Visual Impact Assessment

Glen Innes Solar Farm

Prepared for Green Gold Energy Pty Ltd

June 2024

Visual Impact Assessment

Glen Innes Solar Farm

Green Gold Energy Pty Ltd

E240278 RP2

June 2024

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1 Introduction

1.1 Background

The developer, Green Gold Energy Pty Ltd, proposes to develop a solar farm called the Glen Innes Solar Farm (the project). The project is situated at Glen Innes in the Glen Innes Severn Local Government Area in north-eastern New South Wales (NSW).

A map of the project location and regional context is shown in Figure 1.1.

This visual impact assessment (VIA) describes the existing landscape and visual character of the site. It then applies a method to assess the visual sensitivity of the site and to assess the visual impact of the changes resulting from the planned development.

1.2 Project description

The project is located approximately 1.1 kilometres (km) west of the town of Glen Innes on the southern side of the Gwydir Highway. The project address is 409 Gwydir Highway, Glen Innes, NSW, 2370, and incorporates lots:

- 59/DP1834
- 60/DP1834
- 61/DP1834
- 62/DP1834.

The project site is located on flat land near the northern bank of Furracabad Creek at an elevation of approximately 1,050 m Australian height datum (AHD). The channel of Furracabad Creek forms a low point in the surrounding landscape, with terrain rising east and west of the site.

The project is a solar farm with a 5.52 megawatt (MW) capacity and the solar array will cover an area of approximately 8 hectares (ha). The facility will include an array of photovoltaic solar panels, battery storage units and will have an overhead connection to the existing Essential Energy network. An existing Essential Energy substation is located 400 m east of the site.

KEY

- Project boundary

Existing environment

- Rail line
- Major road
- Minor road
- Vehicular track
- Named watercourse
- Named waterbody

INSET KEY

- Major road
- NPWS reserve
- State forest

Source: EMM (2024); ABS (2021); DCSSS (2024); ESRI (2024); GA (2009)

0 1 2 km

GDA2020 MGA Zone 56

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Project location

Glen Innes Solar Farm
Visual Impact Assessment
Figure 1.1

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1.2.1 Project layout

The project consists of approximately 400 rows of PV panels arranged with a north-south orientation along the northern boundary of the site. An indicative plan of the site layout is shown in Figure 1.3.

Permanent facilities to be installed at the site include:

- Solar array covering approximately 8 ha
- One inverter station
- 2 – 8 battery units (to be confirmed in future design)
- One high voltage switchboard
- Poles for overhead connection to Essential Energy network
- Security fence – 1,800 millimetres (mm) high chain mesh with three strands of barbed wire to a total height of 2,250 mm
- Perimeter screen planting.

i Site access

Access will be via an existing sealed driveway off the Gwydir Highway at the north-eastern corner of the site. This access is on adjoining crown land at lot 7031/DP1059108.

ii Project construction

The construction of the project is expected to take a period of 9 months. During this period, there may be noticeable activity within the project site as solar infrastructure components are transported into the site and installed.

During construction, a storage building and an amenities block for the construction workers will be located on the site. These will be removed when construction is complete. No permanent buildings will be located on the site after the construction stage.

iii Solar panels

The proposed solar arrays comprise of photovoltaic panels approximately 2.3 metres (m) wide and with a maximum height of approximately 2.6 m. The panels will be installed on a tracking system with a north – south axis that aligns the panels with the moving sun for maximum efficiency. They will maintain a clearance of 0.5 m off the ground (refer to Figure 1.2). In a horizontal position the panels will be approximately 1.6 m above the ground.

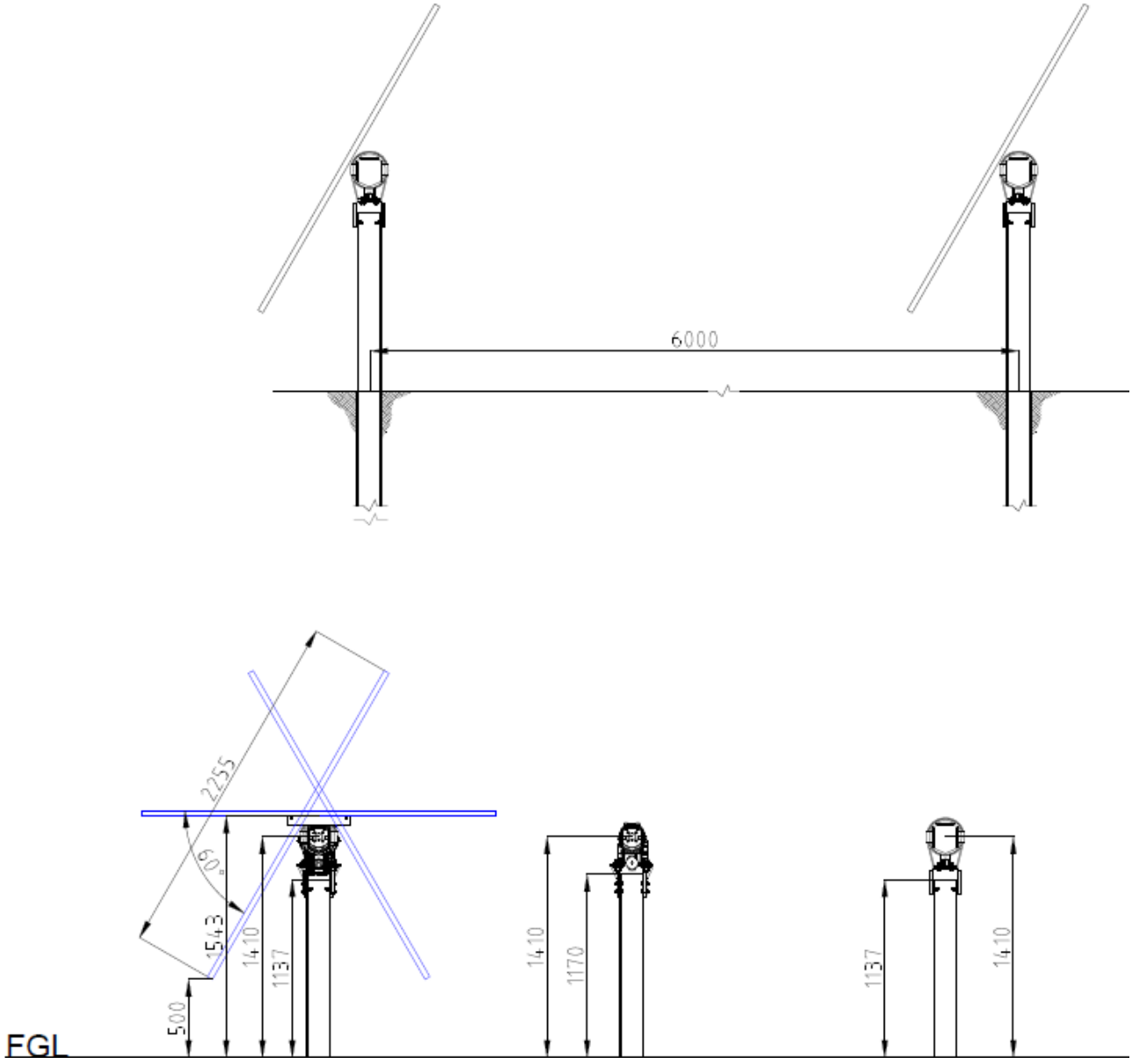

Figure 1.2 **Typical solar panel on tracking system (not to scale)**

KEY

- Project boundary
- Site layout
- Transmission line easement

Electricity transmission line

- 11 kv
- 66 kv
- 132 kV

Existing environment

- Major road
- Vehicular track
- Named watercourse

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Source: EMM (2024); DCSSS (2024); ESRI (2024); GA (2009)

0 100 200 m

GDA2020 MGA Zone 56

N

Site plan

Glen Innes Solar Farm
Visual Impact Assessment
Figure 1.3

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2 Assessment methodology

There are a number of recognised methods for undertaking visual impact assessments for solar projects in New South Wales, although no particular method is prescribed by state or local government for this scale of solar project. Therefore, the method used in this visual impact assessment is based on established practices and policies. Documents used for broad guidance include:

- *Guideline for Landscape Character and Visual Impact Assessment*, EIA-N04, Version 2.2 (2020), Transport for NSW Centre for Urban Design
- *Guidelines for Landscape and Visual Impact Assessment* Third Edition (2013) (the GLVIA), prepared by the Landscape Institute and Institute of Environmental Management and Assessment.

EMM employs a system that enables the evaluation of the visual impact in rural and urban environments. The study method for the LVIA follows three key steps outlined below:

- Existing visual environment:
  - review proposal and extents of the development
  - landscape character description
  - visual catchment area defined through reviewing maps and satellite imagery to identify where the site is visible from
  - site visit – undertake inspections from viewpoints, including photographs of the site from each location and verifying the visual catchment.
- Visual Impact Assessment of the visual impact by applying the visual sensitivity and visual effect criteria:
  - superimpose the visual model into the viewpoints (photomontages)
  - review against baseline information (impact of change from proposal).
- Acceptability of the visual impact assessment of the acceptability of the visual impact against relevant considerations:
  - drawing conclusion and recommendations.

2.1 Assessment criteria

The potential visual impact of the planned development is measured through the combination of two factors:

- visual sensitivity of the development to the viewer
- visual effect of the development on the landscape.

To measure the visual sensitivity and the visual effect of the site, specific locations known as viewpoints are chosen as representative views (refer to Section 5.2). These are then assessed to determine the overall visual impact. Visual sensitivity and visual effect are defined below.

2.1.1 Visual sensitivity

Visual sensitivity is a measure of the extent to which activities or components of a proposal may change the landscape and be visible from surrounding areas. This takes into account the relative number of viewers, the period of view, viewing distance and context of view.

The rationale for the assessment is that if a proposal is not visible the impact is nil and if the number of people who would potentially see the proposal is low, then the visual impact would be lower than if a potential large number of people had the same view.

For the purpose of this study, the general category of visual sensitivity has been divided into two elements. The first, viewing location, is a rating based on distance from the site and the landscape type as shown in Table 2.1. The second, viewer experience is based on the number of people affected and the duration of the impact as indicated in Table 2.2.

Table 2.1 Visual sensitivity rating – location

Viewing location	Distance from site (km)				
Landscape type	**0–0.5**	**0.5–1.0**	**1.0–2.5**	**2.5–4.0**	**>4.0**
Townships	High	Moderate	Moderate	Moderate	Low
Recreation reserve	High	Moderate	Moderate	Moderate	Low
Residence	High	Moderate	Moderate	Low	Low
Rural township	High	Moderate	Low	Low	Nil
Main highway	Moderate	Low	Low	Low	Nil
Local roads	Moderate	Low	Low	Low	Nil
Farm roads	Low	Low	Low	Nil	Nil
Agricultural land	Low	Low	Low	Nil	Nil

Table 2.2 Visual sensitivity rating – experience

Viewer experience	Number of viewers		
Duration of view	**Large**	**Moderate**	**Small**
Long (>10 minutes)	High	High	Moderate
Moderate (1–10 minutes)	High	Moderate	Low
Short (<1 minute)	Moderate	Low	Low

The two sensitivity ratings above are combined to form the visual sensitivity rating as indicated in Table 2.3. The resulting combined rating is applied to the visual impact rating shown in Table 2.5.

Table 2.3 Visual sensitivity rating

Visual sensitivity rating		Viewing location		
Viewer experience		High	Moderate	Low
	High	High	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Low

2.1.2 Visual effect

Visual effect is an estimation of the capacity of the landscape to absorb development without creating significant visual change. The capacity to absorb development is primarily dependent on landform, vegetation cover and the presence of other development.

The extent to which portions of the site can potentially absorb development without reducing the scenic quality of the area is assessed under these criteria. Generally, an urban context is able to absorb buildings and structures with low impact to the scenic value, while erecting structures in a natural or agricultural setting may impact the scenic quality significantly.

The level of contrast is also strongly influenced by the nature of the backdrop against which development is viewed. In particular, structures that are viewed above the skyline will potentially create a higher degree of contrast than the same elements viewed against a backdrop of similar structures or a landscape of similar colour/textures as the building or structure.

The degree of contrast between proposed development and the existing landscape (buildings and vegetation) can be reduced by careful attention to the colour, scale, texture, and reflectivity of building materials and by avoiding development that breaks the height of the existing tree canopy. Where possible these considerations are to be incorporated into the design and locations of buildings, roads and other structures.

Table 2.4 Visual effect criteria

Criteria	Definition
High	A substantial or obvious change to the landscape due to a total loss or change to characteristic elements or features of the landscape. Existing landscape is unable to absorb the change/development and a high degree of visual contrast is apparent. There is little, or no screening or integration with the vegetation, topography or existing urban context.
Moderate	Discernible changes to the landscape due to partial loss or change to elements or features that are characteristic of the landscape. The changes may be partly mitigated, but will leave an adverse, recognisable change to the landscape. Existing landscape is able to visually absorb some of the development, but there is some visual contrast and the development is visible.
Low	Minor loss or change to key landscape elements or features that may alter the landscape but still maintain the existing landscape character. Existing landscape or built environment is able to visually absorb the development. There is a low degree of visual contrast and effective use of screening.

2.1.3 Visual impact rating

Visual impact refers to the change in the appearance of the landscape because of development. This report addresses a number of factors that contribute to the visual impacts and has presented them in a measurable way.

Table 2.5 provides a matrix that combines the visual sensitivity rating with the visual effect rating to determine the visual impact rating. This rating is applied to each viewpoint to measure the impacts of a development from particular locations.

Table 2.5 Visual impact rating matrix

Visual impact rating		**Visual effect**		
		High	Moderate	Low
Visual sensitivity	High	High	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Low

3 Existing visual environment

3.1 Existing visual context

3.1.1 Land zoning and surrounding land use

The site lies on land zoned RU1 – Primary Production under Glen Innes Severn Local Environmental Plan 2012. The objectives of this land zone (as listed in Table 3.1) contribute to a landscape that is characterised by diverse agricultural uses on large blocks of land. This leads to a diverse mix of structures, including private dwellings, sheds, silos and large agricultural buildings that are often clustered within the landscape. Vegetation reflects this diversity, with large areas of crops and pasture interrupted by roads, buildings and large agricultural structures.

Table 3.1 Zone RU1 objectives

Zone RU1 objectives
To encourage sustainable primary industry production by maintaining and enhancing the natural resource base.
To encourage diversity in primary industry enterprises and systems appropriate for the area.
To minimise the fragmentation and alienation of resource lands.
To minimise conflict between land uses within this zone and land uses within adjoining zones.

Land surrounding the project is predominantly used for grazing and cropping, with views similar to that in Photograph 3.2 being characteristic of much of the surrounding landscape. Other adjoining or nearby land uses include:

- The western edge of the town of Glen Innes lies approximately 1.1 km east of the site, marked by residential and industrial development along the eastern side of Dumaresq Street.
- The Glen Innes Racecourse is located at Robertson-Cunninghame Park on the western edge of Glen Innes, with spectator areas situated approximately 1 km east of the site.
- An Essential Energy substation lies 400 m west of the site.
- The channel of Furracabad Creek, running along the east and south of the stie, is crown land.

The features mentioned above are visible in aerial photos in Figure 1.1 and Figure 1.3.

The footprint of the proposed solar installation is of a similar size to typical paddocks or landholdings in the vicinity and is not out-of-scale with existing land uses.

In Photograph 3.1 below the approximate site location is highlighted in the middle-ground on the right side of the image. The Glen Innes Racecourse can be seen to the left of the site, and the town of Glen Innes extends beyond the racecourse.

Photograph 3.1 View from Tuttles Lane looking south-east toward the project site and Glen Innes

3.1.2 Topography and landform

The project site is located near the centre of the New England Tableland Bioregion of north-eastern NSW. This region lies on elevated land that is part of the Great Dividing Range. Landform around the site is characterised by flat or very gently undulating land along drainage lines such as Furracabad Creek, with surrounding hills rising to over 1,200 m AHD, providing a local relief of approximately 150 m.

Furracabad Creek flows north-east as it passes the site, but generally flows north-west and is part of the Gwydir River catchment, eventually joining the Murray – Darling River basin in western NSW.

Photograph 3.2 below shows the flat land of the site beside Furracabad Creek, which flows from right to left behind the trees in the mid-ground of this image. Beyond the creek the hills in the background are typical of the location.

Photograph 3.2 View of the site from the Gwydir Highway looking south-west

3.1.3 Vegetation

The type and extent of vegetation on land surrounding the project has a significant impact on both the visual character of the area and the on the potential visibility of the project. On high ground surrounding the site vegetation is typically retained native woodland or forest. The town of Glen Innes is marked by a combination of native and exotic evergreen and deciduous trees. Vegetation on the agricultural plains surrounding the site consists mainly of pasture, with trees scattered randomly, or arranged in clumps or alignments along roads, fences and creeks.

The site is close to scattered clumps of trees and shrubs along Furracabad Creek. The project site itself has almost no woody vegetation or trees, having been used as pasture for a number of years.

Photograph 3.3 below, taken from Martins Lookout on the eastern outskirts of Glen Innes, shows the typical pattern of native trees on high ground (visible here in the foreground and on distant hills), with pastures on lower slopes and plains. In this image the plantings of exotic trees in the streets and gardens of the town can be seen to contrast with the native vegetation.

Photograph 3.3 View west, with the project site just beyond the town of Glen Innes

3.2 Project visibility

3.2.1 Zone of visual influence

A zone of visual influence (ZVI) diagram has been prepared to illustrate the theoretical visibility of the proposed solar infrastructure. The ZVI for this project (Figure 3.1) represents the area over which a development can potentially be seen.

The ZVI was generated using a digital elevation model (DEM). The DEM is representative of the bare earth surface and only considers the topography of the landscape. It is common practice to use only a DEM for the theoretical viewsheds, as this ensures the worst-case scenarios are identified for further evaluation.

GIS software uses these points to simulate whether the points will be visible from the surrounding landscape. This simulates a person's view from the surrounding area (assuming an eye-level of 1.6 m).

It is important to note that the ZVI does not consider the diminishing size of the project elements as the viewer moves further away. It only indicates where the project elements may be visible.

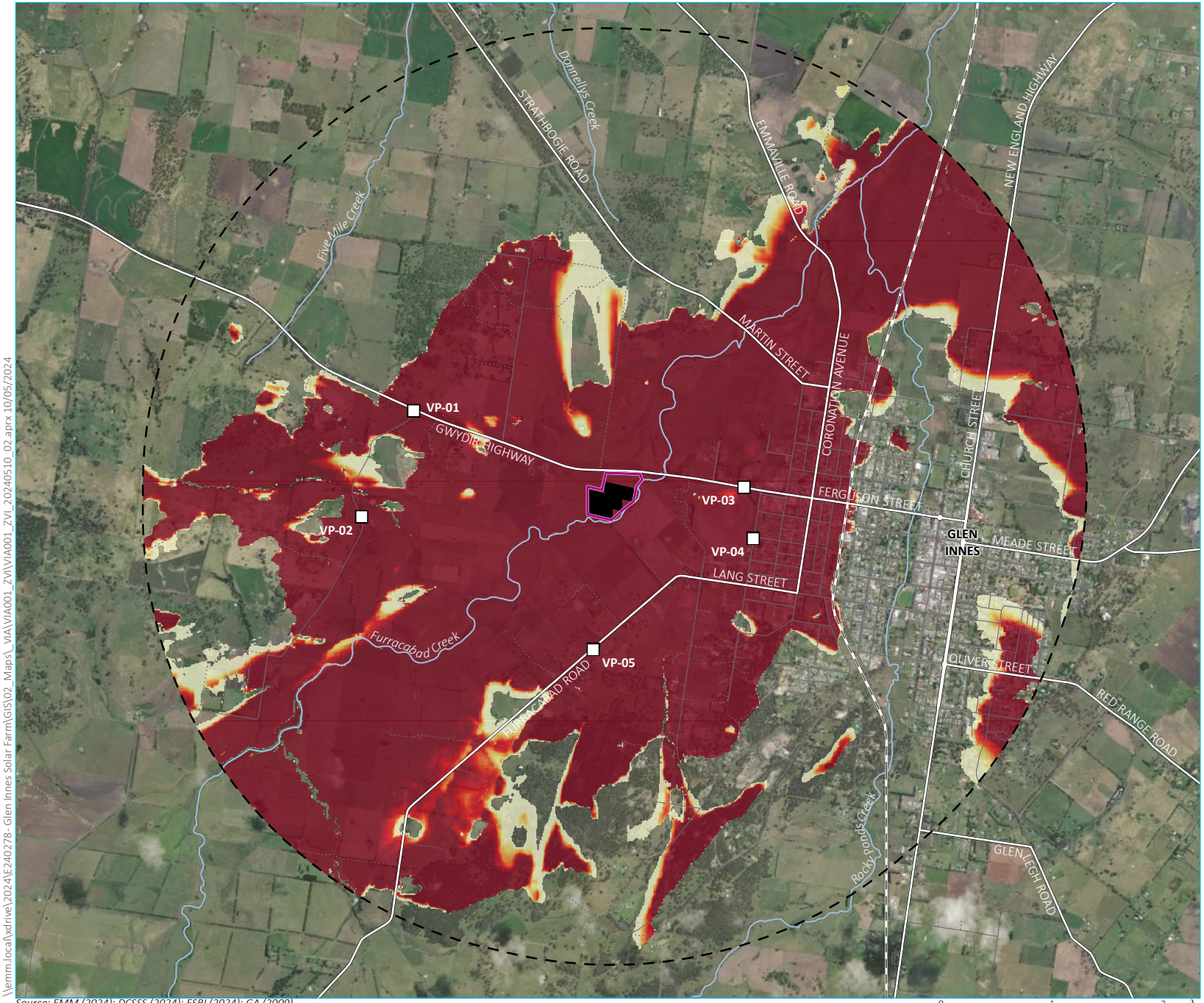
i Summary of ZVI

The ZVI shows the project will potentially be visible from rural or non-urban locations in a broad corridor running from south-west to north-east. The western edge of the town of Glen Innes has a westerly aspect and is shown to have potential views of the project. Some high locations in eastern Glen Innes around Oliver Street also have potential views of the project.

3.2.2 Confirmed visibility

Based on the ZVI and ground truthing undertaken during site visits, the following points can be made:

- Due to the visual screening effect of existing structures and trees, only the extreme western edge of the town of Glen Innes will have potential views of the project. These views would generally be across the Glen Innes Racecourse and heavily filtered by existing trees and structures.
- There will be no views from the main commercial areas of Glen Innes.
- The project will be partially visible from the Gwydir Highway for approximately 3 km from West Furracabad Street to near the Glen Innes Racecourse. Views from the road will be filtered by existing trees and shrubs.
- Views into the site from surrounding private land are limited slightly by topography, but more by vegetation and built structures.



Source: EMM (2024); DCSSS (2024); ESRI (2024); GA (2009)

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Zone of visual influence

Glen Innes Solar Farm
Visual Impact Assessment
Figure 3.1

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4 Visual impact – viewpoint selection

4.1 View locations

Site visibility helps to determine where the site can be seen from. This is important in mapping out the visual catchment of the site and determining viewing zones and viewpoint locations. The areas from which the site can potentially be seen are illustrated in the ZVI shown in Figure 3.1.

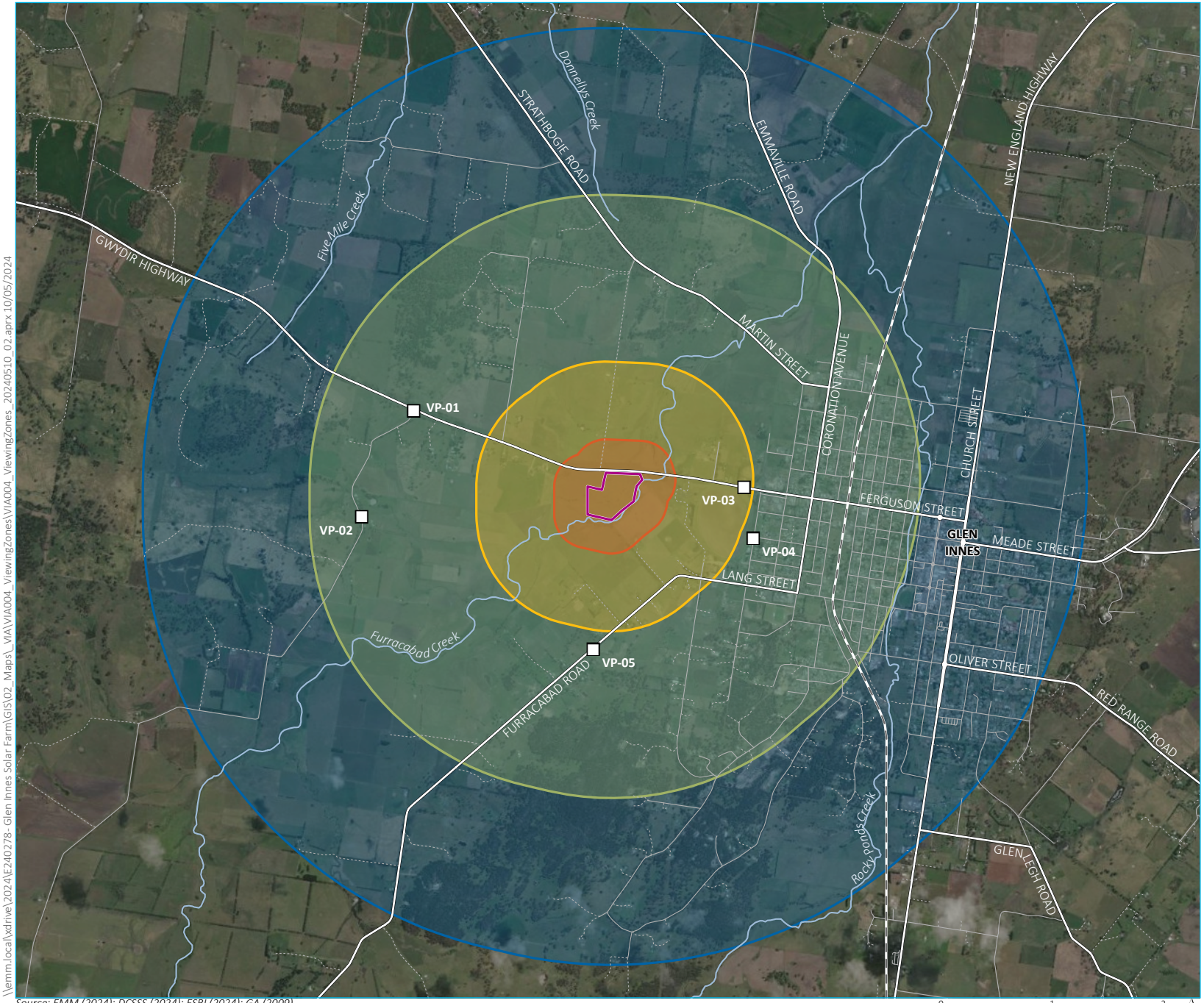
Viewing zones are areas outside the site that have potential views into the site. These are categorised by distance since visibility diminishes with distance. The categories are the site context, immediate vicinity, local area, district area and regional area as listed in Table 4.1.

After the viewing zones are determined, viewpoints are selected. Viewpoints are locations from which photographs are taken that will illustrate the views from that area. These are then tested through field investigations and photography to determine if the site is visible and how much of the site can be seen from the viewpoint.

Five representative viewpoints were identified with distances from the project ranging from 970 – 1,990 m. Despite the proximity of Glen Innes, with much of the town in the local area, most of the town is anticipated to have no views of the project. This is due to the low site elevation, the relatively higher surrounding terrain, and the screening effect of existing trees and structures. The selected viewpoints focus on public locations with greatest potential impact, including the Gwydir Highway and the Glen Innes Racecourse. Each view is addressed separately in Chapter 5 of this report. The viewpoints are listed in Table 4.1.

Table 4.1 Selected viewpoints

Viewing zone	Viewpoints	Notes
Site context (0–0.3 km)	None selected.	Except for the Gwydir Highway, there are no public viewpoints in this viewing zone. Views from the Gwydir Highway are represented by viewpoints VP-01 and VP-03.
Immediate vicinity (0.3–1.0 km)	VP-03	One viewpoint has been selected in this zone.
Local area (1.0–2.5 km)	VP-01, VP-02, VP-04 and VP-05	Four viewpoints have been identified in this viewing zone (VP-01 and VP-02 to the west, and VP-04 and VP-05 to the east and south respectively).
District area (2.5–4.0 km)	None selected.	The ZVI indicates potential views from this distance. However, no viewpoints have been identified. Any views that do occur from this distance will experience lower visual impact than those identified above in the local area.
Regional area (>4.0 km).	None selected.	The ZVI indicates potential views from this distance. However, no viewpoints have been identified. Any views that do occur from this distance will experience lower visual impact than those identified above in the local area.



KEY

- Project boundary
- Viewpoint

Viewing zone

- Site context (300 m)
- Immediate vicinity (1 km)
- Local area (2.5 km)
- District area (4 km)
- Regional area (>4 km)

Existing environment

- Rail line
- Major road
- Minor road
- Vehicular track
- Named watercourse

Source: EMM (2024); DCSSS (2024); ESRI (2024); GA (2009)

0 1 2 km

GDA2020 MGA Zone 56

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Viewing zones and viewpoint locations

Glen Innes Solar Farm
Visual Impact Assessment
Figure 4.1

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5 Visual impact assessment

An inspection of the Glen Innes site considered the existing landscape and how it is seen from various points in the surrounding region. Five viewpoints were selected for this study and have been captured through photographs. These viewpoints were each individually assessed for potential visual impacts from the development.

5.1 Viewpoint assessment

The following viewpoint worksheets provide photographs and analysis data from each of the viewpoints (refer to Figure 4.1 for viewpoint locations). The images were taken using a digital camera with a focal length equal to a standard 50 mm for a conventional 35 mm camera. This focal length is widely accepted as closely approximating the vision of the human eye.

5.1.1 Site visit

Site visits were undertaken on 18–19 April 2024 by a registered landscape architect with substantial experience analysing and mitigating visual impacts on the landscape. During the site visits, viewpoints were confirmed, and an assessment was made of each potential public viewpoint against the extent of the project.

At the time of the site visits, the weather varied from overcast to clear and sunny.

Viewpoint 1 - Gwydir Highway (B76) at West Furracabad Road

Visual assessment table	
Landscape type (table 2.1)	Main highway
Distance from site	1,730 m
Visual sensitivity rating - location (table 2.1)	Low
Number of viewers	Large
Duration of view	Short
Visual sensitivity rating - experience (table 2.2)	Moderate
Visual sensitivity rating (table 2.3)	Low
Visual effect criteria (table 2.4)	Low
Visual impact rating (table 2.5)	**Low**

Description:

View from the corner of the Gwydir Highway and West Furracabad Road, looking east toward the proposed development.

Comments:

This view is available to a large number of east bound travellers for a short duration as they approach Glen Innes from the west. The elevation of this viewpoint above the proposed solar array increases the visibility of the panels, however intervening trees and shrubs will partially screen the solar array.

As motorists descend along the Gwydir Highway towards Glen Innes the proposed solar array will become more visible, but it will only be seen in combination with existing industrial buildings and existing electrical infrastructure, which will reduce its potential visual impact. Also, the reduced viewing angle as motorists approach the project will reduce the vertical mass of the development.

Views from further west than this location will be blocked by existing trees and buildings.

Viewpoint 1 photomontage - Gwydir Highway (B76) at West Furracabad Road

Viewpoint 2 - West Furracabad Road

Visual assessment table	
Landscape type (table 2.1)	Local road
Distance from site	1,990 m
Visual sensitivity rating - location (table 2.1)	Low
Number of viewers	Small
Duration of view	Short
Visual sensitivity rating - experience (table 2.2)	Low
Visual sensitivity rating (table 2.3)	Low
Visual effect criteria (table 2.4)	Low
Visual impact rating (table 2.5)	**Low**

Description:

View from beside West Furracabad Road, looking east toward the proposed development.

Comments:

The distance of this viewpoint from the project, the varied landscape and the presence of existing trees combine to ensure that visual impact from this location will be minimal. Views toward the project for motorists on this road will be generally close to perpendicular to the path of travel, meaning views will be fleeting and only out of side windows.

This image, when compared to VP-01, also demonstrates the mitigating effect of existing tree planting as distance from the project increases.

Viewpoint 2 photomontage - West Furracabad Road

Viewpoint 3 - Gwydir Highway near racecourse

Visual assessment table	
Landscape type (table 2.1)	Main highway
Distance from site	970 m
Visual sensitivity rating - location (table 2.1)	Low
Number of viewers	Large
Duration of view	Short
Visual sensitivity rating - experience (table 2.2)	Moderate
Visual sensitivity rating (table 2.3)	Low
Visual effect criteria (table 2.4)	Low
Visual impact rating (table 2.5)	**Low**

Description:

View westbound from the Gwydir Highway as it passes Glen Innes Racecourse.

Comments:

Views of the project from this viewpoint are largely obscured by the existing substation and by existing trees near Furracabad Creek. Glimpses of the proposed solar array will be possible through gaps in the trees, and the panels will become more visible as motorists approach and pass the project site.

The low elevation of the project site relative to surrounding land is apparent in this image. This low elevation will maximise the screening effect of existing trees and structures, and reduce any potential impact on local visual character.

As visitors depart Glen Innes via this route local landscape character is dominated by existing industrial buildings on the western edge of Glen Innes, by the racecourse, and by the existing Essential Energy substation. The addition of the proposed solar array at it's proposed location will be visible but will have a negligible impact on local landscape character.

Viewpoint 3 photomontage - Gwydir Highway near racecourse

Viewpoint 4 - Dumaresq Street

Visual assessment table	
Landscape type (table 2.1)	Recreation reserve
Distance from site	1,050 m
Visual sensitivity rating - location (table 2.1)	Moderate
Number of viewers	Large
Duration of view	Long
Visual sensitivity rating - experience (table 2.2)	High
Visual sensitivity rating (table 2.3)	High
Visual effect criteria (table 2.4)	Low
Visual impact rating (table 2.5)	**Moderate**

Description:

View from Dumaresq Street, looking west over Glen Innes Racecourse toward the proposed development.

Comments:

This view, taken from just outside the racecourse fence, is representative of views that may be obtained from public areas of the racecourse. Views from Dumaresq Street and nearby dwellings will be from at least 15m further east, and will be significantly screened by existing street trees on the western side of Dumaresq Street.

From this viewpoint the proposed solar array will be significantly screened by existing trees on the far side of the racecourse.

The existing substation and nearby Glen Innes Regional Saleyards will have a much greater impact on visual amenity from this viewpoint than the proposed solar array.

Viewpoint 4 photomontage - Dumaresq Street

Viewpoint 5 - Furracabad Road

Visual assessment table	
Landscape type (table 2.1)	Local road
Distance from site	1,150 m
Visual sensitivity rating - location (table 2.1)	Low
Number of viewers	Small
Duration of view	Short
Visual sensitivity rating - experience (table 2.2)	Low
Visual sensitivity rating (table 2.3)	Low
Visual effect criteria (table 2.4)	Low
Visual impact rating (table 2.5)	**Low**

Description:

View from beside Furracabad Road, looking north toward the proposed development.

Comments:

Significant amounts of established tree canopy on private land along Furracabad Road will make views for motorists along this road no more than glimpses.

Approaching from this direction views will be parallel to the north-south alignment of the panels, meaning the panels will be seen end-on. This end-on perspective will reduce the solar array's visual mass and potential impact.

In the photomontage on the following page, the proposed solar panels are just visible in a narrow horizontal band between existing trees.

Viewpoint 5 photomontage - Furracabad Road

5.2 Viewpoint analysis

Of the five representative viewpoints assessed in this VIA four received a visual impact rating of low, and one received a visual impact rating of moderate. No viewpoints were identified that would receive a high visual impact rating.

One viewpoint, VP-04 near Glen Innes Racecourse, received a visual sensitivity rating of high, reflecting its public function. However, its overall visual impact rating is moderate, mainly because of the screening effect of existing vegetation. Visual impact at this location is further reduced by mitigating effect of other nearby development, including the Glen Innes Regional Saleyards and the Essential Energy Substation.

Two viewpoints (VP-01 and VP-03) were rated as having moderate visual sensitivity, reflecting their location on the Gwydir Highway and the resultant large number of viewers from each viewpoint. The overall visual rating for both these viewpoints was rated as low, reflecting the low visibility and therefore low visual impact of the project from these locations. While not directly assessed, views on the Gwydir Highway from locations closer to the site may be rated as high due to their proximity to the project compared to VP-01 and VP-03. However, these views would be brief at the assigned speed limit of 100 km/hour, and in the context of nearby existing industrial development would not significantly detract from or alter the landscape character.

The generally flat terrain of the project site and its low elevation relative to the surrounding area indicate potential visual impacts can be significantly reduced by increases in tree cover.

5.2.1 Visual impact for nearby private residences

There are approximately 17 existing private residences on land zoned R1 – Primary production that are within 1,000 m of the project and that may have views of the proposed solar array from the dwellings. Access to the residences has not been obtained and the visual impact on each residence has not been assessed. However, based on the analysis of viewpoints VP-01 – VP-05, and analysis of aerial photos, the following points can be made:

- In all cases the nature of any impact will be significantly affected by trees and shrubs around the dwellings, with views of the project site in many cases being blocked by existing vegetation.
- The potential impact will decrease significantly with distance from the project site.
- The project site has a lower elevation than all surrounding houses. This will reduce any potential visual impact when viewed from these receivers.
- The visual sensitivity – location (Table 2.1) would probably be rated as high for two of these residences that are less than 500 m from the project. The remainder would have a visual sensitivity rating of moderate at most.
- The visual sensitivity – experience (Table 2.2) for all these private residences would likely be rated as moderate for a long duration view by a small number of viewers.
- Based on the above, the maximum potential visual impact rating for the two closest dwellings would be high. The remainder have a maximum potential visual impact rating of moderate. If fully assessed, the visual impact ratings for these private residences may be lower due to existing structures and vegetation that may block potential views.
- The proposed planting shown in Appendix A will significantly reduce any potential visual impact.

5.3 Viewpoint impact summary

The visual impact for all viewpoints is rated from low to moderate as shown in Table 5.1 below. It is also important to note that the project will be difficult to see from most public locations other than nearby roads. The Gwydir Highway passes beside the site and will provide views to motorists leaving and approaching Glen Innes. The two assessed viewpoints on the highway (VP-01 and VP-03) are rated as having a low visual impact.

The project will be partially visible from parts of the public areas of Glen Innes Racecourse, however at distances of approximately 1 km these views will not be significantly impacted. Any potential visual impact from the racecourse is further mitigated by the varied landform and vegetation of the background, and by closer development such as the Essential Energy Substation and even the fencing surrounding the race track itself.

Table 5.1 Viewpoint visual impact summary

Viewpoint	Visual sensitivity	Visual effect	Visual impact rating
VP-01	Low	Low	**Low**
VP-02	Low	Low	**Low**
VP-03	Low	Low	**Low**
VP-04	High	Low	**Moderate**
VP-05	Low	Low	**Low**

6 Glint and glare analysis

6.1 Reflectivity and glare

Glint and glare are potential impacts of sunlight reflecting off the proposed solar project elements. When sunlight is reflected off a smooth, reflective surface, it can result in glint or glare. Glint refers to short, momentary periods of intense levels of exposure to reflection. Glare refers to sustained or continuous periods of exposure to excessive brightness, but at a reduced level of intensity. Glint is a quick reflection or flash of light, while glare is experience for a longer period of time. Both of these can be annoying and dangerous in certain situations by causing momentary blindness.

Reflection in the form of glint and glare will only be possible when direct sunlight occurs. Therefore, in those instances where glint and glare from the project elements may occur, people will also likely experience direct sunlight, which will be a significantly brighter and more intense source of light than reflections. Nonetheless, glint and glare may result from the project and may have an impact on receptors (dwellings within proximity of the development, motorists travelling along the local road network and pilots landing at or taking off from nearby runways).

6.1.1 Reflectivity

Generally, the light reflected is diminished by first hitting the substrate that reflected it. Since solar cells are designed to absorb light energy to create electrical currents, they will only reflect a portion of the sunlight that falls on them.

Typically, solar panels are constructed from a treated glass that is designed to minimise reflection and maximise the amount of light transmitted through the glass to the receptor. Typical treated glass that is used for solar cells reflects about 4% of the light that hits the cell. This is equivalent to a water body (pond or lake), which is considered to be a fairly low amount of reflection.

6.1.2 Angle of reflection

The angle of reflection of light off a reflective surface is directly related to the angle of incidence of the light from the source. In the case of a PV array, the sunlight will reflect off the panel at the same angle as it arrives from the sun. If the panel is stationary, the sun's angle relative to the solar panel will vary by time of day and therefore reflect toward the west in the morning and eastward in the evening.

The solar arrays proposed for this solar project will track the sun's movement across the sky to maximise exposure to the sun. Solar arrays can also use backtracking to minimise shading of one panel by another when the sun is low in the morning and afternoon. This may increase glare from the solar array at these times. This analysis assumes backtracking will be used in this installation. The seasonal change of the sun's movements will vary the refection angles as well. As the sun move southward in the summer months, the reflection will move northward, and vice versa in the winter months (when the sun is north of the equator). This movement changes the reflection angle in a north-south direction.

6.2 Analysis

Knowing the characteristics of reflected light helps us determine where glare is likely to be an issue. In the case of the Glen Innes Solar Farm project, trackers will be used to maximise the sunlight absorbed by the cells. The trackers are designed to keep the panel perpendicular to the sun. We can therefore assume that the sunlight reflected will reflect perpendicular to the cell and directly back toward the sun for most of the daylight hours. The glare analysis below has been performed to identify the location that might experience glint or glare.

6.2.1 ForgeSolar glare analysis

A glare analysis was performed using specialised software (ForgeSolar). The calculations were based on the solar array properties outlined in Chapter 2. Further parameters include:

- PV cells will be 1.6 m above ground level when horizontal.
- The panels will use solar glass that has an anti-reflection surface treatment.
- Single axis tracking rotation aligned on a north-south axis, with a range of +/- 60^0 from vertical.
- Panels will use backtracking.

The software calculates the minutes of potential glare predicted at each location every day through the course of a year. The results indicate the number of minutes predicted at each location along with the type of glare expected. The classifications of glare from the software are:

- Green glare – glare is present with only a low potential for temporary after-image or flash blindness.
- Yellow glare – glare has a moderate potential for temporary after-image or flash blindness.
- Red glare – glare with high potential for permanent eye damage.

The glare analysis produced by the software does not account for physical obstructions between the solar arrays and the residences and motorists. This includes the presence of buildings, trees and other structures. It also assumes the weather is sunny each day for the duration of daylight hours. Therefore, a worst-case scenario is calculated.

Glare impacts were assessed from surrounding residence locations, from the Gwydir Highway, six other nearby roads, from the Glen Innes Racecourse, and from local houses.

A separate glare assessment for the battery units and other structures has not been done. It is assumed that since these elements are centrally located close to the solar array and the solar panels reach a height of 2.6 m when fully tilted, any glint and glare from these components would be shielded or represented by the glint and glare from the solar panels.

Table 6.1 summarises the findings of the glare assessment. Refer to Appendix B for the full ForgeSolar glare analysis results.

Table 6.1 Glare analysis results

Location	Location name assigned by software	Green glare (minutes per year)	Yellow glare (minutes per year)	Red glare (minutes per year)
Abbotts Road	Abbotts Road	0	0	0
Bradleys Lane	Bradleys Lane	0	0	0

Location	Location name assigned by software	Green glare (minutes per year)	Yellow glare (minutes per year)	Red glare (minutes per year)
Dumaresq Street	Dumaresq Street	0	0	0
Furracabad Road	Furracabad Road	343	0	0
Gwydir Highway	Gwydir Highway	596	75	0
Tuttles Lane	Tuttles Lane	0	0	0
West Furracabad Road	West Furracabad Road	799	0	0
Glen Innes Airport	FP 1–FP 4	0	0	0
Glen Innes Racecourse – tower	OP 1	413	0	0
Glen Innes Racecourse – spectator area	OP 2	403	0	0
2 Bradleys Lane, Glen Innes	0P 3	297	0	0
268 Furracabad Road, Glen Innes	OP 4	50	0	0
Nearby residences	OP5 – OP37	0	0	0

Note: Duration of "glare from solar arrays" may include duplicate times of glare from multiple solar array areas.

6.3 Glare analysis summary

Based on the glare analysis, there will be no glare impact on most receivers. The following glare impacts are predicted:

- Locations on three roads may experience some green glare, with some locations on the Gwydir Highway near the project potentially exposed to yellow glare at limited times.
- Parts of the Glen Innes Racecourse are predicted to experience green glare at limited times.
- Two private dwellings may experience some green glare.

A summary of the glare analysis results is provided Table 6.2 below. Full details of the glare analysis are included in Appendix B.

Table 6.2 Glare analysis summary

Location	Location name assigned by software	Green / yellow glare (minutes per year)	
Furracabad Road	Furracabad Road	343	Two locations at the northern end of Furracabad Road may experience green glare with a low potential for an after image for less than 10 minutes late in the evening from May to July.
Gwydir Highway	Gwydir Highway	596 / 75	Some locations near the site may experience yellow glare of less than 5 minutes duration in the early morning / late afternoon for several weeks each year.
West Furracabad Road	West Furracabad Road	799	Some days with less than 10 minutes of glare with low potential for after image.

Location	Location name assigned by software	Green / yellow glare (minutes per year)	
Glen Innes Racecourse – tower	OP 1	413	The ForgeSolar model predicts green glare of less than 10 minutes duration per day in the late afternoon from mid-May to July.
Glen Innes Racecourse – spectator area	OP 2	403	The ForgeSolar model predicts green glare of less than 10 minutes duration per day in the late afternoon from mid-May to early August.
2 Bradleys Lane, Glen Innes	0P 3	297	The ForgeSolar model predicts green glare of less than 10 minutes duration per day in the late afternoon from mid-May to July.
268 Furracabad Road, Glen Innes	OP 4	50	The ForgeSolar model predicts green glare of less than 5 minutes duration per day in the late afternoon in June and early July.

6.3.1 Glare mitigation

The glint and glare analysis has been based on the assumption that backtracking would be used by the solar array. Running the analysis with no backtracking shows that no glare impacts would be produced by the proposed solar array at any viewpoints. This implies that backtracking can be managed to avoid all the above glare impacts. This can be done by programming the panels to move to angles that do not produce glare at the times identified in the glint and glare assessment (Appendix B) when glare impacts can occur.

It is recommended that backtracking be used to avoid glare impacts identified in Table 6.2 above.

It should also be noted that the ForgeSolar analysis is based on topography and the height above ground level of the solar array and potential receivers. It does not allow for existing or proposed vegetation or structures. In many of the cases listed in Table 6.2 these will have a significant mitigating effect and may even eliminate potential glare impacts.

7 Mitigation measures

7.1 Recommendations

The visual impact assessment in Chapter 5 of this report assigns either a high, medium or low visual impact rating when viewed from the site context, immediate vicinity, local area, district area and regional views. The visual impact rating for all viewpoints for this project ranged from low to moderate.

The following mitigation measures are recommended for VP-04, where the visual impact rating was rated as moderate. For other viewpoints that received a visual impact rating of low, mitigation measures are not required, however the following mitigation measures will have a beneficial result by further reducing the low visual impacts of the project for all viewpoints.

7.1.1 Mitigation measures

To maintain the visual character of the area around the site, the following recommendations are suggested:

- Install perimeter screen planting of native trees and shrubs as shown in Appendix A.
- Irrigation and maintenance of screen planting shall be provided for minimum three years from date of planting.
- If moderate or high levels of visual impact are identified at any residences within 1 km of the project, this impact could be significantly mitigated, and with time even eliminated, by planting of trees and shrubs close to these residences.

7.1.2 Infrastructure, materials, and colours

To minimise the visual impact of infrastructure on the landscape, the following are recommended:

- materials, textures and colour selection should relate to the palette of the surrounding environment to minimise visibility and potential for visual impact
- reflective surfaces and bright, contrasting colours should be avoided.

7.1.3 Glare mitigation

Glare analysis has identified potential glare impacts at locations listed in Table 6.2. These glare impacts can be eliminated by adjustments to backtracking method used by the solar array as provided in section 6.3.1 of this report.

References

Google Maps (2024), http://google.com/maps/

Six Maps (2024), https://maps.six.nsw.gov.au/

Glen Innes Severn Council, 2014, *Glen Innes Severn Council Development Control Plan 2014*.

Glen Innes Severn Council, 2010, *Glen Innes Severn Land Use Strategy: May 2010.*

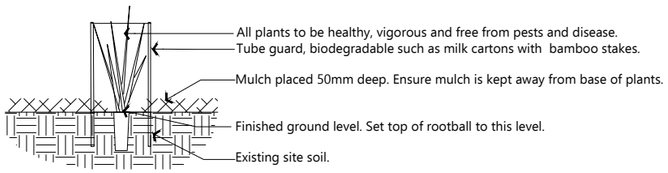
Glen Innes Severn Council, 2012, *Glen Innes Severn Local Environmental Plan 2012*.

Transport for NSW (2020), *Guideline for Landscape Character and Visual Impact Assessment*, EIA-N04, Version 2.2, Centre for Urban Design.

The Landscape Institute with the Institute of Environmental Management and Assessment (2013), *Guidelines for Landscape and Visual Assessment*, Third Edition, Newport, Lincoln.

Appendix A
Planting plan

EMM
creating opportunities



Planting Detail - Tubestock Scale 1:20 @ A3

Plant Schedule

Botanical Name	Common Name	Pot Size	Density
Trees			
Eucalyptus melliodora	Yellow Box	Tubestock	1 individual per 10m2
Eucalyptus nicholii	Willow peppermint	Tubestock	
Eucalyptus tereticornis	Forest red gum	Tubestock	
Allocasuarina littoralis	Black She-oak	Tubestock	1 individual per 7m2
Banksia intergrifolia	Coastal Banksia	Tubestock	
Brachychiton populneus	Kurrajong	Tubestock	
Casuarina cristata	Belah	Tubestock	
Shrubs			
Acacia filicifolia	Fern-leaved Wattle	Tubestock	1 individual per 4m2
Acacia implexa	Hickory Wattle	Tubestock	
Correa reflexa	Native Fuchsia	Tubestock	
Dodonaea viscosa	Hop Bush	Tubestock	
Grevillea junipurina	Juniper Grevillea	Tubestock	

Plants may require thinning once established to allow for suitable space for trees and shrubs to reach mature size and prevent growth suppression.

Note

This drawing is to be read as an appendix to the Jerilderie Micro Solar Farm Visual Impact Assessment report.

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Scale 1 : 2500 @ A3

Revisions

Issue	Details	Date
A	For Review	03.05.24

Project: Glen Innes Solar Farm

Client: Green Gold Energy Pty Ltd

Title: **Planting Plan**

Site: Glen Innes NSW

Date: 03 May 2024

Job No: E240278

Revision: A Sheet: L01

Appendix B

Glint and glare analysis results

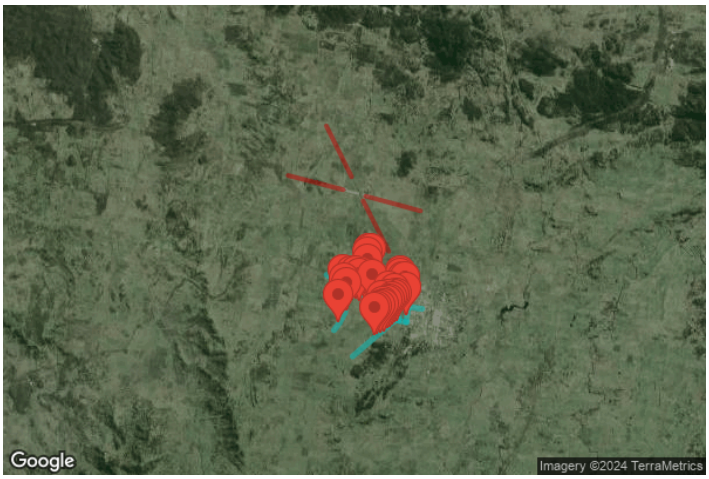
EMM
creating opportunities

FORGESOLAR GLARE ANALYSIS

Project: **Glen Innes SF**
Site configuration: **Glen Innes SF - 01**

Created 02 May, 2024
Updated 02 May, 2024
Time-step 1 minute
Timezone offset UTC10
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 5 MW to 10 MW
Site ID 118134.20292

Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
PV analysis methodology V2



Summary of Results

Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	2,901	48.4	75	1.2	-

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Abbotts Road	0	0.0	0	0.0
Bradleys Lane	0	0.0	0	0.0
Dumaresq Street	0	0.0	0	0.0
Furracabad Road	343	5.7	0	0.0
Gwydir Highway	596	9.9	75	1.2
Tuttles Lane	0	0.0	0	0.0
West Furracabad Road	799	13.3	0	0.0
FP 1	0	0.0	0	0.0
FP 2	0	0.0	0	0.0
FP 3	0	0.0	0	0.0
FP 4	0	0.0	0	0.0
OP 1	413	6.9	0	0.0
OP 2	403	6.7	0	0.0
OP 3	297	5.0	0	0.0
OP 4	50	0.8	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array 1
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.4
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-29.732100	151.704500	1051.17	1.60	1052.77
2	-29.732700	151.707600	1049.21	1.60	1050.81
3	-29.733600	151.707600	1049.21	1.60	1050.81
4	-29.735100	151.705500	1049.13	1.60	1050.73
5	-29.734600	151.703000	1049.48	1.60	1051.08
6	-29.733700	151.703000	1049.48	1.60	1051.08
7	-29.732800	151.703500	1049.79	1.60	1051.39
8	-29.732800	151.703500	1049.79	1.60	1051.39
9	-29.732800	151.703500	1049.79	1.60	1051.39

Route Receptors

Name: Abbotts Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-29.713904	151.698286	1103.64	1.50	1105.14
2	-29.728818	151.695586	1062.78	1.50	1064.28

Name: Bradleys Lane
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-29.738413	151.714177	1055.91	1.50	1057.41
2	-29.740034	151.713855	1059.90	1.50	1061.40

Name: Dumaresq Street
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-29.729963	151.720095	1051.03	1.50	1052.53
2	-29.740714	151.718078	1063.52	1.50	1065.02

Name: Furracabad Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-29.758170	151.686771	1065.86	1.50	1067.36
2	-29.739981	151.711522	1058.08	1.50	1059.58
3	-29.739814	151.711844	1058.00	1.50	1059.50
4	-29.739851	151.712166	1058.00	1.50	1059.50
5	-29.740801	151.718668	1065.37	1.50	1066.87

Name: Gwydir Highway
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-29.716733	151.671502	1112.97	1.50	1114.47
2	-29.717497	151.672918	1108.52	1.50	1110.02
3	-29.718559	151.674291	1101.01	1.50	1102.51
4	-29.721130	151.677081	1103.81	1.50	1105.31
5	-29.722379	151.678540	1111.34	1.50	1112.84
6	-29.722752	151.679291	1112.70	1.50	1114.20
7	-29.726143	151.687530	1091.24	1.50	1092.74
8	-29.727000	151.689848	1079.96	1.50	1081.46
9	-29.730876	151.701470	1049.99	1.50	1051.49
10	-29.731062	151.702285	1049.92	1.50	1051.42
11	-29.731137	151.703529	1052.44	1.50	1053.94
12	-29.731286	151.707757	1047.67	1.50	1049.17
13	-29.731640	151.710975	1048.48	1.50	1049.98
14	-29.731920	151.713142	1049.61	1.50	1051.11
15	-29.732963	151.719580	1057.23	1.50	1058.73
16	-29.734081	151.727605	1070.39	1.50	1071.89

Name: Tuttles Lane
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-29.715256	151.707468	1074.00	1.50	1075.50
2	-29.731076	151.704672	1050.06	1.50	1051.56

Name: West Furracabad Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-29.726324	151.687361	1089.97	1.50	1091.47
2	-29.727032	151.686975	1084.69	1.50	1086.19
3	-29.728560	151.683584	1091.15	1.50	1092.65
4	-29.729715	151.683219	1090.40	1.50	1091.90
5	-29.731914	151.681782	1081.79	1.50	1083.29
6	-29.732380	151.681589	1082.35	1.50	1083.85
7	-29.732864	151.681503	1081.75	1.50	1083.25
8	-29.733348	151.681546	1080.93	1.50	1082.43
9	-29.734988	151.682404	1076.85	1.50	1078.35
10	-29.735454	151.682468	1076.70	1.50	1078.20
11	-29.735957	151.682361	1077.03	1.50	1078.53
12	-29.736460	151.682061	1078.93	1.50	1080.43
13	-29.740950	151.679293	1071.32	1.50	1072.82
14	-29.744919	151.675838	1067.28	1.50	1068.78

Flight Path Receptors

Name: FP 1
Description:
Threshold height: 15 m
Direction: 333.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-29.679154	151.692920	1047.17	15.24	1062.41
Two-mile	-29.704918	151.708041	1067.78	163.32	1231.10

Name: FP 2
Description:
Threshold height: 15 m
Direction: 153.6°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-29.667071	151.686201	1045.05	15.24	1060.29
Two-mile	-29.641162	151.671415	1020.59	208.39	1228.97

Name: FP 3
Description:
Threshold height: 15 m
Direction: 104.5°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-29.673577	151.681254	1042.31	15.24	1057.55
Two-mile	-29.666342	151.648998	1032.26	193.97	1226.24

Name: FP 4
Description:
Threshold height: 15 m
Direction: 285.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-29.676839	151.694450	1044.12	15.24	1059.36
Two-mile	-29.684347	151.726624	1057.37	170.67	1228.04

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-29.737812	151.718234	1060.34	10.00
OP 2	2	-29.737393	151.718293	1059.20	1.60
OP 3	3	-29.738357	151.711550	1057.34	1.60
OP 4	4	-29.737195	151.708081	1053.02	1.60
OP 5	5	-29.740759	151.713156	1057.51	1.60
OP 6	6	-29.740703	151.712448	1057.80	1.60
OP 7	7	-29.740927	151.711354	1059.37	1.60
OP 8	8	-29.742203	151.709873	1062.22	1.60
OP 9	9	-29.743647	151.708597	1063.22	1.60
OP 10	10	-29.743824	151.707277	1062.90	1.60
OP 11	11	-29.741355	151.707642	1058.99	1.60
OP 12	12	-29.741933	151.704155	1057.68	1.60
OP 13	13	-29.744429	151.704530	1064.91	1.60
OP 14	14	-29.746972	151.701054	1066.38	1.60
OP 15	15	-29.747876	151.699981	1067.23	1.60
OP 16	16	-29.745966	151.705056	1068.56	1.60
OP 17	17	-29.746684	151.703189	1071.81	1.60
OP 18	18	-29.732375	151.717948	1055.60	1.60
OP 19	19	-29.732198	151.716725	1053.80	1.00
OP 20	20	-29.732179	151.716285	1053.27	1.60
OP 21	21	-29.729132	151.715319	1049.73	1.60
OP 22	22	-29.730269	151.715180	1052.26	1.60
OP 23	23	-29.722961	151.695457	1079.39	1.60
OP 24	24	-29.719439	151.695509	1098.81	1.60
OP 25	25	-29.717799	151.696260	1098.57	1.60
OP 26	26	-29.718088	151.697922	1084.35	1.60
OP 27	27	-29.731273	151.698198	1053.16	1.60
OP 28	28	-29.730239	151.696856	1057.27	1.60
OP 29	29	-29.729968	151.695751	1059.68	1.60
OP 30	30	-29.729680	151.694496	1065.48	1.60
OP 31	31	-29.730406	151.691063	1069.62	1.60
OP 32	32	-29.729400	151.688974	1078.86	1.60
OP 33	33	-29.729000	151.686420	1083.65	1.60
OP 34	34	-29.728506	151.681560	1103.11	1.60
OP 35	35	-29.733006	151.681882	1079.42	1.60
OP 36	36	-29.735139	151.683309	1070.95	1.60
OP 37	37	-29.741045	151.678363	1077.77	1.60

Glare Analysis Results

Summary of Results

Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	2,901	48.4	75	1.2	-

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Abbotts Road	0	0.0	0	0.0
Bradleys Lane	0	0.0	0	0.0
Dumaresq Street	0	0.0	0	0.0
Furracabad Road	343	5.7	0	0.0
Gwydir Highway	596	9.9	75	1.2
Tuttles Lane	0	0.0	0	0.0
West Furracabad Road	799	13.3	0	0.0
FP 1	0	0.0	0	0.0
FP 2	0	0.0	0	0.0
FP 3	0	0.0	0	0.0
FP 4	0	0.0	0	0.0
OP 1	413	6.9	0	0.0
OP 2	403	6.7	0	0.0
OP 3	297	5.0	0	0.0
OP 4	50	0.8	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0

PV: PV array 1 potential temporary after-image

Receptor results ordered by category of glare

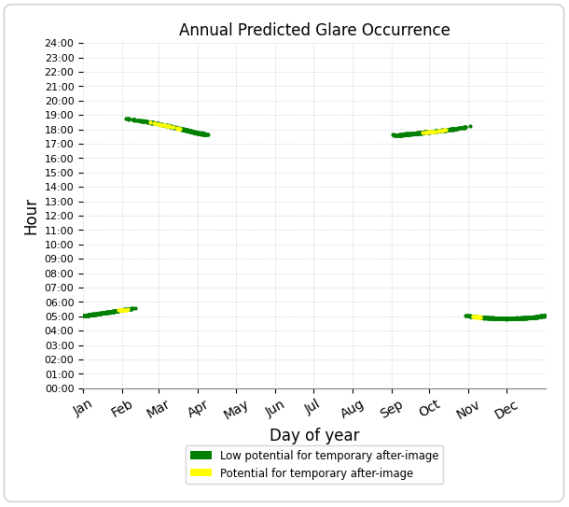
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Gwydir Highway	596	9.9	75	1.2
Furracabad Road	343	5.7	0	0.0
West Furracabad Road	799	13.3	0	0.0
Abbotts Road	0	0.0	0	0.0
Bradleys Lane	0	0.0	0	0.0
Dumaresq Street	0	0.0	0	0.0
Tuttles Lane	0	0.0	0	0.0
FP 1	0	0.0	0	0.0
FP 2	0	0.0	0	0.0
FP 3	0	0.0	0	0.0
FP 4	0	0.0	0	0.0
OP 1	413	6.9	0	0.0
OP 2	403	6.7	0	0.0
OP 3	297	5.0	0	0.0
OP 4	50	0.8	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0

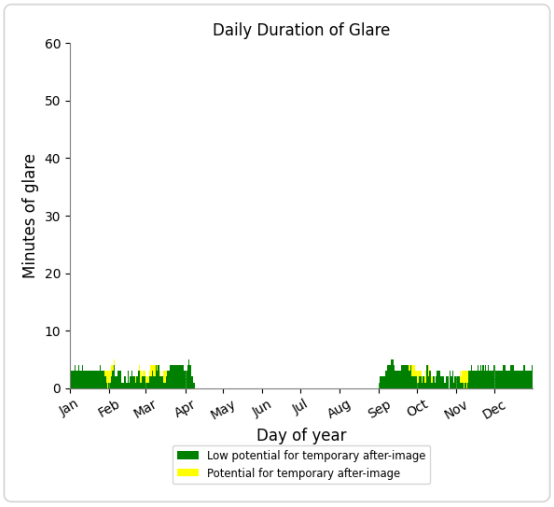
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0

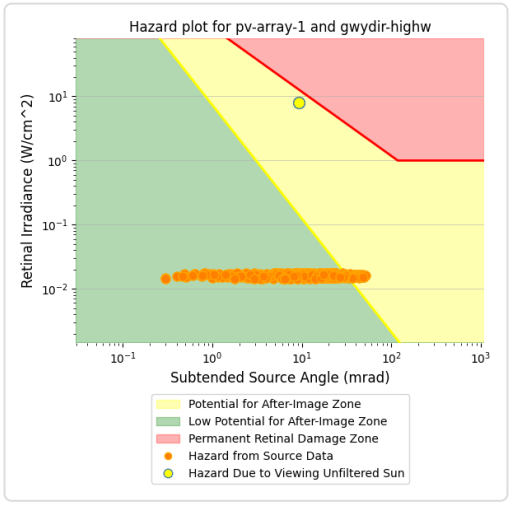
PV array 1 and Route: Gwydir Highway

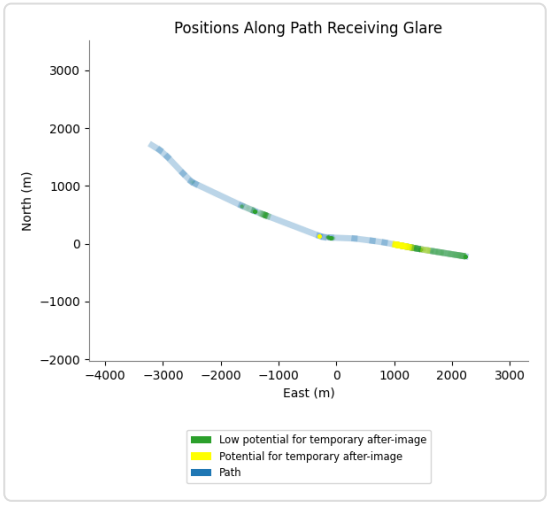
Yellow glare: 75 min.

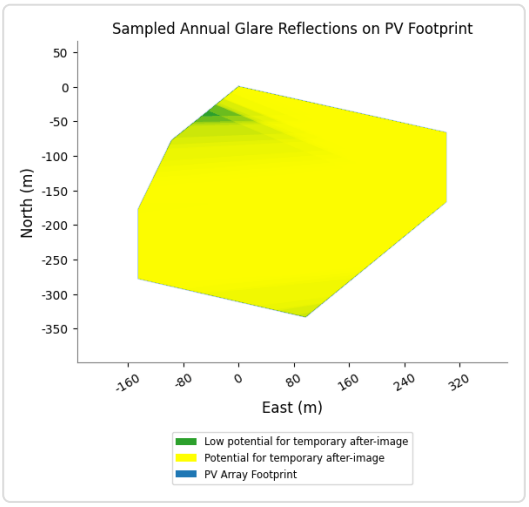
Green glare: 596 min.







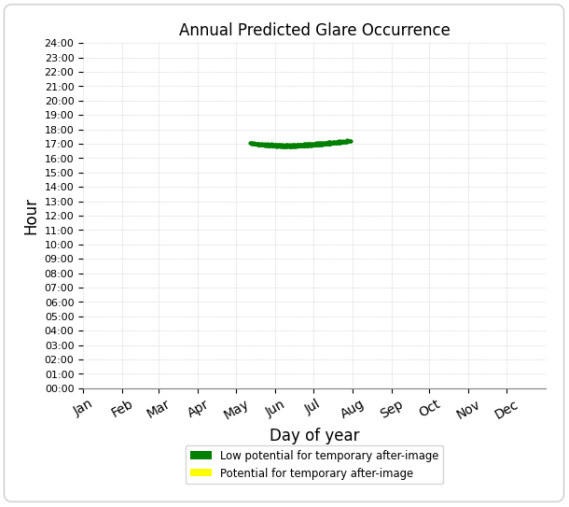


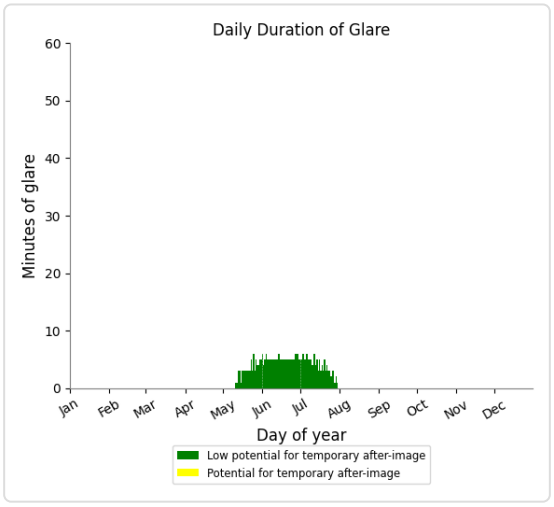


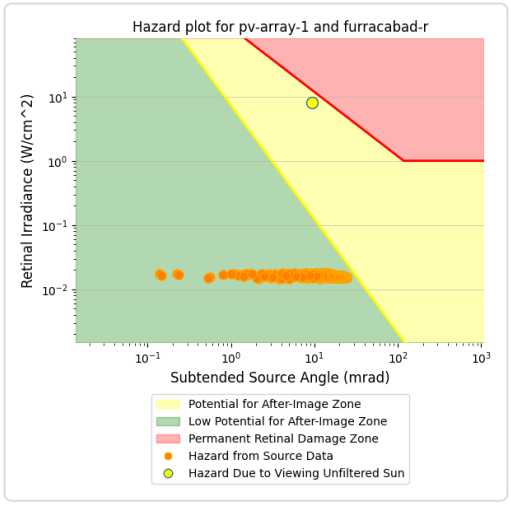
PV array 1 and Route: Furracabad Road

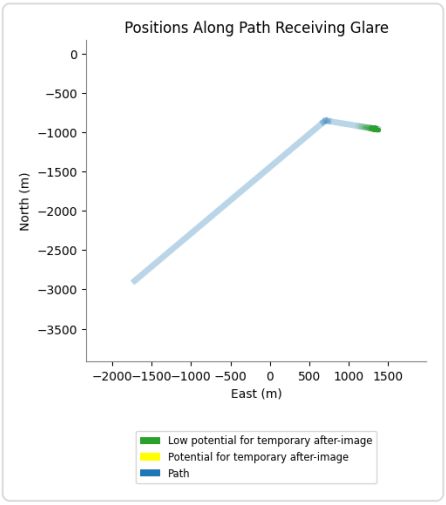
Yellow glare: none

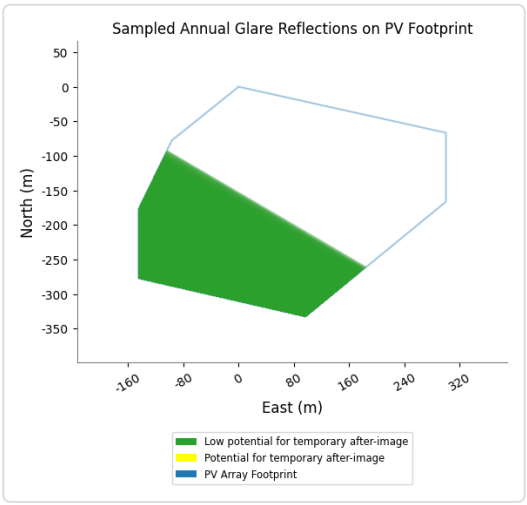
Green glare: 343 min.







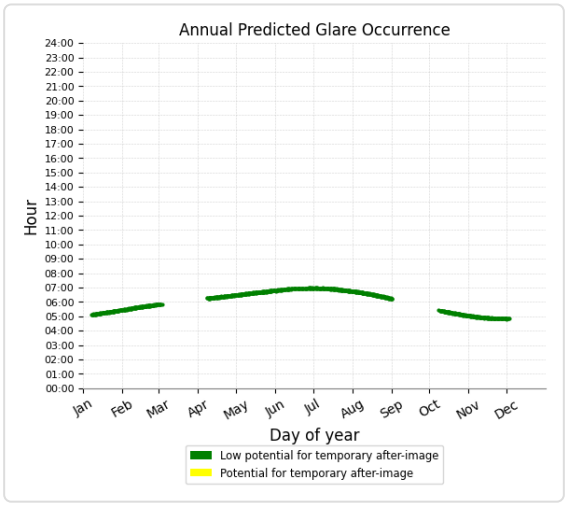


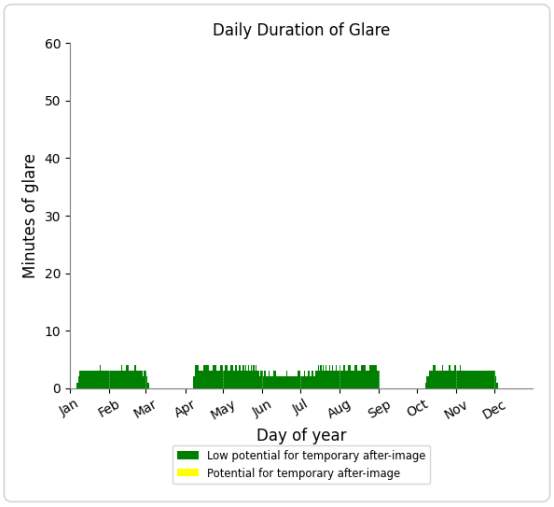


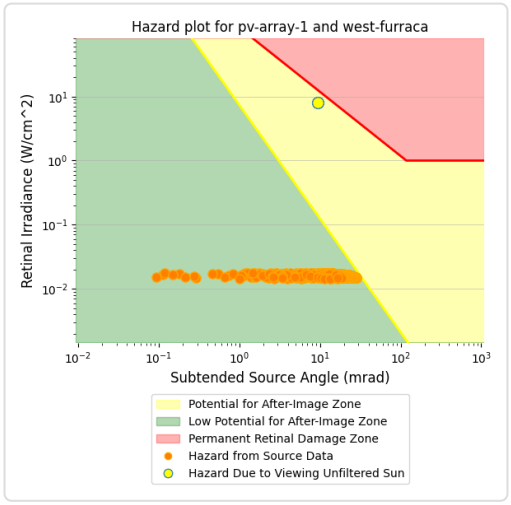
PV array 1 and Route: West Furracabad Road

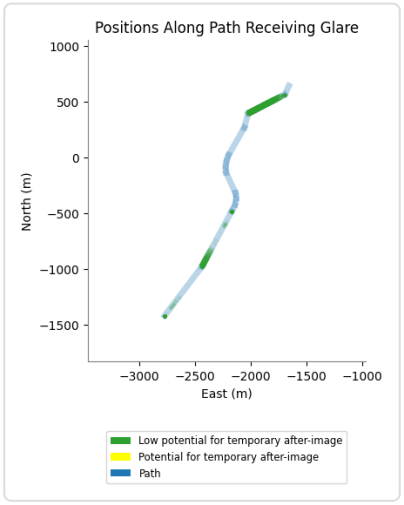
Yellow glare: none

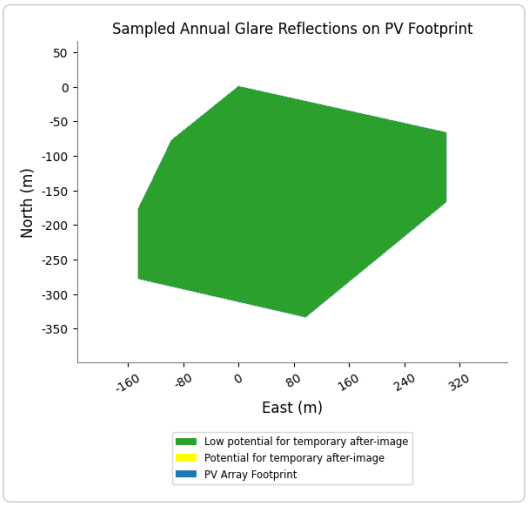
Green glare: 799 min.











PV array 1 and Route: Abbotts Road

No glare found

PV array 1 and Route: Bradleys Lane

No glare found

PV array 1 and Route: Dumaresq Street

No glare found

PV array 1 and Route: Tuttles Lane

No glare found

PV array 1 and FP: FP 1

No glare found

PV array 1 and FP: FP 2

No glare found

PV array 1 and FP: FP 3

No glare found

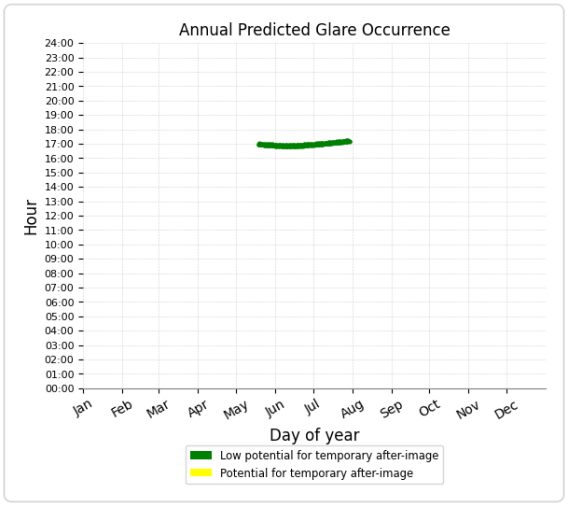
PV array 1 and FP: FP 4

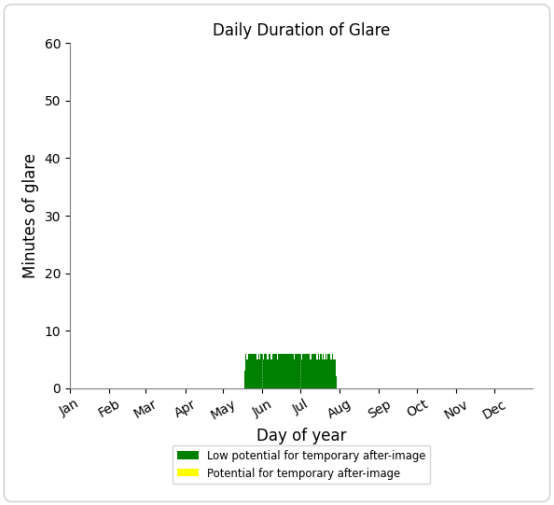
No glare found

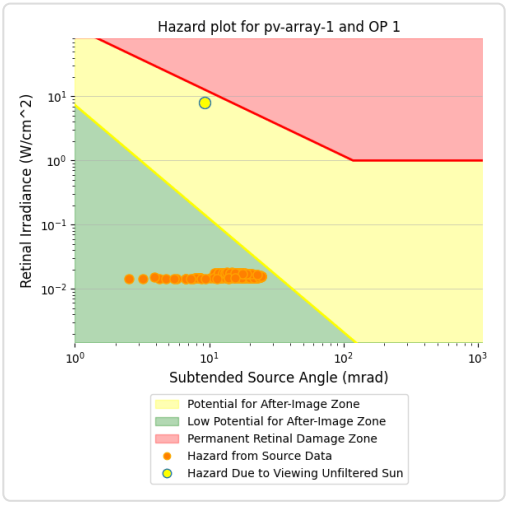
PV array 1 and OP 1

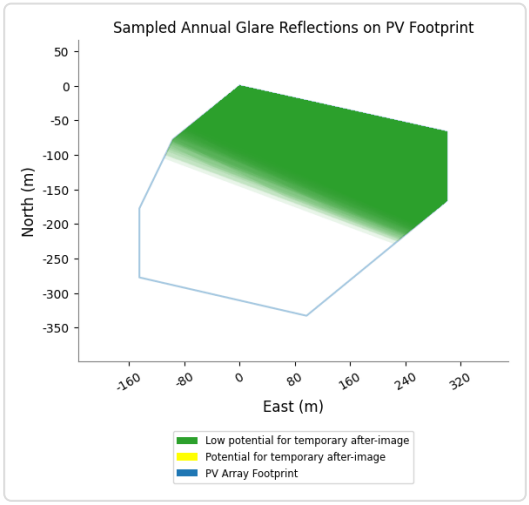
Yellow glare: none

Green glare: 413 min.





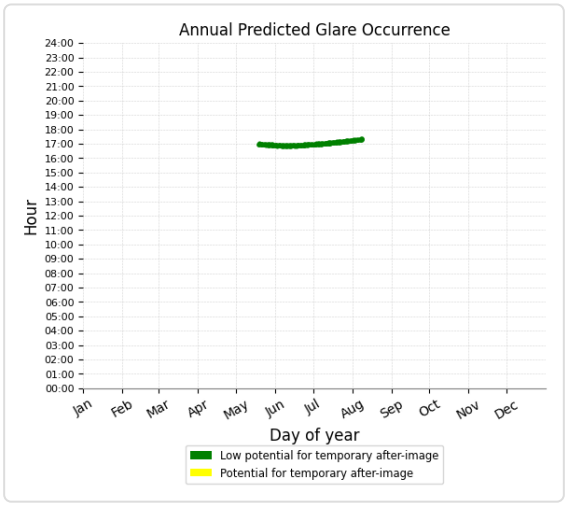


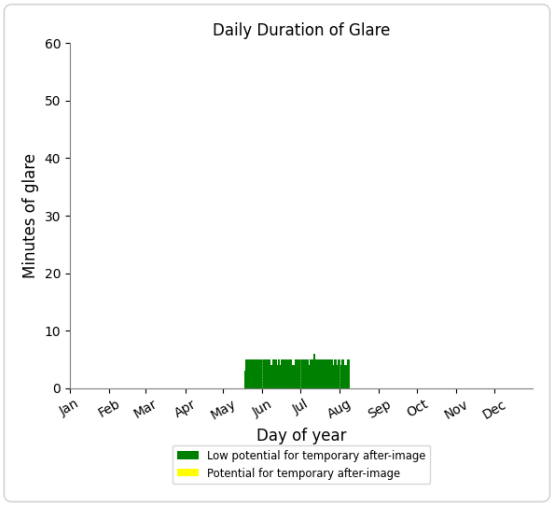


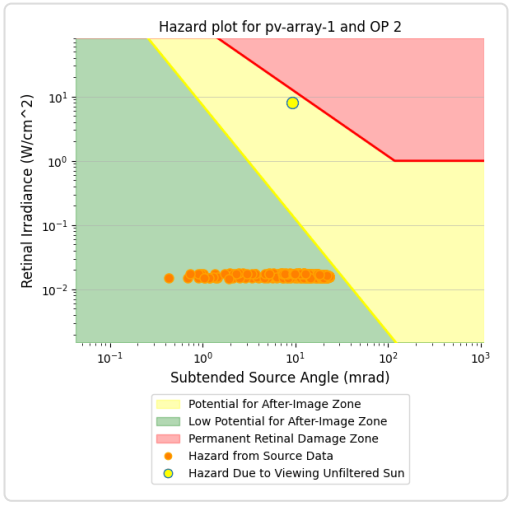
PV array 1 and OP 2

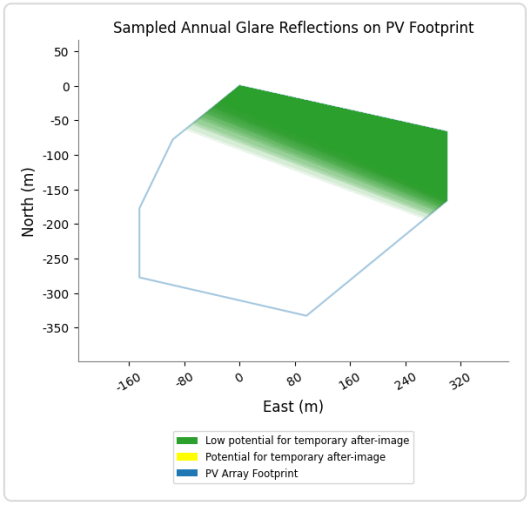
Yellow glare: none

Green glare: 403 min.





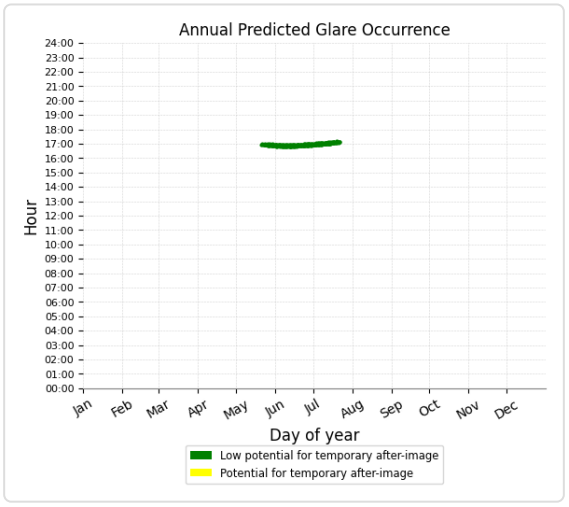


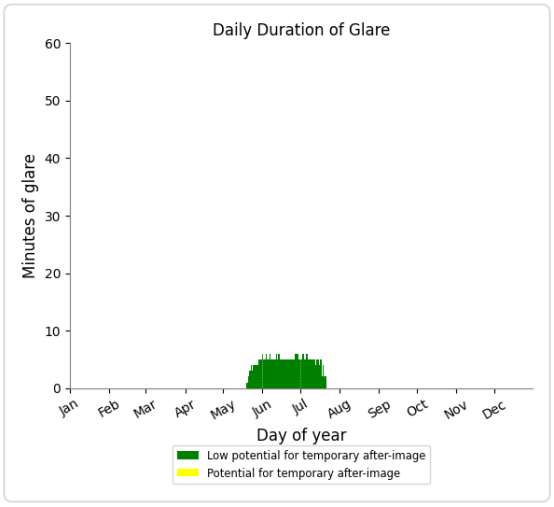


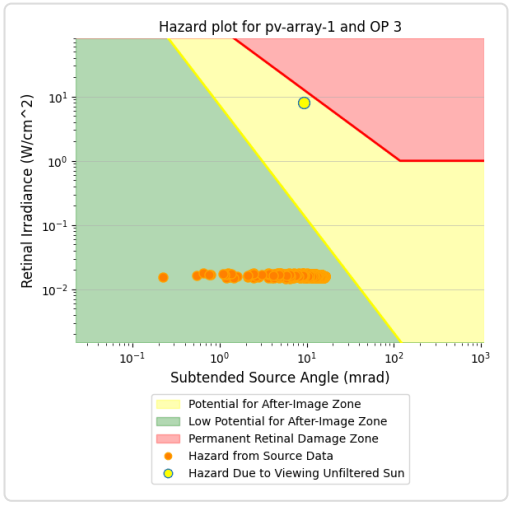
PV array 1 and OP 3

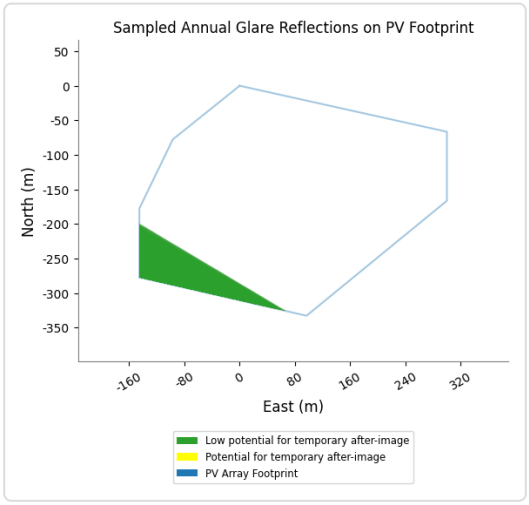
Yellow glare: none

Green glare: 297 min.



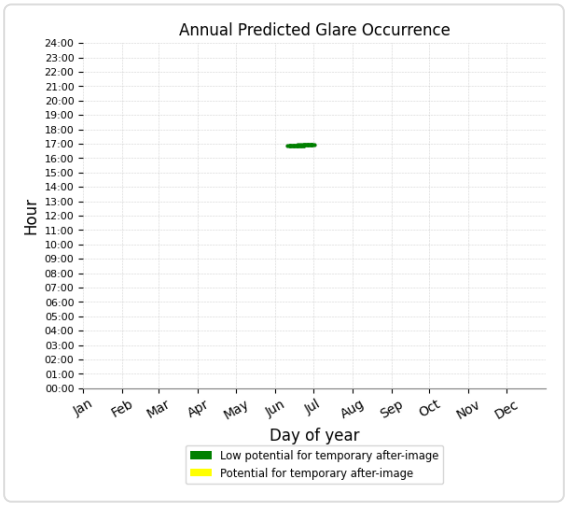


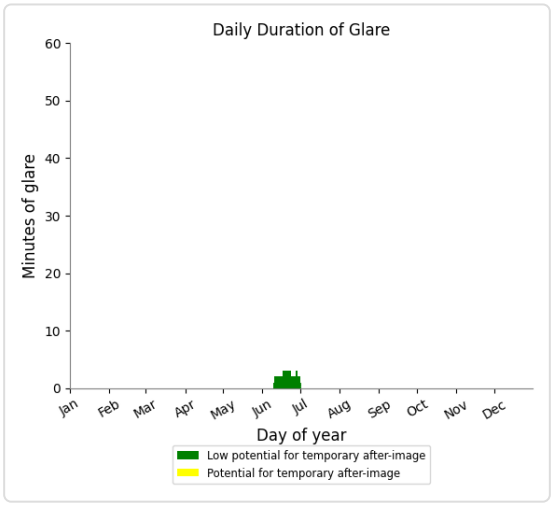


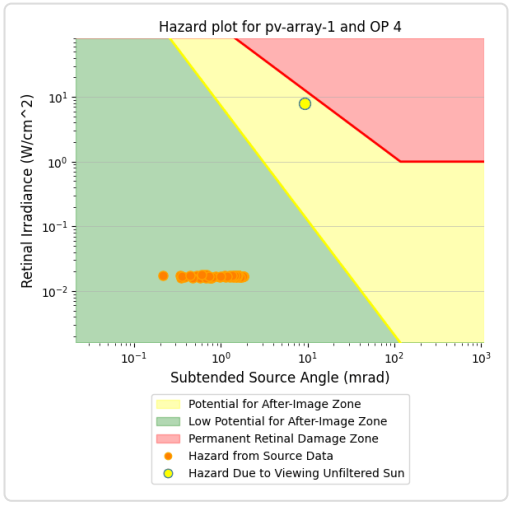


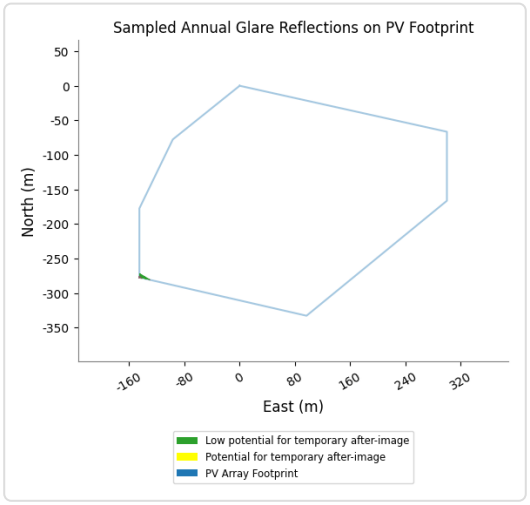
PV array 1 and OP 4

Yellow glare: none
Green glare: 50 min.









PV array 1 and OP 5

No glare found

PV array 1 and OP 6

No glare found

PV array 1 and OP 7

No glare found

PV array 1 and OP 8

No glare found

PV array 1 and OP 9

No glare found

PV array 1 and OP 10

No glare found

PV array 1 and OP 11

No glare found

PV array 1 and OP 12

No glare found

PV array 1 and OP 13

No glare found

PV array 1 and OP 14

No glare found

PV array 1 and OP 15

No glare found

PV array 1 and OP 16

No glare found

PV array 1 and OP 17

No glare found

PV array 1 and OP 18

No glare found

PV array 1 and OP 19

No glare found

PV array 1 and OP 20

No glare found

PV array 1 and OP 21

No glare found

PV array 1 and OP 22

No glare found

PV array 1 and OP 23

No glare found

PV array 1 and OP 24

No glare found

PV array 1 and OP 25

No glare found

PV array 1 and OP 26

No glare found

PV array 1 and OP 27

No glare found

PV array 1 and OP 28

No glare found

PV array 1 and OP 29

No glare found

PV array 1 and OP 30

No glare found

PV array 1 and OP 31

No glare found

PV array 1 and OP 32

No glare found

PV array 1 and OP 33

No glare found

PV array 1 and OP 34

No glare found

PV array 1 and OP 35

No glare found

PV array 1 and OP 36

No glare found

PV array 1 and OP 37

No glare found

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
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, we have validated our 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, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
Several V1 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 V1 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 ATCTs. Note that the SGHAT/ ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
The analysis does not automatically 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 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 variable direct normal irradiance (DNI) feature (if selected) 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.
The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We 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 speed of SGHAT allows expedited sensitivity and parametric analyses.
The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

Default glare analysis parameters and observer eye characteristics (for reference only):

- 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

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