Solar Photovoltaic Glint & Glare Study Aviation Specific (Dublin Airport)

For roof mounted PV panels at a proposed residential development at Parkside, Phase 4, Malahide Road, Balgriffin, Dublin 13

October 2019

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Executive Summary

This report assesses the potential for ocular impact of glare emanating from sunlight reflections from proposed rooftop solar PV panels and its potential to cause an impact to users of the nearby Dublin Airport. Receptors considered for assessment include the final approaches to Runways 10L & 28R (Under Construction), 10R, 28L, 16 & 34 as well as both the existing and under construction Air Traffic Control Towers (ATCT) at Dublin Airport.

Using sun-path algorithms for every minute of the year, it was calculated if and when glare may theoretically occur at a particular receptor. If reflection was found geometrically possible at a particular location, further desk analysis was then carried out to ascertain if a view of the proposal (and thus potential for glare) would indeed be possible in reality.

The level of potential glare from solar PV panels is similar to that of water and much less than that of materials such as concrete and vegetation. Many common elements of the Irish landscape offer similar, if not higher levels of glare than that caused by solar PV systems such as shed roofs, poly tunnels and still lakes.

This is an aviation specific glint and glare report focusing only on the nearby Dublin Airport. It does not consider ground based receptors such as nearby roads, railway lines, residences or other aerodromes. However, due to the height above ground of the apartment blocks, it would not be deemed necessary to assess these receptors, due to the fact that a view of the panels themselves is highly unlikely.

For the purpose of aviation analysis the US Federal Aviation Administration (FAA) recommend the use of the Solar Glare Hazard Plot (Figure 9) to measure the ocular impact of a solar array. Receptors with theoretical potential for glare can fall into one of three different areas: Green - “Low potential for after-image”, Yellow - “Potential for after-image” and Red - “Potential for Permanent Eye Damage (retinal burn)”.

Figure 1 below gives a brief overview of the results of this glint and glare report. From this it can be seen that none of the five solar arrays assessed have the potential to be a source of glare for an aircraft landing at any of the runways (both built or under construction) at Dublin Airport. Similarly, both air traffic control towers (ATCT) at Dublin Airport will be unaffected from a glint and glare perspective, by the inclusion of solar PV panels on the roofs of any of the apartment blocks in this development, based on the current design parameters.

It will be shown from the report and analyses herein that nuisance or hazardous glare **can not** be expected for users of the nearby Dublin Airport as a result of the inclusion of solar PV panels to the roofs of any of the apartment blocks in this development.

Receptor	No. of Assessed Arrays	No. with Theoretical Potential for Glare	No. with no Theoretical potential for Glare
Runway 10L	5	0	5
Runway 10R	5	0	5
Runway 16	5	0	5
Runway 28L	5	0	5
Runway 28R	5	0	5
Runway 34	5	0	5
Existing ATCT	5	0	5
Recently Complete ATCT	5	0	5

FIGURE 1: RESULTS AT A GLANCE

Introduction

Innovision has been appointed by Cairn Homes to carry out an aviation specific glint and glare study for roof mounted solar PV panels on proposed residential apartment blocks at Parkside, Phase 4, Malahide Road, Balgriffin, Dublin 13. The subject site is located approximately 6km east south east of Dublin Airport (Figure 2). The proposed development consists of four apartment blocks of similar size, height and orientation. It is a possibility that the client may wish to propose solar PV panels to certain parts of the roof of each block.

Innovision is a leading visualisation, mapping & geographical information systems (GIS) analysis company. Our innovative team has over ten years' experience in the photomontage and 3D visualisation industry, working on a wide range of proposed commercial developments including numerous wind and solar farms, both in Ireland and abroad. Innovision is also a certified Forge Solar 'Glare Expert'. This is currently the only glint and glare assessor qualification available internationally.

Using desk-based analysis, this report has assessed the potential for glare on aircraft taking off and landing at Dublin Airport. Using sun-path algorithms for every minute of the year (assuming 100% sunshine for all daylight hours), it is determined if and when reflections may occur at these selected receptors. If reflection is found geometrically possible from a particular location, further analysis is then carried out. This further analysis determines the significance of the glare that could potentially be experienced and also if, in reality, these effects are likely to be experienced by an observer at that location. In certain cases, where glare is found to be significant and a likely source of hazard or nuisance, mitigation factors can then be discussed.

Proposed Solar PV Array Details

If included, the proposed solar arrays will be mounted on the flat roofs of some or all apartment blocks. For the purpose of this report, each block of apartments has been given a unique identifier. Please refer to Map 1 for a breakdown of these areas.

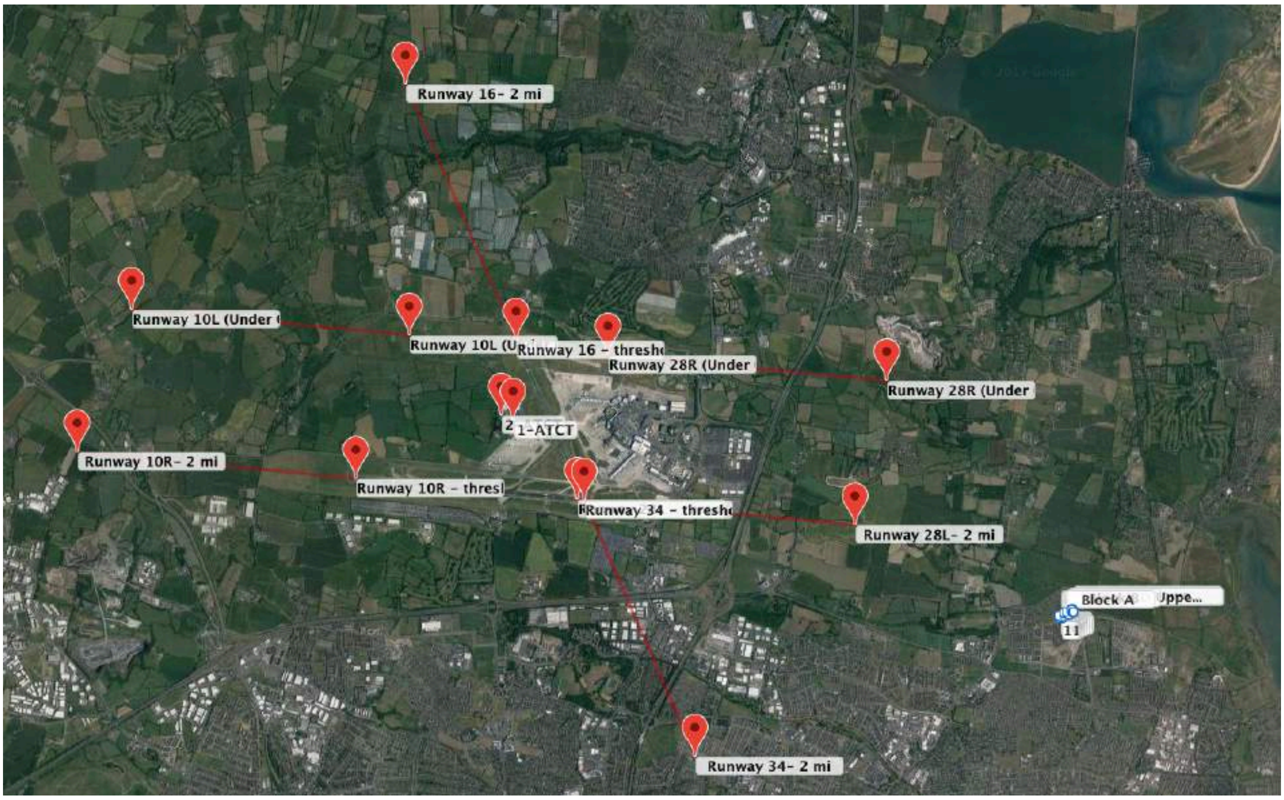


FIGURE 2: SITE LOCATION RELATIVE TO DUBLIN AIRPORT

If included, all panels will be facing due south for maximum energy output. The pitch angle of the panels will be 15 degrees. Both the pitch angle and the orientation angle of the panels will be fixed so the panels will not track the sun throughout the day/year.

Glint and Glare Overview

What are Glint and Glare?

Glint and glare are phenomenon caused by many reflective materials, whereby light from the sun is reflected off such materials with a potential to cause hazard, nuisance or unwanted visual impact. Glint and glare have been best defined by the United States Federal Aviation Administration (FAA) in their "*Technical Guidance for Evaluating Selected Solar Technologies on Airports*"[1]:

> **Glint** is a momentary flash of bright light.
>
> **Glare** is a continuous source of bright light.

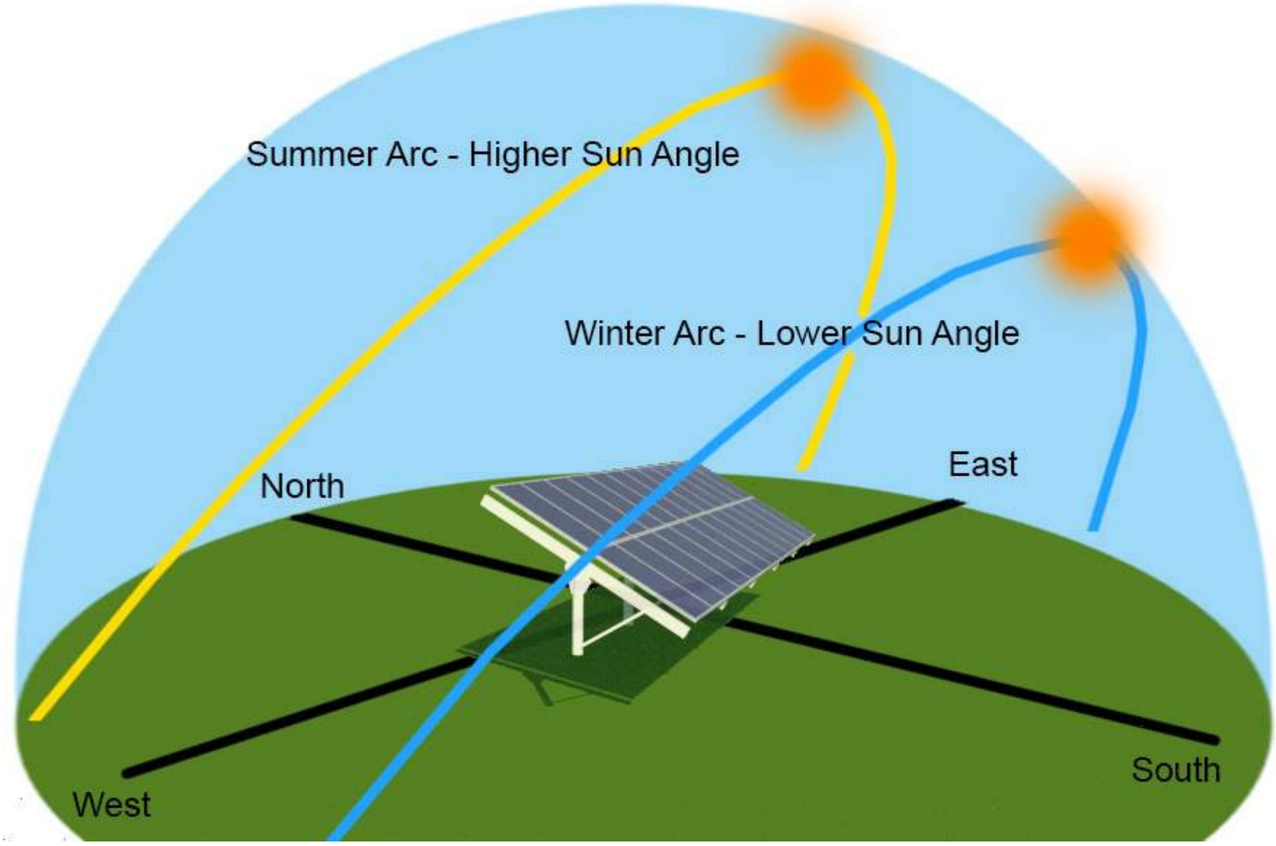
Glint and Glare are also commonly referred to as 'solar reflection'. To determine the impact that solar reflection could potentially have on members of the public, it is sometimes necessary to carry out a glint and glare assessment for proposed solar PV farms or roof mounted arrays.

When do Glint and Glare Occur?

The sun rises in the east and sets in the west and in the northern hemisphere, tracks a southerly arc across the sky (Figure 3). The elevation angle that the sun reaches varies depending on the time of year, with high angles in the summer months and much lower angles in winter.

Once the sun reaches a certain elevation in the sky, the incident angle of the sun will reflect off the solar panels at an opposing angle that will not impact on any ground-based receptors. As a result of this, for ground-based receptors, glint and glare from solar farms will generally only occur in the mornings and the evenings. At these times, the sun will also be shining from a similar direction as any potential glare. For aviation receptors however, glare can potentially occur at any time of day depending on the location of the aircraft.

[1] Federal Aviation Administration, November 2010: *Technical Guidance for Evaluating Selected Solar Technologies on Airports*



Meteorological & Atmospheric Conditions

It is also worth noting that glint and glare can only occur when there is direct sunlight reaching the solar panels. In overcast or rainy conditions, no glint or glare will occur. Met Éireann, Ireland's National Meteorological Service, suggests that due to Ireland's position off the northwest of Europe we are kept in humid, cloudy airflows for much of the time. *"Irish skies are completely covered by cloud for well over fifty percent of the time."*[2]

For this proposed development, historical sunshine duration data from 1981-2010, recorded at Dublin Airport has been analysed. Dublin Airport is the nearest Met Éireann weather station to the proposed development that records sunshine data. From looking at Figure 4 & Figure 5 below it can be seen that for this particular site, the number of days glare could potentially be experienced at each receptor could realistically be reduced by 70% and still offer an overstated prediciton of glare.

[2] Met Éireann "Sunshine and Solar Radiation" www.met.ie.

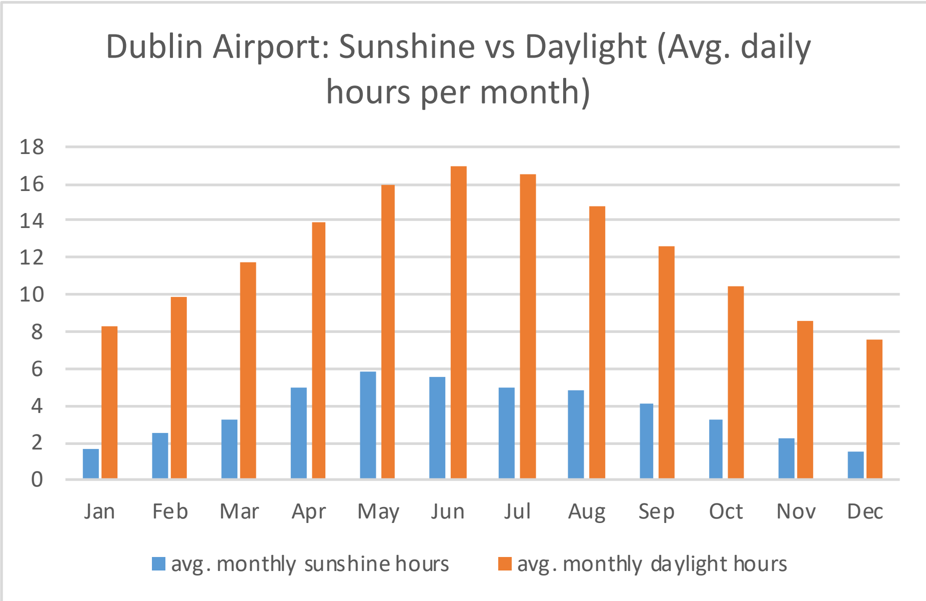


FIGURE 4: DUBLIN AIRPORT: SUNSHINE VS DAYLIGHT (AVG. DAILY HOURS PER MONTH)

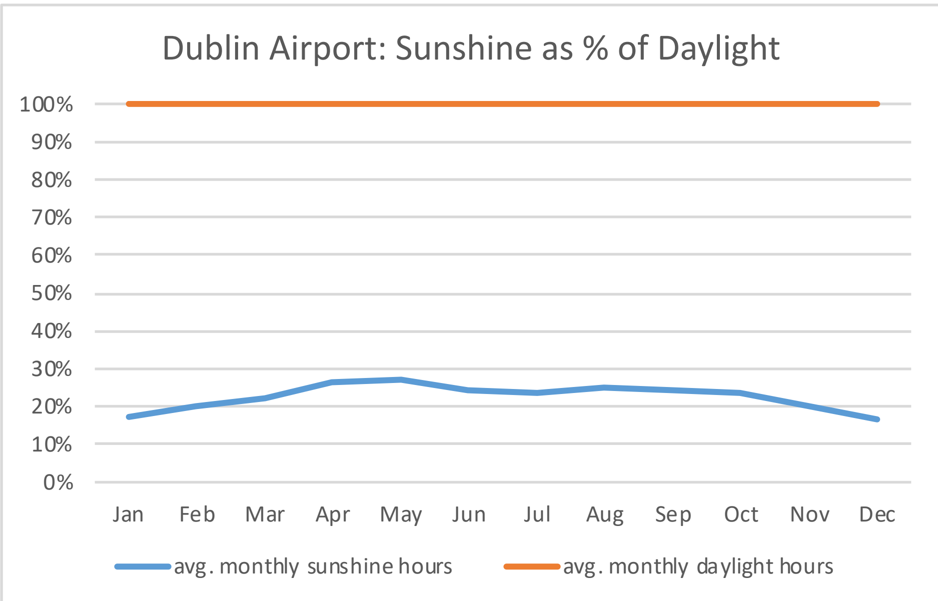


FIGURE 5: DUBLIN AIRPORT: SUNSHINE AS A PERCENTAGE OF DAYLIGHT

Solar Reflectance from PV Panels

Surface Reflectance

All surface types have different reflectivity characteristics. This results in varying degrees of sunlight reflection. Solar panels, by their nature, are designed to absorb as much sunlight as possible, thus converting the sun's energy to electricity. As a result, the amount of light reflected off these installations is far less than one might expect. The figure below (Figure 6) is taken from the FAA 2010 Solar Guidance and illustrates that the reflectance of solar PV panels is of a similar nature to water. Typical values for the reflectance levels of solar PV panels are far less than that of materials such as snow, concrete and even vegetation. It should be noted however, that at certain times of the day, generally early morning and late evening, with the sun low in the sky, the amount of light reflected off solar panels can increase, causing a potential for glare in certain directions.

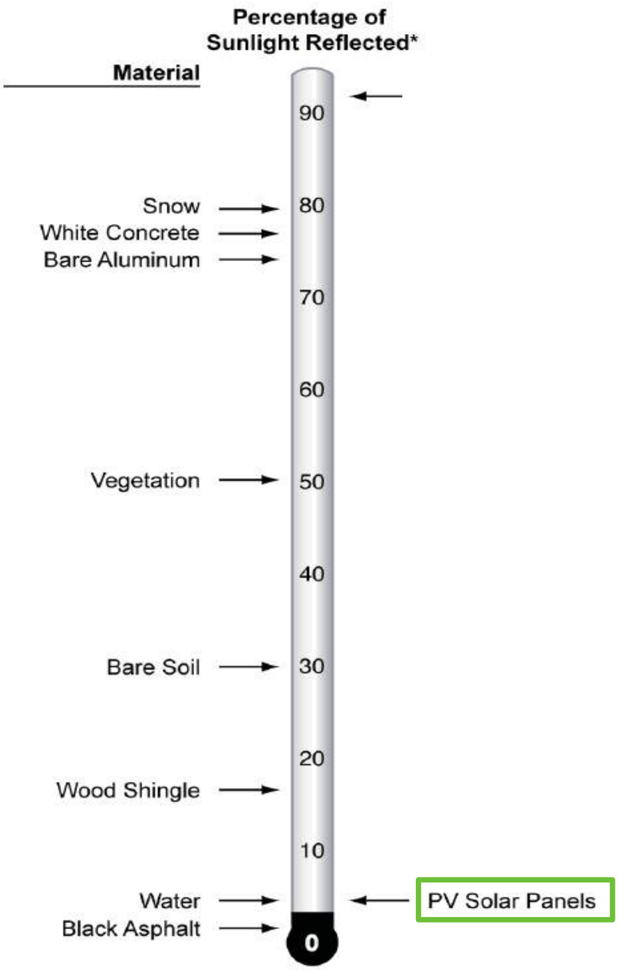


FIGURE 6: REFLECTIVITY PRODUCED BY DIFFERENT SURFACES (SOURCE: FAA)

Types of Reflection

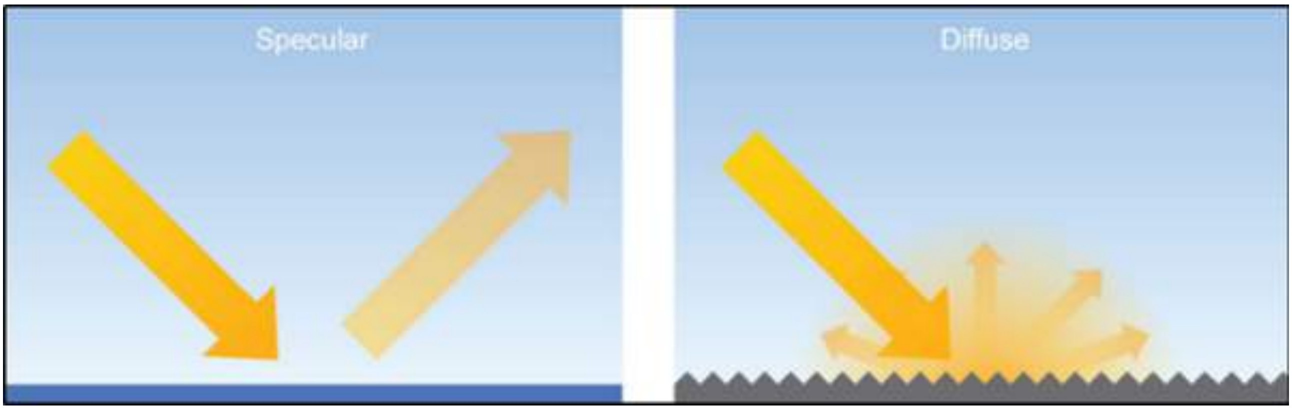


FIGURE 7: DIFFERENT TYPES OF REFLECTION (SOURCE: FAA)

There are two types of reflection which can occur on a surface; specular and diffuse. Specular reflection is a direct reflection which produces a more “focused” type of light. It occurs when light reflects off a smooth or polished surface like glass or still water. Diffuse reflection, on the other hand, produces a less “focused” type of light. Diffuse reflection occurs as a result of light reflecting off a rough surface such as vegetation, concrete or wavy water. Figure 7 helps to illustrate the difference between these two types of reflection. The main type of reflectance from solar PV panels is specular due to the glass like texture of the outer layer of the panels. However, in reality, like all surfaces, there will be a combination of both specular and diffuse reflection

As discussed earlier, the level of potential glare from solar PV panels is similar to that of water and much less than that of materials such as concrete and vegetation. Many common elements of the Irish landscape offer similar, if not higher levels of glare than that caused by solar PV systems such as shed roofs, still lakes and even the strips of plastic sheeting used on farms to produce maize (Figure 8).

FIGURE 8: PLASTIC MAIZE WRAP IN A FIELD WITH POTENTIAL TO CAUSE SIMILAR LEVELS OF GLARE AS SOLAR PV FARMS

Relevant Guidance & Studies

Republic of Ireland

In the Republic of Ireland (ROI), there is currently no guidance, policy or recommendations in relation to the assessment of glint and glare effects on aviation, road & rail users or residential buildings. Future Analytics in conjunction with the Sustainable Energy Authority of Ireland (SEAI) have produced planning and development guidance recommendations for utility scale solar photovoltaic schemes in Ireland [3]. While this is not formal guidance, it does set out recommended elements of the assessment based on international practice.

United Kingdom

In the United Kingdom (UK), where the development of large scale solar PV is more mature, certain studies have been carried out which help to establish an accepted best practice and planning guidance recommends the assessment of glint and glare effects. However, there is still no specific guidance by way of a prescriptive methodology document. In the absence of formal policy, the Civil Aviation Authority (CAA) have provided interim guidance in relation to the development of solar PV systems on, and in the vicinity (<15km) of aerodromes. This guidance recommends that solar PV developers should *"provide safety assurance documentation regarding the full potential impact of the SPV installation on aviation interests."* [4] The Building Research Establishment (BRE) have also issued several relevant papers, however neither the BRE nor the CAA have produced a methodology for assessing the effects of glint and glare on aviation, road & rail users or residential buildings.

Germany

In Germany, glare is considered an emission not unlike noise, odour or vibration. *"Licht-Leitlinie"* [5] or Light Guidelines produced by The Federal Ministry of the Environment defines acceptable levels of glare as being anything less than 30 minutes per day or 30 hours per year. The guidance also states that there is only additional impact to an observer as a result of glare from a solar array if the angle between the source of the glare and the sun is greater than ten degrees. These factors are taken into consideration at classification of impact stage in this report.

[3] *Future Analytics. October 2016. Planning and Development Guidance Recommendations for Utility Scale Solar Photovoltaic Schemes in Ireland*

[4] Civil Aviation Authority. December 2010. *"Interim CAA Guidance - Solar Photovoltaic Systems".*

[5] Leitlinie des Ministeriums fur Umwelt. Gesundheit und Verbraucherschutz zur Messung und Beurteilung von Lichtimmissionen (Licht-Leitlinie). 2014 Available: http://www.mlul.brandenburg.de/media_fast/4055/licht_leitlinie.pdf

United States of America

The main form of guidance in assessing the likely effects of glint and glare (on aviation infrastructure) comes from the FAA in the United States. Their document, "*Technical Guidance for Evaluating Selected Solar Technologies on Airports*"[6] is accepted internationally as the most detailed methodology for assessing the effects of glint and glare. This document is currently under review and an interim policy document[7] was produced in October 2013. The 2013 interim policy further addresses glint and glare issues and recommends the use of a particular analysis tool, the Solar Glare Hazard Analysis Tool (SGHAT), when carrying out glint & glare assessments of solar PV systems. This is a tool that was developed by the US Department of Energy research laboratories, Sandia National Laboratories, to assess the ocular impact of proposed solar energy systems.

Innovision has created a methodology for assessing glint and glare taking all of the above studies and guidelines into consideration. Although SGHAT is a tool which was created to assess the impact of solar PV systems on aviation infrastructure, Innovision has employed this tool and prescribed methodology to all receptor types including road & rail users, aviation & residential buildings. This is currently the **only FAA approved tool** for measuring the ocular impact of solar PV systems on receptors. Until formal guidance is provided in Ireland, Innovision will continue to follow international guidelines and best practice.

Methodology

Innovision's methodology can be broken down into seven key stages:

1. Study Area Selection
2. Receptor Identification
3. Geometric Analysis
4. Examination of Screening and Receptor Orientation
5. Determination of Impact
6. Mitigation

[6] Federal Aviation Administration. November 2010. "*Technical Guidance for Evaluating Selected Solar Technologies on Airports*"
[7] Federal Aviation Administration. October 2013. *"Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports."*

1. Study Area Selection

The first stage of any glint and glare assessment is to identify the study area. In the case of this development, only the runways and ATCT at Dublin Airport will be considered. For ease of interpretation, the site has been broken up into blocks and each apartment block has been given a unique identifier. Please refer to Map 1 for a breakdown of these areas.

2. Receptor Identification

Once the study area has been defined, receptors can then be identified. For this site, the four runways at Dublin Airport are being considered.

AIRPORTS & AIRSTRIPS

The two main receptors that need to be considered when assessing the glint and glare effects of solar PV farms on aerodromes are Air Traffic Control Towers (ATCT) and the final approach path to a runway. An ATCT is assessed much like any other receptor point using the correct altitude of the tower. For final runway approach paths, a line is extrapolated 2 miles back from the runway threshold (the point at which an aircraft enters the runway) at an angle of 3 degrees. This results in a continuous analysis of every point along the final approach to the runway. For this report, the above process is carried out for Dublin Airport only. For utility scale solar PV systems any aerodromes within the vicinity of a proposed solar PV farm would be assessed. "Vicinity" in this case is within 15km as defined by the CAA interim guidance referred to earlier. It should also be noted that these calculations take the pilots field of view into consideration and thus limit the angle of view to 100 degrees in the horizontal and a downward viewing angle of 30 degrees.

4. Geometric Analysis

As discussed previously in this document, Innovision employs the use of the SGHAT in order to run the calculations for its glint and glare analysis. This is currently the only FAA approved tool for measuring the ocular impact of solar PV systems on receptors.

A number of parameters are considered in order to run these geometric analyses. These include, but are not limited to:

- The apparent position and height of the sun at a particular time of day and year (for every minute of the year).
- The position, height, orientation & pitch of the solar PV array.

- The position and height of the receptor.

The severity of the glare is influenced mainly by two factors:

- The distance of the observer from the glare spot, and
- The angle of the sunlight hitting the solar panels relevant to the observer

5. Examination of Screening and Receptor Orientation

The geometrical glare analysis does not consider screening from landform such as hills and mountains, or any vegetative or built environment elements of the landscape that may screen the development from view. For this reason, once the receptors that could potentially experience glare have been identified, their level of existing screening must be assessed. This is done through a combination of desk-based analysis of both Google StreetView and aerial photography and sometimes requires a site visit for further verification. Receptor orientation is also considered. Geometric analysis may suggest that a dwelling will experience glare, but the orientation of the dwelling also needs to be considered. If a dwelling is facing away from the solar array, any potential glare could have little or no impact. Similarly, a road may show up as having potential to experience glare, but unless the direction of travel is towards the source of glare, it is unlikely to cause significant impact.

6. Determination of Impact

Once all of the above steps are carried out, a determination of likely impacts can be made for each receptor. Results are collated into a comprehendable table with comments as to the likely glint and glare impact or otherwise, of the propsed solar PV panels on all assessed receptors. An initial determination is made using the table below, based purely on the theroetical amount of time a receptor may potentially experience glare.

Classification	Description
High	Potential for more than 45 mins of glare per day and/or more than 50 hours per year
Medium	Potential for no more than 45 mins of glare per day and/or no more than 50 hours per year
Low	Potential for 20 - 30 mins of glare per day and/or no more than 30 hours per year
Very Low	Potential for 10 - 20 mins of glare per day and/or no more than 20 hours per year
Negligible	Potential for less than 10 mins of glare per day and/or less than 10 hours per year
None	No geometric potential for glare / Any potential for glare fully screened by intervening landform, vegetation or the built environment

The above table is used as a guide only and final classification is based on a combination of additional factors including level of intervening screening (vegetative or otherwise), receptor orientation, position of sun in relation to source of glare, as well as professional judgement.

7. Mitigation

If it is determined that glare will be experienced at a particular receptor and there is no screening between the receptor and the solar array, mitigation may be recommended depending on the severity of the glare. Mitigating glare impact from a solar array can be achieved in a number of different ways. The most common method is to add vegetative screening to essentially form a visual barrier between the receptor and the development. This type of mitigation is often required for ecological and visual impact reasons also. Other forms of mitigation include changing the design of the solar array, such as a change in pitch and orientation of the panels.

Receptor Selection

As discussed, this report assesses the final approach at all runways (including the new under construction runway) and both the existing and under construction ATCT at Dublin Airport only. These receptors have been analysed for glint and glare effects that may be experienced during take off and landing as a result of the propsed roof mounted solar PV arrays. The accompanying Maps 1 - 3 will help in identifying solar array locations and also give a graphical overview of any arrays that could potentially be a source of glare to aircraft taking off and landing at Dublin Airport.

Results & Discussion

Tables 1 - 8 give an overview of the findings of this glint and glare report and can be used to assist in comprehension of the following discussion, along with the included maps (Maps 1 - 3). For more detailed information on the particulars of potential glare experienced at each receptor, please refer to the appendix of this report. The appendix contain graphs for each solar array showing the date and time of potential glare, the potential duration of the glare, the hazard plot indicating the magnitude of the potential glare and also where along the final approach the glare might potentially be experienced.

Please note, all references to time herein refer to Irish Standard Time (IST) which equates to UTC/GMT +1 hour. Between mid-March and early November Ireland uses Daylight Savings Time (DST) and as a result, 1 hour needs to be subtracted from any results occuring outside this time period.

TABLE 1: RESULTS OF GLINT AND GLARE ANALYSIS ON FLIGHT PATH ON APPROACH TO RUNWAY 10L (UNDER CONSTRUCTION)

Identifier	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
A	-	-	Glare not geometrically possible from this receptor									No Glare
B	-	-	Glare not geometrically possible from this receptor									No Glare
C	-	-	Glare not geometrically possible from this receptor									No Glare
D North	-	-	Glare not geometrically possible from this receptor									No Glare
D South	-	-	Glare not geometrically possible from this receptor									No Glare

TABLE 2: RESULTS OF GLINT AND GLARE ANALYSIS ON FLIGHT PATH ON APPROACH TO RUNWAY 10R

Identifier	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
A	-	-	Glare not geometrically possible from this receptor									No Glare
B	-	-	Glare not geometrically possible from this receptor									No Glare
C	-	-	Glare not geometrically possible from this receptor									No Glare
D North	-	-	Glare not geometrically possible from this receptor									No Glare
D South	-	-	Glare not geometrically possible from this receptor									No Glare

TABLE 3: RESULTS OF GLINT AND GLARE ANALYSIS ON FLIGHT PATH ON APPROACH TO RUNWAY 16

Identifier	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
A	-	-	Glare not geometrically possible from this receptor									No Glare
B	-	-	Glare not geometrically possible from this receptor									No Glare
C	-	-	Glare not geometrically possible from this receptor									No Glare
D North	-	-	Glare not geometrically possible from this receptor									No Glare
D South	-	-	Glare not geometrically possible from this receptor									No Glare

TABLE 4: RESULTS OF GLINT AND GLARE ANALYSIS ON FLIGHT PATH ON APPROACH TO RUNWAY 28L

Identifier	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
A	-	-	Glare not geometrically possible from this receptor									No Glare
B	-	-	Glare not geometrically possible from this receptor									No Glare
C	-	-	Glare not geometrically possible from this receptor									No Glare
D North	-	-	Glare not geometrically possible from this receptor									No Glare
D South	-	-	Glare not geometrically possible from this receptor									No Glare

TABLE 5: RESULTS OF GLINT AND GLARE ANALYSIS ON FLIGHT PATH ON APPROACH TO RUNWAY 28R (UNDER CONSTRUCTION)

Identifier	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
A	-	-	Glare not geometrically possible from this receptor									No Glare
B	-	-	Glare not geometrically possible from this receptor									No Glare
C	-	-	Glare not geometrically possible from this receptor									No Glare
D North	-	-	Glare not geometrically possible from this receptor									No Glare
D South	-	-	Glare not geometrically possible from this receptor									No Glare

TABLE 6: RESULTS OF GLINT AND GLARE ANALYSIS ON FLIGHT PATH ON APPROACH TO RUNWAY 34

Identifier	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
A	-	-	Glare not geometrically possible from this receptor									No Glare
B	-	-	Glare not geometrically possible from this receptor									No Glare
C	-	-	Glare not geometrically possible from this receptor									No Glare
D North	-	-	Glare not geometrically possible from this receptor									No Glare
D South	-	-	Glare not geometrically possible from this receptor									No Glare

TABLE 7: RESULTS OF GLINT AND GLARE ANALYSIS ON DUBLIN AIRPORT ATCT (EXISTING)

Identifier	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
A	-	-	Glare not geometrically possible from this receptor									No Glare
B	-	-	Glare not geometrically possible from this receptor									No Glare
C	-	-	Glare not geometrically possible from this receptor									No Glare
D North	-	-	Glare not geometrically possible from this receptor									No Glare
D South	-	-	Glare not geometrically possible from this receptor									No Glare

TABLE 8: RESULTS OF GLINT AND GLARE ANALYSIS ON DUBLIN AIRPORT ATCT (RECENTLY CONSTRUCTED)

Identifier	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
A	-	-	Glare not geometrically possible from this receptor									No Glare
B	-	-	Glare not geometrically possible from this receptor									No Glare
C	-	-	Glare not geometrically possible from this receptor									No Glare
D North	-	-	Glare not geometrically possible from this receptor									No Glare
D South	-	-	Glare not geometrically possible from this receptor									No Glare

Interpreting the Results

For the purpose of aviation analysis, the methodology produced by SANDIA National Laboratories must be followed to comply with FAA guidance. This approach adopts the Solar Glare Hazard Plot (Figure 9) to measure the ocular impact of a solar array. Receptors with theoretical potential for glare can fall into one of three different areas: Green - “Low potential for after-image”, Yellow - “Potential for after-image” and Red - “Potential for Permanent Eye Damage (retinal burn)”.

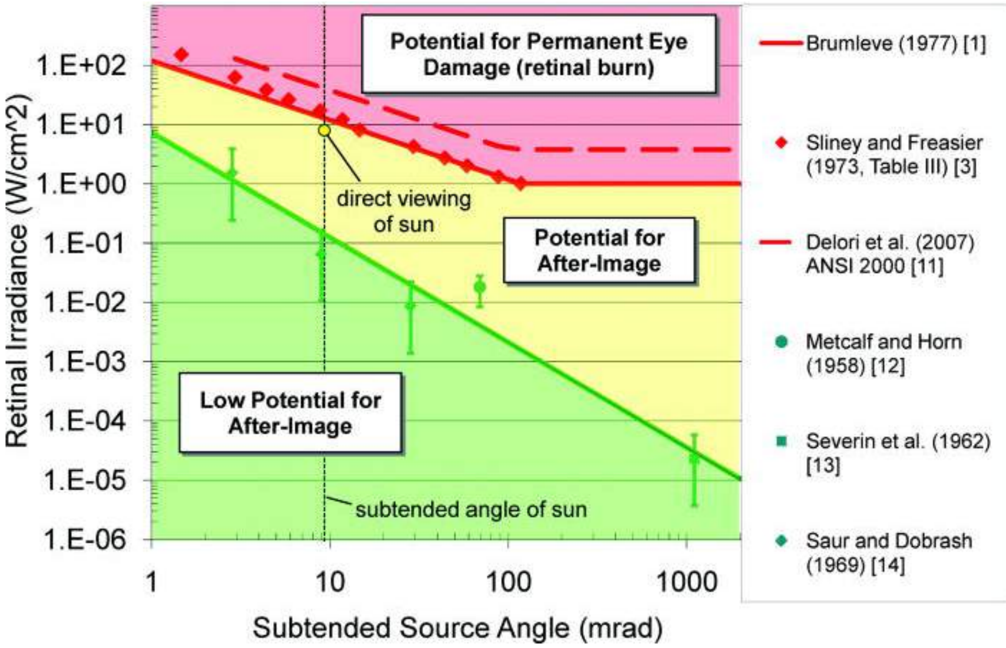


FIGURE 9: SOLAR GLARE HAZARD ANALYSIS PLOT (FIGURE 1 FROM FAA POLICY DOCUMENT)

The hazard plot above displays the ocular impact as a function of glare subtended source angle (the amount of an observer’s field-of-view taken up by a glare spot) and retinal irradiance (the amount of light reaching the observer’s retina). Each minute of potential glare is plotted on the chart. As a guide, a reference point which illustrates the hazard from viewing the sun without filtering is displayed on every graph.

From the 2013 FAA interim guidance, in order to obtain FAA approval for a proposed solar array the development must demonstrate that it meets the following standards:

“1. No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, and

2. No potential for glare or ‘‘low potential for after-image’’ (shown in green in Figure 1) along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport

Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath."

Runway 10L (Under Construction)

From Table 1 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Runway 10R

From Table 2 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Runway 16

From Table 3 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Runway 28L

From Table 4 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Runway 28R (Under Construction)

From Table 5 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Runway 34

From Table 6 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Dublin Airport ATCT (Existing)

From Table 7 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

Dublin Airport ATCT (Recently Constructed)

From Table 8 it can be seen that none of the proposed arrays have the potential to cause glare impact on this receptor.

For all of the above receptors analysed a number of factors should also be noted, which add to the argument that hazardous glare as a result of the roof mounted PV panels on the proposed residential development at Parkside, Phase 4, Malahide Road, Balgriffin, Dublin 13 **can not** be expected.

Duration of Glare: While a detailed breakdown of the duration of potential glare has been provided, in reality, an aircraft will be past any reflectance in a matter of seconds.
Location of Development: A pilot landing at any of Dublin Airport's runways would most likely be focusing on the runway and final approach and would need to look away from this in order to observe the development which would be situated among many other developments (many of which have highly reflective materials in their make-up) and mature vegetation.
Weather: As mentioned previously in this report, in order for glare to be experienced, the sun needs to be shining on the panels. From analysis of historical data it can be shown that the number of days glare could potentially be experienced at each receptor could realistically be reduced by 70% and still offer an overstated prediciton of glare.

Conclusion

In conclusion, it can be shown from the above analyses that nuisance or hazardous glare **can not** be expected for aircraft landing at any of the runways or the ATCT at Dublin Airport. Based on the "worst case" scenario analysed, there is the no potential for glare from any rooftop arrays (based on the design parameters discussed), should the developer decide to include them. The results achieve a **pass** by FAA standards based on the fact that there is no potential for glare at all.

Appendix

Please note the following assumptions will apply to the following graphs:

- Please note, all references to time herein refer to Irish Standard Time (IST) which equates to UTC/GMT +1 hour. Between mid-March and early November Ireland uses Daylight Savings Time (DST) and as a result, 1 hour needs to be subtracted from any results occuring outside this time period.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.

Site Configuration: Parkside 4

Project site configuration details and results.

Created **Aug. 9, 2019 7:37 a.m.**
Updated **Oct. 2, 2019 9 a.m.**
DNI **varies** and peaks at **1,000.0 W/m^2**
Analyze every **1** minute(s)
0.5 ocular transmission coefficient
0.002 m pupil diameter
0.017 m eye focal length
9.3 mrad sun subtended angle
Timezone **UTC1**
Site Configuration ID: 30255.3994

Summary of Results No glare predicted!

PV name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
Block A	15.0	180.0	0	0	-
Block B	15.0	180.0	0	0	-
Block C	15.0	180.0	0	0	-
Block D North	15.0	180.0	0	0	-
Block D South	15.0	180.0	0	0	-

Component Data

PV Array(s)

Name: Block A
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
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	53.408227	-6.167267	13.16	20.24	33.40
2	53.408261	-6.167101	13.06	20.34	33.40
3	53.408062	-6.166988	13.80	19.60	33.40
4	53.408030	-6.167162	13.83	19.57	33.40

Name: Block B
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
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	53.408367	-6.166567	14.00	19.40	33.40
2	53.408399	-6.166398	14.24	19.16	33.40
3	53.408202	-6.166288	13.66	19.74	33.40
4	53.408167	-6.166457	14.31	19.09	33.40

Name: Block C
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
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	53.408519	-6.165867	14.16	18.84	33.00
2	53.408549	-6.165698	13.93	19.07	33.00
3	53.408343	-6.165580	13.74	19.26	33.00
4	53.408311	-6.165749	13.85	19.15	33.00

Name: Block D North
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
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	53.408735	-6.165170	14.09	18.91	33.00
2	53.408794	-6.165006	13.80	19.20	33.00
3	53.408673	-6.164888	14.12	18.88	33.00
4	53.408615	-6.165052	13.95	19.05	33.00

Name: Block D South
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg
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	53.408415	-6.164904	14.64	21.06	35.70
2	53.408428	-6.164832	14.81	20.89	35.70
3	53.408449	-6.164837	14.80	20.90	35.70
4	53.408460	-6.164762	14.56	21.14	35.70
5	53.408402	-6.164671	13.94	21.76	35.70
6	53.408362	-6.164872	14.48	21.22	35.70

2-Mile Flight Path Receptor(s)

Name: Runway 10L (Under Construction)
Description:
Threshold height : 15 m
Direction: 95.4 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.437241	-6.280170	71.95	15.24	87.19
2-mile point	53.439962	-6.328547	75.52	180.36	255.87

Name: Runway 10R
Description:
Threshold height : 15 m
Direction: 95.4 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	53.422405	-6.289531	74.02	15.24	89.26
2-mile point	53.425146	-6.337888	80.37	177.58	257.95

Name: Runway 16
Description:
Threshold height : 15 m
Direction: 156.7 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	53.436695	-6.261765	66.48	15.24	81.72
2-mile point	53.463248	-6.280993	69.95	180.45	250.40

Name: Runway 28L
Description:
Threshold height : 15 m
Direction: 275.4 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	53.420291	-6.251115	62.01	15.24	77.25
2-mile point	53.417596	-6.202754	41.73	204.21	245.94

Name: Runway 28R (Under Construction)
Description:
Threshold height : 15 m
Direction: 275.4 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	53.435248	-6.245649	63.27	15.24	78.51
2-mile point	53.432527	-6.197275	30.99	216.20	247.19

Name: Runway 34
Description:
Threshold height : 15 m
Direction: 336.8 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.420207	-6.249810	62.21	15.24	77.45
2-mile point	53.393632	-6.230675	49.36	196.78	246.14

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
1-ATCT	53.428491	-6.262204	65.73	22.00	87.73
2-ATCT	53.428920	-6.264277	65.54	80.50	146.04

1-ATCT map image

2-ATCT map image

PV Array Results

Block A

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L (Under Construction)	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R (Under Construction)	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

Block B

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L (Under Construction)	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R (Under Construction)	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

Block C

Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L (Under Construction)	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R (Under Construction)	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

Block D North

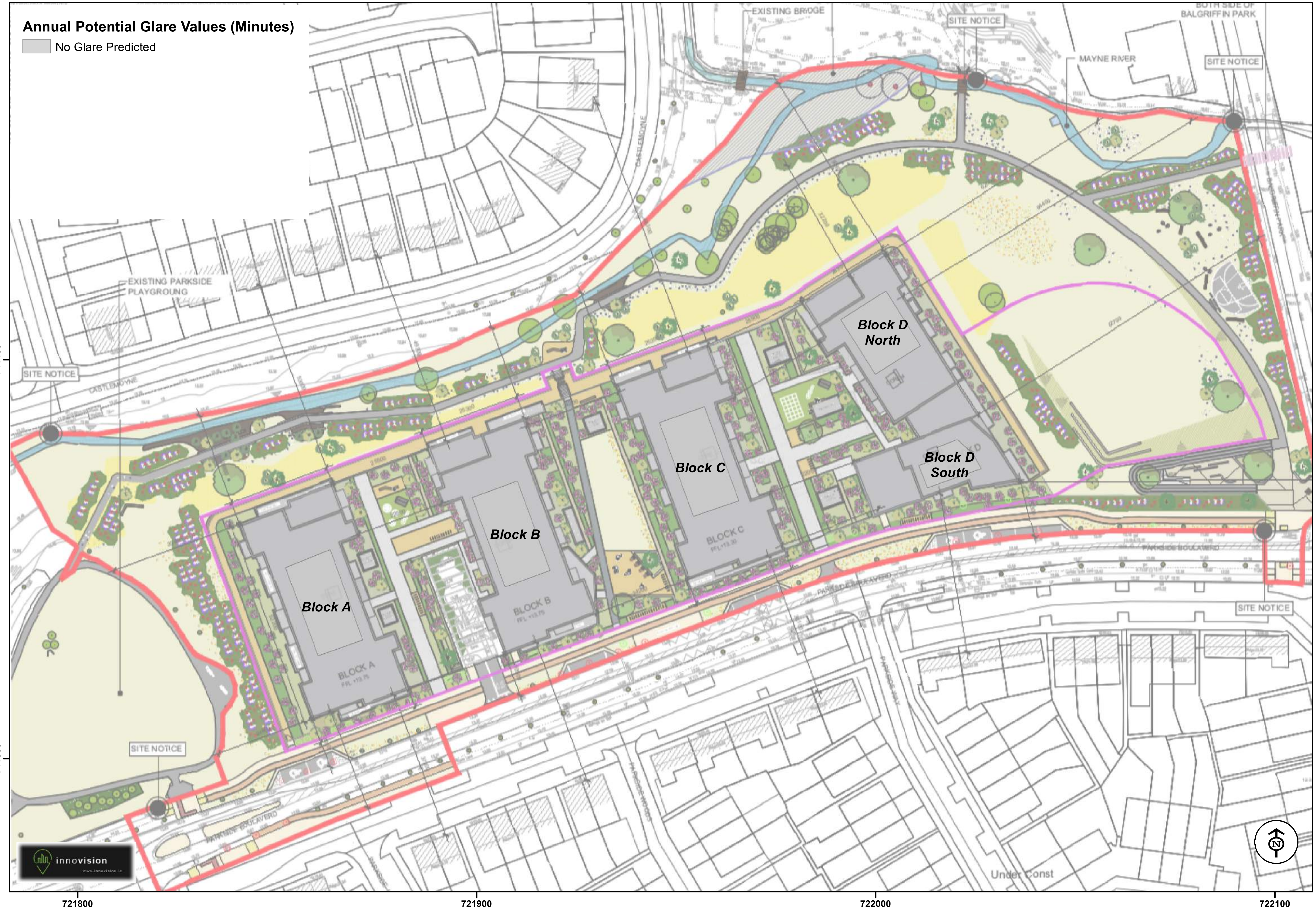
Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L (Under Construction)	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R (Under Construction)	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

Block D South

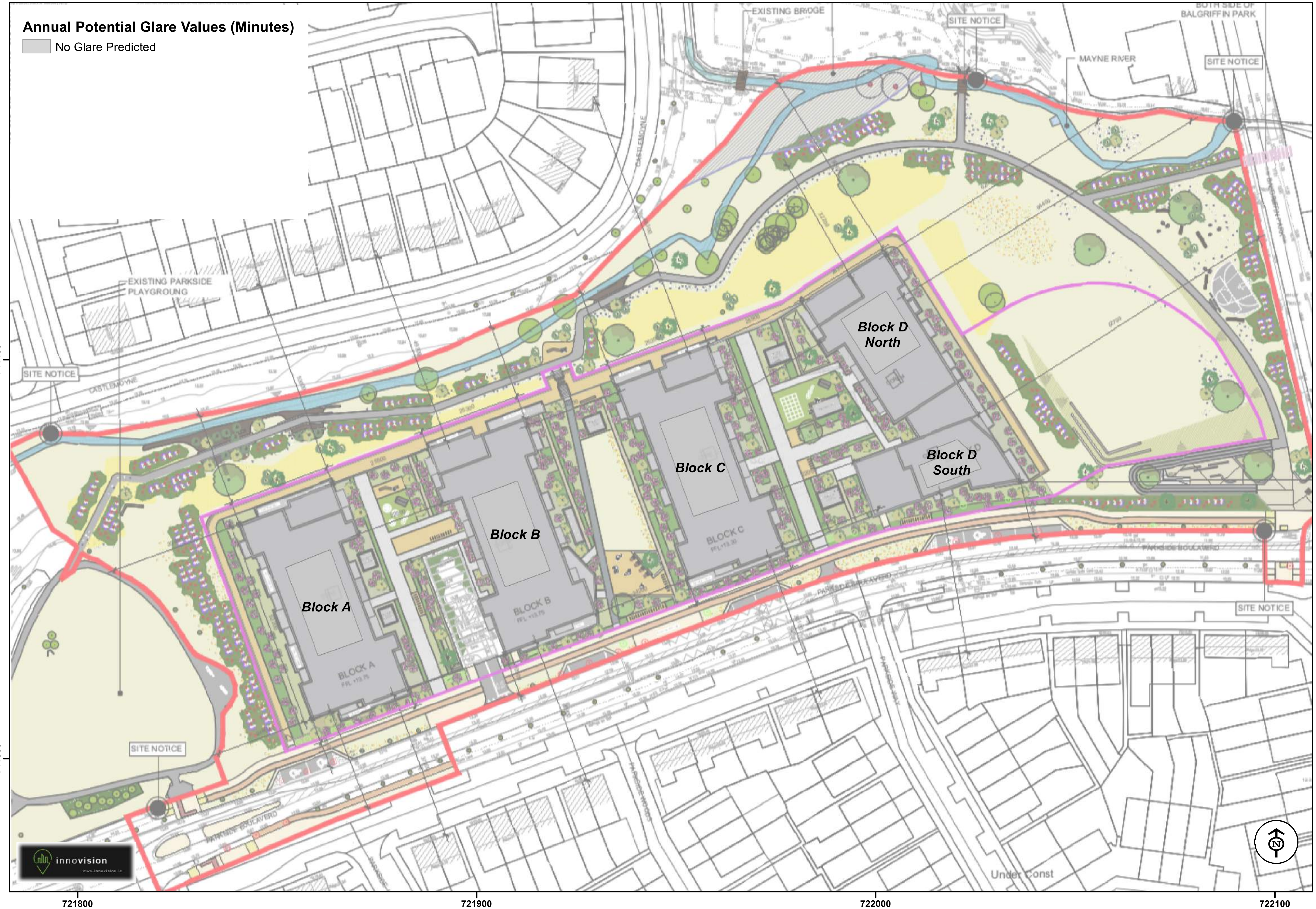
Component	Green glare (min)	Yellow glare (min)
FP: Runway 10L (Under Construction)	0	0
FP: Runway 10R	0	0
FP: Runway 16	0	0
FP: Runway 28L	0	0
FP: Runway 28R (Under Construction)	0	0
FP: Runway 34	0	0
OP: 1-ATCT	0	0
OP: 2-ATCT	0	0

Map 1 Glint and Glare Zones Overview Map - Roof Mounted Solar PV Arrays at the proposed Parkside (Phase 4) Residential Development

Map 2 Potential Glint and Glare Impact on all runways (existing and under construction) at Dublin Airport as a result of Roof Mounted Solar PV Arrays at the proposed Parkside (Phase 4) Proposal



Map 3 Potential Glint and Glare Impact on both the existing and recently constructed ATCT at Dublin Airport as a result of Roof Mounted Solar PV Arrays at the proposed Parkside (Phase 4) Proposal



Brenda Butterly

From:	Brenda Butterly
Sent:	Thursday 10 October 2019 11:45
To:	Brenda Butterly
Subject:	Proposed Residential Development at Parkside 4, Parkside, Dublin 13 - Glare and Glint Study
Attachments:	19164 Parkside 4 Development Rev I.pdf; 304387 Notice of Pre-Application Consultation Opinion.pdf; Parkside_4_GG_Report_20191003.pdf; Seha Technical Services Ltd Parkside 4 - Clongriffin obs 18.09.19.docx
Importance:	High

From: MACCRIOSTAIL Cathal <Cathal.MacCriostail@IAA.ie>
Sent: Wednesday 9 October 2019 16:07
To: Shane Mullins <ShaneMullins@seha.ie>
Cc: Nigel Somerfield <nigel.somerfield@daa.ie>; HUGHES John <John.HUGHES@IAA.ie>; Simon Killeen <SimonKilleen@seha.ie>
Subject: FW: Proposed Residential Development at Parkside 4, Parkside, Dublin 13 - Glare and Glint Study
Importance: High

Dear Shane,

Our conversation just now refers along with the attached correspondence in relation to a proposed Residential Development at Parkside 4, Parkside, Dublin 13

In my capacity of IAA Air Navigation Service Provider(ANSP) Manager Airspace and Navigation, I can confirm that I accept the findings of the attached Glint and Glare report, completed by Innovision, do not create any impact for flight procedures to and from Dublin Airport.

I have copied my Regulatory Colleague, John Hughes, Manager Aerodromes with the Safety Regulatory Directorate for information.

I'll be happy to follow up with additional formal correspondence as required and you're welcome to refer any queries to me.

Kind regards,

Cathal

Cathal Mac Criostail
Údarás Eitlíochta na hÉireann / Irish Aviation Authority
The Times Building, 11-12 D'Olier Street, Dublin 2, D02 T449, Ireland
✉ cathal.maccriostail@iaa.ie
☎ +353 (0)1 6031173
+353 (0)86 0527130
www.iaa.ie
Do you *really* need to print this?

From: Shane Mullins <ShaneMullins@seha.ie>
Sent: Friday 4 October 2019 11:53
To: Nigel Somerfield <nigel.somerfield@daa.ie>; MACCRIOSTAIL Cathal <Cathal.MacCriostail@IAA.ie>
Cc: Simon Killeen <SimonKilleen@seha.ie>
Subject: Proposed Residential Development at Parkside 4, Parkside, Dublin 13 - Glare and Glint Study
Importance: High

Hi Nigel and Cathal

Further to our recent discussions with your IAA colleague Deirdre Forrest we have been advised that you are the point of contact for future correspondence on this development for the DAA and the IAA respectively.
We have enclosed a copy of the glare and glint report as issued by Innovision for the development at Parkside 4, Dublin 13 and we would ask if you could review the report and if acceptable issue correspondence confirming acceptance of the proposed installation

Regards

Shane Mullins
Senior Engineer

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SEHA Technical Services Ltd

04th October 2019

Mr. Nigel Somerfield
Aerodrome Standards Manager
daa

cc
Mr. Cathal Mac Criostail
Údarás Eitlíochta na hÉireann / Irish Aviation Authority
The Times Building, 11-12 D'Olier Street, Dublin 2, D02 T449, Ireland

Reference: Proposed Residential Development at Parkside 4, Parkside, Dublin 13

Dear Sirs,

Further to our recent discussions with your IAA colleague Deirdre Forrest please note we have been advised that you are the point of contact for future correspondence on this development.

With regards to The Bord Pleanala Pre-Application Consultation opinion (attached) and specifically item 11, as the building is on the Dublin Airport flight path our client Cairn Homes Properties Limited has engaged a specialist glare and glint study to address any concerns relating to the proposed Photo Voltaic Installation and aviation for the Parkside 4 residential development.

We have enclosed a copy of the glare and glint report as issued by Innovision and we would ask if you could review the report and if acceptable issue correspondence confirming acceptance of the proposed installation.

Should you have any queries do not hesitate to contact me.

Yours sincerely,

____
Shane Mullins
Senior MEP Engineer
SEHA Technical Services Ltd
Mobile: +353 (0)86 776 9555
E-mail: shanemullins@seha.ie

Encl:
Parkside_4_ GG_report
Seha Technical Services Ltd Parkside 4 Clongriffin Obs 18.9.2019
304387 Opinion