SELWYN DISTRICT COUNCIL

Solar Glare Report Review
For Proposed Brookside Solar Farm

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CONTENTS

1 INTRODUCTION

1.1 Overview

At request of Selwyn District Council, the following report is based on a review of a Glare and Glint Study carried out by Pager Power on the proposed Solar Farm located at Brookside in the Selwyn District.

Figure 1. Brookside Solar Farm outlined in red

1.2 Scope/Brief

Brief: To review report provided by Pager Power on the Solar Farm at Brookside and assess the accuracy of findings in terms of impact of the potential glare and glint on surrounding dwellings as well as road users.

Scope: To review the Pager Power Solar Glare Study report provided to Selwyn District Council with the following considerations;

This review assessment is based on the Figures 3 and 4 shown below.

1. Assessment of the accuracy of the Pager Power Report (PPR) through independent assessment of;
   - Impact, if any, on Christchurch airport and air traffic.
   - A sample of the dwellings considered in the report. (The Pager Power report considers up to 40 dwellings. This review will consider a sample of up to 10 dwellings to compare against the results of their report.)
   - Assessment of glare impacts on adjacent roads as indicated in the Figure 4 with regard to any potential safety implications.
   - Review of the report discussed mitigation measures (e.g vegetation shielding) for the sample of 10 dwellings in terms of the accuracy of the report assessment.
2. Provision of any additional recommendations based on the outcomes of the analysis as well as mitigation measures.
3. Report on above findings.

1.3 PV Array Information Considered

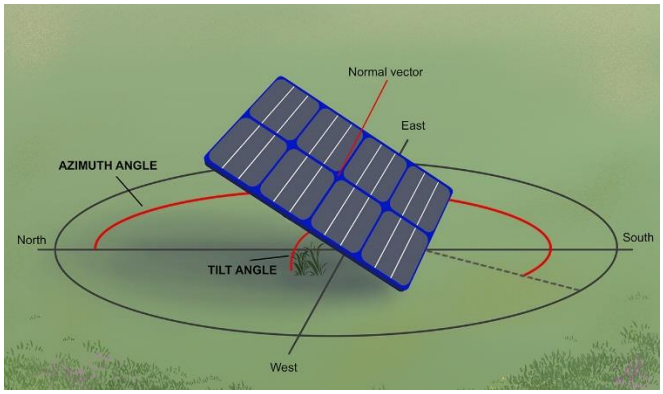
The Pager Power Report is based on the following Solar Panel information which is derived from their report.

Panel Information	
Azimuth angle	0° (north-facing)
Elevation angle	30°
Assessed centre height	1.86m agl (above ground level)[6]

This analysis considers the same PV panel parameters as used by Pager Power.

That is Azimuth angle (panel orientation north facing 0°) and the Elevation angle (tilt 30°) with assessed centre of array height of 1.86m above ground level.

Orientation and tilt as considered in the simulations used in this report is defined as per diagram below.



Other PV panel parameter considerations are that these are expected to have anti-reflective coating. The modelling used in this review report assumes this is the case.

The author agrees with Pager Power assessment in terms of consideration around dwelling eye height and that for modelling purposes and allowance for tolerances, changes to eye level heights by a meter or so is not expected to change the modelling results.

Figure 2. Pager Power Assessment Area (in orange) of the PV array area (in blue) and Dwellings considered numbered 1-47.

Figure 3. Development Stages A (PV1), B (PV2) and C (PV3) for Brookside Solar Farm and sample of Dwellings locations 1 to 10 used in this assessment.

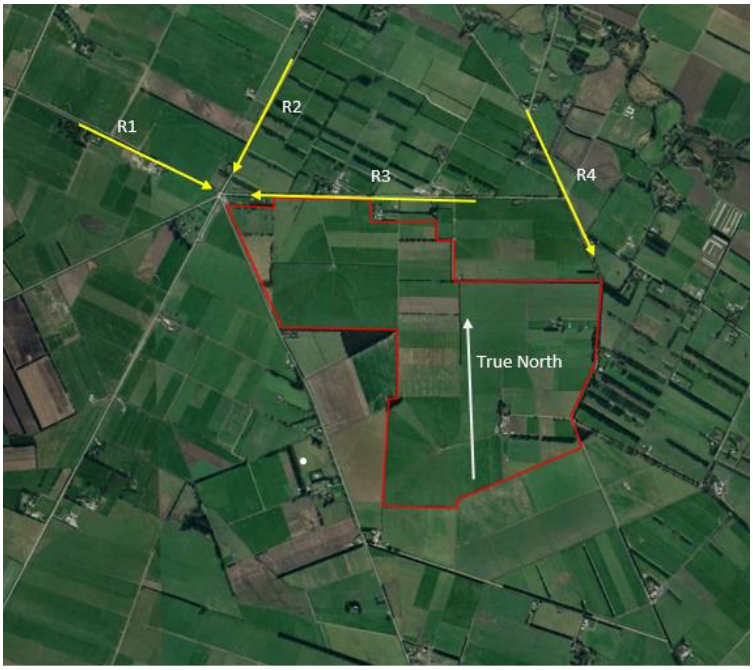


Figure 4. Road Impact Assessment Sample

The assessment of potential glare on road traffic is taken for the roads indicated R1, R2, R3 and R4. The intersection of roads for R1, R2 and R3 was an important consideration given potential safety risk at this junction with regard to glare when turning onto it and approaching traffic.

1.4 Glint and Glare Impact Significance

A definition of significance from the PagerPower study is covered in the table below and also detailed in Appendix E of this report and states this as the representing the 'recommended definition of impact significance' and is elaborated further here.

The definition considered here is to assist with understanding of the extent of any impact and what it means for the general public.

Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not required e.g. intervening screening will limit the view of the reflecting solar panels.	No mitigation required.
Moderate	A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case.	Whilst the impact may be acceptable, consultation and/or further analysis should be undertaken to determine the requirement for mitigation.
Major	A solar reflection is geometrically possible and visible under conditions that will produce a significant impact. Mitigation and consultation is recommended.	Mitigation will be required if the proposed solar development is to proceed.

Table 1.4 Impact Significance Definition

In terms of the above table from Pager Power, the definition around 'Low' impact should consider the following.

This assume intervening screening is present which while likely in most cases due to existing vegetation on and around the periphery of the site, is still not presentative of intervening screening existing around all parts of the site.

The proposed plantings are expected to provide this once they have matured in which case the Low and No impact will apply to all dwellings and road users.

Until such time that this happens, temporary screening may be required to provide mitigation and any such instances would be considered Moderate at most.

As suggested in the table, and also in the report, consultation may be required on a case-by-case basis where dwelling residents perceive any issue.

It is expected however, that mitigation of any such issues would be simple with temporary vegetation or other form of screening, until the overall planned landscaping provides sufficient screening to eliminate impacts or render them 'Low' according to the above definition.

2 EXECUTIVE SUMMARY

This report comprises a review undertaken by Velden Aviation Consulting Limited (VACL) of the Pager Power Study for glare and glint impact from the Brookside Solar Farm.

The review was to determine the accuracy of the Pager Power study by carrying out an independent assessment and then correlating the results.

The Pager Power study consisted of assessment of the impact on Christchurch international airport and associated aviation, permanent residents and their dwelling locations surrounding the Brookside Solar Farm, and potential impacts to road users.

The Pager Power study assessed there would be no impact to Christchurch Airport and associated aviation.

Also, that Low impact (as defined in previous section table 1.4) to adjacent dwellings is expected to be temporary based on screening from existing vegetation that should obstruct the majority of glare received form the reflecting panels.

It is expected that the long-term effects, once vegetation is established around the site, should eliminate any remaining glare impacts on surrounding dwellings and road users.

Pager Power did not carry out any assessment on Local roads nearby which were considered to have little traffic density so deemed to have low impact on users of these roads.

Results determined from VACL independent assessment, as detailed in this report, compared very well with the Pager Power study results and overall would therefore agree with the conclusions reached by Pager Power for High Level Aviation and Dwellings.

VACL however did not agree with Pager Power conclusion for Roads as it considers risks imposed by solar glare on road safety to be applicable irrespective of the number of road users.

As such an assessment was carried out on any potential impact to road users which determined that some mitigation measures would be necessary, but that these could be resolved through the proposed vegetation plantings.

While it is difficult to completely review every scenario where glare impact may be experienced, the report offers that this could be best handled on a case-by-case basis for residents that may be affected given the number involved may be small.

An approach is proposed that may assist Selwyn District Council to resolve such circumstances where residents express concerns. It is suggested also that the responsibility for addressing the temporary resolution for such concerns through use of temporary screening be on the Brookside Solar Farm owners as part of their Resource Consent approval.

3 BACKGROUND DATA

3.1 Arrays Proposed

The PV layout being considered as in the Pager Power report and the Boffa Miskell site plan indicates the Brookside solar farm will be implemented in three stages, A, B and C.

For the purposes of the assessment each of the stages is taken as one PV array. That is;

- Stage A area is designated PV Array 1
- Stage B area is designated PV array 2
- Stage C area is designated PV array 3

Stage Development Component Data

Stage A (PV1) PV Array Layout as per Pager Power study, Reference section 2.1

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 30.0°
Orientation: 0.0°
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	-43.701237	172.277066	38.00	1.86	39.86
2	-43.701454	172.280671	37.00	1.86	38.86
3	-43.704587	172.280499	36.00	1.86	37.86
4	-43.704897	172.285177	35.00	1.86	36.86
5	-43.708496	172.284834	34.00	1.86	35.86
6	-43.708310	172.280800	35.00	1.86	36.86

Stage B (PV2) PV Array Layout

Name: PV array 2
Axis tracking: Fixed (no rotation)
Tilt: 30.0°
Orientation: 0.0°
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	-43.700957	172.280972	37.00	1.86	38.86
2	-43.704432	172.280714	36.00	1.86	37.86
3	-43.704711	172.285606	35.00	1.86	36.86
4	-43.708558	172.285134	34.00	1.86	35.86
5	-43.708713	172.289683	33.00	1.86	34.86
6	-43.712281	172.289426	32.00	1.86	33.86
7	-43.712467	172.294104	32.00	1.86	33.86
8	-43.706169	172.294619	33.00	1.86	34.86
9	-43.706076	172.293803	33.00	1.86	34.86
10	-43.703812	172.294018	33.00	1.86	34.86
11	-43.703812	172.292902	33.00	1.86	34.86
12	-43.703036	172.292988	33.00	1.86	34.86
13	-43.702788	172.288181	34.00	1.86	35.86
14	-43.701361	172.288181	35.00	1.86	36.86

Stage C (PV3) PV Array Area Layout

Name: PV array 3
Axis tracking: Fixed (no rotation)
Tilt: 30.0°
Orientation: 0.0°
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	-43.706169	172.294876	32.15	1.86	34.01
2	-43.712808	172.294318	32.00	1.86	33.86
3	-43.712498	172.288739	32.00	1.86	33.86
4	-43.718143	172.288053	32.00	1.86	33.86
5	-43.718422	172.293331	31.00	1.86	32.86
6	-43.717926	172.293374	31.00	1.86	32.86
7	-43.715445	172.302773	30.00	1.86	31.86
8	-43.713956	172.302129	30.00	1.00	31.00
9	-43.711164	172.304232	30.00	1.86	31.86
10	-43.706604	172.305090	31.00	1.86	32.86

3.2 Solar Glare Impact Analysis

Solar Glare Impact

Although most PV solar panels have anti-glare coatings to minimise glare as much as possible there is always some residual glare present that has potential to create a hazard particularly in airport environments.

General Consideration

Solar glare hazard analysis (SGHA) is based on potential to cause damage to any observer's eyes.

The chart in the figure below applies a colour code of green, yellow or red depending on the hazard potential. Any PV arrays causing issues to designated observation points.

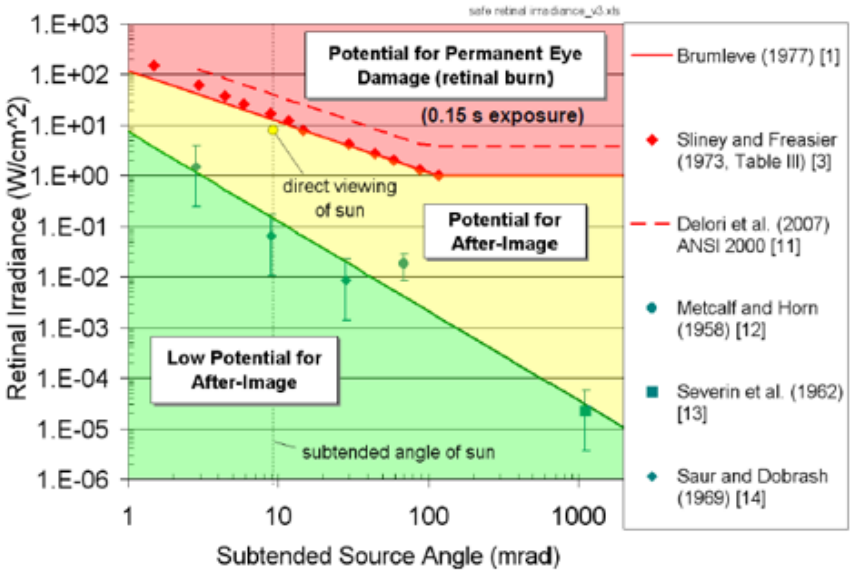


Figure 5.1: Potential ocular impact

"**Green zone**" glare is considered to have low potential to cause after –image (flash blindness) when observed prior to a typical blink response.

"**Yellow zone**" glare is considered to have potential to cause after image (flash blindness) when observed prior to a typical blink response time.

"**Red Zone**" glare is considered to have high potential to cause permanent eye damage.

Although any PV arrays that create issues that fall in the green zone have low potential for after-image, and less chance of ocular damage over time, This is seen as less of a problem for dynamic or moving receptors such as vechicles or aircraft.

Use of SGHA comes with the following assumptions applied;

1 Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.

2 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.

3 The subtended source angle (glare spot size) is constrained by the PV array footprint size.

4 Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.

5 Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.

6 The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence may differ.

7 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.

It should be added that solar glare is experienced every day, however static occupational observation points such as dwellings does not necessarily mean that solar glare impacts the predominant direction the observer is looking.

Most dwellings have blinds as well as tinted windows that limit glare. This should not be seen as a precursor for mitigating 'Green Glare' however.

These are considerations that can be taken into account when deciding overall impact of solar glare from proposed PV arrays

4 SOLAR GLARE ANALYSIS RESULTS

4.1 Impact on Airport and Aviation

There is strong agreement with Pager Power with regard to insignificant or no impact to the Christchurch airport and associated aviation. This is primarily due to the distance involved which is more than 30km away and likely to be shielded by the many tree belts, random vegetation as well as buildings and any terrain obstacles between Brookside Solar Farm and the Airport over that distance.

The important phase for landing aircraft occurs within 2 NM from the runway which is still well away from the Brookside Solar Farm.

4.2 Impact on Dwellings

The below table summarises the Pager Power Study results for the sample properties listed.

As noted earlier, a sample of only 10 properties were considered for the independent review and analysis to determine correlation of these results with those of the Pager Power Assessment.

Dwelling Observation Point (OP) Number	**Pager Power Dwelling Number**	**Pager Power Reflection possible towards Receptor**		**Pager Power Comments Modelling Results (Bare earth Terrain, no screening considered)**
		am	pm	
1	1	Yes	No	Solar reflections predicted for **less** than 60 minutes per day and for **less** than 3 months of the year
2	4	Yes	No	Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year
3	8	Yes	No	Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
4	9	Yes	No	Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
5	11	Yes	No	Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
6	22	No	Yes	Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.

7	23	No	Yes	Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
8	33	No	Yes	Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
9	40	No	Yes	Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.
10	42	No	Yes	Solar reflections predicted for **less** than 60 minutes per day and for **more** than 3 months of the year.

Table 1. Pager Power Geometric Calculation Results for Dwelling Receptors.

Velden Aviation Consulting Summary of Glare-Glint Analysis on Sample Properties

The table below summarise the results for this review independent analysis for the sample properties listed based on results shown in Appendix A.

As per the Pager Power study, the modelling used in this report is also based on no existing vegetation or obstructions providing any screening. Any areas that may show up as producing some glare from the modelling may therefore produce none in practice due to existing screening and likely to be completely eliminated once prosed landscaping is established.

It however provides an analysis for each of the three stages considered for the development of Brookside Solar Farm to determine how each stage may contribute to potential glare.

The collective result of all three stages however are considered in relation to how well it correlates with the Pager Power Assessment.

Observation Points (Dwelling #)	**PV1 (Stage 1 Development)**		**PV2 (Stage 2 Development)**		**PV3 (Stage 3 Development)**		**Comments of sample Dwellings**
	am	**pm**	**am**	**pm**	**am**	**pm**	
1 (1)	No	No	No	No	Yes	No	**PV1**. No glare **PV2**. No glare **PV3.** Glare duration <14mins around 7am from Feb to April and Sept to Nov.
2 (4)	No	No	No	No	Yes	No	**PV1**. No glare **PV 2** no glare **PV 3**. Negligible Glare <3min around 7 am from mid Sept to end March.

3 (8)	Yes	No	Yes	No	Yes	No	**PV1**. Duration <10mins from around 7am from Mid Sep to end March. **PV2**. Duration <10min from mid Sept to end March **PV 3**. Green and Yellow glare Duration <10 min from around 7 am from Oct to March
4 (9)	Yes	No	Yes	No	Yes	No	**PV1.** Negligible glare <3 mins **PV2**. Duration <10mins around 7 am From Oct to March **PV3.** Green and Yellow glare Duration < 10mins around 7 am from Late October to mid-Feb
5 (11)	No	No	No	No	Yes	No	**PV1**. No glare **PV2**. Negligible PV3 Glare Green only<10mins Around 7 am from Nov to Feb
6 (22)	No	Yes	No	Yes	No	No	**PV1.** Duration <10 mins from around 6 pm from Oct to mid-March. **PV2**. Duration <15 mins from around 6pm from Oct to mid-March **PV3.** no glare
7 (23)	No	Yes	No	Yes	No	No	**PV1.** Negligible < 3 mins **PV2**. Duration <10mins around 6 pm from Oct to mid-March **PV3**. No glare
8 (33)	No	Yes	No	Yes	No	Yes	**PV1**. Negligible glare <11 min **PV2.** Negligible glare <3 mins between 6 -7 pm form Oct - Mar. **PV3**. Duration <6 mins, around 6 pm. From mid-October to mid-Feb
9 (40)	No	No	No	No	No	Yes	**PV1**. No glare **PV2**. No glare **PV3.** Negligible glare <2 mins
10 (42)	No	No	No	Yes	No	Yes	**PV1.** No glare **PV2.** Negligible **PV3.** Glare duration <15 mins around 6:30 pm from end Sept to mid-March.

Table 2. Velden Aviation Consulting Simulation Results – Dwelling Receptors

Correlation of Results of Impact on Dwellings

The below table shows results from both the Pager Power assessment, and this reports independent assessment from Velden Aviation Consulting Limited (VACL).

Dwelling Receptor Observation Point OP. (Pager Power Dwelling number)	Pager Power Reflection possible towards Receptor		VACL Report Review Findings Reflection possible towards Receptor		Comments
	am	pm	am	pm	
1 (1)	Yes	No	Yes	No	Agree with duration of less than 60mins. (Review give <15 mins per day.) Agree with less than 3 months
2 (4)	Yes	No	Yes	No	Agree with duration less than 60 mins. (Review gives <3 mins and negligible glare.) Agree with more than 3 months
3 (8)	Yes	No	Yes	No	Agree with duration less than 60 mins Agree with more than 3 months
4 (9)	Yes	No	Yes	No	Agree with duration less than 60 mins Agree with more than 3 months
5 (11)	Yes	No	Yes	No	Agree with duration less than 60 mins Agree with more than 3 months
6 (22)	No	Yes	No	Yes	Agree with duration less than 60 mins Agree with more than 3 months
7 (23)	No	Yes	No	yes	Agree with duration less than 60 mins Agree with more than 3 months
8 (33)	No	Yes	no	yes	Agree with duration less than 60 mins Agree with more than 3 months
9 (40)	No	Yes	No	yes	Agree with duration less than 60 mins Agree with more than 3 months
10 (42)	No	Yes	No	Yes	Agree with duration less than 60 mins Agree with more than 3 months

Table 3. Comparison of results from Pager Power and this independent review**.**

Dwelling Review General Comments

Overall, there is generally good agreement with the Pager Power Report results and analysis undertaken with regard to glare assessment for the dwellings considered and that of this independent review. This is shown by comparing the results of Pager Power and this review as shown in Appendix B.

Pager Power conservatively estimates less than 60mins of glare for the sample of dwellings considered whereas results of this assessment indicate that for the sample considered, the expected glare should be less than 15 mins in most cases. This is based on Pager Power modelling that which excludes any existing vegetation or obstructions.

From Pager Power study, they also set a threshold of three months and whether the glare duration is more or less than this.

Pager power uses both the 60 minutes and 3 months as thresholds.

In page 35 of their report, they state that where the glare impact is less than 60 minutes and less than 3 months the impact will be Low and no mitigation is required.

Where the glare impact is for less than 60 minutes but for more than 3 months, the impact significance is 'Moderate' based on their definition (refer table 1.4) and any mitigation needs to be considered on a case-by-case basis.

Where the glare impact is determined to be for more than 60 minutes and more than 3 months, the impact is considered to be high and mitigation is deemed necessary to screen any glare.

Overall, they have determined however that the existing screening plus the proposed vegetation or landscaping will provide the mitigation necessary to significantly obstruct the views form the dwellings to the reflecting panels.

On this basis they have stated that the observers located at all the potentially impacted dwellings will not experience and solar reflections in practice.

Based on the sample of dwellings considered in the review there is good agreement with the Pager Power report.

However, the Pager Power report leaves open the need to address any potential dwellings that are not completely screened by existing vegetation. Also, the need to address any of these in the interim before the proposed vegetation or landscaping is completely mature and eliminates the remaining issues of glare.

Proposals or options considered further in this report suggest interim or temporary measures to mitigate such impacts until the proposed landscaping is established to a height that ensures no impact to all affected dwellings.

4.3 Impact on Road Traffic

Pager Power study contends that there is little impact to road users given the designation of adjacent roads as 'Local' and expected minimal traffic and hence have not carried out any study in relation glare impact on road users near the Brookside Solar Farm.

The reviewer believes that the glare analysis needs to be performed on some adjacent roads due to potential impact of any risks associated with excessive glare on road users and hence potential safety implications. Whether there is heavy traffic or light, the safety risks are expected to be the same to each road user irrespective of amount of traffic.

That is, the same level of safety should be accorded to the few road users just as it should be if there are many vehicles on the road.

As such, this review considered an assessment on 4 roads as indicated to determine what risks may be for vehicles approaching major intersections.

Appendix C provides results of the modelling analysis carried out of which the table below provides a summary. Modelling is based on road traffic travelling in either direction.

	Stage A Array (PV1). Glare		**Stage B Array (PV2). Glare**		**Stage C Array (PV3) Glare**		**Comments**
	am	pm	am	pm	am	pm	
R1	Yes	No	Yes	No	Yes	No	Some glare conditions in the morning only. Mitigation recommended.
R2	No	No	No	No	No	No	No significant glare conditions expected for road traffic along R2
R3	Yes	Yes	Yes	Yes	Yes	No	Significant glare conditions expected for road traffic. Mitigation recommended.
R4	No	No	No	No	No	No	No significant glare conditions expected for road traffic along R4

With regard to R1 (Dunsandel and Brookside Road) and R3 (Buckleys road) the above results indicate that glare conditions could be expected if there was insufficient obstructions such vegetation along the roadside to shield glare effects from the PV arrays.

These two roads connect at a major intersection hence there are possible safety concerns to traffic if impacted by excessive solar glare near this intersection.

As indicated previously, the modelling used in this report, as with the modelling used by PagerPower, does not include any existing vegetation or obstructions.

It is expected that the actual glare experienced should be significantly less due to the lines of trees, hedge rows and clusters of bushes and other vegetation that already exist along the sides of these roads.

It should be noted that the extent of this glare in practice is not readily quantifiable due to the overwhelming amount of detail required to capture every bit of vegetation that already exists that contributes to the potential mitigation or screening of the reflecting panels.

Where the above table indicates potentially significant glare conditions (deemed Moderate based on the Pager Power definition), these would be temporary until the proposed landscaping is sufficiently developed. Once the proposed landscaping is matured to a height of at least 2meters, the longterm effect should be full mitigation of any glare impact.

The following section on mitigation measures considers how the extent of any proposed landscaping or vegetation may significantly overcome such glare conditions.

5. MITIGATION CONSIDERATIONS

The PV panels are assumed to have a centre height of around 1.86 m on which reflections are based. Pager Power study has assumed a typical eye level of 1.8m on the ground floor for dwelling residents.

As noted previously, the modelling used in each case by Pager Power and VACL is based on a clear terrain with no vegetation or obstruction to the solar panels.

There are many shelterbelts, hedgerows and clusters or lines of trees that serve as obstructions to the Brookside Solar farm and will already provide a large degree of mitigation or obstruction screening to any potential glare.

VACL is largely in agreement of the findings from Pager Power given the very good correlation of the comparison of the results.

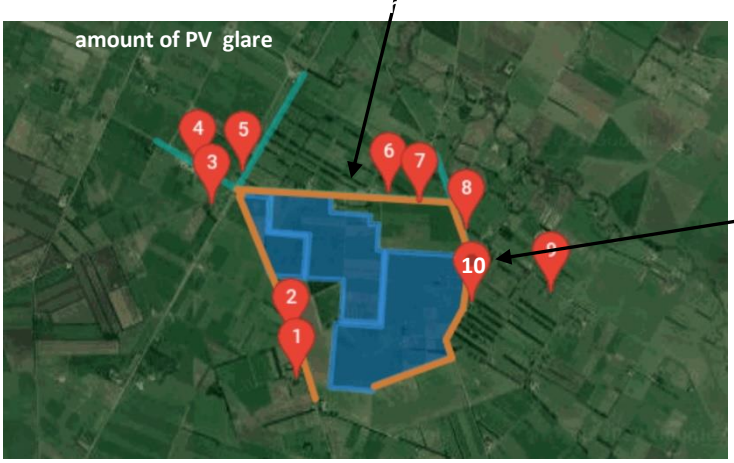
However, given the extent of any mitigation from existing vegetation and tree belts etc is unknown without undue and excessive modelling, VACL has considered an obstruction assessment that may simulate the landscape plantings being proposed around the area to determine the extent of screening (mitigation) that these will provide to road suers and dwelling residents.

An obstruction height of 2m (i.e. hedgerow or vegetation height) is considered. This is shown as an orange line around Brookside Solar farm area as shown in the figure below.

Figure 5.1 2m high virtual hedge row 'Obstruction' model surrounding Brookside Solar Farm

Relative positions of visual references. The Boffa Miskell Visual Simulation Report Viewpoints are considered here.

The Boffa Miskell Visual simulation viewpoint 3 proposes planting along this road.



The Boffa Miskell Visual simulation Viewpoint 4 proposes planting along this road.

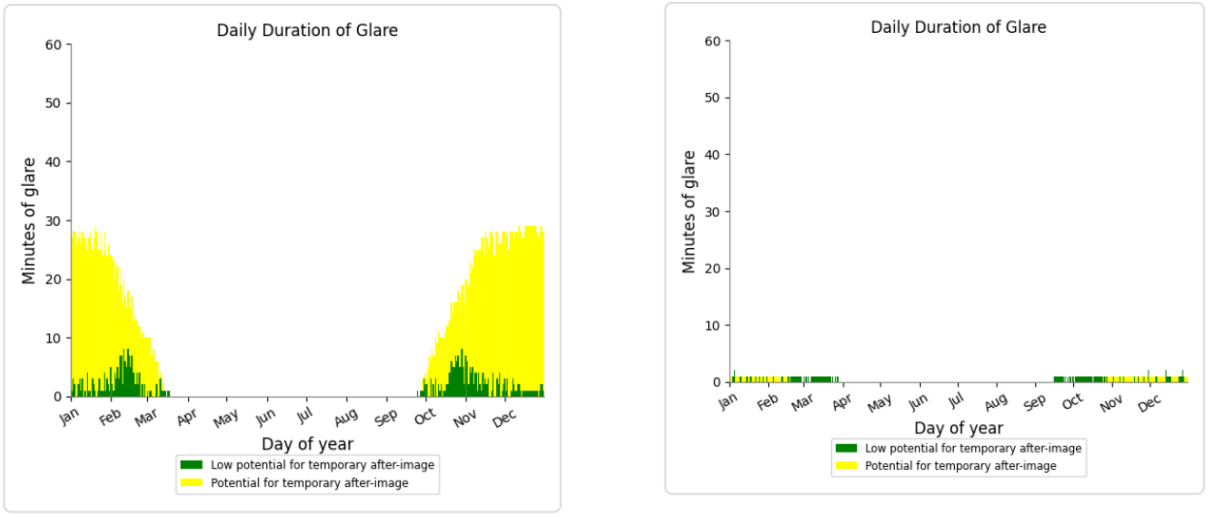
The Boffa Miskell Visual simulation Viewpoint 2 proposes planting along this road.

The above visual references illustrate areas where vegetation may be scarce and possibly need additional planting. This has however been taken into consideration by the Boffa Miskell planned vegetation plantings as detailed in their Visual Simulation report.

Simulations of the 2m obstruction surrounding the Brookside Solar farm indicate that the Boffa Miskell planned plantings as per their Visual Simulations should be effective in significantly reducing any remaining glare.

The majority of any potential glare is expected to already be obstructed by the existing vegetation and trees etc in the Brookside area.

The below example shows the difference of impact on glare mitigation in having 2m high vegetation on the side of the road and not having it.



(a) (b)

Figure 5.2. Impact of glare on Buckleys Road (R3) from Stage A PV development with no 2m high plantings (a) and with 2m high plantings (b)

6. TEMPORARY EFFECTS OF SOLAR GLARE PRIOR TO LANDSCAPING

The Pager Power study, which is supported by this review, indicates that the existing plantings and vegetation within and around the Brookside Solar Farm boundaries will effectively already create significant mitigation of potential solar glare.

The proposed plantings as modelled based on a 2m height of such plantings, should significantly reduce if not eliminate any remaining glare.

It is difficult to assess the full extent of how much the existing vegetation will eliminate any potential glare due to the overwhelming amount of vegetation that would need to be taken into account and modelled relative to how much it screens any glare affects from the panel to each of the dwellings.

As such, the temporary effects or impact of solar glare before the proposed landscaping is established would be difficult to quantify.

A means by which temporary mitigation may be accomplished however is to see what glare issues may arise from each of the residents based on any concerns they may come back to the Selwyn District Council with.

Residents should also be requested to provide evidence of this.

Mitigation measures could then be considered on a case-by-case basis as it could be expected that not all residents may feel the same way about any impact. E.g. some may determine it to be insignificant, some may just draw their blinds for the short duration of glare and others may choose to complain about it.

Given there are only 40 dwellings or residents that may be impacted, based on the Pager Power study, this may not be too onerous.

If such an approach is considered worthwhile by Selwyn District Council, then an arrangement could be made with the Brookside Solar Farm owners that they would need to be responsible for providing temporary mitigation measures as part of any Resource Consent agreement.

Temporary measures could be considered by erecting temporary structures or plantings of at least 2m high along the sector where glare is experienced.

The situation below as considered from the Pager Power study offers an example of how temporary mitigation may be implemented once a resident has raised concerns.

Possible process of follow up for temporary mitigation once resident has raised concerns.

Addition of temporary planting or screening on the property belonging to Brookside Solar Farm to cover only the sector to obstruct glare from an angle that the resident has raised concerns about. Any such screening should be the responsibility of the Brookside Solar Farm owners.

7. SUMMARY OF RESULTS FOR BROOKSIDE SOLAR FARM

The following summarises this independent of assessment and review of the Pager Power Brookside Solar Farm Study.

It should be noted that Pager Power have considered the whole of the Brookside Solar Farm as one complete area in their analysis. This review considers three areas based on each of the stages A, B and C of the development of the Brookside Solar Farm.

The overall result would be the same however between the separate approaches in terms of determination of glare impact.

Brookside Solar Farm impacts on Aviation

This independent assessment concurs with the Pager Power study on the impact to Christchurch airport and aviation environment.
That is, that the PV arrays planned for installation at Brookside Solar Farm are not expected to create any significant impact to the Christchurch airport operations which is located 32 km away.

Brookside Solar Farm impacts on nearby Dwellings

Pager Power study notes that 'where effects are predicted to be experienced for more than 3 months per year and more than 60 minutes per day, the impact significance is high, and mitigation is required.'

For the dwellings considered by Pager Power, none of them are expected to experience glare for more than 60mins of any day.

This independent assessment as determined from this study concurs with the Pager Power result based on the sample of dwellings considered that these should experience any solar reflections less than 60 mins per day.

This independent assessment showed that the predicted duration of glare for the dwelling considered was at most 15 mins per day for the sample considered and based on the modelling it used.

Pager Power also uses 3 months per year as a standard threshold for consideration of period that glare can be experienced without stating which months of the year and summarises glare as being either more or less than this period.

Where glare is less than 3 months and less than 60 minutes per day it is seen as having Low impact with no further mitigation being required.

Where they have indicated dwellings having less than 60 minutes per day but more than 3 months of the year Pager Power have deemed this to be of Moderate impact requiring further assessment on a case by case basis.

The long-term impact will be Low to no impact at all once the proposed landscape planting is established which should screen any potential glare.

The short-term impact prior to the proposed plantings being established and based on existing vegetation are expected to be Low to Moderate. This essentially means that any impact may need to be considered on a case-by-case basis depending on concerns raised by any of the dwelling residents.

Overall, based on the random sample of 10 dwellings that were considered for this review, this independent assessment concurs with the Pager Power study based on comparison of results for the sample of dwellings considered.

Brookside Solar Farm impact on adjacent Road Traffic.

The Pager Power Study considers adjacent roads to be Local with low traffic density and hence low impact with no mitigation necessary.

This consideration appears mainly due to the expected low traffic density for local roads and hence low probability of any impact or issue.

VACL believes consideration should be around risk associated with safety rather than probability associated with traffic density. That is, risk factors remain the same whether there are high numbers of traffic or just a few.

Overall, results based on the obstruction modelling used, indicate that there may be a high level of glare if there was no existing vegetation.

In practice however, any existing vegetation already at heights of 2m or more along portions of the road will reduce the impact of any potential solar glare where it screens the reflection from PV panels.

In the long term, once the proposed plantings reach a height of at least 2m, they should substantially eliminate any remaining glare not already screened by existing vegetation on the Brookside proposed solar farm site.

8. SUMMARY AND RECOMMENDATIONS

The analysis and simulations performed are based on information and data received from Selwyn District Council and based on the Pager Power Study report as well as drawings that were provided.

Given the importance to understanding of the assessments on solar impact modelling, it needs to be reiterated that the modelling used as noted in both the Pager Power study and this review of it does not take into account any obstructions or vegetation that currently exist.
The modelling only predicts solar glare from PV panels at any location in the world for any time of day throughout the year based on angles relative to the sun, the PV panel and the point of the observer. It does not take into account consideration of the extent of any local obstructions or vegetation which may provide screening between the observer and the PV panels causing solar reflections.

It should be noted that potential solar glare reflections from the PV panels are likely to be be less than that from bodies of water such as ponds or lakes etc.

Although there were some differences for a couple of the dwellings based on the sample of ten dwellings considered, the given duration of glare or glint for these was predicted to be around 15 minutes at most per day and the glare was also expected to be negligible.

As such, it is expected that this should have minimal impact on residents even over the temporary period before plantings are established to a 2m height.

With regard to any temporary impacts that any of the dwelling residents adjacent to the Solar farm may experience, it is uncertain to what extent there may be any glare seepage though existing vegetation and whether this is an issue or not.

As per section 8 considerations however, it is recommended to Selwyn District Council that this may only be able to be sorted on a case-by-case basis until the plantings proposed have reached at least 2m.

Overall, this review of the Pager Power Report concurs with their findings given the good correlation between the model they have used and the one used for this report.

VACL considers that a primary concern of any study related to impact of solar arrays is to determine if there is any associated compromise to safety.

While this is not believed to be an issue for residents in the surrounding dwellings considered in this study, the review considers this could potentially be an issue for road traffic users on Buckleys Road as they turn south onto Drain Branch Road or Smythes road.

Plantings planned as per the Boffa Miskell simulations are expected to largely eliminate any residual glare that may get through more sparse vegetation or tree lines even with growth up to 2m. This is expected to significantly reduce, if not eliminate, any impact on road traffic.

It is recommended that with plantings being considered to mitigate potential impact of glare and glint, that it does not create another issue by introducing visual obstruction to road users particularly near the junction of Buckleys, Smythes and Stewards Road.

9. IMPORTANT NOTES

While care is taken on the input data accuracy it is based on what information has been provided by the client and any noted assumptions.

While the overall results from the ForgeSolar glare analysis simulation generally provide an accurate analysis of potential glare based on comparison of simulation against actual installations, these are based on implementation of PV arrays as per tilts and orientations provided.

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 on glare results.

The algorithm does not consider obstacles, either man made or natural, between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills buildings, etc.

Reference Documents

[1]: Pager Power, Solar PhotoVoltaic Glint and Glare Study, Aug 2022
[2]: Boffa Miskell, Brookside Solar Farm Visual Simulations, 01 Sept 2022
[3]: Boffa Miskell, Brookside Solar Farm, Site Plan, Aug 2022
[4]: S-Rack Solar Panel Plan, Solar Mounting Systems
[5]: Emails Correspondence

APPENDIX A: Stage A (PV1 array) Development Impact on Dwellings

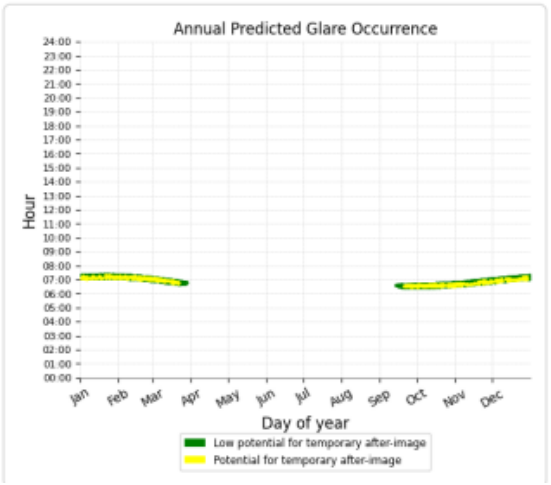
Note: Obervation Points (OP) are as per table below.

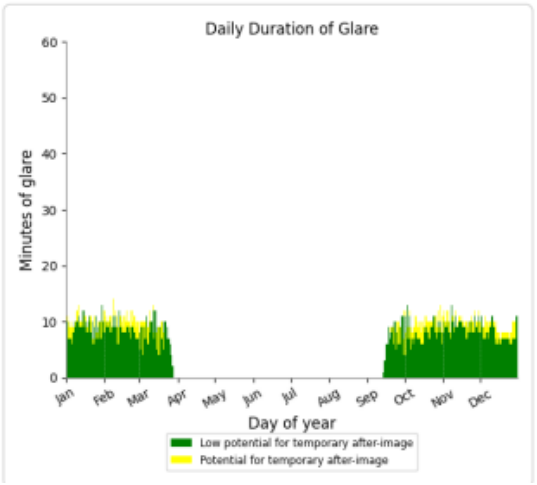
OP1	OP2	OP3	OP4	OP5	OP6	OP7	OP8	OP9	OP10
Dwelling 1	4	8	9	11	22	23	33	40	42

No Glare Found for OP1, OP2, OP5, OP9 and OP10

PV array 1 and OP 3

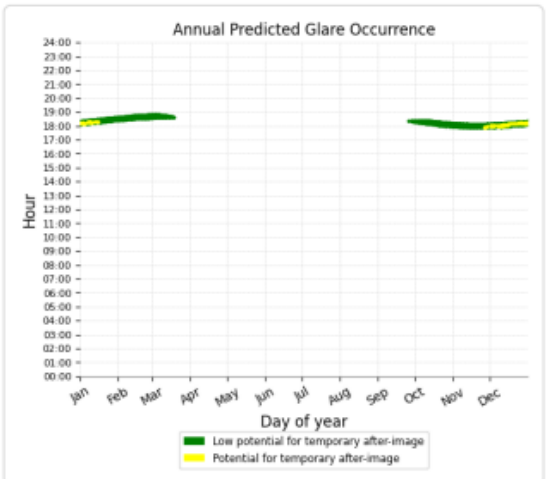
Receptor type: Observation Point
293 minutes of yellow glare
1,613 minutes of green glare

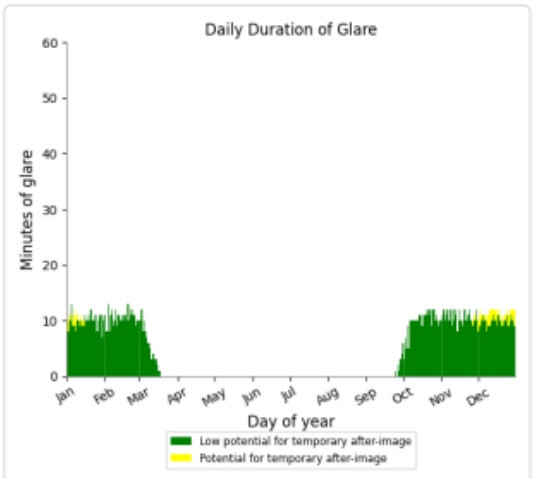




PV array 1 and OP 6

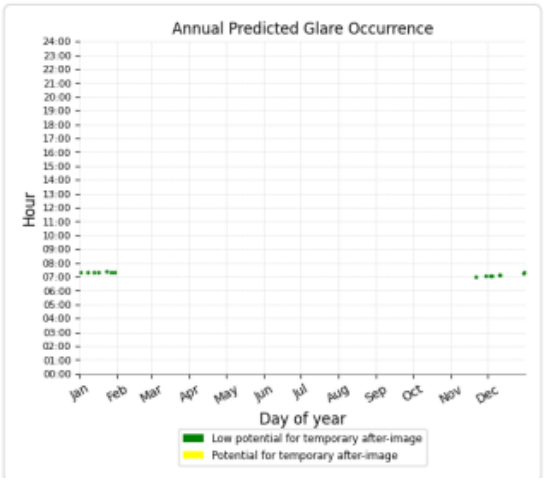
Receptor type: Observation Point
75 minutes of yellow glare
1,620 minutes of green glare

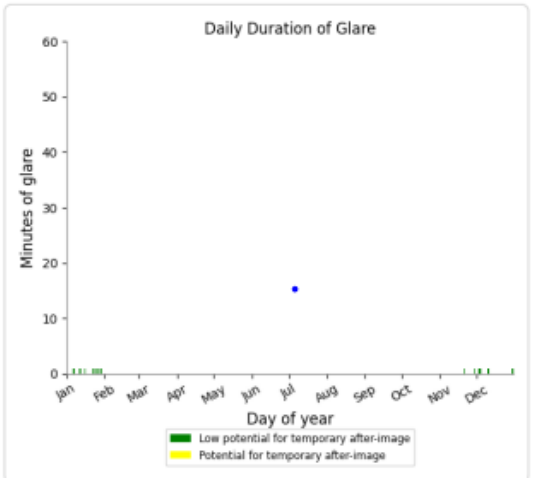




PV array 1 and OP 4

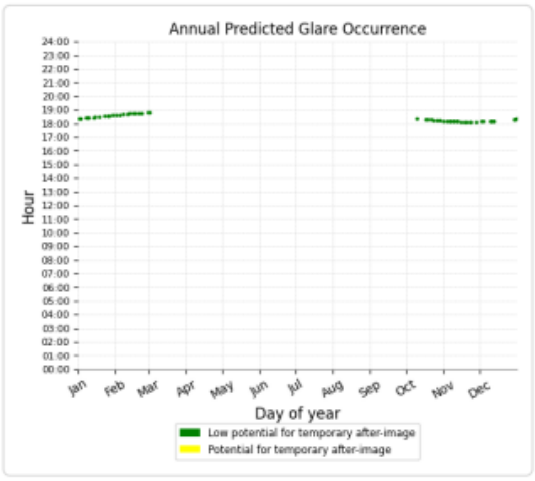
Receptor type: Observation Point
0 minutes of yellow glare
15 minutes of green glare

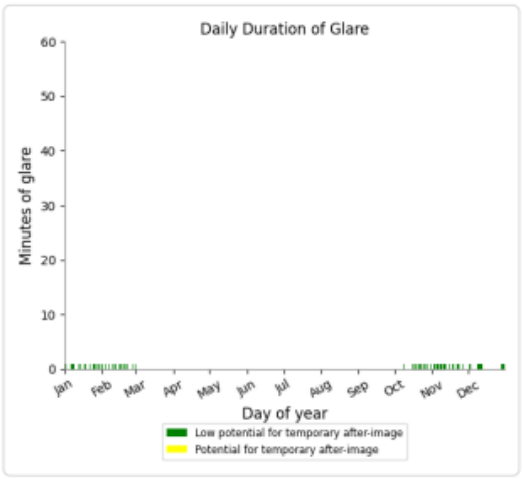




PV array 1 and OP 7

Receptor type: Observation Point
0 minutes of yellow glare
53 minutes of green glare



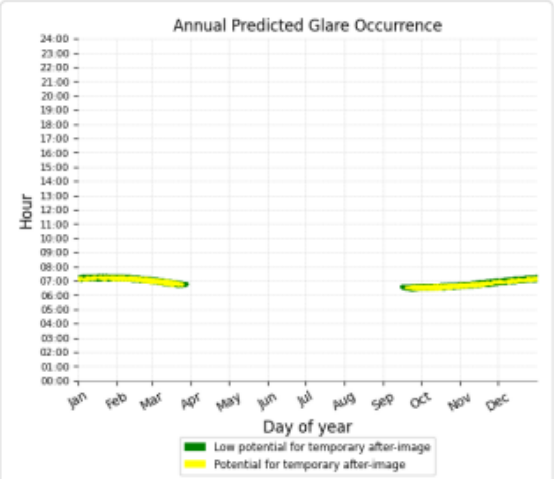


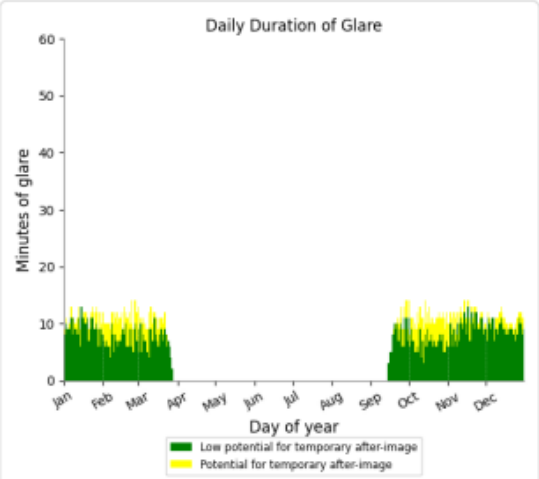
Stage B (PV2 array) Development Impact on Dwellings

No Glare Found for OP1, OP2 and OP9

PV array 2 and OP 3

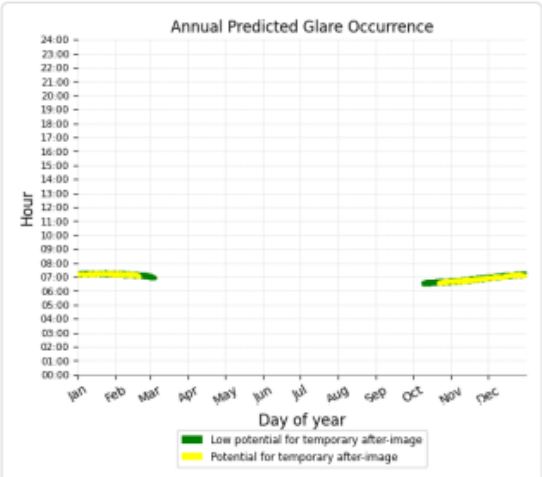
Receptor type: Observation Point
500 minutes of yellow glare
1,579 minutes of green glare

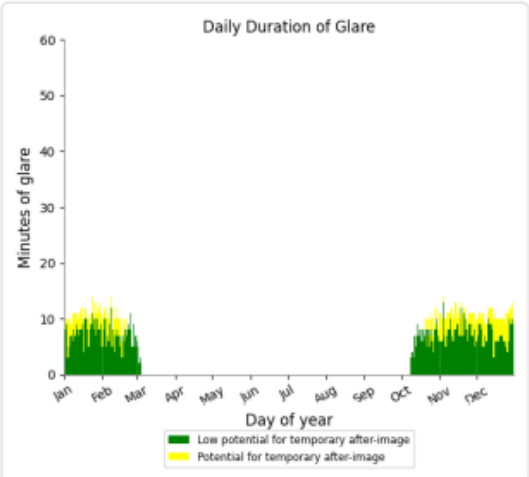




PV array 2 and OP 4

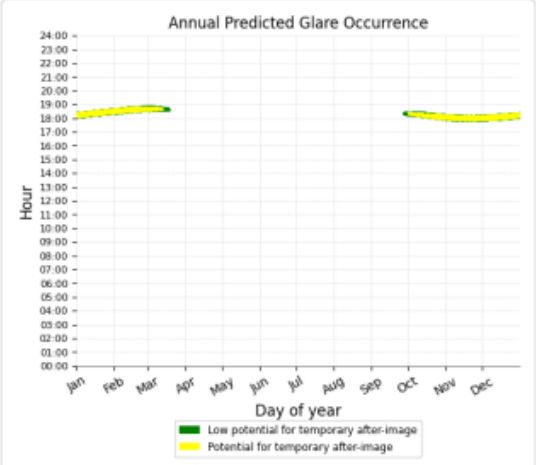
Receptor type: Observation Point
390 minutes of yellow glare
1,062 minutes of green glare

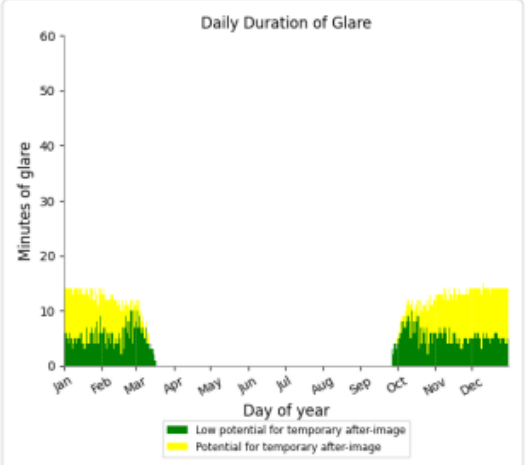




PV array 2 and OP 6

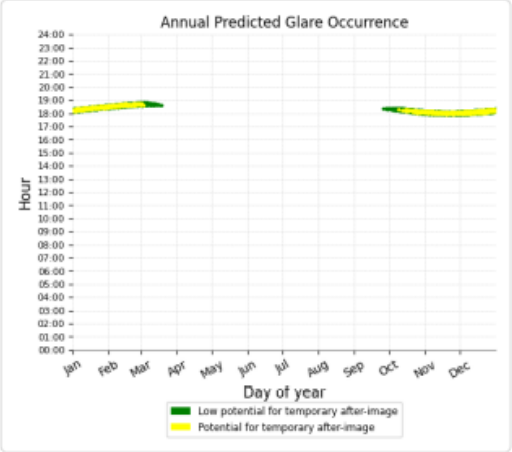
Receptor type: Observation Point
1,091 minutes of yellow glare
921 minutes of green glare

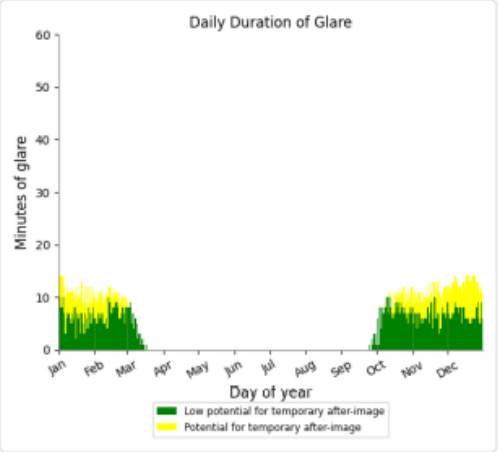




PV array 2 and OP 7

Receptor type: Observation Point
626 minutes of yellow glare
1,094 minutes of green glare



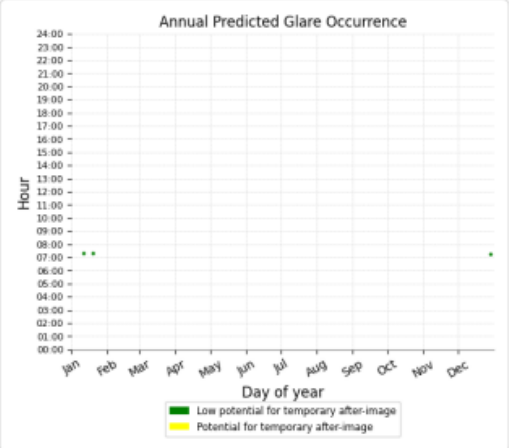


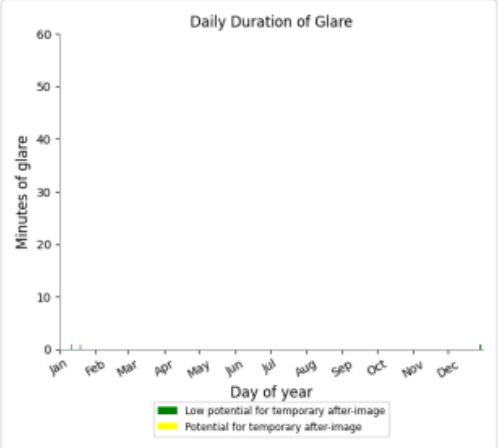
PV array 2 and OP 5

Receptor type: Observation Point

0 minutes of yellow glare

3 minutes of green glare



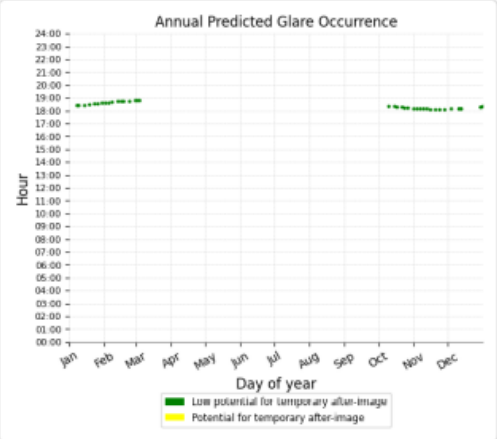


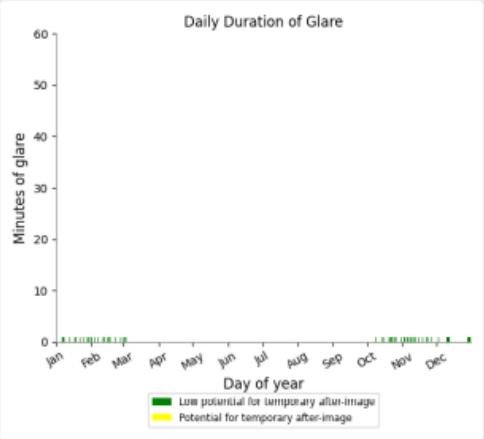
PV array 2 and OP 8

Receptor type: Observation Point

0 minutes of yellow glare

39 minutes of green glare



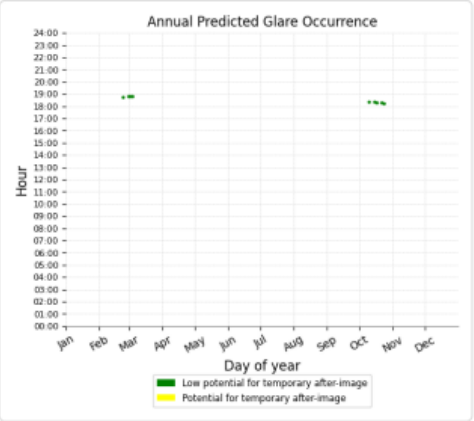


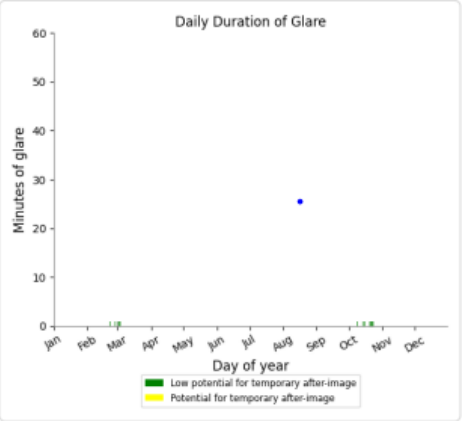
PV array 2 and OP 10

Receptor type: Observation Point

0 minutes of yellow glare

9 minutes of green glare



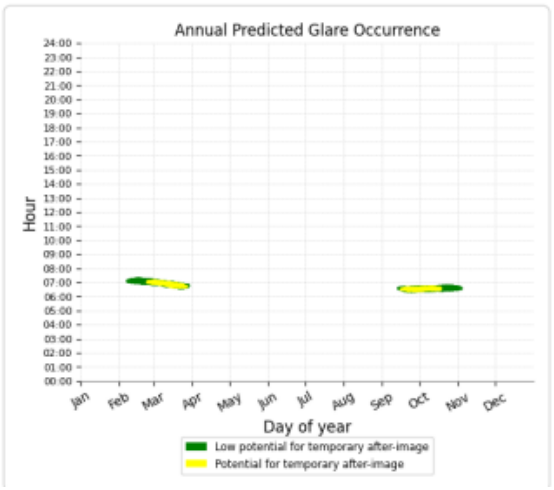


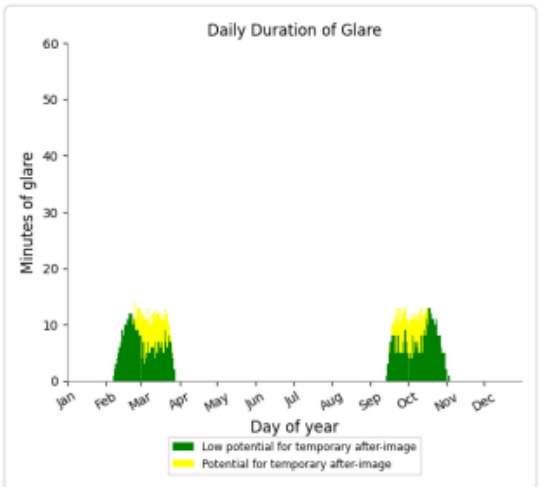
Stage C (PV3 array) Development Impact on Dwellings

No Glare Found for OP6 and OP7

PV array 3 and OP 1

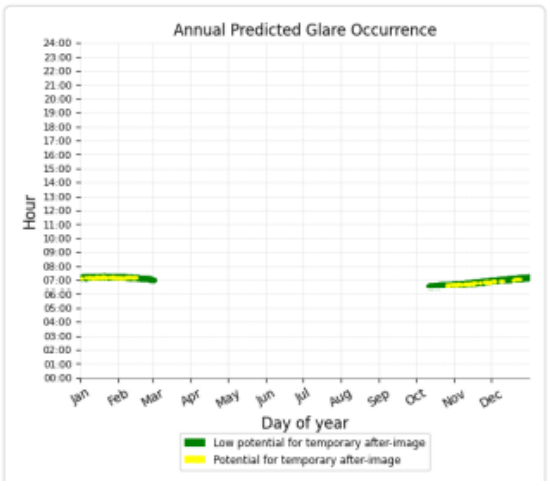
Receptor type: Observation Point
301 minutes of yellow glare
685 minutes of green glare

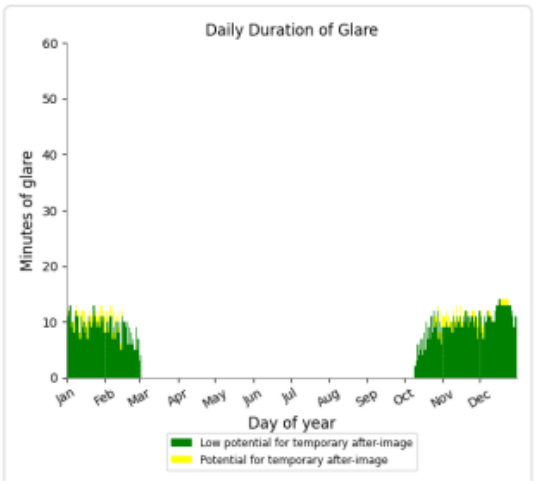




PV array 3 and OP 3

Receptor type: Observation Point
122 minutes of yellow glare
1,362 minutes of green glare



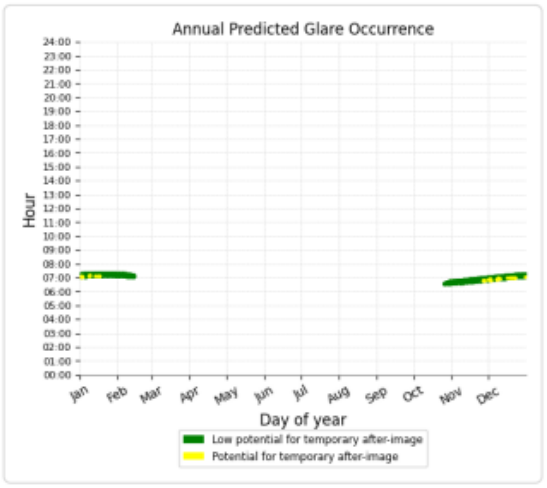


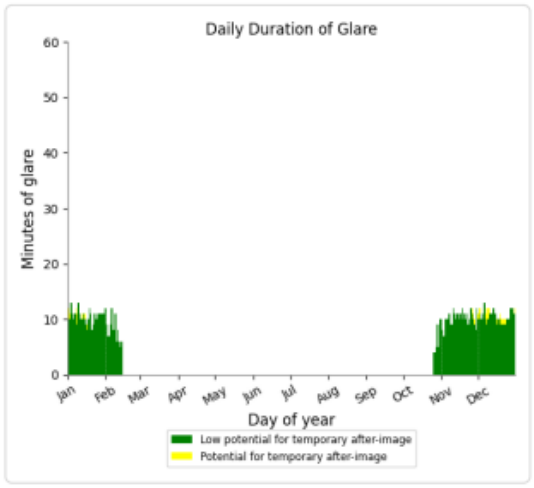
PV array 3 and OP 4

Receptor type: Observation Point

32 minutes of yellow glare

1,106 minutes of green glare



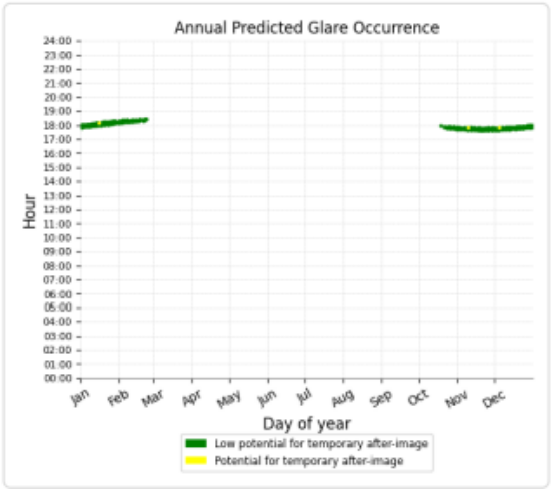


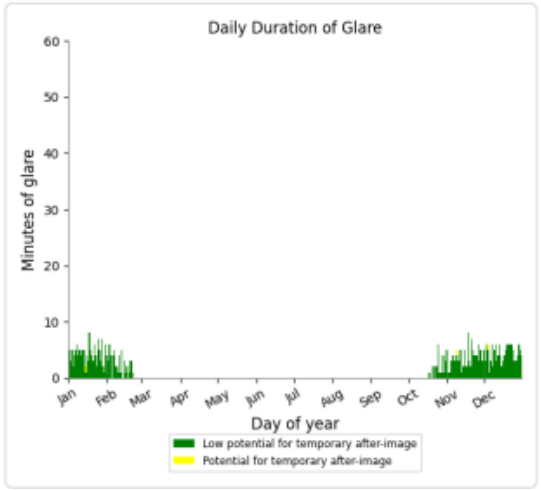
PV array 3 and OP 8

Receptor type: Observation Point

3 minutes of yellow glare

460 minutes of green glare



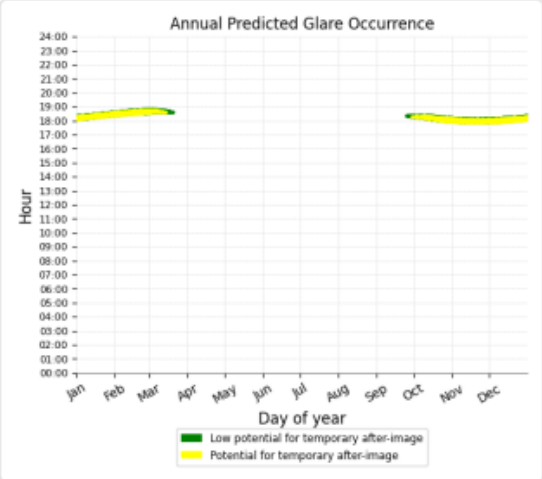


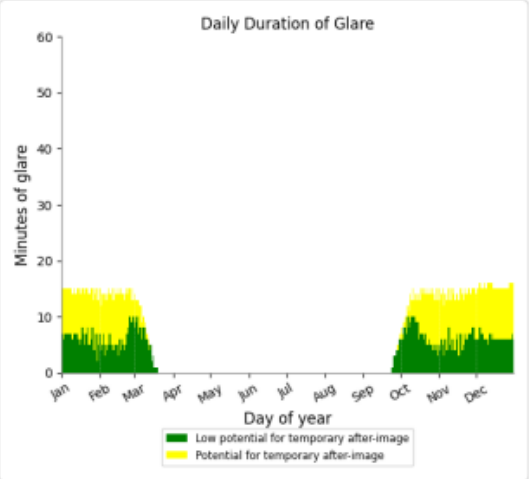
PV array 3 and OP 10

Receptor type: Observation Point

1,250 minutes of yellow glare

1,054 minutes of green glare



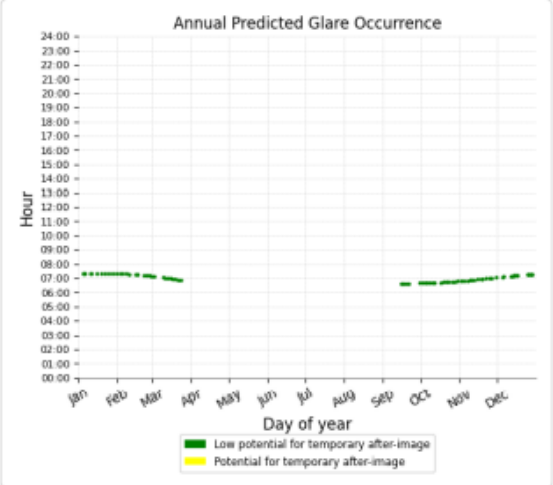


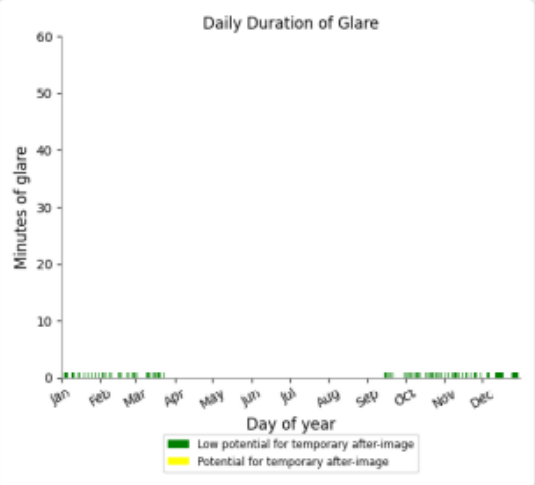
PV array 3 and OP 2

Receptor type: Observation Point

0 minutes of yellow glare

74 minutes of green glare



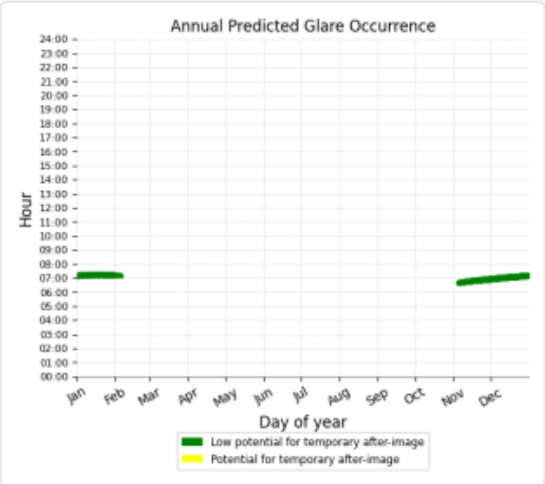


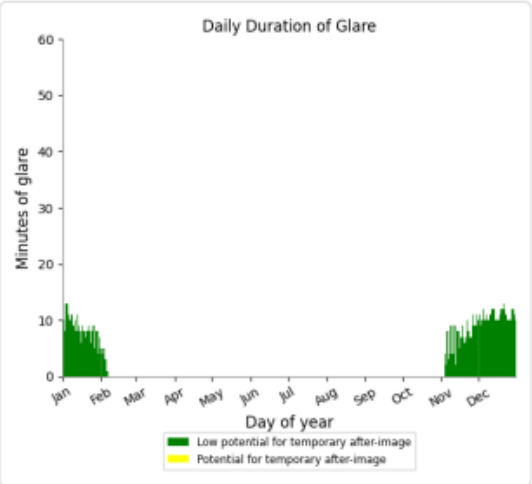
PV array 3 and OP 5

Receptor type: Observation Point

0 minutes of yellow glare

816 minutes of green glare



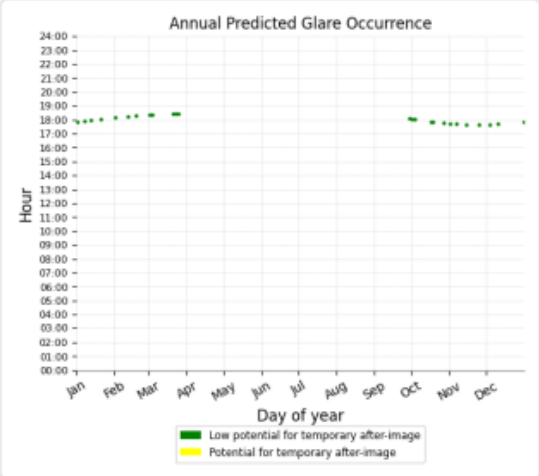


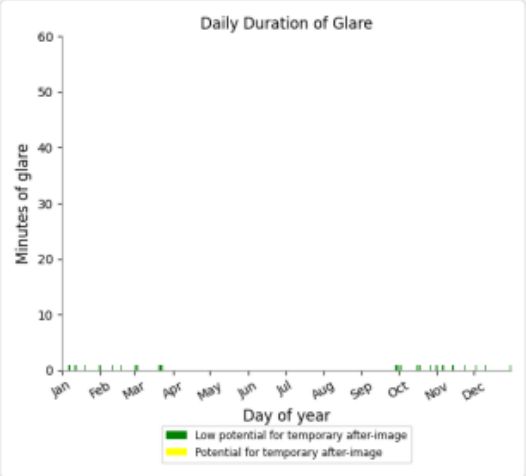
PV array 3 and OP 9

Receptor type: Observation Point

0 minutes of yellow glare

25 minutes of green glare



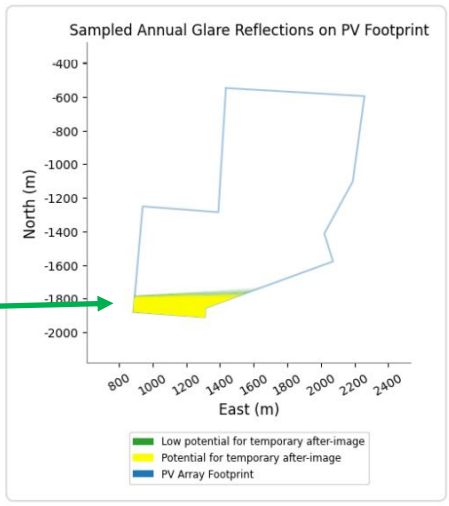


APPENDIX B: Sample Comparison with Pager Power Study

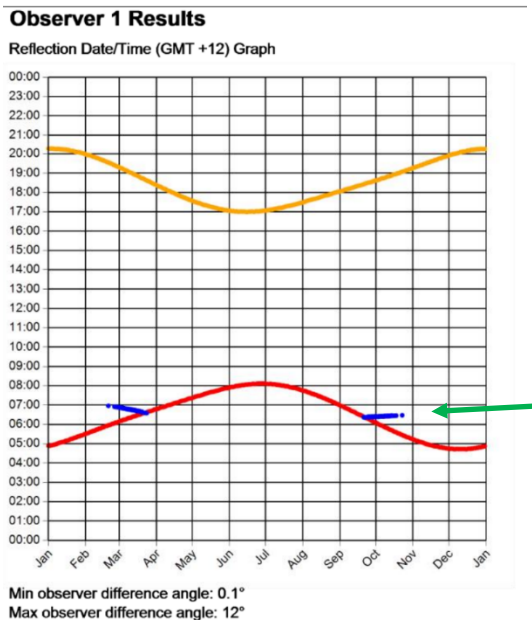
Pager Power Dwelling 1 Results

Brookside Solar Farm whole area outline

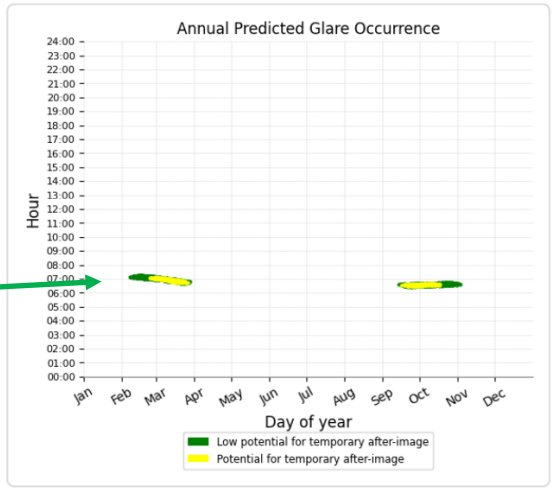
VACL Dwelling 1 Results



Brookside Stage C area outline



Pager Power period of glare from mid-Feb to mid-March and mid-Sept to mid-Oct

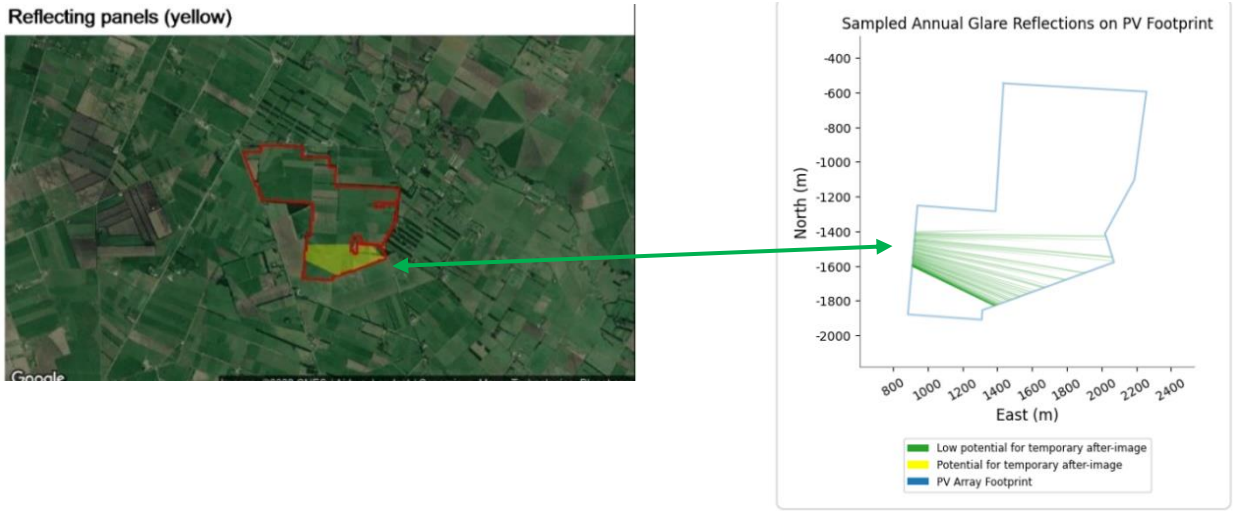


VACL result shows same periods for yellow glare and for same time periods around 7am -6 am

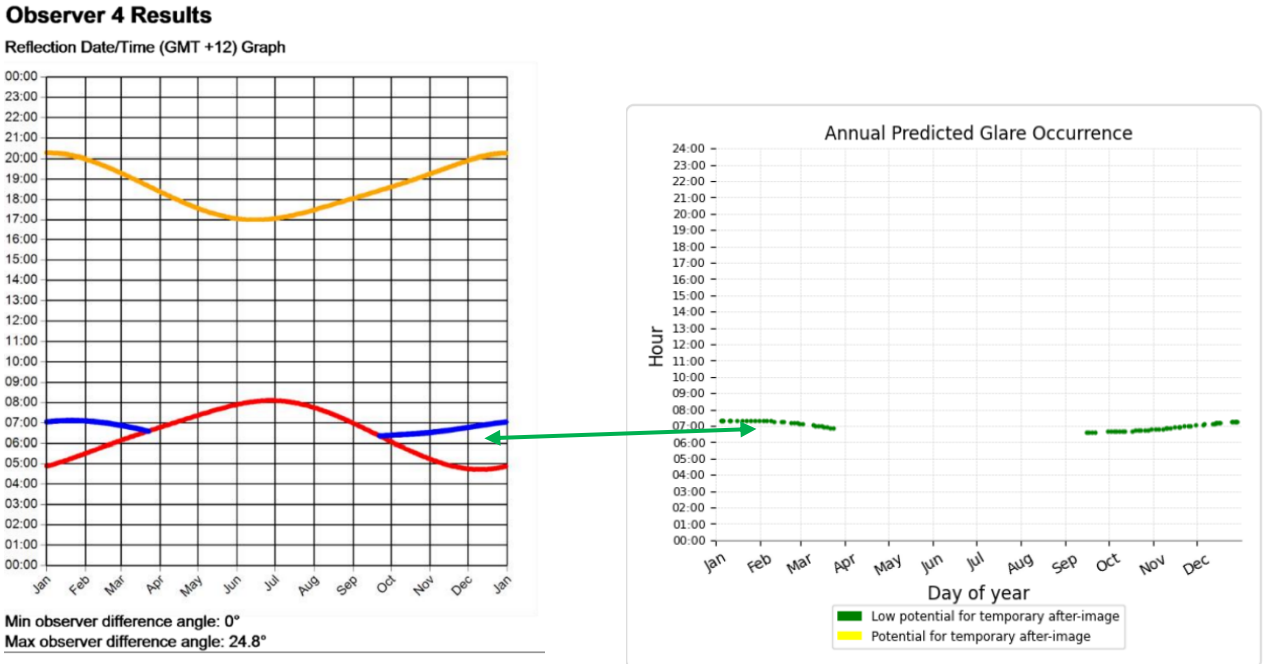
The results above show good agreement between both the Pager Power study and the independent analysis by VACL.

The reflection area has the same footprint for both for both Pager Power diagram for the whole Brookside Farm area and the Stage C area and also the same time frames for predicted glare occurrence.

Pager Power Observer 4 Results **VACL Dwelling 4 Observer Results**



Brookside Solar farm outline in red gives the same reflection footprint as Stage 3 area outline in green in VACL model.



The results for Observer 4 (Dwelling 4) above show good agreement between both the Pager Power study and the independent analysis by VACL.

The reflection area has the same footprint for both for both Pager Power diagram for the whole Brookside Farm area and the Stage C area and the same time frames for predicted glare occurrence.

APPENDIX C:Route Receptors

R1 Location

Name: Route 1
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.696548	172.267019	42.00	1.50	43.50
2	-43.700644	172.276503	38.00	1.50	39.50

R2 Location

Name: Route 2
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.690682	172.284897	38.00	1.50	39.50
2	-43.700517	172.276914	38.00	1.50	39.50

R3

Name: Route 3
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.701517	172.295043	33.00	1.50	34.50
2	-43.700866	172.277319	38.00	1.50	39.50

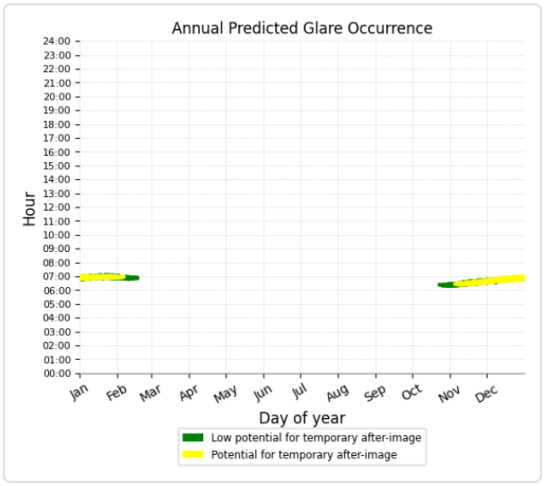
R4

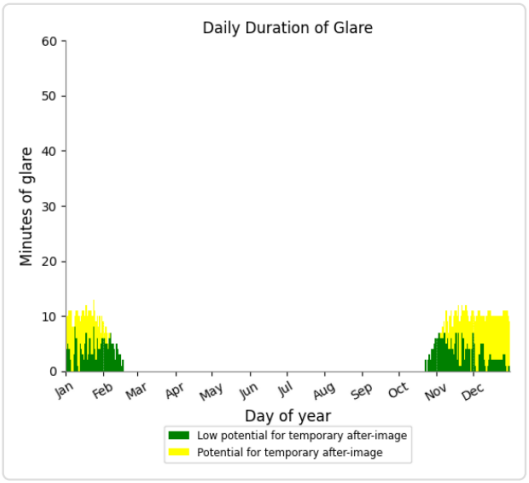
Name: Route 4
Path type: Two-way
Observer view angle: 50.0°

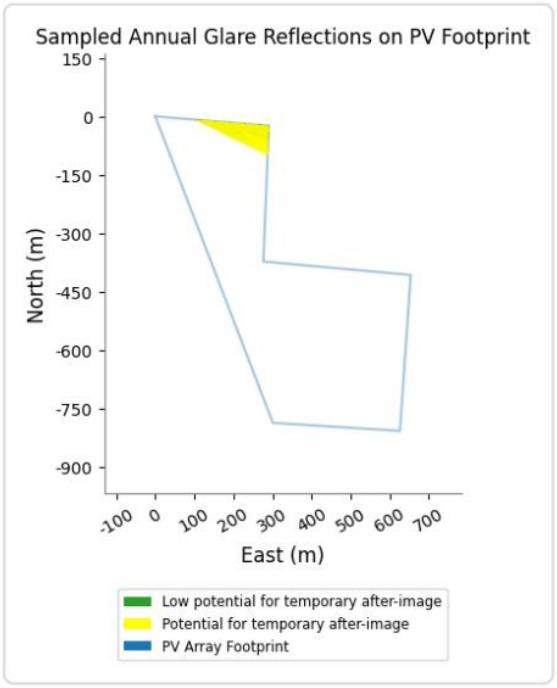
Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.697701	172.300922	33.00	1.50	34.50
2	-43.706109	172.304956	31.00	1.50	32.50

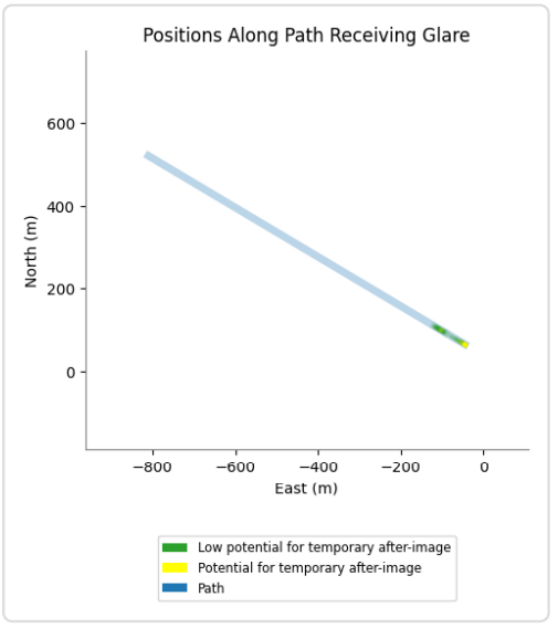
APPENDIX C: Staged Development Impact on Route Receptors

Stage A Array and R1



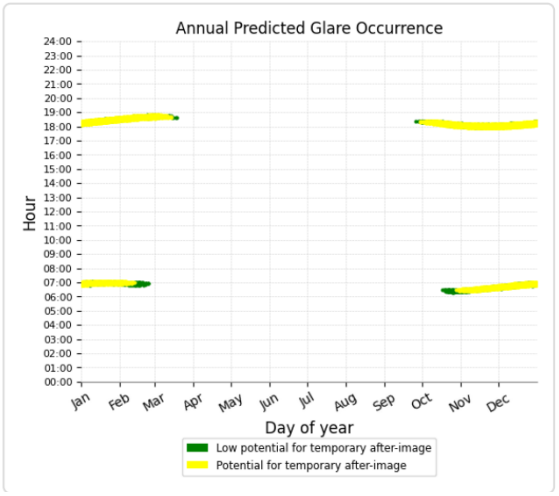


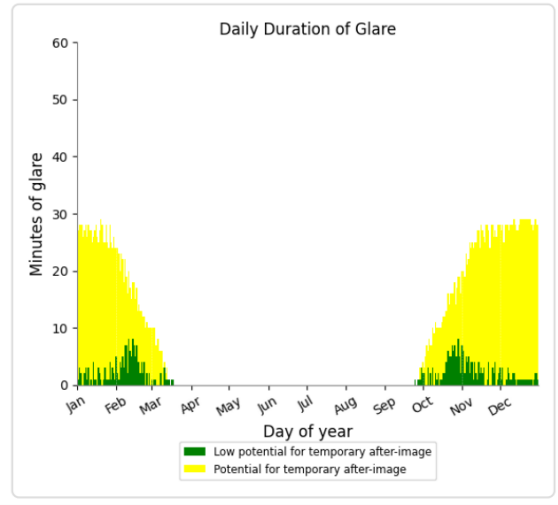


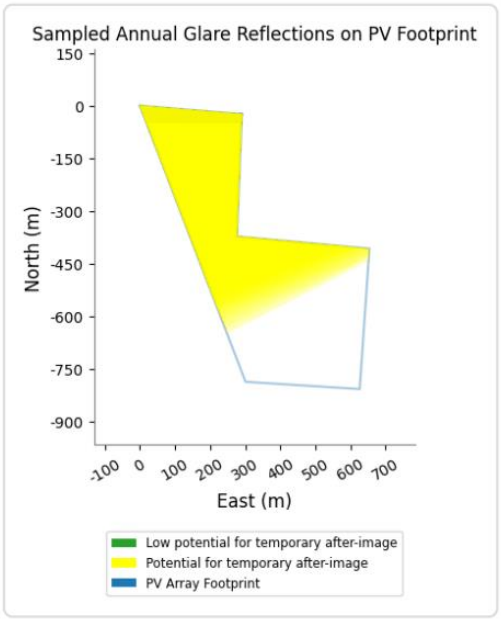


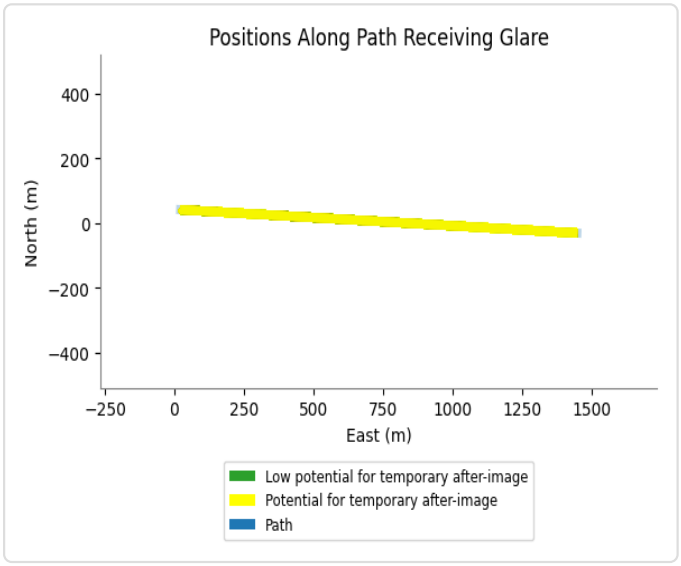
Impact on Traffic: Glare mainly in morning around 7 am for easterly moving traffic, duration <10 mins. Glare impact is expected from late October through to end Feb.

Stage A Array and R3





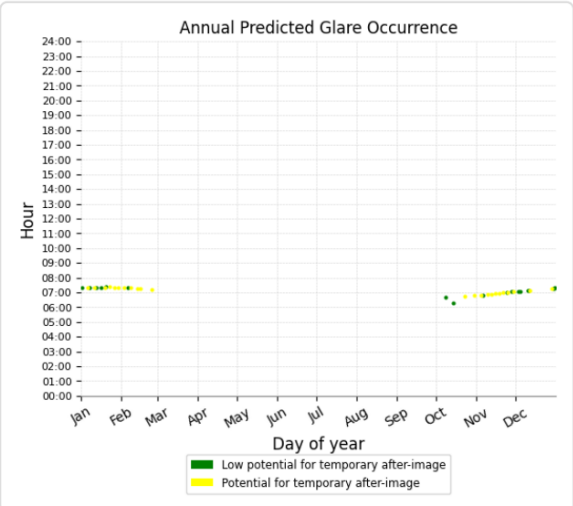


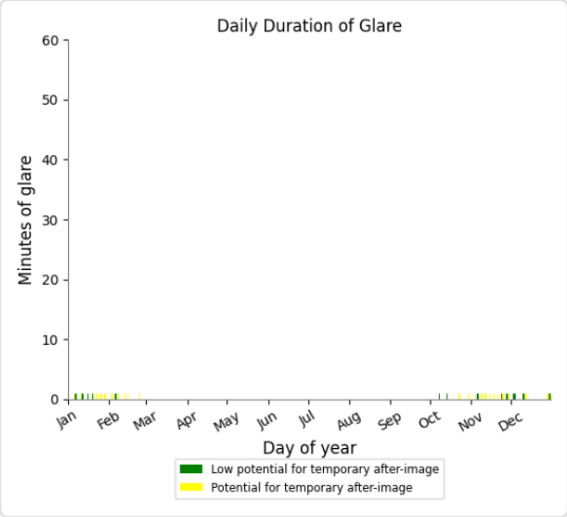


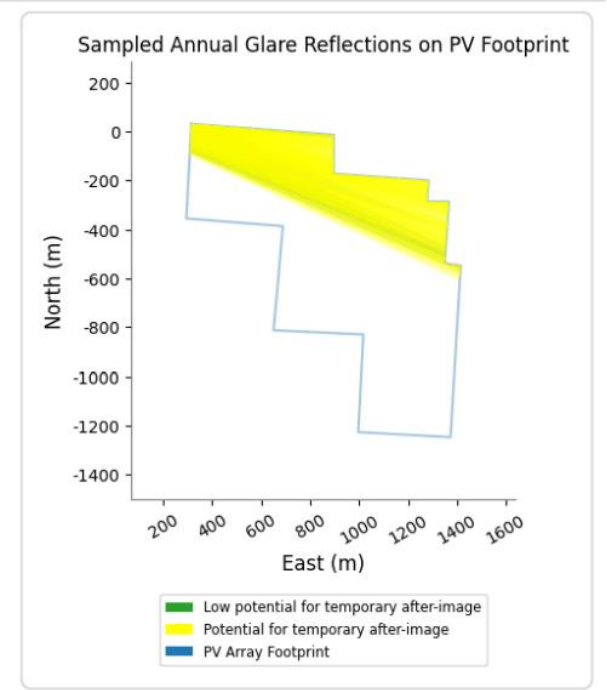
Impact on Traffic: Glare mainly in morning around 7 am for easterly moving traffic of and around 6pm for westerly moving traffic, duration <30 mins. Glare impact is expected from October through to early March.

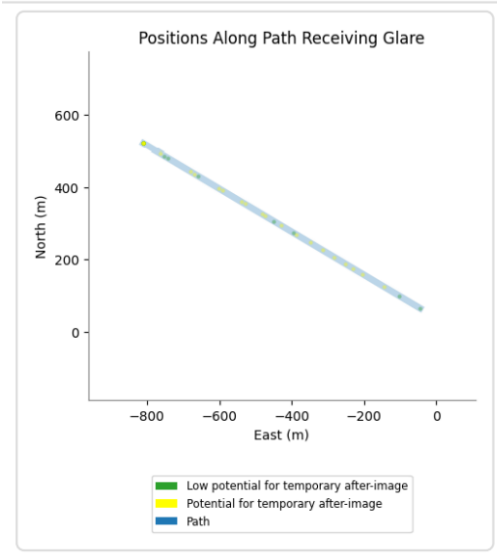
Stage A Array and R2, R4: No glare found.

Stage B Array and R1



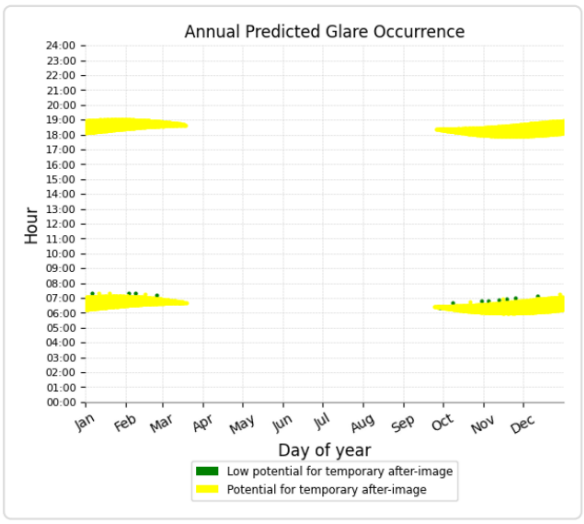


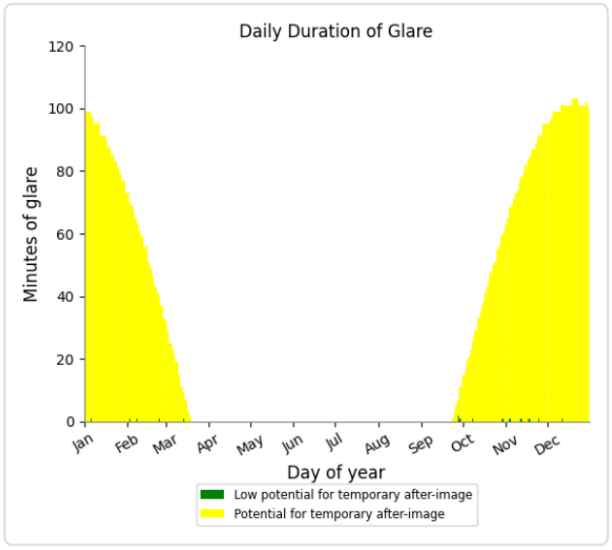


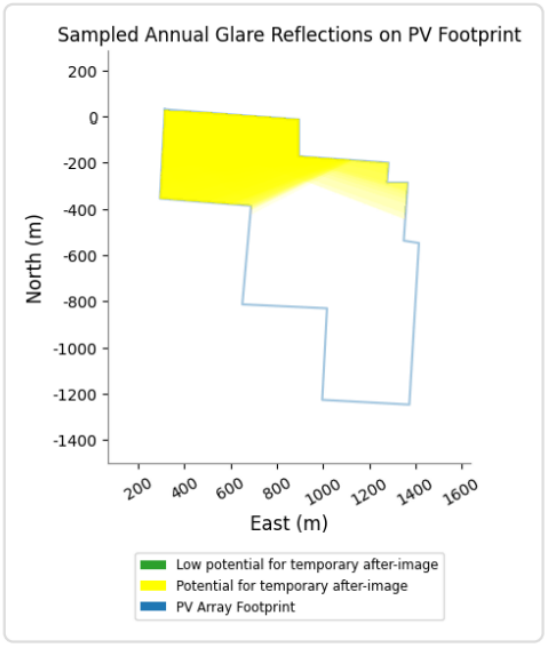


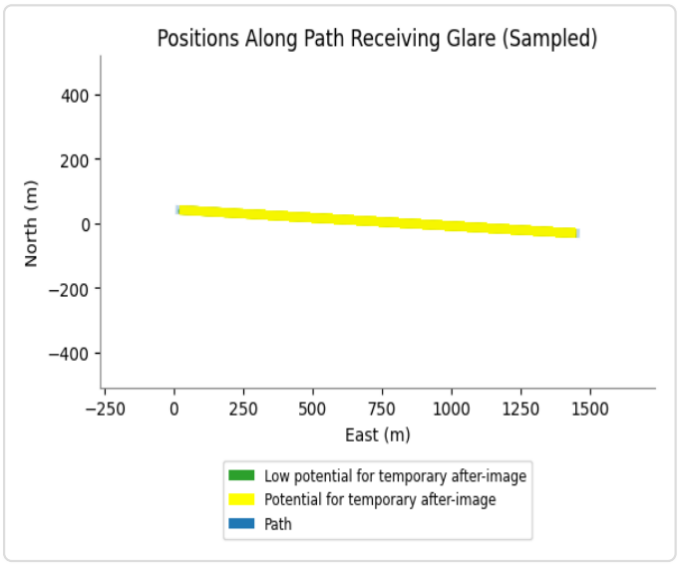
Impact on Traffic: Glare mainly in morning around 7 am for easterly moving traffic, of duration <3 mins. Glare impact is minimal and expected from October through to Feb

Stage B Array and R3





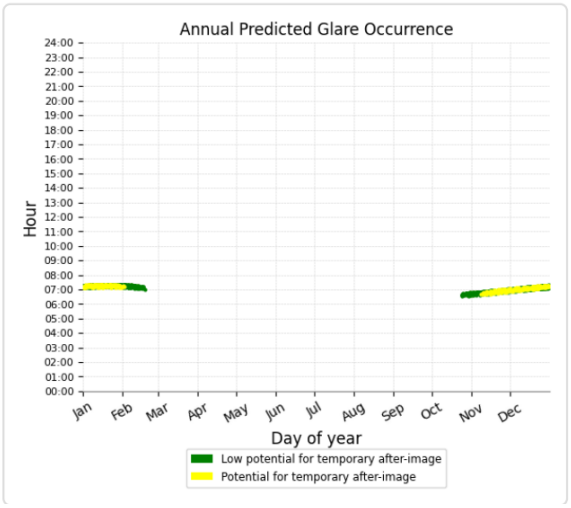


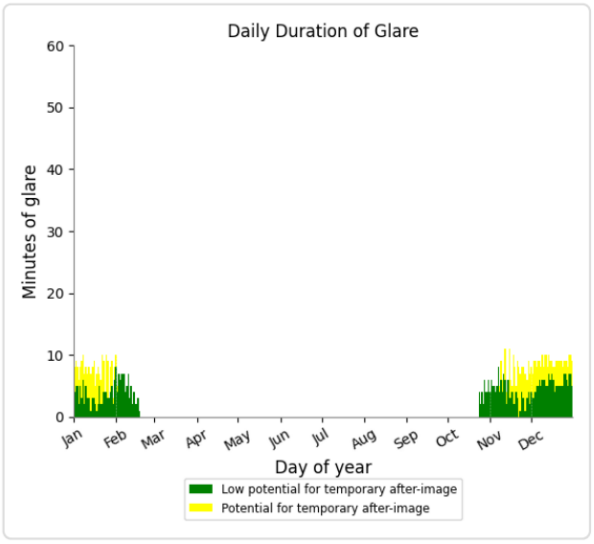


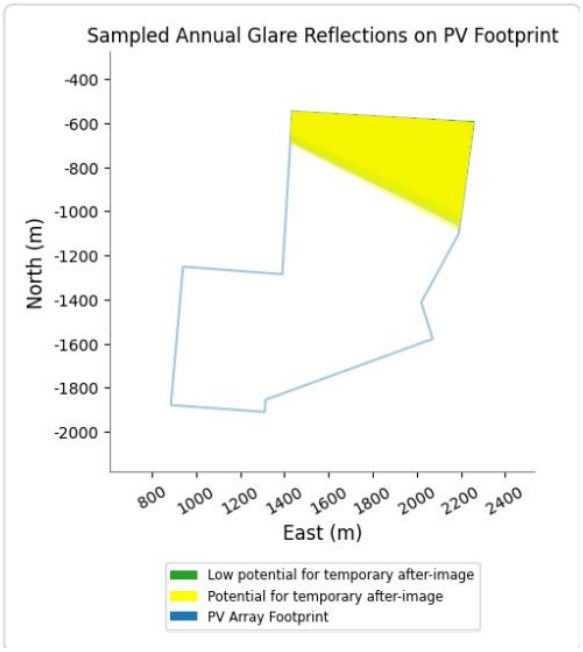
Impact on Traffic: Glare mainly in morning around 7 am for easterly moving traffic and in evening around 6 to 7 pm for westerly moving traffic, duration of <100 mins. Impact found all along road R3. Glare impact expected from October through to mid-March

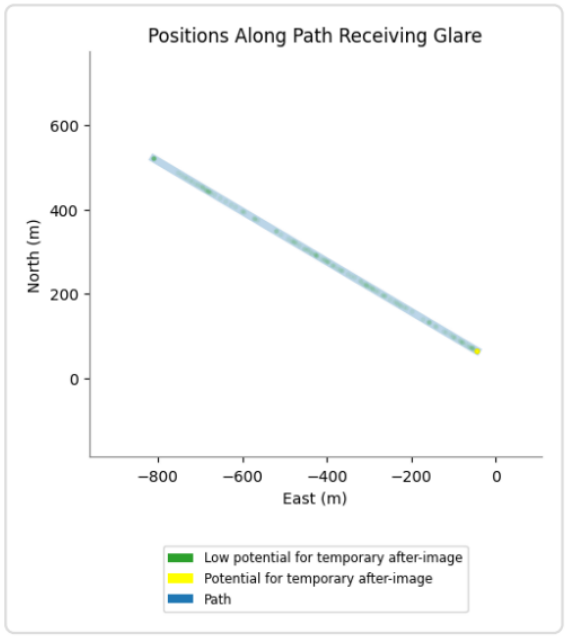
Stage B Array and R2, R4: No glare expected

Stage C Array and R1



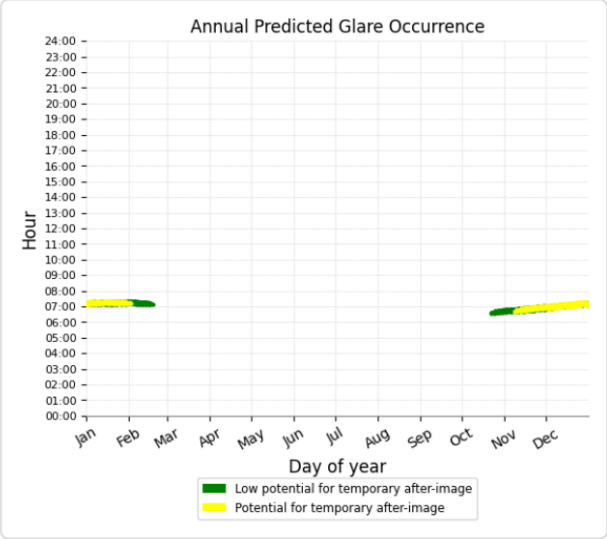


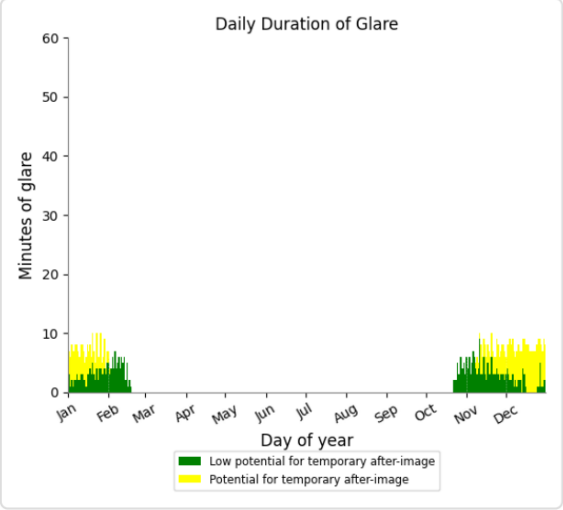


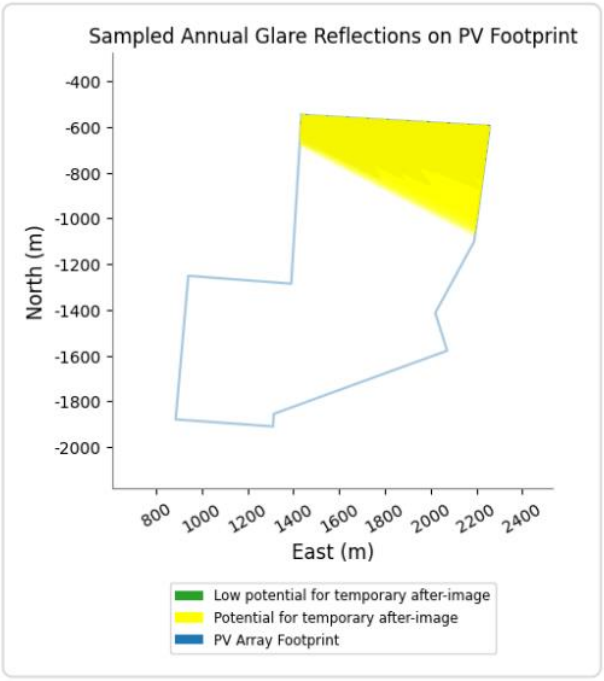


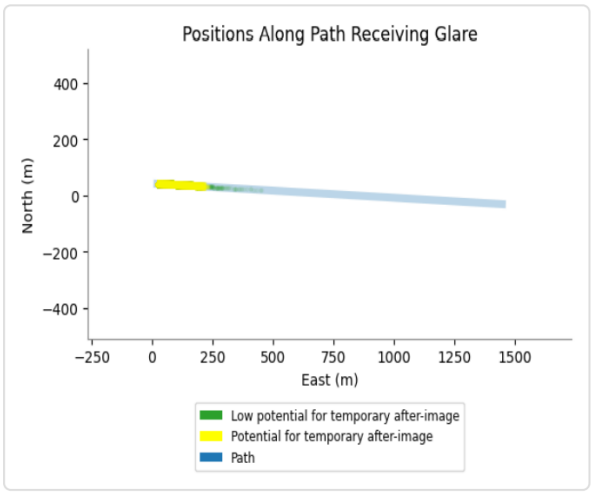
Impact on Traffic: Glare mainly in morning around 7 am for duration of <10mins. Impact found mainly at the junction travelling in easterly direction. Glare impact expected from mid-October through to end Feb.

Stage C Array and R3









Impact on Traffic: Glare mainly in morning around 7 am for duration of <10mins. Impact found mainly at the junction travelling in easterly direction. Glare impact expected from mid-October through to end Feb.

Stage C Array and R2 , R4: No glare found

APPENDIX E : GLINT AND GLARE IMPACT SIGNIFICANCE

The following definition from the PagerPower study is considered with regard to consideration of relative impacts of glare and glint.

Overview

The significance of glint and glare will vary for different receptors. The following section presents a general overview of the significance criteria with respect to experiencing a solar reflection.

Impact Significance Definition

The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not required e.g. intervening screening will limit the view of the reflecting solar panels.	No mitigation required.
Moderate	A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case.	Whilst the impact may be acceptable, consultation and/or further analysis should be undertaken to determine the requirement for mitigation.
Major	A solar reflection is geometrically possible and visible under conditions that will produce a significant impact. Mitigation and consultation is recommended.	Mitigation will be required if the proposed solar development is to proceed.

Impact significance definition

Based on the above define tion from Pager Power