Sunrise Solar Project

Solar Glare Hazard Analysis Report

Client: Sunrise Solar Project LP
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Report Prepared for:
Sunrise Solar Project LP

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Executive Summary

Sunrise Solar Project LP (the Proponent) is developing a solar photovoltaic (PV) project called the Sunrise Solar Project (the Project). The Project site is located directly northwest of the Town of Pincher Creek, Alberta. The Project will use a single-axis tracking (SAT) system with a total capacity of up to 75-megawatts (MWAC). The Proponent retained Green Cat Renewables Canada Corporation (GCR) to conduct a solar glare hazard analysis for the potential of glare on receptors near the Project.

GCR utilizes ForgeSolar's GlareGauge software to assess user-input PV arrays for potential glare on identified roadways 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 (AUC) Rule 007 for the receptors to be included in a solar glare assessment but 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, Alberta Transportation guidelines,[3] and other relevant literature.

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:

- Twelve observation points representing nearby dwellings;
- Three highways;
- Four local roads; and
- Two registered aerodromes: the Pincher Creek Airport and the Pincher Creek Health Centre Heliport.

The glare analysis indicates that the Project is predicted to create green and/or yellow glare conditions for the dwellings, roads, airplane flight paths, and helicopter flight paths that were assessed. The actual glare impacts that will be experienced in the field along road routes, airplane flight paths, and helicopter flight paths are anticipated to be only a fraction of the results presented in this report. The actual impact is expected to be less because the observers will be travelling past the affected areas, not standing still while looking at the solar PV arrays. The impact of the glare on affected receptors may also be reduced by sun-masking as the glare occurs around sunrise/sunset when the sun aligns with the glare spot and observer, and the sunlight glances across the arrays at a shallow angle. The assessment is also conservative as it assumes that there are no existing obstructions between the sun and the Project, or between the predicted glare spots and observers, and that there are clear skies and bright sunshine throughout the day.

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[1] AUC Rule 007: *Applications for Power Plants, Substations, Transmission Lines, Industrial System Designations, Hydro Developments and Gas Utility Pipelines* (April 2022), subsection 4.4.2 SP14.

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

[3] *Assessment requirements for solar development near provincial highways* (Alberta Transportation, December 2021).

Based on the assessment results, glare from the Project will require mitigation to comply with precedent set by the AUC pertaining to glare along airplane flight paths.[4] GCR recommends a detailed mitigation plan be developed once the Project layout is finalized. Preliminary modelling and analysis indicate that glare mitigation may be achieved by limiting backtracking operations to a minimum angle of 7° or steeper to eliminate yellow glare within the critical viewing range of airplane flight paths. This backtracking limit is also expected to eliminate glare at all other receptors included in the assessment.

Only green glare is predicted along helicopter flight path (HP) 2, which is not generally considered to be a hazard, regardless of the FOV assessed. As such, no mitigation is recommended for glare along HPs at this time. If glare along final approach flight paths landing at the Pincher Creek Health Centre Heliport is raised as a concern once the Project is operational, implementing a minimum backtracking angle of 4° or steeper is expected to eliminate all glare from the Project within the ±25° FOV for HP2. Backtracking limits targeting mitigation of glare on airplane flight paths are also expected to eliminate glare on the evaluated helicopter flight paths.

Since Highway 507 is predicted to observe yellow glare in the evenings when the effect of this glare is expected to be diminished by sun-masking, no mitigation is recommended at this time. However, if glare is raised as a concern along Highway 507 during the Project's operation, mitigation measures may include limiting the resting angle to 2° or steeper to eliminate glare within the critical viewing range. Backtracking limits targeting mitigation of glare on airplane flight paths are also expected to eliminate glare along Highway 507.

Glare is not expected to have an adverse effect on a resident's use of their home, so mitigation is not expected to be required for residential receptors. Backtracking limits targeting mitigation of glare on airplane flight paths are also expected to eliminate glare at all assessed residential receptors.

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[4] *Decision 25296-D01-2021* (AUC, February 11, 2021), para. 53-56.

Table of Contents

1 Introduction

Sunrise Solar Project LP (the Proponent) retained Green Cat Renewables Canada Corporation (GCR) to conduct a solar glare hazard analysis for the proposed Sunrise Solar Project (the Project). The solar photovoltaic (PV) project is located directly northwest of the Town of Pincher Creek, Alberta, and will have a total capacity of up to 75-megawatts (MW_{AC}).

It is considered that a developer, in this case Sunrise Solar Project LP, should provide safety assurances regarding the full potential impact of the installation on nearby receptors in the form of a glare assessment.

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, as is the case with the modules selected for the Project. 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 that being used for the Project, can safely coexist with roads and aerodromes.

The assessment considers the glare impact of the Project on dwellings and ground transportation routes within 800m of the Project, and two aerodromes within 4,000m of the Project.

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.

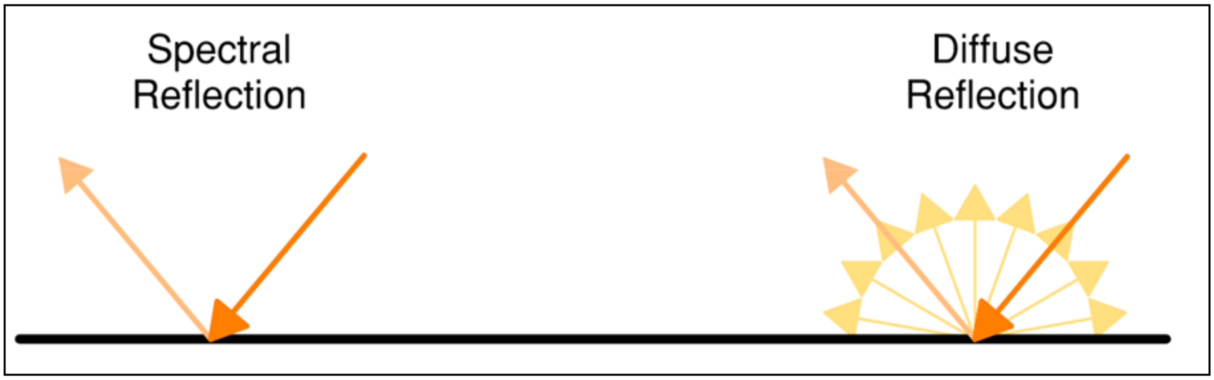

Figure 2-1 – Types of Light Reflection from Solar Modules

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.

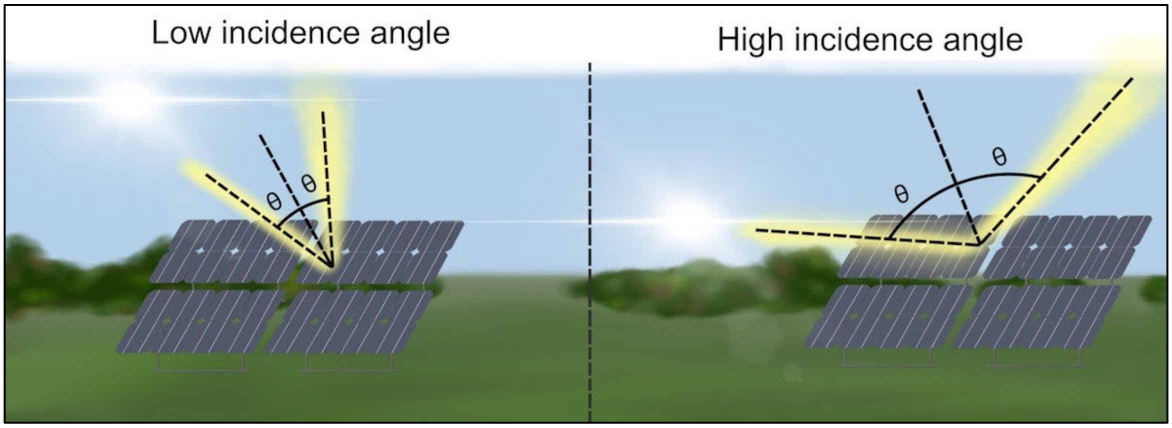

Figure 2-2 – Angles of Incidence relative to the Sun's Position

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.

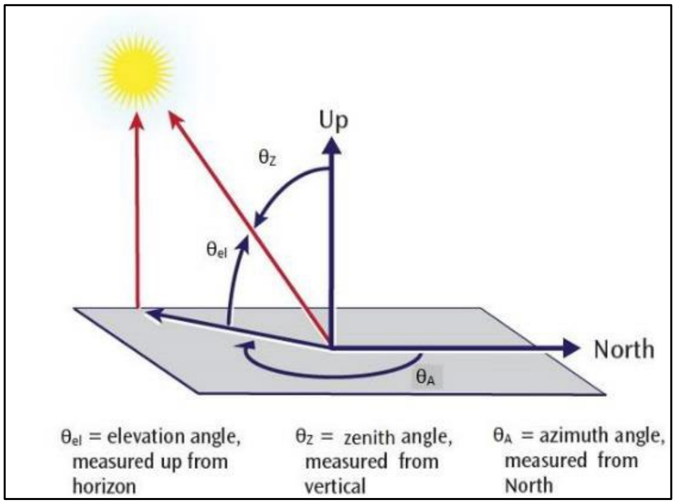

Figure 2-3 – Sun's Position relative to Solar Module

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 (SAT) systems will often include a backtracking function, as is the case with the system selected for the Project. 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 proposed Project site is located in the Municipal District of Pincher Creek No. 9, Alberta, directly northwest of the Town of Pincher Creek. The Project location relative to the Town of Pincher Creek is shown in **Figure 3-1**.

The Project has a total fenced area of approximately 520 acres (210 ha) with a total capacity of up to 75 MW_{AC}. The PV modules will be mounted on single-axis trackers secured to the ground with piles.

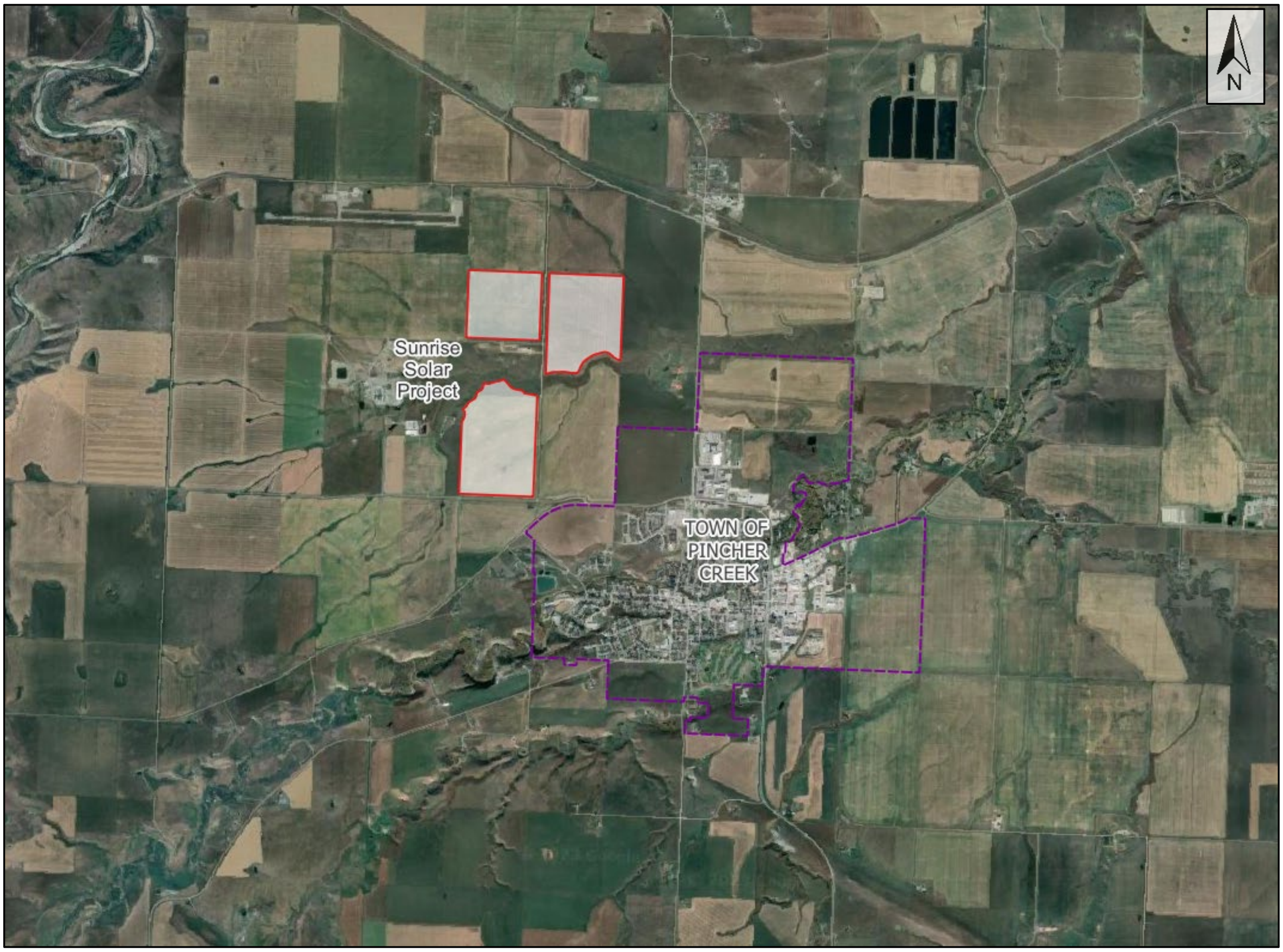

Figure 3-1 – Sunrise Solar Project Location

4 Legislation and Guidelines

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. Transport Canada publication TP1247E indicates that glare from solar arrays should be evaluated when proposed near aerodromes but does not provide additional specifications.[5]

The AUC's Rule 007 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.[6] 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.

Alberta Transportation developed requirements for the assessment of solar PV projects being proposed near provincial highways. The guideline is based on AUC Rule 007 with additional specifications for the assessment of roads. This includes vehicle heights, consideration of potential shading and sun-masking, and discussion of potential mitigation for glare predicted within ±15° of a driver's heading.[7]

This report will abide by: requirements in AUC Rule 007; suggestions made in Zehndorfer Engineering's *Solar Glare and Glint Project Report* from September 2019;[8] Alberta Transportation guidelines; and other relevant literature.

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."*[9] This approach has been adopted for this assessment.

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[5] *Aviation – Land Use in the Vicinity of Aerodromes – TP1247E* (Transport Canada, 2013/14).

[6] AUC Rule 007: *Applications for Power Plants, Substations, Transmission Lines, Industrial System Designations, Hydro Developments and Gas Utility Pipelines* (April 2022), subsection 4.4.2 SP14.

[7] *Assessment requirements for solar development near provincial highways* (Alberta Transportation, December 2021).

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

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

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.*"[10]

In addition to Zehndorfer's report, the US Federal Aviation Administration (FAA) have provided the *Technical Guidance for Evaluating Selected Solar Technologies on Airports*.[11] This document states that potential for glare might vary depending on site specifics such as existing land uses, location, and size of the project.

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.[12]

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.[13]

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

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

[12] *Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach* (Rogers, J. A., et al., July 2015).

[13] *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. Pincher Creek Airport and Pincher Creek Health Centre Heliport are located within 4,000m of the Project and were assessed.

The decision for Proceeding 25296 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*".[14] 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° and downward up to 30° below the approach vector 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.[15]

For ground-based routes, the Zehndorfer report recommends modelling the FOV within ±15° from the vehicle operator's heading.[16] 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. In line with Alberta Transportation guidelines,[17] passenger, truck, and commercial vehicle heights are considered in the analysis.

In line with AUC Rule 007's guidelines for choosing receptors to include in a solar glare analysis, the assessment evaluated the receptors listed below.

- Twelve observation points representing nearby dwellings;
- Three highways;
- Four local roads; and
- Two registered aerodromes: the Pincher Creek Airport and the Pincher Creek Health Centre Heliport.

There were no railways identified within 800m of the Project, so none were evaluated in this assessment. There are no other known solar power projects with shared receptors in the area, so a cumulative assessment was not completed.

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 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.

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[14] *Decision 25296-D01-2021* (AUC, February 11, 2021), para. 53.

[15] *Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach* (Rogers, J. A., et al., July 2015).

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

[17] *Assessment requirements for solar development near provincial highways* (Alberta Transportation, December 2021).

5.1.1 PV Array

The general PV array areas were plotted on the interactive Google map as shown in Figure 5-1. The Project was split into 10 sub-arrays to avoid conflict between complex array geometry and software calculations, while also providing additional detail in areas with greater topographical variation. The modelled 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 modelled sub-arrays were plotted to balance the influences of several factors on the glare modelling and results. Sub-array polygons were sized to be small enough to capture varying topographical changes, but large enough to allow for representative glare spot sizes. The modelled polygons were also designed to follow and be representative of the module layout, while also avoiding concave perimeters and including extra area to be conservative.

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

Table 5-1– PV Array Specified Parameters – Current Assessment

Required Inputs	Specified Parameters	Description
Axis Tracking	Single	Modules are mounted on single-axis trackers
Tilt of Tracking Axis	0°	Elevation angle of tracking axis with 0° being faced up (flat) parallel to the ground
Orientation	180°	Azimuthal position measured from true north
Maximum Tracking Angle	50°	Rotation limit of the arrays in each direction
Resting Angle, Backtracking	0°-11°	Minimum rotation angle of modules outside of the normal tracking range (during backtracking)
Ground Coverage Ratio	32.1%	Ratio between the PV module area and total ground area
Offset Angle	0°	Additional elevation angle between tracking axis and modules
Module Surface Material	Smooth glass with anti-reflective coating	Surface material of modules
Module Height Above Ground	1.40m	Array centroid height

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 (typical of solar PV modules) will generally reflect less light, i.e., create less glare, than uncoated or conventional glass.

The backtracking operation of the SAT system has been considered in this analysis. The GlareGauge backtracking algorithms account for the geometry between arrays and the sun, as well as the slope of the plotted sub-arrays. In the morning and evening when the sun is outside of the normal tracking range, the rotation angle in the model will adjust to shallower angles to avoid inter-row shading. The user-specified resting angle sets the lower limit for backtracking rotation.

The elevation variation across the site is moderate, ranging from approximately 1,136m to 1,178m above mean sea level (AMSL). Ground elevations are generally higher in the southern area of the Project than the north area. As noted, topographical variations were incorporated into the sub-array breakdown in the models.

5.1.2 Route Paths

Seven route paths were evaluated for glare impacts from the Project: Highway 3, Highway 6, Highway 507, Township Road 64, Township Road 65, Range Road 303, and Beaver Road within approximately 800m of the Project. **Figure 5-2** shows the assessed routes in relation to the Project.

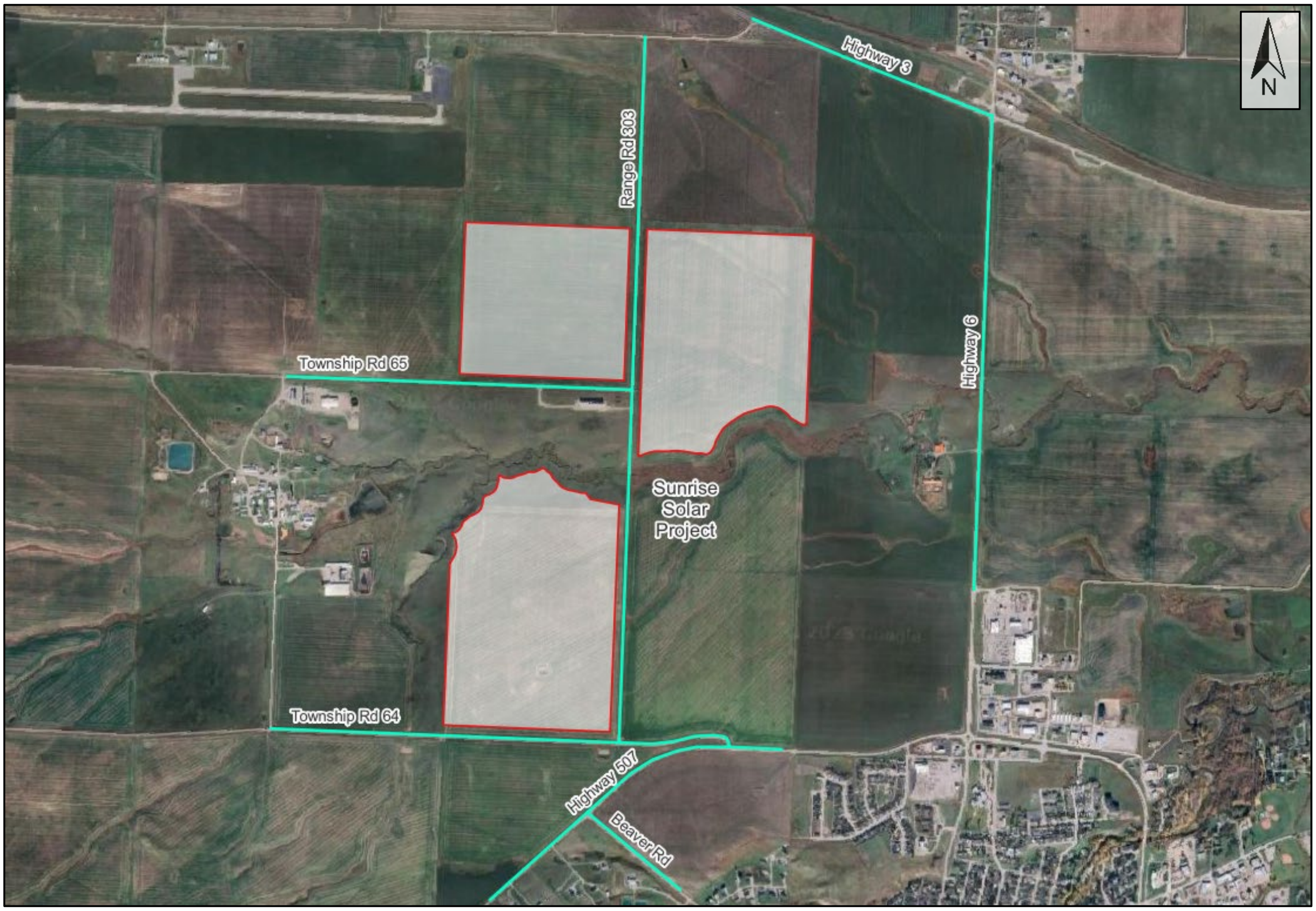

Figure 5-2 – Roads near the Project

All routes were modelled as two-way routes to represent vehicles travelling in both possible directions. Two horizontal viewing angles were evaluated for vehicle operators: ±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.[18] The ±25° range is a more conservative view representing a person's extended visual range that may be impacted by glare. The road routes were set at an elevation of 1.08m to represent the height of a typical passenger vehicle, 1.8m to represent the height of a typical truck or bus, and 2.3m to represent the height of a commercial truck in accordance with Alberta Transportation guidelines.[19] Commercial vehicles are typically more susceptible to glare than passenger vehicles due to their increased height.

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

[19] *Assessment requirements for solar development near provincial highways* (Alberta Transportation, December 2021).

5.1.3 Dwellings

Twelve receptors were assessed to represent dwellings near the Project. 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 on the second floor. The model assumes the receptors have an unobstructed view of the arrays, i.e., the view is not affected by any part of the building being evaluated, or by any objects between the receptor and the Project. **Figure 5-3** shows the dwellings in relation to the Project.

GCR followed the guidelines provided in AUC Rule 007 to identify dwellings within 800m of the Project. R12, R24, R25, R27, and R62-R65 are slightly further away from the Project than 800m but have been included due to their proximity to the 800m assessment area. GCR also conducted a site visit in June 2023 to confirm dwelling details.

Figure 5-3 – Dwellings near the Project

5.1.4 Pincher Creek Airport

Two airplane flight paths approaching Pincher Creek Airport have been included in this glare assessment, representing the landing approaches to the runway. Flight paths can be seen in **Figure 5-4**. The two-mile (3.2km) long flight paths utilize a typical glide slope of three degrees, ending 50 feet (15m) above the runway threshold. The SGHAT simulates flight paths with a maximum downward viewing angle of 30° from horizontal, accounting for obstructions in the cockpit below the windshield. This analysis has set the horizontal viewing angle for airplane pilots to ±50° from center (100° total field of view). This encompasses a conservative region where glare could have an adverse impact on a pilot when landing their airplane. A ±25° horizontal range has also been modelled as this is the region where yellow-grade glare is expected to adversely impact pilots.[20] Glare occurring outside of this range is not expected to adversely impact the pilot.

Figure 5-4 – Pincher Creek Airport Airplane Flight Paths near the Project

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[20] *Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach* (Rogers, J.A., et al., July 2015).

5.1.5 Pincher Creek Health Centre Heliport

There is currently no clear, standardized guidance for assessing the impacts of glare on heliports. However, the FAA guideline AC 150/5390-2C discusses heliports (general, transport, and hospital) and states that a helicopter's final approach commences at a distance of 4,000 feet (1.2km) from the heliport, and a height of 500 feet (152m) above the elevation of the heliport.[21] Helicopters are theoretically able to carry out their final approach from any direction, rather than following a specific approach flight path. However, the Canada Flight Supplement[22] provides two recommended paths for pilots to take when departing/approaching Pincher Creek Health Centre Heliport as shown in **Figure 5-5**. The two flight paths' angles are stated as 74° (HP2) and 238° (HP1) relative to magnetic north with a magnetic variation of +14° and a slope of 16%. The SGHAT simulates flight paths with a maximum downward viewing angle of 30° from horizontal, accounting for obstructions below the windshield. This analysis has set the horizontal viewing angle for helicopter pilots to ±50° from center (100° total field of view). This encompasses a conservative region where glare could have an adverse impact on a pilot when landing their helicopter. A ±25° horizontal range has also been modelled as this is the region where yellow-grade glare is expected to adversely impact pilots.[23] Glare occurring outside of this range is not expected to adversely impact the pilot.

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[21] *2012, FAA — AC 150/5390-2C*

[22] *Canada Flight Supplement effective 10 August 2023 to 5 October 2023* (NAV CANADA, 2023).

[23] *Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach* (Rogers, J.A., et al., July 2015).

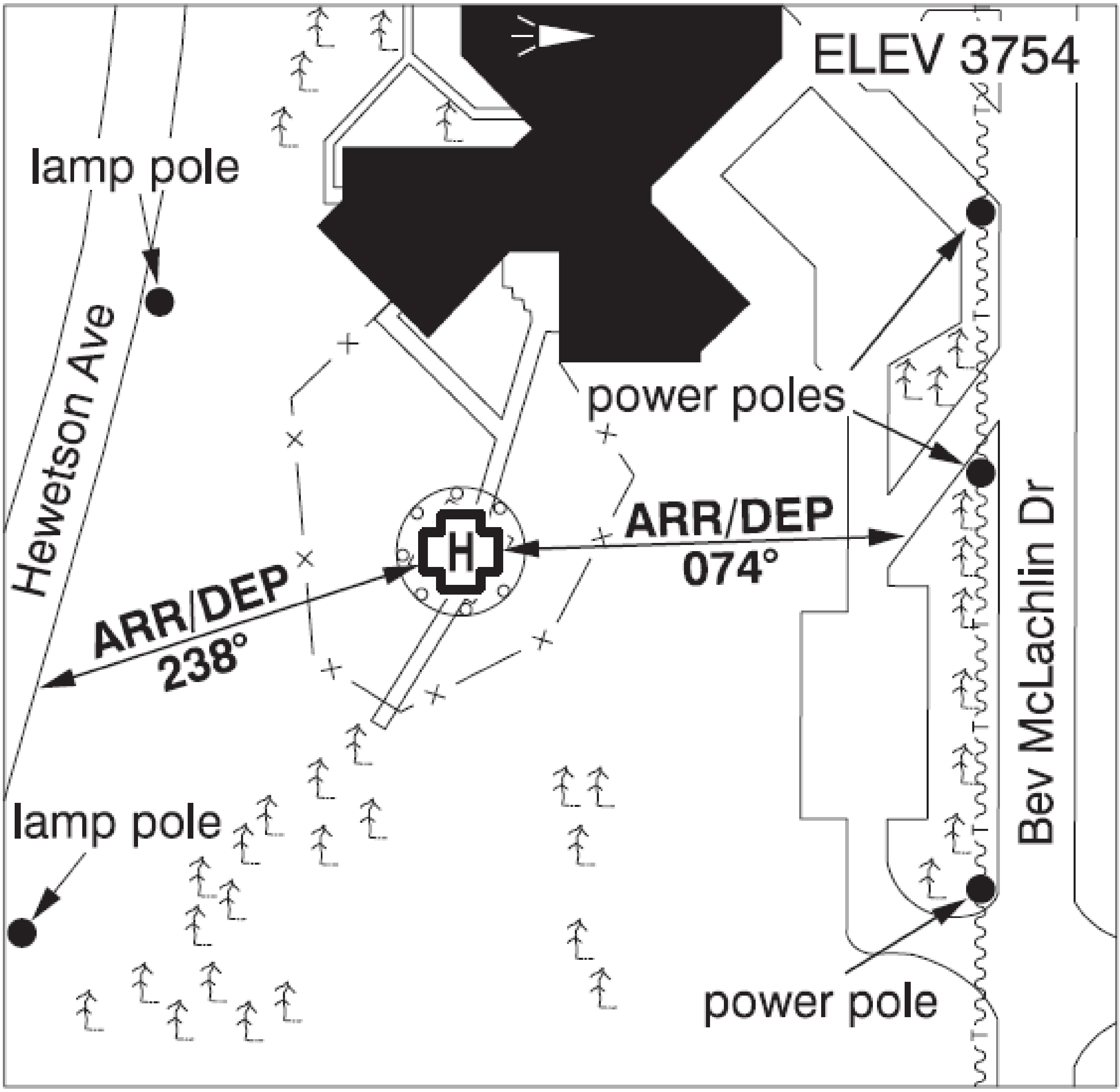

Figure 5-5 – Canada Flight Supplement suggested Helicopter Paths approaching/departing the Pincher Creek Health Centre Heliport

Figure 5-6 shows the 1.2km long helicopter flight paths from Pincher Creek Health Centre Heliport in relation to the Project.

Figure 5-6 – Pincher Creek Health Centre Helicopter Flight Paths near the Project

5.1.6 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.
- 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.[24] 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

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

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."*[25]

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 FOV. 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 5-7 shows an example of the hazard plot.

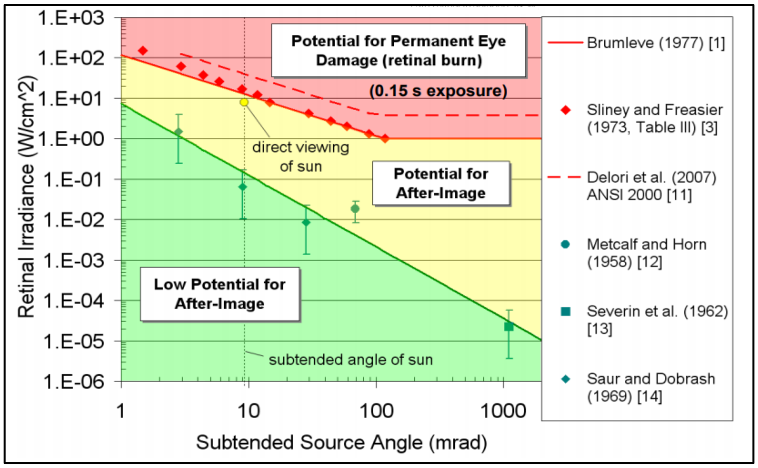

Figure 5-7 – Hazard Plot depicting the Retinal Effects of Light

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[25] *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.[26] 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 may convert the footprint of a concave polygon to a convex polygon.[27] 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 "*random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including [air traffic control towers].*"[28]

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.

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[26] *Evaluation of glare at the Ivanpah Solar Electric Generating System* (C.K. Ho et al., Elsevier Ltd., 2015).

[27] *ForgeSolar "Help" page*. Retrieved November 27, 2023.

[28] *ForgeSolar "Help" page*. Retrieved November 27, 2023.

6 Assessment of Impact

This 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,[29] Alberta Transportation guidelines,[30] and other relevant literature.

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.

The results showed that glare may be seen by the evaluated receptors if the resting angle is set between 0° to 10°. The greatest potential glare impact for the roads is in the case using a 0° resting angle. For dwellings, a 1° resting angle resulted in the greatest impact for all but one of the assessed receptors. A 2° resting angle produced the greatest impact for the helicopter flight paths. Finally, a 2° resting angle resulted in the greatest impact for airplane flight paths. The results presented below pertain to the worst-case minimum resting angle for the appropriate receptors.

6.1 Route Path Results

The following tables present the glare results for the route paths assessed from the array centroid height. Results are shown for passenger, trucks, and commercial road vehicles at 1.08m, 1.8m, and 2.3m, 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.

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

[30] *Assessment requirements for solar development near provincial highways (Alberta Transportation, December 2021).*

Table 6-1 – Annual Route Path Glare Levels for Passenger Vehicles, Trucks/Buses, and Commercial Vehicles (±15° FOV, 0° Resting Angle)

Receptor	Green Glare (min/year)	Yellow Glare (min/year)	Red Glare (min/year)	Max Daily Glare (min/day)
Highway 507 (Passenger)	485	3	0	9
Highway 507 (Truck/Bus)	487	5	0	9
Highway 507 (Commercial)	481	9	0	9
Township Road 64 (Passenger)	813	590	0	9
Township Road 64 (Truck/Bus)	895	544	0	11
Township Road 64 (Commercial)	854	595	0	11
Township Road 65 (Passenger)	267	424	0	7
Township Road 65 (Truck/Bus)	574	582	0	17
Township Road 65 (Commercial)	544	802	0	18
Beaver Road (Passenger)	0	0	0	0
Beaver Road (Truck/Bus)	0	0	0	0
Beaver Road (Commercial)	0	0	0	0
Highway 3 (Passenger)	0	0	0	0
Highway 3 (Truck/Bus)	0	0	0	0
Highway 3 (Commercial)	0	0	0	0
Highway 6 (Passenger)	0	0	0	0
Highway 6 (Truck/Bus)	0	0	0	0
Highway 6 (Commercial)	0	0	0	0
Range Road 303 (Passenger)	0	0	0	0
Range Road 303 (Truck/Bus)	0	0	0	0
Range Road 303 (Commercial)	0	0	0	0

Table 6-2 – Annual Route Path Glare Levels for Passenger Vehicles, Trucks/Buses, and Commercial Vehicles (±25° FOV, 0° Resting Angle)

Receptor	Green Glare (min/year)	Yellow Glare (min/year)	Red Glare (min/year)	Max Daily Glare (min/day)
Highway 507 (Passenger)	637	171	0	9
Highway 507 (Truck/Bus)	626	192	0	9
Highway 507 (Commercial)	652	169	0	9
Township Road 64 (Passenger)	690	733	0	9
Township Road 64 (Truck/Bus)	713	750	0	10
Township Road 64 (Commercial)	711	807	0	11
Township Road 65 (Passenger)	426	747	0	9
Township Road 65 (Truck/Bus)	846	1,234	0	19
Township Road 65 (Commercial)	756	1,586	0	20
Beaver Road (Passenger)	0	0	0	0
Beaver Road (Truck/Bus)	0	0	0	0
Beaver Road (Commercial)	0	0	0	0
Highway 3 (Passenger)	0	0	0	0
Highway 3 (Truck/Bus)	0	0	0	0
Highway 3 (Commercial)	0	0	0	0
Highway 6 (Passenger)	0	0	0	0
Highway 6 (Truck/Bus)	0	0	0	0
Highway 6 (Commercial)	0	0	0	0
Range Road 303 (Passenger)	0	0	0	0
Range Road 303 (Truck/Bus)	0	0	0	0
Range Road 303 (Commercial)	0	0	0	0

Drivers travelling along the evaluated sections of Highway 3, Highway 6, Range Road 303, and Beaver Road are not predicted to observe glare at any level from the Project, while Highway 507, Township Road 64, and Township Road 65 are predicted to observe green and yellow glare from the Project.

No green or yellow glare is predicted along Highway 507 at a resting angle of 2° or steeper. A minimum resting angle of 7° could be used to eliminate glare along all assessed road routes within both the ±15° and ±25° FOVs. The following describes the results for the 0° resting angle model, which showed the most potential glare.

Alberta Transportation guidelines state that there should be no glare within the ±15° FOV of a driver on a provincial highway.[31] It is also expected that Highway 507 will be more heavily travelled than Township Road 64 or Township Road 65. As such, although observers along Township Road 65 are expected to observe the most yellow glare from the Project, at a maximum of 802 minutes/year and 18 minutes/day (for up to 9 minutes/morning and 10 minutes/evening), within the ±15° FOV, it is expected that drivers using Highway 507 will have a higher likelihood of being impacted by glare and the consequences of glare have a greater chance of being significant.

Commercial vehicles along Highway 507 are predicted to observe yellow glare in the more critical ±15° FOV for a maximum of 9 minutes/year. The yellow glare along Highway 507 is predicted around sunset in late April and mid-August. Yellow glare may be seen along this route between 19:25 and 19:35 MST, for up to 3 minutes per day.[32] Green glare is predicted along this route within the ±15° FOV for a maximum of 487 minutes/year. Green glare along Highway 507 is predicted around sunset between late March and late April, as well as between mid-August and mid-September. Green glare may be seen along this route between 18:28 and 19:37 MST for a maximum of 9 minutes/day.

Highway 507 is predicted to observe yellow glare in the evenings when glare is expected to originate from the same general direction as the sun, so glare impacts may be eclipsed by the direct effects of the sun if both can be seen simultaneously by the observer. This is an effect called "sun-masking". The actual impact is expected to be less because vehicle operators will be travelling past the affected areas, not standing still while looking at the solar PV arrays.

The following figures represent the predicted glare within the ±15° FOV of commercial vehicle drivers travelling along Highway 507. **Figure 6-1** shows the daily time periods during which glare is predicted, and **Figure 6-2** shows the daily duration of predicted glare.

Figure 6-3 presents the glare hazard plot for glare predicted to affect drivers of commercial vehicles using Highway 507. The hazard plot shows that the glare seen from Highway 507 will be approximately four times the subtended angle of the sun, but it will be around 483 times dimmer. The glare is also over two orders of magnitude below the threshold for glare that has the potential to cause permanent eye damage at the same subtended angle.

6.1.1 Mitigation Recommendations

Since Highway 507 is predicted to observe yellow glare in the evenings when the effect of this glare is expected to be diminished by sun-masking, no mitigation is recommended at this time. Further, due to the minor nature of Township Road 64 and Township Road 65, mitigation is not expected to be required along these roads. Overall, GCR does not recommend any mitigation for the glare predicted on the route paths.

Alberta Transportation guidelines indicate that potential mitigation measures should be explored if glare is predicted within the ±15° FOV of drivers using provincial highways. Once the Project is operational, if glare is raised as a concern along the route paths, its effects could be mitigated by implementing a minimum resting angle. This assessment, which assumes all sub-arrays have the same minimum resting angle, suggests that utilizing a minimum resting angle of 2° or steeper is expected to eliminate glare within the ±15° FOV for Highway 507.

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[31] *Assessment requirements for solar development near provincial highways* (Alberta Transportation, December 2021).

[32] These results apply to a portion of the route, not just a single point along the route. The results describe a time period during which a vehicle operator may see glare from the Project, but it is highly unlikely that an observer will be affected by the glare for the full duration.

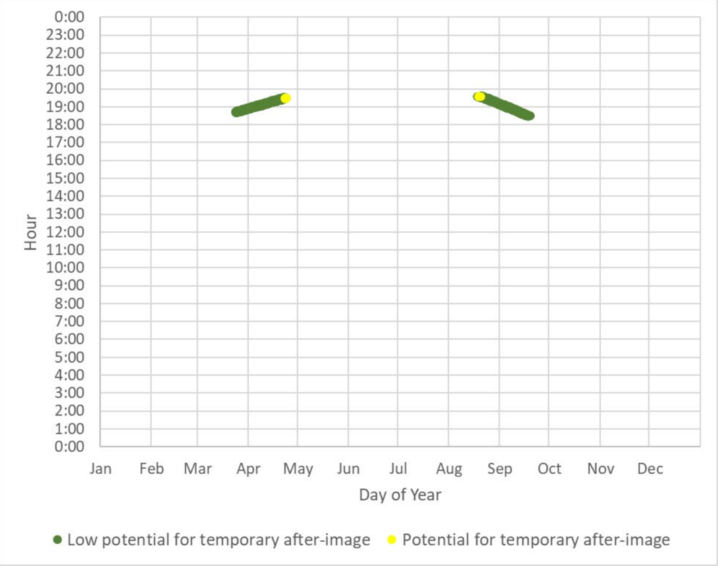

Figure 6-1 – Annual Predicted Glare occurrence for Highway 507 (Commercial, ±15° FOV, 0° Resting Angle)

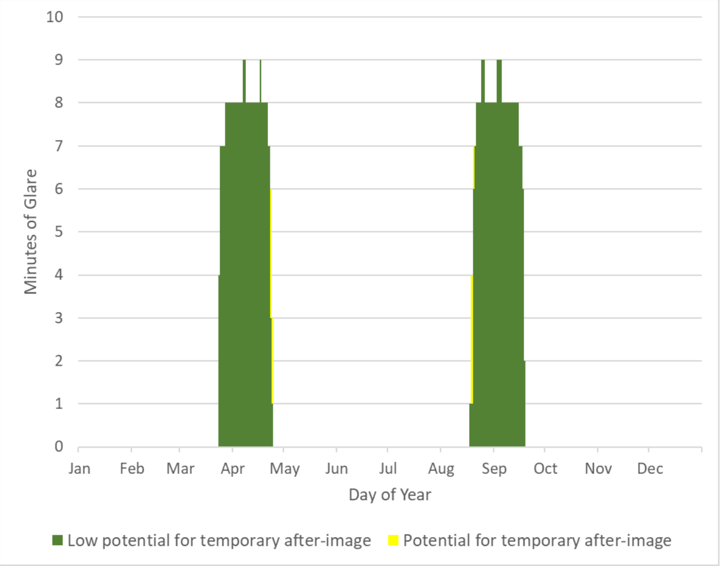

Figure 6-2 – Daily Duration of Glare for Highway 507 (Commercial, ±15° FOV, 0° Resting Angle)

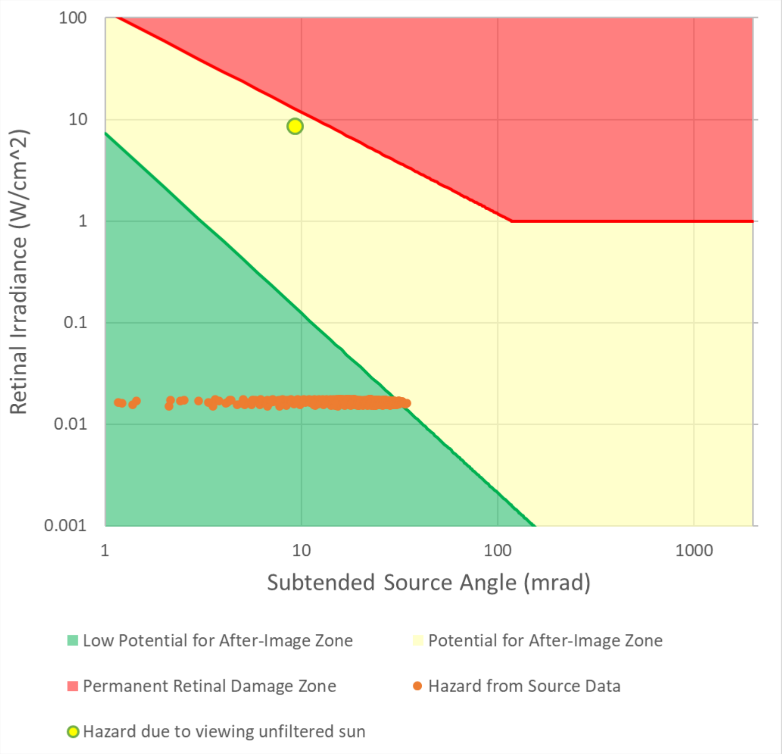

Figure 6-3 – Hazard Plot for Highway 507 (Commercial, ±15° FOV, 0° Resting Angle)

6.2 Dwelling Results

Twelve receptors were assessed to represent dwellings near the Project. 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 on the second floor. The model assumes the receptors have an unobstructed view of the arrays, i.e., the view is not affected by any part of the building being evaluated, or by any objects between the receptor and the Project. Glare observed at dwellings outside of the 800m assessment zone is expected to be less impactful than that observed at residences closer to the Project because the solar glare forms a lesser part of the resident's view at farther distances.

A resting angle of 1° had the greatest glare impact on the dwellings, therefore the results from that model are shown below. Table 6-3 provides the glare results for the dwellings assessed.

Table 6-3 – Annual Glare Levels for Dwellings near the Project (1° Resting Angle)

Receptor	Receptor Height (m)	Green Glare (min/year)	Yellow Glare (min/year)	Red Glare (min/year)	Max Daily Glare (min/day)
R11[33]	4.5	26	0	0	7
R12	1.5	448	0	0	11
R24	4.5	0	0	0	0
R25	4.5	0	0	0	0
R26	4.5	0	0	0	0
R27	1.5	0	0	0	0
R28	1.5	0	0	0	0
R29	4.5	0	0	0	0
R62	4.5	623	0	0	11
R63	1.5	588	0	0	11
R64	1.5	584	0	0	11
R65	1.5	455	0	0	11

Dwellings R24-R29 are not predicted to observe any level of glare from the Project. Dwellings R11, R12, R62, R63, R64, and R65 are only predicted to observe green glare from the Project. No dwellings are predicted to observe yellow glare from the Project. Glare was not predicted for any of the evaluated dwellings in the models using a resting/minimum backtracking angle of 3° or steeper. The results for R62 are described in further detail below as it is the dwelling predicted to be most impacted by glare from the Project.

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[33] No glare of any level was predicted for R11 at a resting angle of 1°. The results for the case using a resting angle of 0° represents the worst-case for R11, so these results are shown instead.

In the worst-case models using a 1° resting angle, observers at R62 are predicted to see green glare for a maximum of 623 minutes/year. The green glare is predicted between 07:05 and 08:50 MST for up to 11 minutes/day intermittently between October and early March. The glare is expected to originate from the same general direction as the sun for these periods, so glare impacts may be eclipsed by sun-masking.

The following figures represent the predicted glare for R62. **Figure 6-4** shows the daily time periods during which glare is predicted, and **Figure 6-5** shows the daily duration of predicted glare.

Figure 6-6 presents the glare hazard plot for glare predicted to be seen at R62. The hazard plot shows that the glare seen from R62 will be approximately twice the subtended angle of the sun, but it will be around 460 times dimmer. The glare is also over two orders of magnitude below the threshold for glare that has the potential to cause permanent eye damage at the same subtended angle. Glare at this level is not expected to create a hazardous situation or affect a resident's use of their home.

6.2.1 Mitigation Recommendations

Due to the predicted duration and level of glare, mitigation is not recommended to address the predicted glare at the modelled dwellings at this time.

If glare is determined to be an issue during the Project's operation, mitigation measures may be designed to reduce or eliminate its impact on an observer, and specific mitigation measures may be developed in consultation with affected stakeholders. Potential mitigation measures may include installing blinds over windows, modified backtracking behaviour, or planting vegetation like trees or hedges.

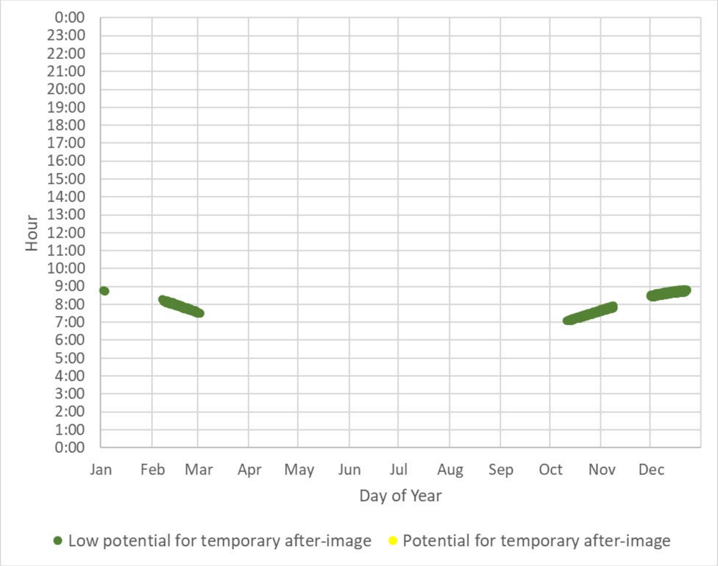

Figure 6-4 – Annual Predicted Glare occurrence for R62 (1° Resting Angle)

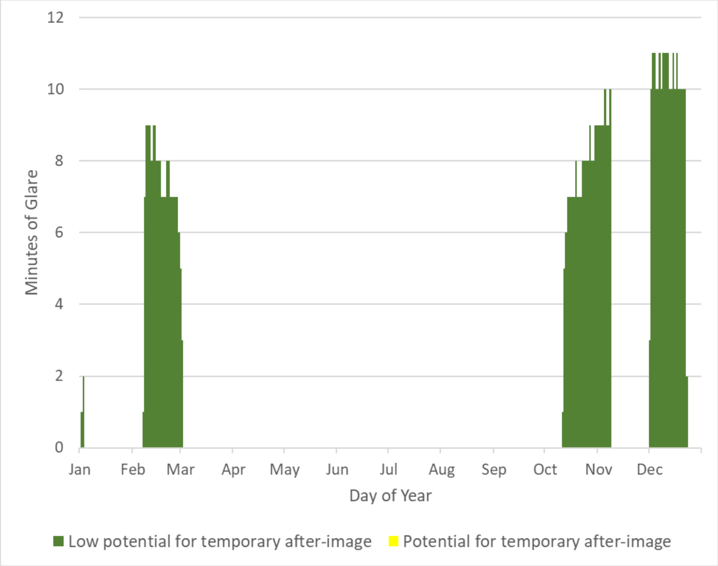

Figure 6-5 – Daily Duration of Glare for R62 (1° Resting Angle)

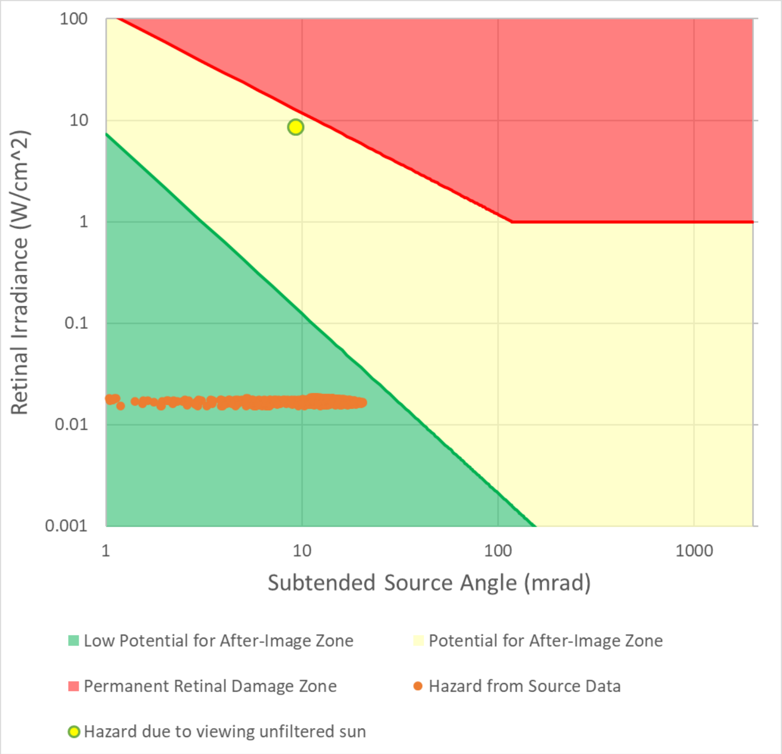

Figure 6-6 – Hazard Plot for R62 (1° Resting Angle)

6.3 Pincher Creek Airport Results

The tables below present the glare results for the airplane flight paths (FPs) assessed from the array centroid height. Table 6-4 shows the results for the flight paths modelled with a ±25° FOV to assess glare within a pilot's critical visual range. Table 6-5 shows the results for the airplane flight paths evaluated with a conservative ±50° horizontal FOV to capture potential glare a pilot may see while landing an airplane. Equivalent levels of glare within ±25° will have a greater impact on the observer than glare outside that range. A resting angle of 2° had the greatest glare impact on the airplane flight paths, therefore the results from that model are shown below.

Table 6-4 – Annual Glare Levels for Airplane Flight Paths from Pincher Creek Airport (±25° FOV, 2° Resting Angle)

Receptor	Green Glare (min/year)	Yellow Glare (min/year)	Red Glare (min/year)	Max Daily Glare (min/day)
FP1 (Eastbound)	445	0	0	12
FP2 (Westbound)	558	1,025	0	24

Table 6-5 – Annual Glare Levels for Airplane Flight Paths from Pincher Creek Airport (±50° FOV, 2° Resting Angle)

Receptor	Green Glare (min/year)	Yellow Glare (min/year)	Red Glare (min/year)	Max Daily Glare (min/day)
FP1 (Eastbound)	1,734	0	0	16
FP2 (Westbound)	859	3,432	0	33

FP1 is expected to observe short annual and daily durations of green glare within both the ±25° and ±50° FOVs. Green glare is predicted along FP1 for a maximum of 445 minutes/year and 12 minutes/day within the ±25° FOV, and for a maximum of 1,734 minutes/year and 16 minutes/day within the ±50° FOV. Notably, green glare is not generally considered a hazard, regardless of the FOV assessed.

FP2 is predicted to observe both green and yellow glare from the Project within both the ±25° and ±50° FOVs. Pilots landing at Pincher Creek Airport along FP2 are predicted to see a maximum of 1,025 minutes/year of yellow glare within the ±25° FOV, and 3,432 minutes/year of yellow glare within the ±50° FOV. The greatest impact to the pilots traveling along FP1 and FP2 will be yellow glare observed within the more critical ±25° FOV, which is only predicted for FP2.

Yellow glare along FP2 within the ±25° FOV is predicted around sunset in February to early March, and October to early November. Yellow glare may be seen along this route around sunset between 16:45 and 18:05 MST for up to 22 minutes/evening.[34] The glare is expected to originate from the same general direction as the sun for these periods, so glare impacts may be eclipsed by sun-masking. The actual impact is expected to be less because pilots will be travelling past the affected portion of the flight path, not standing still while looking at the solar PV arrays.

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[34] These results apply to a portion of the route, not just a single point along the route. The results describe a time period during which a pilot may see glare from the Project, but it is highly unlikely that an observer will be affected by the glare for the full duration.

A minimum resting angle of 7° can be used to eliminate only the yellow glare within the ±25° FOV for FP2, and a minimum resting angle of 9° can be used to eliminate only the yellow glare within the ±50° FOV for FP2. FP1 is not predicted to observe any yellow glare from the Project.

The following figures represent the predicted glare for the ±25° FOV for FP2. **Figure 6-7** shows the daily time periods during which glare is predicted, and **Figure 6-8** shows the daily duration of predicted glare.

Figure 6-9 presents the glare hazard plot for glare predicted to affect ±25° FOV for FP2. The hazard plot shows that the glare seen from FP2 will have approximately seven times the subtended angle as the sun, but it will be around 560 times dimmer. The glare is also around two orders of magnitude below the threshold for glare that has the potential to cause permanent eye damage at the same subtended angle.

6.3.1 Mitigation Recommendations

Since yellow glare is predicted along FP2 within the inner FOV, it is expected that mitigation will be necessary to eliminate this glare, as per the precedent set by the AUC decision in Proceeding 25296.[35] As such, GCR recommends that a detailed mitigation plan be developed once the final layout for the Project is complete. Preliminary modelling, which assumes all sub-arrays have the same minimum resting angle, suggests that restricting the minimum resting angle to one steep enough to eliminate glare along the flight paths will be a viable mitigation method. A minimum resting angle of 7° can be used to eliminate only the yellow glare within the ±25° FOV for FP2.

GCR recommends that yellow glare within the ±25° FOV for the flight paths be mitigated. Preliminary modelling indicates that a minimum resting angle of 7° can be used to eliminate the yellow glare within the ±25° FOV for FP2; however, GCR recommends that a detailed mitigation plan be developed once the final Project layout is complete.

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[35] *Decision 25296-D01-2021* (AUC, February 11, 2021), para. 53-56.

Figure 6-7 – Annual Predicted Glare occurrence for FP2 (±25° FOV, 2° Resting Angle)

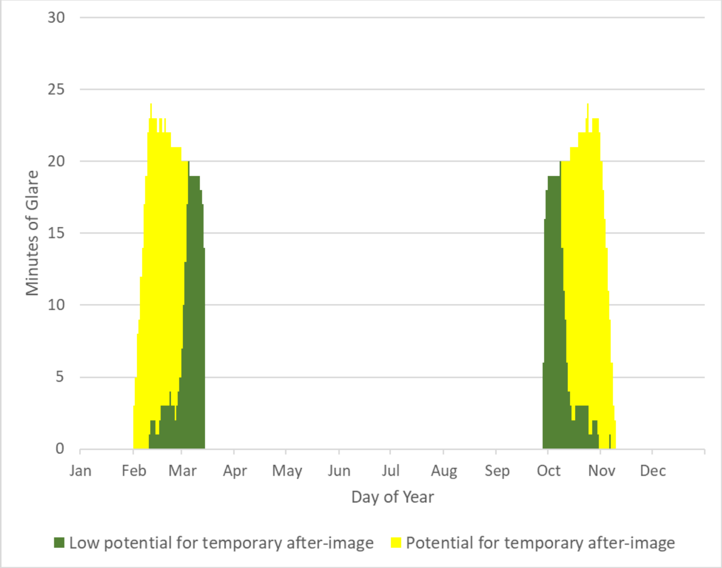

Figure 6-8 – Daily Duration of Glare for FP2 (±25° FOV, 2° Resting Angle)

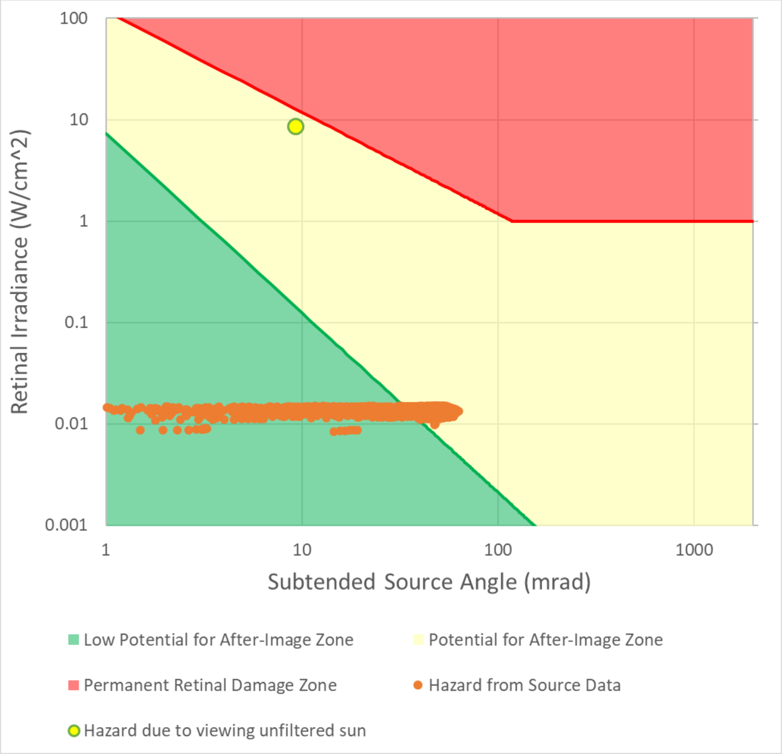

Figure 6-9 – Hazard Plot for FP2 (±25° FOV, 2° Resting Angle)

6.4 Pincher Creek Health Centre Heliport Results

The tables below present the glare results for the helicopter flight paths assessed from the array centroid height. **Table 6-6** shows the results for the HPs modelled with a ±25° FOV to assess glare within a pilot's critical visual range. **Table 6-7** shows the results for the helicopter flight paths evaluated with a conservative ±50° horizontal FOV to capture potential glare a pilot may see while landing an airplane. Equivalent levels of glare within ±25° will have a greater impact on the observer than glare outside that range. A resting angle of 2° had the greatest glare impact on the HPs, therefore the results from that model are shown below.

Table 6-6 – Annual Glare Levels for Helicopter Flight Paths from Pincher Creek Health Centre Heliport (±25° FOV, 2° Resting Angle)

Receptor	Green Glare (min/year)	Yellow Glare (min/year)	Red Glare (min/year)	Max Daily Glare (min/day)
HP1 (North-eastbound)	0	0	0	0
HP2 (Westbound)	495	0	0	11

Table 6-7 – Annual Glare Levels for Helicopter Flight Paths from Pincher Creek Health Centre Heliport (±50° FOV, 2° Resting Angle)

Receptor	Green Glare (min/year)	Yellow Glare (min/year)	Red Glare (min/year)	Max Daily Glare (min/day)
HP1 (North-eastbound)	0	0	0	0
HP2 (Westbound)	1,537	0	0	23

HP1 is not predicted to observe any glare from the Project within either of the ±25° and ±50° FOVs. However, HP2 is predicted to observe short durations of green glare within both the ±25° and ±50° FOVs. Green glare is not generally considered a hazard for pilots, regardless of the FOV assessed.

Green glare along HP2 within the ±25° FOV is predicted for up to 495 minutes per year. The glare is predicted to occur around sunset in late March to mid-May, and late July to mid-October between 18:29 and 20:03 MST.[36] The glare is expected to originate from the same general direction as the sun for these periods, so glare impacts may be eclipsed by sun-masking. The actual impact is expected to be less because pilots will be travelling past the affected portion of the flight path, not standing still while looking at the solar PV arrays.

A minimum resting angle of 4° eliminates all glare within the ±25° FOV for HP2.

The following figures represent the predicted glare for the ±25° FOV for HP2. **Figure 6-10** shows the daily time periods during which glare is predicted, and **Figure 6-11** shows the daily duration of predicted glare.

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[36] These results apply to a portion of the route, not just a single point along the route. The results describe a time period during which a pilot may see glare from the Project, but it is highly unlikely that an observer will be affected by the glare for the full duration.

Figure 6-12 presents the glare hazard plot for glare predicted to affect ±25° FOV for HP2. The hazard plot shows that the glare seen from HP2 will have approximately three times the subtended angle as the sun, but it will be around 555 times dimmer. The glare is also around two orders of magnitude below the threshold for glare that has the potential to cause permanent eye damage at the same subtended angle.

6.4.1 Mitigation Recommendations

Precedent set by the AUC decision in Proceeding 25296 indicates that yellow glare within ±25° of a pilot's heading must be mitigated.[37] No yellow glare is predicted within the inner FOV of either of the evaluated HPs, so no mitigation is recommended at this time. If glare along final approach flight paths landing at the Pincher Creek Health Centre Heliport is raised as a concern once the Project is operational, its effects could be mitigated by implementing a minimum resting angle. This assessment, which assumes all sub-arrays have the same minimum resting angle, suggests that utilizing a minimum resting angle of 4° or steeper is expected to eliminate glare within the ±25° FOV for HP2.

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[37] *Decision 25296-D01-2021* (AUC, February 11, 2021), para. 53-56.

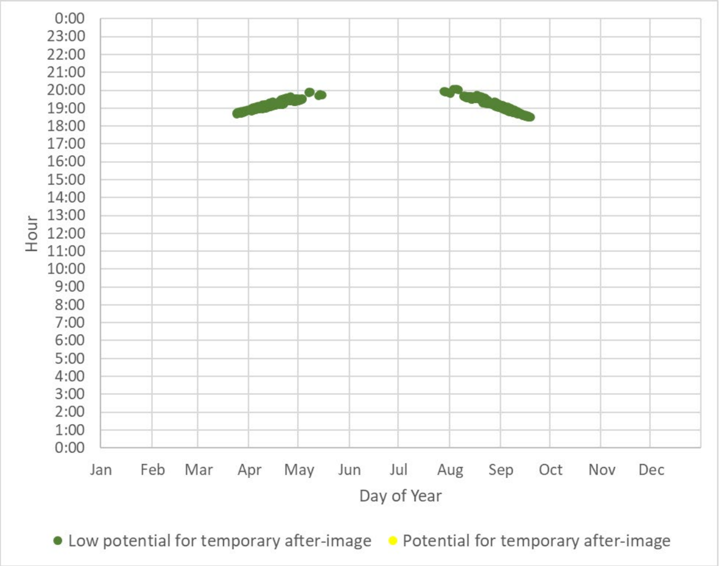

Figure 6-10 – Annual Predicted Glare occurrence for HP2 (±25° FOV, 2° Resting Angle)

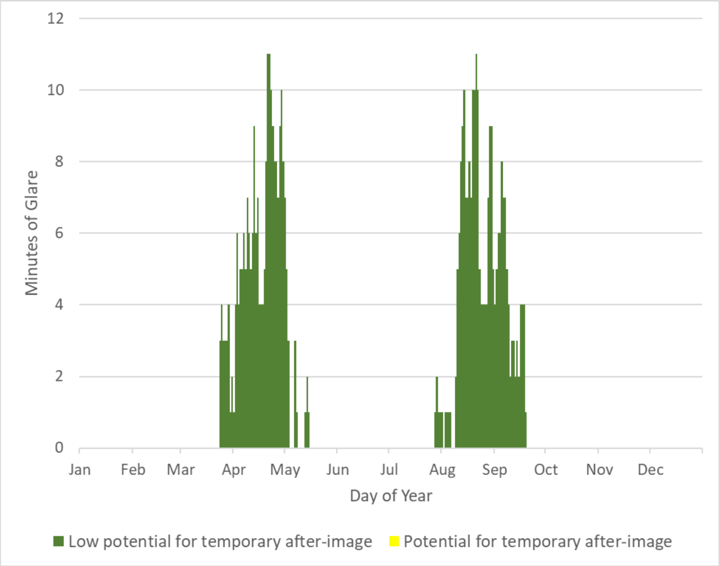

Figure 6-11 – Daily Duration of Glare for HP2 (±25° FOV, 2° Resting Angle)

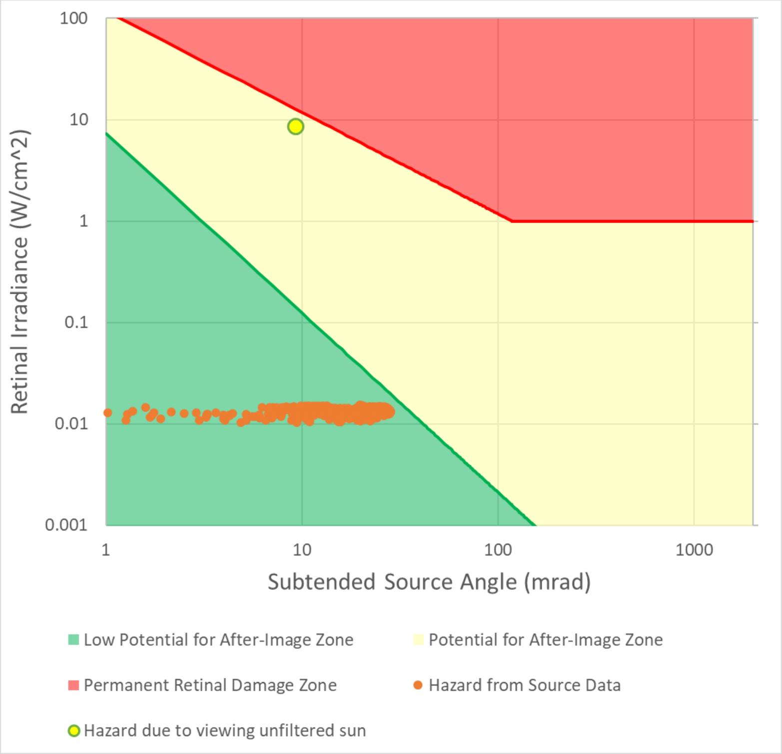

Figure 6-12 – Hazard Plot for HP2 (±25° FOV, 2° Resting Angle)

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, as is the case with the modules selected for the Project.

The assessment of the Project was undertaken using GlareGauge software. The SAT systems were modelled at their centroid heights with a maximum tracking angle of 50°. The assessment included models using resting/minimum backtracking angles of 0°-11°, with various resting angles between 0°-2° resulting in the most potential glare for different receptors.

The ground-based route paths assessed for glare impacts included both directions of travel on sections of Highway 3, Highway 507, Highway 6, Township Road 64, Township Road 65, Range Road 303, and Beaver Road at passenger, truck, and commercial vehicle heights. The 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. Drivers travelling along the evaluated sections of Highway 3, Highway 6, Range Road 303, and Beaver Road are not predicted to observe glare at any level from the Project, while Highway 507, Township Road 64, and Township Road 65 are predicted to observed green and yellow glare from the Project. Highway 507 is not predicted to observe glare from the Project within the ±15° FOV at a resting angle of 2° or steeper.

In the worst-case (0° resting angle), the assessed portion of Highway 507 is the ground route expected to be most affected by glare from the Project since it is the most heavily travelled route. The results indicate that vehicle height has a negligible effect on the results for this road. Along this route, observers are predicted to see yellow glare in the more critical ±15° FOV for a maximum of 9 minutes/year. The yellow glare is predicted around sunset in late April and mid-August. The actual impact is expected to be less because vehicle operators will be travelling past the affected areas, not standing still while looking at the solar PV arrays. Sun-masking is also expected to reduce potential impacts from the glare. Given these points, mitigation is not deemed to be required for Highway 507 or any of the other assessed routes. If concerns regarding glare along the roads are raised once the Project is operational, implementing minimum backtracking angle limitations can be used for mitigation.

Twelve dwellings were evaluated in this assessment. 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 on the second floor. Dwellings R11, R12, R62, R63, R64, and R65 are only predicted to observe green glare from the Project, while R24-R29 are not predicted to observe any level of glare from the Project. No dwellings are predicted to observe yellow glare from the Project. In the worst-case models, R62 is predicted to be the dwelling that is most impacted by glare from the Project. Observers are predicted to see green glare for a maximum of 623 minutes/year. The green glare is predicted intermittently around sunset between October and early March. Sun-masking is also expected to reduce potential impacts from the glare. Implementing a resting angle of 3° or steeper is predicted to eliminate glare at all of the modelled dwellings. Visual obstructions may also be considered for glare mitigation, though no mitigation is recommended for the predicted glare at the modelled dwellings. If glare concerns are raised once the Project is operational, the aforementioned mitigation methods may be implemented to eliminate glare.

Two airplane flight paths approaching the Pincher Creek Airport north of the Project were included in this glare assessment. The flight paths were evaluated with a horizontal viewing angle of ±25° to capture potential glare within a pilot's critical visual range, as well as ±50° to identify routes that may observe peripheral glare. FP1 was predicted to observe short annual and daily durations of green glare within both the ±25° and ±50° FOV, but this level of glare is not generally considered a hazard. FP2 is predicted to observe both green and yellow glare from the Project within both the ±25° and ±50° FOVs. FP2 approaches the Pincher Creek Airport while heading west, and it is the airplane flight path predicted to observe the most glare from the Project. Along this flight path, pilots are predicted to see yellow glare around sunset in February to early March, and October to early November for up to 22 minutes/evening. Pilots will only see a fraction of the predicted glare since they will be travelling past the affected portion of the flight path, not standing still while looking at the solar PV arrays, and sun-masking may also reduce potential glare impacts. A minimum resting angle of 7° can be used to eliminate only the yellow glare within the ±25° FOV for FP2.

Two helicopter flight paths approaching a Pincher Creek Health Centre Heliport southeast of the Project were included in this glare assessment. The helicopter flight paths were evaluated with a horizontal viewing angle of ±25° to capture potential glare within a pilot's critical visual range, as well as ±50° to identify routes that may observe peripheral glare. HP1 is not predicted to observe any glare from the Project within either the ±25° or ±50° FOV. HP2 is predicted to observe short durations of green glare from the Project within both the ±25° and ±50° FOVs, which is not generally considered a hazard. HP2 approaches the Pincher Creek Health Centre Heliport while heading west, and it is the helicopter flight path predicted to observe the most glare from the Project. Along this flight path, pilots are predicted to see green glare around sunset in late March to mid-May, and late July to mid-October. Pilots will only see a fraction of the predicted glare since they will be travelling past the affected portion of the flight path, not standing still while looking at the solar PV arrays, and sun-masking may also reduce potential glare impacts. A minimum resting angle of 4° eliminates all glare within the ±25° FOV for HP2.

There are no railways within 800m of the Project, so none were evaluated in this assessment.

Due to the presence of yellow grade glare within the ±25° FOV of FP2, GCR recommends a detailed mitigation plan be developed once the Project layout is finalized. Preliminary modelling, which assumes all sub-arrays have the same minimum resting angle, indicates that using a resting angle of 7° or steeper achieves the AUC precedent of eliminating yellow glare within the ±25° FOV of the assessed flight paths. GCR does not recommend any glare mitigation for the dwellings, road receptors, or helicopter flight paths that were assessed; however, implementing a minimum resting angle of 7° or steeper to mitigate glare on FP2 is also expected to eliminate glare at all other receptors in the assessment. More conservative mitigation may be adopted to mitigate glare within the ±50° FOV of FP2; however, based on the available studies and information, GCR understands that glare within the ±50° FOV but outside the ±25° FOV is less likely to negatively impact pilots, so it does not necessarily need to be mitigated.

8 Conclusion

In conclusion, the Sunrise Solar Project has the potential to create green and/or yellow glare conditions for the dwellings, roads, airplane flight paths, and helicopter flight paths that were assessed.

The actual glare impacts that will be experienced in the field along road routes, airplane flight paths, and helicopter flight paths are anticipated to be only a fraction of the results presented in this report. The actual impact is expected to be less because observers will be travelling past the affected areas, not standing still while looking at the solar PV arrays. The impact of the glare on affected receptors is expected to be reduced by sun-masking as the glare occurs around sunrise/sunset when the sun aligns with the glare spot and observer, and the sunlight glances across the arrays at a shallow angle. The assessment is also conservative as it assumes that there are no existing obstructions between the sun and the Project, or between the predicted glare spots and observers, and that there are clear skies and bright sunshine throughout the day.

Based on the assessment results, glare from the Project will require mitigation to comply with precedent set by the AUC pertaining to glare along airplane flight paths. GCR recommends a detailed mitigation plan be developed once the Project layout is finalized. Preliminary modelling and analysis indicate that glare mitigation may be achieved by limiting backtracking operations to rotation angles of 7° or steeper to eliminate yellow glare within the critical viewing range of airplane flight paths. Backtracking limits targeting mitigation of glare on FP2 are also expected to eliminate glare at all other receptors included in the assessment, regardless of whether those receptors require glare mitigation.

Since Highway 507 is predicted to observe yellow glare in the evenings when the effect of this glare is expected to be diminished by sun-masking, no mitigation is recommended at this time. However, if glare is raised as a concern along Highway 507 during operations, mitigation measures may include limiting the resting angle to 2° or steeper to eliminate glare within the critical viewing range.

Glare is not expected to have an adverse effect on a resident’s use of their home, so mitigation is not expected to be required for residential receptors.

Only green glare is predicted along HP2, which is not generally considered to be a hazard, regardless of the FOV assessed. As such, no mitigation is recommended for glare along HPs at this time. If glare along final approach flight paths landing at the Pincher Creek Health Centre Heliport is raised as a concern once the Project is operational, implementing a minimum backtracking angle of 4° or steeper is expected to eliminate all glare from the Project within the ±25° FOV for HP2.

9 Glare Practitioners’ Information

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

Table 9-1 – Summary of Practitioners' Information

Name	**Bridie Kafrissen**	**Jason Mah**	**Cameron Sutherland**
Title	Renewable Energy EIT	Senior Renewable Energy Engineer	Technical Director
Role	Glare Analyst, Author	Glare Analyst, Technical Reviewer	Technical Reviewer and Approver
Experience	• Analyst on multiple glare assessments in Alberta • BSc Environmental Engineering	• Analyst on 50+ glare assessments in Alberta, BC, Nunavut, the USA, and the UK • Technical support for AUC information requests and hearings • Expert witness experience in technical solar development for the Sollair Solar Energy Project and Three Hills Solar Project • BSc Chemical Engineering • P.Eng. (APEGA)	• Expert witness experience in technical solar development in Canada for Brooks II Solar Project, East Strathmore Solar Project, Foothills Solar Project, and Fox Coulee Solar Project • Technical oversight, technical review, or authorship of 40+ glare assessments for 20+ proceedings in Alberta • MSci Physics • MSc Renewable Energy Systems Technology

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