APPENDIX J – RADIO FREQUENCY STRUCTURE STUDY AND ANALYSIS

ENGINEERING REPORT
CONCERNING THE EFFECTS UPON
FCC LICENSED RF FACILITIES
DUE TO CONSTRUCTION OF THE
DAKOTA RANGE III WIND ENERGY PROJECT
In
GRANT & ROBERTS COUNTIES, SOUTH DAKOTA

Prepared for:
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Charlottesville, VA

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I. INTRODUCTION

This engineering report describes the results of a study and analysis to determine the locations of federally-licensed (FCC) microwave and fixed station radio frequency (RF) facilities that may be adversely impacted as a result of the construction of the Dakota Range III Wind Energy Project in Grant and Roberts Counties, South Dakota. This document describes impact zones and any necessary mitigation procedures, along with recommendations concerning individual wind turbine siting. All illustrations, calculations and conclusions contained in this document are based on FCC database records[1].

Frequently, wind turbines located on land parcels near RF facilities can cause more than one mode of RF impact, and may require an iterative procedure to minimize adverse effects. This procedure is necessary in order to ensure that disruption of RF facilities either does not occur or, in the alternative, that mitigation procedures will be effective. The purpose of this study is to facilitate the siting of turbines to avoid such unacceptable impact.

The Dakota Range III wind project as currently planned involves the construction of approximately 36 wind turbines just west of the town of Summit, South Dakota. The wind turbines proposed to be erected will have a hub height of 105.5 meters AGL and a rotor diameter of 136 meters. The maximum blade tip height therefore would be 173.5 meters AGL. The wind farm will be connected to the electrical grid via an approximately 8-mile long 345 kV transmission line.

Using industry standard procedures and FCC databases, a search was conducted to determine the presence of any existing microwave paths crossing the subject property, land mobile and other

[1] The databases used in creating the attached tables and maps are generally accurate, but anomalies have been known to occur. Generally, for wind turbine siting, an on-site verification survey is often suggested as part of the due diligence process.

RF facilities within or adjacent to the identified area and broadcast signals receivable in the area. A specific turbine layout has been submitted for analysis. Accordingly, this report will address the potential conflicts that may be caused by the proposed turbines.

The following tabulation and analysis consists of five sections:

1. Microwave point-to-point path analysis[2]
2. Land mobile and public safety stations
3. Broadcast AM, FM and TV signals
4. Radar stations, military operations and NTIA notification
5. Electromagnetic fields (EMF) from overhead power transmission line

The attached figures were generated based upon the operating parameters of the FCC-licensed stations as contained in the FCC station database, with corrections of the antenna locations as needed.

The following analysis examines the pertinent FCC licensed services in the area for impact. This analysis assumes that all licensed services have been designed and constructed according to FCC requirements and good engineering practice. If this is not the case, the impacted facility must share responsibility with the wind project developer for the costs of any mitigation measures[3].

Each of the RF analyses is described separately in the sections that follow.

II. ANALYSIS OF MICROWAVE LINKS

An extensive analysis was undertaken to determine the likely effect of the new wind turbine farm upon the existing microwave paths, consisting of a Fresnel x/y/z axis study. The microwave paths have been overlaid on Google Earth™ maps, and the images of the microwave paths and the proposed turbines are also available in a KMZ file.

Important Note: Microwave path studies are based upon third party and FCC databases that normally exhibit a high degree of accuracy and reliability. Although Evans performs due diligence to ensure that all existing microwave facilities are represented, we cannot be responsible for errors in FCC databases that may lead to incomplete results. However, should such situations occur, Evans would perform an engineering analysis to determine how the

[2] Only point-to point microwave facilities were considered (for instance, a study of earth station facilities is not included).

[3] For instance, some microwave paths may have insufficient ground clearances as they are presently configured.

additional facilities can be accommodated or, if wind turbine structures are already built, determine a method to re-direct an impacted beam path.

For this microwave study, *Worst Case Fresnel Zones* (WCFZ) were calculated for each microwave path. The mid-point of a microwave path is the location where the widest (or worst case) Fresnel zone occurs. Possible geographic coordinate errors must be taken into account[4]. The radius *R* of the Worst Case Fresnel Zone, in meters, is calculated for each path using the following formula:

$$R \cong 8.65\sqrt{\frac{D}{F_{GHz}}}$$

where *D* is the microwave path length in kilometers and F_{GHz} is the frequency in gigahertz.

In general, the WCFZ is defined by the cylindrical area whose axis is the direct line between the microwave link endpoints and whose radius is *R* as calculated above. This is the zone where the siting of obstructions should be avoided. Evans Engineering Solutions has identified only one unique licensed microwave path from the FCC database within 0.5 kilometer of the turbine area. This microwave path, listed in Table 1 and mapped in Figures 1 and 2, crosses the turbine area.

Call Sign 1	Call Sign 2	Site 1 Name	Site 2 Name	Freq. (MHz)	WCFZ (m)	Licensee
WMN496	WPVJ218	Summit	South Shore	6685/6845	17.3	New Cingular Wireless PCS LLC

Table 1 – Licensed Microwave Links in and near Dakota Range Project Area

As seen in Figures 1 and 2, no planned turbines would be in the Fresnel Zone of the microwave path.

[4] Many microwave facilities were built before accurate methods were available to establish exact geographic coordinates (such as GPS). It is not unusual for database errors of up to 4 or 5 seconds to occur, which can affect the positioning of critical turbines located near Fresnel paths.

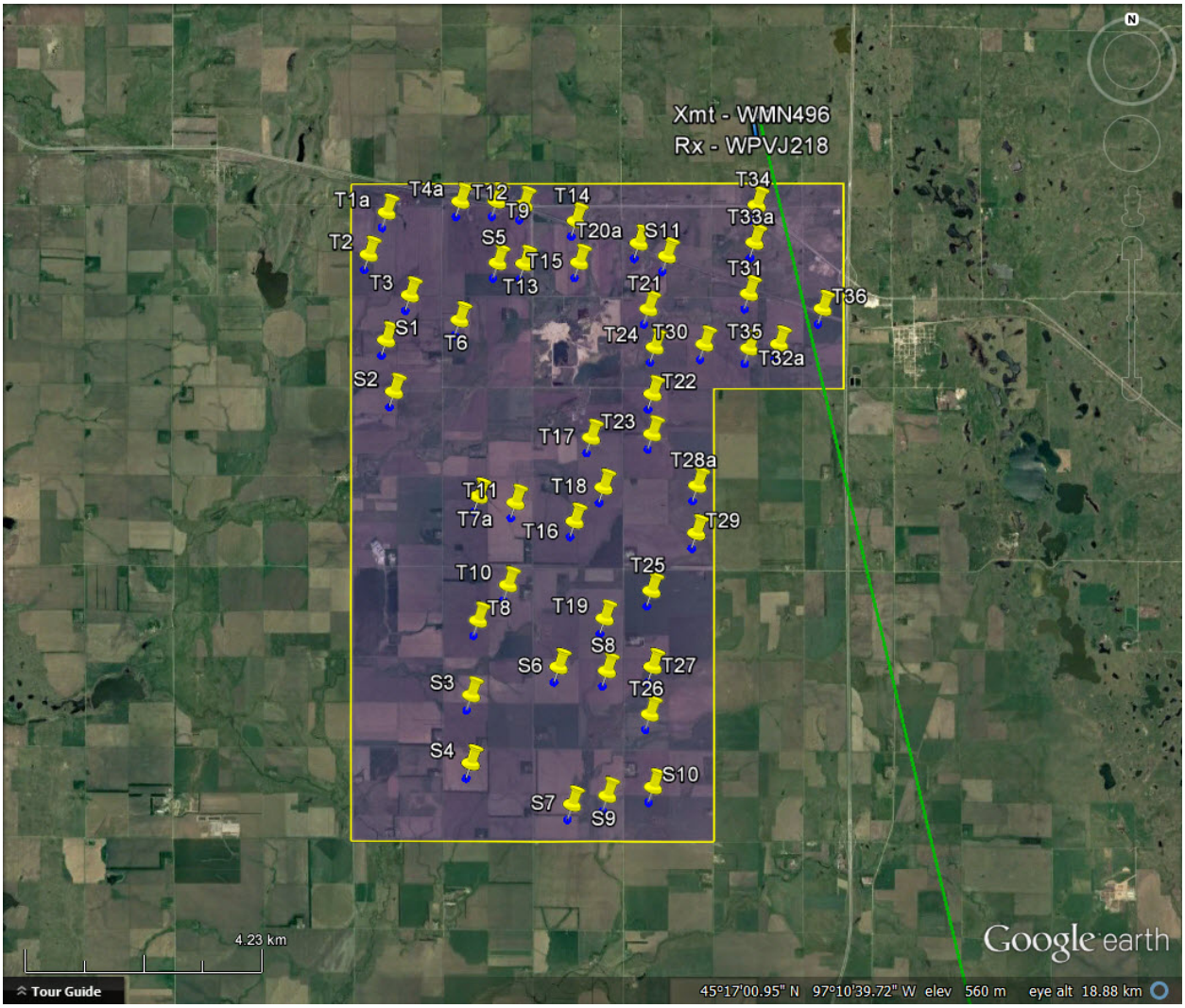

Figure 1 – Licensed Microwave Paths in or near Dakota Range III Turbine Area

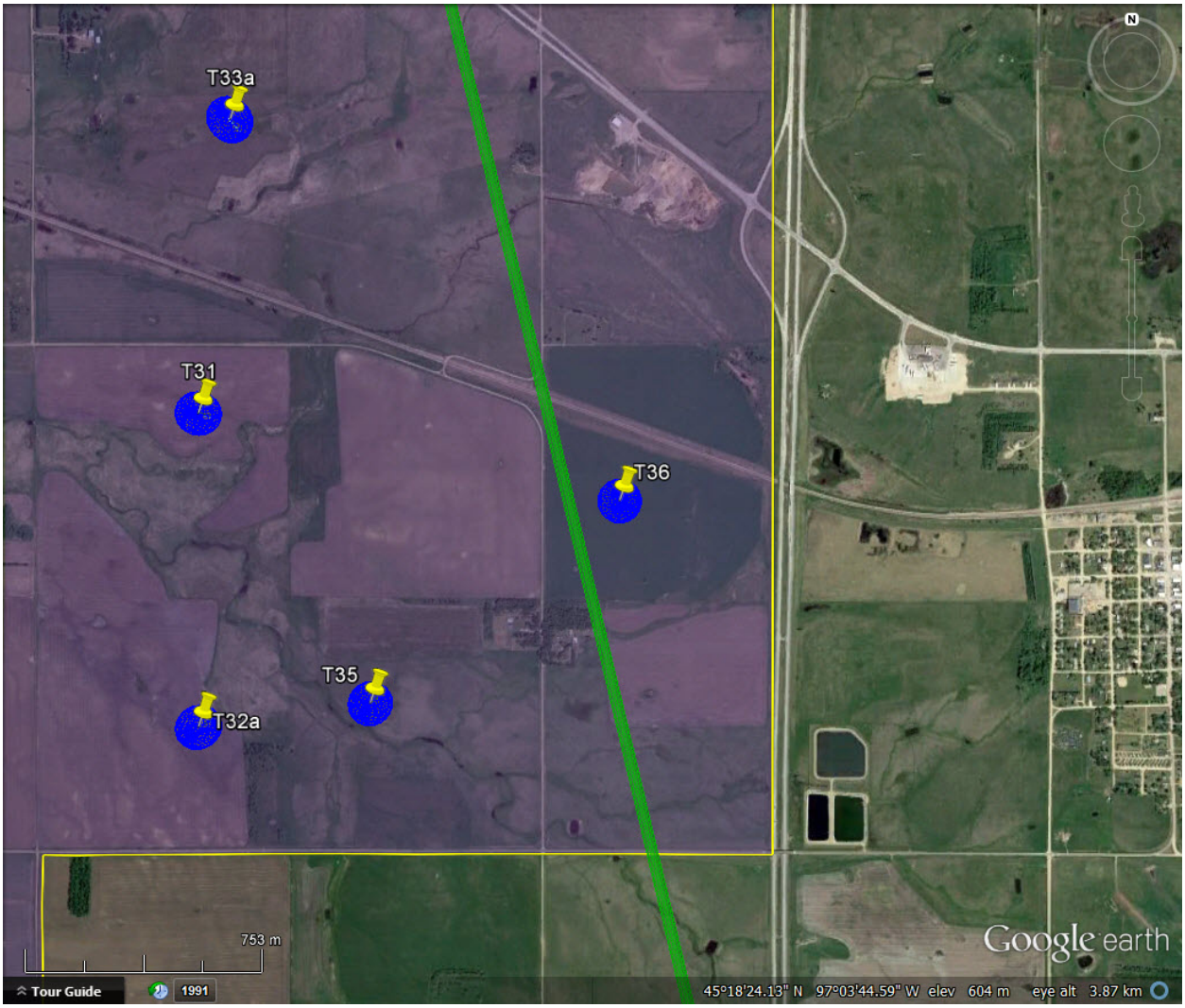

Figure 2 – Close-Up of Licensed Microwave Paths in or near Dakota Range III Turbine Area

III. ANALYSIS OF LAND MOBILE & PUBLIC SAFETY FACILITIES

A search of the FCC's land mobile/public safety radio database revealed **no** land mobile transmitter stations that fall within the search area (0.5 kilometer beyond the turbine area boundary). Thus, based on the current project layout, no adverse impact is expected to be caused to the transmissions of land mobile stations that are licensed by the FCC.

IV. ANALYSIS OF BROADCAST FACILITIES

4.1 TV Broadcast Facilities

The rotating blades of a wind turbine have the potential to disrupt over-the-air broadcast TV reception within a few miles of the turbine, especially when the direct path from the viewer's residence is obstructed by terrain. Interference is caused when signals reflected by the blades arrive at the viewer's TV antenna along with the direct signal. This is known as "multipath interference." However, as turbine manufacturers have replaced all-metal blades with blades constructed of mostly nonmetallic materials[5], this effect has been reduced. Also, the new generation of HDTV receivers is better equipped to deal with minor multipath interference (which is manifested by "pixilating" or "freezing" of the digital picture) than analog TV sets, as special circuitry is employed to suppress the weaker reflected signal. Occasionally, however, multipath interference from one or more turbines can cause video failure in HDTV receivers, especially if the receiver location is in a valley or other place of low elevation.

There is some possibility of signal disruption for residences that have to point their outdoor antennas through the turbine area, or that utilize "rabbit ear" antennas and/or older HDTV receivers. Most of this effect should be dissipated for locations three or more miles from a turbine, but some residual problems could be noted for HDTV receivers that are located below the grade level at the turbine base. Usually, a rule of thumb is that approximately 10% of the receiver locations are affected to some extent within three miles of a large turbine when the turbine is between the TV station and the receiver. The usual effect is intermittent "pixilation" or freezing of the digital TV picture. This estimate is based upon Evans Engineering's experience with similar wind energy projects.

Grant and Roberts Counties are in the Sioux Falls (Mitchell), SD Designated Market Area (DMA) as defined by Nielsen Media Research. However, only three of the TV stations from that

[5] Modern turbine blades are usually constructed from glass-reinforced plastic (GRP), although they usually contain some metal for strengthening, balance and grounding.

market have been determined to place a predicted FCC primary over-the-air service signal over at least a portion of the wind project area or its immediate environs. All TV stations that are predicted to serve the project area are listed in Table 2. The TV stations' service area boundaries are mapped in Figure 3.

Call Sign	Network Affiliate	Virtual Channel	RF Channel	City of License	Power (KW)	Ant. Height (m HAAT)	Dist. (km)	Azimuth (°T)
KWCM-TV	PBS	10	10	Appleton, MN	50	381	89.7	95.8
KDLO-TV	CBS	3	3	Florence, SD	14.4	513	48.0	228.3
KESD-TV	PBS	8	8	Brookings, SD	15	229	102.1	184.2
KDSD-TV	PBS	16	17	Aberdeen, SD	37.8	349	50.2	302.9
K32DK[6]	FOX	-	32	Watertown, SD	2.28	96	43.3	176.9

Table 2 - TV Stations Serving Dakota Range III Project Area

In addition to the TV stations that are currently on the air, there are six FCC construction permits for low-power stations at Watertown and Summit whose service areas would include all or part of the wind project area. However, the FCC construction permits for all of these authorized stations expired over two and a half years ago; thus, the future operational status of these stations is very much in doubt. The following are those permitted TV stations:

Call Sign	RF Channel	City	Permittee	FCC File No.	Expire Date of Permit
K14OP	14	Summit, SD	Landover 2 LLC	BNPDTL20100505ADV	11/17/2014
K22KF	22	Watertown, SD	Frank Digital Bcstg LLC	BNPDTL20100331AFD	2/22/2015
K23LI	23	Watertown, SD	Frank Digital Bcstg LLC	BNPDTL20100331AFE	2/22/2015
K25MD	25	Summit, SD	Landover 2 LLC	BNPDTL20100505ADW	11/17/2014
K32KJ	32	Summit, SD	Landover 2 LLC	BNPDTL20100505ADX	11/17/2014
K35KS	35	Summit, SD	Landover 2 LLC	BNPDTL20100505ADY	11/17/2014

Table 3 – Permitted TV Stations to Serve Dakota Range III Project Area

If the Dakota Range wind project should cause disruptions to over-the-air TV viewing, methods to resolve them are available, and are as follows:

1. Relocation of the household antenna to receive a better signal
2. Installation of a better outside antenna, or one with a higher gain
3. Installation of satellite or cable TV

[6] This is a low-power station that rebroadcasts KTTW, Channel 7, in Sioux Falls, South Dakota.

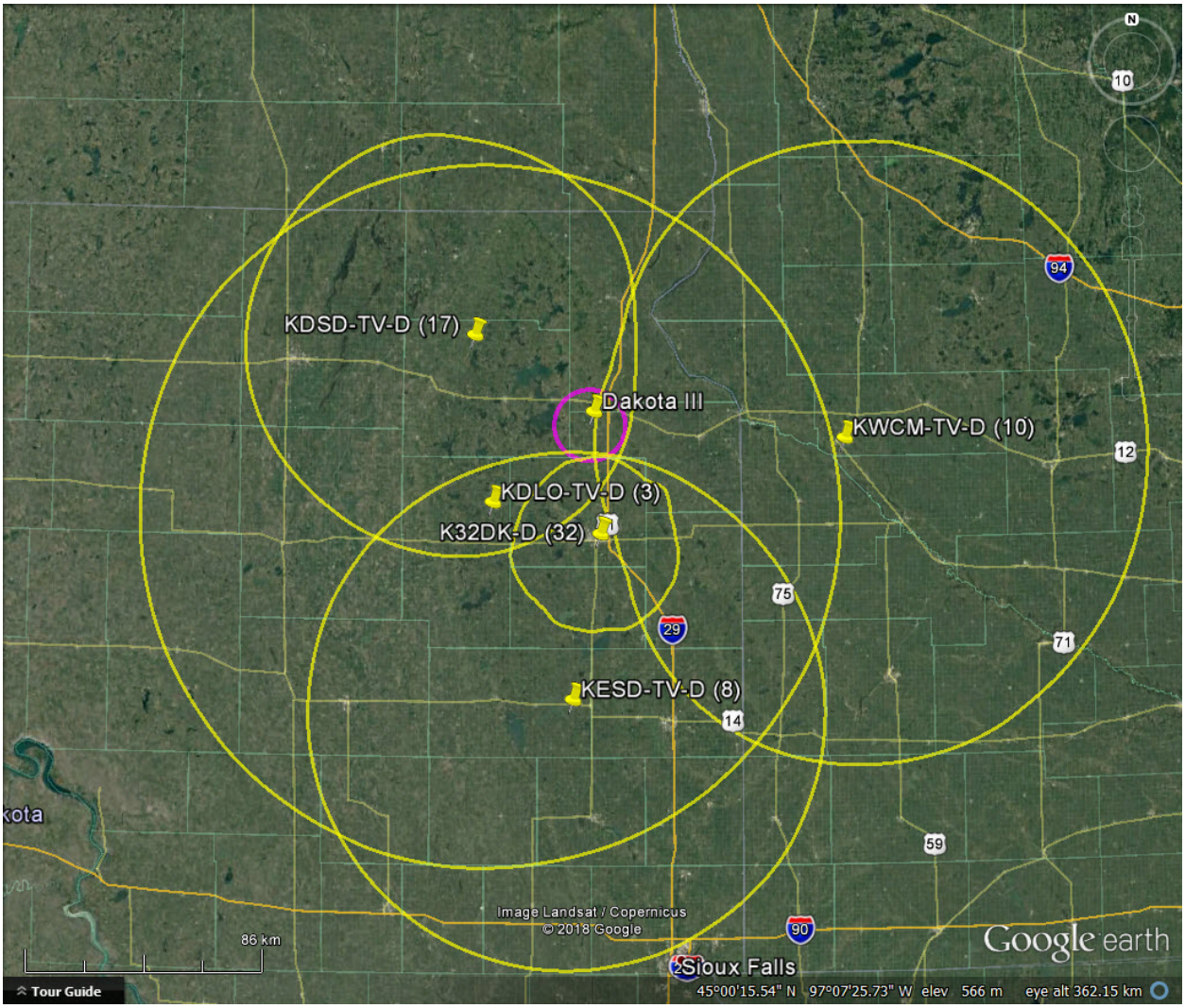

Figure 3 – Predicted Over-the-Air Television Coverage into Dakota Range Project Area

According to this engineer's calculations, there are approximately 350 households within an area likely to be affected (approximately 193 square miles). It is conservatively estimated that 55%, or 193, of the households receive TV programming primarily by satellite dish or cable. This leaves an estimated 157 households relying on transmitted over-the-air TV signals. Based on the 10% criteria described previously, up to 16 TV receiving locations may be affected to varying degrees in the worst-case. Mitigation costs would be approximately $200 per location for an upgraded outdoor antenna, or $400 per year per location for a satellite or cable subscription.

It is the opinion of this consultant that any disruptions to over-the-air TV broadcast signals, if they occur, can be resolved satisfactorily.

4.2 FM Facilities

The full-service FM stations that place a predicted primary signal over at least part of the project area are listed in the following Table 4. The FM stations' service area boundaries are mapped in Figure 4.

Call Sign	Format	Freq. (MHz)	City of License	Power (KW)	Ant. Height (m HAAT)	Dist. (km)	Azimuth (°T)
KCGN-FM	Christian	101.5	Ortonville, MN	100	305	15.4	29.4
KPHR	Classic Rock	106.3	Ortonville, MN	100	291	20.2	145.1
KJSD	News/Talk/Music	90.3	Watertown, SD	10.5	175	30.1	150.1
KDSD-FM	News/Talk/Music	90.9	Pierpont, SD	70	323	50.3	302.8
KSDR-FM	Country	92.9	Watertown, SD	100	298	14.6	127.0
KIXX	Adult Contemp.	96.1	Watertown, SD	100	298	14.6	127.0
KDLO-FM	Country	96.9	Watertown, SD	100	479	48.0	228.3
KXLG	Classic Hits	99.1	Milbank, SD	37	167	30.1	150.1
KJKQ	Adult Hits	99.5	Sisseton, SD	25	170	45.6	356.7
KBWS-FM	Country	102.9	Sisseton, SD	100	140	45.6	331.5
KKSD	Classic Hits	104.3	Milbank, SD	100	254	14.6	127.1

Table 4 – FM Stations Serving Dakota Range Project Area

Real-world experience with wind farms has shown that FM broadcast station signals (88 to 108 MHz) are fairly insensitive to wind turbines, even in cases where the FM transmitter tower is surrounded by turbines that are higher than the FM antenna. Because of the "capture effect" supported by the "discriminator" in FM receivers, significant disruptions to the above facilities are not expected. Although the received signal may vary with the blade rotation at some receiver locations in the immediate area, good quality FM radios should factor out such time-varying signals.

4.3 AM Facilities

Large metallic structures such as wind turbines can adversely affect the transmitted signals of AM broadcast stations up to three kilometers away. A search of the FCC's database revealed no AM facilities within the required notification distance of three kilometers from any planned turbine. There should therefore be no reasonable expectations of disruptions in transmitted signals on the AM band due to the presence of the turbines. Occasionally, depending upon ground conditions, local AM receivers may experience slight signal changes due to local effects, but such anomalies are not recognized by the FCC or the standards of good engineering practice as having an unduly adverse effect.

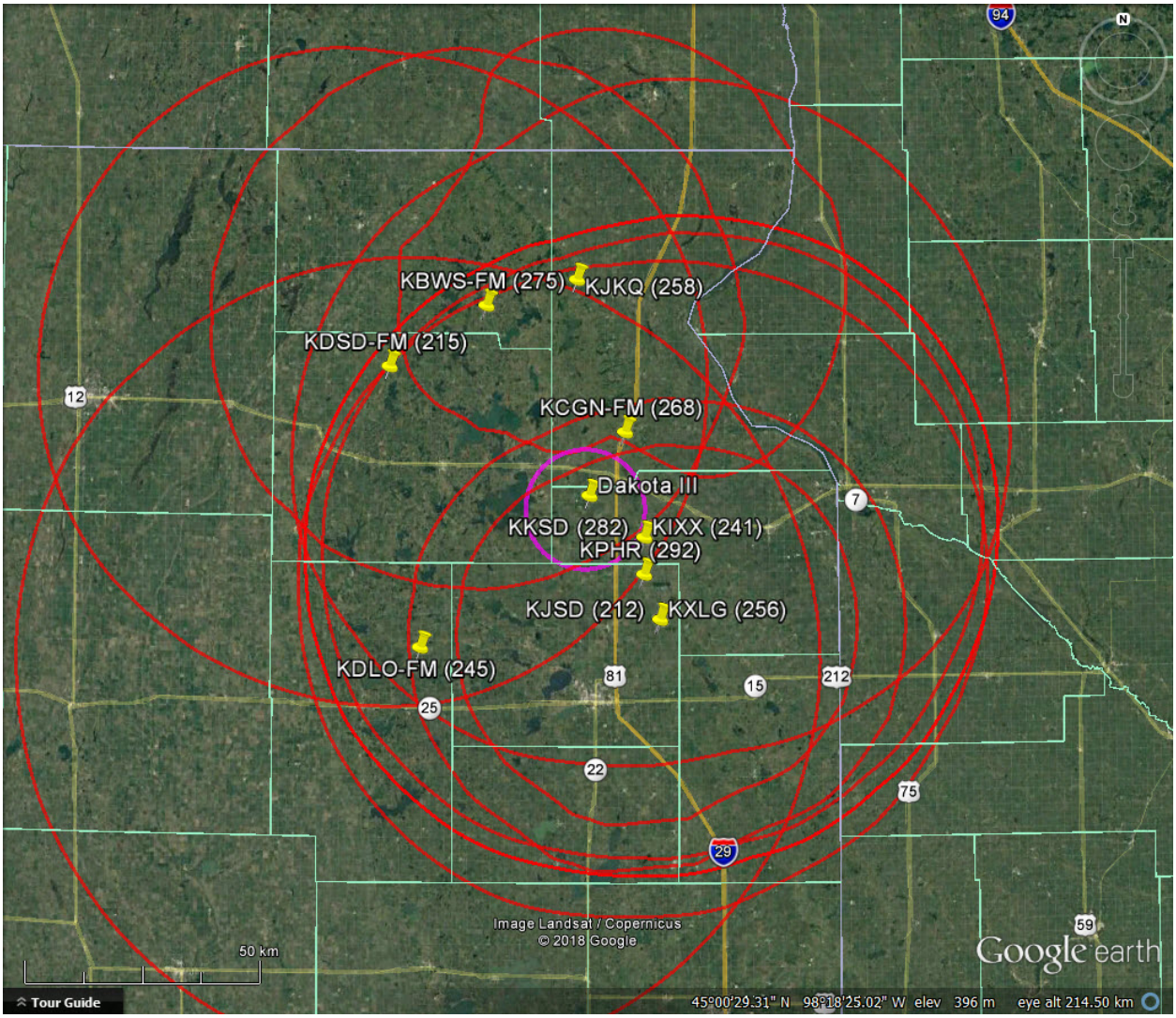

Figure 4 – Predicted FM Radio Coverage into Dakota Range III Project Area

V. RADAR FACILITIES, MILITARY AIRSPACE & NTIA NOTIFICATION

5.1 DoD Radar Concerns

The Department of Defense (DoD) and the Department of Homeland Security *Long Range Radar Joint Program Office* "JPO" has adopted a "pre-screening tool" to evaluate the impact of wind turbines on air defense long-range radar. This tool was applied to the Dakota Range project area, and it returned a result of "no anticipated impact" (green) to Air Defense and Homeland Security radars, as seen in Figure 5. However, a definitive determination is obtained only after formal study by the DoD, which is triggered by the FAA 7460-1 notification process.

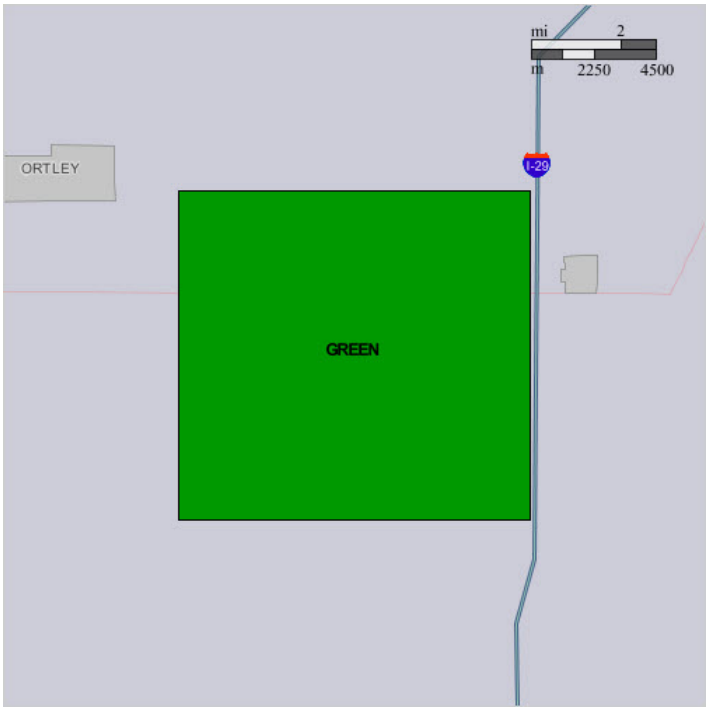

Figure 5 – DoD Long-Range Radar Screening

Map Legend:

- **Green:** No anticipated impact to Air Defense and Homeland Security radars. Aeronautical study required.

5.2 NEXRAD

A pre-screening tool has been developed to evaluate the potential impact of obstructions to the NEXRAD Weather Surveillance Doppler Radar Stations. This tool was applied to the Dakota Range project area, and it returned a result, shown in Figure 6, of "impacts not likely" to weather radar operations. However, a definitive determination is obtained only after the NTIA review process.

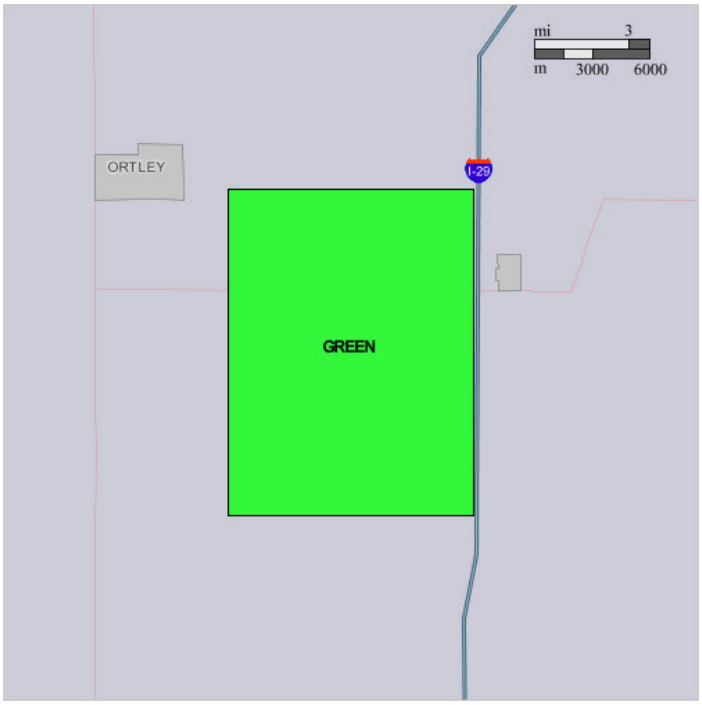

Figure 6 – NEXRAD Weather Radar Screening

Map Legend:

- **Green: No Impact Zone.** Impacts not likely. NOAA will not perform a detailed analysis, but would still like to know about the project.

5.3 Military Airspace

A preliminary review of the Dakota Range wind proposal does not return any likely impacts to military airspace. Confirmation and documentation from the Regional Environmental Coordination Office for the appropriate military branch can be obtained if requested.

5.4 NTIA Notification

Operation of RF frequencies for federal government use is managed by the National Telecommunication Information Agency (NTIA), which is part of the U.S. Department of Commerce. The technical specifications for most government facilities are unavailable to the public. In order to avoid the derailment of the wind energy project due to late objections from a government agency, the NTIA should be notified of the proposed project during pre-construction planning. The NTIA has set in place a review process, wherein the Interdepartmental Radio Advisory Committee (IRAC), consisting of representatives from various government agencies, reviews new proposals for wind turbine projects for impact on government frequencies. In almost all cases, no adverse impact is found, and IRAC usually issues a determination in about 60 days.

On September 18, 2018, this office sent a notification of the Dakota Range III wind project to the NTIA, and a determination is expected around the middle of November 2018.

VI. ELECTROMAGNETIC FIELDS FROM OVERHEAD POWER LINE

An assessment has been made of the expected levels of electromagnetic fields, commonly referred to as EMF, that would be emitted by the overhead transmission line to be built to interconnect the wind farm with the electrical grid.

The overhead transmission line to be built for the Dakota Range III wind project will be similar to one that has been proposed as one alternative design of the Huntley-Wilmarth 345 kV transmission line project in southern Minnesota. The transmission line for Dakota Range III will be a 345 kV voltage single circuit line using wood H-frame supports. The right-of-way will be 150 feet in width (75 feet from the center of the right-of-way to the edge). At 151.2 MW maximum wind farm power output, the maximum current in the 345 kV transmission line would be approximately 282 amperes.

In the Certificate of Need Application for the Huntley-Wilmarth project[7], dated January 17, 2018, tables and graphs were presented showing the calculated electric and magnetic fields near ground level over a range of distances from the transmission line for several alternative project designs. One of these designs involves a 345 kV single circuit with wood H-frame supports, the same as for the Dakota Range III transmission line project. Thus, the calculated values of electric

[7] This document is available at https://www.huntleywilmarth.com/staticfiles/microsites/hw/HW-Certificate-of-Need-Application.pdf.

and magnetic fields specified in the Huntley-Wilmarth Certificate of Need Application for the 345 kV single circuit with H-frame supports were used as reference for assessing the EMF values for the Dakota Range III project. The relevant data used for this assessment are in pages 131 through 136 of the Certificate of Need Application.

Using the Huntley-Wilmarth data as reference, the levels of electric and magnetic fields calculated for a 345 kV transmission line with H-frame supports at a maximum current of 282 amps are as follows (at a height above ground of 1 meter):

	Maximum in R.O.W.	Edge of R.O.W. (+/-75 ft)
Electric Field	2.58	1.24 kV/m
Magnetic Field	66.8 mG	15.3 mG

For the calculated magnetic fields, the data for the 345 kV single circuit H-frame "High Wind Utilization (375 MVA)" in Table 29 of the Huntley-Wilmarth application (page 134) were used. The values given in the table are for a current of 628 amps, so these were scaled down proportionally to derive the values at 282 amps (the maximum current of the proposed Dakota Range III line)[8].

There is no regulatory limit on electric field levels in the transmission line right-of-way in the state of South Dakota. However, the neighboring states of Minnesota and North Dakota have such limits, which are 8 and 9 kV/m, respectively. The predicted Dakota Range III transmission line's maximum electric field level, at 2.58, would be well below those limits.

Currently, only the states of Florida and New York have limits on magnetic field strength in the transmission line right-of-way. Both states limit the magnetic field to no greater than 200 milliGauss at the edge of the right-of-way. As seen in the table above, the Dakota Range III transmission line would fall well below this level.

There have been no federal standards established for power transmission line EMF. The EMF limits adopted by states (currently seven of them) are based on the desire to not increase levels of EMF that are currently encountered by the public. To date, after over 40 years of studies on the health effects of EMF, no scientific or health agency in the US or elsewhere has made a determination of a cause-and-effect relationship between exposure to low levels of EMF, such as from power lines, and risk to human health.

[8] The magnetic field strength from a conductive wire is directly proportional to the current through the wire.

VII. CONCLUSIONS AND RECOMMENDATIONS

1. One FCC-licensed microwave path crosses the project area which potentially affects turbine siting. According to the current planned turbine layout, no turbine would be sited so as to conflict with the path.

2. Because construction would commence more than six months from the date of this report, it is recommended that an updated microwave study be conducted prior to construction.

3. A search of the FCC's land mobile station database showed no land mobile or public safety stations in the turbine area. Thus, no such stations are expected to be adversely affected.

4. Over-the-air TV interference due to the wind turbines is not expected to be a significant problem. Effective mitigation methods to resolve any interference that may occur are available, with satellite or cable service installation providing the worst-case solution. No AM or FM radio broadcast facilities are likely to be affected.

5. The power transmission line to be built for the wind project would not produce EMF levels higher than those of similar projects that have been built or have been approved.

Respectfully Submitted,

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RF Impact Consultant

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