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IAMP One Phase Two Development

Planning Application and Environmental Impact Assessment

Appendix 3.4 Glint Assessment

June 2021

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APPROVED BY:

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EXECUTIVE SUMMARY

This report seeks to demonstrate the possible effects that reflected sunlight from a proposed roof mounted solar array would have on receptors in the vicinity. These receptors include residential properties, road, rail, air traffic and national trails. The methodology employs the use of: a ZTV to identify whether local topography screens those receptors; a computer model to determine the times, dates and duration that glint may theoretically be visible; and a discussion of screening such that a realistic assessment of potential effects can be made.

The reflectivity of solar panels is considerably less than many other common materials seen in the built or natural environment. Water bodies such as reservoirs, lakes (and on a calm day the ocean) have very similar reflective properties to solar panels (see Figure 4) and represent much larger areas than that taken up by the solar panels at the site. In any case, the overall potential for glint at receptors within the vicinity of the site is low.

One road (Follingsby Lane) was predicted to potentially receive glint due to lack of complete screening. This road lies north of the proposed array. It is unlikely that the glint received would pose a material risk to motorists, nevertheless anti-reflective measures are recommended for north-facing solar panels.

No glint was predicted on flight paths, railway lines or footpaths.

No cumulative, simultaneous glint from existing sites was predicted for receptors with potential to receive glint from the proposed site.

1 INTRODUCTION

1.1.1 This assessment entails the installation of solar photovoltaic arrays to be rooftop-mounted on a proposed factory as part of a development in Sunderland. The proposed panels will be set at various angles to the horizontal due to the curvature of the roof. Their maximum height above ground will be 30 m. The National Grid reference for the site is 433514, 558883 (Easting, Northing).

1.1.2 This assessment considers the potential effects of glint and glare caused by the proposed development on ground-based receptors and aircraft operations in the surrounding area. Figure 1 shows the site boundary in red and the surrounding land, but the PV arrays will only cover some of this area (more detailed drawing in appendices).

Figure 1: Aerial Photography of the Panel Area and Surrounding Land (Google 2020)

2 ASSESSMENT APPROACH

2.1 Defining Glint

2.1.1 Glint, glare and dazzle are often used interchangeably but are defined in this report as described below and shown in Figure 2.

- **Glint** – Also known as a specular reflection is produced as a direct reflection of the sun on the surface of the solar panel. It occurs with the reflection of light from smooth surfaces such as glass, steel, and calm water.

- **Glare** – A scattered reflection of light. Glare is significantly less intense than glint and is produced from rougher surfaces such as concrete, tarmac, and vegetation.
- **Dazzle** – An effect caused by intense glint and glare, which can cause distraction, and if strong enough reduce the ability of the receptor (pilot or otherwise) to distinguish details and objects.

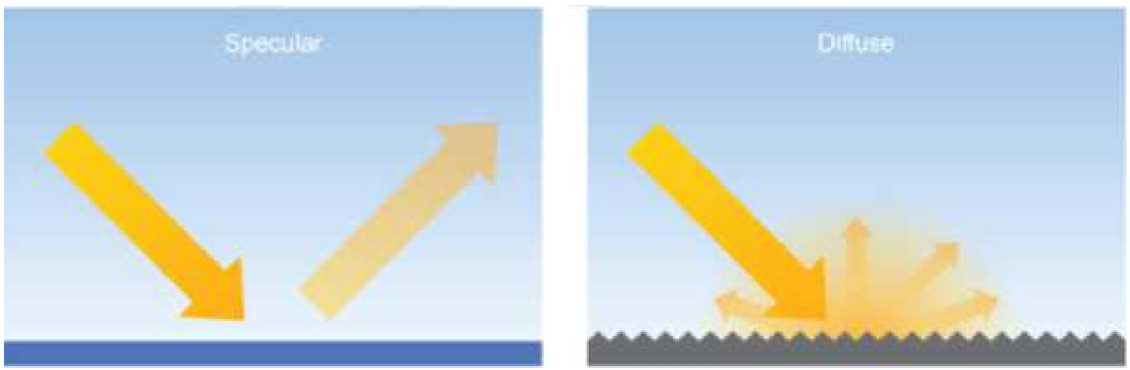

Figure 2: Types of Reflection, Specular or Glint (left), Diffused or Glare (right) (Federal Aviation Administration, 2010)

2.1.2 It is noted that different organisations and agencies refer to the terms glint and glare interchangeably and Table 1 summarises the definitions and shows how they relate to the definitions used in this report.

Table 1: Definitions of Glint, Glare and Dazzle

Organisation	Organisations Terminology	Our Terminology
Sandia National Laboratories[1]	The term “glare” represents the specular direct reflection of sunlight off smooth materials such as solar panels and does not account for the diffuse component.	The Sandia and ForgeSolar software use the term “glare” which our report defines as “glint”.
US Federal Aviation Administration	“Glint is referred to as momentary flash of bright light and “glare” is defined as continuous source of bright light. Specular reflection is caused by reflections from smooth surfaces while diffuse reflections are from rough surfaces.	Our terminology is in agreement with this definition of glint as a momentary flash of bright light caused by a specular reflection.
UK Building Research Establishment	“Glint” and “dazzle” are used when referring to sunlight reflected from a glazed façade. Although not explicitly mentioned this is referring to specular reflections.	Our terminology uses the term “glint” in place of “glare” and “dazzle” as used by BRE.

2.1.3 Owing to the intensity of glint being much higher than glare, this report will focus on glint alone. The perceived intensity of glint will vary depending on the ambient light level, direction and distance to the receptor.

[1] Sandia National Laboratories is a research and development facility in the United States and is responsible for the development of glint and glare modelling software and associated research.

2.2 Guidelines

2.2.1 There has been no formal technical guidance issued by national government relating to glint and glare arising from utility scale solar PV developments. This is not unusual and until such guidance is provided this report will consider the guidance provided elsewhere which is shown in Appendix 1.

2.3 When Can Glint Occur?

2.3.1 In the northern hemisphere, the sun appears to rise in the north-east. This is as a result of the tilt of the earth at the summer solstice. When the sun reaches a sufficient elevation in the sky to allow sunlight to strike the solar panels ground glint may occur. When the sun's angle in the sky attains a certain value, the reflected beam will be directed back into the sky towards the south-west. Put simply, ground-based glint will normally only occur to ground-based receptors in the early morning or evening when the sun appears low in the sky.

2.3.2 As a result of this glint will only occur in a relatively small area in an approximate bow tie shape with the solar panels in the centre as shown in Appendix 2. Glint does not usually occur during winter months due to sunlight striking the panels from the front and reflecting upwards for receptors outside the immediate vicinity of the site. As ground-based glint outside the immediate vicinity of the site cannot occur during winter, the lack of leaves on deciduous trees will not affect the level of glint experienced.

2.3.3 Broadly speaking in the northern hemisphere for south facing solar farms in general, glint has the potential to occur on land towards the west and southwest of the solar farm in the early morning and towards the east and southeast of the solar farm in the early evening. Glint will only usually occur in the morning or evening for fixed receptors but not both unless a receptor is to the immediate south of the solar farm or positioned between solar farms.

2.3.4 Glint can only occur when direct sunlight can reach the solar panels. Diffused lighting, caused by weather conditions such as cloud, fog, and mist, cannot cause glint due to the low energy intensity of the light incident on the panels.

2.3.5 Figure 3 shows the total number of daylight hours available each month (red) based on the regional variation for the site. Also shown is the average number of hours of sunshine each month (blue), taken from The Meteorological Office data recorded at Durham University Observatory (this is the closest active weather station to the site). Durham University Observatory is approximately 18 miles from the site and is expected to be broadly representative of the weather conditions that the site will be expected to experience.

2.3.6 Figure 3 also shows the ratio of sunshine to daylight displayed as a percentage (green) for each month at the site. As can be seen, the sunniest month on average was June with 230 hours of sunshine. Even then, the actual incidence of glint events can only be expected to be approximately 35% of the theoretical maximum. This is because the ratio of sunshine to daylight is approximately 35% at this time. During less sunny months, glint events may occur for as little as 18 % of the theoretical maximum because the ratio of sunshine to daylight is much less at these times.

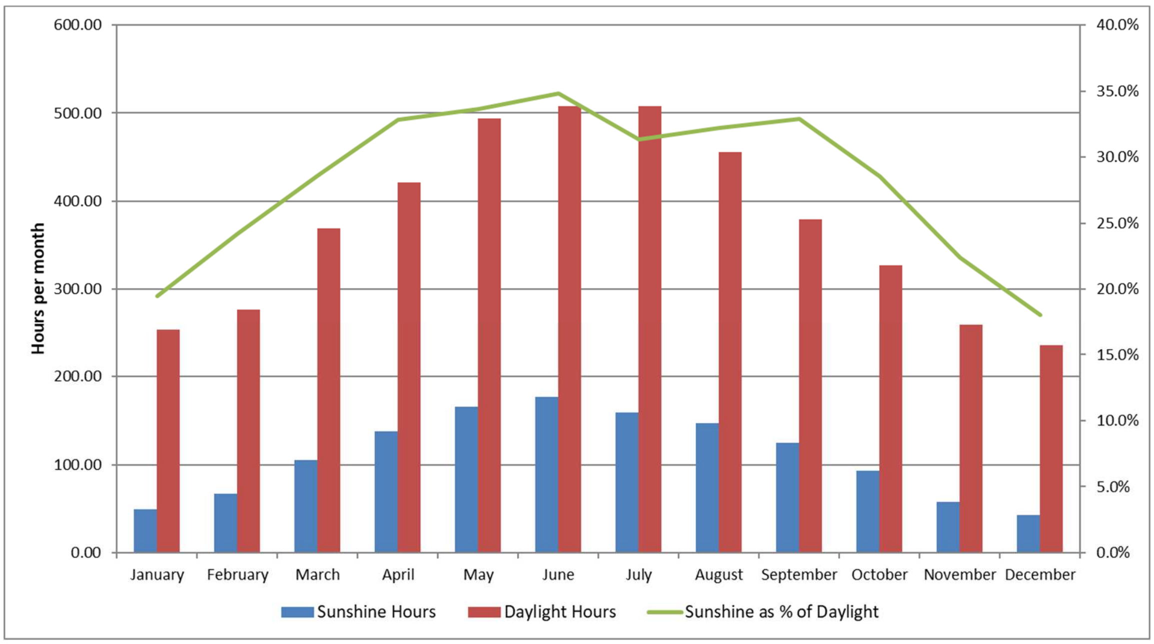

Figure 3: Number of Daylight and Sunshine Hours per Month at Durham

2.4 Reflectivity

2.4.1 Solar PV panels are designed to absorb light and convert this to electricity. Solar PV panels are not designed to reflect sunlight although there is a small reflective component for modern solar panels. The glass that coats solar panels is specifically designed with a low iron content to aid the absorption of daylight and thus has a much lower level of reflectivity than the glass typically seen in conventional windows. This means that less than 9% of the total incident visible light is reflected, while normal glass reflects approximately 19%. Thus, reflectance levels from a given solar site are much lower than the reflectance generated by standard glass and other common reflective surfaces, although reflectance characteristics vary with the incidence angle.

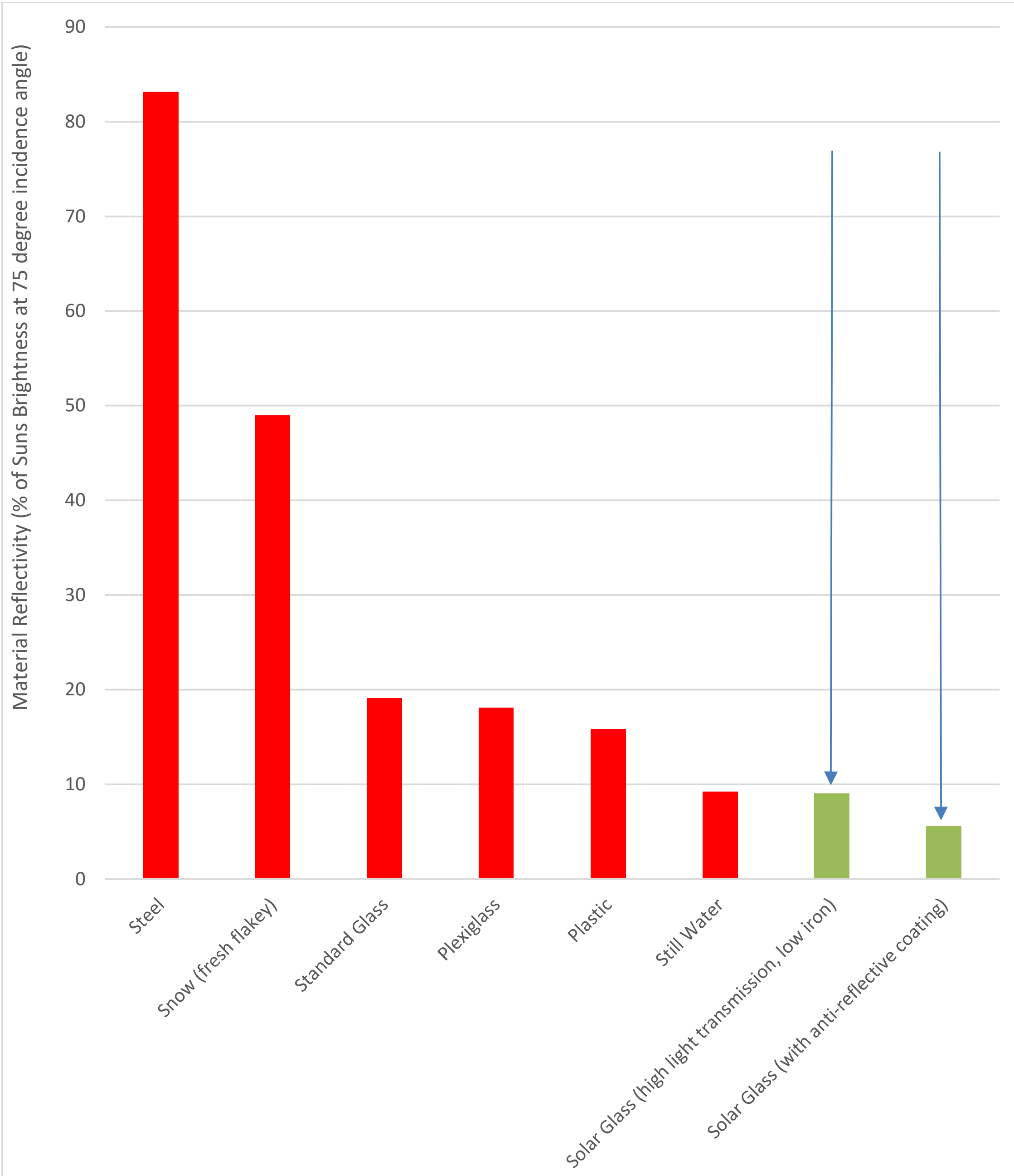

Figure 4: Approximate Reflectivity of Common Materials (Sunpower Corporation, 2010)

2.4.2 Solar panels have a comparable reflectivity to that of calm water and considerably lower than that of snow. Any glint that may occur would be less intense than that seen when flying over a reservoir on a calm day or a snow-covered landscape on a bright day. As can be seen from Figure 4 the reflective properties of solar glass (green) are considerably less than other materials found in the built and natural environment and are approximately half that of standard glass.

2.4.3 It has been raised as an issue that the solar PV panels themselves may not be the only source of reflection from a solar farm. Although the steel mounts used to support the panels could reflect sunlight, the frames are well shaded by the solar panels above them and any exposed elements on the end of rows cover an extremely small area. Owing to being mounted vertically, reflections will be directed into the ground.

2.4.4 As distance from the glint source increases, the intensity of the event drops appreciably. This is due to both the diffraction of light after it reflects off the panel and atmospheric conditions such as the presence of particulates, haze, or low cloud, in addition to the subtended viewing angle.

3 BASELINE CONDITIONS

3.1.1 As identified in Figure 4 there is a range of common materials and surfaces that are likely to cause glint already present in the study area. These include glass in windows, conservatories or greenhouses, flashes caused by light reflecting off passing vehicles, and calm water. It is not possible to quantify the level of glint currently experienced by receptors in the vicinity of the proposed site and it is therefore presumed for the purposes of this report that no glint currently occurs at receptors in the vicinity of the site.

3.1.2 Cumulative effects in conjunction with existing PV arrays are discussed in section 5.2.

4 METHODOLOGY

4.1 Introduction

4.1.1 A geometric analysis was conducted to study where and when glint events may occur. This examines receptors present at ground level, such as dwellings, roads, national waymarked trails, and railway lines. Receptors are identified using available mapping, aerial photography, and street level imagery. The mathematical calculations used, including limitations are provided in Appendix 4.

4.1.2 The glint analysis is completed in several stages using various methods, software models and tools to progressively assess the potential for glint effects, while building an understanding of the local environmental conditions either existing or proposed that impact the potential for glint in the local area. The stages and tools used in the assessment are discussed below.

4.2 Zone of Theoretical Visibility

4.2.1 The Zone of Theoretical Visibility (ZTV) is a computer model which determines whether any part of the site is visible from land surrounding the site based on local topography only; it does not account for screening from land obstacles such as trees, hedgerows or buildings. It does not determine whether views of the site will exist, purely whether they can exist if no surface features are present. It is calculated in the following way and is a tool used to reduce the study area and rule out multiple receptors quickly.

4.2.2 A selection of sample points is identified on the boundary of the area of panels . ample points are chosen as it is infeasible to perform this calculation on every panel on site. Terrain data in the form of a Digital Terrain Model (DTM) forms the basis for determining whether the site could be visible at local receptors. The DTMs form is a selection of squares or rectangles on a grid called cells. Each cell is given a height value and the GIS allows this data to be displayed easily.

4.2.3 Terrain data comes in various resolutions determined by the cell size which determines overall accuracy and quality of the terrain data. WA uses OS Profile DTM data which has a 10 m resolution. The data used is considered to be sufficiently accurate for the purposes of modelling a ZTV.

4.2.4 The model then calculates how many of the sample points are visible out to 5 km using a line of sight model for each cell to each sample point. The output is called a viewshed. For completeness and to provide a worst case, the output viewshed is converted to binary. For instance, if a cell has visibility of 1 sample point or 100 they are both given a yes result.

4.2.5 The ZTV does not account for screening from surface features such as trees or hedgerows but does account for intervening topography, for instance screening from an intervening hill.

4.2.6 Only receptors that are within the ZTV, i.e. have potential visibility of the site, are progressed to further assessment. Those receptors that do not lie within the ZTV will not receive glint.

4.3 Geometric Analysis

4.3.1 The detailed geometric analysis uses a software model to make a prediction on the dates, times and durations of glint effects at fixed positions over the course of a year. The software calculations are complex and completed in several stages, details are provided in Appendix 4. The software used is the GlareGuage tool originally developed in the United States by the Sandia National Laboratory and since improved upon and licensed to ForgeSolar. The times reported as to when glint may occur are reported in Coordinated Universal Time (UTC) and therefore daylight savings should be considered when observing the results.

4.3.2 The computer model predicts whether glint effects are possible at a 1-minute temporal resolution over the course of a full year. The model accounts for the maximum panel height, the area taken up by the panels and an observer height.

4.3.3 It is important to understand certain limitations within the model. The model can only predict glint visibility for fixed positions on the ground and therefore when assessing receptors that are not fixed points (e.g. a public road), several selection points are taken to run for simulation. These are chosen based on experience, the positions likely to have the greatest variation in potential glint effects. This typically provides a worst case as the results are interpreted and the earliest and latest start times and dates reported.

4.3.4 The model calculates its results based on the geometric relationship between the observation point at height, the reflective plane at height (panels) and the position of the sun at each time interval. It therefore takes no account of any screening features whatsoever. It does not account for surface features such as buildings or trees or intervening topography. The software also assumes it is sunny, at the maximum intensity possible given the season, 365 days per year. The computer model suggests when glint can happen not when it will happen, which is why further interpretation by the assessor is essential.

4.3.5 There is, at present, no way to incorporate screening features into the model's algorithm.

4.3.6 It is also important to interpret the results correctly for highways as the model is providing results for a fixed position, not for a full stretch of road, nor does it consider the orientation or direction of travel of a motorist.

4.3.7 The results are processed, and key information is provided as reported by the model with its inherent limitations in **Error! Reference source not found.**. It is essential to interpret these results in the context of the wider assessment and the methods and limitations discussed. These results are further refined to account for local prevailing climatic conditions such as cloud cover as well as descriptive statistics.

4.3.8 Although the predictions made by the computer model as to when glint can occur does not account for screening features directly, other tools used in the assessment take this into consideration such as the ZTV and aerial photography, site visit photography, mapping and observations made by the design team.

4.4 Analysis of Effects

4.4.1 Alongside the ZTV, inspection of available aerial photography and ground level imagery is used to identify the orientation of a receptor and the presence of any intervening obstacles which may screen a receptor from potential glint effects. Screening features such as intervening topography, hedgerows, trees, buildings, proposed planting, and other obstacles can have a substantial effect on the glint levels that are predicted when compared with the raw results provided by computer simulation. This is used to provide a more realistic assessment of the anticipated effects. Each receptor is examined in detail to determine whether what glint, if any, is expected after accounting for local environmental conditions.

4.5 Cumulative Effects

4.5.1 The assessment considers the potential for cumulative glint effects caused by both the proposed site and existing sites. Cumulative effects using the methods described above are applied to other solar PV sites to determine the overall effect expected at receptors surrounding the site. The full cumulative assessment is provided in Section 5.7.

4.6 Software, Data and Methods

4.6.1 The methodology discussed has been developed over several years. Improvements and adjustments to the methodology are applied as and when better data, updated methods, software, and guidance become available, in addition to changes in best practise techniques, consultee engagement and regulatory or policy updates.

4.6.2 Improvements to the algorithm used in the ForgeSolar glint prediction model used in the geometric analysis have been made. Recent changes, in simplified terms, include improvements to how reflected light is modelled in the software. These improvements now account for scattering of reflected sunlight which spreads from the glint source (PV modules) opposed to behaving like a laser beam. Once the scattering is incorporated into the calculations, different parts of the site can produce glint at the same receptor at the same time, in addition to increasing the theoretical time when glint is reported to occur. The calculations also make use of a random number generator in the results to significantly reduce the time taken for the calculations to be completed. This can cause variations in the results between runs of the software but is essential to ensure practicable results can be calculated.

4.6.3 It should be noted that aviation regulators in the United States, where the model is produced and maintained, are aware of the ongoing improvements to the model. Full details of the mathematical calculations and limitations are provided in Appendix 4.

5 KEY EFFECTS

5.1 Glint Receptors and Effects

5.1.1 Figure 5 shows the approximate geographical extent of potential ground glint events. For a glint event to occur on the ground the receptor must be in the zone of theoretical visibility (ZTV).

5.1.2 The calculated ZTV shows the points where any part of the solar farm has potential to be visible from, it does not account for screening by vegetation, buildings, or other features (excluding topography). Only certain portions of the solar farm can cause glint at points on the ground (for example the most northerly panels cannot cause glint to far southern receptors). So, while a point may lie in the ZTV further inspection of the orientation of the site and receptor could reveal that it cannot receive glint, which will be discussed where relevant.

5.1.3 The southernmost receptors within the glint zone have much shorter extents than shown in the drawing as the light reflected from the panels is angled slightly downwards. Conversely the northernmost receptors are only relevant on surrounding higher ground as glint is angled slightly upwards.

5.1.4 Receptors would have to be able to see the panels to experience glint events and this may not be possible due to screening from intervening hedgerows, trees, and buildings. When the sun is not shining directly onto the panels due to cloud or mist (approximately 2/3 of daylight hours during the year), it will also not be possible for glint to occur.

5.1.5 The ZTV shown uses a bare earth model and does not account for screening surrounding the site such as hedgerows or trees. Inspection of aerial photography and ground level imagery may suggest that glint will not be visible in all locations due to screening. When this is relevant to a receptor, it is discussed under the relevant observation point. Figure 5 shows an overhead view of the proposed site (red) the ZTV in light blue.

5.1.6 To narrow down the number of potential receptors, a ground glint zone (GGZ) would usually be drawn to show where glint can geometrically occur. The GGZ is based on the tilt angle of the solar panels (generally 15-30 degrees) and the sun's path. In this case, the curved rooftop means that the tilt angle varies and is at a maximum of around 5 degrees, so a GGZ cannot be accurately applied.

5.1.7 Given that the proposed installation is located within a built-up, urban area, to assess potential receptors, they have been visually inspected from aerial photography and those with structures between them and the site have not been considered further.

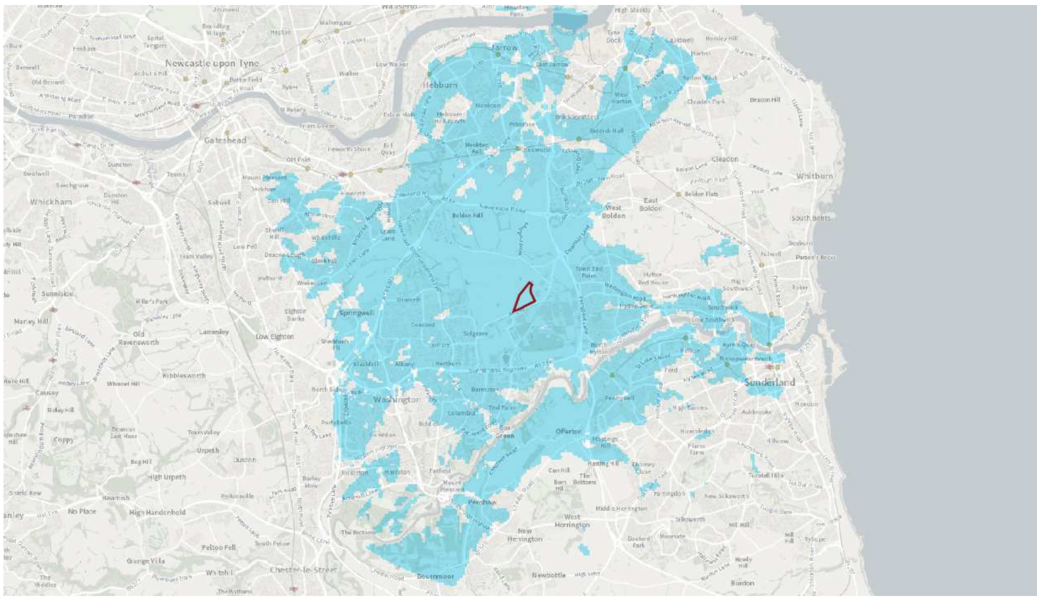

Figure 5: Site (red) and ZTV (light blue) (Ordnance Survey 2021)

5.2 Effect on Local Properties

5.2.1 There are many properties within the vicinity of the proposed solar installation. For a south facing array, properties to the south and north of the proposed solar farm will not receive glint as glint does not occur in these areas. This is due to the sun's path, combined with the angle and orientation of the solar panels not causing reflections in these areas. For arrays at an offset to south, the area of no glint will be offset accordingly.

5.2.2 For the purposes of this assessment where a cluster of properties is present in a small area, a representative observation point has been selected to provide information on the likely effects that may be observed. In such an instance the times, dates, duration, and intensity of glint may vary slightly from property to property, but the effects described are expected to be representative of any property in that cluster. Modelling is based on the theoretical observation of a typical person standing at ground level and maximum panel heights of 14 m, 15 m, 16 m, 28 m, 29 m, and 30 m, and the results would be relatively unchanged year-on year.

5.2.3 The results of the computer modelling are shown in Table 2. It should be noted that these results show when glint can occur based on the sun's path and relative locations to the panels and receptors. No consideration of screening is provided in the results. The presence of screening features such as trees, hedgerows, buildings, intervening topography, and other obstacles will reduce the dates, times and durations of when glint is predicted to occur. In addition, the results shown in Table 3 assume it is sunny, at the maximum intensity possible given the season and does not account for local climatic conditions, such as cloud cover. Local prevailing climatic conditions will reduce the extents of the predicted effects, particularly annual durations and is accounted for in Table 3.

5.2.4 The Observation Point (OP) designation provided in Table 2 and Table 3 is shown in Figure 6.

Figure 6: OPs (Google 2021, ForgeSolar 2021)

5.2.5 There are many properties that lie in the ZTV within 5km of the site. Properties perpendicularly above and below the proposed solar array (i.e. offset from north and south by the same amount as the panels) will not receive glint as glint does not occur in these areas. This is due to the sun's path, combined with the angle and orientation of the solar panels not causing reflections in these areas.

5.2.6 No consideration of screening is provided in the results. The presence of screening features such as trees, hedgerows, buildings, intervening topography, and other obstacles will reduce the dates, times, and durations of when glint is predicted to occur. In addition, the results shown in Table 2 assume it is sunny, at the maximum intensity possible given the season and does not account for local climatic conditions, such as cloud cover. Although the earliest and latest times and dates of when glint could occur is reported, glint would not continuously occur between these periods at a fixed receptor. These represent the limits of when glint effects are predicted.

5.2.7 Local prevailing climatic conditions will reduce the extents of the predicted effects, particularly annual durations and is accounted for in Table 3.

5.2.8 The computer model used is of industry standard, approved and recommended by regulators in the United States and aviation authorities in the United Kingdom. The model is continuously improved for accuracy which can show variations in results from historic assessments. Details of the computer model can be found in Appendix 4.

Table 2: Modelling Results for Local Receptors

OP	Maximum Annual Duration (min)	Earliest Start Time	Latest End Time	Earliest Start Date	Latest Finish Date	Screening Present	Site Visibility
OP1	2841	17:40	19:58	20/03/2021	23/09/2021	Trees	Views from upper levels possible
OP2	2864	19:15	20:20	09/05/2021	04/08/2021	Trees	Views from upper levels possible
OP3	349	17:25	18:29	01/01/2021	29/09/2021	Trees	Views from upper levels possible
OP4	No glint predicted						
OP5	911	03:40	04:21	19/05/2021	24/07/2021	Trees	Views from upper levels possible
OP6	72	04:08	04:39	07/05/2021	05/08/2021	Trees	No visibility expected
OP7	69	04:52	05:30	13/04/2021	30/08/2021	Trees	No visibility expected
OP8	386	05:13	06:02	02/04/2021	09/09/2021	Trees	Views from upper levels possible
OP9	1181	05:50	06:55	16/03/2021	27/09/2021	Trees	No visibility expected
OP10	1829	06:16	07:34	27/02/2021	14/10/2021	Trees	No visibility expected
OP11	59	03:48	03:55	14/06/2021	29/06/2021	Trees	Glimpses possible
OP12	No glint predicted						
OP13	5705	08:32	10:10	01/01/2021	31/12/2021	Trees, hedgerows	Views from upper levels possible
OP14	3681	07:39	09:08	04/01/2021	07/12/2021	Trees, hedgerows	No visibility expected
OP15	1321	06:16	07:17	05/03/2021	08/10/2021	Buildings, trees	No visibility expected
OP16	No glint predicted						

Table 2: Modelling Results for Local Receptors							
OP	**Maximum Annual Duration (min)**	**Earliest Start Time**	**Latest End Time**	**Earliest Start Date**	**Latest Finish Date**	**Screening Present**	**Site Visibility**
OP17	1406	15:10	16:34	02/01/2021	08/12/2021	Trees	No visibility expected
OP18	No glint predicted						
OP19	No glint predicted						
OP20	251	11:31	11:53	12/12/2021	30/12/2021	Woodland, hedgerows	Distant glimpses possible
OP21	131	10:36	11:24	07/01/2021	30/12/2021	Woodland, hedgerows	Distant glimpses possible
OP22	2412	09:52	10:55	01/01/2021	31/12/2021	Trees	Views from upper levels possible
OP23	5803	08:33	09:50	01/01/2021	31/12/2021	Trees	No visibility expected
OP24	No glint predicted						
OP25	3954	14:23	15:21	01/01/2021	31/12/2021	Trees, intervening topography	No visibility expected
OP26	2585	07:00	08:09	10/02/2021	31/10/2021	Trees, intervening topography	No visibility expected
OP27	3719	05:42	06:24	21/03/2021	22/09/2021	Buildings, trees	No visibility expected
OP28	539	04:25	04:59	27/04/2021	16/08/2021	Buildings, trees	No visibility expected
OP29	No glint predicted						
OP30	No glint predicted						
OP31	1412	03:45	04:30	13/05/2021	30/07/2021	Trees	No visibility expected

5.2.9 It is essential to understand that the modelled results show when glint can occur based on the relative locations of the sun, the panels, and receptors. It is provided for information purposes to highlight even without the consideration of screening, glint can only occur during a highly constricted timeframe. These results do not consider existing or proposed screening which can limit or eliminate the theoretical results modelled. A detailed discussion of screening implications is provided in the subsequent sections for each Observation Point such that a realistic assessment of glint potential can be established.

Table 3: Modelling Results for Local Receptors Including Climatic Conditions					
Observation Point (OP)	**Climate Adjusted Annual Duration (minutes)**	**Glint Events Proportion of Daylight Hours**	**Number of Glint Days**	**Maximum Duration of Glint Event (minutes)**	**Average Duration of Event (min)**
OP1	994	0.3693%	189	35	15
OP2	1002	0.3723%	89	53	32
OP3	122	0.0454%	50	13	7
OP4	No glint predicted				
OP5	319	0.1184%	68	21	13
OP6	25	0.0094%	27	5	3
OP7	24	0.0090%	25	5	3
OP8	135	0.0502%	35	22	11
OP9	413	0.1535%	43	53	27
OP10	640	0.2378%	50	73	37
OP11	21	0.0077%	17	5	3
OP12	No glint predicted				
OP13	1997	0.7417%	101	99	56
OP14	1288	0.4785%	105	69	35
OP15	462	0.1717%	43	67	31
OP16	No glint predicted				
OP17	492	0.1828%	81	36	17
OP18	No glint predicted				
OP19	No glint predicted				
OP20	88	0.0326%	20	17	13
OP21	46	0.0170%	33	7	4
OP22	844	0.3136%	69	51	35
OP23	2031	0.7544%	111	67	52
OP24	No glint predicted				
OP25	1384	0.5140%	70	72	56
OP26	905	0.3361%	67	70	39
OP27	1302	0.4835%	49	132	76
OP28	189	0.0701%	38	30	14
OP29	No glint predicted				
OP30	No glint predicted				
OP31	494	0.1836%	80	30	18

5.2.10 As can be seen in Table 3, OP11 has the highest exposure to potential glint effects. At OP11 glint is modelled to occur for approximately 1.2% of annual daylight hours. The second highest level of exposure was at OP1 where glint may occur for 0.8% of annual daylight hours. The times and dates when glint has the possibility of occurring at the receptors is provided in Table 2.

5.2.11 The effects modelled will be further reduced by existing and proposed screening in the form of trees, hedgerows, buildings, and other obstacles which is discussed below.

Observation Point 1

5.2.12 OP1 represents the nearest part of the Nissan business park that lies just south of the proposed site. Adjusting for climatic conditions, 994 minutes of glint are predicted here annually from March to September. There are trees between this OP and the site that will screen views at ground level, but views from upper levels are possible. From street imagery, there are few windows on these buildings at upper levels, and given that views would be extremely restricted, glint will not have a material impact on receptors here.

Observation Point 2

5.2.13 OP2 represents the westernmost part of the Nissan business park including the sports and leisure complex. Adjusting for climatic conditions, 1,002 minutes of glint are predicted here annually from May to August. There are trees between this OP and the site that will screen views at ground level and given that views through windows from upper levels would be extremely restricted, glint will not have a material impact on receptors here.

Observation Point 3

5.2.14 OP3 represents the easternmost part of the Nissan business park and some properties just east of the site on Washington Road including the Three Horseshoes hotel. Adjusting for climatic conditions, 122 minutes of glint are predicted here annually from March to September. There are trees between this OP and the site that will screen views at ground level and most views at upper levels. Given that views through windows from upper levels would be extremely restricted, glint will not have a material impact on receptors here.

Observation Point 4

5.2.15 OP4 represents the Unipres buildings of the business park. No glint was predicted at this location.

Observation Point 5

5.2.16 OP5 represents the westernmost part of the entire business park that lies just south of the proposed site. Adjusting for climatic conditions, 319 minutes of glint are predicted here annually from May to July before 5:00 am. There are trees between this OP and the site that will screen views at ground level and given that views through windows from upper levels would be extremely restricted and the early hours, glint will not have a material impact on receptors here.

Observation Point 6

5.2.17 OP6 represents a cluster of mainly residential properties which lies 1.6 km WSW of the site. Adjusting for climatic conditions, 25 minutes of glint are predicted here annually from May to August before 5:00 am. There are trees between this OP and the site that will screen most if not all views, and given the early hours, glint will not have a material impact on receptors here.

Observation Point 7

5.2.18 OP7 is a short distance north of OP6 and represents more dwellings west of the site. Adjusting for climatic conditions, 24 minutes of glint are predicted here annually from March to September before 5:00 am. There are trees between this OP and the site that will screen most views, and given the early hours, glint will not have a material impact on receptors here.

Observation Point 8

5.2.19 OP8 represents a small cluster of commercial properties 1.6 km west of the proposed site. Adjusting for climatic conditions, 135 minutes of glint are predicted here annually from April to September. There are trees between this OP and the site that will screen views at ground level, but views from upper levels are possible. From street imagery, there are few windows on these buildings at upper levels, and given that views would be extremely restricted, glint will not have a material impact on receptors here.

Observation Point 9

5.2.20 OP9 is just north of OP8 and represents another commercial property west of the proposed site. Adjusting for climatic conditions, 413 minutes of glint are predicted here annually from March to September before 7:00 am. There are tall trees between this OP and the site that will screen most views at all levels, and given the relatively early hours, glint will not have a material impact on receptors here.

Observation Point 10

5.2.21 OP10 represents a cluster of mainly residential properties 1.9 km WNW of the proposed site. Adjusting for climatic conditions, 640 minutes of glint are predicted here annually from March to September. There are tall trees between this OP and the site that will screen most views at all levels, so glint will not have a material impact on receptors here.

Observation Point 11

5.2.22 OP11 represents the nearest part of an industrial estate on Spire Road which lies 2 km southwest of the proposed site and a proposed addition of industrial units on Hillthorn Farm. Adjusting for climatic conditions, 21 minutes of glint are predicted here annually in June. There are trees between this OP and the site that are expected to screen most views. Given also the relatively low annual duration, glint will not have a material impact on receptors here.

Observation Point 12

5.2.23 OP12 represents the nearest part of the business park, which lies just south of the proposed site. No glint was predicted at this location.

Observation Point 13

5.2.24 OP13 represents a small cluster of properties that lies 1.6 km northwest of the proposed site. Adjusting for climatic conditions, 1,997 minutes of glint are predicted here throughout the year. All glint is predicted as 'green' meaning it has low potential to cause a temporary after-image. There are some trees and hedgerows between this OP and the site that will screen some views at ground level, but views especially from upper levels are possible from some buildings in this cluster. Given that views of the site from this location will be restricted and that the glint predicted is unlikely to leave an after-image, glint is unlikely to have a material impact on receptors here.

Observation Point 14

5.2.25 OP14 represents the Follingsby Park which lies 2.6 km northwest of the proposed site. Adjusting for climatic conditions, 1,288 minutes of glint are predicted here throughout the year. There are many trees and hedgerows between this OP and the site that are expected to screen all views, so glint will not occur here.

Observation Point 15

5.2.26 OP15 represents a cluster of mainly residential properties including Sunderland College Washington Campus which lies 2.7 km west of the site. It is also near playing fields on Stephen Road where development to the pavilion has been proposed. Adjusting for climatic conditions, 462 minutes of glint are predicted here annually from March to October. This is a relatively built-up area there are many trees surrounding the area, so visibility of the array is not possible from this location.

Observation Point 16

5.2.27 OP16 represents the nearest part of the properties in the Town End Farm area on Washington Road which lie 1.3 km east of the proposed site. No glint was predicted at this location.

Observation Point 17

5.2.28 OP17 is near the Downhill Lane and A19 junction and represents the northernmost properties in the Town End Farm area. Adjusting for climatic conditions, 492 minutes of glint are predicted here throughout the year. There are thick trees between this OP and the site, so visibility will not be possible.

Observation Point 18

5.2.29 OP18 represents a cluster of commercial properties around West Bolden Lodge, which lies north east of the proposed site. No glint was predicted at this location.

Observation Point 19

5.2.30 OP19 represents the most south-easterly of the residential area of Fellgate, which lies north of the proposed site. No glint was predicted at this location.

Observation Point 20

5.2.31 OP20 is just west of OP19 and represents properties of Fellgate, which are north of the site. Adjusting for climatic conditions, 88 minutes of glint are predicted annually in the month of December. The array is expected to be mostly screened by intervening woodland, trees and hedgerows, so although distant glimpses are possible, glint will not have a material impact here.

Observation Point 21

5.2.32 OP21 is just west of OP20 and represents the most westerly properties of Fellgate. Adjusting for climatic conditions, 46 minutes of 'green' glint are predicted throughout the year. The array is expected to be mostly screened by intervening woodland, trees and hedgerows, so although distant glimpses are possible. As glint is unlikely to cause a temporary after-image, it is not expected to have a material impact on receptors here.

Observation Point 22

5.2.33 OP22 represents a business park 4 km northwest of the proposed site. Adjusting for climatic conditions, 844 minutes of glint are predicted throughout the year. Surrounding trees will screen views from ground level, but visibility is possible from upper levels. Given that views through windows on upper levels will be restricted and the distance from the array, glint will not have a material impact here.

Observation Point 23

5.2.34 OP23 represents the nearest properties in the Wardley area and a proposed housing development at Wardley Colliery. Adjusting for climatic conditions, there are 2,031 minutes of glint are predicted throughout the year here. There are trees surrounding the area that will completely screen the array, so visibility is not possible from this location.

Observation Point 24

5.2.35 OP24 represents the nearest part of the business park, which lies just south of the proposed site. No glint was predicted at this location.

Observation Point 25

5.2.36 OP25 represents properties in Boldon 2.8 km northeast of the site. Adjusting for climatic conditions, 1,384 minutes of glint are predicted throughout the year here. Owing to intervening topography and surrounding trees, visibility of the array is not possible from this location.

Observation Point 26

5.2.37 OP26 represents the nearest properties in the Leam Lane area. Adjusting for climatic conditions, 905 minutes of glint are predicted annually from February to October. Visibility is not possible from here due to vegetation and intervening topography.

Observation Point 27

5.2.38 OP27 represents the nearest properties in Springwell. Adjusting for climatic conditions, 1,302 minutes of glint are predicted from March to September here. This area is built-up and has lots of intervening screening, so no visibility is possible.

Observation Point 28

5.2.39 OP28 represents properties in Armstrong Blackfell which lie 2.8 km WSW of the site. Adjusting for climatic conditions, 189 minutes of glint are predicted from April to August here. This area is built-up and has lots of intervening screening, so no visibility is possible.

Observation Point 29

5.2.40 OP29 represents the nearest part of the residential area in Penshaw, which lies south of the proposed site. No glint was predicted at this location.

Observation Point 30

5.2.41 OP30 represents the nearest part of the residential area in Pennywell, which lies south east of the proposed site. No glint was predicted at this location.

Observation Point 31

5.2.42 OP31 represents Elm Tree Farm Garden Nursery. Adjusting for climatic conditions, 189 minutes of glint are predicted from May to July here. There are thick trees between this point and the proposed array, so visibility is not expected.

Local Properties Conclusion

5.2.43 The analysis has shown that there is potential for local properties receive glint. Where views of the site exist, this is more likely to be from buildings' upper floors where the potential for glint will not have a large impact of receptors.

5.2.44 For all receptors in the absence of any screening but accounting for local prevailing climatic conditions, the glint has been modelled to be at most 0.74 % of daylight hours and significantly less in other cases. Considering the modelled effects and screening, the conditions are not considered to have a material impact on the properties surrounding the site. Any glimpses of glint would be no worse than viewing a sunlight reflection from window glass similar to those used in glasshouses or still water.

5.3 Effect on National Trails and Paths

5.3.1 The nearest national trail is the North East England Coast Path in Sunderland, which is over 6 km away, and will not be affected by this proposed solar farm.

5.3.2 Four public rights of way (PROW) were identified in the vicinity of the array. They are shown in Figure 7.

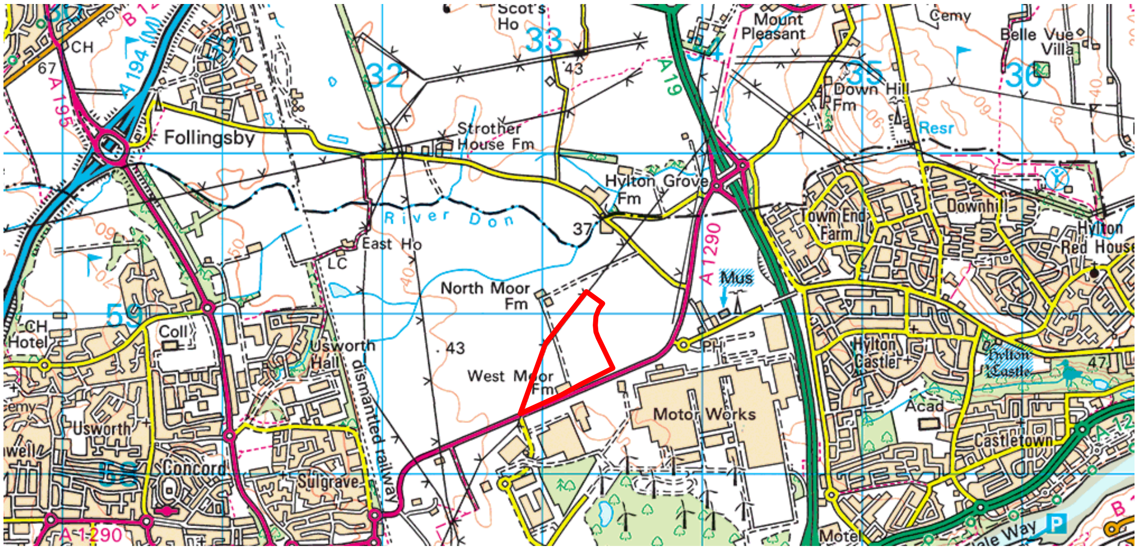

Figure 7: Public Rights of Way (pink dashed lines) in Vicinity of Site (red outline)

5.3.3 After analysis, glint was predicted for all PROWs. From aerial photography, however, all PROWs are expected to be mostly screened by intervening trees and hedgerows. Given also that the receptors will likely be on foot, glint is not expected to have a material impact at these PROWs.

5.4 Effect on Public Roads

5.4.1 There are several roads within the study area. There are no motorways with the potential to receive glint. Motorists are, as a matter of routine, used to driving towards the sun, which provides a much more intense source of light than glint. Notwithstanding this, roads within the immediate vicinity of the site have been assessed for glint effects.

5.4.2 Stretches of road within ZTV have been identified and representative observation points selected for computer simulation. Although the dates and times when glint has the potential to be visible for specific stretches of the road may vary, the results reported are expected to be representative of the road in general. It should be noted that the glint results reported (dates and times) do not account for screening which will limit or eliminate the potential for glint effects, the results reported should therefore be placed in context with the discussion of screening which is provided for each road. The dates and times reported are the extents of when glint could be geometrically possible, but glint would not necessarily occur continuously during that period.

5.4.3 Each road that has been assessed is shown in Figure 8. All the roads modelled are at least partially or completely within the ZTV. Motorists on roads that are not in the ZTV will not experience glint events.

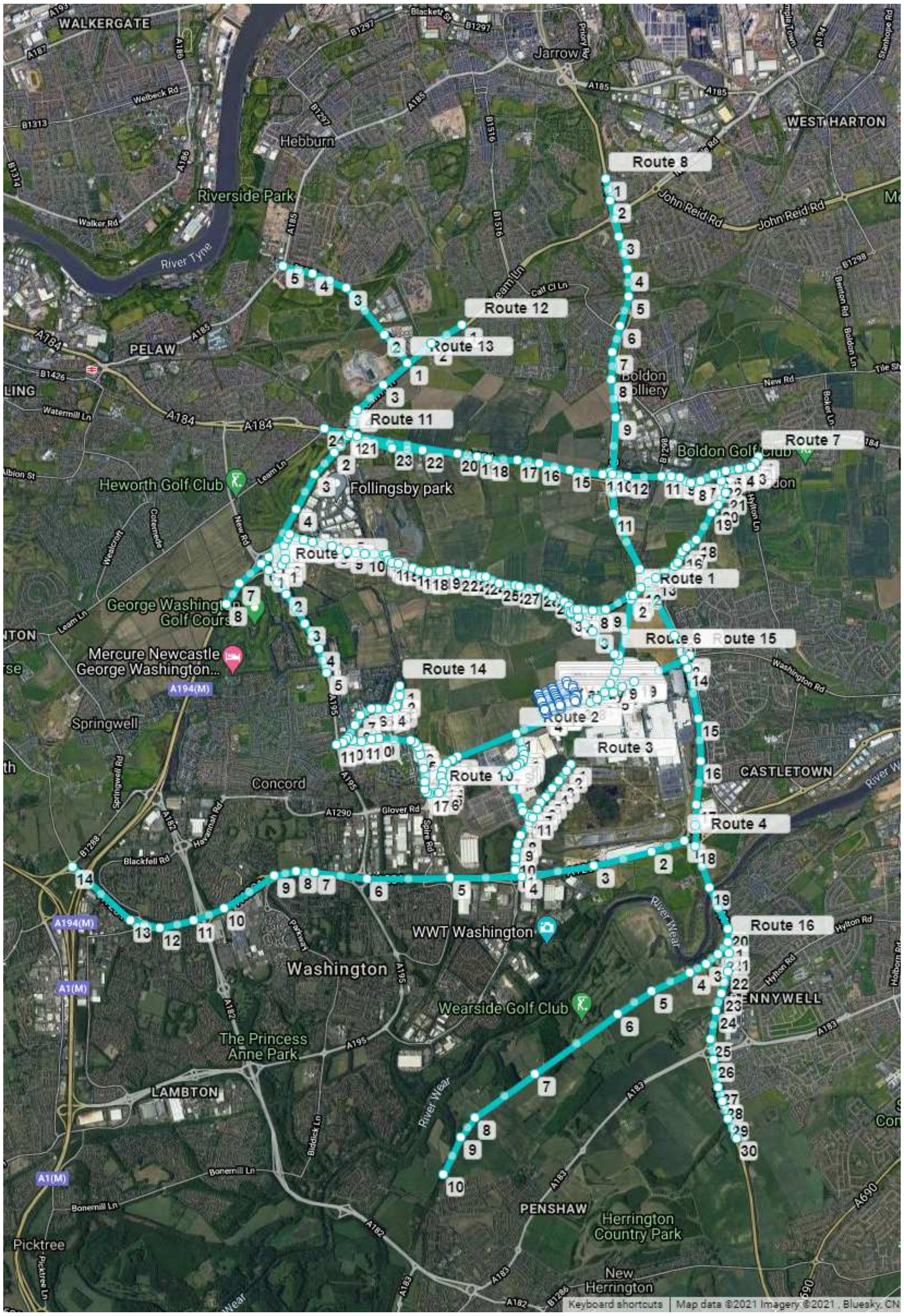

Figure 8: Routes with the potential to receive glint (ForgeSolar 2021)

A1290 (Route 1)

5.4.4 The A1290 runs along the southern boundary of the site. The array will be mostly screened to motorists by vegetation that lines the road, but glimpses and distant views are possible. This road is predicted 2708 minutes of glint annually (climate adjusted) throughout the year. Given that passing motorists will only experience glint for a short duration, if any, it is not expected to pose a tangible risk on this road.

Cherry Blossom Way (Route 2)

5.4.5 This road runs through the business park to the south of the site. The road is surrounded by trees and buildings so no visibility of the site is expected.

Nissan Way (Route 3)

5.4.6 This road runs such that the business park is between it and the site. It is surrounded by tall trees, so visibility of the site is not expected.

A1231 (Route 4)

5.4.7 This road runs east to west 1.7 km south of the site at its closest. It is completely screened from the proposed site by topography, vegetation and buildings.

Follingsby Ln (Route 5)

5.4.8 This road runs to the north of the site. It is partially screened by hedgerows but will have visibility to the array. This road is predicted 9829 minutes of glint annually (climate adjusted) throughout the year originating from the north-facing panels. All glint predicted on this road is 'green' meaning it has a low potential to cause a temporary after-image.

5.4.9 The proposed building has been roughly drawn in Google Earth to better understand the visibility of the panels from this road.

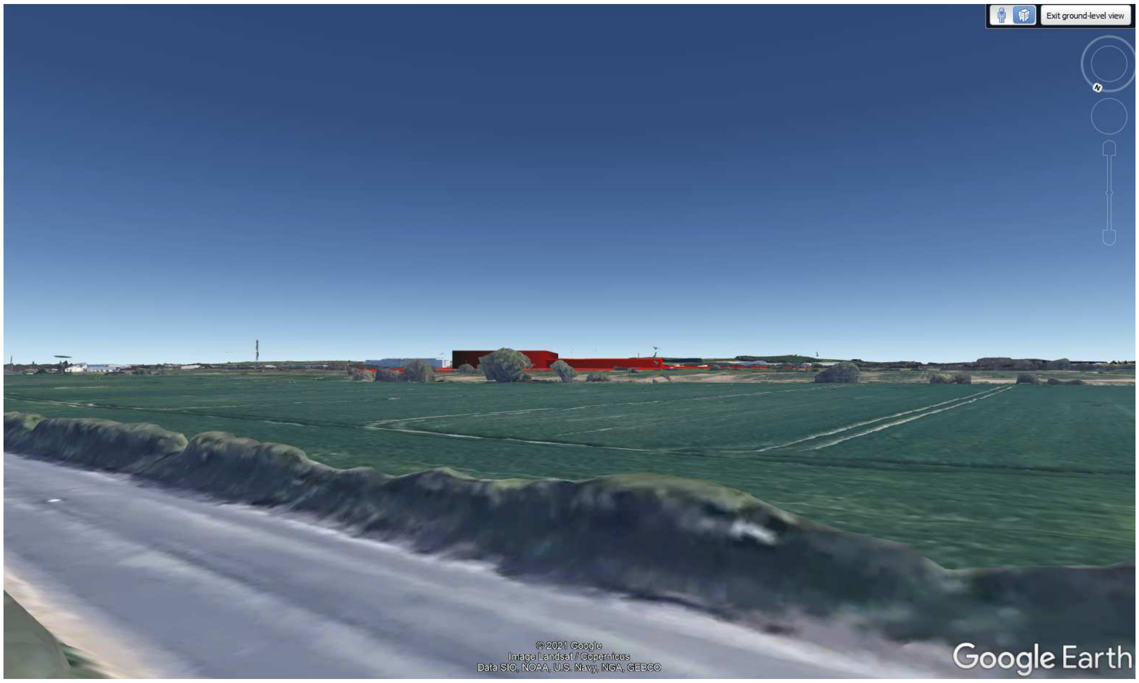

Figure 9 – Simulated view of proposed buildings from Follingsby Lane mid-road (Google Earth 2021)

5.4.10 Given that the panels will be tilted at a relatively shallow angle, more intense sunlight during the summer will be reflected upwards. When glint does occur, motorists travelling on this road will not directly face the site while they are moving, and views will be partially screened by intervening trees. Glint will be less intense than direct sunlight, which motorists routinely experience.

5.4.11 Owing to the intermittency and low intensity of glint that can theoretically be experienced on this road, it is not expected to pose a danger to passing motorists. Nevertheless, surface texturing should be considered for the north-facing panels, as well as anti-reflective coatings, to mitigate glint effects.

Downhill Ln (Route 6)

5.4.12 This road runs to the northeast of the site. It is partially screened by trees and hedgerows, so glimpses of the array are possible. This road is predicted 3892 minutes of glint annually (climate adjusted) throughout the year. Given that passing motorists will only experience glint for a short duration, if any, it is not expected to pose a tangible risk on this road.

A184/Newcastle Rd (Route 7)

5.4.13 This road runs just over 2 km to the north of the site. It is lined with thick trees, so no visibility to the site is possible.

A19 (Route 8)

5.4.14 The A19 runs 1.2 km east of the site. This road is screened by trees, so visibility of the site is not possible.

A195 (Route 9)

5.4.15 The A195 runs approximately 2.4 km west of the site. This road is screened by buildings and thick trees, so visibility of the site is not possible.

Sulgrave Rd (Route 10)

5.4.16 Sulgrave Road runs through an industrial estate 1.6 km west of the site. This road is mostly screened by trees, but glimpses of the array are possible.

A194(M) (Route 11)

5.4.17 The A194 runs approximately 3.8 km west of the site. This road is screened by thick trees, so visibility of the site is not possible.

Learn Ln (Route 12)

5.4.18 Learn Lane runs 3.6 km northwest of the site. This road is screened by hedgerows and intervening topography, so visibility of the site is not possible.

B1306 (Route 13)

5.4.19 The B1306 runs 3.6 km northwest of the site. This road is screened by trees, so visibility of the site is not possible.

Rutherford Rd (Route 14)

5.4.20 Rutherford Road runs through an industrial estate 1.6 km west of the site. This road is screened by trees and buildings so visibility of the site is not possible.

Washington Rd (Route 15)

5.4.21 Washington Road lies 1.3 km east of the site at its nearest. This road is screened by trees and buildings so visibility of the site is not possible.

Public Roads Conclusion

5.4.22 The analysis has shown that there is low potential for roads to receive glint. In most cases, roads are completely screened by existing screening. Motorists on roads that are not completely screened are unlikely to be affected by glint as the duration will be short.

5.4.23 Glint effects are more likely on Follingsby Lane because it has visibility of the north-facing panels. Although it is unlikely to be dangerous, measures should be considered to mitigate glint effects, such as surface texturing of these panels and anti-reflective coatings.

5.5 Effect on Railways

5.5.1 The Tyne and Wear Metro Green Line runs 4 km from the site at its closest. The stretch that lies in the ZTV was not predicted any glint. No other railway lines were identified within 5 km of the site.

5.6 Effect on Airfields & Aircraft

5.6.1 There are concerns that glint could have a negative effect on both airport and aircraft operations while on the ground and on aircraft flying over or near to the site.

5.6.2 The nearest major airport to the site is Newcastle International Airport which lies 20 km northwest. After analysis, no glint was predicted from the proposed PV arrays on final approach.

5.6.3 No aerodromes were identified within 15km of the site boundary, therefore there will be no effect visible to pilots during critical flight times (final approach). Although glint could be visible to overflying light aircraft, any effect visible would not be sustained for extended durations and would be orders of magnitude lower than large bodies of still water.

5.7 Cumulative Effects

5.7.1 There are several other sources of reflection in the vicinity of the proposed site so there is a potential for cumulative glint effects to be received by receptors surrounding the site. This Cumulative Effects section addresses any potential cumulative glint effect that may arise from existing and proposed sites together with this site.

5.7.2 Figure 10 shows a chart for an illustrative Observation Point demonstrating the timings of cumulative effects. The geometric potential for glint associated with the proposed site, as described in Section 5.2 is shown in Orange. Cumulative effects include the glint associated with both the proposed site and existing sites (grey). Simultaneous cumulative effects have the potential to occur when the times and dates when glint is possible, overlap between the arrays, as shown in Figure 10 in Yellow.

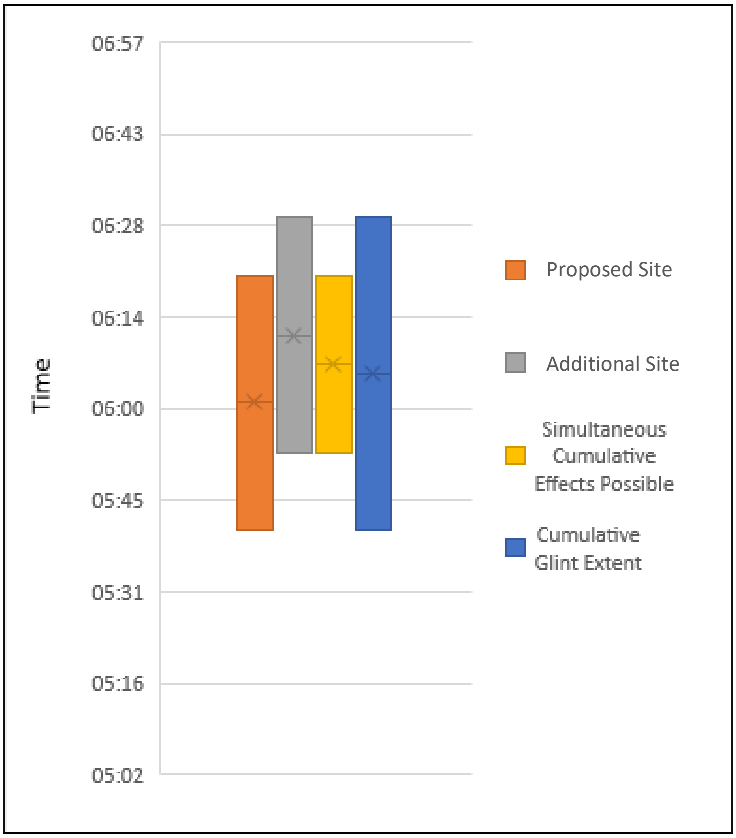

Figure 10: Example Chart Representation of Simultaneous Cumulative Effects

5.7.3 Only simultaneous cumulative effects will be considered as this is when glint is more intense in a particular location.

5.7.4 A set of south-facing solar arrays has been identified south of the proposed site. Because the tilt angle of these arrays is unknown, it was modelled at 15 degrees, 20 degrees and 30 degrees.

5.7.5 No cumulative, simultaneous glint was predicted for the receptors that have potential to receive glint from the proposed array.

5.7.6 Several other small, rooftop solar arrays were identified in the vicinity of the area, however these are all located south of the site and are mainly south-facing. They will have no impact on the receptors with potential to receive glint from the proposed site because they are north of the proposed site.

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Appendix 1 Policy & Guidance

Policies & Guidance

Buildings

In the UK at the domestic level the closest guidelines regarding glint are the BRE guidelines on 'Site layout planning for Daylight and Sunlight'[1] With regard to solar dazzle these state that:

> "*Glare or dazzle can occur when sunlight is reflected from a glazed façade or an area of metal cladding. This can affect road users outside and the occupants of adjoining buildings. The problem can occur where there are large areas of reflective glass or cladding on the façade, or where there are areas of glass or cladding slope back so that high altitude sunlight can be reflected along the ground. Thus solar dazzle is only a long-term problem for some heavily glazed (or mirror clad) buildings. Photovoltaic panels tend to cause less dazzle because they are designed to absorb light.*
>
> *"If it is likely that a building may cause solar dazzle the exact scale of the problem should be evaluated. This is done by identifying key locations such as road junctions and windows of nearby buildings, and working out the numbers of hours of the year that sunlight can be reflected to these points. BRE information paper IP 3/87 gives details.*
>
> *"Glare to motorists approaching the building can be an issue. The worst problems occur when drivers are travelling directly towards the building and sunlight can reflect off surfaces in the drivers direct line of sight (usually this will be off the lower parts of the building)."*

After setting out a methodology for calculating solar reflections from sloping glazed facades, BRE information paper IP 3/87[2] summarises effects as follows:

> "*Initial experience suggests that, in Europe and the USA at least, the greatest problems occur with facades facing within 90^o of due south, sloping back at angles between 5^o and 30^o to the vertical. Where the façade slopes at more than 40^o to the vertical (less than 50^o to the horizontal) solar reflections are likely to be less of a problem, unless nearby buildings are very high; and facades which slope forward, so that the top of the building forms an effective overhang, should also cause few problems in this respect. In the northern hemisphere, north facing facades should only cause reflected solar glare on a few occasions during the year, if at all."*

In the domestic setting the guidelines therefore suggest that glare and dazzle are only likely to be issues if the facade (or panel in this case) is within 40 degrees of the vertical or 50 degrees of the horizontal. Beyond this angle, incident light will be reflected primarily skywards. This is because the angle of reflection of light from a point source will always be the same as the angle of incidence.

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[1] Site Layout Planning for Daylight and Sunlight: A guide to good practice. (2nd Edition) Paul Littlefair, BRE Trust, First published 2011.

[2] Building Research Establishment IP 3/87 "*Solar dazzle reflected from sloping glazed facades*" P J Littlefair, April 1987

Aviation

The fact that this incident light will be reflected skywards is of principle concern for aircraft. The health and safety of passengers and crew on flights into and out of airports is of paramount importance and it is therefore critical to demonstrate that the effects of the proposed solar farm will not compromise this.

In Ireland, no guidance has been issued by the Irish Aviation Authority (IAA) relating to glint and glare issues associated with solar PV developments. The closest guidance is provided in, Irish Aviation Authority (Aerodromes and Visual Ground Aids) Order, 2008, it states:

Dangerous lights: A person shall not exhibit any light which:

- by reason of its glare is liable to endanger aircraft taking off from or landing at an aerodrome; or
- by reason of its liability to be mistaken for an aeronautical light is liable to endanger aircraft

Guidance was issued by the IAA in 2014 in relation to land use planning and offshore development. In the safeguarding section, it states:

“Holders of a public use aerodrome licence should have in place a system for monitoring local authority planning applications to identify any proposed construction of objects within a radial distance of at approximately 15 kilometres from the aerodrome reference point, where such objects have the potential to infringe areas of obstacle limitation surfaces (OLS)… In addition, licensees should safeguard their aerodromes against any land development which is likely to attract a large number of birds into an area within 13 kilometres radius of the aerodrome and which may pose a risk to aircraft as a result of a bird strike”

The effect of this guidance suggests that aerodrome operators should safeguard their aerodromes up to a distance of 15km for developments with the potential to infringe on protected surfaces and 13km for developments which may attract birds. No guidance on safeguarding distances is provided for solar PV developments which may have a potential glint effect on aviation.

Wardell Armstrong has contacted the IAA to ascertain whether they have any guidance or comment on the potential impact of glint on aviation operations in the ROI and at this time a response has not been received.

In the UK the guidance offers slightly more detail as it relates to solar PV directly. In 2010 the Civil Aviation Authority (CAA) issued interim guidance on Solar Photovoltaic Systems on and near to licensed aerodromes while formal policy was being developed (Civil Aviation Authority, 2010). This covers development:

"principally on or in the vicinity of licensed aerodromes but will also include guidance on installations away from aerodromes (or 'en-route')."

'Vicinity' in the above statement is defined as within 15km of an aerodrome.

The CAA identified the key issue as being:

"perceived to be the potential for reflection from SPV (solar photo-voltaic) to cause glare, dazzling pilots or leading them to confuse reflections with aeronautical lights."

It gives the following articles of the Air Navigation Order that should be considered.

- Article 137 - Endangering safety of an aircraft.
- Article 221 - Lights liable to endanger.
- Article 222 – Lights which dazzle or distract.

It is not considered that there is opportunity for pilots to confuse reflections with aeronautical lighting. The times when aeronautical lighting is lit and is most prominent in the pilot's view are times when there are low light levels such as at night-time or when weather conditions like cloud or fog reduce visibility. At these times panels will produce no glint or glare due to low light levels. The CAA has not yet adopted formal policy regarding this issue.

The European Aviation Safety Agency (EASA) Notice of Proposed Amendments NPA 2011-20 (B.III) (2011) provides notice and advice on the effect of dazzle to aircraft on final approach and ascent, with specific reference to solar panels. It should be noted that this document does not constitute formal policy but does provide an indication as to the EASAs position on the effects of glint from solar farms while formal policy is developed. It states: -

"A safety assessment is conducted in order to identify situations where the risk of dazzling becomes unacceptable. Thus, it is noted that dazzle represents such a risk in the following situations:

(1) during approach, especially after the aircraft has descended below the decision height: the pilot shall not lose any visual cue;

(2) at touchdown the pilot shall not be surprised by a flash;

(3) during rolling (landing or take-off), the pilot shall be able to perceive his environment and detect any deviation from the centre line: the pilot shall not lose any visual cue.

(4) Thus:

(i) prejudicial dazzle due to veiling luminance shall not occur during approach (slightly before the decision height) and rolling;

(ii) surprise effect shall not occur at touchdown."

The document then places the above into perspective in direct reference to solar panels.

"(l) The following assumptions can be made:

(1) solar panels are inclined so as to efficiently capture the sunlight, conducting to a range of cross section surfaces;

(2) the maximum acceptable luminance value has been fixed to 20,000 cd/m^2;

(3) the surfaces varied from 100 m^2 to several hectares;

(m) It is assumed that the aircraft maintains precisely its trajectory whereas in reality the approach is conducted into a conical envelop around the expected trajectory."

Research into the effects of glint and glare from solar PV is much more mature in the United States where significant work has been undertaken. The US Federal Aviation Administration (FAA) in their Solar Guide (Federal Aviation Administration, 2010) 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."*

The geometric analysis (full details in appendix 4), 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 will follow the methodology required by the FAA as it offers the most robust assessment method available.

At very close distances to the site – when glint is at its strongest - the solar farm will appear below the aircraft, out of view of the crew. Similarly, if climbing or flying away from the solar farm any glint will strike the underside of the fuselage and will not be visible to the crew.

The significance of an effect is defined as a function of the receptor's sensitivity and the magnitude of the effect. There are no current formal guidelines either within the ROI or internationally as to what constitutes a significant effect. However, the FAA, which utilises the analytical method used in this report, states in guidance that it will consider issuing an objection if the glint has the potential to form a temporary after image (medium intensity glint), other factors, such as the direction of frequency of the glint, also play a role in the choice of issuing an objection or not.

1.1 Operational Examples

There are a considerable number of large-scale solar installations that are already operating and located near to airports overseas. These include Newquay Airport in Cornwall, UK and Dunsfold Aerodrome in Surrey, also in the UK. Figure 1 shows a large scale solar farm similar to the proposed scheme constructed at Dusseldorf Airport, glint from the solar farm has not affected flight operations.

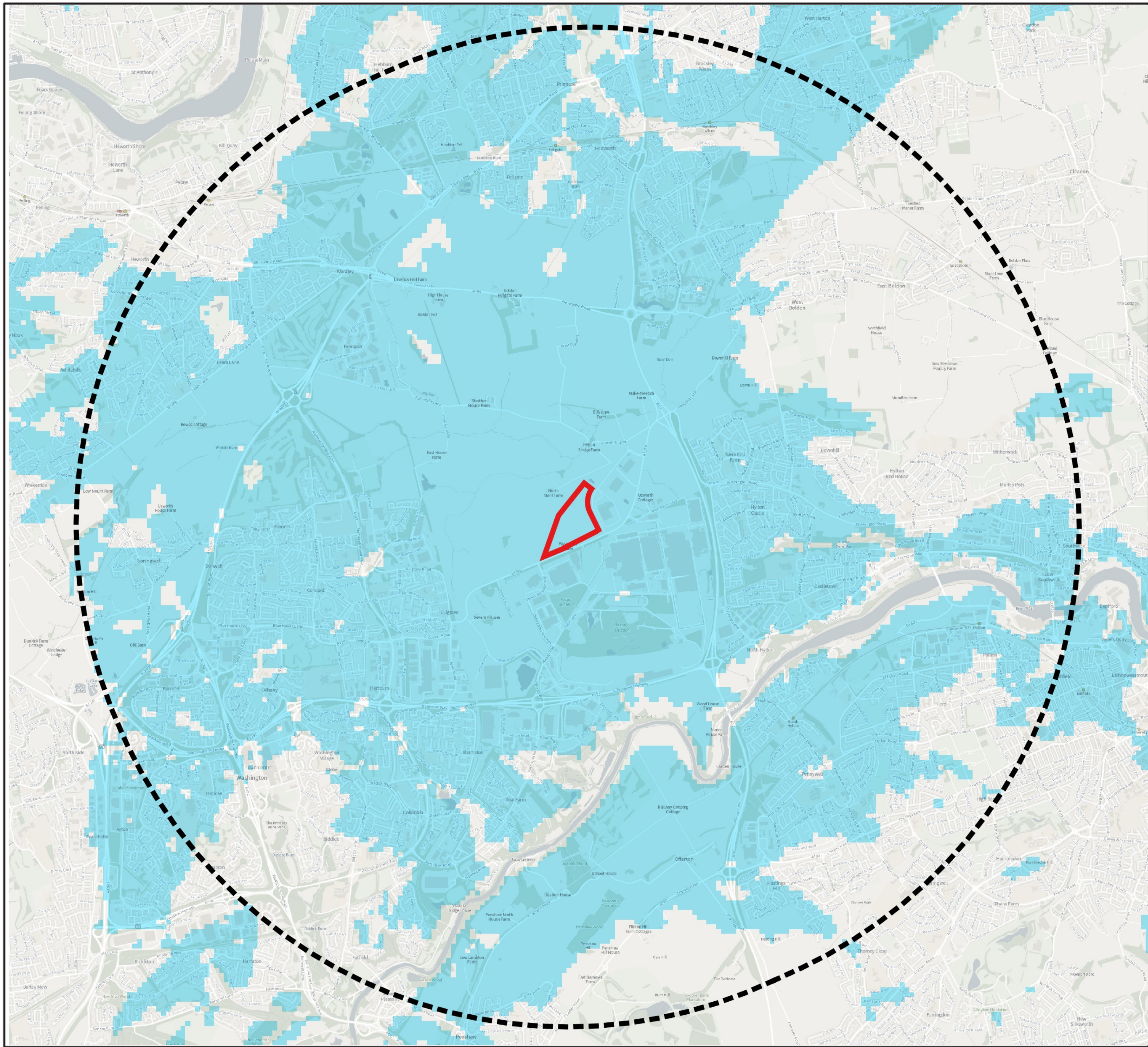
Figure 1 Solar Farm Adjacent to the Runway at Dusseldorf Airport (Aviation Pros, 2013)

A ground-mounted array of panels has also been installed at London Gatwick on land adjacent to the runway and taxiway (see Figure 2). Consultation was undertaken between the developer and the Gatwick aerodrome safeguarding team, National Air Traffic Services (NATS), and NATS (En Route) Plc (NERL) (Crawley Borough Council, Planning Ref: CR/2011/0602/CON). These consultees did not object to the proposal on any grounds including glint.

Figure 2 Solar Array next to Gatwick Runway (Business Green, 2013)

It is not expected that the potential for glint generated by the proposed solar farm could cause any serious operational effects to aircraft but since the position of the sun in the sky and the angle of the panels will be known, it is possible to predict exactly when there would be any chance of affecting a particular flight path and hence it would be possible to forewarn any pilots.

Appendix 2 Zone of Theoretical Visibility



DO NOT SCALE FROM THIS DRAWING

ZTV
Site Boundary
5 km Buffer

0 1 2 km

The figure shows the geographical extent of potential glint events out to 5km. For a glint event to occur on the ground, the receptor must be in both the ZTV and the GGZ. The ZTV is based on 3m high panels, a receptor height of 1.8m and OS Terrain 50 data with a 50m resolution.

Receptors would have to be able to see the panels to experience glint events and this may not be possible due to screening from hedgerows, trees, buildings, and other obstacles positioned between the panel and the receptor. When clouds obscure the sun from the site, it would not be possible for glint to occur.

The max and min azimuth angles used to create the ground glint zone were calculated and applied to the panel extents on the map. The southernmost vectors of the glint zone have much shorter extents than shown in the drawing as the light reflected from the panels is angled slightly downwards so can only be experienced in nearby valleys. Conversely, the northernmost receptors are only relevant on surrounding higher ground as glint is angled slightly upwards.

CLIENT	Envision AESC
PROJECT	NT15313 IAMP One Phase 2 Glint Assessment
DRAWING TITLE	IAMP One Phase 2 Zone of Theoretical Visibility
DRG No.	NT15313_0016
REV	1
DRG SIZE	A3
SCALE	1:55,000
DATE	21/6/2021
DRAWN BY	BS
CHECKED BY	
APPROVED BY	

Wardell Armstrong
Wheal Jane Earth Science Park
Baldhu
TR3 6EH

wardell armstrong your earth our world

Appendix 3 Glint Analysis

IAMP Sunderland rooftop

Ground and aerial 2

Created June 17, 2021
Updated June 18, 2021
Time-step 1 minute
Timezone offset UTC0
Site ID 55229.9902

Project type Advanced
Project status: active
Category 1 MW to 5 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

Glare with potential for temporary after-image predicted

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh
PV array 10	5.0	337.0	15,356	0	-
PV array 11	2.0	337.0	7,561	0	-
PV array 12	2.0	157.0	669	0	-
PV array 13	5.0	157.0	1,981	760	-
PV array 14	5.0	337.0	21,156	0	-
PV array 15	2.0	337.0	7,660	0	-
PV array 16	0.0	180.0	2,865	0	-
PV array 17	3.0	157.0	544	0	-
PV array 18	4.0	157.0	1,053	0	-
PV array 19	4.0	157.0	3,207	0	-
PV array 2	5.0	337.0	21,532	0	-
PV array 3	2.0	337.0	7,903	0	-
PV array 4	2.0	157.0	2,791	24	-
PV array 5	5.0	157.0	3,425	1,415	-
PV array 6	5.0	337.0	16,693	0	-
PV array 7	2.0	337.0	15,598	0	-
PV array 8	3.0	157.0	1,515	0	-
PV array 9	0.0	180.0	4,146	0	-

Component Data

PV Array(s)

Total PV footprint area: 67,823 m^2

Name: PV array 10
Axis tracking: Fixed (no rotation)
Tilt: 5.0 deg
Orientation: 337.0 deg
Footprint area: 4,720 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.922818	-1.483295	37.81	28.00	65.81
2	54.922564	-1.483106	37.94	28.00	65.94
3	54.923116	-1.480842	37.22	28.00	65.22
4	54.923356	-1.481025	36.82	28.00	64.82

Name: PV array 11
Axis tracking: Fixed (no rotation)
Tilt: 2.0 deg
Orientation: 337.0 deg
Footprint area: 4,766 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.922564	-1.483106	37.94	29.00	66.94
2	54.922320	-1.482929	38.35	29.00	67.35
3	54.922861	-1.480647	37.29	29.00	66.29
4	54.923116	-1.480842	37.22	29.00	66.22

Name: PV array 12
Axis tracking: Fixed (no rotation)
Tilt: 2.0 deg
Orientation: 157.0 deg
Footprint area: 5,154 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.922317	-1.482929	38.35	29.00	67.35
2	54.922105	-1.482768	38.69	29.00	67.69
3	54.922755	-1.479979	37.64	29.00	66.64
4	54.922983	-1.480145	37.46	29.00	66.46

Name: PV array 13
Axis tracking: Fixed (no rotation)
Tilt: 5.0 deg
Orientation: 157.0 deg
Footprint area: 5,030 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.922105	-1.482767	38.69	28.00	66.69
2	54.921883	-1.482602	38.28	28.00	66.28
3	54.922545	-1.479823	37.46	28.00	65.46
4	54.922754	-1.479979	37.64	28.00	65.64

Name: PV array 14
Axis tracking: Fixed (no rotation)
Tilt: 5.0 deg
Orientation: 337.0 deg
Footprint area: 4,020 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.921701	-1.482462	38.67	28.00	66.67
2	54.922367	-1.479705	37.97	28.00	65.97
3	54.922206	-1.479576	37.91	28.00	65.91
4	54.921517	-1.482330	38.65	28.00	66.65

Name: PV array 15
Axis tracking: Fixed (no rotation)
Tilt: 2.0 deg
Orientation: 337.0 deg
Footprint area: 3,192 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.921382	-1.482229	38.68	29.00	67.68
2	54.922068	-1.479464	38.21	29.00	67.21
3	54.922206	-1.479576	37.91	29.00	66.91
4	54.921515	-1.482328	38.65	29.00	67.65

Name: PV array 16
Axis tracking: Fixed (no rotation)
Tilt: 0.0 deg
Orientation: 180.0 deg
Footprint area: 3,095 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.921382	-1.482228	38.68	30.00	68.68
2	54.921251	-1.482129	38.96	30.00	68.96
3	54.921938	-1.479362	38.30	30.00	68.30
4	54.922071	-1.479464	38.21	30.00	68.21

Name: PV array 17
Axis tracking: Fixed (no rotation)
Tilt: 3.0 deg
Orientation: 157.0 deg
Footprint area: 2,953 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.921252	-1.482130	38.96	29.00	67.96
2	54.921106	-1.482023	38.99	29.00	67.99
3	54.921658	-1.479737	37.85	29.00	66.85
4	54.921818	-1.479861	38.21	29.00	67.21

Name: PV array 18
Axis tracking: Fixed (no rotation)
Tilt: 4.0 deg
Orientation: 157.0 deg
Footprint area: 3,066 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.921106	-1.482017	38.99	28.00	66.99
2	54.920949	-1.481905	38.86	28.00	66.86
3	54.921497	-1.479619	38.28	28.00	66.28
4	54.921661	-1.479737	37.85	28.00	65.85

Name: PV array 19
Axis tracking: Fixed (no rotation)
Tilt: 4.0 deg
Orientation: 157.0 deg
Footprint area: 2,850 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.920952	-1.481906	38.86	14.00	52.86
2	54.921106	-1.482019	38.99	14.00	52.99
3	54.920556	-1.484319	39.79	14.00	53.79
4	54.920415	-1.484213	39.51	14.00	53.51

Name: PV array 2
Axis tracking: Fixed (no rotation)
Tilt: 5.0 deg
Orientation: 337.0 deg
Footprint area: 4,657 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.922817	-1.483302	37.81	14.00	51.81
2	54.922262	-1.485533	39.64	14.00	53.64
3	54.922022	-1.485368	39.45	14.00	53.45
4	54.922561	-1.483113	37.94	14.00	51.94

Name: PV array 3
Axis tracking: Fixed (no rotation)
Tilt: 2.0 deg
Orientation: 337.0 deg
Footprint area: 4,542 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.922558	-1.483108	37.94	15.00	52.94
2	54.922320	-1.482931	38.35	15.00	53.35
3	54.921779	-1.485195	38.95	15.00	53.95
4	54.922021	-1.485368	39.45	15.00	54.45

Name: PV array 4
Axis tracking: Fixed (no rotation)
Tilt: 2.0 deg
Orientation: 157.0 deg
Footprint area: 3,956 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.922320	-1.482926	38.35	15.00	53.35
2	54.921779	-1.485193	38.95	15.00	53.95
3	54.921574	-1.485050	39.24	15.00	54.24
4	54.922108	-1.482770	38.69	15.00	53.69

Name: PV array 5
Axis tracking: Fixed (no rotation)
Tilt: 5.0 deg
Orientation: 157.0 deg
Footprint area: 4,348 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.922106	-1.482770	38.69	14.00	52.69
2	54.921886	-1.482604	38.29	14.00	52.29
3	54.921342	-1.484878	39.33	14.00	53.33
4	54.921577	-1.485047	39.22	14.00	53.22

Name: PV array 6
Axis tracking: Fixed (no rotation)
Tilt: 5.0 deg
Orientation: 337.0 deg
Footprint area: 3,550 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

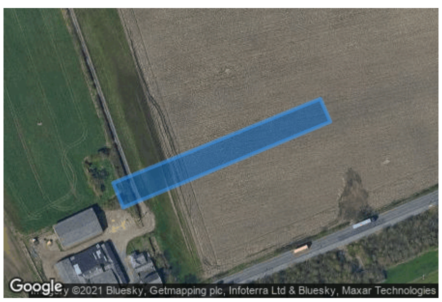
Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	54.921517	-1.482332	38.65	14.00	52.65
2	54.920967	-1.484615	39.61	14.00	53.61
3	54.921157	-1.484744	39.33	14.00	53.33
4	54.921700	-1.482466	38.66	14.00	52.66

Name: PV array 7
Axis tracking: Fixed (no rotation)
Tilt: 2.0 deg
Orientation: 337.0 deg
Footprint area: 2,520 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	54.921382	-1.482230	38.68	15.00	53.68
2	54.921516	-1.482330	38.65	15.00	53.65
3	54.920967	-1.484613	39.60	15.00	54.60
4	54.920837	-1.484522	40.11	15.00	55.11

Name: PV array 8
Axis tracking: Fixed (no rotation)
Tilt: 3.0 deg
Orientation: 157.0 deg
Footprint area: 2,927 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	54.921251	-1.482132	38.96	15.00	53.96
2	54.920714	-1.484433	40.18	15.00	55.18
3	54.920557	-1.484320	39.79	15.00	54.79
4	54.921105	-1.482020	39.00	15.00	54.00



Name: PV array 9
Axis tracking: Fixed (no rotation)
Tilt: 0.0 deg
Orientation: 180.0 deg
Footprint area: 2,477 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	54.920713	-1.484437	40.28	16.00	56.28
2	54.920841	-1.484520	40.11	16.00	56.11
3	54.921382	-1.482230	38.68	16.00	54.68
4	54.921251	-1.482130	38.96	16.00	54.96