PROJECT MEMORANDUM

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LANDSCAPE ARCHITECTS

Project:	**Darfield Agrivoltaic Development**	**Memo: 1**/R2	**Page:** 1 of 26
Topic:	**Glint & Glare Analysis**		
Date:	25 June 2024		
Attention:	Tracey Morse - NZ Clean Energy Ltd		
From:	Dave Mansergh (DipP&RM(Hons), BLA(Hons), MLA, Registered ANZILA).		

INTRODUCTION

Mansergh Graham Landscape Architect Ltd was engaged by NZ Clean Energy Limited to evaluate the potential of the proposed agrivoltaic development at Darfield to cause glint or glare issues for nearby homes, roads, railway, and the adjacent reserve.

PURPOSE

The purpose of this assessment is to identify the location, frequency and intensity of the glint and glare likely to be experienced within the visual catchment surrounding the proposed Darfield Agrivoltaic Development. The information contained in this report is intended to inform the visual amenity section of the *Assessment of Landscape and Visual Effects*, the safety section of the *Assessment of Traffic Effects* and the planning section of the *Planning Analysis* and the *Assessment of Environmental Effects*.

SOLAR GLINT AND GLARE

Solar glint and glare are environmental phenomena caused by bright sunlight reflecting off a surface causing visual discomfort, a brief loss of vision and/or *afterimaging*[1].

Glare is continuous bright light reflected off a surface, experienced by stationary or moving observers.

Glint is a brief flash of bright light, typically seen by fast-moving observers (like motorists or boaters) or from moving reflectors (such as solar tracking tables, car windshields, or wind turbine blades).

FACTORS AFFECTING GLARE FROM SOLAR FARMS

The following key factors affect glint and glare from solar farms for observers within the visual catchment where glare can be experienced:

a) **Sun Position:** The angle and position of the sun relative to the observer and the reflective surface.
b) **Reflective Properties of the PV Panels:** The material and surface characteristics, including texture and/or the presence of anti-reflective coatings.
c) **The Type of Mounting/Tracking System:** Whether the mounting is fixed or tracking, panel height and configuration.
d) **PV Panel Tilt and Orientation:** The tilt and orientation of the reflecting surface (e.g. PV panels)

[1] *Afterimaging*, in the context of solar glare, refers to the phenomenon where a bright image, such as the reflection of sunlight off a shiny surface like solar panels, continues to appear in one's vision after the direct view of the glare source has ceased. When someone looks away from the source of intense solar glare, they may see a lingering image, often in complementary colours to the original bright light. This afterimage is a result of the overstimulation of the photoreceptors in the eyes, which continue to send visual signals to the brain even after the glare source is no longer in direct view. This can cause temporary visual discomfort and can affect visual tasks until the afterimage fades.

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e) **Observer Angle & Distance:** The angle & distance of the observer relative to the reflective surface.
f) **The Surrounding Environment:** Nearby structures, vegetation, and terrain can block or reflect light differently.
g) **Atmospheric Conditions:** Weather conditions and atmospheric clarity can influence the intensity of reflected light.

While more appropriate in the consideration of other types of environmental glint and glare (such as reflections of car windscreens) and not usually a factor when considering glint and glare from PV Panels, the geometry of a surface significantly influences the characteristics of reflected glare. Planar surfaces reflect light uniformly, causing predictable and consistent glare in specific directions. Concave surfaces, curving inward, concentrate glare to a focal point, potentially increasing its intensity at that location. Convex surfaces, curving outward, disperse reflected light over a wider area, reducing glare intensity but affecting a broader range of angles. Distorted or irregular surfaces, create complex patterns of reflection, leading to unpredictable and varied glare effects. These surfaces can both intensify and diffuse glare, depending on their specific curvature and orientation.

The following key factors, considered in the analysis, are discussed in more detail below:

Sun Position

The sun's movement across the sky, described in terms of azimuth and altitude, varies between summer and winter, affecting the potential for solar glare off a PV array differently over the year. The azimuth is the compass direction from which the sunlight is coming, measured in degrees, with 0° corresponding to true north, 90° to east, 180° to south, and 270° to west. The altitude is the angle of the sun above the horizon, ranging from 0° (at the horizon) to 90° (directly overhead).

In summer, the sun rises earlier in the northeast, travels a higher arc across the sky, and sets later in the northwest. During this period, the sun reaches a higher maximum altitude during the day, meaning it is more directly overhead at noon. This higher altitude reduces the likelihood of direct glare to surrounding areas because the sunlight is more likely to be absorbed or diffused rather than reflected horizontally. However, the longer daylight hours mean there are more periods when potential glare can occur, especially in the early morning and late afternoon when the sun is lower on the horizon.

In winter, the sun rises later in the southeast, travels a lower arc, and sets earlier in the southwest. The sun's maximum altitude is lower, meaning it stays closer to the horizon throughout the day. This lower altitude increases the likelihood of direct glare because the sunlight hits the solar panels at a shallower angle, making horizontal reflections more common. These reflections can cause more glare for nearby observers, particularly during midday when the sun is at its highest but still relatively low in the sky compared to summer.

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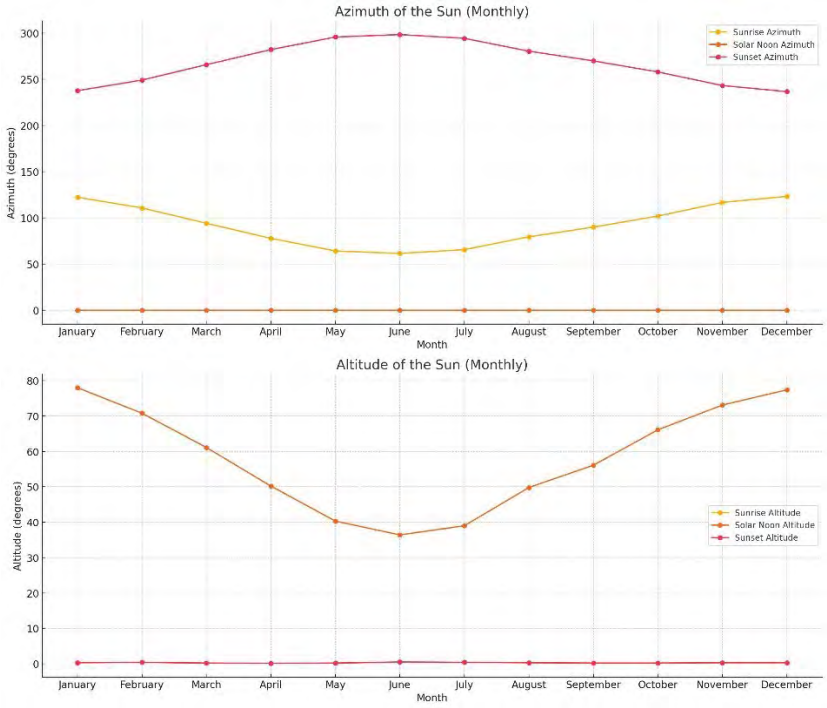

Figure 1: Sun azimuth and altitude plots for Darfield

Reflective Properties of the PV Panels

Photovoltaic panels are designed to maximise the amount of light that is received by the photovoltaic cells within the panel. The use of an anti-reflective coating means that any reflected light will be diffuse, rather than specular, reducing the effects of any glare that occurs on the receiver.

While it is commonly reported that PV panels reflect only approximately 4% of the sun's rays, this figure is based on the angle of incidence that the light reflected off the surface of the panel is less than 60 degrees, as indicated in the Figure below. Under these conditions, most light will pass through the panel, with only approximately 1-4% reflected as illustrated in the figure below:

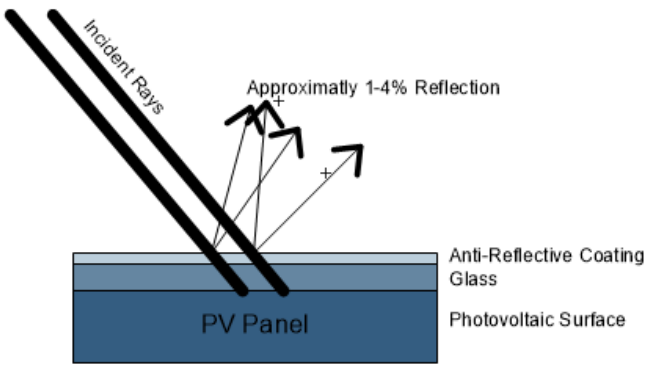

Figure 2: Diffuse Reflection

Most PV panels have a protective glass surface which, depending on their orientation, can produce specular solar reflections, which cause glint and glare. Although most panels have an anti-reflective coating, the

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following figure shows that these coatings only reduce the percentage of sunlight reflected off the panel slightly (when the angle of incidence is below 60 degrees).

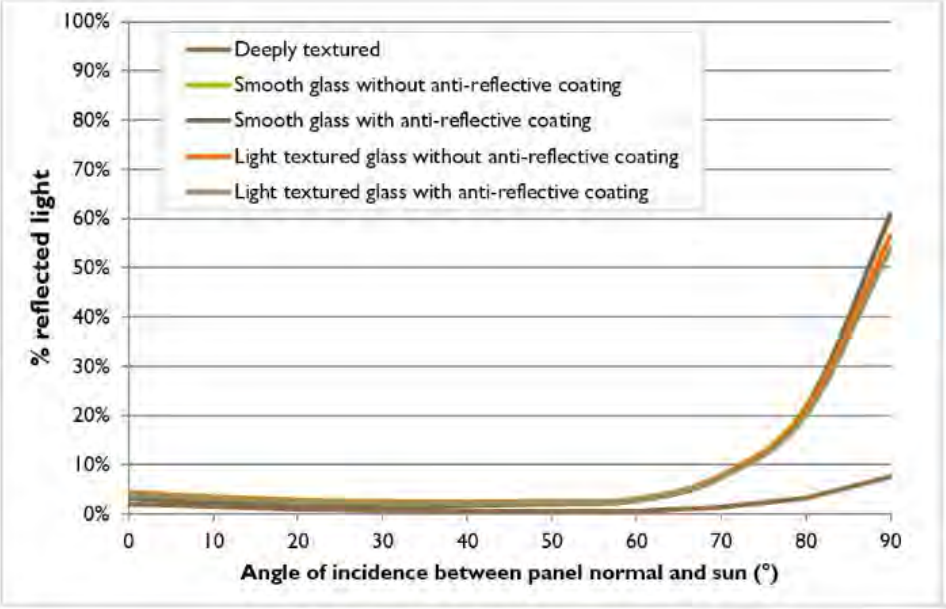

Figure 3: Percentage of light reflected at different angles of incidence[2].

More importantly, the graph also illustrates how the percentage of reflected light varies with the angle of incidence across common solar panel surface types, with the percentage of reflected light changing only marginally with the different surface types. Only solar panels with a "deeply textured" surface reflect relatively low levels of incoming light across all angles of incidence. However, the use of deeply textured panels is often not viable for PV developments due to cost.

The implication of this is that glint and glare will be more intense when the angle of incidence between the panel and the sun is higher, as more light is reflected.

While sunlight reflected off PV panels can produce glint and glare, the panels have relatively low reflectivity when compared to many common materials like vegetation.

Consequently, other surfaces may also reflect sunlight to produce glint and glare.

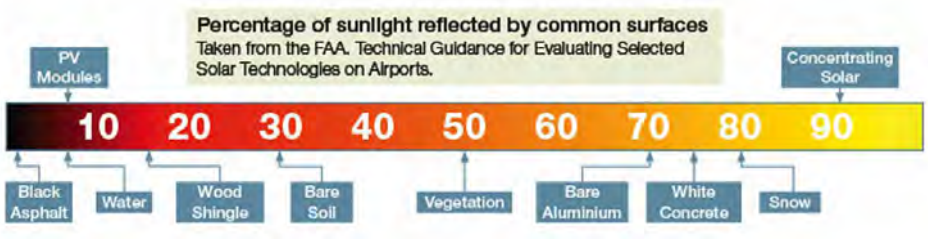

Figure 4: Comparative Reflectivity of Common Surfaces[3]

[2] ForgeSolar
[3] IBID

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As seen in the figure above, the reflective value of a PV panel is comparable to that of water.

Mounting and Tracking System Parameters

Photovoltaic systems utilize various mounting and tracking configurations to increase solar energy capture and efficiency. The main types of PV mountings and tracking systems are *fixed tilt*, *single-axis tracking*, and *dual-axis tracking*. Each mounting system has distinct characteristics which affect the potential for glint and glare to arise in different ways.

Fixed Tilt: Fixed tilt systems have panels set at a constant angle and orientation (usually north-facing).

Single Axis Tracking: Single-axis tracking systems, like that proposed in Darfield, rotate panels along a north-south axis to follow the sun's east-west movement. This keeps the panels closer to perpendicular to the sun for most of the day, reducing the angle of incidence and thus the potential for glare. This is shown in the following figure:

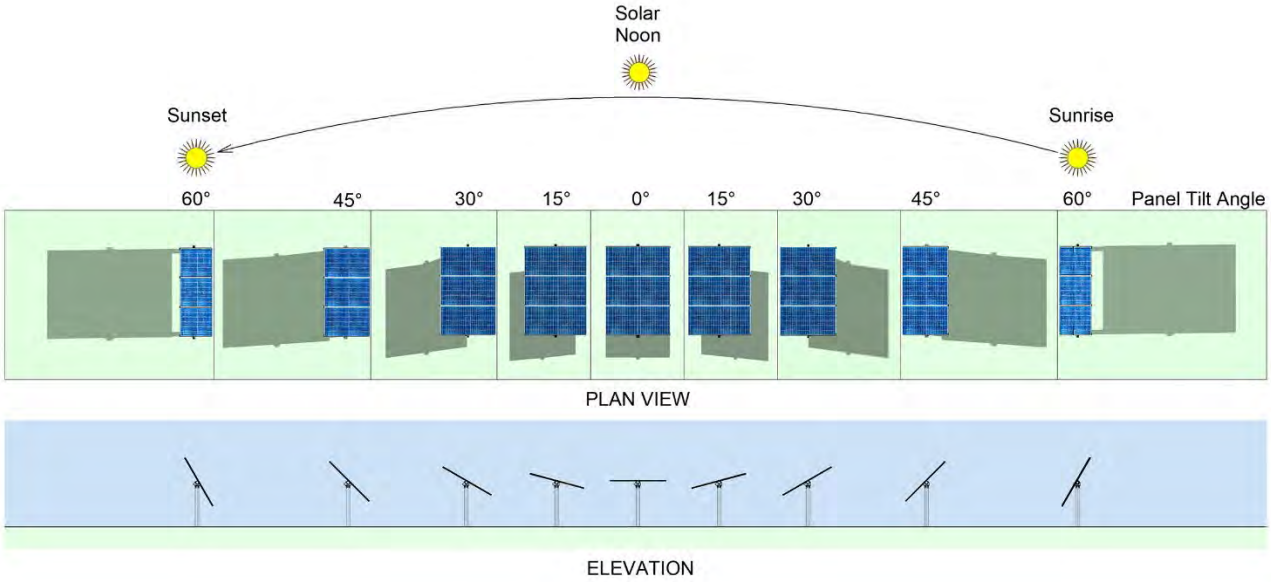

Figure 5: Diagram showing the panel orientation relative to the sun on a fixed tilt system over the day (without backtracking).

Dual Axis Tracking*:* Dual axis tracking systems adjust both horizontally and vertically to follow the sun's path. By maintaining a near perpendicular orientation to the sun, these systems minimize the angle of incidence, reducing glare potential during most of the day.

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PV Panel Tilt and Orientation

On a fixed tilt system, the angle of incidence changes significantly throughout the day, leading to higher levels of glare, especially when the sun is low in the sky at sunrise and sunset. Since the panels do not move, the range of the angle of incidence is greater, causing more frequent and intense glare.

On single and dual-axis tracking systems, a technique called *backtracking* can be used to adjust the angle of PV panels towards the horizontal in the early morning and late afternoon to avoid the panels shading themselves when the sun is low. This is shown in the following figures:

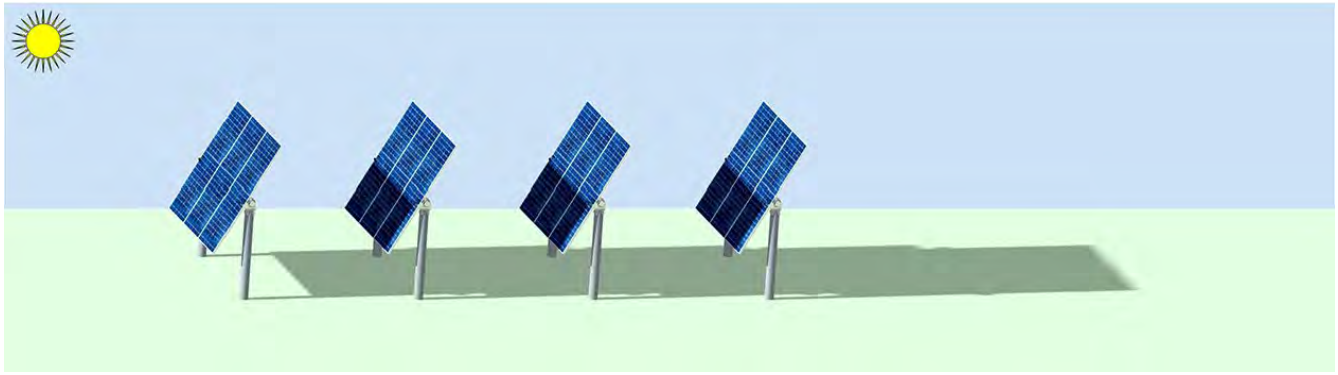

Figure 6: No Backtracking: PV panels in the late afternoon are shaded without backtracking. The low sun angle causes the leading panel to cast a shadow on the panel behind it.

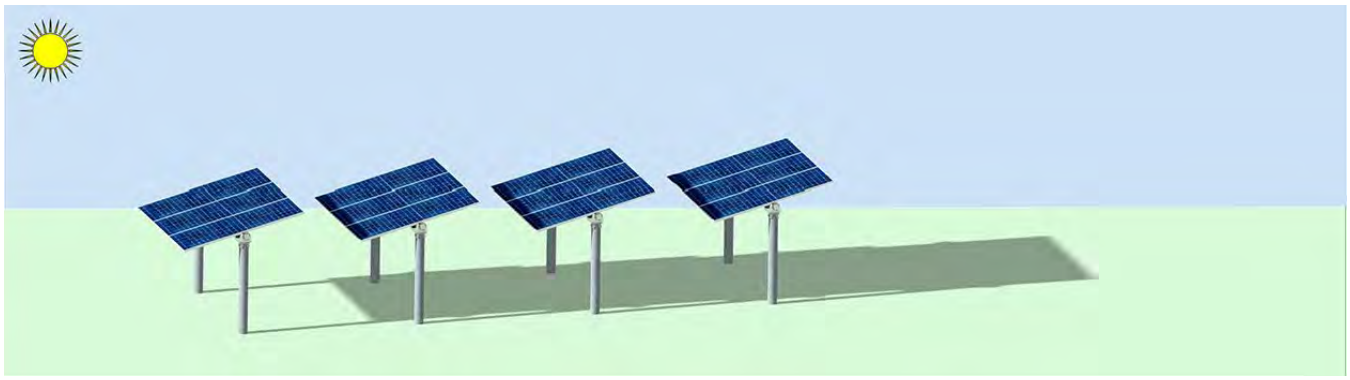

Figure 7: With Backtracking: In the late afternoon, PV panels with backtracking are not shaded. The low sun angle no longer causes the leading panel to cast a shadow on the panel behind it.

However, this technique increases the angle in incidence between the panel and the sun, changing where the glare is experienced.

Because a dual-axis system can more accurately follow the path of the sun, the angle of incidence with the sun is lower than for a single-axis system. Consequently, less glare is produced.

While *backtracking* is mostly used to maximise solar gain across the PV array in the early morning and late afternoon, it can also be used at different times of the day to mitigate the effects of glare on the surrounding environment. This is done by adjusting the angle of panels within those parts of the solar farm more likely to produce a glare problem so that any reflected light is directed away from the potentially affected location (e.g. adjacent dwelling or roads).

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The following table shows the relationship between time of day and panel tilt angle for 1 January for a single axis tracker with a maximum tilt of 60 degrees.

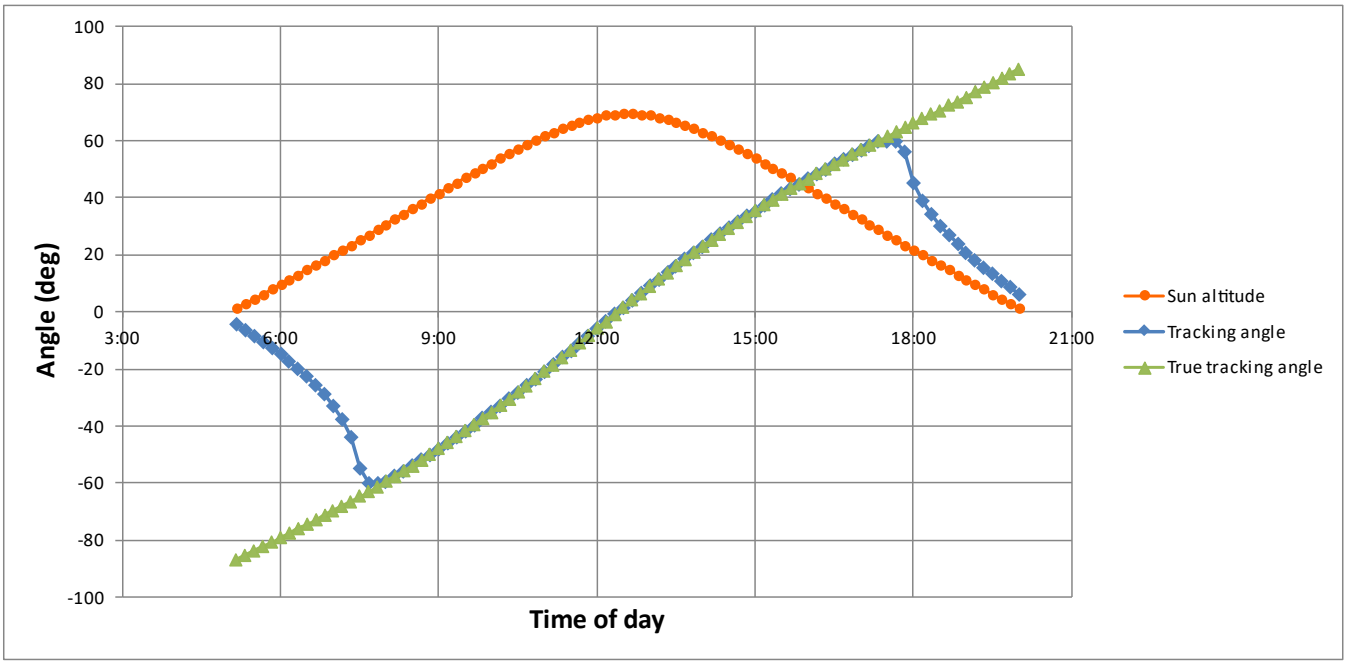

Figure 8: Single Axis Tracker Tilt Angles for 1 January

Observer Angle, Elevation and Distance

Glare is likely to be more intense for observers closer to the source because the reflected light is less diffused by the anti-glare coating and the atmosphere over shorter distances. Subsequently, observers that are further away are less likely to be affected at the same intensity.

The angle and elevation at which an observer views the reflective surface also influence how glare is experienced. Observers positioned at elevations and angles where the reflection is most direct will experience the most intense glare, while those located outside of this path will experience less or no glare. This is shown in the following figure:

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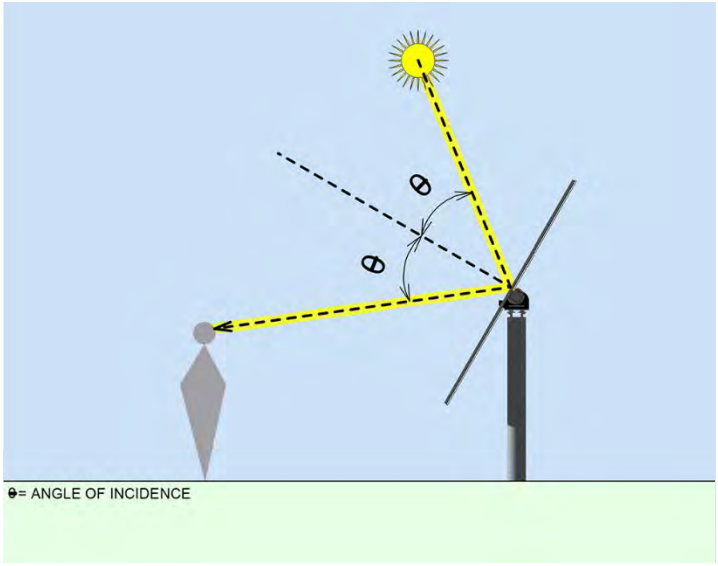

Figure 9: The relationship of the sun, panel tilt and observer for glare required for to be experienced.

Glare from a solar farm is most intense when viewed from locations where the angle of incidence aligns directly with the viewer's line of sight to the panels. While some glare will also be visible from adjacent panels with similar angles of incidence, the intensity is reduced due to diffusion caused by the antiglare coating on the panels. This coating helps to scatter light, diminishing the glare's brightness and making it less noticeable from panels that are not perfectly aligned with the viewer's perspective.

The Surrounding Environment

Topography, vegetation, and other environmental features, such as buildings, affect the area and intensity of glare. Visually impervious features like dense vegetation and bunding block glare by screening the source. More open vegetation can allow dappled glare, creating a less uniform and more diffuse glare pattern, which reduces the intensity compared to unfiltered glare.

Atmospheric Conditions

Atmospheric conditions can influence both the intensity and duration of glare experienced from reflective surfaces like solar panels.

On clear days, the direct sunlight is more intense, leading to stronger reflections and more pronounced glare from shiny surfaces. The lack of atmospheric scattering means that more sunlight reaches the surface directly, potentially resulting in increased levels of glare (intensity).

Conversely, on cloudy or overcast days, sunlight is diffused, reducing its intensity, and scattering it in multiple directions. This diffused light results in softer reflections, which generally cause less glare. Overcast conditions can significantly mitigate glare, making it less likely to cause visual discomfort or hazards. On foggy or hazy days sunlight is similarly scattered, decreasing the potential for glare to occur.

Other particulate matter in the air, such as dust or smoke may also affect glare intensity.

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ASSESSMENT GUIDELINES

New Zealand does not have formal guidelines for assessing the effects of glint and glare on the surrounding environment. Consequently, the assessment process has followed the recommendations contained in the *New South Wales Large-Scale Solar Energy Guideline* and the FAA aviation guidelines[4] (which are not applicable in this situation due to distance from the nearest airstrip).

This approach is consistent with other recent glint and glare assessments undertaken in New Zealand.

New South Wales Large-Scale Solar Energy Guideline

The Appendix C of the New South Wales Guideline recommends the following:

> *The glint and glare assessment should represent a 'worst case' scenario that assumes no cloud cover throughout the year. The assessment should address the general requirements outlined below and in **Table 7**. The glint and glare assessment include:*
> - *a description of the proposed PV panels, indicating:*
>   - *the axis of rotation and maximum tilt angle*
>   - *the light absorption efficiency and/or refractive index values at different angles*
>   - *whether any backtracking is proposed and the time and duration of these operations*
> - *results of the glint and glare analysis for each assessable receiver*
> - *identification of existing vegetation or built structures and a qualitative assessment of whether these features would eliminate or reduce the modelled impacts*
> - *a justification for excluding any modelled glare results because they would be insignificant due to the size, position and luminance of the glare source, or high ambient luminance.*
> - *details of strategies to either avoid or mitigate impacts including re-siting or sizing the project, altering the tracking patterns, implementing vegetation screening, or entering into agreements with landholders if all other measures have been exhausted.*[5]

[4] FAA Policy requires the assessment of glint and glare on pilots for all solar farms proposed on US Federal airports. While in a strict sense this policy does not apply in New Zealand, in the absence of a similar policy from the CAA (NZ), the best practice approach has been to assess the effect of glare on the 2 mile approach vectors and control towers of any airport or airstrip within 5km of a proposed solar farm.

[5] Page 50. Large-Scale Solar Energy Guideline. August 2022. Department of Planning and Environment. NSW Government.

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Table 7 of the guidelines is included below (Emphasis added):

Table 7: Glint and glare requirements			
	Scope	***Methodology***	***Performance objective***
Residential receivers	*All residential viewpoints within 3 km of the proposed solar array that have a line of sight.* *Representative viewpoints may be used for residential receivers that are clustered together (see additional guidance in the technical supplement).*	*Analysis of the daily and yearly glare impacts in minutes.* *All residential receivers must be assessed at a height of 1.5 m above ground level.*	*See impact ratings and performance objectives for residential receivers outlined in* ***Table 2****.*
Road and Rail	*All roads and rail lines within 1km of the proposed solar array.*	*Solar glare analysis to identify whether glint and glare are geometrically possible within the forward looking eyeline of motorists and rail operators.*	*If glare is geometrically possible then measures should be taken to eliminate the occurrence of glare. Alternatively, the applicant must demonstrate that glare would not significantly impede the safe operation of vehicles or the interpretation of signals and signage.*
Aviation	*All air traffic control towers and take off/landing approaches to any runway or landing strip within 5km of the proposed solar array.*	*Solar glare analysis that is worst case in all scenarios accounting for all aircraft using the airport (e.g. gliders, helicopters etc).*	*Any glint and glare should be avoided unless the aerodrome operator agrees that the impact would not be material (e.g. occurs at times when there are no flights or would not pose a safety risk to airport operations).*

The effect of glint or glare diminishes over distance, as reflected light is increasingly diffused.

Other Guidance Documents

Other overseas guidance documents suggest:

> *There is no technical limit (distance) within which solar reflections is possible for a surrounding dwelling receptor however, the significance of a reflection decreases with distance. This is because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases*[6]*;*

[6] Page 50. *Solar Photovoltaic and Building Development – Glint and Glare Guidance*. PagerPower Urban and Renewables. September 2022.

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These documents also recommend that effects associated with glint and/or glare on surrounding roads and dwellings should be considered within 1km of the solar farm site[7] as follows:

Overall

- *National roads, or those with greater significance, within approximately 1km of a proposed solar PV development that may have a view of the PV panels should be assessed. Dwellings within approximately 1km of a proposed solar PV development that may have a view of the PV panels should be assessed.*
- *Terrain heights and an additional height to account for the solar panel and eye level within the relevant floor of the dwelling should also be considered.*

Dwellings

- *Identify dwellings in the immediate surrounding area (out to approximately 1km from the solar PV development boundary) that may have visual line of sight to the solar panels.*
- *If visual line of sight exists between the proposed solar PV development and a dwelling, then a solar reflection could be experienced if it is geometrically possible. If there is no line of sight, then a reflection cannot be experienced.*
- *An additional height should be added to the ground level at a dwelling to represent a viewing height.*
- *For dwellings, a recommended additional height of 1.8 metres above ground level should be added to account for eye level on the ground floor, with additional floors being assessed as required. Additional heights should be considered where a receptor is higher than a first floor. Modelling is recommended for ground floor receptors because it is typically the most occupied during daylight hours[8].*

Roads

- *Identify roads in the immediate surrounding area (out to approximately 1km from the solar PV development boundary) that may have visual line of sight to the solar panels;*
- *If visual line of sight exists between the proposed solar PV development and the road, then a solar reflection could be experienced if it is geometrically possible;*
- *Assess a length of road, choosing individual receptor locations no more than 200 metres apart*
- *An additional height should be added to the ground level height to represent the typical viewing height from a road user. For road users, a height of 1.5 metres is recommended[9];*

For this study, the Glint and Glare has been assessed out to a distance of 3km.

GLINT AND GLARE ANALYSIS METHODOLOGY

A glint and glare analysis has been undertaken for the application site using *ForgeSolar GlareGauge* analysis software. The software conforms to the American Federal Aviation Authority (FAA) guidelines. The analysis takes into consideration the methodological recommendations from similar overseas studies and guidelines, including Appendix C of the New South Wales (NSW) guidelines for the implementation and assessment of large-scale solar farms in Australia[10].

GlareGauge

The *ForgeSolar GlareGauge* software is used extensively throughout the world to help predict glint and glare and uses an algorithm developed by the Sandia National Laboratories in the USA for the assessment of effects on observers, routes, and flight paths.

[7] *IBID*
[8] Page 51. *IBID*.
[9] Page 59. *Solar Photovoltaic and Building Development Glint and Glare Guidance.*
[10] Large-Scale Solar Energy Guideline. Department of Planning and Environment. NSW Government. August 2022.

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The tool uses either an interactive Google map[11] (lower resolution data) or a high-resolution digital elevation model (DEM/lidar data) to locate a site, outline proposed PV arrays, and specify observer point (OP), routes (paths) and runway approach paths (flight paths). Other data, for sun position and vector calculations, including latitude, longitude, elevation data, the orientation and tilt of the PV panels, reflectance, tracking, and ocular factors are either added automatically (if using the Google interface) or imported.

For this analysis, a high-resolution digital elevation model was used to determine the relative heights of the various components and observers.

If glare is detected, the tool calculates the retinal irradiance and subtended angle (size/distance) of the glare source to predict potential ocular hazards, ranging from temporary after-image to retinal burn. The results are displayed in a series of simple, easy-to-interpret plots that specify when glare will occur throughout the year, using colour codes to indicate the potential ocular hazard. Additionally, the tool can predict relative energy production and evaluate alternative designs, layouts, and locations to identify configurations that maximize energy production while minimizing glare impacts.

The *GlareGauge* tool identifies potential glare from PV arrays and classifies its ocular impact into three categories based on after-image ocular effects:

- **Green**: Low potential to cause after-image.
- **Yellow**: Potential to cause temporary after-image.
- **Red**: Potential to cause retinal burn.

If glare occurs in the model, it is classified into these three colour-coded categories, as shown in Figure 4 below.

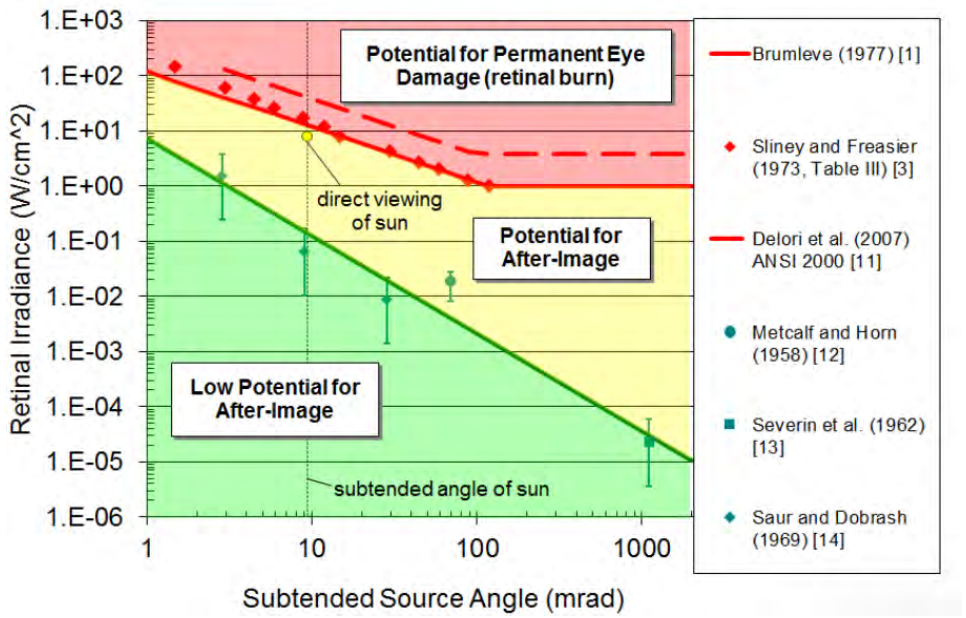

Figure 10: Glare hazard plot defining ocular impact as a function of retinal irradiance and subtended source angle (Ho 2011).

Essentially, if the simulation predicts glare, the ocular impact is plotted on the graph in Figure 4 to determine its category.

[11] The resolution of the Google Maps terrain model for Darfield, New Zealand, is approximately 8 meters. This data is sourced from the Digital Elevation Model (DEM) provided by Land Information New Zealand (LINZ) and incorporates various elevation datasets to create detailed terrain representations. By comparison the resolution of the terrain model derived from the 2023 Lidar data for the area is 1m, making it more accurate.

- **Subtended Source Angle:** This represents the apparent size of the PV array viewed by an observer. Larger source angles (closer proximity) can result in high-intensity glare, even with low retinal irradiance.
- **Retinal Irradiance:** Measures the amount of energy impacting the observer's retina. The further the observer is from the array, the smaller the subtended angle, reducing glare intensity.

The analysis results for PV arrays predicting glare will include various plots detailing the expected times, duration, and locations of glare for each receptor on an annual basis. These plots are described below.

- **Annual Glare Occurrence Plot:** This plot shows when glare is expected throughout the year and day for a specified receptor. The x-axis represents the times of the year, and the y-axis shows the times of day. Glare occurrences are colour-coded by their predicted ocular impact.

- **Daily Glare Duration Plot:** This plot displays the total minutes of expected glare each day over a year. It provides an annual approximation of daily glare duration.

- **Glare Hazard Plot:** This plot indicates the ocular impact of each minute of predicted glare. The x-axis shows the subtended source angle (the visible glare spot's angle), and the y-axis represents retinal irradiance impacting the observer. The plot has three colour-coded hazard zones (green, yellow, red) derived from literature, indicating the expected impact. A reference point marks the hazard from viewing the unfiltered sun.

- **PV Footprint Glare-Spot Heatmap Plot:** This heatmap shows the aggregate locations within the PV footprint where glare spots are expected to appear annually from the receptor's point of view. The areas are color-coded based on the expected glare hazard.

- **A plot of Path Location and Time of Glare:** This plot visualizes the distances along a path (or in the case of an airport runway, the 2-mile approach path vector) where glare will be evident, relative to the time of year.

- **Predicted PV Glare Illumination:** The luminance charts extract and display the peak luminance per day for the given PV array and/or receptor.

The following figure shows examples of the above-mentioned plots.

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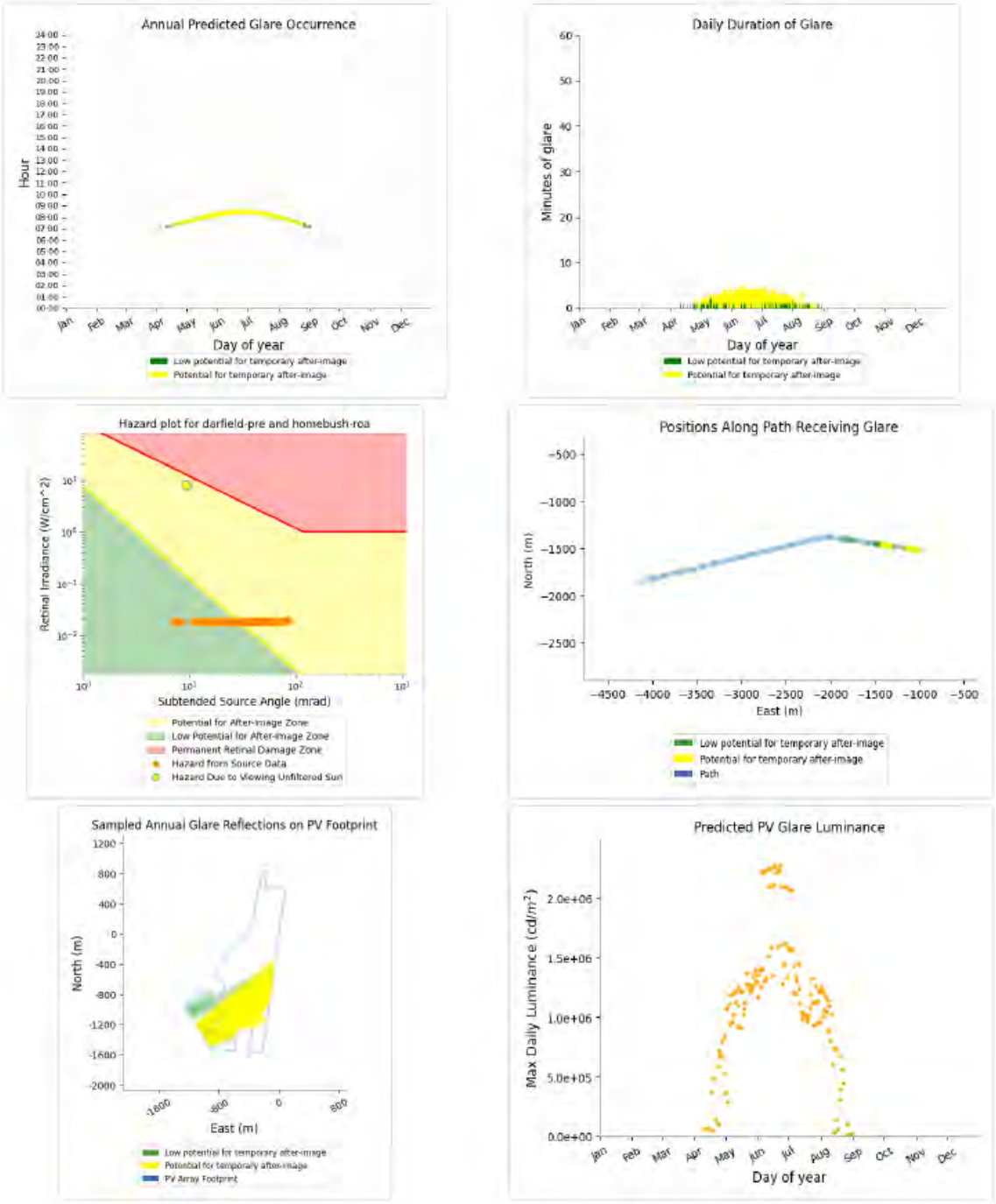

Figure 11: Glare Analysis Plots - Annual Occurrence, Daily Occurrence, Ocular Hazard, and Glare Footprint

If no glare is predicted for a particular receptor or path, a set of plots is not generated, and the tool returns a finding of "*No glare found*".

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Software Limitations and Assumptions

GlareGauge is limited by the following configuration constraints:

ANALYSIS TYPE/FEATURE TYPE	MAXIMUM ANALYSIS FEATURES	MAXIMUM VERTICES
System size (approx.)	Any size	N/A
PV area	Any size	N/A
Glare analyses	30	N/A
Optimizations	5	N/A
PV footprints	20	40 per PV array
Vertical surfaces	20	10 per feature
Flight paths	20	2 per approach
Routes	20	30 per route
Observation points	40	40
Obstructions	10	10 per feature

The tool works on the following key assumptions and limitations:

(1) *Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.*
(2) *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.*
(3) *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.*
(4) *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.*
(5) *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.)*
(6) *The algorithm assumes that the PV array is aligned with a plane defined by the approximate total heights of the PV vertices. For increased accuracy, the user should perform runs using minimum and maximum values for the vertex heights to bound the height of the plane containing the solar array. Doing so will expand the range of observed solar glare when compared to results using a single height value.*
(7) *The algorithm 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.*
(8) *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.*
(9) *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.*
(10) *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 modelling methods.*
(11) *Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.*
(12) *Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.*

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The Glint and Glare simulation uses a "Clear Sky" model simulation, which represents the worst-case scenario (i.e., does not include clouds or other atmospheric conditions which would reduce glint and glare). Direct Normal Irradiation (DNI) values can be adjusted for the time of day and atmospheric conditions are required.

In addition, because the glint and glare software only use two elevation reference points to analyse the glint and glare potential from surrounding viewer location points (the solar farm elevation and the viewer location point elevation), the analysis does not take into consideration intervening topography, vegetation, or buildings, which may screen, or partially screen the glint and glare associated with the proposed development from view. The degree of screening provided by existing topography, vegetation and/ or buildings located between the proposed solar farm and any observer points (Ops) or routes identified as having glint or glare also needs to be considered. This has been discussed in the analysis of visual effects from the identified view locations section of the *Visual and Landscape Assessment Report*.

DARFIELD AGRIVOLTAIC SITE ANALYSIS PARAMETERS

For the Darfield Agrivoltaic site, the potential for glint and glare associated with the proposed development was assessed within a 3km radius to evaluate the impact on the landscape and visual amenity as part of the overall landscape and visual assessment.

Because the potential for glint and glare only exists in locations with a direct line of sight to the proposed solar farm, the visual catchment identified through GIS viewshed analysis (also known as Zone of Theoretical Visibility or ZTV analysis) was used to identify and select observer points (OP) for analysis and potentially affected dwellings and occupied buildings and roads within 3km of the site.

Photovoltaic Arrays

For this analysis, the entire application site, up to 10 meters from the external boundaries, was evaluated as a potential source of glint and glare. This assessment includes areas of the proposed development that are unlikely to produce glare, such as the substation and the BESS units and hardstand.

Observer Point and Route Selection

Dwellings, within the visual catchment of the application site (ZTV) and 3km of the site, were identified using aerial photography and selected as Observer Points (OPs) for analysis. Generic points representing future dwellings within the, yet undeveloped, large-lot residential zone to the south of Homebush Road have been included.

Route receptor locations, along the sections of road and rail that traverse the visual catchment were identified. Analysis points for each route were identified at regular intervals, with the car driver's eye-level height of 1.1m and a truck driver's eye level of 2.4m as per the table contained in Figure 1 below. For the railway line, the Engine Driver's eye level was set at 3m and 3.5m[12].

[12] The difference in the duration of predicted glare between 3m and 3.5m is 19 minutes over the course of the year. Glare is predicted to occur longer at 3m than 3.5m.

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Table 5.1: Vertical height parameters

Vertical height parameter[1]	Height (m)	Typical application
Height of eye of driver h_1		
Passenger car	1.1	All car sight distance models.
Truck	2.4	All truck sight distance models where a truck is travelling in daylight hours and at night-time where the road is lit.
Bus	1.8	Specific case for bus only facilities, e.g. busways.
Headlight height h_1		
Passenger car	0.65	1. Headlight stopping sight distance in sags. 2. Check case for night time stopping for cars (no road lighting).
Commercial vehicle	1.05	Check case for night time stopping for trucks (no road lighting).

Figure 12: Table 5.1 from Guide to Road Design Part 3[13]

A separate analysis was run for the passenger car and truck eye level heights identified in the table above. The view angle was set to 50° (default) which implies the observer has a field-of-view (FoV) of 50° to their left and right (i.e. a total FoV of 100°)[14]. This default is based on the findings of FAA research[15] into the effect of solar farm glare on pilots on approach to landing. Glare may still be experienced if a driver/passenger looks around.

Existing Environmental Screening

The following features were identified as obstructions in the *GlareGauge* analysis tool:

- Existing earth bunds and hedgerows within the adjacent dairy factor site.
- The dairy factory cool store (adjacent to the railway siding).
- The vegetation and hedgerows that surround existing dwellings adjacent to the site.
- McHughs Forest Park.

Glare analysis was run with the above obstructions and without the vegetative obstruction (most likely to be removed or lost).

Observer Point and Route Location Map

Observer points and routes within the visual catchment surrounding them are identified on the following map. Areas located outside the ZTV are not subject to the effects of glint and glare.

[13] *Guide to Road Design Part 3: Geometric Design*. Austroads. 2021
[14] ForgeSolar help. Help | ForgeSolar
[15] *Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach.* J. Rogers et al. July 2015.

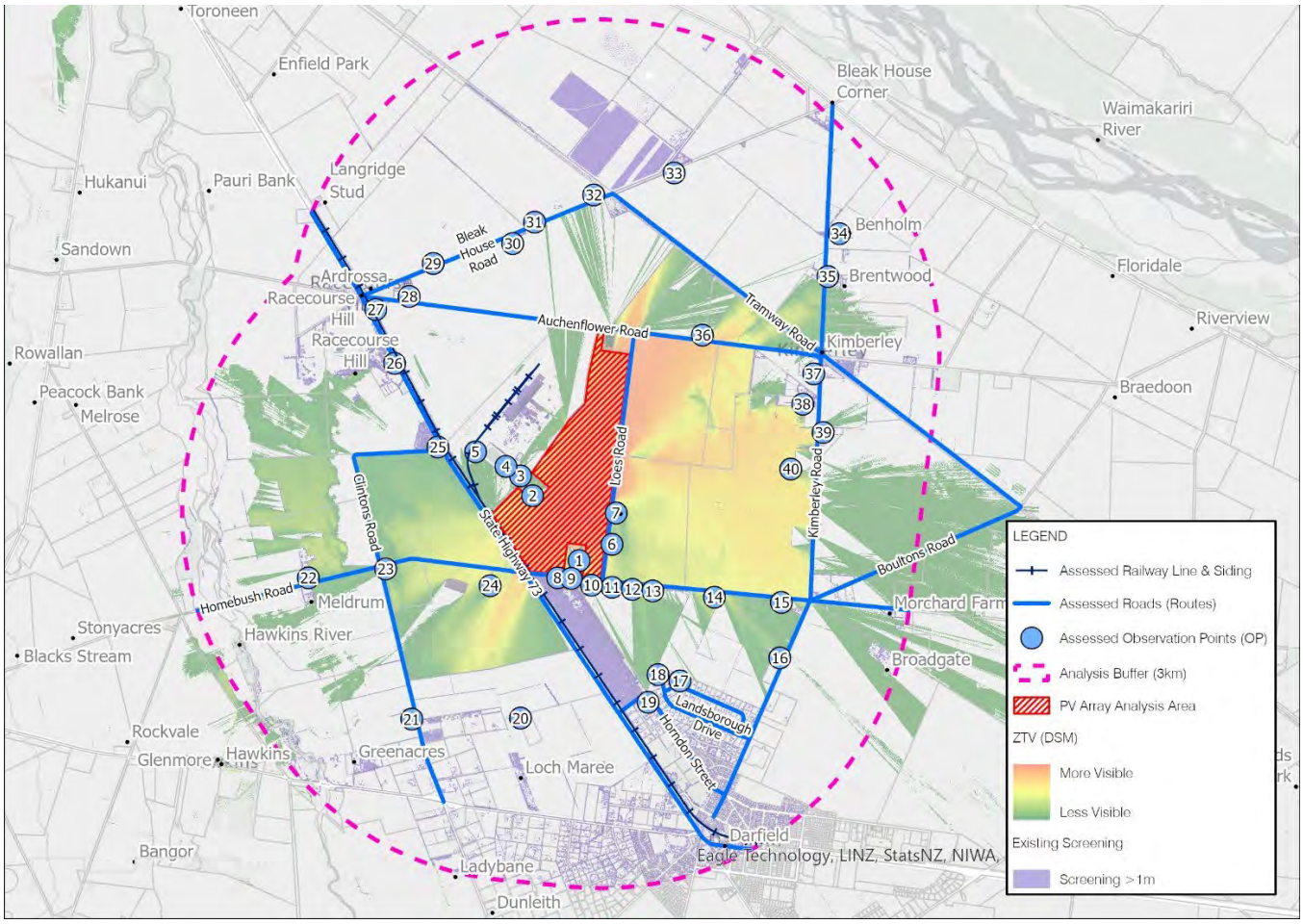

Figure 13: Observer Points and Routes within the ZTV, Assessed using the ForgeSolar GlareGuage Tool

The nature of each OP and Route is identified in the following table:

OP2 / ROUTE	TYPE	OBSERVER TYPES	ADDRESS	APPELLATION
1	Dwelling	Resident/Visitor	1352 Homebush Road, Darfield	Lot 2 DP 60325
2	Dwelling	Resident/Visitor	1/3792 West Coast Road, Darfield	Lot 1 DP 456083
3	Workshop or Shed	Workplace	1/3792 West Coast Road, Darfield	Lot 1 DP 456083
4	Fonterra	Workplace	1/3792 West Coast Road, Darfield	Lot 1 DP 456083
5	Dwelling	Resident/Visitor	1/3792 West Coast Road, Darfield	Lot 1 DP 456083
6	Dwelling	Resident/Visitor	32 Loes Road, Darfield	Lot 2 DP 365731
7	Dwelling	Resident/Visitor	68 Loes Road, Darfield	Lot 1 DP 365731
8	Forest Park	Visitor		Lot 1 DP 61566
9	Forest Park	Visitor		Lot 1 DP 61566
10	Future LLRZ	Future Residential		Lot 2 DP 460046
11	Future LLRZ	Future Residential		Lot 2 DP 460046
12	Future LLRZ	Future Residential		Lot 2 DP 460046
13	Future LLRZ	Future Residential		Lot 2 DP 460046
14	Future LLRZ	Future Residential		Lot 2 DP 460046
15	Workshop or Shed	Workplace		Lot 2 DP 460046
16	Dwelling	Resident/Visitor	165 Kimberley Road,	Lot 1 DP 77597
17	Dwelling	Resident/Visitor	38 Whitcombe Place,	Lot 52 DP 459779
18	Dwelling	Resident/Visitor	47 Landsborough Drive,	Lot 47 DP 459779
19	Dwelling	Resident/Visitor	45 McHugh Crescent,	Lot 13 DP 362859

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OP2 / ROUTE	TYPE	OBSERVER TYPES	ADDRESS	APPELLATION
20	Workshop or Shed	Workplace		Section 1 SO 438579
21	Dwelling	Resident/Visitor	1827 Clintons Road,	Lot 1 DP 2920
22	Dwelling	Resident/Visitor	1616 Homebush Road,	Lot 4 DP 2920
23	Workshop or Shed	Workplace	1976 Clintons Road,	Lot 1 DP 8545
24	Dwelling	Resident/Visitor	1433 Homebush Road,	Lot 1 DP 11000
25	Dwelling	Resident/Visitor	2171 Clintons Road,	Lot 1 DP 304774
26	Dwelling	Resident/Visitor	3967 West Coast Road,	Lot 2 DP 367426
27	Workshop or Shed	Workplace		Lot 4 DP 20115
28	Workshop or Shed	Workplace	832 Auchenflower Road,	Lot 1 DP 77605
29	Dwelling	Resident/Visitor		Part RS 19733
30	Workshop or Shed	Workplace	156 Bleak House Road,	Lot 1 DP 6850
31	Dwelling	Resident/Visitor	181 Bleak House Road,	Lot 1 DP 322756
32	Dwelling	Resident/Visitor	245 Bleak House Road,	Lot 2 DP 322756
33	Dwelling	Resident/Visitor	324 Bleak House Road,	Lot 3 DP 2802
34	Dwelling	Resident/Visitor	594 Kimberley Road,	Lot 1 DP 8674
35	Dwelling	Resident/Visitor		Lot 1 DP 58608
36	Dwelling	Resident/Visitor	526 Auchenflower Road,	Lot 3 DP 20115
37	Cemetery	Visitor		RES 2355
38	Workshop or Shed	Workplace	427 Kimberley Road,	Lot 1 DP 471812
39	Dwelling	Resident/Visitor	398 Kimberley Road,	RS 23450
40	Dwelling	Resident/Visitor	355 Kimberley Road,	Lot 2 DP 309346
Auchenflower Road	Local Road	Road user		
Bleak House Road	Local Road	Road user		
Boultons Road	Local Road	Road user		
Clintons Road	Local Road	Road user		
Homebush Road	Local Road	Road user		
Kimberley Road	Local Road	Road user		
Landsborough Drive	Local Road	Road user		
Loes Road	Local Road	Road user		
State Highway 73	State Highway	Road user		
Tramway Road	Local Road	Road user		
Whitcombe Place	Local Road	Road user		
Main Trunk Line	Railway Line	Railway user		
Fonterra Siding	Railway Line	Railway user		

Assessment Parameters

The key assessment parameters used in the analysis are summarised as follows:

a) Timestep**:** 1 min – meaning glare is assessed at 1-minute intervals during daylight hours over a year.
b) Timezone**:** New Zealand Solar Time (UTC12. Daylight savings are not considered).
c) Tracking**:** Single Access Tracking. A single-axis tracking is a mechanical system used to rotate a PV table around a single axis so that the PV panels always face the sun throughout the day. This movement helps the panel maximize its energy production compared to fixed panels by ensuring it's always directed towards the sun.
d) Tracking Orientation: Seven and a half degrees/7.54^0 (true).
e) Backtracking: Shade, meaning the angle of the panels adjusts automatically to maximise solar gain across the array.
f) Max Angle: 60^0
g) Resting Angle: 0^0

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h) PV Panel Material: Light textured glass with antireflective coating.

Other constants and the coordinates of each array are contained in the *ForgeSolar* report.

NSW PERFORMANCE OBJECTIVES AND EFFECT RATINGS

Table 2 of the NSW guidelines provide the following performance objective guidance in terms of effect levels and duration:

Table 2: Impact rating and performance objectives for glare impacts to residential dwellings		
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.

The above table suggests that the effect of glare experienced at a residential location of a duration of less than 10 minutes per day will be ***low*** and is therefore acceptable as it meets the performance objective contained table. Within the New Zealand planning context, this suggests that glare experienced from less than 10 minutes per day or 10 hours per annum will have a ***minor*** or ***less than minor*** level of effect.

The following table shows the relationship between the 3-point and 7-point rating systems identified in the *Te Tangi a te Manu - Aotearoa New Zealand Landscape Assessment Guidelines*[16], the rating system contained in the NSW Guidelines and the various effect thresholds in the RMA.

Document	**Effect Rating**						
Te Tangi a te Manu - Aotearoa New Zealand Landscape Assessment Guidelines	**VERY LOW**	**LOW**	**LOW-MOD**	**MODERATE**	**MOD-HIGH**	**HIGH**	**VERY HIGH**
Table 2: NSW Guidelines	**LOW**			**MODERATE**		**HIGH**	
	< 10 minutes per day < 10 hours per year			< 30 minutes & > 10 minutes per day < 30 hours & > 10 hours per year		> 30 minutes per day > 30 hours per year	
Act/Policy	**Threshold**						
RMA	**Less than Minor**		**Minor**	**More than Minor**		**Significant**	

The NSW Guidelines do not differentiate between the effects of green glare, yellow glare, or red glare. Nor does it contain any guidance around the ratings of glare effects on the public road or rail network (drivers/passengers/cyclists/pedestrians). It does however recommend that, for road and rail, if glare is geometrically possible then measures should be taken to eliminate the occurrence of glare, or the applicant must demonstrate that glare would not significantly impede the safe operation of vehicles or the interpretation of signals and signage (Table 7).

FINDINGS

The ForgeSolar GlareGauge tool has been used to predict glare occurrences and their potential ocular impacts at various observer points (OPs) and routes within a 3km radius of the site. Key parameters included single-axis tracking systems with backtracking, anti-reflective coated panels, and annual clear-sky conditions. The analysis considered both a worst-case scenario without surrounding obstructions such as trees and shelter belts, and the

[16] Para 6.21. Te Tangi a te Manu - Aotearoa New Zealand Landscape Assessment Guidelines

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existing environment scenario, where hedgerows and trees in the surrounding environment were taken into consideration.

The results without vegetative screening indicated significant glare potential at various OPs and routes, particularly during early morning and late afternoon. The observer points closer to the site and directly in line with panel reflections experienced higher glare intensity.

The established hedgerows, woodlots, and shelterbelts along the site's western boundary or within the adjacent private properties, as well as the adjacent dairy factory, earth bunding and the mature trees within McHughs Forest Park, significantly reduced the annual and daily duration of glare occurring at the surrounding dwellings, roads, and reserve areas. The removal of any of these features has the potential to increase glare levels in different parts of the landscape.

Glare durations of less than 10 minutes per day can be categorized as a ***low*** level of effect under the NSW guidelines, while glare experienced for more than 30 minutes per day or 30 hours per year is considered to have a ***high*** adverse effect and should be avoided.

The ForgeSolar analysis report found potential for yellow and green glare only, with no potential for red glare from any of the surrounding OP's or road/rail networks.

Overall, the effect of yellow and green glare on surrounding dwellings was predicted to be ***low*** (based on the NSW glare ratings where glare duration is less than 10 minutes per day) with or without the retention of existing vegetation and built obstructions. Field verification suggests that, in many instances, existing screening surrounding the identified OP's will eliminate the adverse effects of glare.

The predicted glare duration for surrounding roads and rail is less than 10 minutes per day for passenger vehicles and trains, regardless of existing vegetation and built obstructions. However, for truck drivers (2.4m above ground), glare is expected to last 10-16 minutes per day and 10-17.5 hours per year on a short stretch of Homebush Road to the east of the railway with or without existing obstructions.

The NSW performance standard, for road and rail, contained in Table 7 (above) suggests that if glare is geometrically possible then measures should be taken to eliminate the occurrence of glare, or the applicant must demonstrate that glare would not significantly impede the safe operation of vehicles or the interpretation of signals and signage (Table 7). This suggests that glare experienced by road or rail users should be mitigated.

The following tables summarise the potential glare effects and duration for the proposed Darfield Agrivoltaic Development under normal operating conditions. Table 1 (below) summarises the results of the glare analysis **without** surrounding vegetative screening and earth bunding taken into consideration. Table 2 (below) summarises the results of the glare analysis **with** the screening effects of the surrounding vegetative and earth bunding taken into consideration.

The analysis does not identify glint and glare caused by the stowing (resetting to 0 degrees) during periods of high wind or for other reasons. All times are New Zealand Standard Time (NZST). Add one hour to adjust for daylight savings. The glint and glare analysis represents a worst-case scenario and must be read within the context of the viewshed (ZTV) analysis provided in Figure 12 of this memorandum. The locations where glare is most likely to be experienced are indicated in the following figure.

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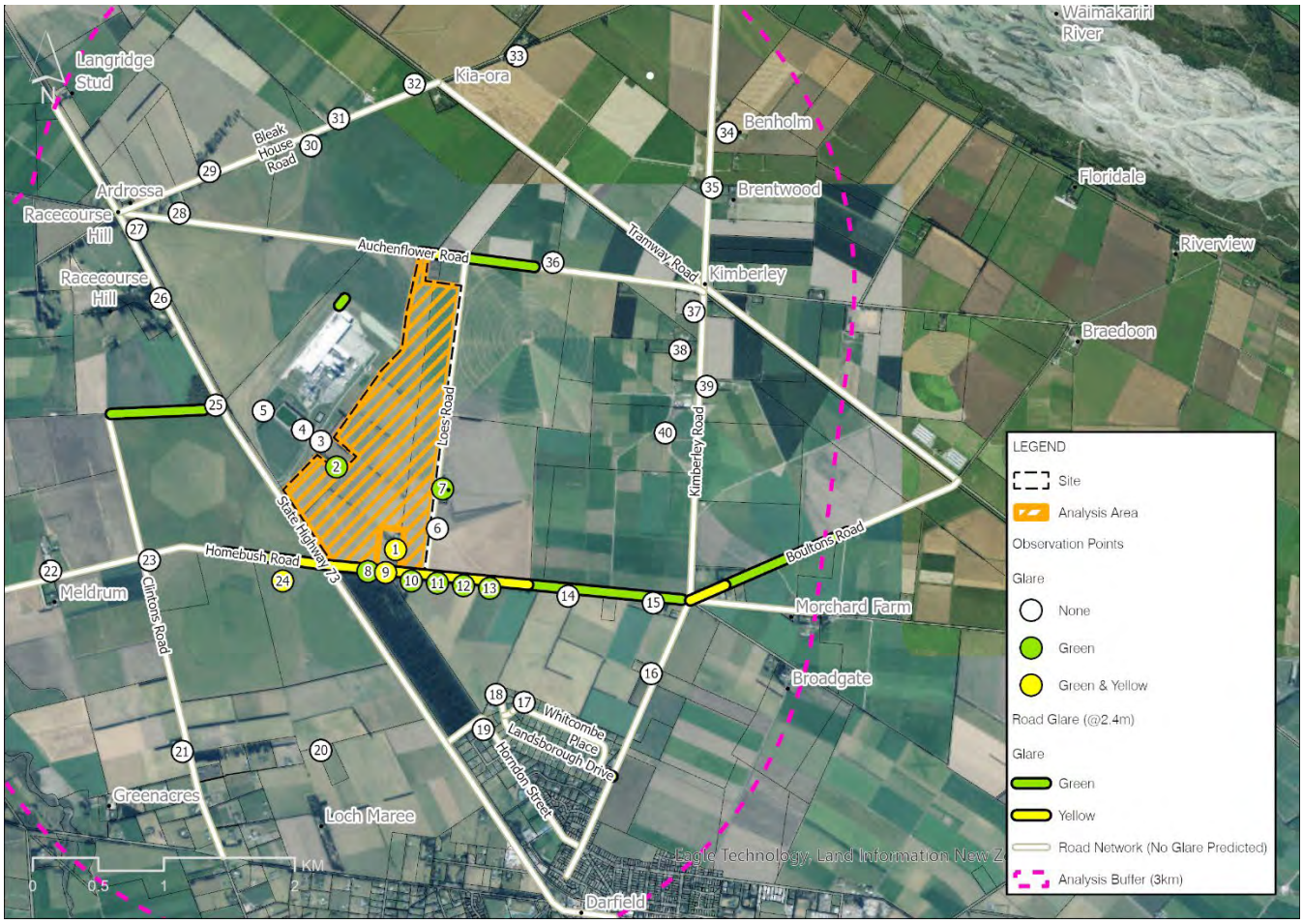

Figure 14: Locations where glint and glare are most likely to occur at different times of the day and year

The following tables summarise the annual and daily glare predicted at each location. Observer Points and Routes where no glare is predicted are not included in the following summary tables. A copy of the ForgeSolar analysis report and the NSW guidelines for large-scale solar energy development is attached to this memo.

SUMMARY OF PREDICTED GLARE AT THE DARFIELD OBSERVATION POINTS (**Without** Existing Vegetation Screening)						
Observer Point	**Annual Glare** (minutes/year)		**Max Daily Glare** (minutes/day)		**Time**	**Duration** (Months of the Year)
	Green	**Yellow**	**Green**	**Yellow**		
OP1*	44	11	1	3	6:30am – 8:00am 4:30pm – 5:00pm	Mid Aug - Mid Sept Late May - Mid July
OP2*	46	5	3	3	6:30am – 8:00am	Early Aug - Mid Sept
OP3	38	6	3	3	6:30am – 8:00am	Early Aug - Mid Sept
OP6*	25	10	1	1	4:30pm – 5:30pm	Late May – Mid July
OP7*	32	0	1	0	4:30pm – 5:15pm	Late May - Mid July
OP8	41	2	3	1	6:30am – 8:00am 4:30pm – 5:00pm	Mid Aug – Mid Sept Late May - Mid July
OP9	41	4	2	3	6:30am – 8:00am 4:30pm – 5:00pm	Mid Aug – Mid Sept Late May – Mid-July
OP10	24	0	1	0	4:30pm – 5:00pm	Late May - Mid July
OP11	25	0	1	0	4:30pm – 5:15pm	Late May – Mid July
OP12	19	0	1	0	4:30pm – 5:00pm	Late May – Late June

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SUMMARY OF PREDICTED GLARE AT THE DARFIELD OBSERVATION POINTS (**With** Existing Vegetation Screening)						
Observer Point	**Annual Glare** (minutes/year)		**Max Daily Glare** (minutes/day)		**Time**	**Duration** (Months of the Year)
	Green	**Yellow**	**Green**	**Yellow**		
OP1*	22	9	3	3	6:30am – 8:00am	Mid Aug – Mid Sept
OP2*	38	3	3	1	6:30am – 8:00am	Early Aug – Mid Sept
OP8	25	0	3	0	6:30am – 8:00am	Mid Aug – Mid Sept
OP9	36	9	2	1	6:30am – 7:30am 4:30 pm – 5:00pm	Mid Aug – Mid Sept Late May – Mid July
OP10	24	0	1	0	4:30 pm – 5:00pm	Late May – Mid July
OP24	22	0	3	0	7:00am – 8:00am	Mid Aug – Early Sept

*Field observation confirmed the existence of substantial established hedgerows and shelterbelts surrounding OP locations 1, 2, 6 and 7, meaning that glare is unlikely to affect these locations (unless the vegetation is removed).

SUMMARY OF PREDICTED GLARE ON PASSENGER VEHICLES – EYE LEVEL = 1.1m (**Without** Existing Vegetation Screening)						
ROUTE	**Annual Glare** (minutes/year)		**Max Daily Glare** (minutes/day)		**Time**	**Duration** (Months of the Year)
	Green	**Yellow**	**Green**	**Yellow**		
Auchenflower Road	36	0	3	0	6:00pm – 7:00pm 6:00pm – 6:30pm	Mid March – Early April Early Sept – Late Sept
Clintons Road	133	0	4	0	7:00am – 8:30am 6:45am – 8:30am	Start April – Late May Mid July – Early Sept
Homebush Road (East of Railway)	187	249	4	6	7:00am – 8:30am 4:30pm – 6:30pm	Start April – Mid Sept Mid April – Mid Sept
Homebush Road (West of Railway)	73	330	2	5	7:00am – 8:45am	Start April – Early Sept

SUMMARY OF PREDICTED GLARE ON PASSENGER VEHICLES – EYE LEVEL = 1.1m (**With** Existing Vegetation Screening)						
ROUTE	**Annual Glare** (minutes/year)		**Max Daily Glare** (minutes/day)		**Time**	**Duration** (Months of the Year)
	Green	**Yellow**	**Green**	**Yellow**		
Clintons Road	142	0	4	0	7:00am – 8:30am 7:00am – 8:30am	Mid April – Late May Mid July – End Aug
Homebush Road (East of Railway)	184	242	4	5	7:00am – 8:30am 4:30pm – 6:00pm	Start April – Early Sept Late April – Start Sept
Homebush Road (West of Railway)	38	365	2	5	7:00am – 8:45am	Start April – Early Sept

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SUMMARY OF PREDICTED GLARE ON TRUCK DRIVERS – EYE LEVEL = 2.4m (**Without** Existing Vegetation Screening)						
ROUTE	**Annual Glare** (minutes/year)		**Max Daily Glare** (minutes/day)		**Time**	**Duration** (Months of the Year)
	Green	**Yellow**	**Green**	**Yellow**		
Auchenflower Road	272	9	5	2	5:30am – 6:30am 5:00am – 6:00am 6:00pm - 7:00pm 6:00pm – 7:00pm	Early Feb – Mid March Start Oct – Early Nov Mid March – Early April Start Sept – End Sept
Bleakhouse Road	23	0	2	0	5:45am – 6:15am 5:15am – 6:00am	Early Feb – Late Feb Mid Oct – End Oct
Boultons Road	542	3[1]	7	5[1]	4:45pm – 7:00pm 5:00pm – 6:45pm	Mid March – Mid May Mid July – Late Sept
Clintons Road	104	0	3	0	7:00am – 8:30am 6:45am – 8:30am	Start April – Late May Mid July – Early Sept
Homebush Road (East of Railway)	700	1051	8	16	6:30am – 8:45am 4:30pm – 6:30pm	Start April –Mid Sept Late March – Mid Sept
Homebush Road (West of Railway)	45	370	2	6	6:30am – 8:30am	Start Apr – Mid Sept
[1] Anomalous result.						

SUMMARY OF PREDICTED GLARE ON TRUCK DRIVERS – EYE LEVEL = 2.4m (**With** Existing Vegetation Screening)						
ROUTE	**Annual Glare** (minutes/year)		**Max Daily Glare** (minutes/day)		**Time**	**Duration** (Months of the Year)
	Green	**Yellow**	**Green**	**Yellow**		
Boultons Road	432	0	6	0	4:45pm – 6:45pm 5:00pm – 6:30pm	Late March – Mid May Late July – Mid Sept
Clintons Road	90	0	3	0	7:00am – 8:30am 7:00am – 8:30am	Mid Apr – Late May Mid July – Late Aug
Homebush Road (East of Railway)	412	602	8	16	6:30am – 8:45am 4:30pm – 6:30pm	Start April – Mid Sept Mid April – Mid Sept
Homebush Road (West of Railway)	108	307	2	5	6:30am – 8:30am	Start April – Mid Sept

SUMMARY OF PREDICTED GLARE ON TRAINS DRIVERS – EYE LEVEL = 3.0m (**Without** Existing Vegetation Screening)						
ROUTE	**Annual Glare** (minutes/year)		**Max Daily Glare** (minutes/day)		**Time**	**Duration** (Months of the Year)
	Green	**Yellow**	**Green**	**Yellow**		
Fonterra Railway Siding#	325	0	5	0	6:45am – 8:30am	Start April – Early Sept
# The Fonterra Rail Siding was not visited due to access limitations.						

SUMMARY OF PREDICTED GLARE ON TRAINS DRIVERS – EYE LEVEL = 3.0m (**With** Existing Vegetation Screening)						
ROUTE	**Annual Glare** (minutes/year)		**Max Daily Glare** (minutes/day)		**Time**	**Duration** (Months of the Year)
	Green	**Yellow**	**Green**	**Yellow**		
Fonterra Railway Siding#	230	0	4	0	7:00am – 8:30am	Mid April – End August
# The Fonterra Rail Siding was not visited due to access limitations.						

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MITIGATION

Since the glare effects on the surrounding observation points (OPs) were found to be ***low***, the NSW guidelines suggest that no mitigation for glare is required for these OPs (dwellings). However, mitigation may be needed for other reasons, such as visual amenity.

Potential green and yellow glare on the road network should however be mitigated for traffic safety purposes through tracking adjustments and/or additional screening measures. Continuous monitoring and adjustments are recommended to ensure minimal visual discomfort and safety risks for road users.

The mitigation of glare effects is considered in the landscape and visual assessment and/or the traffic safety assessment and is addressed in those documents as necessary.

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ATTACHMENTS - FORGE SOLAR GLARE ANALYSIS REPORTS

No	REPORT/SITE CONFIGURATION NAME	DESCRIPTION	ANALYSIS DATE
1	Darfield – Without Obstruction R2	Analysis of surrounding observation points within the visual catchment surrounding the application site to 3km, comprised of dwellings, and pedestrian routes. Analysis obstructions are limited to the existing earth bunding and main store in the adjacent dairy factory.	24/5/2024
2	Darfield – With Obstruction R2	Analysis of surrounding observation points within the visual catchment surrounding the application site to 3km, comprised of dwellings, and pedestrian routes. Analysis obstructions include surrounding hedgerows and woodlots, the existing earth bunding and the main store in the adjacent dairy factory.	24/5/2024
3	Darfield – NZTA Truck without Obstructions R2	Analysis of the surrounding road network surrounding the application site to 3km. Analysis obstructions are limited to the existing earth bunding and main store in the adjacent dairy factory. Driver eye level set at 2.4m.	24/5/2024
4	Darfield – NZTA Truck with Obstructions R2	Analysis of the surrounding road network surrounding the application site to 3km. Analysis obstructions include surrounding hedgerows and woodlots, the existing earth bunding and the main store in the adjacent dairy factory. Driver eye level set at 2.4m.	24/5/2024
5	Darfield – NZTA Car without Obstructions R2	Analysis of the surrounding road network surrounding the application site to 3km. Analysis obstructions are limited to the existing earth bunding and main store in the adjacent dairy factory. Driver eye level set at 1.1m.	24/5/2024
6	Darfield – NZTA Car without Obstructions R2	Analysis of the surrounding road network surrounding the application site to 3km. Analysis obstructions include surrounding hedgerows and woodlots, the existing earth bunding and the main store in the adjacent dairy factory. Driver eye level set at 1.1m.	24/5/2024

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FORGESOLAR GLARE ANALYSIS

Project: **Darfield Solar**
Site configuration: **Darfield - WITHOUT OBSTRUCTIONS R2**

Client: NZ Clean Energy

Site description: Darfield Observer Points without vegetation obstructions

Created 30 May, 2024
Updated 30 May, 2024
Time-step 1 minute
Timezone offset UTC12
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 100 to 500 kW
Site ID 120491.20038

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	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
Darfield Preliminary	SA tracking	SA tracking	335	5.6	38	0.6	-	349,401

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
OP 1	44	0.7	11	0.2
OP 2	46	0.8	5	0.1
OP 3	38	0.6	6	0.1
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	25	0.4	10	0.2
OP 7	32	0.5	0	0.0
OP 8	41	0.7	2	0.0
OP 9	41	0.7	4	0.1
OP 10	24	0.4	0	0.0
OP 11	25	0.4	0	0.0
OP 12	19	0.3	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

Component Data

PV Arrays

Name: Darfield Preliminary
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 7.5467°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.434
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	-43.451667	172.097071	231.90	1.40	233.30
2	-43.465951	172.094370	221.20	1.40	222.60
3	-43.465778	172.092183	221.10	1.50	222.60
4	-43.463059	172.092676	223.80	1.40	225.20
5	-43.462839	172.090390	224.50	1.40	225.90
6	-43.465596	172.089889	222.20	1.40	223.60
7	-43.465287	172.085972	223.20	1.40	224.60
8	-43.460230	172.081414	229.00	1.40	230.40
9	-43.457955	172.084528	230.10	1.40	231.50
10	-43.459237	172.086705	228.40	1.40	229.80
11	-43.457965	172.088370	229.40	1.40	230.80
12	-43.457442	172.087479	229.80	1.40	231.20
13	-43.457410	172.087512	229.80	1.50	231.30
14	-43.456653	172.086246	230.60	1.40	232.00
15	-43.454706	172.088200	232.30	1.40	233.70
16	-43.453924	172.088971	232.60	1.40	234.00
17	-43.452312	172.090606	233.40	1.40	234.80
18	-43.452239	172.090630	233.60	1.40	235.00
19	-43.450710	172.092674	234.00	1.50	235.50
20	-43.450660	172.092704	234.00	1.40	235.40
21	-43.450585	172.092739	233.90	1.40	235.30
22	-43.447953	172.093245	236.10	1.40	237.50
23	-43.447856	172.093289	236.10	1.40	237.50
24	-43.444192	172.094476	238.40	1.40	239.80
25	-43.444256	172.095094	237.70	1.50	239.20
26	-43.446052	172.094744	237.20	1.40	238.60
27	-43.446405	172.098146	235.30	1.40	236.70

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-43.464387	172.091797	222.80	1.60
OP 2	2	-43.458671	172.086307	229.40	1.60
OP 3	3	-43.456912	172.084893	230.80	1.60
OP 4	4	-43.456103	172.083137	232.10	1.60
OP 5	5	-43.454771	172.079477	234.00	1.60
OP 6	6	-43.462983	172.095766	223.30	1.60
OP 7	7	-43.460258	172.096295	225.30	1.60
OP 8	8	-43.465873	172.089187	222.00	1.60
OP 9	9	-43.465961	172.090847	221.40	1.60
OP 10	10	-43.466551	172.093262	220.30	1.60
OP 11	11	-43.466745	172.095720	219.90	1.60
OP 12	12	-43.466939	172.098178	219.40	1.60
OP 13	13	-43.467133	172.100636	218.50	1.60
OP 14	14	-43.467714	172.108010	215.70	1.60
OP 15	15	-43.468240	172.116054	213.70	1.60
OP 16	16	-43.473094	172.115783	210.30	1.60
OP 17	17	-43.474994	172.103772	211.80	1.60
OP 18	18	-43.474423	172.101117	212.10	1.60
OP 19	19	-43.476828	172.099929	210.70	1.60
OP 20	20	-43.478120	172.084550	213.10	1.60
OP 21	21	-43.478109	172.071468	214.60	1.60
OP 22	22	-43.465628	172.059271	229.30	1.60
OP 23	23	-43.464938	172.068560	226.90	1.60
OP 24	24	-43.466480	172.081114	225.70	1.60
OP 25	25	-43.454336	172.074992	236.10	1.60
OP 26	26	-43.446973	172.069888	246.00	1.60
OP 27	27	-43.442225	172.067733	250.50	1.60
OP 28	28	-43.441146	172.071761	250.30	1.60
OP 29	29	-43.438282	172.074647	250.80	1.60
OP 30	30	-43.436611	172.084236	246.90	1.60
OP 31	31	-43.434756	172.086878	246.80	1.60
OP 32	32	-43.432439	172.094054	244.90	1.60
OP 33	33	-43.430610	172.103736	241.70	1.60
OP 34	34	-43.436036	172.123475	230.60	1.60
OP 35	35	-43.439780	172.122011	229.50	1.60
OP 36	36	-43.444801	172.106926	233.20	1.60
OP 37	37	-43.448283	172.120202	226.00	1.60
OP 38	38	-43.450926	172.118838	224.60	1.60
OP 39	39	-43.453415	172.121308	222.30	1.60
OP 40	40	-43.456588	172.117357	220.90	1.60

Obstruction Components

Name: Fonterra Store
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.451541	172.082794	245.15
2	-43.448948	172.085712	245.09
3	-43.449104	172.085959	245.34
4	-43.447959	172.087279	245.13
5	-43.448340	172.087890	245.03

Name: Middle Bund
Top height: 3.5 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.455798	172.084829	237.04
2	-43.454229	172.086216	239.21
3	-43.453606	172.086961	239.16
4	-43.451971	172.088831	240.67

Name: Northern Bund
Top height: 3.5 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.451649	172.089161	240.09
2	-43.450888	172.090035	240.48

Name: Southern Bund
Top height: 3.2 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.459270	172.082155	233.41
2	-43.458222	172.083424	234.83
3	-43.457932	172.083542	234.74
4	-43.457457	172.083678	235.11
5	-43.457056	172.083960	235.70
6	-43.456573	172.084411	236.95
7	-43.455726	172.085567	238.55

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	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
Darfield Preliminary	SA tracking	SA tracking	335	5.6	38	0.6	-	349,401

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
OP 1	44	0.7	11	0.2
OP 2	46	0.8	5	0.1
OP 3	38	0.6	6	0.1
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	25	0.4	10	0.2
OP 7	32	0.5	0	0.0
OP 8	41	0.7	2	0.0
OP 9	41	0.7	4	0.1
OP 10	24	0.4	0	0.0
OP 11	25	0.4	0	0.0
OP 12	19	0.3	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

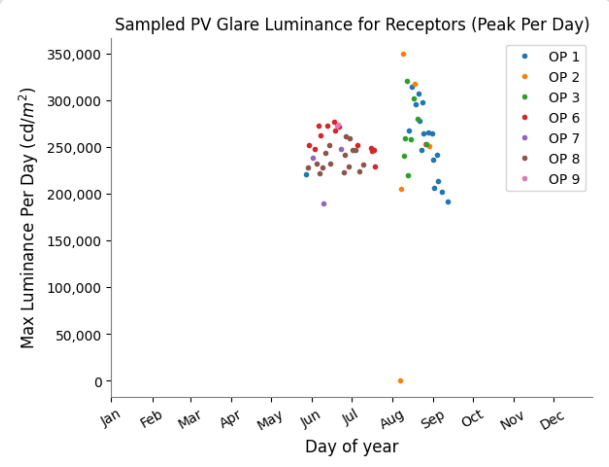
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

PV: Darfield Preliminary potential temporary after-image

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
OP 1	44	0.7	11	0.2	314,185
OP 2	46	0.8	5	0.1	349,401
OP 3	38	0.6	6	0.1	320,179
OP 6	25	0.4	10	0.2	277,069
OP 8	41	0.7	2	0.0	261,911
OP 9	41	0.7	4	0.1	273,828
OP 7	32	0.5	0	0.0	247,518
OP 10	24	0.4	0	0.0	250,764
OP 11	25	0.4	0	0.0	230,408
OP 12	19	0.3	0	0.0	183,192
OP 4	0	0.0	0	0.0	0
OP 5	0	0.0	0	0.0	0
OP 13	0	0.0	0	0.0	0
OP 14	0	0.0	0	0.0	0
OP 15	0	0.0	0	0.0	0
OP 16	0	0.0	0	0.0	0
OP 17	0	0.0	0	0.0	0
OP 18	0	0.0	0	0.0	0
OP 19	0	0.0	0	0.0	0
OP 20	0	0.0	0	0.0	0
OP 21	0	0.0	0	0.0	0
OP 22	0	0.0	0	0.0	0
OP 23	0	0.0	0	0.0	0
OP 24	0	0.0	0	0.0	0
OP 25	0	0.0	0	0.0	0
OP 26	0	0.0	0	0.0	0
OP 27	0	0.0	0	0.0	0
OP 28	0	0.0	0	0.0	0
OP 29	0	0.0	0	0.0	0
OP 30	0	0.0	0	0.0	0
OP 31	0	0.0	0	0.0	0
OP 32	0	0.0	0	0.0	0
OP 33	0	0.0	0	0.0	0
OP 34	0	0.0	0	0.0	0
OP 35	0	0.0	0	0.0	0
OP 36	0	0.0	0	0.0	0

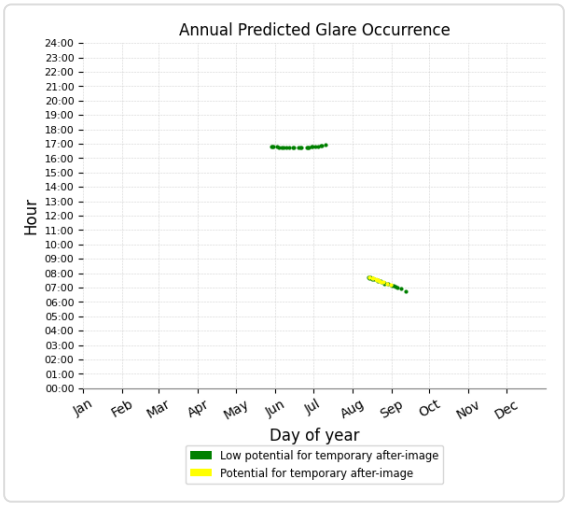
Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
OP 37	0	0.0	0	0.0	0
OP 38	0	0.0	0	0.0	0
OP 39	0	0.0	0	0.0	0
OP 40	0	0.0	0	0.0	0

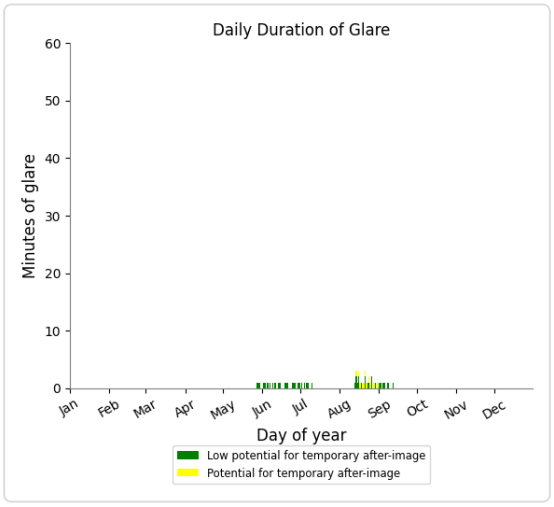


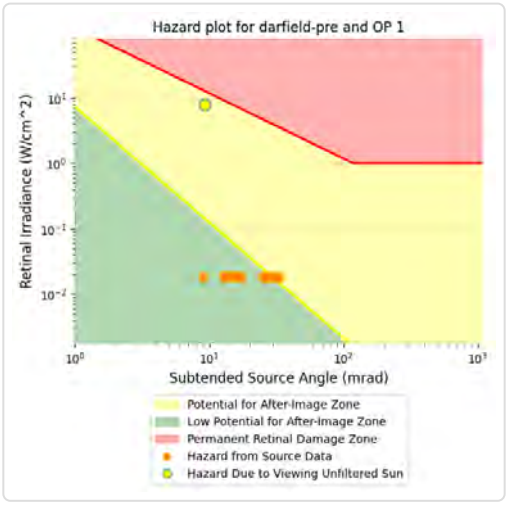
Darfield Preliminary and OP 1

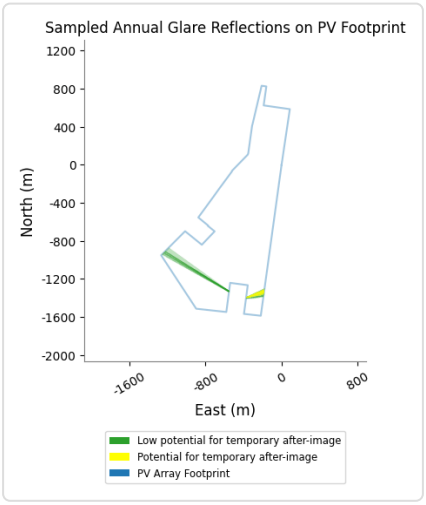
Yellow glare: 11 min.

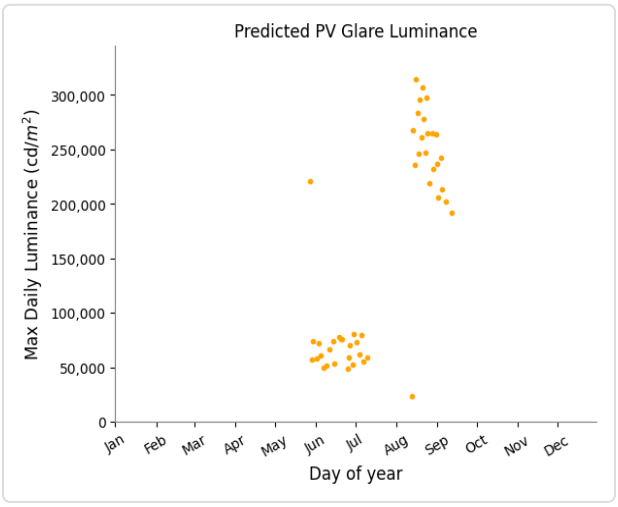
Green glare: 44 min.







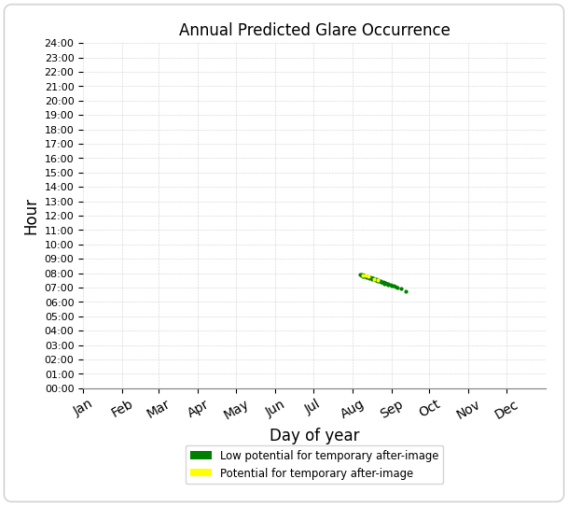


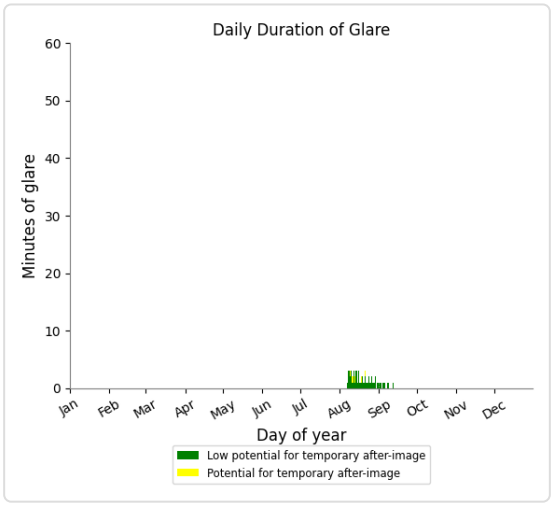


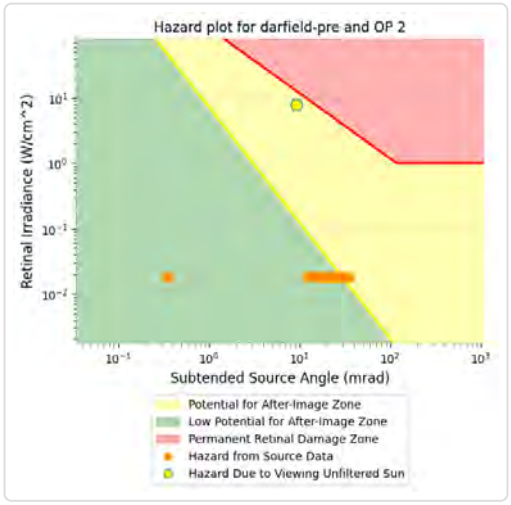
Darfield Preliminary and OP 2

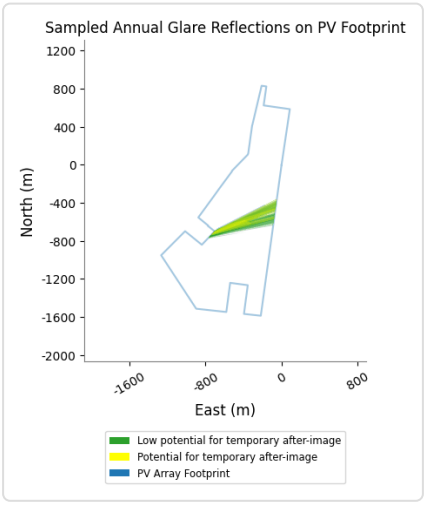
Yellow glare: 5 min.

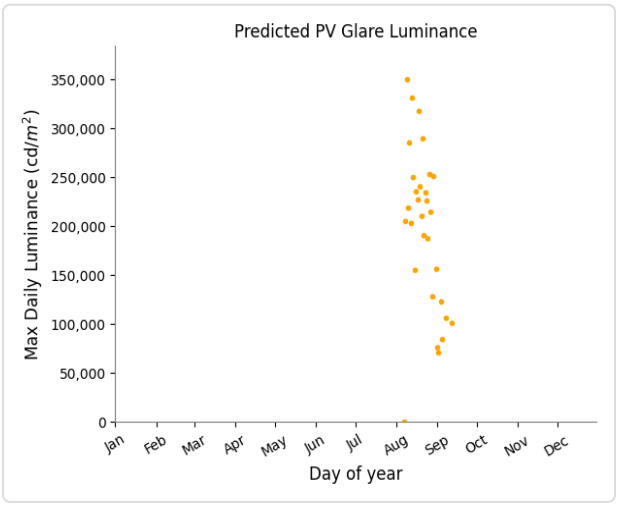
Green glare: 46 min.







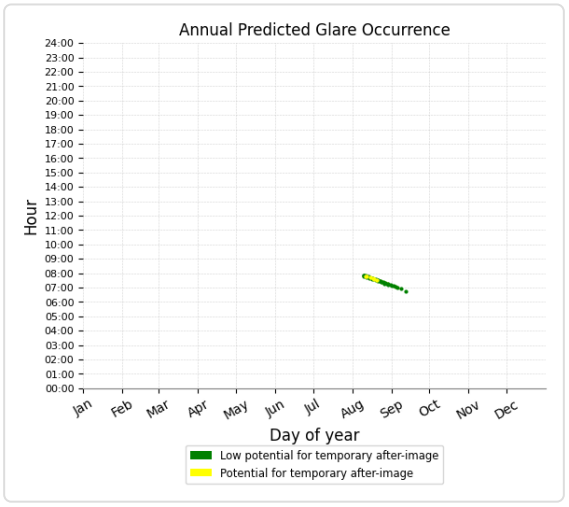


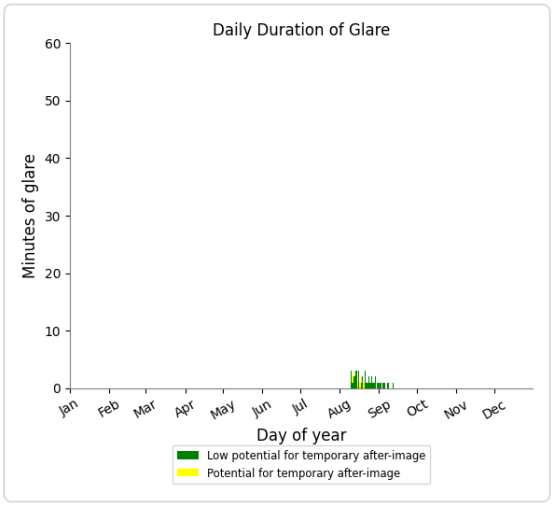


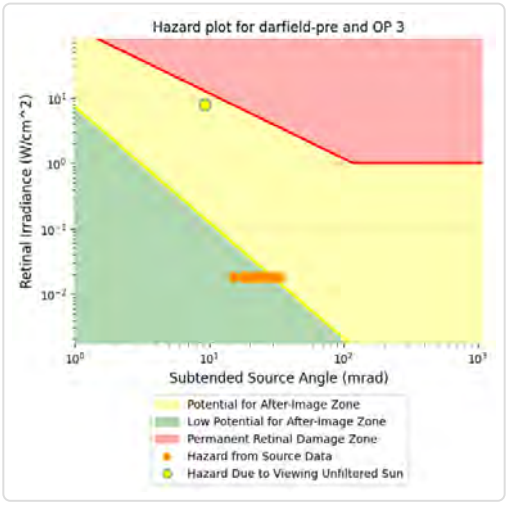
Darfield Preliminary and OP 3

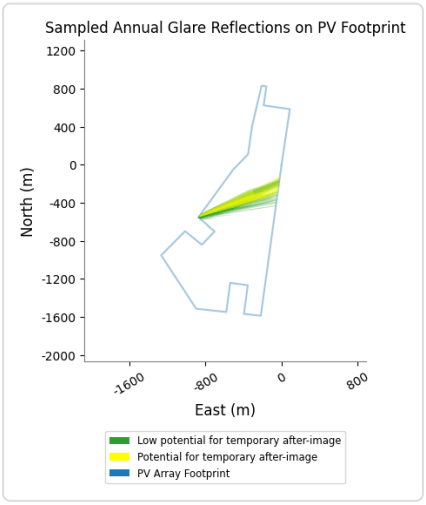
Yellow glare: 6 min.

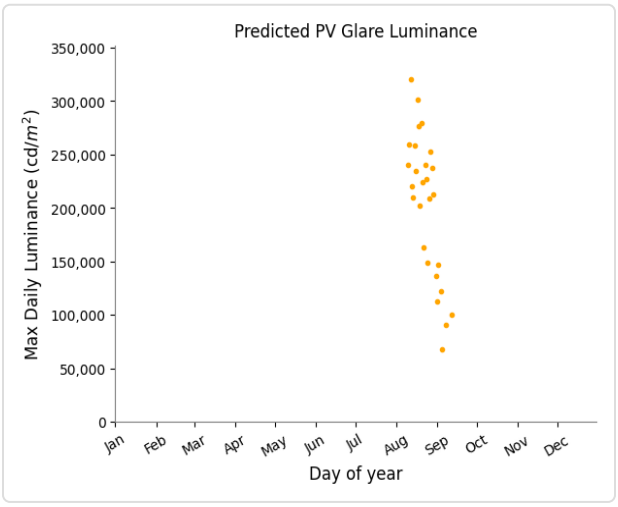
Green glare: 38 min.







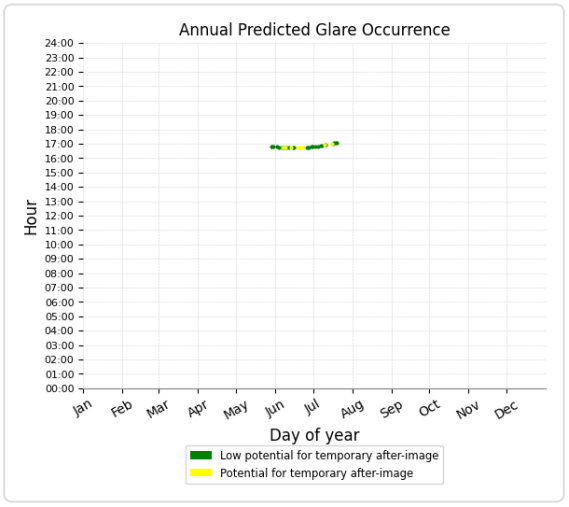


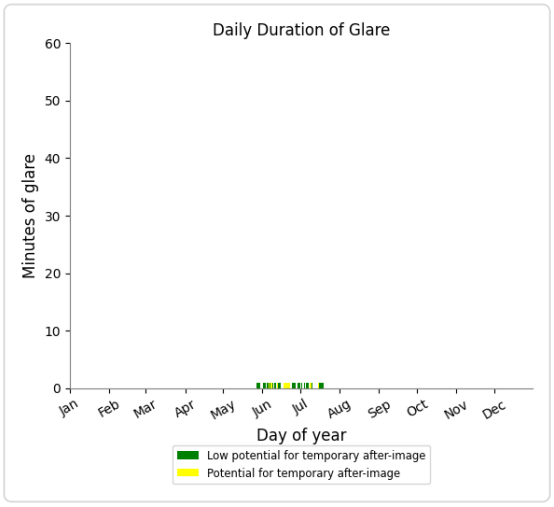


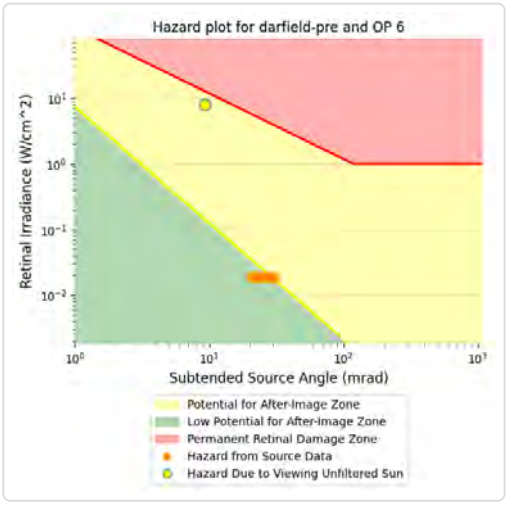
Darfield Preliminary and OP 6

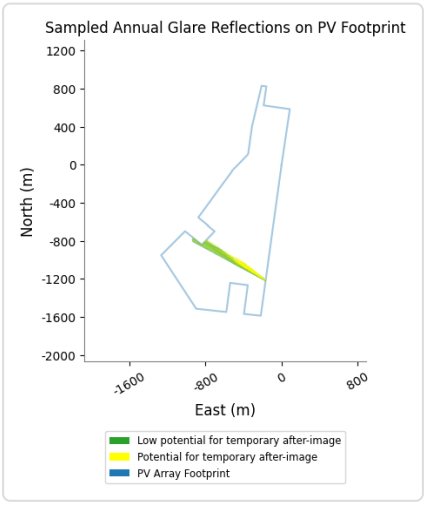
Yellow glare: 10 min.

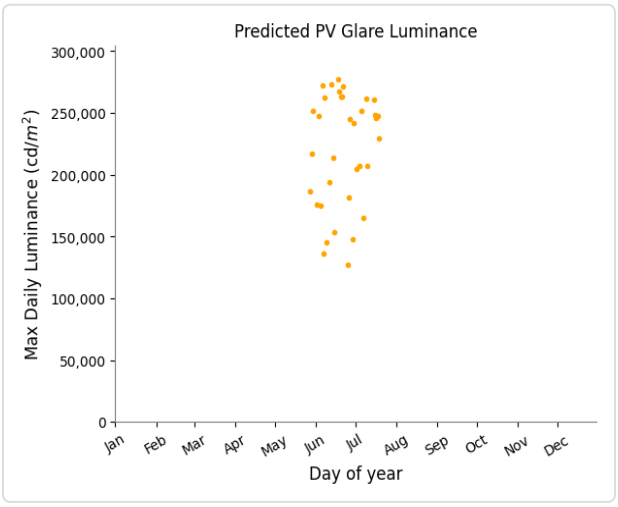
Green glare: 25 min.







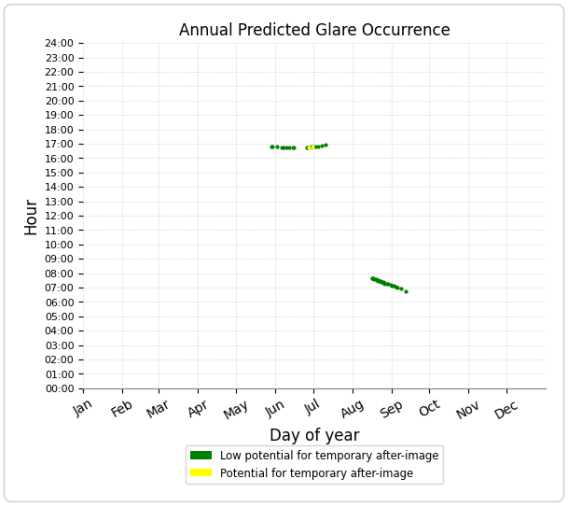


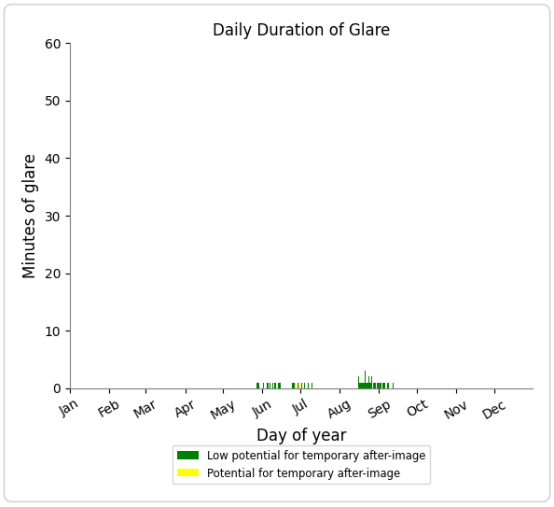


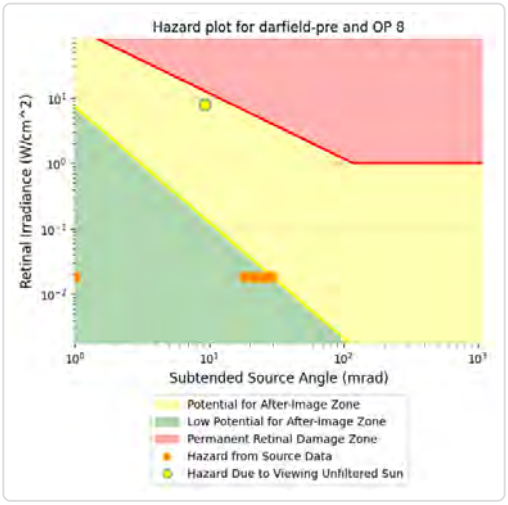
Darfield Preliminary and OP 8

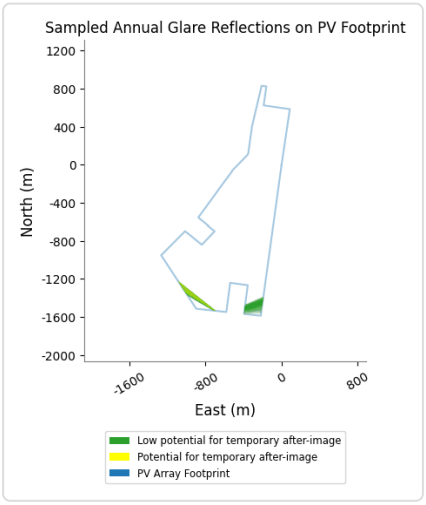
Yellow glare: 2 min.

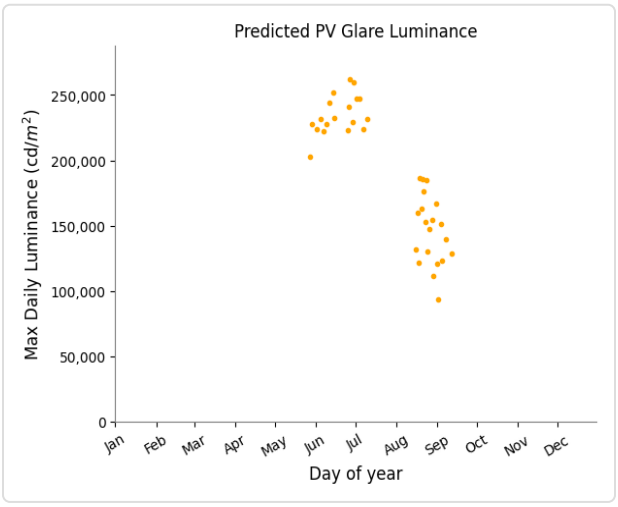
Green glare: 41 min.







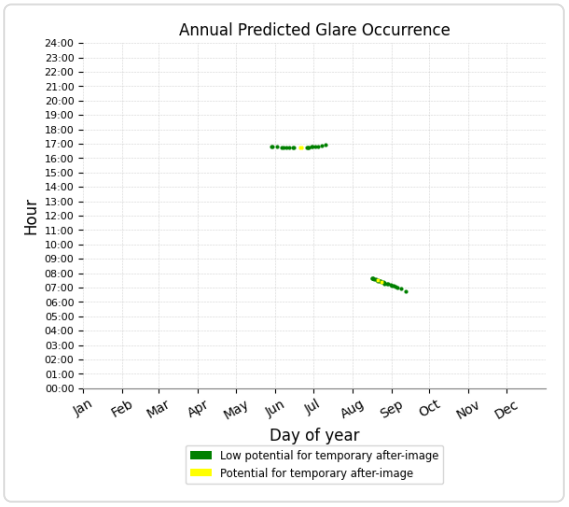


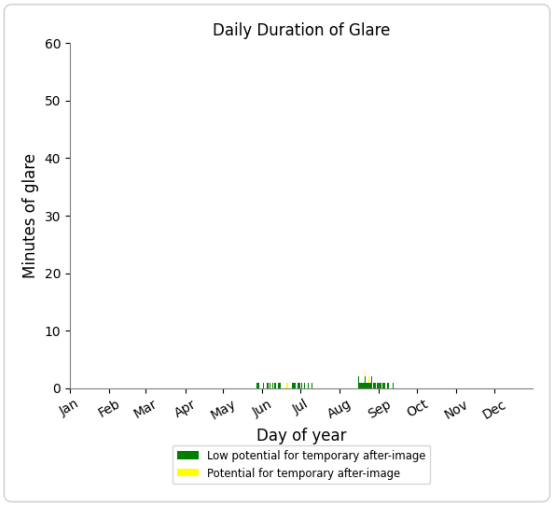


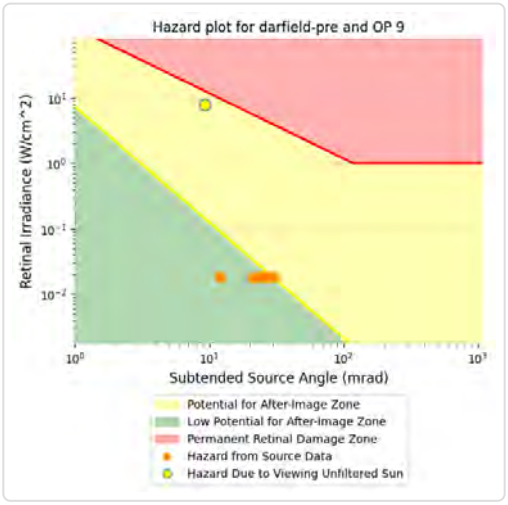
Darfield Preliminary and OP 9

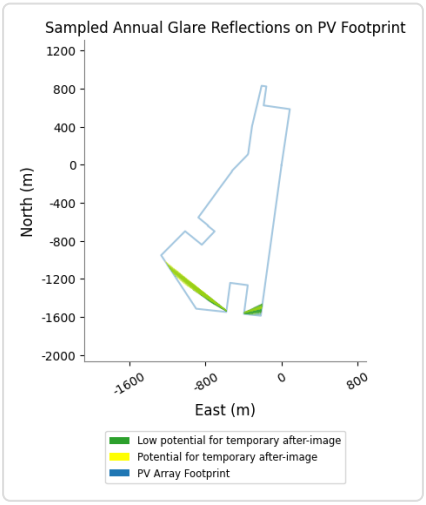
Yellow glare: 4 min.

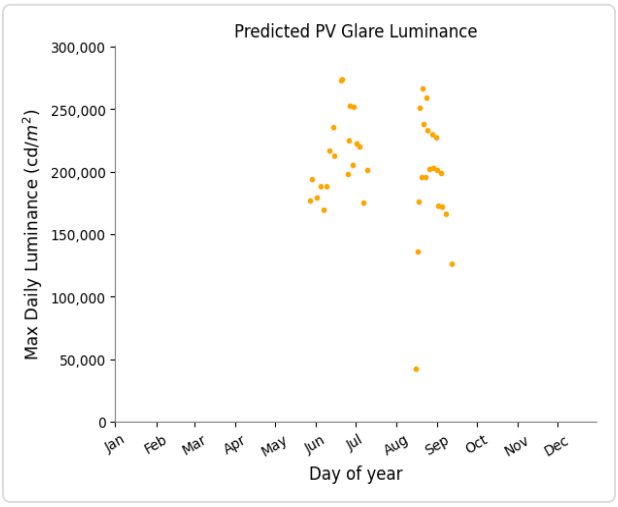
Green glare: 41 min.







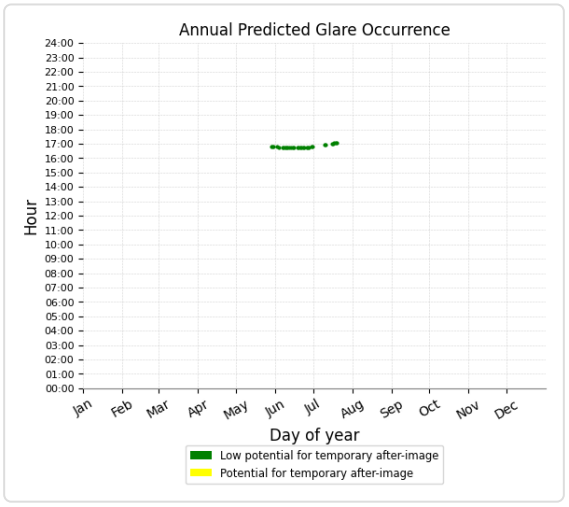


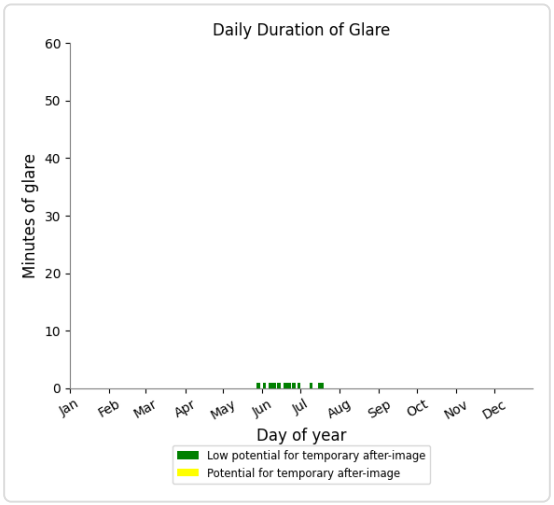


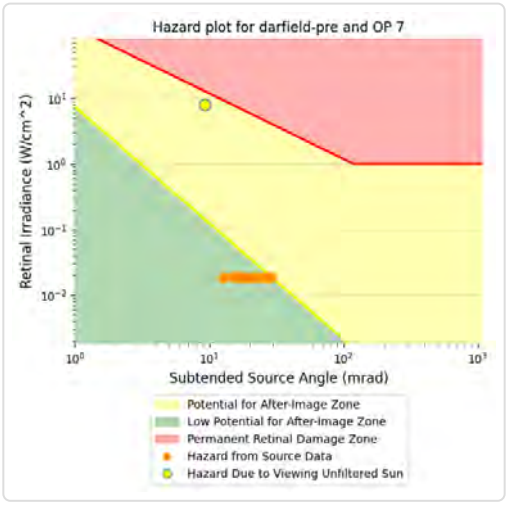
Darfield Preliminary and OP 7

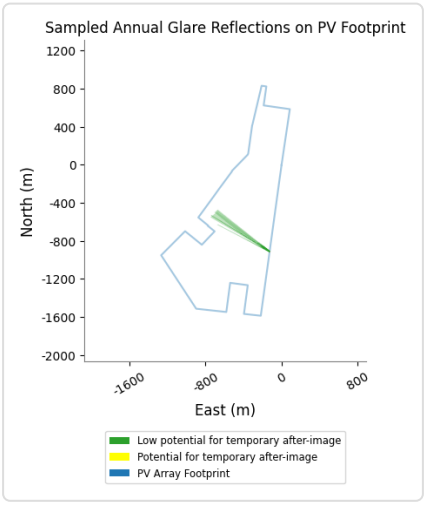
Yellow glare: none

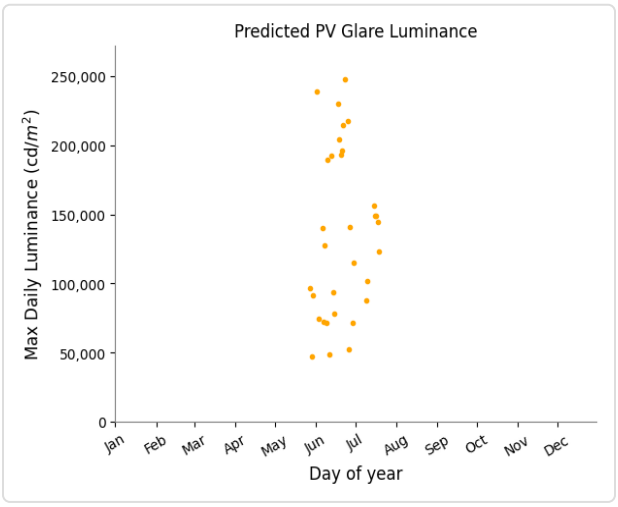
Green glare: 32 min.







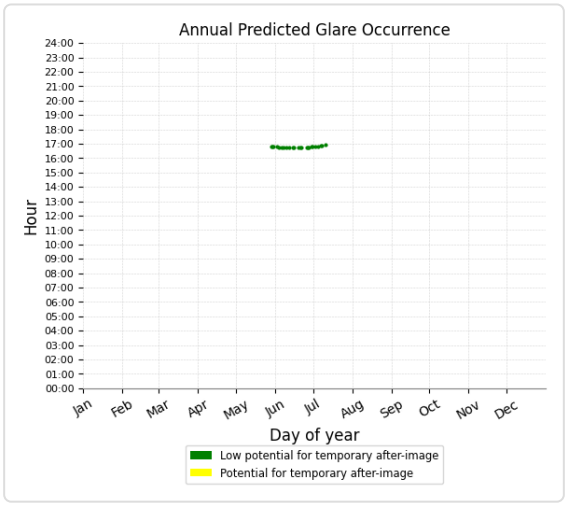


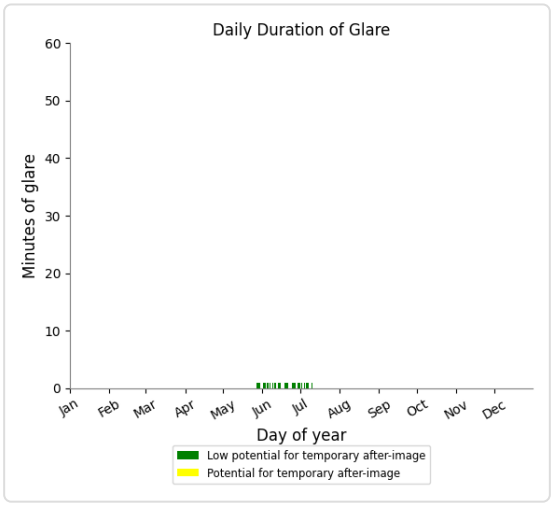


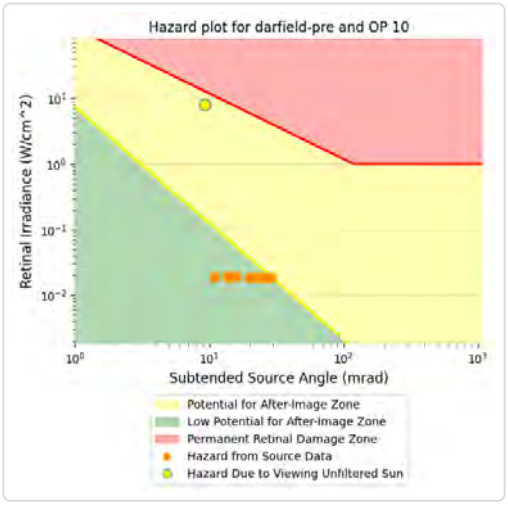
Darfield Preliminary and OP 10

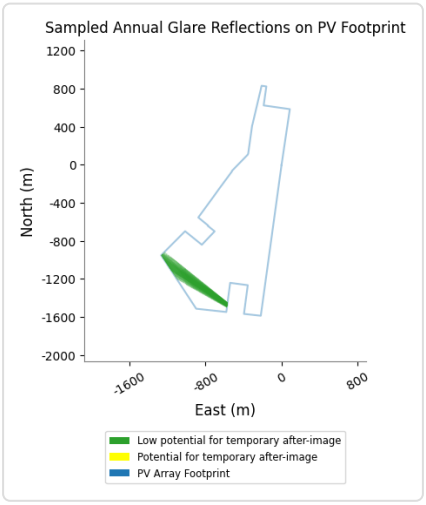
Yellow glare: none

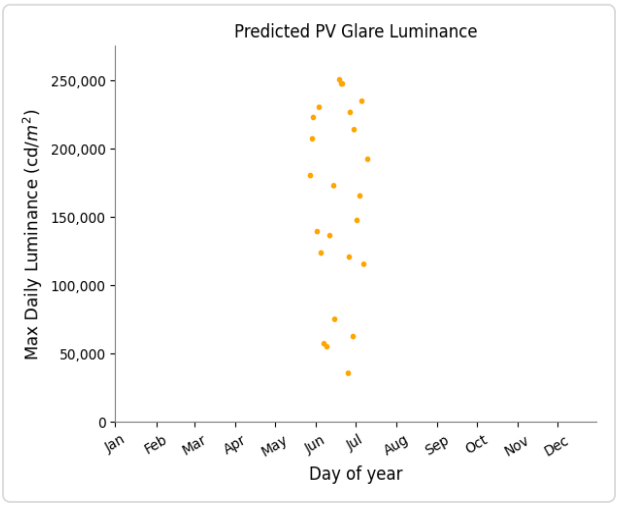
Green glare: 24 min.







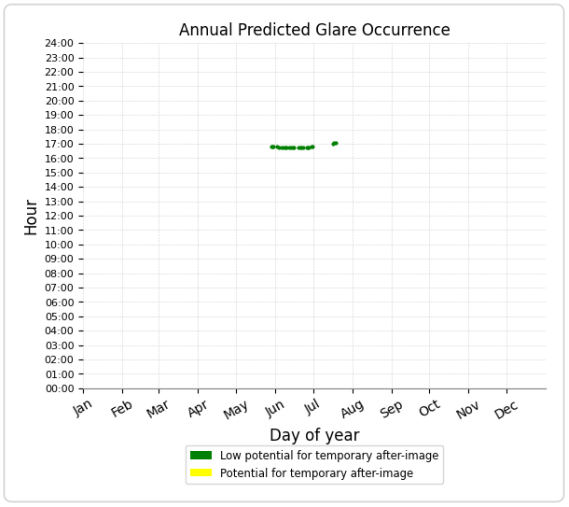


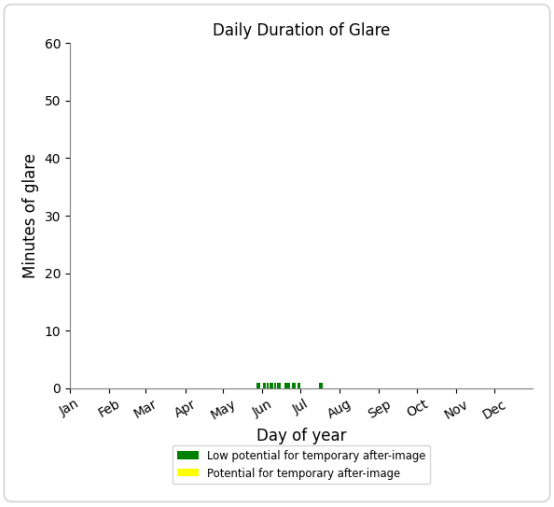


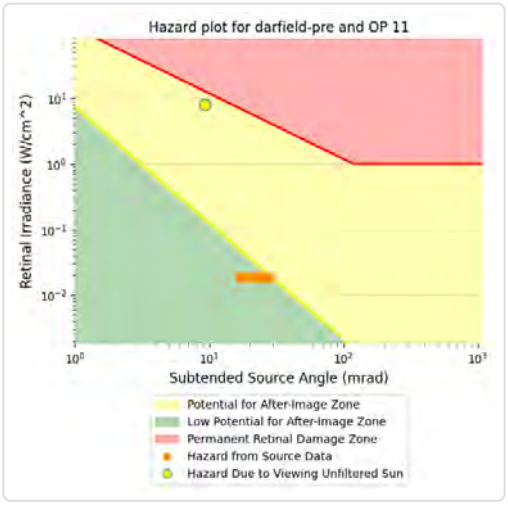
Darfield Preliminary and OP 11

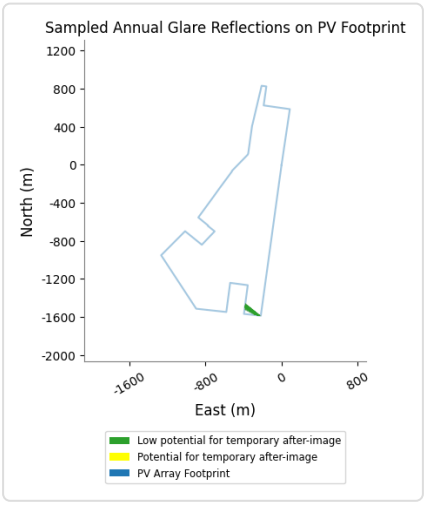
Yellow glare: none

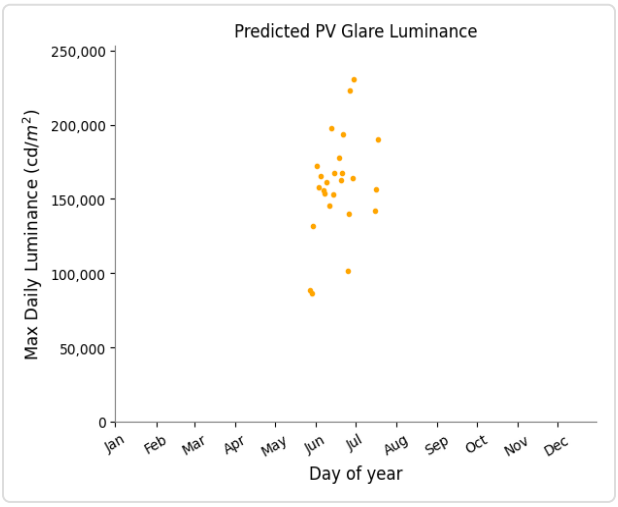
Green glare: 25 min.







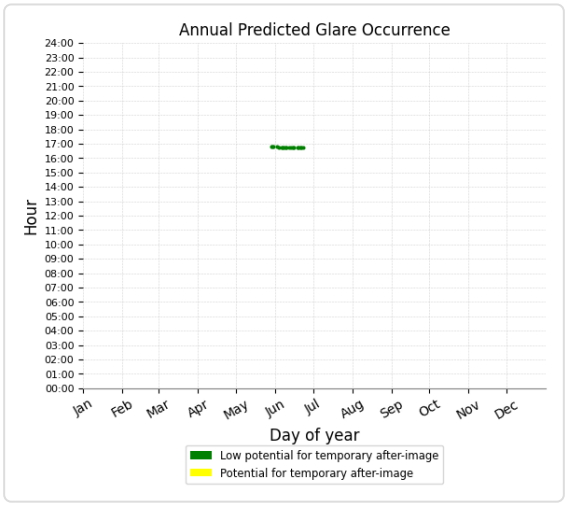


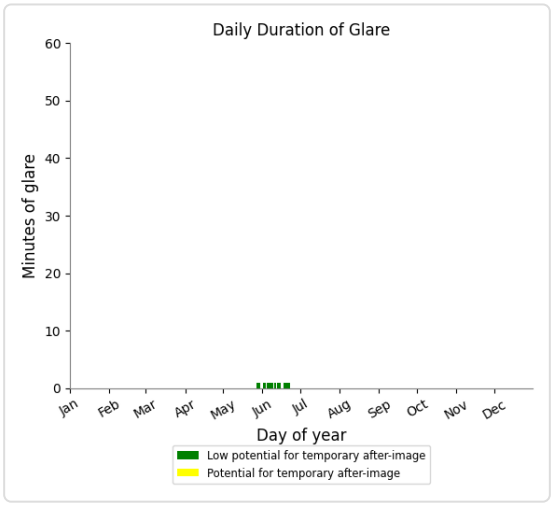


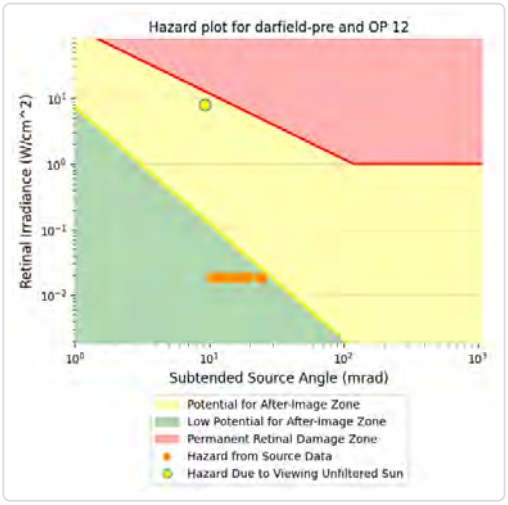
Darfield Preliminary and OP 12

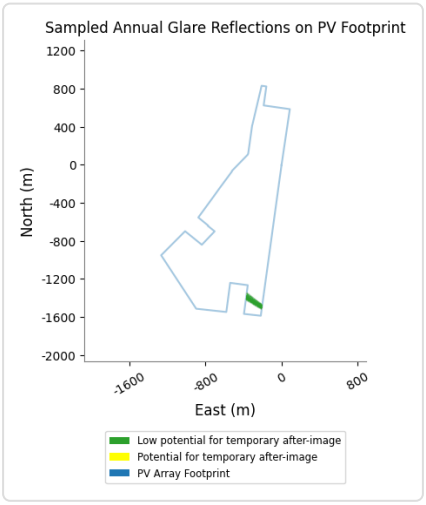
Yellow glare: none

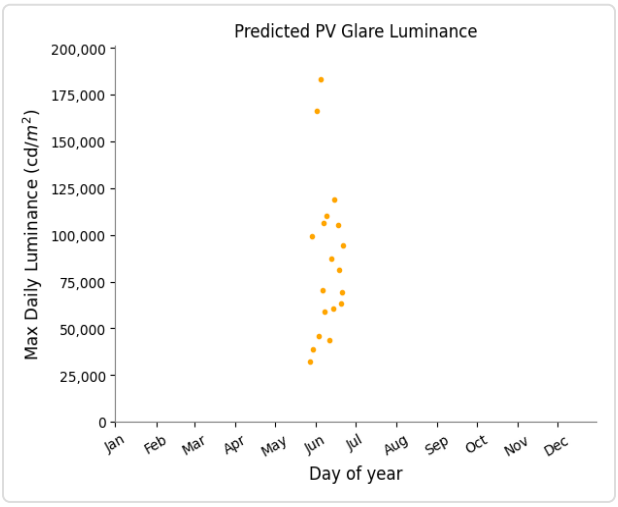
Green glare: 19 min.











Darfield Preliminary and OP 4

No glare found

Darfield Preliminary and OP 5

No glare found

Darfield Preliminary and OP 13

No glare found

Darfield Preliminary and OP 14

No glare found

Darfield Preliminary and OP 15

No glare found

Darfield Preliminary and OP 16

No glare found

Darfield Preliminary and OP 17

No glare found

Darfield Preliminary and OP 18

No glare found

Darfield Preliminary and OP 19

No glare found

Darfield Preliminary and OP 20

No glare found

Darfield Preliminary and OP 21

No glare found

Darfield Preliminary and OP 22

No glare found

Darfield Preliminary and OP 23

No glare found

Darfield Preliminary and OP 24

No glare found

Darfield Preliminary and OP 25

No glare found

Darfield Preliminary and OP 26

No glare found

Darfield Preliminary and OP 27

No glare found

Darfield Preliminary and OP 28

No glare found

Darfield Preliminary and OP 29

No glare found

Darfield Preliminary and OP 30

No glare found

Darfield Preliminary and OP 31

No glare found

Darfield Preliminary and OP 32

No glare found

Darfield Preliminary and OP 33

No glare found

Darfield Preliminary and OP 34

No glare found

Darfield Preliminary and OP 35

No glare found

Darfield Preliminary and OP 36

No glare found

Darfield Preliminary and OP 37

No glare found

Darfield Preliminary and OP 38

No glare found

Darfield Preliminary and OP 39

No glare found

Darfield Preliminary and OP 40

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

FORGESOLAR GLARE ANALYSIS

Project: **Darfield Solar**
Site configuration: **Darfield - WITH OBSTRUCTIONS R2**

Client: NZ Clean Energy

Site description: Observer locations with environmental obstructions

Created 30 May, 2024
Updated 30 May, 2024
Time-step 1 minute
Timezone offset UTC12
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 100 to 500 kW
Site ID 120492.20038

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	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
Darfield Preliminary	SA tracking	SA tracking	167	2.8	21	0.3	-	307,275

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
OP 1	22	0.4	9	0.1
OP 2	38	0.6	3	0.1
OP 3	0	0.0	0	0.0
OP 4	0	0.0	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	25	0.4	0	0.0
OP 9	36	0.6	9	0.1
OP 10	24	0.4	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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	22	0.4	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
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

Component Data

PV Arrays

Name: Darfield Preliminary
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 7.5467°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.434
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	-43.451667	172.097071	231.90	1.40	233.30
2	-43.465951	172.094370	221.20	1.40	222.60
3	-43.465778	172.092183	221.10	1.50	222.60
4	-43.463059	172.092676	223.80	1.40	225.20
5	-43.462839	172.090390	224.50	1.40	225.90
6	-43.465596	172.089889	222.20	1.40	223.60
7	-43.465287	172.085972	223.20	1.40	224.60
8	-43.460230	172.081414	229.00	1.40	230.40
9	-43.457955	172.084528	230.10	1.40	231.50
10	-43.459237	172.086705	228.40	1.40	229.80
11	-43.457965	172.088370	229.40	1.40	230.80
12	-43.457442	172.087479	229.80	1.40	231.20
13	-43.457410	172.087512	229.80	1.50	231.30
14	-43.456653	172.086246	230.60	1.40	232.00
15	-43.454706	172.088200	232.30	1.40	233.70
16	-43.453924	172.088971	232.60	1.40	234.00
17	-43.452312	172.090606	233.40	1.40	234.80
18	-43.452239	172.090630	233.60	1.40	235.00
19	-43.450710	172.092674	234.00	1.50	235.50
20	-43.450660	172.092704	234.00	1.40	235.40
21	-43.450585	172.092739	233.90	1.40	235.30
22	-43.447953	172.093245	236.10	1.40	237.50
23	-43.447856	172.093289	236.10	1.40	237.50
24	-43.444192	172.094476	238.40	1.40	239.80
25	-43.444256	172.095094	237.70	1.50	239.20
26	-43.446052	172.094744	237.20	1.40	238.60
27	-43.446405	172.098146	235.30	1.40	236.70

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-43.464387	172.091797	222.80	1.60
OP 2	2	-43.458671	172.086307	229.40	1.60
OP 3	3	-43.456912	172.084893	230.80	1.60
OP 4	4	-43.456103	172.083137	232.10	1.60
OP 5	5	-43.454771	172.079477	234.00	1.60
OP 6	6	-43.462983	172.095766	223.30	1.60
OP 7	7	-43.460258	172.096295	225.30	1.60
OP 8	8	-43.465873	172.089187	222.00	1.60
OP 9	9	-43.465961	172.090847	221.40	1.60
OP 10	10	-43.466551	172.093262	220.30	1.60
OP 11	11	-43.466745	172.095720	219.90	1.60
OP 12	12	-43.466939	172.098178	219.40	1.60
OP 13	13	-43.467133	172.100636	218.50	1.60
OP 14	14	-43.467714	172.108010	215.70	1.60
OP 15	15	-43.468240	172.116054	213.70	1.60
OP 16	16	-43.473094	172.115783	210.30	1.60
OP 17	17	-43.474994	172.103772	211.80	1.60
OP 18	18	-43.474423	172.101117	212.10	1.60
OP 19	19	-43.476828	172.099929	210.70	1.60
OP 20	20	-43.478120	172.084550	213.10	1.60
OP 21	21	-43.478109	172.071468	214.60	1.60
OP 22	22	-43.465628	172.059271	229.30	1.60
OP 23	23	-43.464938	172.068560	226.90	1.60
OP 24	24	-43.466480	172.081114	225.70	1.60
OP 25	25	-43.454336	172.074992	236.10	1.60
OP 26	26	-43.446973	172.069888	246.00	1.60
OP 27	27	-43.442225	172.067733	250.50	1.60
OP 28	28	-43.441146	172.071761	250.30	1.60
OP 29	29	-43.438282	172.074647	250.80	1.60
OP 30	30	-43.436611	172.084236	246.90	1.60
OP 31	31	-43.434756	172.086878	246.80	1.60
OP 32	32	-43.432439	172.094054	244.90	1.60
OP 33	33	-43.430610	172.103736	241.70	1.60
OP 34	34	-43.436036	172.123475	230.60	1.60
OP 35	35	-43.439780	172.122011	229.50	1.60
OP 36	36	-43.444801	172.106926	233.20	1.60
OP 37	37	-43.448283	172.120202	226.00	1.60
OP 38	38	-43.450926	172.118838	224.60	1.60
OP 39	39	-43.453415	172.121308	222.30	1.60
OP 40	40	-43.456588	172.117357	220.90	1.60

Obstruction Components

Name: Amenity Planting OP1
Top height: 6.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.465829	172.091864	227.36
2	-43.464766	172.091971	228.22
3	-43.464415	172.092110	228.47
4	-43.463968	172.092194	228.88
5	-43.463514	172.091472	229.63
6	-43.464303	172.091134	228.36
7	-43.464698	172.091842	228.33
8	-43.464760	172.091901	228.27
9	-43.465330	172.091848	227.76
10	-43.465714	172.091805	227.64

Name: Fonterra Boundary Planting
Top height: 3.2 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.460182	172.081254	232.80
2	-43.457827	172.084483	233.75
3	-43.459100	172.086682	231.82
4	-43.457936	172.088195	232.38
5	-43.456647	172.086098	233.97
6	-43.452500	172.090266	236.71
7	-43.452126	172.090421	236.72
8	-43.450646	172.092444	237.45
9	-43.447900	172.092996	239.38
10	-43.444376	172.094150	241.66

Name: Fonterra Store
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.451541	172.082794	245.15
2	-43.448948	172.085712	245.09
3	-43.449104	172.085959	245.34
4	-43.447959	172.087279	245.13
5	-43.448340	172.087890	245.03

Name: Forestry Woodlot Auchenflower Road
Top height: 4.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.444200	172.095249	241.73
2	-43.445969	172.094874	241.17
3	-43.446109	172.096156	240.37
4	-43.444337	172.096462	241.11
5	-43.444200	172.095249	241.73

Name: Hedge Row OP6
Top height: 3.2 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.463235	172.095310	226.09
2	-43.462384	172.095482	227.18
3	-43.462439	172.096176	226.78
4	-43.463089	172.096050	226.29
5	-43.463149	172.096144	226.49
6	-43.463379	172.096101	225.89
7	-43.463313	172.095299	225.99

Name: Hedge Row OP7
Top height: 6.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.460108	172.095870	231.59
2	-43.459682	172.095959	231.84
3	-43.459781	172.096686	231.48
4	-43.460052	172.096635	231.41
5	-43.460081	172.096858	231.29
6	-43.461243	172.096627	230.41
7	-43.461127	172.095672	230.76
8	-43.460157	172.095865	231.63

Name: McHughs Forest Park
Top height: 20.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.477307	172.096737	231.48
2	-43.465698	172.086308	242.70
3	-43.466033	172.090750	241.89
4	-43.473150	172.097187	234.32
5	-43.473267	172.096973	234.38
6	-43.474886	172.098571	232.74
7	-43.476054	172.099258	231.44

Name: Middle Bund
Top height: 3.5 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.455798	172.084829	237.04
2	-43.454229	172.086216	239.21
3	-43.453606	172.086961	239.16
4	-43.451971	172.088831	240.67

Name: Northern Bund
Top height: 3.5 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.451649	172.089161	240.09
2	-43.450888	172.090035	240.48

Name: Southern Bund
Top height: 3.2 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.459270	172.082155	233.41
2	-43.458222	172.083424	234.83
3	-43.457932	172.083542	234.74
4	-43.457457	172.083678	235.11
5	-43.457056	172.083960	235.70
6	-43.456573	172.084411	236.95
7	-43.455726	172.085567	238.55

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	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
Darfield Preliminary	SA tracking	SA tracking	167	2.8	21	0.3	-	307,275

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
OP 1	22	0.4	9	0.1
OP 2	38	0.6	3	0.1
OP 3	0	0.0	0	0.0
OP 4	0	0.0	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	25	0.4	0	0.0
OP 9	36	0.6	9	0.1
OP 10	24	0.4	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	22	0.4	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

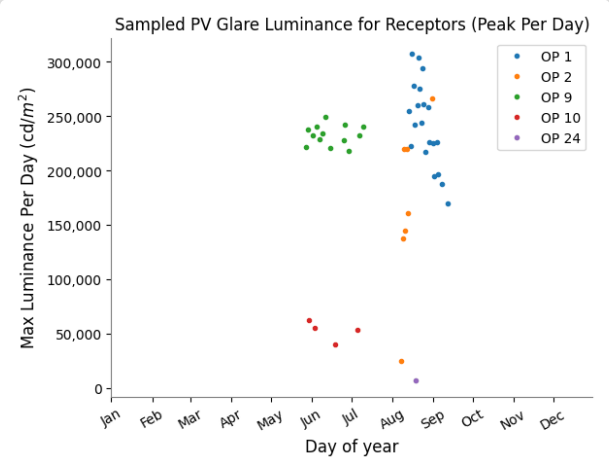
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

PV: Darfield Preliminary potential temporary after-image

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
OP 1	22	0.4	9	0.1	307,275
OP 2	38	0.6	3	0.1	294,093
OP 9	36	0.6	9	0.1	277,364
OP 8	25	0.4	0	0.0	195,956
OP 10	24	0.4	0	0.0	62,815
OP 24	22	0.4	0	0.0	161,373
OP 3	0	0.0	0	0.0	0
OP 4	0	0.0	0	0.0	0
OP 5	0	0.0	0	0.0	0
OP 6	0	0.0	0	0.0	0
OP 7	0	0.0	0	0.0	0
OP 11	0	0.0	0	0.0	0
OP 12	0	0.0	0	0.0	0
OP 13	0	0.0	0	0.0	0
OP 14	0	0.0	0	0.0	0
OP 15	0	0.0	0	0.0	0
OP 16	0	0.0	0	0.0	0
OP 17	0	0.0	0	0.0	0
OP 18	0	0.0	0	0.0	0
OP 19	0	0.0	0	0.0	0
OP 20	0	0.0	0	0.0	0
OP 21	0	0.0	0	0.0	0
OP 22	0	0.0	0	0.0	0
OP 23	0	0.0	0	0.0	0
OP 25	0	0.0	0	0.0	0
OP 26	0	0.0	0	0.0	0
OP 27	0	0.0	0	0.0	0
OP 28	0	0.0	0	0.0	0
OP 29	0	0.0	0	0.0	0
OP 30	0	0.0	0	0.0	0
OP 31	0	0.0	0	0.0	0
OP 32	0	0.0	0	0.0	0
OP 33	0	0.0	0	0.0	0
OP 34	0	0.0	0	0.0	0
OP 35	0	0.0	0	0.0	0
OP 36	0	0.0	0	0.0	0

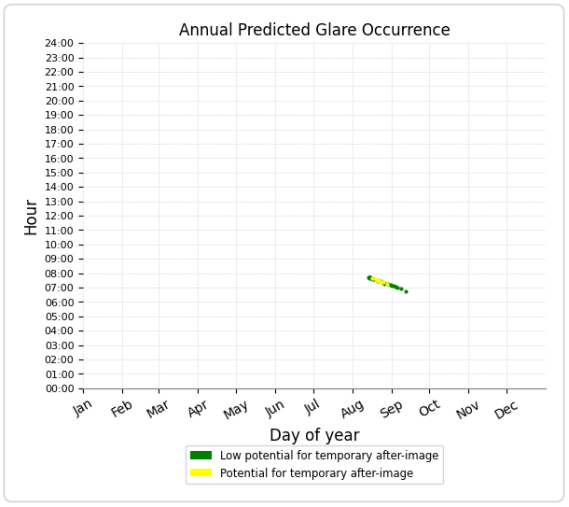
Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
OP 37	0	0.0	0	0.0	0
OP 38	0	0.0	0	0.0	0
OP 39	0	0.0	0	0.0	0
OP 40	0	0.0	0	0.0	0

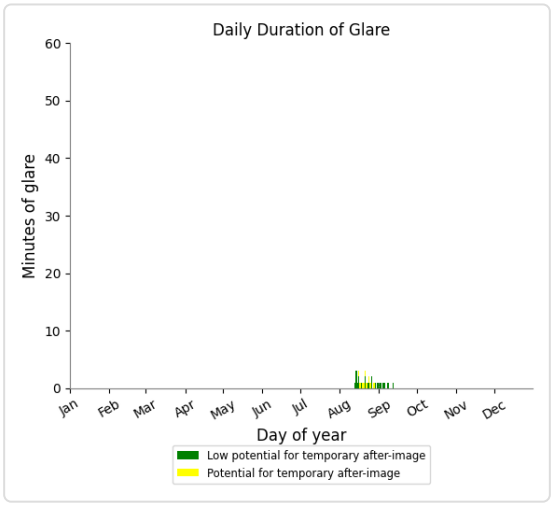


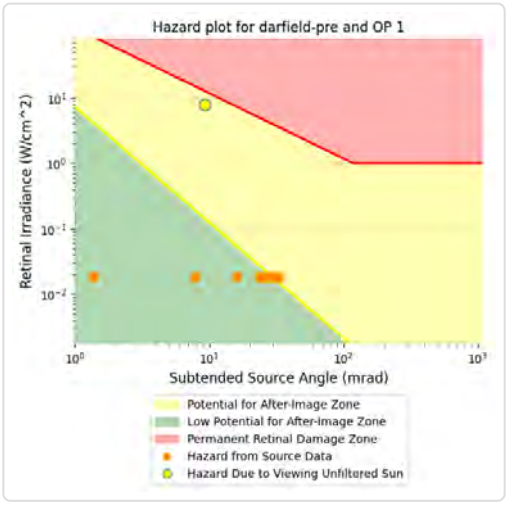
Darfield Preliminary and OP 1

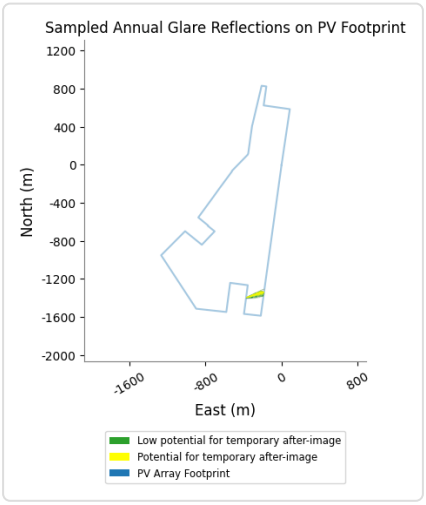
Yellow glare: 9 min.

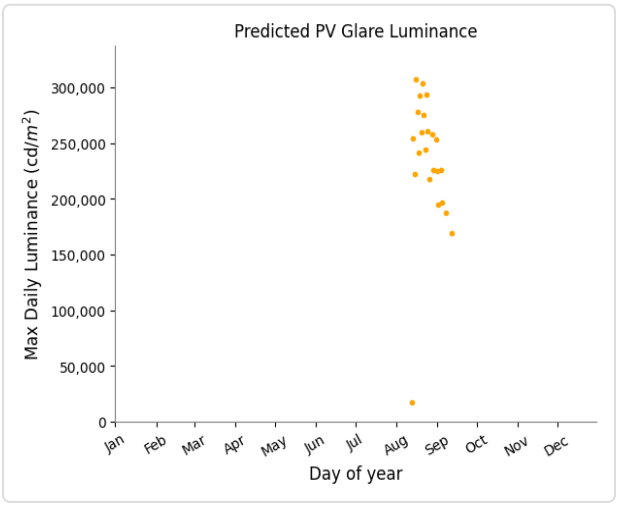
Green glare: 22 min.







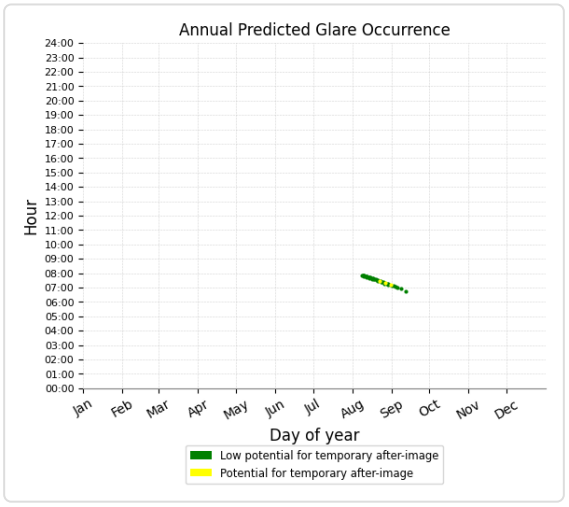


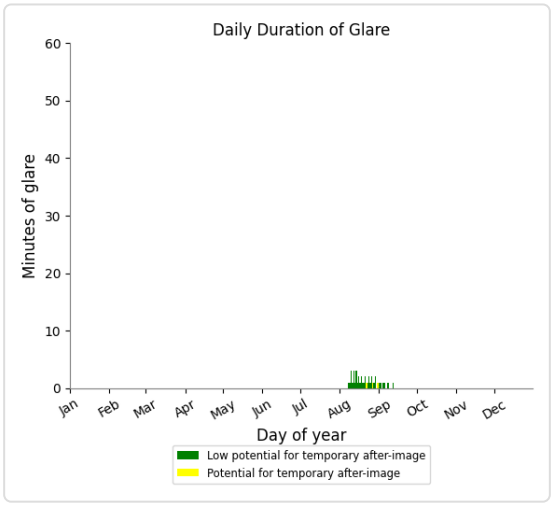


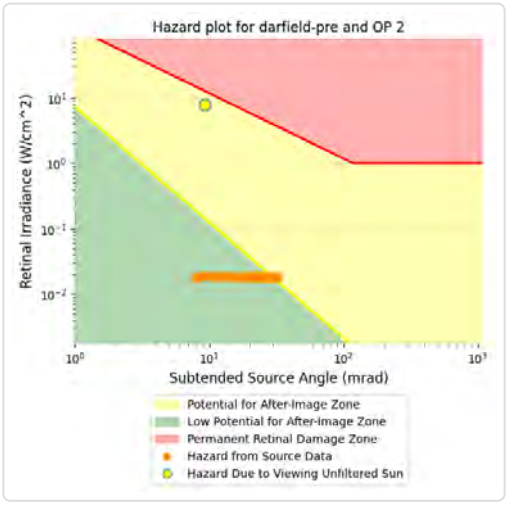
Darfield Preliminary and OP 2

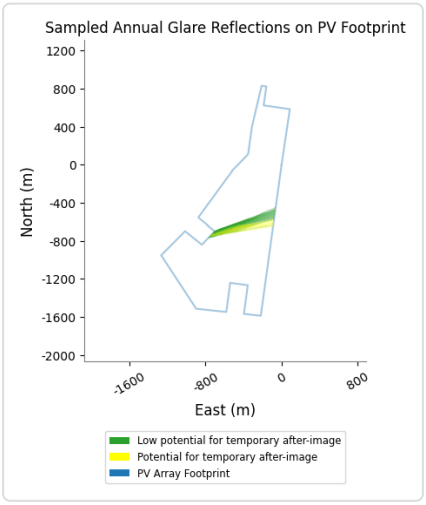
Yellow glare: 3 min.

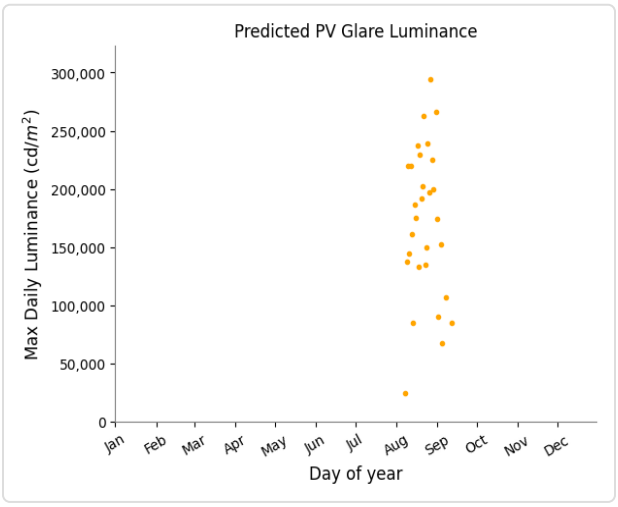
Green glare: 38 min.







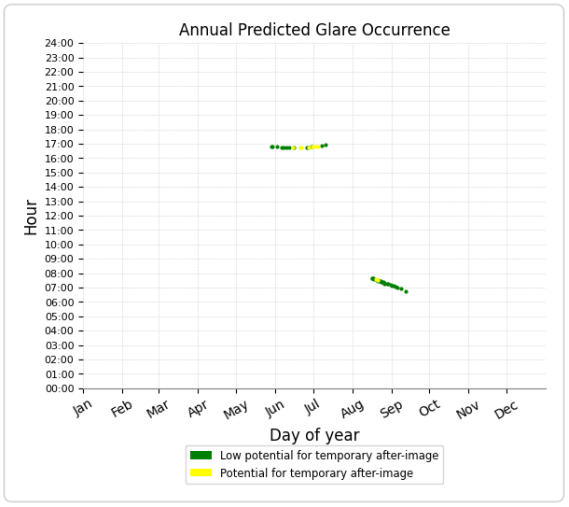


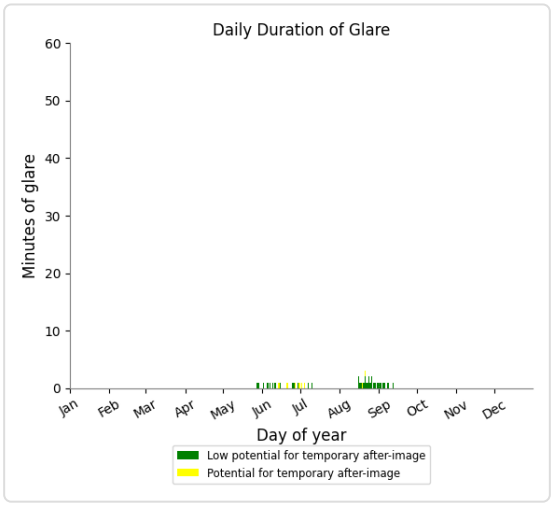


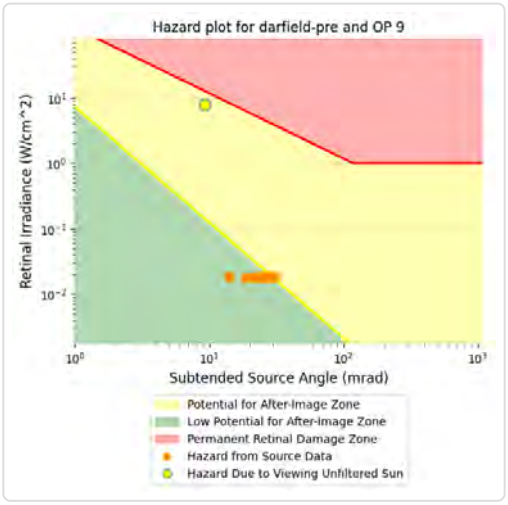
Darfield Preliminary and OP 9

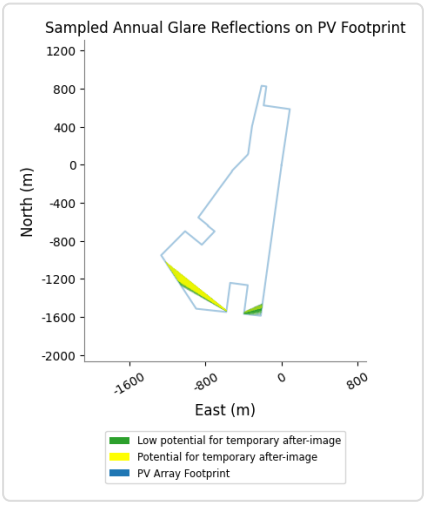
Yellow glare: 9 min.

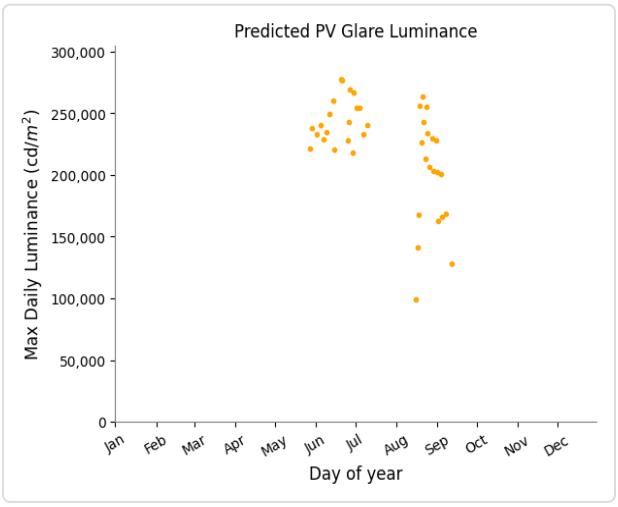
Green glare: 36 min.







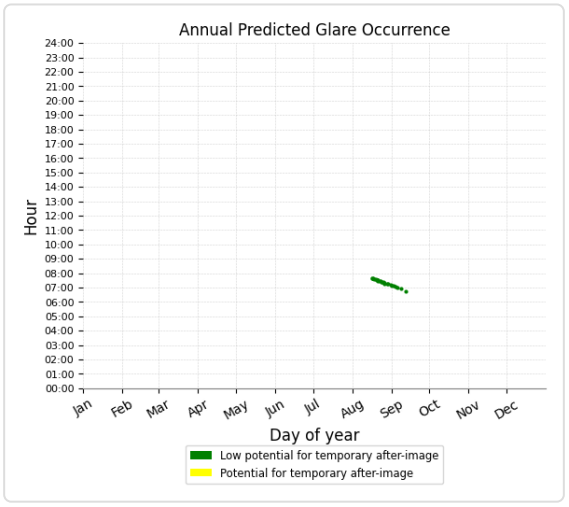


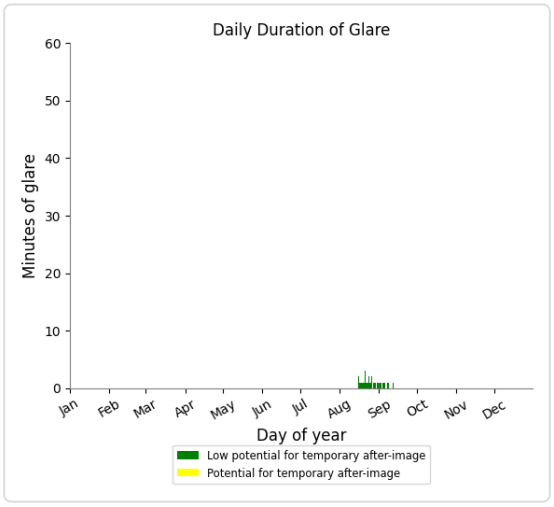


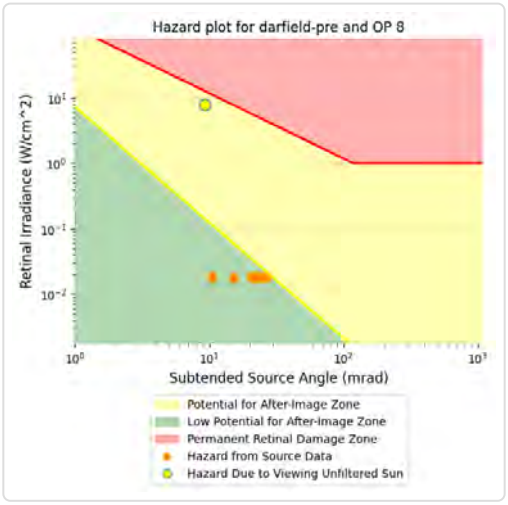
Darfield Preliminary and OP 8

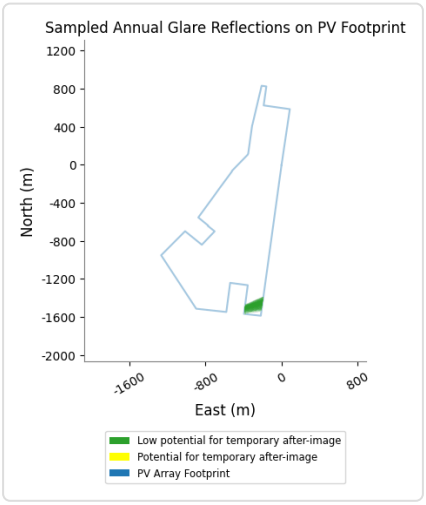
Yellow glare: none

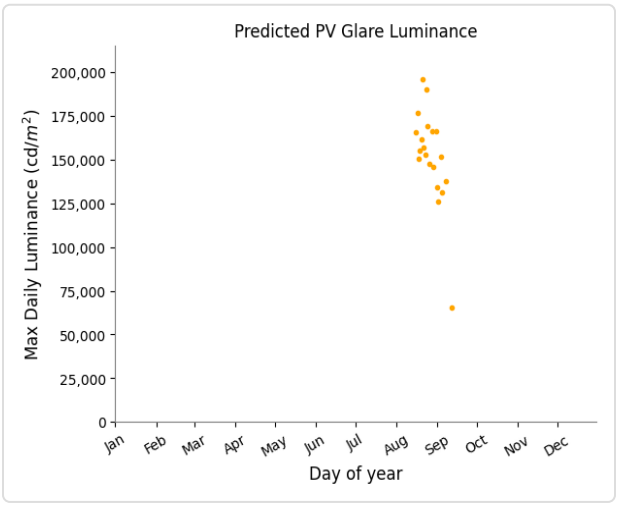
Green glare: 25 min.







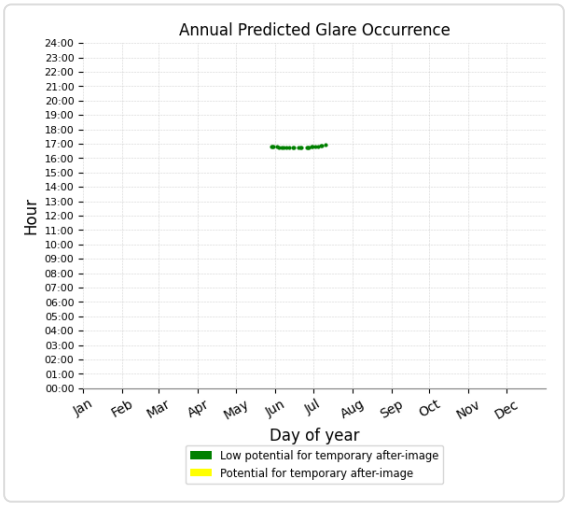


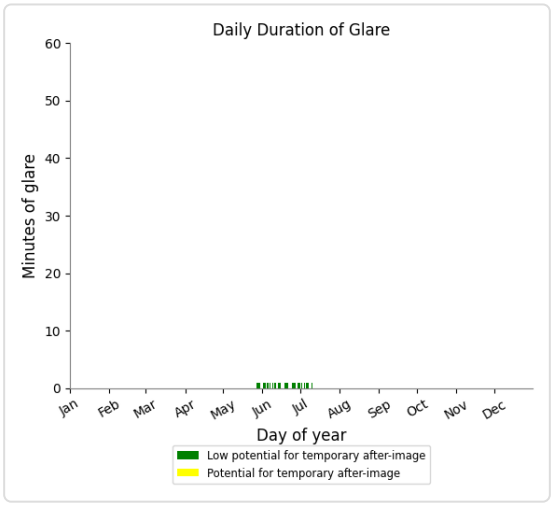


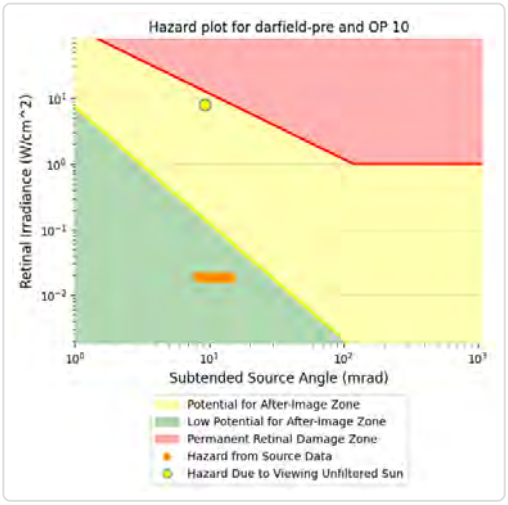
Darfield Preliminary and OP 10

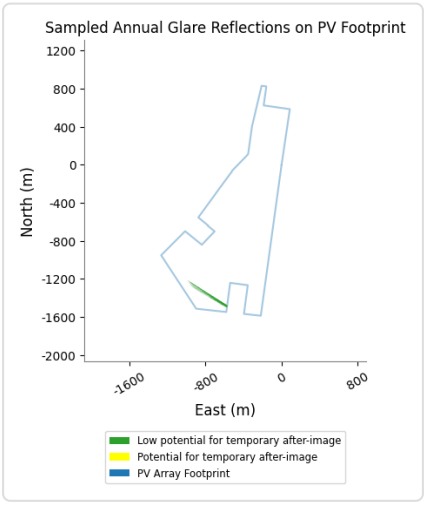
Yellow glare: none

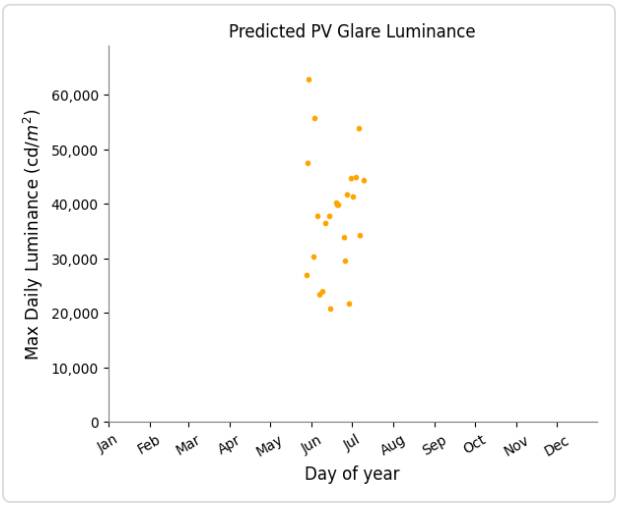
Green glare: 24 min.







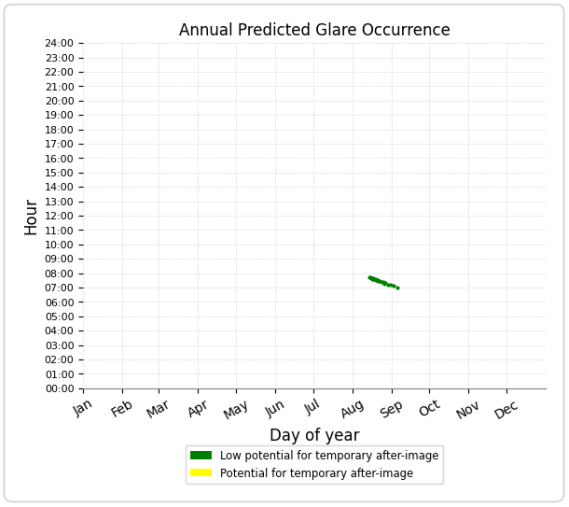


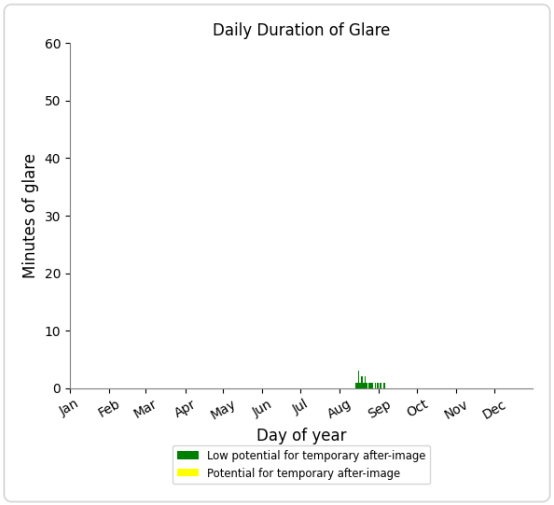


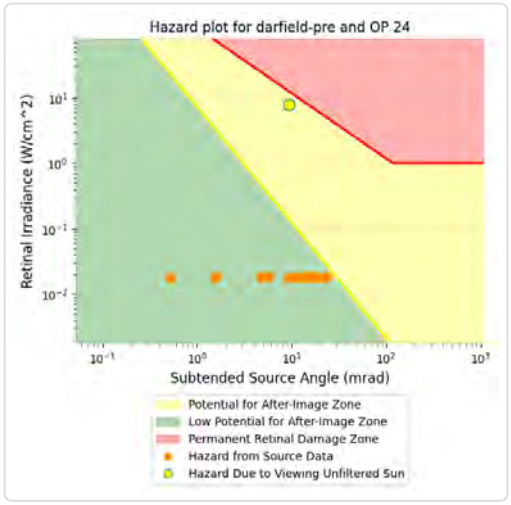
Darfield Preliminary and OP 24

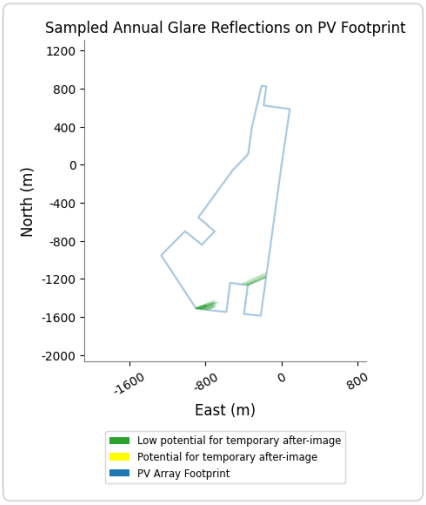
Yellow glare: none

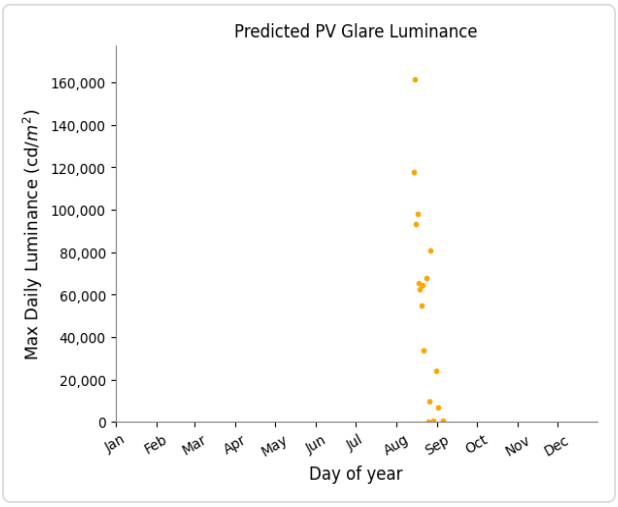
Green glare: 22 min.











Darfield Preliminary and OP 3

No glare found

Darfield Preliminary and OP 4

No glare found

Darfield Preliminary and OP 5

No glare found

Darfield Preliminary and OP 6

No glare found

Darfield Preliminary and OP 7

No glare found

Darfield Preliminary and OP 11

No glare found

Darfield Preliminary and OP 12

No glare found

Darfield Preliminary and OP 13

No glare found

Darfield Preliminary and OP 14

No glare found

Darfield Preliminary and OP 15

No glare found

Darfield Preliminary and OP 16

No glare found

Darfield Preliminary and OP 17

No glare found

Darfield Preliminary and OP 18

No glare found

Darfield Preliminary and OP 19

No glare found

Darfield Preliminary and OP 20

No glare found

Darfield Preliminary and OP 21

No glare found

Darfield Preliminary and OP 22

No glare found

Darfield Preliminary and OP 23

No glare found

Darfield Preliminary and OP 25

No glare found

Darfield Preliminary and OP 26

No glare found

Darfield Preliminary and OP 27

No glare found

Darfield Preliminary and OP 28

No glare found

Darfield Preliminary and OP 29

No glare found

Darfield Preliminary and OP 30

No glare found

Darfield Preliminary and OP 31

No glare found

Darfield Preliminary and OP 32

No glare found

Darfield Preliminary and OP 33

No glare found

Darfield Preliminary and OP 34

No glare found

Darfield Preliminary and OP 35

No glare found

Darfield Preliminary and OP 36

No glare found

Darfield Preliminary and OP 37

No glare found

Darfield Preliminary and OP 38

No glare found

Darfield Preliminary and OP 39

No glare found

Darfield Preliminary and OP 40

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

FORGESOLAR GLARE ANALYSIS

Project: **Darfield Solar**
Site configuration: **Darfield - NZTA TRUCK WITHOUT OBSTRUCTIONS R2**

Client: NZ Clean Energy

Site description: Darfield - Truck Driver Eye Level Glare Analysis - Without Existing Vegetation Obstructions R1

Created 30 May, 2024
Updated 30 May, 2024
Time-step 1 minute
Timezone offset UTC12
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 100 to 500 kW
Site ID 120589.20038

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	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
Darfield Preliminary	SA tracking	SA tracking	2,011	33.5	1,433	23.9	-	2,530,465

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
Auchenflower Road	272	4.5	9	0.1
Bleak House Road	23	0.4	0	0.0
Boultons Road	542	9.0	3	0.1
Clintons Road	104	1.7	0	0.0
Fonterra Railway Siding	325	5.4	0	0.0
Homebush Road East of Railway	700	11.7	1,051	17.5
Homebush Road West of Railway	45	0.8	370	6.2
Horndon Street	0	0.0	0	0.0
Kimberley Road North	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Kimberley Road South	0	0.0	0	0.0
Landsborough Drive	0	0.0	0	0.0
Loes Road	0	0.0	0	0.0
Main Trunk Line	0	0.0	0	0.0
SH 73 North of Homebush Road	0	0.0	0	0.0
SH 73 South of Homebush Road	0	0.0	0	0.0
Tramway Road East of Kimberley Road	0	0.0	0	0.0
Tramway Road West of Kimberley Road	0	0.0	0	0.0
Whitcombe Place	0	0.0	0	0.0

Component Data

PV Arrays

Name: Darfield Preliminary
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 7.5467°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.434
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	-43.451667	172.097071	231.90	1.40	233.30
2	-43.465951	172.094370	221.20	1.40	222.60
3	-43.465778	172.092183	221.10	1.40	222.50
4	-43.463059	172.092676	223.80	1.40	225.20
5	-43.462839	172.090390	224.50	1.40	225.90
6	-43.465596	172.089889	222.20	1.40	223.60
7	-43.465287	172.085972	223.20	1.40	224.60
8	-43.460230	172.081414	229.00	1.40	230.40
9	-43.457955	172.084528	230.10	1.40	231.50
10	-43.459237	172.086705	228.40	1.40	229.80
11	-43.457965	172.088370	229.40	1.40	230.80
12	-43.457442	172.087479	229.80	1.40	231.20
13	-43.457410	172.087512	229.80	1.40	231.20
14	-43.456653	172.086246	230.60	1.40	232.00
15	-43.454706	172.088200	232.30	1.40	233.70
16	-43.453924	172.088971	232.60	1.40	234.00
17	-43.452312	172.090606	233.40	1.40	234.80
18	-43.452239	172.090630	233.60	1.40	235.00
19	-43.450710	172.092674	234.00	1.40	235.40
20	-43.450660	172.092704	234.00	1.40	235.40
21	-43.450585	172.092739	233.90	1.40	235.30
22	-43.447953	172.093245	236.10	1.40	237.50
23	-43.447856	172.093289	236.10	1.40	237.50
24	-43.444192	172.094476	238.40	1.40	239.80
25	-43.444256	172.095094	237.70	1.40	239.10
26	-43.446052	172.094744	237.20	1.40	238.60
27	-43.446405	172.098146	235.30	1.40	236.70

Route Receptors

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.446950	172.121125	226.70	2.40	229.10
2	-43.446557	172.119438	227.60	2.40	230.00
3	-43.446355	172.117663	227.80	2.40	230.20
4	-43.446175	172.115884	228.60	2.40	231.00
5	-43.445995	172.114104	229.70	2.40	232.10
6	-43.445815	172.112325	230.50	2.40	232.90
7	-43.445635	172.110545	231.50	2.40	233.90
8	-43.445456	172.108766	232.10	2.40	234.50
9	-43.445276	172.106987	233.00	2.40	235.40
10	-43.445096	172.105207	233.70	2.40	236.10
11	-43.444914	172.103428	234.20	2.40	236.60
12	-43.444732	172.101649	235.20	2.40	237.60
13	-43.444549	172.099870	236.50	2.40	238.90
14	-43.444365	172.098091	236.80	2.40	239.20
15	-43.444178	172.096313	237.60	2.40	240.00
16	-43.443990	172.094535	238.20	2.40	240.60
17	-43.443803	172.092757	239.40	2.40	241.80
18	-43.443617	172.090979	240.30	2.40	242.70
19	-43.443433	172.089200	240.60	2.40	243.00
20	-43.443250	172.087422	241.00	2.40	243.40
21	-43.443066	172.085643	242.50	2.40	244.90
22	-43.442883	172.083864	243.30	2.40	245.70
23	-43.442700	172.082085	244.00	2.40	246.40
24	-43.442516	172.080306	245.90	2.40	248.30
25	-43.442333	172.078528	246.90	2.40	249.30
26	-43.442152	172.076748	247.70	2.40	250.10
27	-43.441972	172.074969	248.20	2.40	250.60
28	-43.441792	172.073190	249.20	2.40	251.60
29	-43.441611	172.071410	249.90	2.40	252.30
30	-43.441431	172.069631	250.30	2.40	252.70

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.441027	172.066132	250.80	2.40	253.20
2	-43.440555	172.067806	250.70	2.40	253.10
3	-43.440072	172.069475	250.90	2.40	253.30
4	-43.439588	172.071143	251.40	2.40	253.80
5	-43.439104	172.072812	251.20	2.40	253.60
6	-43.438623	172.074482	250.70	2.40	253.10
7	-43.438144	172.076153	249.90	2.40	252.30
8	-43.437664	172.077824	249.60	2.40	252.00
9	-43.437185	172.079495	249.10	2.40	251.50
10	-43.436705	172.081165	249.00	2.40	251.40
11	-43.436220	172.082833	247.70	2.40	250.10
12	-43.435732	172.084499	246.70	2.40	249.10
13	-43.435244	172.086166	246.60	2.40	249.00
14	-43.434757	172.087832	246.70	2.40	249.10
15	-43.434269	172.089498	246.30	2.40	248.70
16	-43.433781	172.091165	245.50	2.40	247.90
17	-43.433310	172.092840	245.20	2.40	247.60
18	-43.432840	172.094516	244.80	2.40	247.20
19	-43.432370	172.096192	244.00	2.40	246.40
20	-43.432338	172.096305	243.90	2.40	246.30

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.468107	172.119551	212.50	2.40	214.90
2	-43.467599	172.121205	211.40	2.40	213.80
3	-43.467090	172.122860	211.70	2.40	214.10
4	-43.466581	172.124514	211.80	2.40	214.20
5	-43.466073	172.126168	211.60	2.40	214.00
6	-43.465564	172.127823	211.60	2.40	214.00
7	-43.465056	172.129477	211.30	2.40	213.70
8	-43.464547	172.131132	211.20	2.40	213.60
9	-43.464039	172.132786	210.80	2.40	213.20
10	-43.463530	172.134440	210.00	2.40	212.40
11	-43.463022	172.136095	209.50	2.40	211.90
12	-43.462513	172.137749	208.40	2.40	210.80
13	-43.462005	172.139403	208.20	2.40	210.60
14	-43.461496	172.141058	208.40	2.40	210.80
15	-43.460987	172.142712	207.40	2.40	209.80
16	-43.460469	172.144360	207.30	2.40	209.70
17	-43.460079	172.144939	207.30	2.40	209.70

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.485350	172.075213	208.50	2.40	210.90
2	-43.484132	172.074572	209.40	2.40	211.80
3	-43.482915	172.073931	210.30	2.40	212.70
4	-43.481697	172.073290	211.50	2.40	213.90
5	-43.480442	172.072814	212.50	2.40	214.90
6	-43.479171	172.072412	213.80	2.40	216.20
7	-43.477898	172.072026	214.70	2.40	217.10
8	-43.476624	172.071640	215.90	2.40	218.30
9	-43.475356	172.071228	216.90	2.40	219.30
10	-43.474084	172.070831	218.10	2.40	220.50
11	-43.472813	172.070434	219.30	2.40	221.70
12	-43.471541	172.070037	220.40	2.40	222.80
13	-43.470269	172.069640	221.50	2.40	223.90
14	-43.468998	172.069243	223.30	2.40	225.70
15	-43.467726	172.068846	224.30	2.40	226.70
16	-43.466454	172.068449	225.20	2.40	227.60
17	-43.465183	172.068052	226.40	2.40	228.80
18	-43.463911	172.067654	227.60	2.40	230.00
19	-43.462641	172.067250	228.70	2.40	231.10
20	-43.461370	172.066848	230.00	2.40	232.40
21	-43.460099	172.066445	231.00	2.40	233.40
22	-43.458828	172.066043	232.40	2.40	234.80
23	-43.457557	172.065641	233.70	2.40	236.10
24	-43.456286	172.065239	235.20	2.40	237.60
25	-43.455025	172.064944	236.50	2.40	238.90
26	-43.454868	172.066674	236.10	2.40	238.50
27	-43.454816	172.068469	236.10	2.40	238.50
28	-43.454765	172.070264	236.30	2.40	238.70
29	-43.454713	172.072059	236.30	2.40	238.70
30	-43.454661	172.073855	236.30	2.40	238.70

Name: Fonterra Railway Siding
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.459032	172.080040	231.20	3.00	234.20
2	-43.457823	172.079373	232.20	3.00	235.20
3	-43.456598	172.078758	232.80	3.00	235.80
4	-43.455313	172.078588	233.30	3.00	236.30
5	-43.454129	172.079293	233.90	3.00	236.90
6	-43.453124	172.080437	234.40	3.00	237.40
7	-43.452121	172.081587	234.50	3.00	237.50
8	-43.451119	172.082736	234.50	3.00	237.50
9	-43.450116	172.083885	234.50	3.00	237.50
10	-43.449114	172.085034	234.60	3.00	237.60
11	-43.448111	172.086184	234.60	3.00	237.60
12	-43.447126	172.087313	234.50	3.00	237.50

Name: Homebush Road East of Railway
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.465355	172.084639	224.00	2.40	226.40
2	-43.465498	172.086425	223.00	2.40	225.40
3	-43.465636	172.088211	222.40	2.40	224.80
4	-43.465774	172.089998	222.10	2.40	224.50
5	-43.465913	172.091784	221.60	2.40	224.00
6	-43.466051	172.093571	221.00	2.40	223.40
7	-43.466200	172.095355	220.50	2.40	222.90
8	-43.466356	172.097139	220.20	2.40	222.60
9	-43.466493	172.098926	219.20	2.40	221.60
10	-43.466630	172.100712	218.90	2.40	221.30
11	-43.466767	172.102499	218.60	2.40	221.00
12	-43.466904	172.104286	217.80	2.40	220.20
13	-43.467041	172.106072	217.00	2.40	219.40
14	-43.467182	172.107858	216.40	2.40	218.80
15	-43.467323	172.109645	215.60	2.40	218.00
16	-43.467463	172.111431	215.40	2.40	217.80
17	-43.467604	172.113217	215.20	2.40	217.60
18	-43.467745	172.115003	214.30	2.40	216.70
19	-43.467886	172.116789	213.80	2.40	216.20
20	-43.468028	172.118575	212.70	2.40	215.10
21	-43.468164	172.120362	211.70	2.40	214.10
22	-43.468302	172.122148	210.90	2.40	213.30
23	-43.468444	172.123934	210.40	2.40	212.80
24	-43.468586	172.125720	210.10	2.40	212.50
25	-43.468729	172.127506	209.30	2.40	211.70
26	-43.468871	172.129292	209.00	2.40	211.40
27	-43.469013	172.131078	208.40	2.40	210.80
28	-43.469035	172.131348	208.20	2.40	210.60

Name: Homebush Road West of Railway
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.468385	172.045917	226.70	2.40	229.10
2	-43.468088	172.047667	226.30	2.40	228.70
3	-43.467788	172.049415	226.20	2.40	228.60
4	-43.467495	172.051166	228.00	2.40	230.40
5	-43.467201	172.052916	229.20	2.40	231.60
6	-43.466908	172.054667	229.00	2.40	231.40
7	-43.466615	172.056418	228.50	2.40	230.90
8	-43.466321	172.058168	228.60	2.40	231.00
9	-43.466028	172.059919	228.50	2.40	230.90
10	-43.465734	172.061669	228.30	2.40	230.70
11	-43.465441	172.063420	228.20	2.40	230.60
12	-43.465148	172.065170	227.70	2.40	230.10
13	-43.464854	172.066921	227.30	2.40	229.70
14	-43.464555	172.068669	227.00	2.40	229.40
15	-43.464259	172.070419	227.40	2.40	229.80
16	-43.464093	172.072184	227.70	2.40	230.10
17	-43.464269	172.073965	227.60	2.40	230.00
18	-43.464444	172.075745	227.50	2.40	229.90
19	-43.464619	172.077525	226.70	2.40	229.10
20	-43.464794	172.079305	226.40	2.40	228.80
21	-43.464970	172.081086	225.40	2.40	227.80
22	-43.465154	172.082864	224.60	2.40	227.00
23	-43.465355	172.084639	224.00	2.40	226.40

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.485008	172.109015	203.30	2.40	205.70
2	-43.484359	172.107457	204.30	2.40	206.70
3	-43.483287	172.106441	205.20	2.40	207.60
4	-43.482198	172.105455	206.30	2.40	208.70
5	-43.481109	172.104465	207.30	2.40	209.70
6	-43.480027	172.103465	207.90	2.40	210.30
7	-43.478936	172.102481	208.80	2.40	211.20
8	-43.477845	172.101498	209.60	2.40	212.00
9	-43.476753	172.100515	210.50	2.40	212.90
10	-43.476200	172.099297	211.60	2.40	214.00
11	-43.476972	172.097849	211.40	2.40	213.80
12	-43.477744	172.096401	211.30	2.40	213.70
13	-43.477773	172.096346	211.40	2.40	213.80

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.449707	172.120924	224.90	2.40	227.30
2	-43.448405	172.121018	225.90	2.40	228.30
3	-43.447102	172.121113	226.40	2.40	228.80
4	-43.445800	172.121220	227.10	2.40	229.50
5	-43.444498	172.121320	227.80	2.40	230.20
6	-43.443196	172.121420	228.60	2.40	231.00
7	-43.441893	172.121520	228.90	2.40	231.30
8	-43.440591	172.121620	229.70	2.40	232.10
9	-43.439288	172.121720	230.00	2.40	232.40
10	-43.437986	172.121820	230.50	2.40	232.90
11	-43.436683	172.121919	230.90	2.40	233.30
12	-43.435380	172.122019	232.10	2.40	234.50
13	-43.434078	172.122119	231.80	2.40	234.20
14	-43.432775	172.122219	231.80	2.40	234.20
15	-43.431472	172.122319	232.70	2.40	235.10
16	-43.430170	172.122419	233.50	2.40	235.90
17	-43.428867	172.122519	234.30	2.40	236.70
18	-43.427564	172.122618	234.50	2.40	236.90
19	-43.426261	172.122718	234.60	2.40	237.00
20	-43.424959	172.122818	234.80	2.40	237.20
21	-43.424766	172.122833	234.80	2.40	237.20

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.486918	172.107630	202.10	2.40	204.50
2	-43.485767	172.108472	202.80	2.40	205.20
3	-43.484599	172.109270	203.40	2.40	205.80
4	-43.483411	172.110007	203.90	2.40	206.30
5	-43.482222	172.110744	204.40	2.40	206.80
6	-43.481032	172.111478	205.30	2.40	207.70
7	-43.479843	172.112216	206.00	2.40	208.40
8	-43.478654	172.112952	206.30	2.40	208.70
9	-43.477465	172.113688	207.50	2.40	209.90
10	-43.476275	172.114424	208.50	2.40	210.90
11	-43.475086	172.115160	208.80	2.40	211.20
12	-43.473897	172.115896	209.70	2.40	212.10
13	-43.472707	172.116632	210.20	2.40	212.60
14	-43.471518	172.117368	210.50	2.40	212.90
15	-43.470329	172.118104	211.20	2.40	213.60
16	-43.469139	172.118840	211.70	2.40	214.10
17	-43.467936	172.119522	212.40	2.40	214.80
18	-43.466636	172.119641	213.20	2.40	215.60
19	-43.465334	172.119741	214.00	2.40	216.40
20	-43.464031	172.119831	215.00	2.40	217.40
21	-43.462729	172.119932	216.10	2.40	218.50
22	-43.461427	172.120033	217.00	2.40	219.40
23	-43.460125	172.120133	218.00	2.40	220.40
24	-43.458823	172.120234	218.70	2.40	221.10
25	-43.457521	172.120332	219.10	2.40	221.50
26	-43.456219	172.120431	220.40	2.40	222.80
27	-43.454917	172.120530	221.30	2.40	223.70
28	-43.453614	172.120629	222.20	2.40	224.60
29	-43.452312	172.120728	223.20	2.40	225.60
30	-43.451010	172.120827	224.10	2.40	226.50

Name: Landsborough Drive
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.480136	172.112034	205.80	2.40	208.20
2	-43.479667	172.110359	206.40	2.40	208.80
3	-43.479131	172.108722	207.40	2.40	209.80
4	-43.478594	172.107084	208.20	2.40	210.60
5	-43.478060	172.105446	209.10	2.40	211.50
6	-43.477526	172.103807	209.90	2.40	212.30
7	-43.476827	172.102337	210.10	2.40	212.50
8	-43.475607	172.101796	211.10	2.40	213.50
9	-43.474323	172.101634	212.30	2.40	214.70
10	-43.473985	172.101752	212.40	2.40	214.80

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.466130	172.094587	221.10	2.40	223.50
2	-43.464839	172.094834	221.60	2.40	224.00
3	-43.463547	172.095081	222.80	2.40	225.20
4	-43.462255	172.095328	223.70	2.40	226.10
5	-43.460964	172.095575	225.10	2.40	227.50
6	-43.459672	172.095822	225.80	2.40	228.20
7	-43.458380	172.096069	226.80	2.40	229.20
8	-43.457089	172.096316	227.80	2.40	230.20
9	-43.455797	172.096563	228.90	2.40	231.30
10	-43.454505	172.096810	229.80	2.40	232.20
11	-43.453213	172.097057	230.80	2.40	233.20
12	-43.451921	172.097304	231.70	2.40	234.10
13	-43.450629	172.097551	232.80	2.40	235.20
14	-43.449337	172.097798	233.60	2.40	236.00
15	-43.448045	172.098045	234.20	2.40	236.60
16	-43.446753	172.098292	234.80	2.40	237.20
17	-43.445461	172.098539	235.90	2.40	238.30
18	-43.444433	172.098736	236.70	2.40	239.10

Name: Main Trunk Line
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.475051	172.094494	214.10	3.00	217.10
2	-43.473960	172.093510	215.10	3.00	218.10
3	-43.472870	172.092525	216.10	3.00	219.10
4	-43.471779	172.091541	217.20	3.00	220.20
5	-43.470688	172.090557	218.20	3.00	221.20
6	-43.469597	172.089573	219.20	3.00	222.20
7	-43.468506	172.088588	220.30	3.00	223.30
8	-43.467415	172.087604	221.50	3.00	224.50
9	-43.466325	172.086620	222.70	3.00	225.70
10	-43.465234	172.085636	223.80	3.00	226.80
11	-43.464143	172.084652	225.10	3.00	228.10
12	-43.463052	172.083667	226.50	3.00	229.50
13	-43.461961	172.082683	227.80	3.00	230.80
14	-43.460870	172.081699	229.00	3.00	232.00
15	-43.459779	172.080715	230.40	3.00	233.40
16	-43.458688	172.079730	231.50	3.00	234.50
17	-43.457597	172.078746	232.80	3.00	235.80
18	-43.456506	172.077762	234.10	3.00	237.10
19	-43.455416	172.076776	235.30	3.00	238.30
20	-43.454313	172.075817	236.70	3.00	239.70
21	-43.453157	172.074986	237.80	3.00	240.80
22	-43.452425	172.074469	238.70	3.00	241.70

Name: SH 73 North of Homebush Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.465209	172.085024	224.00	2.40	226.40
2	-43.464120	172.084037	225.30	2.40	227.70
3	-43.463031	172.083049	226.40	2.40	228.80
4	-43.461942	172.082060	227.70	2.40	230.10
5	-43.460853	172.081072	229.00	2.40	231.40
6	-43.459763	172.080084	230.10	2.40	232.50
7	-43.458674	172.079096	231.30	2.40	233.70
8	-43.457582	172.078113	232.60	2.40	235.00
9	-43.456487	172.077138	234.00	2.40	236.40
10	-43.455392	172.076162	235.00	2.40	237.40
11	-43.454228	172.075354	236.20	2.40	238.60
12	-43.453073	172.074519	237.90	2.40	240.30
13	-43.451918	172.073684	239.30	2.40	241.70
14	-43.450763	172.072849	240.80	2.40	243.20
15	-43.449608	172.072015	243.00	2.40	245.40
16	-43.448447	172.071195	244.90	2.40	247.30
17	-43.447287	172.070375	246.10	2.40	248.50
18	-43.446126	172.069554	246.20	2.40	248.60
19	-43.444966	172.068734	248.00	2.40	250.40
20	-43.443805	172.067914	249.60	2.40	252.00
21	-43.442645	172.067094	250.50	2.40	252.90
22	-43.441484	172.066273	250.70	2.40	253.10
23	-43.440343	172.065403	250.80	2.40	253.20
24	-43.439215	172.064502	251.00	2.40	253.40
25	-43.438087	172.063599	251.30	2.40	253.70
26	-43.436960	172.062695	251.80	2.40	254.20
27	-43.435830	172.061795	252.70	2.40	255.10
28	-43.434702	172.060893	253.80	2.40	256.20
29	-43.433743	172.060124	254.70	2.40	257.10

Name: SH 73 South of Homebush Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.489806	172.112097	198.70	2.40	201.10
2	-43.489625	172.110318	199.50	2.40	201.90
3	-43.489443	172.108539	199.90	2.40	202.30
4	-43.489077	172.106867	200.80	2.40	203.20
5	-43.488112	172.105696	201.20	2.40	203.60
6	-43.487021	172.104713	202.40	2.40	204.80
7	-43.485930	172.103730	203.50	2.40	205.90
8	-43.484838	172.102747	204.20	2.40	206.60
9	-43.483747	172.101764	204.90	2.40	207.30
10	-43.482656	172.100781	206.00	2.40	208.40
11	-43.481566	172.099796	206.80	2.40	209.20
12	-43.480476	172.098811	208.10	2.40	210.50
13	-43.479385	172.097826	209.40	2.40	211.80
14	-43.478300	172.096831	210.70	2.40	213.10
15	-43.477216	172.095832	211.70	2.40	214.10
16	-43.476129	172.094840	212.80	2.40	215.20
17	-43.475030	172.093874	213.90	2.40	216.30
18	-43.473940	172.092889	214.90	2.40	217.30
19	-43.472849	172.091904	216.00	2.40	218.40
20	-43.471759	172.090919	217.10	2.40	219.50
21	-43.470668	172.089934	218.00	2.40	220.40
22	-43.469578	172.088950	219.20	2.40	221.60
23	-43.468487	172.087965	220.30	2.40	222.70
24	-43.467397	172.086980	221.60	2.40	224.00
25	-43.466306	172.085996	222.90	2.40	225.30
26	-43.465209	172.085024	224.00	2.40	226.40

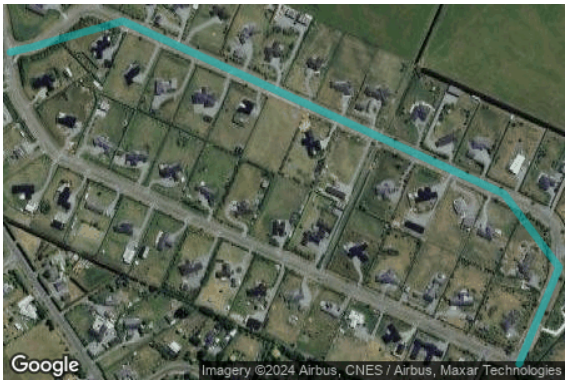
Name: Tramway Road East of Kimberley Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.446791	172.121624	226.30	2.40	228.70
2	-43.447596	172.123037	225.00	2.40	227.40
3	-43.448402	172.124451	223.70	2.40	226.10
4	-43.449207	172.125864	222.70	2.40	225.10
5	-43.450013	172.127277	221.50	2.40	223.90
6	-43.450818	172.128690	220.50	2.40	222.90
7	-43.451624	172.130103	219.20	2.40	221.60
8	-43.452429	172.131516	218.40	2.40	220.80
9	-43.453234	172.132929	216.90	2.40	219.30
10	-43.454040	172.134343	216.00	2.40	218.40
11	-43.454845	172.135756	214.90	2.40	217.30
12	-43.455651	172.137169	213.70	2.40	216.10
13	-43.456456	172.138582	212.60	2.40	215.00
14	-43.457261	172.139995	211.30	2.40	213.70
15	-43.458067	172.141408	209.80	2.40	212.20
16	-43.458872	172.142821	208.80	2.40	211.20
17	-43.459677	172.144234	207.80	2.40	210.20
18	-43.460079	172.144939	207.30	2.40	209.70

Name: Tramway Road West of Kimberley Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.432338	172.096305	243.90	2.40	246.30
2	-43.433128	172.097732	243.10	2.40	245.50
3	-43.433935	172.099143	242.40	2.40	244.80
4	-43.434743	172.100554	241.30	2.40	243.70
5	-43.435551	172.101964	240.60	2.40	243.00
6	-43.436359	172.103375	239.70	2.40	242.10
7	-43.437167	172.104786	238.60	2.40	241.00
8	-43.437974	172.106197	237.80	2.40	240.20
9	-43.438781	172.107608	237.10	2.40	239.50
10	-43.439589	172.109020	236.10	2.40	238.50
11	-43.440396	172.110431	235.10	2.40	237.50
12	-43.441203	172.111843	233.90	2.40	236.30
13	-43.442010	172.113254	232.60	2.40	235.00
14	-43.442817	172.114666	231.10	2.40	233.50
15	-43.443623	172.116079	230.30	2.40	232.70
16	-43.444427	172.117493	229.60	2.40	232.00
17	-43.445231	172.118908	228.40	2.40	230.80
18	-43.446035	172.120322	227.20	2.40	229.60
19	-43.446791	172.121624	226.30	2.40	228.70

Name: Whitcombe Place
Path type: Two-way
Observer view angle: 50.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.479746	172.110610	206.50	2.40	208.90
2	-43.478548	172.111298	206.90	2.40	209.30
3	-43.477634	172.110351	207.80	2.40	210.20
4	-43.477095	172.108715	208.50	2.40	210.90
5	-43.476558	172.107078	209.70	2.40	212.10
6	-43.476023	172.105440	210.50	2.40	212.90
7	-43.475487	172.103802	211.10	2.40	213.50
8	-43.475809	172.102251	210.90	2.40	213.30
9	-43.475874	172.101869	210.90	2.40	213.30

Obstruction Components

Name: Fonterra Store
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.451541	172.082794	245.15
2	-43.448948	172.085712	245.09
3	-43.449104	172.085959	245.34
4	-43.447959	172.087279	245.13
5	-43.448340	172.087890	245.03

Name: Middle Bund
Top height: 3.5 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.455798	172.084829	237.04
2	-43.454229	172.086216	239.21
3	-43.453606	172.086961	239.16
4	-43.451971	172.088831	240.67

Name: Northern Bund
Top height: 3.5 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.451649	172.089161	240.09
2	-43.450888	172.090035	240.48

Name: Southern Bund
Top height: 3.2 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.459270	172.082155	233.41
2	-43.458222	172.083424	234.83
3	-43.457932	172.083542	234.74
4	-43.457457	172.083678	235.11
5	-43.457056	172.083960	235.70
6	-43.456573	172.084411	236.95
7	-43.455726	172.085567	238.55

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	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
Darfield Preliminary	SA tracking	SA tracking	2,011	33.5	1,433	23.9	-	2,530,465

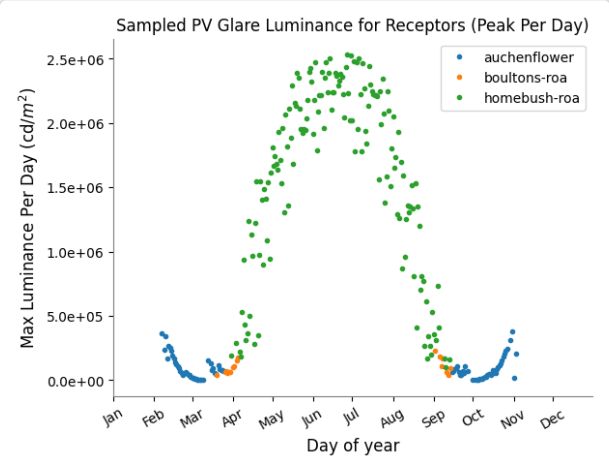
Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Auchenflower Road	272	4.5	9	0.1
Bleak House Road	23	0.4	0	0.0
Boultons Road	542	9.0	3	0.1
Clintons Road	104	1.7	0	0.0
Fonterra Railway Siding	325	5.4	0	0.0
Homebush Road East of Railway	700	11.7	1,051	17.5
Homebush Road West of Railway	45	0.8	370	6.2
Horndon Street	0	0.0	0	0.0
Kimberley Road North	0	0.0	0	0.0
Kimberley Road South	0	0.0	0	0.0
Landsborough Drive	0	0.0	0	0.0
Loes Road	0	0.0	0	0.0
Main Trunk Line	0	0.0	0	0.0
SH 73 North of Homebush Road	0	0.0	0	0.0
SH 73 South of Homebush Road	0	0.0	0	0.0
Tramway Road East of Kimberley Road	0	0.0	0	0.0
Tramway Road West of Kimberley Road	0	0.0	0	0.0
Whitcombe Place	0	0.0	0	0.0

PV: Darfield Preliminary potential temporary after-image

Receptor results ordered by category of glare

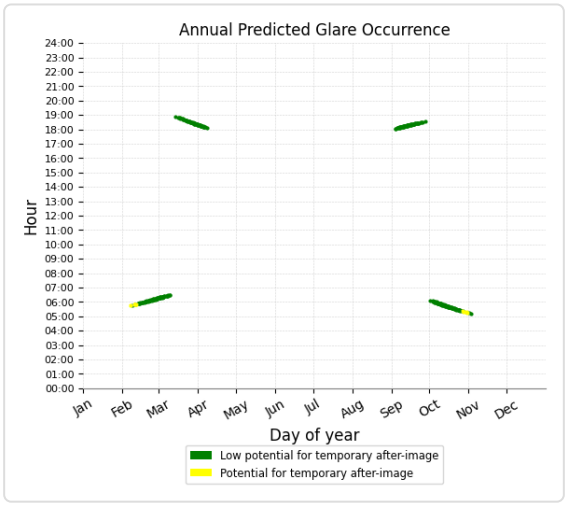
Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
Auchenflower Road	272	4.5	9	0.1	382,175
Boultons Road	542	9.0	3	0.1	282,990
Homebush Road East of Railway	700	11.7	1,051	17.5	1,985,202
Homebush Road West of Railway	45	0.8	370	6.2	2,530,465
Bleak House Road	23	0.4	0	0.0	53,265
Clintons Road	104	1.7	0	0.0	53,481
Fonterra Railway Siding	325	5.4	0	0.0	202,578
Horndon Street	0	0.0	0	0.0	0
Kimberley Road North	0	0.0	0	0.0	0
Kimberley Road South	0	0.0	0	0.0	0
Landsborough Drive	0	0.0	0	0.0	0
Loes Road	0	0.0	0	0.0	0
Main Trunk Line	0	0.0	0	0.0	0
SH 73 North of Homebush Road	0	0.0	0	0.0	0
SH 73 South of Homebush Road	0	0.0	0	0.0	0
Tramway Road East of Kimberley Road	0	0.0	0	0.0	0
Tramway Road West of Kimberley Road	0	0.0	0	0.0	0
Whitcombe Place	0	0.0	0	0.0	0

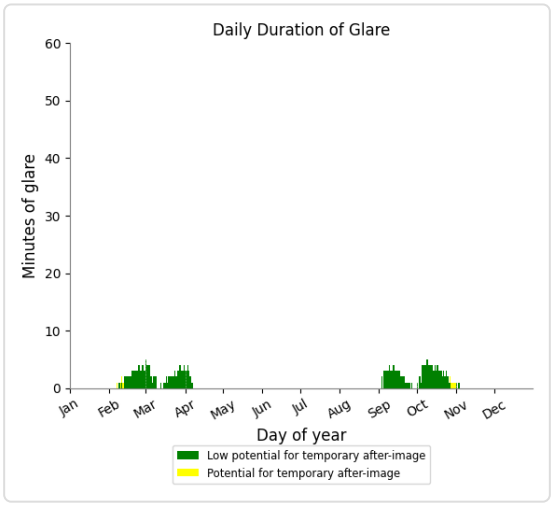


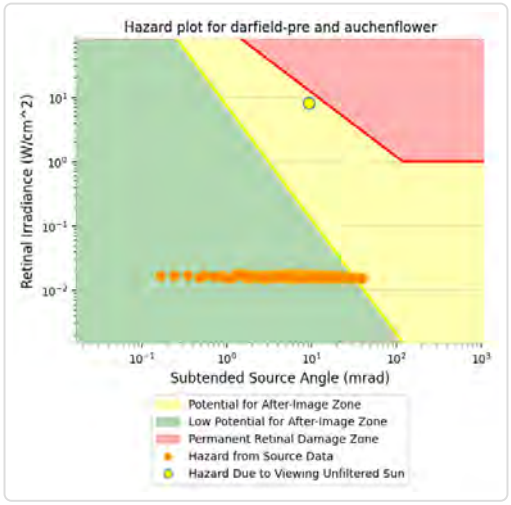
Darfield Preliminary and Route: Auchenflower Road

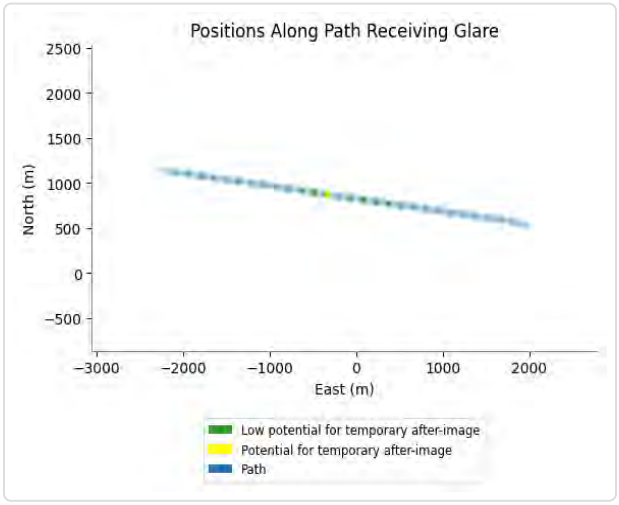
Yellow glare: 9 min.

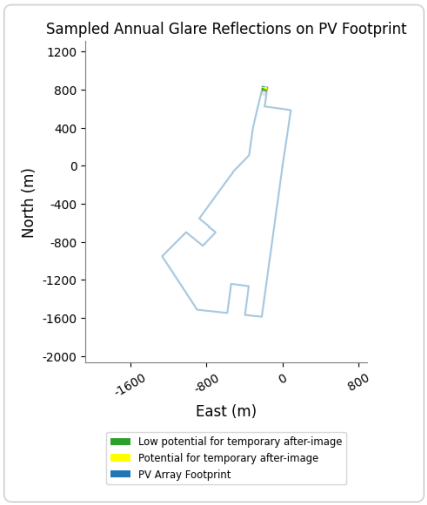
Green glare: 272 min.

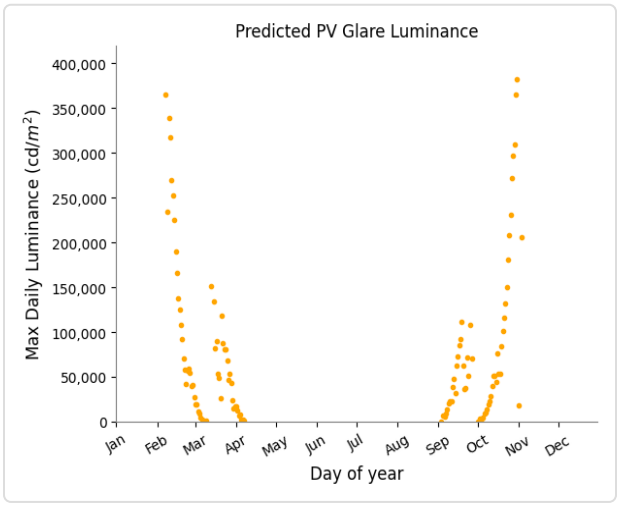








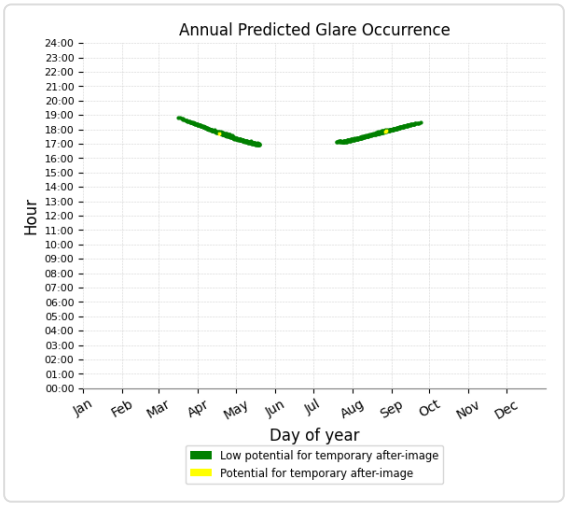


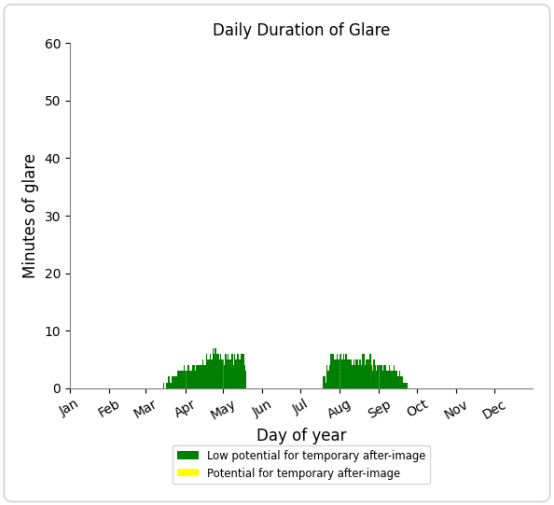


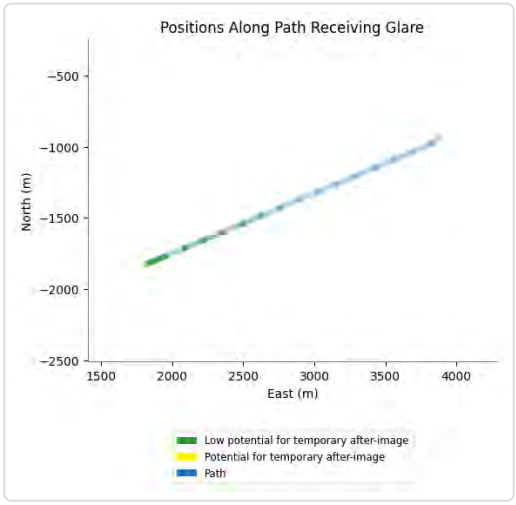
Darfield Preliminary and Route: Boultons Road

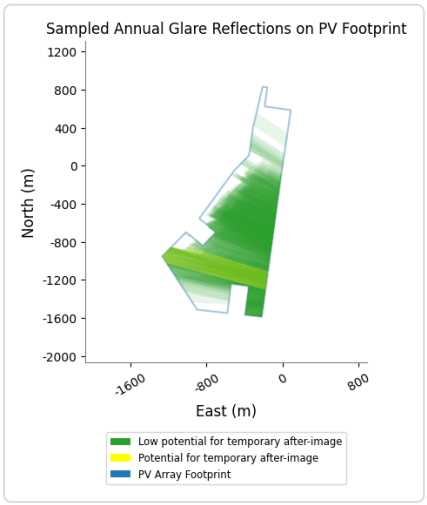
Yellow glare: 3 min.

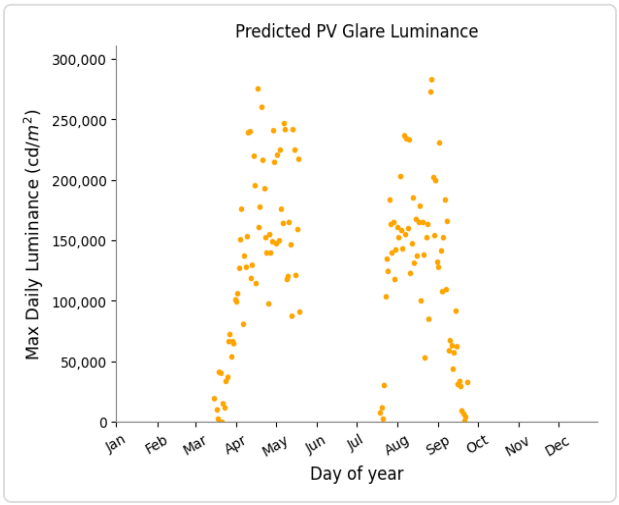
Green glare: 542 min.







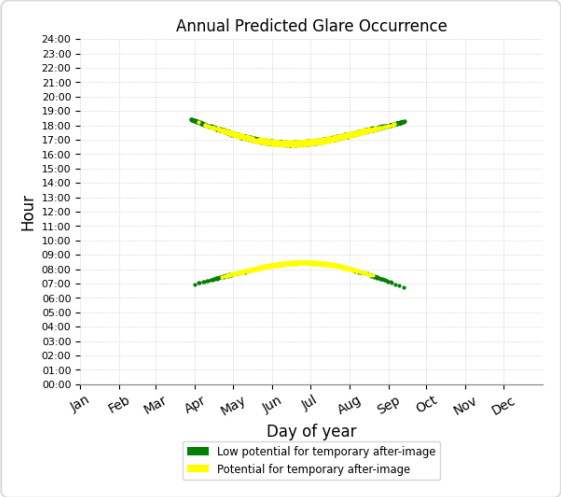


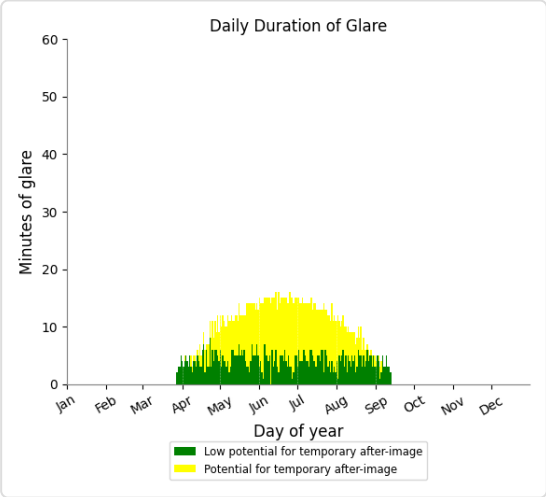


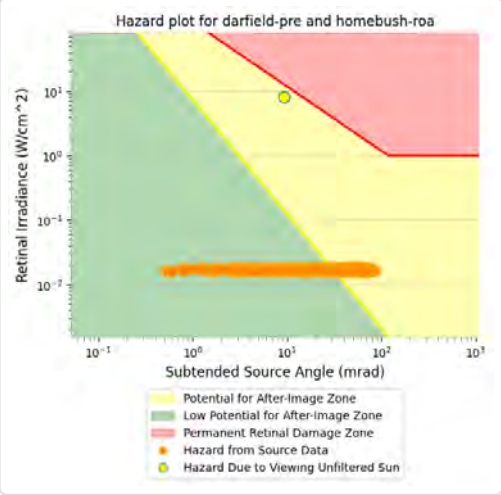
Darfield Preliminary and Route: Homebush Road East of Railway

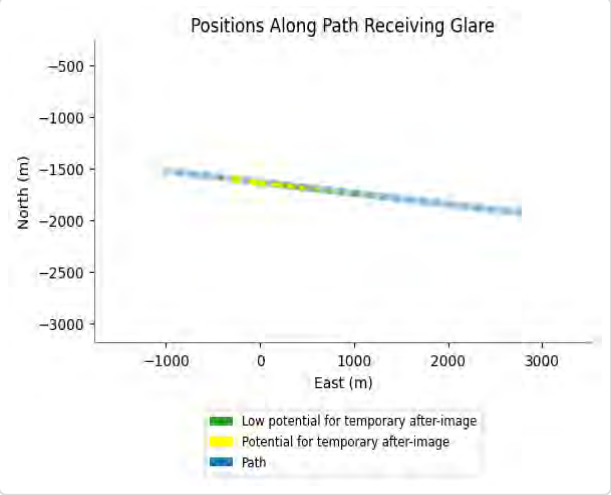
Yellow glare: 1,051 min.

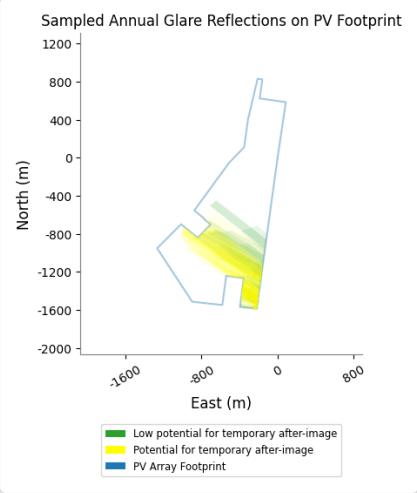
Green glare: 700 min.

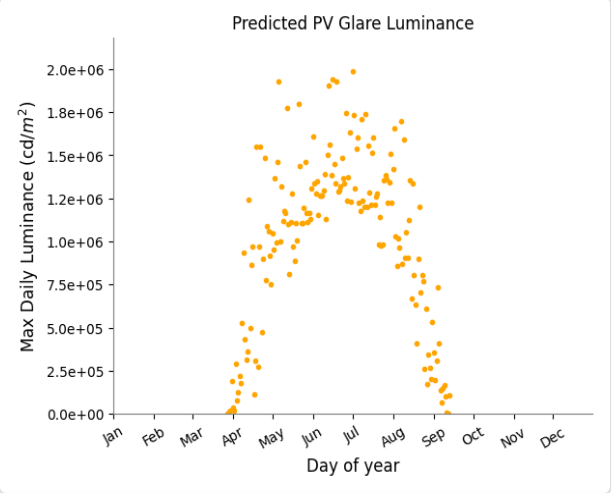








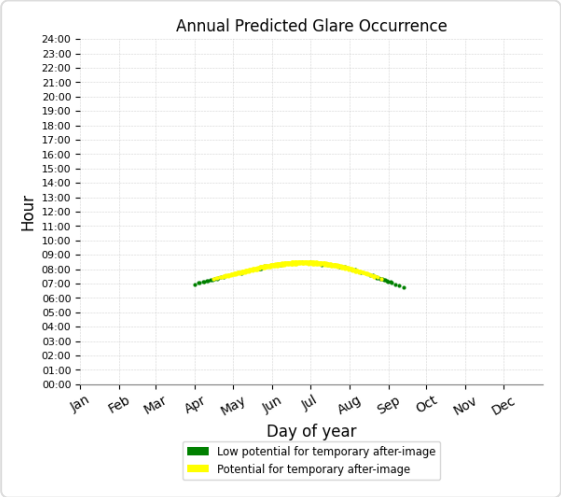


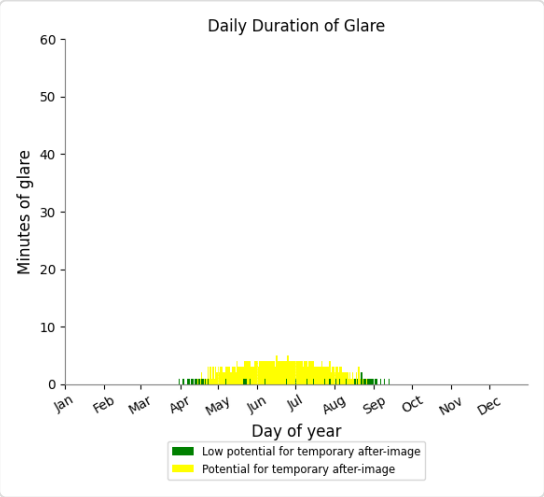


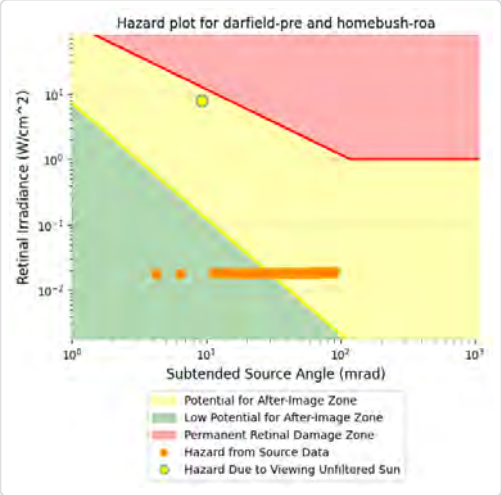
Darfield Preliminary and Route: Homebush Road West of Railway

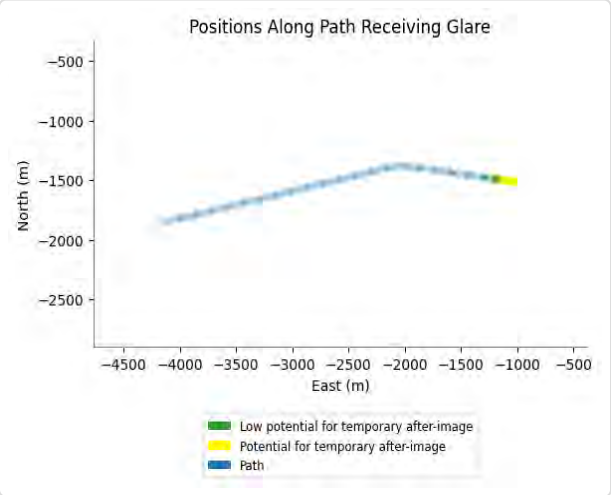
Yellow glare: 370 min.

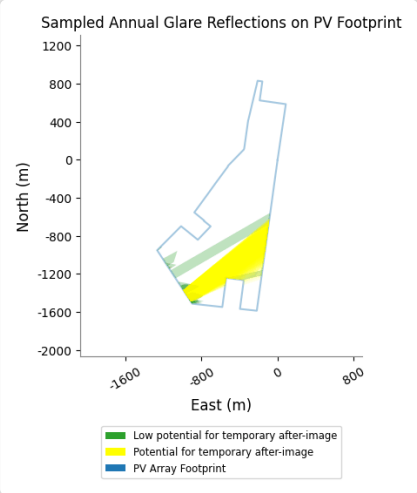
Green glare: 45 min.

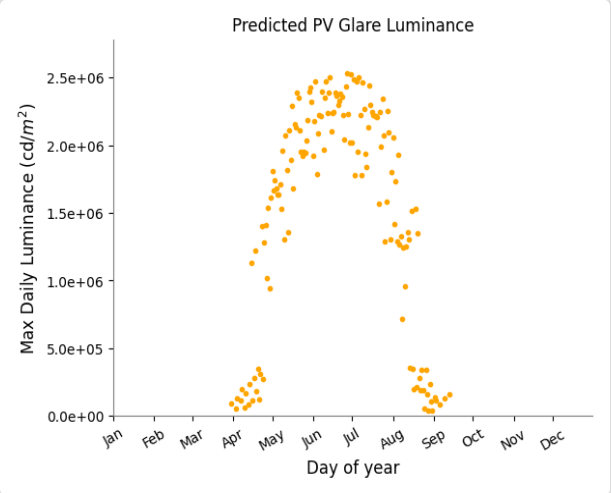








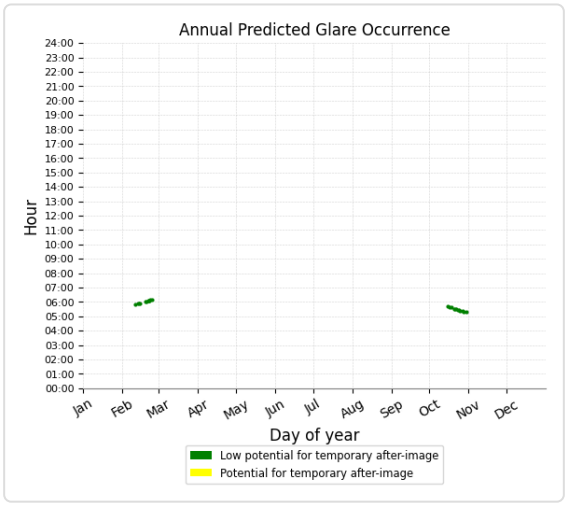


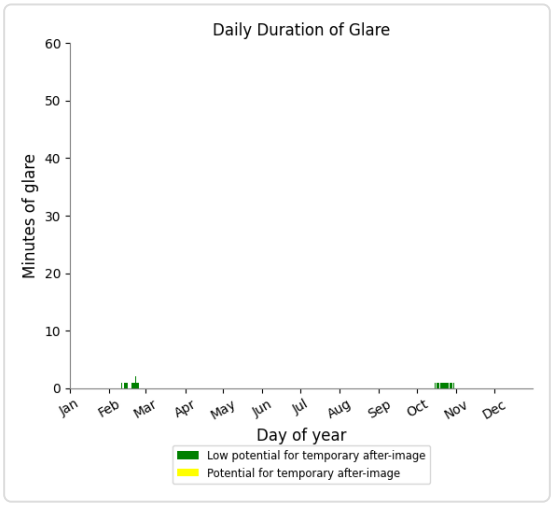


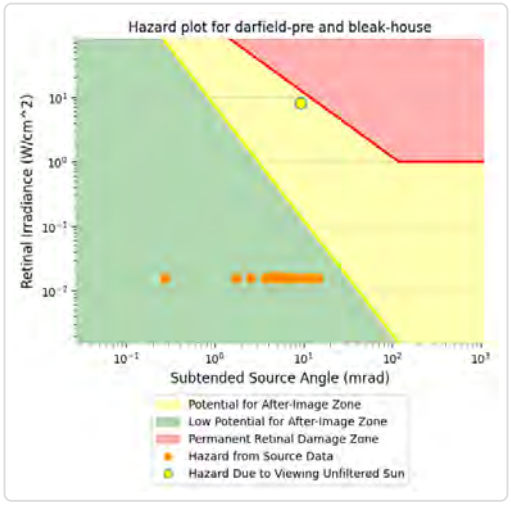
Darfield Preliminary and Route: Bleak House Road

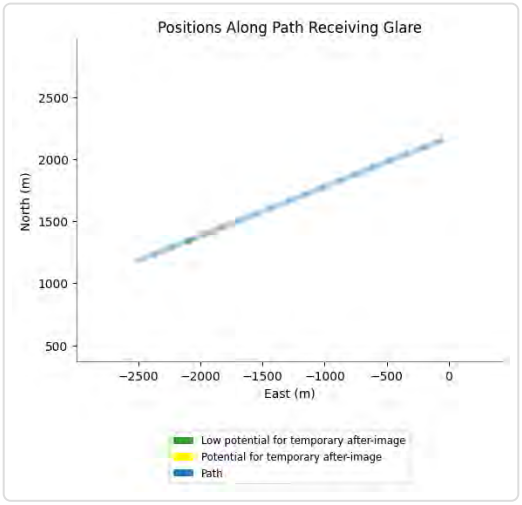
Yellow glare: none

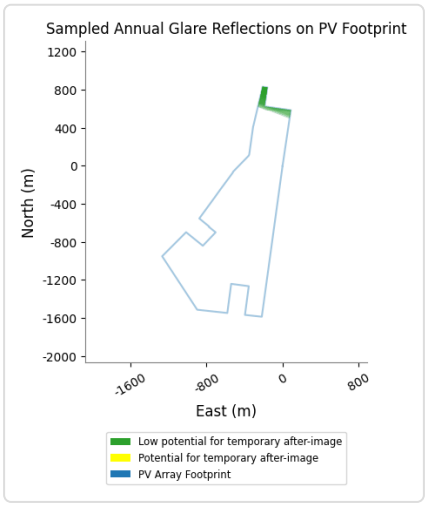
Green glare: 23 min.

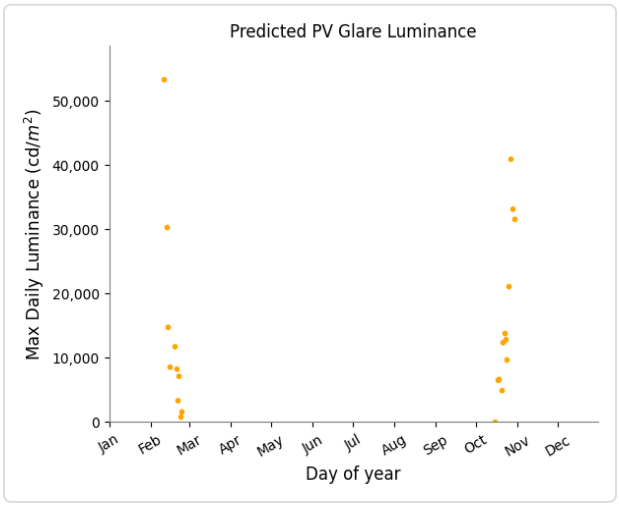








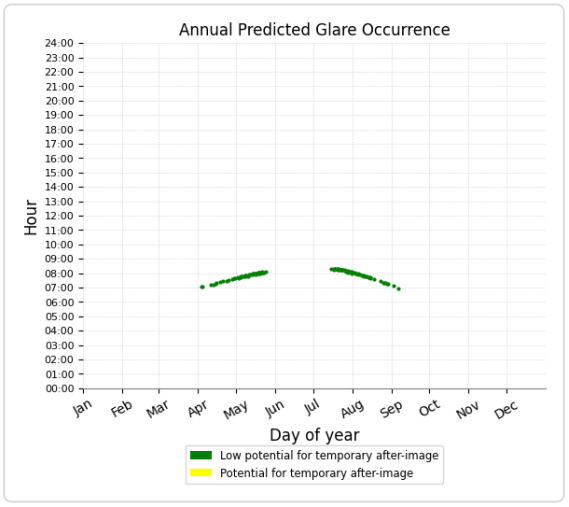


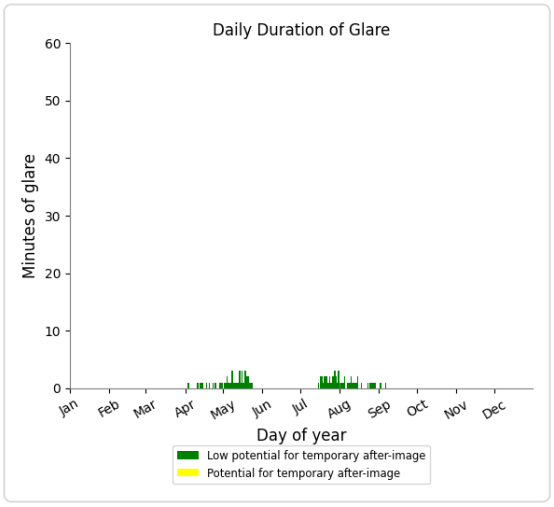


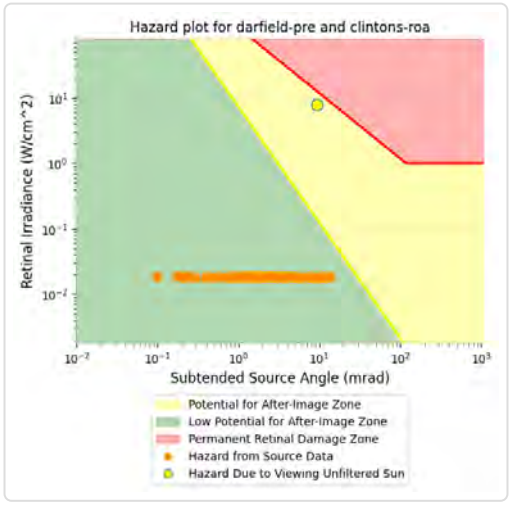
Darfield Preliminary and Route: Clintons Road

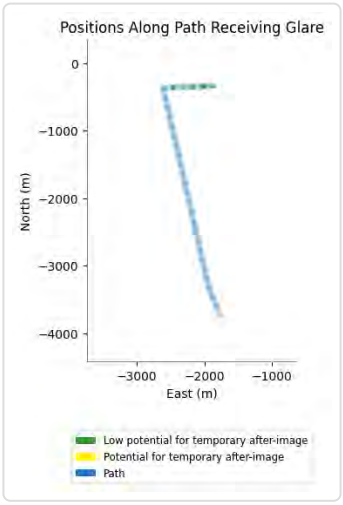
Yellow glare: none

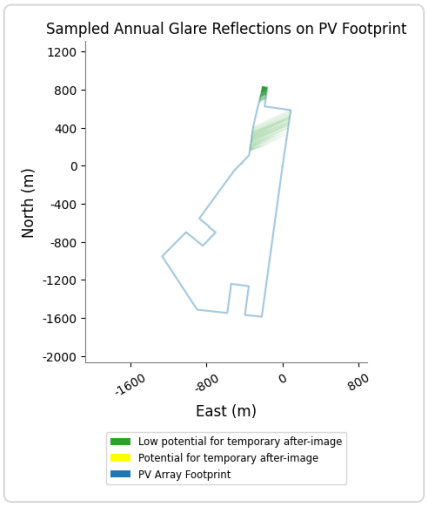
Green glare: 104 min.

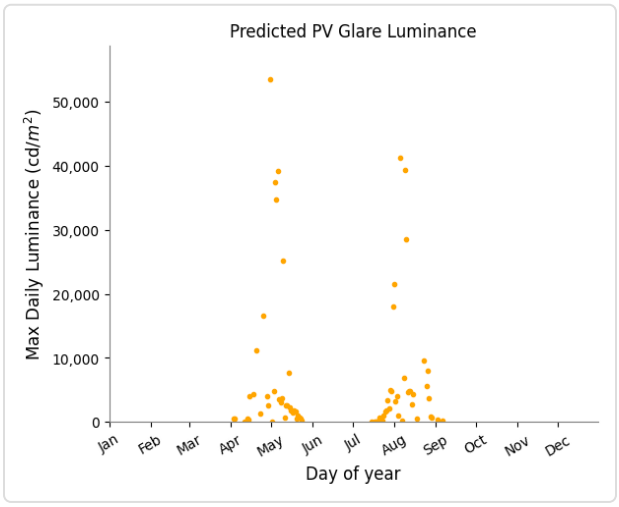








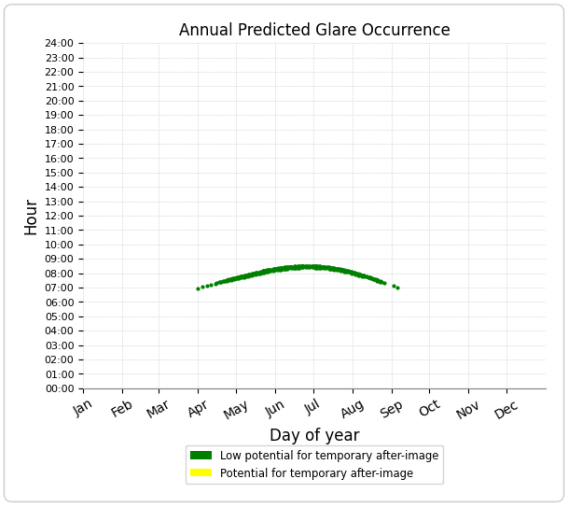


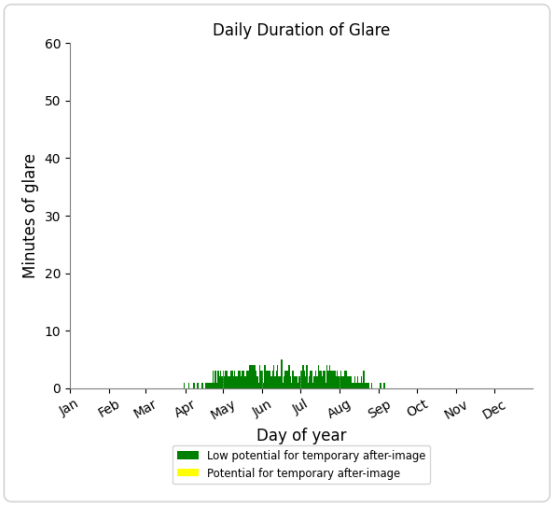


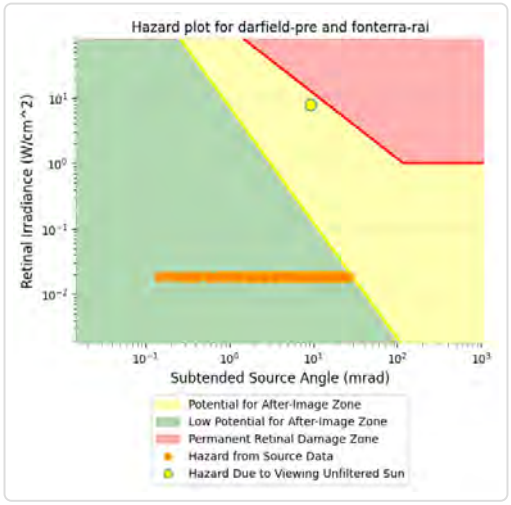
Darfield Preliminary and Route: Fonterra Railway Siding

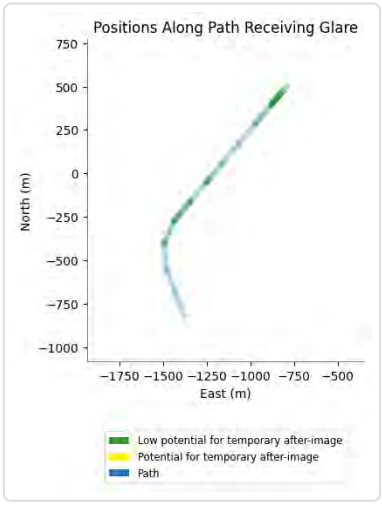
Yellow glare: none

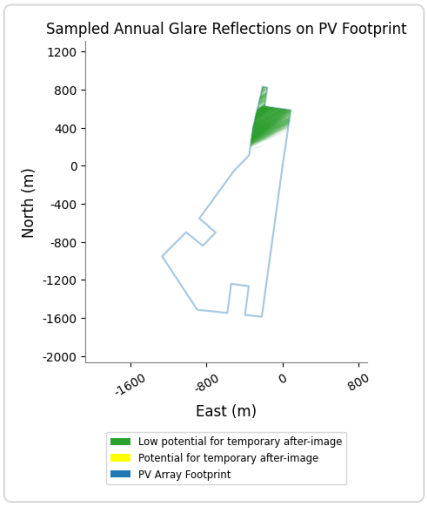
Green glare: 325 min.

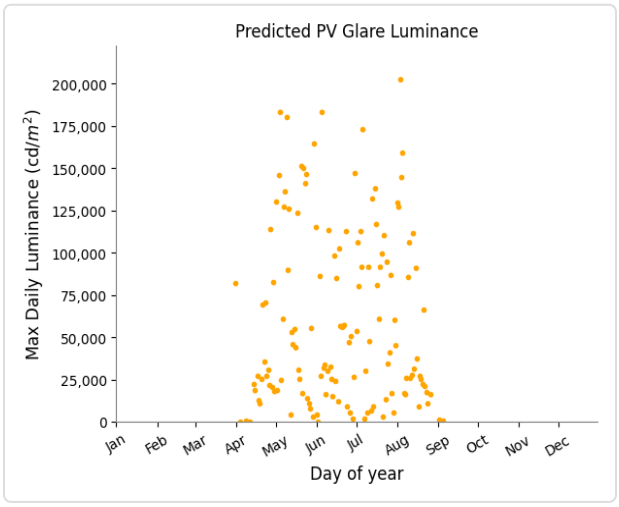












Darfield Preliminary and Route: Horndon Street

No glare found

Darfield Preliminary and Route: Kimberley Road North

No glare found

Darfield Preliminary and Route: Kimberley Road South

No glare found

Darfield Preliminary and Route: Landsborough Drive

No glare found

Darfield Preliminary and Route: Loes Road

No glare found

Darfield Preliminary and Route: Main Trunk Line

No glare found

Darfield Preliminary and Route: SH 73 North of Homebush Road

No glare found

Darfield Preliminary and Route: SH 73 South of Homebush Road

No glare found

Darfield Preliminary and Route: Tramway Road East of Kimberley Road

No glare found

Darfield Preliminary and Route: Tramway Road West of Kimberley Road

No glare found

Darfield Preliminary and Route: Whitcombe Place

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

FORGESOLAR GLARE ANALYSIS

Project: **Darfield Solar**
Site configuration: **Darfield - NZTA TRUCK WITH OBSTRUCTIONS R2**

Client: NZ Clean Energy

Site description: Darfield - NZTA Truck Driver Eye Level Glare Analysis - With Existing Environmental Obstructions R1

Created 21 May, 2024
Updated 30 May, 2024
Time-step 1 minute
Timezone offset UTC12
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 100 to 500 kW
Site ID 119728.20038

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	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
Darfield Preliminary	SA tracking	SA tracking	1,272	21.2	909	15.2	-	2,571,142

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
Auchenflower Road	0	0.0	0	0.0
Bleak House Road	0	0.0	0	0.0
Boultons Road	432	7.2	0	0.0
Clintons Road	90	1.5	0	0.0
Fonterra Railway Siding	230	3.8	0	0.0
Homebush Road East of Railway	412	6.9	602	10.0
Homebush Road West of Railway	108	1.8	307	5.1
Horndon Street	0	0.0	0	0.0
Kimberley Road North	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Kimberley Road South	0	0.0	0	0.0
Landsborough Drive	0	0.0	0	0.0
Loes Road	0	0.0	0	0.0
Main Trunk Line	0	0.0	0	0.0
SH 73 North of Homebush Road	0	0.0	0	0.0
SH 73 South of Homebush Road	0	0.0	0	0.0
Tramway Road East of Kimberley Road	0	0.0	0	0.0
Tramway Road West of Kimberley Road	0	0.0	0	0.0
Whitcombe Place	0	0.0	0	0.0

Component Data

PV Arrays

Name: Darfield Preliminary
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 7.5467°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.434
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	-43.451667	172.097071	231.90	1.40	233.30
2	-43.465951	172.094370	221.20	1.40	222.60
3	-43.465778	172.092183	221.10	1.40	222.50
4	-43.463059	172.092676	223.80	1.40	225.20
5	-43.462839	172.090390	224.50	1.40	225.90
6	-43.465596	172.089889	222.20	1.40	223.60
7	-43.465287	172.085972	223.20	1.40	224.60
8	-43.460230	172.081414	229.00	1.40	230.40
9	-43.457955	172.084528	230.10	1.40	231.50
10	-43.459237	172.086705	228.40	1.40	229.80
11	-43.457965	172.088370	229.40	1.40	230.80
12	-43.457442	172.087479	229.80	1.40	231.20
13	-43.457410	172.087512	229.80	1.40	231.20
14	-43.456653	172.086246	230.60	1.40	232.00
15	-43.454706	172.088200	232.30	1.40	233.70
16	-43.453924	172.088971	232.60	1.40	234.00
17	-43.452312	172.090606	233.40	1.40	234.80
18	-43.452239	172.090630	233.60	1.40	235.00
19	-43.450710	172.092674	234.00	1.40	235.40
20	-43.450660	172.092704	234.00	1.40	235.40
21	-43.450585	172.092739	233.90	1.40	235.30
22	-43.447953	172.093245	236.10	1.40	237.50
23	-43.447856	172.093289	236.10	1.40	237.50
24	-43.444192	172.094476	238.40	1.40	239.80
25	-43.444256	172.095094	237.70	1.40	239.10
26	-43.446052	172.094744	237.20	1.40	238.60
27	-43.446405	172.098146	235.30	1.40	236.70

Route Receptors

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.446950	172.121125	226.70	2.40	229.10
2	-43.446557	172.119438	227.60	2.40	230.00
3	-43.446355	172.117663	227.80	2.40	230.20
4	-43.446175	172.115884	228.60	2.40	231.00
5	-43.445995	172.114104	229.70	2.40	232.10
6	-43.445815	172.112325	230.50	2.40	232.90
7	-43.445635	172.110545	231.50	2.40	233.90
8	-43.445456	172.108766	232.10	2.40	234.50
9	-43.445276	172.106987	233.00	2.40	235.40
10	-43.445096	172.105207	233.70	2.40	236.10
11	-43.444914	172.103428	234.20	2.40	236.60
12	-43.444732	172.101649	235.20	2.40	237.60
13	-43.444549	172.099870	236.50	2.40	238.90
14	-43.444365	172.098091	236.80	2.40	239.20
15	-43.444178	172.096313	237.60	2.40	240.00
16	-43.443990	172.094535	238.20	2.40	240.60
17	-43.443803	172.092757	239.40	2.40	241.80
18	-43.443617	172.090979	240.30	2.40	242.70
19	-43.443433	172.089200	240.60	2.40	243.00
20	-43.443250	172.087422	241.00	2.40	243.40
21	-43.443066	172.085643	242.50	2.40	244.90
22	-43.442883	172.083864	243.30	2.40	245.70
23	-43.442700	172.082085	244.00	2.40	246.40
24	-43.442516	172.080306	245.90	2.40	248.30
25	-43.442333	172.078528	246.90	2.40	249.30
26	-43.442152	172.076748	247.70	2.40	250.10
27	-43.441972	172.074969	248.20	2.40	250.60
28	-43.441792	172.073190	249.20	2.40	251.60
29	-43.441611	172.071410	249.90	2.40	252.30
30	-43.441431	172.069631	250.30	2.40	252.70

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.441027	172.066132	250.80	2.40	253.20
2	-43.440555	172.067806	250.70	2.40	253.10
3	-43.440072	172.069475	250.90	2.40	253.30
4	-43.439588	172.071143	251.40	2.40	253.80
5	-43.439104	172.072812	251.20	2.40	253.60
6	-43.438623	172.074482	250.70	2.40	253.10
7	-43.438144	172.076153	249.90	2.40	252.30
8	-43.437664	172.077824	249.60	2.40	252.00
9	-43.437185	172.079495	249.10	2.40	251.50
10	-43.436705	172.081165	249.00	2.40	251.40
11	-43.436220	172.082833	247.70	2.40	250.10
12	-43.435732	172.084499	246.70	2.40	249.10
13	-43.435244	172.086166	246.60	2.40	249.00
14	-43.434757	172.087832	246.70	2.40	249.10
15	-43.434269	172.089498	246.30	2.40	248.70
16	-43.433781	172.091165	245.50	2.40	247.90
17	-43.433310	172.092840	245.20	2.40	247.60
18	-43.432840	172.094516	244.80	2.40	247.20
19	-43.432370	172.096192	244.00	2.40	246.40
20	-43.432338	172.096305	243.90	2.40	246.30

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.468107	172.119551	212.50	2.40	214.90
2	-43.467599	172.121205	211.40	2.40	213.80
3	-43.467090	172.122860	211.70	2.40	214.10
4	-43.466581	172.124514	211.80	2.40	214.20
5	-43.466073	172.126168	211.60	2.40	214.00
6	-43.465564	172.127823	211.60	2.40	214.00
7	-43.465056	172.129477	211.30	2.40	213.70
8	-43.464547	172.131132	211.20	2.40	213.60
9	-43.464039	172.132786	210.80	2.40	213.20
10	-43.463530	172.134440	210.00	2.40	212.40
11	-43.463022	172.136095	209.50	2.40	211.90
12	-43.462513	172.137749	208.40	2.40	210.80
13	-43.462005	172.139403	208.20	2.40	210.60
14	-43.461496	172.141058	208.40	2.40	210.80
15	-43.460987	172.142712	207.40	2.40	209.80
16	-43.460469	172.144360	207.30	2.40	209.70
17	-43.460079	172.144939	207.30	2.40	209.70

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.485350	172.075213	208.50	2.40	210.90
2	-43.484132	172.074572	209.40	2.40	211.80
3	-43.482915	172.073931	210.30	2.40	212.70
4	-43.481697	172.073290	211.50	2.40	213.90
5	-43.480442	172.072814	212.50	2.40	214.90
6	-43.479171	172.072412	213.80	2.40	216.20
7	-43.477898	172.072026	214.70	2.40	217.10
8	-43.476624	172.071640	215.90	2.40	218.30
9	-43.475356	172.071228	216.90	2.40	219.30
10	-43.474084	172.070831	218.10	2.40	220.50
11	-43.472813	172.070434	219.30	2.40	221.70
12	-43.471541	172.070037	220.40	2.40	222.80
13	-43.470269	172.069640	221.50	2.40	223.90
14	-43.468998	172.069243	223.30	2.40	225.70
15	-43.467726	172.068846	224.30	2.40	226.70
16	-43.466454	172.068449	225.20	2.40	227.60
17	-43.465183	172.068052	226.40	2.40	228.80
18	-43.463911	172.067654	227.60	2.40	230.00
19	-43.462641	172.067250	228.70	2.40	231.10
20	-43.461370	172.066848	230.00	2.40	232.40
21	-43.460099	172.066445	231.00	2.40	233.40
22	-43.458828	172.066043	232.40	2.40	234.80
23	-43.457557	172.065641	233.70	2.40	236.10
24	-43.456286	172.065239	235.20	2.40	237.60
25	-43.455025	172.064944	236.50	2.40	238.90
26	-43.454868	172.066674	236.10	2.40	238.50
27	-43.454816	172.068469	236.10	2.40	238.50
28	-43.454765	172.070264	236.30	2.40	238.70
29	-43.454713	172.072059	236.30	2.40	238.70
30	-43.454661	172.073855	236.30	2.40	238.70

Name: Fonterra Railway Siding
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.459032	172.080040	231.20	3.00	234.20
2	-43.457823	172.079373	232.20	3.00	235.20
3	-43.456598	172.078758	232.80	3.00	235.80
4	-43.455313	172.078588	233.30	3.00	236.30
5	-43.454129	172.079293	233.90	3.00	236.90
6	-43.453124	172.080437	234.40	3.00	237.40
7	-43.452121	172.081587	234.50	3.00	237.50
8	-43.451119	172.082736	234.50	3.00	237.50
9	-43.450116	172.083885	234.50	3.00	237.50
10	-43.449114	172.085034	234.60	3.00	237.60
11	-43.448111	172.086184	234.60	3.00	237.60
12	-43.447126	172.087313	234.50	3.00	237.50

Name: Homebush Road East of Railway
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.465355	172.084639	224.00	2.40	226.40
2	-43.465498	172.086425	223.00	2.40	225.40
3	-43.465636	172.088211	222.40	2.40	224.80
4	-43.465774	172.089998	222.10	2.40	224.50
5	-43.465913	172.091784	221.60	2.40	224.00
6	-43.466051	172.093571	221.00	2.40	223.40
7	-43.466200	172.095355	220.50	2.40	222.90
8	-43.466356	172.097139	220.20	2.40	222.60
9	-43.466493	172.098926	219.20	2.40	221.60
10	-43.466630	172.100712	218.90	2.40	221.30
11	-43.466767	172.102499	218.60	2.40	221.00
12	-43.466904	172.104286	217.80	2.40	220.20
13	-43.467041	172.106072	217.00	2.40	219.40
14	-43.467182	172.107858	216.40	2.40	218.80
15	-43.467323	172.109645	215.60	2.40	218.00
16	-43.467463	172.111431	215.40	2.40	217.80
17	-43.467604	172.113217	215.20	2.40	217.60
18	-43.467745	172.115003	214.30	2.40	216.70
19	-43.467886	172.116789	213.80	2.40	216.20
20	-43.468028	172.118575	212.70	2.40	215.10
21	-43.468164	172.120362	211.70	2.40	214.10
22	-43.468302	172.122148	210.90	2.40	213.30
23	-43.468444	172.123934	210.40	2.40	212.80
24	-43.468586	172.125720	210.10	2.40	212.50
25	-43.468729	172.127506	209.30	2.40	211.70
26	-43.468871	172.129292	209.00	2.40	211.40
27	-43.469013	172.131078	208.40	2.40	210.80
28	-43.469035	172.131348	208.20	2.40	210.60

Name: Homebush Road West of Railway
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.468385	172.045917	226.70	2.40	229.10
2	-43.468088	172.047667	226.30	2.40	228.70
3	-43.467788	172.049415	226.20	2.40	228.60
4	-43.467495	172.051166	228.00	2.40	230.40
5	-43.467201	172.052916	229.20	2.40	231.60
6	-43.466908	172.054667	229.00	2.40	231.40
7	-43.466615	172.056418	228.50	2.40	230.90
8	-43.466321	172.058168	228.60	2.40	231.00
9	-43.466028	172.059919	228.50	2.40	230.90
10	-43.465734	172.061669	228.30	2.40	230.70
11	-43.465441	172.063420	228.20	2.40	230.60
12	-43.465148	172.065170	227.70	2.40	230.10
13	-43.464854	172.066921	227.30	2.40	229.70
14	-43.464555	172.068669	227.00	2.40	229.40
15	-43.464259	172.070419	227.40	2.40	229.80
16	-43.464093	172.072184	227.70	2.40	230.10
17	-43.464269	172.073965	227.60	2.40	230.00
18	-43.464444	172.075745	227.50	2.40	229.90
19	-43.464619	172.077525	226.70	2.40	229.10
20	-43.464794	172.079305	226.40	2.40	228.80
21	-43.464970	172.081086	225.40	2.40	227.80
22	-43.465154	172.082864	224.60	2.40	227.00
23	-43.465355	172.084639	224.00	2.40	226.40

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.485008	172.109015	203.30	2.40	205.70
2	-43.484359	172.107457	204.30	2.40	206.70
3	-43.483287	172.106441	205.20	2.40	207.60
4	-43.482198	172.105455	206.30	2.40	208.70
5	-43.481109	172.104465	207.30	2.40	209.70
6	-43.480027	172.103465	207.90	2.40	210.30
7	-43.478936	172.102481	208.80	2.40	211.20
8	-43.477845	172.101498	209.60	2.40	212.00
9	-43.476753	172.100515	210.50	2.40	212.90
10	-43.476200	172.099297	211.60	2.40	214.00
11	-43.476972	172.097849	211.40	2.40	213.80
12	-43.477744	172.096401	211.30	2.40	213.70
13	-43.477773	172.096346	211.40	2.40	213.80

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.449707	172.120924	224.90	2.40	227.30
2	-43.448405	172.121018	225.90	2.40	228.30
3	-43.447102	172.121113	226.40	2.40	228.80
4	-43.445800	172.121220	227.10	2.40	229.50
5	-43.444498	172.121320	227.80	2.40	230.20
6	-43.443196	172.121420	228.60	2.40	231.00
7	-43.441893	172.121520	228.90	2.40	231.30
8	-43.440591	172.121620	229.70	2.40	232.10
9	-43.439288	172.121720	230.00	2.40	232.40
10	-43.437986	172.121820	230.50	2.40	232.90
11	-43.436683	172.121919	230.90	2.40	233.30
12	-43.435380	172.122019	232.10	2.40	234.50
13	-43.434078	172.122119	231.80	2.40	234.20
14	-43.432775	172.122219	231.80	2.40	234.20
15	-43.431472	172.122319	232.70	2.40	235.10
16	-43.430170	172.122419	233.50	2.40	235.90
17	-43.428867	172.122519	234.30	2.40	236.70
18	-43.427564	172.122618	234.50	2.40	236.90
19	-43.426261	172.122718	234.60	2.40	237.00
20	-43.424959	172.122818	234.80	2.40	237.20
21	-43.424766	172.122833	234.80	2.40	237.20

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.486918	172.107630	202.10	2.40	204.50
2	-43.485767	172.108472	202.80	2.40	205.20
3	-43.484599	172.109270	203.40	2.40	205.80
4	-43.483411	172.110007	203.90	2.40	206.30
5	-43.482222	172.110744	204.40	2.40	206.80
6	-43.481032	172.111478	205.30	2.40	207.70
7	-43.479843	172.112216	206.00	2.40	208.40
8	-43.478654	172.112952	206.30	2.40	208.70
9	-43.477465	172.113688	207.50	2.40	209.90
10	-43.476275	172.114424	208.50	2.40	210.90
11	-43.475086	172.115160	208.80	2.40	211.20
12	-43.473897	172.115896	209.70	2.40	212.10
13	-43.472707	172.116632	210.20	2.40	212.60
14	-43.471518	172.117368	210.50	2.40	212.90
15	-43.470329	172.118104	211.20	2.40	213.60
16	-43.469139	172.118840	211.70	2.40	214.10
17	-43.467936	172.119522	212.40	2.40	214.80
18	-43.466636	172.119641	213.20	2.40	215.60
19	-43.465334	172.119741	214.00	2.40	216.40
20	-43.464031	172.119831	215.00	2.40	217.40
21	-43.462729	172.119932	216.10	2.40	218.50
22	-43.461427	172.120033	217.00	2.40	219.40
23	-43.460125	172.120133	218.00	2.40	220.40
24	-43.458823	172.120234	218.70	2.40	221.10
25	-43.457521	172.120332	219.10	2.40	221.50
26	-43.456219	172.120431	220.40	2.40	222.80
27	-43.454917	172.120530	221.30	2.40	223.70
28	-43.453614	172.120629	222.20	2.40	224.60
29	-43.452312	172.120728	223.20	2.40	225.60
30	-43.451010	172.120827	224.10	2.40	226.50

Name: Landsborough Drive
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.480136	172.112034	205.80	2.40	208.20
2	-43.479667	172.110359	206.40	2.40	208.80
3	-43.479131	172.108722	207.40	2.40	209.80
4	-43.478594	172.107084	208.20	2.40	210.60
5	-43.478060	172.105446	209.10	2.40	211.50
6	-43.477526	172.103807	209.90	2.40	212.30
7	-43.476827	172.102337	210.10	2.40	212.50
8	-43.475607	172.101796	211.10	2.40	213.50
9	-43.474323	172.101634	212.30	2.40	214.70
10	-43.473985	172.101752	212.40	2.40	214.80

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.466130	172.094587	221.10	2.40	223.50
2	-43.464839	172.094834	221.60	2.40	224.00
3	-43.463547	172.095081	222.80	2.40	225.20
4	-43.462255	172.095328	223.70	2.40	226.10
5	-43.460964	172.095575	225.10	2.40	227.50
6	-43.459672	172.095822	225.80	2.40	228.20
7	-43.458380	172.096069	226.80	2.40	229.20
8	-43.457089	172.096316	227.80	2.40	230.20
9	-43.455797	172.096563	228.90	2.40	231.30
10	-43.454505	172.096810	229.80	2.40	232.20
11	-43.453213	172.097057	230.80	2.40	233.20
12	-43.451921	172.097304	231.70	2.40	234.10
13	-43.450629	172.097551	232.80	2.40	235.20
14	-43.449337	172.097798	233.60	2.40	236.00
15	-43.448045	172.098045	234.20	2.40	236.60
16	-43.446753	172.098292	234.80	2.40	237.20
17	-43.445461	172.098539	235.90	2.40	238.30
18	-43.444433	172.098736	236.70	2.40	239.10

Name: Main Trunk Line
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.475051	172.094494	214.10	3.00	217.10
2	-43.473960	172.093510	215.10	3.00	218.10
3	-43.472870	172.092525	216.10	3.00	219.10
4	-43.471779	172.091541	217.20	3.00	220.20
5	-43.470688	172.090557	218.20	3.00	221.20
6	-43.469597	172.089573	219.20	3.00	222.20
7	-43.468506	172.088588	220.30	3.00	223.30
8	-43.467415	172.087604	221.50	3.00	224.50
9	-43.466325	172.086620	222.70	3.00	225.70
10	-43.465234	172.085636	223.80	3.00	226.80
11	-43.464143	172.084652	225.10	3.00	228.10
12	-43.463052	172.083667	226.50	3.00	229.50
13	-43.461961	172.082683	227.80	3.00	230.80
14	-43.460870	172.081699	229.00	3.00	232.00
15	-43.459779	172.080715	230.40	3.00	233.40
16	-43.458688	172.079730	231.50	3.00	234.50
17	-43.457597	172.078746	232.80	3.00	235.80
18	-43.456506	172.077762	234.10	3.00	237.10
19	-43.455416	172.076776	235.30	3.00	238.30
20	-43.454313	172.075817	236.70	3.00	239.70
21	-43.453157	172.074986	237.80	3.00	240.80
22	-43.452425	172.074469	238.70	3.00	241.70

Name: SH 73 North of Homebush Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.465209	172.085024	224.00	2.40	226.40
2	-43.464120	172.084037	225.30	2.40	227.70
3	-43.463031	172.083049	226.40	2.40	228.80
4	-43.461942	172.082060	227.70	2.40	230.10
5	-43.460853	172.081072	229.00	2.40	231.40
6	-43.459763	172.080084	230.10	2.40	232.50
7	-43.458674	172.079096	231.30	2.40	233.70
8	-43.457582	172.078113	232.60	2.40	235.00
9	-43.456487	172.077138	234.00	2.40	236.40
10	-43.455392	172.076162	235.00	2.40	237.40
11	-43.454228	172.075354	236.20	2.40	238.60
12	-43.453073	172.074519	237.90	2.40	240.30
13	-43.451918	172.073684	239.30	2.40	241.70
14	-43.450763	172.072849	240.80	2.40	243.20
15	-43.449608	172.072015	243.00	2.40	245.40
16	-43.448447	172.071195	244.90	2.40	247.30
17	-43.447287	172.070375	246.10	2.40	248.50
18	-43.446126	172.069554	246.20	2.40	248.60
19	-43.444966	172.068734	248.00	2.40	250.40
20	-43.443805	172.067914	249.60	2.40	252.00
21	-43.442645	172.067094	250.50	2.40	252.90
22	-43.441484	172.066273	250.70	2.40	253.10
23	-43.440343	172.065403	250.80	2.40	253.20
24	-43.439215	172.064502	251.00	2.40	253.40
25	-43.438087	172.063599	251.30	2.40	253.70
26	-43.436960	172.062695	251.80	2.40	254.20
27	-43.435830	172.061795	252.70	2.40	255.10
28	-43.434702	172.060893	253.80	2.40	256.20
29	-43.433743	172.060124	254.70	2.40	257.10

Name: SH 73 South of Homebush Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.489806	172.112097	198.70	2.40	201.10
2	-43.489625	172.110318	199.50	2.40	201.90
3	-43.489443	172.108539	199.90	2.40	202.30
4	-43.489077	172.106867	200.80	2.40	203.20
5	-43.488112	172.105696	201.20	2.40	203.60
6	-43.487021	172.104713	202.40	2.40	204.80
7	-43.485930	172.103730	203.50	2.40	205.90
8	-43.484838	172.102747	204.20	2.40	206.60
9	-43.483747	172.101764	204.90	2.40	207.30
10	-43.482656	172.100781	206.00	2.40	208.40
11	-43.481566	172.099796	206.80	2.40	209.20
12	-43.480476	172.098811	208.10	2.40	210.50
13	-43.479385	172.097826	209.40	2.40	211.80
14	-43.478300	172.096831	210.70	2.40	213.10
15	-43.477216	172.095832	211.70	2.40	214.10
16	-43.476129	172.094840	212.80	2.40	215.20
17	-43.475030	172.093874	213.90	2.40	216.30
18	-43.473940	172.092889	214.90	2.40	217.30
19	-43.472849	172.091904	216.00	2.40	218.40
20	-43.471759	172.090919	217.10	2.40	219.50
21	-43.470668	172.089934	218.00	2.40	220.40
22	-43.469578	172.088950	219.20	2.40	221.60
23	-43.468487	172.087965	220.30	2.40	222.70
24	-43.467397	172.086980	221.60	2.40	224.00
25	-43.466306	172.085996	222.90	2.40	225.30
26	-43.465209	172.085024	224.00	2.40	226.40

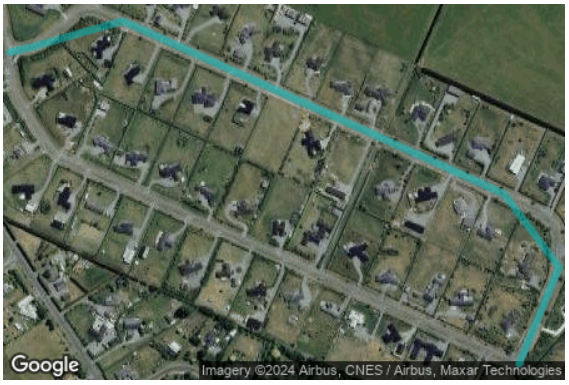
Name: Tramway Road East of Kimberley Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.446791	172.121624	226.30	2.40	228.70
2	-43.447596	172.123037	225.00	2.40	227.40
3	-43.448402	172.124451	223.70	2.40	226.10
4	-43.449207	172.125864	222.70	2.40	225.10
5	-43.450013	172.127277	221.50	2.40	223.90
6	-43.450818	172.128690	220.50	2.40	222.90
7	-43.451624	172.130103	219.20	2.40	221.60
8	-43.452429	172.131516	218.40	2.40	220.80
9	-43.453234	172.132929	216.90	2.40	219.30
10	-43.454040	172.134343	216.00	2.40	218.40
11	-43.454845	172.135756	214.90	2.40	217.30
12	-43.455651	172.137169	213.70	2.40	216.10
13	-43.456456	172.138582	212.60	2.40	215.00
14	-43.457261	172.139995	211.30	2.40	213.70
15	-43.458067	172.141408	209.80	2.40	212.20
16	-43.458872	172.142821	208.80	2.40	211.20
17	-43.459677	172.144234	207.80	2.40	210.20
18	-43.460079	172.144939	207.30	2.40	209.70

Name: Tramway Road West of Kimberley Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.432338	172.096305	243.90	2.40	246.30
2	-43.433128	172.097732	243.10	2.40	245.50
3	-43.433935	172.099143	242.40	2.40	244.80
4	-43.434743	172.100554	241.30	2.40	243.70
5	-43.435551	172.101964	240.60	2.40	243.00
6	-43.436359	172.103375	239.70	2.40	242.10
7	-43.437167	172.104786	238.60	2.40	241.00
8	-43.437974	172.106197	237.80	2.40	240.20
9	-43.438781	172.107608	237.10	2.40	239.50
10	-43.439589	172.109020	236.10	2.40	238.50
11	-43.440396	172.110431	235.10	2.40	237.50
12	-43.441203	172.111843	233.90	2.40	236.30
13	-43.442010	172.113254	232.60	2.40	235.00
14	-43.442817	172.114666	231.10	2.40	233.50
15	-43.443623	172.116079	230.30	2.40	232.70
16	-43.444427	172.117493	229.60	2.40	232.00
17	-43.445231	172.118908	228.40	2.40	230.80
18	-43.446035	172.120322	227.20	2.40	229.60
19	-43.446791	172.121624	226.30	2.40	228.70

Name: Whitcombe Place
Path type: Two-way
Observer view angle: 50.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.479746	172.110610	206.50	2.40	208.90
2	-43.478548	172.111298	206.90	2.40	209.30
3	-43.477634	172.110351	207.80	2.40	210.20
4	-43.477095	172.108715	208.50	2.40	210.90
5	-43.476558	172.107078	209.70	2.40	212.10
6	-43.476023	172.105440	210.50	2.40	212.90
7	-43.475487	172.103802	211.10	2.40	213.50
8	-43.475809	172.102251	210.90	2.40	213.30
9	-43.475874	172.101869	210.90	2.40	213.30

Obstruction Components

Name: Amenity Planting OP1
Top height: 6.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.465829	172.091864	227.36
2	-43.464766	172.091971	228.22
3	-43.464415	172.092110	228.47
4	-43.463968	172.092194	228.88
5	-43.463514	172.091472	229.63
6	-43.464303	172.091134	228.36
7	-43.464698	172.091842	228.33
8	-43.464760	172.091901	228.27
9	-43.465330	172.091848	227.76
10	-43.465714	172.091805	227.64

Name: Fonterra Boundary Planting
Top height: 3.2 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.460182	172.081254	232.80
2	-43.457827	172.084483	233.75
3	-43.459100	172.086682	231.82
4	-43.457936	172.088195	232.38
5	-43.456647	172.086098	233.97
6	-43.452500	172.090266	236.71
7	-43.452126	172.090421	236.72
8	-43.450646	172.092444	237.45
9	-43.447900	172.092996	239.38
10	-43.444376	172.094150	241.66

Name: Fonterra Store
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.451541	172.082794	245.15
2	-43.448948	172.085712	245.09
3	-43.449104	172.085959	245.34
4	-43.447959	172.087279	245.13
5	-43.448340	172.087890	245.03

Name: Forestry Woodlot Auchenflower Road
Top height: 4.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.444200	172.095249	241.73
2	-43.445969	172.094874	241.17
3	-43.446109	172.096156	240.37
4	-43.444337	172.096462	241.11
5	-43.444200	172.095249	241.73

Name: Hedge Row OP6
Top height: 3.2 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.463235	172.095310	226.09
2	-43.462384	172.095482	227.18
3	-43.462439	172.096176	226.78
4	-43.463089	172.096050	226.29
5	-43.463149	172.096144	226.49
6	-43.463379	172.096101	225.89
7	-43.463313	172.095299	225.99

Name: Hedge Row OP7
Top height: 6.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.460108	172.095870	231.59
2	-43.459682	172.095959	231.84
3	-43.459781	172.096686	231.48
4	-43.460052	172.096635	231.41
5	-43.460081	172.096858	231.29
6	-43.461243	172.096627	230.41
7	-43.461127	172.095672	230.76
8	-43.460157	172.095865	231.63

Name: McHughs Forest Park
Top height: 20.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.477307	172.096737	231.48
2	-43.465698	172.086308	242.70
3	-43.466033	172.090750	241.89
4	-43.473150	172.097187	234.32
5	-43.473267	172.096973	234.38
6	-43.474886	172.098571	232.74
7	-43.476054	172.099258	231.44

Name: Middle Bund
Top height: 3.5 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.455798	172.084829	237.04
2	-43.454229	172.086216	239.21
3	-43.453606	172.086961	239.16
4	-43.451971	172.088831	240.67

Name: Northern Bund
Top height: 3.5 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.451649	172.089161	240.09
2	-43.450888	172.090035	240.48

Name: Southern Bund
Top height: 3.2 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.459270	172.082155	233.41
2	-43.458222	172.083424	234.83
3	-43.457932	172.083542	234.74
4	-43.457457	172.083678	235.11
5	-43.457056	172.083960	235.70
6	-43.456573	172.084411	236.95
7	-43.455726	172.085567	238.55

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	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
Darfield Preliminary	SA tracking	SA tracking	1,272	21.2	909	15.2	-	2,571,142

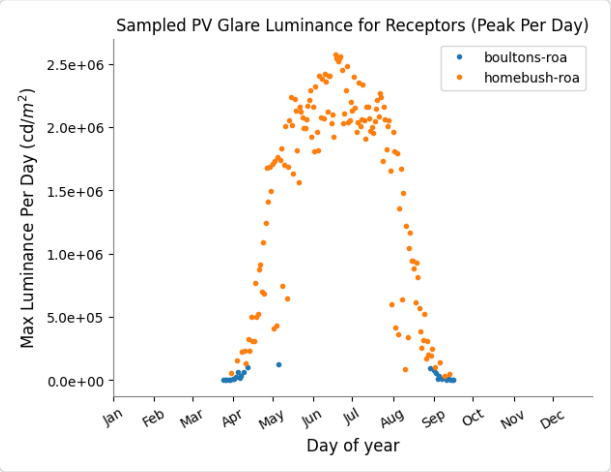
Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Auchenflower Road	0	0.0	0	0.0
Bleak House Road	0	0.0	0	0.0
Boultons Road	432	7.2	0	0.0
Clintons Road	90	1.5	0	0.0
Fonterra Railway Siding	230	3.8	0	0.0
Homebush Road East of Railway	412	6.9	602	10.0
Homebush Road West of Railway	108	1.8	307	5.1
Horndon Street	0	0.0	0	0.0
Kimberley Road North	0	0.0	0	0.0
Kimberley Road South	0	0.0	0	0.0
Landsborough Drive	0	0.0	0	0.0
Loes Road	0	0.0	0	0.0
Main Trunk Line	0	0.0	0	0.0
SH 73 North of Homebush Road	0	0.0	0	0.0
SH 73 South of Homebush Road	0	0.0	0	0.0
Tramway Road East of Kimberley Road	0	0.0	0	0.0
Tramway Road West of Kimberley Road	0	0.0	0	0.0
Whitcombe Place	0	0.0	0	0.0

PV: Darfield Preliminary potential temporary after-image

Receptor results ordered by category of glare

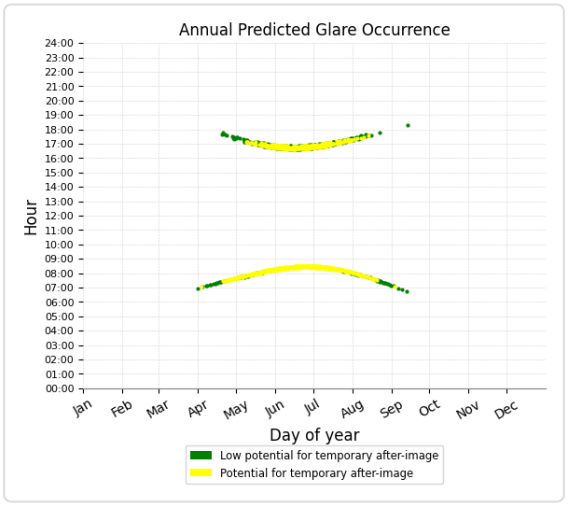
Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
Homebush Road East of Railway	412	6.9	602	10.0	2,167,793
Homebush Road West of Railway	108	1.8	307	5.1	2,571,142
Boultons Road	432	7.2	0	0.0	216,416
Clintons Road	90	1.5	0	0.0	63,718
Fonterra Railway Siding	230	3.8	0	0.0	214,775
Auchenflower Road	0	0.0	0	0.0	0
Bleak House Road	0	0.0	0	0.0	0
Horndon Street	0	0.0	0	0.0	0
Kimberley Road North	0	0.0	0	0.0	0
Kimberley Road South	0	0.0	0	0.0	0
Landsborough Drive	0	0.0	0	0.0	0
Loes Road	0	0.0	0	0.0	0
Main Trunk Line	0	0.0	0	0.0	0
SH 73 North of Homebush Road	0	0.0	0	0.0	0
SH 73 South of Homebush Road	0	0.0	0	0.0	0
Tramway Road East of Kimberley Road	0	0.0	0	0.0	0
Tramway Road West of Kimberley Road	0	0.0	0	0.0	0
Whitcombe Place	0	0.0	0	0.0	0

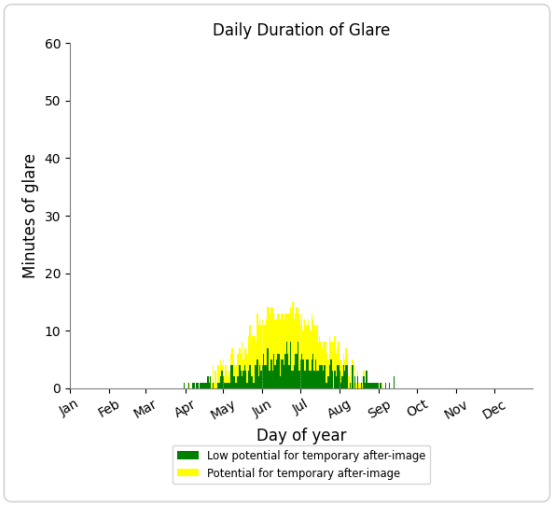


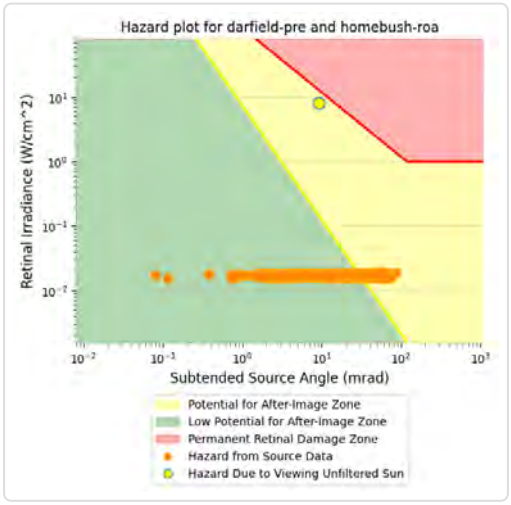
Darfield Preliminary and Route: Homebush Road East of Railway

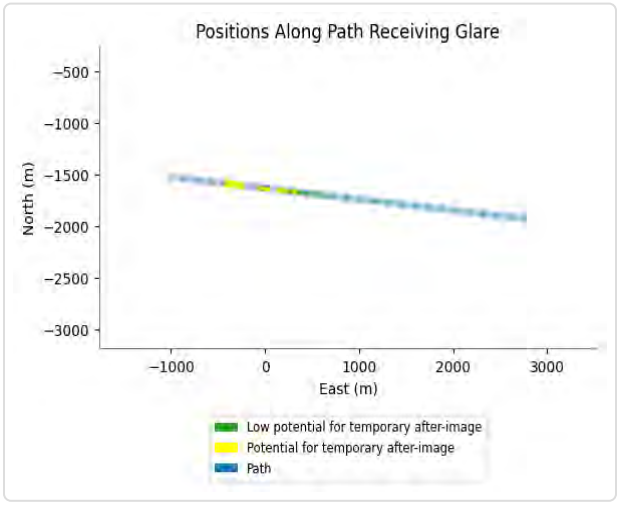
Yellow glare: 602 min.

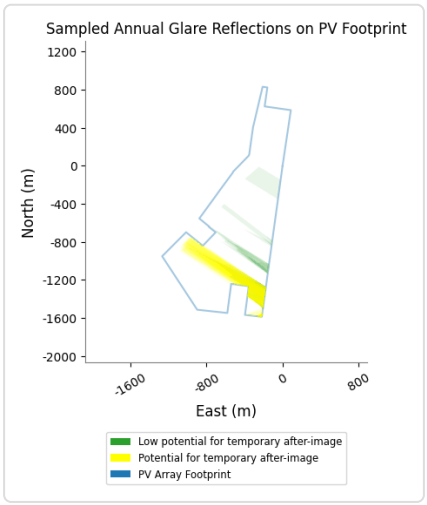
Green glare: 412 min.

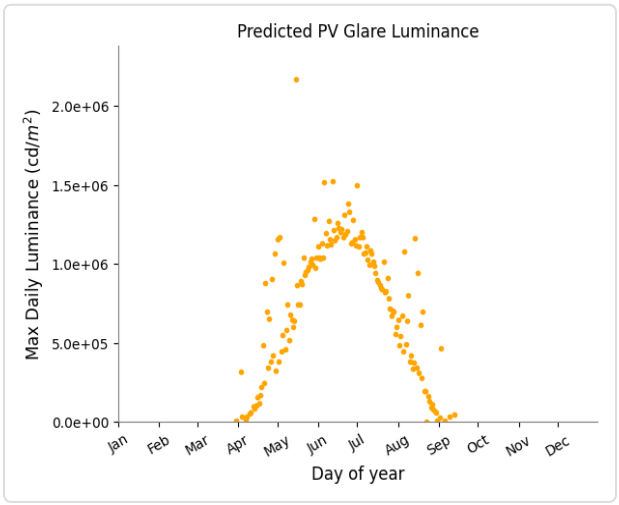








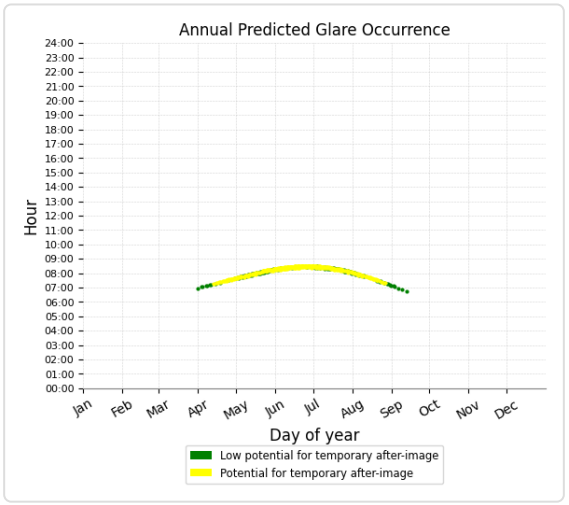


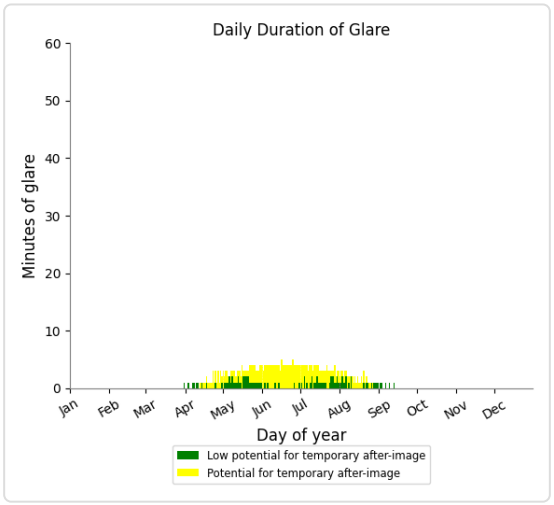


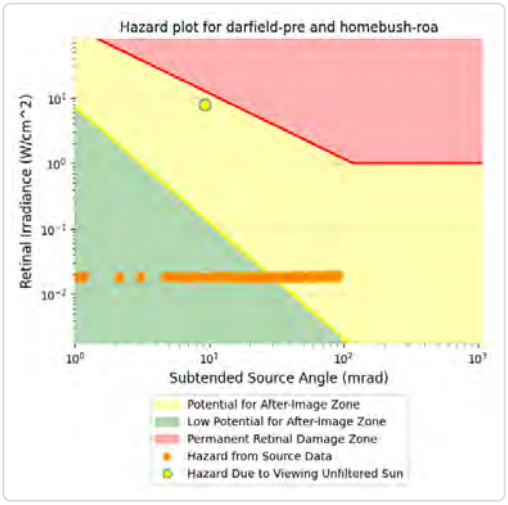
Darfield Preliminary and Route: Homebush Road West of Railway

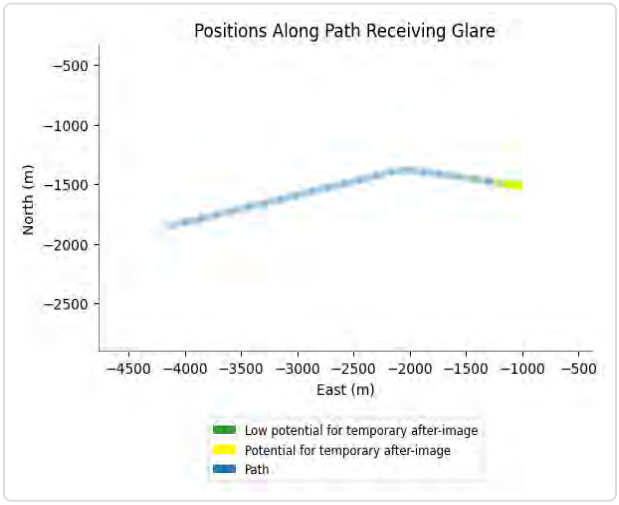
Yellow glare: 307 min.

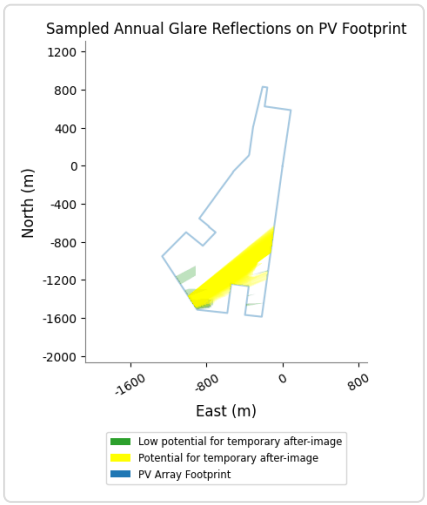
Green glare: 108 min.

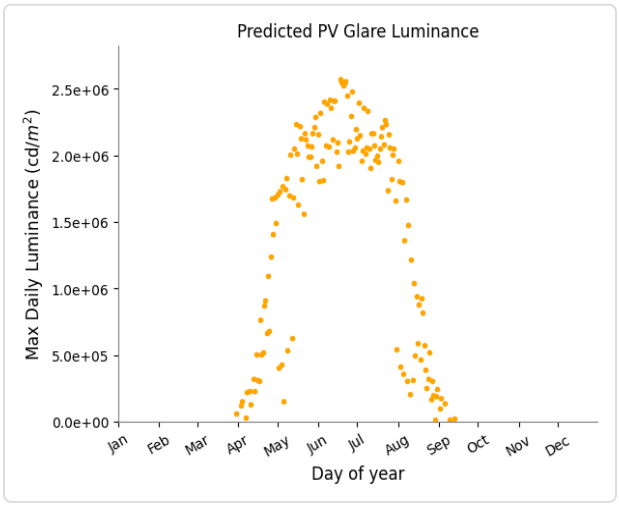








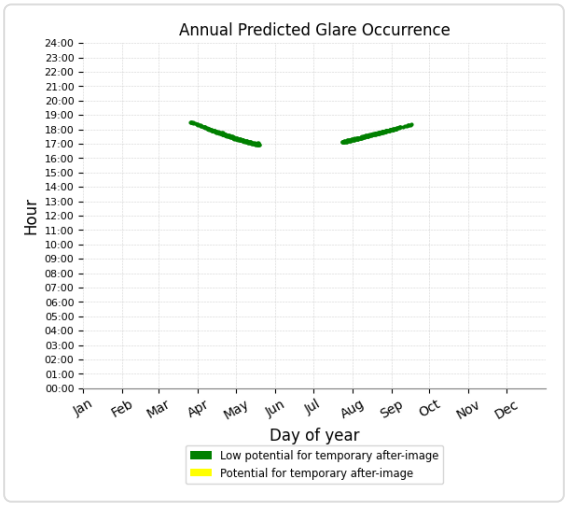


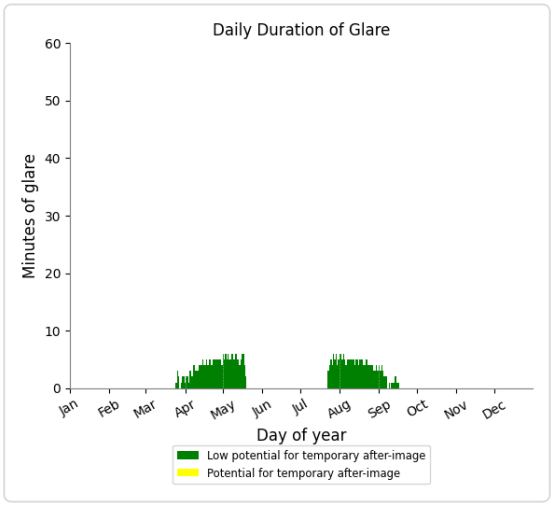


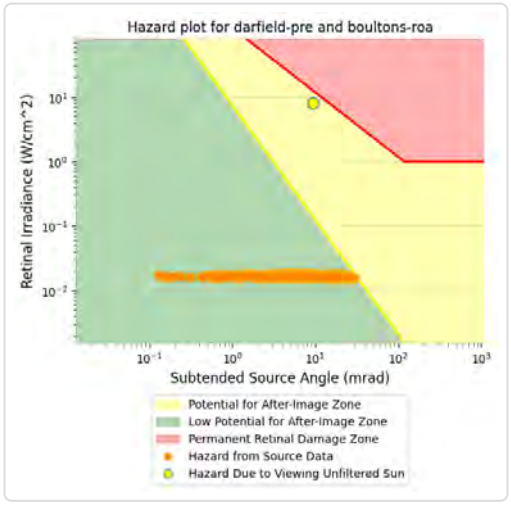
Darfield Preliminary and Route: Boultons Road

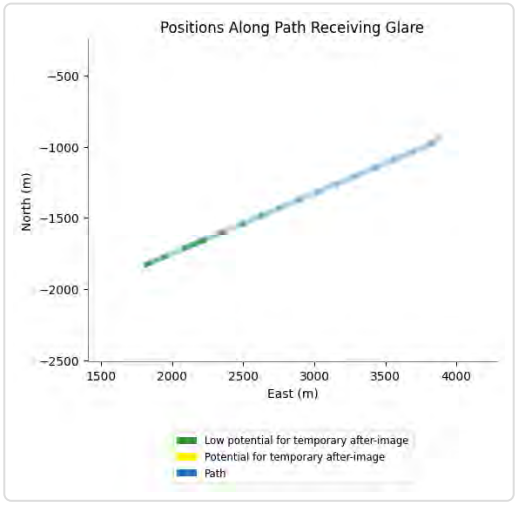
Yellow glare: none

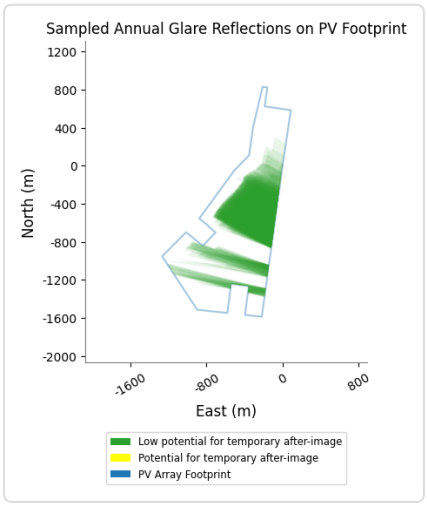
Green glare: 432 min.

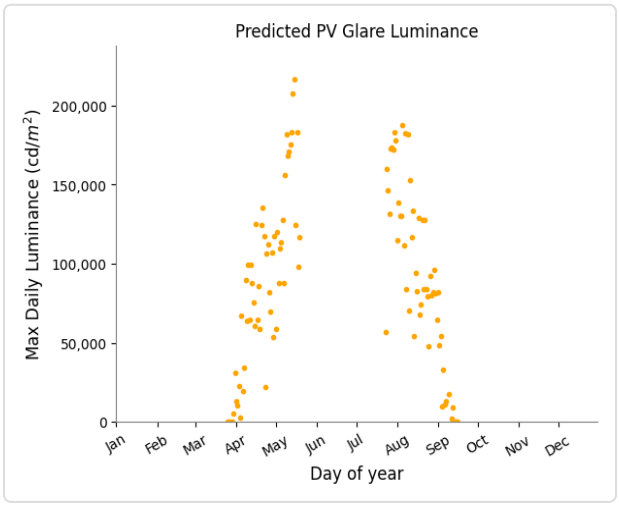








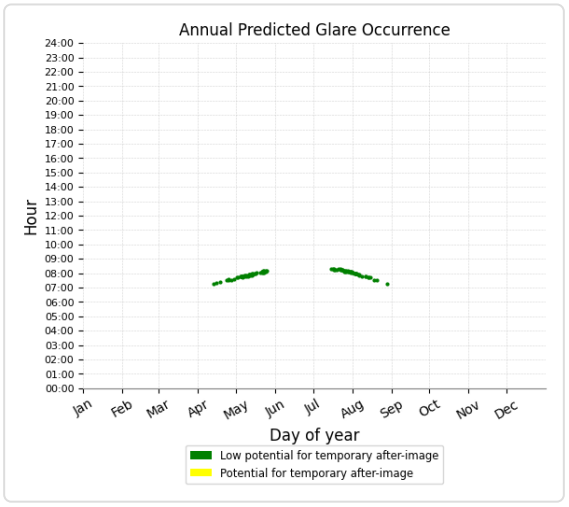


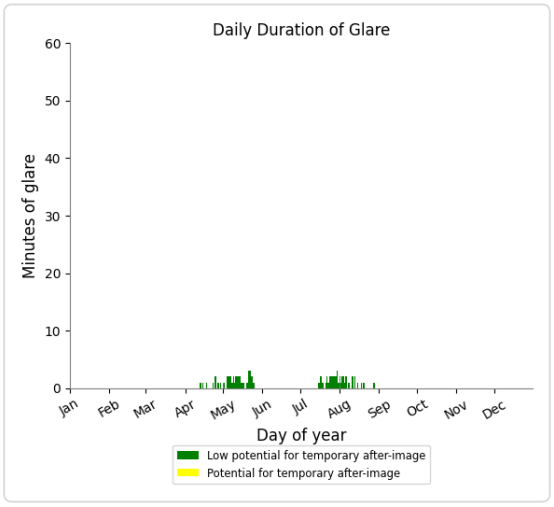


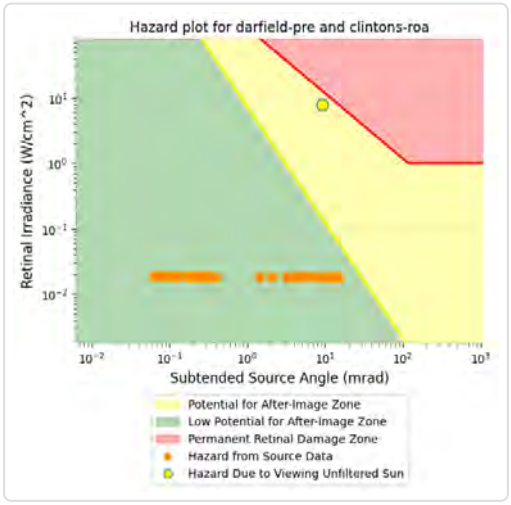
Darfield Preliminary and Route: Clintons Road

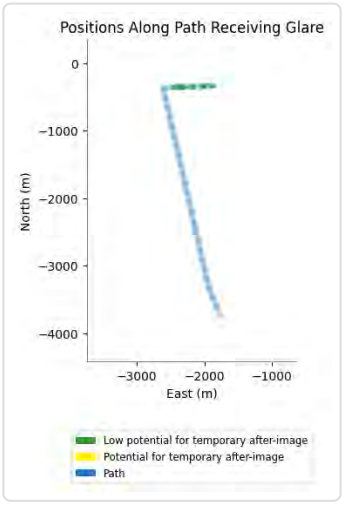
Yellow glare: none

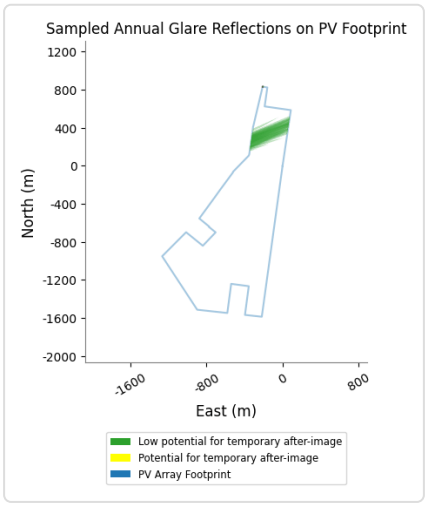
Green glare: 90 min.

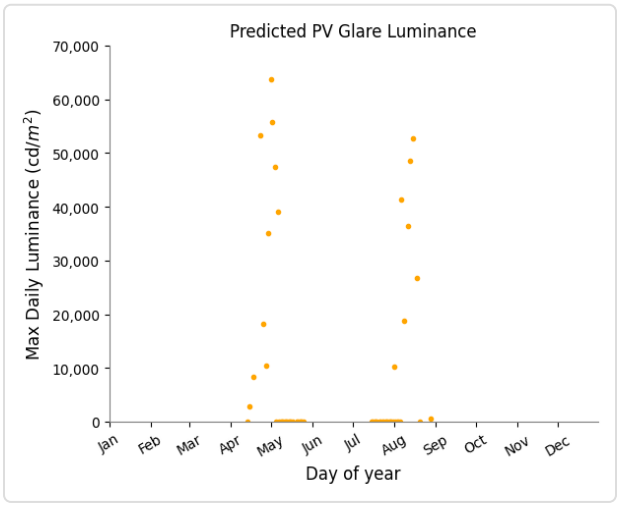








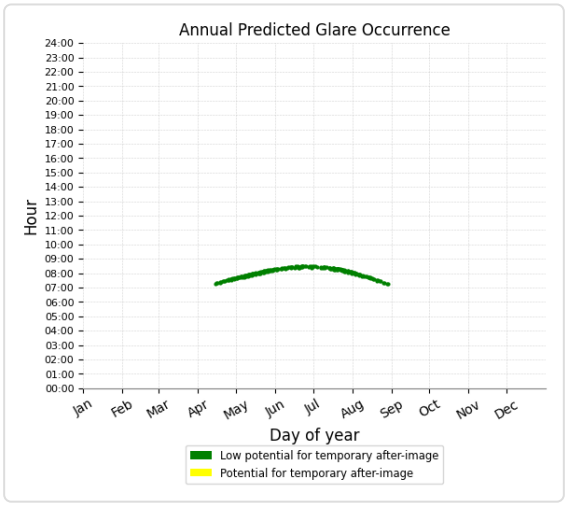


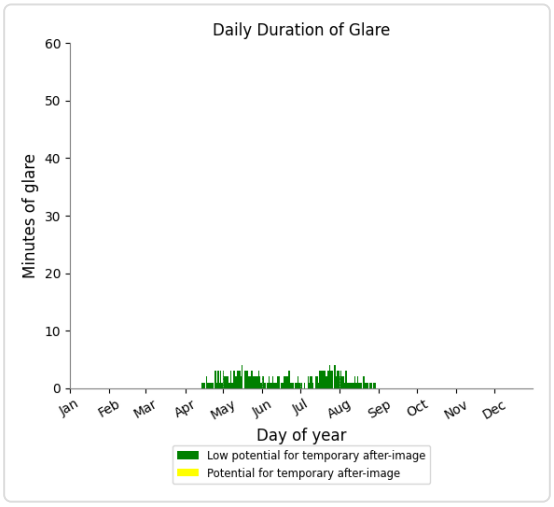


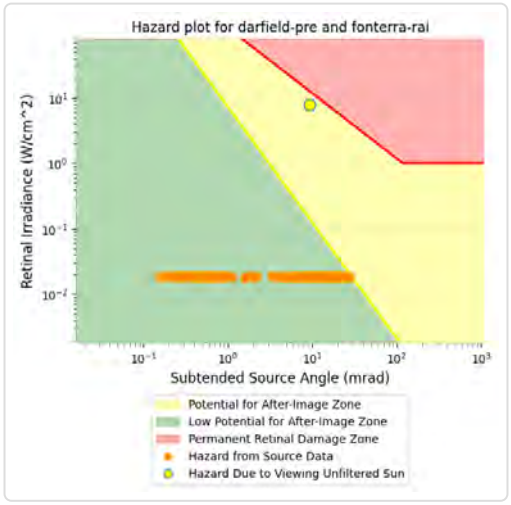
Darfield Preliminary and Route: Fonterra Railway Siding

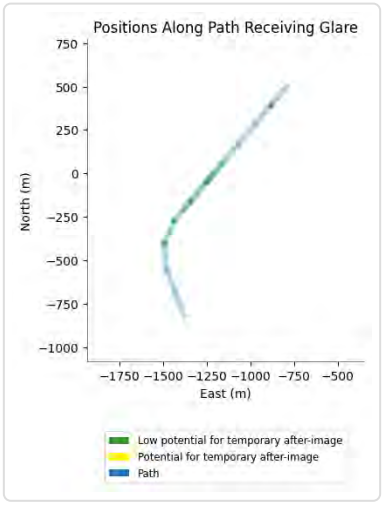
Yellow glare: none

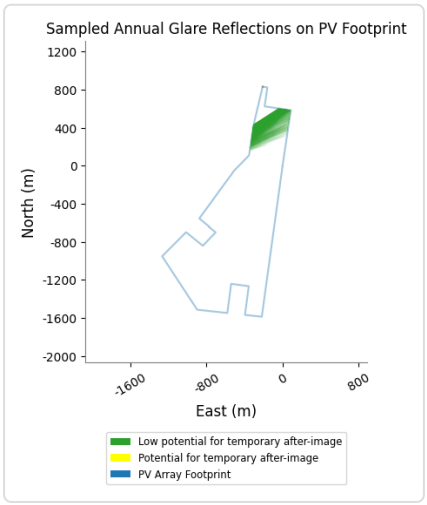
Green glare: 230 min.

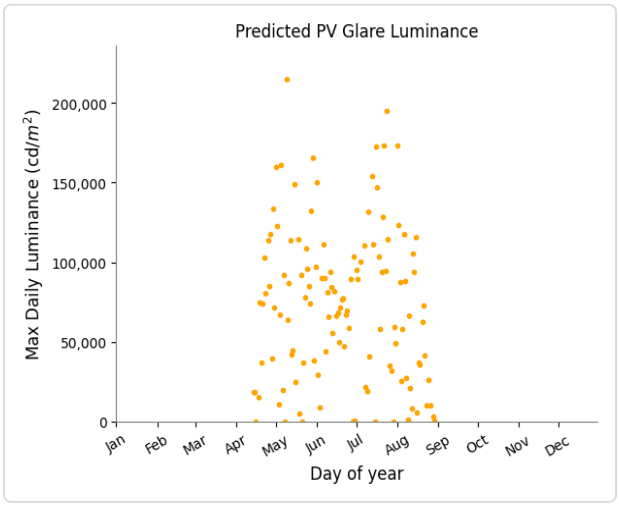












Darfield Preliminary and Route: Auchenflower Road

No glare found

Darfield Preliminary and Route: Bleak House Road

No glare found

Darfield Preliminary and Route: Horndon Street

No glare found

Darfield Preliminary and Route: Kimberley Road North

No glare found

Darfield Preliminary and Route: Kimberley Road South

No glare found

Darfield Preliminary and Route: Landsborough Drive

No glare found

Darfield Preliminary and Route: Loes Road

No glare found

Darfield Preliminary and Route: Main Trunk Line

No glare found

Darfield Preliminary and Route: SH 73 North of Homebush Road

No glare found

Darfield Preliminary and Route: SH 73 South of Homebush Road

No glare found

Darfield Preliminary and Route: Tramway Road East of Kimberley Road

No glare found

Darfield Preliminary and Route: Tramway Road West of Kimberley Road

No glare found

Darfield Preliminary and Route: Whitcombe Place

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

FORGESOLAR GLARE ANALYSIS

Project: **Darfield Solar**
Site configuration: **Darfield - NZTA CAR WITHOUT OBSTRUCTIONS R2**

Client: NZ Clean Energy

Site description: Darfield NZTA Car Driver eye level without vegetation obstructions

Created 30 May, 2024
Updated 30 May, 2024
Time-step 1 minute
Timezone offset UTC12
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 100 to 500 kW
Site ID 120493.20038

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	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
Darfield Preliminary	SA tracking	SA tracking	429	7.2	579	9.7	-	2,233,499

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
Auchenflower Road	36	0.6	0	0.0
Bleak House Road	0	0.0	0	0.0
Boultons Road	0	0.0	0	0.0
Clintons Road	133	2.2	0	0.0
Homebush Road East of Railway	187	3.1	249	4.2
Homebush Road West of Railway	73	1.2	330	5.5
Horndon Street	0	0.0	0	0.0
Kimberley Road North	0	0.0	0	0.0
Kimberley Road South	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Landsborough Drive	0	0.0	0	0.0
Loes Road	0	0.0	0	0.0
Main Trunk Line	0	0.0	0	0.0
SH 73 North of Homebush Road	0	0.0	0	0.0
SH 73 South of Homebush Road	0	0.0	0	0.0
Tramway Road East of Kimberley Road	0	0.0	0	0.0
Tramway Road West of Kimberley Road	0	0.0	0	0.0
Whitcombe Place	0	0.0	0	0.0

Component Data

PV Arrays

Name: Darfield Preliminary
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 7.5467°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.434
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	-43.451667	172.097071	231.90	1.40	233.30
2	-43.465951	172.094370	221.20	1.40	222.60
3	-43.465778	172.092183	221.10	1.40	222.50
4	-43.463059	172.092676	223.80	1.40	225.20
5	-43.462839	172.090390	224.50	1.40	225.90
6	-43.465596	172.089889	222.20	1.40	223.60
7	-43.465287	172.085972	223.20	1.40	224.60
8	-43.460230	172.081414	229.00	1.40	230.40
9	-43.457955	172.084528	230.10	1.40	231.50
10	-43.459237	172.086705	228.40	1.40	229.80
11	-43.457965	172.088370	229.40	1.40	230.80
12	-43.457442	172.087479	229.80	1.40	231.20
13	-43.457410	172.087512	229.80	1.40	231.20
14	-43.456653	172.086246	230.60	1.40	232.00
15	-43.454706	172.088200	232.30	1.40	233.70
16	-43.453924	172.088971	232.60	1.40	234.00
17	-43.452312	172.090606	233.40	1.40	234.80
18	-43.452239	172.090630	233.60	1.40	235.00
19	-43.450710	172.092674	234.00	1.40	235.40
20	-43.450660	172.092704	234.00	1.40	235.40
21	-43.450585	172.092739	233.90	1.40	235.30
22	-43.447953	172.093245	236.10	1.40	237.50
23	-43.447856	172.093289	236.10	1.40	237.50
24	-43.444192	172.094476	238.40	1.40	239.80
25	-43.444256	172.095094	237.70	1.40	239.10
26	-43.446052	172.094744	237.20	1.40	238.60
27	-43.446405	172.098146	235.30	1.40	236.70

Route Receptors

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.446950	172.121125	226.70	1.10	227.80
2	-43.446557	172.119438	227.60	1.10	228.70
3	-43.446355	172.117663	227.80	1.10	228.90
4	-43.446175	172.115884	228.60	1.10	229.70
5	-43.445995	172.114104	229.70	1.10	230.80
6	-43.445815	172.112325	230.50	1.10	231.60
7	-43.445635	172.110545	231.50	1.10	232.60
8	-43.445456	172.108766	232.10	1.10	233.20
9	-43.445276	172.106987	233.00	1.10	234.10
10	-43.445096	172.105207	233.70	1.10	234.80
11	-43.444914	172.103428	234.20	1.10	235.30
12	-43.444732	172.101649	235.20	1.10	236.30
13	-43.444549	172.099870	236.50	1.10	237.60
14	-43.444365	172.098091	236.80	1.10	237.90
15	-43.444178	172.096313	237.60	1.10	238.70
16	-43.443990	172.094535	238.20	1.10	239.30
17	-43.443803	172.092757	239.40	1.10	240.50
18	-43.443617	172.090979	240.30	1.10	241.40
19	-43.443433	172.089200	240.60	1.10	241.70
20	-43.443250	172.087422	241.00	1.10	242.10
21	-43.443066	172.085643	242.50	1.10	243.60
22	-43.442883	172.083864	243.30	1.10	244.40
23	-43.442700	172.082085	244.00	1.10	245.10
24	-43.442516	172.080306	245.90	1.10	247.00
25	-43.442333	172.078528	246.90	1.10	248.00
26	-43.442152	172.076748	247.70	1.10	248.80
27	-43.441972	172.074969	248.20	1.10	249.30
28	-43.441792	172.073190	249.20	1.10	250.30
29	-43.441611	172.071410	249.90	1.10	251.00
30	-43.441431	172.069631	250.30	1.10	251.40

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.441027	172.066132	250.80	1.10	251.90
2	-43.440555	172.067806	250.70	1.10	251.80
3	-43.440072	172.069475	250.90	1.10	252.00
4	-43.439588	172.071143	251.40	1.10	252.50
5	-43.439104	172.072812	251.20	1.10	252.30
6	-43.438623	172.074482	250.70	1.10	251.80
7	-43.438144	172.076153	249.90	1.10	251.00
8	-43.437664	172.077824	249.60	1.10	250.70
9	-43.437185	172.079495	249.10	1.10	250.20
10	-43.436705	172.081165	249.00	1.10	250.10
11	-43.436220	172.082833	247.70	1.10	248.80
12	-43.435732	172.084499	246.70	1.10	247.80
13	-43.435244	172.086166	246.60	1.10	247.70
14	-43.434757	172.087832	246.70	1.10	247.80
15	-43.434269	172.089498	246.30	1.10	247.40
16	-43.433781	172.091165	245.50	1.10	246.60
17	-43.433310	172.092840	245.20	1.10	246.30
18	-43.432840	172.094516	244.80	1.10	245.90
19	-43.432370	172.096192	244.00	1.10	245.10
20	-43.432338	172.096305	243.90	1.10	245.00

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.468107	172.119551	212.50	1.10	213.60
2	-43.467599	172.121205	211.40	1.10	212.50
3	-43.467090	172.122860	211.70	1.10	212.80
4	-43.466581	172.124514	211.80	1.10	212.90
5	-43.466073	172.126168	211.60	1.10	212.70
6	-43.465564	172.127823	211.60	1.10	212.70
7	-43.465056	172.129477	211.30	1.10	212.40
8	-43.464547	172.131132	211.20	1.10	212.30
9	-43.464039	172.132786	210.80	1.10	211.90
10	-43.463530	172.134440	210.00	1.10	211.10
11	-43.463022	172.136095	209.50	1.10	210.60
12	-43.462513	172.137749	208.40	1.10	209.50
13	-43.462005	172.139403	208.20	1.10	209.30
14	-43.461496	172.141058	208.40	1.10	209.50
15	-43.460987	172.142712	207.40	1.10	208.50
16	-43.460469	172.144360	207.30	1.10	208.40
17	-43.460079	172.144939	207.30	1.10	208.40

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.485350	172.075213	208.50	1.10	209.60
2	-43.484132	172.074572	209.40	1.10	210.50
3	-43.482915	172.073931	210.30	1.10	211.40
4	-43.481697	172.073290	211.50	1.10	212.60
5	-43.480442	172.072814	212.50	1.10	213.60
6	-43.479171	172.072412	213.80	1.10	214.90
7	-43.477898	172.072026	214.70	1.10	215.80
8	-43.476624	172.071640	215.90	1.10	217.00
9	-43.475356	172.071228	216.90	1.10	218.00
10	-43.474084	172.070831	218.10	1.10	219.20
11	-43.472813	172.070434	219.30	1.10	220.40
12	-43.471541	172.070037	220.40	1.10	221.50
13	-43.470269	172.069640	221.50	1.10	222.60
14	-43.468998	172.069243	223.30	1.10	224.40
15	-43.467726	172.068846	224.30	1.10	225.40
16	-43.466454	172.068449	225.20	1.10	226.30
17	-43.465183	172.068052	226.40	1.10	227.50
18	-43.463911	172.067654	227.60	1.10	228.70
19	-43.462641	172.067250	228.70	1.10	229.80
20	-43.461370	172.066848	230.00	1.10	231.10
21	-43.460099	172.066445	231.00	1.10	232.10
22	-43.458828	172.066043	232.40	1.10	233.50
23	-43.457557	172.065641	233.70	1.10	234.80
24	-43.456286	172.065239	235.20	1.10	236.30
25	-43.455025	172.064944	236.50	1.10	237.60
26	-43.454868	172.066674	236.10	1.10	237.20
27	-43.454816	172.068469	236.10	1.10	237.20
28	-43.454765	172.070264	236.30	1.10	237.40
29	-43.454713	172.072059	236.30	1.10	237.40
30	-43.454661	172.073855	236.30	1.10	237.40

Name: Homebush Road East of Railway
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.465355	172.084639	224.00	1.10	225.10
2	-43.465498	172.086425	223.00	1.10	224.10
3	-43.465636	172.088211	222.40	1.10	223.50
4	-43.465774	172.089998	222.10	1.10	223.20
5	-43.465913	172.091784	221.60	1.10	222.70
6	-43.466051	172.093571	221.00	1.10	222.10
7	-43.466200	172.095355	220.50	1.10	221.60
8	-43.466356	172.097139	220.20	1.10	221.30
9	-43.466493	172.098926	219.20	1.10	220.30
10	-43.466630	172.100712	218.90	1.10	220.00
11	-43.466767	172.102499	218.60	1.10	219.70
12	-43.466904	172.104286	217.80	1.10	218.90
13	-43.467041	172.106072	217.00	1.10	218.10
14	-43.467182	172.107858	216.40	1.10	217.50
15	-43.467323	172.109645	215.60	1.10	216.70
16	-43.467463	172.111431	215.40	1.10	216.50
17	-43.467604	172.113217	215.20	1.10	216.30
18	-43.467745	172.115003	214.30	1.10	215.40
19	-43.467886	172.116789	213.80	1.10	214.90
20	-43.468028	172.118575	212.70	1.10	213.80
21	-43.468164	172.120362	211.70	1.10	212.80
22	-43.468302	172.122148	210.90	1.10	212.00
23	-43.468444	172.123934	210.40	1.10	211.50
24	-43.468586	172.125720	210.10	1.10	211.20
25	-43.468729	172.127506	209.30	1.10	210.40
26	-43.468871	172.129292	209.00	1.10	210.10
27	-43.469013	172.131078	208.40	1.10	209.50
28	-43.469035	172.131348	208.20	1.10	209.30

Name: Homebush Road West of Railway
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.468385	172.045917	226.70	1.10	227.80
2	-43.468088	172.047667	226.30	1.10	227.40
3	-43.467788	172.049415	226.20	1.10	227.30
4	-43.467495	172.051166	228.00	1.10	229.10
5	-43.467201	172.052916	229.20	1.10	230.30
6	-43.466908	172.054667	229.00	1.10	230.10
7	-43.466615	172.056418	228.50	1.10	229.60
8	-43.466321	172.058168	228.60	1.10	229.70
9	-43.466028	172.059919	228.50	1.10	229.60
10	-43.465734	172.061669	228.30	1.10	229.40
11	-43.465441	172.063420	228.20	1.10	229.30
12	-43.465148	172.065170	227.70	1.10	228.80
13	-43.464854	172.066921	227.30	1.10	228.40
14	-43.464555	172.068669	227.00	1.10	228.10
15	-43.464259	172.070419	227.40	1.10	228.50
16	-43.464093	172.072184	227.70	1.10	228.80
17	-43.464269	172.073965	227.60	1.10	228.70
18	-43.464444	172.075745	227.50	1.10	228.60
19	-43.464619	172.077525	226.70	1.10	227.80
20	-43.464794	172.079305	226.40	1.10	227.50
21	-43.464970	172.081086	225.40	1.10	226.50
22	-43.465154	172.082864	224.60	1.10	225.70
23	-43.465355	172.084639	224.00	1.10	225.10

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.485008	172.109015	203.30	1.10	204.40
2	-43.484359	172.107457	204.30	1.10	205.40
3	-43.483287	172.106441	205.20	1.10	206.30
4	-43.482198	172.105455	206.30	1.10	207.40
5	-43.481109	172.104465	207.30	1.10	208.40
6	-43.480027	172.103465	207.90	1.10	209.00
7	-43.478936	172.102481	208.80	1.10	209.90
8	-43.477845	172.101498	209.60	1.10	210.70
9	-43.476753	172.100515	210.50	1.10	211.60
10	-43.476200	172.099297	211.60	1.10	212.70
11	-43.476972	172.097849	211.40	1.10	212.50
12	-43.477744	172.096401	211.30	1.10	212.40
13	-43.477773	172.096346	211.40	1.10	212.50

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.449707	172.120924	224.90	1.10	226.00
2	-43.448405	172.121018	225.90	1.10	227.00
3	-43.447102	172.121113	226.40	1.10	227.50
4	-43.445800	172.121220	227.10	1.10	228.20
5	-43.444498	172.121320	227.80	1.10	228.90
6	-43.443196	172.121420	228.60	1.10	229.70
7	-43.441893	172.121520	228.90	1.10	230.00
8	-43.440591	172.121620	229.70	1.10	230.80
9	-43.439288	172.121720	230.00	1.10	231.10
10	-43.437986	172.121820	230.50	1.10	231.60
11	-43.436683	172.121919	230.90	1.10	232.00
12	-43.435380	172.122019	232.10	1.10	233.20
13	-43.434078	172.122119	231.80	1.10	232.90
14	-43.432775	172.122219	231.80	1.10	232.90
15	-43.431472	172.122319	232.70	1.10	233.80
16	-43.430170	172.122419	233.50	1.10	234.60
17	-43.428867	172.122519	234.30	1.10	235.40
18	-43.427564	172.122618	234.50	1.10	235.60
19	-43.426261	172.122718	234.60	1.10	235.70
20	-43.424959	172.122818	234.80	1.10	235.90
21	-43.424766	172.122833	234.80	1.10	235.90

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.486918	172.107630	202.10	1.10	203.20
2	-43.485767	172.108472	202.80	1.10	203.90
3	-43.484599	172.109270	203.40	1.10	204.50
4	-43.483411	172.110007	203.90	1.10	205.00
5	-43.482222	172.110744	204.40	1.10	205.50
6	-43.481032	172.111478	205.30	1.10	206.40
7	-43.479843	172.112216	206.00	1.10	207.10
8	-43.478654	172.112952	206.30	1.10	207.40
9	-43.477465	172.113688	207.50	1.10	208.60
10	-43.476275	172.114424	208.50	1.10	209.60
11	-43.475086	172.115160	208.80	1.10	209.90
12	-43.473897	172.115896	209.70	1.10	210.80
13	-43.472707	172.116632	210.20	1.10	211.30
14	-43.471518	172.117368	210.50	1.10	211.60
15	-43.470329	172.118104	211.20	1.10	212.30
16	-43.469139	172.118840	211.70	1.10	212.80
17	-43.467936	172.119522	212.40	1.10	213.50
18	-43.466636	172.119641	213.20	1.10	214.30
19	-43.465334	172.119741	214.00	1.10	215.10
20	-43.464031	172.119831	215.00	1.10	216.10
21	-43.462729	172.119932	216.10	1.10	217.20
22	-43.461427	172.120033	217.00	1.10	218.10
23	-43.460125	172.120133	218.00	1.10	219.10
24	-43.458823	172.120234	218.70	1.10	219.80
25	-43.457521	172.120332	219.10	1.10	220.20
26	-43.456219	172.120431	220.40	1.10	221.50
27	-43.454917	172.120530	221.30	1.10	222.40
28	-43.453614	172.120629	222.20	1.10	223.30
29	-43.452312	172.120728	223.20	1.10	224.30
30	-43.451010	172.120827	224.10	1.10	225.20

Name: Landsborough Drive
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.480136	172.112034	205.80	1.10	206.90
2	-43.479667	172.110359	206.40	1.10	207.50
3	-43.479131	172.108722	207.40	1.10	208.50
4	-43.478594	172.107084	208.20	1.10	209.30
5	-43.478060	172.105446	209.10	1.10	210.20
6	-43.477526	172.103807	209.90	1.10	211.00
7	-43.476827	172.102337	210.10	1.10	211.20
8	-43.475607	172.101796	211.10	1.10	212.20
9	-43.474323	172.101634	212.30	1.10	213.40
10	-43.473985	172.101752	212.40	1.10	213.50

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.466130	172.094587	221.10	1.10	222.20
2	-43.464839	172.094834	221.60	1.10	222.70
3	-43.463547	172.095081	222.80	1.10	223.90
4	-43.462255	172.095328	223.70	1.10	224.80
5	-43.460964	172.095575	225.10	1.10	226.20
6	-43.459672	172.095822	225.80	1.10	226.90
7	-43.458380	172.096069	226.80	1.10	227.90
8	-43.457089	172.096316	227.80	1.10	228.90
9	-43.455797	172.096563	228.90	1.10	230.00
10	-43.454505	172.096810	229.80	1.10	230.90
11	-43.453213	172.097057	230.80	1.10	231.90
12	-43.451921	172.097304	231.70	1.10	232.80
13	-43.450629	172.097551	232.80	1.10	233.90
14	-43.449337	172.097798	233.60	1.10	234.70
15	-43.448045	172.098045	234.20	1.10	235.30
16	-43.446753	172.098292	234.80	1.10	235.90
17	-43.445461	172.098539	235.90	1.10	237.00
18	-43.444433	172.098736	236.70	1.10	237.80

Name: Main Trunk Line
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.475051	172.094494	214.10	3.00	217.10
2	-43.473960	172.093510	215.10	3.00	218.10
3	-43.472870	172.092525	216.10	3.00	219.10
4	-43.471779	172.091541	217.20	3.00	220.20
5	-43.470688	172.090557	218.20	3.00	221.20
6	-43.469597	172.089573	219.20	3.00	222.20
7	-43.468506	172.088588	220.30	3.00	223.30
8	-43.467415	172.087604	221.50	3.00	224.50
9	-43.466325	172.086620	222.70	3.00	225.70
10	-43.465234	172.085636	223.80	3.00	226.80
11	-43.464143	172.084652	225.10	3.00	228.10
12	-43.463052	172.083667	226.50	3.00	229.50
13	-43.461961	172.082683	227.80	3.00	230.80
14	-43.460870	172.081699	229.00	3.00	232.00
15	-43.459779	172.080715	230.40	3.00	233.40
16	-43.458688	172.079730	231.50	3.00	234.50
17	-43.457597	172.078746	232.80	3.00	235.80
18	-43.456506	172.077762	234.10	3.00	237.10
19	-43.455416	172.076776	235.30	3.00	238.30
20	-43.454313	172.075817	236.70	3.00	239.70
21	-43.453157	172.074986	237.80	3.00	240.80
22	-43.452425	172.074469	238.70	3.00	241.70

Name: SH 73 North of Homebush Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.465209	172.085024	224.00	1.10	225.10
2	-43.464120	172.084037	225.30	1.10	226.40
3	-43.463031	172.083049	226.40	1.10	227.50
4	-43.461942	172.082060	227.70	1.10	228.80
5	-43.460853	172.081072	229.00	1.10	230.10
6	-43.459763	172.080084	230.10	1.10	231.20
7	-43.458674	172.079096	231.30	1.10	232.40
8	-43.457582	172.078113	232.60	1.10	233.70
9	-43.456487	172.077138	234.00	1.10	235.10
10	-43.455392	172.076162	235.00	1.10	236.10
11	-43.454228	172.075354	236.20	1.10	237.30
12	-43.453073	172.074519	237.90	1.10	239.00
13	-43.451918	172.073684	239.30	1.10	240.40
14	-43.450763	172.072849	240.80	1.10	241.90
15	-43.449608	172.072015	243.00	1.10	244.10
16	-43.448447	172.071195	244.90	1.10	246.00
17	-43.447287	172.070375	246.10	1.10	247.20
18	-43.446126	172.069554	246.20	1.10	247.30
19	-43.444966	172.068734	248.00	1.10	249.10
20	-43.443805	172.067914	249.60	1.10	250.70
21	-43.442645	172.067094	250.50	1.10	251.60
22	-43.441484	172.066273	250.70	1.10	251.80
23	-43.440343	172.065403	250.80	1.10	251.90
24	-43.439215	172.064502	251.00	1.10	252.10
25	-43.438087	172.063599	251.30	1.10	252.40
26	-43.436960	172.062695	251.80	1.10	252.90
27	-43.435830	172.061795	252.70	1.10	253.80
28	-43.434702	172.060893	253.80	1.10	254.90
29	-43.433743	172.060124	254.70	1.10	255.80

Name: SH 73 South of Homebush Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.489806	172.112097	198.70	1.10	199.80
2	-43.489625	172.110318	199.50	1.10	200.60
3	-43.489443	172.108539	199.90	1.10	201.00
4	-43.489077	172.106867	200.80	1.10	201.90
5	-43.488112	172.105696	201.20	1.10	202.30
6	-43.487021	172.104713	202.40	1.10	203.50
7	-43.485930	172.103730	203.50	1.10	204.60
8	-43.484838	172.102747	204.20	1.10	205.30
9	-43.483747	172.101764	204.90	1.10	206.00
10	-43.482656	172.100781	206.00	1.10	207.10
11	-43.481566	172.099796	206.80	1.10	207.90
12	-43.480476	172.098811	208.10	1.10	209.20
13	-43.479385	172.097826	209.40	1.10	210.50
14	-43.478300	172.096831	210.70	1.10	211.80
15	-43.477216	172.095832	211.70	1.10	212.80
16	-43.476129	172.094840	212.80	1.10	213.90
17	-43.475030	172.093874	213.90	1.10	215.00
18	-43.473940	172.092889	214.90	1.10	216.00
19	-43.472849	172.091904	216.00	1.10	217.10
20	-43.471759	172.090919	217.10	1.10	218.20
21	-43.470668	172.089934	218.00	1.10	219.10
22	-43.469578	172.088950	219.20	1.10	220.30
23	-43.468487	172.087965	220.30	1.10	221.40
24	-43.467397	172.086980	221.60	1.10	222.70
25	-43.466306	172.085996	222.90	1.10	224.00
26	-43.465209	172.085024	224.00	1.10	225.10

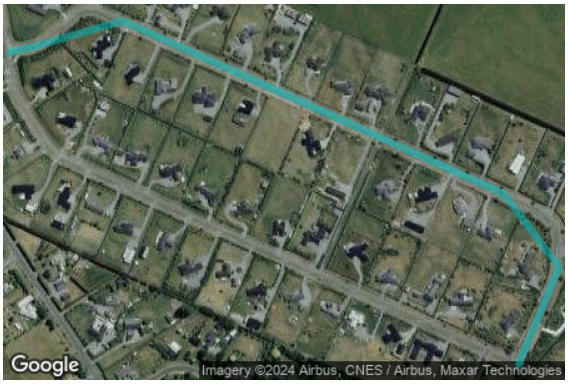
Name: Tramway Road East of Kimberley Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.446791	172.121624	226.30	1.10	227.40
2	-43.447596	172.123037	225.00	1.10	226.10
3	-43.448402	172.124451	223.70	1.10	224.80
4	-43.449207	172.125864	222.70	1.10	223.80
5	-43.450013	172.127277	221.50	1.10	222.60
6	-43.450818	172.128690	220.50	1.10	221.60
7	-43.451624	172.130103	219.20	1.10	220.30
8	-43.452429	172.131516	218.40	1.10	219.50
9	-43.453234	172.132929	216.90	1.10	218.00
10	-43.454040	172.134343	216.00	1.10	217.10
11	-43.454845	172.135756	214.90	1.10	216.00
12	-43.455651	172.137169	213.70	1.10	214.80
13	-43.456456	172.138582	212.60	1.10	213.70
14	-43.457261	172.139995	211.30	1.10	212.40
15	-43.458067	172.141408	209.80	1.10	210.90
16	-43.458872	172.142821	208.80	1.10	209.90
17	-43.459677	172.144234	207.80	1.10	208.90
18	-43.460079	172.144939	207.30	1.10	208.40

Name: Tramway Road West of Kimberley Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.432338	172.096305	243.90	1.10	245.00
2	-43.433128	172.097732	243.10	1.10	244.20
3	-43.433935	172.099143	242.40	1.10	243.50
4	-43.434743	172.100554	241.30	1.10	242.40
5	-43.435551	172.101964	240.60	1.10	241.70
6	-43.436359	172.103375	239.70	1.10	240.80
7	-43.437167	172.104786	238.60	1.10	239.70
8	-43.437974	172.106197	237.80	1.10	238.90
9	-43.438781	172.107608	237.10	1.10	238.20
10	-43.439589	172.109020	236.10	1.10	237.20
11	-43.440396	172.110431	235.10	1.10	236.20
12	-43.441203	172.111843	233.90	1.10	235.00
13	-43.442010	172.113254	232.60	1.10	233.70
14	-43.442817	172.114666	231.10	1.10	232.20
15	-43.443623	172.116079	230.30	1.10	231.40
16	-43.444427	172.117493	229.60	1.10	230.70
17	-43.445231	172.118908	228.40	1.10	229.50
18	-43.446035	172.120322	227.20	1.10	228.30
19	-43.446791	172.121624	226.30	1.10	227.40

Name: Whitcombe Place
Path type: Two-way
Observer view angle: 50.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.479746	172.110610	206.50	1.10	207.60
2	-43.478548	172.111298	206.90	1.10	208.00
3	-43.477634	172.110351	207.80	1.10	208.90
4	-43.477095	172.108715	208.50	1.10	209.60
5	-43.476558	172.107078	209.70	1.10	210.80
6	-43.476023	172.105440	210.50	1.10	211.60
7	-43.475487	172.103802	211.10	1.10	212.20
8	-43.475809	172.102251	210.90	1.10	212.00
9	-43.475874	172.101869	210.90	1.10	212.00

Obstruction Components

Name: Fonterra Store
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.451541	172.082794	245.15
2	-43.448948	172.085712	245.09
3	-43.449104	172.085959	245.34
4	-43.447959	172.087279	245.13
5	-43.448340	172.087890	245.03

Name: Middle Bund
Top height: 3.5 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.455798	172.084829	237.04
2	-43.454229	172.086216	239.21
3	-43.453606	172.086961	239.16
4	-43.451971	172.088831	240.67

Name: Northern Bund
Top height: 3.5 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.451649	172.089161	240.09
2	-43.450888	172.090035	240.48

Name: Southern Bund
Top height: 3.2 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.459270	172.082155	233.41
2	-43.458222	172.083424	234.83
3	-43.457932	172.083542	234.74
4	-43.457457	172.083678	235.11
5	-43.457056	172.083960	235.70
6	-43.456573	172.084411	236.95
7	-43.455726	172.085567	238.55

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	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
Darfield Preliminary	SA tracking	SA tracking	429	7.2	579	9.7	-	2,233,499

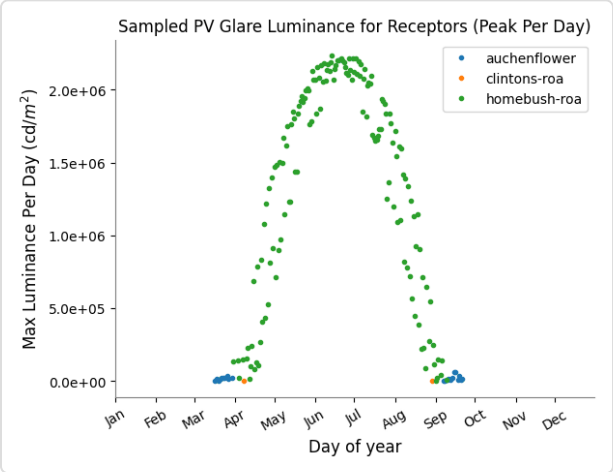
Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Auchenflower Road	36	0.6	0	0.0
Bleak House Road	0	0.0	0	0.0
Boultons Road	0	0.0	0	0.0
Clintons Road	133	2.2	0	0.0
Homebush Road East of Railway	187	3.1	249	4.2
Homebush Road West of Railway	73	1.2	330	5.5
Horndon Street	0	0.0	0	0.0
Kimberley Road North	0	0.0	0	0.0
Kimberley Road South	0	0.0	0	0.0
Landsborough Drive	0	0.0	0	0.0
Loes Road	0	0.0	0	0.0
Main Trunk Line	0	0.0	0	0.0
SH 73 North of Homebush Road	0	0.0	0	0.0
SH 73 South of Homebush Road	0	0.0	0	0.0
Tramway Road East of Kimberley Road	0	0.0	0	0.0
Tramway Road West of Kimberley Road	0	0.0	0	0.0
Whitcombe Place	0	0.0	0	0.0

PV: Darfield Preliminary potential temporary after-image

Receptor results ordered by category of glare

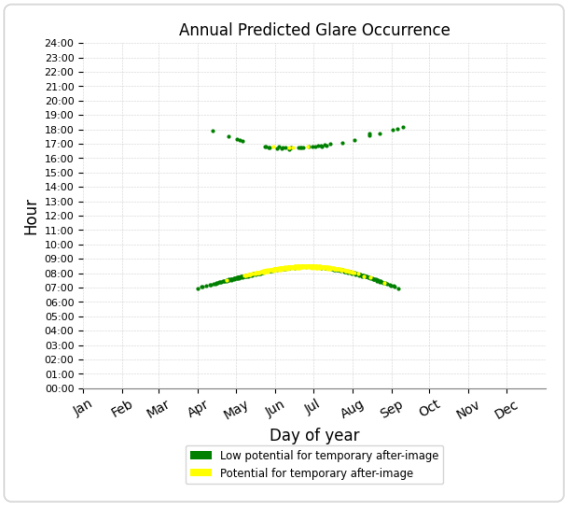
Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
Homebush Road East of Railway	187	3.1	249	4.2	769,885
Homebush Road West of Railway	73	1.2	330	5.5	2,233,499
Auchenflower Road	36	0.6	0	0.0	63,525
Clintons Road	133	2.2	0	0.0	55,537
Bleak House Road	0	0.0	0	0.0	0
Boultons Road	0	0.0	0	0.0	0
Horndon Street	0	0.0	0	0.0	0
Kimberley Road North	0	0.0	0	0.0	0
Kimberley Road South	0	0.0	0	0.0	0
Landsborough Drive	0	0.0	0	0.0	0
Loes Road	0	0.0	0	0.0	0
Main Trunk Line	0	0.0	0	0.0	0
SH 73 North of Homebush Road	0	0.0	0	0.0	0
SH 73 South of Homebush Road	0	0.0	0	0.0	0
Tramway Road East of Kimberley Road	0	0.0	0	0.0	0
Tramway Road West of Kimberley Road	0	0.0	0	0.0	0
Whitcombe Place	0	0.0	0	0.0	0

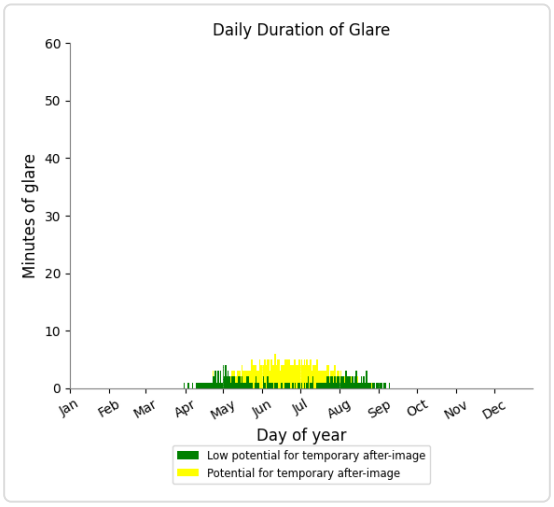


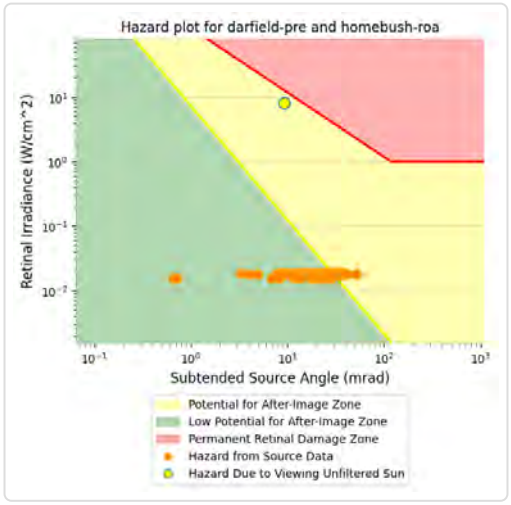
Darfield Preliminary and Route: Homebush Road East of Railway

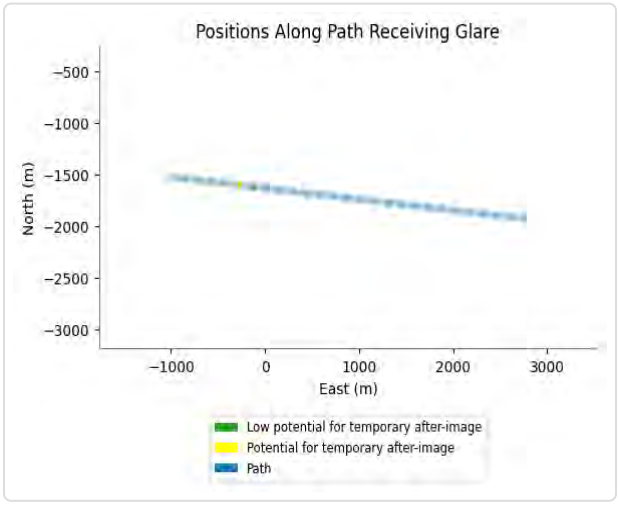
Yellow glare: 249 min.

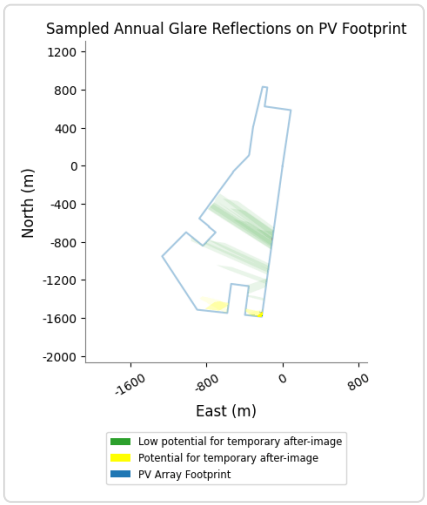
Green glare: 187 min.

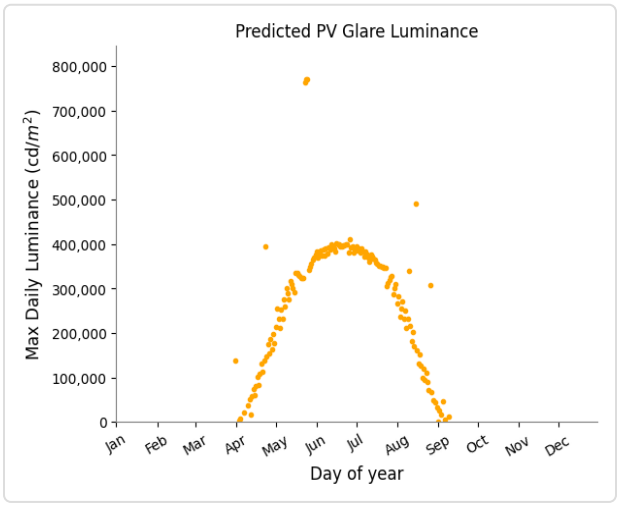








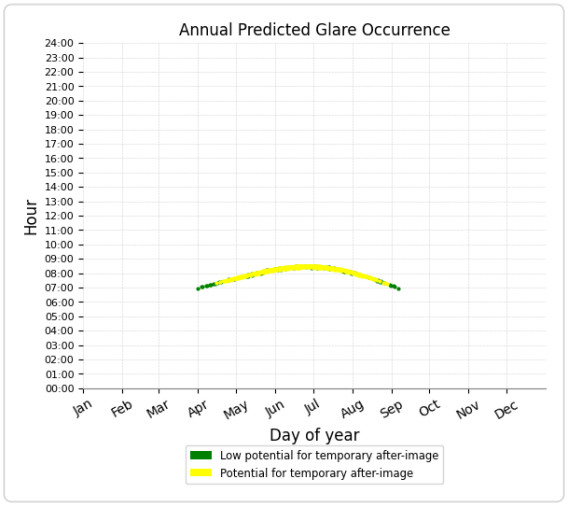


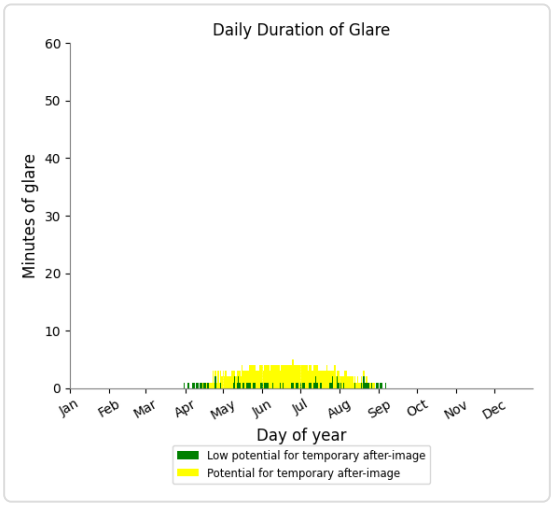


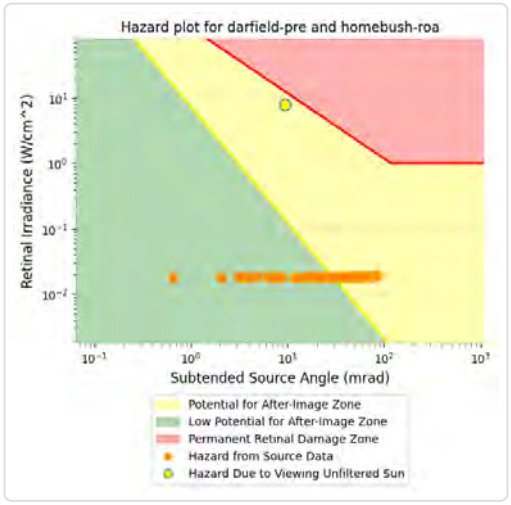
Darfield Preliminary and Route: Homebush Road West of Railway

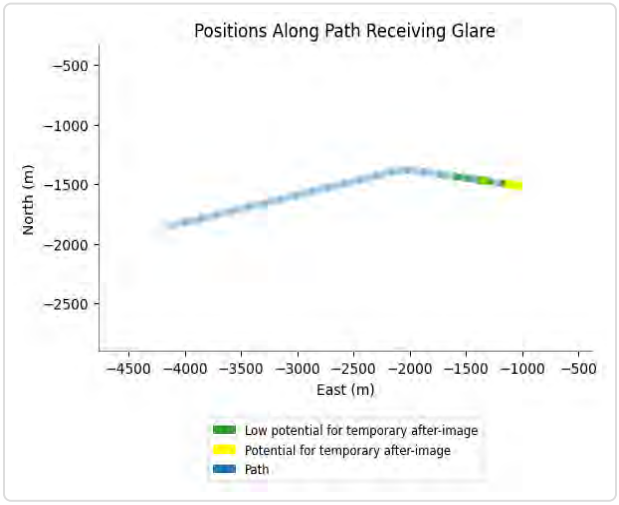
Yellow glare: 330 min.

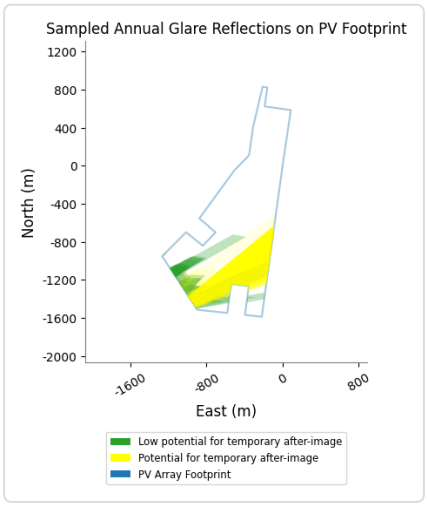
Green glare: 73 min.

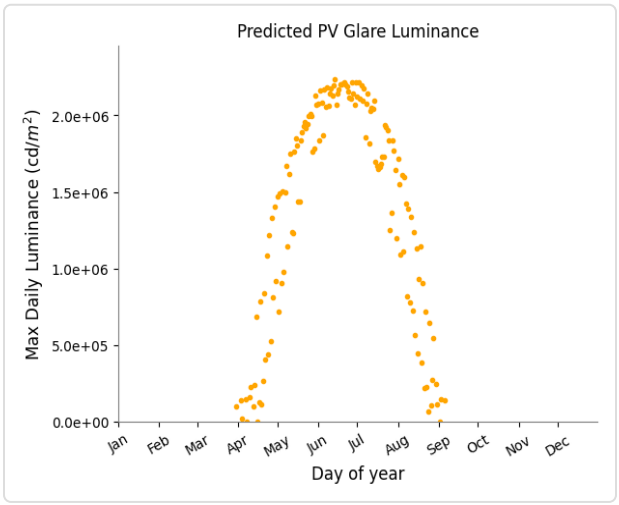








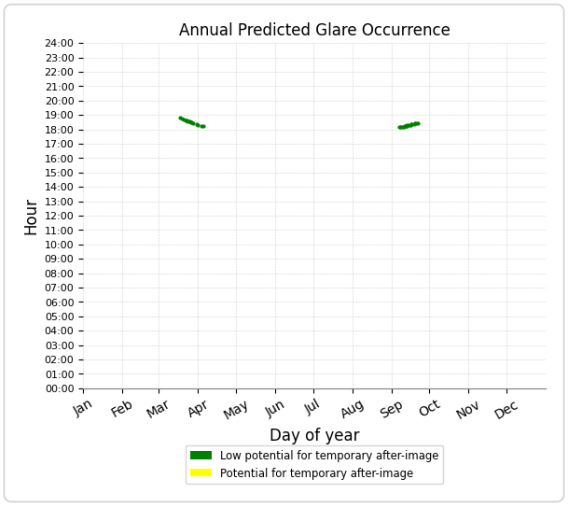


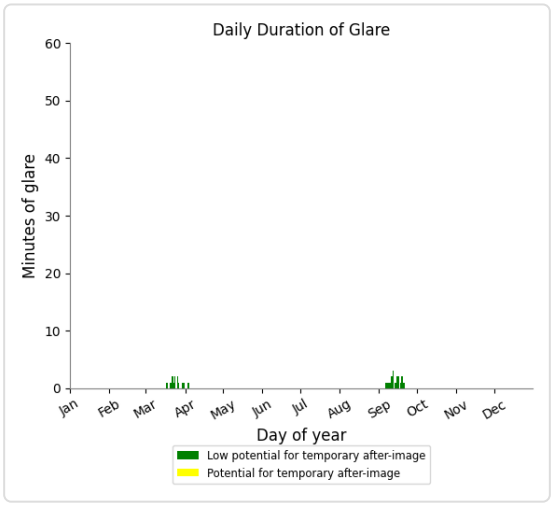


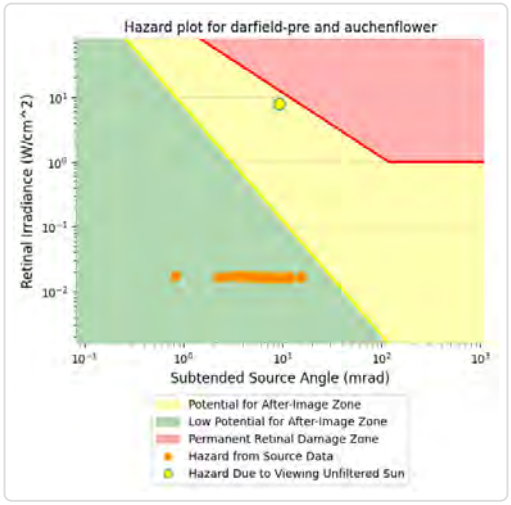
Darfield Preliminary and Route: Auchenflower Road

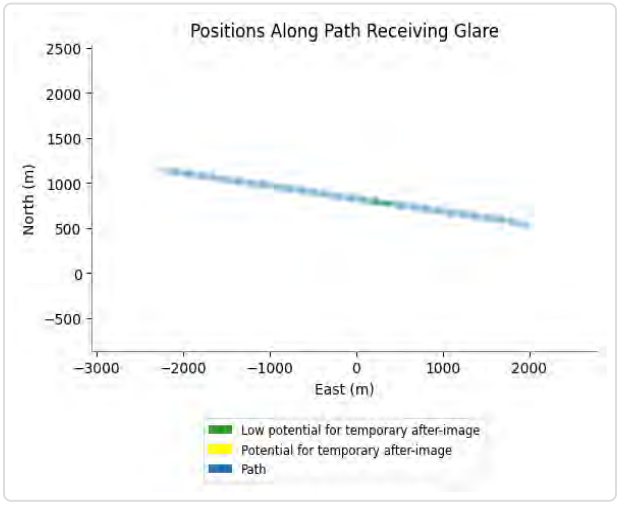
Yellow glare: none

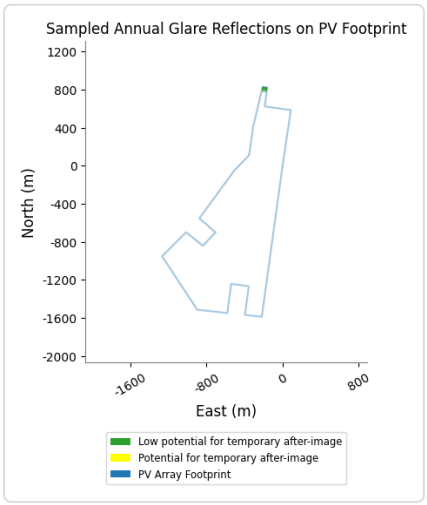
Green glare: 36 min.

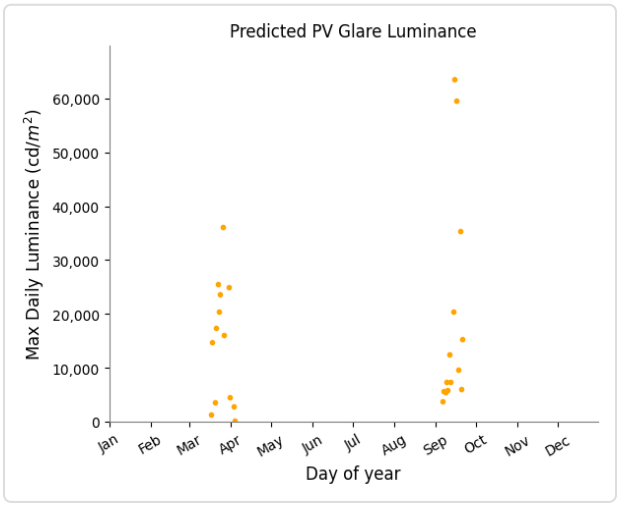








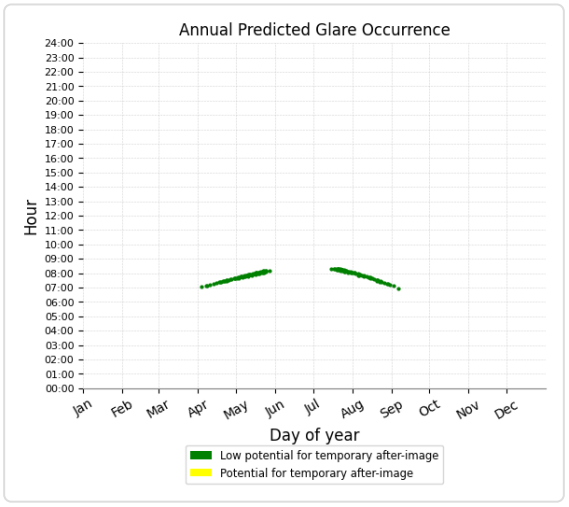


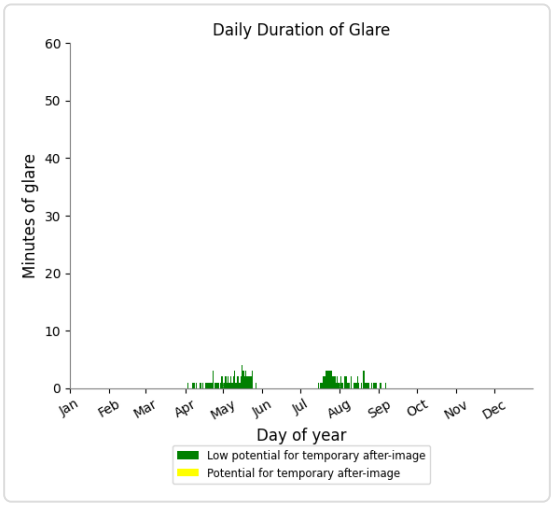


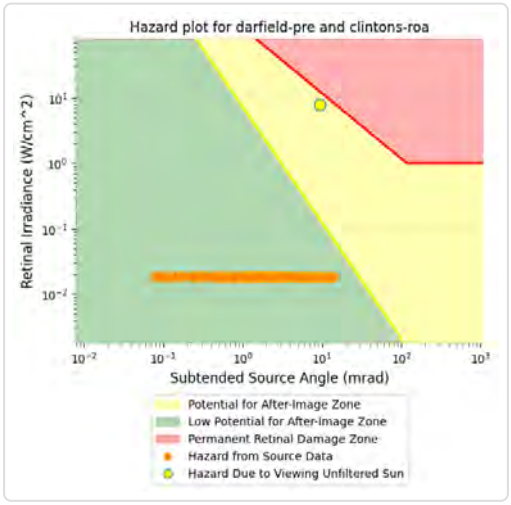
Darfield Preliminary and Route: Clintons Road

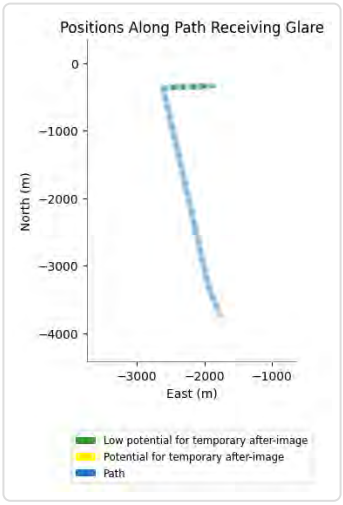
Yellow glare: none

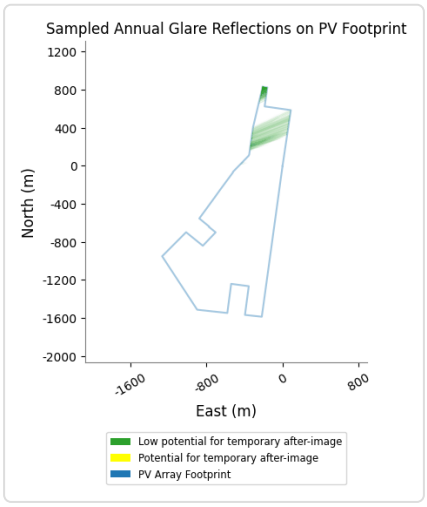
Green glare: 133 min.

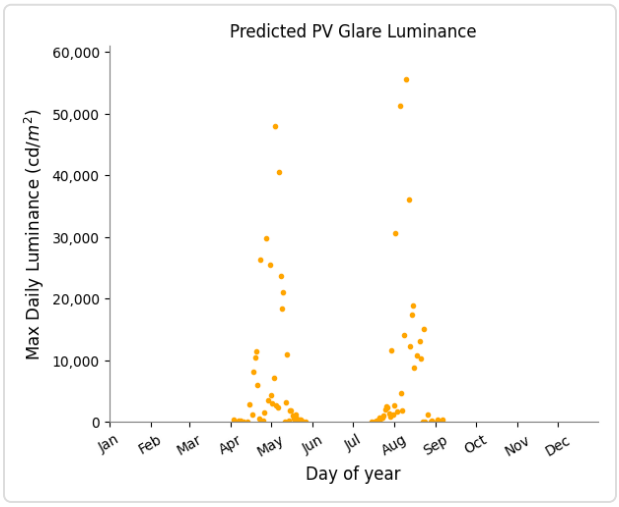












Darfield Preliminary and Route: Bleak House Road

No glare found

Darfield Preliminary and Route: Boultons Road

No glare found

Darfield Preliminary and Route: Horndon Street

No glare found

Darfield Preliminary and Route: Kimberley Road North

No glare found

Darfield Preliminary and Route: Kimberley Road South

No glare found

Darfield Preliminary and Route: Landsborough Drive

No glare found

Darfield Preliminary and Route: Loes Road

No glare found

Darfield Preliminary and Route: Main Trunk Line

No glare found

Darfield Preliminary and Route: SH 73 North of Homebush Road

No glare found

Darfield Preliminary and Route: SH 73 South of Homebush Road

No glare found

Darfield Preliminary and Route: Tramway Road East of Kimberley Road

No glare found

Darfield Preliminary and Route: Tramway Road West of Kimberley Road

No glare found

Darfield Preliminary and Route: Whitcombe Place

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

FORGESOLAR GLARE ANALYSIS

Project: **Darfield Solar**
Site configuration: **Darfield - NZTA CAR WITH OBSTRUCTIONS R2**

Client: NZ Clean Energy

Created 30 May, 2024
Updated 30 May, 2024
Time-step 1 minute
Timezone offset UTC12
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 100 to 500 kW
Site ID 120494.20038

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	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
Darfield Preliminary	SA tracking	SA tracking	577	9.6	607	10.1	-	2,067,295

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
Auchenflower Road	0	0.0	0	0.0
Bleak House Road	0	0.0	0	0.0
Boultons Road	0	0.0	0	0.0
Clintons Road	142	2.4	0	0.0
Fonterra Railway Siding	213	3.5	0	0.0
Homebush Road East of Railway	184	3.1	242	4.0
Homebush Road West of Railway	38	0.6	365	6.1
Horndon Street	0	0.0	0	0.0
Kimberley Road North	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Kimberley Road South	0	0.0	0	0.0
Landsborough Drive	0	0.0	0	0.0
Loes Road	0	0.0	0	0.0
Main Trunk Line	0	0.0	0	0.0
SH 73 North of Homebush Road	0	0.0	0	0.0
SH 73 South of Homebush Road	0	0.0	0	0.0
Tramway Road East of Kimberley Road	0	0.0	0	0.0
Tramway Road West of Kimberley Road	0	0.0	0	0.0
Whitcombe Place	0	0.0	0	0.0

Component Data

PV Arrays

Name: Darfield Preliminary
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 7.5467°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.434
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	-43.451667	172.097071	231.90	1.40	233.30
2	-43.465951	172.094370	221.20	1.40	222.60
3	-43.465778	172.092183	221.10	1.40	222.50
4	-43.463059	172.092676	223.80	1.40	225.20
5	-43.462839	172.090390	224.50	1.40	225.90
6	-43.465596	172.089889	222.20	1.40	223.60
7	-43.465287	172.085972	223.20	1.40	224.60
8	-43.460230	172.081414	229.00	1.40	230.40
9	-43.457955	172.084528	230.10	1.40	231.50
10	-43.459237	172.086705	228.40	1.40	229.80
11	-43.457965	172.088370	229.40	1.40	230.80
12	-43.457442	172.087479	229.80	1.40	231.20
13	-43.457410	172.087512	229.80	1.40	231.20
14	-43.456653	172.086246	230.60	1.40	232.00
15	-43.454706	172.088200	232.30	1.40	233.70
16	-43.453924	172.088971	232.60	1.40	234.00
17	-43.452312	172.090606	233.40	1.40	234.80
18	-43.452239	172.090630	233.60	1.40	235.00
19	-43.450710	172.092674	234.00	1.40	235.40
20	-43.450660	172.092704	234.00	1.40	235.40
21	-43.450585	172.092739	233.90	1.40	235.30
22	-43.447953	172.093245	236.10	1.40	237.50
23	-43.447856	172.093289	236.10	1.40	237.50
24	-43.444192	172.094476	238.40	1.40	239.80
25	-43.444256	172.095094	237.70	1.40	239.10
26	-43.446052	172.094744	237.20	1.40	238.60
27	-43.446405	172.098146	235.30	1.40	236.70

Route Receptors

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.446950	172.121125	226.70	1.10	227.80
2	-43.446557	172.119438	227.60	1.10	228.70
3	-43.446355	172.117663	227.80	1.10	228.90
4	-43.446175	172.115884	228.60	1.10	229.70
5	-43.445995	172.114104	229.70	1.10	230.80
6	-43.445815	172.112325	230.50	1.10	231.60
7	-43.445635	172.110545	231.50	1.10	232.60
8	-43.445456	172.108766	232.10	1.10	233.20
9	-43.445276	172.106987	233.00	1.10	234.10
10	-43.445096	172.105207	233.70	1.10	234.80
11	-43.444914	172.103428	234.20	1.10	235.30
12	-43.444732	172.101649	235.20	1.10	236.30
13	-43.444549	172.099870	236.50	1.10	237.60
14	-43.444365	172.098091	236.80	1.10	237.90
15	-43.444178	172.096313	237.60	1.10	238.70
16	-43.443990	172.094535	238.20	1.10	239.30
17	-43.443803	172.092757	239.40	1.10	240.50
18	-43.443617	172.090979	240.30	1.10	241.40
19	-43.443433	172.089200	240.60	1.10	241.70
20	-43.443250	172.087422	241.00	1.10	242.10
21	-43.443066	172.085643	242.50	1.10	243.60
22	-43.442883	172.083864	243.30	1.10	244.40
23	-43.442700	172.082085	244.00	1.10	245.10
24	-43.442516	172.080306	245.90	1.10	247.00
25	-43.442333	172.078528	246.90	1.10	248.00
26	-43.442152	172.076748	247.70	1.10	248.80
27	-43.441972	172.074969	248.20	1.10	249.30
28	-43.441792	172.073190	249.20	1.10	250.30
29	-43.441611	172.071410	249.90	1.10	251.00
30	-43.441431	172.069631	250.30	1.10	251.40

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.441027	172.066132	250.80	1.10	251.90
2	-43.440555	172.067806	250.70	1.10	251.80
3	-43.440072	172.069475	250.90	1.10	252.00
4	-43.439588	172.071143	251.40	1.10	252.50
5	-43.439104	172.072812	251.20	1.10	252.30
6	-43.438623	172.074482	250.70	1.10	251.80
7	-43.438144	172.076153	249.90	1.10	251.00
8	-43.437664	172.077824	249.60	1.10	250.70
9	-43.437185	172.079495	249.10	1.10	250.20
10	-43.436705	172.081165	249.00	1.10	250.10
11	-43.436220	172.082833	247.70	1.10	248.80
12	-43.435732	172.084499	246.70	1.10	247.80
13	-43.435244	172.086166	246.60	1.10	247.70
14	-43.434757	172.087832	246.70	1.10	247.80
15	-43.434269	172.089498	246.30	1.10	247.40
16	-43.433781	172.091165	245.50	1.10	246.60
17	-43.433310	172.092840	245.20	1.10	246.30
18	-43.432840	172.094516	244.80	1.10	245.90
19	-43.432370	172.096192	244.00	1.10	245.10
20	-43.432338	172.096305	243.90	1.10	245.00

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.468107	172.119551	212.50	1.10	213.60
2	-43.467599	172.121205	211.40	1.10	212.50
3	-43.467090	172.122860	211.70	1.10	212.80
4	-43.466581	172.124514	211.80	1.10	212.90
5	-43.466073	172.126168	211.60	1.10	212.70
6	-43.465564	172.127823	211.60	1.10	212.70
7	-43.465056	172.129477	211.30	1.10	212.40
8	-43.464547	172.131132	211.20	1.10	212.30
9	-43.464039	172.132786	210.80	1.10	211.90
10	-43.463530	172.134440	210.00	1.10	211.10
11	-43.463022	172.136095	209.50	1.10	210.60
12	-43.462513	172.137749	208.40	1.10	209.50
13	-43.462005	172.139403	208.20	1.10	209.30
14	-43.461496	172.141058	208.40	1.10	209.50
15	-43.460987	172.142712	207.40	1.10	208.50
16	-43.460469	172.144360	207.30	1.10	208.40
17	-43.460079	172.144939	207.30	1.10	208.40

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.485350	172.075213	208.50	1.10	209.60
2	-43.484132	172.074572	209.40	1.10	210.50
3	-43.482915	172.073931	210.30	1.10	211.40
4	-43.481697	172.073290	211.50	1.10	212.60
5	-43.480442	172.072814	212.50	1.10	213.60
6	-43.479171	172.072412	213.80	1.10	214.90
7	-43.477898	172.072026	214.70	1.10	215.80
8	-43.476624	172.071640	215.90	1.10	217.00
9	-43.475356	172.071228	216.90	1.10	218.00
10	-43.474084	172.070831	218.10	1.10	219.20
11	-43.472813	172.070434	219.30	1.10	220.40
12	-43.471541	172.070037	220.40	1.10	221.50
13	-43.470269	172.069640	221.50	1.10	222.60
14	-43.468998	172.069243	223.30	1.10	224.40
15	-43.467726	172.068846	224.30	1.10	225.40
16	-43.466454	172.068449	225.20	1.10	226.30
17	-43.465183	172.068052	226.40	1.10	227.50
18	-43.463911	172.067654	227.60	1.10	228.70
19	-43.462641	172.067250	228.70	1.10	229.80
20	-43.461370	172.066848	230.00	1.10	231.10
21	-43.460099	172.066445	231.00	1.10	232.10
22	-43.458828	172.066043	232.40	1.10	233.50
23	-43.457557	172.065641	233.70	1.10	234.80
24	-43.456286	172.065239	235.20	1.10	236.30
25	-43.455025	172.064944	236.50	1.10	237.60
26	-43.454868	172.066674	236.10	1.10	237.20
27	-43.454816	172.068469	236.10	1.10	237.20
28	-43.454765	172.070264	236.30	1.10	237.40
29	-43.454713	172.072059	236.30	1.10	237.40
30	-43.454661	172.073855	236.30	1.10	237.40

Name: Fonterra Railway Siding
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.459032	172.080040	231.20	3.00	234.20
2	-43.457823	172.079373	232.20	3.00	235.20
3	-43.456598	172.078758	232.80	3.00	235.80
4	-43.455313	172.078588	233.30	3.00	236.30
5	-43.454129	172.079293	233.90	3.00	236.90
6	-43.453124	172.080437	234.40	3.00	237.40
7	-43.452121	172.081587	234.50	3.00	237.50
8	-43.451119	172.082736	234.50	3.00	237.50
9	-43.450116	172.083885	234.50	3.00	237.50
10	-43.449114	172.085034	234.60	3.00	237.60
11	-43.448111	172.086184	234.60	3.00	237.60
12	-43.447126	172.087313	234.50	3.00	237.50

Name: Homebush Road East of Railway
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.465355	172.084639	224.00	1.10	225.10
2	-43.465498	172.086425	223.00	1.10	224.10
3	-43.465636	172.088211	222.40	1.10	223.50
4	-43.465774	172.089998	222.10	1.10	223.20
5	-43.465913	172.091784	221.60	1.10	222.70
6	-43.466051	172.093571	221.00	1.10	222.10
7	-43.466200	172.095355	220.50	1.10	221.60
8	-43.466356	172.097139	220.20	1.10	221.30
9	-43.466493	172.098926	219.20	1.10	220.30
10	-43.466630	172.100712	218.90	1.10	220.00
11	-43.466767	172.102499	218.60	1.10	219.70
12	-43.466904	172.104286	217.80	1.10	218.90
13	-43.467041	172.106072	217.00	1.10	218.10
14	-43.467182	172.107858	216.40	1.10	217.50
15	-43.467323	172.109645	215.60	1.10	216.70
16	-43.467463	172.111431	215.40	1.10	216.50
17	-43.467604	172.113217	215.20	1.10	216.30
18	-43.467745	172.115003	214.30	1.10	215.40
19	-43.467886	172.116789	213.80	1.10	214.90
20	-43.468028	172.118575	212.70	1.10	213.80
21	-43.468164	172.120362	211.70	1.10	212.80
22	-43.468302	172.122148	210.90	1.10	212.00
23	-43.468444	172.123934	210.40	1.10	211.50
24	-43.468586	172.125720	210.10	1.10	211.20
25	-43.468729	172.127506	209.30	1.10	210.40
26	-43.468871	172.129292	209.00	1.10	210.10
27	-43.469013	172.131078	208.40	1.10	209.50
28	-43.469035	172.131348	208.20	1.10	209.30

Name: Homebush Road West of Railway
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.468385	172.045917	226.70	1.10	227.80
2	-43.468088	172.047667	226.30	1.10	227.40
3	-43.467788	172.049415	226.20	1.10	227.30
4	-43.467495	172.051166	228.00	1.10	229.10
5	-43.467201	172.052916	229.20	1.10	230.30
6	-43.466908	172.054667	229.00	1.10	230.10
7	-43.466615	172.056418	228.50	1.10	229.60
8	-43.466321	172.058168	228.60	1.10	229.70
9	-43.466028	172.059919	228.50	1.10	229.60
10	-43.465734	172.061669	228.30	1.10	229.40
11	-43.465441	172.063420	228.20	1.10	229.30
12	-43.465148	172.065170	227.70	1.10	228.80
13	-43.464854	172.066921	227.30	1.10	228.40
14	-43.464555	172.068669	227.00	1.10	228.10
15	-43.464259	172.070419	227.40	1.10	228.50
16	-43.464093	172.072184	227.70	1.10	228.80
17	-43.464269	172.073965	227.60	1.10	228.70
18	-43.464444	172.075745	227.50	1.10	228.60
19	-43.464619	172.077525	226.70	1.10	227.80
20	-43.464794	172.079305	226.40	1.10	227.50
21	-43.464970	172.081086	225.40	1.10	226.50
22	-43.465154	172.082864	224.60	1.10	225.70
23	-43.465355	172.084639	224.00	1.10	225.10

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.485008	172.109015	203.30	1.10	204.40
2	-43.484359	172.107457	204.30	1.10	205.40
3	-43.483287	172.106441	205.20	1.10	206.30
4	-43.482198	172.105455	206.30	1.10	207.40
5	-43.481109	172.104465	207.30	1.10	208.40
6	-43.480027	172.103465	207.90	1.10	209.00
7	-43.478936	172.102481	208.80	1.10	209.90
8	-43.477845	172.101498	209.60	1.10	210.70
9	-43.476753	172.100515	210.50	1.10	211.60
10	-43.476200	172.099297	211.60	1.10	212.70
11	-43.476972	172.097849	211.40	1.10	212.50
12	-43.477744	172.096401	211.30	1.10	212.40
13	-43.477773	172.096346	211.40	1.10	212.50

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.449707	172.120924	224.90	1.10	226.00
2	-43.448405	172.121018	225.90	1.10	227.00
3	-43.447102	172.121113	226.40	1.10	227.50
4	-43.445800	172.121220	227.10	1.10	228.20
5	-43.444498	172.121320	227.80	1.10	228.90
6	-43.443196	172.121420	228.60	1.10	229.70
7	-43.441893	172.121520	228.90	1.10	230.00
8	-43.440591	172.121620	229.70	1.10	230.80
9	-43.439288	172.121720	230.00	1.10	231.10
10	-43.437986	172.121820	230.50	1.10	231.60
11	-43.436683	172.121919	230.90	1.10	232.00
12	-43.435380	172.122019	232.10	1.10	233.20
13	-43.434078	172.122119	231.80	1.10	232.90
14	-43.432775	172.122219	231.80	1.10	232.90
15	-43.431472	172.122319	232.70	1.10	233.80
16	-43.430170	172.122419	233.50	1.10	234.60
17	-43.428867	172.122519	234.30	1.10	235.40
18	-43.427564	172.122618	234.50	1.10	235.60
19	-43.426261	172.122718	234.60	1.10	235.70
20	-43.424959	172.122818	234.80	1.10	235.90
21	-43.424766	172.122833	234.80	1.10	235.90

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.486918	172.107630	202.10	1.10	203.20
2	-43.485767	172.108472	202.80	1.10	203.90
3	-43.484599	172.109270	203.40	1.10	204.50
4	-43.483411	172.110007	203.90	1.10	205.00
5	-43.482222	172.110744	204.40	1.10	205.50
6	-43.481032	172.111478	205.30	1.10	206.40
7	-43.479843	172.112216	206.00	1.10	207.10
8	-43.478654	172.112952	206.30	1.10	207.40
9	-43.477465	172.113688	207.50	1.10	208.60
10	-43.476275	172.114424	208.50	1.10	209.60
11	-43.475086	172.115160	208.80	1.10	209.90
12	-43.473897	172.115896	209.70	1.10	210.80
13	-43.472707	172.116632	210.20	1.10	211.30
14	-43.471518	172.117368	210.50	1.10	211.60
15	-43.470329	172.118104	211.20	1.10	212.30
16	-43.469139	172.118840	211.70	1.10	212.80
17	-43.467936	172.119522	212.40	1.10	213.50
18	-43.466636	172.119641	213.20	1.10	214.30
19	-43.465334	172.119741	214.00	1.10	215.10
20	-43.464031	172.119831	215.00	1.10	216.10
21	-43.462729	172.119932	216.10	1.10	217.20
22	-43.461427	172.120033	217.00	1.10	218.10
23	-43.460125	172.120133	218.00	1.10	219.10
24	-43.458823	172.120234	218.70	1.10	219.80
25	-43.457521	172.120332	219.10	1.10	220.20
26	-43.456219	172.120431	220.40	1.10	221.50
27	-43.454917	172.120530	221.30	1.10	222.40
28	-43.453614	172.120629	222.20	1.10	223.30
29	-43.452312	172.120728	223.20	1.10	224.30
30	-43.451010	172.120827	224.10	1.10	225.20

Name: Landsborough Drive
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.480136	172.112034	205.80	1.10	206.90
2	-43.479667	172.110359	206.40	1.10	207.50
3	-43.479131	172.108722	207.40	1.10	208.50
4	-43.478594	172.107084	208.20	1.10	209.30
5	-43.478060	172.105446	209.10	1.10	210.20
6	-43.477526	172.103807	209.90	1.10	211.00
7	-43.476827	172.102337	210.10	1.10	211.20
8	-43.475607	172.101796	211.10	1.10	212.20
9	-43.474323	172.101634	212.30	1.10	213.40
10	-43.473985	172.101752	212.40	1.10	213.50

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.466130	172.094587	221.10	1.10	222.20
2	-43.464839	172.094834	221.60	1.10	222.70
3	-43.463547	172.095081	222.80	1.10	223.90
4	-43.462255	172.095328	223.70	1.10	224.80
5	-43.460964	172.095575	225.10	1.10	226.20
6	-43.459672	172.095822	225.80	1.10	226.90
7	-43.458380	172.096069	226.80	1.10	227.90
8	-43.457089	172.096316	227.80	1.10	228.90
9	-43.455797	172.096563	228.90	1.10	230.00
10	-43.454505	172.096810	229.80	1.10	230.90
11	-43.453213	172.097057	230.80	1.10	231.90
12	-43.451921	172.097304	231.70	1.10	232.80
13	-43.450629	172.097551	232.80	1.10	233.90
14	-43.449337	172.097798	233.60	1.10	234.70
15	-43.448045	172.098045	234.20	1.10	235.30
16	-43.446753	172.098292	234.80	1.10	235.90
17	-43.445461	172.098539	235.90	1.10	237.00
18	-43.444433	172.098736	236.70	1.10	237.80

Name: Main Trunk Line
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.475051	172.094494	214.10	3.00	217.10
2	-43.473960	172.093510	215.10	3.00	218.10
3	-43.472870	172.092525	216.10	3.00	219.10
4	-43.471779	172.091541	217.20	3.00	220.20
5	-43.470688	172.090557	218.20	3.00	221.20
6	-43.469597	172.089573	219.20	3.00	222.20
7	-43.468506	172.088588	220.30	3.00	223.30
8	-43.467415	172.087604	221.50	3.00	224.50
9	-43.466325	172.086620	222.70	3.00	225.70
10	-43.465234	172.085636	223.80	3.00	226.80
11	-43.464143	172.084652	225.10	3.00	228.10
12	-43.463052	172.083667	226.50	3.00	229.50
13	-43.461961	172.082683	227.80	3.00	230.80
14	-43.460870	172.081699	229.00	3.00	232.00
15	-43.459779	172.080715	230.40	3.00	233.40
16	-43.458688	172.079730	231.50	3.00	234.50
17	-43.457597	172.078746	232.80	3.00	235.80
18	-43.456506	172.077762	234.10	3.00	237.10
19	-43.455416	172.076776	235.30	3.00	238.30
20	-43.454313	172.075817	236.70	3.00	239.70
21	-43.453157	172.074986	237.80	3.00	240.80
22	-43.452425	172.074469	238.70	3.00	241.70

Name: SH 73 North of Homebush Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.465209	172.085024	224.00	1.10	225.10
2	-43.464120	172.084037	225.30	1.10	226.40
3	-43.463031	172.083049	226.40	1.10	227.50
4	-43.461942	172.082060	227.70	1.10	228.80
5	-43.460853	172.081072	229.00	1.10	230.10
6	-43.459763	172.080084	230.10	1.10	231.20
7	-43.458674	172.079096	231.30	1.10	232.40
8	-43.457582	172.078113	232.60	1.10	233.70
9	-43.456487	172.077138	234.00	1.10	235.10
10	-43.455392	172.076162	235.00	1.10	236.10
11	-43.454228	172.075354	236.20	1.10	237.30
12	-43.453073	172.074519	237.90	1.10	239.00
13	-43.451918	172.073684	239.30	1.10	240.40
14	-43.450763	172.072849	240.80	1.10	241.90
15	-43.449608	172.072015	243.00	1.10	244.10
16	-43.448447	172.071195	244.90	1.10	246.00
17	-43.447287	172.070375	246.10	1.10	247.20
18	-43.446126	172.069554	246.20	1.10	247.30
19	-43.444966	172.068734	248.00	1.10	249.10
20	-43.443805	172.067914	249.60	1.10	250.70
21	-43.442645	172.067094	250.50	1.10	251.60
22	-43.441484	172.066273	250.70	1.10	251.80
23	-43.440343	172.065403	250.80	1.10	251.90
24	-43.439215	172.064502	251.00	1.10	252.10
25	-43.438087	172.063599	251.30	1.10	252.40
26	-43.436960	172.062695	251.80	1.10	252.90
27	-43.435830	172.061795	252.70	1.10	253.80
28	-43.434702	172.060893	253.80	1.10	254.90
29	-43.433743	172.060124	254.70	1.10	255.80

Name: SH 73 South of Homebush Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.489806	172.112097	198.70	1.10	199.80
2	-43.489625	172.110318	199.50	1.10	200.60
3	-43.489443	172.108539	199.90	1.10	201.00
4	-43.489077	172.106867	200.80	1.10	201.90
5	-43.488112	172.105696	201.20	1.10	202.30
6	-43.487021	172.104713	202.40	1.10	203.50
7	-43.485930	172.103730	203.50	1.10	204.60
8	-43.484838	172.102747	204.20	1.10	205.30
9	-43.483747	172.101764	204.90	1.10	206.00
10	-43.482656	172.100781	206.00	1.10	207.10
11	-43.481566	172.099796	206.80	1.10	207.90
12	-43.480476	172.098811	208.10	1.10	209.20
13	-43.479385	172.097826	209.40	1.10	210.50
14	-43.478300	172.096831	210.70	1.10	211.80
15	-43.477216	172.095832	211.70	1.10	212.80
16	-43.476129	172.094840	212.80	1.10	213.90
17	-43.475030	172.093874	213.90	1.10	215.00
18	-43.473940	172.092889	214.90	1.10	216.00
19	-43.472849	172.091904	216.00	1.10	217.10
20	-43.471759	172.090919	217.10	1.10	218.20
21	-43.470668	172.089934	218.00	1.10	219.10
22	-43.469578	172.088950	219.20	1.10	220.30
23	-43.468487	172.087965	220.30	1.10	221.40
24	-43.467397	172.086980	221.60	1.10	222.70
25	-43.466306	172.085996	222.90	1.10	224.00
26	-43.465209	172.085024	224.00	1.10	225.10

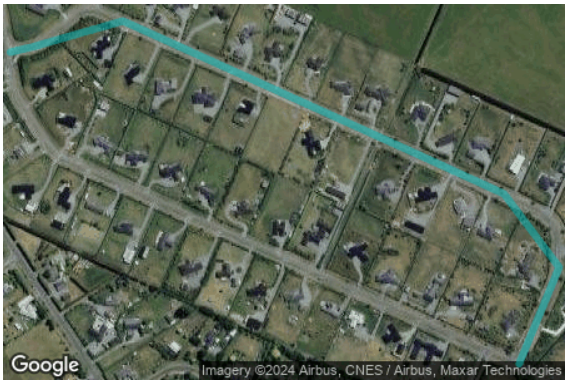
Name: Tramway Road East of Kimberley Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.446791	172.121624	226.30	1.10	227.40
2	-43.447596	172.123037	225.00	1.10	226.10
3	-43.448402	172.124451	223.70	1.10	224.80
4	-43.449207	172.125864	222.70	1.10	223.80
5	-43.450013	172.127277	221.50	1.10	222.60
6	-43.450818	172.128690	220.50	1.10	221.60
7	-43.451624	172.130103	219.20	1.10	220.30
8	-43.452429	172.131516	218.40	1.10	219.50
9	-43.453234	172.132929	216.90	1.10	218.00
10	-43.454040	172.134343	216.00	1.10	217.10
11	-43.454845	172.135756	214.90	1.10	216.00
12	-43.455651	172.137169	213.70	1.10	214.80
13	-43.456456	172.138582	212.60	1.10	213.70
14	-43.457261	172.139995	211.30	1.10	212.40
15	-43.458067	172.141408	209.80	1.10	210.90
16	-43.458872	172.142821	208.80	1.10	209.90
17	-43.459677	172.144234	207.80	1.10	208.90
18	-43.460079	172.144939	207.30	1.10	208.40

Name: Tramway Road West of Kimberley Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.432338	172.096305	243.90	1.10	245.00
2	-43.433128	172.097732	243.10	1.10	244.20
3	-43.433935	172.099143	242.40	1.10	243.50
4	-43.434743	172.100554	241.30	1.10	242.40
5	-43.435551	172.101964	240.60	1.10	241.70
6	-43.436359	172.103375	239.70	1.10	240.80
7	-43.437167	172.104786	238.60	1.10	239.70
8	-43.437974	172.106197	237.80	1.10	238.90
9	-43.438781	172.107608	237.10	1.10	238.20
10	-43.439589	172.109020	236.10	1.10	237.20
11	-43.440396	172.110431	235.10	1.10	236.20
12	-43.441203	172.111843	233.90	1.10	235.00
13	-43.442010	172.113254	232.60	1.10	233.70
14	-43.442817	172.114666	231.10	1.10	232.20
15	-43.443623	172.116079	230.30	1.10	231.40
16	-43.444427	172.117493	229.60	1.10	230.70
17	-43.445231	172.118908	228.40	1.10	229.50
18	-43.446035	172.120322	227.20	1.10	228.30
19	-43.446791	172.121624	226.30	1.10	227.40

Name: Whitcombe Place
Path type: Two-way
Observer view angle: 50.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.479746	172.110610	206.50	1.10	207.60
2	-43.478548	172.111298	206.90	1.10	208.00
3	-43.477634	172.110351	207.80	1.10	208.90
4	-43.477095	172.108715	208.50	1.10	209.60
5	-43.476558	172.107078	209.70	1.10	210.80
6	-43.476023	172.105440	210.50	1.10	211.60
7	-43.475487	172.103802	211.10	1.10	212.20
8	-43.475809	172.102251	210.90	1.10	212.00
9	-43.475874	172.101869	210.90	1.10	212.00

Obstruction Components

Name: Amenity Planting OP1
Top height: 6.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.465829	172.091864	227.36
2	-43.464766	172.091971	228.22
3	-43.464415	172.092110	228.47
4	-43.463968	172.092194	228.88
5	-43.463514	172.091472	229.63
6	-43.464303	172.091134	228.36
7	-43.464698	172.091842	228.33
8	-43.464760	172.091901	228.27
9	-43.465330	172.091848	227.76
10	-43.465714	172.091805	227.64

Name: Fonterra Boundary Planting
Top height: 3.2 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.460182	172.081254	232.80
2	-43.457827	172.084483	233.75
3	-43.459100	172.086682	231.82
4	-43.457936	172.088195	232.38
5	-43.456647	172.086098	233.97
6	-43.452500	172.090266	236.71
7	-43.452126	172.090421	236.72
8	-43.450646	172.092444	237.45
9	-43.447900	172.092996	239.38
10	-43.444376	172.094150	241.66

Name: Fonterra Store
Top height: 10.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.451541	172.082794	245.15
2	-43.448948	172.085712	245.09
3	-43.449104	172.085959	245.34
4	-43.447959	172.087279	245.13
5	-43.448340	172.087890	245.03

Name: Forestry Woodlot Auchenflower Road
Top height: 4.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.444200	172.095249	241.73
2	-43.445969	172.094874	241.17
3	-43.446109	172.096156	240.37
4	-43.444337	172.096462	241.11
5	-43.444200	172.095249	241.73

Name: Hedge Row OP6
Top height: 3.2 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.463235	172.095310	226.09
2	-43.462384	172.095482	227.18
3	-43.462439	172.096176	226.78
4	-43.463089	172.096050	226.29
5	-43.463149	172.096144	226.49
6	-43.463379	172.096101	225.89
7	-43.463313	172.095299	225.99

Name: Hedge Row OP7
Top height: 6.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.460108	172.095870	231.59
2	-43.459682	172.095959	231.84
3	-43.459781	172.096686	231.48
4	-43.460052	172.096635	231.41
5	-43.460081	172.096858	231.29
6	-43.461243	172.096627	230.41
7	-43.461127	172.095672	230.76
8	-43.460157	172.095865	231.63

Name: McHughs Forest Park
Top height: 20.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.477307	172.096737	231.48
2	-43.465698	172.086308	242.70
3	-43.466033	172.090750	241.89
4	-43.473150	172.097187	234.32
5	-43.473267	172.096973	234.38
6	-43.474886	172.098571	232.74
7	-43.476054	172.099258	231.44

Name: Middle Bund
Top height: 3.5 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.455798	172.084829	237.04
2	-43.454229	172.086216	239.21
3	-43.453606	172.086961	239.16
4	-43.451971	172.088831	240.67

Name: Northern Bund
Top height: 3.5 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.451649	172.089161	240.09
2	-43.450888	172.090035	240.48

Name: Southern Bund
Top height: 3.2 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-43.459270	172.082155	233.41
2	-43.458222	172.083424	234.83
3	-43.457932	172.083542	234.74
4	-43.457457	172.083678	235.11
5	-43.457056	172.083960	235.70
6	-43.456573	172.084411	236.95
7	-43.455726	172.085567	238.55

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	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
Darfield Preliminary	SA tracking	SA tracking	577	9.6	607	10.1	-	2,067,295

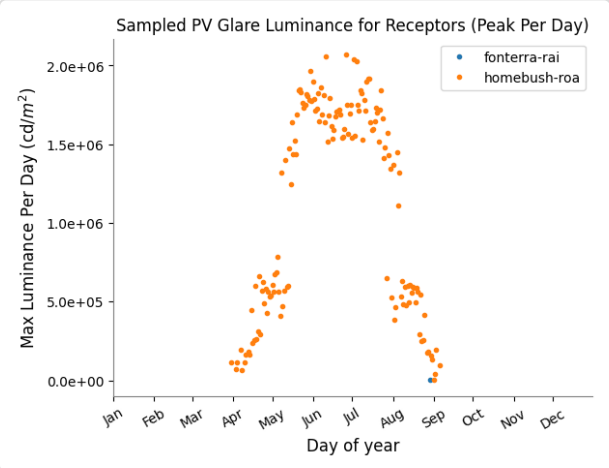
Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Auchenflower Road	0	0.0	0	0.0
Bleak House Road	0	0.0	0	0.0
Boultons Road	0	0.0	0	0.0
Clintons Road	142	2.4	0	0.0
Fonterra Railway Siding	213	3.5	0	0.0
Homebush Road East of Railway	184	3.1	242	4.0
Homebush Road West of Railway	38	0.6	365	6.1
Horndon Street	0	0.0	0	0.0
Kimberley Road North	0	0.0	0	0.0
Kimberley Road South	0	0.0	0	0.0
Landsborough Drive	0	0.0	0	0.0
Loes Road	0	0.0	0	0.0
Main Trunk Line	0	0.0	0	0.0
SH 73 North of Homebush Road	0	0.0	0	0.0
SH 73 South of Homebush Road	0	0.0	0	0.0
Tramway Road East of Kimberley Road	0	0.0	0	0.0
Tramway Road West of Kimberley Road	0	0.0	0	0.0
Whitcombe Place	0	0.0	0	0.0

PV: Darfield Preliminary potential temporary after-image

Receptor results ordered by category of glare

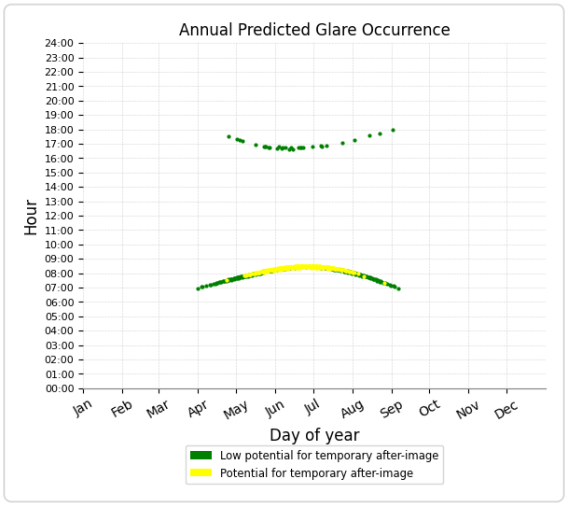
Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
Homebush Road East of Railway	184	3.1	242	4.0	479,595
Homebush Road West of Railway	38	0.6	365	6.1	2,067,295
Clintons Road	142	2.4	0	0.0	51,099
Fonterra Railway Siding	213	3.5	0	0.0	203,399
Auchenflower Road	0	0.0	0	0.0	0
Bleak House Road	0	0.0	0	0.0	0
Boultons Road	0	0.0	0	0.0	0
Horndon Street	0	0.0	0	0.0	0
Kimberley Road North	0	0.0	0	0.0	0
Kimberley Road South	0	0.0	0	0.0	0
Landsborough Drive	0	0.0	0	0.0	0
Loes Road	0	0.0	0	0.0	0
Main Trunk Line	0	0.0	0	0.0	0
SH 73 North of Homebush Road	0	0.0	0	0.0	0
SH 73 South of Homebush Road	0	0.0	0	0.0	0
Tramway Road East of Kimberley Road	0	0.0	0	0.0	0
Tramway Road West of Kimberley Road	0	0.0	0	0.0	0
Whitcombe Place	0	0.0	0	0.0	0

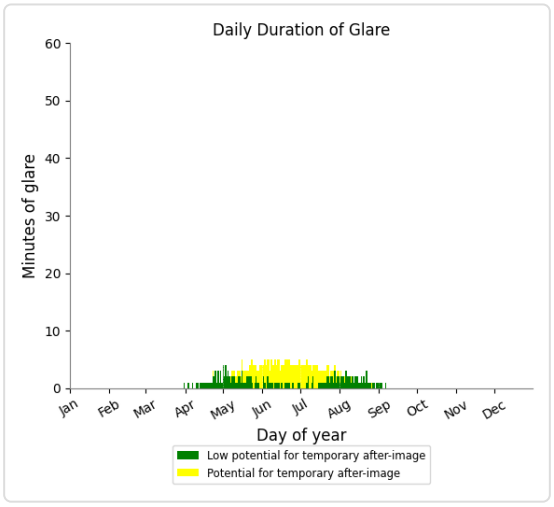


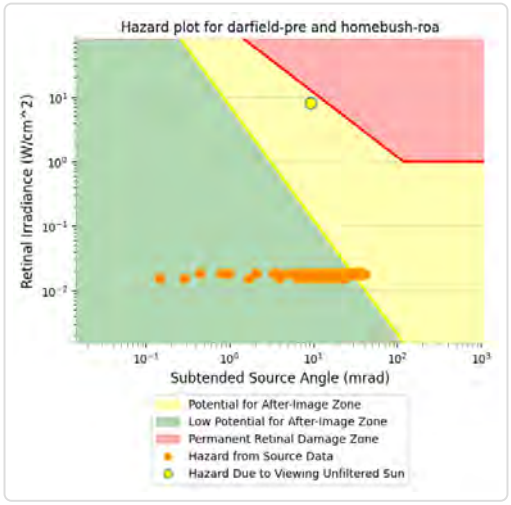
Darfield Preliminary and Route: Homebush Road East of Railway

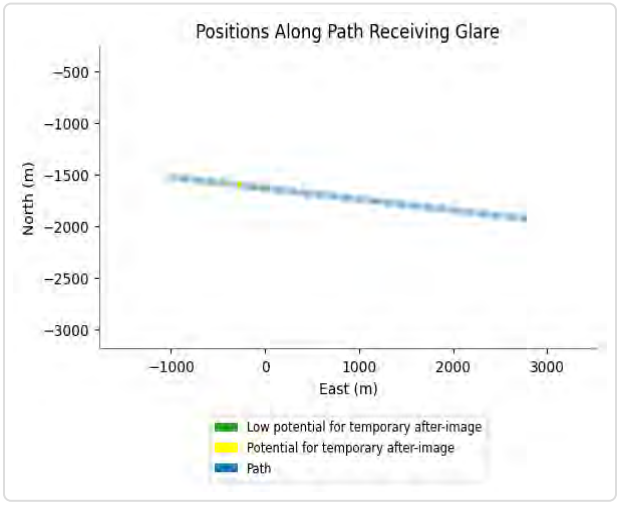
Yellow glare: 242 min.

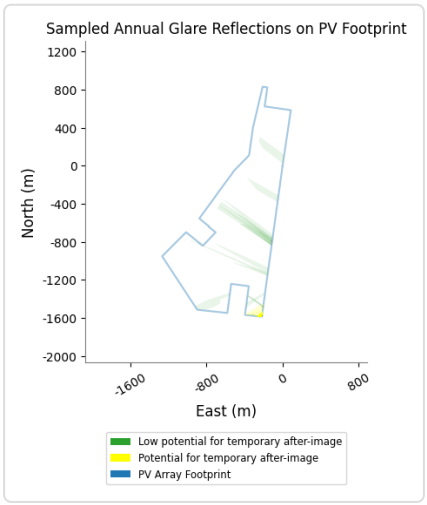
Green glare: 184 min.

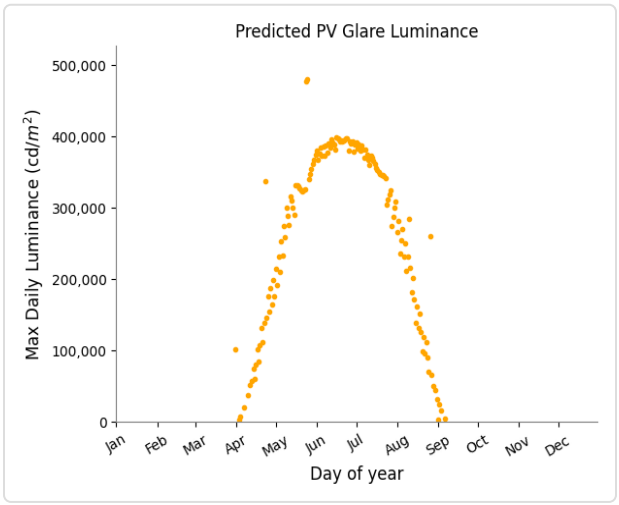








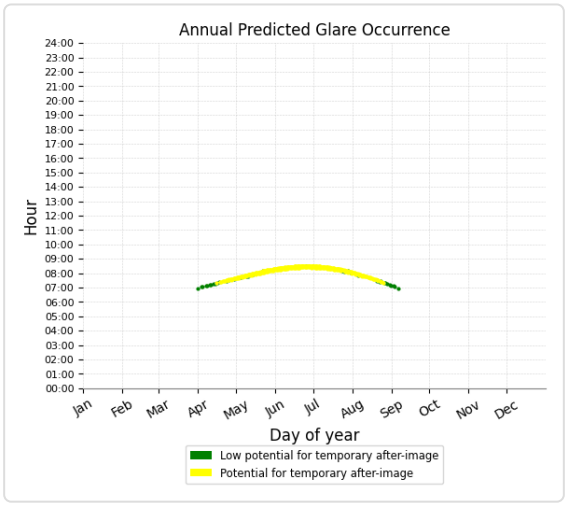


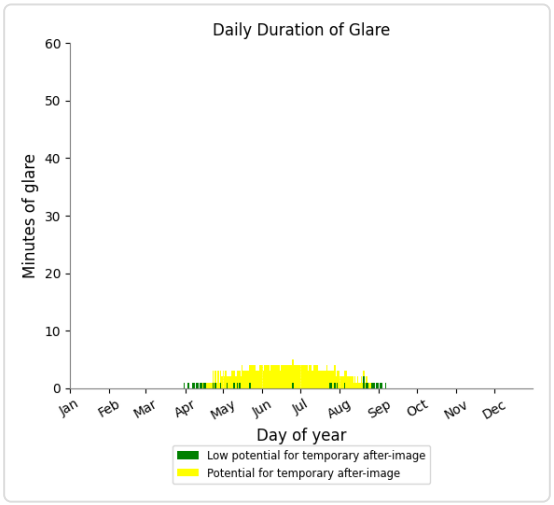


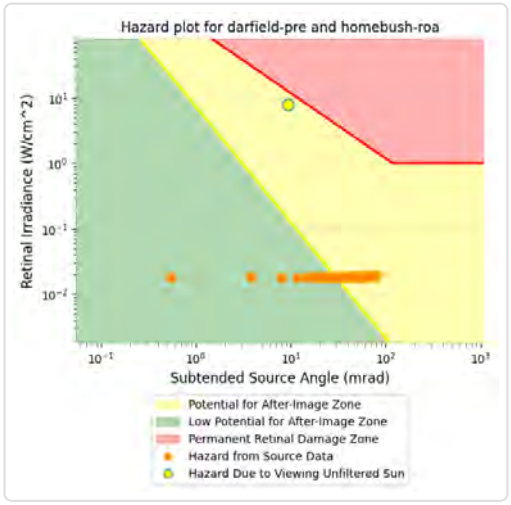
Darfield Preliminary and Route: Homebush Road West of Railway

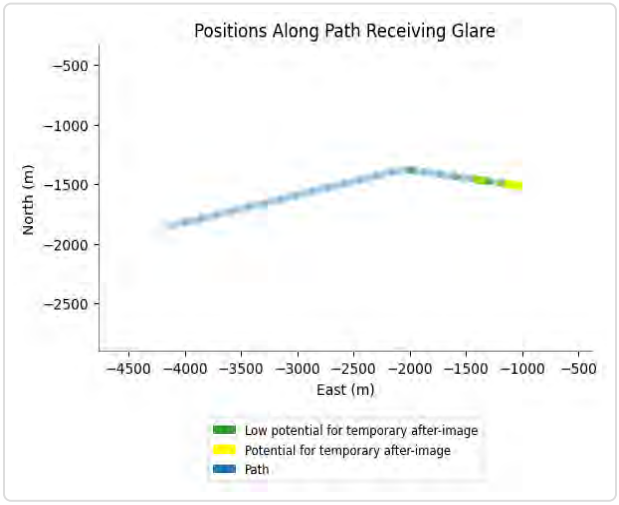
Yellow glare: 365 min.

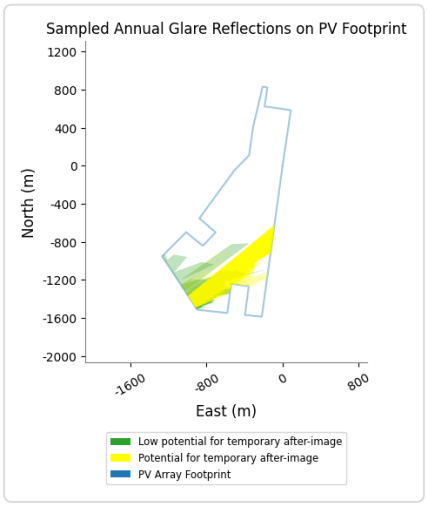
Green glare: 38 min.

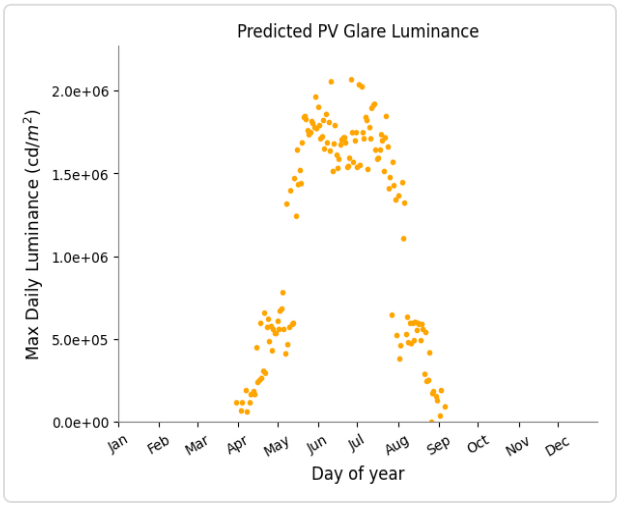








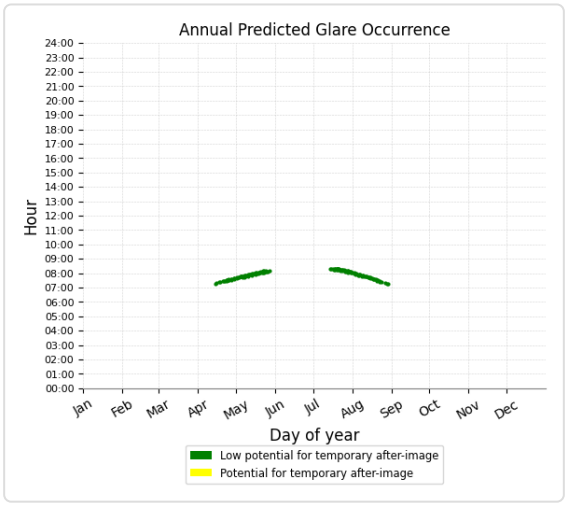


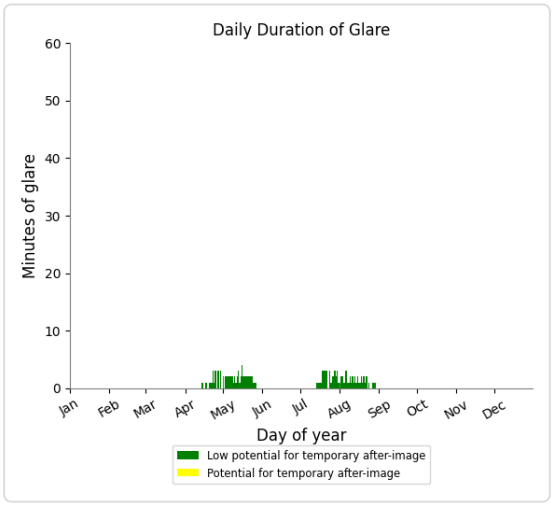


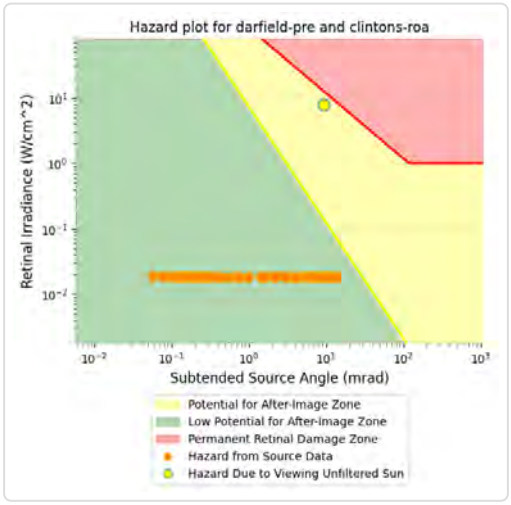
Darfield Preliminary and Route: Clintons Road

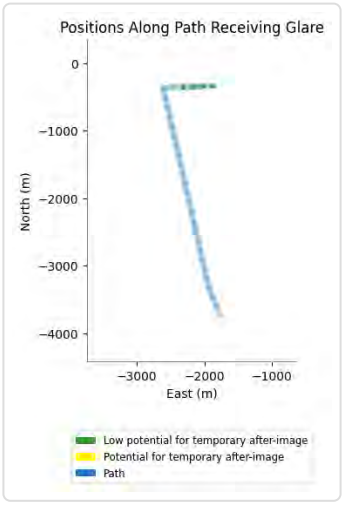
Yellow glare: none

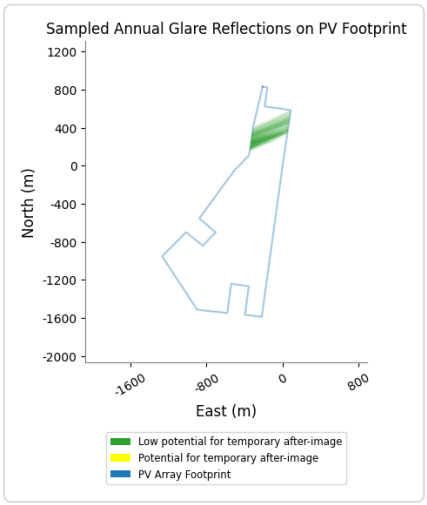
Green glare: 142 min.

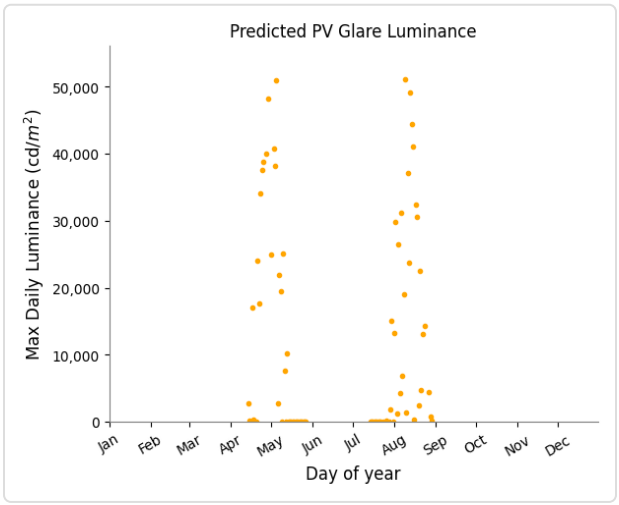








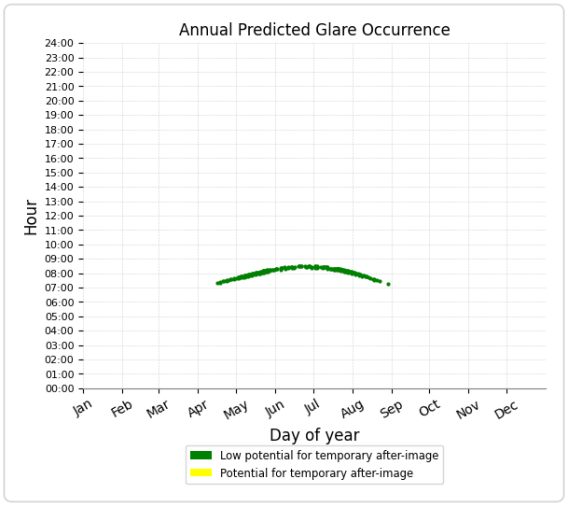


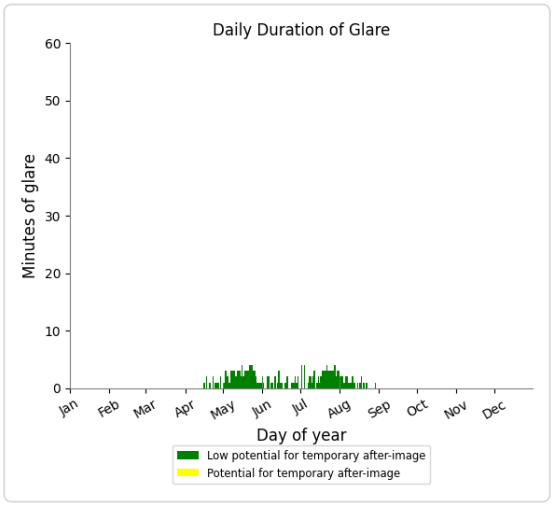


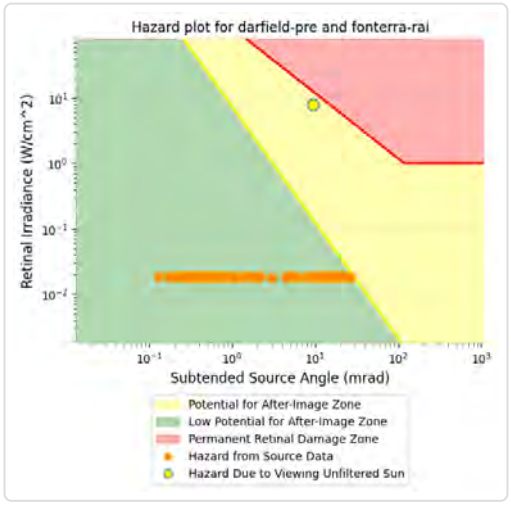
Darfield Preliminary and Route: Fonterra Railway Siding

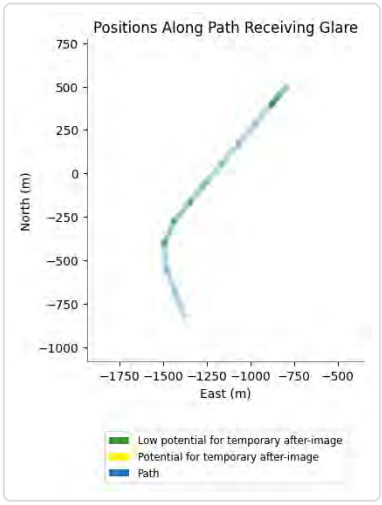
Yellow glare: none

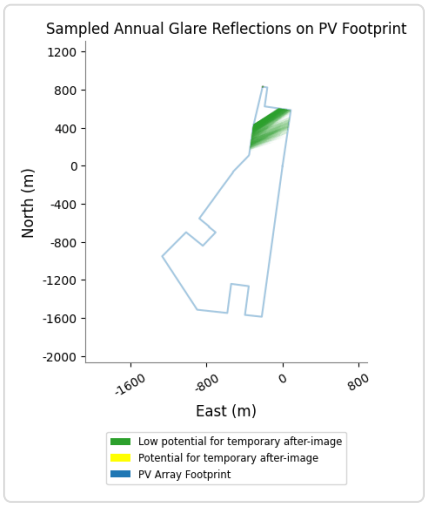
Green glare: 213 min.

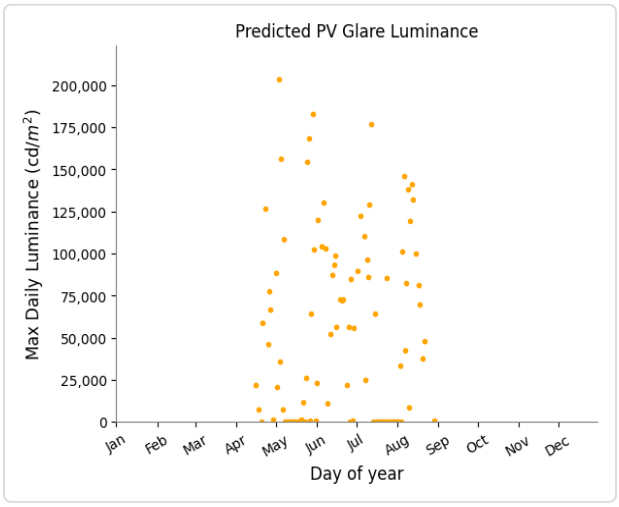












Darfield Preliminary and Route: Auchenflower Road

No glare found

Darfield Preliminary and Route: Bleak House Road

No glare found

Darfield Preliminary and Route: Boultons Road

No glare found

Darfield Preliminary and Route: Horndon Street

No glare found

Darfield Preliminary and Route: Kimberley Road North

No glare found

Darfield Preliminary and Route: Kimberley Road South

No glare found

Darfield Preliminary and Route: Landsborough Drive

No glare found

Darfield Preliminary and Route: Loes Road

No glare found

Darfield Preliminary and Route: Main Trunk Line

No glare found

Darfield Preliminary and Route: SH 73 North of Homebush Road

No glare found

Darfield Preliminary and Route: SH 73 South of Homebush Road

No glare found

Darfield Preliminary and Route: Tramway Road East of Kimberley Road

No glare found

Darfield Preliminary and Route: Tramway Road West of Kimberley Road

No glare found

Darfield Preliminary and Route: Whitcombe Place

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