

Appendix J: Flicker Analysis

**Shadow Flicker Impact Analysis
for Seneca Wind
Seneca County, Ohio**

July 2018

Prepared for
Seneca Wind LLC

Prepared by



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Acronyms and Abbreviations

GE	General Electric
Hz	Hertz
m	meter
MW	megawatt
NCDC	National Climatic Data Center
NAD83	North American 1983 Datum
NOAA	National Oceanic and Atmospheric Administration
OAC	Ohio Administrative Code
OPSB	Ohio Power Siting Board
the Project	Seneca Wind
Seneca Wind	Seneca Wind LLC

1.0 INTRODUCTION

Seneca Wind LLC (Seneca Wind) is proposing to develop the Seneca Wind project (the Project), a 212-megawatt (MW) wind energy facility, located in Seneca County, Ohio. The Project consists of a total of 85 General Electric (GE) GE 2.3-116 and GE 2.5-127 wind turbine models, which have the following characteristics:

- **General Electric GE 2.3-116** – A 3-blade 116-meter (m) rotor diameter and generating capacity of 2.3 MW. A total of 10 GE2.3-116 turbines will be used. Most of these turbines will have a hub height of 94 m. However, one of these turbines will have a hub height of 80 m and another will have a hub height of 90 m.
- **General Electric GE 2.5-127** – A 3-blade 127-meter rotor diameter and generating capacity of 2.5 MW. A total of 75 GE 2.5-127 turbines will be used. This turbine will have a hub height of 134 m. It is possible that 112-m towers may be used in a few select locations to address location-specific issues.

Although a total of 85 turbines are proposed for the Project, nine additional turbine locations have been included in the evaluation to allow for siting flexibility. Therefore, a total of 94 turbines, in the locations shown in Figure 1, are assessed. This will provide conservative results, as the effect of shadow flicker in some locations could be reduced if a contributing turbine is one that is not constructed.

2.0 SHADOW FLICKER BACKGROUND

A wind turbine's moving blades can cast a moving shadow on locations within a certain distance of a turbine. These moving shadows, called shadow flicker, are a temporary phenomenon experienced near the turbines; the effect decreases with distance. The impact area depends on the time of year and day (which determine the sun's azimuth and altitude angles) and the wind turbine's physical characteristics (height, rotor diameter, blade width, and orientation of the rotor blades). Shadow flicker impact to surrounding properties generally occurs during low angle sunlight conditions, which typically occur during sunrise and sunset. However, when the sun angle gets very low (less than 3 degrees), sunlight passes through more of the atmosphere and becomes too diffused to form a coherent shadow (i.e., would not be perceived as flash). Shadow flicker will also not occur when the sun is obscured (e.g., by clouds or fog or at night) or when the source turbine(s) are not operating. In addition, shadow flicker is only an issue when at least 20 percent of the sun's disc is covered by the turbine blades.

Shadow flicker intensity is defined as the difference in brightness at a given location in the presence and absence of a shadow. Shadow flicker intensity diminishes with greater receptor-to-turbine separation distance. Shadow flicker intensity for receptor-to-turbine distances beyond 2,500 m (8,202 feet) is very low, and generally considered imperceptible. In general, closer proximity to turbines may make shadow flicker more noticeable, with the largest number of shadow flicker hours, along with greatest shadow flicker intensity, occurring in locations closest to the wind turbines.

Shadow flicker frequency is related to the wind turbine's rotor blade speed and the number of blades on the rotor. From a health standpoint, the low flicker frequencies associated with wind turbines are harmless, and public concerns that flickering light from wind turbines can have negative health effects, such as triggering seizures in people with epilepsy, are unfounded. Epilepsy Action (the working name for the British Epilepsy Foundation) states that there is no evidence that wind turbines can cause seizures (Epilepsy Action 2018). However, they recommend that wind turbine flicker frequency be limited to 3 Hertz (Hz); for comparison, strobe lights used in discos have frequencies which range from about 3 Hz to 10 Hz (1 Hz = 1 flash per second). Since the Project's wind turbine blade pass frequency is approximately 0.8 Hz (less than 1 blade pass per second), no negative health effects to individuals with photosensitive epilepsy are expected.

The Ohio Power Siting Board (OPSB) has established specific standards for shadow flicker related to wind energy facilities in Ohio Administrative Code (OAC) 4906-4-09(H)(1). This regulation requires that applicable facilities, such as the Project, be designed to avoid unreasonable adverse shadow flicker effect at any non-participating sensitive receptor within 1,000 m of any turbine, and establishes shadow flicker levels of 30 hours per year as a minimum threshold for determining impacts. This metric has been used as a benchmark for the shadow flicker analysis.

3.0 WINDPRO SHADOW FLICKER ANALYSIS

An analysis of potential shadow flicker impacts from the Project was conducted using the WindPro software package. As described above, 94 turbine locations have been evaluated with WindPro, although only 85 wind turbines will be installed.

The WindPro analysis was conducted to determine shadow flicker impacts under realistic impact conditions (actual expected shadow). This analysis calculated the total amount of time (hours and minutes per year) that shadow flicker could occur at receptors surrounding the Project. The realistic impact condition scenario is based on the following:

- The elevation and position geometries of the wind turbines and surrounding receptors (potentially occupied residences). Elevations were determined using United States Geological Survey digital elevation model data. Position geometries were determined using geographic information system and referenced to Universal Transverse Mercator Zone 17 (North American 1983 Datum [NAD83]).
- The position of the sun and the incident sunlight relative to the wind turbine and receptors on a minute-by-minute basis over the course of a year (WindPro-generated values).
- Historical sunshine availability (percent of total hours available). Historical sunshine rates for the area, as summarized by the National Climatic Data Center (National Oceanic and Atmospheric Administration [NOAA] 2016) for nearby Toledo, Ohio, used in this analysis are as follows:
 - January – 41 percent
 - February – 48 percent
 - March – 50 percent
 - April – 53 percent
 - May – 59 percent
 - June – 61 percent
 - July – 65 percent
 - August – 61 percent
 - September – 58 percent
 - October – 52 percent
 - November – 34 percent
 - December – 29 percent
- Estimated wind turbine operations and orientation (based on over 8 years of wind data from October 2009 through June 2018, including wind speed/wind direction, frequency, and distribution, measured at meteorological towers located in the Project area).
- Receptor viewpoints (i.e., house windows) are assumed to always be directly facing turbine-to-sun line-of-sight (“greenhouse mode”).

WindPro incorporates terrain elevation contour information, and the analysis accounts for terrain elevation differences. The sun’s path with respect to each turbine location is calculated by the software to determine the cast shadow paths every minute over a full year. Sun angles less than 3 degrees above the horizon were excluded for the reasons identified in Section 2. Since shadow flicker is only an issue when at least 20 percent of the sun disc is covered by the blades, WindPro uses blade width dimension data to calculate the maximum distance from the turbine where shadow flicker must be calculated. Beyond this distance, the turbine will not contribute to the shadow flicker impact. No potential screening effect from trees, shrubs,

barns, or other obstacles was assumed in the shadow flicker analysis. In reality, such factors can block shadows from falling onto windows of receptors, and eliminate the effect.

A total of 1,299 structures were identified within and near the Project Area and were assumed to be occupied or potentially occupied residences (receptors for the purpose of this analysis). A receptor in the model is defined as a 1 square meter area (the approximate size of a typical window) that is located 1 m (3.28 feet) above ground level. Approximate eye level is set at 1.5 m (4.94 feet). Figure 1 shows the locations of all 1,299 shadow flicker receptors (presumed to be occupied residences), along with the 94 potential turbine locations evaluated.

4.0 SHADOW FLICKER ANALYSIS RESULTS

As expected, WindPro predicts that shadow flicker impacts will be greatest at locations nearer to the wind turbines. Figure 2 illustrates the WindPro-predicted shadow flicker impact areas. A detailed WindPro shadow flicker analysis summary, for each of the modeled receptor locations, is provided in Attachment A.

Table 1 presents the WindPro predicted shadow flicker impacts for 48 receptors for which potential impacts were calculated as being over 30 hours per year. Of these receptors, 26 have entered into agreements with Seneca Wind, and are considered participating landowners.

The shadow flicker impact prediction statistics are summarized in Table 2. The predicted shadow flicker impacts for non-participating residences range from 62 hours, 18 minutes per year (Receptor 284) to 30 hours, 23 minutes (Receptor 1060). Even the highest predicted shadow flicker impacts (62 hours and 18 minutes) reflects only approximately 1.4 percent of annual daylight hours.

Seneca Wind is committed to reducing shadow flicker impacts to meet the OPSB requirements. For each of the 22 non-participating residences that currently show impacts greater than that standard, additional investigation and/or coordination will occur to determine the most effective approach. This may include refined analyses that incorporate the potential for vegetation to block line-of-sight and/or to refine window exposures; and consideration of mitigation measures such as window shades or other screening measures. As decisions are made regarding which specific turbine locations will be constructed, flicker modeling may be revised, as contributing turbines (if not to be constructed) may be skewing the results higher than will be actually experienced. If necessary, curtailed operation under certain conditions can also be considered.

5.0 CONCLUSION

The analysis of potential shadow flicker impacts from the Project on nearby receptors shows that shadow flicker impacts within the area of study are expected to be minor, although for 22 non-participating receptors impact potential is greater than 30 hours per year. The highest level of impact for non-participating receptors reflects impacts occurring just 1.4 percent of annual daylight hours, as compared to the 0.7 percent of annual daylight hours reflected by 30 hours per year. This small incremental difference is not expected to be significant. However, as noted above, Seneca Wind is committed to achieving compliance with the OPSB standard, and will conduct additional investigations and/or coordination to identify the most effective and appropriate approach.

The analysis was deliberately conservative and actual shadow flicker is expected to occur for less than the modeled durations. The analysis assumes that the receptors all have a direct in-line view of the incoming shadow flicker sunlight and does not account for trees or other obstructions which may block sunlight. Impacts will also be reduced given that the windows of many houses will not face the sun directly during the key shadow flicker impact times. Adding to the conservatism reflected in these results, the 94 turbines were modeled cumulatively; because Seneca Wind will only construct up to 85 turbines, some turbines that contribute to potential shadow flicker effects at certain residences will be eliminated, reducing the potential for impact.

6.0 REFERENCES

Epilepsy Action. 2018. Information Web Page on Photosensitive Epilepsy. British Epilepsy Association. http://www.epilepsy.org.uk/info/photo_other.html. Accessed July 2018.

National Oceanic and Atmospheric Administration (NOAA). 2016. Comparative Climatic Data for the United States Through 2015.

FIGURES

**Figure 1
Turbine and Receptor
Locations**

Seneca Wind
Seneca County, Ohio

- Project Area**
- Proposed Turbines (Hub Height)**
- GE 2.3-116 (80 m)
 - GE 2.3-116 (90 m)
 - GE 2.3-116 (94 m)
 - GE 2.5-127 (134 m)
- Receptor**
- Participating
 - Non-Participating

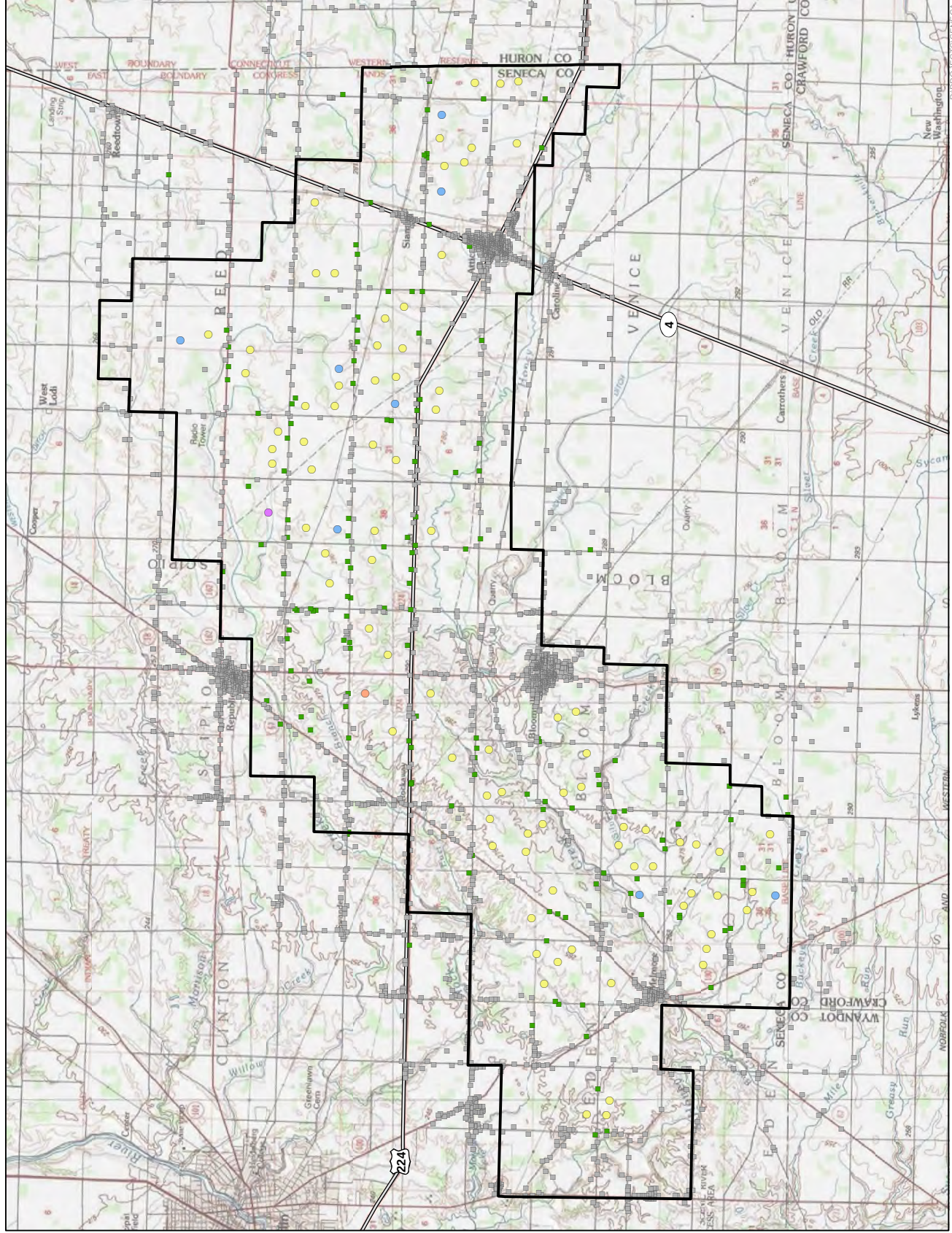
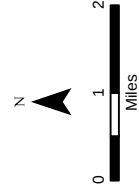
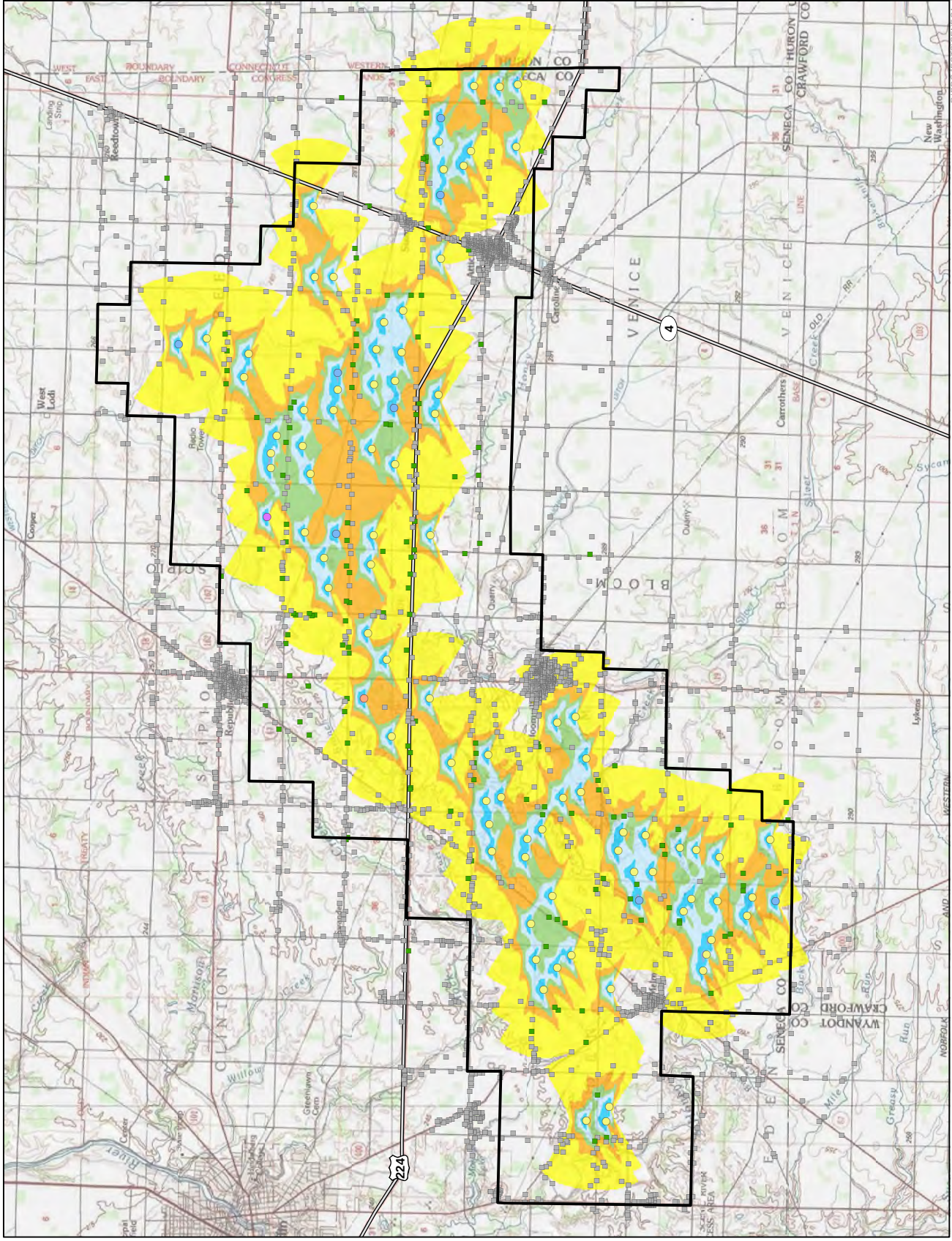
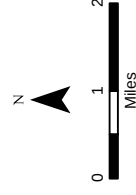


Figure 2
Expected Shadow Flicker
Impact Areas

Seneca Wind
Seneca County, Ohio

- Project Area**
- Proposed Turbines (Hub Height)
 - GE 2.3-116 (80 m)
 - GE 2.3-116 (90 m)
 - GE 2.3-116 (94 m)
 - GE 2.5-127 (134 m)
- Receptor**
- Participating
 - Non-Participating
- Shadow Flicker (hours per year)**
- 0 - 15
 - >15 - 30
 - >30 - 50
 - >50 - 100
 - >100 - 200
 - >200



R:\PROJECTS\SENECA_1353\SHADOW_Flicker\MAPS\Figure 2_Shadow_Flicker.mxd

TABLES

Table 1. WindPro Shadow Flicker Impacts		
Receptor ID	Project Participation Status	Shadow Hours per Year (expected) (hh:mm / year)
584	Participating	101:19
304	Participating	65:47
129	Participating	63:17
284	Non-Participating	62:18
578	Participating	60:23
446	Participating	58:13
791	Participating	57:46
279	Non-Participating	57:43
605	Non-Participating	54:02
305	Participating	52:27
594	Participating	50:09
2506	Participating	48:35
427	Participating	48:21
128	Participating	44:47
2123	Non-Participating	44:29
830	Participating	43:47
1512	Non-Participating	42:13
2213	Participating	39:16
2491	Participating	38:34
2124	Non-Participating	38:32
2504	Non-Participating	38:28
590	Participating	37:31
1566	Participating	36:13
2538	Non-Participating	36:06
1032	Non-Participating	35:59
3217	Non-Participating	35:15
291	Participating	35:06
1630	Non-Participating	34:35
2482	Non-Participating	34:21
780	Participating	34:18
1001	Non-Participating	34:01
911	Participating	33:54
2211	Participating	33:49
123	Participating	33:44
348	Participating	33:41
746	Non-Participating	33:40
1034	Non-Participating	33:38
2885	Non-Participating	33:02
1777	Non-Participating	32:24
2260	Participating	32:22
1090	Non-Participating	32:20
1083	Participating	32:18
301	Non-Participating	32:00
2936	Non-Participating	31:52

Table 1. WindPro Shadow Flicker Impacts		
Receptor ID	Project Participation Status	Shadow Hours per Year (expected) (hh:mm / year)
834	Participating	31:38
1516	Non-Participating	31:14
1060	Non-Participating	30:23
1088	Participating	30:23

Table 2. Statistical Summary of WindPro Shadow Flicker Impacts	
Cumulative Shadow Flicker Time (expected)	Number of Receptors
Total	1299
= 0 Hours	767
> 0 Hours < 10 Hours	297
≥ 10 Hours < 20 Hours	132
≥ 20 Hours < 30 Hours	55
≥ 30 Hours	48 *

* Only 22 of the receptors predicted to have greater than 30 hours per year shadow flicker impact occur at non-participating receptors.

Attachment A:
Detailed Summary of WindPro Shadow Flicker Analysis Results

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
1	330,779.48	4,540,044.33	0:00
4	330,888.78	4,540,035.55	0:00
5	330,435.42	4,539,874.10	0:00
10	329,890.56	4,539,941.57	0:00
12	329,023.39	4,539,625.44	0:00
13	328,062.74	4,539,898.98	3:16
17	327,500.87	4,540,037.43	0:00
19	326,691.48	4,539,836.63	1:07
26	326,131.31	4,539,967.47	4:05
32	325,612.56	4,539,783.52	0:00
33	323,044.76	4,540,078.27	0:00
35	322,908.84	4,540,115.21	0:00
37	322,311.00	4,539,743.50	0:00
40	321,805.95	4,540,152.45	0:00
43	320,833.47	4,540,182.88	0:00
48	320,691.15	4,539,780.28	0:00
51	320,528.49	4,540,980.44	0:00
53	320,622.52	4,540,973.95	0:00
55	320,659.16	4,540,965.21	0:00
56	320,650.74	4,540,884.19	0:00
58	320,667.64	4,541,331.04	0:00
65	320,835.02	4,540,845.34	0:00
69	321,231.88	4,541,292.23	0:00
70	321,110.27	4,541,212.91	0:00
71	321,341.54	4,541,295.13	0:00
72	321,673.27	4,541,532.08	0:00
76	321,296.45	4,541,773.42	0:00
79	321,438.11	4,541,773.21	0:00
80	321,539.62	4,541,763.69	0:00
81	321,556.54	4,541,778.40	0:00
83	322,297.42	4,541,620.71	7:02
85	321,870.11	4,540,410.08	0:00
87	322,242.93	4,540,481.46	0:00
93	322,362.16	4,541,223.50	0:00
96	322,357.38	4,541,777.62	4:08
100	323,344.91	4,541,053.22	2:48
102	323,370.99	4,540,944.49	3:16
103	323,599.82	4,540,680.22	8:43
105	323,644.24	4,540,446.51	1:19
108	323,830.89	4,540,175.75	2:28
112	323,860.02	4,540,870.73	16:52
114	323,442.18	4,541,669.13	2:14
116	323,579.66	4,541,662.25	5:16
118	323,889.05	4,541,721.95	10:35
119	323,751.91	4,541,680.54	8:04
120	324,008.73	4,540,171.85	4:19
123	324,306.33	4,541,677.97	33:44
128	325,534.43	4,541,351.38	44:47
129	325,401.56	4,541,362.24	63:17
136	325,842.92	4,540,450.54	20:12
137	325,893.12	4,540,279.10	12:27
139	326,004.26	4,540,714.81	27:29
141	325,835.33	4,541,357.65	21:06

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
146	326,170.25	4,541,416.52	12:21
148	327,049.26	4,541,665.84	12:57
150	327,144.02	4,540,719.84	21:38
154	327,101.69	4,540,398.79	0:00
158	326,705.99	4,540,142.97	0:46
159	326,588.00	4,540,128.88	1:03
160	326,529.45	4,540,169.59	1:13
163	327,182.40	4,540,226.00	0:00
165	327,626.51	4,540,272.72	12:59
173	328,272.10	4,540,383.49	1:47
177	328,666.32	4,541,269.15	0:00
180	327,238.71	4,541,404.60	6:57
182	329,097.84	4,540,070.79	0:00
185	329,658.76	4,540,061.16	0:00
186	329,690.75	4,540,075.29	0:00
190	329,973.56	4,540,071.58	0:00
192	330,379.02	4,540,335.05	0:00
193	330,439.96	4,540,370.52	0:00
196	330,418.10	4,540,781.17	0:00
199	330,430.83	4,541,012.16	0:00
203	330,458.24	4,541,435.23	0:00
204	330,517.51	4,541,465.97	0:00
209	330,458.79	4,541,583.28	0:00
214	330,566.33	4,543,083.97	0:00
217	330,340.77	4,543,248.55	0:00
222	330,197.36	4,543,203.83	0:00
224	329,957.04	4,543,263.02	0:00
226	329,820.67	4,543,250.68	0:00
228	329,560.71	4,543,236.45	0:00
229	329,513.75	4,543,205.90	0:00
233	329,459.00	4,541,699.57	0:00
240	329,949.18	4,541,774.35	0:00
243	330,473.11	4,541,835.41	0:00
247	330,420.13	4,542,509.76	0:00
249	330,413.72	4,542,667.85	0:00
252	328,688.79	4,542,923.69	0:00
255	328,344.20	4,543,247.45	2:06
258	327,740.03	4,542,939.99	5:19
262	327,464.68	4,542,903.12	10:24
265	327,243.49	4,541,782.62	5:09
268	327,894.34	4,541,705.33	5:12
271	328,548.37	4,541,840.65	0:00
275	326,319.60	4,543,328.67	20:29
279	325,633.82	4,542,448.44	57:43
284	325,782.09	4,541,870.96	62:18
288	327,201.83	4,542,303.71	15:43
291	326,950.60	4,542,997.77	35:06
298	325,283.03	4,543,330.64	17:27
301	325,191.38	4,543,425.89	32:00
303	324,966.41	4,543,212.15	24:51
304	324,638.63	4,542,960.74	65:47
305	324,578.31	4,542,961.77	52:27
308	324,264.99	4,541,811.50	20:02

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
313	323,813.67	4,543,297.03	8:20
316	323,807.63	4,543,199.88	4:51
324	322,925.10	4,542,986.89	8:14
329	323,182.18	4,543,372.63	0:00
331	323,106.98	4,543,362.01	0:00
334	322,697.43	4,543,383.87	0:00
337	322,520.73	4,543,380.56	0:00
339	322,588.93	4,543,283.72	2:04
341	322,563.81	4,543,115.18	6:21
344	322,559.22	4,542,938.29	7:57
345	322,418.01	4,542,842.89	5:50
348	322,818.64	4,542,166.19	33:41
356	323,244.23	4,541,867.69	12:19
357	323,594.70	4,541,804.43	5:06
365	320,960.27	4,543,386.48	0:00
367	320,773.43	4,542,844.22	0:00
370	320,769.41	4,542,797.04	0:00
373	320,775.04	4,542,768.06	0:00
378	320,774.39	4,542,730.44	0:00
379	320,770.32	4,542,379.31	0:00
383	322,093.01	4,542,183.88	3:23
386	321,921.31	4,542,264.23	2:25
390	320,719.56	4,542,770.01	0:00
398	320,631.53	4,543,164.13	0:00
400	320,715.19	4,543,392.17	0:00
403	319,748.00	4,543,404.57	0:00
409	319,120.15	4,543,829.98	0:00
413	318,957.76	4,543,950.17	0:00
415	318,959.20	4,544,211.33	4:20
418	319,123.60	4,544,435.16	17:27
422	319,114.81	4,544,620.04	29:20
424	319,081.51	4,544,799.17	24:10
425	318,911.17	4,545,026.62	27:37
426	319,193.87	4,545,018.07	24:17
427	319,203.09	4,544,790.95	48:21
430	319,193.32	4,544,580.01	11:23
436	320,657.56	4,543,464.18	0:00
439	320,740.69	4,544,083.76	0:00
444	320,777.38	4,545,009.49	13:46
446	320,266.59	4,545,017.14	58:13
448	320,793.32	4,543,577.09	0:00
452	321,034.70	4,543,573.35	0:00
454	320,997.51	4,544,626.13	12:34
456	321,850.56	4,544,797.88	3:43
460	322,158.67	4,544,538.17	10:48
464	322,268.97	4,544,374.22	10:34
467	322,359.77	4,544,362.21	0:00
468	322,350.32	4,544,295.35	0:00
469	322,358.95	4,544,395.74	5:24
470	322,252.86	4,544,217.91	0:00
472	322,272.38	4,544,190.83	0:00
474	322,285.08	4,544,160.79	0:00
475	322,325.90	4,544,085.07	0:00

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
476	322,346.66	4,544,040.75	0:00
477	322,362.99	4,544,132.70	0:00
481	322,486.55	4,544,033.22	0:00
482	322,425.99	4,543,932.60	0:00
483	322,422.68	4,543,665.09	0:00
485	322,528.25	4,543,669.99	0:00
486	322,541.82	4,543,585.36	0:00
487	322,634.91	4,543,514.07	0:00
488	322,615.59	4,543,431.60	0:00
489	322,662.46	4,543,424.41	0:00
490	322,674.95	4,543,425.79	0:00
491	322,747.51	4,543,406.96	0:00
492	322,764.11	4,543,535.82	0:00
493	322,705.86	4,543,680.68	0:00
494	322,912.87	4,543,858.38	0:00
496	322,772.45	4,543,816.36	0:00
498	322,471.18	4,543,975.94	0:00
499	322,489.51	4,543,438.42	0:00
504	322,843.61	4,543,413.80	0:00
506	322,941.75	4,543,432.25	0:00
508	323,005.42	4,543,416.77	0:00
510	323,031.55	4,543,411.85	0:00
512	323,141.44	4,543,481.25	0:00
514	323,539.69	4,543,552.08	3:05
518	323,945.64	4,544,712.36	6:06
520	323,782.21	4,544,726.68	7:23
522	323,801.10	4,544,839.52	6:55
524	323,930.28	4,544,953.34	5:16
525	323,792.43	4,544,967.86	7:14
527	323,542.21	4,544,980.56	11:01
528	322,423.76	4,544,932.68	13:02
534	322,432.86	4,544,495.52	25:07
536	322,798.45	4,543,980.97	0:00
539	322,857.56	4,544,016.71	0:00
541	322,909.76	4,544,077.73	0:00
543	322,956.08	4,544,094.19	0:00
546	323,016.01	4,544,084.53	0:00
548	324,037.83	4,544,924.87	3:35
549	324,181.68	4,544,912.17	2:49
550	324,423.90	4,543,866.12	10:56
551	324,658.43	4,543,915.48	22:36
558	324,623.33	4,544,208.69	13:22
564	324,775.43	4,544,353.44	19:23
565	325,584.83	4,544,832.83	8:02
566	325,568.85	4,544,777.48	8:52
571	324,408.04	4,544,831.08	3:38
576	324,365.67	4,544,932.19	2:06
578	325,204.50	4,544,195.82	60:23
584	325,552.81	4,544,028.00	101:19
588	325,706.37	4,544,870.50	9:27
590	327,260.80	4,544,606.04	37:31
594	327,267.47	4,544,348.75	50:09
596	327,216.25	4,543,575.98	18:08

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
599	326,539.04	4,543,383.70	25:50
601	327,335.91	4,544,919.27	11:45
602	327,650.13	4,544,738.58	12:03
605	327,298.46	4,544,195.77	54:02
607	327,810.99	4,543,343.71	16:11
610	327,922.52	4,543,397.09	7:17
612	328,595.28	4,543,382.50	0:00
615	328,668.68	4,543,362.49	0:00
616	328,909.11	4,544,546.52	0:00
618	328,550.40	4,544,581.67	0:00
625	327,895.47	4,544,791.93	5:57
626	327,939.45	4,544,793.97	5:32
632	328,911.17	4,543,328.07	0:00
634	328,941.01	4,543,477.01	0:00
635	329,147.97	4,543,344.17	0:00
639	329,198.52	4,543,372.08	0:00
641	328,950.22	4,543,824.21	0:00
642	328,947.15	4,543,863.12	0:00
643	328,943.75	4,543,904.66	0:00
646	329,363.54	4,544,899.07	2:45
651	329,838.65	4,544,866.99	6:32
656	330,515.59	4,543,366.37	0:00
659	330,353.52	4,543,328.05	0:00
663	330,170.41	4,543,450.29	0:00
664	329,658.87	4,544,149.09	0:00
667	329,712.67	4,544,061.86	0:00
668	329,776.89	4,544,059.26	0:00
670	330,100.63	4,544,071.19	0:00
671	330,153.96	4,544,065.04	0:00
673	330,860.08	4,544,835.47	0:00
675	330,670.49	4,543,665.83	0:00
677	330,607.76	4,543,668.40	0:00
678	330,595.48	4,543,627.88	0:00
679	330,599.91	4,543,603.14	0:00
681	330,850.49	4,544,952.45	3:55
682	330,822.55	4,544,935.74	0:43
687	330,632.52	4,545,574.98	18:13
689	331,041.20	4,545,767.04	5:12
690	331,038.87	4,545,826.86	5:05
693	330,948.38	4,545,711.44	6:12
694	331,056.72	4,546,022.74	4:52
695	331,216.95	4,546,092.06	3:41
696	331,420.87	4,546,441.07	0:00
697	331,220.29	4,546,281.92	3:22
698	331,239.22	4,546,445.88	1:27
699	331,367.13	4,546,509.89	0:00
700	331,277.12	4,546,734.93	0:00
701	331,206.88	4,546,765.21	0:00
702	330,824.26	4,546,821.18	4:31
703	330,681.67	4,546,916.04	0:20
704	330,370.66	4,546,892.42	0:00
705	330,212.96	4,546,664.63	0:00
706	330,063.82	4,546,548.09	3:27

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
707	330,018.42	4,546,555.88	0:29
709	330,110.44	4,546,488.44	11:01
710	330,252.42	4,546,474.09	12:23
714	330,333.73	4,546,333.97	8:24
715	330,437.85	4,546,297.85	6:32
716	330,448.31	4,546,172.96	11:54
717	330,600.89	4,546,082.77	11:38
718	331,154.24	4,546,099.44	4:07
719	331,498.10	4,546,415.94	0:00
723	331,617.12	4,546,411.09	0:00
724	331,702.09	4,546,422.59	0:00
725	331,683.72	4,546,475.10	0:00
727	331,647.15	4,546,486.94	0:00
729	331,602.45	4,546,495.41	0:00
731	331,553.18	4,546,502.22	0:00
732	331,440.55	4,546,166.44	0:00
733	332,250.98	4,546,118.75	0:00
737	329,835.52	4,546,475.15	0:26
738	329,799.02	4,546,491.89	0:00
743	329,083.97	4,546,509.60	13:06
746	329,006.65	4,545,659.69	33:40
753	329,796.81	4,544,939.55	5:59
755	330,036.26	4,544,930.53	3:15
756	330,154.96	4,544,927.08	2:32
757	330,436.76	4,544,923.78	0:00
759	330,480.43	4,544,909.23	0:00
765	330,440.61	4,545,476.61	12:10
766	328,317.60	4,545,050.74	5:52
768	328,177.12	4,545,006.71	2:16
772	327,926.29	4,544,978.08	21:35
773	327,352.94	4,544,991.51	8:09
774	327,347.05	4,545,664.83	14:08
780	327,504.31	4,546,343.36	34:18
783	327,503.37	4,546,519.62	29:58
786	328,415.78	4,546,209.79	16:07
787	328,954.49	4,546,259.67	19:54
791	327,305.96	4,546,405.06	57:46
795	327,195.26	4,545,951.18	23:58
796	326,893.17	4,545,019.14	16:22
797	326,797.35	4,545,056.52	9:15
798	325,779.17	4,545,032.74	12:02
799	326,608.51	4,545,686.14	10:55
808	326,748.72	4,545,783.37	10:59
809	325,610.04	4,545,011.34	7:42
812	325,444.53	4,545,058.25	5:24
816	324,876.34	4,545,244.31	10:47
817	324,446.63	4,545,165.42	1:48
818	324,374.05	4,545,038.06	2:00
819	324,291.01	4,545,041.07	2:18
821	324,073.25	4,545,181.90	3:21
824	323,918.11	4,545,146.99	4:25
829	324,577.08	4,545,838.92	22:01
830	324,669.05	4,546,016.76	43:47

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
834	324,734.87	4,546,243.08	31:38
836	324,004.01	4,546,309.59	20:06
838	322,462.93	4,546,095.54	16:47
841	322,375.11	4,545,404.87	3:01
843	322,395.52	4,546,011.55	15:34
846	321,425.21	4,546,581.07	1:58
848	321,314.82	4,546,611.86	1:38
850	321,268.05	4,546,609.09	1:31
851	321,228.48	4,546,610.49	0:00
852	321,181.39	4,546,609.87	0:00
853	321,115.43	4,546,611.00	0:00
855	321,101.72	4,546,539.91	0:00
857	321,154.30	4,546,507.26	0:00
859	320,881.84	4,546,529.78	0:00
861	320,870.86	4,546,575.62	0:00
862	320,872.34	4,546,619.82	0:00
865	320,861.01	4,546,396.75	0:00
868	320,867.79	4,546,293.20	0:17
877	321,701.13	4,545,045.76	2:31
881	321,586.91	4,545,306.21	2:06
886	321,347.10	4,545,671.99	3:06
888	321,141.77	4,546,610.72	0:00
891	319,230.21	4,545,655.33	18:27
895	319,235.86	4,545,735.12	12:25
899	319,262.17	4,545,875.20	0:00
901	319,264.87	4,545,949.34	0:00
904	320,812.82	4,546,614.29	0:00
908	320,792.20	4,546,162.04	3:04
911	319,105.93	4,545,079.92	33:54
915	318,804.43	4,545,114.35	18:23
919	319,056.56	4,545,767.23	11:17
921	319,101.51	4,545,808.90	9:02
923	318,837.72	4,545,879.78	7:02
925	318,845.47	4,546,039.79	2:37
930	319,038.08	4,545,895.59	5:18
931	319,122.19	4,545,954.07	0:00
933	319,128.68	4,546,769.41	0:00
935	320,881.50	4,546,808.33	0:00
941	320,692.63	4,547,460.27	0:00
942	320,820.12	4,547,902.76	0:00
944	320,824.88	4,547,992.55	0:00
947	320,794.81	4,548,090.08	0:00
950	320,665.70	4,548,193.96	0:00
951	320,559.39	4,548,192.22	0:00
953	320,504.05	4,548,189.25	0:00
955	320,924.45	4,548,215.63	0:00
956	320,894.94	4,547,557.73	0:00
960	320,823.97	4,547,434.12	0:00
961	320,848.65	4,547,417.97	0:00
965	320,894.08	4,547,134.75	0:00
967	321,487.09	4,546,672.43	2:00
970	321,680.32	4,546,688.37	2:34
974	321,865.55	4,546,674.48	3:31

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
979	322,157.77	4,546,649.93	10:44
981	321,900.17	4,547,972.05	0:00
990	322,540.10	4,547,972.98	0:00
992	322,523.35	4,547,703.98	0:00
994	322,530.23	4,547,606.50	0:00
995	322,527.17	4,547,553.05	1:04
997	322,626.45	4,546,948.41	3:37
1001	322,572.14	4,546,683.54	34:01
1002	324,025.19	4,547,286.09	5:54
1004	323,780.60	4,548,175.17	0:00
1007	323,444.60	4,548,194.15	0:00
1013	322,515.69	4,547,815.78	0:00
1014	324,238.25	4,548,178.60	0:00
1016	324,177.46	4,548,003.82	0:00
1017	324,156.44	4,547,921.19	0:00
1019	324,186.61	4,547,519.67	0:00
1020	324,152.21	4,547,489.59	0:00
1022	324,100.00	4,547,481.93	0:00
1025	324,138.66	4,547,199.86	12:26
1027	325,512.53	4,547,180.51	19:03
1032	325,719.46	4,547,495.44	35:59
1034	325,594.68	4,547,436.25	33:38
1039	325,726.81	4,548,129.81	9:33
1041	325,583.54	4,548,156.88	6:58
1043	325,527.12	4,548,173.55	6:18
1045	325,411.93	4,548,174.10	3:50
1048	325,015.70	4,547,988.68	2:05
1049	324,988.83	4,548,147.50	2:00
1051	326,150.15	4,548,183.56	6:05
1058	326,427.32	4,548,172.37	12:12
1060	326,850.03	4,548,156.18	30:23
1064	328,016.48	4,546,600.00	6:50
1068	328,947.02	4,546,705.97	8:32
1069	328,495.52	4,546,955.91	8:50
1073	328,622.09	4,546,994.74	9:31
1074	328,818.05	4,547,024.90	7:17
1077	328,975.36	4,547,129.90	10:34
1078	328,950.83	4,547,197.02	11:33
1080	328,940.88	4,547,282.07	8:37
1083	328,851.72	4,548,069.67	32:18
1088	328,611.75	4,548,114.45	30:23
1090	328,509.33	4,548,110.86	32:20
1092	328,199.00	4,548,129.40	25:15
1096	329,143.45	4,546,561.58	8:39
1099	329,025.39	4,546,561.11	11:36
1104	329,284.04	4,547,436.52	3:47
1108	329,397.68	4,547,532.65	23:20
1112	329,576.84	4,547,580.92	10:33
1114	329,803.34	4,547,582.73	5:26
1117	330,096.62	4,547,610.14	3:01
1120	330,639.41	4,547,174.12	0:00
1124	330,181.16	4,548,005.87	2:18
1126	332,661.07	4,546,395.47	0:00

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
1130	332,779.83	4,546,374.88	0:00
1134	333,018.16	4,546,380.06	0:00
1135	333,068.00	4,546,374.92	0:00
1136	333,268.58	4,546,374.23	0:00
1138	333,760.67	4,546,350.12	0:00
1141	334,403.67	4,546,135.71	0:00
1147	334,791.45	4,546,204.65	0:00
1151	335,372.02	4,546,264.21	0:00
1153	335,402.56	4,546,111.04	0:00
1154	335,492.44	4,546,008.21	0:00
1157	336,366.55	4,546,304.69	0:00
1160	337,086.56	4,546,281.25	0:00
1162	338,887.51	4,546,251.68	0:00
1168	339,852.29	4,546,239.38	0:00
1170	340,617.86	4,545,792.36	0:00
1171	340,643.55	4,545,855.40	0:00
1172	340,594.62	4,545,851.25	0:00
1173	340,551.77	4,545,847.26	0:00
1175	340,732.32	4,545,894.88	0:00
1178	340,650.71	4,545,898.43	0:00
1181	340,677.74	4,545,935.41	0:00
1184	340,676.01	4,546,217.28	0:00
1185	340,636.46	4,546,217.18	0:00
1187	340,736.48	4,546,194.53	0:00
1188	340,780.19	4,546,165.86	0:00
1189	340,794.97	4,546,074.55	0:00
1190	340,754.98	4,546,090.79	0:00
1191	340,962.62	4,546,126.47	0:00
1192	341,008.43	4,546,203.32	0:00
1193	341,058.87	4,546,228.04	0:00
1194	341,040.80	4,546,293.19	0:00
1195	340,948.68	4,546,347.12	0:00
1196	340,851.88	4,546,281.03	0:00
1202	341,116.03	4,546,158.64	0:00
1205	341,086.36	4,546,214.20	0:00
1206	341,114.35	4,546,195.89	0:00
1208	341,165.62	4,546,179.11	0:00
1209	341,287.83	4,546,136.17	0:00
1212	341,756.47	4,545,915.07	0:00
1216	341,964.91	4,545,983.99	0:00
1217	342,038.00	4,545,883.10	0:00
1219	342,045.37	4,545,928.72	0:00
1221	342,454.50	4,545,754.98	0:00
1223	345,268.14	4,545,761.35	0:00
1227	345,570.57	4,545,684.20	0:00
1230	345,457.36	4,545,909.45	0:00
1231	345,467.04	4,545,908.89	0:00
1232	330,689.23	4,547,154.50	0:00
1236	331,142.28	4,546,798.70	0:00
1241	331,922.14	4,546,473.92	0:00
1244	332,224.53	4,546,983.59	0:00
1245	332,235.52	4,546,972.53	0:00
1250	332,255.55	4,547,798.59	0:00

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
1253	331,938.03	4,547,938.61	0:00
1255	331,856.86	4,547,937.13	0:00
1257	331,820.01	4,547,671.02	0:00
1261	331,651.48	4,547,976.44	0:00
1263	331,044.53	4,548,102.57	0:00
1266	330,714.44	4,548,041.80	0:00
1268	330,693.68	4,547,967.40	0:00
1271	330,704.46	4,547,684.18	0:00
1272	330,798.85	4,547,637.51	0:00
1274	332,256.78	4,546,446.48	0:00
1276	332,269.35	4,546,527.40	0:00
1277	332,349.71	4,546,444.56	0:00
1280	332,274.45	4,546,582.26	0:00
1281	332,310.57	4,546,639.46	0:00
1282	332,258.33	4,546,685.41	0:00
1284	332,272.37	4,546,721.26	0:00
1286	332,261.64	4,546,766.49	0:00
1288	332,279.64	4,546,809.95	0:00
1304	333,603.76	4,546,576.12	0:00
1306	333,484.01	4,546,423.99	0:00
1308	333,953.90	4,547,524.33	0:00
1311	334,523.20	4,546,541.79	0:00
1314	335,511.90	4,547,172.32	0:00
1319	334,788.27	4,547,967.33	0:00
1324	334,356.37	4,547,769.03	0:00
1326	334,143.05	4,547,972.04	0:00
1327	334,264.21	4,547,419.49	0:00
1330	335,602.27	4,547,964.71	0:00
1335	336,948.80	4,547,353.75	0:00
1345	336,535.84	4,547,381.53	0:00
1348	336,919.29	4,546,892.29	0:00
1352	336,080.36	4,547,021.64	0:00
1355	337,149.91	4,547,907.73	0:00
1356	337,283.44	4,546,806.09	0:00
1362	338,594.57	4,546,638.30	0:00
1364	338,524.31	4,546,639.50	0:00
1366	338,442.60	4,546,643.89	0:00
1368	338,028.08	4,546,755.94	0:00
1370	338,311.79	4,547,810.06	0:00
1378	337,523.52	4,547,899.66	0:00
1380	338,977.70	4,547,889.45	0:00
1386	339,640.43	4,546,377.80	0:00
1388	339,123.63	4,546,455.69	0:00
1389	340,370.16	4,547,798.67	0:00
1390	340,423.36	4,547,790.40	0:00
1392	340,690.71	4,547,788.68	0:0
1393	340,658.15	4,547,790.20	0:00
1394	340,735.21	4,547,775.77	0:00
1395	340,886.15	4,547,822.37	0:00
1400	341,816.30	4,547,093.37	0:00
1401	341,713.87	4,547,025.49	0:00
1402	341,460.74	4,546,340.49	0:00
1403	340,898.82	4,546,395.83	0:00

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
1408	341,047.26	4,547,531.87	0:00
1411	341,055.37	4,547,376.67	0:00
1413	341,065.39	4,546,874.65	0:00
1415	341,039.76	4,546,759.45	0:00
1416	341,017.63	4,546,698.50	0:00
1418	341,091.10	4,546,748.27	0:00
1423	341,205.97	4,547,019.10	0:00
1425	341,241.18	4,547,134.77	0:00
1426	341,302.34	4,547,217.74	0:00
1428	341,549.51	4,546,266.54	0:00
1431	342,067.21	4,547,168.22	0:00
1432	342,325.79	4,547,046.65	0:00
1433	342,327.81	4,547,164.17	0:00
1435	342,298.09	4,547,244.33	0:00
1442	342,056.93	4,547,313.22	0:00
1444	341,804.30	4,547,805.25	0:00
1447	341,852.42	4,548,052.31	0:00
1448	341,766.45	4,548,056.35	0:00
1449	341,790.74	4,548,205.43	0:00
1450	341,884.02	4,548,280.07	0:00
1452	341,660.04	4,548,382.31	6:49
1454	341,587.97	4,548,203.81	0:00
1455	341,422.90	4,548,190.04	1:56
1456	341,348.83	4,547,994.96	0:00
1457	341,294.47	4,547,979.28	0:00
1458	341,195.36	4,547,912.41	0:00
1459	341,104.92	4,547,780.23	0:00
1460	341,010.88	4,547,909.62	0:00
1461	340,940.06	4,547,952.16	0:00
1462	340,886.71	4,547,970.54	0:00
1463	340,881.74	4,547,879.90	0:00
1465	340,444.89	4,547,898.71	0:00
1469	340,526.81	4,547,894.82	0:00
1470	340,583.64	4,547,892.88	0:00
1473	340,751.06	4,548,024.81	0:00
1476	340,685.68	4,548,067.78	0:00
1477	340,696.71	4,548,133.40	0:00
1482	342,539.58	4,547,038.57	1:52
1487	342,778.54	4,547,002.00	2:51
1491	342,878.03	4,547,010.51	3:22
1493	342,994.99	4,546,938.54	4:27
1494	343,226.25	4,546,807.43	10:47
1498	342,652.40	4,547,699.26	6:58
1500	342,855.53	4,547,846.12	8:52
1502	343,308.25	4,547,750.48	4:12
1504	343,600.35	4,547,732.20	0:00
1506	343,718.90	4,547,734.31	0:00
1509	343,984.83	4,547,662.55	1:35
1512	345,025.02	4,547,351.03	42:13
1516	345,125.99	4,546,943.92	31:14
1518	344,571.44	4,546,163.80	0:00
1523	343,985.50	4,546,438.05	0:00
1529	343,950.08	4,546,366.15	0:00

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
1531	343,737.59	4,546,423.48	0:00
1535	345,219.27	4,547,162.14	21:48
1540	346,095.40	4,547,857.34	19:34
1542	345,239.43	4,546,339.23	0:00
1548	345,355.11	4,546,628.43	3:55
1552	345,720.77	4,549,276.68	6:22
1554	345,664.77	4,549,252.41	7:11
1558	345,228.79	4,547,899.69	22:04
1562	344,951.60	4,549,319.02	13:29
1566	343,849.91	4,549,322.97	36:13
1573	343,742.74	4,549,332.48	21:22
1575	343,669.65	4,547,795.61	0:00
1578	344,463.35	4,547,862.69	11:04
1580	344,655.13	4,547,855.56	27:34
1584	342,347.14	4,547,877.99	8:43
1602	342,060.17	4,549,267.74	13:27
1606	342,897.15	4,549,365.03	13:25
1616	341,787.19	4,548,565.25	5:44
1620	341,818.18	4,548,629.80	5:11
1625	341,737.09	4,548,620.82	4:04
1626	341,750.93	4,548,673.63	3:45
1627	341,785.60	4,548,723.43	21:20
1630	341,809.28	4,548,789.34	34:35
1632	341,841.39	4,548,908.37	20:47
1634	341,796.04	4,548,995.80	20:31
1636	341,774.86	4,549,406.59	13:29
1638	341,525.82	4,549,403.92	3:43
1641	341,177.86	4,549,412.23	5:46
1646	341,078.42	4,549,411.44	10:59
1647	341,050.94	4,549,416.40	12:37
1648	340,989.36	4,549,421.44	15:50
1649	340,991.22	4,548,001.50	0:00
1650	341,001.73	4,547,995.68	0:00
1651	341,032.22	4,547,994.50	0:00
1652	341,049.77	4,547,993.53	0:00
1654	340,380.35	4,549,442.92	7:17
1656	339,913.83	4,549,425.49	10:21
1658	339,096.92	4,549,274.21	2:52
1659	338,872.22	4,549,378.53	17:23
1661	338,773.58	4,547,966.04	0:00
1663	339,148.43	4,547,938.71	0:00
1669	339,389.23	4,547,937.10	0:00
1671	340,198.36	4,548,371.65	2:19
1674	339,761.36	4,548,395.13	3:34
1676	339,569.82	4,548,684.47	0:00
1678	340,346.10	4,548,642.44	11:31
1681	337,658.92	4,549,509.59	17:28
1682	337,302.04	4,547,961.36	0:00
1685	337,727.72	4,547,984.54	0:00
1688	338,273.47	4,547,971.18	0:00
1689	338,805.62	4,549,374.26	17:58
1690	337,082.87	4,549,509.56	19:56
1696	336,421.05	4,549,547.48	9:17

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
1698	335,872.15	4,549,563.70	3:11
1700	335,850.23	4,548,007.26	0:00
1705	336,413.09	4,548,076.27	0:00
1708	336,551.61	4,548,007.58	0:00
1709	336,664.92	4,547,990.15	0:00
1710	337,058.05	4,548,407.79	0:00
1711	335,543.86	4,549,557.30	2:56
1716	334,898.94	4,549,592.30	24:53
1719	334,683.07	4,549,610.61	17:25
1722	333,966.20	4,549,628.25	12:49
1727	333,947.58	4,548,084.12	0:00
1729	334,972.57	4,548,026.59	0:00
1734	335,452.33	4,548,295.19	0:00
1735	335,464.28	4,548,353.67	0:00
1738	333,808.60	4,549,623.35	13:06
1739	333,338.00	4,549,636.75	3:51
1741	332,348.34	4,549,673.24	4:07
1743	332,332.39	4,549,055.02	0:00
1744	332,343.45	4,549,107.00	0:00
1749	332,316.05	4,548,567.67	0:00
1752	333,877.84	4,548,355.12	0:00
1757	333,899.60	4,548,849.01	0:00
1761	332,093.11	4,549,598.77	0:00
1764	332,021.39	4,549,631.83	0:00
1765	331,974.03	4,549,615.41	0:00
1766	331,876.13	4,549,629.69	0:00
1768	331,260.93	4,549,679.74	4:03
1774	330,752.14	4,549,368.69	14:46
1775	330,748.20	4,549,217.12	18:57
1777	330,739.38	4,549,115.59	32:24
1780	330,723.28	4,548,976.61	6:11
1784	330,749.29	4,549,152.11	23:36
1785	330,724.69	4,548,827.15	0:00
1786	330,846.04	4,548,120.36	0:00
1789	330,802.23	4,548,220.59	0:00
1792	331,115.37	4,548,356.67	0:00
1794	331,305.03	4,548,408.23	0:00
1799	331,701.52	4,548,686.56	3:15
1803	332,164.21	4,548,573.38	0:00
1811	329,734.91	4,549,693.86	17:54
1812	329,663.81	4,549,595.61	10:10
1813	329,613.12	4,549,656.17	8:45
1821	329,425.06	4,548,156.27	10:58
1822	329,778.14	4,548,198.38	11:32
1824	329,692.98	4,548,208.24	16:03
1826	329,860.26	4,548,140.38	10:26
1830	330,308.37	4,548,130.01	1:50
1832	330,352.33	4,548,166.84	1:42
1834	330,396.52	4,548,166.08	1:36
1836	330,458.55	4,548,148.21	0:00
1839	330,663.42	4,548,132.75	0:00
1841	330,659.91	4,548,339.71	0:00
1845	330,646.16	4,548,414.66	0:00

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
1848	330,626.76	4,548,905.72	0:00
1849	328,880.73	4,549,723.35	2:11
1855	328,454.69	4,549,721.34	0:00
1856	327,998.71	4,549,717.91	6:32
1857	327,959.96	4,549,720.57	5:35
1862	327,429.50	4,549,724.06	1:08
1864	327,460.46	4,549,634.67	2:54
1865	327,443.92	4,549,406.16	2:38
1866	327,455.03	4,549,261.40	2:46
1871	327,405.67	4,548,705.20	3:15
1876	328,041.98	4,548,189.00	28:08
1877	328,310.41	4,548,218.54	24:31
1879	328,619.60	4,548,170.44	17:42:
1883	327,155.46	4,549,739.25	0:00
1889	326,584.72	4,549,714.59	0:00
1891	326,286.47	4,549,743.93	0:00
1896	325,598.00	4,549,775.67	0:00
1901	324,939.55	4,549,760.81	0:00
1903	324,577.73	4,549,775.99	0:00
1904	324,162.26	4,549,622.32	0:00
1909	324,144.17	4,549,052.65	0:00
1910	324,142.90	4,548,997.96	0:00
1912	324,142.72	4,548,968.45	0:00
1913	324,142.40	4,548,930.32	0:00
1914	324,140.81	4,548,895.86	0:00
1915	324,137.87	4,548,859.77	0:00
1916	324,138.66	4,548,809.69	0:00
1917	324,136.80	4,548,778.55	0:00
1918	324,135.17	4,548,741.78	0:00
1919	324,134.64	4,548,710.95	0:00
1920	324,134.95	4,548,671.15	0:00
1921	324,400.88	4,548,266.69	0:00
1925	324,597.37	4,548,239.43	0:00
1926	324,631.21	4,548,240.51	0:00
1927	324,664.72	4,548,241.26	0:00
1928	324,710.43	4,548,238.81	0:00
1929	324,749.94	4,548,241.45	0:00
1930	324,780.04	4,548,237.29	0:00
1933	325,158.79	4,548,242.04	2:33
1934	325,278.30	4,548,231.36	2:59
1938	325,313.12	4,548,385.28	3:15
1939	325,705.54	4,548,260.16	9:51
1941	323,893.04	4,549,775.86	0:00
1946	324,095.17	4,549,319.37	0:00
1949	324,024.76	4,548,715.11	0:00
1951	324,068.60	4,548,546.24	0:00
1952	324,066.24	4,548,486.27	0:00
1953	323,716.85	4,548,240.94	0:00
1957	323,324.08	4,548,288.81	0:00
1958	322,827.44	4,548,273.35	0:00
1962	322,606.98	4,548,511.87	0:00
1965	322,621.64	4,548,612.08	0:00
1966	322,757.81	4,548,686.31	0:00

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
1967	322,327.79	4,548,294.83	0:00
1974	321,961.35	4,548,272.84	0:00
1976	321,670.29	4,548,264.59	0:00
1979	321,566.07	4,548,296.89	0:00
1980	321,495.46	4,548,304.29	0:00
1982	321,273.91	4,548,327.55	0:00
1985	320,925.49	4,548,479.45	0:00
1991	320,870.39	4,548,691.68	0:00
1993	324,149.40	4,549,894.61	0:00
1997	324,220.93	4,550,056.59	0:00
1998	324,128.69	4,550,270.87	0:00
1999	324,590.90	4,549,842.22	0:00
2006	325,018.63	4,549,938.84	0:00
2007	325,259.39	4,549,851.86	0:00
2011	325,604.49	4,551,372.69	0:00
2013	325,822.42	4,551,340.23	0:00
2014	325,783.07	4,551,374.24	0:00
2015	326,373.79	4,551,126.80	0:00
2017	326,686.16	4,551,340.14	0:00
2019	326,725.24	4,551,307.35	0:00
2021	326,919.65	4,551,308.29	0:00
2023	324,395.95	4,553,046.70	0:00
2024	327,050.61	4,551,343.33	0:00
2024	324,222.18	4,552,407.74	0:00
2025	327,056.37	4,551,274.92	0:00
2025	324,317.24	4,552,424.32	0:00
2026	327,025.04	4,551,238.16	0:00
2026	324,269.85	4,551,584.01	0:00
2027	327,258.44	4,551,337.44	0:00
2028	324,212.87	4,551,351.40	0:00
2029	327,434.84	4,551,327.48	0:00
2029	324,325.86	4,551,419.65	0:00
2030	324,441.60	4,551,414.62	0:00
2031	327,484.33	4,551,326.62	0:00
2031	324,683.90	4,551,405.22	0:00
2032	327,455.47	4,551,260.78	0:00
2032	324,793.86	4,551,403.48	0:00
2033	327,449.89	4,551,070.78	0:00
2033	324,880.42	4,551,347.07	0:00
2034	327,426.60	4,550,906.49	0:00
2036	327,435.82	4,550,828.44	0:00
2037	327,469.92	4,550,796.50	0:00
2039	327,470.39	4,550,766.13	0:00
2040	327,469.84	4,550,734.45	0:00
2041	327,467.38	4,550,706.77	0:00
2042	327,466.84	4,550,675.10	0:00
2043	327,466.01	4,550,646.40	0:00
2044	327,460.08	4,550,589.40	0:00
2046	327,464.17	4,550,423.98	0:00
2047	327,428.93	4,550,160.23	0:00
2049	327,477.09	4,549,966.99	0:00
2051	326,612.04	4,549,812.57	0:00
2054	326,195.66	4,549,877.82	0:00

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
2055	325,981.75	4,549,836.62	0:00
2061	327,805.47	4,550,529.23	1:50
2063	327,550.05	4,550,147.82	0:00
2071	327,591.02	4,550,015.76	0:00
2074	328,380.11	4,549,784.35	10:10
2079	329,044.43	4,549,781.49	2:45
2082	328,875.14	4,550,760.33	1:57
2083	329,124.79	4,551,305.21	2:06
2090	327,556.73	4,550,535.83	0:00
2091	327,531.55	4,550,472.56	0:00
2093	329,361.39	4,551,173.07	3:45
2096	330,238.41	4,551,315.17	0:00
2104	330,297.90	4,549,840.58	10:09
2105	329,928.41	4,549,756.14	9:05
2111	329,732.14	4,549,768.83	11:22
2112	329,665.04	4,549,783.75	11:05
2113	330,017.39	4,550,364.17	10:52
2114	331,373.43	4,551,272.98	11:48
2119	331,529.38	4,551,274.39	9:56
2120	331,913.00	4,551,271.88	9:13
2122	332,319.91	4,550,957.86	24:20
2123	332,319.73	4,550,666.49	44:29
2124	332,308.96	4,550,624.25	38:32
2126	332,302.48	4,550,420.81	7:36
2127	332,282.15	4,550,385.43	7:50
2128	331,837.85	4,549,738.51	1:33
2131	331,456.74	4,549,822.10	2:44
2136	332,640.34	4,551,261.97	10:52
2139	333,064.77	4,551,261.70	13:46
2140	333,394.16	4,551,258.12	12:08
2144	333,880.67	4,551,222.95	1:15
2152	333,935.89	4,550,410.02	0:00
2159	332,353.73	4,549,732.81	8:13
2166	332,399.70	4,549,960.51	4:15
2167	332,394.16	4,550,395.25	8:04
2168	332,400.52	4,550,527.25	22:45
2171	334,068.28	4,551,236.86	13:07
2174	334,627.42	4,551,178.84	4:04
2177	335,355.83	4,551,193.48	12:43
2182	335,493.92	4,549,638.97	3:17
2187	334,738.78	4,549,676.16	10:38
2193	334,540.74	4,549,672.13	2:38
2200	334,175.57	4,549,817.21	0:00
2208	337,186.92	4,551,150.79	25:42
2211	337,128.19	4,550,333.14	33:49
2213	337,124.49	4,550,233.47	39:16
2215	336,980.99	4,549,621.69	22:54
2218	336,666.08	4,549,601.81	12:38
2225	336,089.57	4,549,632.57	4:30
2228	335,805.63	4,549,740.16	1:51
2230	335,731.80	4,549,630.29	2:07
2231	337,842.85	4,550,996.90	24:28
2232	338,363.54	4,551,108.00	11:10

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
2235	338,518.87	4,549,582.24	18:28
2237	338,081.86	4,549,574.14	23:56
2240	337,748.03	4,549,593.65	7:12
2245	337,528.03	4,549,601.45	6:23
2246	337,372.15	4,549,581.80	11:42
2249	339,092.50	4,551,087.73	12:35
2251	339,390.49	4,551,082.97	24:35
2256	339,724.81	4,551,070.52	16:42
2260	340,364.61	4,550,300.01	32:22
2262	340,379.69	4,549,706.23	18:40
2267	340,463.27	4,551,049.93	6:26
2268	340,621.78	4,551,049.43	7:59
2270	340,938.21	4,551,035.43	2:39
2272	340,983.71	4,551,041.34	2:24
2276	342,027.93	4,549,726.17	0:39
2277	340,827.23	4,549,473.71	16:27
2280	340,469.19	4,550,767.02	8:39
2282	342,158.92	4,549,582.35	12:32
2283	342,144.93	4,549,677.48	4:37
2284	342,260.29	4,549,959.04	0:56
2285	342,332.24	4,549,966.74	0:00
2286	342,162.78	4,549,914.58	0:00
2287	342,057.39	4,549,801.78	0:00
2288	342,124.46	4,549,828.54	0:00
2289	342,175.70	4,549,444.96	14:47
2292	342,626.03	4,549,427.53	8:04
2295	342,956.48	4,549,428.54	10:27
2296	343,008.57	4,549,428.02	9:39
2299	343,321.32	4,549,438.26	7:25
2301	343,458.82	4,549,427.71	15:48
2302	343,539.82	4,549,399.15	19:01
2303	343,661.16	4,549,400.78	18:04
2305	343,819.16	4,549,392.48	21:59
2309	344,656.84	4,549,373.97	22:04
2310	344,715.63	4,549,374.08	20:30
2315	345,219.98	4,550,030.73	0:00
2317	344,615.82	4,550,946.85	0:00
2319	344,049.13	4,550,949.16	0:00
2325	342,285.15	4,550,051.34	0:00
2328	342,297.79	4,550,072.33	0:00
2330	342,318.88	4,550,108.43	0:00
2331	342,356.80	4,550,106.29	0:00
2332	342,349.16	4,550,073.31	0:00
2334	342,327.79	4,550,129.12	0:00
2335	342,311.62	4,550,184.10	0:00
2342	342,582.21	4,550,857.80	0:00
2345	342,620.19	4,550,794.26	0:00
2346	342,601.65	4,550,754.76	0:00
2348	342,425.26	4,550,451.55	0:00
2352	345,265.89	4,549,363.59	13:14
2359	345,302.94	4,550,349.05	0:00
2361	345,299.10	4,550,493.12	0:00
2363	345,437.61	4,550,908.98	0:00

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
2365	346,062.63	4,550,302.13	0:00
2368	346,093.08	4,550,060.48	0:00
2369	345,996.39	4,549,934.14	0:00
2370	345,709.87	4,549,927.83	0:00
2372	346,091.22	4,549,637.43	1:47
2375	346,357.09	4,549,647.74	0:54
2380	346,434.66	4,549,701.10	0:00
2384	346,342.81	4,552,286.80	0:00
2391	345,621.42	4,552,510.45	0:00
2394	345,333.71	4,551,447.82	0:00
2398	344,915.68	4,551,092.84	0:00
2400	343,830.51	4,551,022.96	0:00
2403	343,734.54	4,552,580.41	3:34
2404	343,962.15	4,552,573.52	2:24
2405	344,434.48	4,552,573.20	0:00
2410	345,079.81	4,552,492.12	0:00
2417	345,250.75	4,551,700.68	0:00
2420	343,233.48	4,552,575.47	11:27
2423	342,734.52	4,552,599.70	0:00
2426	342,678.48	4,552,608.10	0:00
2428	342,628.65	4,552,610.45	0:00
2433	342,383.03	4,552,608.73	5:00
2436	342,285.31	4,551,061.30	3:25
2440	341,796.09	4,552,639.77	9:37
2443	341,420.02	4,552,647.36	11:58
2449	341,231.02	4,552,649.50	4:31
2452	340,538.17	4,552,478.35	20:08
2458	340,988.07	4,551,096.01	2:30
2460	341,319.08	4,551,086.22	0:00
2465	339,390.47	4,552,701.37	1:51
2470	338,863.15	4,552,526.63	5:35
2473	338,943.00	4,551,156.60	21:33
2476	339,649.52	4,551,148.90	22:07
2478	339,987.68	4,551,316.11	21:41
2480	340,266.00	4,551,120.42	2:46
2482	340,396.55	4,551,505.55	34:21
2484	340,178.57	4,551,855.74	26:35
2486	338,483.61	4,552,705.05	4:19
2487	338,021.93	4,552,733.84	19:44
2491	337,537.07	4,552,734.38	38:34
2497	338,053.30	4,551,184.53	5:44
2501	338,624.92	4,551,165.39	18:08
2504	337,230.66	4,552,776.38	38:28
2506	337,055.70	4,552,751.11	48:35
2511	336,256.19	4,552,783.12	25:28
2517	335,778.80	4,552,807.71	22:08
2522	335,813.53	4,551,258.71	11:27
2523	336,219.44	4,551,254.33	5:05
2524	336,279.08	4,551,238.41	6:25
2528	336,427.82	4,551,232.50	14:42
2529	336,657.75	4,551,229.66	9:01
2533	337,198.04	4,552,027.49	27:05
2535	335,544.13	4,552,808.62	18:01

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm:]
2538	335,085.80	4,552,815.77	36:06
2542	334,603.76	4,552,829.65	5:50
2546	334,417.08	4,552,836.96	4:11
2547	334,166.78	4,552,845.00	0:42
2550	333,954.51	4,552,792.83	13:47
2551	333,246.92	4,552,825.49	4:09
2557	332,527.05	4,552,901.89	2:22
2558	332,430.87	4,552,718.97	2:05
2565	333,571.54	4,551,320.23	15:35
2567	332,347.13	4,552,809.01	0:00
2570	332,375.33	4,552,652.60	1:49
2572	332,340.51	4,552,489.09	3:26
2575	332,360.27	4,552,253.57	10:36
2576	332,315.29	4,552,191.45	8:55
2578	332,333.48	4,552,124.16	9:46
2579	332,356.40	4,551,747.91	16:30
2581	332,189.46	4,551,345.91	7:03
2583	331,806.34	4,551,355.86	7:10
2585	331,736.80	4,551,336.96	6:13
2587	331,637.77	4,551,356.53	4:52
2589	331,578.83	4,551,434.20	4:02
2592	331,378.97	4,551,368.05	6:59
2595	330,794.06	4,552,021.17	0:00
2599	330,821.49	4,552,403.62	0:00
2601	330,810.13	4,552,759.57	0:00
2606	331,619.54	4,552,854.85	0:00
2608	331,827.36	4,552,799.91	1:08
2610	332,043.89	4,552,883.63	0:00
2612	330,128.32	4,552,923.65	0:00
2617	329,418.30	4,552,794.84	0:00
2623	329,646.43	4,552,493.21	0:00
2625	329,308.65	4,552,261.98	0:00
2628	328,955.77	4,551,997.51	0:00
2629	328,895.89	4,552,064.04	0:00
2633	328,748.19	4,551,850.00	0:00
2634	328,765.12	4,551,860.87	0:00
2638	328,570.29	4,551,632.76	0:00
2640	328,445.32	4,551,420.56	0:00
2644	328,267.56	4,551,384.55	0:00
2645	328,198.74	4,551,386.11	0:00
2647	328,145.89	4,551,385.53	0:00:
2650	328,094.88	4,551,383.80	0:00
2652	327,844.56	4,551,391.46	0:00
2655	327,737.01	4,551,434.25	0:00
2656	327,555.16	4,551,765.98	0:00
2660	327,646.73	4,552,112.72	0:00
2662	327,547.80	4,552,418.83	0:00
2667	327,684.20	4,552,732.80	0:00
2670	327,667.08	4,552,927.34	0:00
2672	327,708.65	4,552,920.67	0:00
2675	327,790.60	4,552,925.59	0:00
2676	327,989.68	4,552,924.76	0:00
2678	328,538.91	4,552,922.00	0:00

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
2684	329,201.95	4,552,635.57	0:00
2687	328,640.65	4,551,375.15	0:41
2688	327,149.51	4,552,108.52	0:00
2691	327,130.30	4,551,393.60	0:00
2693	326,799.05	4,551,391.12	0:00
2698	326,654.88	4,551,404.02	0:00
2699	326,582.72	4,551,405.63	0:00
2700	326,226.14	4,551,401.73	0:00
2702	327,413.50	4,552,987.66	0:00
2704	328,215.56	4,552,980.31	0:00
2708	328,680.93	4,552,991.50	0:00
2714	329,048.51	4,554,535.51	0:00
2716	328,849.40	4,554,543.20	0:00
2718	329,323.23	4,554,523.64	0:00
2720	329,363.49	4,554,523.28	0:00
2721	329,428.47	4,554,501.70	0:00
2723	329,560.87	4,554,522.01	0:00
2724	329,753.00	4,554,526.80	0:00
2726	329,837.62	4,554,534.91	0:00
2728	329,942.36	4,554,522.21	0:00
2730	329,980.28	4,554,520.57	0:00
2732	330,024.63	4,554,431.69	0:00
2734	330,092.39	4,554,533.82	0:00
2737	330,223.23	4,554,533.02	0:00
2738	330,257.37	4,554,539.65	0:00
2739	330,309.49	4,554,531.88	0:00
2740	330,408.58	4,554,537.04	0:00
2741	330,442.69	4,554,581.49	0:00
2742	330,787.25	4,554,788.33	0:00
2743	330,788.78	4,554,757.71	0:00
2745	330,828.62	4,554,715.43	0:00
2746	330,830.57	4,554,788.61	0:00
2747	330,891.16	4,554,574.45	0:00
2749	330,915.88	4,554,513.18	0:00
2750	330,963.42	4,554,419.55	0:00
2751	331,114.26	4,554,335.82	0:00
2752	330,893.69	4,554,262.62	0:00
2753	330,771.10	4,554,130.33	0:00
2754	330,766.03	4,553,796.30	0:00
2755	330,440.86	4,553,797.09	0:00
2756	330,106.37	4,553,775.69	0:00
2757	330,186.98	4,553,885.68	0:00
2758	330,280.00	4,554,017.45	0:00
2759	330,353.27	4,554,120.34	0:00
2760	330,249.98	4,554,170.25	0:00
2761	330,280.21	4,554,269.07	0:00
2762	330,330.86	4,554,315.98	0:00
2763	330,306.36	4,554,410.24	0:00
2764	330,277.91	4,554,454.73	0:00
2765	330,148.10	4,554,066.64	0:00
2768	329,527.87	4,553,023.04	0:00
2773	329,617.13	4,553,116.37	0:00
2774	329,838.23	4,553,299.56	0:00

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
2776	329,861.07	4,553,328.39	0:00
2777	329,883.34	4,553,364.44	0:00
2778	329,948.33	4,553,305.57	0:00
2779	329,970.25	4,553,281.13	0:00
2782	329,948.67	4,553,445.13	0:00
2783	330,736.83	4,553,179.07	0:00
2785	330,860.78	4,553,110.59	0:00
2787	330,521.71	4,554,745.50	0:00
2792	329,914.04	4,554,586.28	0:00
2793	329,837.07	4,554,587.60	0:00
2796	329,726.21	4,554,637.64	0:00
2798	329,689.23	4,554,606.31	0:00
2800	331,064.33	4,553,013.03	0:00
2802	331,559.05	4,552,957.42	0:00
2803	331,666.36	4,553,020.53	0:00
2813	332,341.19	4,554,014.82	0:00
2815	331,631.69	4,554,519.29	0:00
2816	331,575.32	4,554,519.80	0:00
2824	331,338.40	4,554,521.59	0:00
2828	331,186.56	4,554,514.13	0:00
2831	331,108.38	4,554,525.10	0:00
2834	330,924.56	4,553,951.59	0:00
2840	332,930.27	4,554,485.31	0:00
2842	333,304.11	4,554,476.46	0:00
2845	333,441.86	4,554,471.33	0:00
2846	333,939.35	4,554,456.92	0:00
2847	334,052.19	4,554,462.19	0:00
2848	333,989.11	4,553,514.21	4:44
2852	333,987.85	4,553,441.01	5:16
2854	333,662.43	4,552,928.60	11:48
2856	333,566.53	4,552,948.81	8:18
2857	333,512.42	4,552,940.12	6:50
2860	333,448.65	4,552,930.22	5:48
2862	333,260.49	4,552,942.39	3:57
2866	332,743.57	4,552,946.49	0:00
2878	335,555.14	4,554,420.29	0:00
2880	335,461.35	4,553,824.82	16:40
2883	335,627.08	4,553,607.82	29:04
2884	335,388.66	4,552,877.35	19:42
2885	335,033.06	4,552,887.26	33:02
2890	334,153.38	4,552,924.76	0:00
2894	335,845.28	4,552,931.39	18:10
2899	336,670.92	4,552,847.81	13:59
2901	337,238.34	4,553,301.39	29:41
2908	336,095.76	4,554,372.57	0:00
2910	337,455.40	4,554,386.55	6:44
2920	338,150.93	4,554,355.32	18:18
2927	338,472.99	4,554,334.65	5:28
2932	338,757.66	4,554,277.84	18:22
2934	338,334.50	4,552,808.58	7:55
2936	337,287.65	4,552,831.65	31:52
2941	337,301.60	4,553,588.09	25:46
2943	338,968.48	4,554,330.17	9:28

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
2946	339,195.14	4,554,318.71	5:19
2949	339,437.19	4,554,301.82	11:40
2952	339,768.51	4,554,299.55	7:45
2962	340,453.08	4,553,353.14	2:03
2965	340,418.98	4,552,770.41	0:00
2968	339,438.61	4,552,768.39	1:52
2970	340,617.40	4,552,746.76	0:00
2973	340,900.81	4,552,737.41	0:00
2980	341,054.43	4,552,735.45	1:29
2982	342,026.38	4,552,771.78	7:01
2984	342,177.82	4,552,723.46	4:23
2988	342,653.02	4,552,673.34	0:00
2992	344,586.36	4,552,625.26	0:00
2993	344,586.03	4,552,646.23	0:00
2994	344,612.04	4,552,639.26	0:00
2996	345,969.69	4,552,595.25	0:00
2998	345,318.15	4,552,958.04	0:00
2999	345,311.48	4,552,996.04	0:00
3003	340,519.26	4,554,351.79	4:59
3005	340,782.33	4,555,754.61	0:43
3011	340,203.59	4,555,926.30	2:43
3018	339,006.33	4,554,402.19	10:17
3021	339,389.92	4,554,381.14	3:41
3028	339,882.80	4,554,478.52	7:38
3035	337,357.37	4,556,002.55	0:00
3038	337,335.49	4,555,343.32	0:00
3042	337,300.13	4,554,588.05	3:55
3047	338,642.95	4,554,399.49	2:49
3057	337,226.23	4,556,018.64	0:00
3064	337,258.04	4,554,448.97	3:19
3065	337,259.70	4,554,505.65	3:13
3066	336,653.24	4,554,489.41	0:00
3070	336,297.86	4,554,476.66	0:00
3074	335,990.86	4,554,474.05	0:00
3080	335,314.90	4,554,490.96	0:00
3084	334,963.98	4,554,507.96	0:00
3091	334,514.65	4,554,521.19	0:00
3098	334,123.45	4,554,539.62	0:00
3100	333,733.74	4,554,541.86	0:00
3101	333,544.03	4,554,543.75	0:00
3104	333,059.93	4,554,551.29	0:00
3106	332,408.41	4,554,563.51	0:00
3111	331,319.04	4,554,581.03	0:00
3112	331,242.16	4,554,567.92	0:00
3115	331,215.02	4,554,688.70	0:00
3117	331,109.84	4,554,569.17	0:00
3119	331,037.56	4,554,583.48	0:00
3120	330,886.86	4,554,891.67	0:00
3121	330,847.97	4,554,908.84	0:00
3122	330,849.07	4,554,952.82	0:00
3123	330,932.72	4,554,959.63	0:00
3124	330,868.18	4,555,004.40	0:00
3127	338,617.14	4,556,024.23	7:00

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
3131	339,180.99	4,556,074.85	0:00
3132	339,530.07	4,556,089.68	0:00
3137	320,311.01	4,542,497.37	0:00
3143	336,829.05	4,547,313.31	0:00
3144	327,314.98	4,548,461.37	6:36
3145	327,279.34	4,548,744.95	2:36
3148	327,349.94	4,549,407.26	0:00
3150	326,135.72	4,548,245.57	5:45
3151	326,192.93	4,548,231.90	6:21
3158	326,243.95	4,548,227.49	6:57
3161	326,854.75	4,548,234.96	9:22
3163	327,086.17	4,548,536.49	2:16
3164	326,526.54	4,548,580.87	3:19
3165	326,559.25	4,548,659.24	4:05
3167	326,694.26	4,548,723.16	0:32
3169	326,636.12	4,548,907.40	0:00
3171	326,882.66	4,548,900.34	0:00
3172	326,729.10	4,549,232.46	0:00
3175	326,968.34	4,549,189.93	0:00
3178	334,203.28	4,551,309.83	8:18
3183	335,039.56	4,551,274.99	26:21
3185	335,582.32	4,551,301.59	9:16
3188	335,590.43	4,551,506.88	9:09
3189	330,161.06	4,551,363.12	0:00
3191	329,901.80	4,551,367.66	2:10
3195	330,552.72	4,552,280.33	0:00
3197	329,801.98	4,552,241.01	0:00
3199	342,810.15	4,551,491.20	0:00
3203	342,987.15	4,551,881.89	0:00
3205	341,771.68	4,547,113.17	0:00
3206	341,832.16	4,547,244.78	0:00
3207	341,857.65	4,547,169.03	0:00
3208	342,220.24	4,549,744.57	3:48
3209	342,317.01	4,549,859.00	2:28
3211	330,907.88	4,554,932.98	0:00
3212	330,881.07	4,554,775.69	0:00
3213	327,427.05	4,550,984.33	0:00
3214	342,076.02	4,549,697.46	2:14
3215	335,820.04	4,548,602.57	6:12
3216	329,895.22	4,546,590.92	0:00
3217	343,181.76	4,549,290.00	35:15
3218	334,226.83	4,547,401.08	0:00
4006	341,423.36	4,554,271.60	0:00
4007	341,035.32	4,554,249.18	0:00
4008	341,343.68	4,554,331.84	0:00
4009	342,092.26	4,554,314.98	0:00
4011	341,984.93	4,554,305.58	0:00
4012	341,942.17	4,554,319.55	0:00
4013	341,791.60	4,554,334.71	0:00
4014	342,742.61	4,554,241.46	0:00
4015	342,789.25	4,554,299.40	0:00
4024	343,167.30	4,554,281.17	0:00
4025	343,696.24	4,553,873.13	0:00

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
4026	343,491.59	4,553,217.72	0:00
4030	341,531.01	4,555,964.93	0:00
4031	342,048.75	4,555,923.98	0:00
4032	342,067.63	4,555,857.60	0:00
4038	341,150.22	4,555,980.58	0:00
4039	341,224.55	4,555,879.40	0:00
4040	342,113.00	4,555,057.81	0:00
4041	342,109.95	4,554,996.34	0:00
4049	343,317.75	4,555,839.22	0:00
4050	343,000.59	4,555,898.94	0:00
4051	342,810.30	4,555,836.06	0:00
4052	343,771.38	4,555,809.24	0:00
4054	344,336.72	4,555,497.95	0:00
4055	344,064.80	4,554,774.69	0:00
4056	344,144.41	4,554,787.61	0:00
4060	344,100.47	4,554,898.92	0:00
5000	341,527.36	4,554,342.66	0:00
5002	332,249.19	4,553,045.01	0:00
5003	330,841.68	4,553,471.13	0:00
5004	330,865.65	4,553,260.47	0:00
5005	327,075.23	4,553,020.56	0:00
5006	326,947.67	4,553,001.13	0:00
5007	327,039.95	4,552,939.23	0:00
5008	326,534.69	4,552,861.85	0:00
5009	326,405.39	4,553,016.22	0:00
5010	326,334.12	4,553,013.87	0:00
5011	325,990.54	4,553,042.91	0:00
5012	325,889.09	4,553,040.83	0:00
5013	325,897.92	4,552,806.25	0:00
5014	325,321.51	4,553,016.20	0:00
5015	325,094.02	4,553,096.17	0:00
5016	325,093.25	4,553,026.60	0:00
5017	325,024.07	4,553,017.03	0:00
5018	324,940.61	4,553,089.06	0:00
5019	324,977.02	4,553,009.62	0:00
5020	324,902.26	4,553,012.31	0:00
5021	324,889.14	4,553,095.67	0:00
5022	326,603.92	4,553,006.57	0:00
5023	324,941.44	4,553,199.05	0:00
5024	325,089.78	4,551,496.94	0:00
5025	324,264.65	4,551,913.66	0:00
5026	324,271.77	4,551,513.90	0:00
5027	324,171.09	4,551,488.93	0:00
5028	345,239.19	4,551,778.35	0:00
5029	324,179.67	4,550,778.04	0:00
5030	324,157.20	4,550,612.40	0:00
5031	329,124.49	4,548,083.24	29:10
5032	345,816.23	4,549,424.58	5:03
5035	329,030.49	4,546,496.24	13:11
5036	318,537.85	4,546,224.15	2:01
5037	318,450.82	4,546,305.56	1:30
5038	318,449.47	4,546,414.81	0:00
5039	318,189.51	4,546,329.12	0:00

Receptor ID	UTM-E (meters)	UTM-N (meters)	Expected Shadow Flicker - hours per year [hh:mm]
5040	317,774.18	4,546,833.50	0:00
5041	317,574.02	4,546,657.82	0:00
5042	317,592.56	4,546,447.91	0:00
5043	317,660.56	4,546,497.45	0:00
5044	317,978.99	4,545,203.10	3:06
5045	318,112.21	4,545,043.82	4:17
5046	318,433.45	4,545,022.71	8:02
5047	318,502.26	4,545,123.04	8:13
5048	318,483.84	4,544,824.40	16:03
5049	318,568.84	4,544,867.70	17:36
5050	317,699.61	4,544,256.27	0:00
5051	317,762.26	4,544,252.91	0:00
5052	317,807.36	4,544,251.79	0:00
5053	318,001.58	4,544,240.67	0:00
5054	318,089.86	4,544,415.61	2:45
5055	318,535.27	4,544,236.53	4:15
5056	317,643.18	4,544,255.42	0:00
5057	322,415.81	4,543,338.73	0:00
5059	320,788.31	4,541,604.26	0:00
5060	345,257.56	4,551,741.14	0:00
5061	325,314.33	4,551,480.35	0:00
5063	324,171.92	4,550,568.03	0:00
5064	346,675.71	4,548,264.14	8:44
5065	325,324.64	4,545,018.25	7:02
5066	317,576.67	4,544,266.52	0:00
5067	324,844.99	4,548,251.21	1:41
5067	345,273.89	4,551,786.41	0:00

Appendix K: Communication Studies

- K-1: Off-Air TV Analysis
- K-2: AM and FM Radio Report
- K-3: Microwave Study

Appendix K-1: Off-Air TV Analysis

Wind Power GeoPlanner™

Off-Air TV Analysis

Seneca Wind Project



Prepared on Behalf of
Seneca Wind LLC
(Seneca Wind)

June 27, 2018





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Off-air television stations broadcast signals from terrestrially-based facilities directly to television receivers. Comsearch identified those off-air stations whose service could potentially be affected by the proposed Seneca Wind Project in Seneca County, Ohio. Comsearch then examined the coverage of the stations and the communities in the area that could potentially have degraded television reception due to the location of the proposed wind turbines.

The proposed wind energy project area and local communities are depicted in Figure 1, below.



To begin the analysis, Comsearch compiled all off-air television stations¹ within 150 kilometers of the center of the project area of interest (AOI). Appendix A contains a tabular summary of these stations. A plot depicting their locations appears in Figure 2, below.

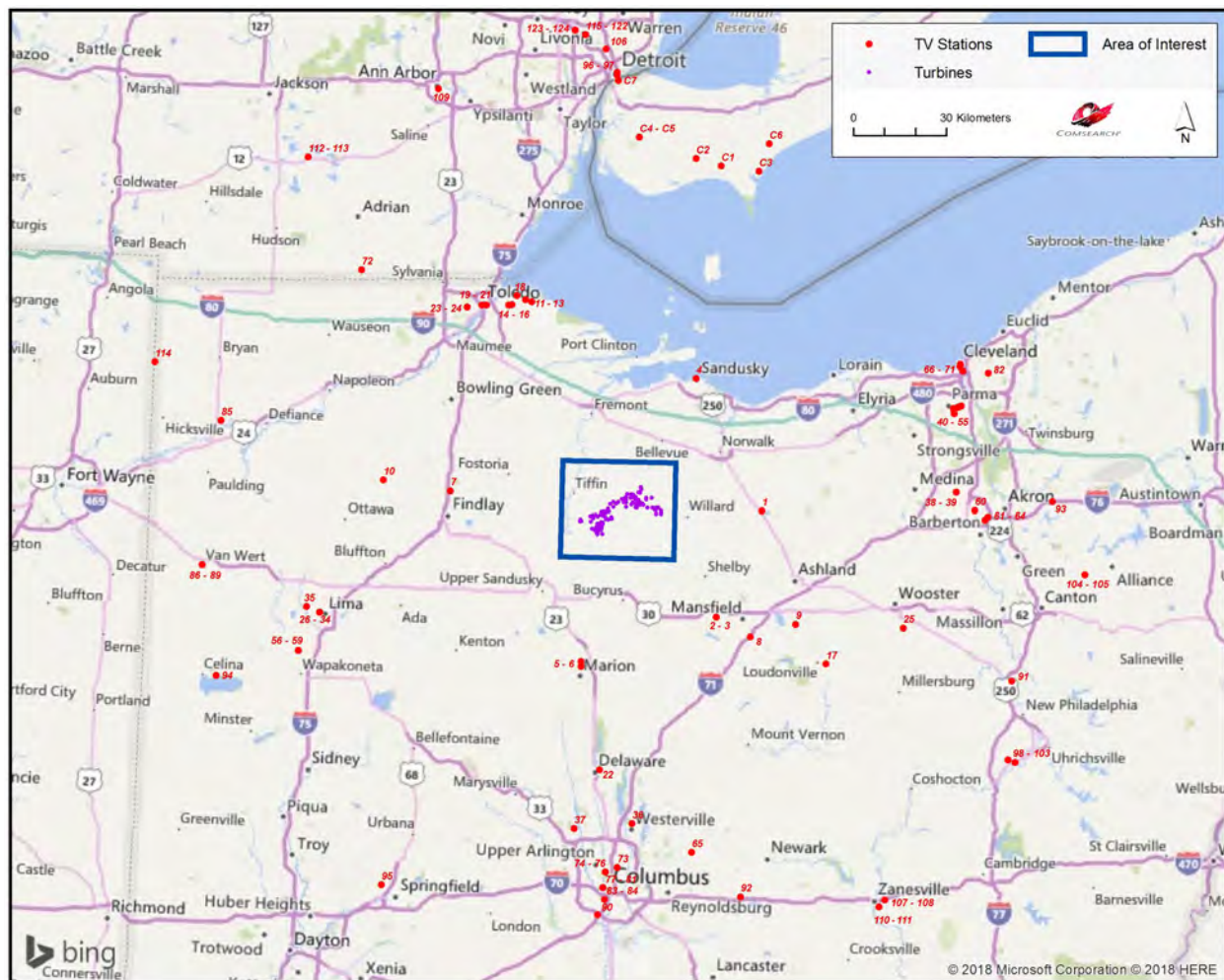


Figure 2: Plot of Off-Air TV Stations within 150 Kilometers of Project Area

TV stations at a distance of 100 kilometers or less are the most likely to provide off-air coverage to the project area and neighboring communities. These stations are listed in Table 1, below, and a plot depicting their locations is provided in Figure 3. There are a total of sixty database records for stations within approximately 100 kilometers of the project. Of these stations, only forty-four are currently licensed and operating, sixteen of which are low-power stations or translators. Translator stations are low-power stations that receive signals from distant

¹ Comsearch makes no warranty as to the accuracy of the data included in this report beyond the date of the report. The data presented in this report is derived from the TV station's FCC license and governed by Comsearch's data license notification and agreement located at http://www.comsearch.com/files/data_license.pdf.

broadcasters and retransmit the signal to a local audience. These stations serve local audiences and have limited range, which is a function of their transmit power and the height of their transmit antenna.

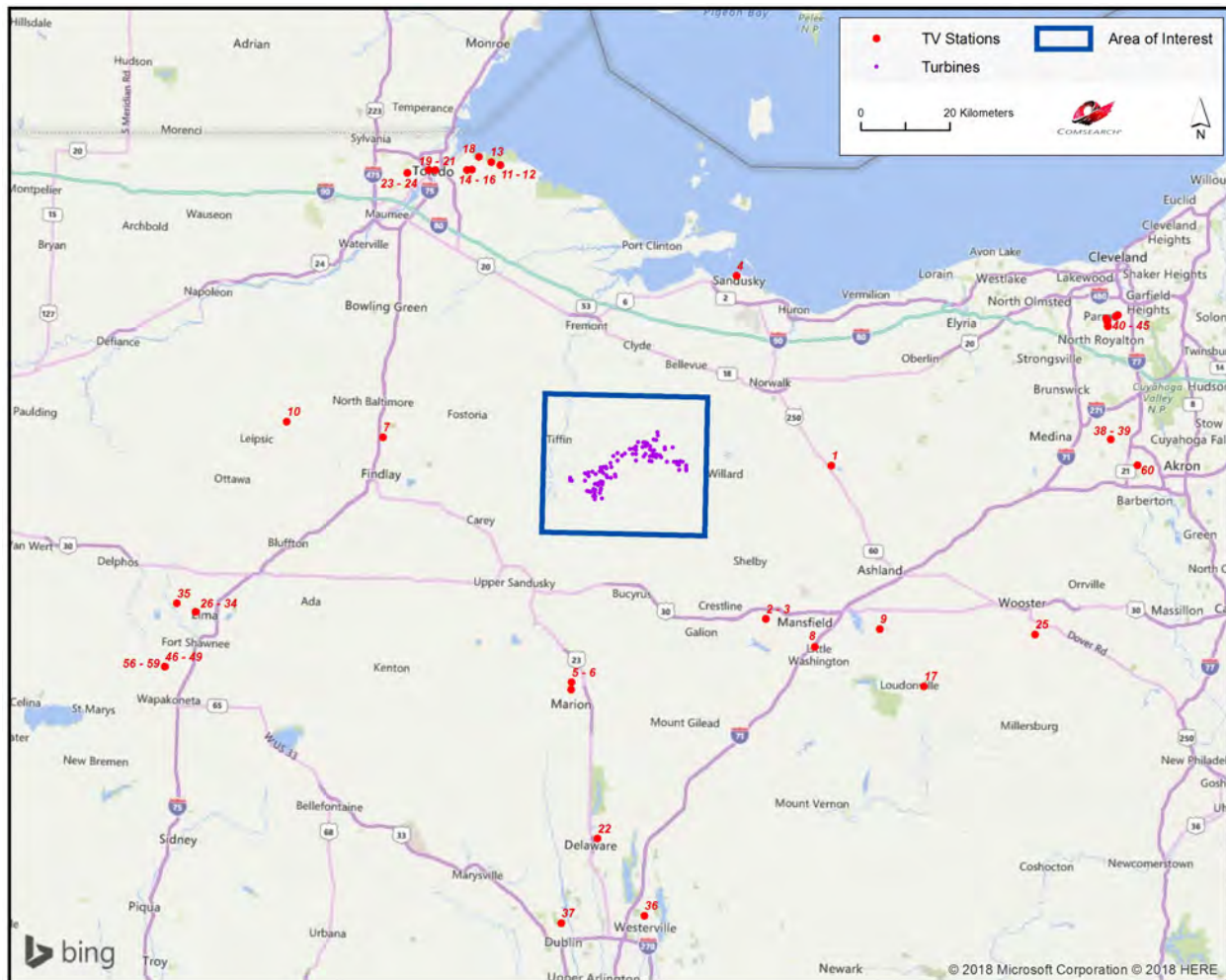


Figure 3: Plot of Off-Air TV Stations within 100 Kilometers of Project Area

ID	Call Sign	Status	Service ²	Channel	Transmit ERP ³ (kW)	Latitude (NAD 83)	Longitude (NAD 83)	Distance to Nearest Turbine (km)
1	WGGN-TV	LIC	DT	42	450.0	41.075083	-82.451111	32.46
2	WMFD-TV	LIC	DT	12	14.0	40.763889	-82.617778	37.69
3	WOHZ-CD	LIC	DC	41	15.0	40.763889	-82.617778	37.69
4	W41AP	LIC	TX	41	10.0	41.455306	-82.713500	39.41
5	WCBZ-CD	LIC	DC	28	7.5	40.627556	-83.129889	41.28
6	WXCB-CD	LIC	DC	45	15.0	40.612778	-83.130000	42.91
7	WFND-LD	LIC	LD	22	15.0	41.111111	-83.648333	42.98
8	W43CZ-D	LIC	LD	43	11.0	40.709222	-82.486278	48.87
9	W33BW	LIC	TX	33	30.0	40.747278	-82.314889	56.02
10	WBGU-TV	LIC	DT	27	153.0	41.136667	-83.906667	64.83
11	WNWO-TV	CP	DT	23	62.5	41.667500	-83.356111	69.50
12	WNWO-TV	LIC	DT	49	105.0	41.667500	-83.356111	69.50
13	WTOL	LIC	DT	11	16.9	41.672778	-83.379722	70.95
14	WGTE-TV	LIC	DT	29	49.5	41.657222	-83.431944	71.61
15	WUPW	LIC	DT	46	110.0	41.656111	-83.444722	72.02
16	WUPW	CP	DT	46	200.0	41.656111	-83.444722	72.02
17	WIVX-LD	LIC	LD	51	1.1	40.633056	-82.196111	71.87
18	WTVG	LIC	DT	13	16.7	41.683333	-83.413611	73.38
19	WMNT-CD	LIC	DC	48	15.0	41.653639	-83.530194	75.47
20	WDTJ-LD	LIC	LD	18	4.0	41.653361	-83.547972	76.09
21	WDTJ-LP	LIC	TX	68	6.6	41.653361	-83.547972	76.09
22	WOCB-CD	LIC	DC	39	2.4	40.313056	-83.051111	76.01
23	WDMY-LP	CP	LD	23	8.0	41.646861	-83.604917	77.69
24	WDMY-LP	LIC	TX	38	8.2	41.646861	-83.604917	77.69
25	WIVX-LD	LIC	LD	51	7.0	40.740528	-81.902972	86.31
26	WLIO	LIC	DT	8	27.5	40.747556	-84.131750	88.97
27	WLIO	CP	DT	8	16.5	40.747556	-84.131750	88.97
28	WLQP-LP	CP	TX	25	7.5	40.747556	-84.131750	88.97
29	WLQP-LP	CP	TX	25	7.5	40.747556	-84.131750	88.97
30	WOHL-CD	LIC	DC	35	9.0	40.747556	-84.131750	88.97
31	WLMO-LP	CP	TX	38	5.3	40.747556	-84.131750	88.97
32	WLMO-LP	CP	TX	38	5.3	40.747556	-84.131750	88.97

² Definitions of service and status codes:

DT – Digital television broadcast station

LD – Low-power digital television broadcast station

TX – Translator station

DC – Class A digital television broadcast station

DX – Digital auxiliary (backup) facility

LIC – Licensed and operational station

CP – Construction permit granted

CP MOD – Modification of construction permit

APP – Application for construction permit, not yet operational

³ ERP = Transmit Effective Radiated Power

ID	Call Sign	Status	Service ²	Channel	Transmit ERP ³ (kW)	Latitude (NAD 83)	Longitude (NAD 83)	Distance to Nearest Turbine (km)
33	WLQP-LP	CP	LD	45	15.0	40.747556	-84.131750	88.97
34	WLMO-LP	CP	LD	47	15.0	40.747556	-84.131750	88.97
35	WTLW	LIC	DT	44	165.0	40.763056	-84.183056	92.43
36	WOSU-TV	LIC	DT	38	503.0	40.159167	-82.923056	93.97
37	-	CP	TX	3	0.03	40.140556	-83.141111	95.27
38	WUEK-LD	LIC	LD	25	6.0	41.134806	-81.705750	95.34
39	KONV-LD	LIC	LD	43	1.0	41.134806	-81.705750	95.34
40	WJW	LIC	DT	8	11.0	41.363333	-81.715833	99.55
41	WJW	CP	DX	31	139.0	41.363333	-81.715833	99.55
42	WRAP-LP	CP MOD	DC	32	15.0	41.363333	-81.715833	99.55
43	WEWS-TV	LIC	DT	15	1000.0	41.373889	-81.717500	99.80
44	WEWS-TV	LIC	DX	15	850.9	41.373917	-81.717333	99.81
45	WUAB	LIC	DT	28	200.0	41.379167	-81.719722	99.82
46	WLFM-LP	LIC	TX	6	3.0	41.382778	-81.701667	101.38
47	WLFM-LP	CP	LD	6	3.0	41.382778	-81.701667	101.38
48	WRAP-LP	CP MOD	LD	32	15.0	41.382778	-81.701667	101.38
49	WQHS-DT	LIC	DT	34	525.0	41.382778	-81.701667	101.38
50	WCDN-LD	LIC	LD	7	0.3	41.383889	-81.695278	101.92
51	W16DO-D	LIC	DC	16	10.0	41.383889	-81.695278	101.92
52	WBNX-TV	LIC	DT	30	1000.0	41.383889	-81.695278	101.92
53	WKYC	LIC	DT	17	868.0	41.386083	-81.689083	102.49
54	WKYC	LIC	DX	17	930.0	41.386083	-81.689083	102.49
55	WVIZ	LIC	DT	26	150.0	41.386083	-81.689083	102.49
56	WLQP-LP	LIC	TX	18	7.7	40.634194	-84.208000	99.99
57	W23DE-D	LIC	LD	23	3.0	40.634194	-84.208000	99.99
58	WLMO-LP	LIC	TX	38	15.0	40.634194	-84.208000	99.99
59	W23DE-D	CP	LD	43	7.85	40.634194	-84.208000	99.99
60	WEAO	LIC	DT	50	250.0	41.082778	-81.633611	101.16

Table 1: Off-Air TV Stations within 100 Kilometers of Project Area

3. Impact Assessment

Based on a contour analysis of the licensed stations within 100 kilometers of the Seneca Wind Project, it was determined that eight of the full-power digital stations, identified below in Table 2, along with Class A station WOHZ-CD, may have their reception disrupted in and around the project. The areas primarily affected would include TV service locations within 10 kilometers of the wind energy project that have clear line-of-sight (LOS) to a proposed wind turbine but not to the respective station. After the wind turbines are installed, communities and homes in these locations may have degraded reception of these stations. This is due to multipath interference caused by signal scattering as TV signals are reflected by the rotating wind turbine blades and mast.

ID	Call Sign	Status	Service ⁴	Channel	Transmit ERP ⁵ (kW)	Latitude (NAD 83)	Longitude (NAD 83)	Distance to Nearest Turbine (km)
1	WGGN-TV	LIC	DT	42	450.0	41.075083	-82.451111	32.46
2	WMFD-TV	LIC	DT	12	14.0	40.763889	-82.617778	37.69
3	WOHZ-CD	LIC	DC	41	15.0	40.763889	-82.617778	37.69
10	WBGU-TV	LIC	DT	27	153.0	41.136667	-83.906667	64.83
12	WNWO-TV	LIC	DT	49	105.0	41.667500	-83.356111	69.50
13	WTOL	LIC	DT	11	16.9	41.672778	-83.379722	70.95
14	WGTE-TV	LIC	DT	29	49.5	41.657222	-83.431944	71.61
15	WUPW	LIC	DT	46	110.0	41.656111	-83.444722	72.02
18	WTVG	LIC	DT	13	16.7	41.683333	-83.413611	73.38

Table 2: Licensed Off-Air TV Stations Subject to Degradation

⁴ Definitions of service and status codes:

DT – Digital television broadcast station

DC – Class A digital television broadcast station

LIC – Licensed and operational station

⁵ ERP = Transmit Effective Radiated Power

4. Recommendations

While TV signals are reflected by wind turbines, which can cause multipath interference to the TV receiver, modern digital TV receivers have undergone significant improvements to mitigate the effects of signal scattering. When used in combination with a directional antenna, it becomes even less likely that signal scattering from wind farms will cause interference to digital TV reception.

Nevertheless, signal scattering could still impact certain areas currently served by the TV station mentioned above, especially those that would have line-of-sight to at least one wind turbine but not to the station antenna. In the unlikely event that interference is observed in any of the TV service areas, it is recommended that a high-gain directional antenna be used, preferably outdoors, and oriented towards the signal origin in order to mitigate the interference.

Both cable service and direct broadcast satellite service will be unaffected by the presence of the wind turbine facility and may be offered to those residents who can show that their off-air TV reception has been disrupted by the presence of the wind turbines after they are installed.

5. Contact

For questions or information regarding the Off-Air TV Analysis, please contact:

Contact person:	David Meyer
Title:	Senior Manager
Company:	Comsearch
Address:	19700 Janelia Farm Blvd., Ashburn, VA 20147
Telephone:	703-726-5656
Fax:	703-726-5595
Email:	dmeyer@comsearch.com
Web site:	www.comsearch.com

Appendix A

ID	Call Sign	Status	Service ⁶	Channel	Transmit ERP ⁷ (kW)	Latitude (NAD 83)	Longitude (NAD 83)	Distance to Nearest Turbine (km)
1	WGGN-TV	LIC	DT	42	450.0	41.075083	-82.451111	32.46
2	WMFD-TV	LIC	DT	12	14.0	40.763889	-82.617778	37.69
3	WOHZ-CD	LIC	DC	41	15.0	40.763889	-82.617778	37.69
4	W41AP	LIC	TX	41	10.0	41.455306	-82.713500	39.41
5	WCBZ-CD	LIC	DC	28	7.5	40.627556	-83.129889	41.28
6	WXCZ-CD	LIC	DC	45	15.0	40.612778	-83.130000	42.91
7	WFND-LD	LIC	LD	22	15.0	41.111111	-83.648333	42.98
8	W43CZ-D	LIC	LD	43	11.0	40.709222	-82.486278	48.87
9	W33BW	LIC	TX	33	30.0	40.747278	-82.314889	56.02
10	WBGU-TV	LIC	DT	27	153.0	41.136667	-83.906667	64.83
11	WNWO-TV	CP	DT	23	62.5	41.667500	-83.356111	69.50
12	WNWO-TV	LIC	DT	49	105.0	41.667500	-83.356111	69.50
13	WTOL	LIC	DT	11	16.9	41.672778	-83.379722	70.95
14	WGTE-TV	LIC	DT	29	49.5	41.657222	-83.431944	71.61
15	WUPW	LIC	DT	46	110.0	41.656111	-83.444722	72.02
16	WUPW	CP	DT	46	200.0	41.656111	-83.444722	72.02
17	WIVX-LD	LIC	LD	51	1.1	40.633056	-82.196111	71.87
18	WTVG	LIC	DT	13	16.7	41.683333	-83.413611	73.38
19	WMNT-CD	LIC	DC	48	15.0	41.653639	-83.530194	75.47
20	WDTJ-LD	LIC	LD	18	4.0	41.653361	-83.547972	76.09
21	WDTJ-LP	LIC	TX	68	6.6	41.653361	-83.547972	76.09
22	WOCB-CD	LIC	DC	39	2.4	40.313056	-83.051111	76.01
23	WDMY-LP	CP	LD	23	8.0	41.646861	-83.604917	77.69
24	WDMY-LP	LIC	TX	38	8.2	41.646861	-83.604917	77.69
25	WIVX-LD	LIC	LD	51	7.0	40.740528	-81.902972	86.31

⁶ Definitions of service and status codes:

TV – Analog television broadcast station

DT – Digital television broadcast station

DS – Digital special temporary authority (STA)

LP – Low power analog television broadcast station

LD – Low power digital television broadcast station

CA – Class A analog television broadcast station

DC – Class A digital television broadcast station

DX – Digital auxiliary (backup) facility

TX – Translator station

DD – Distributed digital television system

LIC – Licensed and operational station

CP – Construction permit granted

CP MOD – Modification of construction permit

APP – Application for construction permit, not yet operational

STA – Special transmit authorization, usually granted by FCC for temporary operation

⁷ ERP = Transmit Effective Radiated Power

ID	Call Sign	Status	Service ⁶	Channel	Transmit ERP ⁷ (kW)	Latitude (NAD 83)	Longitude (NAD 83)	Distance to Nearest Turbine (km)
26	WLIO	LIC	DT	8	27.5	40.747556	-84.131750	88.97
27	WLIO	CP	DT	8	16.5	40.747556	-84.131750	88.97
28	WLQP-LP	CP	TX	25	7.5	40.747556	-84.131750	88.97
29	WLQP-LP	CP	TX	25	7.5	40.747556	-84.131750	88.97
30	WOHL-CD	LIC	DC	35	9.0	40.747556	-84.131750	88.97
31	WLMO-LP	CP	TX	38	5.3	40.747556	-84.131750	88.97
32	WLMO-LP	CP	TX	38	5.3	40.747556	-84.131750	88.97
33	WLQP-LP	CP	LD	45	15.0	40.747556	-84.131750	88.97
34	WLMO-LP	CP	LD	47	15.0	40.747556	-84.131750	88.97
35	WTLW	LIC	DT	44	165.0	40.763056	-84.183056	92.43
36	WOSU-TV	LIC	DT	38	503.0	40.159167	-82.923056	93.97
37	-	CP	TX	3	0.03	40.140556	-83.141111	95.27
38	WUEK-LD	LIC	LD	25	6.0	41.134806	-81.705750	95.34
39	KONV-LD	LIC	LD	43	1.0	41.134806	-81.705750	95.34
40	WJW	LIC	DT	8	11.0	41.363333	-81.715833	99.55
41	WJW	CP	DX	31	139.0	41.363333	-81.715833	99.55
42	WRAP-LP	CP MOD	DC	32	15.0	41.363333	-81.715833	99.55
43	WEWS-TV	LIC	DT	15	1000.0	41.373889	-81.717500	99.80
44	WEWS-TV	LIC	DX	15	850.9	41.373917	-81.717333	99.81
45	WUAB	LIC	DT	28	200.0	41.379167	-81.719722	99.82
46	WLFM-LP	LIC	TX	6	3.0	41.382778	-81.701667	101.38
47	WLFM-LP	CP	LD	6	3.0	41.382778	-81.701667	101.38
48	WRAP-LP	CP MOD	LD	32	15.0	41.382778	-81.701667	101.38
49	WQHS-DT	LIC	DT	34	525.0	41.382778	-81.701667	101.38
50	WCDN-LD	LIC	LD	7	0.3	41.383889	-81.695278	101.92
51	W16DO-D	LIC	DC	16	10.0	41.383889	-81.695278	101.92
52	WBNX-TV	LIC	DT	30	1000.0	41.383889	-81.695278	101.92
53	WKYC	LIC	DT	17	868.0	41.386083	-81.689083	102.49
54	WKYC	LIC	DX	17	930.0	41.386083	-81.689083	102.49
55	WVIZ	LIC	DT	26	150.0	41.386083	-81.689083	102.49
56	WLQP-LP	LIC	TX	18	7.7	40.634194	-84.208000	99.99
57	W23DE-D	LIC	LD	23	3.0	40.634194	-84.208000	99.99
58	WLMO-LP	LIC	TX	38	15.0	40.634194	-84.208000	99.99
59	W23DE-D	CP	LD	43	7.85	40.634194	-84.208000	99.99
60	WEAO	LIC	DT	50	250.0	41.082778	-81.633611	101.16
61	WDLI-TV	LIC	DT	49	900.0	41.055556	-81.593611	104.51
62	WAKN-LP	LIC	TX	11	1.5	41.064639	-81.582861	105.41
63	WVPX-TV	LIC	DT	23	1000.0	41.064639	-81.582861	105.41
64	WOIO	LIC	LD	24	11.0	41.064639	-81.582861	105.41
65	WSFJ-TV	LIC	DT	24	1000.0	40.079000	-82.694861	106.75
66	WRAP-LP	CP	LD	32	15.0	41.501139	-81.694278	107.08
67	WQDI-LD	LIC	LD	21	0.25	41.487000	-81.683639	107.20

ID	Call Sign	Status	Service ⁶	Channel	Transmit ERP ⁷ (kW)	Latitude (NAD 83)	Longitude (NAD 83)	Distance to Nearest Turbine (km)
68	WUEK-LD	CP	LD	25	0.5	41.487000	-81.683639	107.20
69	WEKA-LD	LIC	LD	27	5.0	41.487000	-81.683639	107.20
70	KONV-LD	CP	LD	43	0.75	41.487000	-81.683639	107.20
71	WRAP-LP	LIC	TX	32	6.37	41.508361	-81.694000	107.46
72	WLMB	LIC	DT	5	10.0	41.744722	-84.018333	107.09
73	WGCT-CD	LIC	DC	8	0.19	40.031111	-82.974889	107.64
74	WCPX-LP	CP	LD	25	9.5	40.017222	-83.019722	108.94
75	WCSN-LD	LIC	LD	33	15.0	40.017222	-83.019722	108.94
76	WCPX-LP	LIC	TX	48	150.0	40.017222	-83.019722	108.94
77	WCMH-TV	LIC	DT	14	902.0	39.971111	-83.027778	114.03
78	WDEM-CD	LIC	DC	17	1.05	39.971111	-83.027778	114.03
79	WCLL-CD	LIC	DC	19	15.0	39.971111	-83.027778	114.03
80	WBNS-TV	LIC	DT	21	1000.0	39.971111	-83.027778	114.03
81	W44DC-D	LIC	LD	44	15.0	39.971111	-83.027778	114.03
82	WRAP-LP	LIC	TX	32	0.07	41.482528	-81.585667	114.46
83	WTTE	LIC	DT	36	1000.0	39.937222	-83.021111	117.81
84	WSYX	LIC	DT	48	1000.0	39.937222	-83.021111	117.81
85	WDFM-LP	LIC	TX	26	7.5	41.291389	-84.537500	120.11
86	W16DM-D	CP	LD	16	0.5	40.872806	-84.588000	122.72
87	W29EL-D	CP	LD	29	0.5	40.872806	-84.588000	122.72
88	W42EP-D	CP	LD	42	0.5	40.872806	-84.588000	122.72
89	W49EM-D	CP	LD	49	0.5	40.872806	-84.588000	122.72
90	W23BZ-D	LIC	LD	23	15.0	39.891944	-83.045556	122.77
91	W27DG-D	LIC	LD	27	2.0	40.587972	-81.487556	125.30
92	W29EG-D	CP	LD	29	15.0	39.952278	-82.506806	125.35
93	WRLM	LIC	DT	47	1000.0	41.109306	-81.336083	126.22
94	W32DS-D	LIC	LD	32	6.8	40.552917	-84.517250	127.48
95	WLWD-LD	LIC	TX	20	8.7	39.962222	-83.863611	132.80
96	WLPC-CD	LIC	DC	40	2.34	42.331944	-83.045000	133.33
97	-	CP	LD	4	0.005	42.340278	-83.045278	134.26
98	WIVD-LD	LIC	LD	22	6.0	40.358833	-81.500417	137.16
99	WIVN-LD	LIC	LD	29	7.4	40.358833	-81.500417	137.16
100	WIVN-LD	CP	LD	29	15.0	40.358833	-81.500417	137.16
101	W32ED-D	CP MOD	LD	32	15.0	40.352194	-81.474056	139.42
102	W32ED-D	CP MOD	LD	32	6.0	40.352194	-81.474056	139.42
103	W48DY-D	CP MOD	LD	48	10.0	40.352194	-81.474056	139.42
104	W27DG-D	CP	LD	27	2.0	40.898611	-81.210000	138.08
105	WIVM-LD	LIC	LD	39	15.0	40.898611	-81.210000	138.08
106	W33BY-D	LIC	DC	33	4.0	42.408083	-83.091583	142.11
107	WOOH-LP	LIC	TX	16	22.7	39.948611	-81.963056	143.91
108	WOOH-LP	CP	LD	16	15.0	39.948611	-81.963056	143.91
109	WFHD-LP	LIC	TX	27	1.5	42.278056	-83.742222	144.33

ID	Call Sign	Status	Service ⁶	Channel	Transmit ERP ⁷ (kW)	Latitude (NAD 83)	Longitude (NAD 83)	Distance to Nearest Turbine (km)
110	WHIZ-TV	CP	DT	30	500.0	39.928333	-81.985000	144.91
111	WHIZ-TV	LIC	DT	40	620.0	39.928333	-81.985000	144.91
112	-	CP	LD	26	0.1	42.066944	-84.240833	146.22
113	-	CP	LD	26	0.1	42.066944	-84.240833	146.22
114	WINM	LIC	DT	12	16.5	41.454167	-84.802778	146.34
115	WUDL-LD	LIC	LD	19	11.6	42.447917	-83.173083	147.34
116	WHNE-LD	LIC	LD	20	15.0	42.447917	-83.173083	147.34
117	WUDT-LD	LIC	LD	23	15.0	42.447917	-83.173083	147.34
118	WHNE-LD	CP	LD	20	15.0	42.448056	-83.173056	147.35
119	WMYD	LIC	DT	21	500.0	42.448056	-83.173056	147.35
120	WUDT-LD	CP	LD	23	15.0	42.448056	-83.173056	147.35
121	WTVS	LIC	DT	43	600.0	42.448056	-83.173056	147.35
122	WWJ-TV	LIC	DT	44	425.0	42.448056	-83.173056	147.35
123	WJBK	LIC	DX	7	15.0	42.460556	-83.213889	149.25
124	WJBK	LIC	DT	7	27.2	42.460556	-83.213889	149.25

Table A: Off-Air TV Stations within 150 Kilometers of Project Area (United States)

ID	Call Sign	Status	Class ⁸	Channel	Transmit ERP (kW)	Latitude (NAD 83)	Longitude (NAD 83)	Distance to Nearest Turbine (km)
1	CFTV-DT	OP	LP	34	1	42.074444	-82.631389	106.98
2	CFTV-DT	TO	LP	34	0.545	42.094444	-82.729722	107.66
3	CIII-DT-22	OP	R	22	49	42.061389	-82.484722	108.98
4	CICO-DT-32	OP	R	32	19	42.153333	-82.953056	113.11
5	CBET-DT	OP	R	9	26	42.153333	-82.953056	113.11
6	CHWI-DT	OP	R	16	3.4	42.141667	-82.446667	118.43
7	CHWI-DT-60	OP	R	26	0.2	42.316111	-83.040000	131.55

Table A-2: Off-Air TV Stations within 150 Kilometers of Project Area (Canada)

⁸ Definitions of class and status codes:
R – Regular VHF Television Broadcast Station
LP – Low-power Television Broadcast Station
OP – Licensed and operational station
TO – Temporary operation

Appendix K-2: AM and FM Radio Report

Wind Power GeoPlanner™

AM and FM Radio Report

Seneca Wind Project



Prepared on Behalf of
Seneca Wind LLC
(Seneca Wind)

June 27, 2018





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1. Introduction

Comsearch analyzed AM and FM radio broadcast stations whose service could potentially be affected by the proposed Seneca Wind Project in Seneca County, Ohio.

2. Summary of Results

AM Radio Analysis

Comsearch found six database records¹ for AM stations within approximately 30 kilometers of the project, as shown in Table 1 and Figure 1. These records represent station WTTF, which broadcasts out of Tiffin, Ohio, to the west of the project area; station WFOB, out of Fostoria, Ohio, also to the west; station WLKR, out of Norwalk, Ohio, to the northeast; and station WBCO, out of Bucyrus, Ohio, to the south. Stations WTTF and WFOB are licensed separately for daytime and nighttime operations.

ID	Call Sign	Status ²	Frequency (kHz)	Transmit ERP ³ (kW)	Operation Time	Latitude (NAD 27)	Longitude (NAD 27)	Required Separation Distance ⁴ (km)	Distance to Nearest Turbine (km)
1	WTTF	LIC	1600	0.5	Daytime	41.125556	-83.231944	1.88	12.04
2	WTTF	LIC	1600	0.019	Nighttime	41.125556	-83.231944	1.88	12.04
3	WFOB	LIC	1430	1.0	Daytime	41.101667	-83.399722	2.10	22.43
4	WFOB	LIC	1430	1.0	Nighttime	41.101667	-83.399722	2.10	22.43
5	WLKR	LIC	1510	0.5	Daytime	41.279167	-82.656389	1.99	26.59
6	WBCO	LIC	1540	0.5	Daytime	40.764167	-82.934722	1.95	28.14

Table 1: AM Radio Stations within 30 Kilometers of Project Area

¹ Comsearch makes no warranty as to the accuracy of the data included in this report beyond the date of the report. The data presented in this report is derived from the AM/FM station's FCC license and governed by Comsearch's data license notification and agreement located at http://www.comsearch.com/files/data_license.pdf. The coordinates provided for AM station KVWC were adjusted slightly based on aerial imagery.

² LIC = Licensed and operational station; APP = Application for construction permit; CP=Construction permit granted; CP MOD = Modification of construction permit.

³ ERP = Transmit Effective Radiated Power.

⁴ The required separation distance is based on the lesser of 10 wavelengths or 3 kilometers for directional antennas and 1 wavelength for non-directional antennas.

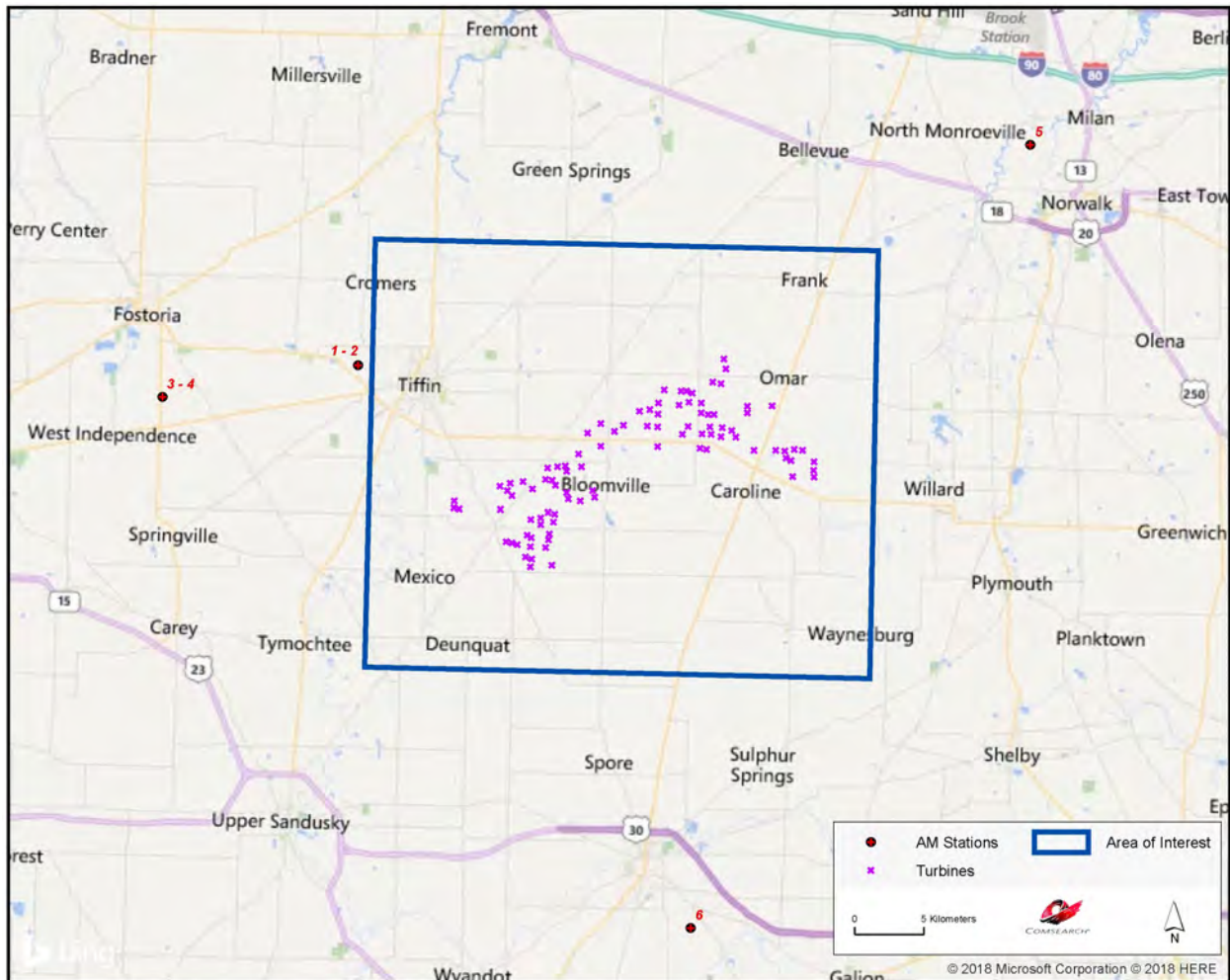


Figure 1: AM Radio Stations within 30 Kilometers of Project Area

FM Radio Analysis

Comsearch determined that there were twenty-seven database records for FM stations within 30 kilometers of the Seneca Wind Project, as shown in Table 2 and Figure 2. Only twenty-four of these stations are currently licensed and operating, seven of which are low-power or translator stations that broadcast with limited range.

ID	Call Sign	Status ⁵	Service ⁶	Frequency (MHz)	Transmit ERP ⁷ (kW)	Latitude (NAD 27)	Longitude (NAD 27)	Distance to Nearest Turbine (km)
1	WYOR	LIC	FM	88.5	0.1	41.108889	-83.003056	1.56
2	WSJG-LP	LIC	FL	103.3	0.1	41.108306	-83.175444	8.10
3	W227BJ	LIC	FX	93.3	0.25	41.112944	-83.180611	8.73
4	WHEI	LIC	FM	88.9	0.1	41.116389	-83.167500	8.80
5	WXMW	LIC	FM	89.3	0.39	40.914722	-83.125556	9.96
6	WXML	LIC	FM	90.1	15.0	40.914722	-83.125556	9.96
7	W218BL	LIC	FX	91.5	0.055	41.035278	-82.708889	11.10
8	WYOR	CP	FM	88.5	20.0	41.248778	-82.912833	12.61
9	WMJK	LIC	FM	100.9	3.0	41.249167	-82.913056	12.66
10	WSHB	LIC	FM	90.9	0.45	41.048028	-82.681278	13.15
11	WOHF	LIC	FM	92.1	5.8	41.238611	-82.837778	13.26
12	WCKY-FM	LIC	FM	103.7	50.0	41.138889	-83.245833	13.92
13	WHVT	LIC	FM	90.5	2.7	41.295833	-82.973889	18.47
14	WSWR	LIC	FM	100.1	3.0	40.945000	-82.661667	19.49
15	WLRD	LIC	FM	96.9	6.0	40.960000	-82.621111	21.27
16	WXML	LIC	FS	90.1	6.0	40.836111	-83.236389	22.26
17	WLBj-LP	LIC	FL	104.1	0.075	41.180500	-83.339750	22.64
18	W289CP	CP	FX	105.7	0.25	41.157778	-83.413611	26.07
19	WLKR-FM	LIC	FM	95.3	3.3	41.280278	-82.657500	26.62
20	NEW	APP	FX	92.9	0.25	41.280278	-82.657222	26.63
21	W270CL	LIC	FX	101.9	0.055	41.153611	-83.426389	26.78
22	WHRQ	LIC	FM	88.1	0.38	41.377167	-82.814528	28.20
23	WQEL	LIC	FM	92.7	3.0	40.763611	-82.933333	28.24
24	W298CC	LIC	FX	107.5	0.25	40.763611	-82.933333	28.24
25	WBVI	LIC	FM	96.7	3.0	41.100000	-83.475556	28.52
26	W206BX	LIC	FX	89.1	0.055	41.366111	-83.088889	29.42
27	WFRO-FM	LIC	FM	99.1	11.5	41.366111	-83.088889	29.42

Table 2: FM Radio Stations within 30 Kilometers of Project Area

⁵ LIC = Licensed and operational station; APP = Application for construction permit; CP=Construction permit granted; CP MOD = Modification of construction permit.

⁶ FM = FM broadcast station; FX = FM translator station; FL = Low-power FM station; FS = FM auxiliary (backup) station; FB = FM booster station.

⁷ ERP = Transmit Effective Radiated Power.

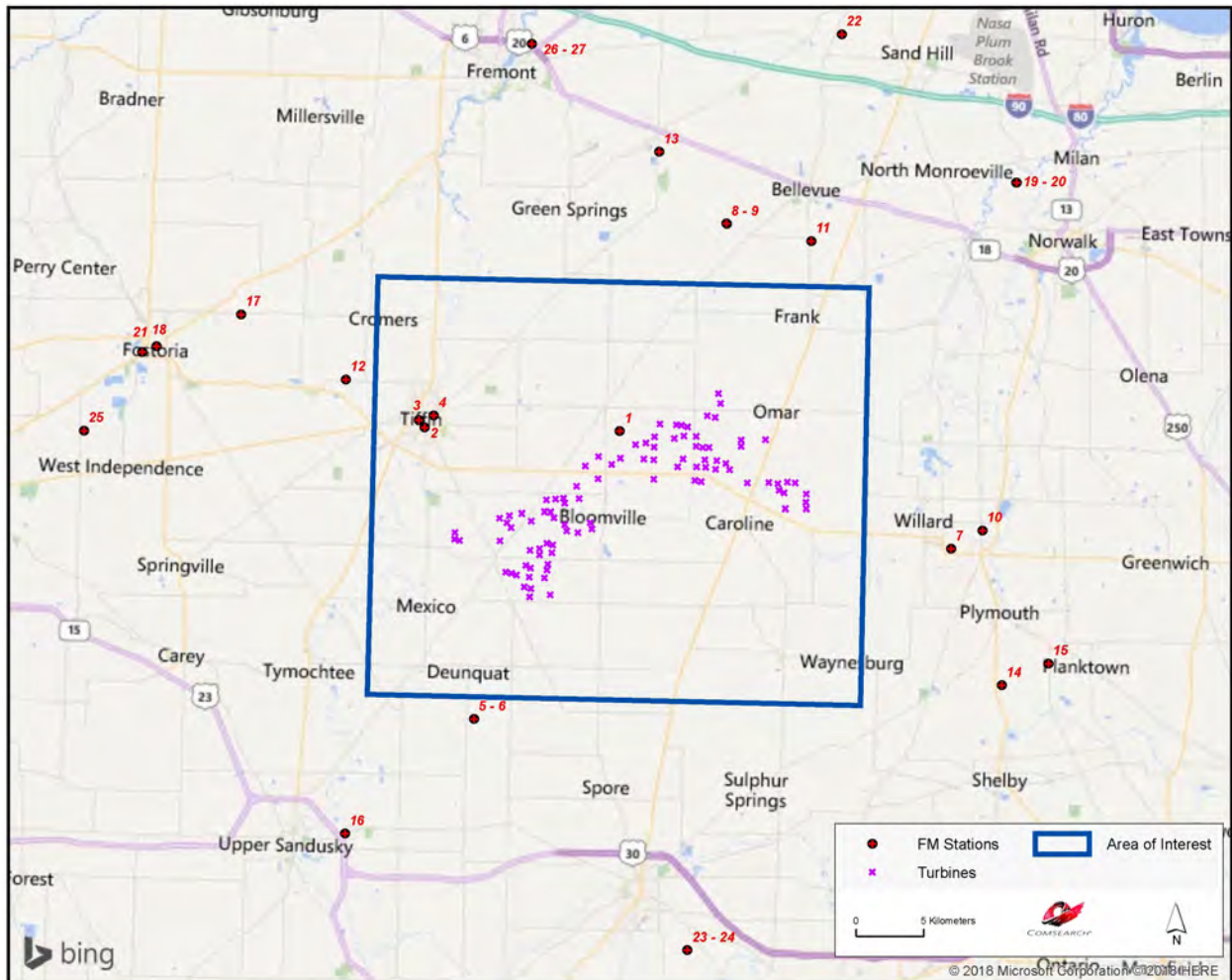


Figure 2: FM Radio Stations within 30 Kilometers of Project Area

3. Impact Assessment

The exclusion distance for AM broadcast stations varies as a function of the antenna type and broadcast frequency. For directional antennas, the exclusion distance is calculated by taking the lesser of 10 wavelengths or 3 kilometers. For non-directional antennas, the exclusion distance is simply equal to 1 wavelength. Potential problems with AM broadcast coverage are only anticipated when AM broadcast stations are located within their respective exclusion distance limit from wind turbine towers. The closest operational AM station to the Seneca Wind Project, WTTF, is more than 12.0 kilometers from the nearest turbine. As there were no stations found within 3 kilometers of project, which is the maximum possible exclusion distance based on a directional AM antenna broadcasting at 1000 KHz or less, the project should not impact the coverage of local AM stations.

The coverage of FM stations is generally not susceptible to interference caused by wind turbines, especially when large objects, such as wind turbines, are sited in the *far field* region of the radiating FM antenna, which avoids the risk of distorting the antenna's radiation pattern. However, at distances less than 450 meters, radiation pattern distortion can become a factor. Signal attenuation is also possible, but is difficult to quantify without precise field measurements. The closest FM station to the Seneca Wind Project, WYOR, is more than 1.5 kilometers from the nearest turbine. At this distance, there should be adequate separation to avoid radiation pattern distortion.

4. Recommendations

Since no impact on the licensed and operational AM or FM broadcast stations' broadcast, retransmission, or reception was identified in our analysis, no recommendations or mitigation techniques are required for this project.

5. Contact

For questions or information regarding the AM and FM Radio Report, please contact:

Contact person:	David Meyer
Title:	Senior Manager
Company:	Comsearch
Address:	19700 Janelia Farm Blvd., Ashburn, VA 20147
Telephone:	703-726-5656
Fax:	703-726-5595
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Web site:	www.comsearch.com

Appendix K-3: Microwave Study

Wind Power GeoPlanner™

Microwave Study

Seneca Wind Project



Prepared on Behalf of
Seneca Wind LLC
(Seneca Wind)

June 27, 2018



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1. Introduction

Microwave bands that may be affected by the installation of wind turbine facilities operate over a wide frequency range (900 MHz – 23 GHz). Comsearch has developed and maintains comprehensive technical databases containing information on licensed microwave networks throughout the United States. These systems are the telecommunication backbone of the country, providing long-distance and local telephone service, backhaul for cellular and personal communication service, data interconnects for mainframe computers and the Internet, network controls for utilities and railroads, and various video services. This report focuses on the potential impact of wind turbines on licensed, proposed and applied non-federal government microwave systems.

2. Project Overview

Project Information

Name: Seneca Wind Project

County: Seneca

State: Ohio

Number of Turbines: 94

Blade Diameter: 116 or 127 meters

Hub Height: 80 - 134 meters

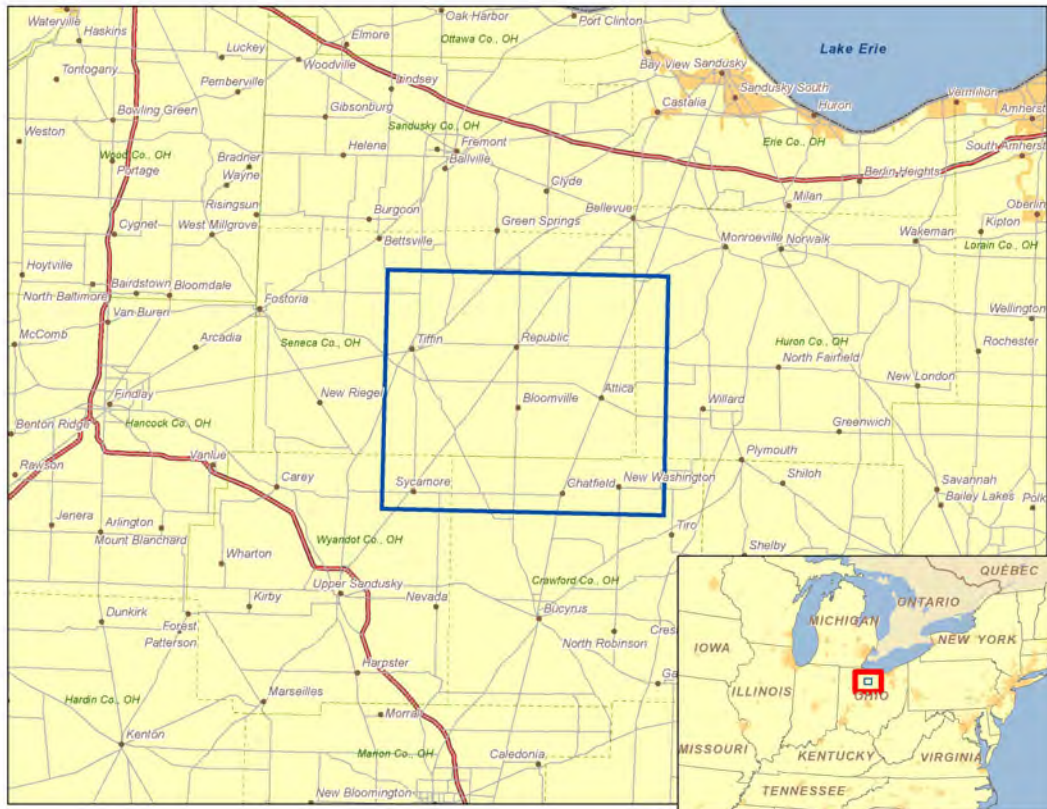


Figure 1: Area of Interest

3. Two-Dimensional Fresnel Zone Analysis

Methodology

Our obstruction analysis was performed using Comsearch's proprietary microwave database, which contains all non-government licensed, proposed and applied paths from 0.9 - 23 GHz¹. First, we determined all microwave paths that intersect the area of interest² and listed them in Table 1. These paths and the area of interest that encompasses the planned turbine locations are shown in Figure 2.

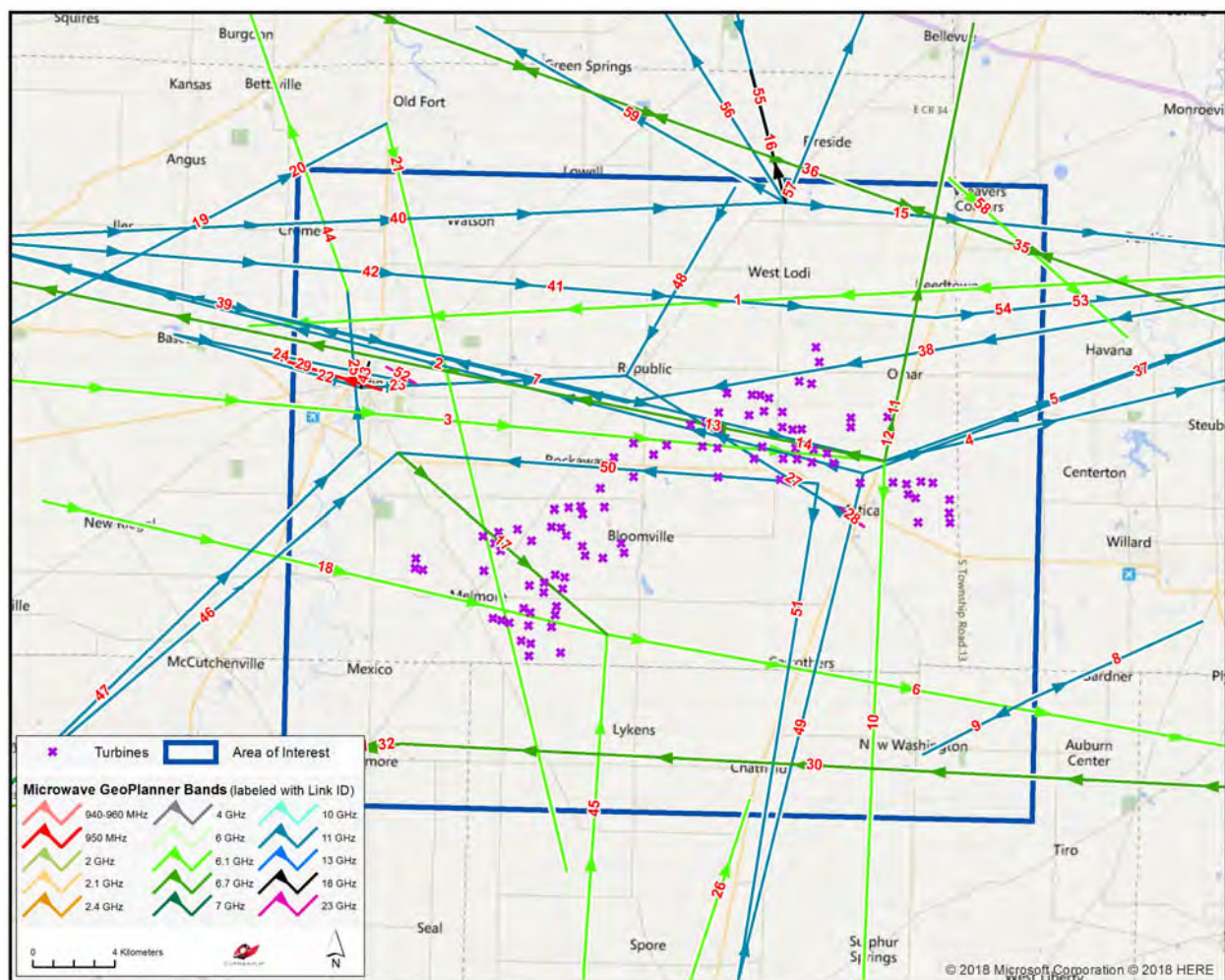


Figure 2: Microwave Paths that Intersect the Area of Interest

¹ Please note that this analysis does not include unlicensed microwave paths or federal government paths that are not registered with the FCC.

² We use FCC-licensed coordinates to determine which paths intersect the area of interest. It is possible that as-built coordinates may differ slightly from those on the FCC license.

ID	Status	Callsign 1	Callsign 2	Band	Path Length (km)	Licensee
1	Proposed	ASR12344	ASR12014	Lower 6 GHz	57.40	Wireless Internetwork LLC
2	Proposed	ASR12516	WQQX871	11 GHz	46.18	Wireless Internetwork LLC
3	Proposed	CCI87204	GTPOH-53	Lower 6 GHz	86.79	Wireless Internetwork LLC
4	Proposed	GTPOH-53	OH96253-	11 GHz	42.17	Wireless Internetwork LLC
5	Proposed	GTPOH-53	WQQX778	11 GHz	28.05	Wireless Internetwork LLC
6	Licensed	KLZ74	KLZ73	Lower 6 GHz	47.22	American Electric Power Service Corp
7	Proposed	REPUBLIC	WQQX871	11 GHz	34.17	Wireless Internetwork LLC
8	Applied	SITEC	SITEB	11 GHz	9.20	Local TV & Electronics, Inc.
9	Applied	SITEC	SITED	11 GHz	5.88	Local TV & Electronics, Inc.
10	Licensed	WAA857	WAA856	Lower 6 GHz	41.10	Norfolk Southern Railway
11	Licensed	WAA857	WAA858	Lower 6 GHz	21.79	Norfolk Southern Railway
12	Licensed	WAA857	WAA858	Upper 6 GHz	21.79	Norfolk Southern Railway
13	Licensed	WAA857	WBB737	Lower 6 GHz	44.30	Norfolk Southern Railway
14	Licensed	WAA857	WBB737	Upper 6 GHz	44.30	Norfolk Southern Railway
15	Proposed	WESTLODI	WQQX778	11 GHz	31.36	Wireless Internetwork LLC
16	Applied	WESTLODI	WRBM897	18 GHz	6.68	Amplex Electric, Inc.
17	Applied	WNEH648	KLZ74	Upper 6 GHz	13.49	American Electric Power Service Corp
18	Licensed	WPQT266	KLZ74	Lower 6 GHz	28.25	American Electric Power Service Corp
19	Licensed	WQCE739	WPUG349	Lower 6 GHz	33.77	W.A.T.C.H. TV Company Inc.
20	Licensed	WQCE739	WPUG349	11 GHz	33.77	W.A.T.C.H. TV Company Inc.
21	Licensed	WQFN956	WQFN957	Lower 6 GHz	37.46	W.A.T.C.H. TV Company Inc.
22	Licensed	WQKL533	WQKL534	11 GHz	9.44	Bascom Long Distance, Inc.
23	Licensed	WQKL533	WQKL535	11 GHz	12.92	Bascom Long Distance, Inc.
24	Licensed	WQKL534	WQUG969	11 GHz	12.00	Bascom Long Distance, Inc.
25	Licensed	WQNB994	WQNB993	11 GHz	7.54	Cellco Partnership - Ohio
26	Licensed	WQND701	WQND702	Lower 6 GHz	11.81	Cellco Partnership - Ohio
27	Licensed	WQNK803	WQKL535	11 GHz	13.73	Bascom Long Distance, Inc.
28	Licensed	WQNK803	WQXG305	23 GHz	1.47	Bascom Long Distance, Inc.
29	Licensed	WQOA205	RXONLY	950 MHz	5.53	Tiffin Broadcasting II, LLC
30	Licensed	WQOV445	WQPC366	Upper 6 GHz	41.09	World Class Wireless, LLC
31	Questionable	WQPC366	WQPG891	Lower 6 GHz	37.72	World Class Wireless, LLC
32	Questionable	WQPC366	WQPG891	Upper 6 GHz	37.72	World Class Wireless, LLC
33	Licensed	WQPC366	WQPJ638	Upper 6 GHz	40.15	World Class Wireless, LLC
34	Licensed	WQPC366	WQPJ638	Upper 6 GHz	40.15	World Class Wireless, LLC
35	Licensed	WQPH316	WQPH317	Upper 6 GHz	56.99	High Voltage Communications LLC (CFN)
36	Licensed	WQPH317	WQPH316	Upper 6 GHz	56.99	High Voltage Communications LLC (CFN)
37	Proposed	WQQX778	ASR12516	11 GHz	29.23	Wireless Internetwork LLC
38	Proposed	WQQX778	REPUBLIC	11 GHz	39.48	Wireless Internetwork LLC
39	Proposed	WQQX871	GTPOH-53	11 GHz	47.04	Wireless Internetwork LLC
40	Proposed	WQQX871	WESTLODI	11 GHz	40.97	Wireless Internetwork LLC
41	Licensed	WQQX871	WQXU839	11 GHz	48.42	Wireless Internetwork LLC
42	Applied	WQQX871	WQXU839	11 GHz	48.42	Wireless Internetwork LLC

ID	Status	Callsign 1	Callsign 2	Band	Path Length (km)	Licensee
43	Licensed	WQRW273	WQKL533	18 GHz	1.30	Bascom Long Distance, Inc.
44	Licensed	WQUA689	WML417	Lower 6 GHz	16.91	New Cingular Wireless PCS LLC - Ohio
45	Licensed	WQUA864	KLZ74	Lower 6 GHz	19.48	American Electric Power Service Corp
46	Licensed	WQUT733	WQVY405	11 GHz	25.18	Agile Network Builders LLC
47	Licensed	WQUT733	WQXM552	11 GHz	24.09	Agile Network Builders LLC
48	Licensed	WQVS476	WQKL535	11 GHz	10.61	Bascom Long Distance, Inc.
49	Licensed	WQVY409	WQXE708	11 GHz	25.44	Agile Network Builders LLC
50	Licensed	WQVY412	WQVY405	11 GHz	20.54	Agile Network Builders LLC
51	Licensed	WQVY412	WQVY409	11 GHz	24.54	Agile Network Builders LLC
52	Licensed	WQWB993	WQUG969	23 GHz	1.65	Bascom Long Distance, Inc.
53	Licensed	WQXU839	WQXX778	11 GHz	24.00	Wireless Internetwork LLC
54	Applied	WQXU839	WQXX778	11 GHz	24.00	Wireless Internetwork LLC
55	Licensed	WQYB310	WQYD931	11 GHz	10.43	Blhc, LLC
56	Licensed	WQYD931	WQUY965	11 GHz	17.56	Blhc, LLC
57	Licensed	WQYD931	WQYC633	11 GHz	11.19	Blhc, LLC
58	Licensed	WQYT575	WQYT658	Lower 6 GHz	11.66	Verizon Wireless (VAW) LLC - Ohio
59	Licensed	WRBT653	WQXH607	11 GHz	17.32	Sprintcom, Inc

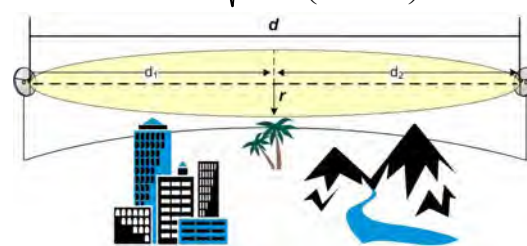
Table 1: Summary of Microwave Paths that Intersect the Area of Interest

(See enclosed mw_geopl.xlsx for more information and
GP_dict_matrix_description.xls for detailed field descriptions)

Verification of Coordinate Accuracy

It is possible that as-built coordinates may differ from those on the FCC license. For this project, 16 paths (IDs 2-3, 10-14, 17-18, 21, 27, 37 – 39, 49 – 50) cross within close proximity of the proposed turbines and the tower locations for these paths will have a critical impact on the result. Therefore, we verified these locations using aerial photography. Some of the towers were found to be slightly off and were moved to their locations based on the aerial photos³.

Next, we calculated a Fresnel Zone for each path based on the following formula:

$$r \cong 17.3 \sqrt{\frac{n}{F_{GHz}} \left(\frac{d_1 d_2}{d_1 + d_2} \right)}$$


³ See enclosed mw_geopl.shp and mw_geopl_fcc.shp for details.

Where,

- r = Fresnel Zone radius at a specific point in the microwave path, meters
- n = Fresnel Zone number, 1
- F_{GHz} = Frequency of microwave system, GHz
- d₁ = Distance from antenna 1 to a specific point in the microwave path, kilometers
- d₂ = Distance from antenna 2 to a specific point in the microwave path, kilometers

In general, this is the area where the planned wind turbines should be avoided, if possible. A depiction of the Fresnel Zones for each microwave path listed can be found in Figure 3, and is also included in the enclosed shapefiles^{4,5}.

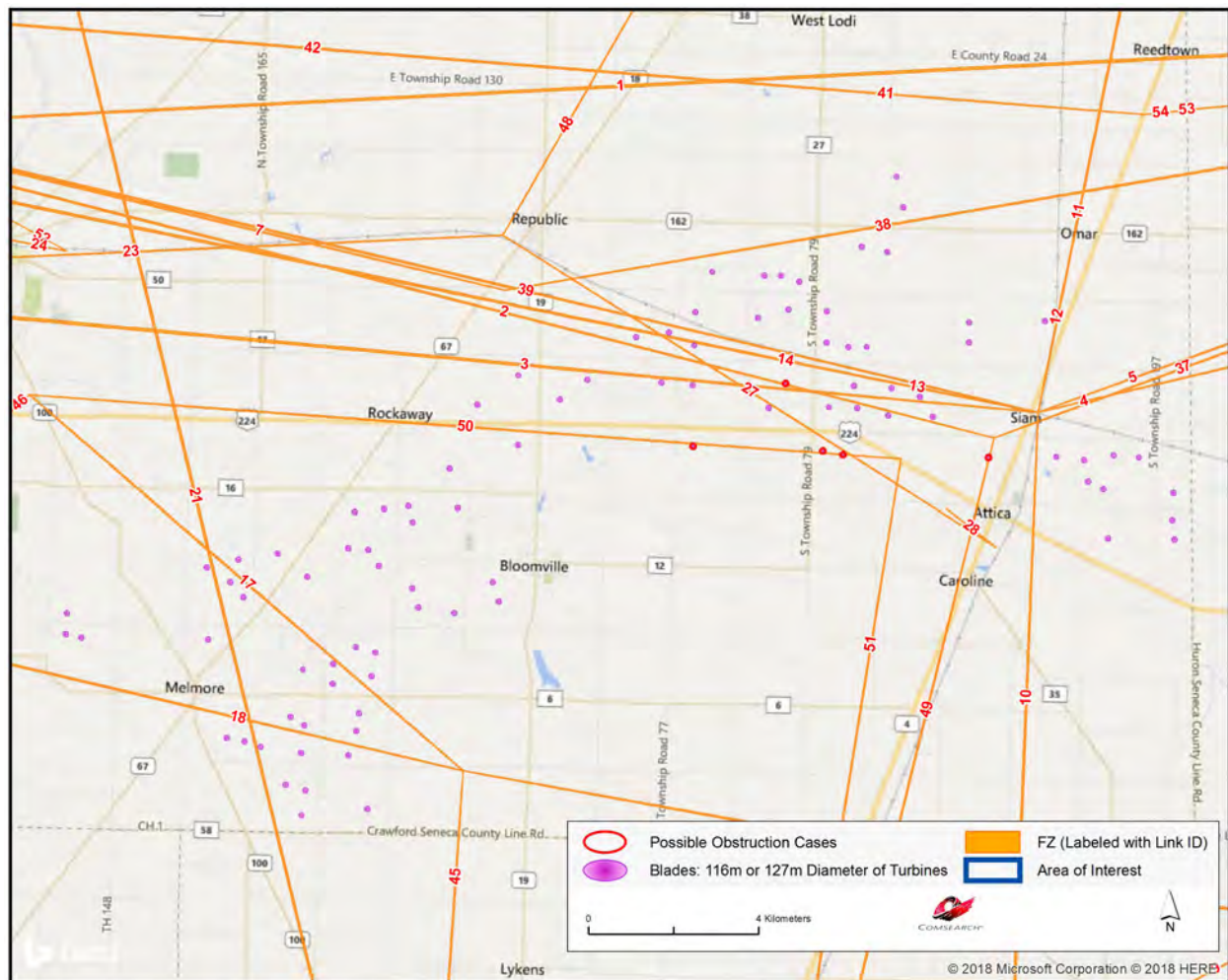


Figure 3: Fresnel Zones in the Area of Interest

⁴ The ESRI® shapefiles enclosed are in NAD 83 UTM Zone 17 projected coordinate system.

⁵ Comsearch makes no warranty as to the accuracy of the data included in this report beyond the date of the report. The data provided in this report is governed by Comsearch's data license notification and agreement located at http://www.comsearch.com/files/data_license.pdf.

Discussion of Potential Two Dimensional Obstructions

Total Microwave Paths	Paths with Affected Fresnel Zones	Total Turbines	Turbines intersecting the Fresnel Zones
59	3	94	5

Table 2: Fresnel Zone Analysis Result

For this project, 94 turbines were considered in the analysis, each with a blade diameter of 116 or 127 meters and turbine hub height of 80 - 134 meters. Of those turbines, five were found to intersect the Fresnel Zones of three microwave paths. Figure 4 contains a detailed depiction of the potential obstruction scenarios and Table 3 contains a summary of the affected turbines. A cross sectional analysis was performed in Section 4 to determine the diagonal clearance value for these cases.

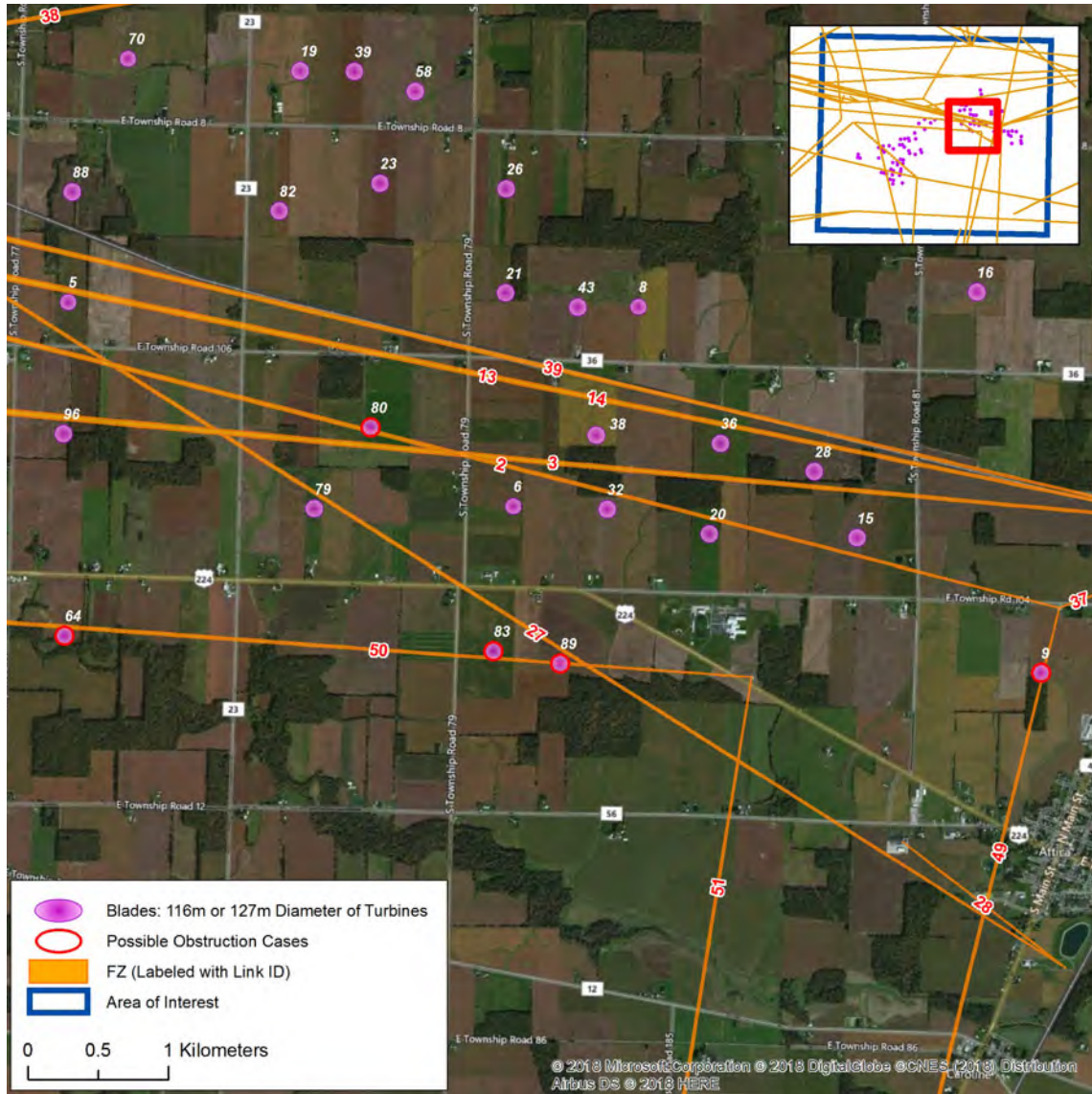


Figure 4: Potential Obstruction Cases

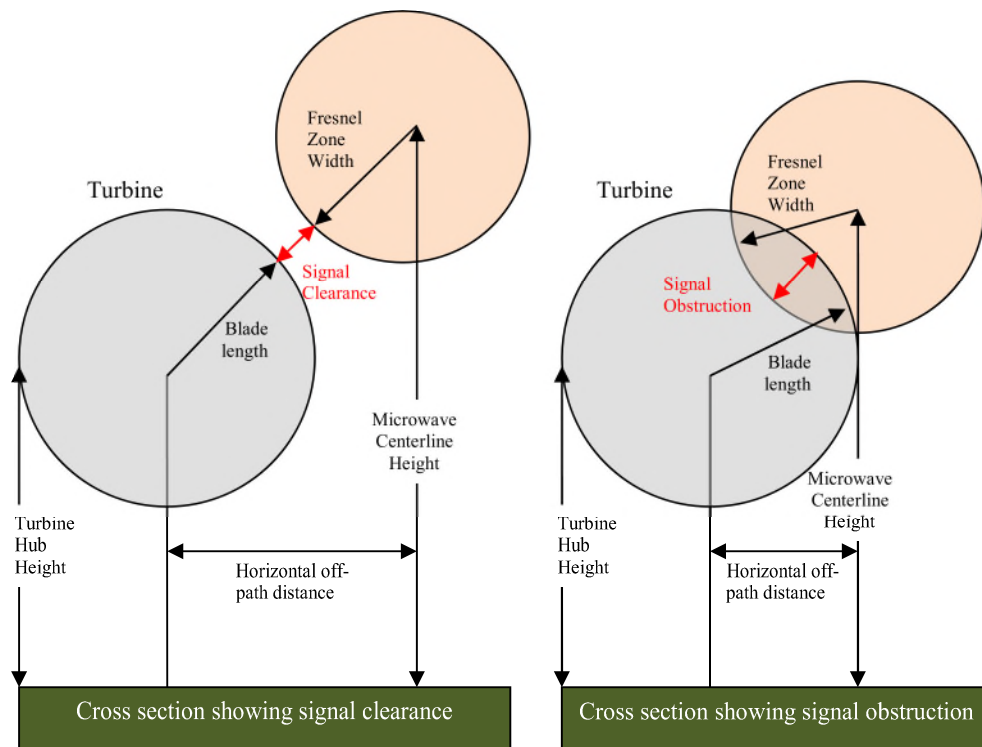
Turbine ID	Latitude (NAD83)	Longitude (NAD83)	Affected Microwave Path ID	Fresnel Zone Width at Turbine Location (m)	Horizontal off-path Distance (m)	Distance along the path from site 1 (km)	Horizontal Clearance (m)
9	41.07626486	-82.88926840	49	3.49	14.06	24.98	-52.93
64	41.07725700	-82.97198800	50	9.98	64.25	4.90	-9.23
80	41.09101575	-82.94648211	2	10.98	24.88	5.06	-49.59
83	41.07687785	-82.93566315	50	6.70	49.24	1.84	-20.96
89	41.07618431	-82.92999272	50	5.83	3.28	1.36	-66.05

Table 3: Turbines that Intersect Fresnel Zones

4. Cross Sectional Analysis

Our Fresnel Zone analysis in the previous section identified five potential obstruction cases that need to be further examined from a cross sectional perspective. The cases that will be analyzed in this section can be found in Table 3.

Our cross sectional analysis calculates the precise height and width of 100% of the first Fresnel Zone at the turbine location based on the antenna heights of the two link endpoints and the earth curvature bulge at the specific turbine location. The horizontal off-path distance was calculated in the previous section and the turbine hub height and blade length were provided by the client. The cross sectional analysis uses these values to calculate the clearance between the blades and the microwave Fresnel Zone as shown in the two diagrams below.



The results of the cross sectional calculations can be seen in Table 4 below. It shows negative clearance values indicating obstruction of the Fresnel zones and positive clearance values indicating clearance of the Fresnel zones.

Microwave Path ID	Fresnel Zone Width at Turbine Location (m)	Microwave Centerline Height at Turbine Location (m)	Turbine ID	Hub Height (m)	Blade Length (m)	Cross Sectional Clearance (m)
49	3.49	64.07	9	134	63.5	4.34
50	9.98	65.48	64	134	63.5	20.45
2	10.98	80.76	80	134	63.5	-15.70
50	6.70	67.16	83	134	63.5	12.82
50	5.83	68.40	89	134	63.5	-3.65

Table 4: Cross Sectional Analysis Results

5. Conclusion

Our study identified 59 microwave paths intersecting the Seneca Wind Project area. The Fresnel Zones for these microwave paths were calculated and mapped. A total of 94 turbines were found to intersect the two dimensional Fresnel Zones of three microwave paths. Based on the cross sectional analysis, it was determined that two turbines (IDs 80 and 89) may obstruct two microwave paths (IDs 2 and 50) respectively and potentially cause signal degradation.

6. Contact

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Case No(s). 18-0488-EL-BGN

Summary: Application Appendices J and K electronically filed by Teresa Orahod on behalf of Dylan F. Borchers