Appendix B – Noise Analysis

Pre-Construction Noise Analysis

for the proposed

Freeborn Wind Farm

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1. Introduction

This report describes the results of a pre-construction noise analysis conducted by Hankard Environmental for the proposed Freeborn Wind Farm (Project). The Project would be constructed in a primarily agricultural area in southern Freeborn County, Minnesota and northern Worth County, Iowa. Figure 1-1 shows the location of Minnesota portion of the Project. The Project would have a nameplate wind energy capacity of up to 84 megawatts (MW) in Minnesota, with up to 42 turbine sites. The remaining turbines would be located in Worth County, Iowa. The Project proposes to use two turbine types: the Vestas V116 and the Vestas V110, both of which are 2.0 MW models.

Per the Minnesota Public Utilities Comission (PUC) *Order Establishing General Wind Permit Standards* (January 2008), the "Project must meet Minnesota noise standards, Minnesota Rules Chapter 7030, at all residential receivers (homes)." Furthermore, the Minnesota Department of Commerce (DOC) *Application Guidance for Site Permitting of Large Wind Energy Conversion Systems in Minnesota* (August 2010) requires a description of ambient noise levels in the Project area, as well as the prediction of Project noise levels at all residences located in the Project area. To satisfy these requirements, Hankard Environmental conducted an ambient noise measurement survey to characterize existing noise levels, and conducted a noise modeling analysis to demonstrate that Project noise emissions will meet the State's limit of 50 dBA at residences, as well as other applicable limits. The following sections describe the applicable noise regulation, the Project and its environs, the results of the pre-construction ambient noise measurements, the methods and results of the noise modeling analysis, and an assessment of compliance with Minnesota Rule 7030.

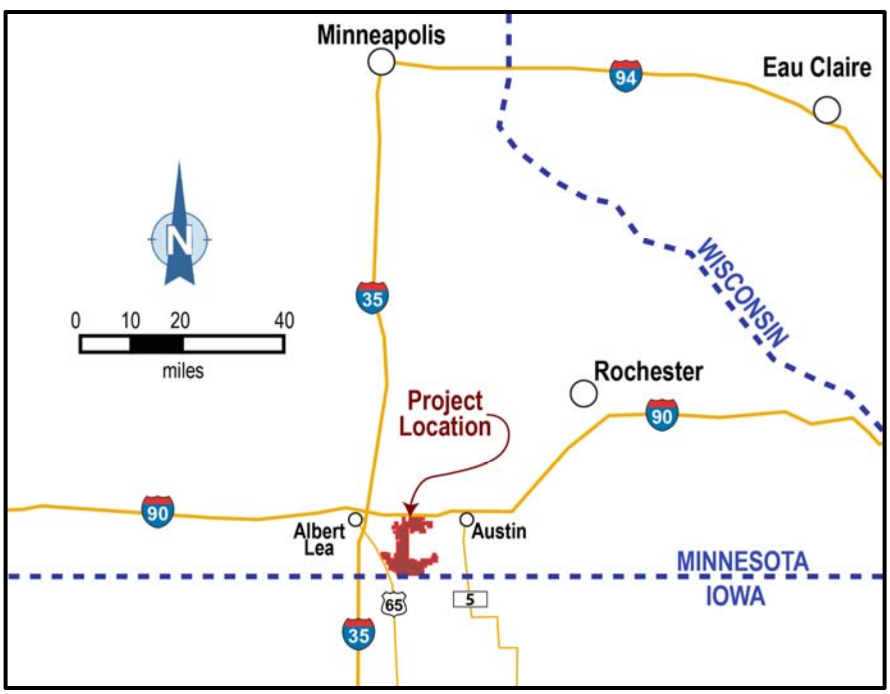

Figure 1-1. Location of the Proposed Freeborn Wind Farm

2. Applicable Regulation

Per the PUC's *Order Establishing General Wind Permit Standards*, the "Project must meet Minnesota noise standards, Minnesota Rules Chapter 7030, at all residential receivers (homes)." The Minnesota Pollution Control Agency (MPCA) is empowered to enforce the noise rules. As defined and more thoroughly explained in MPCA's *A Guide to Noise Control in Minnesota* (November 2015), noise level limits are set by the noise area classification (NAC) of the location where the noise is received. The classifications are based on land use. The most stringent limits are for NAC-1, which includes residential land use and campgrounds, as well as religious, educational, and medical uses. Higher limits are applied to business and commercial land uses (NAC-2), and higher limits still to agricultural land uses (NAC-3). NAC-4 includes undeveloped land, non-commercial forest, and water areas, but there are no associated limits.

Table 2-1 shows the State of Minnesota noise level limits (Part 7030.0040, *Noise standards*), which are expressed in terms of the A-weighted sound pressure level (dBA) using the one-hour L_{50} and the one-hour L_{10} noise level metrics. The L_{50} is the noise level exceeded 50% of the time over the measurement interval (one hour in this case), and the L_{10} is the noise level exceeded 10% of the time. The controlling limit on this Project is the nighttime L_{50} of 50 dBA because (1) wind turbines operate at any time of day, and turbine sound level output does not depend on the time of day, so meeting the lower nighttime limit guarantees meeting the daytime limit; (2) over the course of one hour, the L_{10} and L_{50} noise levels emitted by wind turbines are similar (within 3 dBA), but the L_{50} limit is more stringent (5 dB lower); and (3) given the layout of the Project and the noise-sensitive receptors that exist in the area, meeting the 50 dBA NAC-1 limit guarantees meeting the higher limits for NAC-2 and NAC-3. Thus, meeting the 50 dBA nighttime L_{50} limit at all NAC-1 receptors in the Project area guarantees meeting all other limits.

To demonstrate that the Project will meet MN Rule 7030 noise limits once in operation, noise levels were modeled, or predicted, at all of the NAC-1 and NAC-2 receptors located within approximately two kilometers of any Project wind turbine. Noise levels at more distant receptors will be lower than those reported herein, and will be well below the limits. Because the Minnesota noise limits are based on the use of land, not its zoning, compliance was assessed at each residence instead of the property line.

Table 2-1. Minnesota Noise Limits

Noise Area Classification	Daytime (7:00 am – 10:00 pm)		Nighttime (10:00 pm – 7:00 am)	
	1-Hour L_{10} (dBA)	1-Hour L_{50} (dBA)	1-Hour L_{10} (dBA)	1-Hour L_{50} (dBA)
1	65	60	55	50
2	70	65	70	65
3	80	75	80	75
4	None	None	None	none

3. Project Site

The layout of the proposed Freeborn Wind Farm is shown in Figures A-1 and A-2 in Appendix A. Included are the locations of the 42 proposed turbines in Minnesota, the 52 northernmost proposed turbines in Iowa, the location of the proposed collector substation, the location of each receptor where noise levels were predicted, and the locations where ambient noise levels were measured. The geographic coordinates of each Project noise source (turbines and substation transformers) and each receptor are provided in Appendix B and C, respectively.

The Project is located in south-central Minnesota and northern Iowa, which consists of primarily agricultural land. A detailed field reconnisance survey and review of aerial photographs was conducted by the Project to identify all NAC-1 and NAC-2 receptors located within approximately two kilometers of any Minnesota turbine in the Project area. Noise levels at more distant receptors will be lower and therefore in compliance with the limits. In Minnesota, a total of 251 NAC-1 receptors were identified, including 249 residences and two churches. Three NAC-2 receptors were identified in Minnesota, including one town hall and two businesses. Receptors in Iowa were also identified, but were not included as part of this analysis.

4. Ambient Noise Level Survey

Ambient noise levels were measured in the Project area, as required by the DOC *Application Guidance for Site Permitting of Large Wind Energy Conversion Systems in Minnesota*. The survey followed the procedures prescribed by the National Association of Regulatory Utility Commissioners (NARUC) guidance document prepared for the Minnesota PUC (*Assessing Sound Emissions from Proposed Wind Farms & Measuring the Performance of Completed Projects*, October 2011).

Note that the results of this survey are not to be used for the purpose of establishing the pre-existing environmental sound level as a baseline against which to compare the measured sound emissions from the completed Project. The background sound level varies dramatically with time, typically over a dynamic range of 30 dBA or more, depending not only on the wind speed but many other factors, such as the prevailing atmospheric conditions, the time of day, season of the year, etc., so the level measured one or two years earlier cannot be taken to accurately represent the background level present during an operational compliance test.

Following the NARUC best practices, ambient noise levels were measured in the Project area in order to characterize the existing acoustic environment as it relates to wind turbine operations. The following sections describe the noise measurement method and equipment employed on this survey, the locations where noise levels were measured, the results of attended measurements, and the results of unattended measurements.

Methodology

Wind turbine projects are unique in the field of environmental acoustics in that operations are correlated with the wind speed at hub height, and ambient noise level is correlated with the wind speed at the ground. In general, the ground and hub-height wind speed are correlated, with wind speed increasing with height according a consistent mathematical formula. The nights when it is very calm and quiet at the ground will, in general, be the nights when the turbines do not operate because there is not enough wind at hub-height. Nights of full operation will often have blustery winds at ground level, causing ambient noise levels to be louder due to the rustle of vegetation. Occasionally, upper-level winds enable full operation while ground winds (and therefore ambient noise levels) are relatively low.

Because the wind speed varies with height, it is important to note the height at which a given speed was measured. In order to allow comparison of wind speeds measured at different heights, the speed values are commonly "normalized" to a standard measurement height according to the known mathematical relationship. In keeping with industry practice and the method outlined in the NARUC document, upper-level wind speeds for this ambient survey were recorded from meteorological towers in the Project area, then normalized to a standard measurement height of 10 meters (33 feet). This normalization used the formulas published in the International Electrotechnical Commission (IEC) standard IEC 61400-11(2002) *Wind turbine generator systems – Part 11: Acoustic noise measurement techniques*.

As noted above, wind turbine noise output is correlated with the hub-height wind speed. Below the cut-in wind speed, there is not enough wind for the turbine to operate, and the blades will not rotate. As the wind speed increases, the blades spin faster and turbine acoustic emission increases. At the critical wind speed, the hub has reached its maximum rated rotational speed, and acoustical output is at its maximum. At the full-power wind speed, the turbine produces its maximum rated electrical power, but the acoustical emission is not significantly higher than at the critical wind speed. Because the upper-level wind speed varies over time, ambient survey measurements must be made over a sufficient interval to cover the range of wind speeds that occur in the area – generally two weeks.

The survey methodology consists of measuring ambient noise levels at representative locations, along with simultaneous upper-level wind speeds and ground wind speeds. Noise levels were measured continuously over a two-week period at the five representative residences shown in Appendix A. The data were then sorted into daytime and nighttime categories, with the focus on nighttime due to the lower noise limits and potential for impacts to residents. Periods of precipitation were removed from the analysis, as were times when the noise levels were clearly not correlated to wind (such as traffic, lawn mowing, and equipment calibration checks).

The resulting ambient noise levels (10-minute L_{90}, dBA) were correlated with hub-height wind speeds (normalized to the standard measurement height of 10 meters). The regression curve fit was performed separately for each measurement site.

Ambient noise levels were measured and analyzed according to applicable portions of American National Standards Institute (ANSI) S12.9-2013/Part 3 *Quantities and Procedures for Description and Measurement of Environmental Sound – Part 3: Short-term Measurements with an Observer Present*, as well as ANSI S12.18-1994(R2009) *Procedures for Outdoor Measurement of Sound Pressure Level*. The ambient noise survey was also conducted in accordance with the NARUC document *Assessing Sound Emissions from Proposed Wind Farms & Measuring the Performance of Completed Projects*.

The noise measurement systems were installed at each site between March 21 and March 22, 2017, and visited again between March 22 and March 23 to confirm successful installation and data logging. All meters were time-synchronized to the clock at the National Institute of Standards and Technology and the U.S. Naval Observatory via www.time.gov, which is the synchronization source for Invenergy's meteorological measurement towers, to allow for the integration of noise and ground wind data with upper-level wind data. The meters were configured to continuously measure and record the 10-minute values of the L_{50}, L_{10}, L_{90} and L_{eq}, as well as one-third octave band levels. Two full weeks of data were collected.

Equipment

Ambient sound levels were measured using Larson Davis sound level meters, all of which conform to Type 1 specifications for sound level measurement systems as defined in ANSI S1.4-1983(R2006), *American National Standard Specification for Sound Level Meters*. All noise measurement and field calibration equipment was certified by a traceable laboratory within the past year. Laboratory calibration certificates and records are available upon request. Field calibrations were conducted upon equipment installation and retrieval with a Larson Davis CAL200 speakerphone calibrator, and the drift in the measured noise level was minimal (-0.2 to +0.2 dB over the measurement period) and within accepted limits (±0.5 dB per ANSI S12.9).

At each measurement location, the microphone was mounted on a steel pole and positioned 1.5 meters above the ground (per ANSI S12.9), in an open area, and away from acoustically reflective surfaces. The microphones were covered with hydrophobically treated seven-inch-diameter 80 pores-per-inch density windscreens (ACO Pacific model WS7-80T). All electronic equipment was contained in weatherproof locked cases, and was self-powered by batteries with solar panels.

At three of the locations, anemometers were also installed. Ten-minute averages of ground wind speed and direction were measured using Vaisala WXT532 or WMT52 sonic anemometers mounted on steel poles approximately 2 meters (6 feet) above the ground (per ANSI S12.18), and located within approximately 3 meters of the microphones. Upper-level wind speed and direction were provided by Invenergy from ongoing measurements at two 58-meter-tall meteorological towers located in the Project area.

Measurement Locations

The purpose of the measurements was to obtain a representative sample of the pre-construction environment in the Project area. Hankard Environmental staff chose the specific locations based on standard industry procedures, analysis requirements, aerial photograph surveys, access to sites via Project land agreements, and in-person site visits. Measurement locations are shown in Figures A-1 and A-2 in Appendix A. The locations are geographically scattered throughout the study area, with some located near Interstate 90 or other major roads, and some located away from any such sources.

Location M1

Measurement location M1 is in the side yard of the single-family house at 86904 200th Street. It is representative of other residences in the north end of the Project area, which experience ambient noise from traffic on Interstate 90. The parcel on which the house sits is bordered by mature trees to the east, north, west, and southwest. The parcel is surrounded by fields, but no farming activity was observed in the area during site visits. The microphone was placed approximately 9 meters southwest of the southwest corner of the house, with a small stand of trees between the microphone stand and 200th Street to the south. At the time of installation, audible sources of noise included wind, wind in trees, occasional automobile pass-bys on unpaved 200th Street, and intermittent distant traffic on Interstate 90, which is approximately one mile north of the house.

Location M2

Measurement location M2 is on the lawn in the middle of the circular driveway at 18311 850th Avenue. It is representative of residences adjacent to active farming and industrial activity, but which do not have significant noise contributions from either Interstate 90 or railroads. The north side of the lot is a garage and staging area for farming vehicles, and the entire lot is surrounded by rows of trees. The microphone was placed approximately 35 meters (115 feet) north of the single-family house on the lot. At the time of installation, audible sources of noise included wind and occasional auto pass-bys on paved 850th Avenue to the east.

Location M3

Measurement location M3 is in the farmyard of 12371 880th Avenue. It is representative of residences near the south of the Minnesota area of the Project that do not have signicant influences from traffic. In addition to a single-family house, there are many outbuildings on the lot, including sheds, milkhouses, garages, and a barn. The microphone was placed approximately 15 meters (50 feet) west of the house and 12 meters (40 feet) southeast of a shed. At the time of installation, audible sources of noise included chickens, ducks, a dog, wind, slamming shed doors, and very occasional auto pass-bys on unpaved 880th Avenue.

Location M4

Measurement location M4 is in the side yard of the house at 84214 110th Street. It is representative of residences in the southern Project area without influences from nearby farm or industrial activity. There are scattered trees in the back yard, and one large oak tree in the front yard. The microphone was placed approximately 15 meters (50 feet) southeast of the house and approximately 26 meters (85 feet) southwest of a large garage on the east side of the lot. At the time of installation, audible sources of noise included wind and very occasional auto pass-bys on paved 110th Street.

Location M5

Measurement location M5 is in the side yard of 13440 810th Avenue. This site is approximately 900 meters east-northeast of U.S. Route 65 and an active Union Pacific rail line parallel to Route 65. It is representative of residences near Glenville that are significantly influenced by noise from Route 65 and the railroad. The lot is bordered by trees on the south and the west, and has scattered trees to the northeast. The microphone was placed approximately 20 meters (65 feet) southwest of the two-story house. At the time of installation, audible sources of noise included wind, wind in trees, vehicle pass-bys on 810th Avenue and Route 65, and freight trains on the rail line.

Attended Measurement Results

In addition to equipment checks, each measurement location was visited twice during the measurement period, once during daytime hours and once during nighttime hours. During each visit, weather conditions (wind speed, air temperature, and relative humidity) and audible sources of sound were noted for two ten-minute intervals. These observations are summarized in Table 4-1. In addition to occasional traffic on local roads and aircraft overflights, common audible sounds included wind in trees, wildlife vocalizations, and dogs. Due to its proximity to Interstate 90, I-90 traffic was audible at M1 during every observation period. Similarly, trains and semi truck pass-bys were clearly audible at M5.

Table 4-1. Attended Ambient Measurement Summary

Location	Type	Temp (F)	Rel Hum (%)	Wind Speed (mph)	Date	Time	Audible Sounds
M1	Night	50	44	1	4/4/17	23:20-23:30	traffic on I-90 distant dog, trees in wind
						23:30-23:40	traffic on I-90, distant dog
	Day	51	49	6	4/5/17	14:00-14:10	traffic on I-90, birds prop aircraft, breeze
						14:10-14:20	traffic on I-90 birds, prop aircraft
M2	Night	58	53	calm	4/4/17	22:20-22:30	jet overflight, distant traffic
						22:30-22:40	distant traffic, frogs
	Day	52	48	1	4/5/17	17:30-17:40	birds, whippoorwil prop aircraft, auto pass-bys
						17:40-17:50	birds, distant traffic jet aircraft, wind in trees
M3	Night	49	63	3	4/5/17	00:10-00:20	frogs, slight wind
						00:20-00:30	frogs, breeze, distant auto
	Day	48	44	5	4/6/17	12:20-12:30	wind, trees in wind, birds, ducks, rooster door creaking, distant jet
						12:30-12:40	wind, wind in doorway birds, ducks, chickens prop aircraft, auto pass-by
M4	Night	44	65	4	4/5/17	01:00-01:10	wind in oak, frogs, birds
						01:10-01:20	wind in oak, frogs, distant dog
	Day	50	55	7	4/5/17	16:10-16:20	wind, wind in oak auto pass-bys, bird
						16:20-16:30	wind, wind in oak distant train horn prop aircraft
M5	Night	45	64	1	4/5/17	01:40-01:50	fluorescent light hum train horns & rumble
						01:50-02:00	light buzz, geese train horns & rumble
	Day	38	57	4	4/6/17	09:30-09:40	wind, wind in trees, birds auto & truck pass-bys
						9:40-09:50	wind, wind in trees, birds distant traffic, jet aircraft

Unattended Measurement Results

Plots of the noise levels measured over time at each location are shown in Appendix D (Figures D-1 through D-5). Figure D-1 includes the periods that were excluded from the analysis because noise levels were clearly correlated to non-wind factors. Figures D-2 and D-3 includes the periods that were excluded from the analysis because no sound level data was available. Figures D-6 through D-10 show the resulting noise level versus wind speed regression plot for each location.

Table 4-2 gives the observed ambient noise levels for three upper-level wind speeds: cut-in (approximately 2.2 meters per second measured at the standard height of 10 meters), critical (approximately 7.2 meters per second measured at 10 meters), and full turbine power output (approximately 10 meters per second at 10 meters). The cut-in values represent calmer conditions when turbines would be just beginning to operate, and as expected the ambient noise levels are relatively low. The critical wind speed is that at which turbines would operate near full acoustic output, yet ground winds would still be moderate. Ambient noise levels under these conditions range from approximately 30 to 40 dBA. At full turbine power output, the turbines would be producing full acoustic emissions. Ambient noise levels under these conditions range from approximately 45 to 50 dBA.

Table 4-2. Observed Nighttime Ambient Noise Levels

Measurement Location	Measurement Period		Average 10-Min L_{90} (dBA)		
	Start	Stop	Cut-In	Critical	Full Power
M1	3/21 17:00	4/05 14:40	30	41	50
M2	3/22 15:00	4/05 18:00	25	36	47[†]
M3	3/22 11:00	4/06 12:50	23	29	44
M4	3/22 14:00	4/05 16:50	29	36	50
M5	3/23 10:00	4/05 8:40	28	33	51

[†] 10 m/s @ 10 m not observed, fit from curve

5. Noise Modeling Methodology

Noise levels from the operation of the proposed Freeborn Wind Farm were predicted using the modeling method set forth in the International Organization for Standardization (ISO) Standard 9613-2, *Attenuation of Sound During Propagation Outdoors - Part 2: General method of calculation*. The method was implemented using the SoundPLAN v7.4 acoustical modeling software program, and cross-checked with a spreadsheet calculation. A sample view of the SoundPLAN model is shown in Figure 5-1.

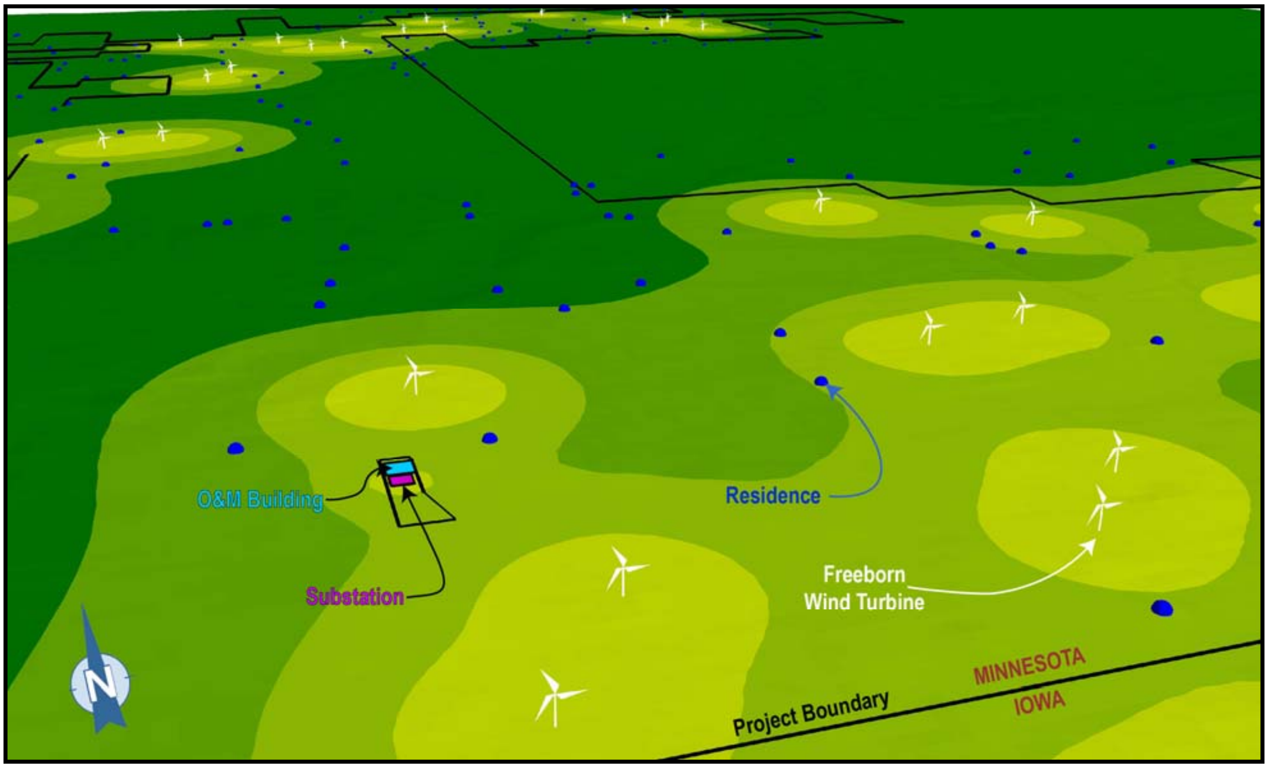

Figure 5-1. Sample View of SoundPLAN Noise Model

Model Inputs

There are a number of parameters in the ISO 9613-2 method, including the location of the noise sources and receivers, noise source characteristics, terrain and ground type, and atmospheric propagation conditions. The ISO method assumes optimal acoustic propagation in all directions, specifically that a "well-developed, moderate ground-based temperature inversion" is present or, equivalently, that all receptors are downwind of all noise sources at all times. The specific ISO 9613-2 settings used in the analysis are described below.

Receptors

In the SoundPLAN model, prediction points were located at each of the NAC-1 and NAC-2 receptors located within approximately two kilometers of any Project wind turbine in Minnesota. This includes 249 residences and 2 churches (total of 251 NAC-1 receptors), as well as 2 businesses and 1 government facility (total of 3 NAC-2 receptors). The geographic coordinates of these buildings were provided by Merjent, Inc., and are based on a thorough on-site review of land use in the Project area. The ground elevation for each point was determined using Digital Elevation Model (DEM) data from the U.S. Geological Survey (USGS) National Elevation Dataset. In accordance with ISO 9613-2, the height above the ground for each receiver was set to 1.5 meters (5 feet). All modeled locations are shown in Figures A-1 and A-2. The geographic coordinates, ground elevation, and NAC of each modeled location are listed in Appendix C.

Wind Turbine Locations and Sound Power Levels

Noise levels were predicted assuming the full operation of all 42 Project turbines located in Minnesota (Layout 058) and the 52 northernmost (within 10,000 feet) Project turbines located in Iowa (Layout 051, revision 1). More distant Iowa turbines will not contribute any significant noise to receptors in Minnesota. The ground elevation for each turbine location was determined using DEM data from the USGS National Elevation Dataset. The modeled turbines are mapped in Figures A-1 and A-2, and Appendix B lists their coordinates and ground elevations.

In the SoundPLAN model, each turbine was represented as an acoustical point source located at its hub height, which is 80 meters (262 feet) above the ground. No directivity was applied to the noise sources, thus assuming maximum acoustic output in all directions. All turbines were assumed to be Vestas V116-2.0 units, with the exception of nine that were assumed to be Vestas V110-2.0 units. The nine V110-2.0 turbines are T18, T23, T29, T33, T34, T41, T42, T47, and T204. All turbines were assumed to be operating at full acoustic output (wind speed of 12 meters per second measured at hub height), in normal operating mode, and fitted with standard blades. The turbine sound power levels used in the analysis are listed in Table 5-1, and were provided by Vestas (*V110-2.0 MW Third octave emission* – document DMS 0059-4340_01 and *V116-2.0 MW Third octave emission* – document DMS 0063-4593_01).

Table 5-1. Source Sound Power Levels

Noise Source	Octave Band Sound Power Level (dB)									Overall Sound Power Level (dBA)
	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1,000 Hz	2,000 Hz	4,000 Hz	8,000 Hz	
Vestas V116-2.0	116.3	112.5	107.1	103.4	104.3	105.4	103.3	97.4	84.4	109.5
Vestas V110-2.0	116.3	113.4	109.5	105.1	103.3	102.9	101.0	94.5	80.5	107.6
120 MVA transformer	90.0	95.8	97.7	92.2	92.8	86.6	81.4	76.6	69.7	93.0

The Vestas sound power levels were determined according to International Electrotechnical Commission standard IEC 61400-11:2012 *Wind Turbines – Part 11: Acoustic noise measurement techniques*. This standard requires sound power levels to be reported for a number of wind speed bins across the operating range of the turbine. In general, emitted sound levels increase with increasing winds speeds, up to approximately 10 meters per second at hub height (approximately 7 meters per second when measured at the standard height of 10 meters). Noise levels do not further increase above this wind speed because the turbines reach a maximum rotational speed.

Note that the IEC 61400-11 standard requires the measurement of noise levels using a one- to 10-minute average noise level, which in acoustics is called the equivalent level (L_{eq}). Thus, in effect, the noise levels predicted using this input data are also in terms of the L_{eq}. However, the Minnesota noise standards are in terms of statistical levels (L_{50} and L_{10}). In theory, for a continuously operating wind turbine, the L_{eq} and L_{50} are almost identical over the time period of interest (one minute in the case of the IEC 61400-11 measurements, and one hour in the case of the Minnesota regulation). Thus, one-hour L_{eq} and L_{50} wind turbine noise levels are considered equivalent for the purposes of this analysis.

Collector Substation

The Project's collector substation will contain transformers, switch gear, metering, electrical control and communication systems, and other equipment required to transform Project wind generated power from 34.5kV to 161kV. The only significant noise-producing equipment are the tranformers (estimated be two 120 MVA transformers). The analysis assumed the simultaneous operation of both 120 MVA transformers at the substation. The substation location is shown in Figure A-2, and transformer coordinates are listed in Appendix B. Ground elevations for the transformers were determined using the USGS National Elevation Dataset. The transformers were modeled as point sources located 3 meters (10 feet) above the ground, with no barriers or directivity reductions. The spectral shape of transformer noise emissions was estimated using published data and adjusted to match the overall sound power level of 93 dBA, which is a typical level estimated by major utility-scale transformer suppliers. The resulting octave band sound power levels are listed in Table 5-1.

Terrain and Ground Effect

Terrain in the Project area was modeled by importing ground elevations contained in National Elevation Dataset digital elevation model files. However, all long-distance terrain barrier effects were removed to keep the analysis conservative and predict the loudest potential noise levels. The acoustical effect of the ground material was modeled using the ISO 9613-2 General Method. This method requires the selection of ground factors for the ground near the source, near the receiver, and in between. A ground factor of 0.0 represents a completely reflective surface such as pavement, which would result in a higher level of sound reaching a receiver. A ground factor of 1.0 represents absorptive ground such as thick grass or fresh snow, resulting in a lower level of sound reaching the receiver. For this Project, a ground factor of 0.0 (completely reflective) was used to be conservative. Actual ground conditions could, at rare times, be 0.0 when the ground is completely frozen and bare, but would generally be closer to 0.5 when the ground is covered with vegetation or is bare and unfrozen.

Atmospheric Conditions

The air temperature, relative humidity, and atmospheric pressure were set to standard day conditions of 10°C, 70%, and 1 atmosphere, respectively. Per ISO 9613-2, these values result in the least amount of atmospheric sound absorption and the highest levels of sound reaching the receivers.

Validation of Noise Prediction Method

The noise level modeling method employed on this Project has been validated by many acoustical consultants, including Hankard Environmental. Hankard Environmental has conducted numerous wind turbine noise level compliance surveys, and routinely compares the results of these measurements with corresponding predicted levels using the same methods employed on this Project. We consistently find that our predicted levels are higher than measured levels, or equal to the very loudest measured levels.

Additionally, the validation compares predicted levels to the very highest measured turbine-only noise levels. A majority of the time, turbine noise levels will be less than those predicted. This is because, in addition to the conservative ground attenuation factor and atmospheric conditions entered into the model, sound levels were calculated assuming maximum turbine operations (which will not always be the case), and the model assumes optimal propagation conditions (i.e. that all receivers are downwind of all turbines at all times – a physical impossibility).

6. Predicted Noise Levels

Noise levels from the full and continuous operation of the Freeborn Wind Farm were predicted at each of the NAC-1 and NAC-2 receptors in the Project study area. Figures A-1 and A-2 show the predicted noise level contours for the study area. The predicted noise level at each receptor is listed in Appendix E. The predicted noise levels are less than 50 dBA at all NAC-1 and NAC-2 locations. For informational purposes, Table 6-1 lists the non-participating receptors where noise levels are within 5 dBA of (but still below) the limit.

Table 6-1. Non-Participating Receptors with Highest Predicted Noise Levels

Receptor ID	Level (dBA)	Receptor ID	Level (dBA)	Receptor ID	Level (dBA)	Receptor ID	Level (dBA)
R190	48.9	R282	46.9	R320	46.4	R336	45.4
R317	47.2	R326	46.7	R220	46.2	R337	45.3
R323	47.2	R315	46.6	R78	45.5	R318	45.0
R228	47.0	R316	46.6	R320	46.4		

Given the conservative nature of this analysis, it can be confidently concluded that maximum turbine noise emissions from the Freeborn Wind Farm will not exceed State of Minnesota limits under any conditions, and a majority of the time turbine noise levels will be well below the limits. Much of the time, wind turbine noise levels will be less than those described herein. This could occur when turbines are operating at less than full acoustic power, during the daytime when propagation conditions are less favorable, during those nights where there is no temperature inversion or wind gradient, and those times when residences are upwind of the nearest turbines.

These results are valid for the turbine layout analyzed, the receptor locations provided, and the sound power levels provided. If the Project Applicant changes the layout or turbine type, chooses alternative turbine sites, and/or employs different turbine operating modes or blades, this noise analysis should be updated accordingly and compliance should again be demonstrated.

APPENDIX A

Project Site Plan and Predicted Noise Level Contours

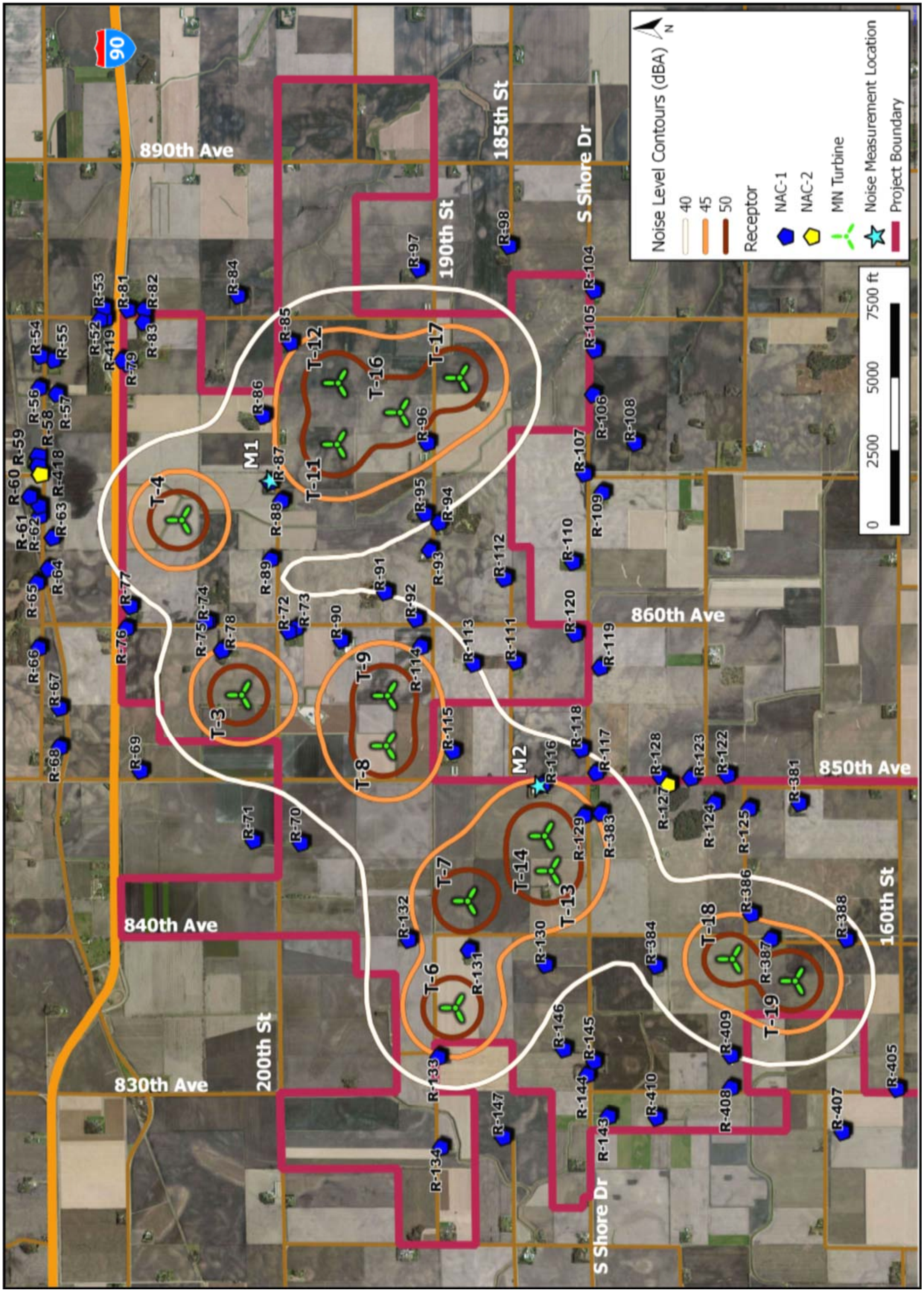

Figure A-1. Northern Site Plan and Predicted Noise Level Contours

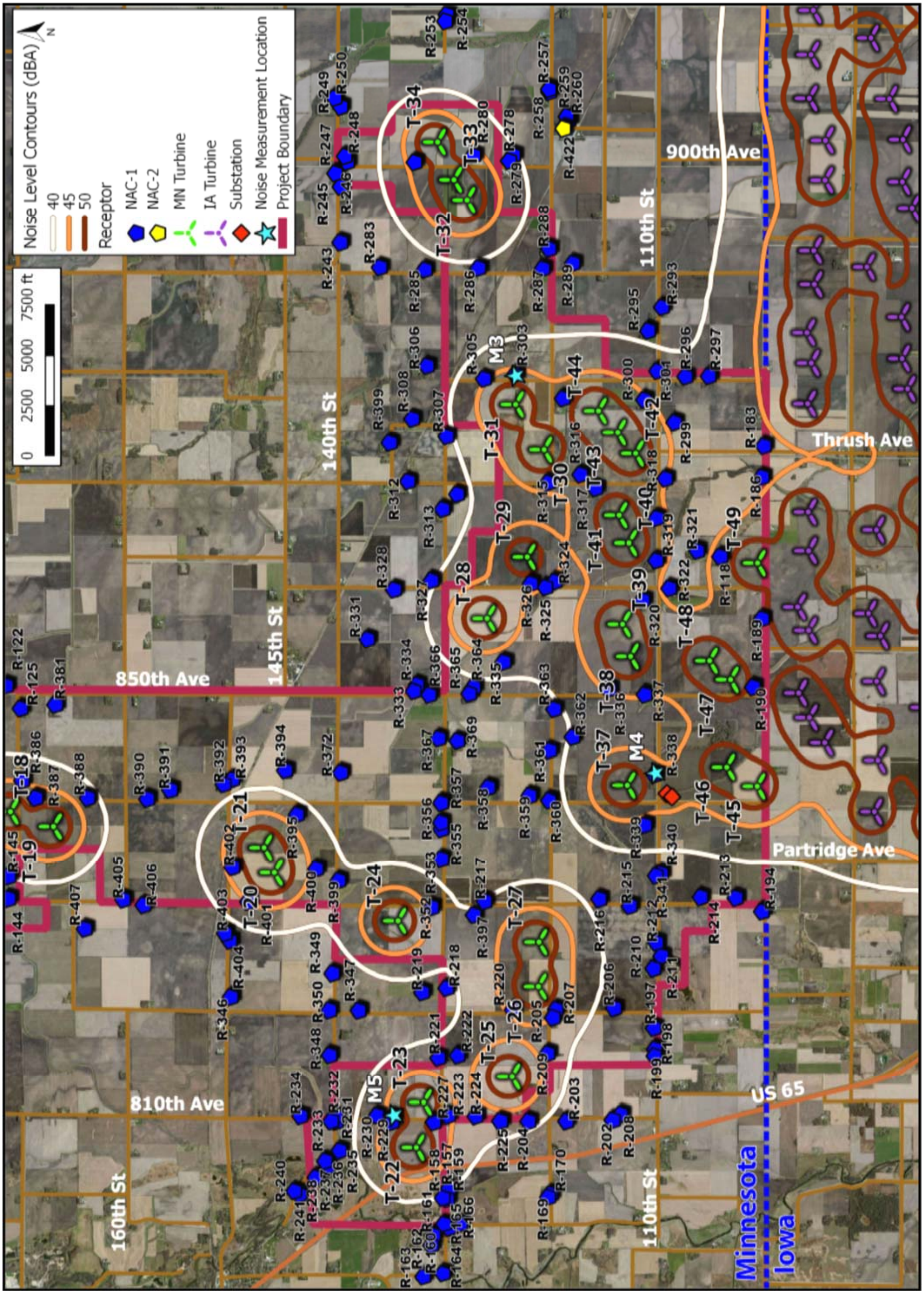

Figure A-2. Southern Site Plan and Predicted Noise Level Contours

APPENDIX B

Turbine and Transformer Locations

Source ID	Source Type	UTM Zone 15 Easting (m)	UTM Zone 15 Northing (m)	Ground Elevation (m ASL)	Source Height (m AGL)
T3	V116	487247.0	4832825.0	381.4	80
T4	V116	489055.6	4833446.4	383.4	80
T6	V116	484004.0	4830617.0	380.4	80
T7	V116	485113.0	4830489.0	381.5	80
T8	V116	486716.8	4831329.7	381.3	80
T9	V116	487241.0	4831317.0	384.1	80
T11	V116	489832.7	4831839.8	388.6	80
T12	V116	490468.8	4831828.5	385.9	80
T13	V116	485425.0	4829628.0	382.6	80
T14	V116	485788.0	4829695.0	384.0	80
T16	V116	490163.7	4831189.2	385.9	80
T17	V116	490522.3	4830571.8	383.5	80
T18	V110	484510.0	4827756.0	383.4	80
T19	V116	484283.1	4827105.4	384.2	80
T20	V116	483581.0	4823771.0	382.8	80
T21	V116	483960.0	4823928.0	384.3	80
T22	V116	479426.2	4821632.8	370.9	80
T23	V110	480103.7	4821522.0	382.4	80
T24	V116	482851.6	4821909.1	382.5	80
T25	V116	480494.3	4820187.6	387.5	80
T26	V116	481859.0	4819789.0	389.7	80
T27	V116	482528.0	4819780.0	393.0	80
T28	V116	487432.0	4820561.0	373.4	80
T29	V110	488362.0	4819958.0	370.9	80
T30	V116	489983.0	4819704.0	378.0	80
T31	V116	490674.7	4820134.1	374.4	80
T32	V116	493766.0	4820864.0	366.7	80
T33	V110	494074.0	4821063.0	363.2	80
T34	V110	494647.9	4821310.4	362.1	80
T37	V116	484905.0	4818449.0	382.9	80
T38	V116	486855.0	4818399.1	375.2	80
T39	V116	487344.0	4818521.0	375.2	80
T40	V116	488572.0	4818424.0	372.9	80
T41	V110	488991.0	4818572.0	373.5	80
T42	V110	489927.0	4818322.0	376.7	80
T43	V116	490247.0	4818593.0	378.3	80
T44	V116	490576.0	4818879.0	377.5	80
T45	V116	484890.0	4816488.0	375.8	80
T46	V116	485179.0	4816948.0	376.7	80
T47	V110	486502.0	4816891.0	377.3	80

Source ID	Source Type	UTM Zone 15		Ground Elevation (m ASL)	Source Height (m AGL)
		Easting (m)	Northing (m)		
T48	V116	486789.0	4817202.0	375.7	80
T49	V116	488270.0	4816483.0	375.3	80
T201	V116	487607.1	4815875.3	372.0	80
T204	V110	486302.9	4815858.2	377.2	80
T206	V116	496632.4	4815638.1	362.8	80
T207	V116	492487.6	4815623.3	370.5	80
T208	V116	490686.3	4815722.2	368.2	80
T209	V116	491303.6	4815669.3	368.7	80
T210	V116	491760.0	4815734.0	370.6	80
T211	V116	493000.1	4815630.8	370.4	80
T212	V116	485930.1	4815696.8	374.5	80
T213	V116	485547.9	4815464.8	377.5	80
T214	V116	495963.7	4815672.9	365.3	80
T215	V116	488455.4	4815708.2	370.8	80
T216	V116	497296.8	4815650.8	362.9	80
T217	V116	495300.3	4815698.3	365.0	80
T218	V116	489040.7	4815714.1	368.7	80
T219	V116	488768.0	4814665.4	369.0	80
T220	V116	486475.3	4814661.9	375.0	80
T221	V116	486084.8	4813900.9	375.2	80
T222	V116	485547.1	4813842.0	374.6	80
T223	V116	489196.2	4813855.3	367.8	80
T224	V116	485285.0	4814641.8	375.4	80
T225	V116	484509.8	4814698.0	377.1	80
T226	V116	491990.7	4814266.9	365.1	80
T227	V116	491371.8	4814256.5	364.5	80
T228	V116	494043.5	4814252.4	367.3	80
T229	V116	494686.5	4814242.9	369.2	80
T231	V116	495292.7	4814458.0	364.3	80
T233	V116	496217.6	4814753.9	363.2	80
T234	V116	497479.4	4814235.8	363.7	80
T235	V116	496952.0	4813829.2	361.6	80
T236	V116	490912.1	4814168.3	364.8	80
T237	V116	487165.4	4814601.7	372.1	80
T238	V116	493641.7	4814097.9	367.3	80
T239	V116	486797.0	4813871.4	374.4	80
T240	V116	487690.3	4813561.4	371.6	80
T240	V116	487507.8	4814791.6	373.7	80
T241	V116	492418.5	4813700.2	366.8	80
T242	V116	492977.5	4813698.6	366.9	80

Source ID	Source Type	UTM Zone 15		Ground Elevation (m ASL)	Source Height (m AGL)
		Easting (m)	Northing (m)		
T243	V116	484311.2	4813670.3	375.0	80
T244	V116	488506.2	4813542.4	370.0	80
T247	V116	496071.1	4813824.1	362.6	80
T291	V116	494069.0	4815461.1	366.2	80
T292	V116	494673.2	4815454.3	365.2	80
T293	V116	497848.3	4815688.3	360.5	80
T294	V116	485087.0	4813670.8	373.7	80
T296	V116	490101.8	4813560.1	366.2	80
T297	V116	490561.4	4813686.3	367.5	80
T298	V116	492751.5	4814817.7	369.5	80
T299	V116	494895.0	4813434.4	371.2	80
T300	V116	495490.0	4813504.7	365.8	80
T303	V116	497842.3	4813615.8	360.3	80
T315	V116	487250.5	4815707.8	373.8	80
Transformer 1a	120 MVA	484751.5	4817764.7	378.9	3
Transformer 1b	120 MVA	484759.0	4817764.7	378.8	3

APPENDIX C

Receptor Locations

Receptor ID	NAC	Participation Status *	UTM Zone 15		Ground Elevation (m ASL)
			Easting (m)	Northing (m)	
R52	1	NP	491123.1	4834254.3	388.8
R53	1	NP	491241.9	4834213.1	387.5
R54	1	NP	490749.6	4834865.8	388.9
R55	1	NP	490708.0	4834734.0	389.0
R56	1	NP	490414.4	4834881.4	387.9
R57	1	NP	490353.8	4834700.9	387.5
R58	1	NP	489695.4	4834897.6	386.5
R59	1	NP	489611.0	4834901.8	385.5
R60	1	NP	489297.7	4834976.7	386.3
R61	1	NP	489201.0	4834880.8	384.2
R62	1	NP	489095.3	4834878.0	384.5
R63	1	NP	488872.7	4834743.0	385.1
R64	1	NP	488547.0	4834785.4	384.6
R65	1	NP	488402.7	4834903.0	384.9
R66	1	NP	487727.7	4834885.5	384.1
R67	1	NP	487110.6	4834670.4	386.7
R68	1	NP	486699.9	4834669.5	390.6
R69	1	NP	486453.7	4833834.6	384.6
R70	1	NP	485711.7	4832179.7	380.6
R71	1	NP	485736.6	4832667.1	381.9
R72	1	NP	487896.6	4832301.7	391.6
R73	1	NP	487929.6	4832232.1	391.6
R74	1	NP	487999.4	4833133.4	390.2
R75	1	NP	488003.0	4833156.3	389.7
R76	1	P	487929.5	4833979.9	389.1
R77	1	P	488159.3	4833937.6	389.1
R78	1	NP	487703.9	4832994.9	391.5
R79	1	NP	490705.8	4834021.9	391.5
R80	1	NP	490667.3	4833970.6	392.0
R81	1	P	491227.3	4833962.1	391.1
R82	1	NP	491226.5	4833797.4	391.2
R83	1	NP	491097.2	4833803.3	392.0
R84	1	P	491371.4	4832825.4	384.6
R85	1	P	490881.9	4832287.3	387.7
R86	1	P	490127.4	4832569.0	392.6
R87	1	P	489445.4	4832495.3	389.8
R88	1	P	489252.0	4832379.2	386.2
R89	1	NP	488643.0	4832486.6	390.1
R90	1	P	487807.7	4831759.1	388.8
R91	1	P	488305.5	4831307.3	390.7

Receptor ID	NAC	Participation Status *	UTM Zone 15		Ground Elevation (m ASL)
			Easting (m)	Northing (m)	
R92	1	P	488025.3	4830990.6	390.4
R93	1	P	488742.3	4830847.4	396.8
R94	1	P	489027.2	4830750.9	391.9
R95	1	NP	489119.5	4830895.2	388.7
R96	1	P	489845.5	4830871.3	385.7
R97	1	NP	491644.5	4830961.0	383.9
R98	1	NP	491882.3	4830026.0	380.3
R104	1	NP	491425.2	4829146.6	381.0
R105	1	NP	490812.6	4829139.3	378.2
R106	1	NP	490347.8	4829157.0	381.8
R107	1	NP	489534.4	4829244.9	389.7
R108	1	NP	489844.4	4828725.2	389.3
R109	1	NP	489338.3	4829061.4	388.5
R110	1	NP	488613.5	4829366.8	388.3
R111	1	P	487587.7	4829959.5	391.8
R112	1	P	488447.4	4830073.9	394.4
R113	1	NP	487565.7	4830393.4	395.2
R114	1	P	487743.9	4830937.5	390.4
R115	1	NP	486656.5	4830605.7	384.3
R116	1	P	486310.1	4829680.3	386.1
R117	1	NP	486435.4	4829125.4	389.2
R118	1	NP	486678.0	4829278.0	387.9
R119	1	P	487527.4	4829082.7	389.6
R120	1	NP	487871.0	4829342.9	386.3
R122	1	P	486409.1	4827770.0	387.3
R123	1	NP	486379.9	4828148.2	384.0
R124	1	NP	486125.4	4827902.8	388.9
R125	1	NP	486064.3	4827547.2	392.3
R127	2	P	486310.4	4828379.9	387.1
R128	1	NP	486394.8	4828457.4	385.7
R129	1	P	485993.1	4829249.9	388.0
R130	1	NP	484448.1	4829649.1	385.1
R131	1	P	484601.6	4830442.8	381.9
R132	1	P	484706.5	4831066.2	382.3
R133	1	NP	483497.8	4830757.1	381.1
R134	1	NP	482567.2	4830728.8	381.2
R143	1	P	482881.7	4828998.7	381.3
R144	1	NP	483316.0	4829217.5	381.8
R145	1	NP	483455.0	4829144.6	383.9
R146	1	NP	483580.4	4829459.2	383.4

Receptor ID	NAC	Participation Status *	UTM Zone 15		Ground Elevation (m ASL)
			Easting (m)	Northing (m)	
R147	1	NP	482672.0	4830086.0	383.7
R157	1	NP	478805.8	4821087.5	370.1
R158	1	P	478664.4	4821178.4	370.5
R159	1	NP	478647.1	4821112.6	370.8
R160	1	NP	478269.4	4821160.6	371.3
R161	1	NP	478097.7	4821320.2	371.0
R162	1	NP	477938.8	4821351.6	371.7
R163	1	NP	477446.5	4821472.3	377.4
R164	1	NP	477497.1	4821175.8	373.3
R165	1	NP	478205.3	4821084.6	371.3
R166	1	NP	478270.2	4820910.2	371.3
R169	1	NP	478677.6	4819587.5	371.9
R170	1	NP	478722.3	4819550.9	371.7
R183	1	NP	490036.5	4816332.4	368.7
R186	1	NP	489569.2	4816363.3	367.7
R188	1	P	488365.5	4816989.5	374.6
R189	1	P	487425.1	4816361.9	377.6
R190	1	NP	486385.8	4816496.9	375.9
R194	1	P	482988.8	4816361.5	383.9
R197	1	NP	481231.9	4817992.2	386.7
R198	1	P	480912.1	4817974.6	384.7
R199	1	P	480808.9	4817981.7	383.4
R202	1	P	479835.7	4818614.0	379.5
R203	1	NP	479817.5	4819314.1	380.4
R204	1	NP	479816.5	4819887.6	381.1
R205	1	P	481387.9	4819516.0	389.6
R206	1	NP	481529.2	4818591.7	386.7
R207	1	P	481510.6	4819469.4	389.3
R208	1	NP	479919.6	4818496.6	377.7
R209	1	P	480843.9	4819595.9	392.9
R210	1	NP	482125.0	4817998.6	389.5
R211	1	NP	482314.1	4817878.9	388.7
R212	1	P	482517.9	4817958.3	387.1
R213	1	NP	483193.4	4816759.1	384.7
R214	1	P	483202.8	4817284.2	386.5
R215	1	NP	483073.1	4818358.1	389.6
R216	1	NP	483174.5	4818814.1	390.0
R217	1	P	483142.7	4820544.2	388.2
R218	1	NP	481832.0	4821123.1	390.7
R219	1	NP	481768.2	4821490.1	391.6

Receptor ID	NAC	Participation Status *	UTM Zone 15		Ground Elevation (m ASL)
			Easting (m)	Northing (m)	
R220	1	NP	481504.9	4820122.5	392.5
R221	1	NP	480777.8	4821245.6	392.9
R222	1	NP	480813.7	4820952.8	396.3
R223	1	P	479901.5	4821098.9	377.0
R224	1	P	479892.2	4820682.1	377.4
R225	1	NP	479820.4	4820309.4	377.2
R227	1	P	479805.6	4821315.8	376.0
R228	1	NP	479810.2	4821948.3	376.9
R229	1	P	479879.7	4821931.5	379.7
R230	1	P	479903.6	4822170.6	380.8
R231	1	NP	479813.7	4822791.9	374.0
R232	1	NP	479887.7	4822797.4	374.4
R233	1	NP	479820.9	4822863.2	373.8
R234	1	NP	479896.0	4823328.3	380.0
R235	1	NP	479376.2	4822736.5	374.2
R236	1	NP	479221.0	4822953.7	375.1
R237	1	NP	479140.5	4822922.4	369.8
R238	1	NP	478974.6	4823097.9	372.0
R240	1	NP	478768.6	4823419.7	371.9
R241	1	NP	478715.5	4823342.3	371.3
R243	1	NP	493118.8	4822721.2	372.4
R245	1	NP	493967.3	4822719.0	368.9
R246	1	NP	494170.6	4822801.1	368.4
R247	1	P	494342.8	4822622.4	368.8
R248	1	P	494430.7	4822653.9	368.1
R249	1	NP	495170.5	4822718.5	363.8
R250	1	NP	495302.6	4822811.4	363.6
R253	1	NP	496467.4	4821141.0	362.8
R254	1	NP	496563.2	4821118.9	364.1
R257	1	NP	495436.8	4819575.3	363.4
R258	1	NP	495394.4	4819572.5	363.4
R259	1	NP	494975.1	4819281.5	364.1
R260	1	NP	495026.9	4819307.0	363.9
R278	1	NP	494446.3	4820117.2	367.4
R279	1	NP	494361.2	4820178.3	367.2
R280	1	P	494443.0	4820713.4	364.1
R282	1	NP	494338.6	4821604.0	367.1
R283	1	NP	492743.9	4822125.5	369.9
R285	1	NP	492707.1	4821448.8	370.9
R286	1	NP	492732.2	4820638.3	371.8

Receptor ID	NAC	Participation Status *	UTM Zone 15		Ground Elevation (m ASL)
			Easting (m)	Northing (m)	
R287	1	NP	492724.4	4819671.7	369.1
R288	1	P	493023.4	4819573.9	368.5
R289	1	NP	492805.0	4819213.6	370.3
R293	1	NP	492137.9	4817869.9	371.3
R295	1	NP	491784.8	4818080.6	372.9
R296	1	P	491095.6	4817515.6	375.2
R297	1	NP	491102.7	4817161.4	373.9
R299	1	P	490398.8	4817681.6	373.3
R300	1	P	490744.2	4818140.1	374.7
R301	1	NP	491180.1	4817942.1	373.6
R302	1	P	490763.4	4819365.9	377.5
R303	1	P	491127.9	4820087.2	377.5
R305	1	P	491061.4	4820555.1	377.9
R306	1	NP	491257.9	4821420.4	375.2
R307	1	NP	490183.6	4821121.2	379.7
R308	1	NP	490451.5	4821641.2	379.8
R309	1	NP	490086.1	4821979.5	382.4
R312	1	NP	489503.5	4821705.4	378.8
R313	1	NP	489079.5	4821180.1	376.4
R314	1	NP	489306.4	4820961.0	376.5
R315	1	NP	489484.4	4819590.8	375.4
R316	1	NP	489606.3	4819098.8	376.8
R317	1	NP	489398.6	4818872.7	376.4
R318	1	NP	489543.4	4817818.3	375.3
R319	1	P	488944.7	4817952.7	372.8
R320	1	NP	488304.4	4817959.3	373.7
R321	1	NP	488451.0	4817336.9	371.4
R322	1	NP	487887.8	4817759.0	372.5
R323	1	NP	487707.5	4818164.1	373.2
R324	1	NP	487989.0	4819491.1	372.6
R325	1	NP	487904.3	4819630.0	373.0
R326	1	NP	487959.5	4819851.5	374.1
R327	1	NP	488005.2	4821349.0	375.6
R328	1	P	487868.1	4821914.0	379.0
R331	1	NP	487112.2	4822314.3	382.9
R333	1	NP	486328.8	4821619.1	373.8
R334	1	NP	486420.7	4821571.0	375.4
R335	1	NP	486766.0	4820261.5	376.1
R336	1	NP	486358.1	4818672.9	378.7
R337	1	NP	486275.2	4818132.2	379.5

Receptor ID	NAC	Participation Status *	UTM Zone 15		Ground Elevation (m ASL)
			Easting (m)	Northing (m)	
R338	1	P	485063.4	4817982.7	381.2
R339	1	NP	484302.3	4818132.0	383.8
R340	1	NP	483562.4	4817886.0	386.9
R341	1	NP	483529.2	4817963.4	386.7
R346	1	NP	481696.4	4824377.1	384.7
R347	1	P	481492.4	4822446.4	388.7
R348	1	NP	480817.4	4822885.5	379.4
R349	1	NP	482052.3	4822841.4	385.4
R350	1	P	481497.8	4822891.8	383.0
R352	1	NP	483051.4	4821347.9	385.3
R353	1	NP	483783.3	4821199.5	384.8
R355	1	P	484240.3	4821199.5	382.8
R356	1	NP	484341.7	4821205.2	382.9
R357	1	NP	484639.2	4821202.9	382.6
R358	1	NP	484870.3	4820492.5	387.1
R359	1	NP	484746.3	4819871.7	389.1
R360	1	NP	484675.7	4819574.2	384.4
R361	1	NP	485426.8	4819567.4	385.6
R362	1	NP	485631.6	4819217.8	384.6
R363	1	NP	486054.8	4819497.9	381.1
R364	1	NP	486289.1	4820776.0	377.4
R365	1	NP	486384.8	4820713.8	377.7
R366	1	P	486273.6	4821385.3	375.7
R367	1	P	485609.1	4821242.8	384.1
R369	1	P	485572.7	4820956.7	386.9
R372	1	P	485095.1	4822716.5	377.7
R381	1	NP	486120.9	4827025.8	386.7
R383	1	NP	486019.4	4829077.4	385.4
R384	1	P	484438.6	4828506.7	384.7
R386	1	P	484976.6	4827525.0	386.3
R387	1	P	484713.3	4827322.2	389.9
R388	1	P	484712.2	4826536.9	391.8
R390	1	NP	484698.5	4825637.6	390.7
R391	1	NP	484836.4	4825292.3	390.5
R392	1	NP	484918.4	4824485.5	389.3
R393	1	P	484991.3	4824354.0	388.2
R394	1	P	485129.3	4823556.0	382.0
R395	1	P	484461.4	4823382.1	383.9
R397	1	NP	482937.0	4820708.0	386.6
R399	1	P	483455.0	4822750.8	382.4

Receptor ID	NAC	Participation Status *	UTM Zone 15		Ground Elevation (m ASL)
			Easting (m)	Northing (m)	
R400	1	NP	483632.8	4823089.2	383.5
R401	1	NP	483134.8	4824113.8	387.5
R402	1	P	483657.9	4824353.2	388.6
R403	1	NP	482658.3	4824464.8	384.0
R404	1	NP	482544.4	4824393.0	385.1
R405	1	NP	483168.9	4826001.9	383.6
R406	1	NP	483085.7	4825693.5	385.1
R407	1	NP	482726.4	4826582.5	381.0
R408	1	NP	483180.3	4827734.7	381.9
R409	1	NP	483516.6	4827733.6	381.7
R410	1	P	482870.3	4828502.9	381.0
R418	2	NP	489526.1	4834877.3	384.7
R419	1	NP	491131.3	4834199.2	388.7
R422	2	NP	494847.5	4819356.5	364.0

*
P= Participating
NP = Non-participating

APPENDIX D

Unattended Ambient Noise Measurement Results

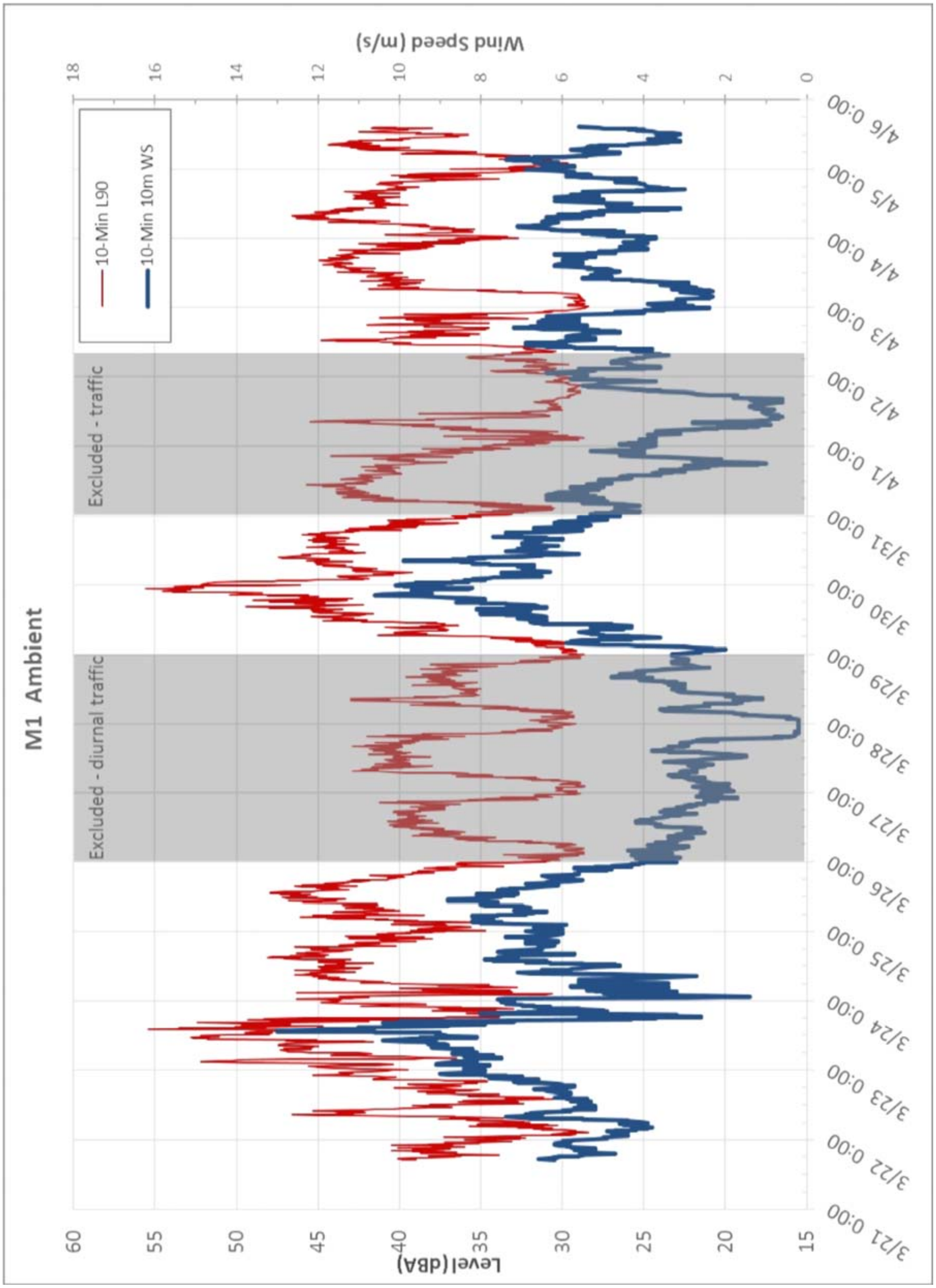

Figure D-1. M1 Ambient Level vs Time

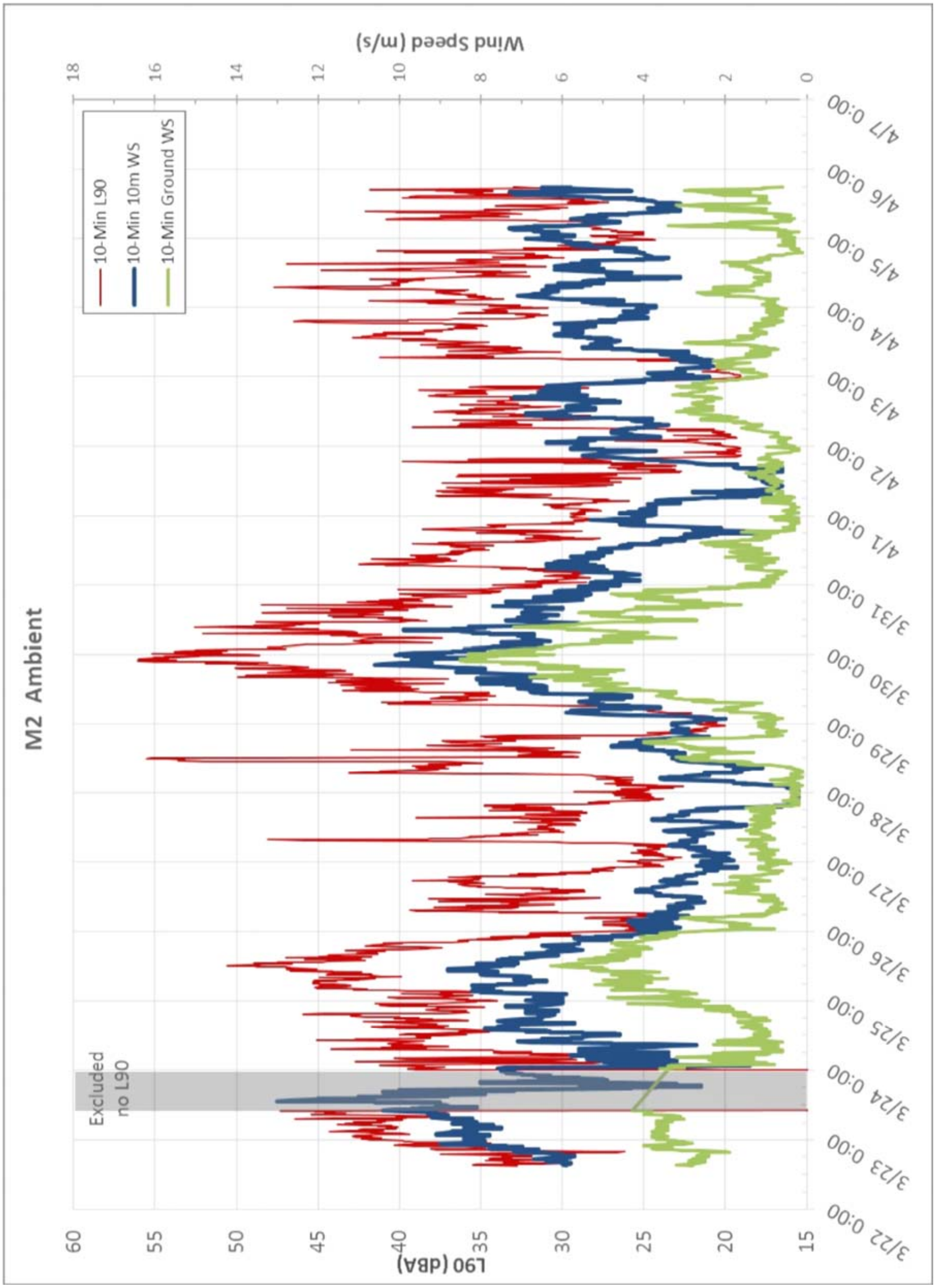

Figure D-2. M2 Ambient Level vs Time

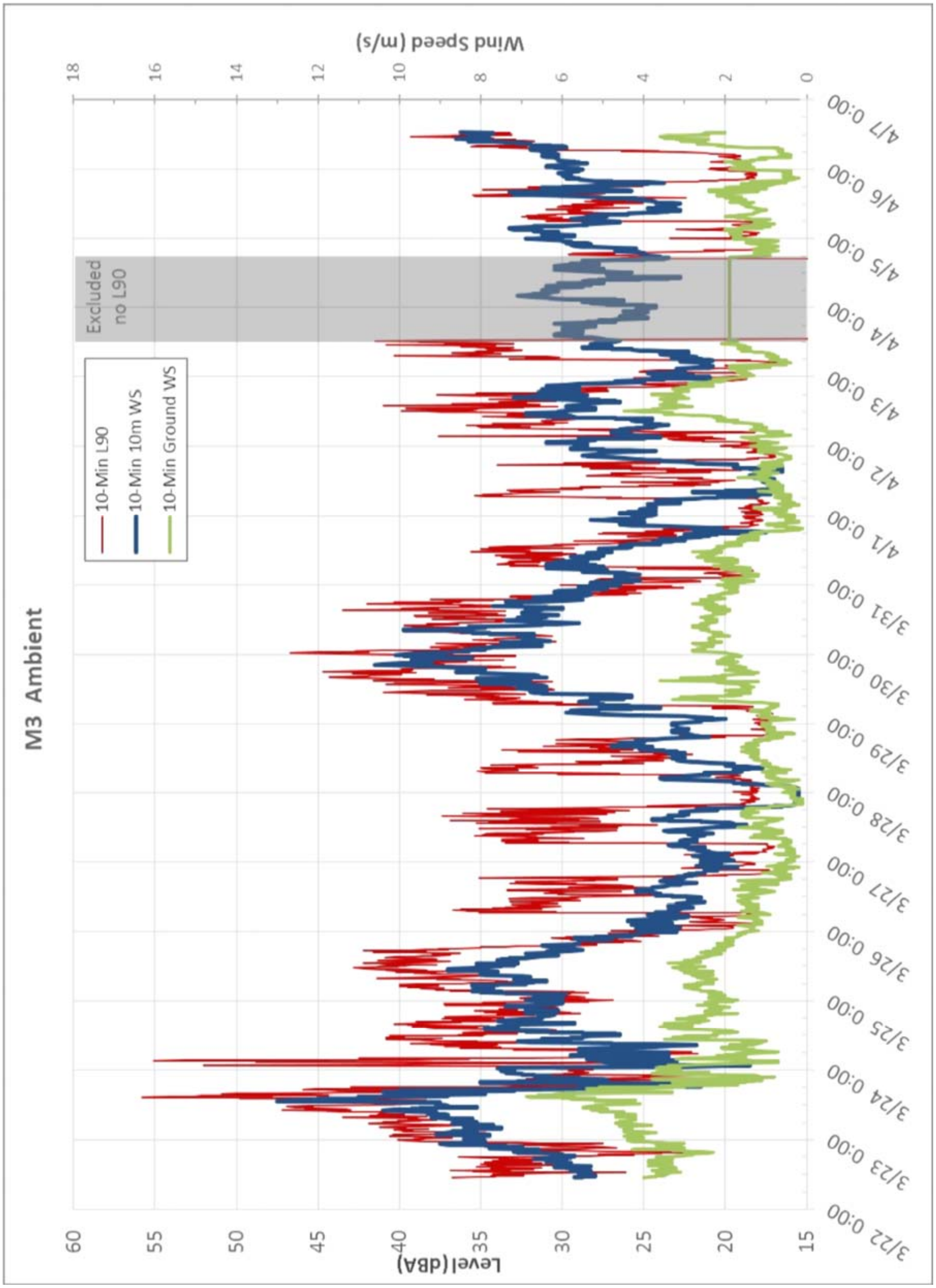

Figure D-3. M3 Ambient Level vs Time

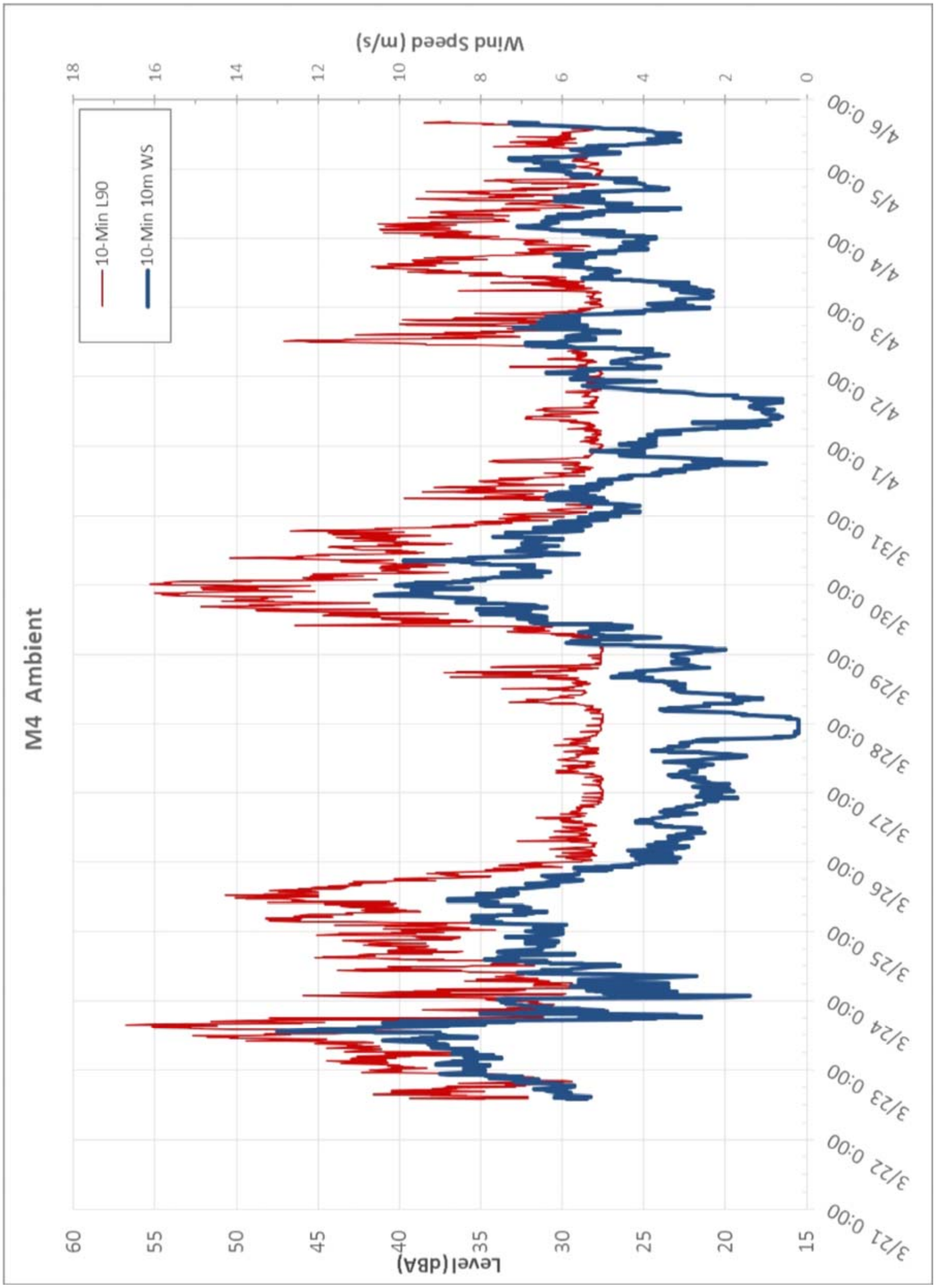

Figure D-4. M4 Ambient Level vs Time

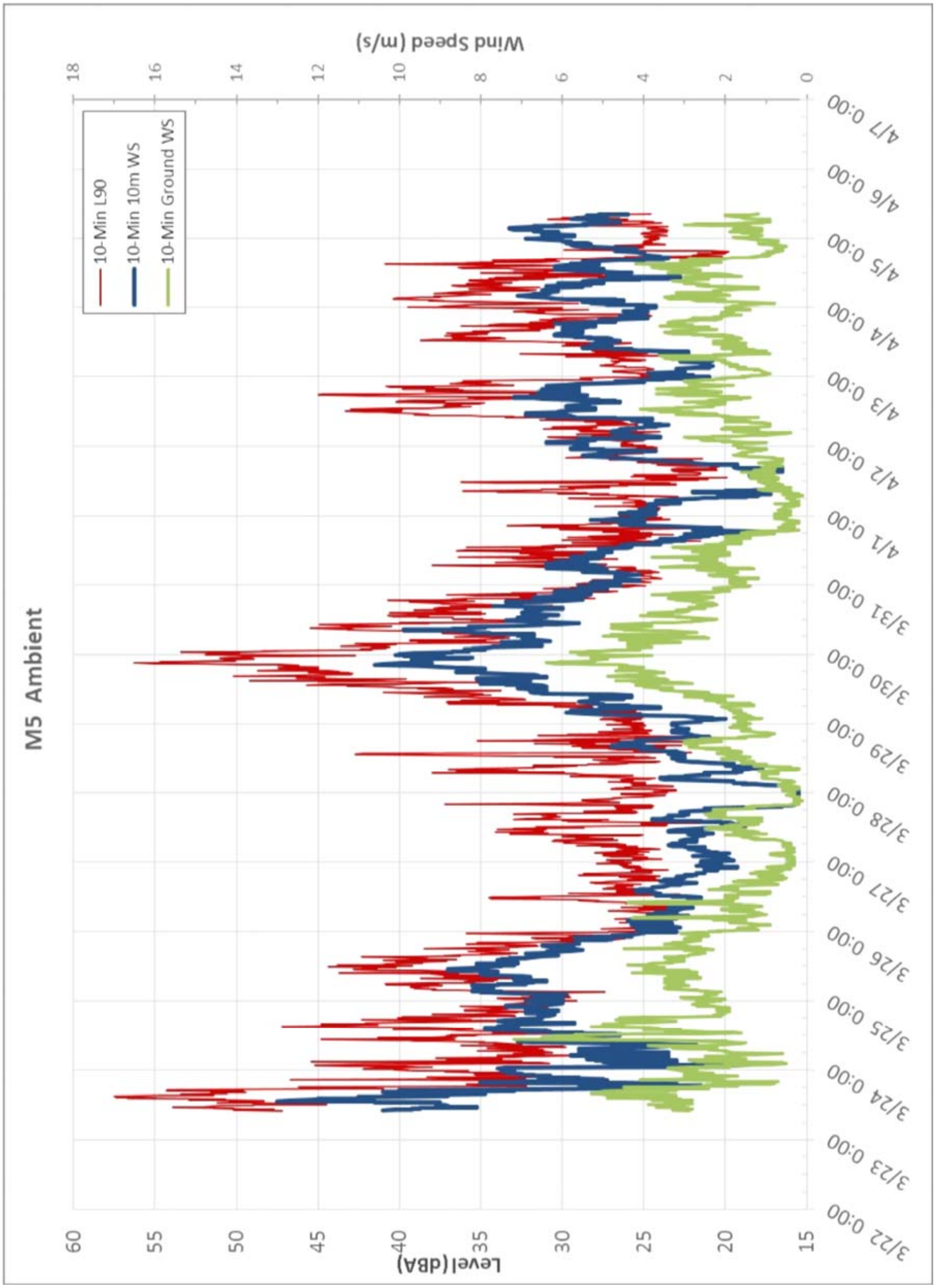

Figure D-5. M5 Ambient Level vs Time

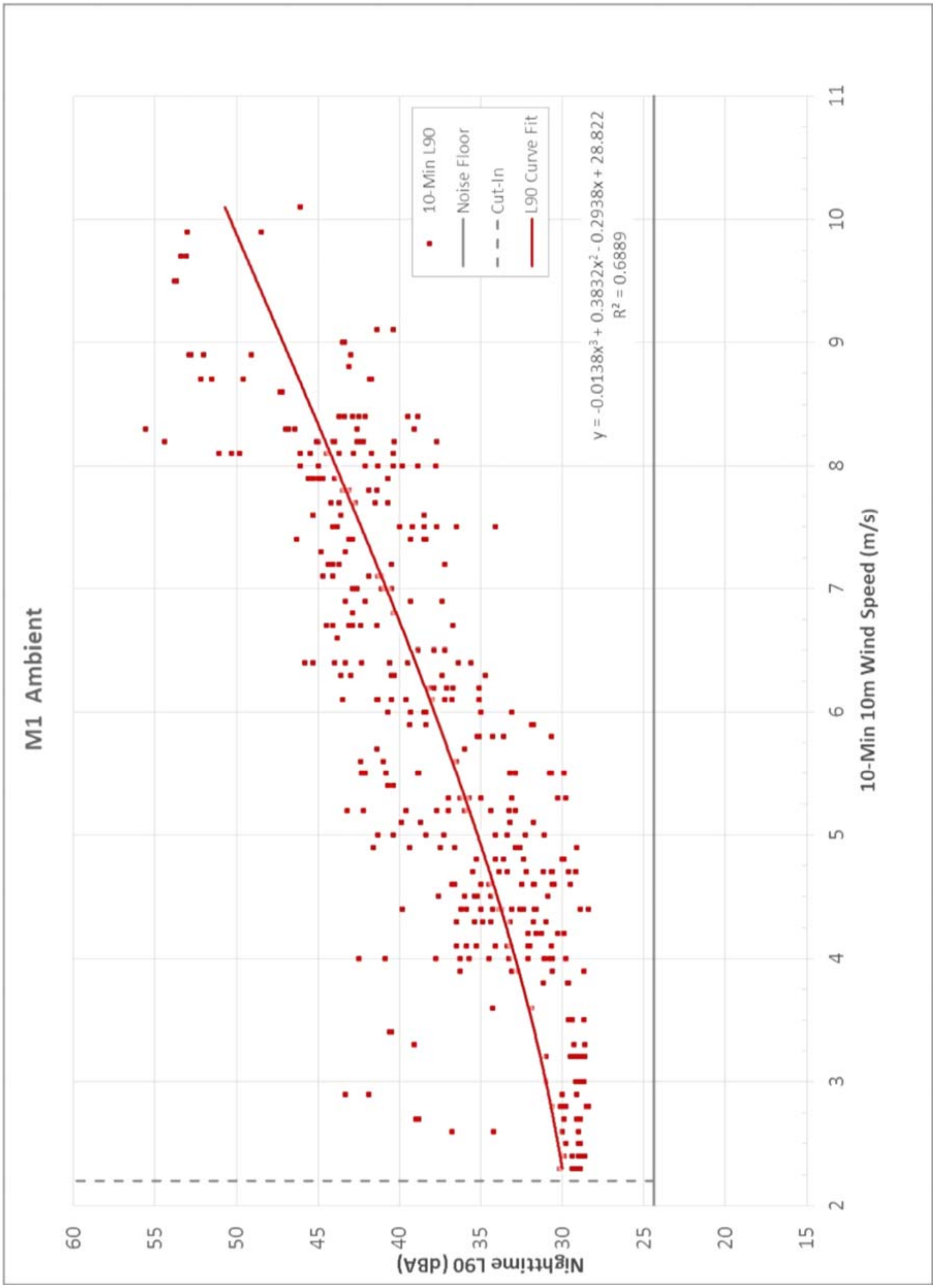

Figure D-6. M1 Nighttime Level vs Wind Speed

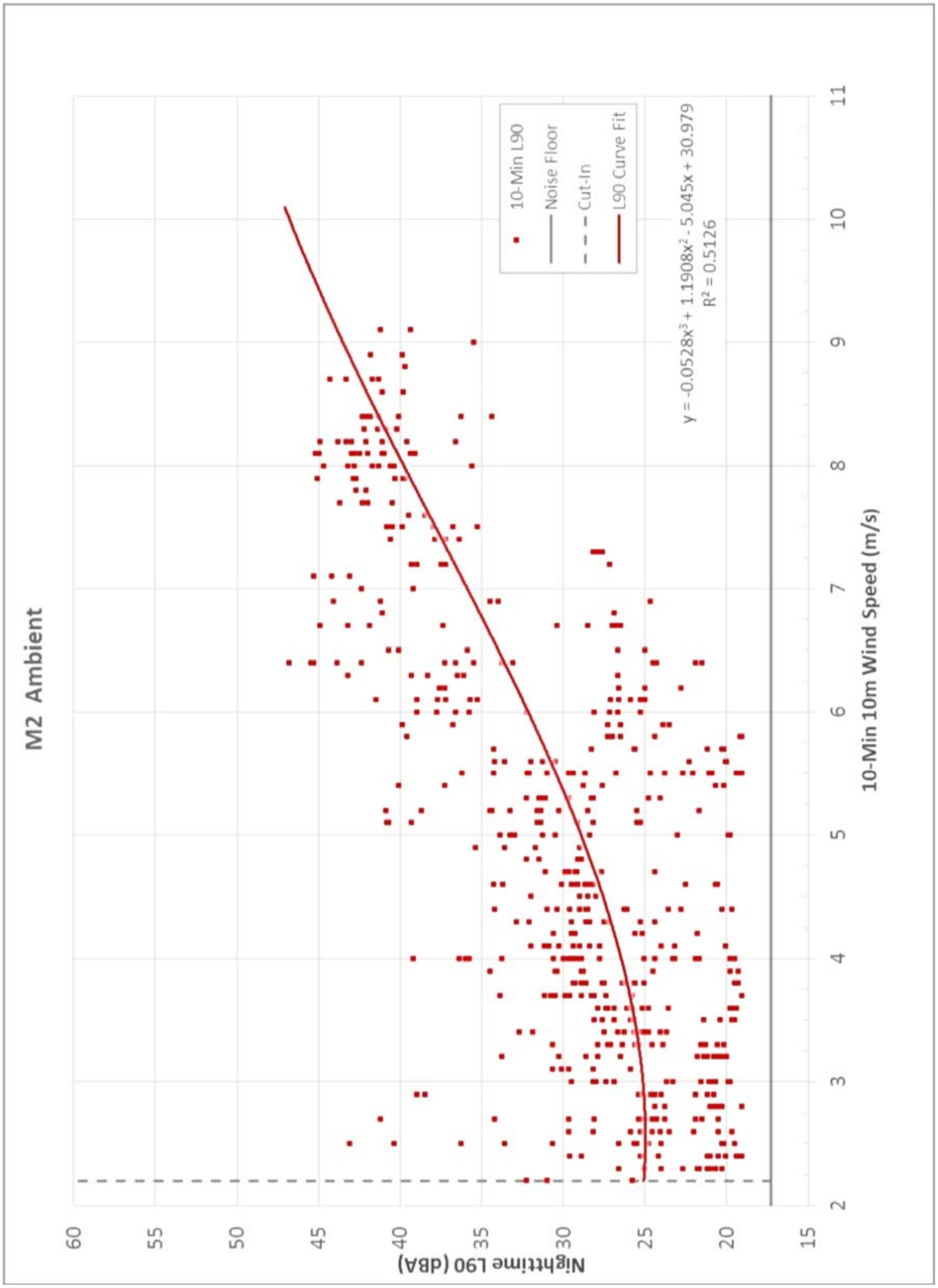

Figure D-7. M2 Nighttime Level vs Wind Speed

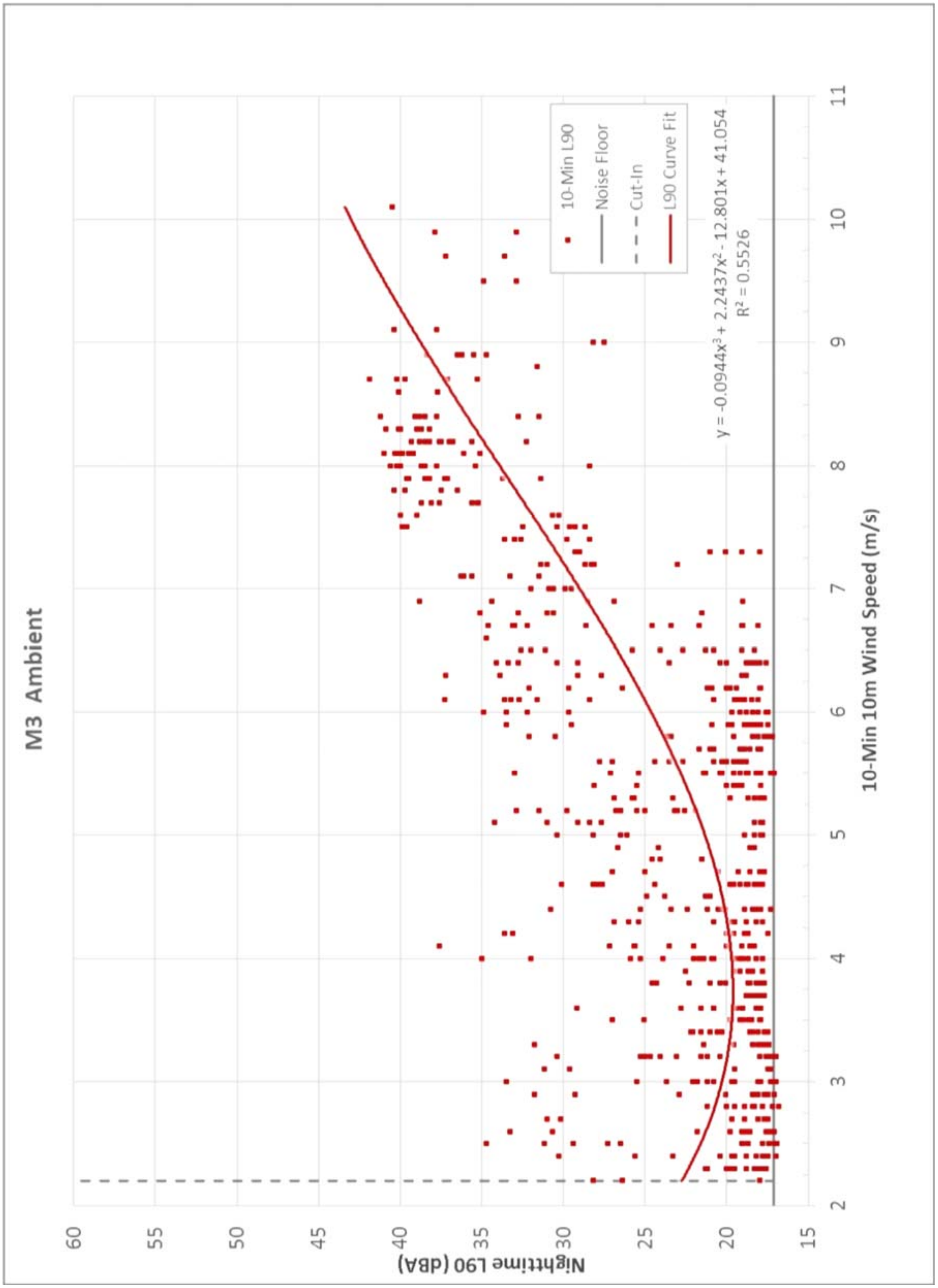

Figure D-8. M3 Nighttime Level vs Wind Speed

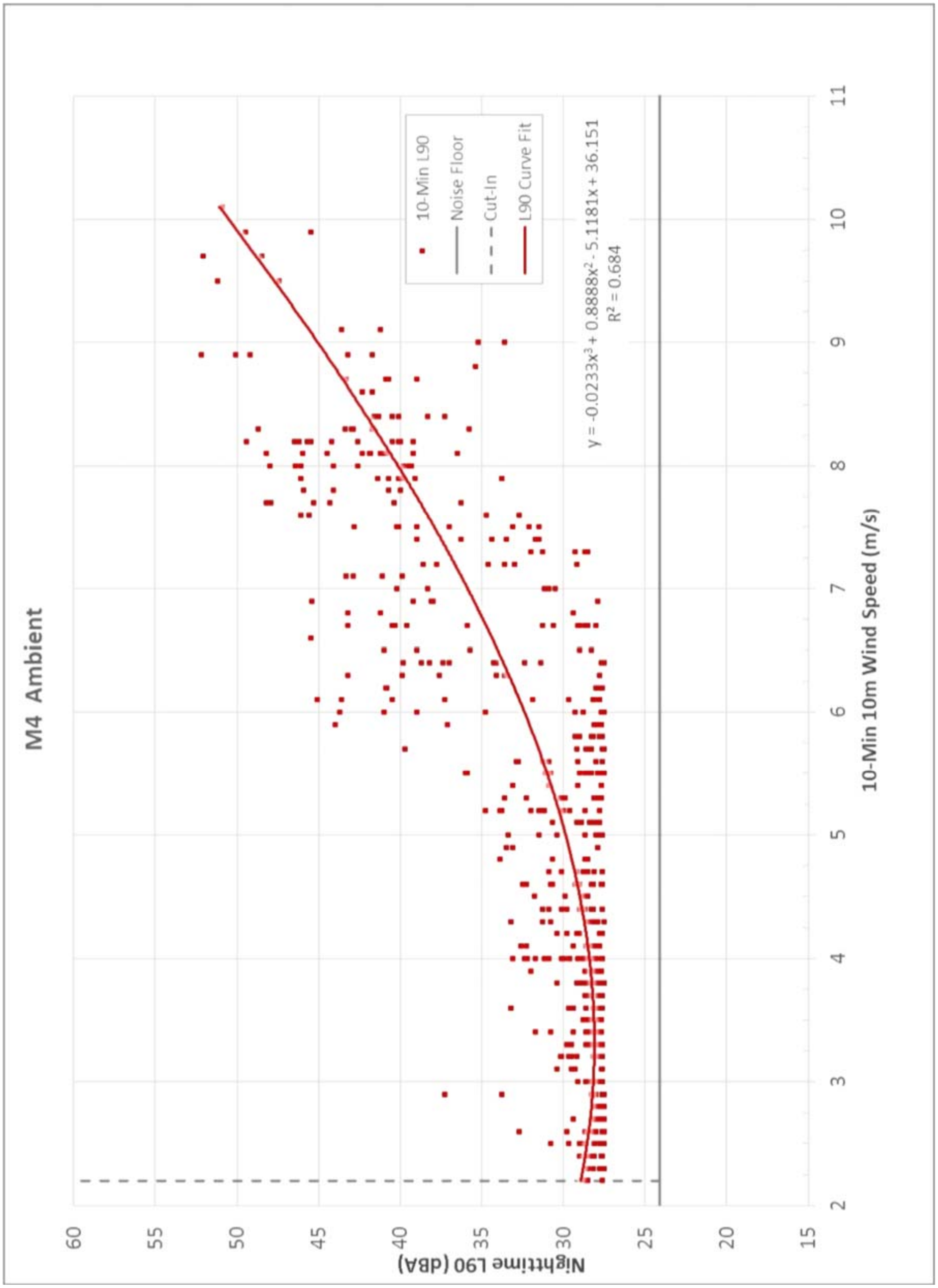

Figure D-9. M4 Nighttime Level vs Wind Speed

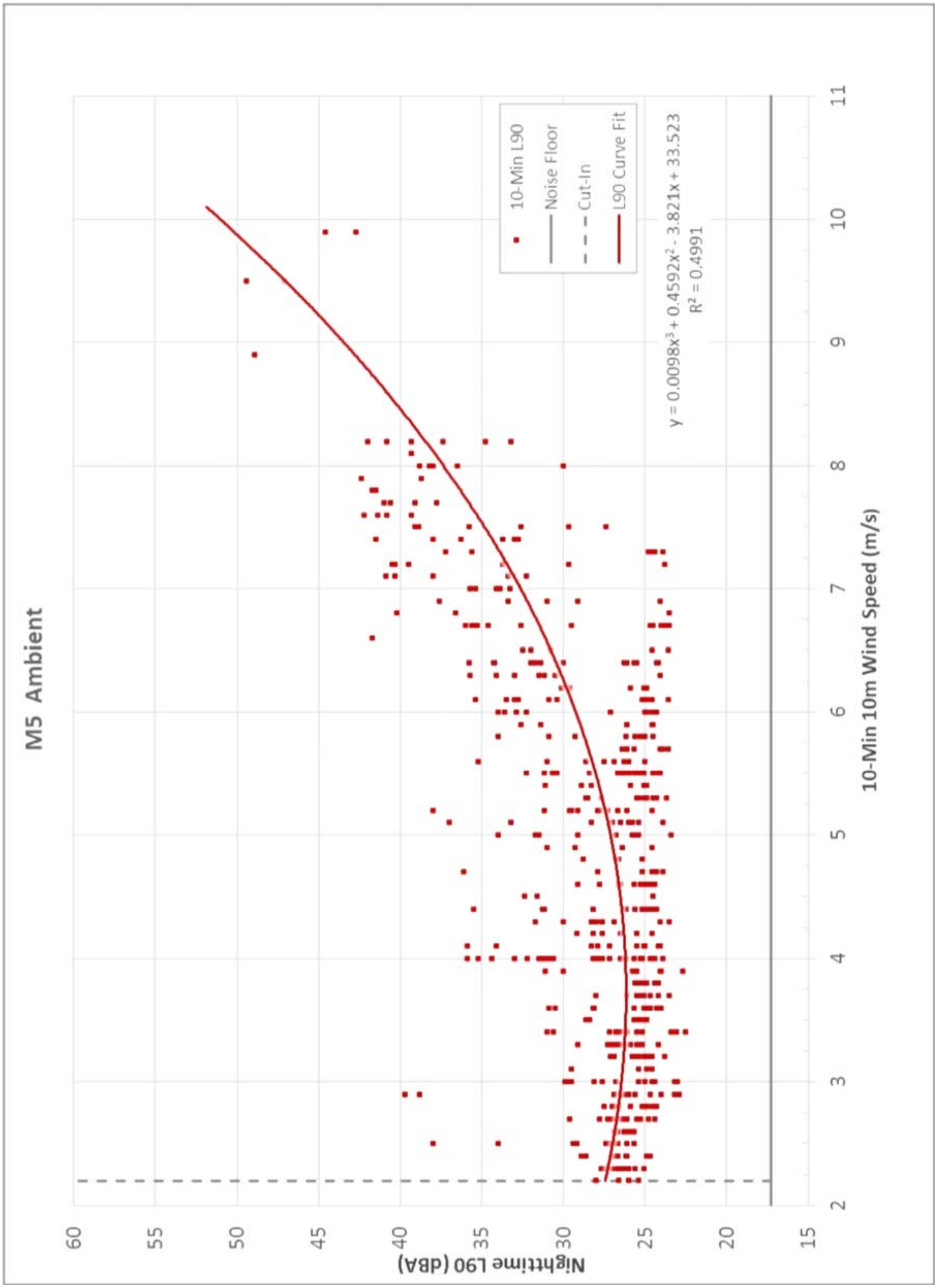

Figure D-10. M5 Nighttime Level vs Wind Speed

APPENDIX E

Predicted Wind Turbine Noise Levels

Receptor ID	Level (dBA)	Receptor ID	Level (dBA)	Receptor ID	Level (dBA)	Receptor ID	Level (dBA)
R52	31.5	R93	38.8	R158	39.5	R223	46.1
R53	31.3	R94	39.6	R159	39.0	R224	43.0
R54	30.5	R95	40.6	R160	35.9	R225	42.6
R55	31.1	R96	47.6	R161	34.9	R227	48.8
R56	31.3	R97	38.5	R162	33.8	R228	47.0
R57	32.2	R98	34.9	R163	30.9	R229	46.9
R58	33.1	R104	33.2	R164	31.1	R230	43.6
R59	33.3	R105	34.7	R165	35.2	R231	37.3
R60	33.3	R106	35.2	R166	35.2	R232	37.2
R61	34.0	R107	34.7	R169	33.0	R233	36.7
R62	34.1	R108	32.7	R170	33.0	R234	33.8
R63	35.1	R109	33.7	R183	43.4	R235	37.6
R64	34.4	R110	34.1	R186	43.8	R236	35.5
R65	33.4	R111	37.7	R188	46.6	R237	35.6
R66	32.4	R112	36.3	R189	48.5	R238	34.0
R67	32.6	R113	40.2	R190	48.9	R240	31.7
R68	31.9	R114	43.7	R194	36.4	R241	32.0
R69	35.7	R115	43.8	R197	34.2	R243	33.8
R70	38.1	R116	45.7	R198	33.6	R245	35.1
R71	36.5	R117	41.2	R199	33.4	R246	34.7
R72	41.8	R118	40.0	R202	33.8	R247	35.9
R73	41.5	R119	35.1	R203	37.4	R248	35.7
R74	41.6	R120	34.9	R204	41.4	R249	34.0
R75	41.5	R122	34.8	R205	45.0	R250	33.1
R76	37.6	R123	36.0	R206	37.7	R253	32.4
R77	38.7	R124	36.1	R207	46.2	R254	32.1
R78	45.5	R125	35.6	R208	33.5	R257	34.6
R79	33.7	R127	37.3	R209	43.0	R258	34.7
R80	34.0	R128	37.3	R210	35.6	R259	35.1
R81	32.1	R129	46.8	R211	35.4	R260	35.0
R82	32.7	R130	42.2	R212	35.8	R278	40.6
R83	33.1	R131	47.0	R213	37.0	R279	41.5
R84	36.4	R132	43.7	R214	36.9	R280	46.5
R85	43.9	R133	44.5	R215	37.3	R282	46.9
R86	43.5	R134	34.3	R216	38.7	R283	35.5
R87	43.1	R143	33.9	R217	40.1	R285	37.9
R88	42.6	R144	35.9	R218	39.5	R286	39.1
R89	40.4	R145	36.3	R219	38.9	R287	37.1
R90	43.0	R146	37.7	R220	46.2	R288	37.0
R91	39.9	R147	34.7	R221	42.0	R289	36.5
R92	41.1	R157	40.3	R222	42.2	R293	38.4

Receptor ID	Level (dBA)	Receptor ID	Level (dBA)	Receptor ID	Level (dBA)	Receptor ID	Level (dBA)
R295	39.2	R322	44.5	R353	37.8	R391	35.4
R296	40.8	R323	47.2	R355	36.0	R392	37.9
R297	41.0	R324	44.6	R356	35.7	R393	37.8
R299	43.6	R325	44.8	R357	35.1	R394	37.1
R300	45.6	R326	46.7	R358	35.6	R395	42.4
R301	41.6	R327	39.5	R359	37.2	R397	40.4
R302	47.3	R328	36.1	R360	38.5	R399	40.9
R303	46.6	R331	34.1	R361	38.7	R400	43.5
R305	44.3	R333	35.5	R362	40.3	R401	44.9
R306	36.5	R334	36.0	R363	39.5	R402	46.7
R307	39.2	R335	42.2	R364	38.0	R403	37.8
R308	36.1	R336	45.4	R365	38.7	R404	37.3
R309	34.6	R337	45.3	R366	36.1	R405	34.9
R312	35.6	R338	46.7	R367	35.0	R406	34.6
R313	37.9	R339	43.4	R369	35.3	R407	33.9
R314	38.9	R340	38.2	R372	35.3	R408	37.1
R315	46.6	R341	38.0	R381	34.4	R409	39.9
R316	46.6	R346	33.1	R383	44.2	R410	34.0
R317	47.2	R347	36.6	R384	41.2	R418	33.6
R318	45.0	R348	35.3	R386	44.6	R419	31.6
R319	46.5	R349	37.3	R387	47.5	R422	35.5
R320	46.4	R350	35.4	R388	41.8		
R321	44.0	R352	43.5	R390	35.7		