ENVIRONMENTAL ETHOS

NHILL RENEWABLE ENERGY FACILITY

GLINT AND GLARE IMPACT ASSESSMENT REPORT
DRAFT ISSUE

Prepared For
Vibe Energy Pty Ltd

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for Vibe Energy Pty Ltd

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1. INTRODUCTION

This report has been prepared by Environmental Ethos on behalf of Vibe Energy Pty Ltd to assess the potential solar glint and glare impacts of the proposed Nhill Renewable Energy Facility (the Project). The Project comprises of the installation and operation of a solar farm up to 5MW AC, which will utilise photovoltaic (PV) modules to generate electricity. The Project will supplying clean energy to power the equivalent of 1,500 average Victorian homes per year, offsetting approximately 11,000tonnes of CO2 annually, making a significant contribution to the Hindmarsh Council area overall emissions profile.

The Project site is located on Lot 1 on Plan of Subdivision 630537Q on Ervins Road, Nhill, on a 27 acre subdivision of 239 Nhill-Harrow Road, Nhill ("the Project site"). The PV panels will face north (Azimuth 8.2 degrees) in 25 rows running east west and will be mounted on a fixed frame supporting system at a tilt angle of approximately 30 degrees. This assessment considered various tilt angles from 29 to 31 degrees to accommodate minor variation in the construction stage. The PV panels, including the mounting structures, will be a maximum height of 2.5 metres.

1.1. Location

The Project site is located approximately 2.5 kilometres south-west of Nhill town centre, *refer Figure 1.* The Project site adjoins Ervins Road on the western boundary, which is a gravel access road. The Western Highway is located between 220 to 500 metres to the west of the Project site. To the north of the site is the Nhill Trailer Exchange, and to the north east is the GWM Water Treatment Plant. To the south and east of the site is open rural land used for cropping. The site is zoned FZ Farming Zone and is currently used for cropping. Farming is the predominant land use within the area.

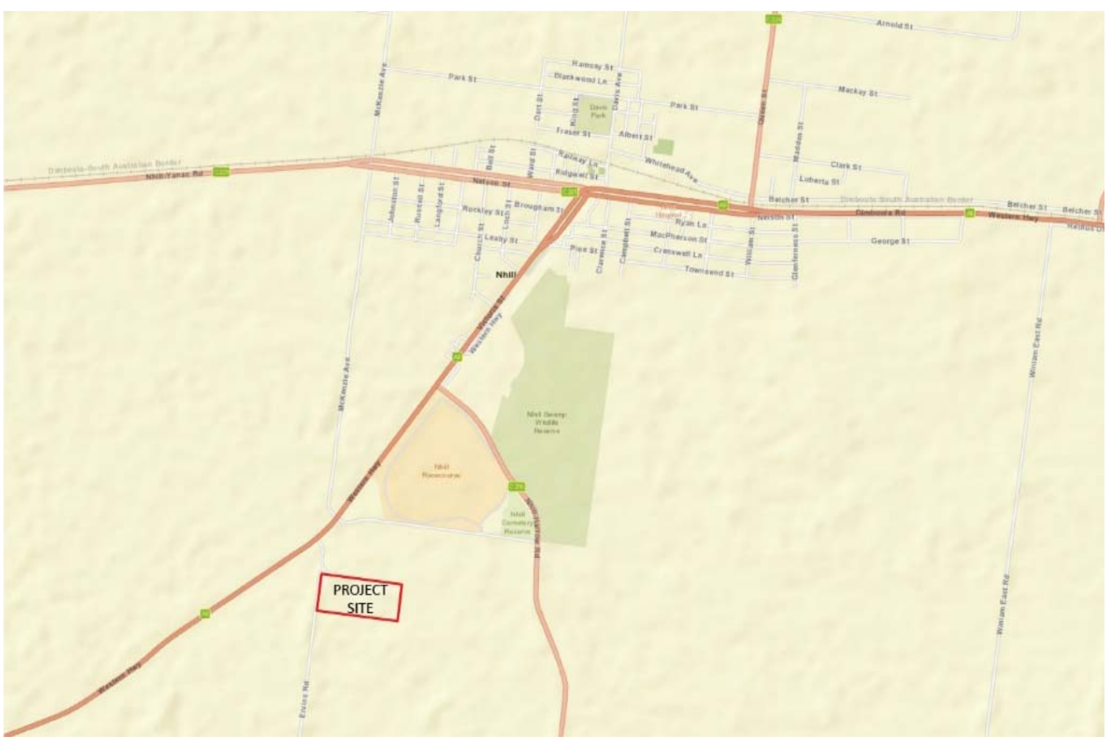


Figure 1. Location Plan

2. SCOPE OF THE ASSESSMENT

The scope of this Glint and Glare Impact Assessment includes the following:

- Description of the methodology used to undertake the study;
- Assessment of the baseline conditions;
- Description of the elements of the Project with the potential to influence glare including size, height, and angle of PV modules, and types of framing;
- Identification of the viewshed and potential visibility of the Project;
- Desktop mapping of potential glare at the location of sensitive receptors within the viewshed, based on Solar Glare Hazard Analysis and viewshed analysis;
- Assessment of the potential risk of glare on sensitive receptors during operation of the Project; and
- Assessment of potential mitigations measures to avoid, mitigate, or manage potential impacts.

3. METHODOLOGY

3.1. Glint and Glare Definitions

Glint and glare refers to the human experience of reflected light. Glint is typically defined as a momentary flash of bright light, (notably over a very short duration), often caused by reflection from a moving source, such as a moving vehicle. Glare is generally associated with stationary objects, which due to the slow relative movement of the sun, reflect sunlight for a longer duration. The difference between glint and glare is duration**.** Industry-standard solar glare analysis tools evaluate the potential impact of glare, since light reflection from stationary or slowly rotating PV panels can result in longer duration glare events.

3.2. Glare Assessment Parameters

Glare assessment modelling for solar farms is based on the following factors:

- the tilt, orientation, and optical properties of the PV modules in the solar array;
- sun position over time, taking into account geographic location;
- the location of sensitive receptors (viewers); and
- Screening potential of surrounding topography and vegetation.

3.3. Glare Intensity Categories

The potential hazard from solar glare is a function of retinal irradiance (power of electromagnetic radiation per unit area produced by the sun) and the subtended angle (size and distance) of the glare source.[1]

[1] HO, C.K., C.M. Ghanbari, and R.B. Diver, 2011, Methodology to Assess Potential Glint and Glare hazards from Concentrated Solar Power Plants

Glare can be broadly classified into three categories: low potential for after-image, potential for after-image, and potential for permanent eye damage, *Figure 2* illustrates the glare intensity categories used in this study.

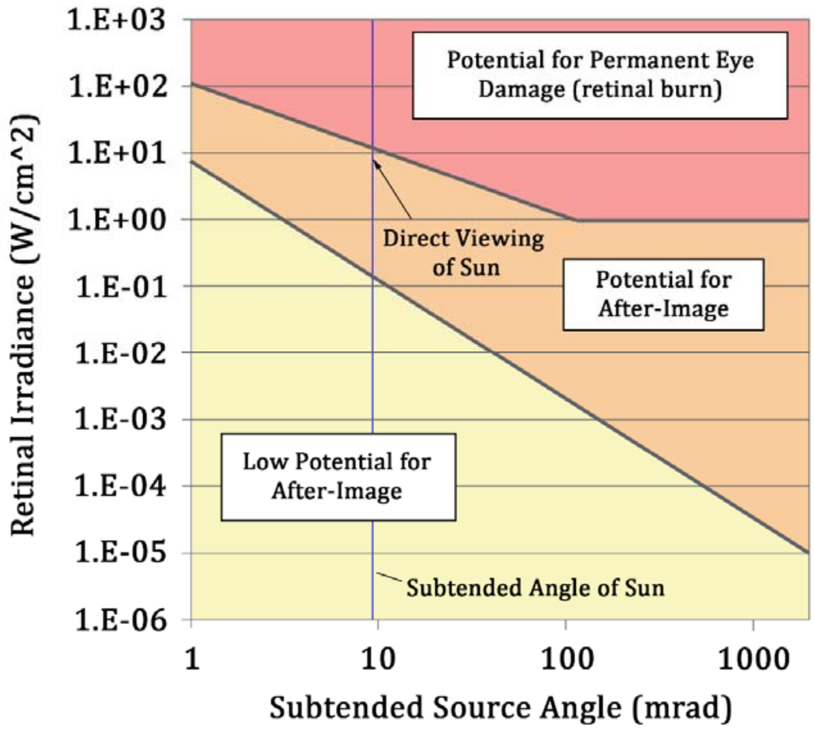


Figure 2. Ocular impacts and Hazard Ranges[2]

The amount of light reflected from a PV module depends on the amount of sunlight hitting the surface, as well as the surface reflectivity. The amount of sunlight interacting with the PV module will vary based on geographic location, time of year, cloud cover, and PV module orientation. 1000W/m^2 is generally used in most counties as an estimate of the solar energy interacting with a PV module when no other information is available. This study modelled scenarios using 2000 W/m^2 in order to cover potentially higher solar energy levels in Australia as compared to other parts of the world. Flash blindness for a period of 4-12 seconds (i.e. time to recovery of vision) occurs when 7-11 W/m^2 (or 650-1,100 lumens/m^2) reaches the eye[3].

3.4. Reflection and Angle of Incidence

PV modules are designed to maximise the absorption of solar energy and therefore minimise the extent of solar energy reflected. PV modules have low levels of reflectivity between 0.03 and 0.20 depending on the specific materials, anti-reflective coatings, and angle of incidence.[4]

[2] Source: Solar Glare Hazard Analysis Tool (SGHAT) Presentation (2013) https://share.sandia.gov/phlux/static/references/glint-glare/SGHAT_Ho.pdf
[3] Sandia National Laboratory, SGHAT Technical Manual
[4] *Ho, C. 2013 Relieving a Glare Problem*

The higher reflectivity values of 0.20, that is 20% of incident light being reflected, can occur when the angle of incidence is greater than 50º. *Figure 3 and 4* show the relationship between increased angles of incidence and increased levels of reflected light. Where the angle of incidence remains below 50° the amount of reflected light remains below 10%. The angle of incidence is particularly relevant to specular reflection (light reflection from a smooth surface). Diffuse reflection (light reflection from a rough surface) may also occur in PV modules, however this is typically a result of dust or similar materials building up on the PV module surface, which would potentially reduce the reflection.

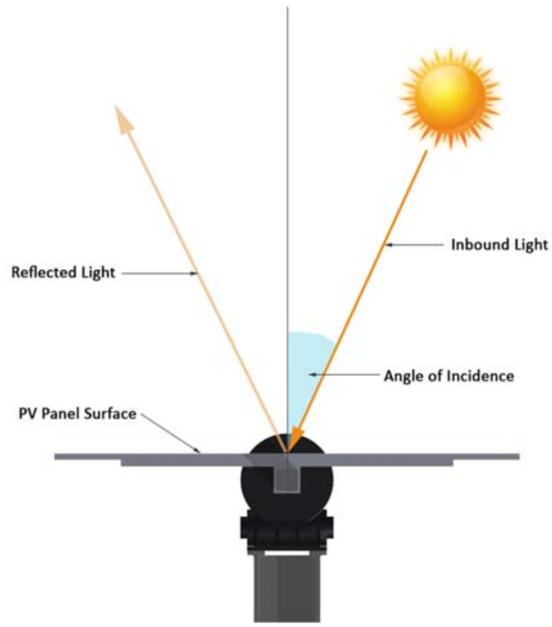


Figure 3. Angle of Incidence Relative to PV Panel Surface

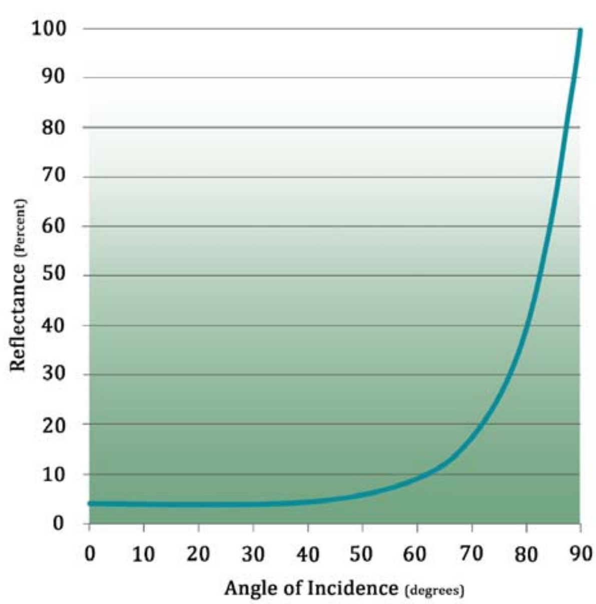


Figure 4. Angles of Incidence and Increased Levels of Reflected Light (Glass (n-1.5))

The sun changes its east-west orientation throughout the day, and the sun's north-south position in the sky changes throughout the year. The sun reaches its highest position at noon on the Summer Solstice (21 December in the Southern Hemisphere) and its lowest position at sunrise and sunset on the Winter Solstice (21 June in the Southern Hemisphere).

In a fixed PV solar array, the angle of incidence varies as the sun moves across the sky, that is the angle of incidence are at their lowest around noon where the sun is directly overhead, and increase in the early mornings and late evenings.

3.5. Viewshed Analysis

A desktop viewshed analysis was undertaken using ArcGIS 3D modelling. The extent of visibility of the proposed solar farm was assessed relative to the location of sensitive receptors (dwellings, roads, etc.) The desktop viewshed analysis is based on topography only and does not take into consideration vegetation. A site assessment of visibility was undertaken as part of the Planning Report for the Project and this information, together with aerial imagery, has been utilised as the basis for assessing the screening effect of existing vegetation in conjunction with the desktop viewshed analysis and glare modelling.

3.6. Solar Glare Hazard Analysis

This assessment has utilised the Solar Glare Hazard Analysis Tool (SGHAT 3.0) co-developed by Sandi National Laboratory[5] and ForgeSolar (Sim Industries) (referred to as GlareGauge) to assess potential glare utilising latitude and longitudinal coordinates, elevation, sun position, and vector calculations. The PV module orientation, reflectance environment and ocular factors are also considered by the software. If potential glare is identified by the model, the tool calculates the retinal irradiance and subtended angle (size/distance) of the glare source to predict potential ocular hazards according to the glare intensity categories (refer *Section 3.3*).

The sun position algorithm used by SGHAT calculates the sun position in two forms: first as a unit vector extending from the Cartesian origin toward the sun, and second as azimuthal and altitudinal angles. The algorithm enables determination of the sun position at one (1) minute intervals throughout the year.

The SGHAT is a high level tool and does not take into consideration the following factors:

- Gaps between PV modules;
- Atmospheric conditions; and
- Vegetation between the solar panels and the viewer (sensitive receptor).

SGHAT has been used extensively in the United States to assess the potential impact of solar arrays located in close proximity to airports. The US Federal Aviation Administration requires the use of SGHAT to demonstrated compliance with the safety requirements for all proposed solar energy systems located at federally obligated airports. Used in conjunction with a viewshed analysis, the two tools represent a conservative assessment.

[5] https://share.sandia.gov/phlux/static/references/glint-glare/SGHAT_Technical_Reference-v5.pdf

3.7. Risk Assessment

Once the potential for glare has been identified through the viewshed analysis and SGHAT, a risk assessment approach is used to identify the potential significance of the hazard based on the magnitude of the glare hazard generated, distance from the Project, existing vegetation, and the sensitivity of the receptors (viewers). Mitigation measures are then considered to avoid, reduce or managed the identified risks.

4. EXISTING CONDITIONS

The baseline is a statement of the characteristics which currently exist in the Project area. The baseline glare condition assessment takes into consideration the following:

- Characteristics of the environment that may affect the potential for glare;
- Land use and human modifications to the landscape such as roads, buildings and existing infrastructure which may influence glare and sensitivity to glare.

4.1. Baseline Conditions

The baseline conditions within the vicinity of the Project site are characteristic of the area, being generally flat rural land. The Project adjoins infrastructure and utility land uses to the north which are compatible with the Project's utility purpose, that is, to generate renewable energy. The majority of remnant vegetation in the area has been cleared as a result of past agricultural practices, some areas of native vegetation remain along roads and within protected wetland areas.

Existing dwellings in the area include scattered rural properties, and the southern residential areas of Nhill. Commercial and industrial properties are also located on the outskirts of Nhill. The Nhill race course is located to the north together with the Nhill cemetery.

Nhill Airport and Aviation Heritage Centre are located 4.7km north of the Project site.

Existing features in the landscape with the potential to contribute to glare include the water bodies associated with the GWM Water Treatment Plant. However, these are generally screened from surround areas by earth bunding.

4.2. Atmospheric Conditions

Atmospheric conditions such as cloud cover, dust and haze will impact light reflection, however these factors have not been accounted for in this glare assessment. The Bureau of Meteorology statistics for Horsham Polkemmet Road 58 km from the Project site (the closest BOM records for cloud cover statistics) recorded 141 cloudy days per year (mean number over the period 1957 to 2008)[6]. Cloudy days predominately occur during the winter months, May to September. Since atmospheric conditions have not been factored into this assessment modelling, statistically the glare potential represents a conservative assessment.

[6] http://www.bom.gov.au/climate/averages/tables/cw_079023.shtml

5. PROJECT DESCRIPTION

The general layout of the Project is as show in *Figure 5.* The main elements of the Project with the potential to influence glare are the tilt, orientation, and optical properties of the PV modules in the solar array. Whilst specific products are yet to be determined for the Project, the general technical properties of the main elements influencing glare are described below.

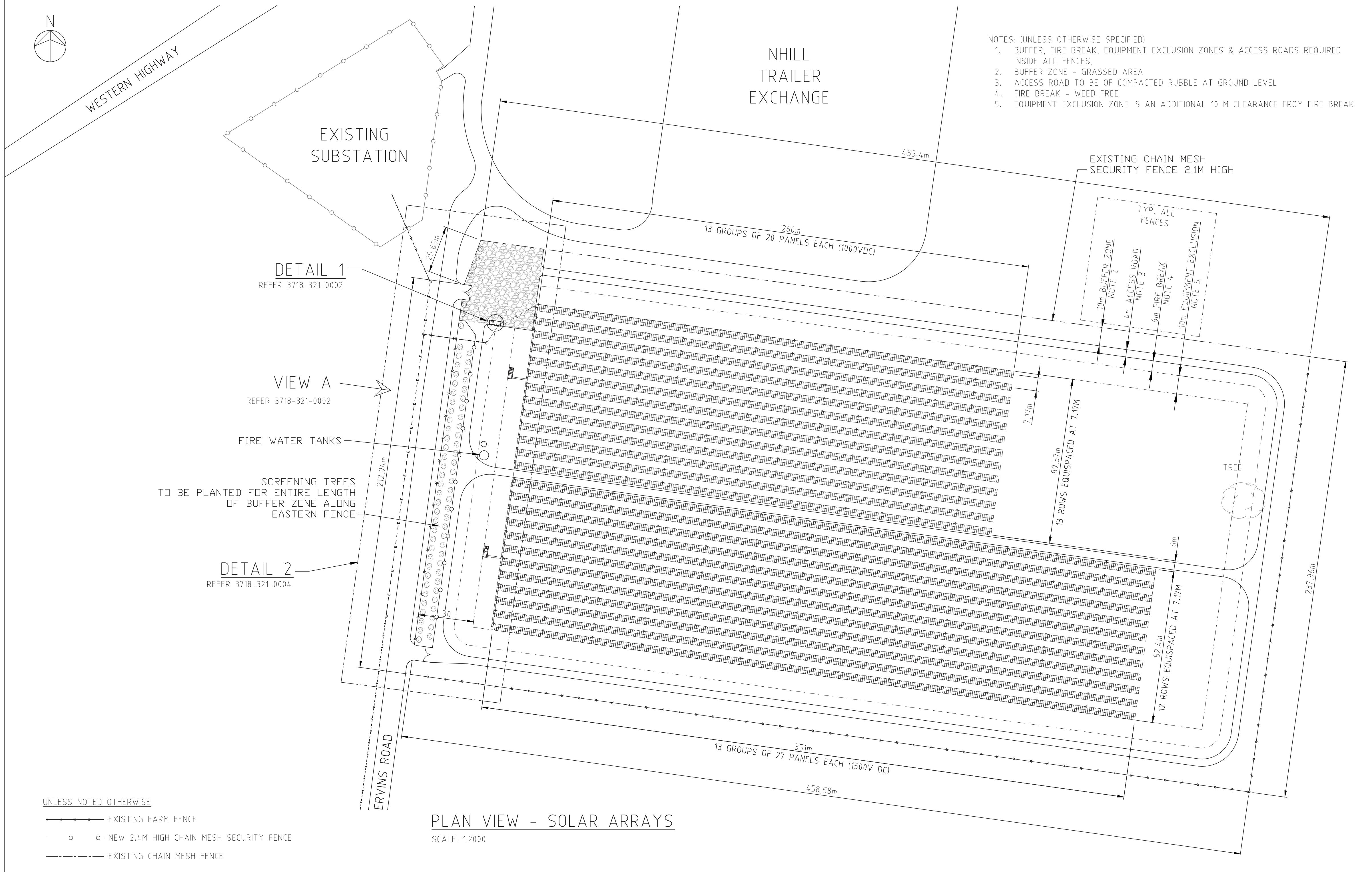
5.1. PV modules

Each PV panel typically comprises of 72 polycrystalline silicon solar cells overlayed by a 3.2 to 4.0 mm tempered glass front and held in an anodised aluminium alloy frame. Half cut cell technology is also available which consists of 144 monocrystalline cells connected in series to reduce ribbon resistant. Dual-glass and frameless PV systems area also available. The approximate dimensions for a typical solar panel is 2 metres x 1 metre. The proposed solar array arrangement for this Project is 2 solar panels in portrait, resulting in an array width of approximately 4.0 metres wide.

5.2. Fixed Frame System

This study assessed the potential glare impacts of a fixed tilt system in which the PV panels are supported by a frame at a fixed angle. The zenith tilt angle of the panels was set at 30 degrees, that is, the panels are tilted to the north at 30 degrees where 0 degrees is parallel to the ground. Additionally, 29 and 31 degree tilts were also tested in the modelling. The PV panels are orientated 8.2 degrees from north, towards east (azimuth), to better fit within the site constraints. The maximum height of the PV modules above natural ground is anticipated to be 2.5 metres, including a 0.5m ground clearance.

Photo 1. Example of a typical fixed tilt system



Source: Vibe Energy
3718-321-001-D

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PROJECT LAYOUT PLAN

FIGURE 5.0

5.3. Solar Inverters, Control Room, and Fencing

The Project will also include solar inverters, a control/switch building (container), and perimeter fencing. These elements are not considered likely to influence glare as they generally comprise of non-reflective surfaces typically found in the built environment.

5.4. Landscape Screening

A landscape screen comprising of native Eucalyptus species is proposed along the western boundary of the Project site. This vegetation, once established, will assist in mitigating potential visual and glare impacts to travellers on Ervins Road and the Western Highway, and properties to the west of the Site.

6. DESKTOP GLARE ASSESSMENT

The aim of the desktop glare assessment is to identify if any sensitive receptors have the potential to be impacted by glare. The software modelling systems used in the desktop assessment include viewshed modelling to identify the location of sensitive receptors with line of sight to the Project, and the SGHAT to identify the potential and ocular significance of glare.

6.1. Viewshed Analysis

The results of the viewshed analysis (based on topography) are shown in *Figure 6.*

The Digital Elevation Model (DEM) for the viewshed modelling was set as 'Finest' (> 10 m). Contour information for the site (DELWP dataset) was assessed and shows the Project site is located within a flat landscape with minor topographic variation.

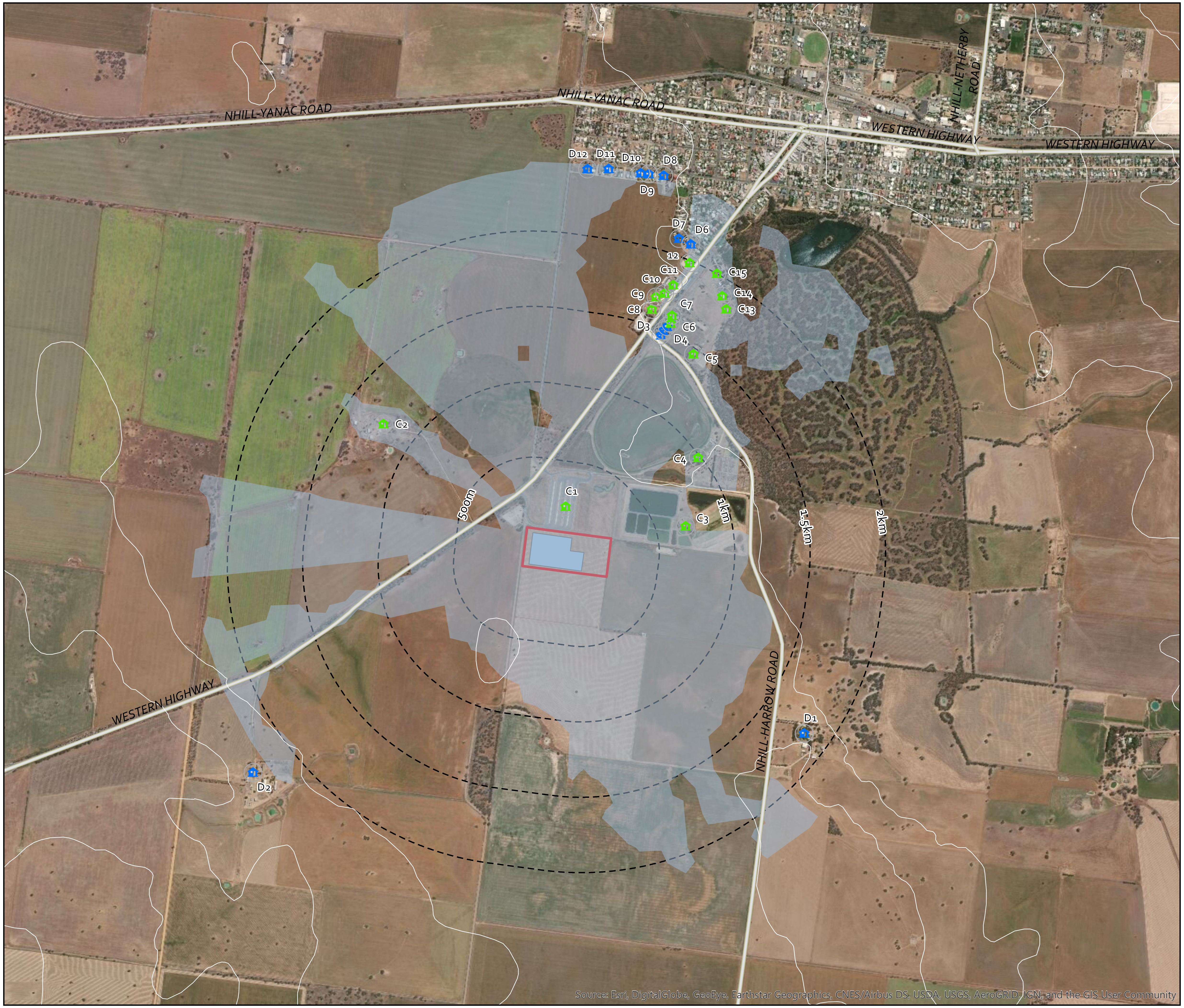
Solar Farms are characterised by their low horizontal profile. The major elements of a solar farm are the PV models, these are generally 2 to 4 metres above ground level. In this study a maximum height of 2.5 metres above ground level was used in the modelling. At distances greater than 1 km a 3 metre high horizontal object in the landscape becomes visually insignificant (perceived as a narrow line in the distance) when viewed across a flat plain. At distances greater than 2 km the Project will be barely visible, therefore the viewshed analysis focussed on potential visibility of the Project within 2km of the site.

The viewshed analysis in this study has utilised the visibility assessment undertaken in the *Planning Report,* [7] and desktop assessment of aerial imagery, to confirm screening provided by minor topographic variations (outside the parameters of the modelling), and the screening potential of existing vegetation.

The results of the viewshed analysis are summarised below:

- The desktop assessment identified the Project is generally visibility within 1km of the site, with visibility decreasing with distance as minor variations in the flat landscape interrupt line of sight.

[7] Vibe Energy, February 2019, Nhill Renewable Energy Facility – Planning Report



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DATUM GDA 1994,
PROJECTION MGA ZONE 56

0 0.25 0.5 1 Kilometer

LEGEND

- Commercial Properties
- Dwellings
- Extent of Visibility *
- Buffer Zones to 2km
- PV Panels
- Site Boundary

*(Analysis based on Digital Terrain Model)

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VIEWSHED ANALYSIS

FIGURE 6.0

- The Project is not considered likely to be visible from (2) two farming properties to the south.
- The Project has the potential to be visible from properties to the north, including commercial and residential properties. However, residential areas of Nhill are not considered likely to have views of the Project due to distance (greater than 2km).
- 27 observation points were assessed within the viewshed including 12 dwellings and 15 commercial properties, as follows:
    - One (1) commercial property within 500 metres of the Project site (C1) at the office of the Nhill Trailer Exchange.
    - Two (2) commercial and recreational properties within 1km of the Project site (C3 & C4) including GWM Water Treatment Plant (buildings) and Nhill Racecourse.
    - Four (4) residential and commercial properties within 1.5km of the Project site (C2, C5, D3, D4).
    - 12 rural, residential and commercial properties within 2km of the Project site (D1, D5, D6 to C15).
    - An additional 8 rural and residential properties were assessed in the modelling, although these were located outside the 2km viewshed. The majority of these dwellings are located to the north of the site, on the southern outskirts of Nhill.
- The Western Highway and Nhill-Harrow Road pass through the viewshed and these were assessed together with minor roads including McKenzie Avenue and Ervins Road, and circulation roads within the Nhill Trailer Exchange.
- Nhill Airport is outside the viewshed of the Project, and at 4.7km from the site this facility is not considered 'close', however the runway flight paths were included in the glare model.

The potential glare hazard impact for identified properties, surrounding roads and highway, and aviation infrastructure, with potential views to the site has been assessed in *Section 6.2.*

6.2. Solar Glare Hazard Analysis

The parameters used in the SGHAT model are detailed in *Tables 1.*

Table 1. Input data for SGHAT Analysis – Fixed Frame System

SGHAT Model Parameters	Values
Time Zone	UTC +10
Axis Tracking	Fixed (no rotation)
Tilt	30 degrees (29 – 31 degrees)
Orientation	8.2 degrees
Module Surface material	Smooth glass without anti-reflective coating (ARC)
Reflectivity	Vary with sun
Correlate slope error with surface type?	Yes
Slope error	6.55mrad
Height of panels above ground	2.5 m maximum height

The assessment outcomes for the SGHAT are detailed in *Appendix A to D*, and outlined in *Table 2.*

Table 2. SGHAT Assessment Results – Fixed Frame System

Sensitive Receptor	Glare Potential
Observation Points Rural and Residential Dwellings D1 to D12	No Glare
Observation Points Commercial and recreational properties – C1, 2, C5 to C15	No Glare
Observation Point C3 – Water Treatment Plant	Glare Potential
Observation Point C4 - Racecourse	Glare Potential
Route 1 – Western Highway	No Glare
Route 2 – Nhill-Harrow Road	Glare Potential
Route 3 – McKenzie Avenue	No Glare
Route 4 – Nhill Trailer Exchange	No Glare
Route 5 – Ervins Road	No Glare
Flight Path 1 – Nhill Airport Asphalt Runway (east)	No Glare
Flight Path 2 – Nhill Airport Asphalt Runway (west)	No Glare
Flight Path 3 – Nhill Airport Grass Runway (south)	No Glare
Flight Path 4 – Nhill Airport Grass Runway (north)	No Glare

7. POTENTIAL IMPACTS

7.1. Solar Glare Hazard Analysis Tool (SGHAT) Results

The SGHAT modelling found no impact to rural and residential dwellings within the study area, *refer Appendix A.*

The SGHAT modelling found potential glare hazard affecting two (2) infrastructure/recreation properties, the GMW Water Treatment Plant and the Nhill Racecourse. The potential glare hazard generally occurs in the late afternoon (17:00 to 18:00 hrs) during the summer months, *refer Appendix B*.

The GMW Water Treatment Plant observation point was located at the buildings, bunding associated with the water ponds, trees and tanks are likely to screen this location from potential glare, therefore the potential impact is considered negligible.

The potential glare hazard affecting the racecourse was minor (91 minutes) and occurs mainly in December, the observation point tested was located at the clubhouse/ticketing building. Additional points were tested along the race track (straight) and no glare potential was identified. Existing vegetation within the racecourse and bunding within the water treatment plant are likely to screen this location from potential glare, therefore the potential impact is considered negligible.

The SGHAT modelling found no impact to the Western Highway, McKenzie Avenue, Ervins Road, and the Nhill Trailer Exchange, however glare hazard was identified along Nhill–Harrow Road, *refer Appendix C.* The potential glare hazard generally occurs in the late afternoon (17:00 to 18:00 hrs) during the summer months. The viewshed analysis identified this section of the Nhill- Harrow Road is partially screened by minor topographic variation and bunding associated with the Water Treatment Plant. Existing vegetation along the road corridor, within the racecourse and cemetery will also provide screening to the Project. As a result of the screening, the glare hazard potential is considered of low impact.

The SGHAT modelling found no impact to aviation infrastructure, *refer Appendix D.*

SGHAT modelling was undertaken for a tilt angle of 30 degrees for the PV panels on a fixed frame system, in addition tilt angles of 29 and 31 degrees were also tested and identified no significant difference in the results.

A summary of the potential glare hazard identified in the SGHAT modelling together with existing mitigation factors, such as minor variation in topography, existing vegetation and distance from the site, is outlined in *Table 5.*

Table 5. Glare potential risk assessment for fixed tilt system

Sensitive Receptor	Glare Potential (based on topography)	Mitigation factors	Distance	Risk
C3 – Water Treatment Plant	Glare Potential (Yellow)	Bunding around the water ponds, existing vegetation and tanks	700m	Negligible
C4 – Racecourse (Clubhouse building)	Glare Potential (Yellow)	Existing vegetation, and bunding within water treatment plant will screen the project	880m	Negligible
Travel Path – Nhill – Harrow Road	Glare Potential (Yellow)	Minor topographic variations (refer to viewshed analysis), bunding within water treatment plant, and existing vegetation along the road corridor and within adjoining properties.	1.1 – 1.5km	Negligible to Low

Yellow = Glare with potential to cause temporary after-image

8. MANAGEMENT AND MITIGATION MEASURES

Under normal operation of the solar farm negligible to low glare potential was identified in this desktop assessment. Potential glare hazard to the Water Treatment Plant (buildings) and Nhill Racecourse (buildings) are considered likely to be mitigated by existing bunding and vegetation. Nhill- Harrow Road is considered likely to be substantially mitigated by bunding within the water treatment plant and existing vegetation.

9. SUMMARY

In summary, based on the assumptions and parameters of this desktop assessment, the following results were identified:

- No glare potential was identified affecting rural and residential dwellings within the viewshed.
- Two (2) properties were identified in the glare modelling with potential to be affected by glare (the Water treatment Plant and Nhill Racecourse buildings) in both cases potential glare is considered likely to be mitigated by existing bunding and vegetation.

- Nhill- Harrow Road was identified in the modelling as potentially affected by glare for a short period of time during the summer months, bunding within the water treatment plant and existing vegetation is considered likely to substantially mitigated the glare potential.
- No glare potential was identified affecting the Western Highway and other local roads within the viewshed.
- The SGHAT modelling found no glare hazard potential affecting Nhill Airport runways.

APPENDIX A:

SOLAR GLARE HAZARD ANALYSIS –DWELLINGS

GlareGauge Glare Analysis Results

Site Configuration: Nhill_OPs

Project site configuration details and results.

Created **April 30, 2020 9:18 p.m.**
Updated **April 30, 2020 9:23 p.m.**
DNI **varies** and peaks at **2,000.0 W/m^2**
Analyze every **1** minute(s)
0.5 ocular transmission coefficient
0.002 m pupil diameter
0.017 m eye focal length
9.3 mrad sun subtended angle
Timezone **UTC10**
Site Configuration ID: 38552.7047

Summary of Results No glare predicted!

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	30.0	8.2	0	0	-

Component Data

PV Array(s)

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 30.0 deg
Orientation: 8.2 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-36.352370	141.634019	135.02	2.50	137.52
2	-36.352629	141.636282	133.14	2.50	135.64
3	-36.353212	141.636186	132.93	2.50	135.43
4	-36.353298	141.637087	132.68	2.50	135.18
5	-36.354288	141.636915	132.06	2.50	134.56
6	-36.353951	141.633767	135.09	2.50	137.59

Discrete Observation Receptors

Number	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total Elevation m
OP 1	-36.362006	141.650127	140.03	1.50	141.53
OP 2	-36.363858	141.617292	145.82	1.50	147.32
OP 3	-36.342882	141.641592	129.76	1.50	131.26
OP 4	-36.342679	141.641731	130.23	1.50	131.73
OP 5	-36.342461	141.641927	130.91	1.50	132.41
OP 6	-36.338559	141.643308	128.14	1.50	129.64
OP 7	-36.338308	141.642632	128.02	1.50	129.52
OP 8	-36.335309	141.641687	134.04	1.50	135.54
OP 9	-36.335209	141.640845	132.85	1.50	134.35
OP 10	-36.335149	141.640376	132.10	1.50	133.60
OP 11	-36.334924	141.638450	134.41	1.50	135.91
OP 12	-36.334963	141.637221	133.68	1.50	135.18

PV Array Results

Summary of PV Glare Analysis PV configuration and predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	30.0	8.2	0	0	-	-

Click the name of the PV array to scroll to its results

PV & Receptor Analysis Results detailed results for each PV array and receptor

PV array 1 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0

No glare found

Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- 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.
- Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- 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.)
- 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.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Glare analysis methods used: OP V1, FP V1, Route V1
- Refer to the **Help page** for assumptions and limitations not listed here.

APPENDIX B:

SOLAR GLARE HAZARD ANALYSIS – OTHER PROPERTY TYPES

ForgeSolar
PV planning & glare analysis

GlareGauge Glare Analysis Results

Site Configuration: Nhill_OP_Commercial

Project site configuration details and results.

Created **April 30, 2020 9:36 p.m.**
Updated **April 30, 2020 9:42 p.m.**
DNI **varies** and peaks at **2,000.0 W/m^2**
Analyze every **1** minute(s)
0.5 ocular transmission coefficient
0.002 m pupil diameter
0.017 m eye focal length
9.3 mrad sun subtended angle
Timezone **UTC10**
Site Configuration ID: 38553.7047

Summary of Results Glare with potential for temporary after-image predicted

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	30.0	8.2	0	1,682	-

Component Data

PV Array(s)

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 30.0 deg
Orientation: 8.2 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-36.352370	141.634019	135.02	2.50	137.52
2	-36.352629	141.636282	133.14	2.50	135.64
3	-36.353212	141.636186	132.93	2.50	135.43
4	-36.353298	141.637087	132.68	2.50	135.18
5	-36.354288	141.636915	132.06	2.50	134.56
6	-36.353951	141.633767	135.09	2.50	137.59

Discrete Observation Receptors

Number	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total Elevation m
OP 1	-36.351154	141.635922	132.04	1.50	133.54
OP 2	-36.346922	141.624802	135.94	1.50	137.44
OP 3	-36.351921	141.643073	133.98	1.50	135.48
OP 4	-36.348762	141.643813	130.09	1.50	131.59
OP 5	-36.343766	141.643569	129.69	1.50	131.19
OP 6	-36.342422	141.642339	131.01	1.50	132.51
OP 7	-36.342094	141.642495	131.16	1.50	132.66
OP 8	-36.341644	141.641070	130.76	1.50	132.26
OP 9	-36.341065	141.641355	130.51	1.50	132.01
OP 10	-36.340913	141.641899	129.87	1.50	131.37
OP 11	-36.340516	141.642452	129.43	1.50	130.93
OP 12	-36.339552	141.643447	128.18	1.50	129.68
OP 13	-36.341593	141.645605	128.73	1.50	130.23
OP 14	-36.340980	141.645326	128.99	1.50	130.49
OP 15	-36.339900	141.644961	128.85	1.50	130.35

PV Array Results

Summary of PV Glare Analysis PV configuration and predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	30.0	8.2	0	1,682	-	-

Click the name of the PV array to scroll to its results

PV & Receptor Analysis Results detailed results for each PV array and receptor

PV array 1 potential temporary after-image

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	1591
OP: OP 4	0	91
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	0
OP: OP 15	0	0

PV array 1 - OP Receptor (OP 1)

No glare found

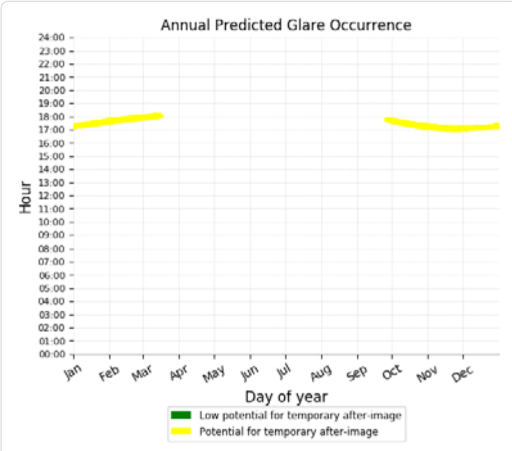
PV array 1 - OP Receptor (OP 2)

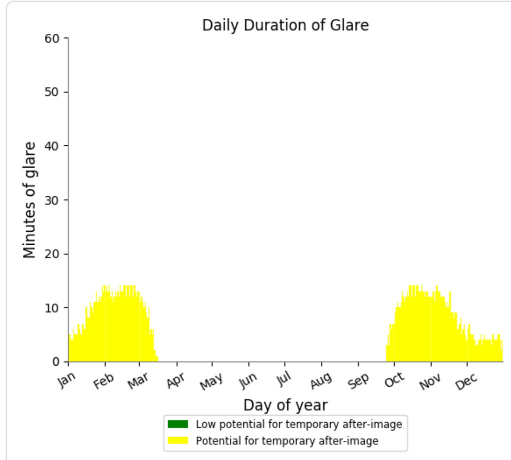
No glare found

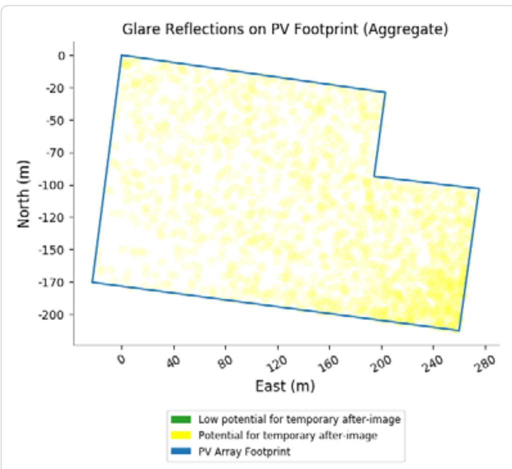
PV array 1 - OP Receptor (OP 3)

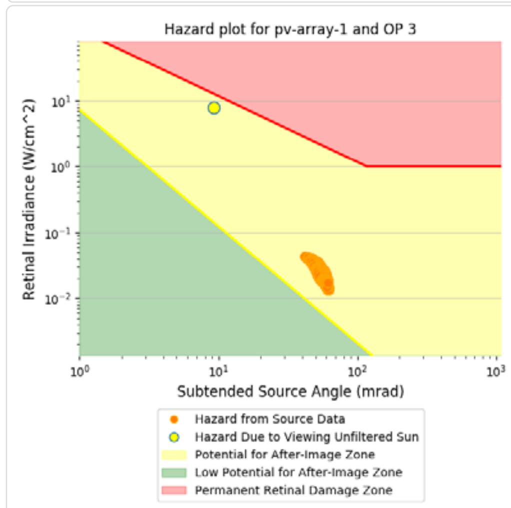
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,591 minutes of "yellow" glare with potential to cause temporary after-image.





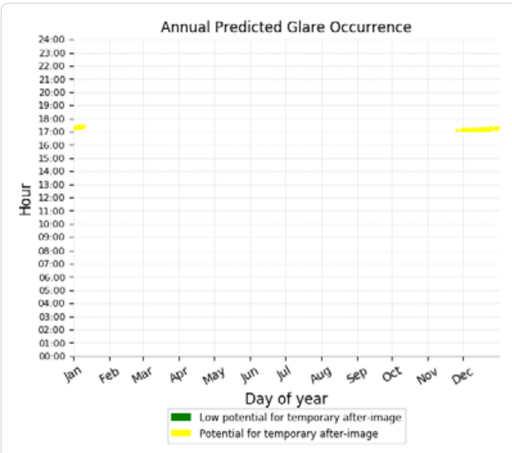


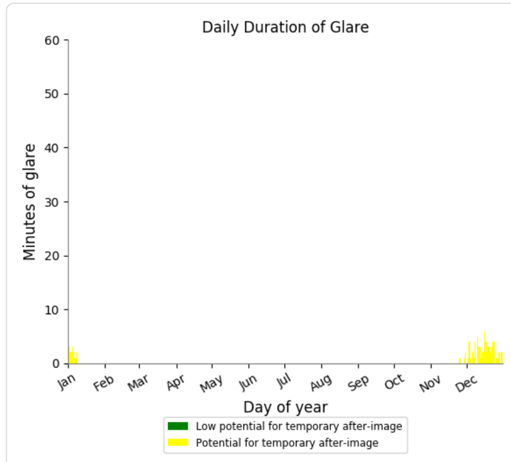


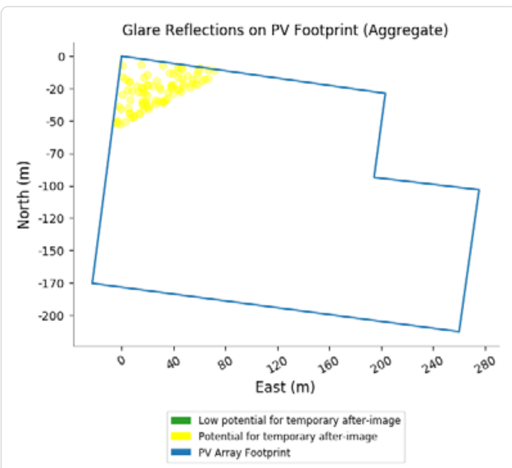
PV array 1 - OP Receptor (OP 4)

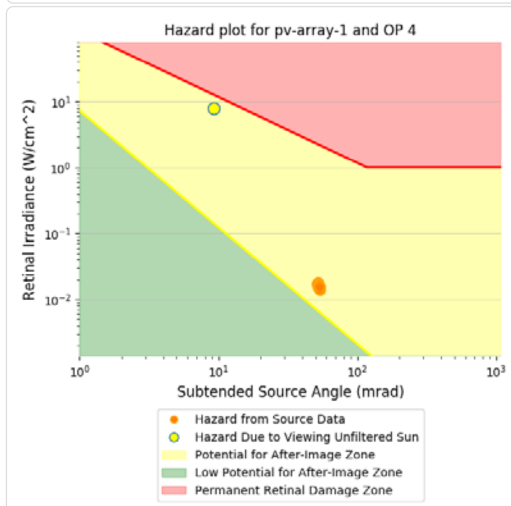
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 91 minutes of "yellow" glare with potential to cause temporary after-image.









PV array 1 - OP Receptor (OP 5)

No glare found

PV array 1 - OP Receptor (OP 6)

No glare found

PV array 1 - OP Receptor (OP 7)

No glare found

PV array 1 - OP Receptor (OP 8)

No glare found

PV array 1 - OP Receptor (OP 9)

No glare found

PV array 1 - OP Receptor (OP 10)

No glare found

PV array 1 - OP Receptor (OP 11)

No glare found

PV array 1 - OP Receptor (OP 12)

No glare found

PV array 1 - OP Receptor (OP 13)

No glare found

PV array 1 - OP Receptor (OP 14)

No glare found

PV array 1 - OP Receptor (OP 15)

No glare found

Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- 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.
- Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- 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.)
- 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.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Glare analysis methods used: OP V1, FP V1, Route V1
- Refer to the **Help page** for assumptions and limitations not listed here.

APPENDIX C:

SOLAR GLARE HAZARD ANALYSIS – LOCAL ROADS AND HIGHWAY

GlareGauge Glare Analysis Results

Site Configuration: Nhill_Roads-temp-0

Project site configuration details and results.

Created **May 7, 2020 8:55 p.m.**
Updated **May 7, 2020 8:57 p.m.**
DNI **varies** and peaks at **2,000.0 W/m^2**
Analyze every **1** minute(s)
0.5 ocular transmission coefficient
0.002 m pupil diameter
0.017 m eye focal length
9.3 mrad sun subtended angle
Timezone **UTC10**
Site Configuration ID: 39014.7047

Summary of Results Glare with potential for temporary after-image predicted

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	30.0	8.2	0	214	-

Component Data

PV Array(s)

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 30.0 deg
Orientation: 8.2 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-36.352370	141.634019	135.02	2.50	137.52
2	-36.352629	141.636282	133.14	2.50	135.64
3	-36.353212	141.636186	132.93	2.50	135.43
4	-36.353298	141.637087	132.68	2.50	135.18
5	-36.354288	141.636915	132.06	2.50	134.56
6	-36.353951	141.633767	135.09	2.50	137.59

Route Receptor(s)

Name: Route 1
Route type Two-way
View angle: 90.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	-36.339450	141.644059	126.97	2.00	128.97
2	-36.349232	141.634682	133.33	2.00	135.33
3	-36.350373	141.633288	132.53	2.00	134.53
4	-36.359135	141.617774	136.18	2.00	138.18

Name: Route 2
Route type Two-way
View angle: 90.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	-36.342721	141.640953	130.05	2.00	132.05
2	-36.343469	141.642107	128.56	2.00	130.56
3	-36.344203	141.643153	129.06	2.00	131.06
4	-36.344799	141.643705	129.45	2.00	131.45
5	-36.346026	141.644499	127.32	2.00	129.32
6	-36.346856	141.645036	127.51	2.00	129.51
7	-36.347660	141.645712	129.43	2.00	131.43
8	-36.348437	141.646516	128.38	2.00	130.38
9	-36.349172	141.647021	128.92	2.00	130.92
10	-36.350468	141.647139	130.53	2.00	132.53
11	-36.353228	141.646989	130.76	2.00	132.76
12	-36.354213	141.647246	130.64	2.00	132.64
13	-36.357582	141.648920	132.81	2.00	134.81
14	-36.358447	141.648899	132.97	2.00	134.97
15	-36.364097	141.647954	140.79	2.00	142.79

Name: Route 3
Route type Two-way
View angle: 90.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	-36.349240	141.634537	133.44	2.00	135.44
2	-36.348990	141.634242	133.95	2.00	135.95
3	-36.348627	141.634071	135.00	2.00	137.00
4	-36.334990	141.636200	133.44	2.00	135.44

Name: Route 4
Route type Two-way
View angle: 90.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-36.349327	141.634661	133.26	2.00	135.26
2	-36.349560	141.634983	133.01	2.00	135.01
3	-36.349491	141.635637	131.96	2.00	133.96
4	-36.349383	141.636265	131.62	2.00	133.62
5	-36.349405	141.637032	131.96	2.00	133.96
6	-36.349469	141.637397	131.59	2.00	133.59
7	-36.349824	141.637423	131.67	2.00	133.67
8	-36.349802	141.636753	132.00	2.00	134.00
9	-36.350303	141.636581	132.00	2.00	134.00
10	-36.352057	141.636265	132.05	2.00	134.05
11	-36.352213	141.635911	133.37	2.00	135.37
12	-36.352057	141.634151	134.81	2.00	136.81
13	-36.351846	141.633776	135.16	2.00	137.16
14	-36.351500	141.633615	134.71	2.00	136.71
15	-36.350964	141.633706	133.93	2.00	135.93
16	-36.350718	141.633647	133.55	2.00	135.55
17	-36.350446	141.633304	132.72	2.00	134.72

Name: Route 5
Route type Two-way
View angle: 90.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-36.351722	141.633587	135.03	2.00	137.03
2	-36.360570	141.632214	136.13	2.00	138.13
3	-36.360674	141.630755	137.05	2.00	139.05
4	-36.362523	141.630412	138.41	2.00	140.41

PV Array Results

Summary of PV Glare Analysis PV configuration and predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	30.0	8.2	0	214	-	-

Click the name of the PV array to scroll to its results

PV & Receptor Analysis Results detailed results for each PV array and receptor

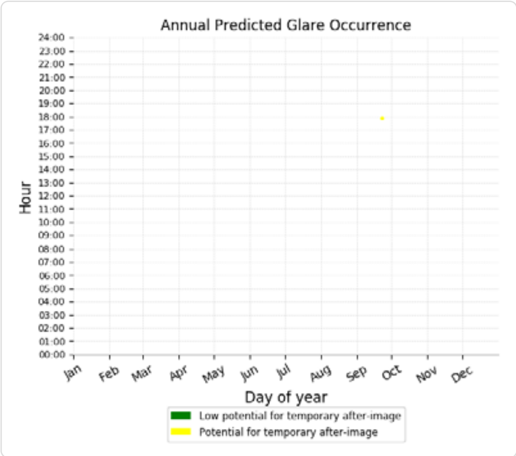
PV array 1 potential temporary after-image

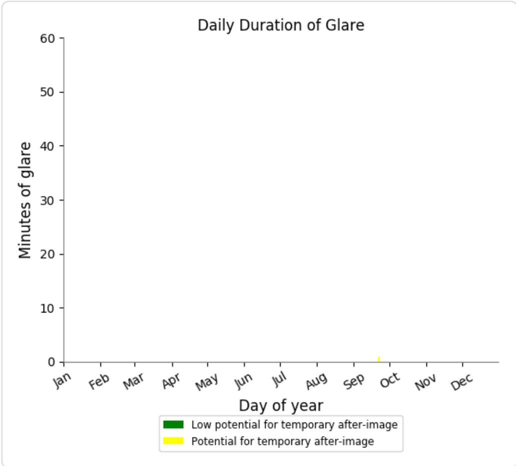
Component	Green glare (min)	Yellow glare (min)
Route: Route 1	0	1
Route: Route 2	0	211
Route: Route 3	0	2
Route: Route 4	0	0
Route: Route 5	0	0

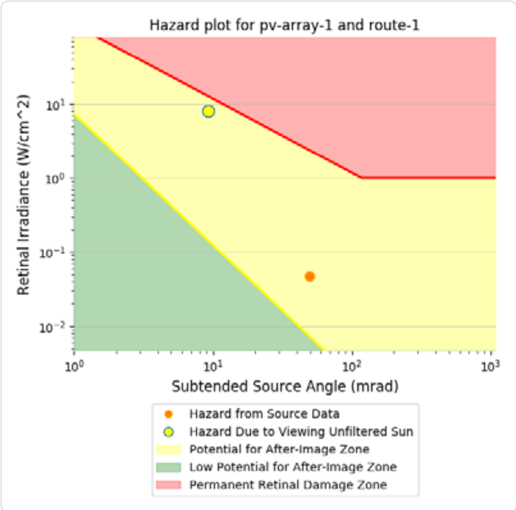
PV array 1 - Route Receptor (Route 1)

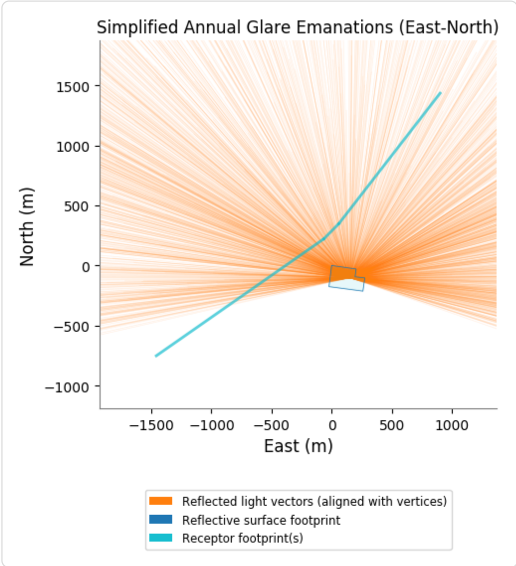
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1 minutes of "yellow" glare with potential to cause temporary after-image.







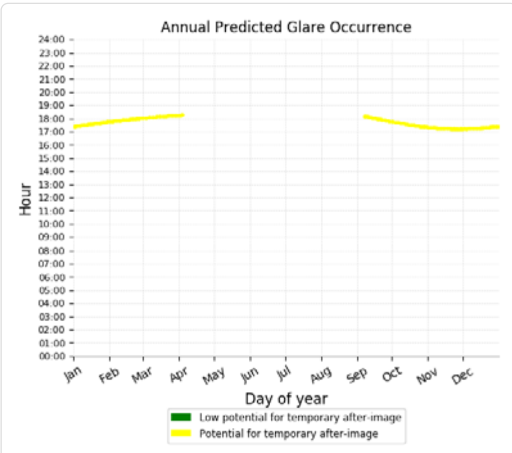


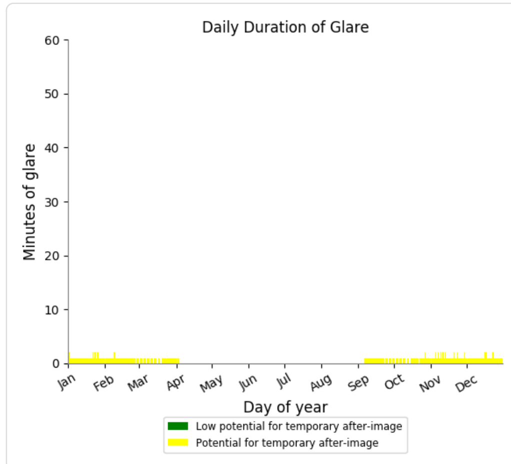
re vectors placed at PV centroid for clarity. Actual glare-spot locations vary.

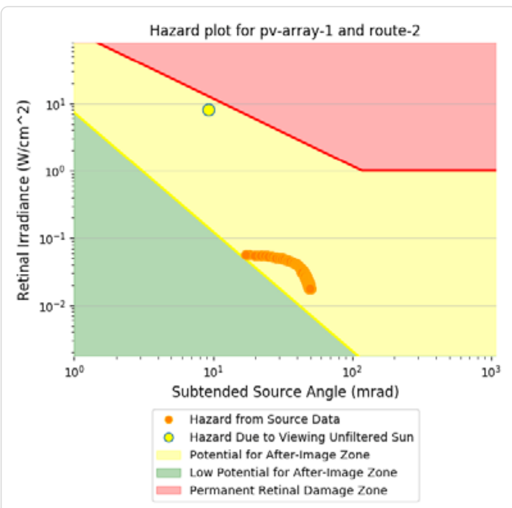
PV array 1 - Route Receptor (Route 2)

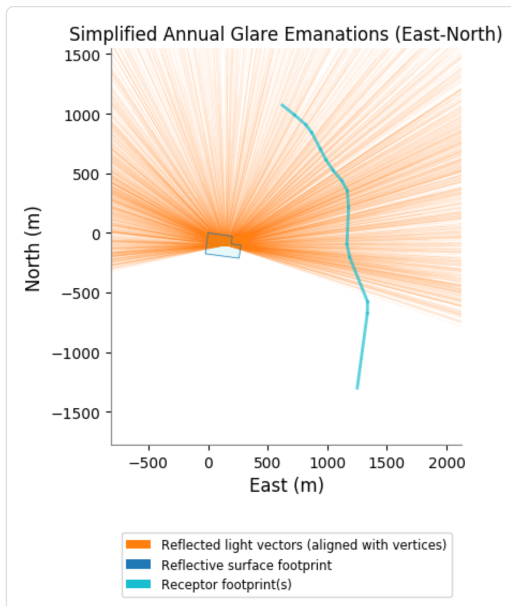
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 211 minutes of "yellow" glare with potential to cause temporary after-image.







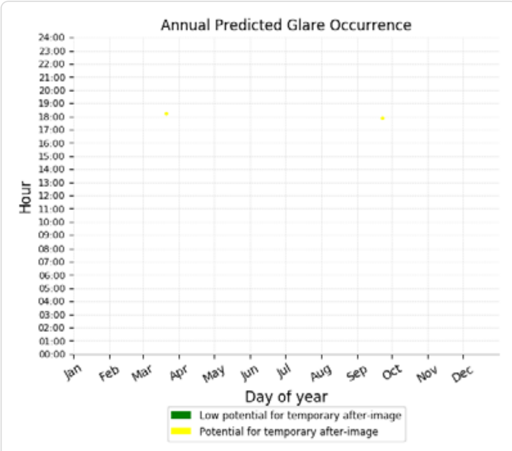


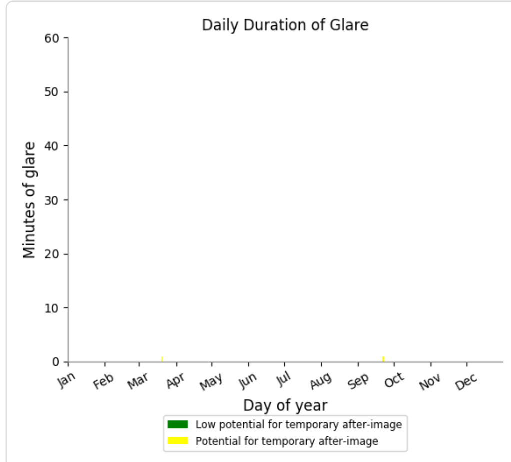
re vectors placed at PV centroid for clarity. Actual glare-spot locations vary.

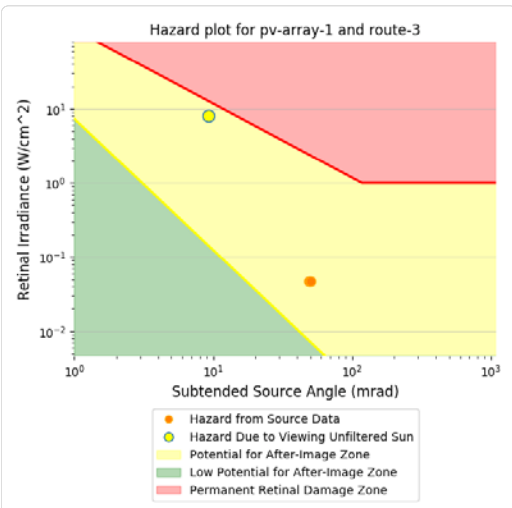
PV array 1 - Route Receptor (Route 3)

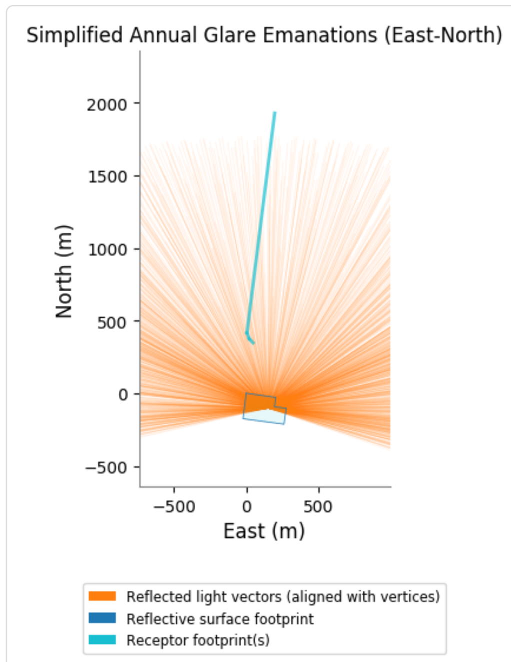
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2 minutes of "yellow" glare with potential to cause temporary after-image.









re vectors placed at PV centroid for clarity. Actual glare-spot locations vary.

PV array 1 - Route Receptor (Route 4)

No glare found

PV array 1 - Route Receptor (Route 5)

No glare found

Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- 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.
- Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- 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.)
- 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.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Glare analysis methods used: OP V1, FP V1, Route V1
- Refer to the **Help page** for assumptions and limitations not listed here.

APPENDIX D:

SOLAR GLARE HAZARD ANALYSIS – AIRPORT

GlareGauge Glare Analysis Results

Site Configuration: Nhill Airport

Project site configuration details and results.

Created **May 7, 2020 2:19 a.m.**
Updated **May 7, 2020 2:19 a.m.**
DNI **varies** and peaks at **2,000.0 W/m^2**
Analyze every **1** minute(s)
0.5 ocular transmission coefficient
0.002 m pupil diameter
0.017 m eye focal length
9.3 mrad sun subtended angle
Timezone **UTC10**
Site Configuration ID: 38921.7047

Summary of Results No glare predicted!

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	30.0	8.2	0	0	-

Component Data

PV Array(s)

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 30.0 deg
Orientation: 8.2 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-36.352370	141.634019	135.02	2.50	137.52
2	-36.352629	141.636282	133.14	2.50	135.64
3	-36.353212	141.636186	132.93	2.50	135.43
4	-36.353298	141.637087	132.68	2.50	135.18
5	-36.354288	141.636915	132.06	2.50	134.56
6	-36.353951	141.633767	135.09	2.50	137.59

2-Mile Flight Path Receptor(s)

Name: FP 1
Description:
Threshold height : 15 m
Direction: 107.0 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	-36.309786	141.641553	128.55	15.24	143.79
2-mile point	-36.301348	141.607196	130.63	181.85	312.47

Name: FP 2
Description:
Threshold height : 15 m
Direction: 281.1 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	-36.311730	141.652407	137.99	15.24	153.23
2-mile point	-36.317297	141.687657	158.80	163.12	321.92

Name: FP 3
Description:
Threshold height : 15 m
Direction: 5.9 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	-36.316901	141.642250	130.81	15.24	146.05
2-mile point	-36.345658	141.638526	134.75	179.99	314.73

Name: FP 4
Description:
Threshold height : 15 m
Direction: 186.6 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	-36.307006	141.643801	133.19	15.24	148.43
2-mile point	-36.278286	141.647948	136.84	180.27	317.12

PV Array Results

Summary of PV Glare Analysis PV configuration and predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	30.0	8.2	0	0	-	-

Click the name of the PV array to scroll to its results

PV & Receptor Analysis Results detailed results for each PV array and receptor

PV array 1 no glare found

Component	Green glare (min)	Yellow glare (min)
FP: FP 1	0	0
FP: FP 2	0	0
FP: FP 3	0	0
FP: FP 4	0	0

No glare found

Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- 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.
- Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- 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.)
- 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.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Glare analysis methods used: OP V1, FP V1, Route V1
- Refer to the **Help page** for assumptions and limitations not listed here.