

APPENDIX D

Electromagnetic Interference Analysis

Walleye Wind, MN Electromagnetic Interference Analysis

The following document was prepared by NextEra Analytics, an indirect wholly-owned subsidiary of NextEra Energy Resources, LLC (NEER) for the use of Walleye Wind, LLC, as an indirect wholly-owned subsidiary of NEER. NextEra Analytics has prepared this report based on available government information by the Federal Communications Commission (FCC) and internal analysis methods. We cannot guarantee the accuracy of the data collected by the FCC. Microwave tower and link information may be inaccurate or incomplete due to FCC applicant error.

Executive Summary

NextEra Analytics, an affiliate of Walleye Wind LLC (Walleye) assessed the potential for interference of licensed communication links in close proximity to the proposed Walleye Wind project area for the purposes of determining exclusion zones to aid the design of a proposed wind energy generation project. This report summarizes the microwave links and towers along with local cellular towers, media towers (AM and FM), television, and aviation towers, identified within and near the assessment area.

A review of the Federal Communications Commission (FCC) national database and the Universal Licensing System was conducted to identify these possible constraints. Wind turbine offset distances were taken in consideration for the design of the wind turbine array.

Electromagnetic analysis results show that interference is not expected to impact nearby microwave, AM, FM, cellular, TV, and aviation towers based on the array design.

The analysis is current as of January 23, 2020. NextEra Analytics recommends a refresh of this analysis if the proposed wind energy generation project has not been constructed after two years.

This report only provides analysis for licensed radio towers and links found within the FCC database. Many local municipalities (police, fire, etc.) do not license microwave links, NextEra Analytics recommends that Walleye Wind LLC coordinate with the appropriate local municipality officials. Also not included within the database are microwave towers and links utilized by the Federal government (Dept. of Defense, Dept. of Commerce, etc.), again for public safety concerns. A letter stating “No Harmful Interference Anticipated (NHIA)” has been received from the National Telecommunications and Information Agency (NTIA).

Walleye Wind, MN – Electromagnetic Interference

NextEra Analytics, an affiliate of Walleye Wind LLC (Walleye), assessed the potential for interference of licensed communication links in close proximity to the proposed Walleye Wind Project area for the purposes of determining exclusion zones to aid the design of a proposed wind energy generation project. This report summarizes the microwave links and towers along with local cellular towers, media towers (AM and FM), television, and aviation towers, identified within and near the assessment area.

A review of the FCC national database and the Universal Licensing System was conducted to identify these possible constraints. Wind turbine offset distances were taken into consideration for the design of the wind turbine array.

The site is located in Rock County, Minnesota, bordering South Dakota and roughly 10 kilometers north of Iowa. Figure 1 below, depicts the project location of Walleye Wind.

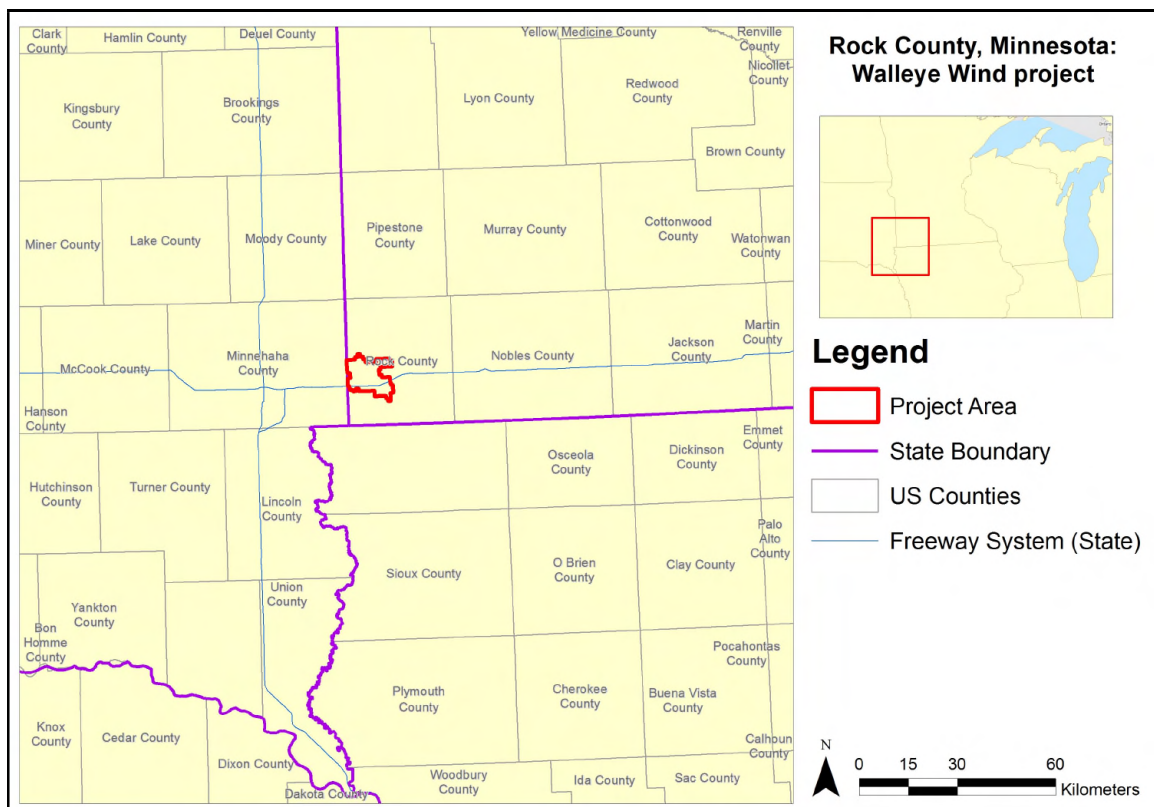


Figure 1: Walleye Wind Project Location

Turbine Technology

Walleye Wind is a proposed wind energy generation site that consists of 51 turbine locations. The layout is composed of 42 (36 primary and 6 alternate) GE2.82-127-114 turbines (2.82MW rated capacity, 127m rotor diameter (RD), 114m hub height (HH)); 5 alternate GE2.82-127-89 turbines (2.82MW rated capacity, 127m RD, 89m HH); and 4 primary GE2.32-116-80 turbines (2.32MW rated capacity, 116m RD, 80m HH) for a total capacity of 110.8MW. Turbine layout details are included in Table 1 and Figure 2.

Turbine Technology	GE2.82-127-114, GE2.82-127-89, GE2.32-116-80
Primary Turbine Count	36, 0, 4
Hub Height (m)	114, 89, 80
Rotor Diameter (m)	127, 127, 116
Turbine Rated Power (MW)	2.82, 2.82, 2.32
Total Capacity (MW)	110.8

Table 1: Walleye Wind Layout Summary

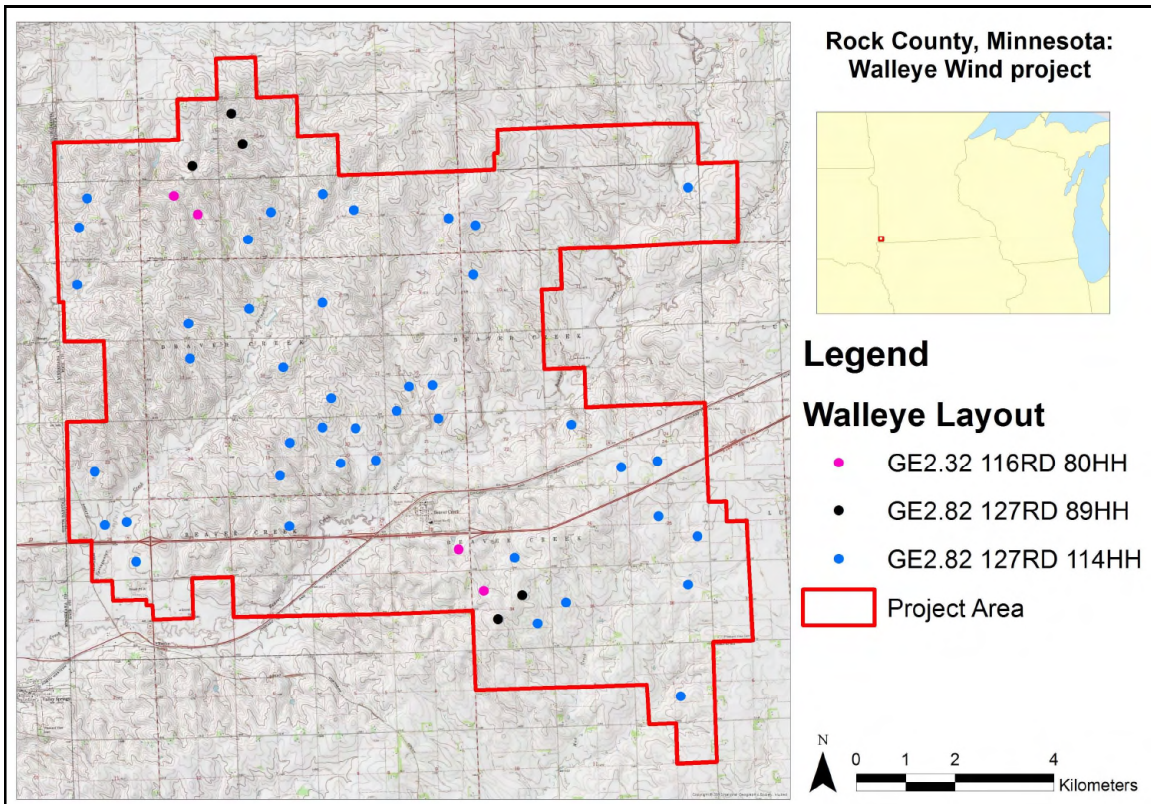


Figure 2: Walleye Wind Turbine Technology Allocation

Data Sources

Within the United States, the location of industrial and commercial telecommunication systems, including microwave links, are collected and maintained by the Wireless Telecommunications Bureau (WTB), a division of the FCC. This data is made publicly available through the ULS database, which contains licensing information on both current and permit pending facilities for microwave, cellular, media, and several radio services utilized by private industry (non-Federal telecommunication systems). License information supplied within the ULS database is updated daily, and is dependent upon information provided by each individual applicant.

NextEra Analytics used several data sources (ESRI satellite imagery, Google Earth, etc.) of high resolution imagery to aid in assessing the accuracy of the geographic locations of each microwave tower with links intersecting the project boundary or area of interest (AOI).

Methodology

The ULS database, described earlier, was used to identify the microwave towers, microwave links, cellular, AM, FM, and aviation towers within a 25-kilometer radius that may impact the Walleye Wind Farm. Television towers were identified within a 100-kilometer radius. The database provides detailed information for each radio tower and link, which was used to calculate turbine exclusion zones to ensure interference compliance.

Exclusion zones for wind turbines near microwave links are calculated using a theory proposed by Bacon (2002), which identifies the radius of the 2nd Fresnel zone, a theoretical sphere representative of a propagating radio wave, as an appropriate offset distance. Calculations of the 2nd Fresnel zone can be determined by:

$$2nd \text{ Fresnel zone Radius} = \sqrt{\frac{2\lambda d_1 d_2}{d_1 + d_2}} \quad (1)$$

Where:

d_1, d_2 = distances from each end of the radio path.

λ = wavelength of the corresponding radio frequency.

To account for precision errors within the ULS database, and to further reduce the potential for interference from a wind turbine, a Worst Case Fresnel Zone (WCFZ) was calculated for each microwave link. The WCFZ provides the maximum offset distance required, and is determined by the 2nd Fresnel zone

radius obtained at the midpoint of the link, where $d_1 = d_2$. Adjusting Eq. 1 to calculate the WCFZ in meters yields the following:

$$WCFZ = 17.32 \sqrt{\frac{nD}{4(F)}} \quad (2)$$

Where:

D = distance between the transmitter and receiver towers.

F = frequency in GHz.

n = Fresnel zone, which for the 2nd Fresnel Zone n = 2.

The calculated radius distance from Eq. 2 provides a three-dimensional turbine exclusion zone around each microwave link that can be used to guide wind turbine array design.

In addition to the WCFZ calculated for each microwave link, NextEra Analytics applies an offset of one-half RD plus 10 meter to account for turbine blade overhang. A turbine overhang offset using a 127m RD turbine technology is included within this analysis to represent the GE2.82-127 wind turbine generator.

The WTB cannot provide quality assurance for every license within the ULS database, so accuracy of the data relies on applicant certifications, and, in extreme cases, license audits. It has been NextEra Analytics' experience that most inaccuracies occur with regard to the location of the radio towers, where approximation or lack of precision of the geographic coordinates can result in a difference in the position of the tower by as much as 500 meters.

To fully account for these location errors, NextEra Analytics recommends on-site verification to identify the exact location of the transmitter and receiver towers. However, for this analysis, NextEra Analytics used high-resolution satellite imagery to identify possible tower location errors. Most microwave, media, and cellular towers extend well over 80m above ground level, and can be clearly viewed within high resolution satellite imagery. Each tower that may impact the project boundary was investigated for potential location error. Adjustments to the location of the microwave, media, and cellular towers are only made if clear evidence from the satellite imagery shows an inaccuracy.

Microwave Links and Microwave Towers

One microwave tower was identified within the project area, 26 microwave links have been identified near the project area, and eight have been found to intersect the AOI. The WCFZ for all of these links has been calculated, and the appropriate turbine offset has been used to minimize any harmful impact from the proposed turbine layout.

Figure 3 below illustrates the position of each microwave link with respect to the project boundary and turbine locations.

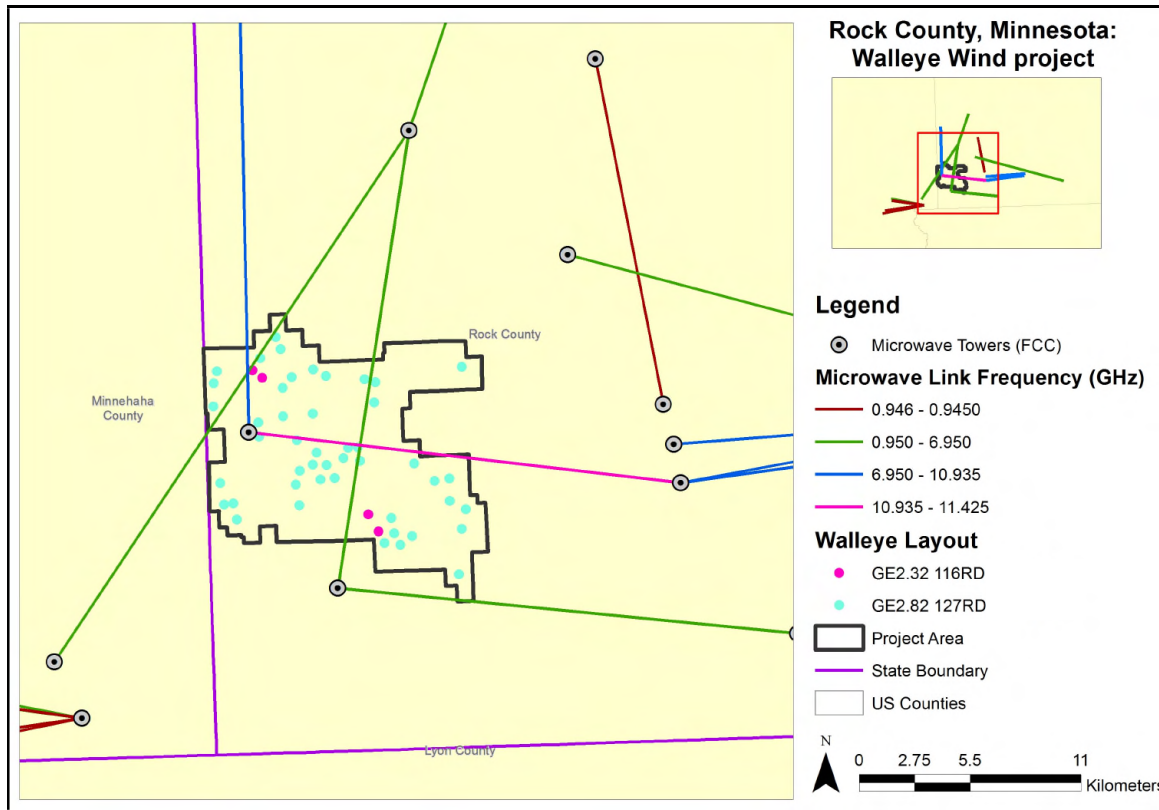


Figure 3: Walleye Wind with Microwave Links

Table 2 provides more detailed information on each microwave link in proximity to the area with the calculated WCFZ. Listed are the eight links that intersect the AOI.

ID	STATUS	TRANSMITTER CALLSIGN	MICROWAVE NAME	BAND FREQ (GHz)	WCFZ (m)	BEAM LENGTH (Km)
1	Active	WQOQ494	Minnesota, State of	6.6	22.8	23.0
2	Active	WQOU364	Minnesota, State of	6.8	22.5	23.0
3	Active	WQVP557	EAST RIVER ELECTRIC POWER COOP	6.6	26.9	31.7
4	Active	WQVP558	EAST RIVER ELECTRIC POWER COOP	6.8	26.5	31.7
5	Active	WQWB937	T-MOBILE LICENSE LLC	11.3	17.7	23.5
6	Active	WQWB939	T-MOBILE LICENSE LLC	10.8	18.0	23.5
7	Active	WQXG280	Sprint Spectrum L.P.	10.9	17.2	21.6
8	Active	WQXG281	Sprint Spectrum L.P.	11.4	16.8	21.6

Table 2: Detailed Information on Microwave Links That Intersect the Project Boundary

There are a number of links that are within relatively close proximity to turbines. The Worst Case Fresnel Zone was calculated for each microwave link and a conservative offset of 74 meters was used to reduce the probability of harmful interference. Figures 4-5 provide aerial imagery of the turbine layout relative to the Fresnel zones and their offsets that intersect the project boundary.

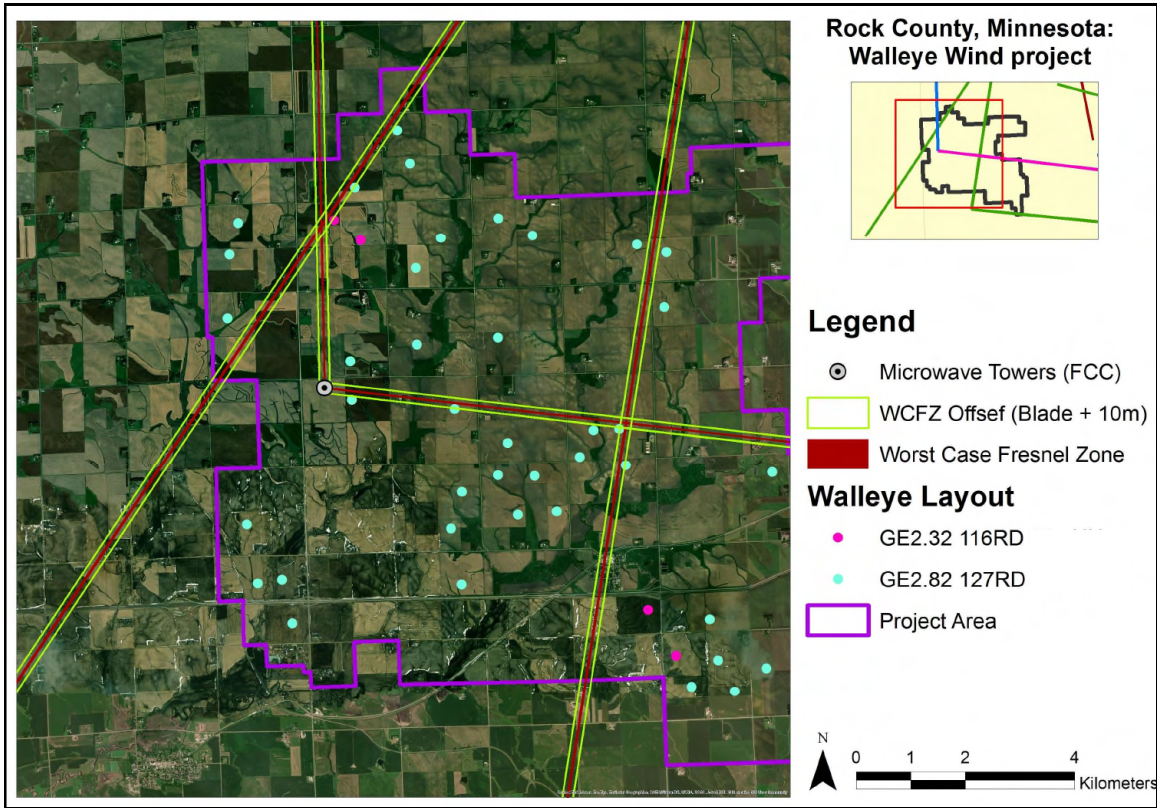


Figure 4: Walleye Wind Fresnel Zone West

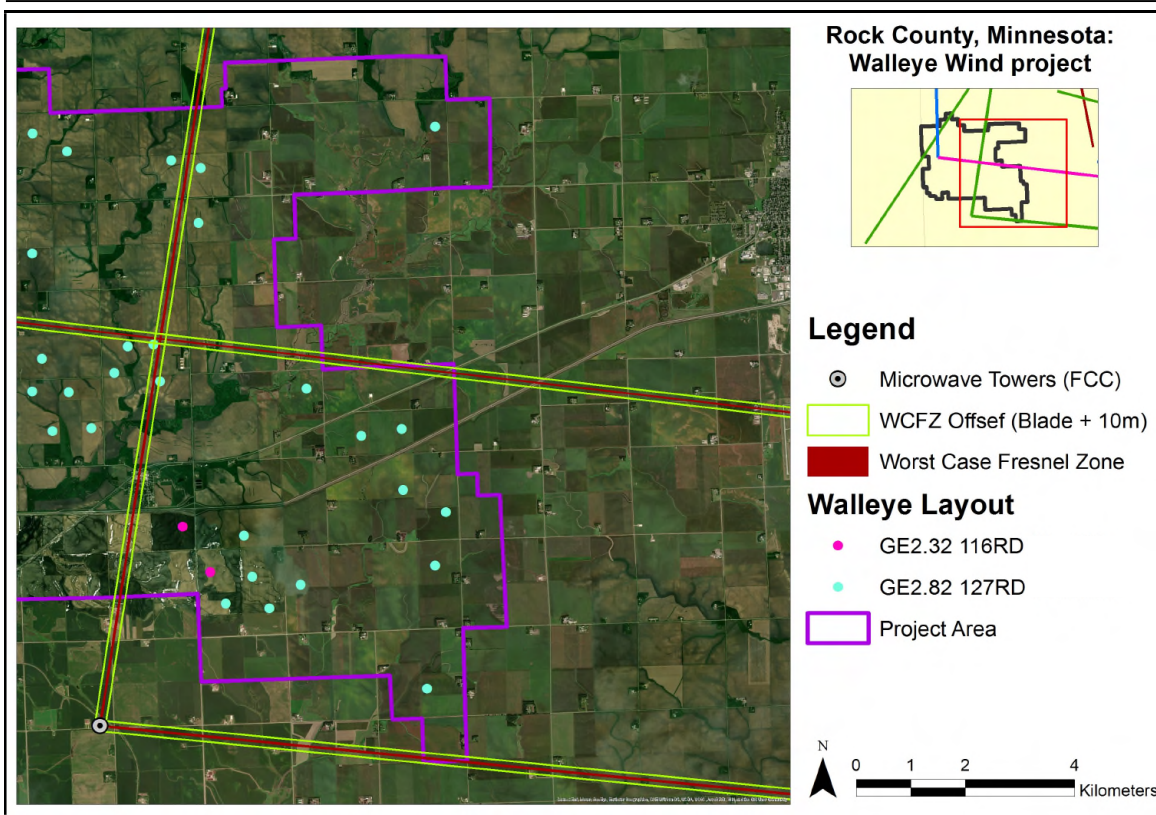


Figure 5: Walleye Wind Fresnel Zone East

Cellular Towers

One cellular tower was identified within the project boundary. Four other towers were discovered within 25 km of the project boundary. All five towers are identified in Table 3 and Figure 6.

Harmful interference associated with cellular towers is not likely as cellular transitions or packet switching occurs when a cellular link becomes unavailable.

ID	STATUS	CALLSIGN	LICENSEE	LATITUDE	LONGITUDE	DISTANCE TO AOI (km)
1	ACTIVE	KNKA597	AT&T Mobility Spectrum LLC	43.692139	-96.485806	2.8
2	ACTIVE	KNKN282	AT&T Mobility Spectrum LLC	43.718861	-96.227417	6.6
3	ACTIVE	KNKN282	AT&T Mobility Spectrum LLC	43.644167	-96.427111	0.0
4	ACTIVE	KNKN282	AT&T Mobility Spectrum LLC	43.855472	-96.424167	10.4
5	ACTIVE	KNKN290	ALLTEL Corporation	43.661389	-96.224722	4.7

Table 3: Cellular Towers within 25 km of the Project Boundary

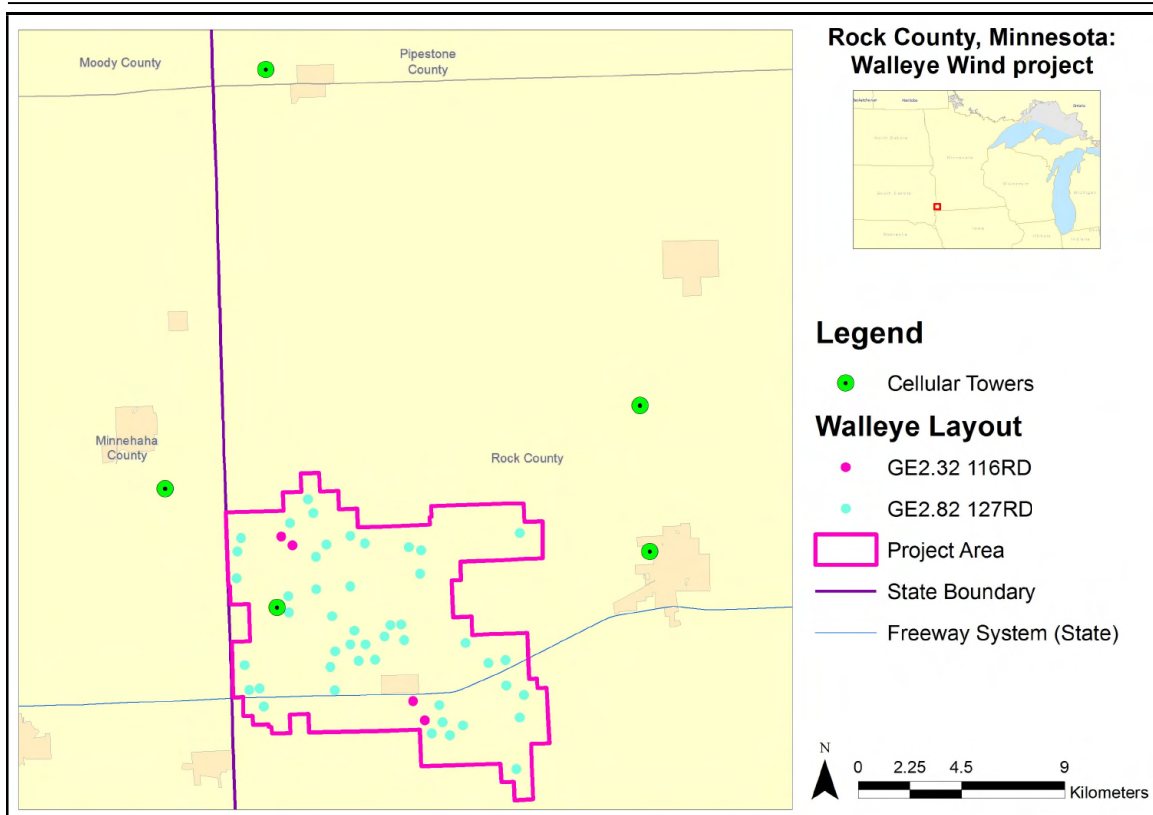


Figure 6: Cellular Towers within 25 km of the Project Boundary

Media Towers

No active AM radio towers were identified within the project boundary. One AM tower was discovered within 25 km of the project boundary and is included in Table 4 and Figure 7.

While no harmful interference to the AM tower is expected, reception of AM radio stations near each individual turbine may be impacted, especially for areas on the edge of AM radio coverage. The exclusion distance from AM towers is 1 wavelength from non-directional antennas and 10 wavelengths or 3 kilometers from directional antennas (Marlowe, 2015). Given most AM radio receptors will be nearby dwellings, which should have a sufficient offset from each turbine, any interruption to reception from the installation of wind turbines is expected to be minimal. The only AM tower, KQAD, is located 9.0 km from the project boundary, and has a broadcasting frequency of 800 kHz which corresponds to a wavelength of 375 m. Thus, the proposed layout is greater than 10 wavelengths away from the closest station.

ID	CALLSIGN	LICENSEE	FREQUENCY (kHz)	LATITUDE	LONGITUDE	DISTANCE TO AOI (km)
1	KQAD	ALPHA 3E LICENSEE LLC	800	43.650278	-96.171944	9.0

Table 4: AM Transmitter Towers within 25 km of the Project Boundary

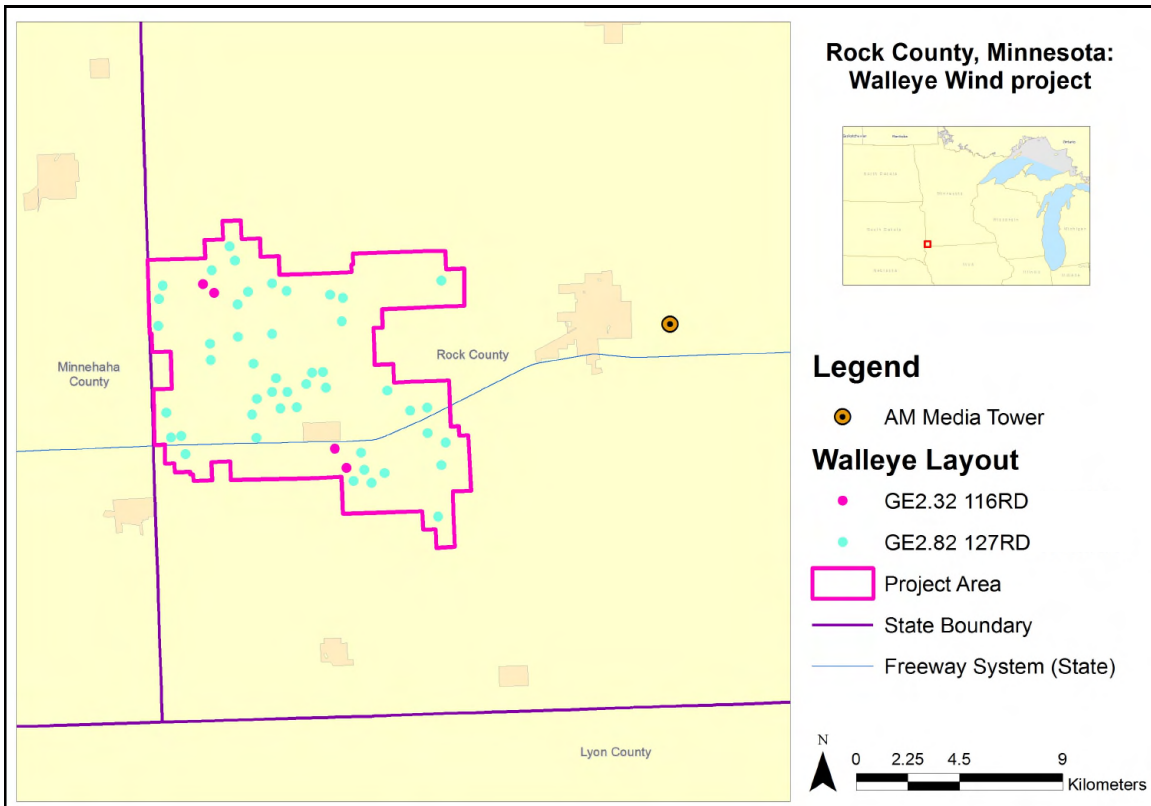


Figure 7: AM Transmitter Towers within 25 km of the Project Boundary

No active FM radio towers were identified within the project boundary. Four FM towers were discovered within 25 km of the project boundary and are included in Table 5 and Figure 8.

While no harmful interference to the FM towers is expected, reception of FM radio stations near each individual turbine may be impacted, especially for areas on the edge of FM radio coverage. The recommended exclusion distance for FM towers is approximately 4 kilometers. FM stations that are closer than 4 kilometers to wind turbines have the potential to experience interference (Marlowe, 2015). Given most FM radio receptors will be nearby dwellings, which should have a sufficient offset from each turbine, any interruption to reception from the installation of wind turbines is expected to be minimal. There are no active FM radio towers within 4 kilometers of the Walleye Wind project boundary.

ID	CALLSIGN	LICENSEE	FREQUENCY (MHz)	LATITUDE	LONGITUDE	DISTANCE TO AOI (km)
1	KLQL	ALPHA 3E LICENSEE LLC	101.1	43.806667	-96.206389	15.5
2	KNWC-FM	UNIVERSITY OF NORTHWESTERN-ST. PAUL	96.5	43.518611	-96.534722	13.6
3	KTWB	MIDWEST COMMUNICATIONS, INC.	92.5	43.518611	-96.534722	13.6
4	KXRB-FM	TOWNSQUARE MEDIA SIOUX FALLS LICENSE, LLC	100.1	43.518611	-96.534722	13.6

Table 5: FM Transmitter Towers within 25 km of the Project Boundary

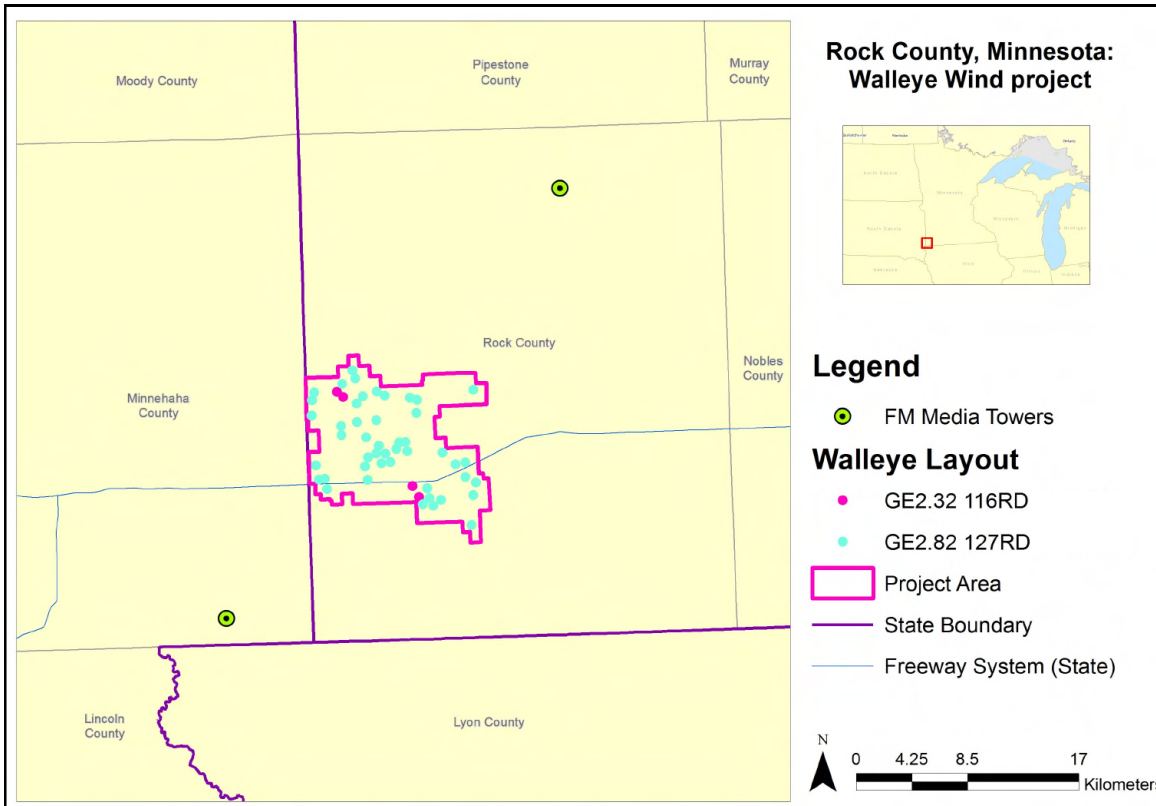


Figure 8: FM Transmitter Towers within 25 km of the Project Boundary

Television Stations

No digital or analog television stations were identified within the project boundary. Within 100km of the project boundary, there are 43 licensed television stations as determined by the FCC; Table 6 identifies these 43 stations, and Figure 9 depicts their locations. Of the 43 stations within 100km of the project boundary, nine of them fall within 50km of the boundary and are likely to be broadcasting to the region.

Electromagnetic Interference

ID	CALLSIGN	CHANNEL	SERVICE	ERP (kW)	LAT	LONG	LICENSEE	Dist to AOI (km)
1	K14QR-D	14	ND	1	43.703333	-96.45175	LANDOVER 2 LLC	0.08
2	K30NS-D	30	ND	1	43.703333	-96.45175	LANDOVER 2 LLC	0.08
3	K40NS-D	40	ND	1	43.703333	-96.45175	LANDOVER 2 LLC	0.08
4	K33NF-D	33	ND	1	43.659861	-96.852556	LANDOVER 2 LLC	32.19
5	K35LZ-D	35	ND	1	43.659861	-96.852556	LANDOVER 2 LLC	32.19
6	K38OZ-D	38	ND	1	43.659861	-96.852556	LANDOVER 2 LLC	32.19
7	K48OK-D	48	ND	1	43.659861	-96.852556	LANDOVER 2 LLC	32.19
8	K43LX-D	43	DA	15	43.379167	-95.803333	IOWA PUBLIC BROADCASTING BOARD	45.91
9	K33PV-D	33	DA	15	43.376583	-95.803167	IOWA PUBLIC BROADCASTING BOARD	46.07
10	KELO-TV	11	ND	30	43.518611	-95.465	NEXSTAR BROADCASTING, INC.	67.29
11	KSFY-TV	13	ND	22.7	43.518611	-95.465	GRAY TELEVISION LICENSEE, LLC	67.29
12	K20MB-D	20	ND	13.2	43.518611	-95.465	GRAY TELEVISION LICENSEE, LLC	67.29
13	KABY-LD	20	ND	13.2	43.518611	-95.465	GRAY TELEVISION LICENSEE, LLC	67.29
14	KDLT-TV	21	ND	589	43.505	-95.443611	GRAY TELEVISION LICENSEE, LLC	69.22
15	KTTW	7	DA	7.5	43.505278	-95.427778	INDEPENDENT COMMUNICATIONS, INC.	70.48
16	KWSD	36	DA	36.9	43.505278	-95.427778	J.F. BROADCASTING, LLC	70.48
17	KWSD	36	DA	18.45	43.505278	-95.427778	J.F. BROADCASTING, LLC	70.48
18	KWSD	36	DA	1000	43.505278	-95.427778	J.F. BROADCASTING, LLC	70.48
19	KCSD-TV	24	ND	80.9	43.574417	-95.344417	SOUTH DAKOTA BOARD OF DIRECTORS FOR EDUCATIONAL TELECOMMUNIC	76.06
20	K22KD-D	22	ND	3	43.553889	-95.315	EDGE SPECTRUM, INC.	78.67
21	K56GF	23	ND	15	43.553889	-95.315	DIGITAL NETWORKS-MIDWEST, LLC	78.67
22	K56GF	56	DA	10.1	43.553889	-95.315	DIGITAL NETWORKS-MIDWEST, LLC	78.67
23	K56GF	56	DA	10.1	43.553889	-95.315	DIGITAL NETWORKS-MIDWEST, LLC	78.67
24	K04RR-D	4	ND	3	43.538083	-95.285694	DTV AMERICA CORPORATION	81.24
25	K06QJ-D	6	ND	3	43.538083	-95.285694	DTV AMERICA CORPORATION	81.24
26	K27LB-D	27	ND	2	44.383222	-96.9895	LANDOVER 2 LLC	82.19
27	K38NI-D	38	ND	2	44.383222	-96.9895	LANDOVER 2 LLC	82.19
28	K42KO-D	42	ND	2	44.383222	-96.9895	LANDOVER 2 LLC	82.19
29	K45LV-D	45	ND	2	44.383222	-96.9895	LANDOVER 2 LLC	82.19
30	KCPO-LP	26	ND	7.57	43.52675	-95.261833	G.I.G., INC.	83.33
31	KAUN-LP	25	ND	0.88	43.535556	-95.256944	J.F. BROADCASTING, LLC	83.58
32	KCWS-LP	27	ND	0.68	43.535556	-95.256944	J.F. BROADCASTING, LLC	83.58
33	KAUN-LP	42	ND	0.88	43.535528	-95.256917	J.F. BROADCASTING, LLC	83.58
34	KCWS-LP	44	ND	0.68	43.535528	-95.256917	J.F. BROADCASTING, LLC	83.58
35	NEW	35	DA	15	43.376667	-95.1945	CASEY C. PETERSON	91.89
36	K18IW-D	18	DA	3	43.752278	-95.114611	DTV AMERICA CORPORATION	94.50
37	K18IW-D	18	DA	3	43.752278	-95.114611	DTV AMERICA CORPORATION	94.50
38	K31KU-D	31	DA	3	43.752278	-95.114611	DTV AMERICA CORPORATION	94.50
39	K31KU-D	31	DA	3	43.752278	-95.114611	DTV AMERICA CORPORATION	94.50
40	K32JG-D	32	DA	3	43.752278	-95.114611	DTV AMERICA CORPORATION	94.50
41	K32JG-D	32	DA	3	43.752278	-95.114611	DTV AMERICA CORPORATION	94.50
42	K32JG-D	32	DA	3	43.752278	-95.114611	DTV AMERICA CORPORATION	94.50
43	K18IW-D	18	ND	3	43.751389	-95.110556	DTV AMERICA CORPORATION	94.82

Table 6: Television Stations within 100 km of the Project Boundary

Electromagnetic Interference

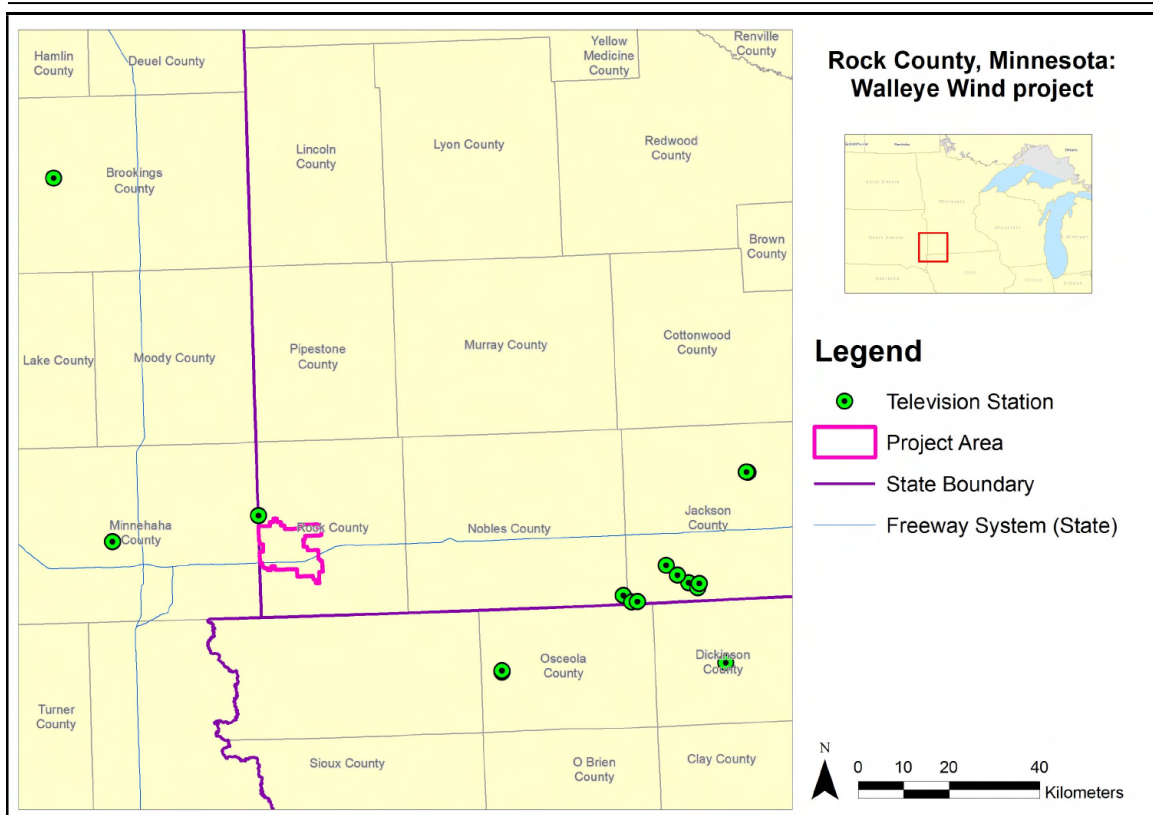


Figure 9: Television Stations within 100 km of the Project Boundary

While the impact of wind turbines on digital television reception is not well known due to limited cases and testing, any interference is expected to be limited to areas near the edge of station reception, areas near a turbine that is within the line-of-sight between the transmit tower and receptor, and areas of complex topography (OfCom, 2009). Most of the stations within 100km are low power stations or translator stations and have limited range and are not anticipated to experience reception degradation. There are 10 full power stations which have a possibility of experiencing reception degradation if the proposed wind farm is located in the line-of-sight. The callsigns of these 10 stations are as follows: KTTW, KELO-TV, KSFY-TV, KSMN, KDLT-TV, KCSD-TV, KUSD-TV, KWSD, KWSD, KWSD.

It is important to note that this assessment is based on broad assumptions, as it is difficult to accurately pinpoint the impact a large wind farm may have on each individual household due to a large number of external variables (topography, weather, antennae, etc.) which affect the propagation of the television radio signal.

Aviation Towers

No active aviation towers were identified within the project boundary. Two aviation towers were discovered within 25 km of the project boundary and are included in Table 7 and Figure 10.

While no harmful interference is expected for the aviation towers; Walleye Wind is subject to the Federal Aviation Agency (FAA) to determine any exclusion zones. Proposed turbine locations maintain the standard appropriate offset distances in addition to any setbacks set by the agency to minimize harmful impact.

ID	STATUS	CALLSIGN	LICENSEE	SERVICE	LATITUDE	LONGITUDE	DISTANCE TO AOI (km)
1	Active	KRQ9	LUVERNE, CITY OF	AF Aeronautical and Fixed	43.620806	-96.218639	5.4
2	Active	WQBL287	Minnesota, State of epartment of Transportation ffcie of Aeronautics	AF Aeronautical and Fixed	43.621667	-96.213889	5.7

Table 7: Aviation Towers within 25 km of the Project Boundary

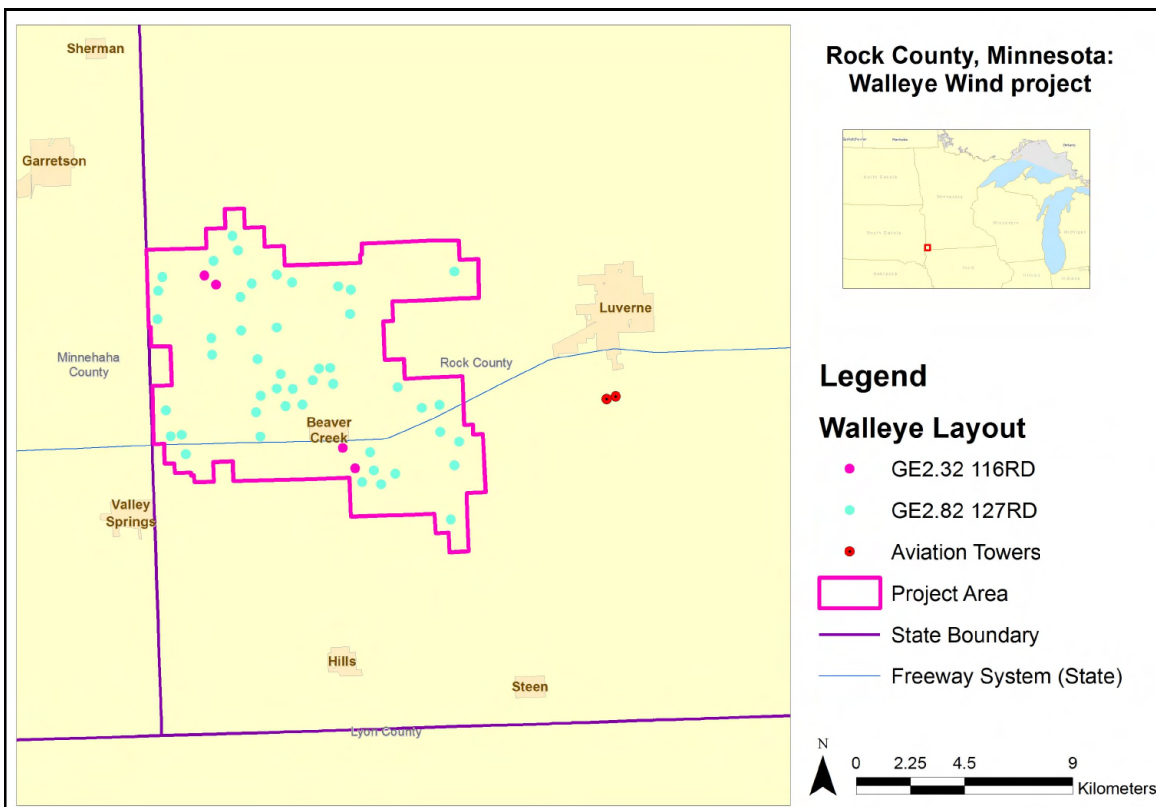


Figure 10: Aviation Towers within 25 km of the Project Boundary

Conclusion and Recommendations

NextEra Analytics analyzed the potential for wind turbine interference on licensed microwave links located within the proposed Walleye Wind Project energy generation site. This report summarizes the microwave towers, microwave links, cellular towers, media towers, television towers, and aviation towers within and near the project boundary.

Eight microwave links were found to intersect the project boundary, and an appropriate offset to the WCFZ has been utilized to mitigate harmful interference from the proposed turbine layout. No interference from the proposed turbine layout is expected near microwave, AM, FM, cellular, aviation, or TV towers. This analysis is current as of January 23, 2020. NextEra Analytics recommends a refresh of this analysis if the proposed wind energy generation project has not been constructed after two years.

It is important to note that this report only provides analysis for licensed radio towers and links found within the FCC-ULS database. Many local municipalities (police, fire, etc.) do not license microwave links, NextEra Analytics recommends Walleye Wind LLC coordinate with the appropriate local municipality officials. Also not included within the database are microwave towers and links utilized by the Federal government (Dept. of Defense, Dept. of Commerce, etc.), again for public safety concerns. A Federal communications study by the National Telecommunications and Information Agency (NTIA) has been conducted stating no harmful interference is expected in the project area.

References

Bacon, David F., "A proposed method for establishing an exclusion zone around a terrestrial fixed radio link outside of which a wind turbine will cause negligible degradation of the radio link performance."

<http://www.ofcom.org.uk/radiocomms/ifi/licensing/classes/fixed/Windfarms/windfarmdavidbacon.pdf,Version> 1.1, Oct 2002.

Ofcom, "Tall structures and their impact on broadcast and other wireless services."

http://www.ofcom.org.uk/radiocomms/ifi/licensing/classes/fixed/Windfarms/tall_structures/tall_structures.pdf, August 2009.

Marlowe, Frank. "The Importance of Electromagnetic-impact Analyses for Wind Permitting." *Windpower Engineering & Development*. Broadcast Wind, 2015. Web. 19 July 2017.