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Memo

To:	Chuck Burdick, National Wind		
From:	Elliott Dick	Project:	National Wind – Goodhue County Wind Farm
cc:	Angela Piner, Tim Casey, Gina Ramirez		
Date:	January 28, 2011	Job No:	137253

Re: Wind Noise Assessment

EXECUTIVE SUMMARY

AWA Goodhue proposes to construct a wind farm in Goodhue County to the west of the city of Goodhue. HDR Engineering, Inc. (HDR) performed a noise analysis in support of the proposed Project. HDR collected 24-hour noise measurements at five locations that are representative of the rural portions of the Project area. HDR evaluated noise due to wind-turbines using the Cadna-software. This analysis modeled turbine noise from all turbine locations operating simultaneously at their highest rated operating speed and highest noise emission operating condition. The monitoring and modeling were performed on a spectral (per octave band) basis, and the broadband A-weighted levels from the monitoring and modeling were compared to the Minnesota Pollution Control Agency (MPCA) noise standards.

Analysis results indicate the following:

- The noise analysis was conducted in accordance with accepted practices in the environmental acoustics industry, and in accordance with methods used on projects approved by the State of Minnesota.
- Existing ambient noise levels were measured within the Project area. The hourly L_{50} results ranged from 33 dBA to 52 dBA. The hourly L_{10} results ranged from 34 dBA to 60 dBA.
- There where some nighttime hours in which the existing ambient noise level exceeded MPCA noise pollution standards. Measured daytime existing ambient noise levels did not exceed MPCA noise standards.
- The maximum noise level from all wind turbines operating simultaneously at their loudest rated operating speed is calculated to be 43 dBA at the nearest noise-sensitive receptor.
- Wind turbine noise levels at any residence are compatible with criteria from Minnesota State Noise Pollution Control Rules 7030.0040 for acceptable levels of noise within residential land uses.

- Analysis results indicate that noise levels at any residence will be more than 2 dB below a 45 dBA noise limit based upon by the MPCA nighttime L_{50} noise limit of 50 dBA with a 5 dB buffer as a surrogate for low-frequency noise suggested by MDH.

NOISE PERCEPTION

Noise is defined as unwanted sound. Sound is made up of tiny fluctuations in air pressure. Sound, within the range of human hearing, can vary in pressure by over one million units. Therefore, a logarithmic scale, known as the decibel scale (dB), is used to quantify sound pressure and to compress the scale to a more manageable range.

Sound is characterized by both its amplitude (how loud it is) and frequency (or pitch). The human ear does not hear all frequencies equally. In fact the human hearing organs of the inner ear deemphasize very low and very high frequencies. The A-weighted scale (dBA) is used to reflect this selective sensitivity of human hearing. This scale puts more weight on the range of frequencies that the average human ear perceives, and less weight on those frequencies we do not hear as well. The human range of hearing extends from approximately 3 dBA to around 140 dBA. Table 1 shows a range of typical noise levels from common activities.

Table 1. Common Noise Sources and Levels

Sound Pressure Level (dBA)	Typical Sources
120	Jet aircraft takeoff at 100 feet
110	Same aircraft at 400 feet
90	Motorcycle at 25 feet
	Gas lawn mower at 3 feet
80	Garbage disposal
70	City street corner
60	Conversational speech
50	Typical office
40	Living room (without TV)
30	Quiet bedroom at night

SOURCE: Environmental Impact Analysis Handbook, ed. by Rau and Wooten, 1980

Using the decibel scale, sound levels from two or more noise sources cannot be arithmetically added together to determine the overall sound level. Rather, the combination of two sounds at the same level yields an increase of 3 dB. On average, a 3 dB change in the A-weighted sound level is generally considered a noticeable change in loudness, whereas a 5 dB increase is clearly noticeable. A 10 dB change is perceived by most people as a doubling or halving of the perceived loudness.

The sounds that we hear are a combination of many sounds of different pitches. It is possible to use a frequency analyzer, and separate sound into its different frequency components. The frequency ranges are called octave bands; frequency is measured in Hertz (Hz), or cycles per second. Data that have been sorted into its octave bands is called spectral data. Data that has not been sorted into its octave bands is called broadband.

Environmental noise is often expressed as a sound level occurring over a stated period of time, typically one hour. When the acoustic energy is averaged over the stated period of time, the resulting equivalent sound level represents the energy-based average sound level. This is called the equivalent level, or L_{eq}. Therefore, the L_{eq} represents a constant sound that, over the specified period, has the same acoustic energy as the time-varying sound.

EVALUATION CRITERIA

The Minnesota Pollution Control Agency (MPCA) noise rules set standards according to a Noise Area Classification (NAC), determined by the land use activities. Residential land use activities fall into NAC-1. Table 2 shows the MPCA noise standards in A-weighted decibels (dBA) according to Minnesota State Noise Pollution Control Rules 7030.0040. These standards are measured in statistical centile sound level descriptors that represent the sound level exceeded during the stated percent of a measurement interval – an hourly interval in the case of MPCA rules. The L_{50} is the sound level exceeded 50% of the time (the median sound level during the measurement interval). The L_{10} is the level exceeded 10% of the time during the interval, and is often higher where intermittent sounds occur during the measurement interval.

Table 2. Minnesota Noise Standards

Noise Area Classification	Hourly Centile Levels (dBA)			
	Daytime		Nighttime	
	L_{10}	L_{50}	L_{10}	L_{50}
NAC-1	65	60	55	50
NAC-2	70	65	70	65
NAC-3	80	75	80	75

The nighttime L_{50} noise limit of 50 dBA for residential receptors (NAC-1) is the most stringent noise limit in the MPCA criteria; therefore it is an appropriate standard for evaluating the acceptability of calculated wind turbine noise levels. The recent MDH white paper (Public

Health Effects of Wind Turbines) indicates a 5 dBA buffer provides an adequate surrogate for low-frequency noise. Therefore this assessment assumed that 45 dBA is the effective nighttime limit for wind turbine noise, which is a conservative assumption.

The Cadna-A model used for this analysis, like other commercially-available environmental acoustics models commonly used for wind turbine noise analyses, calculates an L_{eq} which is the average amount of equivalent acoustical energy occurring in the stated time period (one hour). The MPCA L_{50} descriptor represents the noise level exceeded 50% of the time, which – by inspection, is a statistical median noise level. For a truly constant noise source, the L_{eq} and the L_{50} will be equal. Most noise sources, including wind turbines, exhibit some fluctuation, resulting in a statistical distribution of noise levels over time. Even with a fluctuating noise source, the L_{eq} is a close approximation or even a conservative overestimate of the L_{50}. For purposes of this analysis, the predicted L_{eq} can be considered a reasonable and appropriate estimate of the L_{50}.

The A-weighting scale approximates the frequency-dependent sensitivity of human hearing, and is the prevalent weighting scale for measuring and discussing environmental noise. However, the May 22, 2009, Minnesota Department of Health (MDH) white paper (Public Health Effects of Wind Turbines) asserts that dBA is the worst predictor of annoyance of available acoustical weighting scales (MDH 2009). MDH notes that the difference between C- and A-weighted is used by many as an indication of the relative contribution of low-frequency noise (the C-weighting scale does not remove as much low-frequency content as the A-weighting scale does). On this basis, MDH claims that the dBC scale is purportedly better able to deal with the annoying low frequency wind turbine noise, and a difference between C- and A-weighted greater than 10 dB is an indicator of the likelihood of annoyance from low frequency noise.

Health Effects of Wind Turbine Noise

Sound levels from modern wind turbines pose no risk of hearing loss or any other nonauditory effect (Ising and Kruppa 2004). Low frequency and infrasound from modern upwind-configured turbines are well below the pressure sound levels at which known health effects occur; there is no scientific evidence to date that vibration from low frequency wind turbine noise causes adverse health effects (CMOH of Ontario 2010). Although some people may be annoyed at the presence of sound from wind turbines, annoyance is a highly-individualized phenomenon, and is not an identified medical condition (Colby *et al.* 2009). While some individuals living near wind turbines report symptoms such as dizziness, headaches, and sleep disturbance, the scientific evidence available to date does not demonstrate a direct causal link between wind turbine noise and adverse health effects (CMOH of Ontario 2010).

The primary concern about wind turbine sound is its fluctuating nature, which can occur under certain circumstances such as turbulent wind conditions. A small number of individuals with particular sensitivities may find this sound annoying, but the reaction depends primarily on the personal characteristics, as opposed to the intensity of the sound level (Colby *et al.* 2009). The substantial body of peer-reviewed literature on the subject of wind turbine noise indicates that there is nothing unique about the sounds and vibrations emitted by wind turbines, and that there is no evidence that the audible or sub-audible sounds emitted by wind turbines have any direct adverse physiological effects (Colby *et al.* 2009).

Geoff Levanthall, an acoustic and vibration expert from the UK who was cited in the MDH white paper for two of his earlier works on low frequency sound, conducted a study in 2006 on infrasound from wind turbines. When studying 1.5 MW wind turbines from a distance of 65 meters (213 feet), Levanthall found that modern upwind turbines produce pulses which are considered infrasound, but only at low levels, typically 50 to 70 dB, which are well below the hearing threshold. Based on his study, Levanthall further concludes that infrasound is inaudible at frequencies below 16 Hz. The threshold which is audible varies by individuals, but Levanthall states that "…it is most unlikely that an individual will be able to hear sound at any frequency which is more than 20 dB below the median threshold for hearing." (Colby, et al. 2009).

Project-specific field studies conducted by Epsilon Associates, Inc. and previously submitted to the PUC in document 20099-41923-01 of docket 09-845 reached similar conclusions (O'Neal, et al, 2009). Epsilon studied the two turbine models most frequently installed – the GE 1.5sle (1.5 MW) and Siemens SWT-2.3-93 (2.3 MW). These field studies consisted of outdoor measurements at various reference distances, and concurrent indoor/outdoor measurements at residences within the wind farm. Epsilon determined all means, methods, and the testing protocol without interference or direction from wind energy industry participants.

Based on field measurements and an extensive literature review, Epsilon concluded that wind farms consisting of GE 1.5sle and Siemens SWT 2.3-93 wind turbines sited at distances beyond 1,000 feet from residences (i) meet the American National Standards Institute (ANSI) standard for low frequency sound in bedrooms, classrooms, and hospitals, (ii) meet the ANSI standard for thresholds of annoyance from low frequency sound, and (iii) caused no window rattles or perceptible vibration of light weight walls or ceilings within homes (O'Neal *et al.* 2009). In homes, there may be slightly audible low frequency sound (depending on other sources of low frequency sound); however, the levels are below criteria and recommendations for low frequency sound within homes (O'Neal et al, 2009). There is no audible infrasound either outside or inside the homes at any of the measurement sites. (O'Neal et al, 2009) Epsilon concluded there should be no adverse public health effects from low frequency sound or infrasound at distances greater than 1,000 feet (O'Neal et al, 2009).

METHODOLOGY

The noise assessment methodology consisted of identifying noise-sensitive land uses, characterizing the existing ambient acoustic environment, and then predicting noise levels due to the proposed wind turbines. The noise-sensitive land use activities are nearly all agricultural and residential. The residential land use activities are more noise-sensitive than agricultural; therefore HDR analyzed noise levels at the residential land uses. National Wind identified residential buildings in the project area and provided the locations to HDR.

The ambient acoustic environment refers to the outdoor noise levels within a given community. Typical existing ambient noise levels in rural areas are dominated by agriculture-related activities, existing wind conditions, local fauna, and proximity to other noise sources such as the noise from road transportation sources or from stationary agricultural machinery. HDR selected locations to be representative of the project area, and deployed noise monitoring systems to collect hourly noise data over a 24-hour period.

To calculate the noise levels due to the proposed wind-turbines, HDR modeled the entire project in acoustic analysis software designed for evaluating environmental noise from stationary and mobile sources. The software, Cadna-A, is a three-dimensional noise model based on the standard ISO 9613-2, "Acoustics – Attenuation of Sound during Propagation Outdoors – Part 2: General Method of Calculation," adopted by the International Organization for Standardization (ISO) in 1996. This standard provides a widely-accepted engineering method for the calculation of outdoor environmental noise levels from sources of known sound emission.

The level of wind turbine sound varies with the operating speed of the turbine. Sound is generated from the wind turbine at points near the hub or nacelle, 80 meters (262.5 feet) to 105 meters (344.5 feet) in the air, from the blade tips as they rotate. For the noise evaluation, the Applicant obtained sound power levels (L_W) of the wind turbines selected for this project. These levels were provided by the wind turbine manufacturers according to standardized measurement procedures and account for all sound generating elements associated with wind turbines. The Cadna-A model utilized the noise emission level at the highest rated operating speed as shown in

Table 3.

Table 3. Noise Emissions Data Provided by Turbine Manufacturer

Turbine Make and Model	Sound Power Level (dBA)
GE 1.5 XLE	104
GE 1.6 XLE	106

In order to provide cumulative noise analysis results, Cadna-A calculated noise emissions from all proposed turbines operating simultaneously and propagating their noise emissions to all known noise-sensitive receptor locations in the study area. This analysis represents the noise level due to all wind turbines operating at the wind-speed corresponding with the turbines' highest noise emission rating.

EXISTING ENVIRONMENT

HDR measured existing noise levels in the Project area. HDR selected monitoring locations by reviewing digital aerial photographs of the Project area and identifying areas whose ambient acoustical environment appeared to be representative of the Project area. Higher noise levels exist near roads and other areas of human activity. The noise monitoring data represents a broad range of ambient acoustic environments in the rural, agricultural Project area. HDR considered many sites for appropriateness and practicality, and performed five 24-hour measurements in the Project area. Noise monitoring activities occurred between June 15 and June 25, 2010; locations are listed in Table 4 and are shown in Figure 1.

Table 4. Site Description of Measurement Locations

	Brief Qualitative Description
Location 1	Removed from traffic noise; near to residence and farm buildings. This location represents residences where agricultural activities occur daily.
Location 2	Far removed from any manmade noise, except for potential mobile farm equipment. This location represents residences which are set far back from any road. There are few places in the project area where potential mobile farm equipment noise is avoidable.
Location 4	Near to low traffic volume unpaved road; near to residence and farm buildings. This location represents residences near unpaved roads and where agricultural activities occur daily.
Location 5	Near to paved county road with moderate traffic volume; set back from road comparable distance to a residence. This location represents residences along County Road 7, County Road 6 and County Road 1
Location 6	Near to paved county road with frequent traffic; set back from road comparable distance to a residence. This location represents residences along County Road 9, which was subjectively judged to be the heaviest-traveled road in the project area.

A sound level meter (SLM) was used to collect noise monitoring data every hour for a continuous 24-hour period. The MPCA noise pollution rules prescribe measurements using the standardized fast exponential time averaging characteristic and the A-weighting characteristic. Each hour, the SLM stored broadband, A-weighted hourly L_{eq}, L_{10}, L_{50}, and L_{90} values. The SLM also stored hourly unweighted spectral (1/3 octave) noise levels, which were used to calculate the difference between C- and A-weighted sound levels (L_{Ceq} - L_{Aeq}). This end of this memorandum includes tables showing the measurement results over 24 hours at each measurement site. Table 5 shows the highest and lowest monitoring results by examination of all the locations' results tables.

Table 5. Summary of Ambient Noise Level Monitoring

	Hourly L_{10} (dBA)		Hourly L_{50} (dBA)		Hourly L_{eq} (dBA)	
	Highest	Lowest	Highest	Lowest	Highest	Lowest
Location 1	47	34	38	33	44	33
Location 2	58	36	52	34	54	35
Location 4	53	34	43	33	48	33
Location 5	55	38	43	37	55	43
Location 6	60	37	48	35	59	43

Table 5 shows that existing ambient noise levels measured within the Project area ranged from 33 to 59 dBA on an hourly L_{eq} basis. This is consistent with HDR's review of ambient noise levels measured in rural settings with high quality wind resources. The highest levels shown in the table occurred during daytime hours and the lowest levels occurred during nighttime hours. The hourly median noise levels ranged from 33 dBA to 52 dBA, based upon the hourly L_{50} results shown in Table 5. Examining the L_{10} results shows an hour in which 10% of the hour exceeded 60 dBA.

The ambient acoustic environment in the Project area is dominated by noise from wind and vehicular traffic, with additional contributions from agriculture-related activities. Daytime background noise levels were dominated by vehicular traffic and natural sources. Nighttime background noise levels were generally dominated by natural sources.

Table 6 shows the number of hours which exceed the MPCA noise pollution standards, as well as the number of hours where the difference between C- and A-weighted sound levels (L_{Ceq} - L_{Aeq}) met or exceeded the 10 dB indicator of likely annoyance from low frequency noise. The counts of exceedances were determined by examination of all the locations' results tables.

Table 6. Existing Ambient Noise Level Exceedances

	Number of Hours Exceeding MPCA Criteria (dBA)				Number of Hours L_{Ceq} - $L_{Aeq} \geq 10$ dB	
	Hourly L_{10}		Hourly L_{50}			
	Nighttime	Daytime	Nighttime	Daytime	Nighttime	Daytime
Location 1	0	0	0	0	7	15
Location 2	0	0	0	0	0	3
Location 4	0	0	0	0	5	15
Location 5	2	0	0	0	2	7
Location 6	2	0	0	0	3	8

HDR's monitoring results show that existing noise levels in the project area exceeded the MPCA standards four times. The exceedances occurred in the 5:00 AM and 6:00 PM hours at both location 5 and at location 6. These were all unattended measurements and there is no way to confirm the source of the exceedances. Nonetheless, exceedances in these hours often occur due to traffic noise picking up in the early morning hours. These locations were both near paved county highways, where vehicle traffic is able to travel at highway speeds. This suggests that the exceedances measured for this project would be due to road vehicle traffic noise. The exceedance often disappears after the 7:00 AM hour begins because the level of the MPCA noise pollution standard increases to the daytime standard which allows higher noise levels than at night.

The number of hours with a low-frequency annoyance indicator was, on average between the five locations, 3.4 hours during the nighttime (from 10:00 PM to 7:00 AM) and 9.6 hours during the daytime (from 7:00 AM to 10:00 PM) for a total of 13 hours per day. This is consistent with HDR's review of 24-hour noise monitoring data collected from other rural communities where the wind resource is suitable for wind energy development. This indicates that there are already sounds in the existing ambient acoustic environment which are likely to cause annoyance due to the low-frequency content.

The measurements which are representing the existing ambient acoustic environment include some very low noise levels. The measurement is intended to capture a sampling of any potential noise source in the area, natural or manmade. However the measurement in effect excluded some commonly found noise sources in the area, specifically mobile agricultural equipment noise was excluded and high or sustained wind noise was excluded.

Before deploying the instrumentation, HDR confirmed with landowners that there would not be crop work during the measurement period. While it would be useful and informative to measure sound levels of agricultural activities, it would present a hazard to the instrumentation. Agricultural activities in the crops near the equipment would have increased the level of measured existing ambient noise levels in daytime hours.

Additionally, the measurement periods were selected to have wind speeds safely lower than 5 meters per second through the entire 24-hour period to comply with the specifications of the microphone windscreen. This area has high and sustained winds, which make it desirable for wind turbines. Wind creates additional natural noise sources in an environment, specifically vegetation rustle or naturally-occurring atmospheric turbulence. Hours with low noise level measurements are likely to represent a relatively calm atmosphere. Higher noise levels may represent higher wind speeds through the hour. Most wind turbines require wind speeds at least 3.5 meters per second to operate.

NOISE ASSESMENT

All proposed wind turbines were modeled in Cadna-A (the turbine layout shape file was imported into Cadna-A as noise sources) and project-related noise levels were calculated at 492 noise-sensitive receptors within the study area (the receptor location shape file was imported into Cadna-A as receptor points).

The Cadna-A modeling done for this project did not utilize project-specific terrain. By eliminating terrain, the Cadna-A model assumes flat ground and reduces the opportunity for terrain to potentially block the line-of-sight between turbines and receptors. Likewise, the Cadna-A modeling done for this project did not utilize project-specific meteorological data (wind rose). By eliminating wind rose data, the Cadna-A conservatively calculates noise levels at all receptors by assuming efficient downwind propagation all directions all the time.

In lieu of specific state and county specifications for ground absorption, a ground absorption factor of 0.7 was used as suggested in the "Noise Guidelines for Wind Farms" document published by the Ontario Ministry of the Environment. This ground absorption factor takes into account the majority of cultivated terrain in the project area; in effect it assumes 70% of the ground cover is porous, or acoustically absorptive, and 30% of the ground is an exposed hard surface, or acoustically reflective.

The modeled noise isopleths are depicted in Figure 2. Table 7 presents an overview of results from modeled receptor locations.

Table 7. Summary of Wind Turbine Noise Assessment

Project-Related Noise Model Result Summary		
Number of modeled receptors	Count	492
Average modeled level at receptors	L_{eq}	31 dBA
Median modeled level at receptors	L_{eq}	32 dBA
Maximum modeled level at receptors	L_{eq}	43 dBA

The maximum calculated noise level, based on assumptions incorporated into the Cadna-A model, results in a 43 dBA L_{eq} at the nearest noise-sensitive receptor. The modeled noise levels will comply with MPCA noise guidelines. Additionally, the maximum calculated noise levels at any residence is 2 dB below the 45 dBA limit based upon the nighttime L_{50} noise limit of 50 dBA with a 5 dB buffer as a surrogate for low-frequency noise suggested by MDH.

CONCLUSIONS

Analysis results indicate the following:

- The noise analysis was conducted in accordance with the accepted environmental noise assessment practices in the industry and in accordance with methods used on projects approved by the State of Minnesota.
- Existing ambient noise levels were measured within the Project area. The hourly L_{A50} results ranged from 33 dBA to 52 dBA. The hourly L_{10} results ranged from 34 dBA to 60 dBA.
- There where some nighttime hours in which the existing ambient noise level exceeded MPCA noise pollution standards. Measured daytime existing ambient noise levels did not exceed MPCA standards.
- The maximum noise level from all wind turbines operating simultaneously at their highest rated operating speed is calculated to be 43 dBA at the nearest noise-sensitive receptor.
- Wind turbine noise levels at any residence are compatible with criteria from Minnesota State Noise Pollution Control Rules 7030.0040 for acceptable levels of noise within residential land uses.
- Analysis results indicate that noise levels at any residence will be more than 2 dB below a 45 dBA noise limit based upon the MPCA nighttime L_{50} noise limit of 50 dBA with a 5 dB buffer as a surrogate for low-frequency noise suggested by MDH.

In conclusion, analysis results and recent literature on wind turbine noise effects indicate that noise as modeled from the proposed wind turbines will not have any undue adverse effect on environmental values, public health or residences in the Project area as a result of noise that accompanies operation of the project.

Location 1 Hourly Noise Monitoring Results

Interval Start		Hourly Leq (dBA)	Low-Freq. (dBC - dBA)	Hourly Centile Levels (dBA)		
Date	Time			L10	L50	L90
6/24/2010	4:00	42	3	47	34	32
6/24/2010	5:00	43	6	46	37	34
6/24/2010	6:00	42	12	42	37	34
6/24/2010	7:00	44	13	47	37	35
6/24/2010	8:00	41	11	43	36	34
6/24/2010	9:00	38	13	39	35	34
6/24/2010	10:00	40	12	41	35	34
6/24/2010	11:00	36	16	38	35	33
6/24/2010	12:00	41	14	43	36	34
6/24/2010	13:00	39	13	43	36	34
6/24/2010	14:00	37	11	39	34	33
6/24/2010	15:00	39	11	40	35	33
6/24/2010	16:00	38	12	40	35	33
6/24/2010	17:00	38	14	39	35	34
6/24/2010	18:00	39	11	40	36	34
6/24/2010	19:00	39	10	42	38	35
6/24/2010	20:00	39	10	42	38	34
6/24/2010	21:00	38	10	38	34	33
6/24/2010	22:00	36	16	37	34	33
6/24/2010	23:00	35	12	34	33	33
6/25/2010	0:00	33	12	34	33	32
6/25/2010	1:00	33	13	34	33	32
6/25/2010	2:00	33	13	34	33	32
6/25/2010	3:00	34	15	34	33	33
Nighttime	Highest	43	16	47	37	34
	Lowest	33	3	34	33	32
Daytime	Highest	44	16	47	38	35
	Lowest	36	10	38	34	33

Location 2 Hourly Noise Monitoring Results

Interval Start		Hourly Leq (dBA)	Low-Freq. (dBC - dBA)	Hourly Centile Levels (dBA)		
Date	Time			L10	L50	L90
6/18/2010	4:00	44	4	43	37	34
6/18/2010	5:00	43	4	47	38	35
6/18/2010	6:00	45	5	50	37	34
6/18/2010	7:00	46	7	50	39	35
6/18/2010	8:00	45	7	49	41	37
6/18/2010	9:00	50	6	54	47	42
6/18/2010	10:00	51	15	55	49	39
6/18/2010	11:00	47	8	50	44	38
6/18/2010	12:00	47	7	50	45	40
6/18/2010	13:00	49	8	52	47	43
6/18/2010	14:00	52	8	56	49	43
6/18/2010	15:00	49	8	53	48	43
6/18/2010	16:00	48	8	52	47	42
6/18/2010	17:00	54	10	57	52	48
6/18/2010	18:00	54	11	58	52	46
6/18/2010	19:00	50	7	53	48	43
6/18/2010	20:00	44	5	47	39	36
6/18/2010	21:00	42	3	42	36	34
6/18/2010	22:00	37	9	39	36	34
6/18/2010	23:00	36	7	38	35	34
6/19/2010	0:00	35	6	36	34	33
6/19/2010	1:00	37	7	38	36	34
6/19/2010	2:00	38	6	39	37	36
6/19/2010	3:00	42	5	44	41	38
Nighttime	Highest	45	9	50	41	38
	Lowest	35	4	36	34	33
Daytime	Highest	54	15	58	52	48
	Lowest	42	3	42	36	34

Location 4 Hourly Noise Monitoring Results

Interval Start		Hourly Leq (dBA)	Low-Freq. (dBC - dBA)	Hourly Centile Levels (dBA)		
Date	Time			L10	L50	L90
6/15/2010	23:00	34	14	35	34	33
6/16/2010	0:00	33	12	34	33	32
6/16/2010	1:00	34	11	34	33	32
6/16/2010	2:00	33	10	34	33	32
6/16/2010	3:00	33	8	34	33	32
6/16/2010	4:00	43	7	47	36	33
6/16/2010	5:00	44	5	49	40	35
6/16/2010	6:00	41	6	44	38	35
6/16/2010	7:00	44	14	47	38	35
6/16/2010	8:00	42	14	43	38	35
6/16/2010	9:00	44	14	46	39	36
6/16/2010	10:00	43	12	45	38	34
6/16/2010	11:00	40	13	43	37	35
6/16/2010	12:00	39	11	41	36	34
6/16/2010	13:00	43	12	45	37	34
6/16/2010	14:00	39	11	43	36	34
6/16/2010	15:00	47	13	51	41	34
6/16/2010	16:00	48	14	53	43	36
6/16/2010	17:00	41	10	42	35	33
6/16/2010	18:00	42	12	43	36	33
6/16/2010	19:00	39	13	41	36	34
6/16/2010	20:00	46	12	41	36	34
6/16/2010	21:00	44	10	39	35	34
6/16/2010	22:00	36	16	36	35	34
Nighttime	Highest	44	16	49	40	35
	Lowest	33	5	34	33	32
Daytime	Highest	48	14	53	43	36
	Lowest	39	10	39	35	33

Location 5 Hourly Noise Monitoring Results

Interval Start		Hourly Leq (dBA)	Low-Freq. (dBC - dBA)	Hourly Centile Levels (dBA)		
Date	Time			L10	L50	L90
6/24/2010	3:00	45	7	39	38	36
6/24/2010	4:00	47	10	46	39	37
6/24/2010	5:00	51	7	**55**	42	38
6/24/2010	6:00	53	7	**55**	43	39
6/24/2010	7:00	53	14	54	43	39
6/24/2010	8:00	49	9	49	42	38
6/24/2010	9:00	49	12	48	39	37
6/24/2010	10:00	52	11	51	39	36
6/24/2010	11:00	51	8	46	38	36
6/24/2010	12:00	50	8	50	38	35
6/24/2010	13:00	55	10	53	38	35
6/24/2010	14:00	52	10	52	38	36
6/24/2010	15:00	53	10	53	38	36
6/24/2010	16:00	51	10	54	38	36
6/24/2010	17:00	53	7	54	40	36
6/24/2010	18:00	52	7	52	38	36
6/24/2010	19:00	51	7	50	39	37
6/24/2010	20:00	49	8	52	39	37
6/24/2010	21:00	51	6	54	39	36
6/24/2010	22:00	47	9	48	38	36
6/24/2010	23:00	45	8	41	37	36
6/25/2010	0:00	45	8	42	37	36
6/25/2010	1:00	46	16	41	37	35
6/25/2010	2:00	43	8	38	37	35
Nighttime	Highest	53	16	55	43	39
	Lowest	43	7	38	37	35
Daytime	Highest	55	14	54	43	39
	Lowest	49	6	46	38	35

Location 6 Hourly Noise Monitoring Results

Interval Start		Hourly Leq (dBA)	Low-Freq. (dBC - dBA)	Hourly Centile Levels (dBA)		
Date	Time			L10	L50	L90
6/18/2010	4:00	48	7	46	36	34
6/18/2010	5:00	54	10	**56**	41	36
6/18/2010	6:00	55	10	**59**	45	37
6/18/2010	7:00	55	9	57	44	37
6/18/2010	8:00	57	10	58	44	38
6/18/2010	9:00	57	11	57	46	40
6/18/2010	10:00	59	13	57	48	41
6/18/2010	11:00	57	11	59	44	38
6/18/2010	12:00	56	10	57	42	37
6/18/2010	13:00	58	9	58	45	39
6/18/2010	14:00	58	9	58	45	38
6/18/2010	15:00	59	10	60	47	39
6/18/2010	16:00	57	9	59	47	39
6/18/2010	17:00	57	10	60	48	43
6/18/2010	18:00	58	10	60	48	42
6/18/2010	19:00	54	8	56	44	39
6/18/2010	20:00	56	5	57	42	36
6/18/2010	21:00	53	9	54	38	34
6/18/2010	22:00	54	9	54	36	34
6/18/2010	23:00	49	6	50	35	34
6/19/2010	0:00	45	4	42	35	34
6/19/2010	1:00	43	6	38	35	34
6/19/2010	2:00	43	5	37	35	34
6/19/2010	3:00	44	10	38	36	34
Nighttime	Highest	55	10	59	45	37
	Lowest	43	4	37	35	34
Daytime	Highest	59	13	60	48	43
	Lowest	53	5	54	38	34

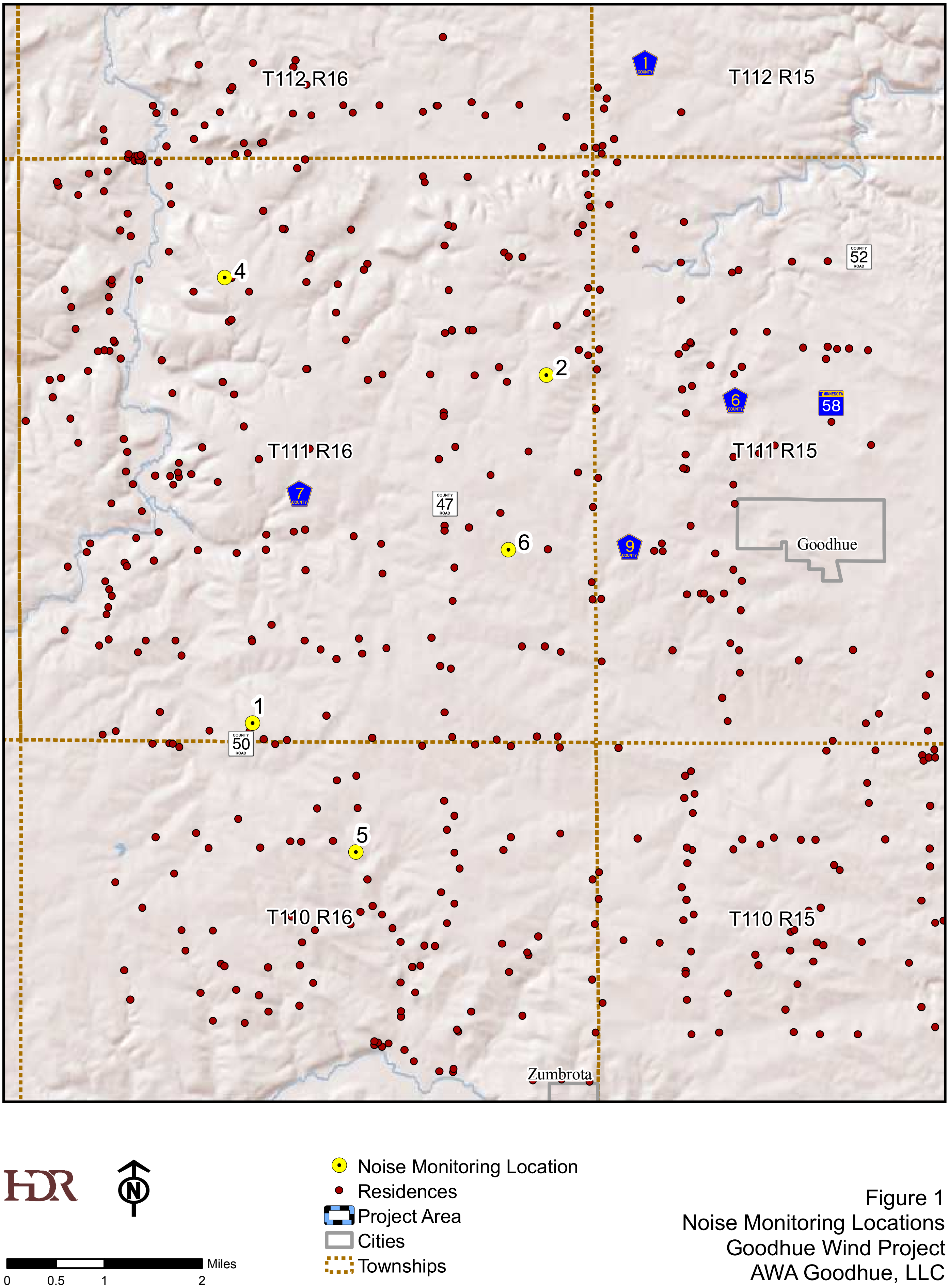

Figure 1
Noise Monitoring Locations
Goodhue Wind Project
AWA Goodhue, LLC

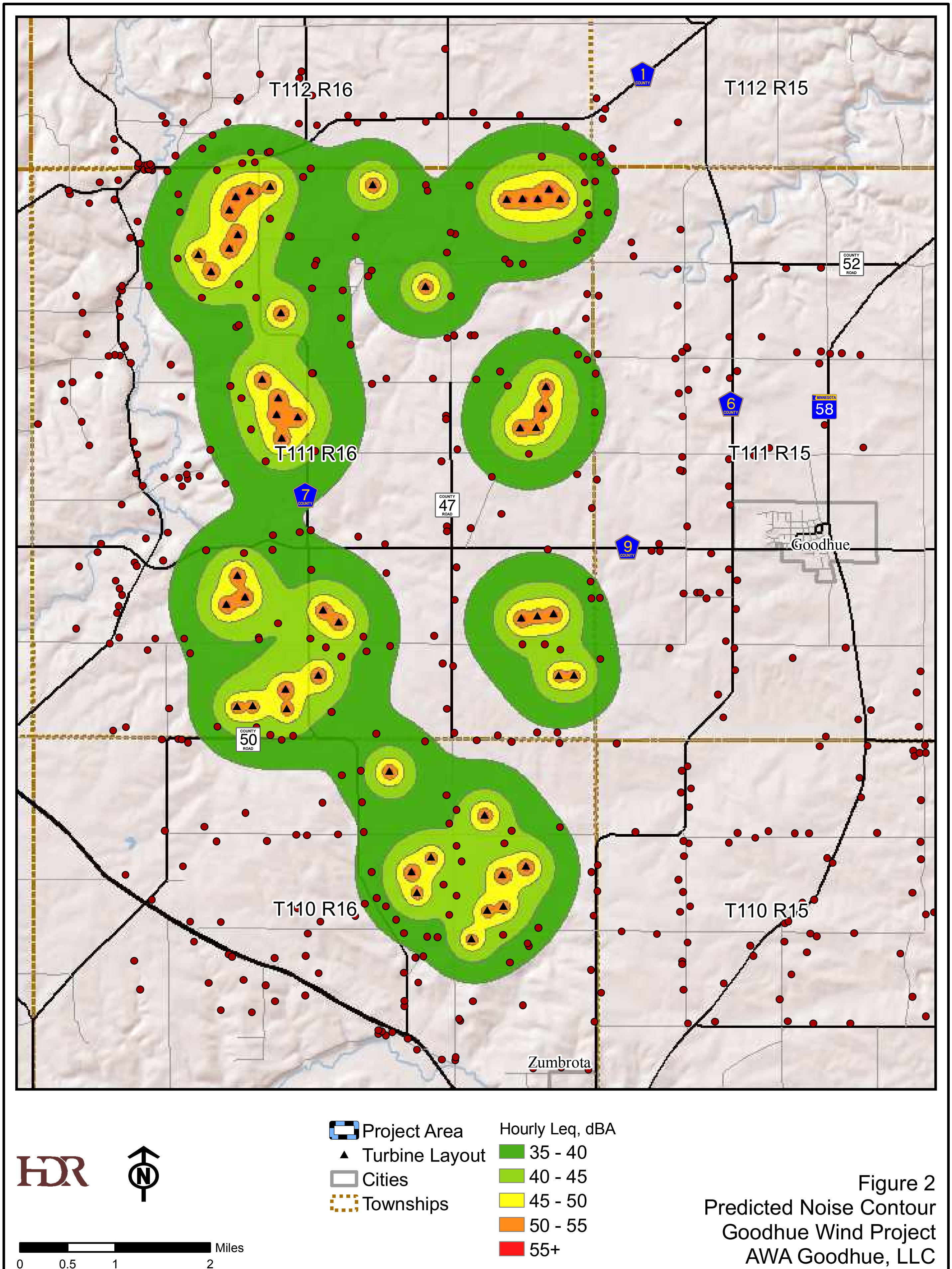

Figure 2
Predicted Noise Contour
Goodhue Wind Project
AWA Goodhue, LLC