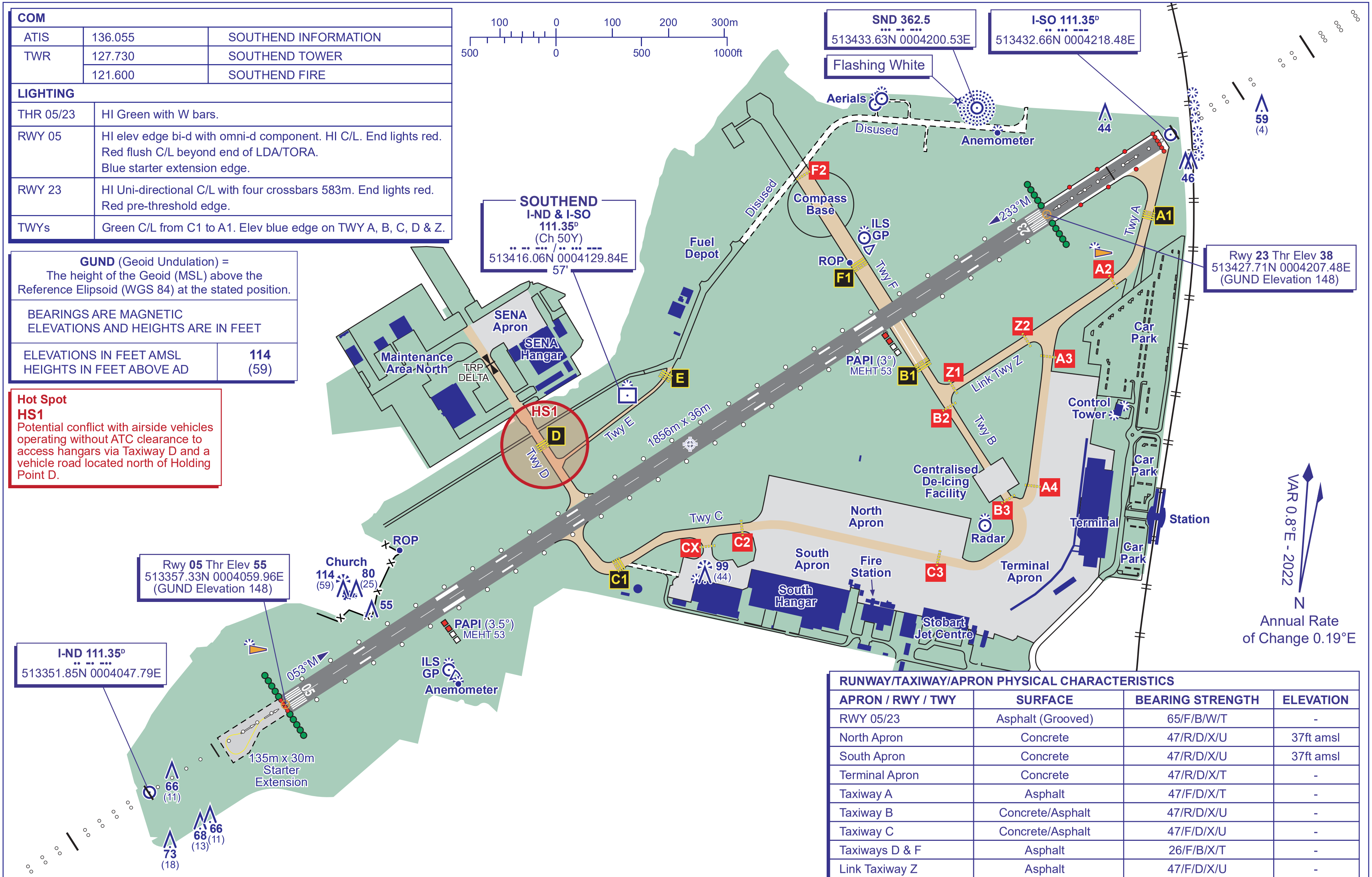
LIGHTING	
THR 05/23	HI Green with W bars.
RWY 05	HI elev edge bi-d with omni-d component. HI C/L. End lights red. Red flush C/L beyond end of LDA/TORA. Blue starter extension edge.
RWY 23	HI Uni-directional C/L with four crossbars 583m. End lights red. Red pre-threshold edge.
TWYs	Green C/L from C1 to 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 HEIGHTS IN FEET ABOVE AD	**114** (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.

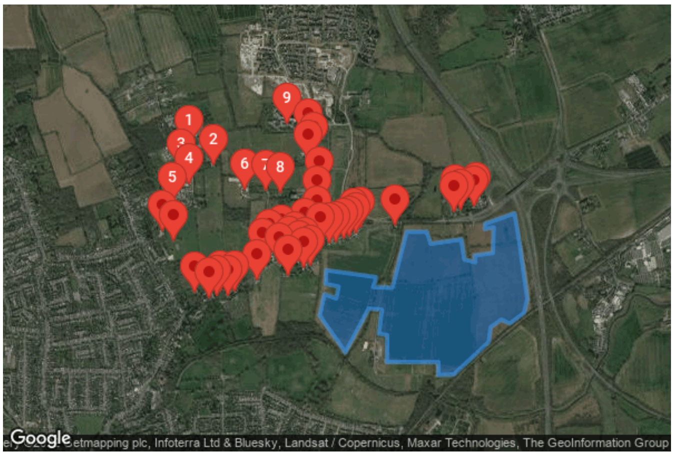
ForgeSolar

Southlands Solar Farm

Southlands Solar Farm Residential Group 1

Created Sept. 8, 2022
Updated Sept. 9, 2022
Time-step 1 minute
Timezone offset UTC0
Site ID 75475.13344

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



Misc. Analysis Settings

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

Analysis Methodologies:
- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

Summary of Results No glare predicted!

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	SA tracking	SA tracking	0	0	-

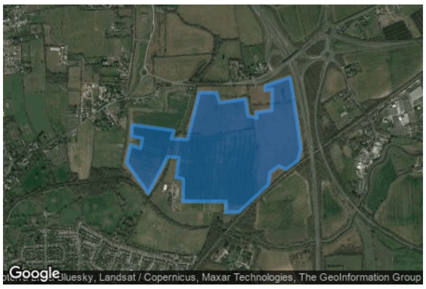
Component Data

PV Array(s)

Total PV footprint area: 512,934 m^2

Name: PV array 1
Footprint area: 512,934 m^2
Axis tracking: Single-axis rotation
Backtracking: None
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 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	51.626083	0.555031	22.65	3.00	25.65
2	51.626523	0.557048	15.51	3.00	18.51
3	51.625683	0.557284	13.75	3.00	16.75
4	51.624911	0.557477	12.61	3.00	15.61
5	51.622433	0.558035	10.52	3.00	13.52
6	51.621767	0.557777	10.88	3.00	13.88
7	51.621261	0.556683	11.85	3.00	14.85
8	51.621447	0.556018	13.60	3.00	16.60
9	51.621087	0.555202	13.44	3.00	16.44
10	51.620381	0.555052	11.42	3.00	14.42
11	51.618832	0.552358	7.42	3.00	10.42
12	51.618806	0.551156	6.28	3.00	9.28
13	51.619418	0.551167	7.80	3.00	10.80
14	51.619425	0.547176	7.86	3.00	10.86
15	51.620711	0.547219	12.76	3.00	15.76
16	51.620777	0.546575	9.94	3.00	12.94
17	51.621923	0.546811	9.59	3.00	12.59
18	51.621976	0.545803	7.42	3.00	10.42
19	51.619898	0.544000	4.51	3.00	7.51
20	51.621643	0.542005	8.60	3.00	11.60
21	51.622660	0.542381	12.59	3.00	15.59
22	51.622467	0.543293	13.55	3.00	16.55
23	51.623027	0.543475	14.76	3.00	17.76
24	51.623153	0.542456	13.78	3.00	16.78
25	51.623813	0.542521	15.53	3.00	18.53
26	51.623486	0.546351	9.60	3.00	12.60
27	51.623246	0.546286	8.89	3.00	11.89
28	51.623013	0.546136	8.68	3.00	11.68
29	51.622973	0.547617	12.53	3.00	15.53
30	51.625644	0.548711	11.78	3.00	14.78
31	51.625644	0.550278	19.86	3.00	22.86
32	51.625071	0.550578	21.99	3.00	24.99
33	51.625284	0.552938	23.46	3.00	26.46
34	51.624325	0.553174	22.23	3.00	25.23
35	51.624192	0.554011	21.78	3.00	24.78
36	51.624512	0.553947	21.87	3.00	24.87
37	51.624632	0.555363	19.02	3.00	22.02
38	51.625857	0.555427	21.19	3.00	24.19
39	51.625764	0.554741	21.85	3.00	24.85
40	51.626029	0.554773	22.68	3.00	25.68

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	51.629710	0.532015	29.11	2.00	31.11
OP 2	51.628777	0.533882	26.88	2.00	28.88
OP 3	51.628544	0.531404	19.81	2.00	21.81
OP 4	51.627892	0.531994	18.49	2.00	20.49
OP 5	51.626966	0.530696	18.04	2.00	20.04
OP 6	51.627582	0.536258	25.96	2.00	27.96
OP 7	51.627535	0.537872	26.24	2.00	28.24
OP 8	51.627472	0.539009	26.02	2.00	28.02
OP 9	51.630762	0.539524	19.46	2.00	21.46
OP 10	51.630029	0.541144	19.78	2.00	21.78
OP 11	51.629004	0.541155	22.50	2.00	24.50
OP 12	51.629370	0.541606	20.60	2.00	22.60
OP 13	51.626979	0.554142	25.57	2.00	27.57
OP 14	51.626786	0.553944	25.10	2.00	27.10
OP 15	51.626653	0.552908	24.97	2.00	26.97
OP 16	51.626849	0.552511	23.79	2.00	25.79
OP 17	51.626523	0.552399	24.23	2.00	26.23
OP 18	51.625903	0.547882	11.89	2.00	13.89
OP 19	51.625781	0.545199	18.51	2.00	20.51
OP 20	51.625742	0.544681	19.86	2.00	21.86
OP 21	51.625524	0.544872	18.39	2.00	20.39
OP 22	51.625381	0.544370	19.11	2.00	21.11
OP 23	51.625240	0.543909	19.96	2.00	21.96
OP 24	51.625100	0.543289	19.14	2.00	21.14
OP 25	51.625070	0.542780	19.93	2.00	21.93
OP 26	51.625030	0.542136	21.27	2.00	23.27
OP 27	51.627691	0.542050	24.29	2.00	26.29
OP 28	51.626818	0.541862	24.36	2.00	26.36
OP 29	51.625839	0.541809	23.65	2.00	25.65
OP 30	51.625273	0.540897	19.58	2.00	21.58
OP 31	51.624966	0.539137	13.93	2.00	15.93
OP 32	51.624720	0.538150	12.21	2.00	14.21
OP 33	51.624294	0.537646	10.74	2.00	12.74
OP 34	51.624071	0.538917	10.96	2.00	12.96
OP 35	51.624404	0.539690	13.44	2.00	15.44
OP 36	51.624610	0.540098	13.81	2.00	15.81
OP 37	51.624370	0.540945	16.32	2.00	18.32
OP 38	51.624001	0.541358	15.99	2.00	17.99
OP 39	51.624197	0.540446	14.68	2.00	16.68
OP 40	51.623861	0.540854	15.22	2.00	17.22
OP 41	51.623525	0.539585	11.82	2.00	13.82
OP 42	51.623296	0.537246	8.34	2.00	10.34
OP 43	51.622743	0.535502	9.22	2.00	11.22
OP 44	51.622556	0.534998	8.90	2.00	10.90
OP 45	51.622753	0.534424	9.47	2.00	11.47
OP 46	51.622526	0.534092	9.46	2.00	11.46
OP 47	51.622416	0.533507	10.92	2.00	12.92
OP 48	51.622719	0.532370	9.83	2.00	11.83
OP 49	51.625181	0.530744	16.30	2.00	18.30
OP 50	51.625620	0.529929	18.05	2.00	20.05

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	SA tracking	SA tracking	0	0	-	

PV & Receptor Analysis Results

Results for each PV array and receptor

PV array 1 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	0
OP: OP 15	0	0
OP: OP 16	0	0
OP: OP 17	0	0
OP: OP 18	0	0
OP: OP 19	0	0
OP: OP 20	0	0
OP: OP 21	0	0
OP: OP 22	0	0
OP: OP 23	0	0
OP: OP 24	0	0
OP: OP 25	0	0
OP: OP 26	0	0
OP: OP 27	0	0
OP: OP 28	0	0
OP: OP 29	0	0
OP: OP 30	0	0
OP: OP 31	0	0
OP: OP 32	0	0
OP: OP 33	0	0
OP: OP 34	0	0
OP: OP 35	0	0
OP: OP 36	0	0
OP: OP 37	0	0
OP: OP 38	0	0
OP: OP 39	0	0
OP: OP 40	0	0
OP: OP 41	0	0
OP: OP 42	0	0
OP: OP 43	0	0
OP: OP 44	0	0
OP: OP 45	0	0
OP: OP 46	0	0
OP: OP 47	0	0
OP: OP 48	0	0
OP: OP 49	0	0
OP: OP 50	0	0

No glare found

Assumptions

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

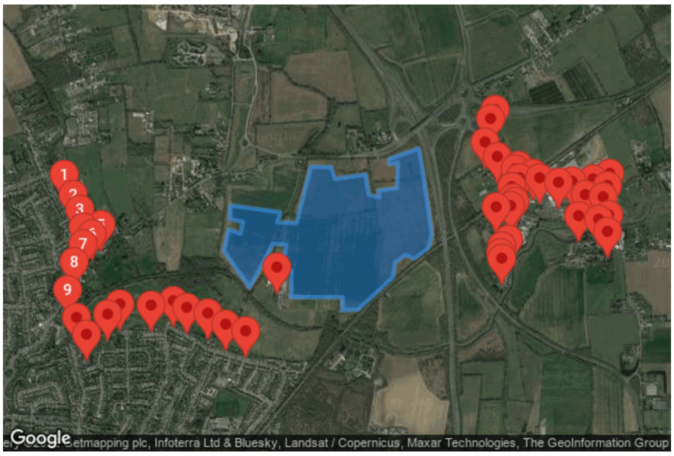
ForgeSolar

Southlands Solar Farm

Southlands Solar Farm Residential Group 2

Created Sept. 9, 2022
Updated Sept. 9, 2022
Time-step 1 minute
Timezone offset UTC0
Site ID 75517.13344

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



Misc. Analysis Settings

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

Analysis Methodologies:
- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

Summary of Results No glare predicted!

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	SA tracking	SA tracking	0	0	-

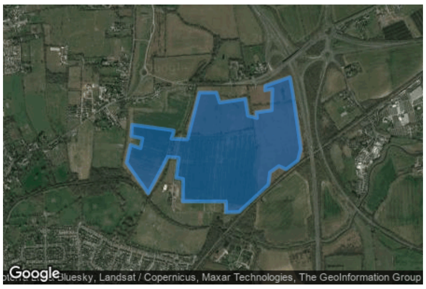
Component Data

PV Array(s)

Total PV footprint area: 512,934 m^2

Name: PV array 1
Footprint area: 512,934 m^2
Axis tracking: Single-axis rotation
Backtracking: None
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 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	51.626083	0.555031	22.65	3.00	25.65
2	51.626523	0.557048	15.51	3.00	18.51
3	51.625683	0.557284	13.75	3.00	16.75
4	51.624911	0.557477	12.61	3.00	15.61
5	51.622433	0.558035	10.52	3.00	13.52
6	51.621767	0.557777	10.88	3.00	13.88
7	51.621261	0.556683	11.85	3.00	14.85
8	51.621447	0.556018	13.60	3.00	16.60
9	51.621087	0.555202	13.44	3.00	16.44
10	51.620381	0.555052	11.42	3.00	14.42
11	51.618832	0.552358	7.42	3.00	10.42
12	51.618806	0.551156	6.28	3.00	9.28
13	51.619418	0.551167	7.80	3.00	10.80
14	51.619425	0.547176	7.86	3.00	10.86
15	51.620711	0.547219	12.76	3.00	15.76
16	51.620777	0.546575	9.94	3.00	12.94
17	51.621923	0.546811	9.59	3.00	12.59
18	51.621976	0.545803	7.42	3.00	10.42
19	51.619898	0.544000	4.51	3.00	7.51
20	51.621643	0.542005	8.60	3.00	11.60
21	51.622660	0.542381	12.59	3.00	15.59
22	51.622467	0.543293	13.55	3.00	16.55
23	51.623027	0.543475	14.76	3.00	17.76
24	51.623153	0.542456	13.78	3.00	16.78
25	51.623813	0.542521	15.53	3.00	18.53
26	51.623486	0.546351	9.60	3.00	12.60
27	51.623246	0.546286	8.89	3.00	11.89
28	51.623013	0.546136	8.68	3.00	11.68
29	51.622973	0.547617	12.53	3.00	15.53
30	51.625644	0.548711	11.78	3.00	14.78
31	51.625644	0.550278	19.86	3.00	22.86
32	51.625071	0.550578	21.99	3.00	24.99
33	51.625284	0.552938	23.46	3.00	26.46
34	51.624325	0.553174	22.23	3.00	25.23
35	51.624192	0.554011	21.78	3.00	24.78
36	51.624512	0.553947	21.87	3.00	24.87
37	51.624632	0.555363	19.02	3.00	22.02
38	51.625857	0.555427	21.19	3.00	24.19
39	51.625764	0.554741	21.85	3.00	24.85
40	51.626029	0.554773	22.68	3.00	25.68

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	51.623985	0.529736	11.84	2.00	13.84
OP 2	51.623002	0.530465	10.95	2.00	12.95
OP 3	51.622356	0.530975	10.82	2.00	12.82
OP 4	51.621494	0.531222	11.87	2.00	13.87
OP 5	51.621564	0.532590	12.02	2.00	14.02
OP 6	51.621134	0.531865	12.21	2.00	14.21
OP 7	51.620678	0.531200	11.86	2.00	13.86
OP 8	51.619844	0.530525	9.62	2.00	11.62
OP 9	51.618502	0.529999	8.54	2.00	10.54
OP 10	51.617140	0.530664	9.60	2.00	11.60
OP 11	51.616367	0.531474	13.52	2.00	15.52
OP 12	51.617323	0.533062	12.82	2.00	14.82
OP 13	51.617782	0.534033	11.31	2.00	13.31
OP 14	51.617756	0.536442	11.83	2.00	13.83
OP 15	51.617959	0.538132	11.58	2.00	13.58
OP 16	51.617626	0.539226	11.14	2.00	13.14
OP 17	51.617356	0.540857	9.31	2.00	11.31
OP 18	51.616843	0.542209	10.34	2.00	12.34
OP 19	51.616527	0.543753	10.01	2.00	12.01
OP 20	51.619568	0.546125	9.70	2.00	11.70
OP 21	51.619975	0.563470	5.51	2.00	7.51
OP 22	51.620242	0.563374	6.17	2.00	8.17
OP 23	51.620595	0.563470	5.42	2.00	7.42
OP 24	51.620895	0.563975	6.10	2.00	8.10
OP 25	51.621254	0.571597	5.96	2.00	7.96
OP 26	51.622044	0.571742	5.10	2.00	7.10
OP 27	51.621877	0.570981	5.17	2.00	7.17
OP 28	51.621995	0.569425	4.25	2.00	6.25
OP 29	51.622915	0.571276	4.98	2.00	6.98
OP 30	51.623427	0.571635	4.63	2.00	6.63
OP 31	51.624037	0.571764	4.41	2.00	6.41
OP 32	51.623787	0.570525	5.84	2.00	7.84
OP 33	51.623014	0.569908	5.20	2.00	7.20
OP 34	51.623681	0.568888	6.17	2.00	8.17
OP 35	51.623594	0.567842	7.22	2.00	9.22
OP 36	51.623804	0.566383	7.22	2.00	9.22
OP 37	51.624034	0.565874	7.36	2.00	9.36
OP 38	51.622452	0.563030	5.20	2.00	7.20
OP 39	51.622508	0.564125	5.43	2.00	7.43
OP 40	51.622685	0.564468	5.08	2.00	7.08
OP 41	51.622855	0.564296	5.57	2.00	7.57
OP 42	51.623394	0.564286	5.71	2.00	7.71
OP 43	51.623837	0.564892	7.58	2.00	9.58
OP 44	51.624260	0.564511	8.57	2.00	10.57
OP 45	51.624387	0.564747	8.35	2.00	10.35
OP 46	51.624846	0.563159	11.53	2.00	13.53
OP 47	51.625546	0.562220	15.23	2.00	17.23
OP 48	51.626661	0.562617	23.75	2.00	25.75
OP 49	51.627087	0.562929	26.08	2.00	28.08

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	SA tracking	SA tracking	0	0	-	

PV & Receptor Analysis Results

Results for each PV array and receptor

PV array 1 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	0
OP: OP 15	0	0
OP: OP 16	0	0
OP: OP 17	0	0
OP: OP 18	0	0
OP: OP 19	0	0
OP: OP 20	0	0
OP: OP 21	0	0
OP: OP 22	0	0
OP: OP 23	0	0
OP: OP 24	0	0
OP: OP 25	0	0
OP: OP 26	0	0
OP: OP 27	0	0
OP: OP 28	0	0
OP: OP 29	0	0
OP: OP 30	0	0
OP: OP 31	0	0
OP: OP 32	0	0
OP: OP 33	0	0
OP: OP 34	0	0
OP: OP 35	0	0
OP: OP 36	0	0
OP: OP 37	0	0
OP: OP 38	0	0
OP: OP 39	0	0
OP: OP 40	0	0
OP: OP 41	0	0
OP: OP 42	0	0
OP: OP 43	0	0
OP: OP 44	0	0
OP: OP 45	0	0
OP: OP 46	0	0
OP: OP 47	0	0
OP: OP 48	0	0
OP: OP 49	0	0

No glare found

Assumptions

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

ForgeSolar

Southlands Solar Farm

Southlands Solar Farm Road

Created Sept. 8, 2022
Updated Sept. 9, 2022
Time-step 1 minute
Timezone offset UTC0
Site ID 75474.13344

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

Misc. Analysis Settings

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

Analysis Methodologies:
- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

Summary of Results No glare predicted!

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	SA tracking	SA tracking	0	0	-

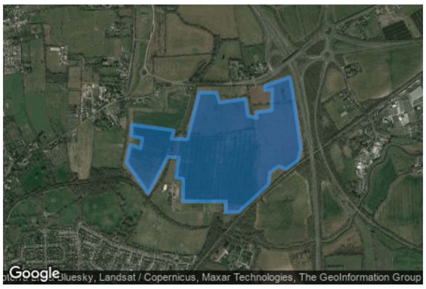
Component Data

PV Array(s)

Total PV footprint area: 512,934 m^2

Name: PV array 1
Footprint area: 512,934 m^2
Axis tracking: Single-axis rotation
Backtracking: None
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 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	51.626083	0.555031	22.65	3.00	25.65
2	51.626523	0.557048	15.51	3.00	18.51
3	51.625683	0.557284	13.75	3.00	16.75
4	51.624911	0.557477	12.61	3.00	15.61
5	51.622433	0.558035	10.52	3.00	13.52
6	51.621767	0.557777	10.88	3.00	13.88
7	51.621261	0.556683	11.85	3.00	14.85
8	51.621447	0.556018	13.60	3.00	16.60
9	51.621087	0.555202	13.44	3.00	16.44
10	51.620381	0.555052	11.42	3.00	14.42
11	51.618832	0.552358	7.42	3.00	10.42
12	51.618806	0.551156	6.28	3.00	9.28
13	51.619418	0.551167	7.80	3.00	10.80
14	51.619425	0.547176	7.86	3.00	10.86
15	51.620711	0.547219	12.76	3.00	15.76
16	51.620777	0.546575	9.94	3.00	12.94
17	51.621923	0.546811	9.59	3.00	12.59
18	51.621976	0.545803	7.42	3.00	10.42
19	51.619898	0.544000	4.51	3.00	7.51
20	51.621643	0.542005	8.60	3.00	11.60
21	51.622660	0.542381	12.59	3.00	15.59
22	51.622467	0.543293	13.55	3.00	16.55
23	51.623027	0.543475	14.76	3.00	17.76
24	51.623153	0.542456	13.78	3.00	16.78
25	51.623813	0.542521	15.53	3.00	18.53
26	51.623486	0.546351	9.60	3.00	12.60
27	51.623246	0.546286	8.89	3.00	11.89
28	51.623013	0.546136	8.68	3.00	11.68
29	51.622973	0.547617	12.53	3.00	15.53
30	51.625644	0.548711	11.78	3.00	14.78
31	51.625644	0.550278	19.86	3.00	22.86
32	51.625071	0.550578	21.99	3.00	24.99
33	51.625284	0.552938	23.46	3.00	26.46
34	51.624325	0.553174	22.23	3.00	25.23
35	51.624192	0.554011	21.78	3.00	24.78
36	51.624512	0.553947	21.87	3.00	24.87
37	51.624632	0.555363	19.02	3.00	22.02
38	51.625857	0.555427	21.19	3.00	24.19
39	51.625764	0.554741	21.85	3.00	24.85
40	51.626029	0.554773	22.68	3.00	25.68

Discrete Observation Receptors

Number	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total Elevation m
OP 1	51.624442	0.529010	11.43	1.50	12.93
OP 2	51.622844	0.530351	9.94	1.50	11.44
OP 3	51.618194	0.528581	6.21	1.50	7.71
OP 4	51.619749	0.529933	6.18	1.50	7.68
OP 5	51.621302	0.531333	10.80	1.50	12.30
OP 6	51.622297	0.533431	10.85	1.50	12.35
OP 7	51.623183	0.536306	7.45	1.50	8.95
OP 8	51.624079	0.538489	9.53	1.50	11.03
OP 9	51.625121	0.541263	19.62	1.50	21.12
OP 10	51.626024	0.543221	20.18	1.50	21.68
OP 11	51.626357	0.545442	17.24	1.50	18.74
OP 12	51.626051	0.548371	11.37	1.50	12.87
OP 13	51.626111	0.551192	22.28	1.50	23.78
OP 14	51.626171	0.554175	24.59	1.50	26.09
OP 15	51.625871	0.557801	16.22	1.50	17.72
OP 16	51.624339	0.558316	17.60	1.50	19.10
OP 17	51.622241	0.559024	12.64	1.50	14.14
OP 18	51.620529	0.559335	14.52	1.50	16.02
OP 19	51.618744	0.559464	9.58	1.50	11.08
OP 20	51.616892	0.559614	7.10	1.50	8.60
OP 21	51.616559	0.569496	10.55	1.50	12.05
OP 22	51.617245	0.566824	7.61	1.50	9.11
OP 23	51.618231	0.564507	6.90	1.50	8.40
OP 24	51.619583	0.562382	10.02	1.50	11.52
OP 25	51.621215	0.560709	14.20	1.50	15.70
OP 26	51.622659	0.559811	16.06	1.50	17.56
OP 27	51.624717	0.559467	15.32	1.50	16.82
OP 28	51.626316	0.560025	15.96	1.50	17.46
OP 29	51.626656	0.562096	21.79	1.50	23.29
OP 30	51.624957	0.563394	11.69	1.50	13.19
OP 31	51.623512	0.564821	6.01	1.50	7.51
OP 32	51.623072	0.567482	4.65	1.50	6.15
OP 33	51.622879	0.570346	3.77	1.50	5.27
OP 34	51.621654	0.572106	3.81	1.50	5.31
OP 35	51.628401	0.566860	21.70	1.50	23.20
OP 36	51.628600	0.569638	15.38	1.50	16.88

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	SA tracking	SA tracking	0	0	-	

PV & Receptor Analysis Results

Results for each PV array and receptor

PV array 1 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	0
OP: OP 15	0	0
OP: OP 16	0	0
OP: OP 17	0	0
OP: OP 18	0	0
OP: OP 19	0	0
OP: OP 20	0	0
OP: OP 21	0	0
OP: OP 22	0	0
OP: OP 23	0	0
OP: OP 24	0	0
OP: OP 25	0	0
OP: OP 26	0	0
OP: OP 27	0	0
OP: OP 28	0	0
OP: OP 29	0	0
OP: OP 30	0	0
OP: OP 31	0	0
OP: OP 32	0	0
OP: OP 33	0	0
OP: OP 34	0	0
OP: OP 35	0	0
OP: OP 36	0	0

No glare found

Assumptions

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

- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

ForgeSolar

Southlands Solar Farm

Southlands Solar Farm Rail

Created Sept. 8, 2022
Updated Sept. 9, 2022
Time-step 1 minute
Timezone offset UTC0
Site ID 75480.13344

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

Misc. Analysis Settings

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

Analysis Methodologies:
- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

Summary of Results No glare predicted!

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh
PV array 1	SA tracking	SA tracking	0	0	-

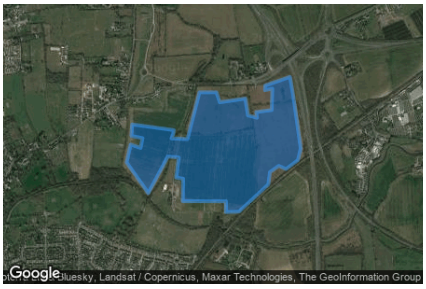
Component Data

PV Array(s)

Total PV footprint area: 512,934 m^2

Name: PV array 1
Footprint area: 512,934 m^2
Axis tracking: Single-axis rotation
Backtracking: None
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 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	51.626083	0.555031	22.65	3.00	25.65
2	51.626523	0.557048	15.51	3.00	18.51
3	51.625683	0.557284	13.75	3.00	16.75
4	51.624911	0.557477	12.61	3.00	15.61
5	51.622433	0.558035	10.52	3.00	13.52
6	51.621767	0.557777	10.88	3.00	13.88
7	51.621261	0.556683	11.85	3.00	14.85
8	51.621447	0.556018	13.60	3.00	16.60
9	51.621087	0.555202	13.44	3.00	16.44
10	51.620381	0.555052	11.42	3.00	14.42
11	51.618832	0.552358	7.42	3.00	10.42
12	51.618806	0.551156	6.28	3.00	9.28
13	51.619418	0.551167	7.80	3.00	10.80
14	51.619425	0.547176	7.86	3.00	10.86
15	51.620711	0.547219	12.76	3.00	15.76
16	51.620777	0.546575	9.94	3.00	12.94
17	51.621923	0.546811	9.59	3.00	12.59
18	51.621976	0.545803	7.42	3.00	10.42
19	51.619898	0.544000	4.51	3.00	7.51
20	51.621643	0.542005	8.60	3.00	11.60
21	51.622660	0.542381	12.59	3.00	15.59
22	51.622467	0.543293	13.55	3.00	16.55
23	51.623027	0.543475	14.76	3.00	17.76
24	51.623153	0.542456	13.78	3.00	16.78
25	51.623813	0.542521	15.53	3.00	18.53
26	51.623486	0.546351	9.60	3.00	12.60
27	51.623246	0.546286	8.89	3.00	11.89
28	51.623013	0.546136	8.68	3.00	11.68
29	51.622973	0.547617	12.53	3.00	15.53
30	51.625644	0.548711	11.78	3.00	14.78
31	51.625644	0.550278	19.86	3.00	22.86
32	51.625071	0.550578	21.99	3.00	24.99
33	51.625284	0.552938	23.46	3.00	26.46
34	51.624325	0.553174	22.23	3.00	25.23
35	51.624192	0.554011	21.78	3.00	24.78
36	51.624512	0.553947	21.87	3.00	24.87
37	51.624632	0.555363	19.02	3.00	22.02
38	51.625857	0.555427	21.19	3.00	24.19
39	51.625764	0.554741	21.85	3.00	24.85
40	51.626029	0.554773	22.68	3.00	25.68

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	51.626676	0.569413	13.13	2.75	15.88
OP 2	51.625700	0.567208	12.27	2.75	15.02
OP 3	51.624621	0.564848	10.97	2.75	13.72
OP 4	51.623525	0.562418	9.26	2.75	12.01
OP 5	51.622496	0.560106	12.74	2.75	15.49
OP 6	51.621537	0.557984	10.80	2.75	13.55
OP 7	51.620199	0.555356	11.02	2.75	13.77
OP 8	51.619060	0.553382	10.88	2.75	13.63
OP 9	51.617787	0.551408	9.04	2.75	11.79

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	SA tracking	SA tracking	0	0	-	

PV & Receptor Analysis Results

Results for each PV array and receptor

PV array 1 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0

No glare found

Assumptions

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

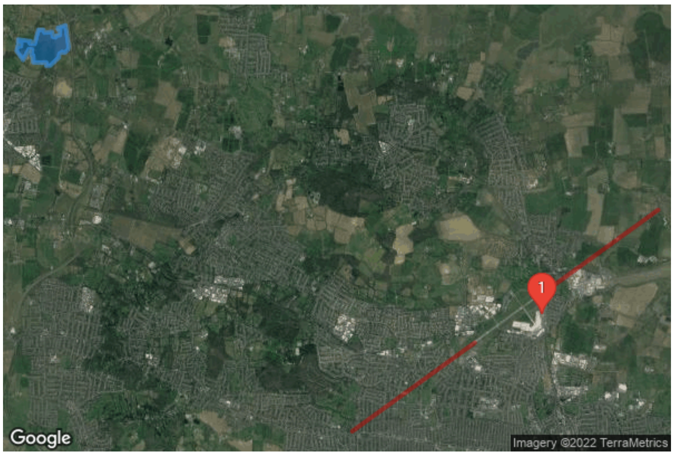
ForgeSolar

Southlands Solar Farm

Southlands Solar Farm Aviation

Created Sept. 9, 2022
Updated Sept. 9, 2022
Time-step 1 minute
Timezone offset UTC0
Site ID 75519.13344

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



Misc. Analysis Settings

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

Analysis Methodologies:
- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

Summary of Results No glare predicted!

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	SA tracking	SA tracking	0	0	-

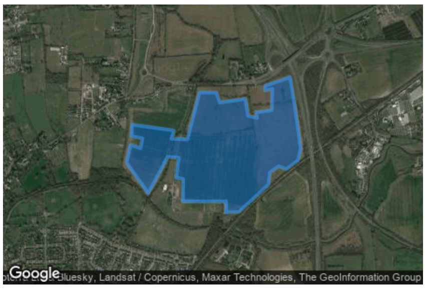
Component Data

PV Array(s)

Total PV footprint area: 512,934 m^2

Name: PV array 1
Footprint area: 512,934 m^2
Axis tracking: Single-axis rotation
Backtracking: None
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 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



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4	51.624911	0.557477	12.61	3.00	15.61
5	51.622433	0.558035	10.52	3.00	13.52
6	51.621767	0.557777	10.88	3.00	13.88
7	51.621261	0.556683	11.85	3.00	14.85
8	51.621447	0.556018	13.60	3.00	16.60
9	51.621087	0.555202	13.44	3.00	16.44
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11	51.618832	0.552358	7.42	3.00	10.42
12	51.618806	0.551156	6.28	3.00	9.28
13	51.619418	0.551167	7.80	3.00	10.80
14	51.619425	0.547176	7.86	3.00	10.86
15	51.620711	0.547219	12.76	3.00	15.76
16	51.620777	0.546575	9.94	3.00	12.94
17	51.621923	0.546811	9.59	3.00	12.59
18	51.621976	0.545803	7.42	3.00	10.42
19	51.619898	0.544000	4.51	3.00	7.51
20	51.621643	0.542005	8.60	3.00	11.60
21	51.622660	0.542381	12.59	3.00	15.59
22	51.622467	0.543293	13.55	3.00	16.55
23	51.623027	0.543475	14.76	3.00	17.76
24	51.623153	0.542456	13.78	3.00	16.78
25	51.623813	0.542521	15.53	3.00	18.53
26	51.623486	0.546351	9.60	3.00	12.60
27	51.623246	0.546286	8.89	3.00	11.89
28	51.623013	0.546136	8.68	3.00	11.68
29	51.622973	0.547617	12.53	3.00	15.53
30	51.625644	0.548711	11.78	3.00	14.78
31	51.625644	0.550278	19.86	3.00	22.86
32	51.625071	0.550578	21.99	3.00	24.99
33	51.625284	0.552938	23.46	3.00	26.46
34	51.624325	0.553174	22.23	3.00	25.23
35	51.624192	0.554011	21.78	3.00	24.78
36	51.624512	0.553947	21.87	3.00	24.87
37	51.624632	0.555363	19.02	3.00	22.02
38	51.625857	0.555427	21.19	3.00	24.19
39	51.625764	0.554741	21.85	3.00	24.85
40	51.626029	0.554773	22.68	3.00	25.68

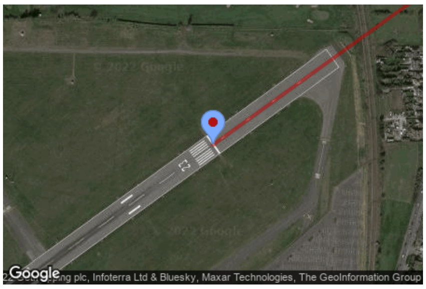
2-Mile Flight Path Receptor(s)

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	51.565934	0.683311	16.47	15.24	31.71
2-mile point	51.549021	0.645542	44.29	156.10	200.40

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

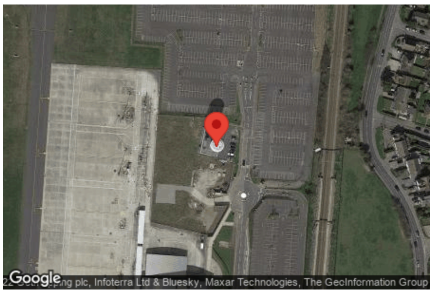
Point	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
Threshold	51.574376	0.702086	11.10	15.24	26.34
2-mile point	51.591289	0.739862	4.98	190.05	195.03



Discrete Observation Receptors

Number	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total Elevation m
1-ATCT	51.571282	0.704275	7.89	32.00	39.89

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	SA tracking	SA tracking	0	0	-	

PV & Receptor Analysis Results

Results for each PV array and receptor

PV array 1 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: Southend RWY 05	0	0
FP: Southend RWY 23	0	0
OP: 1-ATCT	0	0

No glare found

Assumptions

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

Appendix G
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:

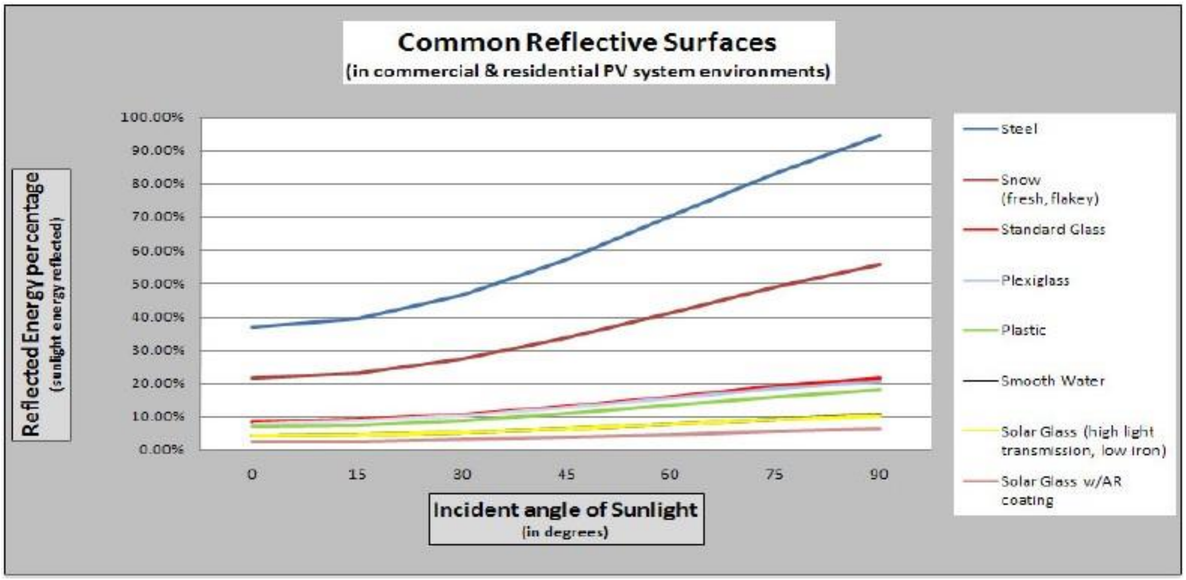
The objective of this document is to increase awareness concerning the possible glare and reflectance impact of PV Systems on their surrounding environment.

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.

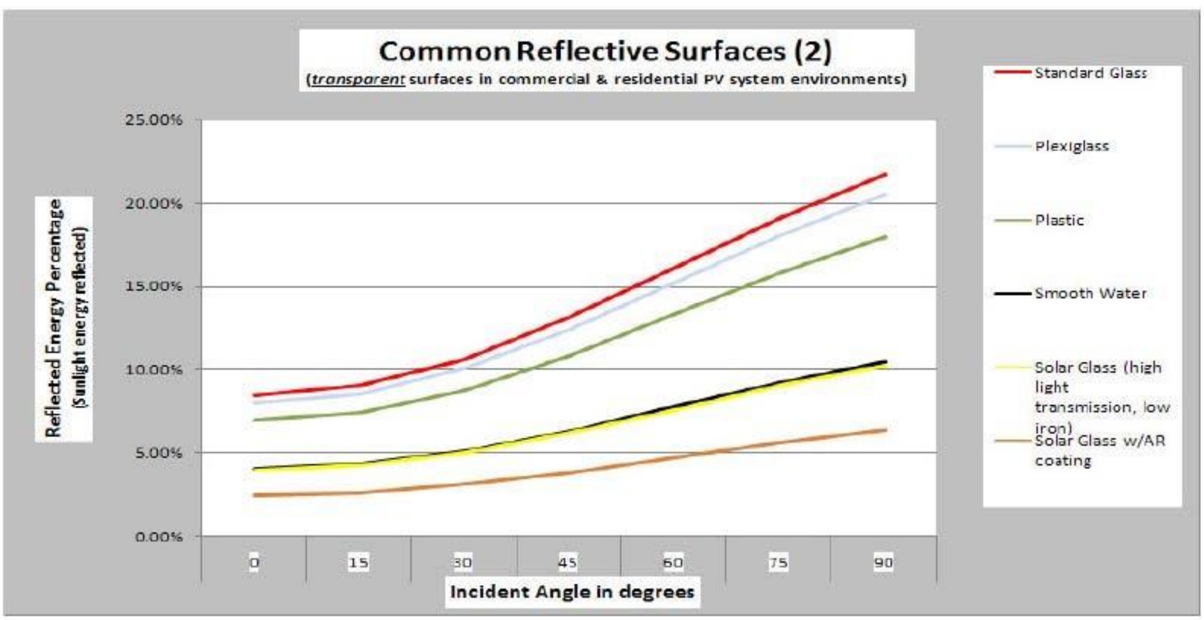
DETAILED EXPLANATION:

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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  - Italy: SunPower – Servizio Tecnico Italia: serviziotecnico@sunpowercorp.com
  - France: SunPower – Support Technique France: supporttechnique@sunpowercorp.com

USA Toll Free number: SunPower Technical Support, **1-800–SUNPOWER (786-76937)**

- **For inquiries by e-mail, please use:** Technicalsupport@Sunpowercorp.com

Australia (Sunpower Corporation Australia PTY LTD) contact number: +61-8-9477-5888.

Korea – SPK (SunPower Korea) contact number: (02) 3453-0941

REFERENCES:

- Center for Sustainable Building Research. College of Dean – University of Minnesota. All rights Reserved. JDP activity by the University of Minnesota and Lawrence Berkeley National Laboratory
- H.K Pulker, Coatings on Glass, (1999), 2ed, Elsevier, Amsterdam
- C.G Granqvist, Materials Science for Solar Energy Conversion Systems, (1991), Pergamon, G.B
- D. Chen, anti-reflection (AR) coatings made by sol-gel processes: A review, Solar energy Materials and Solar Cells, 68, (2000), 313-336
- P. Nostell, A. Roos, B. Karlsson, Antireflection of glazings for solar energy applications, Solar Energy Materials and Solar Cells, 54, (1998), 23-233
- M. Fukawa, T. Ikeda, T. Yonedaans K. Sato, Antireflective coatings y single layer with refractive index of 1.3, Proceedings of the 3rd International Conference on Coatings on Glass (ICGG), (2000), 257-264
- J. Karlsson and A. Roos, Modeling the angular behavior of the solar energy transmittance of windows, Solar Energy, 69, 4, (2000)
- J. Karlsson, B. Karlsson and A. Roos, A Simple model for assessing the energy efficiency of windows, In Press, Energy and Buildings

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