Railsplitter I and Railsplitter II Solar Project
Glare Hazard Analysis

York and Augusta Township, Michigan

March 22, 2024

Prepared for:

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Executive Summary

Stantec Consulting Services, Inc. (Stantec) utilized the web-based ForgeSolar glare hazard analysis program to analyze the potential for glare from the proposed Railsplitter I and Railsplitter II Project (Project), a utility-scale solar-powered electric generation facility that will have a solar generating capacity of up to 150.15 megawatts-ac (MWac), located in York and Augusta Townships, Michigan, and depicted in **Figure 1**. The Project will include photovoltaic (PV) solar panels mounted on a racking system to maximize solar energy capture and electric generation of the array. The Project area encompasses approximately 1,420 acres in a rural agricultural and forested area located approximately 1.5 miles northeast of the village of Milan.

The ForgeSolar program identifies the three following types of glare (no color indicates no glare predicted):

GREEN - Low potential for temporary after-image.
YELLOW - Potential for temporary after-image.
RED - Potential for permanent eye damage.

Based on the solar array parameters provided and the current site design, no glare is predicted for pilots approaching the nine airports and 18 approach paths located within 10 miles of the project site, or for helicopter pilots hovering over four helipads within 10 miles of the project. Glare is also not predicted for the six road segments, one railroad, and 39-- houses included in the analysis.

Abbreviations

AGL	Above Ground Level
deg	degrees (0 is due north, 180 is due south)
DNI	Direct Normal Irradiance
FAA	Federal Aviation Administration
FP	Flight Path (landing path from threshold to two miles out)
ft	Feet
kW	Kilowatt
kWh	kilowatt hour
m	Meters
mi	Mile
min	Minutes
mrad	Milliradian
MW	Megawatt
MSL	Mean Sea Level
OP	Observation Point (e.g., control tower, structure)
PV	Photovoltaic

Glossary

Correlate Slope Error with Surface Type?	Correlates the slope error value based on the surface material type; default value is 8.43 milliradians (mrads).
Eye Focal Length (m)	Typical distance between the cornea and the retina of the human eye, default is 0.017, though some sources indicate that the typical length is 0.022.
Glide Slope (deg)	Angle at which the plane approaches the runway during landing (default is 3 degrees [deg] from horizontal).
Maximum Tracking Angle (deg)	Rotation limit of panels in either direction. Full rotation is 2*maximum tracking angle. E.g., maximum tracking angle of 60 deg indicates full panel rotation range of 120 deg.
Resting Angle (deg)	Angle modules return to after maximum angle is reached.
Observation Point	A specific location, such as a control tower or structure, from which an observer might experience glare.
Ocular Transmission Coefficient	Related to the ability of the eye to transmit light, set by at 0.5 by Forge Solar.
Offset angle of module (deg)	Additional tilt/elevation angle between the tracking axis and the panel.
Orientation of Tracking Axis (deg)	Azimuthal position of tracking axis measured clockwise from true north. Tracking systems in the northern hemisphere are typically oriented near 180 deg. Tracking systems in the southern hemisphere are typically oriented near 0 deg.
Peak DNI (W/m^2)**	This value is set at 1,000 by ForgeSolar and is the amount of solar radiation per unit surface area by a surface perpendicular to the sun's rays in a straight line from the direction of the sun at its current position in the sky.
Pupil Diameter (m)	Typical pupil diameter for observer, default is 0.002 meters (m).
PV Array Axis Tracking	Panel tracking mode, if any. Panel can be set to track along one (single) or two (dual) axis tracking. This parameter affects the positioning of the panels at every time step when the sun is up.
PV Array Panel Material	Surface material of panels, including use of anti-reflective coating (ARC). Options include: smooth glass without ARC, smooth glass with ARC, light-textured glass without ARC, light-textured glass with ARC, and deeply textured glass.
Rated Power (kW)	Power rating of the solar array - used to estimate the energy output per year of the array (optional).
Slope Error (mrad)	Accounts for beam scatter of sunlight on the array. Default is 8.43 mrads but the value may be adjusted based on the panel material type.
Subtended Angle of Sun (mrad)	The angle above horizontal at which the viewer observes the sun, default value is 9.3 mrad.
Threshold	The physical beginning of the runway. Aircraft are typically expected to be 50 ft above ground at this point.

Time Interval (min)	Time step intervals used by the program for analyses. Default is set to analyze for glare at every one-minute interval throughout the year.
Time zone	Time zone difference from Greenwich Mean Time at the location of the analysis.
Tilt of Tracking Axis (deg)	The elevation angle of the tracking axis upon which panels rotate (e.g., torque tube), measured from flat ground. 0 deg implies the axis is on level, flat ground. Values between 0 and 30 deg are typical.
Vary Reflectivity	Varies panel reflectivity with sun position at each time step.
Maximum Downward Viewing Angle (deg)	The angle extending downward from the horizon indicating the maximum downward viewing angle from the cockpit. Used to determine whether glare is visible by the pilot along the flight path. Default is 30 degrees.

Sources:

Ho, Clifford, K., Cianan A. Sims, Julius E. Yellowhair. 2015. Solar Glare Hazard Analysis Tool (SGHAT) User's Manual v. 2H. Sandia National Laboratories.

ForgeSolar – PV Planning & Glare Analysis. https://www.forgesolar.com/

**Source: http://www.3tier.com/en/support/solar-prospecting-tools/what-direct-normal-irradiance-solar-prospecting/

1.0 INTRODUCTION

On behalf of White Tail Solar, LLC (White Tail Solar), Stantec utilized the web based ForgeSolar glare hazard analysis program to complete a glare analysis for the Railsplitter I and Railsplitter II Solar Project (the Project) to determine the potential for glint/glare from the photovoltaic (PV) solar panels to affect residents in the area and drivers passing through the vicinity of the array. The Project is located in a rural agricultural area of Augusta and York Townships, southeast Michigan (**Figure 1**), located approximately 1.5 miles northeast of the community of Milan.

ForgeSolar is an interactive tool that provides a quantified assessment of (1) when and where glare will occur throughout the year for a prescribed solar project and (2) potential effects on the human eye at locations where glare occurs. Glare can occur from the reflection of sunlight on the PV solar panels of utility-scale solar-powered electric generating facilities. While PV solar panels absorb direct sunlight, some reflection can occur especially when the panels are directed close to horizontal, which predominately occurs during sunset and sunrise when the incidence angle of the panels is highest, as depicted in **Figure 2** below.

ForgeSolar employs an interactive Google map for site location, mapping the proposed PV array(s), and specifying observer locations, vehicular travel routes, or flight paths. Latitude, longitude, and elevation are automatically recorded through the Google interface, providing necessary information for sun position and vector calculations. Additional information regarding the orientation and tilt of the PV solar panels, reflectance, environment, and ocular factors are entered by the user.

If glare is found, the tool calculates the retinal irradiance and subtended 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 plot that specifies when glare will occur throughout the year, with color codes indicating the potential ocular hazard.

The airports and helipads included in the analysis are shown in **Figure 3** below while arrays, routes, and structures are shown in **Figures 4-6**. In addition, due to program limitations on the number of subarrays that may be drawn per analysis, the site was divided into two analysis blocks. All houses, routes, and airports were analyzed with all analysis blocks. All features were analyzed using 6.5-ft and 8.58-ft above ground level (AGL) panel heights using a 60-degree resting angle.

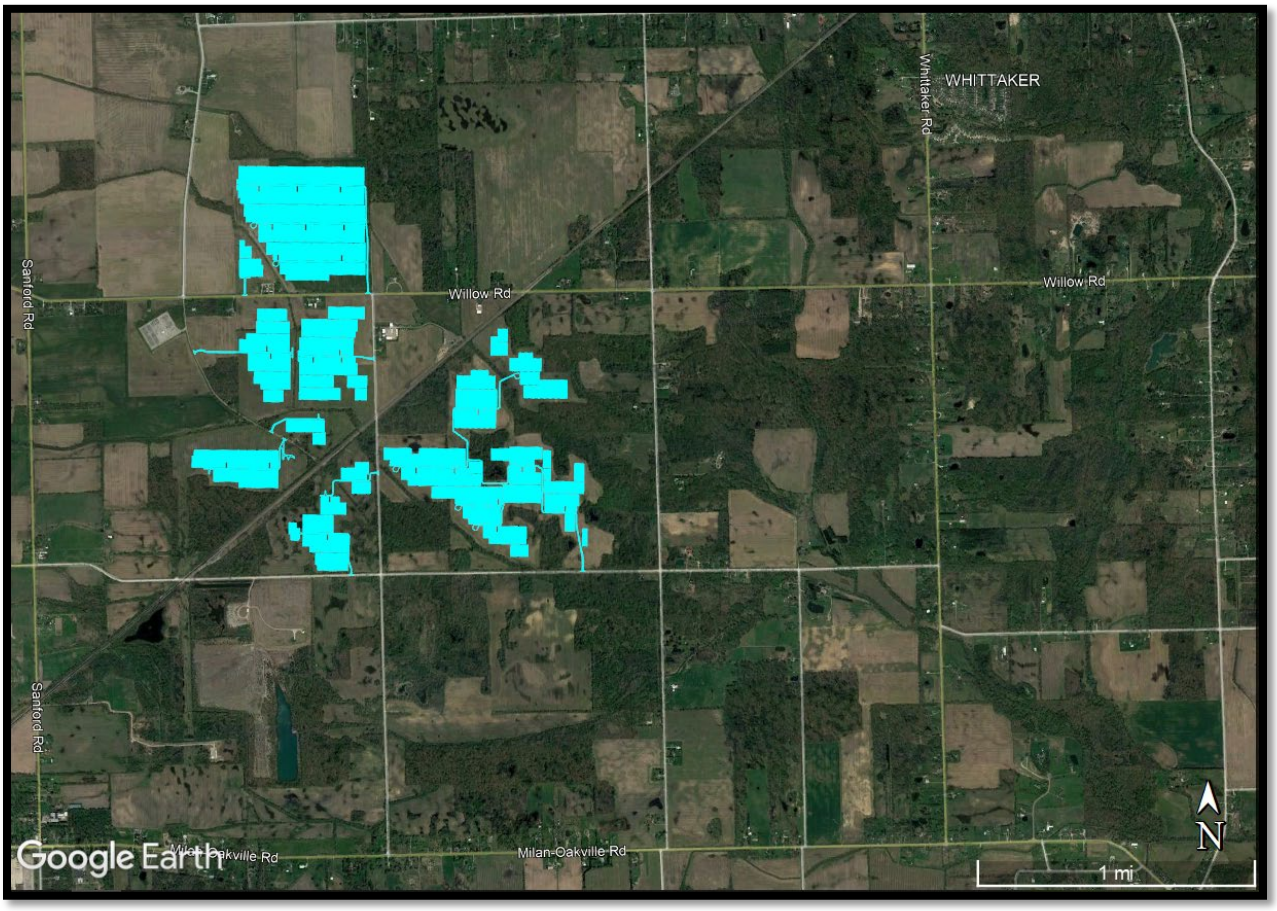

Figure 1. Project Location Map*
*Blue lines represent the PV array. Source: Google Earth Imagery

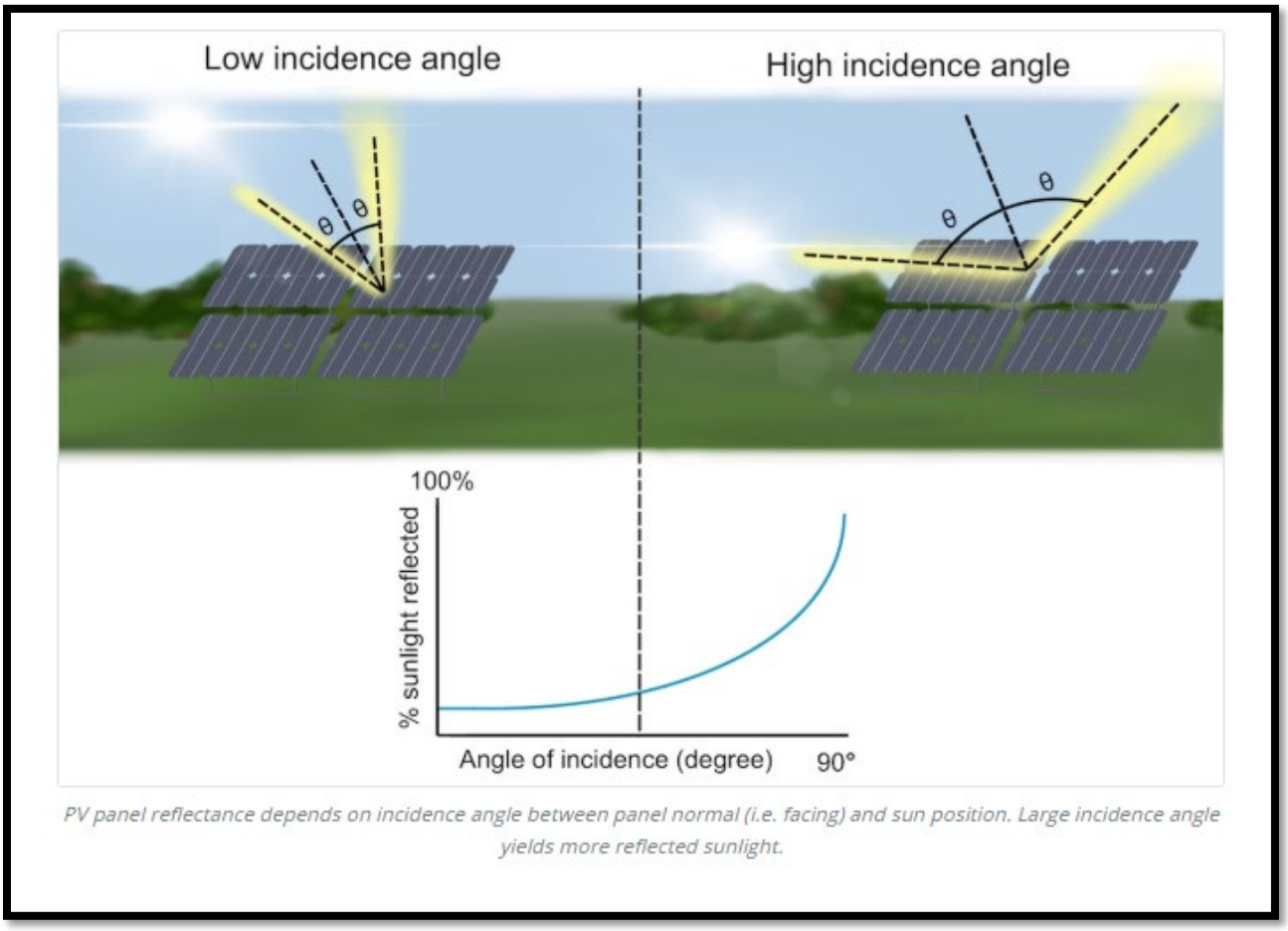

Figure 2. Reflectivity differences between low and high incidence angles.
Source: ForgeSolar.com 2023

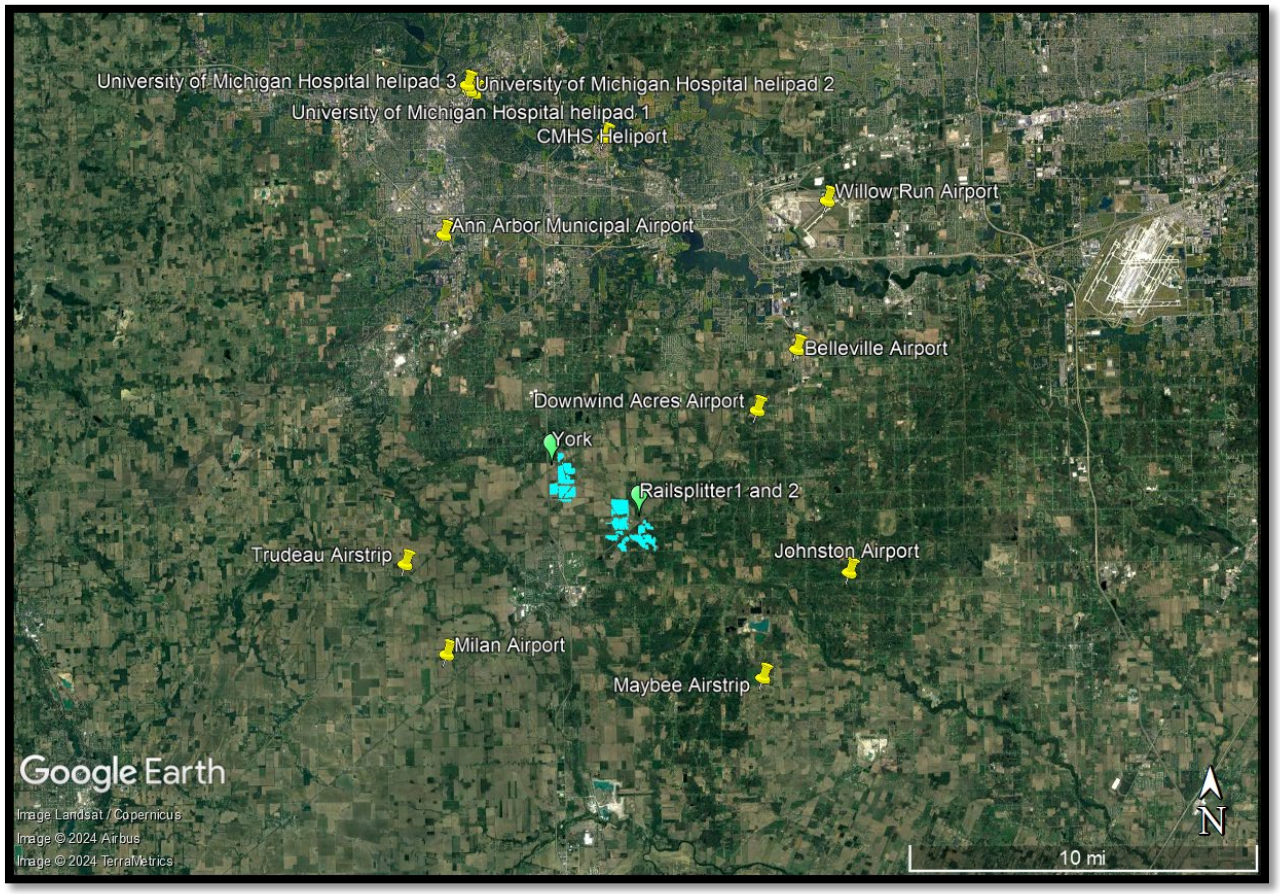

Figure 3. Analysis area and airports and helipads

Source: Google Earth Imagery.

2.0 DATA INPUT SUMMARY

The parameters used for the analyses are listed in **Table 1** below. “Default” indicates the default parameter value set by ForgeSolar and is generally considered a conservative value for the parameter. “Provided” parameters are Project specific information provided by the client.

2.1 SOLAR ARRAY

The location of the solar array and array parameters used for the analyses are based on information provided by White Tail Solar. A detailed description of each parameter is provided in the Glossary.

Table 1: Solar Panel Parameters Used for the Glare Analysis

Parameter	Value Used	Default or Provided?
Axis tracking	Single axis	Provided
Tracking Axis Tilt (deg)	Calculated by ForgeSolar	Default
Tracking Axis Orientation (deg)	180.0	Provided
Tracking Axis Panel Offset (deg)	0.0	Default
Maximum Tracking Angle (deg)	60	Provided
Resting Angle (deg)	60	Provided
Rated Power (kW)	Not Used	NA
Vary reflectivity?	Yes	Default
Panel material	Smooth glass with Anti-Reflective Coating	Provided
Time zone offset	-5	Based on site location
Subtended angle of sun (mrad)	9.3	Default
Peak DNI (W/m^2)	1,000	Default
Ocular transmission coefficient	0.5	Default
Pupil diameter (m)	0.002	Default
Eye focal length (m)	0.017	Default
Time interval (min)	1	Default
Correlate slope error with surface type?	Yes	Default
Slope error (mrad)	8.43	Default
Ground Cover Ratio (%)	42	Provided

2.2 AIRPORT APPROACH PATHS AND AIR TRAFFIC CONTROL TOWER

Potential glare was analyzed for six airports and 18 approach paths, as well as for two Air Traffic Control Towers (ATCTs) associated with the Ann Arbor Municipal Airport and the Willow Run Airport. Since the height of the ATCTs are not published, a conservative estimate of 100-fl AGL was assumed for these airports. Four heliports, three of which are located at the University of Michigan, were included in this analysis.

2.3 ROADWAYS AND PROPERTIES LOCATED ADJACENT TO THE SOLAR ARRAYS

This analysis included potential glare to vehicles travelling on six different roads and one railroad in the vicinity of the Project area (**Figures 4-5**), including: Arkona Road, Gooding Road, Hitchingham Road, McCrone Road, a Railroad, Sanford Road, and Willow Road. The ForgeSolar program sets the default viewing angle of the array at 50 degrees from the driver's direct line of sight (when looking forward). The

Federal Aviation Administration (FAA) has determined that glare beyond 50 degrees from the line of sight will have no impact on the viewer[1]. Potential glare to drivers was evaluated for both passenger vehicles and semi-trucks, where the passenger vehicles were assumed to have a maximum viewing height of 5-ft AGL while the viewing height for drivers of semi-trucks was assumed to be a maximum of 9-ft AGL. The viewing height for the train was assumed to be 15-ft AGL.

Potential glare to viewers at 39 houses, shown as observation points (OPs) in **Figures 4-5**, in the vicinity of the Project was also analyzed at 16-ft AGL viewing heights. All structures and roadways were analyzed for 6.5-ft and 8.58-ft panel heights.

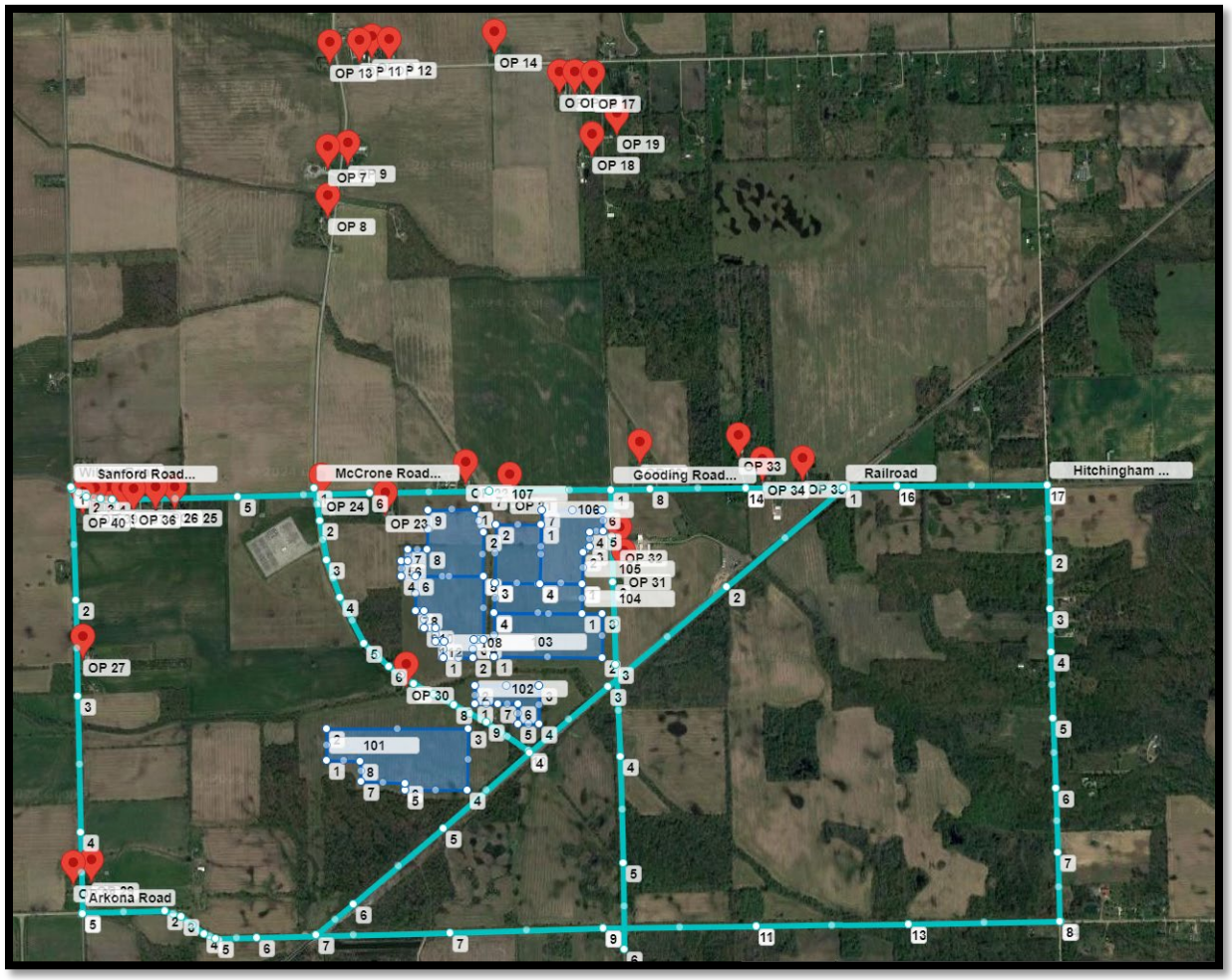

Figure 4. Block 1 Analysis area, structures and roadways*

*Turquoise lines indicate roads, blue polygons indicate PV arrays, and red pins indicate structures. Source: ForgeSolar, Google Earth Imagery.

[1] Rogers, J. A., et al. (2015). Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach, Federal Aviation Administration (https://www.faa.gov/sites/faa.gov/files/data_research/research/med_humanfacs/oamtechreports/201512.pdf)

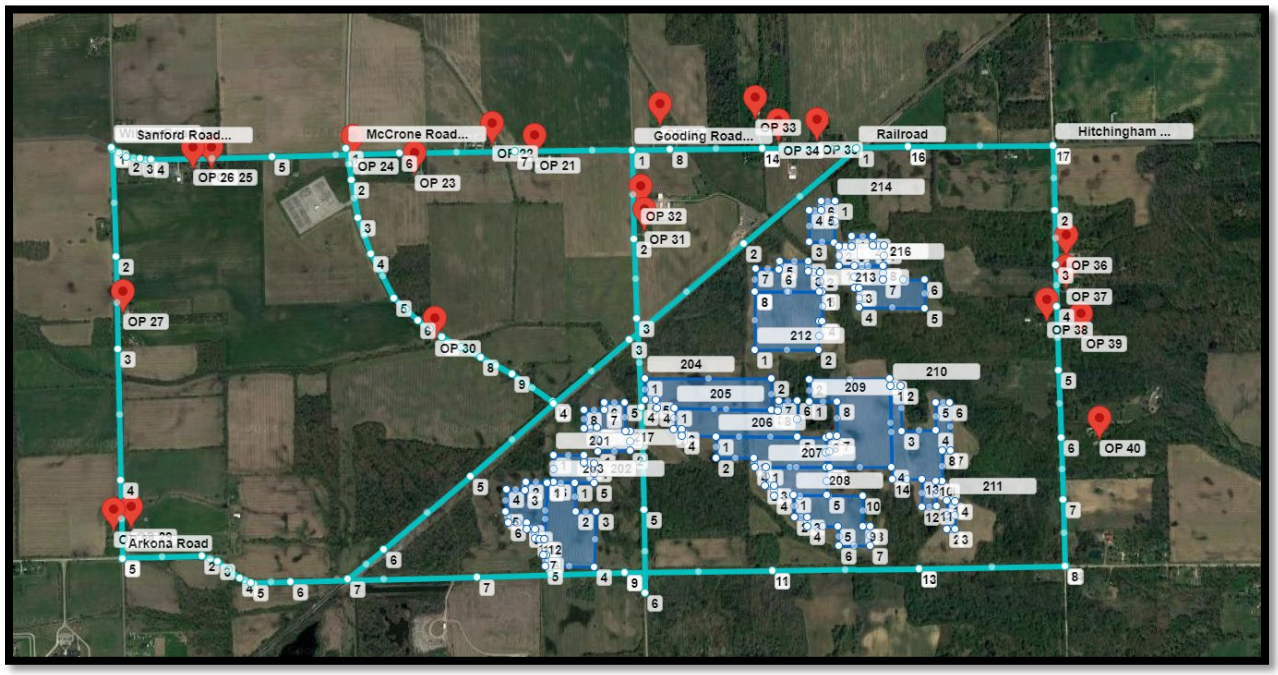

Figure 5. Block 2 Analysis area, structures and roadways*
*Turquoise lines indicate roads, blue polygons indicate PV arrays, and red pins indicate structures. Source: ForgeSolar, Google Earth Imagery.

3.0 GLARE ANALYSES RESULTS

The web-based ForgeSolar program was used to analyze glare potential in one-minute increments throughout the year and results are presented in **Appendix A** (ForgeSolar reports). The program identifies the three following types of glare (no color indicates no glare predicted):

GREEN - Low potential for temporary after-image.
YELLOW - Potential for temporary after-image.
RED - Potential for permanent eye damage.

3.1 AIRPORT APPROACH PATHS AND CONTROL TOWERS

Glare is not predicted for pilots approaching the 18 runways at the five airports or for helicopters hovering over the four helipads included in the analysis.

3.2 ROADWAYS AND PROPERTIES LOCATED ADJACENT TO THE SOLAR ARRAYS

Glare is not predicted for the six roads and one railroad included in this analysis. Glare is also not predicted for the 39 structures included in the analysis.

4.0 CONCLUSIONS

Based on the solar array parameters provided and the current site design, no glare is predicted for pilots approaching the five airports and its two approach paths included in the analysis. Glare is not predicted for helicopters hovering over four helipads included in the analysis. Glare is not predicted for the six road segments and one railroad included in the analysis. Glare is not predicted for the 39 houses included in the analysis. These results assume a 60-degree resting angle.

APPENDIX A

ForgeSolar Reports