BLUEARTH

YELLOW LAKE SOLAR PROJECT

GLARE STUDY

wsp

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REVISION HISTORY

Version	Issue Date	Author	Description
1	July 31, 2019	Alexander Medd	Glare assessment for the Yellow Lake Solar Project in southern Alberta
2	August 9, 2019	Alexander Medd	Text edits including a correction to maximum daily glare in the body of the report and context regarding MW_{AC} vs MW_{DC} is provided. Modeling results for the Foremost Airport are included.

SIGNATURES

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1 INTRODUCTION

WSP has performed an independent glare assessment for the Yellow Lake Solar Project on behalf of BluEarth. The project is located approximately 70 km south-west of Medicine Hat, Alberta and 20 km south of Burdett. The project lands[1] (Approx. 200 Acres) consist of farm land and the terrain within the project is relatively simple. A map of the project site and the glare assessment points is shown in Figure 1. The project has several houses in the vicinity, gravel roads surrounding the project lands and several intersections. Table 1 outlines key project characteristics.[2] The project size quantified in MW_{DC} corresponds to the number of modules installed onsite which are modeled as part of the glare calculation. The project interconnection capacity is limited to 19 MW_{AC}.

Table 1: Yellow Lake Project Summary

Project Size	30.4 MW_{DC} , 19 MW_{AC}
Racking Style	30 Degree Fixed Tilt
Ground Clearance	1 m
Azimuth	180 Degrees (South)

[1] YL_PanelsFixed10m_BER_20180426.shp
[2] Yellow Lake Site Assumptions 20181013.xlsx

Figure 1: Yellow Lake Project Site Map

2 BACKGROUND

Photovoltaic (PV) solar panels generate electricity from sunlight; however, some of the light is reflected and can cause glint, a momentary flash of bright light and glare, a continuous source of bright light. Glare is typically associated with stationary objects which reflect sunlight for a longer duration. Reflections from solar panels have the potential to impair observers which may cause risk to public safety if a driver is affected.

The ocular impact of glare is a function of the radiation that reaches the retina and the apparent size of the source point. It is typically assumed that 50% of incoming radiation is absorbed prior to reaching the retina.[3]

The ocular impact of glare is classified into three qualitative categories[4] based on the intensity and angle of incoming light as shown in Figure 2:

- Green: low potential for after image.
- Yellow: potential to cause a temporary after image.
- Red: potential to cause permanent damage.

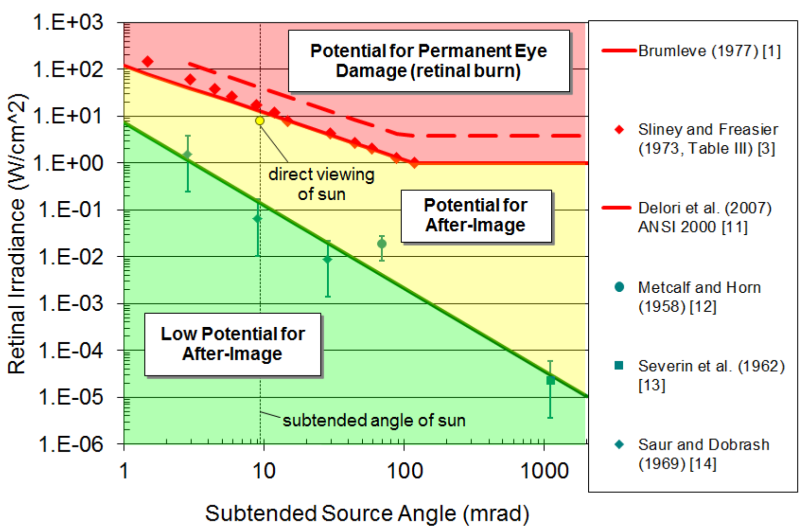

Figure 2: Glare Assessment Plot

[3] 'Methodology to Assess Potential Glint and glare Hazards from Concentrating Solar Power Plants: Analytical Models and Experimental Validation' Ho, 2011
[4] 'Summary of Impact Analyses of Renewable Energy Technologies on Aviation and Airports' Ho, 2011

An after image is an image that continues to appear in one's vision after the exposure to the original image has ceased. Direct viewing of the sun has the potential to cause an after image. As shown in Figure 2, the retinal irradiance associated with direct viewing of the sun is below the level at which there is potential for permanent eye damage. Because sunlight does not cause retinal burn, permanent damage is not possible from the reflection from a solar panel.

Approximately 7% of incoming light must be reflected from a solar panel to cause an after image. The amount of light reflected is a function of the incident angle of the incoming light on the solar panel and the surface roughness. Under high angle of incidence up to 60% of incoming light can be reflected[5] resulting in the potential for higher intensity glare at fixed tilt solar projects.

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[5] J. Yellowhair, 'Assessment of Photovoltaic Surface texturing on Transmittance Effects and Glint/Glare Impacts',, 2015

3 METHODOLOGY

WSP used the ForgeSolar[6] Solar Glare Hazard Analysis Tool (SGHAT) to complete the glare analysis. The program considers the angle of the panel, the path of the sun, the incoming radiation and the PV array shape and panel reflectivity characteristics when calculating the amount of glare at each input receptor point and path. The panels are modelled as infinitesimally small panels covering the entire defined array area reflecting sunlight in the trajectory of the input tilt and azimuth. The program has the following limitations resulting in conservative estimates of glare duration:

- Obstacles such as trees and buildings are not considered in the analysis.
- Row spacing and shading from panels is not considered.
- Reduction of reflectivity of the panel due to soiling is not considered.
- Path receptor glare is calculated based on the centroid of the array area.
- Receptors are modelled as greenhouses with windows on all sides. Building design may significantly change the number of hours a home is affected by glare.

Table 2 outlines additional key assumptions for the analysis.

Table 2: Analysis Assumptions

Peak Direct Normal Irradiance	1000 W/m^2 varying by time of day
Ocular Transmission Coefficient	0.5
Pupil Diameter	0.002 m
Eye Focal Length	0.017 m

The output is a quantification of the amount of time glare is possible and the time of day most likely to be affected. Based on the manufacturer's specifications, the computation has assumed an anti reflective coating on the panels which reduces reflectivity by a small amount. There are no regulations for glare in Canada and limits for time spent in each glare category are not defined.

[6] https://www.forgesolar.com

4 RESULTS

WSP calculated glare for houses identified by BluEarth, nearby road intersections, and a 2-mile 3° glide slope path at the Foremost Airport located 18 km south of the project lands. Path features and intersection point features were calculated at heights of 1.5 m to account for passenger vehicles and 3.0 m to account for trucks.

Results from the analysis are presented in Table 3 and Table 4 for the intensity, approximate times of day/time of year when glare is expected, and maximum daily duration of glare for intersections and receptors at heights of 1.5 m and 3.0 m. Graphical results in Appendix A provide additional detail.

Table 3: Glare at Intersections

Intersection	Glare Intensity	Affected Months	Affected Times of Day (Approximate) (MST)	Maximum Daily Glare at 1.5 m (Minutes)	Maximum Daily Glare at 3 m (Minutes)
TWP 82 and RR 120	None	-	-		
TWP 82 and RR 121	None	-	-		
TWP 82 and RR 122	Yellow	May-August	7:00 AM	13	11
Access Road Intersection	Yellow	March-May August-September	7:00 AM	7	15

Glare duration increases by approximately 130% at the access road intersection between 1.5 m and 3.0 m. The glare duration at TWP 82 and RR 122 does not change significantly between 1.5 m and 3.0 m due to its distance from the project.

Glare was calculated for a 2-mile 3° glide slope path from the Foremost Airport (24-6-12 W4M) located 18 km south of the project lands. Calculations show that no glare is expected for this flight path. The impact of glare on aviation outside the context of the Foremost Airport was not considered within the scope of this assessment.

Glare was calculated at receptors surrounding the project. Houses were assumed to be 4.5 m tall to account for two-storey buildings. Only receptor 4 is expected to be affected by glare with a maximum daily duration of 11 minutes. Glare may be mitigated at the receptor because it is surrounded by trees. Results are presented in Table 4.

Table 4: Glare at Receptors

Receptor	Assessment Height	Glare Intensity	Affected Months	Affected Time of Day (Approximate) (MST)	Maximum Daily Glare (Minutes)
1	4.5 m	None	-	-	-
2	4.5 m	None	-	-	-
3	4.5 m	None	-	-	-
4	4.5 m	Yellow	May-July	6:45 AM	11
5	4.5 m	None	-	-	-

5 CONCLUSIONS

INTERSECTIONS

Some of the minor intersections modeled near the project are expected to experience periods of yellow glare between the months of March and September and a maximum daily duration of 15 minutes. Consultation with traffic safety experts is recommended to ensure that the anticipated impacts are acceptable.

FOREMOST AIRPORT

The analysis identified no potential glare impacts at the Foremost Airport.

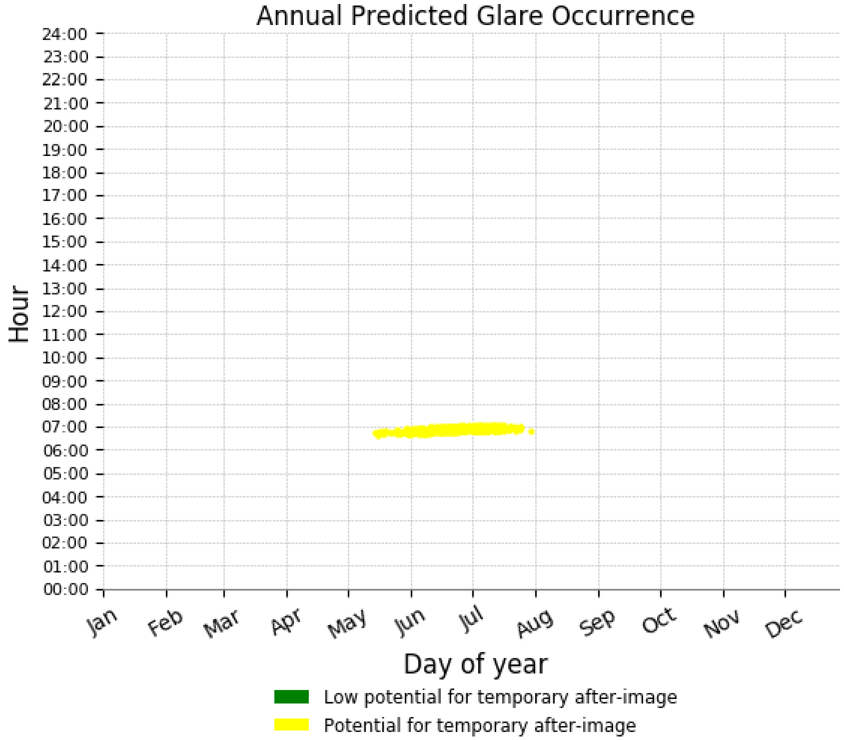
RECEPTORS

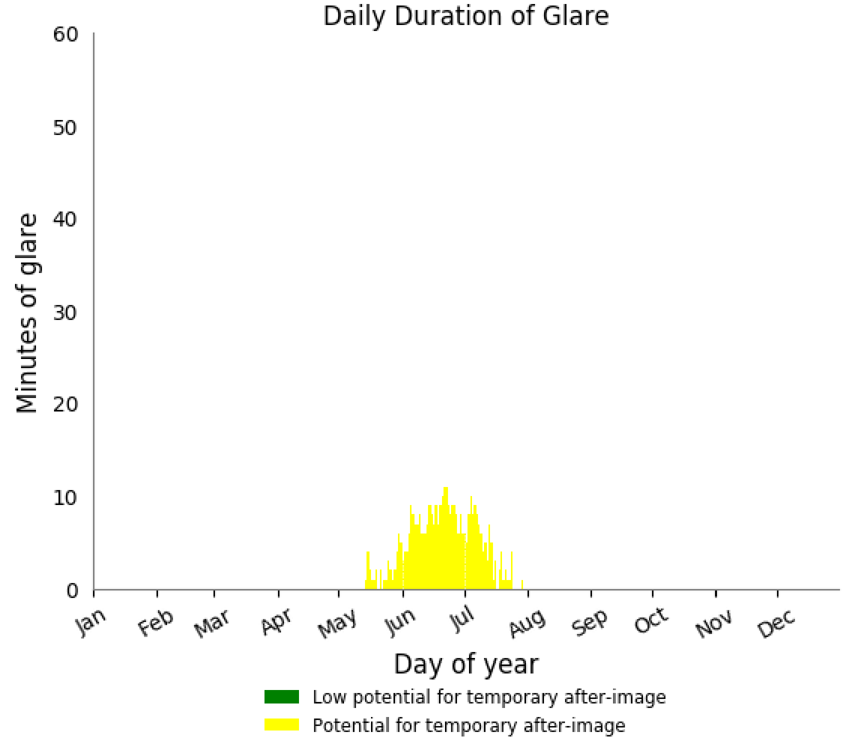
Yellow Glare is expected at one residential receptor between the months of May and July. The maximum daily duration of glare at this receptor is 11 minutes. The results are considered to be conservative due to fact that the analysis does not account for vegetation and assumes two-storey receptor heights. Consultation with the landowner is recommended.

APPENDIX

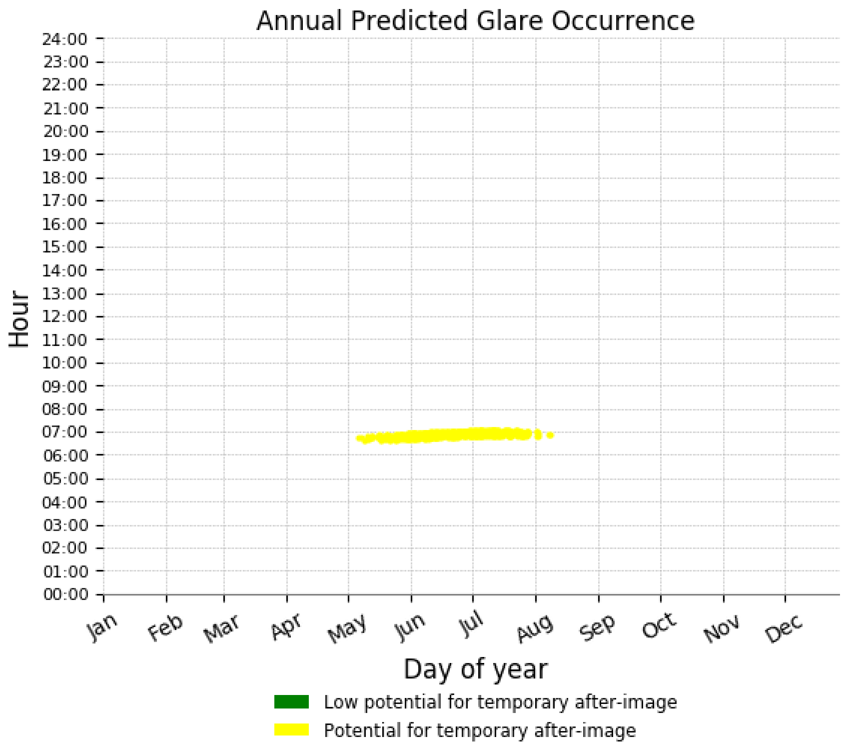
A DETAILED GLARE RESULTS

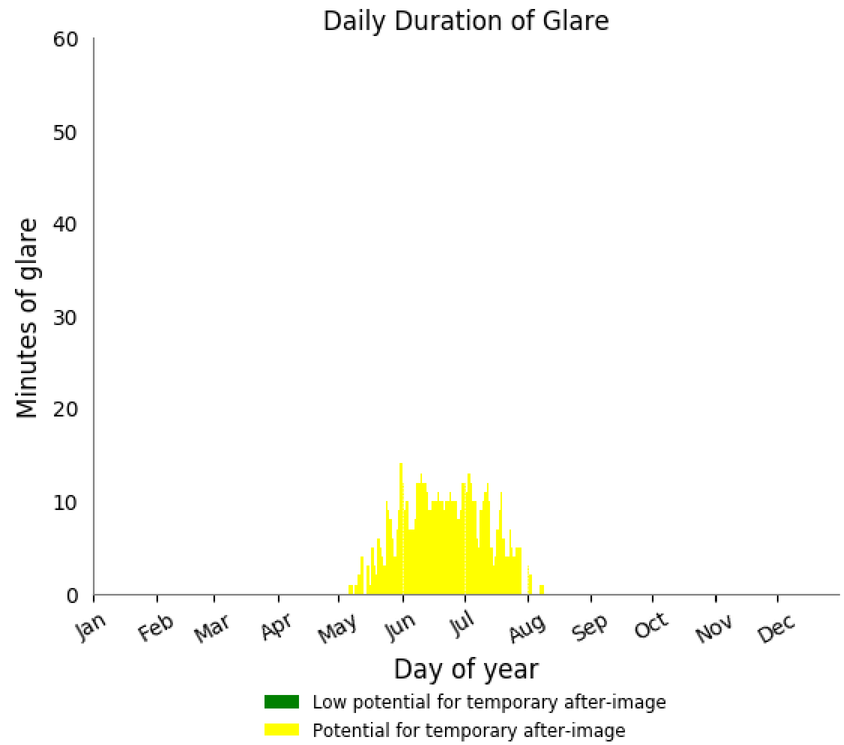
Receptor 4 at 4.5 m



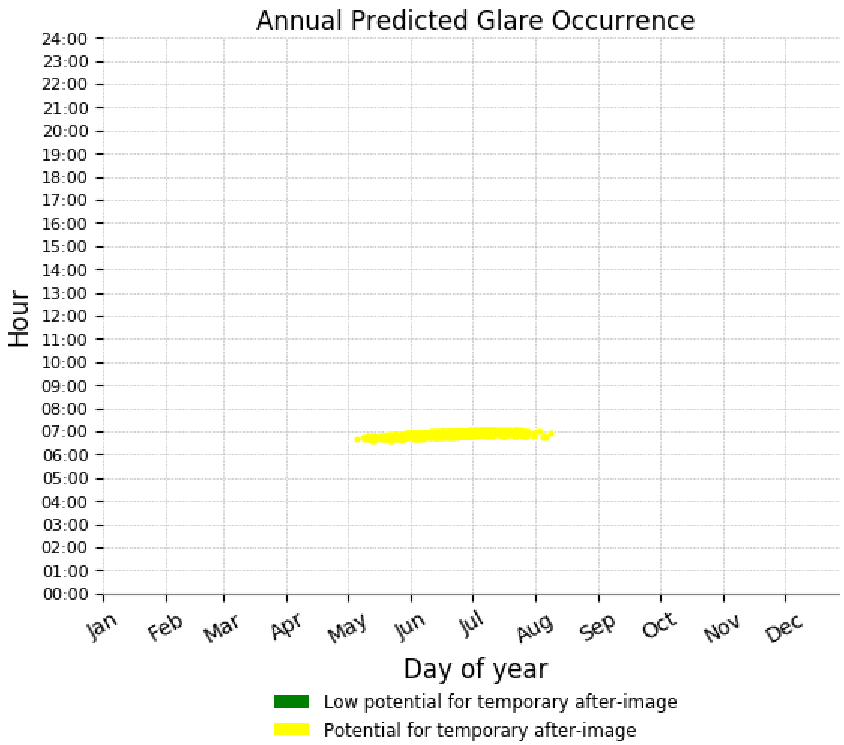


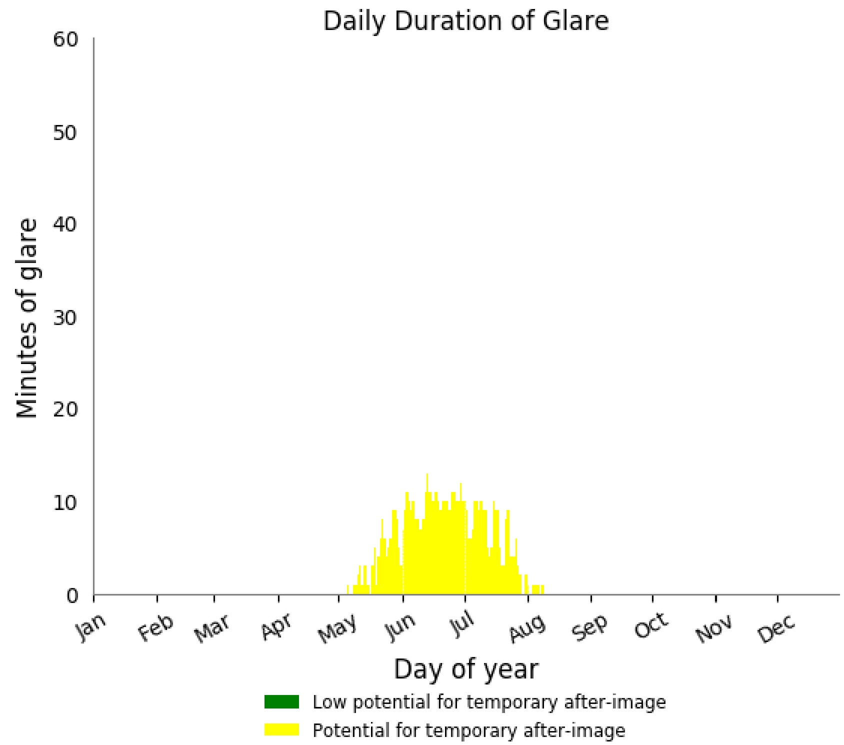
TWP 82 and RR 122 at 1.5 m



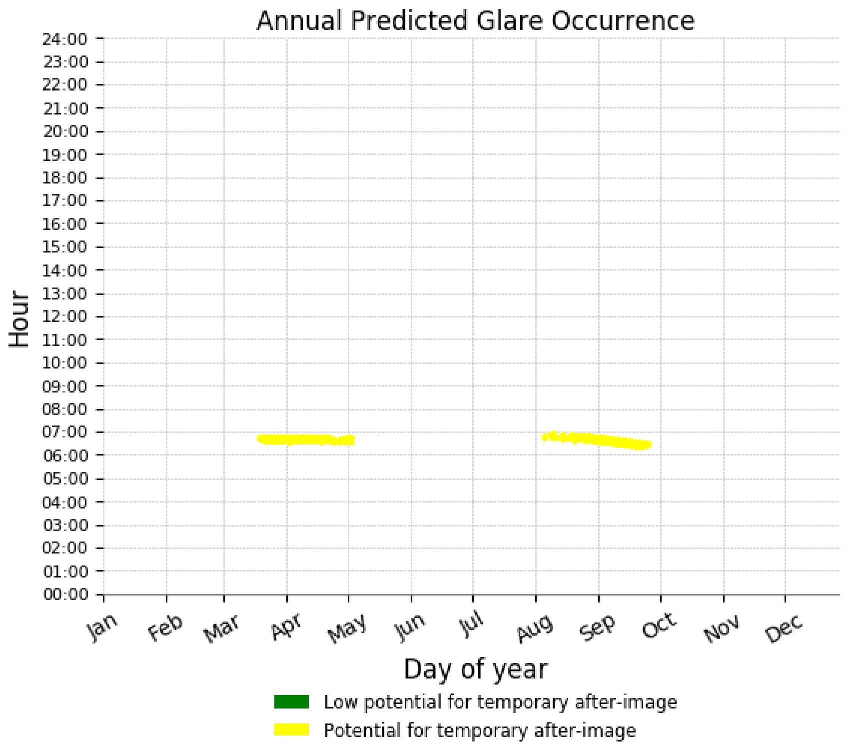


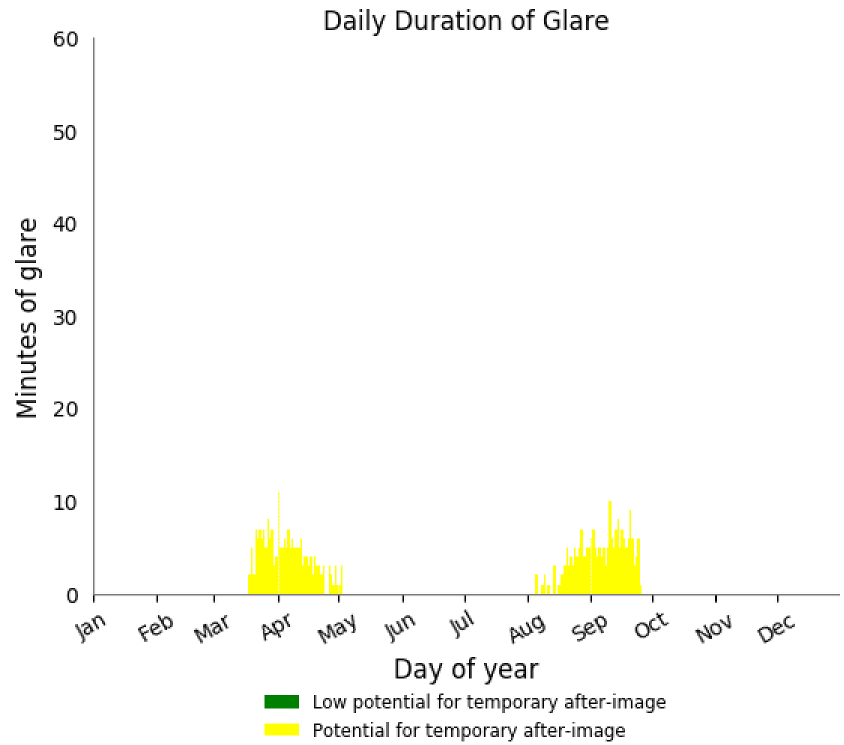
TWP 82 and RR 122 at 3 m





New Intersection at 1.5 m





New Intersection at 3 m