

# Arlington Microgrid Glare Study



## **Snohomish County Public Utility District No. 1**

**Arlington Microgrid Project  
Project No. 104583**

**Revision 0  
1/31/2018**

# **Arlington Microgrid Glare Study**

prepared for

**Snohomish County  
Public Utility District No. 1  
Arlington Microgrid Project  
Everett, WA**

**Project No. 104583**

**Revision 0  
1/31/2018**

prepared by

**Burns & McDonnell Engineering Company, Inc.  
Fort Worth, TX**

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## LIST OF ABBREVIATIONS

<b><u>Abbreviation</u></b>	<b><u>Term/Phrase/Name</u></b>
ARC	Antireflective coating
ATCT	Air traffic control tower
Burns & McDonnell	Burns & McDonnell Engineering Company, Inc.
FAA	Federal Aviation Association
PV	Photovoltaic
SGHAT	Solar Glare and Hazard Analysis Tool
TCH	Threshold clearing height

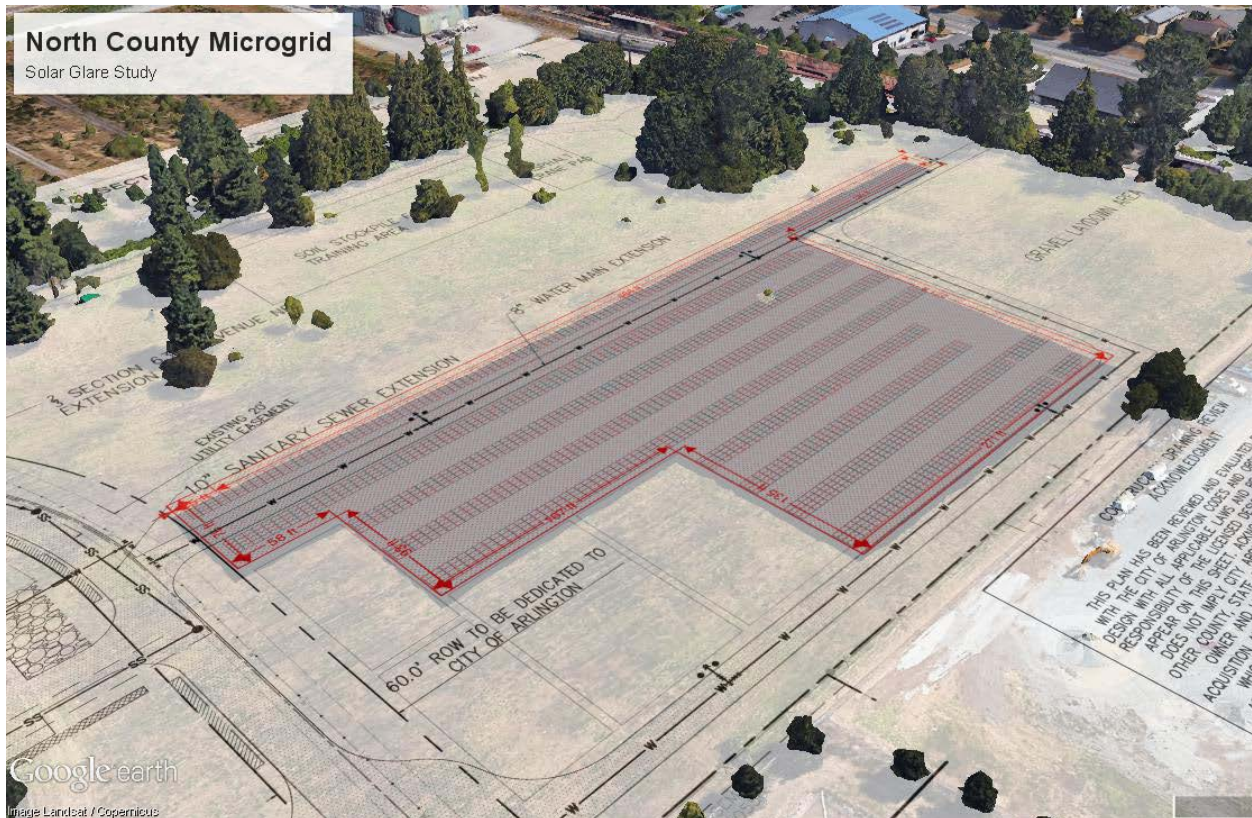
## 1.0 SUMMARY

Solar glare hazard analysis was performed on the proposed solar array in Snohomish County. The result indicates none of the flight paths are showing potential for after image glare.

### 1.1 Methodology

Solar glare hazard analysis is performed utilizing the GlareGauge module from Forge Solar. The Glare hazard analysis utilizes proposed general site locations and typical initial panel array orientation and tilt for the latitude for the site. Determination of glare occurrence requires knowledge of the following: sun position, observer location, and the tilt, orientation, location, extent, and optical properties of the modules in the solar array. Vector algebra is then used to determine if glare is visible from the prescribed observation points.

The area of the array is geo located and input to SGHAT.



### 1.2 Assumptions and Limitations

The following flight paths were selected for evaluation:

- Runway 11
- Runway 16
- Runway 29
- Runway 34

The following assumptions were made for the site and input data

- PV Orientation 180 degrees
- Tilt 30 degrees
- Panels with textured glass and with ARC
- All analysis based on straight-in approach and ATCT criteria
- Approach glide slopes per FAA published values TCH of 50'.

The following is a list of assumptions and limitations of the model and method used in SGHAT

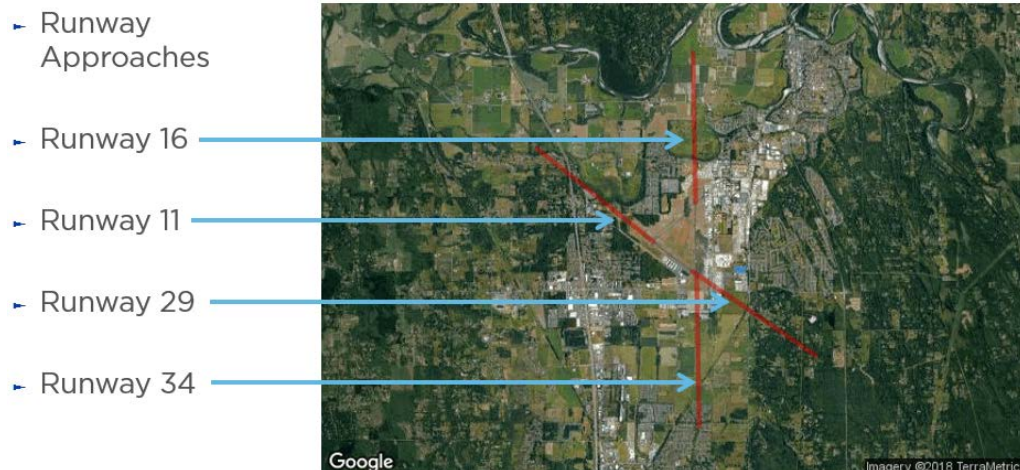
- SGHAT does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results.
- SGHAT assumes that the PV array is aligned with a plane defined by the total heights of the coordinates outlined in the Google map.
- SGHAT does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
- The variable direct normal irradiance (DNI) feature (if selected) scales the user prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm [2] and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
- The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain.
- Single- and dual-axis tracking compute the panel normal vector based on the position of the sun once it is above the horizon. Dual-axis tracking does not place a limit on the angle of rotation,

unless the sun is below the horizon. For single-axis tracking, a maximum angle of rotation can be applied to both the clockwise and counterclockwise directions.

## 2.0 RESULTS

All flight paths analyzed show the glare produced either has zero or low potential for after-image. The results for all paths analyzed fall within the FAA acceptance criteria. Refer to Appendix A for full report results.

- Runway 11
  - No measurable glare predicted along this flight path.
- Runway 16
  - No measurable glare predicted along this flight path.
- Runway 29
  - Glare produced within the flight path for Runway 29 occurs in the months of May-July between 6:30 am and 7:00 am and has a duration of less than 10 minutes. This glare is beyond 50 degrees from the pilot line-of-sight and is not considered to be a glare hazard. There are 0 minutes of annual “green” glare – the minimum threshold considered to be a glare hazard.
- Runway 34
  - Glare produced within the flight path for Runway 34 occurs in the months of April-August between 6:00 am and 7:00 am and has a duration of less than 5 minutes. This glare is beyond 50 degrees from the pilot line-of-sight and is not considered to be a glare hazard. There are 0 minutes of annual “green” glare – the minimum threshold considered to be a glare hazard.



## **APPENDIX A - RESULTS**



# FORGESOLAR GLARE ANALYSIS

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Project: **Snohomish Glare Study**

Arlington Airport

Site configuration: **PV30 textured with ARC**

Analysis conducted by Ryan Wubbens (rwubbens@burnsmcd.com) at 19:23 on 26 Jan, 2018.

## 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)	N/A	No ATCT receptors designated

Default glare analysis and observer eye characteristics are as follows:

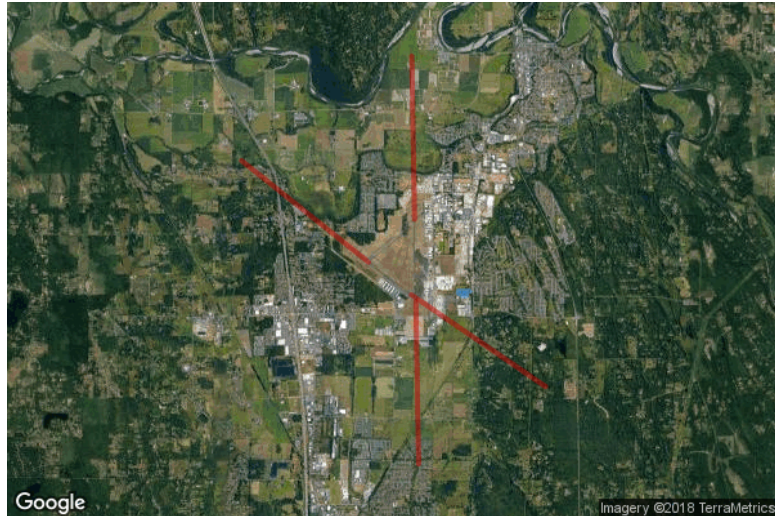
- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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<sup>2</sup>  
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: 14487.2216



## PV Array(s)

**Name:** PV array 1  
**Axis tracking:** Fixed (no rotation)  
**Tilt:** 30.0°  
**Orientation:** 180.0°  
**Rated power:** -  
**Panel material:** Light textured 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	48.156573	-122.144808	130.78	0.00	130.78
2	48.156362	-122.144816	131.30	0.00	131.30
3	48.156359	-122.144577	130.95	0.00	130.95
4	48.156105	-122.144580	131.82	0.00	131.82
5	48.156102	-122.143884	131.69	0.00	131.69
6	48.155737	-122.143900	130.97	0.00	130.97
7	48.155731	-122.142770	131.67	0.00	131.67
8	48.156466	-122.142782	132.85	0.00	132.85
9	48.156464	-122.141993	132.99	0.00	132.99
10	48.156558	-122.141989	134.00	0.00	134.00

## Flight Path Receptor(s)

**Name:** FP 11

**Description:**

**Threshold height:** 50 ft

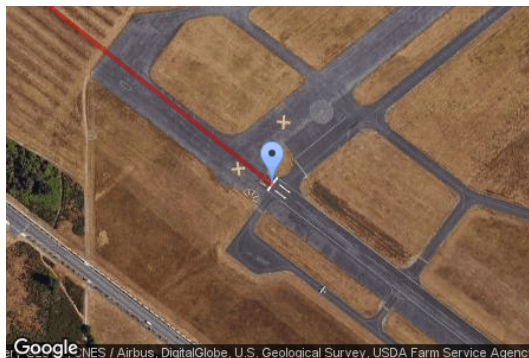
**Direction:** °

**Glide slope:** 3.5°

**Pilot view restricted?** Yes

**Vertical view:** 30.0°

**Azimuthal view:** 120.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	48.161674	-122.168811	125.49	50.00	175.49
Two-mile	48.179716	-122.202721	36.53	784.88	821.40

**Name:** FP 16

**Description:**

**Threshold height:** 50 ft

**Direction:** °

**Glide slope:** 3.0°

**Pilot view restricted?** Yes

**Vertical view:** 30.0°

**Azimuthal view:** 120.0°

Flight path map

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	48.169334	-122.156543	133.85	50.00	183.85
Two-mile	48.198242	-122.157300	44.16	693.15	737.30

**Name:** FP 29

**Description:**

**Threshold height:** 50 ft

**Direction:** °

**Glide slope:** 4.0°

**Pilot view restricted?** Yes

**Vertical view:** 30.0°

**Azimuthal view:** 120.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	48.155894	-122.157401	117.59	50.00	167.59
Two-mile	48.139581	-122.121577	407.75	498.31	906.06

**Name:** FP 34

**Description:**

**Threshold height:** 50 ft

**Direction:** °

**Glide slope:** 3.0°

**Pilot view restricted?** Yes

**Vertical view:** 30.0°

**Azimuthal view:** 120.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	48.154756	-122.156210	121.02	50.00	171.02
Two-mile	48.125848	-122.155453	98.54	625.94	724.48

## GLARE ANALYSIS RESULTS

### Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV array 1	30.0	180.0	0	0	-

*Total annual glare received by each receptor*

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
FP 11	0	0
FP 16	0	0
FP 29	0	0
FP 34	0	0

### Results for: PV array 1

Receptor	Green Glare (min)	Yellow Glare (min)
FP 11	0	0
FP 16	0	0
FP 29	0	0

Receptor	Green Glare (min)	Yellow Glare (min)
FP 34	0	0

**Flight Path: FP 11**

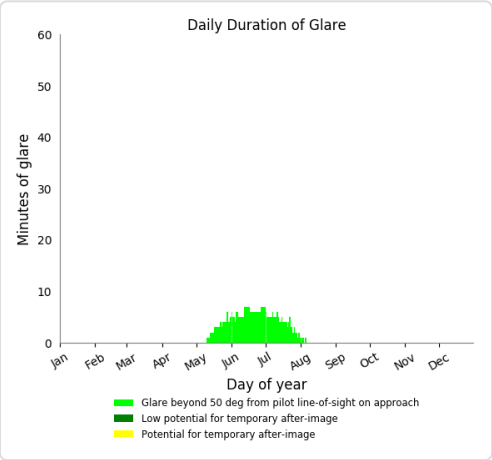
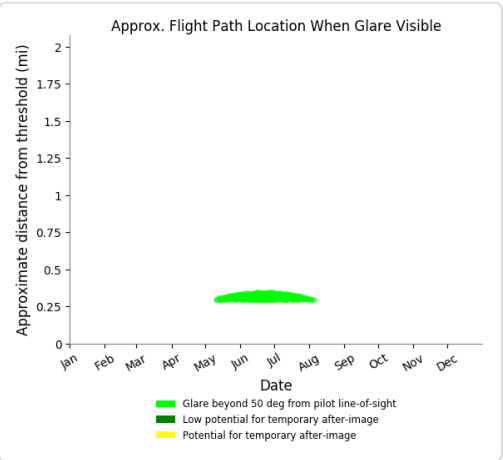
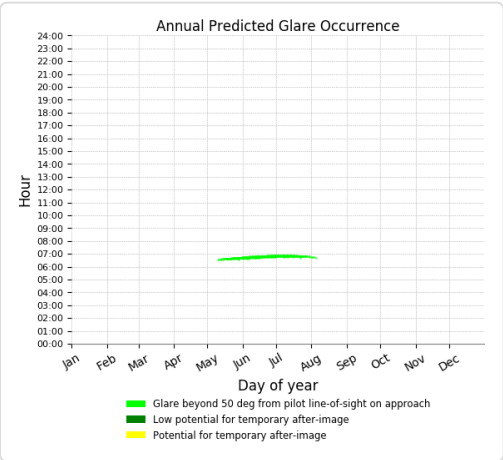
0 minutes of yellow glare  
0 minutes of green glare

**Flight Path: FP 16**

0 minutes of yellow glare  
0 minutes of green glare

**Flight Path: FP 29**

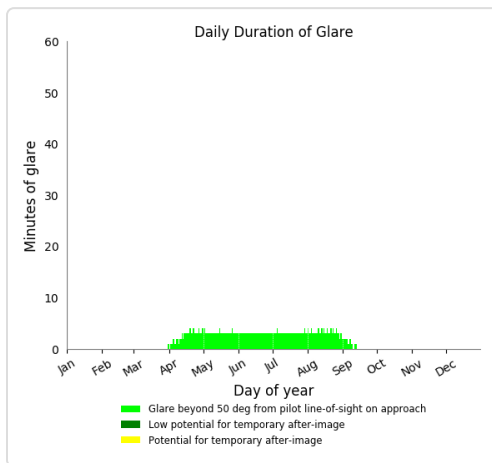
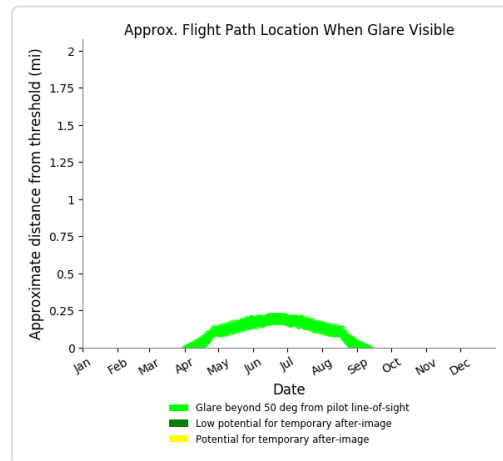
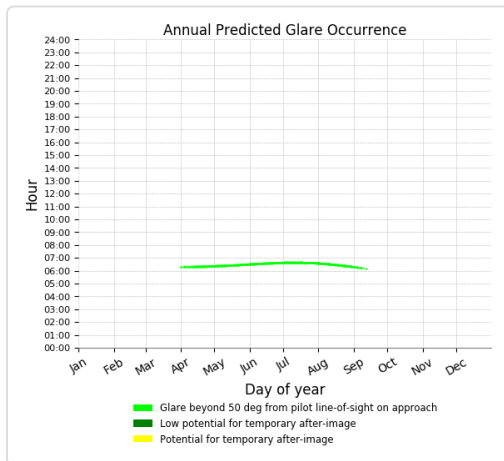
0 minutes of yellow glare  
0 minutes of green glare



**Flight Path: FP 34**

0 minutes of yellow glare

0 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.

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 based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.

## **APPENDIX B DRAWINGS**



SITE ADDRESS:  
17601 59TH AVE NE  
ARLINGTON, WA 98223

APPLICANT/OWNER/PROJECT LEAD  
SNOHOMISH COUNTY PUD NO. 1  
PO BOX1107  
EVERETT, WA 98206-8624  
CONTACTS: BEN DAVIS, PE  
PHONE: 425-783-8465  
EMAIL: brdavis@snopud.com

SURVEYOR:  
DAVID EVANS AND ASSOCIATES  
CONTACT: GIL LAAS  
PHONE: 425-519-6500  
EMAIL: webmaster@deainc.com

CIVIL ENGINEER:  
KPFF CONSULTING ENGINEERS  
CONTACT: JORDAN BROWN  
PHONE: 206-622-5822  
EMAIL: jordan.brown@kpff.com

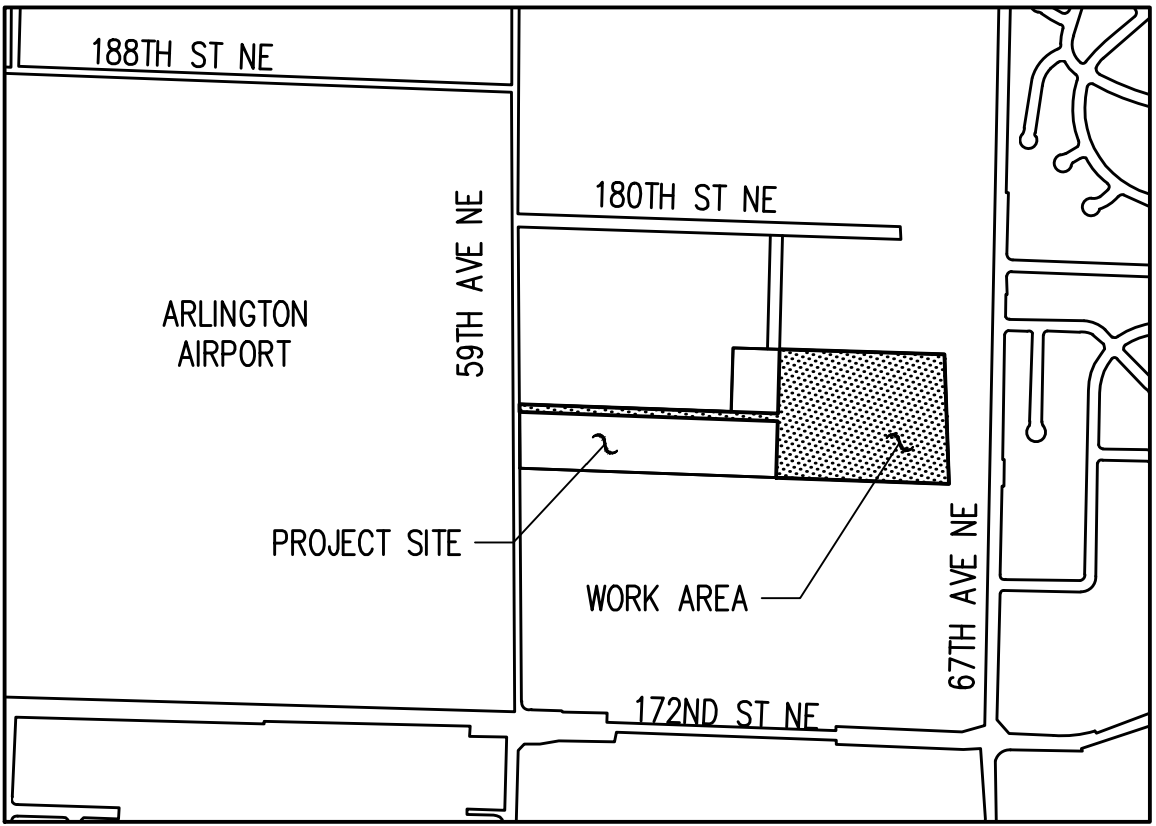
SECURITY/ELECTRICAL ENGINEER:  
HARGIS  
CONTACT: SUJE ANTON  
PHONE: 206-448-3376  
EMAIL: suje.anton@hargis.biz

SE 1/4, SECTION 22, TOWNSHIP 31, RANGE 5 EAST, WM

# NORTH COUNTY MICROGRID

CITY OF ARLINGTON GENERAL CONSTRUCTION NOTES:

- ALL WORK AND MATERIALS SHALL CONFORM TO THE CURRENT EDITION OF THE CITY OF ARLINGTON PUBLIC WORKS STANDARDS AND SPECIFICATIONS, AND THE CURRENT EDITION OF THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT) STANDARD SPECIFICATIONS FOR ROAD, BRIDGE, AND MUNICIPAL CONSTRUCTION. A COPY OF THESE DOCUMENTS SHALL BE ON SITE DURING CONSTRUCTION.
- IT IS THE SOLE RESPONSIBILITY OF THE DEVELOPER/CONTRACTOR TO OBTAIN A GRADING PERMIT, RIGHT-OF-WAY PERMIT, AND UTILITY PERMITS, FROM THE CITY. ALL REQUIRED PERMITS FROM OTHER AGENCIES MUST ALSO BE OBTAINED BY THE DEVELOPER/CONTRACTOR.
- PRIOR TO ANY CONSTRUCTION ACTIVITY, THE DEVELOPER/ CONTRACTOR SHALL ATTEND A PRECONSTRUCTION CONFERENCE WITH THE CITY. THE CONTRACTOR SHALL SCHEDULE THE PRE-CONSTRUCTION CONFERENCE BY CALLING (360) 403-3500. PRIOR TO SCHEDULING, THE CONTRACTOR MUST SUBMIT AND RECEIVE APPROVAL FOR THE TRAFFIC CONTROL PLAN, CITY PERMITS, TEMPORARY EROSION AND SEDIMENT CONTROL PLAN, PERFORMANCE BOND, COPY OF OTHER AGENCY PERMITS, A COPY OF THE CONTRACTOR'S LICENSE, AND PROOF OF INSURANCE COVERAGE.
- A COPY OF THE APPROVED CONSTRUCTION PLANS MUST BE ON THE JOB SITE WHEN CONSTRUCTION IS IN PROGRESS.
- ALL SITE WORK SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE APPROVED PLANS. ANY DEVIATION FROM THE APPROVED PLANS WILL REQUIRE PRIOR APPROVAL FROM THE OWNER, THE CITY ENGINEER, AND OTHER APPROPRIATE PUBLIC AGENCIES.
- ALL OF THE LOCATIONS OF THE EXISTING UTILITIES SHOWN IN THE PLANS HAVE BEEN ESTABLISHED BY FIELD SURVEY OR OBTAINED FROM AVAILABLE RECORDS AND SHALL THEREFORE BE CONSIDERED APPROXIMATE AND NOT NECESSARILY COMPLETE. IT IS THE SOLE RESPONSIBILITY OF THE CONTRACTOR TO INDEPENDENTLY VERIFY THE ACCURACY OF ALL UTILITY LOCATIONS.
- THE CONTRACTOR SHALL LOCATE AND PROTECT ALL CASTINGS AND UTILITIES DURING CONSTRUCTION AND SHALL CONTACT THE UNDERGROUND UTILITIES LOCATE SERVICE (1-800-424-5555 OR 811) AT LEAST 48 HOURS PRIOR TO CONSTRUCTION.
- INSPECTION AND ACCEPTANCE OF ALL WORK WILL BE ACCOMPLISHED BY REPRESENTATIVES OF THE CITY OF ARLINGTON. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO COORDINATE AND SCHEDULE APPROPRIATE INSPECTIONS, ALLOWING PROPER ADVANCE NOTICE. THE INSPECTOR MAY REQUIRE REMOVAL AND REPLACEMENT OF ITEMS THAT DO NOT MEET CITY STANDARDS OR WERE CONSTRUCTED WITHOUT INSPECTION.
- THE CONTRACTOR SHALL KEEP THE ON-SITE AND OFF-SITE STREETS CLEAN AT ALL TIMES BY CLEANING WITH A SWEEPING AND/OR VACUUM TRUCK. WASHING OF THESE STREETS WILL NOT BE ALLOWED WITHOUT PRIOR APPROVAL FROM THE CITY INSPECTOR.
- THE CONTRACTOR SHALL MAINTAIN TWO (2) SETS OF "AS- BUILT" PLANS SHOWING ALL FIELD CHANGES AND MODIFICATIONS. IMMEDIATELY AFTER CONSTRUCTION COMPLETION, THE CONTRACTOR SHALL DELIVER BOTH COPIES OF RED-LINED PLANS TO THE CITY. THE CITY WILL FORWARD ONE OF THE COPIES TO THE DESIGN ENGINEER.



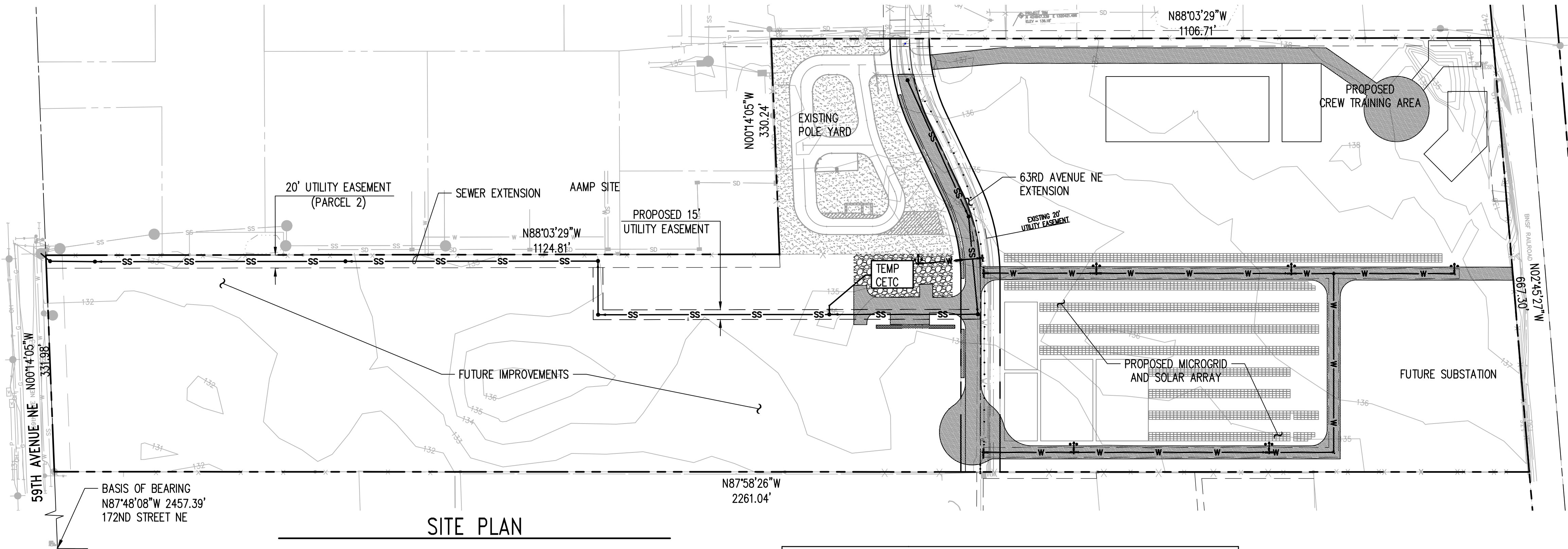
VICINITY MAP

NTS



SHEET INDEX

SHEET NO.	SHEET TITLE
C-1.0	COVER SHEET AND SITE PLAN
C-2.0	EXISTING CONDITIONS PLAN
C-2.1	EXISTING CONDITIONS PLAN
C-2.2	EXISTING CONDITIONS PLAN
C-2.3	EXISTING CONDITIONS PLAN
C-2.4	EXISTING CONDITIONS PLAN
C-2.5	EXISTING CONDITIONS PLAN
C-3.0	DEMOLITION AND TESC PLAN
C-3.1	DEMOLITION AND TESC PLAN
C-3.2	DEMOLITION AND TESC PLAN
C-3.3	DEMOLITION AND TESC PLAN
C-3.4	DEMOLITION AND TESC PLAN
C-3.5	DEMOLITION AND TESC PLAN
C-3.6	TESC DETAILS
C-3.7	TESC DETAILS
C-4.0	HORIZONTAL CONTROL AND PAVING PLAN
C-4.1	HORIZONTAL CONTROL AND PAVING PLAN
C-4.2	HORIZONTAL CONTROL AND PAVING PLAN
C-4.3	HORIZONTAL CONTROL AND PAVING PLAN
C-4.4	HORIZONTAL CONTROL AND PAVING PLAN
C-4.5	HORIZONTAL CONTROL AND PAVING PLAN
C-4.6	SITE IMPROVEMENT DETAILS
C-5.0	GRADING AND DRAINAGE PLAN
C-5.1	GRADING AND DRAINAGE PLAN
C-5.2	GRADING AND DRAINAGE PLAN
C-5.3	GRADING AND DRAINAGE PLAN
C-5.4	GRADING AND DRAINAGE DETAILS
C-6.0	COMPOSITE UTILITY PLAN
C-6.1	COMPOSITE UTILITY PLAN
C-6.2	COMPOSITE UTILITY PLAN
C-6.3	COMPOSITE UTILITY PLAN
C-6.4	COMPOSITE UTILITY PLAN
C-6.5	SEWER AND WATER NOTES AND DETAILS
C-6.6	
C-7.0	63RD ROADWAY PLAN AND PROFILE
E-1.0	ELECTRICAL



SITE PLAN

CONSTRUCTION DRAWING REVIEW  
ACKNOWLEDGMENT

THIS PLAN HAS BEEN REVIEWED AND EVALUATED FOR GENERAL COMPLIANCE WITH THE CITY OF ARLINGTON CODES AND ORDINANCES. CONFORMANCE OF THIS DESIGN WITH ALL APPLICABLE LAWS AND REGULATIONS IS THE FULL AND COMPLETE RESPONSIBILITY OF THE LICENSED DESIGN ENGINEER, WHOSE STAMP AND SIGNATURE APPEAR ON THIS SHEET. ACKNOWLEDGMENT OF CONSTRUCTION DRAWING REVIEW DOES NOT IMPLY CITY APPROVAL FOR CONSTRUCTION ACTIVITIES THAT REQUIRE OTHER COUNTY, STATE OR FEDERAL PERMIT REVIEW AND APPROVAL. THE PROPERTY OWNER AND LICENSED DESIGN ENGINEER SHALL BE RESPONSIBLE FOR THE ACQUISITION AND COMPLIANCE OF ALL APPLICABLE PERMITS AND/OR AUTHORIZATIONS WHICH MAY INCLUDE, BUT ARE NOT LIMITED TO, WSDFW HYDRAULIC PROJECT APPROVAL (HPA), WSDOE NOTICE OF INTENT (NOI), ANY CORP OF ENGINEERS FILL PERMITS AND THE REQUIREMENTS OF THE ENDANGERED SPECIES ACT.

BY: \_\_\_\_\_  
City Engineer

DATE: \_\_\_\_\_  
THIS APPROVAL VALID FOR 18 MONTHS

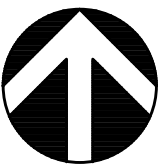
CONSTRUCTION DRAWING APPROVAL

THIS PLAN SHEET HAS BEEN REVIEWED AND APPROVED PER THE CONDITIONS ON THE TITLE SHEET.

BY: \_\_\_\_\_  
City Engineer, CITY OF ARLINGTON

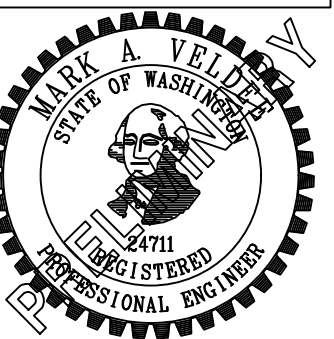
DATE: \_\_\_\_\_  
THIS APPROVAL VALID FOR 18 MONTHS

0 50 100 200  
1 inch = 100 feet



SNOHOMISH COUNTY  
**PUD**  
PUBLIC UTILITY DISTRICT NO. 1

FACILITIES DEPARTMENT  
2320 CALIFORNIA STREET,  
EVERETT, WA 98201  
PHONE (425) 783-8545  
FAX (425) 783-8455



**kpff**

1601 5th Avenue, Suite 1600  
Seattle, WA 98101  
206.622.5822  
www.kpff.com

Call 811  
two business days  
before you dig

NO.	DATE	REVISION

PROJECT: **NORTH COUNTY  
MICROGRID**

SHEET TITLE:  
COVER SHEET  
AND SITE PLAN

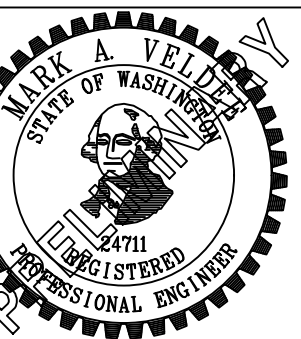
ARLINGTON, WASHINGTON

LEAD: BROWN  
DRAFTER: DEWITT  
DATE: 12/08/17  
SHEET: **C-1.0**  
OF XX



**SNOHOMISH COUNTY**  
**PUD**  
**PUBLIC UTILITY DISTRICT NO. 1**

**FACILITIES DEPARTMENT**  
**120 CALIFORNIA STREET,**  
**EVERETT, WA 98201**  
**PHONE (425) 783-8545**  
**FAX (425) 783-8455**



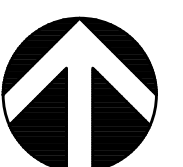
**811** **Call 811**  
two business days  
before you dig

[illegible]

**NORTH COUNTY  
MICROGRID**

AD:	BROWN
AFTER:	DEWITT
ATE:	12/08/17
REET:	

**C-1.1**





CREATE AMAZING.

Burns & McDonnell World Headquarters  
9400 Ward Parkway  
Kansas City, MO 64114  
O 816-333-9400  
F 816-333-3690  
[www.burnsmcd.com](http://www.burnsmcd.com)