Technical Memorandum

To: Janine Padia, SRG Perris, L.P.
From: Nick Johnson, Johnson Aviation, Inc.
Date: August 13, 2019

Subject: Solar Glare Analysis – Solar Photovoltaic (PV) Installation, Mead Valley Development Project

Findings

The findings of this Solar Glare Analysis are that the Proposed Project **PASSES** the FAA's recommended solar glare tests and **PASSES** these same tests for four critical flight paths required by the March Air Reserve Base. This Technical Memorandum outlines the study of the proposed solar PV project and substantiates these findings.

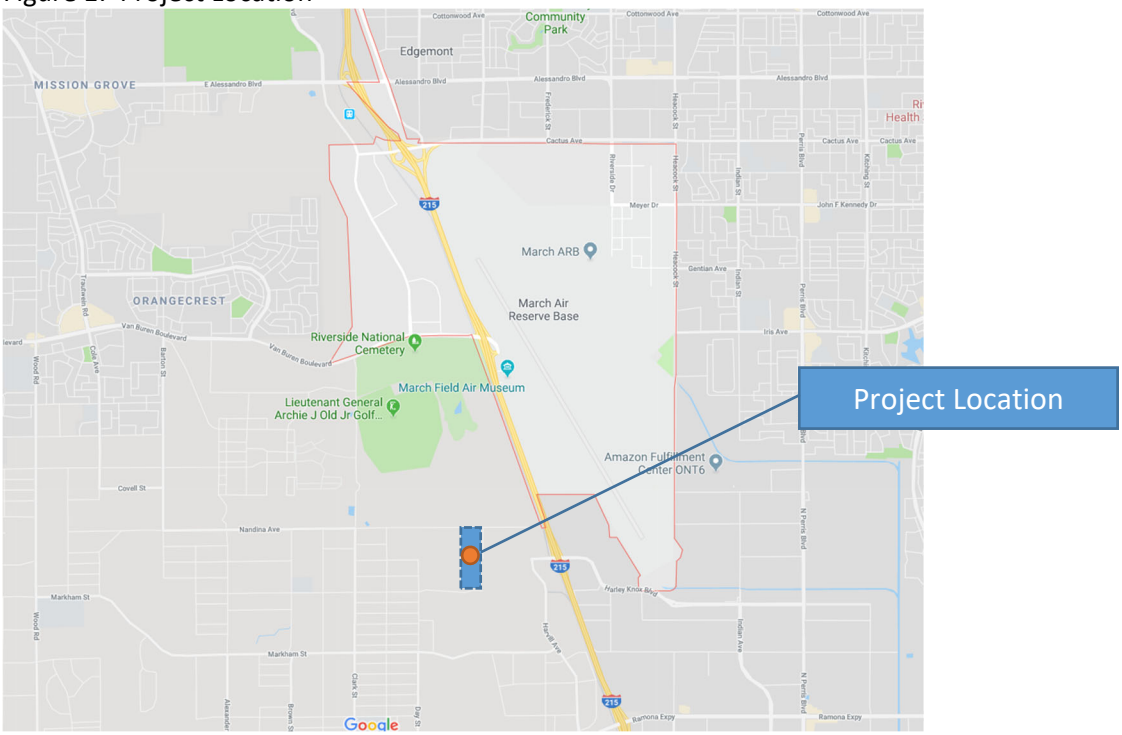
Introduction

The purpose of this technical memorandum is to assess the airport compatibility of two proposed solar (PV) installations on a portion of the roof of each of two buildings that comprise the Mead Valley Development Project. The Project is to be located at the southwest corner of Nandina Avenue and Decker Road in the County of Riverside and within the March Air Reserve Base (March ARB) airport influence area (AIA) (See Figure 1). The analysis and findings of this memo are intended for review and acceptance by Riverside County, Riverside County Airport Land Use Commission (ALUC) and the March ARB.

Project Description

SRG Perris, L.P., the Project Owner, proposes to develop two roof-top solar PV installations on the Mead Valley Development Project. The Project site is located south of Nandina Avenue, west of Decker Road, North of Oleander Avenue and bisected by Harley Knox Boulevard, west of I-215. This site is southwest of March ARB (See Figure 1).

Figure 1: Project Location



The proposed solar PV installations are located on the northern portion of Building A and Building B (See Figure 2) in a total site area of approximately 30,000 square feet for each installation.

Figure 2: Mead Valley Development Project – Solar PV Installations

Standard of Review

This study and its findings have been prepared consistent with the Federal Aviation Administration's (FAA) policy to eliminate hazards to air navigation that may arise as the result of implementing solar energy facilities on and near airports. The FAA adopted an Interim Policy[1] for Solar PV project review in 2013. The FAA was finding that solar PV reflections of sunlight glint and glare were affecting pilots' vision, particularly on final approach to runways, and was also impacting some air traffic controllers' vision when controlling aircraft near airports. In conjunction with Sandia National Laboratories, the FAA developed a computer analysis tool to measure the potential impact of reflected glint and glare from Solar PV installations. The analysis of this impact is achieved through use of the Solar Glare Hazard Assessment Tool (SGHAT). At the time of the Interim Policy, Sandia Labs produced the tool to meet the analysis requirement. Since then, Sandia Labs has licensed the tool to other providers to sell commercially for solar glare analysis. ForgeSolar licensed the SGHAT tool and incorporated its software into their Glare Analysis tool. Johnson Aviation, Inc. uses the ForgeSolar Glare Analysis tool under subscription license from Sims Industries d/b/a ForgeSolar.

[1] Background on the Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports, Federal Register, October 23, 2013.

The FAA Interim Policy is for federally-obligated airports for development on those airports to be included on the Airport Layout Plan (ALP). Solar energy systems located on an airport that is not federally-obligated or located outside the property of a federally-obligated airport are not subject to this policy because the FAA (and in this case, the US Department of Defense (DOD) does not control land use off of airport property. According to the FAA's Interim Policy, "***Proponents of solar energy systems located off-airport property or on non-federally-obligated airports are strongly encouraged to consider the requirements of this policy when siting such systems [emphasis added]***." The following is the Standard for Measuring Ocular Impact from the FAA's Interim Policy:

> Standard for Measuring Ocular Impact
> FAA adopts the Solar Glare Hazard Analysis Plot as the standard for measuring the ocular impact of any proposed solar energy system on a federally-obligated airport. To obtain FAA approval to revise an airport layout plan to depict a solar installation and/or a "no objection" to a Notice of Proposed Construction Form 7460-1, the airport sponsor will be required to demonstrate that the proposed solar energy system meets the following standards:
>
> 1. No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab; and
> 2. No potential for glare or "low potential for after-image" along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath.
> 3. Ocular impact must be analyzed over the entire calendar year in one (1) minute intervals from when the sun rises above the horizon until the sun sets below the horizon.

In addition to the FAA's standards for runway final approach paths and air traffic control tower visibility, the March ARB staff in conjunction with the Riverside County ALUC staff have established a series of air traffic patterns for the two runways located at the Base. Their concern is to ensure that land uses around the base are compatible with its air operations and that solar PV installations will not create a hazard to air navigation as a result of reflected sunlight and the associated potential glare. March ARB staff have provided four sets of geographic coordinates to define the standard traffic patterns listed below:

- Runway 12/30 General Aviation Traffic Pattern (See Attachment A)
- Runway 14/32 General Aviation Traffic Pattern (See Attachment B)
- Runway 14/32 C-17/KC-135 Traffic Pattern (See Attachment C)
- Runway 14/32 Overhead Traffic Pattern (See Attachment D)

Solar Glare Analysis Reports

The following pages of this Technical Memorandum provide the solar glare analysis reports for each of the required studies. The FAA standard study of the final approach paths to the runway ends and the Air Traffic Control Tower analysis is included in each individual report. The four reports are grouped by the flight path studies required by the March ARB and ALUC staff using the SGHAT program.

Attachment A
March ARB Runway 12/30 General Aviation Traffic Pattern Analysis

FORGESOLAR GLARE ANALYSIS

Project: **SRG Perris - Mead Valley**
Proposed solar PV installation under the traffic pattern at March Air Reserve Base, Riverside, California

Site configuration: **Mead Valley-MARB Runway 12-30 GA Analysis**
Analysis conducted by Nick Johnson (nick.johnson@johnson-aviation.com) at 23:17 on 12 Aug, 2019.

U.S. FAA 2013 Policy Adherence

The following table summarizes the policy adherence of the glare analysis based on the 2013 U.S. Federal Aviation Administration Interim Policy 78 FR 63276. This policy requires the following criteria be met for solar energy systems on airport property:

- No "yellow" glare (potential for after-image) for any flight path from threshold to 2 miles
- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics (see list below)

ForgeSolar does not represent or speak officially for the FAA and cannot approve or deny projects. Results are informational only.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
Flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	PASS	Receptor(s) marked as ATCT do not receive glare

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

FAA Policy 78 FR 63276 can be read at https://www.federalregister.gov/d/2013-24729

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 30305.5333

PV Array(s)

Name: Mead Valley Business Park-Bldg A
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 160.0°
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.861655	-117.271672	1617.08	48.00	1665.08
2	33.861644	-117.270914	1617.08	48.00	1665.08
3	33.861294	-117.270909	1617.08	48.00	1665.08
4	33.861293	-117.271675	1617.08	48.00	1665.08

Name: Mead Valley Business Park-Bldg B
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 160.0°
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.865497	-117.271631	1597.08	48.00	1645.08
2	33.865494	-117.270857	1597.08	48.00	1645.08
3	33.865144	-117.270858	1597.08	48.00	1645.08
4	33.865148	-117.271642	1597.08	48.00	1645.08

Flight Path Receptor(s)

Name: RWY 12 Final
Description: None
Threshold height: 50 ft
Direction: 135.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	33.890258	-117.260681	1500.07	50.00	1550.08
Two-mile	33.898508	-117.270608	1500.07	1300.06	2800.14

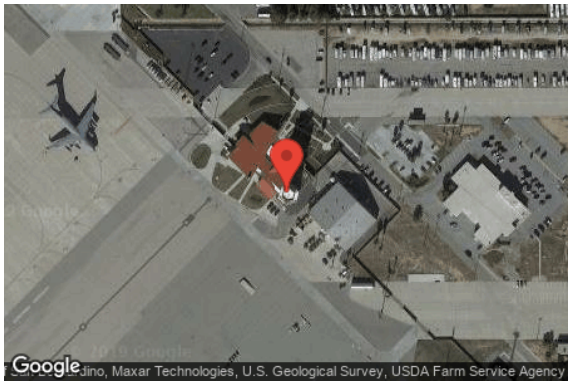
Name: RWY 30 Final
Description: None
Threshold height: 50 ft
Direction: 315.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	33.884319	-117.253536	1500.07	50.00	1550.08
Two-mile	33.876069	-117.243611	1500.07	1300.06	2800.14

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (ft)	Height (ft)
1-ATCT	1	33.891572	-117.251203	1511.07	118.01

Map image of 1-ATCT



Route Receptor(s)

Name: RWY 12 GA Pattern Route
Path type: One-way (toward increasing index)
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.884319	-117.253536	1500.07	50.00	1550.08
2	33.876069	-117.243611	1500.07	1300.06	2800.14
3	33.876081	-117.235119	1500.07	1300.06	2800.14
4	33.880814	-117.229467	1500.07	1300.06	2800.14
5	33.887897	-117.229483	1500.07	1300.06	2800.14
6	33.910333	-117.256469	1500.07	1300.06	2800.14
7	33.910322	-117.264967	1500.07	1300.06	2800.14
8	33.905592	-117.270622	1500.07	1300.06	2800.14
9	33.898508	-117.270608	1500.07	1300.06	2800.14
10	33.890258	-117.260681	1500.07	50.00	1550.08

Name: RWY 30 GA Pattern Route
Path type: One-way (toward increasing index)
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.890258	-117.260681	1500.07	50.00	1550.08
2	33.898508	-117.270608	1500.07	1300.06	2800.14
3	33.905592	-117.270622	1500.07	1300.06	2800.14
4	33.910322	-117.264967	1500.07	1300.06	2800.14
5	33.910333	-117.256469	1500.07	1300.06	2800.14
6	33.887897	-117.229483	1500.07	1300.06	2800.14
7	33.880814	-117.229467	1500.07	1300.06	2800.14
8	33.876081	-117.235119	1500.07	1300.06	2800.14
9	33.876069	-117.243611	1500.07	1300.06	2800.14
10	33.884319	-117.253536	1500.07	50.00	1550.08

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
Mead Valley Business Park-Bldg A	10.0	160.0	969	0	-
Mead Valley Business Park-Bldg B	10.0	160.0	1,869	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
RWY 12 Final	0	0
RWY 30 Final	0	0
1-ATCT	0	0
RWY 12 GA Pattern Route	0	0
RWY 30 GA Pattern Route	2838	0

Results for: Mead Valley Business Park-Bldg A

Receptor	Green Glare (min)	Yellow Glare (min)
RWY 12 Final	0	0
RWY 30 Final	0	0
1-ATCT	0	0
RWY 12 GA Pattern Route	0	0
RWY 30 GA Pattern Route	969	0

Flight Path: RWY 12 Final

0 minutes of yellow glare
0 minutes of green glare

Flight Path: RWY 30 Final

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: 1-ATCT

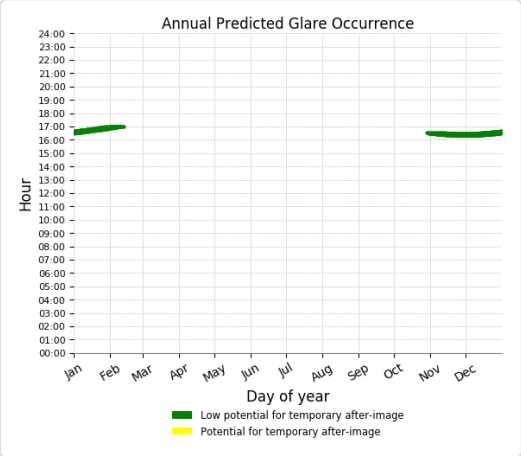
0 minutes of yellow glare
0 minutes of green glare

Route: RWY 12 GA Pattern Route

0 minutes of yellow glare
0 minutes of green glare

Route: RWY 30 GA Pattern Route

0 minutes of yellow glare
969 minutes of green glare



Results for: Mead Valley Business Park-Bldg B

Receptor	Green Glare (min)	Yellow Glare (min)
RWY 12 Final	0	0
RWY 30 Final	0	0
1-ATCT	0	0
RWY 12 GA Pattern Route	0	0
RWY 30 GA Pattern Route	1869	0

Flight Path: RWY 12 Final

0 minutes of yellow glare
0 minutes of green glare

Flight Path: RWY 30 Final

0 minutes of yellow glare

0 minutes of green glare

Point Receptor: 1-ATCT

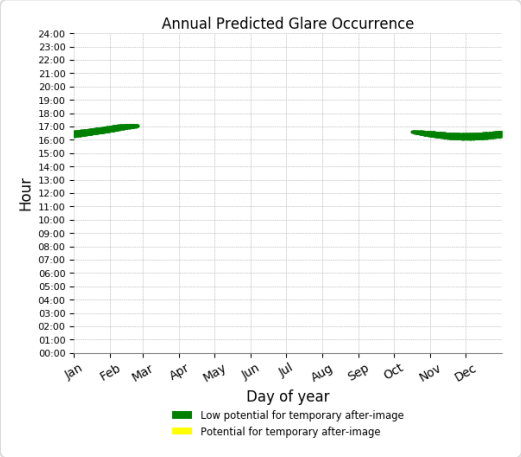
0 minutes of yellow glare
0 minutes of green glare

Route: RWY 12 GA Pattern Route

0 minutes of yellow glare
0 minutes of green glare

Route: RWY 30 GA Pattern Route

0 minutes of yellow glare
1869 minutes of green glare



Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
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. This includes buildings, tree cover and geographic obstructions.
Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence may differ.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.

Attachment B
March ARB Runway 14/32 General Aviation Traffic Pattern Analysis

FORGESOLAR GLARE ANALYSIS

Project: **SRG Perris - Mead Valley**
Proposed solar PV installation under the traffic pattern at March Air Reserve Base, Riverside, California

Site configuration: **Mead Valley-MARB Runway 14-32 GA Analysis3**
Analysis conducted by Nick Johnson (nick.johnson@johnson-aviation.com) at 22:55 on 12 Aug, 2019.

U.S. FAA 2013 Policy Adherence

The following table summarizes the policy adherence of the glare analysis based on the 2013 U.S. Federal Aviation Administration Interim Policy 78 FR 63276. This policy requires the following criteria be met for solar energy systems on airport property:

- No "yellow" glare (potential for after-image) for any flight path from threshold to 2 miles
- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics (see list below)

ForgeSolar does not represent or speak officially for the FAA and cannot approve or deny projects. Results are informational only.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
Flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	PASS	Receptor(s) marked as ATCT do not receive glare

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

FAA Policy 78 FR 63276 can be read at https://www.federalregister.gov/d/2013-24729

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 30306.5333

PV Array(s)

Name: Mead Valley Business Park-Bldg A
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 160.0°
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

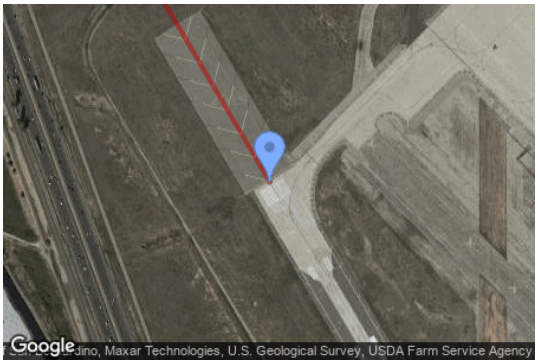
Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.861655	-117.271672	1617.08	48.00	1665.08
2	33.861644	-117.270914	1617.08	48.00	1665.08
3	33.861294	-117.270909	1617.08	48.00	1665.08
4	33.861293	-117.271675	1617.08	48.00	1665.08

Name: Mead Valley Business Park-Bldg B
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 160.0°
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.865497	-117.271631	1597.08	48.00	1645.08
2	33.865494	-117.270857	1597.08	48.00	1645.08
3	33.865144	-117.270858	1597.08	48.00	1645.08
4	33.865148	-117.271642	1597.08	48.00	1645.08

Flight Path Receptor(s)

Name: RWY 14 Final
Description: None
Threshold height: 50 ft
Direction: 149.5°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	33.896431	-117.270636	1500.07	50.00	1550.08
Two-mile	33.906486	-117.277783	1500.07	1500.07	3000.15

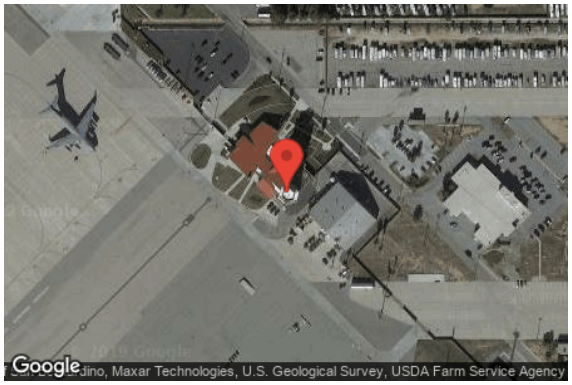
Name: RWY 32 Final
Description: None
Threshold height: 50 ft
Direction: 329.5°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	33.864994	-117.248281	1500.07	50.00	1550.08
Two-mile	33.854942	-117.241136	1500.07	1500.07	3000.15

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (ft)	Height (ft)
1-ATCT	1	33.891572	-117.251203	1511.07	118.01

Map image of 1-ATCT



Route Receptor(s)

Name: RWY 14 GA Pattern Route
Path type: One-way (toward increasing index)
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.864994	-117.248281	1500.07	50.00	1550.08
2	33.854942	-117.241136	1500.07	1500.07	3000.15
3	33.848078	-117.243236	1500.07	1500.07	3000.15
4	33.844669	-117.250119	1500.07	1500.07	3000.15
5	33.846422	-117.258344	1500.07	1500.07	3000.15
6	33.897972	-117.295011	1500.07	1500.07	3000.15
7	33.904833	-117.292903	1500.07	1500.07	3000.15
8	33.908242	-117.286017	1500.07	1500.07	3000.15
9	33.906486	-117.277783	1500.07	1500.07	3000.15
10	33.896431	-117.270636	1500.07	50.00	1550.08

Name: RWY 32 GA Pattern Route
Path type: One-way (toward increasing index)
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.896431	-117.270636	1500.07	50.00	1550.08
2	33.906486	-117.277783	1500.07	1500.07	3000.15
3	33.908242	-117.286017	1500.07	1500.07	3000.15
4	33.904833	-117.292903	1500.07	1500.07	3000.15
5	33.897972	-117.295011	1500.07	1500.07	3000.15
6	33.846422	-117.258344	1500.07	1500.07	3000.15
7	33.844669	-117.250119	1500.07	1500.07	3000.15
8	33.848078	-117.243236	1500.07	1500.07	3000.15
9	33.854942	-117.241136	1500.07	1500.07	3000.15
10	33.864994	-117.248281	1500.07	50.00	1550.08

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
Mead Valley Business Park-Bldg A	10.0	160.0	23,077	0	-
Mead Valley Business Park-Bldg B	10.0	160.0	38,024	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
RWY 14 Final	0	0
RWY 32 Final	3429	0
1-ATCT	0	0
RWY 14 GA Pattern Route	18886	0
RWY 32 GA Pattern Route	38786	0

Results for: Mead Valley Business Park-Bldg A

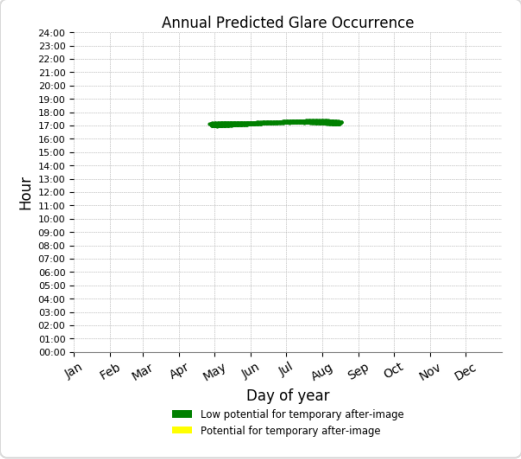
Receptor	Green Glare (min)	Yellow Glare (min)
RWY 14 Final	0	0
RWY 32 Final	1047	0
1-ATCT	0	0
RWY 14 GA Pattern Route	8973	0
RWY 32 GA Pattern Route	13057	0

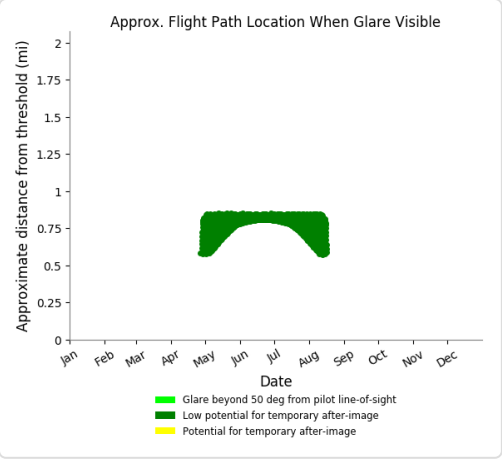
Flight Path: RWY 14 Final

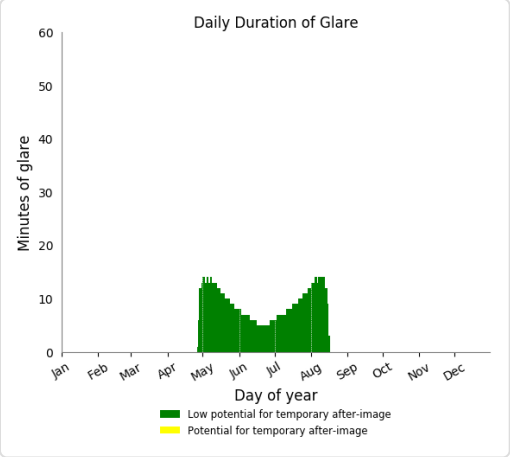
0 minutes of yellow glare
0 minutes of green glare

Flight Path: RWY 32 Final

0 minutes of yellow glare
1047 minutes of green glare





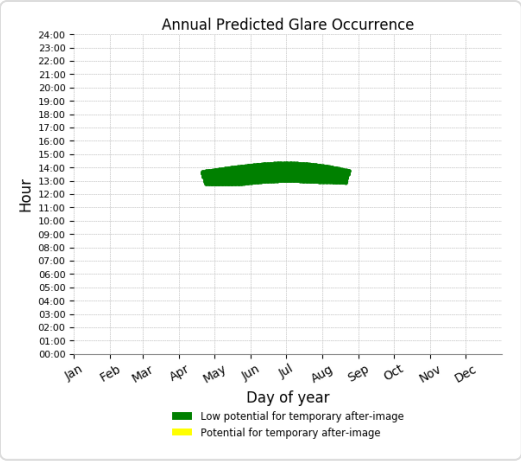


Point Receptor: 1-ATCT

0 minutes of yellow glare
0 minutes of green glare

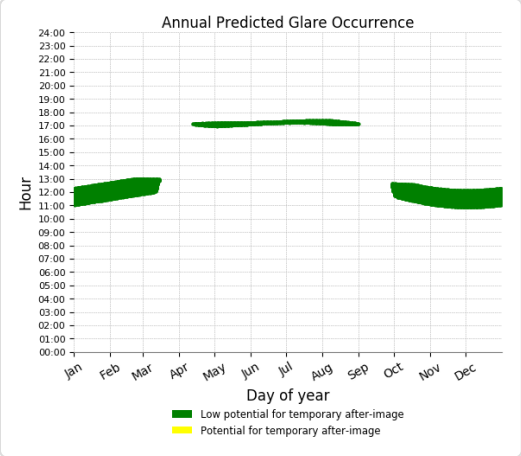
Route: RWY 14 GA Pattern Route

0 minutes of yellow glare
8973 minutes of green glare



Route: RWY 32 GA Pattern Route

0 minutes of yellow glare
13057 minutes of green glare



Results for: Mead Valley Business Park-Bldg B

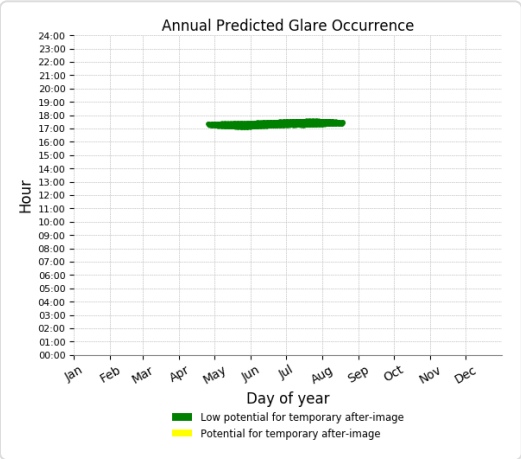
Receptor	Green Glare (min)	Yellow Glare (min)
RWY 14 Final	0	0
RWY 32 Final	2382	0
1-ATCT	0	0
RWY 14 GA Pattern Route	9913	0
RWY 32 GA Pattern Route	25729	0

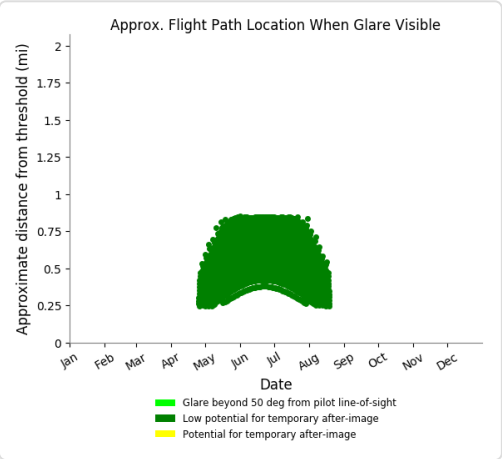
Flight Path: RWY 14 Final

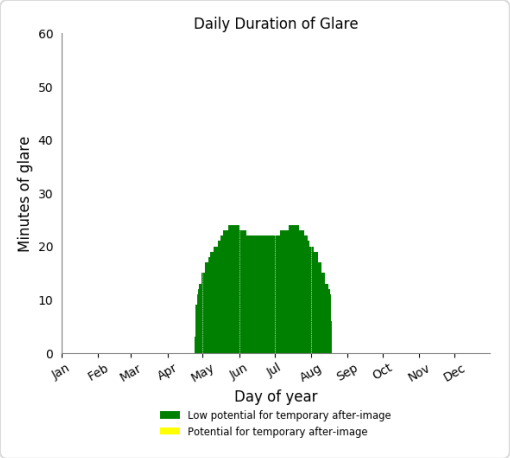
0 minutes of yellow glare
0 minutes of green glare

Flight Path: RWY 32 Final

0 minutes of yellow glare
2382 minutes of green glare





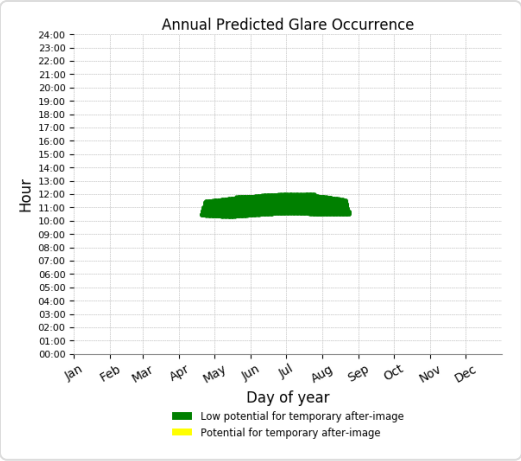


Point Receptor: 1-ATCT

0 minutes of yellow glare
0 minutes of green glare

Route: RWY 14 GA Pattern Route

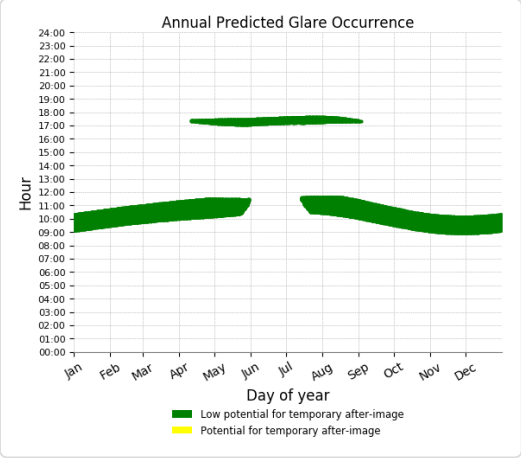
0 minutes of yellow glare
9913 minutes of green glare



Route: RWY 32 GA Pattern Route

0 minutes of yellow glare

25729 minutes of green glare



Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
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. This includes buildings, tree cover and geographic obstructions.
Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence may differ.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.

Attachment C
March ARB Runway 14/32 C-17/KC-135 Traffic Pattern Analysis

FORGESOLAR GLARE ANALYSIS

Project: **SRG Perris - Mead Valley**
Proposed solar PV installation under the traffic pattern at March Air Reserve Base, Riverside, California

Site configuration: **Mead Valley-MARB Runway 14-32 C-17 Analysis**
Analysis conducted by Nick Johnson (nick.johnson@johnson-aviation.com) at 23:10 on 12 Aug, 2019.

U.S. FAA 2013 Policy Adherence

The following table summarizes the policy adherence of the glare analysis based on the 2013 U.S. Federal Aviation Administration Interim Policy 78 FR 63276. This policy requires the following criteria be met for solar energy systems on airport property:

- No "yellow" glare (potential for after-image) for any flight path from threshold to 2 miles
- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics (see list below)

ForgeSolar does not represent or speak officially for the FAA and cannot approve or deny projects. Results are informational only.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
Flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	PASS	Receptor(s) marked as ATCT do not receive glare

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

FAA Policy 78 FR 63276 can be read at https://www.federalregister.gov/d/2013-24729

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 30307.5333

PV Array(s)

Name: Mead Valley Business Park-Bldg A
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 160.0°
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

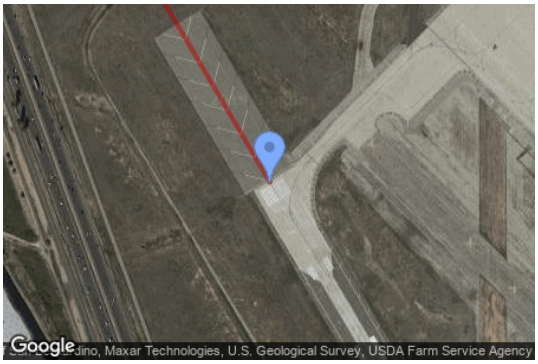
Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.861655	-117.271672	1617.08	48.00	1665.08
2	33.861644	-117.270914	1617.08	48.00	1665.08
3	33.861294	-117.270909	1617.08	48.00	1665.08
4	33.861293	-117.271675	1617.08	48.00	1665.08

Name: Mead Valley Business Park-Bldg B
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 160.0°
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.865497	-117.271631	1597.08	48.00	1645.08
2	33.865494	-117.270857	1597.08	48.00	1645.08
3	33.865144	-117.270858	1597.08	48.00	1645.08
4	33.865148	-117.271642	1597.08	48.00	1645.08

Flight Path Receptor(s)

Name: RWY 14 Final
Description: None
Threshold height: 50 ft
Direction: 149.5°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	33.896431	-117.270636	1500.07	50.00	1550.08
Two-mile	33.906486	-117.277783	1500.07	1500.07	3000.15

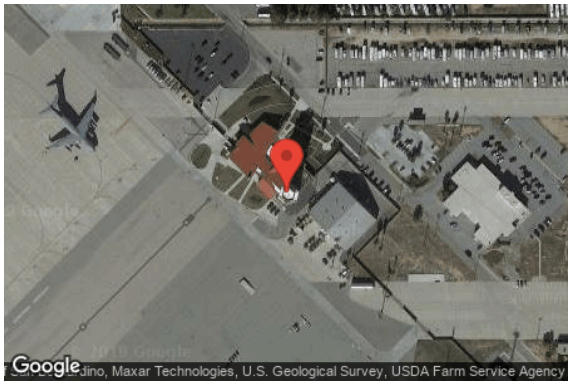
Name: RWY 32 Final
Description: None
Threshold height: 50 ft
Direction: 329.5°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	33.864994	-117.248281	1500.07	50.00	1550.08
Two-mile	33.854942	-117.241136	1500.07	1500.07	3000.15

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (ft)	Height (ft)
1-ATCT	1	33.891572	-117.251203	1511.07	118.01

Map image of 1-ATCT



Route Receptor(s)

Name: RWY 14 C-17 - KC-135 Pattern Route
Path type: One-way (toward increasing index)
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.864994	-117.248281	1500.07	50.00	1550.08
2	33.836269	-117.227869	1500.07	1500.07	3000.15
3	33.821961	-117.228367	1500.07	1500.07	3000.15
4	33.813147	-117.244350	1500.07	1500.07	3000.15
5	33.819225	-117.262269	1500.07	1500.07	3000.15
6	33.908131	-117.325528	1500.07	1500.07	3000.15
7	33.922394	-117.325047	1500.07	1500.07	3000.15
8	33.931244	-117.309014	1500.07	1500.07	3000.15
9	33.925156	-117.291061	1500.07	1500.07	3000.15
10	33.896431	-117.270636	1500.07	50.00	1550.08

Name: RWY 32 C-17 - KC-135 Pattern Route
Path type: One-way (toward increasing index)
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.896431	-117.270636	1500.07	50.00	1550.08
2	33.925156	-117.291061	1500.07	1500.07	3000.15
3	33.931244	-117.309014	1500.07	1500.07	3000.15
4	33.922394	-117.325047	1500.07	1500.07	3000.15
5	33.908131	-117.325528	1500.07	1500.07	3000.15
6	33.819225	-117.262269	1500.07	1500.07	3000.15
7	33.813147	-117.244350	1500.07	1500.07	3000.15
8	33.821961	-117.228367	1500.07	1500.07	3000.15
9	33.836269	-117.227869	1500.07	1500.07	3000.15
10	33.864994	-117.248281	1500.07	50.00	1550.08

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
Mead Valley Business Park-Bldg A	10.0	160.0	2,528	0	-
Mead Valley Business Park-Bldg B	10.0	160.0	3,921	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
RWY 14 Final	0	0
RWY 32 Final	3429	0
1-ATCT	0	0
RWY 14 C-17 - KC-135 Pattern Route	0	0
RWY 32 C-17 - KC-135 Pattern Route	3020	0

Results for: Mead Valley Business Park-Bldg A

Receptor	Green Glare (min)	Yellow Glare (min)
RWY 14 Final	0	0
RWY 32 Final	1047	0
1-ATCT	0	0
RWY 14 C-17 - KC-135 Pattern Route	0	0
RWY 32 C-17 - KC-135 Pattern Route	1481	0

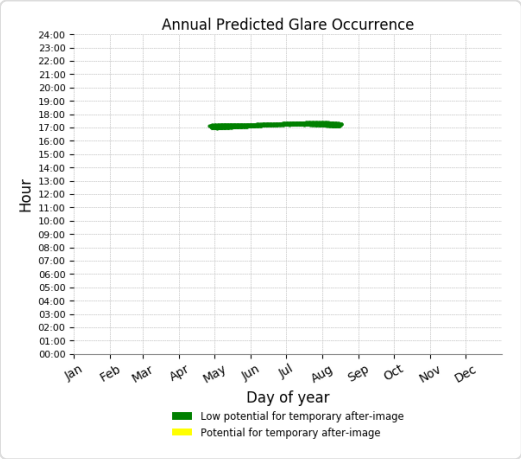
Flight Path: RWY 14 Final

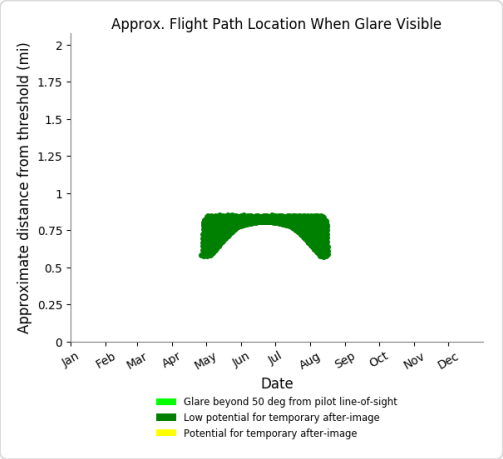
0 minutes of yellow glare
0 minutes of green glare

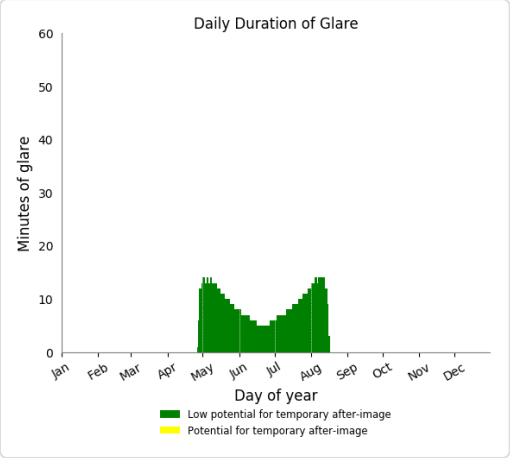
Flight Path: RWY 32 Final

0 minutes of yellow glare

1047 minutes of green glare







Point Receptor: 1-ATCT

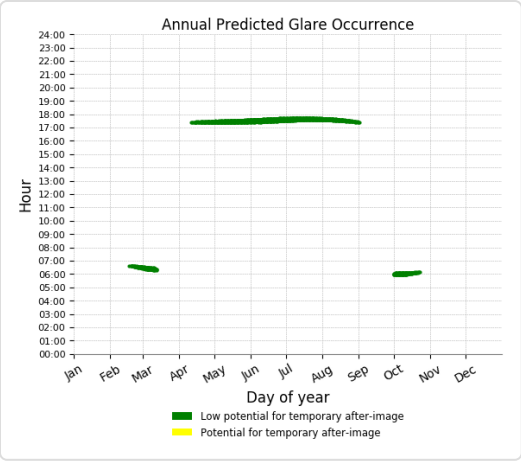
0 minutes of yellow glare
0 minutes of green glare

Route: RWY 14 C-17 - KC-135 Pattern Route

0 minutes of yellow glare
0 minutes of green glare

Route: RWY 32 C-17 - KC-135 Pattern Route

0 minutes of yellow glare
1481 minutes of green glare



Results for: Mead Valley Business Park-Bldg B

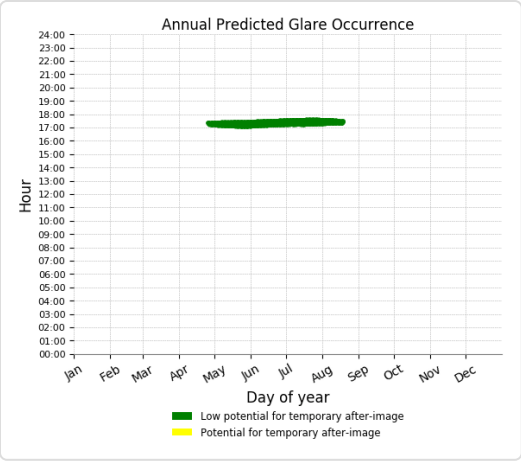
Receptor	Green Glare (min)	Yellow Glare (min)
RWY 14 Final	0	0
RWY 32 Final	2382	0
1-ATCT	0	0
RWY 14 C-17 - KC-135 Pattern Route	0	0
RWY 32 C-17 - KC-135 Pattern Route	1539	0

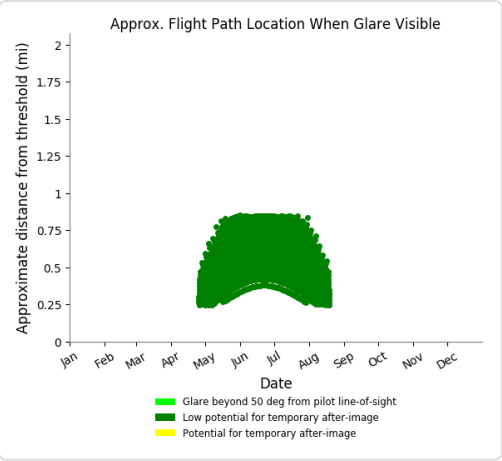
Flight Path: RWY 14 Final

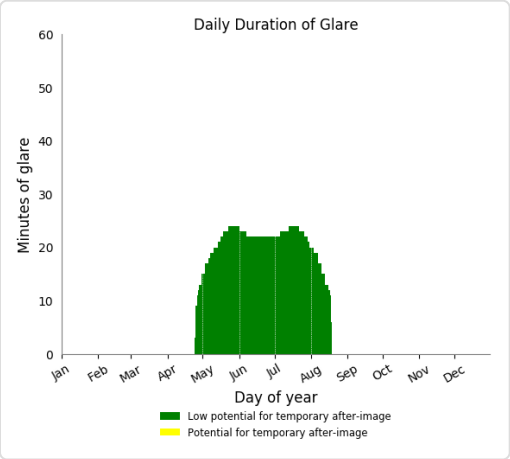
0 minutes of yellow glare
0 minutes of green glare

Flight Path: RWY 32 Final

0 minutes of yellow glare
2382 minutes of green glare







Point Receptor: 1-ATCT

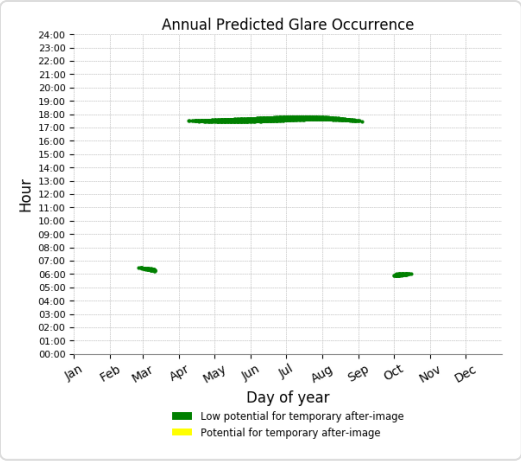
0 minutes of yellow glare
0 minutes of green glare

Route: RWY 14 C-17 - KC-135 Pattern Route

0 minutes of yellow glare
0 minutes of green glare

Route: RWY 32 C-17 - KC-135 Pattern Route

0 minutes of yellow glare
1539 minutes of green glare



Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
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. This includes buildings, tree cover and geographic obstructions.
Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence may differ.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.

Attachment D
March ARB Runway 14/32 Overhead Traffic Pattern Analysis

FORGESOLAR GLARE ANALYSIS

Project: **SRG Perris - Mead Valley**
Proposed solar PV installation under the traffic pattern at March Air Reserve Base, Riverside, California

Site configuration: **Mead Valley-MARB Runway 14-32 Overhead Analysis**
Analysis conducted by Nick Johnson (nick.johnson@johnson-aviation.com) at 23:25 on 12 Aug, 2019.

U.S. FAA 2013 Policy Adherence

The following table summarizes the policy adherence of the glare analysis based on the 2013 U.S. Federal Aviation Administration Interim Policy 78 FR 63276. This policy requires the following criteria be met for solar energy systems on airport property:

- No "yellow" glare (potential for after-image) for any flight path from threshold to 2 miles
- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics (see list below)

ForgeSolar does not represent or speak officially for the FAA and cannot approve or deny projects. Results are informational only.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
Flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	PASS	Receptor(s) marked as ATCT do not receive glare

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

FAA Policy 78 FR 63276 can be read at https://www.federalregister.gov/d/2013-24729

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 30300.5333

PV Array(s)

Name: Mead Valley Business Park-Bldg A
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 160.0°
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

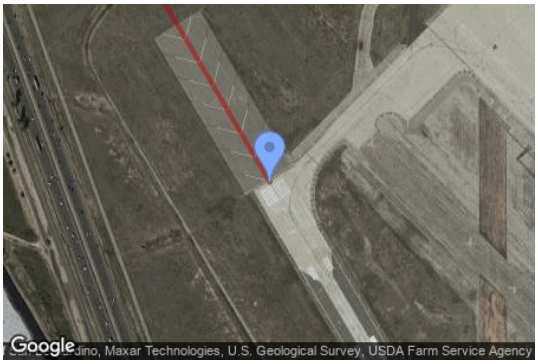
Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.861655	-117.271672	1617.08	48.00	1665.08
2	33.861644	-117.270914	1617.08	48.00	1665.08
3	33.861294	-117.270909	1617.08	48.00	1665.08
4	33.861293	-117.271675	1617.08	48.00	1665.08

Name: Mead Valley Business Park-Bldg B
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 160.0°
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.865497	-117.271631	1597.08	48.00	1645.08
2	33.865494	-117.270857	1597.08	48.00	1645.08
3	33.865144	-117.270858	1597.08	48.00	1645.08
4	33.865148	-117.271642	1597.08	48.00	1645.08

Flight Path Receptor(s)

Name: RWY 14 Final
Description: None
Threshold height: 50 ft
Direction: 149.5°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	33.896431	-117.270636	1500.07	50.00	1550.08
Two-mile	33.906486	-117.277783	1500.07	2000.10	3500.17

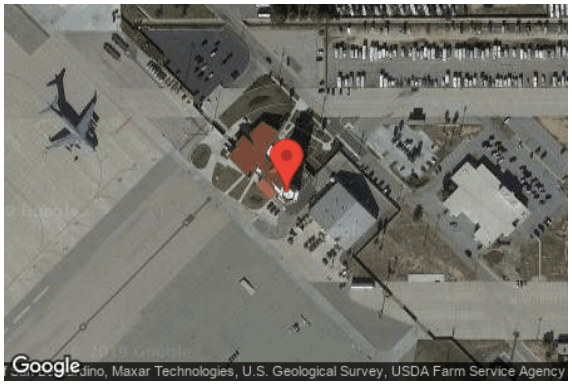
Name: RWY 32 Final
Description: None
Threshold height: 50 ft
Direction: 329.5°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	33.864994	-117.248281	1500.07	50.00	1550.08
Two-mile	33.854942	-117.241136	1500.07	2000.10	3500.17

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (ft)	Height (ft)
1-ATCT	1	33.891572	-117.251203	1511.07	118.01

Map image of 1-ATCT



Route Receptor(s)

Name: RWY 14 Overhead Route
Path type: One-way (toward increasing index)
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.968036	-117.322128	1500.07	2000.10	3500.17
2	33.880706	-117.259453	1500.07	2000.10	3500.17
3	33.863564	-117.293808	1500.07	2000.10	3500.17
4	33.908131	-117.325528	1500.07	2000.10	3500.17
5	33.925156	-117.291061	1500.07	2000.10	3500.17
6	33.896431	-117.270636	1500.07	50.00	1550.08

Name: RWY 32 Overhead Route
Path type: One-way (toward increasing index)
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	33.793375	-117.196878	1500.07	2000.10	3500.17
2	33.880706	-117.259453	1500.07	2000.10	3500.17
3	33.863564	-117.293808	1500.07	2000.10	3500.17
4	33.819225	-117.262269	1500.07	2000.10	3500.17
5	33.836269	-117.227869	1500.07	2000.10	3500.17
6	33.864994	-117.248281	1500.07	50.00	1550.08

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
Mead Valley Business Park-Bldg A	10.0	160.0	4,911	0	-
Mead Valley Business Park-Bldg B	10.0	160.0	7,011	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
RWY 14 Final	0	0
RWY 32 Final	4245	0
1-ATCT	0	0
RWY 14 Overhead Route	0	0
RWY 32 Overhead Route	7677	0

Results for: Mead Valley Business Park-Bldg A

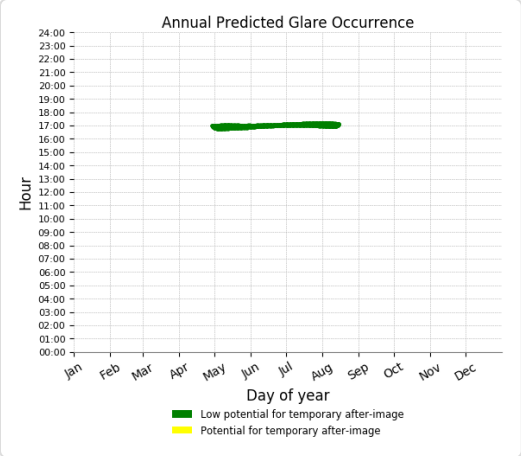
Receptor	Green Glare (min)	Yellow Glare (min)
RWY 14 Final	0	0
RWY 32 Final	1336	0
1-ATCT	0	0
RWY 14 Overhead Route	0	0
RWY 32 Overhead Route	3575	0

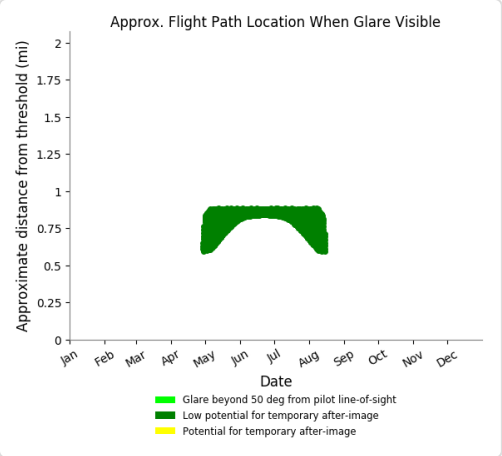
Flight Path: RWY 14 Final

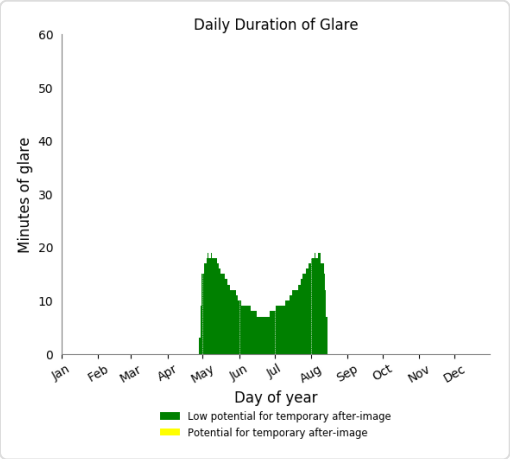
0 minutes of yellow glare
0 minutes of green glare

Flight Path: RWY 32 Final

0 minutes of yellow glare
1336 minutes of green glare







Point Receptor: 1-ATCT

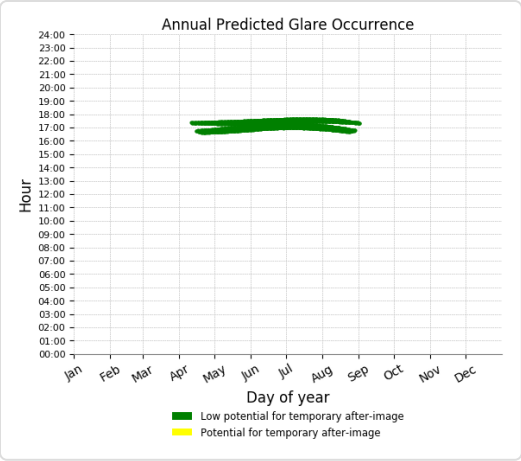
0 minutes of yellow glare
0 minutes of green glare

Route: RWY 14 Overhead Route

0 minutes of yellow glare
0 minutes of green glare

Route: RWY 32 Overhead Route

0 minutes of yellow glare
3575 minutes of green glare



Results for: Mead Valley Business Park-Bldg B

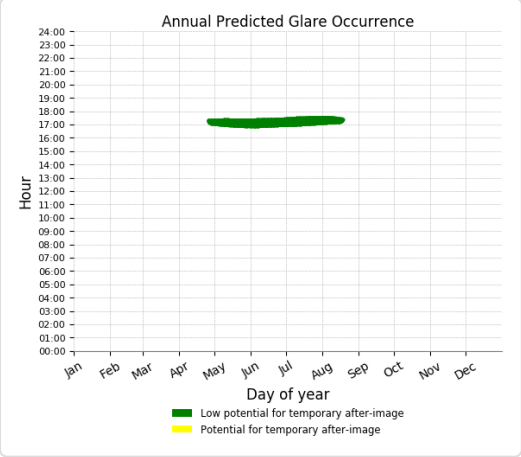
Receptor	Green Glare (min)	Yellow Glare (min)
RWY 14 Final	0	0
RWY 32 Final	2909	0
1-ATCT	0	0
RWY 14 Overhead Route	0	0
RWY 32 Overhead Route	4102	0

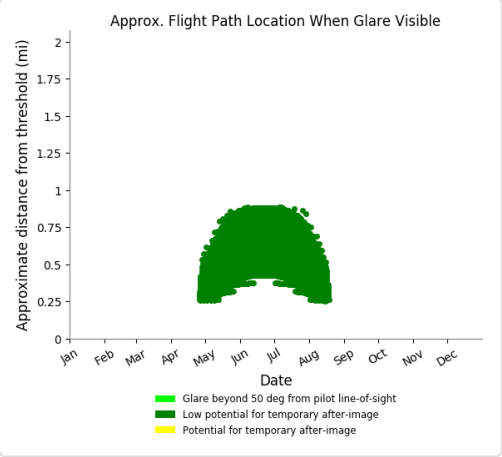
Flight Path: RWY 14 Final

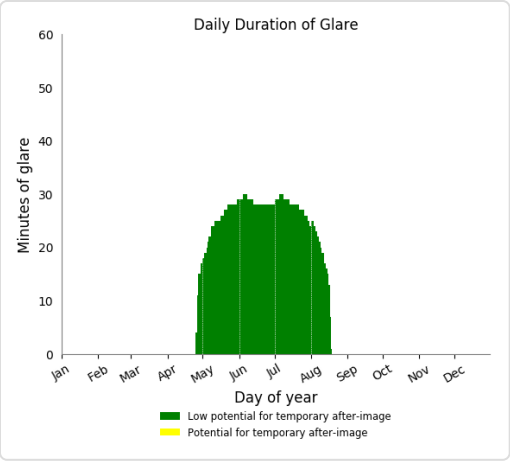
0 minutes of yellow glare
0 minutes of green glare

Flight Path: RWY 32 Final

0 minutes of yellow glare
2909 minutes of green glare







Point Receptor: 1-ATCT

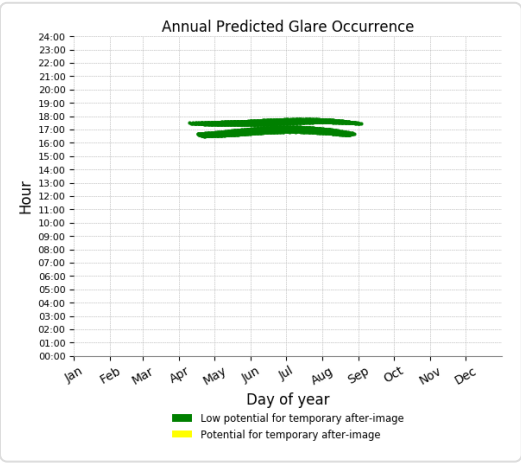
0 minutes of yellow glare
0 minutes of green glare

Route: RWY 14 Overhead Route

0 minutes of yellow glare
0 minutes of green glare

Route: RWY 32 Overhead Route

0 minutes of yellow glare
4102 minutes of green glare



Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
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. This includes buildings, tree cover and geographic obstructions.
Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence may differ.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.