Homestead Solar Project

Solar Glare Hazard Analysis Report

Client: Kiwetinohk Energy Corp.
Reference: 21-053
Version 1.0

November 2021

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Approved by	Stephanie Wood	Date	November 19, 2021

Issue History	Date	Details
V1.0	November 25, 2021	Final for Issue

Executive Summary

Kiwetinohk Energy Corp. (KEC) is developing a utility-scale solar photovoltaic project called the Homestead Solar Project (the Project). The Project is located approximately 12.5 kilometres southeast of the Town of Claresholm in the Municipal District of Willow Creek No. 26, Alberta. KEC retained Green Cat Renewables Canada Corporation (GCR) to conduct a solar glare hazard analysis for the potential of glare at dwellings and along transportation routes near the Project.

GCR utilizes ForgeSolar's GlareGauge software to assess user-input PV arrays for potential glare on identified roadways, dwellings, and aviation assets. The software evaluates the occurrence of glare on a minute-by-minute basis. If glare is predicted, each minute of glare as a function of retinal irradiance and subtended angle is plotted on a hazard plot. Retinal irradiance and subtended angle predict the ocular hazard associated with the glare as either green (low potential for after-image), yellow (potential for temporary after-image), or red (potential for retinal damage). The software does not consider obstacles such as trees, hills, buildings, etc. between the PV array and glare receptor.

GCR followed the guidelines provided in Alberta Utilities Commission updated Rule 007 for the receptors to be included in a solar glare assessment but notes that Rule 007 does not specify any modelling parameters or glare threshold limits.[1] GCR also referred to the information provided in Zehndorfer Engineering's Solar Glare and Glint Project Report,[2] which was written to inform the AUC's update to Rule 007, and precedent set by recent AUC proceedings.

GCR evaluated the area within 4,000m of the Project for aerodromes and within 800m for any other receptors. The assessment considered the following receptors near the Project:

- Seven residences; and
- Four local roads.

The glare analysis indicates that the Project is not likely to have the potential to create hazardous glare conditions for the dwellings or transportation routes assessed. None of the receptors evaluated are expected to experience glare of any level from the Project. As no glare is predicted, mitigation is not required.

[1] AUC Rule 007: *Applications for Power Plants, Substations, Transmission Lines, Industrial System Designations, Hydro Developments and Gas Utility Pipelines*, subsection 4.3.2 SP14, (September 2021).

[2] *Solar Glare and Glint Project* (Zehndorfer Engineering, September 2019).

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1 Introduction

Kiwetinohk Energy Corp. (KEC) retained Green Cat Renewables Canada Corporation (GCR) to conduct a solar glare hazard analysis for the Homestead Solar Project (the Project). The solar photovoltaic (PV) project is located approximately 12.5 kilometres southeast of the Town of Claresholm in the Municipal District of Willow Creek No. 26, Alberta. The proposed solar Project will have a total capacity of 400 megawatts (MW_{AC}), utilizing a fixed tilt racking system.

The assessment considers the glare impact of the Project on dwellings and roadways within approximately 800 metres of the site. The evaluated roads include Township Road 120, Township Road 122, Range Road 254, and Range Road 260.

There are no registered aerodromes within 4,000 metres of the Project. GCR conducted a high-level search for unregistered aerodromes within 4,000 metres of the Project but did not find any.

Glint and glare refer to light reflected off smooth surfaces, either momentarily and intense (glint) or less intense for a more sustained period (glare). Solar PV technology is specifically designed to absorb as much sunlight as possible and modules are generally coated in an anti-reflective coating. Solar PV sites have been developed alongside major transport routes and airports around the world, including adjacent to road infrastructure. This suggests that solar PV technology, such as the Georgetown Solar Project, can safely coexist with roads and airports.

It is considered that a developer, in this case KEC, should provide safety assurances regarding the full potential impact of the installation on routes, roads, and dwellings in the form of a glare assessment

2 Background Information

The potential for glint and glare from solar PV modules on the surrounding roads, residential properties and nearby aerodromes should be fully considered when planning a solar project.

Glint and glare are both caused by the reflection of light from a surface, in this case sunlight from a solar module. Glare is caused by a continuous but less intense reflection of a bright light, whereas glint is caused by a strong, momentary reflection of sunlight. Reflections from smooth surfaces produce more direct "specular" reflections, and rougher surfaces disperse the light in multiple directions, creating "diffuse" reflections. Figure 2-1 shows these two types of reflections from a solar PV module.

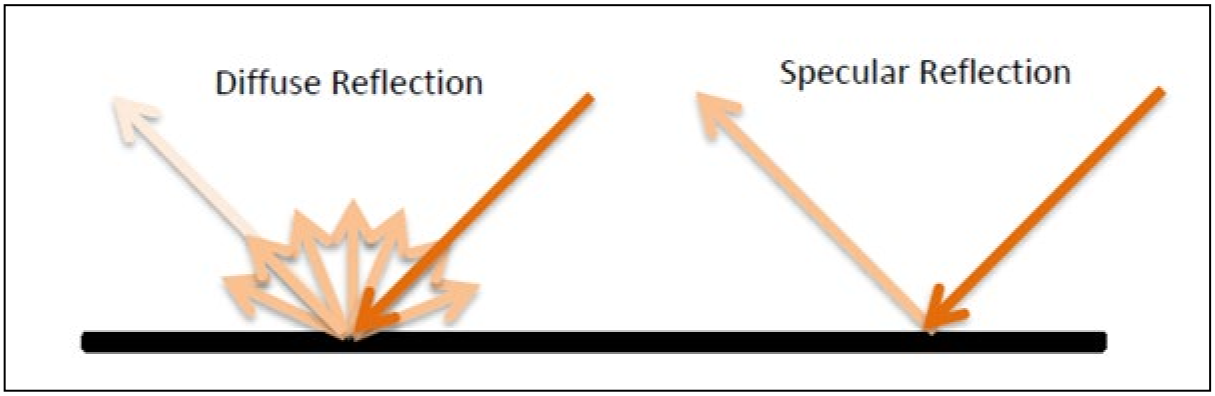

Figure 2-1 – Types of light reflection from solar modules

Calculation of potential glare requires the azimuth and elevation angle of the sun, and the consequent angles of incidence and reflection at the array, at all times throughout the year.

The angle of incidence is the angle at which the sun strikes the module (measured from normal/perpendicular to the surface). The angle of reflection is equal and opposite the angle of incidence. Light transmission through the glass and absorption by the PV module is greatest when the light is normal to the glass surface, while more light is reflected at shallower angles. As shown in Figure 2-2 a low incidence angle in a fixed tilt system is associated with the sun being high in the sky such that the sun's rays are shining at close to a right angle with the module surface. The highest incidence angles will occur in the early morning and late evening when the sun is low in the sky.

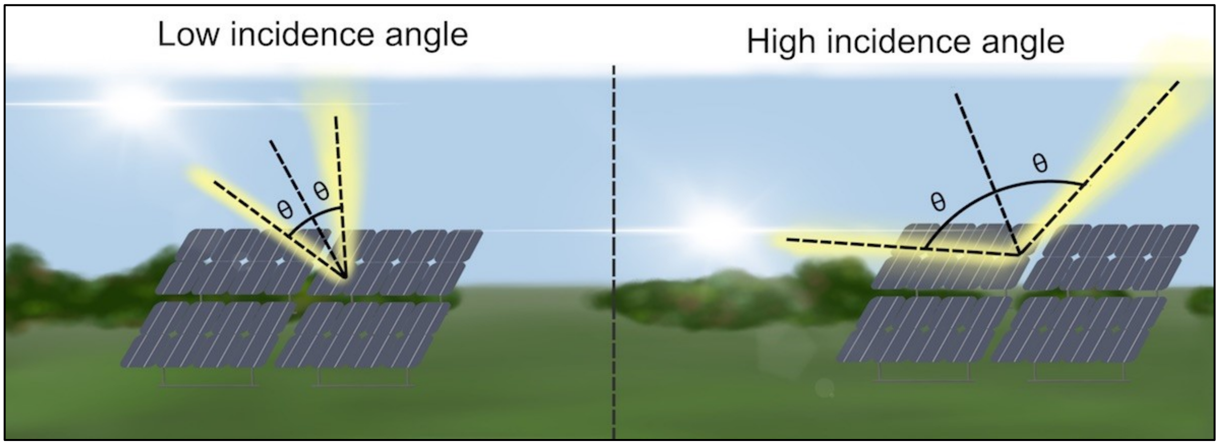

Figure 2-2 – Angles of incidence relative to Sun's position

Throughout the day the sun will track across the sky; therefore, the angle at which the light is incident on the module will vary. Figure 2-3 shows the two angles (azimuth and elevation/zenith) required to define the orientation of the sun with respect to the solar module.

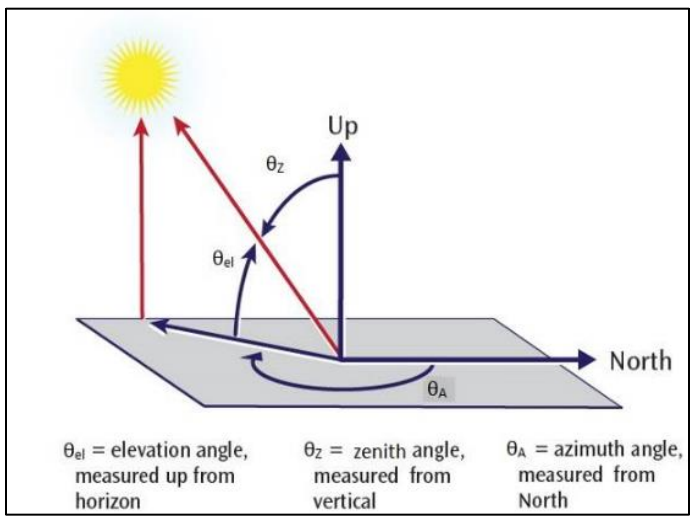

Figure 2-3 – Sun's position relative to solar module

There are many factors that affect the glare level. These include but are not limited to:

- The type of solar module
- The module's tilt angle and orientation
- Size of solar development
- Shape of solar development
- Location of solar development
- Distance between solar development and observer
- Angle to observer
- Relative height of observer

Single-axis tracking systems will often include a backtracking function. At low sun elevation angles, high array tilt angles will result in shading from rows nearer the sun on those behind them. To mitigate consequent production losses, the trackers will gradually tilt away from the sun back toward horizontal.

The following section describes the proposed development and the associated infrastructure in detail.

3 Project Description

The Project location is shown in **Figure 3-1**.

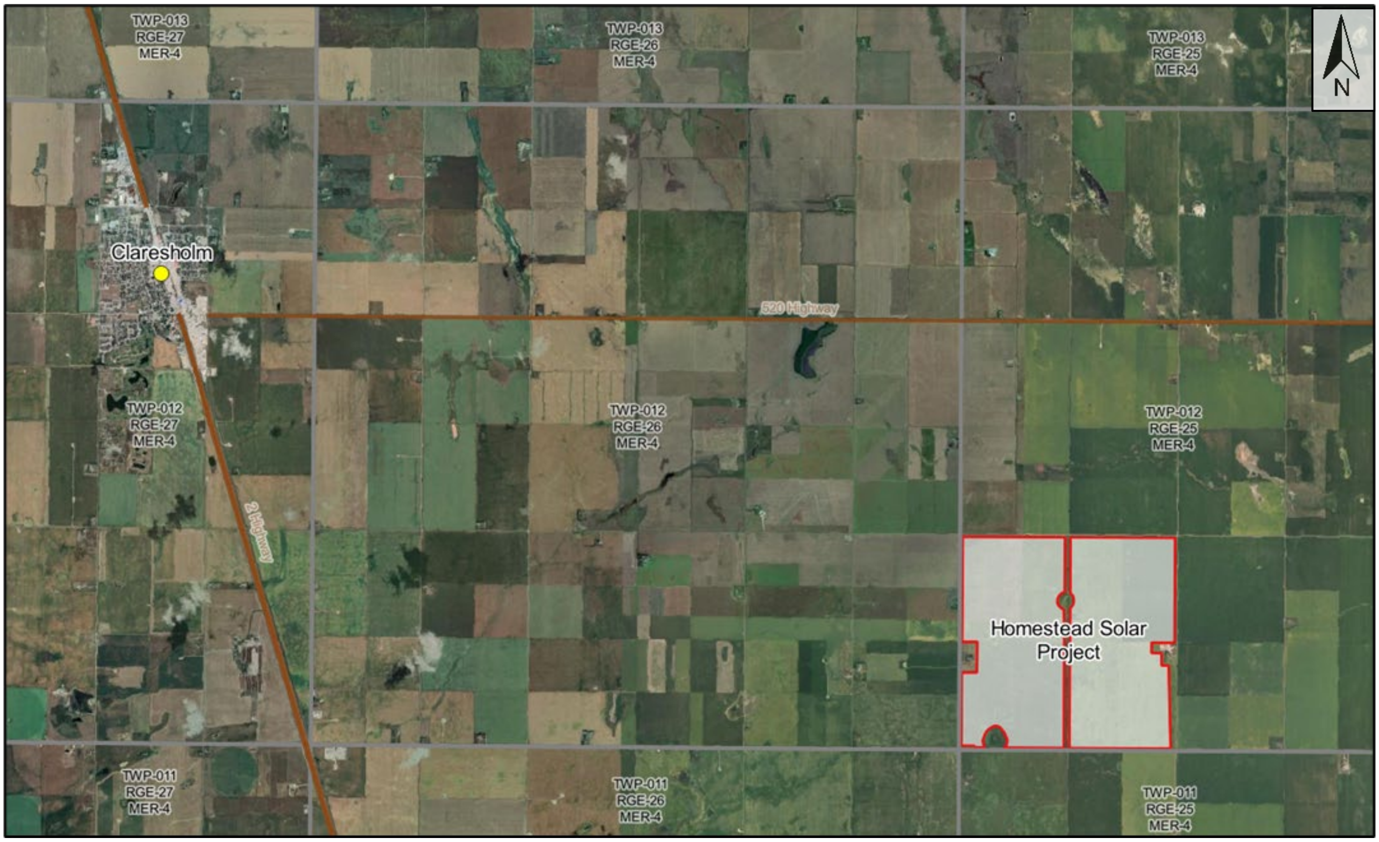

Figure 3-1 – Homestead Solar Project Location

The Project spans over 16 quarter sections of land and covers an area of approximately 640 acres with a total generating capacity of 400 MW_{AC}. The PV modules will be mounted on fixed tilt racking secured to the ground with piles.

4 Legislation and Guidance

There is currently no adopted legislation for assessing the impacts of glare for solar energy development in Alberta or Canada, and standardized guidance only specifies what receptors to include in an assessment without specifying acceptable thresholds.

The AUC have released an update to Rule 007 that states that solar glare assessment reports must include receptors within 800m from the boundary of the project and aerodromes within 4,000m from the boundary of the project.[3] It continues to state the following requirements:

- Describe the time, location, duration, and intensity of solar glare predicted to be caused by the project.
- Describe the software or tools used in the assessment, the assumptions, and the input parameters (equipment-specific and environmental) utilized.
- Describe the qualification of the individual(s) performing the assessment.
- Identify the potential solar glare at critical points along highways, major roadways, and railways.
- Identify the potential solar glare at any aerodrome within 4,000 metres from the boundary of the project, including the potential effect on runways, flight paths and air traffic control towers.
- Include a map (or maps) identifying the solar glare receptors, critical points along highways, major roadways and railways, and aerodromes that were assessed.
- Include a table that provides the expected intensity of the solar glare (e.g., green, yellow, or red) and the expected duration of solar glare at each identified receptor, critical points along highways, major roadways and railways, and any registered and known unregistered aerodromes that were assessed.

This report will abide by the requirements in Rule 007; suggestions made in Zehndorfer Engineering's Solar Glare and Glint Project Report from September 2019;[4] and precedent set by recent AUC proceedings.

As observed in the Zehndorfer document, solar glare assessments in Canada typically utilize Sandia National Laboratories' Solar Glare Hazard Analysis Tool (SGHAT) through ForgeSolar's software called GlareGauge. The Zehndorfer report notes that: "*the typical Solar Glare Assessment in Canada consists of more than just the plain SGHAT report. It describes the geometric situation, highlights glare duration and suggests glare-reducing measures*."[5] This approach has been adopted for this assessment.

The Zehndorfer report also comments that: "*with respect to dwellings, geometrical considerations can be useful. The inclination angle towards a window makes a difference, because light rays perpendicular towards the glass will penetrate the window, while window recesses will shade flat-angled rays of light*."[6]

In addition to Zehndorfer's report, the US Federal Aviation Administration (FAA) have provided the Technical Guidance for Evaluating Selected Solar Technologies on Airports. 7 This document, last updated in April 2018, states that potential for glare might vary depending on site specifics such as existing land uses, location, and size of the project.

[3] AUC Rule 007: *Applications for Power Plants, Substations, Transmission Lines, Industrial System Designations, Hydro Developments and Gas Utility Pipelines* (September 2021), subsection 4.3.2 SP14.

[4] *Solar Glare and Glint Project* (Zehndorfer Engineering, September 2019).

[5] *Solar Glare and Glint Project* (Zehndorfer Engineering, September 2019), PDF page 8.

[6] *Solar Glare and Glint Project* (Zehndorfer Engineering, September 2019), PDF page 6.

[7] *Technical Guidance for Evaluating Selected Solar Technologies on Airports* (FAA, April 2018), pg. 40.

A geometric analysis may be required to assess any reflectivity issues coming from the solar modules. FAA guidelines have also been informed by the 2015 study, Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach, by Rogers, et al. This study concludes that glare of sufficient size and intensity in an airplane pilot's view, within ±25° of heading, may have an adverse impact on the pilot's ability to read their instruments or land their plane. The study also indicates that glare beyond ±50° of heading is not likely to impair a pilot.[8]

4.1 Geometric Analysis – Use of the Solar Glare Hazard Analysis Tool

The SGHAT is a validated tool specifically designed to estimate potential glare according to a Solar Glare Hazard Analysis Plot at a certain module height, tilt, type, and observer location. ForgeSolar's GlareGauge/SGHAT software allows for the analysis of potential glare on flight paths, routes, and stationary observation points. It is widely accepted as the most comprehensive tool to assess potential glare impacts on receptors near solar power projects. The Zehndorfer report reviewed several glare software packages that may be used to assess solar PV glare, including ForgeSolar's GlareGauge/SGHAT. The report does not make a specific recommendation, but the findings suggest that the SGHAT is the most accessible tool of those evaluated, and the most robust with respect to the output information.[9]

[8] *Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach* (Rogers, J. A., et al., July 2015).
[9] *Solar Glare and Glint Project* (Zehndorfer Engineering, September 2019).

5 Assessment Methodology

The SGHAT is configured to enable an analysis on flight paths using a 2-mile approach to a runway when landing. No airports were reported within 4,000m of the Project, so no airplane flight paths were included in this assessment.

Decision 25296-D01-2021 set out the AUC's understanding of the viewing angles relevant to pilots: *"The Commission understands the FAA study to conclude that yellow-grade glare has an adverse effect on pilots within a +/- 25 degree viewing angle range and that yellow-grade glare between 25 and 50 degrees has the potential to adversely affect pilots"*.[10]

This suggests that flight paths approaching a runway should model a pilot's perspective looking straight out the cockpit windshield with a peripheral range of ±50° to provide context on potential glare during final descent. Further analysis of a narrower ±25° field-of-view (FOV) encompasses the region where a pilot's vision is more susceptible to glare impacts. Glare occurring outside of this range is less likely or not expected to adversely impact a pilot.[11]

For ground-based routes, the Zehndorfer report recommends modelling the FOV within ±15° from the vehicle operator's heading.[12] This covers the region where a person's vision will be most focussed, which is the critical area of concern. A more conservative ±25° FOV can also be modelled to identify routes that may be peripherally impacted by glare. This wider FOV is based on the information presented in the Rogers FAA report for airplane pilots, adapted to suit vehicle operators using ground-based routes. Both passenger and commercial vehicles are considered in the analysis.

In line with AUC Rule 007's guidelines (effective September 2021) for choosing receptors to include in a solar glare analysis, the assessment evaluated:

- Seven residences; and
- Four local roads.

Note, if the modules are not visible to the individual receptor, then no glare can be observed at that receptor.

5.1 Assessment Input Parameters

The solar arrays, observation points, and transportation routes were plotted using an interactive Google map, and site-specific data was entered into the software prior to modelling. The following sections provide details of the parameters specified for the analysis calculations in the GlareGauge software.

[10] Decision 25296-D01-2021 (AUC, February 11, 2021), para. 53.
[11] *Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach* (Rogers, J. A., et al., July 2015).
[12] *Solar Glare and Glint Project* (Zehndorfer Engineering, September 2019).

5.1.1 PV Array

The general PV array area was plotted on the interactive Google map as shown in **Figure 5-1**. The Project was split into six sub-arrays to avoid conflict between complex array geometry and software calculation limitations, while also providing additional detail in areas with greater topographical variation. The modelled sub-arrays include more land than the proposed PV array coverage, which results in a more conservative analysis.

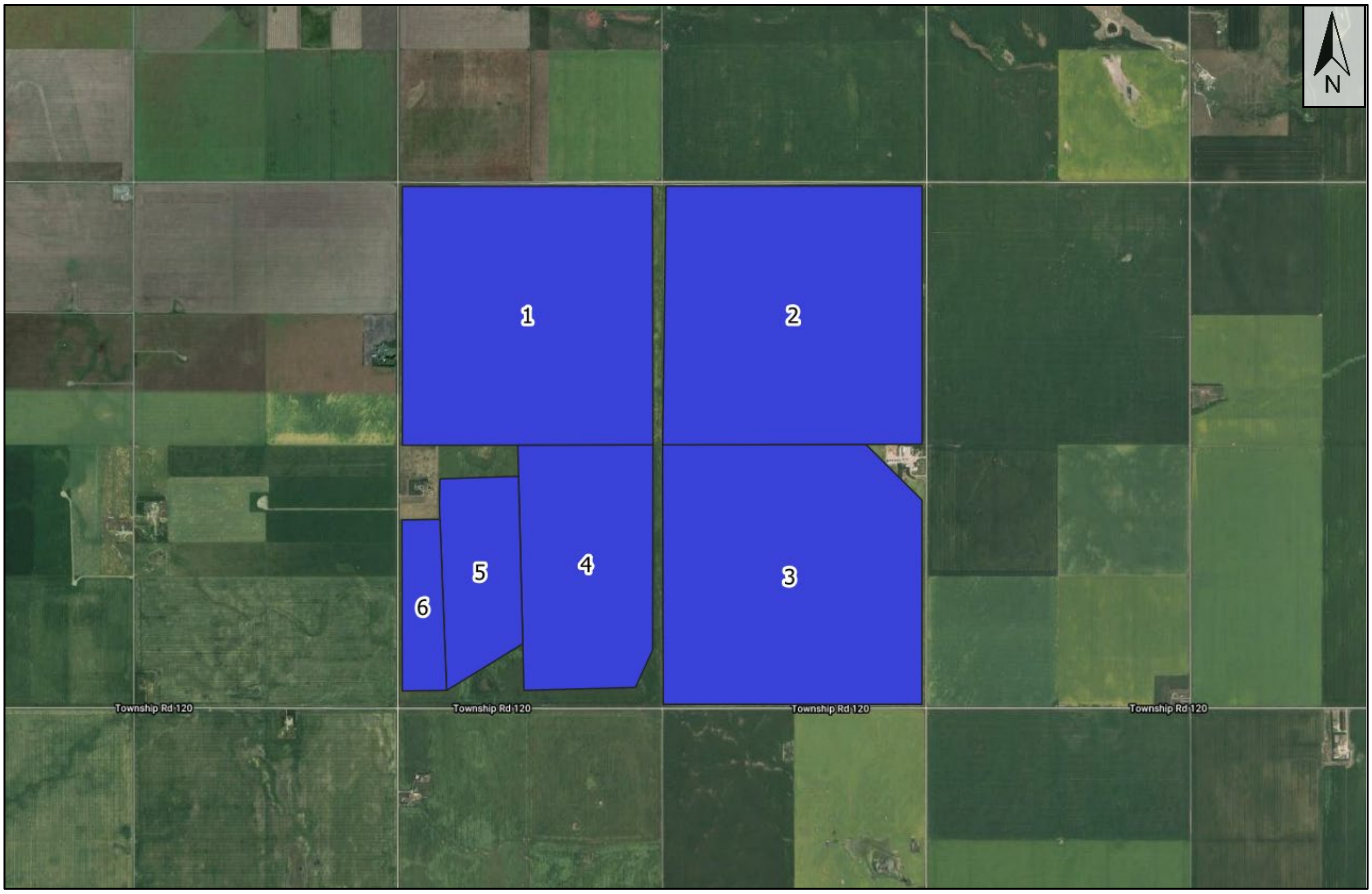

Figure 5-1 – General PV array areas plotted in GlareGauge Software

The Project details in **Table 5-1** were specified in the model.

Table 5-1 – PV Array Specified Parameters

Required Inputs	Specified Parameters	Description
Axis Tracking	Single Axis Rotation	Deploys a tracking system oriented one-way
Tilt of Tracking Axis	0°	Elevation angle of tracking axis with 0° being faced up (flat) parallel to the ground
Orientation	180° (south)	Azimuthal position measured from true north
Maximum Tracking Angle	52°	Rotation limit of modules in each direction
Resting Angle	5°/15°/25°/52°	Rotation angle of modules outside of the determined range (backtracking angle). 52° represents no backtracking.
Offset Angle	0°	Additional elevation angle between tracking axis and modules
Module Surface Material	Smooth glass with anti-reflective coating	Surface material of modules
Minimum Module Height Above Ground	1.4m	Height of the array centroid point

Solar PV modules are designed to maximize light absorption and conversion to electricity. Specifying different types of glass and coatings used on the modules can affect a system's energy production and glare potential. Smooth glass with anti-reflective coatings will generally reflect less light, i.e., create less glare, than uncoated glass.

The backtracking operation of the single-axis tracking system has been considered in this analysis. The GlareGauge evaluation of backtracking is a simplified approximation of actual behaviour, so four cases were modelled. The first case analyzed the system without backtracking applied (52°) when the sun's elevation is below the normal tracking range. The other cases applied tracking angles of 5°, 15°, or 25° during backtracking periods to approximate the average angle that the trackers would utilize throughout the year.

The centroid height is modelled instead of the top or bottom of the module as this captures the most representative prediction of glare levels. Using the module top or bottom may result in an over or underestimate of glare impact as this does not account for the change in module height due to rotation.

5.1.2 Route Paths

Four route paths were evaluated for glare impacts from the Project in this assessment, specifically four local roads adjacent to the Project. Sections of Township Road 120, Township Road 122, Range Road 254 and Range Road 260 near the Project boundary were modelled as two-way routes to represent vehicles travelling in both possible directions. **Figure 5-2** shows the routes in relation to the Project.

Two horizontal viewing angles were evaluated for motorists: ±15° and ±25° (30° and 50° total FOV). The ±15° range encompasses the region where a person's vision will be most focussed, which is the critical area of concern.[13] The ±25° range is a more conservative view that indicates the routes that may be impacted by glare. The road routes were set at 1.5m elevation to represent the typical height of passenger vehicles and 3.0m to represent the typical height of commercial trucks. Commercial vehicles are typically more susceptible to glare than passenger vehicles due to their increased height.

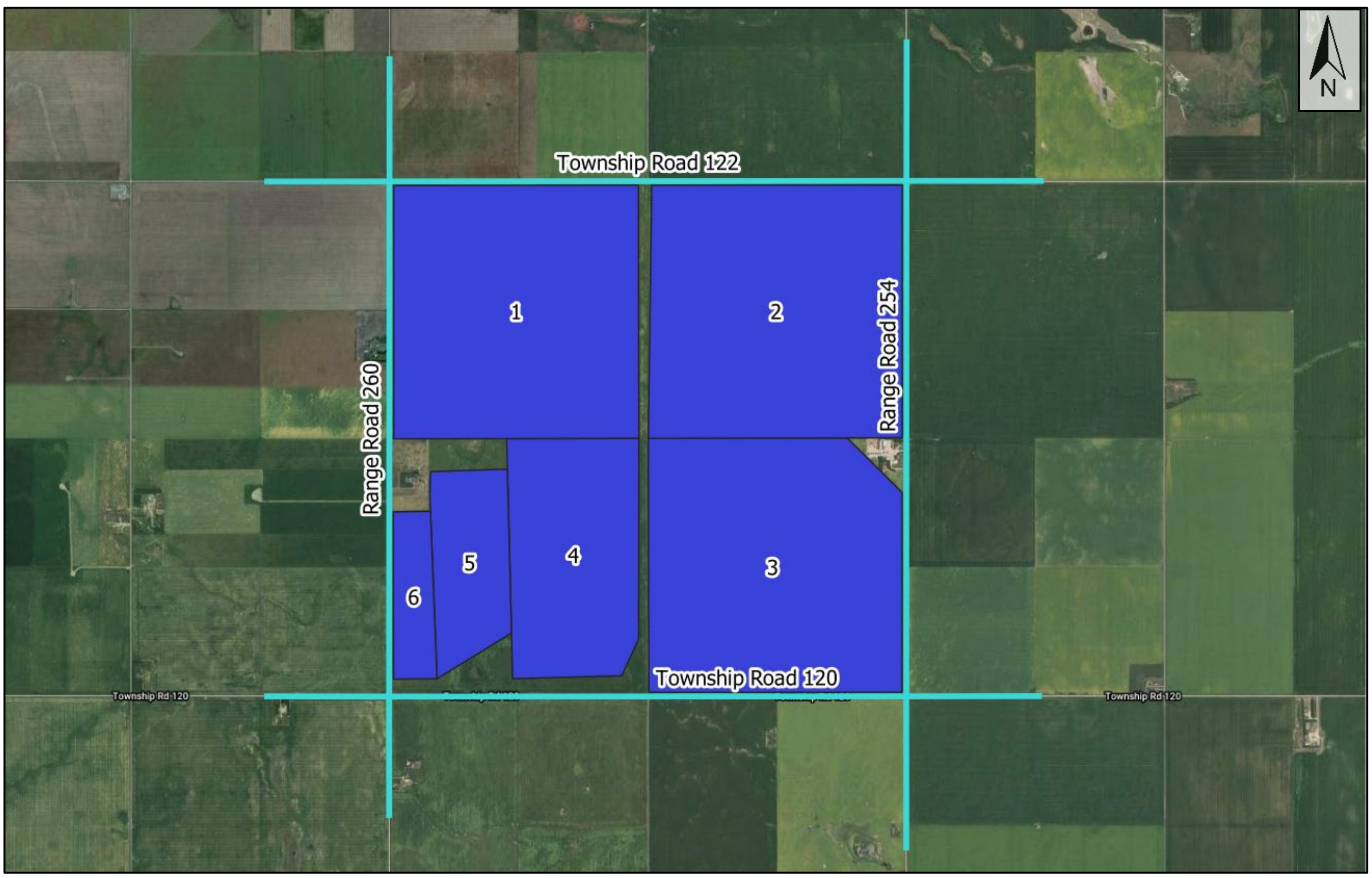

Figure 5-2 – Roads near the Project

[13] *Solar Glare and Glint Project* (Zehndorfer Engineering, September 2019).

5.1.3 Dwellings

Seven dwellings were assessed within approximately 800m of the Project boundary. GCR conducted a site visit in November 2021 to determine the existence and heights of the surrounding residences. Dwellings were modelled at 1.5m above ground for single-storey buildings, and 4.5m above ground for two-storey buildings to represent a scenario where an observer can see the Project from a window. To provide a conservative assessment, any dwellings with the potential to be considered as higher than a one-storey dwelling were modelled at a two-storey elevation of 4.5m. The model assumes that receptors have an unobstructed view of the arrays, i.e., the view is not affected by any part of the building being evaluated. **Figure 5-3** shows the dwellings in relation to the Project.

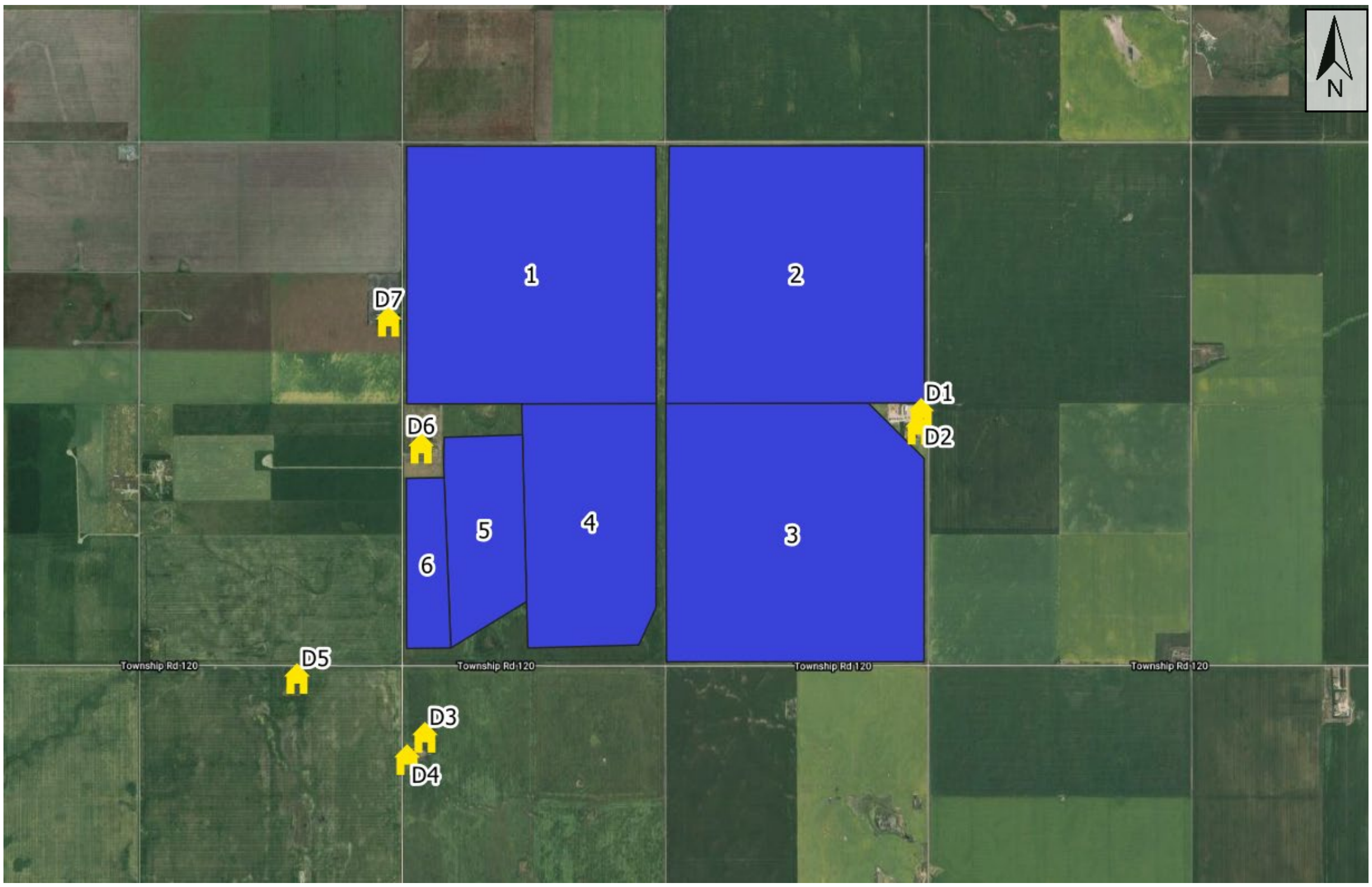

Figure 5-3 – Dwellings near the Project

5.1.4 Other Assumptions

The following assumptions have been made in setting the parameters for this analysis:

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors that may mitigate impacts. This includes buildings, tree cover and geographic obstructions.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values may differ.
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare analysis does not account for change in weather patterns. It is assessed as clear sunny skies throughout the year.
- To increase accuracy of modelling results, parts of the array may be divided into sub-sections if the footprint covers a large surface area with drastic elevation changes, or to avoid concave outlines.
- Average backtracking angles of 5°, 15°, and 25° were assumed, based on understanding of similar tracking systems in Alberta. These angles generally occur more frequently throughout the year during backtracking periods, but it is also important to note that the trackers will rotate continuously across a range of angles between horizontal and the maximum tracking angle. Section 5.2.1 further explains the limitations of ForgeSolar's backtracking algorithm
- Default parameters, as alluded to in the following section, highlight ocular metrics used in this assessment as has been acceptable according to the Sandia National Laboratories methodology on assessing potential glint and glare hazards.[14] These are shown below in Table 5-2.

Table 5-2 – Default Parameters

GlareGauge Parameters	
Direct Normal Irradiance, DNI (amount of solar radiation received in a collimated beam on a surface normal to the sun during a 60-minute period)	Varies and peaks at 1000 W/m^2
Ocular Transmission Coefficient (absorption of radiation within the eye before it reaches the retina)	0.5
Pupil Diameter (Typical daylight adjusted length)	0.002m
Eye Focal Length (distance where rays intersect in the eye)	0.017m
Sun Subtended Angle	9.3 mrad

[14] Ho, C.K., C.M. Ghanbari and R.B. Diver, 2011, *Methodology to Assess Potential Glint and Glare Hazards from Concentrating Solar Power Plants: Analytical Models and Experimental Validation*, Journal of Solar Energy Engineering-Transactions of the ASME, 133 (3).

5.2 Glare Analysis Procedure

GCR calculated the potential glare for observation points and route receptors using the SGHAT. Although effects from glare are subjective, depending on variables such as a person's ocular parameters and size/distance from the glare source, the SGHAT has a generalized approach to specify the hazard that glare may produce. GCR's commentary on the levels of glare found and related sources of mitigation, if required, are intended to help decision makers evaluate potential impacts.

The SGHAT User's Manual v3.0 states that: "*If glare is found, the tool calculates the retinal irradiance and subtended source angle (size/distance) of the glare source to predict potential ocular hazards ranging from temporary after-image to retinal burn. The results are presented in a simple, easy-to-interpret plot that specifies when glare will occur throughout the year, with color codes indicating the potential ocular hazard.*"[15]

The colour codes are based on a red, yellow, and green structure to categorize the level of risk to a person's eyes. Glare classification is dependent on the glare intensity and the apparent size of the glare area as viewed from the eye. The severity of glare is proportional to the effects of an after-image, which can be described as a lingering image of glare in the field-of-view, or a flash blindness when observed prior to a typical blink response time. The descriptions for each category are as follows:

- Green: Glare is present but there is a low potential for temporary after-image;
- Yellow: Glare is present with the potential for temporary after-image; and
- Red: Glare is present with the potential for permanent eye damage.

The level of glare is derived using the graph below that plots the level of irradiance against the angle that is occupied by the glare in the field-of-view.

ForgeSolar have developed a plot to categorize glare based on its intensity at the eye and its size in the observer's field-of-view. The plot is divided into the red, yellow, and green regions described above. The hazard associated with directly viewing the sun unfiltered is also plotted for comparison. Figure 5-4 shows an example of the hazard plot.

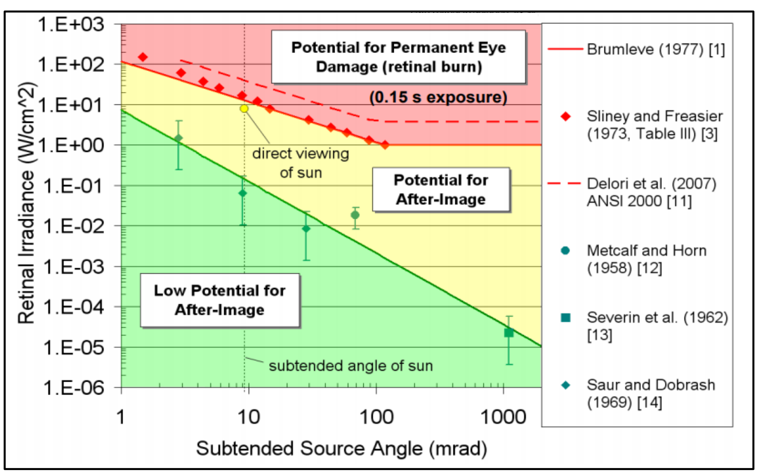

Figure 5-4 – Hazard plot depicting the retinal effects of light

15 *Solar Glare Hazard Analysis Tool (SGHAT) User's Manual v 3.0* (Ho and Sims, Sandia National Laboratories, 2016).

Ho et al. developed a model to estimate potential impacts to eyesight with regards to retinal irradiance (amount of light entering the eye and reaching the retina) and subtended source angle (the size of the glare divided by the distance from the emitting source). Significant damage, including retinal burn, may occur at high retinal irradiances and large subtended angles. This is highlighted in the red region. The yellow section denotes the potential for a temporary after-image. The size and impact of the after-image is dependent upon the subtended source angle.[16] At a low retinal irradiance and small subtended angle, the hazard will be in the green section where there is very low potential for after-image.

5.2.1 Limitations

The SGHAT will convert the footprint of a concave polygon to a convex polygon.[17] For example, an array that is in the shape of a 'C' has a concave section and GlareGauge will modify the 'C' shape into a semi-circle. By closing the 'C' shape, the size of the PV array is increased thus potentially over-estimating the size of the array, and consequently over-predicting the glare effects. This change in geometry is required by the glare-check algorithm during analysis. PV arrays with significant concavities should be modelled as multiple arrays to avoid over-estimating the size of the PV array and the resultant glare. The limitations of the software have been carefully considered to ensure the PV array is not concave in order to represent the glare impacts as accurately as possible.

An unavoidable limitation of the SGHAT is that a "*random number of computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including [air traffic control towers].*"[18]

For SAT systems, ForgeSolar states that their software "*utilizes a simplified model of backtracking which assumes modules instantaneously revert to the resting angle whenever the sun is outside the rotation range. For example, modules with max tracking angle of 60° and resting angle of 0° would lie flat from sunrise until the sun enters the rotation range, and immediately after the sun leaves the rotation range until sunset daily*."[19] This means that the continuous rotational motion of the SAT system during backtracking periods is not natively modelled by the SGHAT. Therefore, the base results of the backtracking angle cases do not necessarily provide the actual amount of glare expected. Instead, the results from these models indicate the potential for glare during backtracking periods.

Wind probabilities are also not considered by the SGHAT, so special operations that change the tilt of a SAT system are not modelled by the software. This includes functions like "stow mode" where arrays will be tilted closer to horizontal to reduce wind loading during high wind events. Special SAT system operations will utilize different tilt angles than standard operations, causing glare results to deviate from the values predicted by the SGHAT; however, non-standard operations are expected to occur so infrequently that it is unreasonable to include them in a general glare assessment.

[16] *Evaluation of glare at the Ivanpah Solar Electric Generating System* (C.K. Ho et al., Elsevier Ltd., 2015).
[17] ForgeSolar "Help" page. Retrieved October 22, 2021.
[18] ForgeSolar "Help" page. Retrieved October 22, 2021.
[19] ForgeSolar "Help" page. Retrieved October 22, 2021.

6 Assessment of Impact

The following section presents the findings of the glare assessment. The results are factual based on the model parameters used, which are considered to be conservative and as reasonable as possible. AUC Rule 007 provides guidelines for the receptors to be included in a solar glare assessment, but modelling parameters and glare threshold limits are not specified. Therefore, this analysis also considers the principles laid out in the Zehndorfer Engineering Report[20] and recent AUC proceedings, as described previously in this report.

The GlareGauge software considers the glare potential for a full one-year period in one-minute intervals to account for the variations between seasons, DNI, and sun angle.

6.1 Route Path Results

The tables below present the glare results for the route paths assessed from the array centroid heights. Results are shown for passenger and commercial road vehicles at 1.5m and 3.0m above ground, respectively. Results in **Table 6-1** used a ±15° FOV, which was modelled to capture potential glare within a vehicle operator's critical visual range. Results in **Table 6-2** were evaluated with a ±25° horizontal FOV to highlight routes that may experience glare from an extended visual range. Equivalent levels of glare within ±15° will have a greater impact on the observer than glare outside that range.

Table 6-1 – Annual route path glare levels for passenger and commercial vehicles, ±15° FOV

Component	Green Glare (min/year)				Yellow Glare (min/year)				Red Glare (min/year)			
Backtracking	None	5°	15°	25°	None	5°	15°	25°	None	5°	15°	25°
Township Road 120 (passenger)	0	0	0	0	0	0	0	0	0	0	0	0
Township Road 120 (commercial)	0	0	0	0	0	0	0	0	0	0	0	0
Township Road 122 (passenger)	0	0	0	0	0	0	0	0	0	0	0	0
Township Road 122 (commercial)	0	0	0	0	0	0	0	0	0	0	0	0
Range Road 254 (passenger)	0	0	0	0	0	0	0	0	0	0	0	0
Range Road 254 (commercial)	0	0	0	0	0	0	0	0	0	0	0	0
Range Road 260 (passenger)	0	0	0	0	0	0	0	0	0	0	0	0
Range Road 260 (commercial)	0	0	0	0	0	0	0	0	0	0	0	0

[20] *Solar Glare and Glint Project* (Zehndorfer Engineering, September 2019).

Table 6-2 – Annual route path glare levels for passenger and commercial vehicles, ±25° FOV

Component	Green Glare (min/year)				Yellow Glare (min/year)				Red Glare (min/year)			
Backtracking	**None**	**5°**	**15°**	**25°**	**None**	**5°**	**15°**	**25°**	**None**	**5°**	**15°**	**25°**
Township Road 120 (passenger)	0	0	0	0	0	0	0	0	0	0	0	0
Township Road 120 (commercial)	0	0	0	0	0	0	0	0	0	0	0	0
Township Road 122 (passenger)	0	0	0	0	0	0	0	0	0	0	0	0
Township Road 122 (commercial)	0	0	0	0	0	0	0	0	0	0	0	0
Range Road 254 (passenger)	0	0	0	0	0	0	0	0	0	0	0	0
Range Road 254 (commercial)	0	0	0	0	0	0	0	0	0	0	0	0
Range Road 260 (passenger)	0	0	0	0	0	0	0	0	0	0	0	0
Range Road 260 (commercial)	0	0	0	0	0	0	0	0	0	0	0	0

There is no red, yellow, or green glare predicted for any of the roads when assessed at the array centroid height, with, or without backtracking.

6.2 Dwelling Results

The dwellings were assessed at 1.5m and 4.5m above ground to represent an observer viewing the Project from a single-storey and second-storey window respectively. **Table 6-3** below provides the glare results for the dwellings assessed at the array centroid height.

Table 6-3 – Annual glare levels for dwellings near the Project

Component	Green Glare (min/year)				Yellow Glare (min/year)				Red Glare (min/year)			
Backtracking	None	5°	15°	25°	None	5°	15°	25°	None	5°	15°	25°
D1 (one-storey)	0	0	0	0	0	0	0	0	0	0	0	0
D2 (one-storey)	0	0	0	0	0	0	0	0	0	0	0	0
D3 (two-storey)	0	0	0	0	0	0	0	0	0	0	0	0
D4 (one-storey)	0	0	0	0	0	0	0	0	0	0	0	0
D5 (two-storey)	0	0	0	0	0	0	0	0	0	0	0	0
D6 (one-storey)	0	0	0	0	0	0	0	0	0	0	0	0
D7 (two-storey)	0	0	0	0	0	0	0	0	0	0	0	0

There is no red, yellow, or green glare predicted for any of the dwellings when assessed at the array centroid height, with, or without backtracking.

7 Summary

Solar modules are specifically designed to absorb light rather than reflect it. Moreover, most modules are now manufactured with anti-reflective coatings that help further mitigate the intensity of reflections.

The assessment of the Homestead Solar Project was undertaken using GlareGauge software. The results are based on the assumptions and limitations set out in previous sections of this report. The arrays were modelled at a centroid height of the single-axis trackers with a maximum tracking angle of 52°. This analysis included scenarios with backtracking at 5°, 15°, 25°, and without backtracking.

The ground-based route paths assessed for glare impacts included both directions of travel on Township Road 120, Township Road 122, Range Road 254 and Range Road 260 within approximately 800m of the Project. The road routes were modelled at both passenger vehicle and commercial vehicle heights. All routes were evaluated with a horizontal viewing angle of ±15° to capture potential glare within a vehicle operator's critical visual range, as well as ±25° to identify routes that may observe peripheral glare. The ground-based routes are not expected to experience glare at any level from the Project.

Seven receptors were identified and evaluated in this assessment as representatives of all the dwellings within approximately 800m of the Project. One-storey buildings were evaluated at 1.5m above ground, and two-storey dwellings were evaluated at 4.5m above ground, to represent an observer looking out a window toward the Project. The dwellings are not expected to experience glare at any level from the Project.

As there are no aerodromes within 4,000m of the Project, no aerodromes were considered in this assessment.

8 Conclusion

In conclusion, the Homestead Solar Project is not likely to have the potential to create hazardous glare conditions for the dwellings or roads assessed. No glare is predicted to be experienced at any level from the Project at receptors assessed. As no glare is predicted, mitigation measures are not recommended.

9 Glare Practitioners' Information

Table 9-1 summarizes the information of the co-authors and technical reviewer of the solar glare hazard analysis.

Table 9-1 – Summary of Practitioners' Information

Name	Alex Van Horne	Jason Mah	Cameron Sutherland
Title	Project Manager	Renewable Energy EIT	Technical Director
Role	Glare Analyst, Co-Author	Glare Analyst, Co-Author	Technical Reviewer
Experience	• Analyst on 5+ glare assessments in Alberta • Technical support for AUC information requests and hearings • Technical support for the AUC as the Lead Application Officer on 15+ solar power plant proceedings in which glare was considered • BSc Chemical Engineering	• Analyst on 30+ glare assessments in Alberta and the USA • Technical support for AUC information requests and hearings • BSc Chemical Engineering	• Expert witness experience in technical solar development in Canada for Brooks II Solar Project, East Strathmore Solar Project, and Fox Coulee Solar Project • Technical oversight, technical review, or authorship of 30+ glare assessments for 20+ proceedings in Alberta • MSci Physics • MSc Renewable Energy Systems Technology

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