

CROWNED RIDGE WIND II POST-CONSTRUCTION SOUND MONITORING PROTOCOL



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Crowned Ridge Wind II Post-Construction Sound Monitoring Protocol

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1.0 INTRODUCTION

This is a Post-Construction & Complaint Sound Monitoring Protocol (the “Post-Con Protocol”) for Crowned Ridge II Wind (the “Project”) built in Codington, Deuel, and Grant Counties in South Dakota. Originally designed and permitted as a 300 MW project, only a 200 MW portion of the project commenced commercial operation in late 2020. The currently operating 200 MW project consists of eighty-eight (88) wind turbines: nine (9) GE 2.1 and seventy-nine (79) GE 2.3 wind turbines. The GE 2.1 models are at an 80-meter hub-height above ground level and the GE 2.3 models are 90 meters above ground level. Both wind turbine models have 116-meter rotor diameters. All wind turbines have low-noise trailing edges (LNTE) installed on the blades.

Noise complaints following the commercial operation of the Project prompted the South Dakota Public Utility Commission (“SD PUC”) to initiate a post-construction sound monitoring study to determine if the sound level attributable to the Project at surrounding residences are in compliance with the applicable noise standards. The basic methodology and conditions are stipulated in the project permit¹ (the “Permit”) issued by the SD PUC and additional SD PUC guidance.

This document details the methodology of the Post-Con Protocol and includes:

- The purpose and scope of the sound monitoring study;
- Proposed monitoring locations;
- Specifications for monitoring duration and instrumentation for data collection;
- Data collection and processing methodology; and
- A discussion of how data will be analyzed, presented, and reported.

¹ Wind energy permit EL19-027, South Dakota Public Utility Commission

2.0 NOISE COMPLIANCE ASSESSMENT

2.1 PERMIT CONDITIONS

Specification of the sound level metrics that shall be assessed for compliance are stated in of Condition #26 of the Project's Permit:

The Crowned Ridge Wind II Project (CRW II), exclusive of all unrelated background noise except for that associated with the pre-existing Crowned Ridge Wind I Project (CRW I), shall not generate a sound pressure level (10-minute equivalent continuous sound level, Leq) of more than 45 dBA as measured within 25 feet of any nonparticipating residence unless the owner of the residence has signed a waiver, or more than 50 dBA (10-minute equivalent continuous sound level, Leq) within 25 feet of any participating residence unless the owner of the residence has signed a waiver.

Subparts a) through f) of Condition #26 further specify the parameters for post-construction noise compliance assessment.

Additionally, methodology for the study was clarified and expanded by the SD PUC² in regard to the recent post-construction monitoring at the neighboring Crowned Ridge Wind I project:

- *require that the study and report focus on time periods near wind turbine shutdowns;*
- *modify the wind turbine shutdown procedure to perform four shutdowns daily at 1 :00 a.m., 7:00 a.m., 1 :00 p.m., and 7:00 p.m. for wind turbines within 1.75 miles of a measurement location shutdown, which is sufficient to conduct sound measurements at the three³ locations, and, which, also, can be modified, as requested, by the...acoustical consultant.*

² EL-19-003 (Crowned Ridge Wind I): Motion for Approval of Mitigation Plan (2021-03-18), which was subsequently approved by the SD PUC on 2021-04-09

³ Specific to Crowned Ridge Wind I

2.2 COMPLIANCE METHODOLOGY

Based on the Permit conditions and details outlined in Section 2.1, a summary of the methodology specified for this post-construction noise compliance study is as follows:

Sound levels and ground level wind speeds shall be continuously monitored at six locations for 14 days or more.

- Sound level meters shall be certified to meet the Class 1 accuracy requirements as specified in ANSI S1.4 and IEC 61672-1.

L_{10min} wind turbine sound levels will be assessed at monitoring locations 25 feet from residences.

- Several wind turbine shutdowns will occur nightly to assess the background sound levels ("Background"). Background sound levels will be determined by shutting down all wind turbines (including any wind turbines from CRW I) within 2.8 kilometers (1.75 miles) of a monitor location. After a background period of at least 10-minutes, the wind turbines will be restarted.
- Up to six 10-minute equivalent continuous sound levels (L_{10min}) will be measured before and after each shutdown with the wind turbines operating normally ("Total" sound levels). Periods more than 1 hour from a turbine shutdown will not be analyzed for compliance purposes.
- Background sound levels shall be removed from measured Total sound levels following ANSI S12.9 Part 3 Section 7.
- The noise limit for non-participating residences is 45 dBA and 50 dBA for participating residences). "Compliance shall be demonstrated if all samples are less than the limits."⁴
- The target condition for compliance includes, at a minimum, the 5 nearest turbines operating and the closest turbine operating within 1 dB of its maximum sound emission⁵

The specific application of this basic methodology is detailed in the following sections.

⁴ Condition #26, Subpart (f)

⁵ Condition #26, Subpart (e) i.

3.0 MONITORING LOCATIONS

3.1 SITE SELECTION

The Project Permit states that at least six monitoring locations shall be selected. For postconstruction sound monitoring, we selected seven locations. Three locations (LT2, LT3, and LT6) were selected for monitoring as a result of formal noise complaints registered at these residences. We selected the remainder using a geographically distributed sample of residences with the highest cumulative modeled⁶ wind turbine sound levels.

Monitoring locations are specified in the following section (Section 3.2). For most locations, an alternative is listed in case permission is not obtained for the preferred site. All non-participating residences will be contacted by the Public Liaison Officer to obtain permission to perform the monitoring on their property. Monitor deployment on non-participating parcels is contingent upon landowner consent. In the event that permission cannot be obtained for the primary monitoring site, the alternate will be utilized. If permission for either site cannot be obtained, the monitor location will be dropped from the study.

3.2 PROPOSED MONITORING LOCATIONS

The primary and alternate monitor locations are listed in Table 1, with modeled sound levels⁶ and coordinates provided. An overview of the geographic location of the proposed monitor locations is provided in Figure 1; detailed maps are provided in Appendix A.

TABLE 1: PROPOSED MONITORING LOCATIONS⁷

MONITOR	TYPE	RECEPTOR ID	PROJECT PARTICIPANT?	MODELED SOUND LEVEL (dBA)	LONGITUDE	LATITUDE
LT1	Primary	CR1-C13-NP	No	43.5	-96.9212	45.00648
LT1	Alternate	CR1-C11-P	Yes	44.9	-96.9172	45.00526
LT2	Primary	CR2-C132-NP	No	42.4	-96.8829	44.99933
LT3	Primary	CR2-C79-NP	No	41.4	-96.8831	44.99555
LT4	Primary	CR2-C97-NP	No	42.4	-96.9718	44.91922
LT4	Alternate	CR2-C98-NP	No	42.2	-96.9705	44.91953
LT5	Primary	CR2-D85-NP	No	44.1	-96.8511	44.91978
LT5	Alternate	CR2-D21-NP	No	43.8	-96.8514	44.93582
LT6	Primary	CR2-D221-NP	No	41.7	-96.8425	44.89467
LT6	Alternate	CR2-D14-NP	No	41.7	-96.8427	44.89501
LT7	Primary	CR2-D212-P	Yes	45.8	-96.8838	44.86177
LT7	Alternate	CR2-D12-NP	No	42.5	-96.8667	44.86183

⁶ EL19-027. Rebuttal Testimony of Jay Haley - Corrected Exhibit JH-R-1 - 01/24/20. "Proposed Array"

⁷ Coordinate reference is WGS 84.

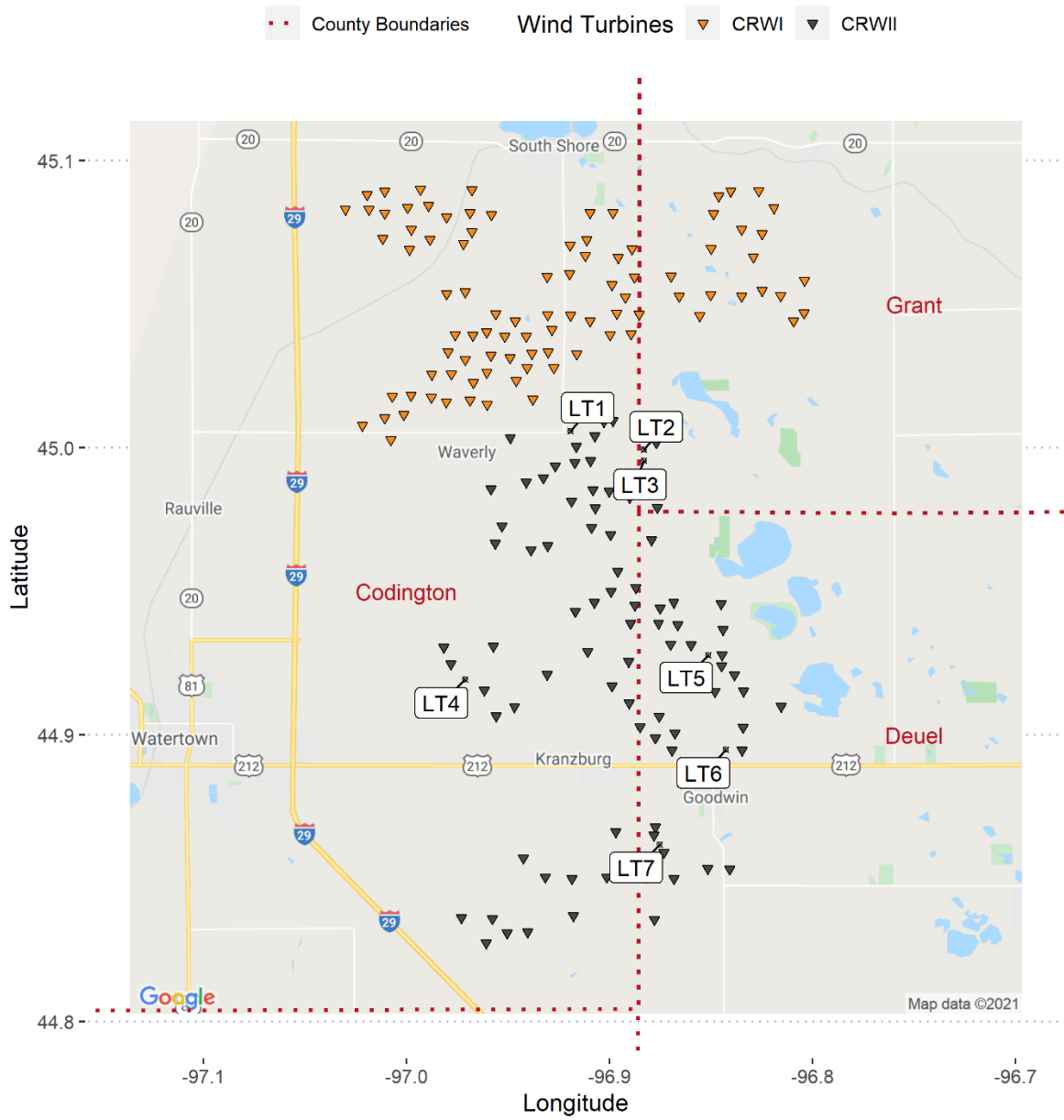


FIGURE 1: PROPOSED MONITOR LOCATION OVERVIEW MAP

4.0 DEPLOYMENT OF MONITORING STUDY

4.1 INSTRUMENTATION

Monitoring equipment at six sites will be deployed for a 14- to 21-day period in the spring of 2021. ANSI/IEC Class 1 sound level meters, logging 1/3 octave band sound pressure levels once each second, coupled with audio recorders to aid in sound source identification and soundscape characterization will be deployed. Anemometers will be located at all locations within 20 feet of the microphone at microphone height to measure wind speed. In addition, precipitation and wind direction will be measured at one location. Additional meteorological data will be obtained from a nearby National Weather Service station and project met tower.

4.2 SITING INDIVIDUAL MONITORS

Sound level meter microphones shall be micro-sited in accordance with the following criteria.

- 1) The microphone shall be fitted with a 7-inch diameter hydrophobic windscreen.
- 2) The microphone shall be placed outside, approximately 1.5 meters above the ground.
- 3) The microphone shall not be placed such that any structure blocks the line of sight between the microphone and otherwise visible wind turbines.
- 4) The microphone shall be located in such a way that it is representative of the noise exposure at the monitoring location.
- 5) The microphone at each site will be placed at least 7.7 meters (25 feet) from the nearest vertical reflective surface facing wind turbines, such as the wall of a building.

If, at a given site, any of these criteria interfere with the others, they shall take precedence in the order listed.

Each sound level meter shall be field-calibrated immediately before and after each monitoring period. Any calibration drift will be noted.

5.0 DATA COLLECTION AND PROCESSING

Overall equivalent continuous A-weighted sound levels and 1/3 octave band spectra⁸ will be logged at one-second time intervals over the entire monitoring period.

Additional supporting data to be logged or otherwise obtained during the monitoring period shall include:

- Wind and gust speed at 1.5 meters above ground level adjacent to each monitor on at least a 1-minute basis at each monitor;
- Wind direction and temperature in at least 1-minute intervals for at least one monitor;
- ASOS meteorological data from Watertown (KATY) or Brandt (WBRA), including regional wind speed and direction, temperature, and regional rainfall data (typically one-hour intervals); and
- Wind speed and power output as measured at each Crowned Ridge II turbines within 2.8 kilometers (1.75 miles) of each monitoring location in 10-minute intervals.⁹

Data shall be excluded from analysis if any of the following conditions occurs:

- Ground level wind gust speeds exceeding 5 m/s or creating notable contaminating noise;
- Ambient temperatures outside the specified limits of the monitoring equipment;
- Precipitation in the form of rain, sleet, or hail.¹⁰
- Humidity outside the monitoring equipment specifications.

The presence of contaminating sound caused by human or other nearby activity will only be eliminated if they occur during periods when the Turbine-only sound level is above the sound standard. Anomalous and invalid data will be determined by examining (listening to) the station's audio recordings and analyzing the spectrograms of logged sound levels.

All periods within 1-hour of a wind turbine shutdown will be evaluated for compliance; periods outside of this range will not be assessed for compliance due to insufficient background sound level information.

⁸ At a minimum, 1/3 octave bands from 20 Hz to 10,000 Hz.

⁹ Similar SCADA data from Crowned Ridge I wind turbines will be requested, but may not be made available to the noise consultant, or may be provided under a protective agreement.

¹⁰ Note that data are excluded for any period of precipitation, regardless of the rain rate, because of the self-noise induced on the microphone windscreen by droplets or hailstones. Periods of precipitation can be pinpointed at each monitor using spectrograms or audio recordings.

6.0 DETERMINATION OF COMPLIANCE

6.1 SHUTDOWN SPECIFICATION

Background sound levels shall be determined using turbine shutdown periods. To this end, all wind turbines from CRWI or CRWII within 2.8 km (1.75 mi) of each deployed monitoring station shall be shut down on several occasions each day.

Shutdown periods shall occur at night to limit background sound levels associated with anthropogenic activity and allow for atmospheric conditions that are most conducive to sound propagation (i.e., a temperature inversion and higher wind shear). The suggested nightly shutdown schedule is provided in Table 2. Wind turbines shall be shut down completely for at least 10 minutes. Wind turbine shutdowns do not need to occur when hub height wind speeds are below 8 m/s¹¹ or under foul weather conditions (e.g., rain, hail, etc).

TABLE 2. SUGGESTED NIGHTLY SCHEDULE OF SHUTDOWNS (24-HOUR TIME)¹²

	SHUTDOWN 1	SHUTDOWN 2	SHUTDOWN 3	SHUTDOWN 4
Shutdown Time	22:00	00:30	03:00	05:30
Startup Time	22:20	00:50	03:20	05:50

6.2 DETERMINATION OF WIND TURBINE-ONLY SOUND LEVELS

Sound levels measured during the periods up to one hour prior to and following each shutdown period shall be designated as “Total” (Turbine + Background).¹³ The sound levels measured during the shutdown period shall be designated as “Background.”

The sound level attributed to turbine operations shall be determined by subtracting, on an energy basis, the Background from the Total sound level, by 1/3 octave band, consistent with ANSI S12.9 Part 3 Section 7. Turbine-only sound levels determined by subtraction for a given shutdown period shall be considered of sufficient accuracy only if the overall Total sound level exceeds the Background sound level by at least 3 dB. If, after subtraction, the sound level attributed to turbine operations (Turbine-only) exceeds 45 dBA outdoors, audio recordings and other data will be examined to determine whether the wind turbine contributed to the sound received at the station. If applicable, anomalous sound sources will be excluded from the aggregation and the results will be recalculated.

¹¹ As determined by the power output from SCADA data and the manufacturer’s power curve.

¹² While the turbines are shut down completely for 10 minutes, 20-minute periods are provided in this table to allow for spin-down and spin-up.

¹³ Elevated sound levels for a few minutes may occur when wind turbines are abruptly started up after a manual shutdown. Therefore, the Total sound level period after the turbine shutdown will start three to five minutes after all turbines have restarted to allow time to return to normal operation.

7.0 REPORTING

A report will be submitted within six weeks of the end of the sound monitoring. It will include the following information:

- 1) Maps and descriptions of each monitoring location, including the distance from each to the nearest turbine.
- 2) A summary of all data collected presented as 10-minute time histories of overall A- and C-weighted sound levels, meteorological data at the monitoring stations, and turbine operating conditions associated with each monitor. Time periods that are more than 1-hour from a turbine shutdown will not be evaluated for compliance due to a lack of background sound level data.
- 3) A summary of the results of the turbine-only sound levels resulting from the shutdown analysis periods at each monitor.
- 4) An assessment of the Project's compliance with the permit based on the results of the shutdown analysis.
- 5) Appendix figures depicting the detailed time history results for the shutdown periods corresponding to the highest calculated wind-turbine only sound level for each monitor.
- 6) Appendix tables listing the conditions and results for each shutdown period for each monitor. The tables will include sound levels during and around each shutdown, calculated turbine-only sound levels for each valid period, and wind turbine conditions such as hub height wind speed, wind direction, and power output. Data will be reported for the closest turbine to each monitor as well as the average conditions at all wind turbines within 2.8 km (1.75 mi) of the specified monitor.

APPENDIX A. MONITOR LOCATION MAPS

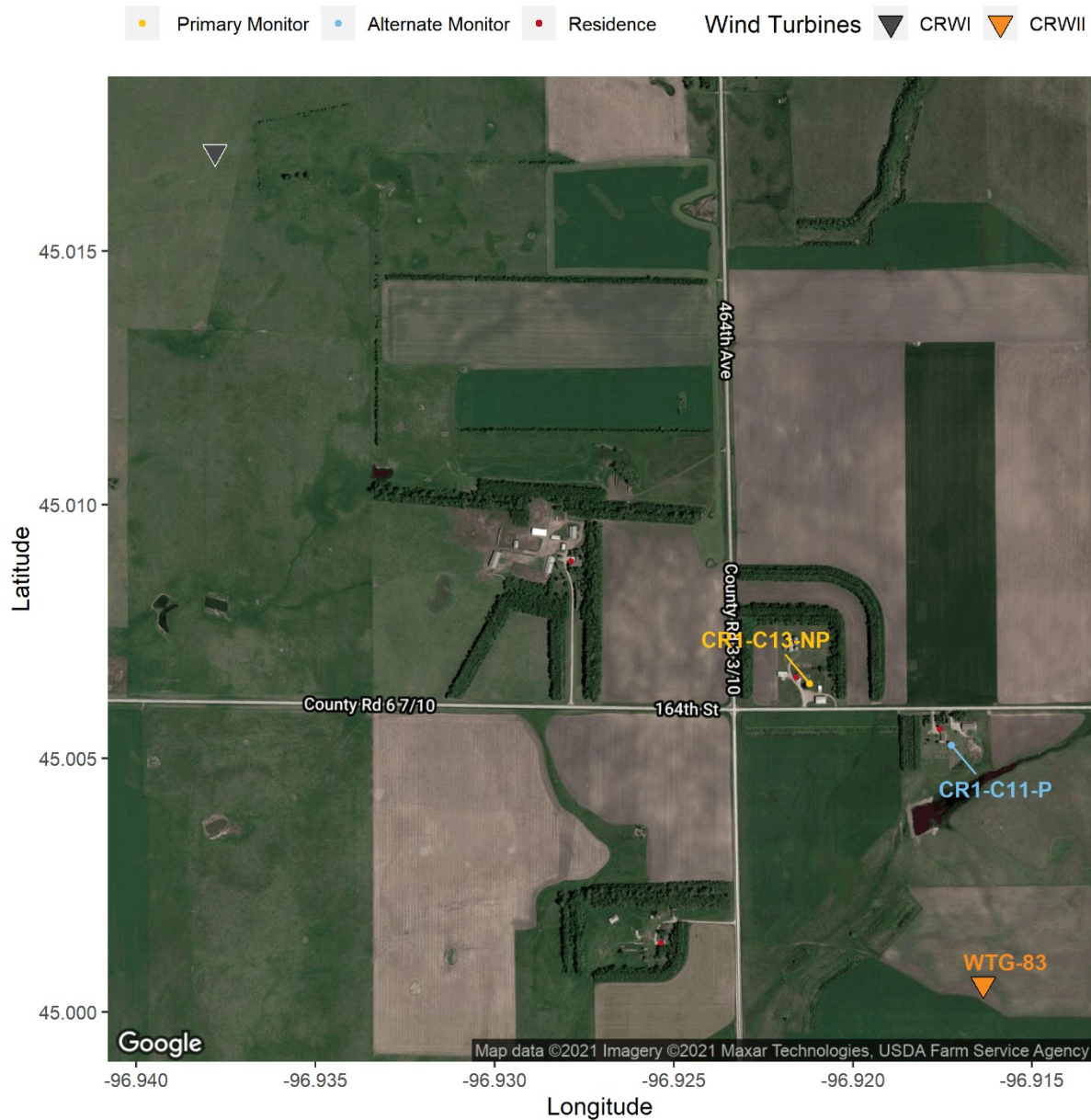


FIGURE 2: PROPOSED PRIMARY AND ALTERNATE MONITORING LOCATIONS (LT1)



FIGURE 3: PROPOSED MONITORING LOCATION (LT2)



FIGURE 4: PROPOSED MONITORING LOCATION (LT3)



FIGURE 5: PROPOSED PRIMARY AND ALTERNATE MONITORING LOCATIONS (LT4)

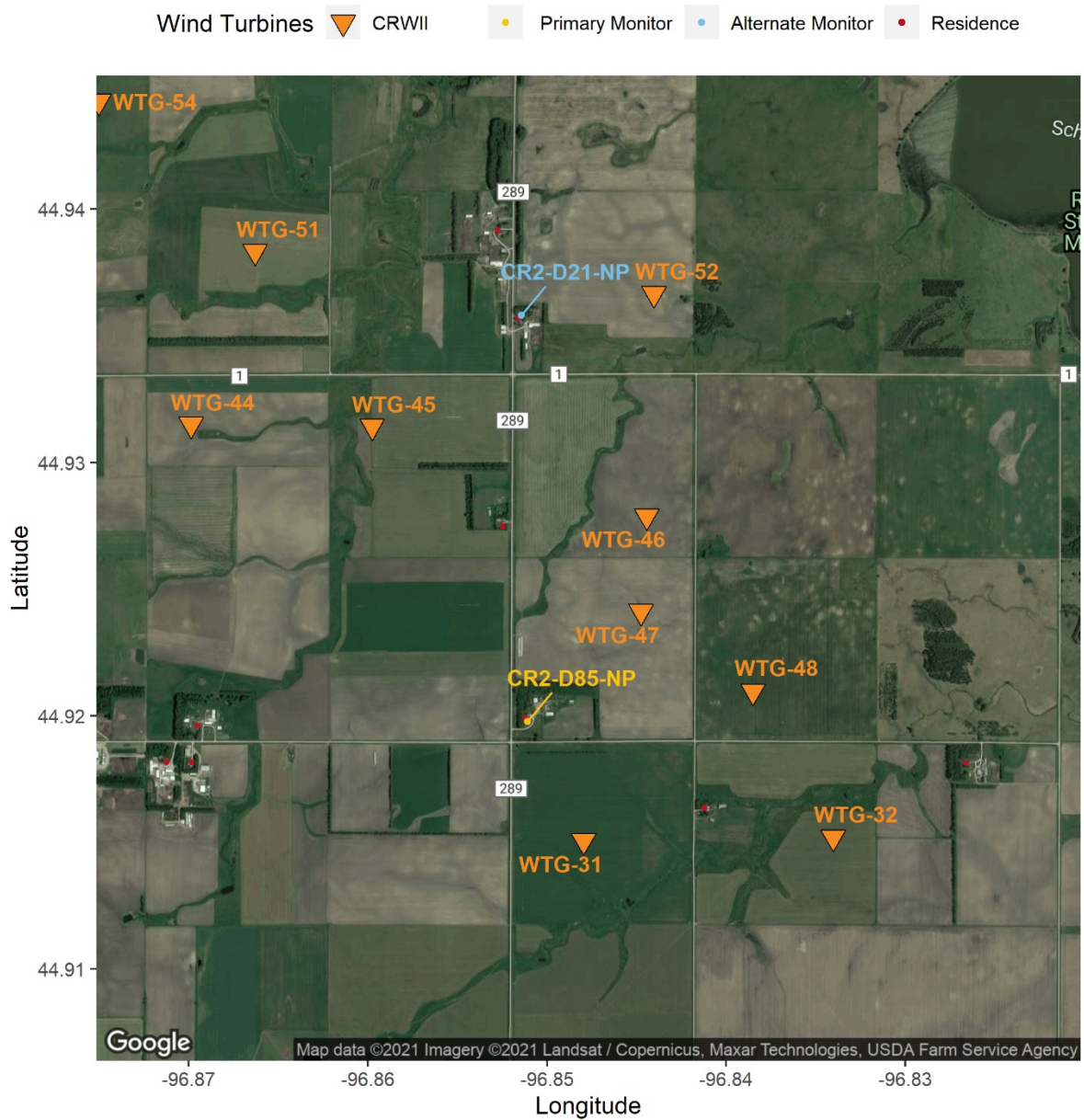


FIGURE 6: PROPOSED PRIMARY AND ALTERNATE MONITORING LOCATIONS (LT5)

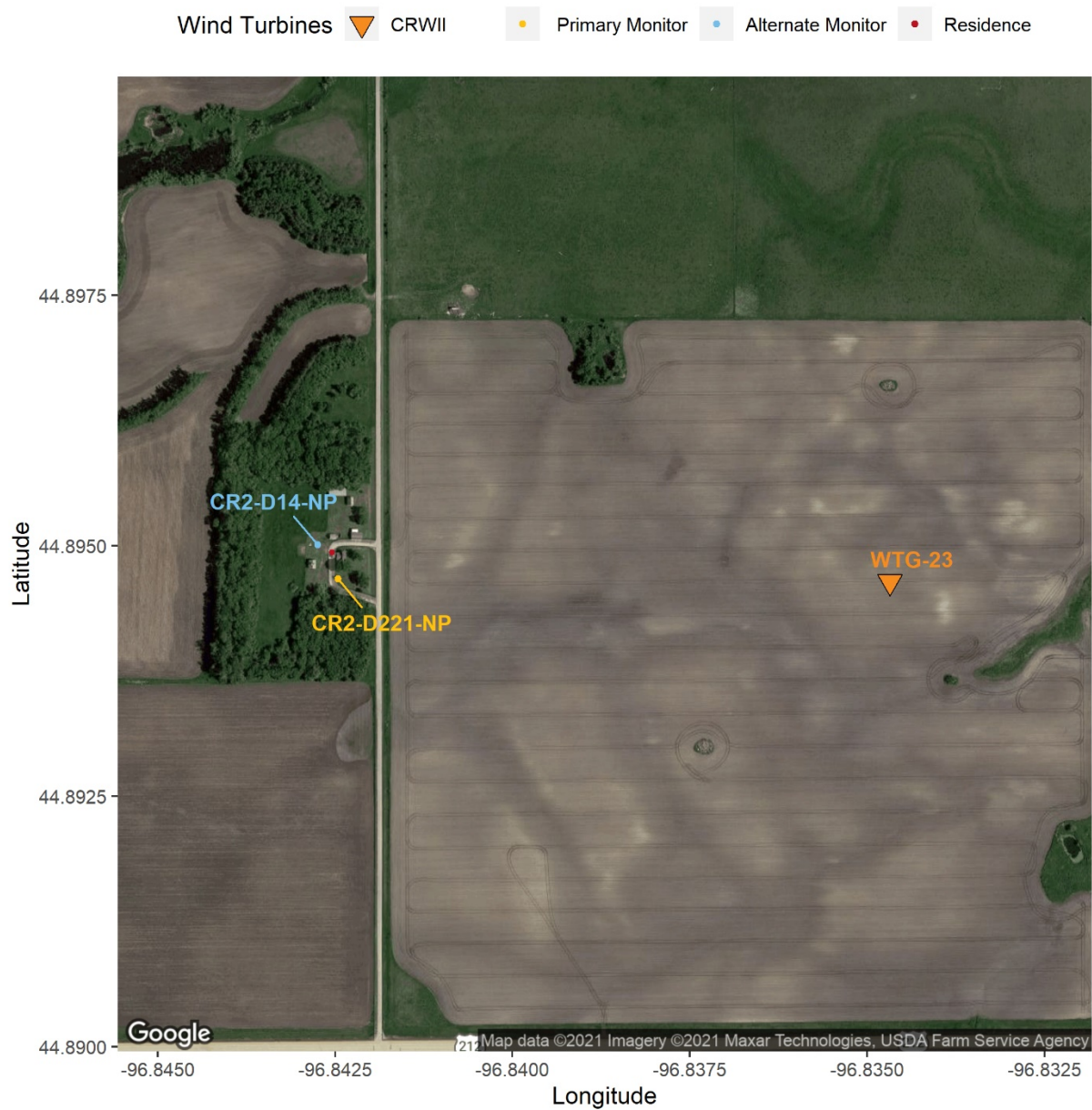


FIGURE 7: PROPOSED PRIMARY AND ALTERNATE MONITORING LOCATIONS (LT6)

The proposed LT6 monitor locations are north of US Highway 212 and just east of 468th Avenue.



FIGURE 8: PROPOSED PRIMARY AND ALTERNATE MONITORING LOCATIONS (LT7)

Both proposed monitoring locations for LT7 are located in Deuel county and are located immediately south of 174th Street. The Primary monitor for LT7 is located east of 466th Avenue, while the Alternate Location for LT7 is located west of 467th Avenue.

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