Robertstown East Solar Farm

Preliminary Glint and Glare Assessment

AMP Power Australia Pty Ltd

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Making Sustainability Happen

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
R01-v1.1	27 June 2024	Peter Hayman	Dr Peter Georgiou	Dr Neihad Al-Khalidy
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Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with AMP Power Australia Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

Executive Summary

SLR Consulting Australia Pty Ltd (SLR) has been engaged by AMP Power Australia Pty Ltd to carry out a Reflective Glare assessment of the proposed 236.4 MW Robertstown East Solar Farm (herein the "Project").

The Project is located just over 10 km to the east-northeast of Robertstown (SA) within the Goyder Regional Council district and would feature PV solar panels in a series of sub-arrays located between Junction Road to the west and Sutherlands Road to the east. The site would be bisected by Lower Bright Road.

The following potential glare conditions have been considered:

- Daytime — Reflective glare (and glint) arising from the solar PV panels within the facility.
- Night-time — Illumination glare from 24/7 operational security lighting within the facility (if such lighting is required).

Baseline Modelling Results

Initial glare modelling was carried under the following assumptions:

- The Back-Tracking Rest Angle was assumed to be 0°.
- No vegetation or other screening (eg buildings) were included in the baseline model.
- No allowance was made for the impact of intervening sections of topography which could obscure the view of the facility for passing motorists or residences.

Predicted glare (refer **Table 2**) was as follows:

- NIL glare was predicted for ALL surrounding Roads and Residences for:
  - PV Sub-Arrays 2, 3, 4, 7, 10 and 11
- Potential glare was predicted for surrounding Roads for:
  - PV Sub-Arrays 1, 5, 6, 8 and 9.
- Potential glare was predicted for surrounding Residences for:
  - PV Sub-Arrays 1 and 8.

Detailed Analysis of Baseline Results

The baseline results shown in **Table 2** were then assessed for the following characteristics:

- Shielding via intervening terrain and/or topography; and
- "Angle Difference" condition - specifically conditions involving a very high angle of incidence where an observer would perceive reflections coming from virtually the same direction as the significantly more intense (in terms of radiance) incoming direct solar ray.

As can be seen in **Table 4,** the remaining potential glare conditions for the Project were identified as:

- Lower Bright Road — PV Sub-Array 01
- Junction Road — PV Sub-Arrays 01 and 08

Mitigation Modelling Results

The two most common mitigation options for eliminating glare from solar facilities are:

- Mitigation via Curtailment of Rest Angle; and/or
- Mitigation via Additional Perimeter Vegetation Screening.

Mitigation Modelling with Rest Angle Curtailment

The SGHAT modelling was re-run with a Rest Angles of 5° and 10°.

The results are shown in **Table 5** and indicate the following:

- Rest Angle 5° potential glare remained for PV Sub-Arrays 01 and 08.
- Rest Angle 10° potential glare was eliminated for PV Sub-Array 01 but remained for PV Sub-Array 08.

Mitigation Modelling via Perimeter Vegetation Screening

The SGHAT modelling was re-run with vertical screens on the west and south sides of PV Sub-Array 08. The modelling yielded NIL glare with the addition of the proposed screens.

Mitigation Recommendations

The mitigation recommendations for the Project are shown in **Table 6**. These would eliminate ALL instances of potential glare from the proposed facility.

- No mitigation is required for PV Sub-Arrays 02-07 and 09-11.
- Rest Angle Curtailment would eliminate potential reflections from PV Sub-Array 01.
  - Note that this ONLY applies to the MORNING Rest Angle and ONLY for the months of May-August.
- Perimeter screening would eliminate potential reflections from PV Sub-Array 08.
  - Note that some sections of the proposed screening can take advantage of existing vegetation.

Due to the large length of the screening identified above, SLR recommends that the Project be reanalysed upon completion of the detailed design. This will allow for other local factors such and traffic frequency and motorist field of vision to be taken into account when determining the exact type and extent of required mitigation.

Night-Time Illumination Glare

If night-time lighting is incorporated into the Project, the potential for any future nuisance glare should be NIL if the following is adopted:

- Setting a goal of limiting light spill to no more than 1 lux falling on the nearby residential facades during night-time curfew hours; combined with
- Following the general light spill minimisation design principles found in AS/NZS 4282-2023.

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1.0 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by AMP Power Australia Pty Ltd to carry out a Reflective Glare assessment of the proposed 236.4 MW Robertstown East Solar Farm (herein the "Project").

It will comprise blocks ("sub-arrays") of panels following the various natural and man-made breaks throughout the site and inverter areas and power stations.

The following potential glare conditions have been considered:

- Daytime Reflective glare (and glint) arising from the solar PV panels within the facility.
- Night-time Illumination glare from 24/7 operational security lighting within the facility (if such lighting is required).

1.1 Structure of Report

The remainder of this report is structured as follows:

- Section 2 describes the Project and surrounding environment.
- Section 3 outlines the requirements of the impact assessment.
- Section 4 provides background information regarding the calculation of reflectivity and glare.
- Section 5 presents the analysis, results and proposed mitigations covering Road Traffic Disability Glare and Residential Nuisance Glare.
- Section 6 presents a qualitative analysis covering night-time illumination glare.

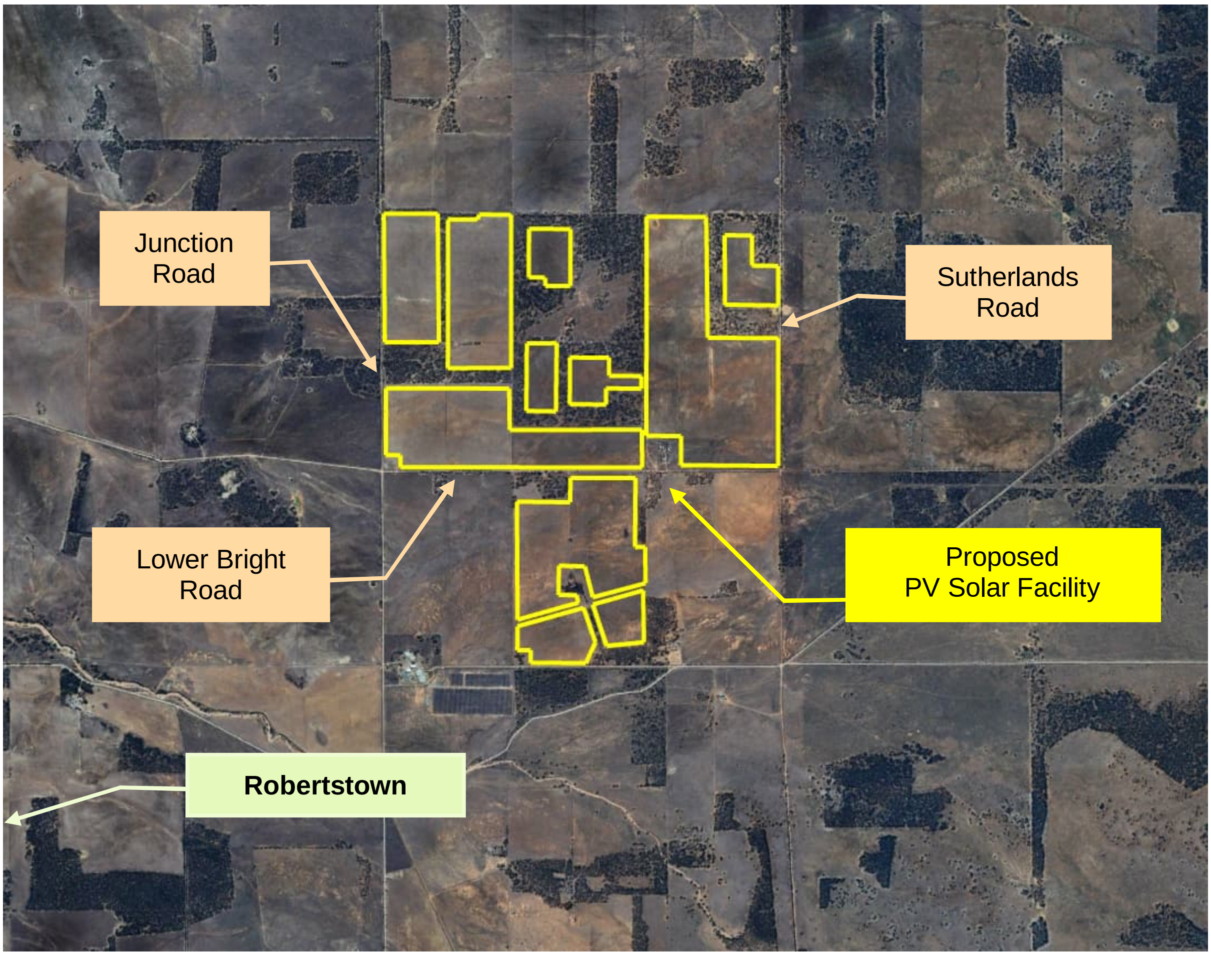
2.0 Proposed Robertstown Solar Farm Project

2.1 Site Location

The Project is seeking development approval for a solar facility (the "Project") at the location shown in **Figure 1**.

- The Project is located just over 10 km to the east-northeast of Robertstown (SA) within the Goyder Regional Council district.
- The Project would feature PV solar panels in a series of sub-arrays located between Junction Road to the west and Sutherlands Road to the east. The site would be bisected by Lower Bright Road.

Figure 1 Robertstown Solar Farm – Location Map



2.2 Site Description and Key Project Components

From a Glare point of view, the key components of the Project are:

- The photovoltaic (PV) modules in relation to their daytime reflective glare potential; and
- The facility's security/emergency lighting design in relation to potential night-time illumination glare issues, if such 24/7 lighting is incorporated into the Project – note: detailed plans of this are not yet available.

Overall Layout

The proposed facility (refer **Figure 2**) would consist of a group of ground-mounted sub-arrays as shown in **Figure 2**.

Figure 2 Site Array Layout

In terms of the relative heights of the Project site and surrounds, the ground elevations at the site exhibit the following variations:

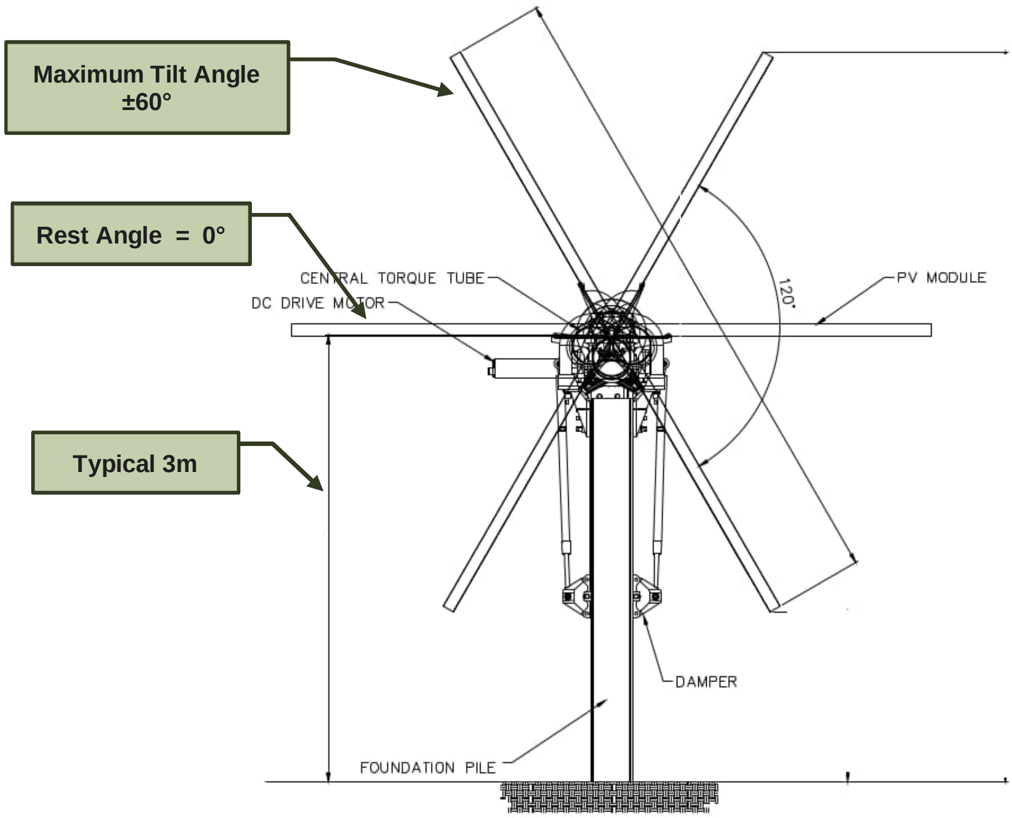
- In general, the topography falls from south to north and west to east
  - West-East variations … RL244m to RL214m respectively
  - South-North variations … RL230m to RL218m respectively

Panel Support System

The facility's solar PV panels will be set up in rows with a north-south orientation mounted on a 2P single-axis tracking system (refer **Figure 3**).

- The average height to the pivot point of the panels will be ~3 m above ground level. It is understood that the ultimate height above ground may vary slightly, depending on the final panel and support structure selection and local ground conditions.
- The ground coverage ratio will be 35.4%.
- During the middle of the day, when the solar panels are in "Normal" tracking mode, the tracking system will have a tilt range of ±60°.
- During Back-tracking, the sunrise and sunset tilt of the panels will have a potential Rest Angle of 0°.

Figure 3 Sideview of Proposed 2P Single-Axis Tracking System



3.0 Requirements

There is currently no known local planning guidance within Goyder Regional Council for quantifying the impacts associated with solar reflections from PV panels covering Aviation Glare, Road and Rail Traffic Disability Glare or Residential Nuisance Glare.

Aviation Glare

With regard to aviation glare, the Forge Solar SGHAT software tool has been generally accepted by regulatory bodies globally, including Australia. The SGHAT impact criteria are:

- Airport Traffic Control Tower (ATCT): NO GREEN or YELLOW Glare
- Aircraft Landing: NO YELLOW Glare (GREEN is permissible)

For this assessment, there are no airfields close enough to the Project site and further analysis in relation to aviation glare is not required.

Residential Nuisance Glare

SLR notes the criteria available in the New South Wales (NSW) Large Scale Solar Energy (LSSE) Guideline (2022). The LSSE Guideline classifies Residential Nuisance Glare into "High", "Moderate" and "Low" impact levels by minutes per day and/or hours per year.

Figure 4 summarises the three impact levels and associated amenity objectives.

When applying the LSSE Guideline to Residential Nuisance Glare, it is standard industry practice to use the occurrence of predicted SGHAT YELLOW glare, noting that:

- SGHAT GREEN glare implies LOW potential for an after-image, and is acceptable in terms of aviation glare for pilots on final landing approach.

Figure 4 Extract (*Table 2*) from NSW Large-Scale Solar Energy Guideline (2022)

High glare impact	Moderate glare impact	Low glare impact
> 30 minutes per day > 30 hours per year	< 30 minutes & > 10 minutes per day < 30 hours & > 10 hours per year	< 10 minutes per day < 10 hours per year
Significant amount of glare that should be avoided.	Implement mitigation measures to reduce impacts as far as practicable.	No mitigation required.

Road and Rail Traffic Disability Glare

There are no SGHAT nor LSSE Guideline criteria for Road and Rail Traffic Disability Glare.

Accordingly, when considering motorists and/or rail operators, the predicted occurrence of SGHAT YELLOW glare for ANY number of minutes per day or hours per year is taken by SLR as necessitating consideration of mitigation, unless the reflection condition occurs at a time of day when the difference in angle between an incoming solar ray and its associated reflection is less than around 10°, in which case a motorist's view would be completely dominated by the radiance level of the sun's direct solar rays.

4.0 Background

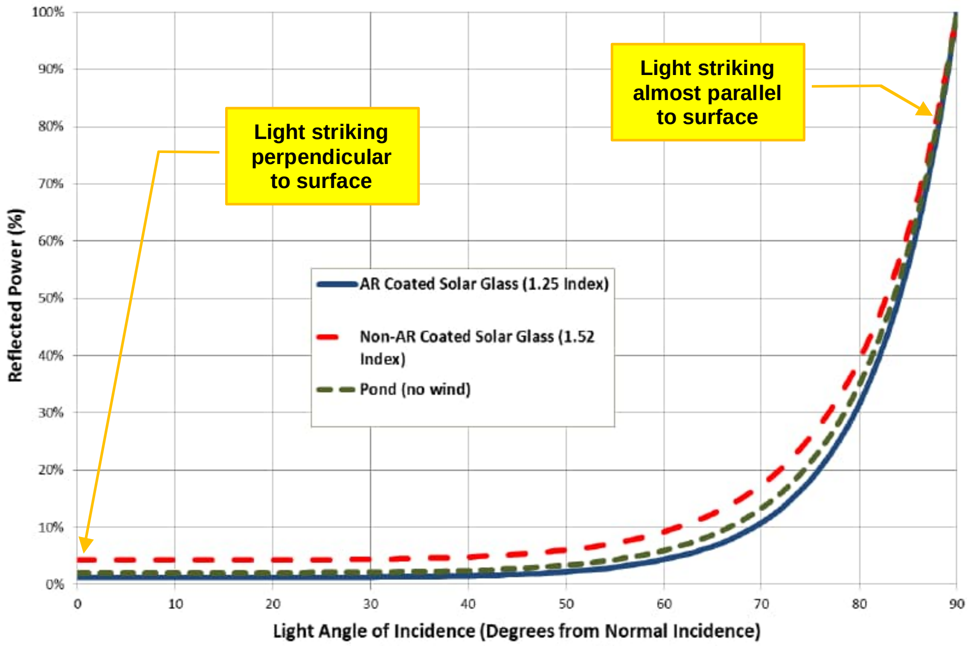
4.1 Solar Panel Reflectivity

Solar PV panels are designed to capture (absorb) the maximum possible amount of light within the layers below the front (external) surface, and hence minimise reflections off the surface of each panel. Reflections are a function of:

- the angle at which the light is incident onto the panel (which will vary depending on the specific location, time of day and day of the year), and
- the index of refraction of the front surface of the panel and associated degree of diffuse (non-directional) versus specular (directional or mirror-like) reflection, which is a function of surface texture of the front module (reflecting) surface.

Representative reflectivity curves are shown in **Figure 5**.

Figure 5 Typical Reflectivity Curves as a Function of Incidence Angle



- When an incoming solar ray strikes the surface of a solar PV panel close to perpendicular to the panel surface (ie low angle of "incidence"), reflectivity is minimal, less than 5% for all solar panel surface types.
- It is only when an incoming solar ray strikes the panel at large "incidence" angles, ie closer to parallel to the panel, that reflectivity values increase. When this happens, reflections become noticeable and potentially at "glare" level – this can occur for all solar panel surface types.
- However, for very high incidence angles, it would almost always be the case that the observer (motorist, resident, etc) would perceive reflections coming from virtually the same direction as the incoming solar rays themselves. Such a condition would not constitute a glare situation as the intensity of the incoming solar ray would dominate the field of vision perceived by the observer.

4.2 Project Site Angles – Annual Variations

One of the challenging issues encountered with daytime solar panel glare is the varying nature of the associated reflections, whose occurrence will vary with time of day and day of the year as the sun's rays follow varying incoming angles between the two extremes of:

- Summer solstice – sunrise incoming rays from south of east, maximum angle altitude rays at midday, sunset incoming rays from south of west.
- Winter solstice – sunrise incoming rays from almost southeast, minimum angle altitude rays at midday, sunset incoming rays from almost southwest.

Any solar glare analysis must take into account the complete cycle of annual reflection variations noted above. The potential range of incoming solar angles at the Project site relevant to daytime glare is shown in **Figure 6**, with critical angles summarised in **Table 1**.

Figure 6 Project Site Incoming Solar Angle Variations

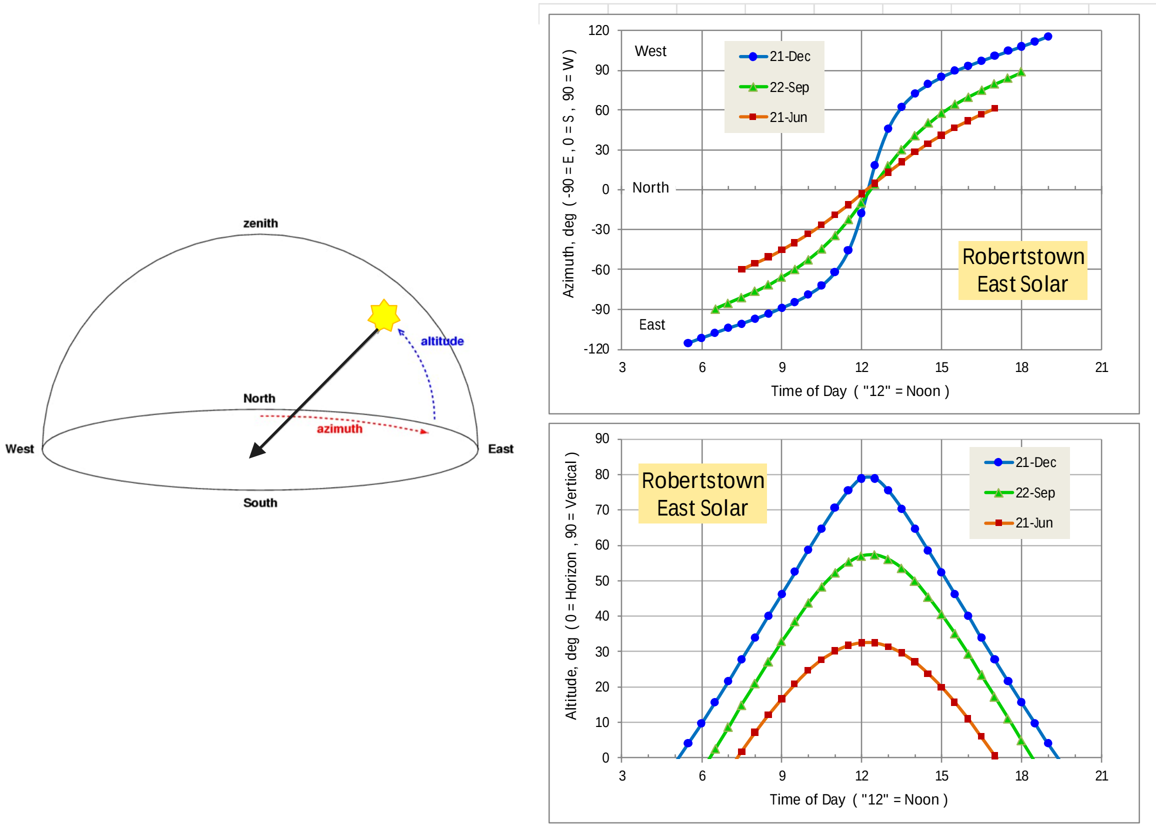


Table 1 Key Annual Solar Angle Characteristics for Project Site

Day of Year	Sunrise	Sunset	Sunrise-Sunset Azimuth Range	Max Altitude
Summer Solstice [1]	5:07 am	7:23 pm	±118.5° East & West of North	79°
Equinox [1]	6:17 am	6:24 pm	±91° East & West of North	57°
Winter Solstice	7:19 am	5:04 pm	±61.5° East & West of North	32.5°

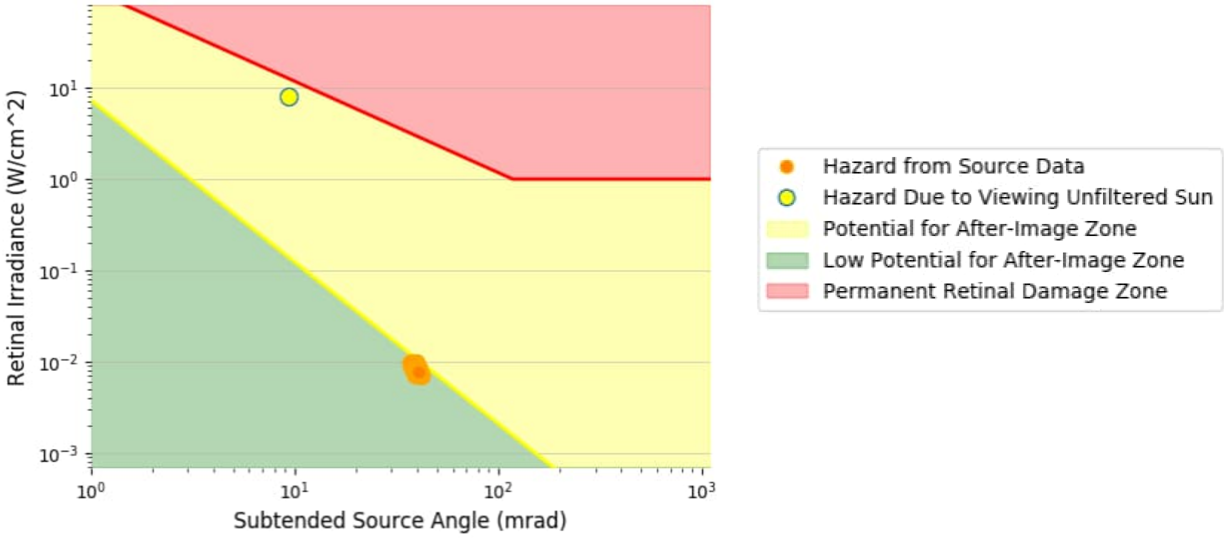
Note 1: Times of day do not take into account Daylight Savings Time

4.3 Modelling Outputs

Modelling has been undertaken using the Forge Solar SGHAT software suite. This provides output in the form of an ocular hazard analysis plot, a sample of which is shown in **Figure 7**.

The analysis displayed in this plot is derived from solar simulations that extend over the entire calendar year in 1-minute intervals, sunrise to sunset.

Figure 7 Example Solar Glare Ocular Hazard Plot (SGHAT Software Output)



The following is noted regarding **Figure 7**.

- SGHAT ocular impact is a function of both the "retinal irradiance" (ie the light seen by the eye) and "subtended source angle" (ie how wide an arc of view the light appears to be arriving from).
- SGHAT ocular impact falls into three categories:
  - . GREEN: low potential to cause "after-image"
  - . YELLOW: potential to cause temporary "after-image"
  - . RED: potential to cause retinal burn (permanent eye damage)
  - o "After Image" is the term applied to a common retinal phenomenon that most people have experienced at some point or other, such as the effect that occurs when a photo with flash is taken in front of a person who then sees spots in front of their eyes for a few seconds. A more extreme example of "after-image" occurs when staring at the sun. "After-image" (also known as "photo bleaching") occurs because of the de-activation of the cells at the back of the eye's retina when subjected to a very bright light.
- The SGHAT plot provides an indication of the relative intensity of both the reflections of interest and the source of light itself (ie the sun).
  - o The occurrence of glare is shown in the plot as a series of **orange circles**, one circle for each minute that a reflection is visible.
  - o A reference point is also shown in each SGHAT plot, the **yellow circle** with the **green outline**, representing the hazard level of viewing the sun without filtering, ie staring at the sun.

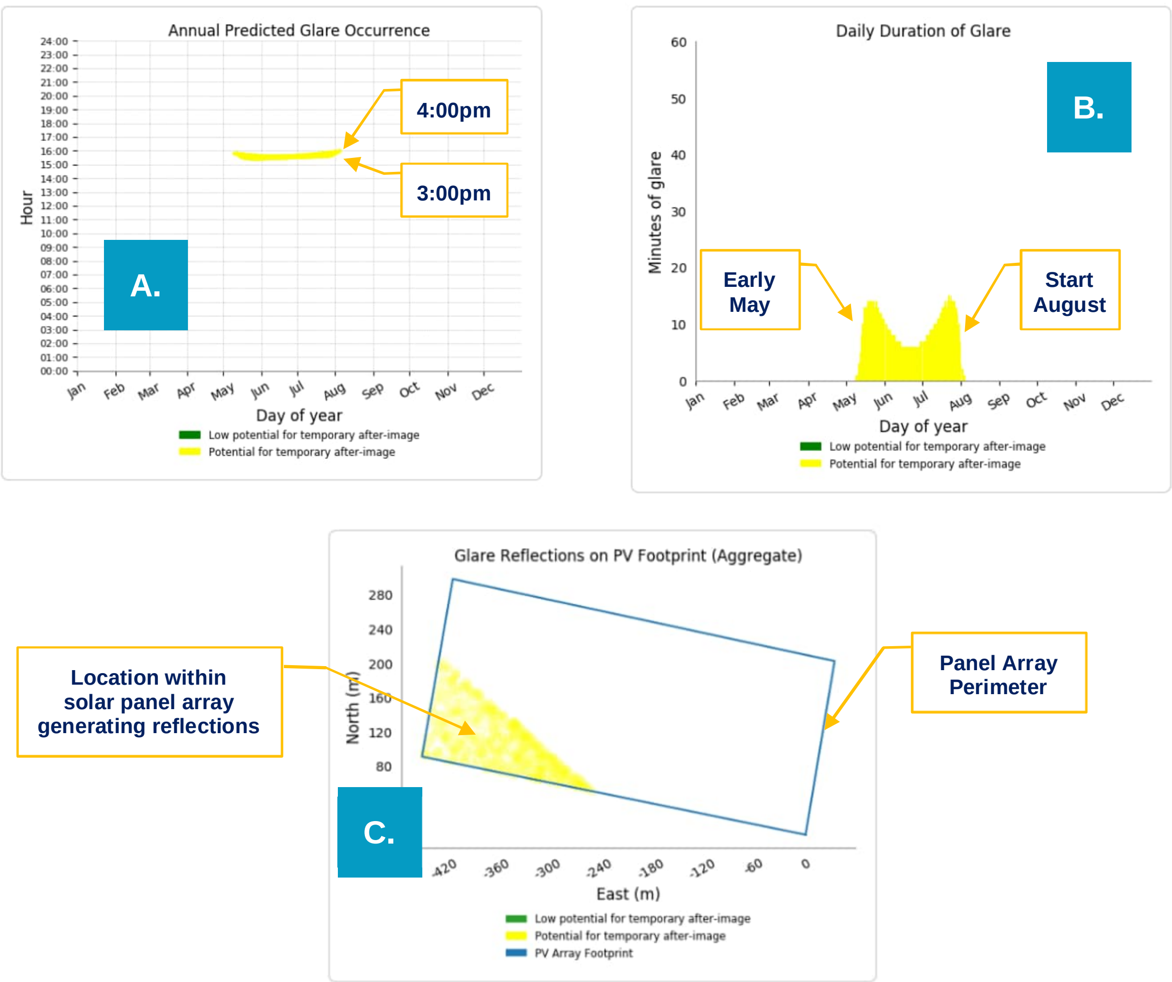
- o In **Figure 7**, it can be seen that the reflection visible by the receiver is roughly one thousand times less intense than the light from the sun.

- Finally, in relation to PV Solar facilities, it is important to note that the third SGHAT Ocular Plot "RED" category is not possible, since standard PV modules do not focus reflected sunlight.

In addition to the above "assessment" output, the SGHAT software package also produces information which reveals the extent of visibility of reflections at any chosen receiver position, regardless of whether the reflections constitute a glare condition or not. An example is shown in **Figure 8**.

- **Figure 8-A** shows the am/pm time periods when reflections occur at a specific receptor throughout the year, in this case between around 3:30 pm and 4:00 pm.
- **Figure 8-B** shows the months during the year and the minutes per day when reflections occur at a specific position, in this case from early-May to the start of August, for periods ranging up to 13 minutes per day.
- Finally, **Figure 8-C** shows where within the solar farm panel array the reflection rays of interest are emanating from, in this case from panels near the southwest corner.

Figure 8 Example Solar Glare Output Plots (SGHAT Software Output)



4.4 Other Factors Relevant to Glare Prediction

Weather

SGHAT model calculations (and indeed all commercially available glare models) assume CLEAR skies all year round.

Bureau of Meteorology records from nearby weather stations include the following data:

- 7.9 hours = mean hours of sunshine per day (annual average)
- 144 days = mean number of cloudy days (annual average)

At the project site, the weather is will therefore be overcast or mostly cloudy over 35% of the time throughout the year.

This means that the total annual minutes of duration for any potential glare conditions predicted using SGHAT (or any “clear sky” glare model) should be reduced by an appropriate “overcast” factor, resulting in overall lower impacts.

- Note however that this would only reduce the likely cumulative impact over the entire year.
- The maximum duration on any one day predicted by SGHAT would not be affected.

Terrain

Terrain features such as natural obstacles (vegetation, tree lines, etc) are not explicitly considered within SGHAT.

These however can be added to the simulation as so-called “obstructions” which can model tree lines for example as solid (obstructing) walls. In this case, it would be assumed that the vegetation has dense coverage and is of an evergreen species.

Topography

Similarly, topography is not modelled within SGHAT.

This can only be overcome by an examination of the Viewshed Analysis often undertaken for such projects, which reveals which surrounding receivers (roadways, houses, etc) will be able to actually ”see” the solar panels within a proposed facility and hence experience reflections.

Alternatively, the “Elevation Profile” function available in Google Earth (or alternative mapping tools) may be able to identify sensitive receivers which do not have a view of the proposed facility.

5.0 Glare Impacts

5.1 Modelling Inputs

Panel Sub-Arrays

Following the layout shown in **Figure 2**, the Project was modelled as 11 “sub-arrays” - refer **Figure 9**.

- This was done to better follow the undulating terrain of the site and give more detailed information as to which specific areas of the proposed facility might be responsible for potential glare occurrences.

Figure 9 Glare Modelling Sub-Arrays PV01-PV11

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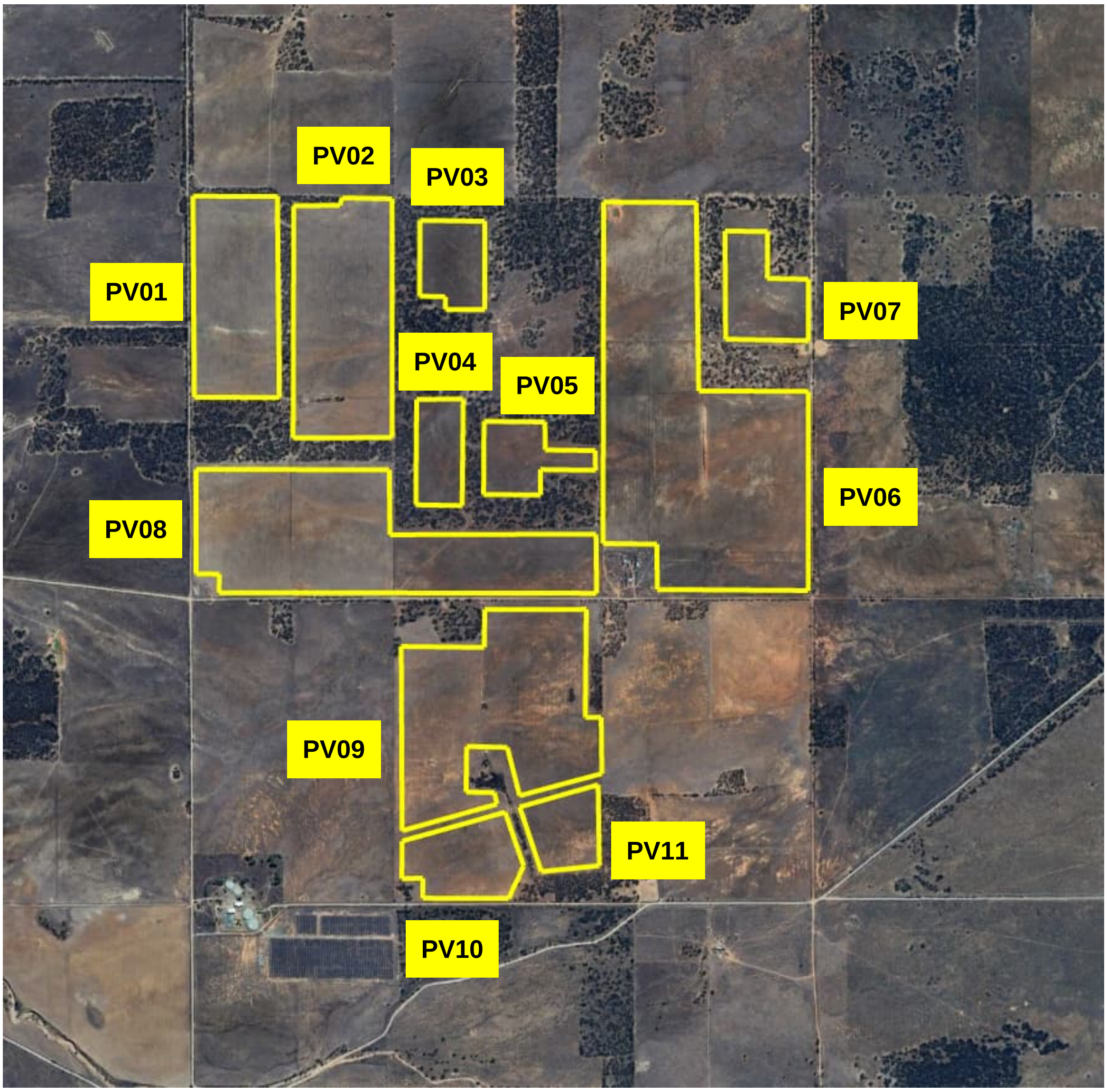


Road Receptors

The roadways included in the analysis are shown in **Figure 10**. These are all local roads with very low traffic volumes. The motorist viewing heights for the roadways were as follows:

- 1.8 m for all roadways.

The roads shown in **Figure 10** were selected following an analysis of viewlines provided to SLR by the Visual Impact Assessment team for the Project – refer **Appendix A**.

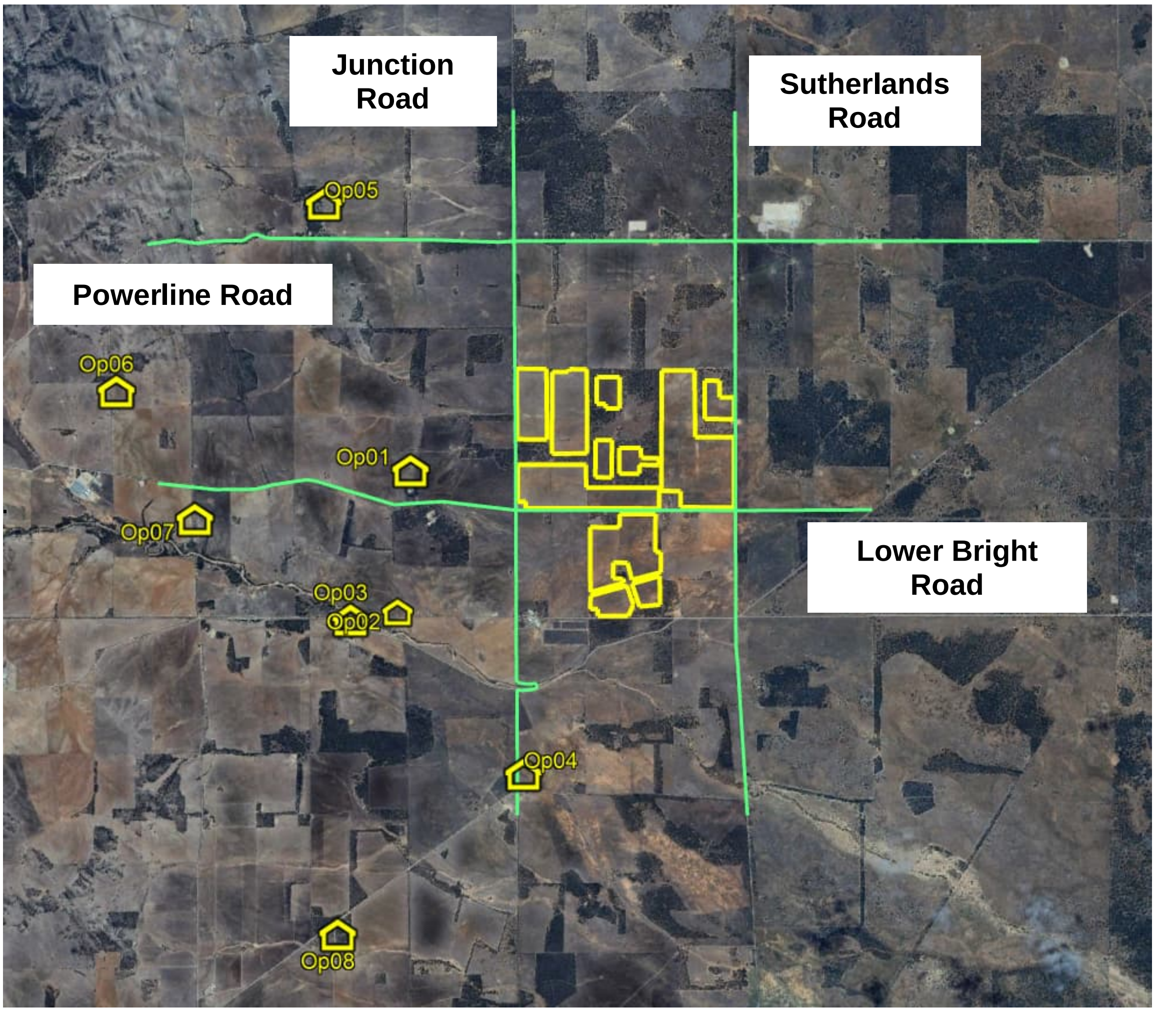
Residential Receptors

The residential locations included in the analysis are also shown in **Figure 10**.

- For surrounding residential dwellings, the default observer height was set at 1.5 m above the ground.

The latitude and longitude coordinates of the representative residential locations shown in **Figure 10** can be found in **Appendix A**. These were also provided to SLR by the Visual Impact Assessment team for the Project.

Figure 10 Roadway and Surrounding Residential Receiver Locations



5.2 Modelling Staging Methodology

The modelling study involved the following stages:

Stage 1 Baseline Modelling

- Rest Angle 0°
- No existing vegetation screens
- No allowance for shielding by intervening topography.

Stage 2 Detailed Analysis of Baseline Results

- Check for shielding by intervening terrain and/or topography; and
- Check for "Angle Difference" scenario.

Stage 3 Mitigation Modelling

- Mitigation options analysed to eliminate any remaining potential glare.

5.3 Stage 1 – Baseline Modelling

The Project was modelled using the "sub-arrays" shown in **Figure 9** with the following assumptions:

- The median solar panel height in each sub-array was 3 m above ground.
- The Rest Angle was set to 0°.
- Vegetation and other potential screening (eg buildings) were not included.
- No allowance was made for the impact of intervening sections of topography which could obscure the view of the facility for passing motorists or residences.

This run was designed to give an initial indication of potential locations of glare prior to considering the need for mitigation and to identify which specific panel sub-arrays were critical from the point of view of glare.

5.3.1 SGHAT Results

Table 2 shows the total annual minutes of potential SGHAT YELLOW glare, with both the individual PV sub-array annual minutes of glare and the total over all sub-arrays.

Where applicable, the residential receiver results in **Table 2** are shown with shading of the annual totals used to identify the relevant LSSE Guideline impact category:

- Green Low Impact < 10min/day OR < 10hr/year
- Orange Moderate Impact 10-30min/day OR 10-30hr/year
- Red High Impact > 30min/day OR > 30hr/year

Note:

- o The above LSSE green/orange/red categories are not relevant to road traffic disability glare.

Table 2 Annual Minutes of SGHAT YELLOW Glare (Baseline Geometry)

Observer	PV Sub-Array											Yearly Total
	01	02	03	04	05	06	07	08	09	10	11	
Lower Bright Road	1438				804	76		8319	737			**11374**
Junction Road	4624							2602				**7226**
Powerline Road												
Sutherlands Road												
Op 01	357											357
Op 02												
Op 03								124				124
Op 04												
Op 05												
Op 06												
Op 07												
Op 08												

Discussion – by Sub-Array

- Almost all instances of potential glare occur for early morning conditions. Lower Bright Road can experience reflections morning and afternoon (depending on the direction of traffic).
- NIL glare is predicted for ALL surrounding Roads and Residences as follows:
  - PV Sub-Arrays 2, 3, 4, 7, 10 and 11
- Potential glare is predicted for surrounding Roads for:
  - PV Sub-Arrays 1, 5, 6, 8 and 9.
- Potential glare is predicted for surrounding Residences for:
  - PV Sub-Arrays 1 and 8.

Note again that, in this first round of modelling, NO allowance was made for existing vegetation screening or topographic screening.

5.4 Stage 2 – Detailed Analysis of Baseline Results

The baseline results shown in **Table 2** were then assessed for the following characteristics:

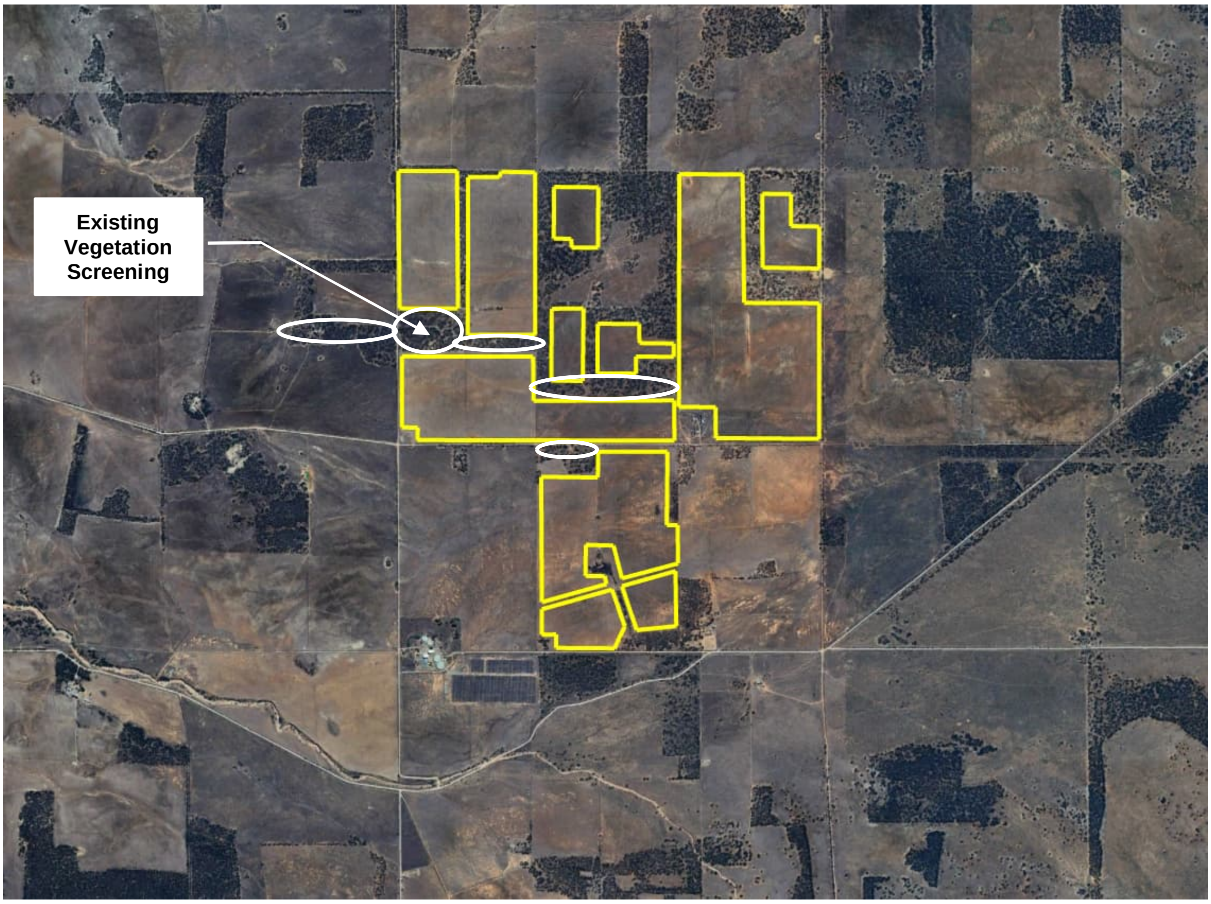
- Shielding via intervening terrain and/or topography; and
- “Angle Difference” condition.

5.4.1 Shielding via Intervening Terrain and/or Topography

Potential reflection conditions shown in **Table 2** were assessed in relation to the presence of intervening terrain and/or topography between the relevant observer and sub-array.

Example locations are shown in **Figure 11** where existing vegetation would have the ability to block potential reflections from impacting nearby roads and residences of interest.

Figure 11 Area of Existing Screening Vegetation



The modelling was re-run with the addition of existing vegetation – the results are shown in **Table 3**. The addition of existing vegetation eliminated all cases of Residential glare.

The remaining conditions of potential glare were as follows:

- Lower Bright Road PV Sub-Arrays 6, 8 and 9.
- Junction Road PV Sub-Arrays 1 and 8.

Table 3 Annual Minutes of SGHAT YELLOW Glare (Baseline + Existing Vegetation)

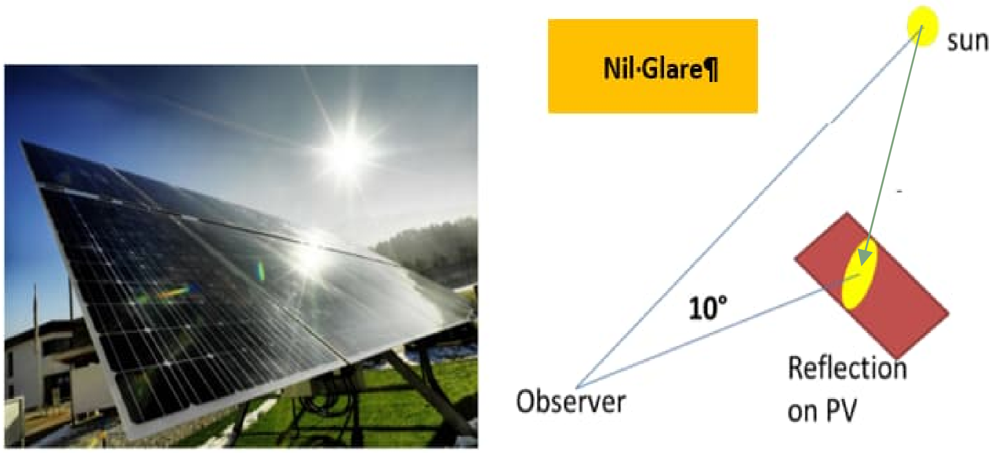
Observer	PV Sub-Array											Yearly Total
	01	02	03	04	05	06	07	08	09	10	11	
Lower Bright Road						76		7794	583			**8453**
Junction Road	4403							2575				**6978**
Powerline Road												
Sutherlands Road												
Op 01 to Op 08												

5.4.2 Angle Difference Condition

The context of this condition refers to the observation made in **Section 3**, where it was noted that for very high incidence angles, it would almost always be the case that an observer would perceive reflections coming from virtually the same direction as the incoming solar rays themselves. Such a condition would not constitute a glare situation as the intensity of the incoming solar ray would dominate the field of vision perceived by the observer.

In fact, this condition has evolved into a globally adopted “acceptability” glare axiom, namely that a glare condition can only exist if the angle difference between an incoming solar ray and its associated reflection is greater than approximately 10° – refer **Figure 12**.

Figure 12 Nil Glare Condition Applicable to High Incidence Angle Reflections



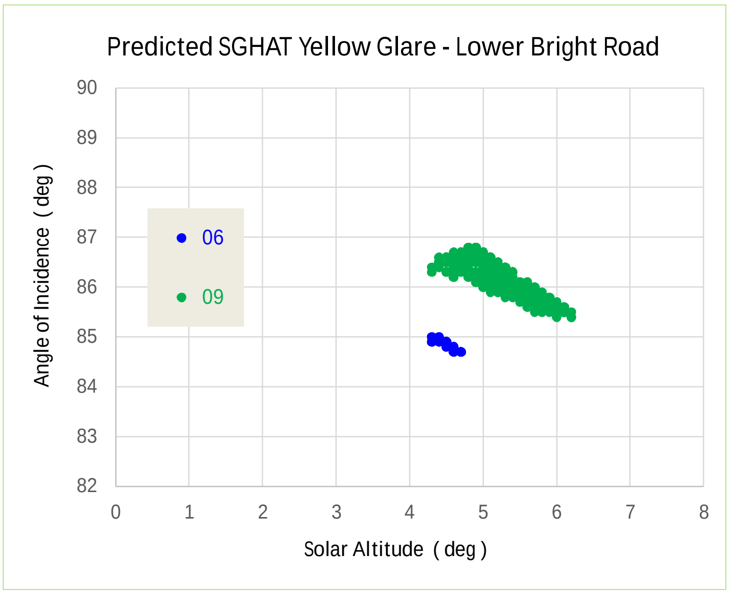
The Incidence Angle Occurrence for Lower Bright Road is shown in **Figure 13** where it can be seen that the potential reflections impacting the road from PV Sub-Arrays 06 and 09 occur for low ALTITUDE angles and high INCIDENCE ANGLES.

- The resulting difference between the angle of incoming direct solar rays and associated reflections would be less than 10°.

On this basis, the predicted reflections would not constitute a glare condition.

Figure 13 Altitude and Incidence Angles for Lower Bright Road / PV Sub-Arrays 06 & 09

Reflections onto Lower Bright Road from PV Sub-Arrays 6 & 9



Following consideration of the "angle difference" condition, the remaining cases of potential glare are shown in **Table 4**.

Table 4 Annual Minutes of SGHAT YELLOW Glare (Baseline + Existing Vegetation + Angle Difference)

Observer	PV Sub-Array											Yearly Total
	01	02	03	04	05	06	07	08	09	10	11	
Lower Bright Road								7794				**7794**
Junction Road	4403							2575				**6978**
Powerline Road & Sutherlands Road												
Op 01 to Op 08												

5.5 Mitigation Modelling

As can be seen in **Table 4,** the remaining potential glare conditions for the Project were identified as:

- Lower Bright Road PV Sub-Array 01
- Junction Road PV Sub-Arrays 01 and 08

The two most common mitigation options for eliminating glare from solar facilities are:

- Mitigation via Curtailment of Rest Angle; and/or
- Mitigation via Additional Perimeter Vegetation Screening.

5.5.1 Mitigation Modelling with Rest Angle Curtailment

The SGHAT modelling was re-run with a Rest Angles of 5° and 10°.

The results are shown in **Table 5** and indicate the following:

- Rest Angle 5° potential glare remains for PV Sub-Arrays 01 and 08.
- Rest Angle 10° potential glare is eliminated for PV Sub-Array 01 but remains for PV Sub-Array 08.

Table 5 Annual Minutes of SGHAT YELLOW Glare (Rest Angles 5° and 10°)

Rest Angle = 5°

Observer	PV Sub-Array											Yearly Total
	01	02	03	04	05	06	07	08	09	10	11	
Lower Bright Road								6951				**6951**
Junction Road	670							3109				**3779**

Rest Angle = 10°

Observer	PV Sub-Array											Yearly Total
	01	02	03	04	05	06	07	08	09	10	11	
Lower Bright Road								2890				**2890**
Junction Road								841				**841**

5.5.2 Mitigation Modelling via Perimeter Vegetation Screening

Following a review of the Baseline results, the SGHAT modelling was re-run with a vertical screen along the south and west sides of PV Sub-Array 08

The SGHAT runs yielded NIL glare for PV Sub-Array 08 with the addition of the proposed screens.

5.6 Mitigation Summary

The results of the baseline and mitigation modelling are shown in **Table 6**.

The mitigations shown in **Table 6** would eliminate ALL instances of potential glare from the proposed facility.

- No mitigation is required for PV Sub-Arrays 02-07 and 09-11.
- Rest Angle Curtailment would eliminate potential reflections from PV Sub-Array 01.
  - Note that this ONLY applies to the MORNING Rest Angle and ONLY for the months of May-August.
- Perimeter screening would eliminate potential reflections from PV Sub-Array 08.
  - Note that some sections of the proposed screening can take advantage of existing vegetation.

Due to the large length of the screening, SLR recommends that the project be reanalysed upon completion of the detailed design. This will allow for other local factors such and traffic frequency and fields of vision to be taken into account when determining the exact type and extent of required mitigation.

Table 6 Mitigation Summary

<table>
<tr><th rowspan="2">PV Sub-Array
(refer Fig.9)</th><th colspan="12">Recommended Mitigation involving:
EITHER
Back-Tracking Rest Angle Curtailment
OR
Perimeter Vegetation Screening</th></tr>
<tr><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td>PV Sub-Array 01</td><td colspan="4">NO
Mitigation Required
for Rest Angle</td><td colspan="4">MORNING:
Rest Angle 10°
AFTERNOON:
NO Restriction
on Rest Angle</td><td colspan="4">NO
Mitigation Required
for Rest Angle</td></tr>
<tr><td>PV Sub-Array 02</td><td colspan="12" rowspan="6">NO MITIGATION Required</td></tr>
<tr><td>PV Sub-Array 03</td></tr>
<tr><td>PV Sub-Array 04</td></tr>
<tr><td>PV Sub-Array 05</td></tr>
<tr><td>PV Sub-Array 06</td></tr>
<tr><td>PV Sub-Array 07</td></tr>
<tr><td>PV Sub-Array 08</td><td colspan="12">Mitigation method to be determined during the detailed design stage
(options include perimeter vegetation screening)</td></tr>
<tr><td>PV Sub-Array 09</td><td colspan="12" rowspan="3">NO MITIGATION Required</td></tr>
<tr><td>PV Sub-Array 10</td></tr>
<tr><td>PV Sub-Array 11</td></tr>
</table>

6.0 Night-Time Illumination Glare

6.1 Background and Criteria

Light spill from outdoor lighting has the potential to impact residents, transport users, transport signalling systems and locations dedicated to astronomical observations. Light spill from outdoor lighting can be influenced by a number of factors:

- Topology: light spill is more likely to be perceived as obtrusive if the lighting installation is located higher up than the observer. Lighting installations are usually directed towards the ground and an observer could hence have a direct view of the luminaire.
- Surrounding Terrain: hills, trees, buildings, fences and general vegetation have a positive effect by shielding the observer from the light installation.
- Existing Lighting Environment: light from a particular light source is seen as less obtrusive if it is located in an area where the lighting levels are already high, eg in cities. The same lighting installation would be seen as far more bothersome in a less well-lit rural residential area.
- Zoning: a residential area is seen as more sensitive compared to commercial areas where high lighting levels are seen as more acceptable.

Typical illuminance levels for a variety of circumstances are given in **Table 7** for comparison.

Table 7 Typical Illuminance Levels for Various Scenarios

Lighting Scenario	Horizontal Illuminance (lux)
Moonless overcast night	0.0001
Quarter Moon	0.01
Full Moon	0.1
Twilight	10
Indoor office	300
Overcast day	1,000
Indirect sunlight clear day	10,000-20,000
Direct sunlight	100,000-130,000

Recommended criteria of light technical parameters for the control of obtrusive lighting relevant to the critical night-time period are provided in various international lighting standards, eg the CIE (International Commission on Illumination) suite of standards. Key objectives for technical lighting parameters found in these standards are summarised in **Table 8**.

- Limits for luminous intensity for *curfew hours* apply in directions where views of bright surfaces of luminaires are likely to be troublesome to residents, from positions where such views are likely to be maintained.
- The vertical illuminance limits for *curfew hours* apply in the plane of the windows of habitable rooms or dwellings on nearby residential properties.
- The vertical illuminance criteria for *pre-curfew hours* apply at the boundary of nearby residential properties in a vertical plane parallel to the boundary.

- Limits for luminous intensity for *pre-curfew* hours apply to each luminaire in the principal plane, for all angles at and above the control direction.
- Values given in **Table 8** are for the direct component of illuminance, ie no reflected light is taken into account.

Table 8 Typical Recommended Maximum Values of Light Technical Parameters

Light Technical Parameter	Time of Operation	Zone "A4"	Zone "A3"	Zone "A2"	Zone "A1"	Zone "A0"
Illuminance in vertical plane (E_v)	Pre-curfew hours	25 lx	10 lx	**5 lx**	2 lx	ALARP [1]
	Curfew hours	5 lx	2 lx	**1 lx**	0.1 lx	0 lx
Luminous Intensity emitted by luminaires (I)	Pre-curfew hours	25,000 Cd	12,500 Cd	**7,500 Cd**	2,500 Cd	ALARP [1]
	Curfew hours	2,500 Cd	2,500 Cd	**1,000 Cd**	500 Cd	0 Cd

Zone A0	"Intrinsically Dark", eg UNESCO Starlight Reserve; IDA Dark Sky Parks; major optical observatories; no road lighting, unless specifically required by the relevant road controlling authority
Zone A1	"Dark", eg relatively uninhabited rural areas; no road lighting, unless specifically required by the relevant road controlling authority
Zone A2	"Low District Brightness", eg sparsely inhabited rural and semi-rural areas
Zone A3	"Medium District Brightness", eg suburban areas in towns and cities
Zone A4	"High District Brightness", eg town and city centres and other commercial areas; residential areas abutting commercial areas
ALARP	As low as reasonably practical

The Project is located in a rural area with the potential to impact on surrounding residential properties.

- These properties would be classed as being in a Zone "A2" area – refer **Table 8**.

The applicable limits for adverse spill light will also depend on the time of operation for the lighting installation, ie Pre-curfew or Curfew hours.

For the Project, it is understood that perimeter lighting may be incorporated into the Project, and that there may some night-time security lighting, suggesting the application of the more restrictive limit relevant to *Curfew hours*.

Accordingly:

- Light spill from the Project onto the facades of the surrounding residential dwellings should be kept below **1 lux** during Curfew hours.

6.2 Night-Time Illumination Glare – Assessment and Mitigation

The only potential for future night-time illumination glare, IF night-time lighting is employed at the site, would be associated with the nearest roadways and residential receivers to the Project.

The recommendations set out below are therefore aimed at achieving the best lighting performance (taking into account safety considerations) while having a minimal impact on the surrounding properties, carriageways and nocturnal fauna.

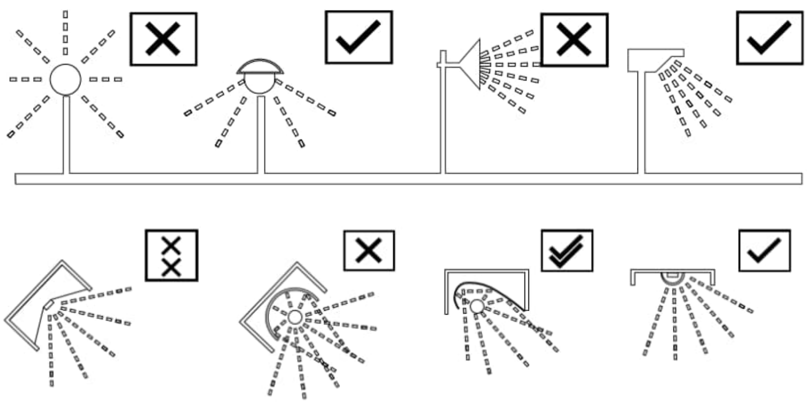
In terms of any future potential night-time lighting, the adopted goal of limiting night-time light spill to no more than 1 lux is expected to be readily achieved given the guidance available in:

- AS/NZS 4282-2023 *Control of the Obtrusive effects of Outdoor Lighting*.

AS/NZS 4282-2023 sets out general principles that should be applied when designing outdoor light to minimise the potential adverse effects of a light installation. It is expected that these will be applied to the design of the project lighting.

- Direct lights downward as much as possible and use luminaires that are designed to minimise light spill, eg full cut-off luminaires where no light is emitted above the horizontal plane, ideally keeping the main beam angle less than 70°. Less spill-light means that more of the light output can be used to illuminate the area and a lower power output can be used, with corresponding energy consumption benefits, but without reducing the illuminance of the area – refer **Figure 14**.
- Do not waste energy and increase light pollution by over-lighting.
- Wherever possible use floodlights with asymmetric beams that permit the front glazing to be kept at or near parallel to the surface being lit.

Figure 14 Luminaire Design Features that Minimise Light Spill (refer AS/NZS 4282-2023)



7.0 Feedback

At SLR, we are committed to delivering professional quality service to our clients. We are constantly looking for ways to improve the quality of our deliverables and our service to our clients. Client feedback is a valuable tool in helping us prioritise services and resources according to our client needs.

To achieve this, your feedback on the team's performance, deliverables and service are valuable and SLR welcome all feedback via https://www.slrconsulting.com/en/feedback. We recognise the value of your time and we will make a $10 donation to our 2023 Charity Partner - Lifeline, for every completed form.

Appendix A Roadway Viewpoints, Residential Receiver Coordinates

Robertstown East Solar Farm

Preliminary Glint and Glare Assessment

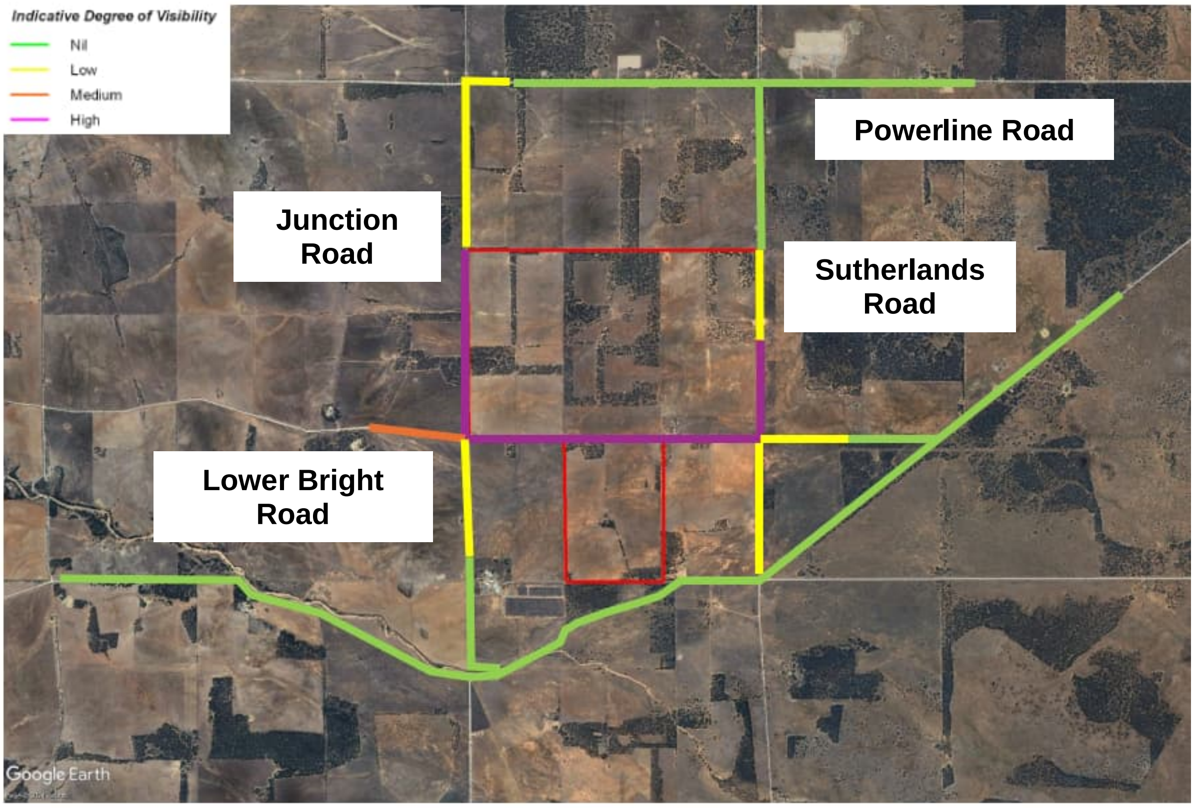
AMP Power Australia Pty Ltd

SLR Project No.: 610.032014.00001

27 June 2024

Revision: R01-1.1

Local Road Visibility Analysis



The latitude and longitude coordinates, and elevation heights of the representative locations examined in this study are shown in **Table A-1**.

Table A-1 Latitude and Longitude of Sensitive Receivers Surrounding Site

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-33.957030	139.172078	272.92	1.50
OP 2	2	-33.972974	139.170435	261.73	1.50
OP 3	3	-33.974358	139.163879	271.48	1.50
OP 4	4	-33.992009	139.187934	240.66	1.50
OP 5	5	-33.926615	139.160647	286.93	1.50
OP 6	6	-33.948048	139.131907	334.33	1.50
OP 7	7	-33.962829	139.142501	297.22	1.50
OP 8	8	-34.010270	139.162179	268.34	1.50

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