MARCH 2024

AVIATION GLINT & GLARE ASSESSMENT

PROPOSED ARLINGTON MULTIPLE-USE DEVELOPMENT ON ERVEN 3988, 4195 AND 6991 ALONG GLENDORE ROAD IN WALMER, GQEBERHA, NELSON MANDELA BAY MUNICIPALITY, EASTERN CAPESOUTH AFRICA

PROJECT NAME	PROPOSED ARLINGTON MULTIPLE-USE DEVELOPMENT ON ERVEN 3988, 4195 AND 6991 ALONG GLENDORE ROAD IN WALMER, GQEBERHA, NELSON MANDELA BAY MUNICIPALITY, EASTERN CAPE.
REPORT	ASSESSMENT REPORT
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CLIENT	ADENDORFF ARCHITECTS (PTY) LTD ON BEHALF OF AFROSTRUCTURES (PTY) LTD [redacted]
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DATE OF RELEASE	26 MARCH 2024
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Amendment History

Version 1	Original	26/03/2024

I hereby declare that I do:

(a) have knowledge of and experience in conducting assessments, including knowledge of the Act, these regulations and guidelines that have relevance to the proposed activity;

(b) perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;

(c) comply with the Act, these regulations, guidelines, and other applicable laws.

I also declare that there is, to my knowledge, no information in my possession that reasonably has or may have the potential of influencing –

(i) any decision to be taken with respect to the application in terms of the Act and the regulations; or

(ii) the objectivity of this report, plan or document prepared in terms of the Act and these regulations.

Dr Brett Williams
Future Impact (Pty) Ltd

EXECUTIVE SUMMARY

Future Impact were appointed by JG Afrika (Pty) Ltd to conduct a desktop review pertaining to glint and glare impacts on aviation receptors as a result of light reflecting off a solar PV installation at the proposed Arlington Multiple-Use Development in Gqeberha Eastern Cape.

The assessment was conducted with the objective of determining how ‘glint’ and ‘glare’ will affect aviation receptors such as pilots on final approach to the airport, as well as the Air Traffic Control Tower (ATCT). These aviation receptors operate at the Chief Dawid Stuurman International Airport (ICAO code: FAPE) in Gqeberha, Eastern Cape.

If the ‘glint’ and ‘glare’ effects are strong enough, it has the potential to cause temporary flash blindness in the receptors and hinder their abilities to conduct their operations. The glare is rated in three categories, namely as green, yellow, and red with red being the highest risk from an aviation perspective as an after image could occur.

The modelling results indicate that the FP Runway 35, FP Runway 26, and Air Traffic Control Tower will be exposed to green glare only. No receptors will be exposed to yellow or red glint and glare during the landing phase of flight. This is due to the fixed axis Solar PV arrays being positioned on the northern side of the aviation receptors and angled towards the north.

Green glare has a low potential to cause temporary flash blindness and is therefore acceptable in terms of the United States FAA Regulations. Furthermore, the model does not take into account building heights, these buildings will obstruct the line of sight from the Air Traffic Control Tower to the Solar panels and therefore further prevent glint exposure to the Tower.

It is therefore recommended that the project receive authorisation from the Civil Aviation Authority from a glint and glare perspective.

Dr Brett Williams

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LIST OF ABBREVIATIONS AND DEFINITIONS

2-Mile Flight Path Receptor: The 2-Mile Flight Path receptor ("FP") simulates an aircraft following a straight-line approach path toward a runway, by default, including a restricted field-of-view to filter unrealistic glare. In addition, it can be modified to represent a worst-case approach and take-off path.

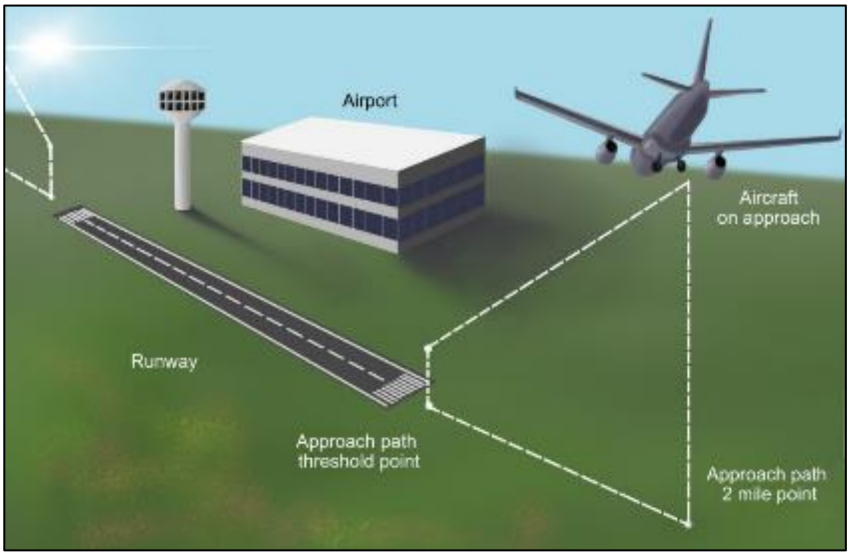

Figure 1: Flight Path

Flight Path Parameters are as follows:

Name: Descriptive alphanumeric label of receptor

Direction (°): Azimuthal angle of approach of aircraft which defines the straight path toward the runway. Measured clockwise from true north.

Glide slope (°): Angle of descent of aircraft toward runway. Default value of 3°.

Threshold crossing height: Height above ground of aircraft when it crosses the runway threshold. (Typically, 50 ft.).

Max downward viewing angle (°): The vertical field-of-view of the pilot, measured positive downward from the XY plane (i.e., flat). A default value of 30° assumes glare appearing beyond that FOV is not visible to the pilot and is acceptable to FAA. A value of 90° assumes the pilot can see glare appearing directly underneath the aircraft.

Azimuthal viewing angle (°): The left and right field-of-view of the pilot during approach. A view angle of 180° implies the pilot can see glare emanating from behind the plane.

Point coordinates: The threshold and 2-mile point ground elevation parameters can be modified in the FP Advanced dialog. The 2-mile point height is calculated from the point elevations and threshold crossing height to ensure a smooth 2-mile descent path.

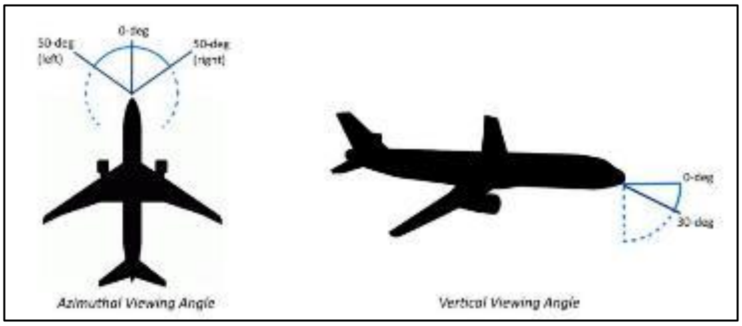

Figure 2: Viewing Angles.

Glint and Glare: Glint is typically defined as a momentary flash of bright light, often caused by a reflection off a moving source. A typical example of glint is a momentary solar reflection from a moving car. Glare is defined as a continuous source of bright light. Glare is generally associated with stationary objects, which, due to the slow relative movement of the sun, reflect sunlight for a longer duration. The difference between glint and glare is duration. Industry-standard glare analysis tools evaluate the occurrence of glare on a minute-by-minute basis; accordingly, they generally refer to solar hazards as 'glare'. Based on figure 3 (below), the ocular impact of solar glare is quantified into three categories:

→Green - low potential to cause after-image (flash blindness)
→Yellow - potential to cause temporary after-image.
→Red - potential to cause retinal burn (permanent eye damage)

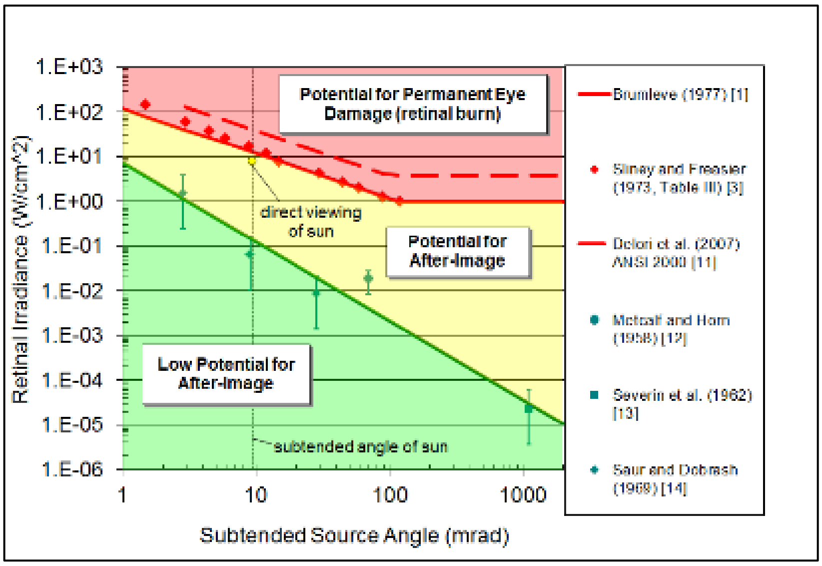

Figure 3: Glare Categories.

mrad: Milliradian, equal to one-thousandth of a radian. A radian is a unit of angular measure equal to the angle subtended at the centre of a circle by an arc equal in length to the radius of the circle, approximately 57°17'44.6".

Peak DNI (W/m2 or Wh/m2): The maximum Direct Normal Irradiance at the given location at solar noon. DNI is the amount of solar radiation received in a collimated beam on a surface normal to the sun during a 60-minute period. On a clear sunny day at solar noon, a typical peak DNI is ~1,000 W/m2.

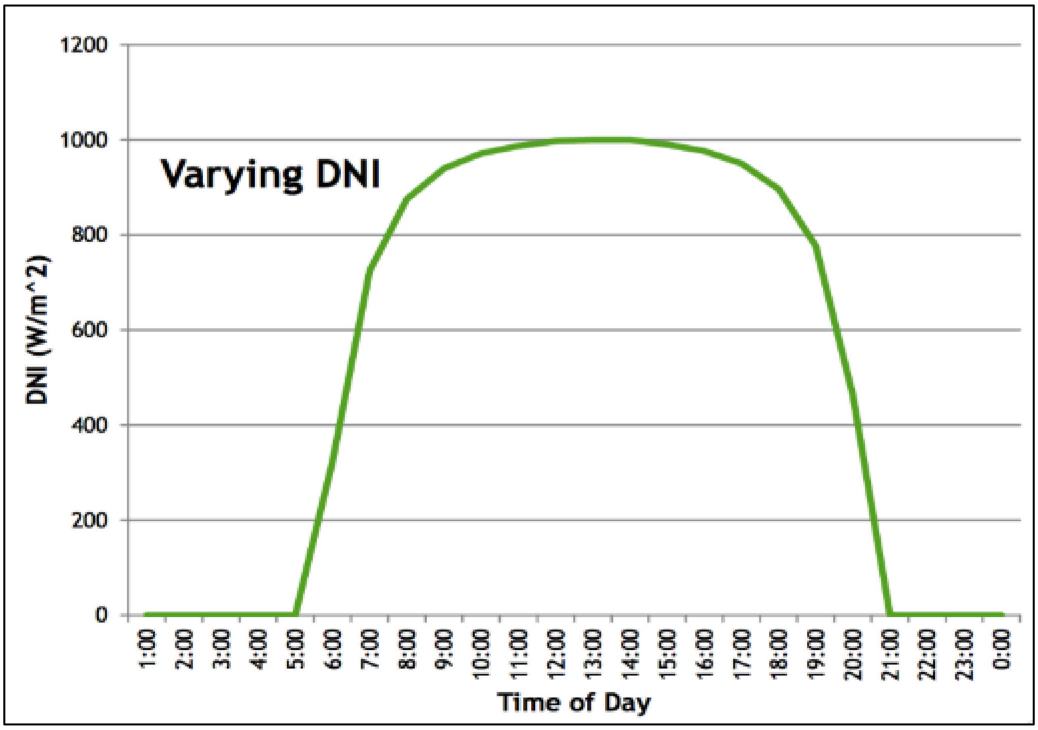

Figure 4: Peak Daily DNI

Slope error (mrad): Specifies the amount of scatter that occurs from the PV module. Mirror-like surfaces that produce specular reflections will have a slope error closer to zero, while rough surfaces that produce more scattered (diffuse) reflections have higher slope errors. Based on observed glare from different PV modules, an RMS slope error of ~10 mrad (which produces a total reflected beam spread of 0.13 rad or 7°) appears to be a reasonable value. Not used if correlate slope error to module surface type is checked. In this report, the worst-case scenario was assumed. Therefore, a light-textured PV panel with an anti-glare coating was selected for modelling. The properties of the selected panel are as follow: 9.16mrad average RMS slope error; 119.00mrad average beam spread; 3.17 standard deviation of slope error; and 38.00 standard deviation of beam error.

AP: *Approach Point*
ATCT: *Air Traffic Control Tower*
FAA: *Federal Aviation Authority*
FAPE: *Airport Code for Chief Dawid Stuurman International Airport*
FoV: *Field of View*
FP: *Flight Path*
mRad: *milliradian*
OP: *Observation Point*
PV: *Photovoltaic*
RMS: *Root Mean Square*

1 INTRODUCTION

1.1 TERMS OF REFERENCE

This report aims to determine the effect that potential solar PV ‘glint and glare’ may have on various aviation receptors due to the construction and operation of the Solar PV Installation as part of the Arlington Multiple-Use Development in Gqeberha, Eastern Cape, South Africa (“The proposed project”). The main receptors of concern are the aviation receptors (i.e., the pilots and ATCT operator) at the Chief Dawid Stuurman International Airport (FAPE).

The proposed project is located approximately 2.8km to the west of the threshold of the Runway 08/26. The Airport consists of two perpendicular, asphalt runways and one air traffic control tower. The primary runway 08/26 is orientated South-West to North-East. The secondary runway 17/35 is orientated North-West to South-East.

Other community receptors have not been modelled, such as the nearby suburbs and motor vehicles, as this report’s focus is solely on the aviation receptors.

At certain angles, the sun may reflect light in a specular manner off the surface of the Photovoltaic panels and affect the receptors vision, thereby causing an ‘after-image’ or ‘temporary blindness’ depending on the strength of the specular reflection. In South Africa, there is limited literature and no regulatory framework with regards to the ‘glint and glare’ effects from solar panels in relation to airspace use. In the absence of a regulatory requirement, the United States Federal Aviation Authority’s (FAA) Technical Guidance for Evaluating Selected Solar Technologies on Airports, version 1.1 of April 2018 was used as the main reference. Within this guideline are numerous case studies of solar projects similar to this project. The FAA approved ForgeSolar software package was used to predict the effects of the glint and glare from the PV panels.

1.2 ASSUMPTIONS AND LIMITATIONS

The design specifications of the project were supplied by the client. A summary of assumptions and abstractions required by the ForgeSolar analysis methodology is provided below:

- The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, the software developers have validated the models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque USA, and the tool accurately predicted the occurrence and intensity of glare at various times and days of the year.
- Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects analyses of path receptors.
- Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including Air Traffic Control Towers (ATCT’s). The ForgeSolar methodology relies on an analytical, qualitative approach to accurately determine the overall hazard (i.e., green vs. yellow) of expected glare on an annual basis.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the

sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)

- The algorithm does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
- The variable direct normal irradiance (DNI) feature scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors such as smoke from fire, mist etc.
- The ocular hazard predicted by the tool depends on several environmental, optical, and human factors, which can be uncertain. The developers provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round.
- Hazard zone boundaries shown in the Glare Hazard plot (based on Figure 4) are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.

2 LEGAL REQUIREMENTS

There are no legal requirements or guidelines that are applicable in South Africa. The US FAA guidelines were used as a reference.

3 PROJECT DESCRIPTION

The client is proposing the installation of a 5MW Solar PV Energy Facility mounted to fixed structures with a midpoint height of 1.2m above ground level and angled towards the north. The proposed solar facility covers an extent of 5.7 ha. This solar facility will form part of the Arlington Multiple-Use Development which will also feature residential clusters, office buildings and communal facilities. The layout and locality map are shown in Figure 5 and Figure 6 below.

Figure 5: Arlington Multiple-Use Development Locality Map (JG Afrika, 2023)

The solar facility will be located on the East side of the development as shown in Figure 6 below.

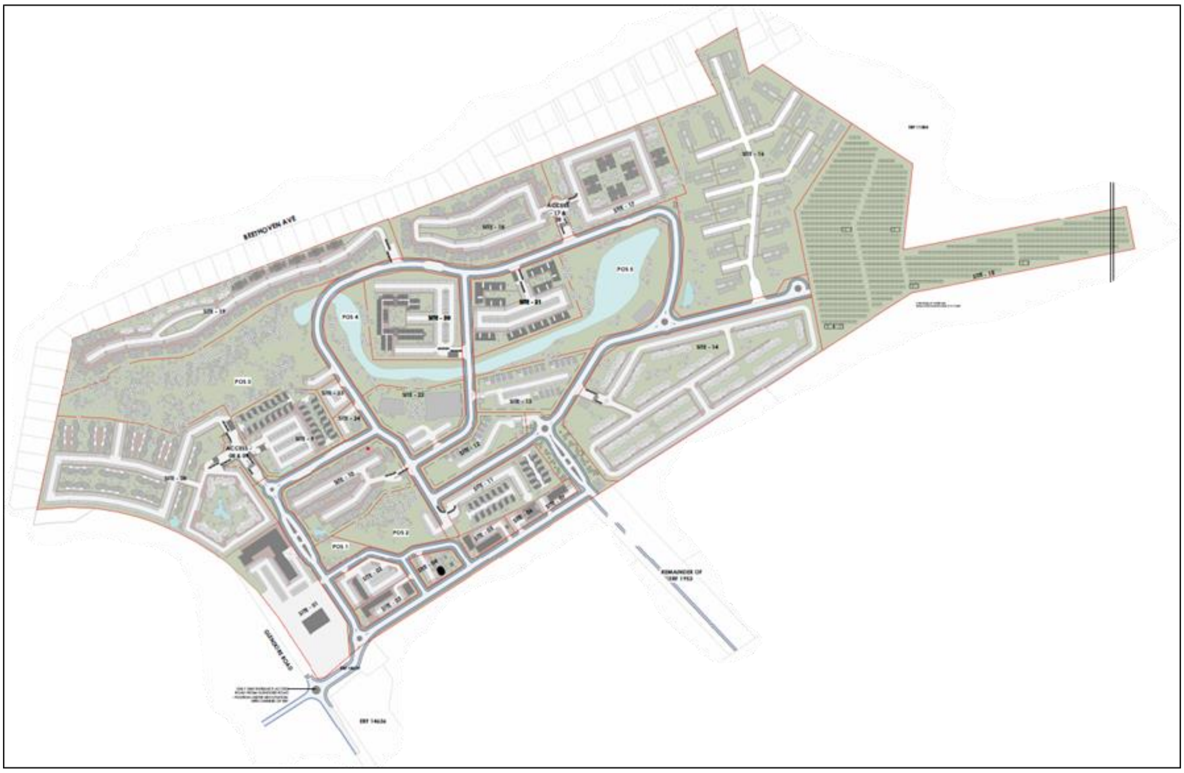

Figure 6: Arlington Multiple-Use Development Master Layout (JG Afrika, 2023)

The final design parameters of the PV panels have not yet been finalized. This report, however, considers a fixed tilt configuration with a tilt angle of between 15˚. The panels will have a lightly-textured anti-glare coating and be orientated towards the north. The panels will be mounted on the fixed axis (i.e., no tracking with the movement of the sun). The project will be located approximately 2.8km to the West of the Airport, as seen below in Figure 7.

4 THE RECEIVING ENVIRONMENT

The proposed project may impact on aviation receptors located in and around the Chief Dawid Stuurman International Airport (ICAO code: FAPE). The Airport consists of two runways with four Flight Paths (FPs) as follows:

- Runway 08/26
    - FP Runway 08
    - FP Runway 26
- Runway 17/35
    - FP Runway 17
    - FP Runway 35

Additionally, one Air Traffic Control Tower ("1-ATCT") is present. The flight paths used in modelling are two miles long (miles is used in aviation studies as the flight navigational aids are referenced in miles). Figure 7 above shows the four flight paths that were assessed. The air traffic control tower is located at 33° 59' 01.31" S; 25° 36' 45.81" E. Due to limited information regarding the geometry of the ATCT, the height for the ATCT receptor is estimated at 15m, although it likely that it is slightly lower (and therefore subject to less impact due to obstacles affecting line of sight between the receptor and the development).

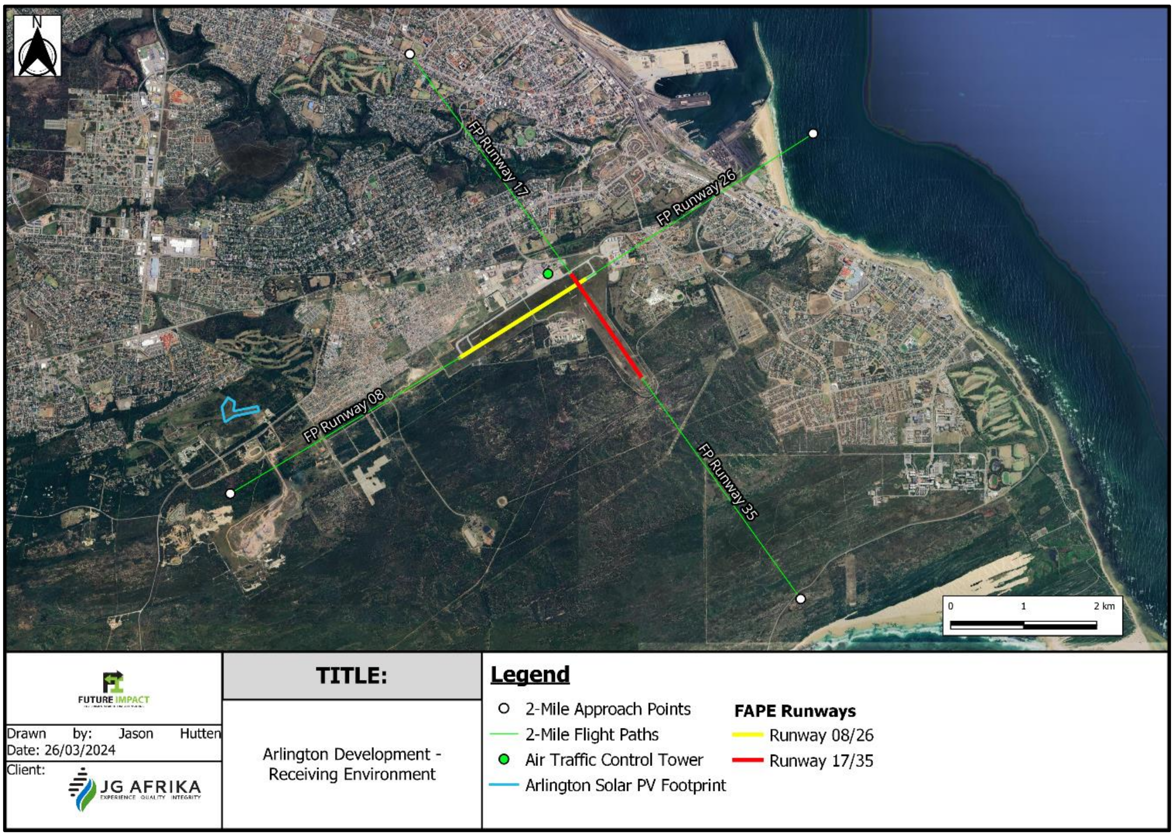

Figure 7: Receiving Environment

5 RESULTS

The modelling results indicate that receptors will experience green glare. No yellow glare or red glare will be present.

The analysis parameters and observer eye characteristics were as follows:

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

Table 1: Glint and Glare Exposure Time Summary

Receiver Name	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)
FP Runway 08	0	0	0
FP Runway 17	0	0	0
FP Runway 26	2 631	0	0
FP Runway 35	96	0	0
1-ATCT	1 178	0	0
Total	**3 905**	**0**	**0**

5.1 MODELLING RESULTS PER RECEPTOR

As shown in Table 1 above, the Flight Paths approaching Runway 08 and Runway 17 will be exposed to no glare. Details are provided below regarding glint and glare exposure to the receptors “FP Runway 26”, “FP Runway 35” and the Air Traffic Control Tower (“1-ATCT”).

FP Runway 26

The 2-Mile Flight Path approaching Runway 26 (approaching the primary runway from Northeast) will experience 2 631 minutes (43.9 hours) of green glare exposure in a given year. Figure 8 below shows that the glare exposure will occur at dawn, between 17h45 and 19h00, when the sun sets in the west.

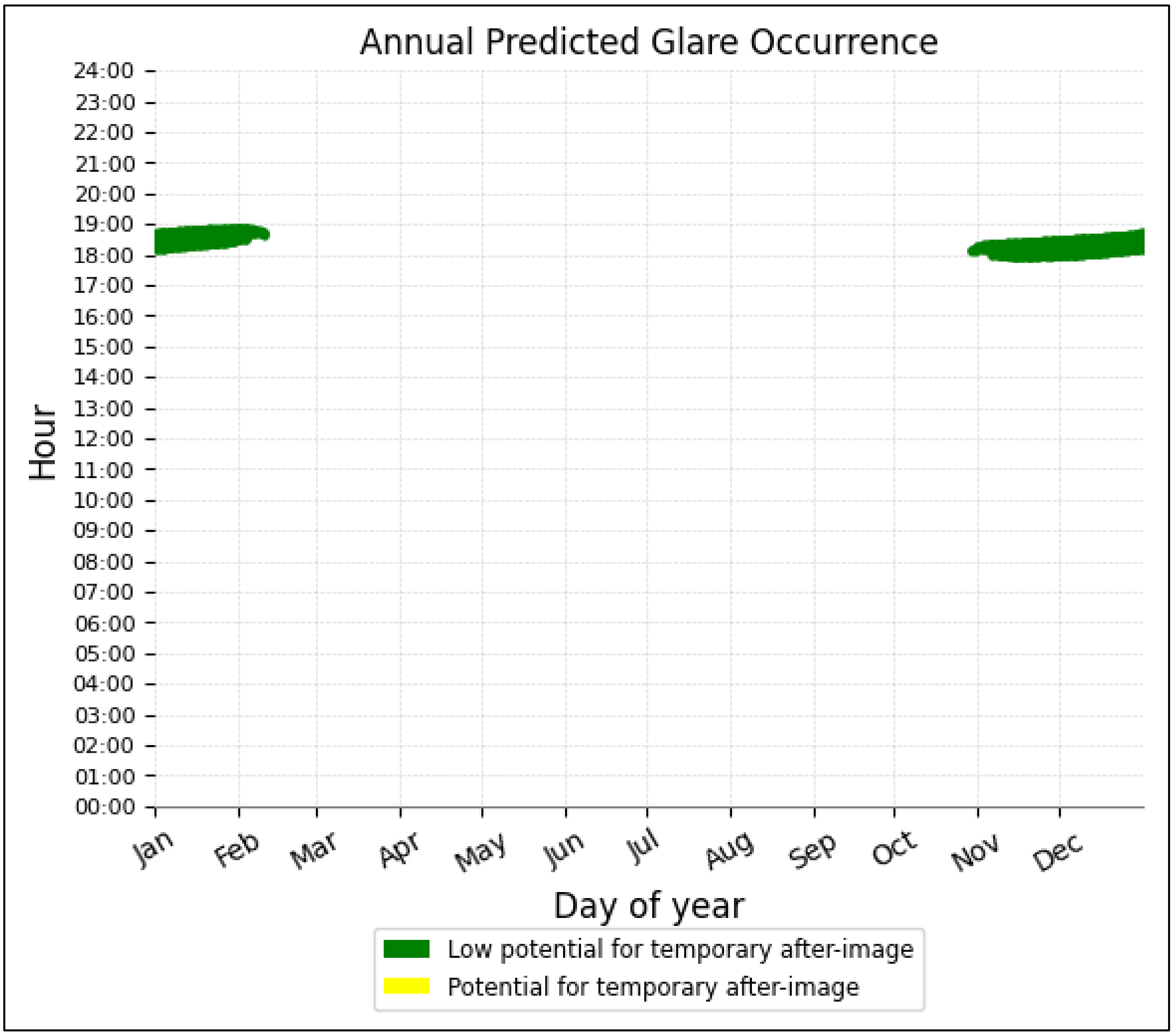

Figure 8: Time of Exposure for FP Runway 26

Furthermore, the exposure will occur along the final three-quarters of the 2-mile Approach Flight Path, as shown in Figure 9 below.

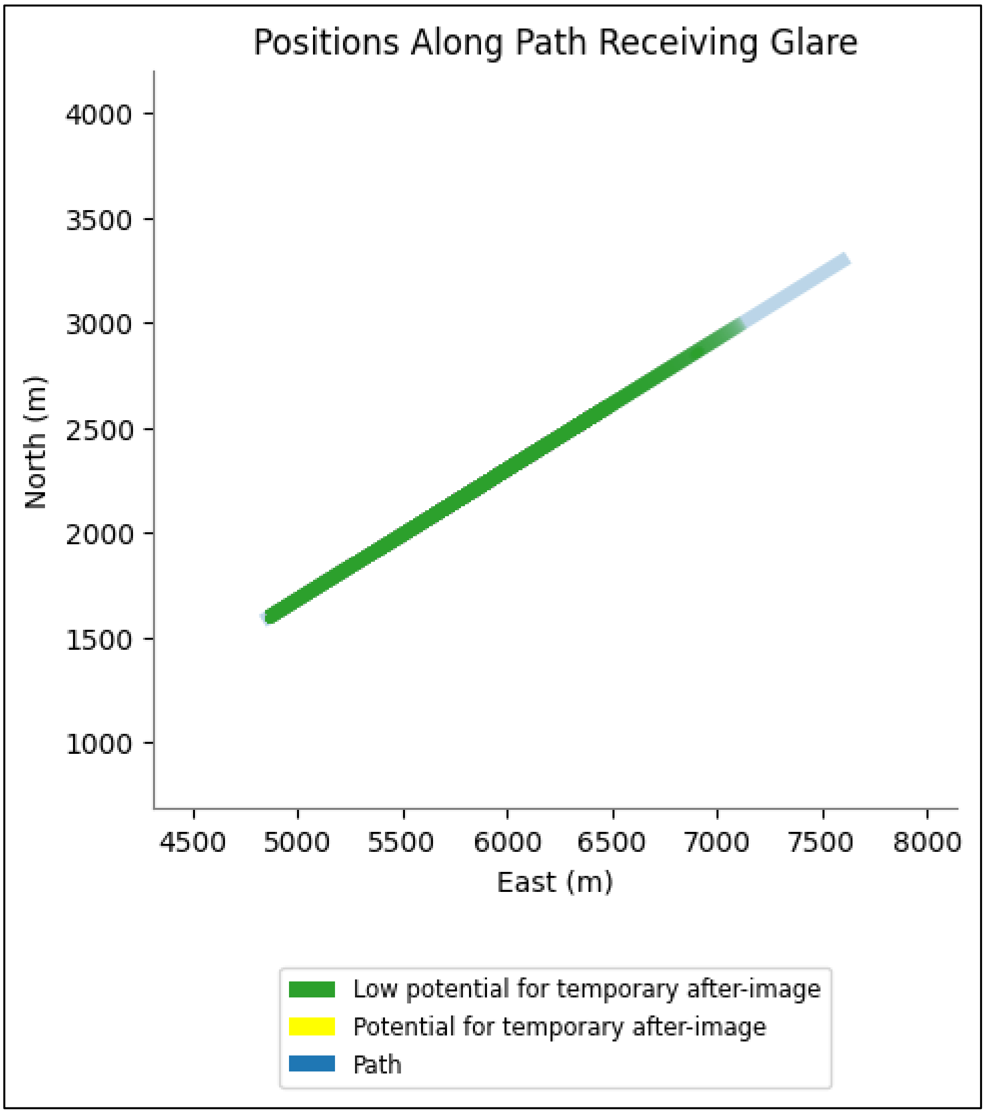

Figure 9: Positions of Exposure Along the Flight Path for Runway 26

Figure 9 below shows that the entire Solar PV Footprint will cause the exposure to green glare for the FP Runway 26 receptor.

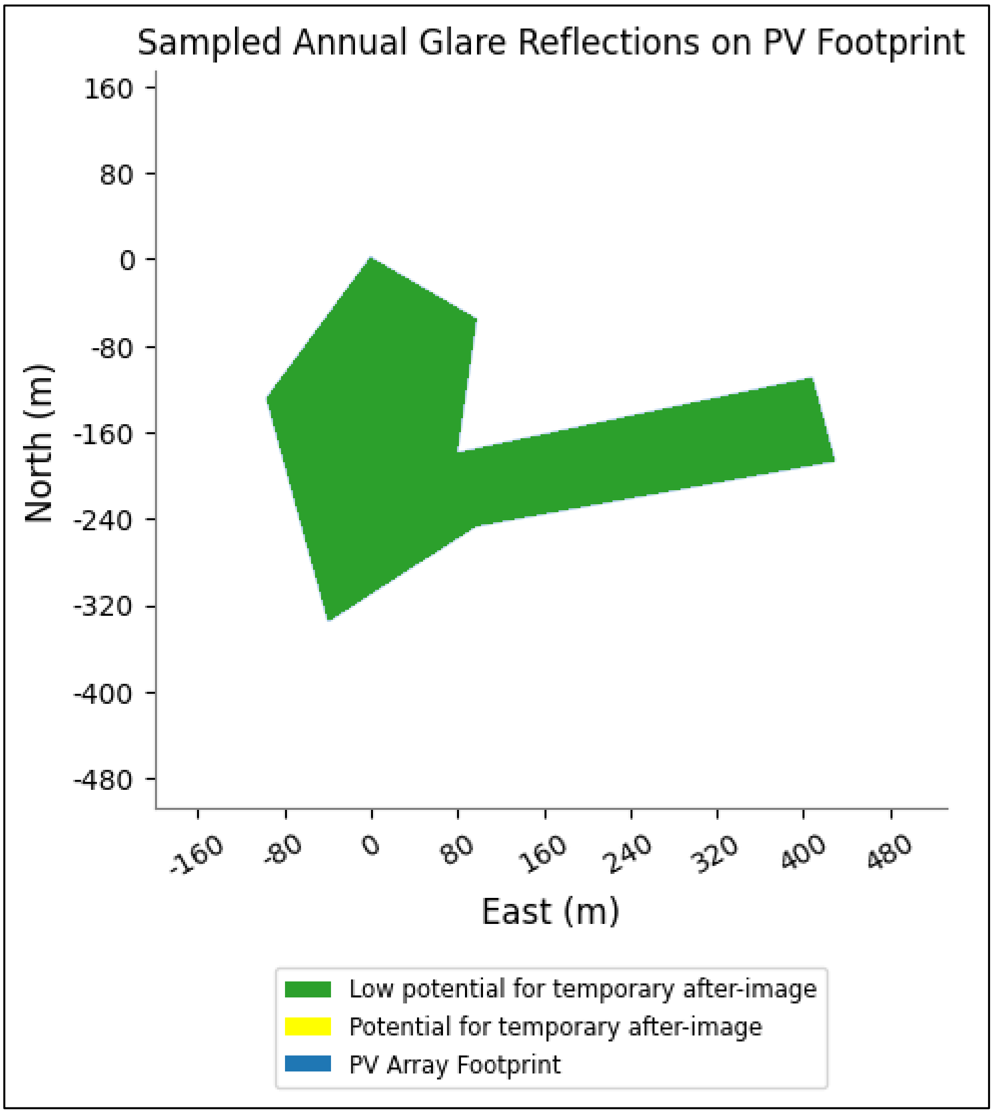

Figure 10: PV Array Footprint Responsible for Glare on the Flight Path for Runway 26

FP Runway 35

The 2-Mile Flight Path approaching Runway 35 (approaching from the secondary runway from the Southeast) will experience 96 minutes (1.6 hours) of green glare exposure in a given year. Figure 11 below shows that the glare exposure will occur for brief periods at dawn, around 18h00, when the sun sets in the west. This exposure will only occur for a few days around the end of March/beginning of April and then again in September.

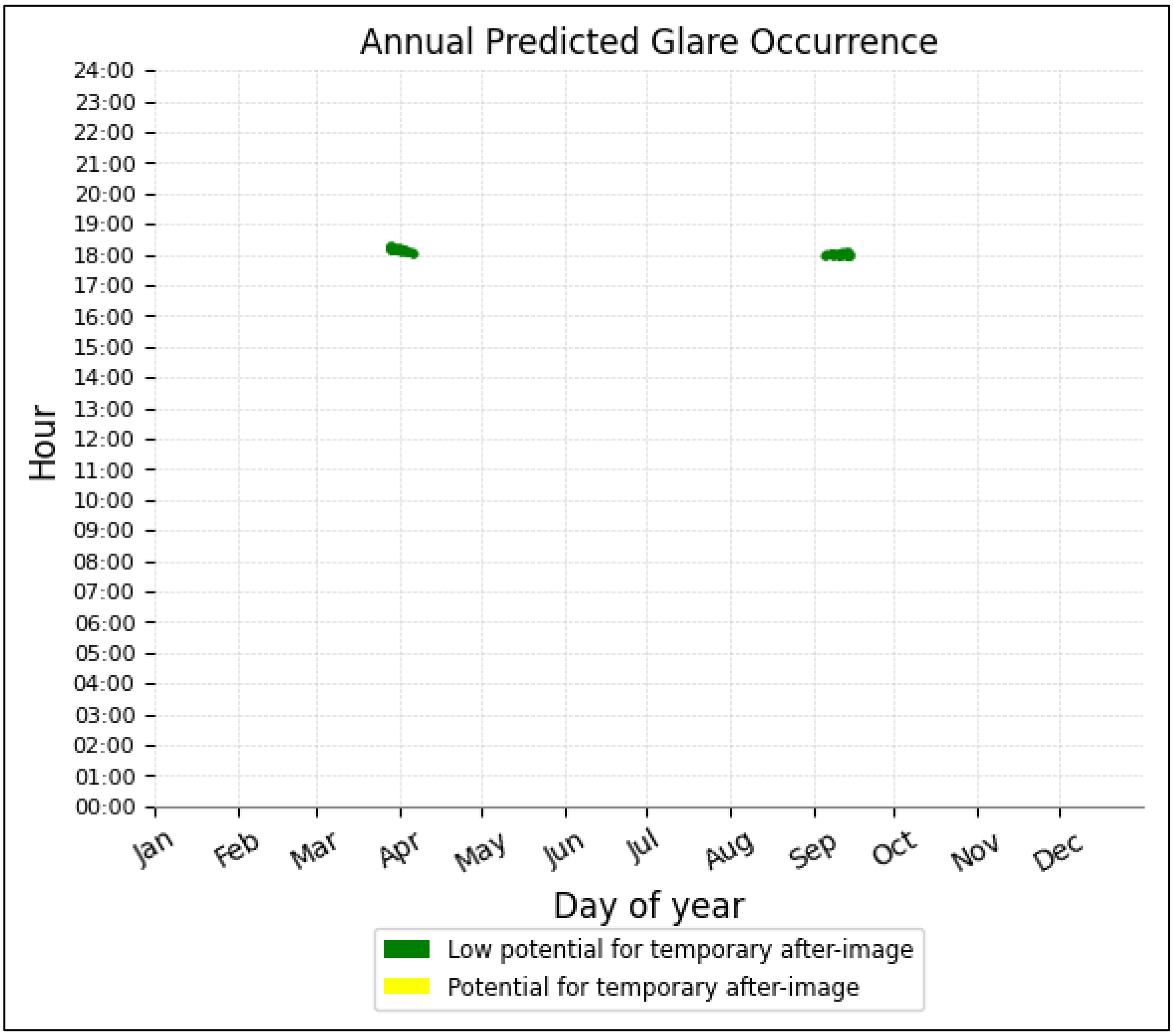

Figure 11: Time of Exposure for FP Runway 35

Furthermore, the exposure will occur briefly around the midway point of the 2-mile Approach Flight Path, as shown in Figure 12 below.

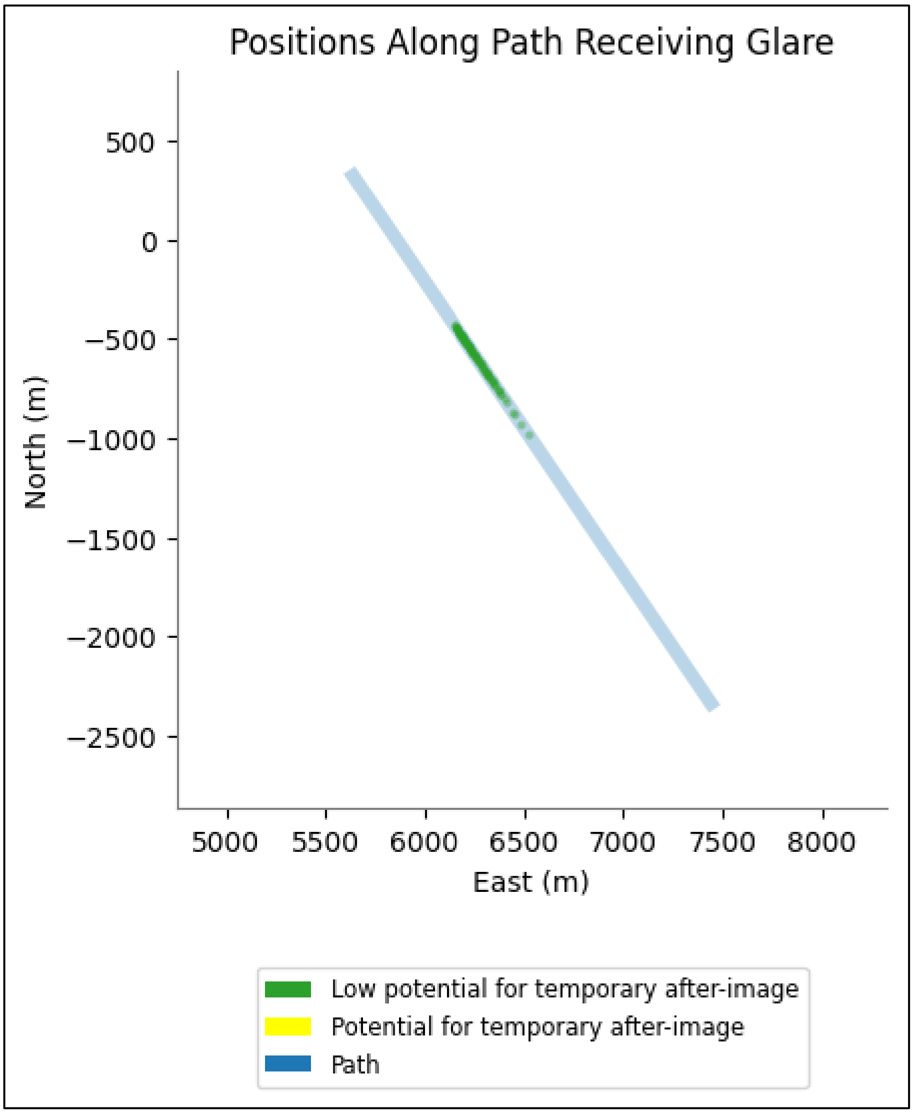

Figure 12: Positions of Exposure Along the Flight Path for Runway 35

Figure 13 below shows that the entire Solar PV Footprint will cause the exposure to green glare for the FP Runway 35 receptor.

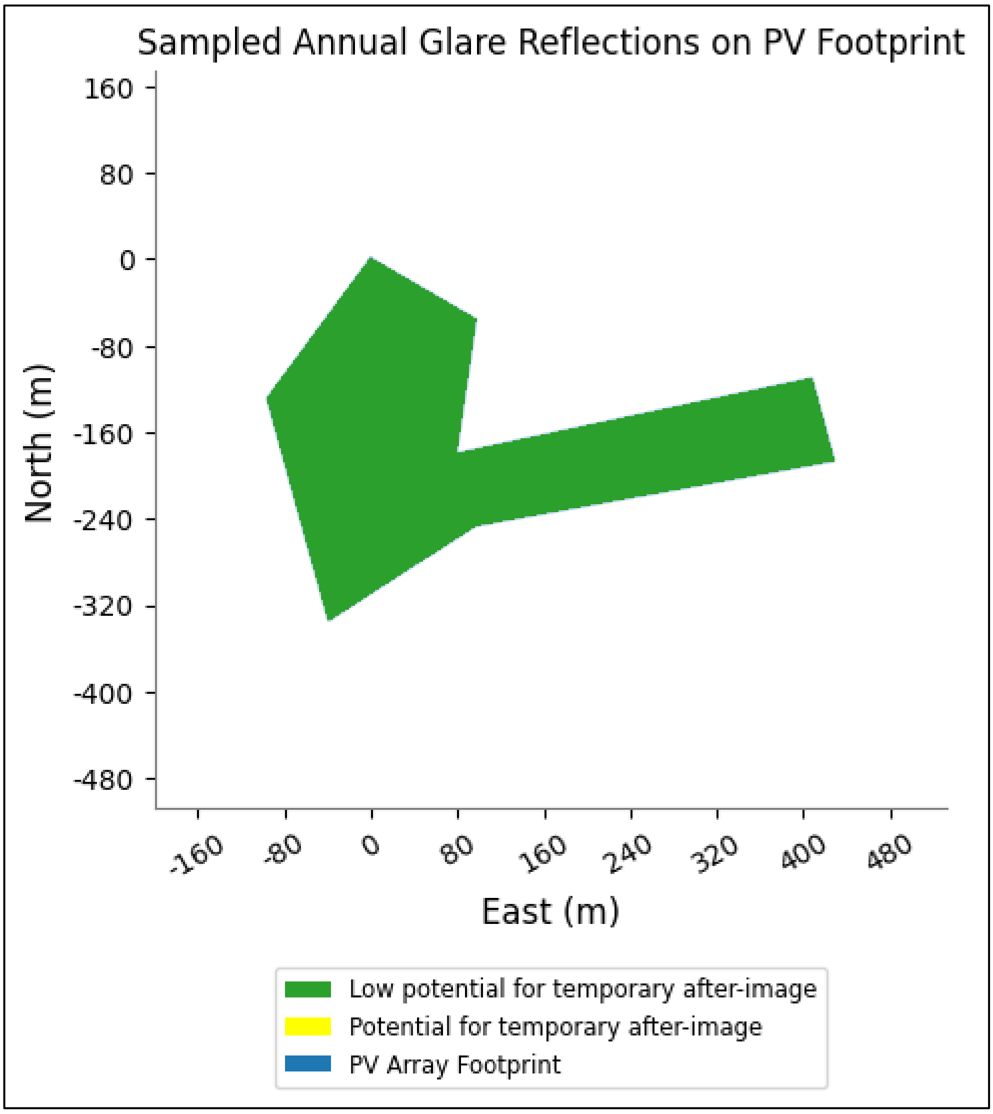

Figure 13: PV Array Footprint Responsible for Glare on the Flight Path for Runway 35

Air Traffic Control Tower (1-ATCT)

The Air Traffic Control Tower at the Chief Dawid Stuurman International Airport will experience 1 178 minutes (19.6 hours) of green glare exposure in a given year. This exposure will occur from early November to the beginning of February the following year. Figure 14 below shows that the glare exposure will occur at dawn, between 18h00 and 19h00, when the sun sets in the west.

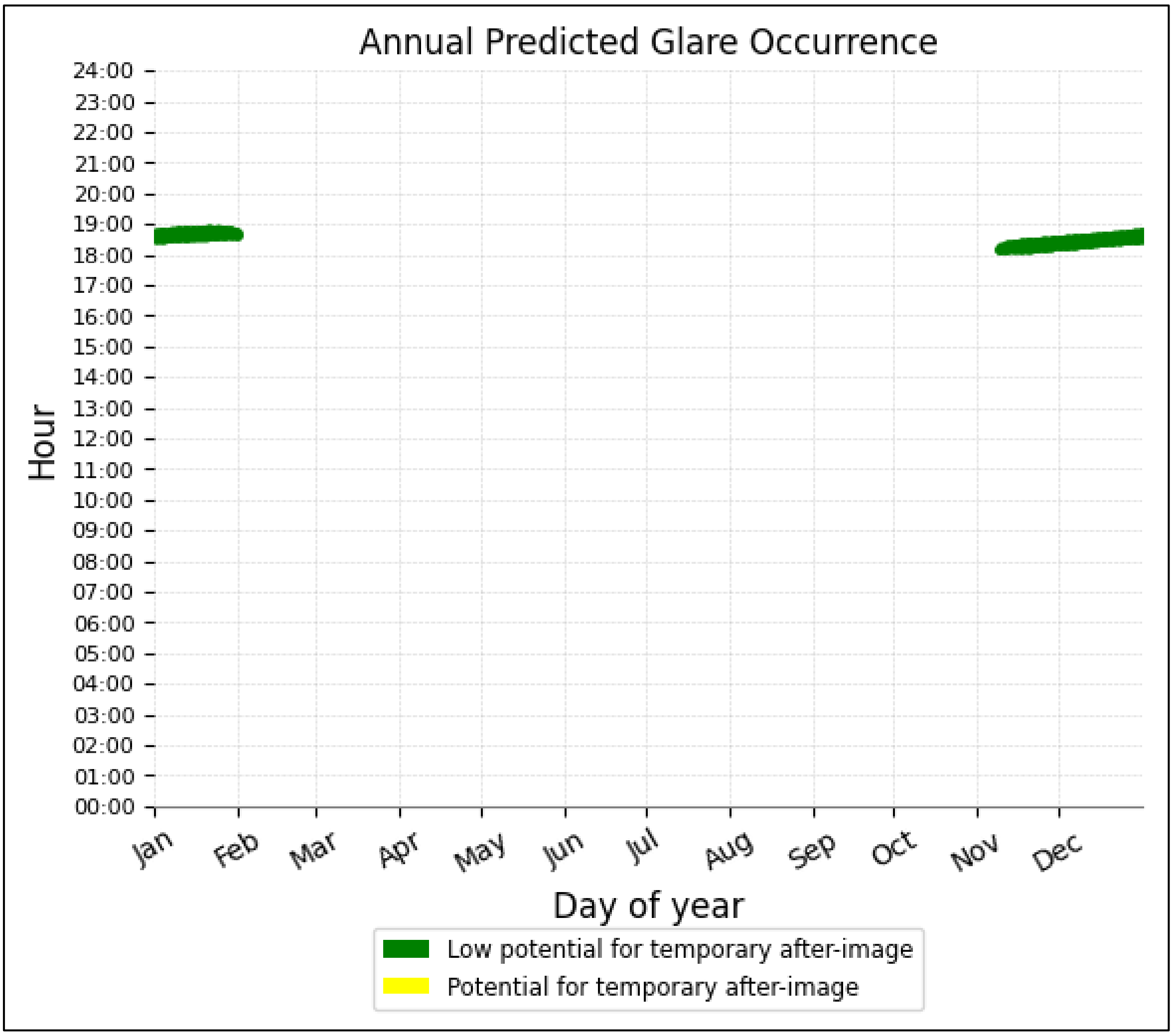

Figure 14: Time of Exposure for the Air Traffic Control Tower

The FAA Guidelines regard Air Traffic Control Towers to be more sensitive to glint and glare exposure. Despite green glare being present for the Air Traffic Control Tower receptor, it is unlikely to have an impact due to the numerous buildings that are obstructing the line of sight between the development and the receptor.

6 CONCLUSIONS AND RECOMMENDATIONS

The aim of this study was to determine the impact that solar glint and glare would have on various aviation receptors. The FAA model considered the 2-mile receptors on the approach to the various runways at the Chief Dawid Stuurman International Airport (ICAO: FAPE). The Air Traffic Control Tower (1-ATCT) was also considered.

The modelling results indicate that the FP Runway 35, FP Runway 26, and Air Traffic Control Tower will be exposed to green glare only. No receptors will be exposed to yellow or red glint and glare during the landing phase of flight. This is due to the fixed axis Solar PV arrays being positioned on the northern side of the aviation receptors and angled towards the north.

Green glare has a low potential to cause temporary flash blindness and is therefore acceptable in terms of the United States FAA Regulations. Furthermore, the model does not take into account building heights, these buildings will obstruct the line of sight from the Air Traffic Control Tower to the Solar panels and therefore further prevent glint exposure to the Tower.

It is therefore recommended that the project receive authorisation from the Civil Aviation Authority from a glint and glare perspective.

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