Report for Selwyn District Council

Peer Review of PDP Glint and Glare Assessment for Solar Farm at 80 Struie Road Hororata

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CONTENTS

1 INTRODUCTION

1.1 Overview

To review a report provided by Pattle Delamore Partners Ltd (PDP) for the 80 Struie Road Solar Farm at Hororata, prepared for Rā Tuatahi No. 1 Limited and assess the accuracy of findings in terms of impact of the potential glare and glint on surrounding dwellings as well as road users and for any nearby railroad and or airfields if applicable.

Figure 1.1 80 Struie Road Solar Farm location and proposed development outline

1.2 Scope:

1. Review PDP report and parameter information it provides with regard to glint and glare assessment.
2. Independent assessment to corroborate results, for Single Axis Tracking with 1 Solar Panel size in portrait position (1P)
3. Review and Comparison of results and record any differences to evaluate report conclusion offered. Dwellings as well as road users to be assessed and compared against PDP report.
4. Review of mitigation measures where required, investigate any shortfalls and investigate additional measures where required.
5. Review of any major impacts to both residents' dwellings and road users. Consideration of specifics to any party and potential additional mitigation
6. Conclusion outcomes and determination of potential shortfalls and associated mitigation requirements as part of any potential consent conditions.

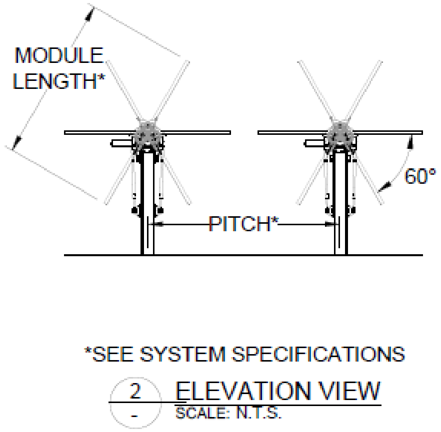
1.3 PV Array Information and Discrepancies Found

This assesment and analysis is based on the following information provided by PDPglint and glare report as well as Assessment of Environmental Effects Report (AEE) prepared for Rā Tuatahi No. 1 Ltd, which their modelling was based for the proposed solar farm development at 80 Struie Road.

PV Parameters as per PDP Report		Comment
System Type	Single Axis Tracking with backtracking	Shade backtracking method utilized basedon PDP ForgeSolar Analysis report
Max Tilt Angle	60 degs	Based on PDP report component data
Rest Angle	60 Degs	Based on PDP report component data
Pivot Centre height above ground level (agl)	1.5m	AEE report gives 1.2 to 1.6 m midpoint height agl. (Ref section 3.2). Hieght of 1.5m is used in analysis as per PDP study.
Max Height (agl)	2.6m	Ref. section 3.2 AEE report
Orientation	East west tracking 180 degs orientation	Rotation Axis orientation set to south
Panel type	CS7N-700TB-AG	This panel has heat strengthened glass with anti-reflective coating (ARC). (Ref: PDP plan Drawings Appendix B and Appendix C in this reprot showing data sheet) **Note:** PDP glint and glare assessment ForgeSolar report indicates they used smooth glass without ARC which is inconsistent with spec for the solar panel considered.
Ground Coverage Ratio (GCR)	0.5 (50%)	This appears to have been rounded up from the 47.68% from the site plan drawing which is appropriate for modelling.

Table 1.3 PDP Parameters used for modelling

Dimensions of panels were also indicated as outlined in the following drawings as shown on plans in Appendix B of PDP AEE report. See below figure 1.3.



SYSTEM SPECIFICATIONS				
MODULE MODEL	CS7N-700TB-AG			
MODULE CAPACITY [W]	700			
MODULES PER STRING	26			
NUMBER OF STRINGS	462			
TOTAL MODULES	12012			
TOTAL CAPACITY [MW]	8.408			
LENGTH	2.384	m	7.822	ft
WIDTH	1.303	m	4.275	ft
PITCH	5.000	m	16.404	ft
GCR [%]	47.680			

Figure 1.3 PDP PV plan drawings and Specification

The above indicate a discrepancy between PDP report data which indicates no anti-reflective coating and that of the panels being used which indicate they have anti reflective coating.

For the purposes of modelling, although there should be no significant difference between consideration of solar panel anti-reflective coating (ARC) and that without, the comparative analysis for this report considers the actual panel specs, that is, with ARC.

1.4 Solar Glint and Glare Impact Analysis

The PDP report does not appear to have given any reference to the significance of glare levels with regard to green, yellow or red levels of glare used by ForgeSolar.

Any potential glint and glare impacts in this report are considered using the same software utility as that used by PDP and has also been used extensively by the author of this VACL report on other assessments both in New Zealand and Internationally.

The PDP Glare Assessment is based on use of the ForgeSolar solar glare hazard analysis software utility. This provides glare assessment associated with impact to the human eye in terms of levels of glare and its hazard potential.

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.

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 and any PV arrays causing issues to designated observation points.

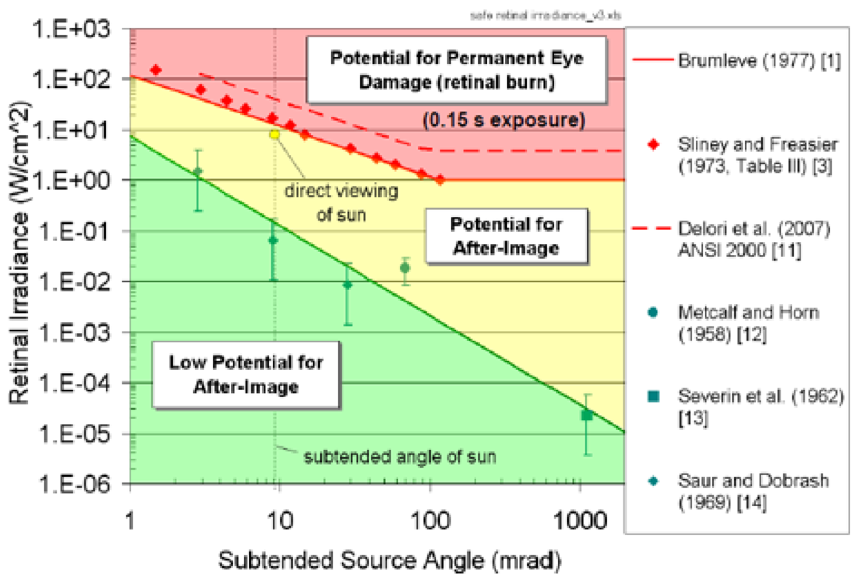


Figure 1.4 -1 . Potential Ocular Impact

"**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.

Typically green and yellow glare are experienced from solar arrays compared to red glare which is rarely experienced from any PV reflection.

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 vehicles, trains 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 for residents of 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 glare however.

Drivers of vehicles and pilots landing their aircraft are restricted hwoever to directions of travel based on roads and orientatiohn of runways. There is greater requirement for mitigation measures therefore for solar glare impacts on drivers and pilots therefore, as potential glare impacts may have more serious consequences and there is greater need to ensure measures to address safety.

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

1.5 Solar Glare Standards and Mitigation

The PDP report only mentions FAA and EU standards but there are no specific details related to these standards presented.

Also, FAA (United States Federal Aviation Authority) standards only apply to aviation and not to dwellings or road and rail users.

A more applicable standard and one which is used in this in this peer review assessment is shown in Table 1.5-1 below. This comes from the Australia New South Wales Government Guidelines for glare impact on Dwellings and is considered in this report to compare the results obtained.

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

Table 1.5-1 Australia NSW Government Guidelines for glare impacts on Dwellings

As noted in the guidelines, glare should ideally be reduced to a point where less than 10 mins per day and less than 10 hours per year is considered. As such, any mitigation measures being considered should be such that it reduces potential glare to dwellings to meet low glare impact durations. This should ideally apply to both green and yellow levels of glare, not just yellow.

It is noted that the PDP report provides no data or results on impact to dwellings except to mention that there is no impact on the seven (7) dwellings that have been considered.

There was also no mention of what observer heights are considered for dwelling owners nor whether the dwelling residences were one or two storey which will be impacted on differently.

The modelling used in this report considers 1.8m as observer heights for one storey dwellings and 3.6m as observer heights for any two storey dwellings.

There is no mention of any modelling or glare assessment done for road users in the PDP report.

Although there are no significant roads directly adjacent to the solar farm, which is up to 480m from the nearest public road (Struie Road), given it is still within a 1km radius of the site it should ideally be taken into account as should any public road or railway within this distance.

This is particularly the case with regard to reducing risks at any significant road intersection where glare should be minimised or mitigated as far as practicable for vehicles turning onto roads and facing oncoming traffic.

	Scope	Methodology	Performance objective
Road and rail	All roads and rail lines within 1km of the proposed solar array.	Solar glare analysis to identify whether glint and glare are geometrically possible within the forward looking eyeline of motorists and rail operators.	If glare is geometrically possible then measures should be taken to eliminate the occurrence of glare. Alternatively, the applicant must demonstrate that glare would not significantly impede the safe operation of vehicles or the interpretation of signals and signage.

Table 1.5-2 Australian Solar Farm Guidelines on Glint and Glare Assessment Approach for Road Users

While there are no definite limits with regard to glare duration constraints as for dwellings, the distinction is to demonstrate that glare would not significantly impact on safe operation of vehicles.

In normal circumstances the duration of exposure to glare from vehicles may be very short due to the dynamics of the moving vehicle and passing any potential glare zones quickly as not to be unduly affected.

The ForgeSolar utility takes into account ±50 degree angle for assumed peripheral vision about the driver's direction of travel.

Road user viewer height for vehicles should also cover small vehicles with driver heights around 1.5m and larger vehicles with driver heights around 2.5m two levels of 1.5m and 2.5m.

The consideration of height for 2.5m is worst case and would also cover the 1.5m driver eye level so the author has assessed potential glare for drivers of larger vehicles only with a 2.5m driver eye level height.

1.6 Mitigation Measures

The PDP glint and glare assessment noted that features such as plantations or hedgerows were not mapped to allow for worst case scenario with no shielding.

As such no mitigation measures were modelled by PDP based on their initial assessment and they mentioned would only be if results warranted it.

VACL believes that while this is understandable it is also dependent on ensuring sufficient dwellings within the 1km radius are taken into account as well as roads, rail and aerodromes nearby.

It should be noted that any glare mitigation should take into account the maximum height of the solar arrays (at approximately 2.6m above ground level) so any existing vegetation and or planned landscaping should ideally be modelled taking this into account.

2 Executive Summary

This peer review report is provided by the author, from Velden Aviation Consulting Limited (VACL), with the results obtained by Pattle Delamore Partners Ltd (PDP) in their Glint and Glare assessment report. There is largely overall agreement by VACL with the results determined by PDP and that there should be no significant potential glare impact expected to nearby dwellings and or road users.

However, some discrepancies were noted in the report with regard to parameters used and further descriptions needed to help clarify standards and mitigation considerations.

These are detailed further in this peer review report including differences in considerations around modelling and reference standards that should be used.

VACL uses Australian New South Wales Government guidelines for solar array developments with regard applicable and conservative standards for acceptable glare levels as they apply to Dwellings and Road or Rail routes.
The PDP assessment reference to U.S. Federal Aviation Administration (FAA) guidelines, while applicable to operations at and around aerodromes is not applicable to dwellings and road or rail routes.

No comparative assessment has been made by VACL for the glare impacts on the Hot Air Ballooning as analysed by PDP as this is considered recreational and with non-directional landing requirements compared to piloted fixed wing aircraft at aerodromes. There is expected to be little or less than minor to no impact for Hot Air Ballooning and the rationale for this without further need for an assessment is further discussed in this report.

Other areas of discrepancy between PDP and VACL assessment relate to the number of dwellings considered and observer heights. VACL considered an additional 9 dwellings that fell within a 1km to 1.5km radius from the proposed solar farm needed to be considered.

The PDP report did not include any assessment of potential glare impact on nearby road traffic routes. This is considered in this VACL peer review report given the impact of potential glare on road traffic safety. It was found however that there would be no significant solar glare impact to road traffic for the four nearby roads that were considered.

Irrespective of some of the differences and discrepancies found, VACL is in agreement with the PDP glare report results which overall indicated that there should be no potential impact of solar glare on dwellings and road routes nearby that were assessed.

3 ASSESSMENT MODELLING COMPARISONS

3.1 Array Parameter Set up

The Photovoltaic array layout being considered as per PDP Glint and Glare Assessment Report and what is shown in the AEE report and actual plans of the site appear to be inconsistent as illustrated in Figure 3.1 below.

(a) From PDP Report Data

Name: PV array 1
Footprint area: 162,779 m^2
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 180.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Ground Coverage Ratio: 0.5
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

(b) AEE Report Proposed Layout

Figure 3.1 Inconsistency in proposed site layout between PDP AEE submitted report and Glint and Glare Assessment Report

It should be noted that although there is inconsistency in the proposed layout area, the PDP glint and glare assessment still contains the area of the AEE report and submitted plan but also includes an additional area adjacent to this as shown in Figure 3.1 (a) above. The combined area is noted as PV1, and any results of the PDP may therefore potentially be for the additional area which this peer review assessment has included as PV2.

This is shown in Figure 3.2 below.

PDP Report PV1 Array

VACL Report PV1 Array

VACL Report PV2 Array

Figure 3.2 PDP Report PV1 Array , VACL peer review report showing this as PV1 and PV2 arrays

The PV1 array area of this VACL peer review assessment is more aligned with the footprint as shown in the PDP AEE report site layout and as per PV site Array Plans (in Appendix B of AEE report) to ensure greater accuracy of the assessment.

The PV2 Array is added so that both the PV1 And PV2 arrays in this peer review assessment can be compared better with the PDP glare assessment which shows these areas combined.

3.2 Dwelling Observer Height Modelling Considerations

The Location of the seven (7) houses and dwellings considered for the PDP assessment are shown in Figure 3.2.1 below with location data as indicated in the associated table.

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	-43.548457	172.007755	172.00	1.00	173.00
OP 2	-43.544849	172.002476	175.00	1.50	176.50
OP 3	-43.543449	172.000717	177.00	1.50	178.50
OP 4	-43.542018	171.998228	178.00	1.00	179.00
OP 5	-43.539696	171.997880	180.00	1.00	181.00
OP 6	-43.538538	172.001184	180.00	0.00	180.00
OP 7	-43.536422	172.000894	183.00	1.50	184.50

Figure 3.2.1 Location of houses and dwellings considered by PDP for Glint and Glare Assessment

It was noted that the PDP report only considered seven nearest dwellings on the basis of line of sight to the solar panels. They also used observer eye heights for discrete receptors of no greater than 1.5m for the dwellings and did not elaborate if these were single or two storey dwellings.

PDP glare report states that 'it is likely that in many cases windbreak hedges and other objects may obscure all of the view of the panels'.

The peer reviewer agrees that this is normally the case however the ForgeSolar software does no take these into account and assumes a clear and flat earth free of obstructions. Unless the results show no adverse impact then local obstructions and or vegetation would then need to be modelled appropriately.

Normal observer height is taken as 1.8m taking into account dwelling foundations and a sitting resident. No other receptor heights have been taken into account for any buildings or dwellings where observer heights may be higher than the 1.8m where normally for 2 storey dwellings this is taken as 3.6m .

While VACL agrees with the dwellings chosen by PDP, it is considered that further dwellings also need to be taken into account that fall within a 1km radius from the Struie road solar farm. These further dwellings are shown in the below diagram Figure 3.2.2 and associated table.

All dwelling is noted as single storey and receptor heights taken as 1.8m.

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-43.548457	172.007755	172.00	1.80
OP 2	2	-43.544849	172.002476	175.00	1.80
OP 3	3	-43.543449	172.000717	177.00	1.80
OP 4	4	-43.542018	171.998228	178.00	1.80
OP 5	5	-43.539696	171.997880	180.00	1.80
OP 6	6	-43.538538	172.001184	180.00	1.80
OP 7	7	-43.536422	172.000894	183.00	1.80
OP 8	8	-43.535140	171.992677	186.00	1.80
OP 9	9	-43.530380	171.994673	190.00	1.80
OP 10	10	-43.551277	172.007772	170.00	1.80
OP 11	11	-43.551510	172.000101	170.00	1.80
OP 12	12	-43.550297	171.997709	171.00	1.80
OP 13	13	-43.547818	171.992844	174.00	1.80
OP 14	14	-43.535017	171.990537	187.00	1.80
OP 15	15	-43.532513	171.989057	190.00	1.80
OP 16	16	-43.530451	171.989100	192.00	1.80

Figure 3.2.2 VACL peer review showing 7 observation points as per PDP report plus additional 9 dwellings(OP8 to OP16) within 1km to 1.5km radius from solar farm.

3.3 Road User Modelling Considerations

Adjacent roads routes were not mentioned or considered in the PDP glint and glare report which was surprising given safety implications associated with potential solar glare impact on drivers. This should ideally be considered for rural roads that may be used for public transport (e.g. school buses, tractors, haulage vehicles etc) to identify if any risks of potential glare to road users exist based on glare analysis on nearby road routes.

The nearby roads considered by the peer reviewer (shown in yellow) are Struie Road, Bealey Road east and west of the intersection, and Derretts Road which have been identified as shown in the Figure 3.3 below.

Figure 3.3 Roads considered in the peer review assessment

Of importance is to identify if there are any potential glare impacts to drivers along these roads and especially at the intersection. This is to determine if any mitigation would be required where turning vehicles may experience potential glare from the road, they are turning onto which can also have potential impact on road safety.

3.4 PDP Hot Air Balloon Impact Assessment

VACL has been involved in studies and assessments of glint and glare for international and well as New Zealand domestic airports including Auckland and Christchurch airports.

VACL does not believe that modelling for the hot air balloon is necessary as this is based on recreational flying and does not involve fixed wing aircraft which are based on pilots being constraint to a more directional view from their aircraft.

This is particularly so for landing and take-off which are the critical phases of flight and require pilot dependency on view in the direction of landing and take-off of their aircraft.

As such, while the PDP assessment of glare impact on hot air balloon flight paths is noted, VACL believes it should not have any significant impact due to the nature of the operation of the hot air balloons and their flight paths and non-critical phases associated with landing that are otherwise required at an airfield.

On this basis no comparative assessment for hot air balloons has been made in this peer review.

4 SOLAR GLARE ANALYSIS RESULTS

4.1 Dwelling Results Comparison

Results are shown in table 4.1 below and based on analysis results shown in Appendix D. An additional 9 dwellings(OP8 to OP16) were considered in this peer review assessment.

Receptor ID	Address	PDP Predicted Results	VACL Predicted Results		Comments
		PV 1	PV1	PV2	
OP1	2152 Bealey Rd (Ballooning Canterbury)	Green Glare predicted	Not Assessed	Not Assessed	VACL did not assess potential glare impact for hot air ballons for reasons noted in section 3.4 above. Also, green glare is not considered an issue by FAA mostly due to its low level and short duration to moving aircraft.
OP2	44 Struie Rd	No glare predicted	No glare predicted	No glare predicted	VACL concurs with PDP result based on parameters provided by PDP
OP3	66 Struie Rd	No glare predicted	No glare predicted	No glare predicted	VACL concurs with PDP result based on parameters provided by PDP
OP4	90 Struie Rd	No glare predicted	No glare predicted	No glare predicted	VACL concurs with PDP result based on parameters provided by PDP
OP5	106 Struie Rd	No glare predicted	No glare predicted	No glare predicted	VACL concurs with PDP result based on parameters provided by PDP
OP6	132 Struie Rd	No glare predicted	No glare predicted	No glare predicted	VACL concurs with PDP result based on parameters provided by PDP
OP7	134 Struie Rd	No glare predicted	No glare predicted	No glare predicted	VACL concurs with PDP result based on parameters provided by PDP
OP8	186 Struie Road	Not Assessed	No glare predicted	No glare predicted	No glare predicted. Impact is expected to be less than minor to no impact
OP9	246 Struie Road	Not Assessed	No glare predicted	No glare predicted	No glare predicted. Impact is expected to be less than minor to no impact
OP10	2143 Bealey Rd	Not Assessed	No glare predicted	No glare predicted	No glare predicted. Impact is expected to be less than minor to no impact
OP11	273 Derretts Rd	Not Assessed	No glare predicted	No glare predicted	No glare predicted. Impact is expected to be less than minor to no impact
OP12	2203 Bealey Rd	Not Assessed	No glare predicted	No glare predicted	No glare predicted. Impact is expected to be less than minor to no impact
OP13	2253 Bealey Rd	Not Assessed	No glare predicted	No glare predicted	No glare predicted. Impact is expected to be less than minor to no impact
OP14	189 Struie Road (2 storey)	Not Assessed	No glare predicted	No glare predicted	No glare predicted. Impact is expected to be less than minor to no impact
OP15	217 Struie Road	Not Assessed	No glare predicted	No glare predicted	No glare predicted. Impact is expected to be less than minor to no impact
OP16	230 Struie Road	Not Assessed	No glare predicted	No glare predicted	No glare predicted. Impact is expected to be less than minor to no impact

Table 4.1 Dwelling glare results comparison

4.2 Road User Results Comparison

Glare assessment results indicate that no glare is predicted along these roads based on the PDP solar farm site location at 80 Struie Road and the parameters associated with the solar array development as outlined by PDP.

Results are shown in table 4.2 below and based on analysis results shown in Appendix D .

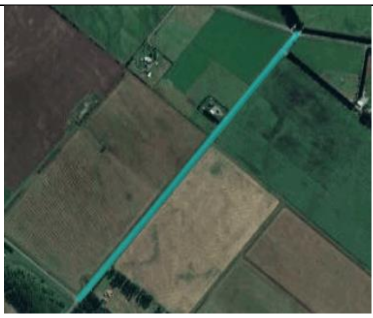
Road Section		PDP Glint and Glare detected for SAT System	VACL Results and comments.
Struie Road		Not Assessed	No glare detected. No further mitigation measures required
Bealey Road East of intersection		Not Assessed	No glare detected. No further mitigation measures required
Bealey Road -West of Intersection		Not Assessed	No glare detected. No further mitigation measures required
Derretts Road		Not Assessed	No glare detected. No further mitigation measures required

Table 4.2 Road User Glare Assessment Comparison

5. MITIGATION CONSIDERATIONS

5.1 Mitigation Requirements for Dwellings

For Dwellings the assessment modelling VACL concurs with the PDP assessment that no glare is predicted for the seven (7) dwellings considered by PDP and also for the additional nine (9) dwellings considered in this peer review.

This is irrespective of the higher observer eye heights chosen in this assessment of 1.8m and 3.6m for one of the dwellings which was 2 storey.

As such, VACL is in agreement with PDP that no mitigation modelling needs to be considered based on this outcome.

As per the Australian guidelines considered this is within the tolerances considered acceptable.

VACL is in agreement with PDP that there should be minimal to no impact. With the added consideration of existing vegetation and plantings VACL agrees with PDP this should most likely mitigate any line of sight views to the solar farm eliminating any further need for landscape plantings.

5.2 Mitigation Requirements for Road Users

For road users, elimination of glare is preferred to ensure driver safety is not compromised.

Given there was no potential glare predicted for the road routes that were assessed, obstruction modelling of existing vegetation to assess glare mitigation effectiveness was not required.

6. SUMMARY AND RECOMMENDATION

Summary of Impact on Dwellings

There were some discrepancies noted in the parameters in the PDP report and in particular the consideration of PV array footprint and anti-reflective coating which was not included in the PDP report where ideally it should have been.

Even though PDP did not take into account some differing observer eye levels for some of the dwellings that were considered, results from the PDP and VACL review indicated that there should be no potential glare impact to the dwellings/residents considered by PDP and the further dwellings considered in this report.

Independent analysis by VACL using the same software utility considering the PV parameter discrepancies, produced results that are largely in agreement with the PDP glint and glare assessment.

This was also based on no existing vegetation nor proposed landscape planting being taken into account.

Summary of Impact on Road Users

There was surprisingly no glare analysis done by PDP on any of the adjacent roads to the solar farm at 80 Struie Road or within a 1km to 1.5km radius of the solar farm.
This may have been due to the fact that the solar farm is some 400m from Struie Road and hence even further from any other nearby public roads.

Regardless, VACL believes that due to due to the potential safety risks associated with glare to road traffic, that roads within a 1 to 2 km radius should ideally be considered.

The results from this report however indicate that there should be no potential glare expected to the roads considered even without inclusion of any mitigation modelling of existing or planned vegetation landscaping.

Recommendation

Overall, VACL is essentially in agreement with the results PDP have obtained from their glint and glare assessment for 80 Struie Road proposed solar farm development given there were no identified impacts of potential solar glare to either dwellings or road users considered.

This is with respect to no mitigation modelling carried out for existing vegetation such as hedgerows or windbreaks formed by large trees as well as surrounding vegetation around the dwellings and along road routes that were considered.

Should there be a change to any of the parameters associated with the Solar Farm development at 80 Struie Road as provided by PDP, and identified in Table 1.3, then it is recommended that a further glint and glare assessment be carried out taking these into account.
This is because it is highly likely that potential glare impacts may manifest with any new PV array parameter set up.

It is recommended also that this should include a more in depth assessment of the number of dwellings and adjacent roads including those further identified in this report, as well as mitigation modelling of associated existing vegetation and any planned landscaping that may be required as a consequence of parameters changes to the PV array.

7. 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 as well as significant undulations in nearby terrain and roads may impact on glare results.

8. REFERENCE DOCUMENTS

[1]: Pattle Delamore Partners Ltd Appendix C, 80 Struie Road PDP Glint and Glare Assessment, 22 July 2024

[2]: Pattle Delamore Partners Ltd, Assessment of Environmental Effects – Struie road , Hororata Solar Array Development. Prepared for Rā Tuatahi No. 1 Ltd. December 2024.

[3]: Appendix B. Solar Array Design and Specification Plans and Drawings. NextTracker Site Id 006458, Project No. 1796308

[4]: PV Panel Module Model Data Sheet. As per NexTracker Plans Appendix B . CS7N-700TB-AG

[5]: Email Correspondence

APPENDIX A: Site Location and Component Data (Map and Satellite View)

Roads Routes Assessed

Appendix B: PV Arrays Footprint

PV Arrays

Name: PV array 1
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 60.0°
Resting angle: 60.0°
Ground Coverage Ratio: 0.5
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

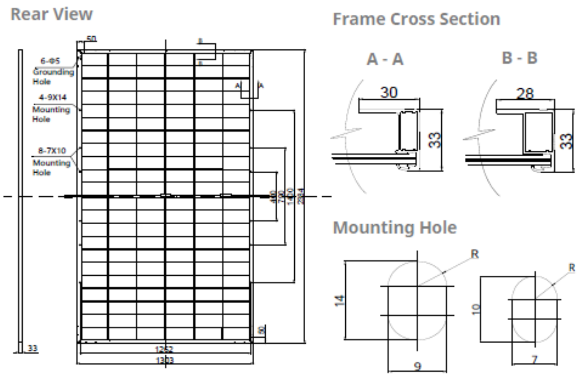
Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.541452	172.002815	178.00	1.50	179.50
2	-43.539788	172.007063	178.00	1.50	179.50
3	-43.538870	172.006548	179.00	1.50	180.50
4	-43.538513	172.005947	179.00	1.50	180.50
5	-43.537937	172.005540	179.16	1.50	180.66
6	-43.539539	172.001377	180.00	1.50	181.50

Name: PV array 2
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 60.0°
Resting angle: 60.0°
Ground Coverage Ratio: 0.5
Rated power: -
Panel material: Smooth glass without AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

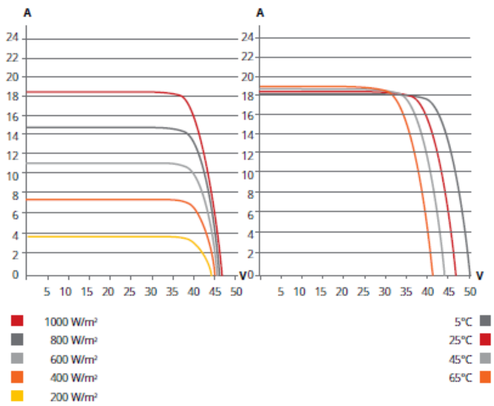
Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.541190	172.003948	178.00	1.50	179.50
2	-43.542232	172.004635	177.00	1.50	178.50
3	-43.542862	172.005997	176.00	1.50	177.50
4	-43.541898	172.008293	176.00	1.50	177.50
5	-43.539945	172.007156	178.00	1.50	179.50

Appendix C: PV Module Specifications

ENGINEERING DRAWING (mm)



CS7N-680TB-AG / I-V CURVES



ELECTRICAL DATA | STC*

		Nominal Max. Power (Pmax)	Opt. Operating Voltage (Vmp)	Opt. Operating Current (Imp)	Open Circuit Voltage (Voc)	Short Circuit Current (Isc)	Module Efficiency
CS7N-695TB-AG		695 W	39.8 V	17.47 A	47.7 V	18.44 A	22.4%
Bifacial Gain**	5%	730 W	39.8 V	18.34 A	47.7 V	19.36 A	23.5%
	10%	765 W	39.8 V	20.18 A	47.7 V	20.28 A	24.6%
	20%	834 W	39.8 V	20.96 A	47.7 V	22.13 A	26.8%
CS7N-700TB-AG		700 W	40.0 V	17.51 A	47.9 V	18.49 A	22.5%
Bifacial Gain**	5%	735 W	40.0 V	18.39 A	47.9 V	19.41 A	23.7%
	10%	770 W	40.0 V	20.22 A	47.9 V	20.34 A	24.8%
	20%	840 W	40.0 V	21.01 A	47.9 V	22.19 A	27.0%
CS7N-705TB-AG		705 W	40.2 V	17.55 A	48.1 V	18.54 A	22.7%
Bifacial Gain**	5%	740 W	40.2 V	18.43 A	48.1 V	19.47 A	23.8%
	10%	776 W	40.2 V	20.27 A	48.1 V	20.39 A	25.0%
	20%	846 W	40.2 V	21.06 A	48.1 V	22.25 A	27.2%
CS7N-710TB-AG		710 W	40.4 V	17.59 A	48.3 V	18.59 A	22.9%
Bifacial Gain**	5%	746 W	40.4 V	18.47 A	48.3 V	19.52 A	24.0%
	10%	781 W	40.4 V	20.32 A	48.3 V	20.45 A	25.1%
	20%	852 W	40.4 V	21.11 A	48.3 V	22.31 A	27.4%
CS7N-715TB-AG		715 W	40.6 V	17.63 A	48.5 V	18.64 A	23.0%
Bifacial Gain**	5%	751 W	40.6 V	18.51 A	48.5 V	19.57 A	24.2%
	10%	787 W	40.6 V	20.36 A	48.5 V	20.50 A	25.3%
	20%	858 W	40.6 V	21.16 A	48.5 V	22.37 A	27.6%
CS7N-720TB-AG		720 W	40.8 V	17.67 A	48.7 V	18.69 A	23.2%
Bifacial Gain**	5%	756 W	40.8 V	18.55 A	48.7 V	19.62 A	24.3%
	10%	792 W	40.8 V	20.41 A	48.7 V	20.56 A	25.5%
	20%	864 W	40.8 V	21.20 A	48.7 V	22.43 A	27.8%

* Under Standard Test Conditions (STC) of irradiance of 1000 W/m², spectrum AM 1.5 and cell temperature of 25°C. Measurement uncertainty: ±3 % (Pmax).
** Bifacial Gain: The additional gain from the back side compared to the power of the front side at the standard test condition. It depends on mounting (structure, height, tilt angle etc.) and albedo of the ground.

ELECTRICAL DATA | NMOT*

	Nominal Max. Power (Pmax)	Opt. Operating Voltage (Vmp)	Opt. Operating Current (Imp)	Open Circuit Voltage (Voc)	Short Circuit Current (Isc)
CS7N-695TB-AG	525 W	37.6 V	13.97 A	45.1 V	14.87 A
CS7N-700TB-AG	528 W	37.8 V	14.00 A	45.3 V	14.91 A
CS7N-705TB-AG	532 W	37.9 V	14.03 A	45.5 V	14.95 A
CS7N-710TB-AG	536 W	38.1 V	14.06 A	45.7 V	14.99 A
CS7N-715TB-AG	540 W	38.3 V	14.09 A	45.8 V	15.03 A
CS7N-720TB-AG	544 W	38.5 V	14.12 A	46.0 V	15.07 A

* Under Nominal Module Operating Temperature (NMOT), irradiance of 800 W/m², spectrum AM 1.5, ambient temperature 20°C, wind speed 1 m/s.

MECHANICAL DATA

Specification	Data
Cell Type	TOPCon cells
Cell Arrangement	132 [2 x (11 x 6)]
Dimensions	2384 × 1303 × 33 mm (93.9 × 51.3 × 1.30 in)
Weight	37.8 kg (83.3 lbs)
Front Glass	2.0 mm heat strengthened glass with anti-reflective coating
Back Glass	2.0 mm heat strengthened glass
Frame	Anodized aluminium alloy
J-Box	IP68, 3 bypass diodes
Cable	4.0 mm² (IEC), 10 AWG (UL)
Cable Length (Including Connector)	460 mm (18.1 in) (+) / 340 mm (13.4 in) (-) or customized length*
Connector	T6 (IEC 1500V) or PV-KST4-EVO2/XY, PV-KBT4-EVO2/XY (IEC 1500V) or PV-KST4-EVO2A/xy, PV-KBT4-EVO2A/xy (IEC 1500V)
Per Pallet	33 pieces
Per Container (40' HQ)	561 pieces

* For detailed information, please contact your local Canadian Solar sales and technical representatives.

ELECTRICAL DATA

Operating Temperature	-40°C ~ +85°C
Max. System Voltage	1500 V (IEC/UL) or 1000 V (IEC/UL)
Module Fire Performance	TYPE 29 (UL 61730) or CLASS C (IEC61730)
Max. Series Fuse Rating	35 A
Application Classification	Class A
Power Tolerance	0 ~ + 5 W
Power Bifaciality*	80 %

* Power Bifaciality = $Pmax_{rear}$ / $Pmax_{front}$, both $Pmax_{rear}$ and $Pmax_{front}$ are tested under STC, Bifaciality Tolerance: ± 5 %

TEMPERATURE CHARACTERISTICS

Specification	Data
Temperature Coefficient (Pmax)	-0.30 % / °C
Temperature Coefficient (Voc)	-0.26 % / °C
Temperature Coefficient (Isc)	0.05 % / °C
Nominal Module Operating Temperature	41 ± 3°C

* The specifications and key features contained in this datasheet may deviate slightly from our actual products due to the on-going innovation and product enhancement. CSI Solar Co., Ltd. reserves the right to make necessary adjustment to the information described herein at any time without further notice.
Please be kindly advised that PV modules should be handled and installed by qualified people who have professional skills and please carefully read the safety and installation instructions before using our PV modules.

PARTNER SECTION

Canadian Solar MSS (Australia) Pty Ltd.
333 Drummond Street, Carlton VIC 3053, Australia, sales.au@csisolar.com, www.csisolar.com/au

* Manufactured and assembled in China, Thailand and Vietnam.

Appendix D: Glare Assessment Results on Dwellings and Roads Routes

Dwelling Data

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-43.548457	172.007755	172.00	1.80
OP 2	2	-43.544849	172.002476	175.00	1.80
OP 3	3	-43.543449	172.000717	177.00	1.80
OP 4	4	-43.542018	171.998228	178.00	1.80
OP 5	5	-43.539696	171.997880	180.00	1.80
OP 6	6	-43.538538	172.001184	180.00	1.80
OP 7	7	-43.536422	172.000894	183.00	1.80
OP 8	8	-43.535140	171.992677	186.00	1.80
OP 9	9	-43.530380	171.994673	190.00	1.80
OP 10	10	-43.551277	172.007772	170.00	1.80
OP 11	11	-43.551510	172.000101	170.00	1.80
OP 12	12	-43.550297	171.997709	171.00	1.80
OP 13	13	-43.547818	171.992844	174.00	1.80
OP 14	14	-43.535017	171.990537	187.00	3.60
OP 15	15	-43.532513	171.989057	190.00	1.80
OP 16	16	-43.530451	171.989100	192.00	1.80

Road Route Data

Name: Bealey Road-east of intersection
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.551901	172.024058	164.00	2.50	166.50
2	-43.551652	172.021419	166.00	2.50	168.50
3	-43.551341	172.018860	167.00	2.50	169.50
4	-43.551026	172.016221	168.00	2.50	170.50
5	-43.550743	172.013576	169.00	2.50	171.50
6	-43.550436	172.010931	170.00	2.50	172.50
7	-43.550144	172.008329	171.00	2.50	173.50
8	-43.549860	172.005792	171.00	2.50	173.50
9	-43.549537	172.003421	172.00	2.50	174.50

Name: Bealey Road -West of intersection
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.543954	171.978200	179.00	2.50	181.50
2	-43.545292	171.985045	178.00	2.50	180.50
3	-43.546956	171.993198	175.00	2.50	177.50
4	-43.548060	171.997554	173.00	2.50	175.50
5	-43.548869	172.000709	172.00	2.50	174.50
6	-43.549524	172.003194	172.00	2.50	174.50

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.556843	171.995086	166.00	2.50	168.50
2	-43.554665	171.997597	167.00	2.50	169.50
3	-43.552516	172.000011	169.00	2.50	171.50
4	-43.549594	172.003301	172.00	2.50	174.50

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-43.527521	171.986591	195.00	2.50	197.50
2	-43.529863	171.988264	193.00	2.50	195.50
3	-43.532282	171.989970	190.00	2.50	192.50
4	-43.533825	171.991110	188.00	2.50	190.50
5	-43.536246	171.992886	185.00	2.50	187.50
6	-43.538630	171.994573	181.00	2.50	183.50
7	-43.541058	171.996311	179.00	2.50	181.50
8	-43.542081	171.997062	178.00	2.50	180.50
9	-43.542917	171.998038	178.00	2.50	180.50
10	-43.544730	171.999556	176.00	2.50	178.50
11	-43.547109	172.001402	174.00	2.50	176.50
12	-43.549512	172.003365	172.00	2.50	174.50

Glare Analysis Results PV Array 1

PV: PV array 1 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Bealey Road-east of intersection	0	0.0	0	0.0
Bealey Road -West of intersection	0	0.0	0	0.0
Derretts Road	0	0.0	0	0.0
Struie Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0

PV: PV array 2 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Bealey Road-east of intersection	0	0.0	0	0.0
Bealey Road -West of intersection	0	0.0	0	0.0
Derretts Road	0	0.0	0	0.0
Struie Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0