

Wind Turbine Noise

With respect to the proposed
Sugar River Wind Project

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Wind Turbine Noise - Overview



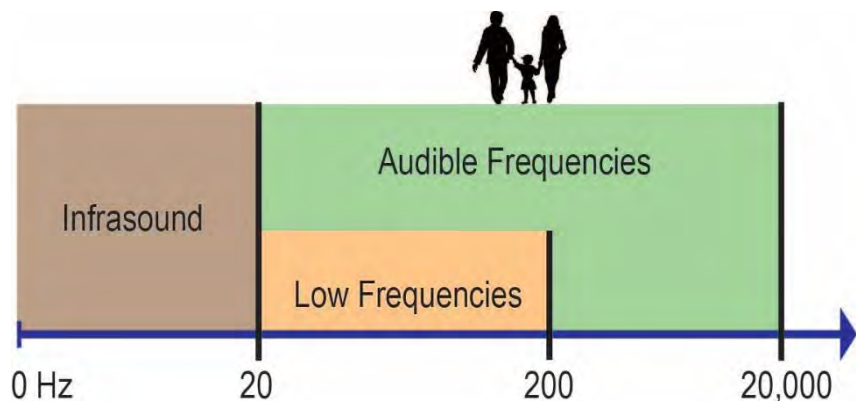
- Why listen to me?
(qualifications)
- Wind turbine noise levels
 - dBA (audible)
 - low-frequency noise (LFN)
 - infrasound
- Wind turbine noise standards
- Noise from the proposed Sugar River Wind project
- Confidence in predictions
- Conclusions

Wind Turbine Noise - Experience



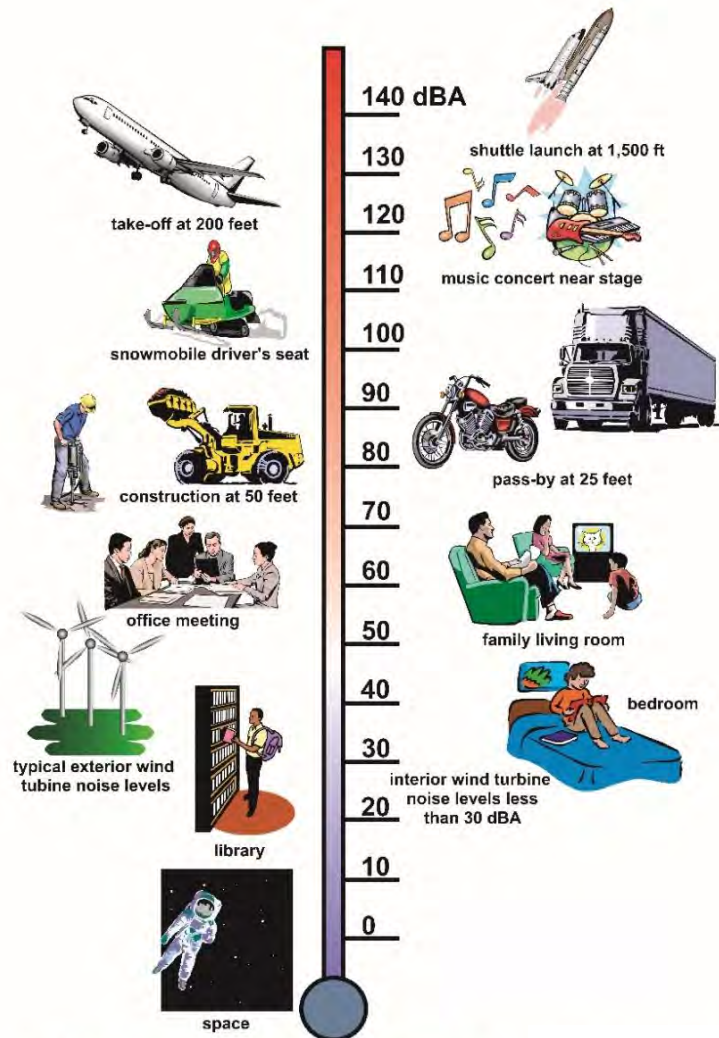
- Entire 30-year career dedicated to the measurement, analysis, and mitigation (reduction) of environmental noise.
- Focus on wind turbine noise in the last decade.
- Consulted on wind turbine projects located in 14 states across U.S.
- Analyzed noise on over 40 wind projects.
- Measured noise on 10+ projects – spent many hours in the field at operating sites, much of it at night.
- Expert testimony; recognized expert by boards, courts, and colleagues.
- Not affiliated with proposed project or EDF.

Wind Turbine Noise – Noise 101



- Humans generally hear frequencies between 20 and 20,000 Hertz (Hz).
- This is “audible noise” and is expressed using A-weighted decibels (dBA).
- A-weighting replicates how the human ear is more sensitive to mid and high frequencies than to low frequencies.
- Low frequency noise (LFN) is that from 20 to 200 Hz. Examples include bass music from car, a freight train, thunder. Expressed as C-weighted or octave band noise levels (dB).
- Infrasound is that below 20 Hz and is produced by wind turbines, vehicles, ocean waves, etc. Expressed using one-third octave or FFT noise levels.

Wind Turbine Noise – Typical A-weighted Levels



- From non-turbine sources, ambient noise levels range from about **20 to 120 dBA**.
- With no wind, traffic, insects/birds/frogs, or noise from resident/farming activities, ambient levels can be in the **20's (dBA)**.
- Traffic produces a wide range of levels, depending mainly on proximity, and levels can range from **30 to 80 dBA**.
- Birds/insects/frogs produce levels in the **30 to 50 dBA** range.
- Wind can at times produce noise levels ranging from less than **35 to 70 dBA** as it blows through vegetation and against structures.

SOUND PRESSURE LEVELS

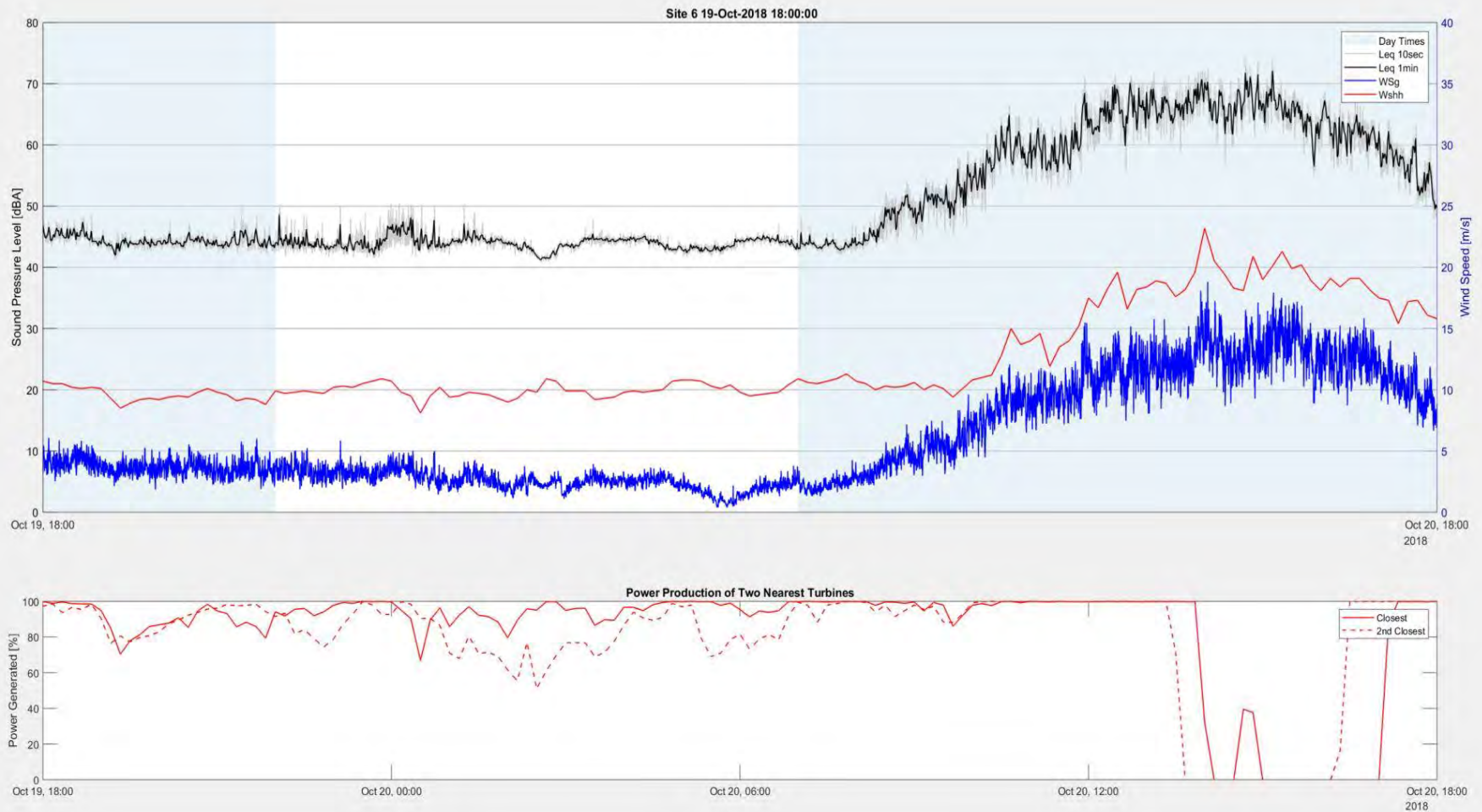
SOURCE: HANKARD ENVIRONMENTAL, INC., OCTOBER 2013

Wind Turbine Noise – How Loud Are They?



- With no wind, there is some residual noise produced by motors and cooling systems. Levels are in the **low 30's, dBA** at a distance of ~1,500 feet from the nearest turbine (nearest residences).
- At ~8 mph at hub-height, the turbines begin to spin and “aerodynamic noise,” that produced by the blades, begins to become audible (**30 to 40 dBA**).
- At ~20 mph at hub-height, turbines reach maximum rotational speed, and produce their maximum noise emission (**45 dBA**).
- At wind speeds greater than ~20 mph the turbines do not spin any faster and do not produce any more noise (still **45 dBA**).

Wind Turbine Noise – Audibility

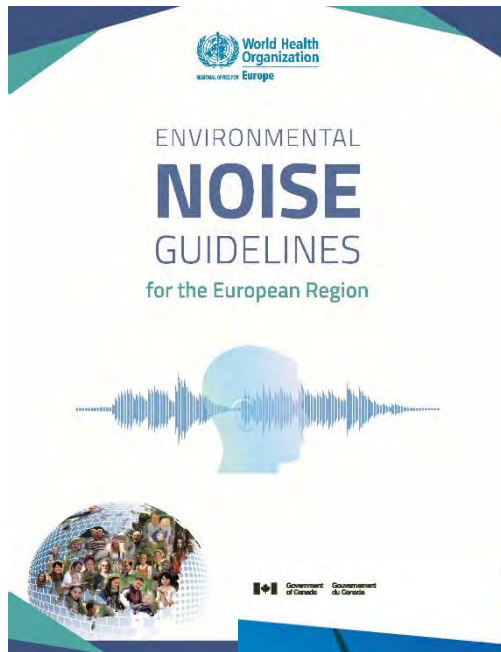


Wind Turbine Noise – How Often?



- Based on two months of measurements at a recent project in Illinois, turbines operated as follows:
 - Off ~25% of the time,
 - Partially ~60% of the time,
 - Full ~15% of the time,
 - Full but inaudible due to noise from the wind itself < 10 % of the time.

Wind Turbine Noise – Standards



- Wisconsin Admin. Code § PSC 128.14. requires 45 dBA or less at all non-participating residences.
- EPA (night) 45 dBA; WHO 2018 (annual avg. L_{den}) 45 dBA, Health Canada (46 dBA).
- Illinois ~47 dBA, Michigan 45 to 50 dBA, MN 47 to 50 dBA, Iowa often none, South Dakota 45 dBA.
- Previously permitted projects in U.S: 50+ dBA.

WHAT IS THE WIND TURBINE NOISE AND HEALTH STUDY?
Health Canada, in partnership with Statistics Canada, has conducted a study involving communities in Southern Ontario and Prince Edward Island to better understand the impacts of wind turbine noise on health and well-being. A total of 1238 households participated, out of a possible 1570.

The study had three parts:

- An in-person questionnaire, which was given to randomly selected participants living at various distances from the wind turbines;
- A collection of physical health measures that assessed stress levels using hair cortisol, blood pressure and resting heart rate, as well as measures of sleep quality; and
- More than 4000 hours of wind turbine noise measurements conducted by Health Canada to support calculations of wind turbine noise levels at all homes in the study.

WIND TURBINE NOISE AND HEALTH STUDY: SUMMARY OF KEY FINDINGS

The Wind Turbine Noise and Health Study is a landmark study and the most comprehensive of its kind. Both the methodology used and the results are significant contributions to the global knowledge base and examples of innovative, leading-edge research.

KEY FINDINGS

IT IS IMPORTANT to note that the results from this study do not provide definitive answers on their own and should be considered along with the other research available on the impacts of wind turbine noise on health. Results may also not be applied to other communities as the wind turbine locations in this study were not randomly selected from all possible sites operating in Canada.

Illness and chronic disease*
No evidence was found to support a link between exposure to wind turbine noise and any of the self-reported illnesses (such as dizziness, tinnitus, migraine) and chronic conditions (such as heart disease, high blood pressure, diabetes).

Stress*
No association was found between the multiple measures of stress (such as hair cortisol, blood pressure, heart rate, self-reported stress) and exposure to wind turbine noise.

Sleep*
The results of this study do not support an association between wind turbine noise and self-reported or measured sleep quality.

* While some people reported some of the health conditions above, their existence was not found to change in relation to exposure to wind turbine noise.

Annoyance and quality of life
An association was found between increasing levels of wind turbine noise and individuals reporting to be very or extremely annoyed.

No association was found with any significant changes in reported quality of life, or with overall quality of life and satisfaction with health. This was assessed using the abbreviated version of the World Health Organization's Quality of Life Scale.

Noise
Calculated noise levels were found to be below levels that would be expected to directly affect health (World Health Organization—Community Noise Guidelines [1999]). This finding is consistent with self-reported and measured results of the study.

HOW WILL THE INFORMATION BE USED?
Health Canada will consider the results of this study, along with other scientific research available, when providing advice on the health impacts of wind turbine noise.

These findings will also support decision-makers, such as provincial and territorial governments, in the development of decisions, advice and policies related to wind power development proposals, installations and operations.

These results are considered preliminary until published in the peer-reviewed scientific literature.

For more information
A more detailed Summary of Findings from the Wind Turbine Noise and Health Study has been published on the Health Canada website at www.hc-sc.gc.ca. For more information, please contact: ccrbp-pcrpc@hc-sc.gc.ca.

Wind Turbine Noise – Low Frequency

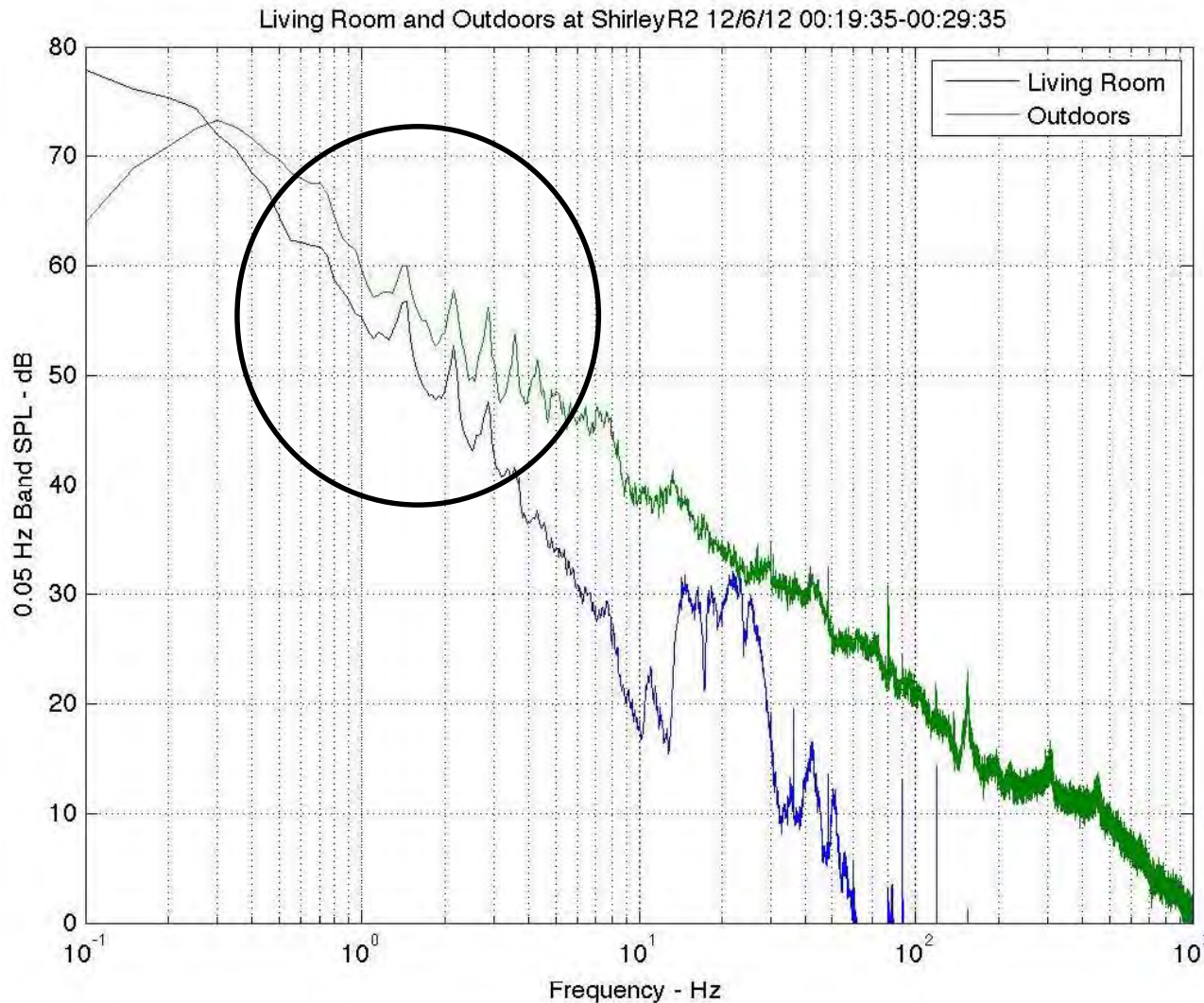


- LFN is that from 20 to 200 Hz.
- Typical sources include freight trains, conventional power plants, aircraft operations, bass music, and thunder.
- Quantified using octave band levels (dB) or overall C-weighted levels (dBC).
- ANSI S12.9 Part 4: “Generally, annoyance is minimal when octave-band sound pressure levels are less than **65 dB** at 16, 31.5, and 63-Hz mid-band frequencies.”
- Hankard Environmental measurements show LFN less than 60 dB.
- Turbines LFN levels not linked to health effects.

Wind Turbine Noise – Infrasound

- Infrasound is that from ~0 to 20 Hz.
- Wind turbines produce infrasound, but at levels orders of magnitude below human hearing thresholds.
- Infrasound is also produced by natural sources such as ocean waves, atmospheric disturbances, earthquakes, thunder, and wind blowing through vegetation and against houses.
- Infrasound produced by man-made sources, such as planes, automobiles, tractors, factories, and agricultural operations.
- No peer-reviewed or government study has linked wind turbine infrasound to health impacts (Health Canada, Japan, France, Germany, Australia, U.S. state studies, including Wisconsin).
- Lots of articles of speculation and fear-based stories on the www.
- ~60,000 operating wind turbines in U.S.

Wind Turbine Noise – Infrasound



Wind Turbine Noise – Infrasound

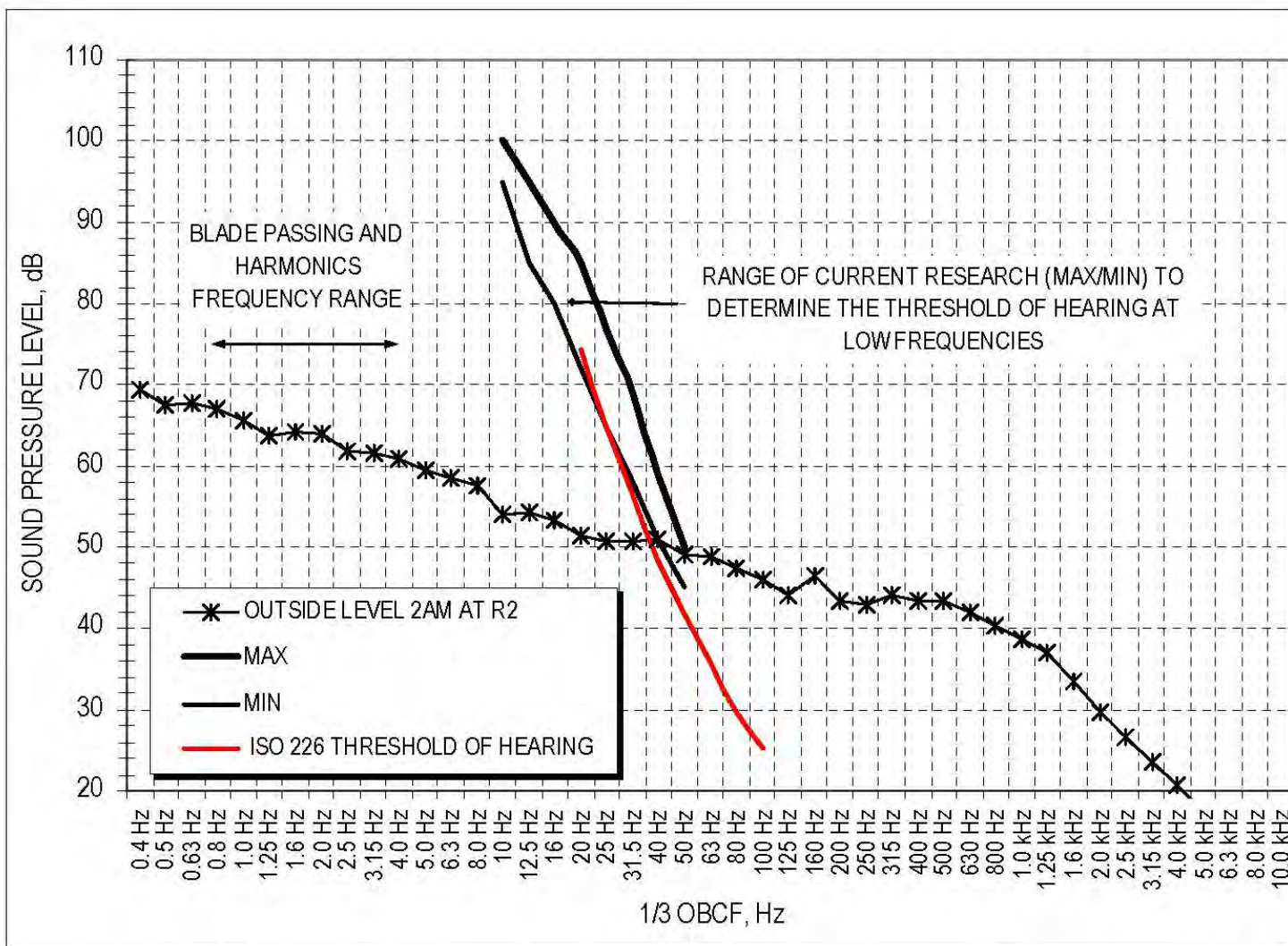
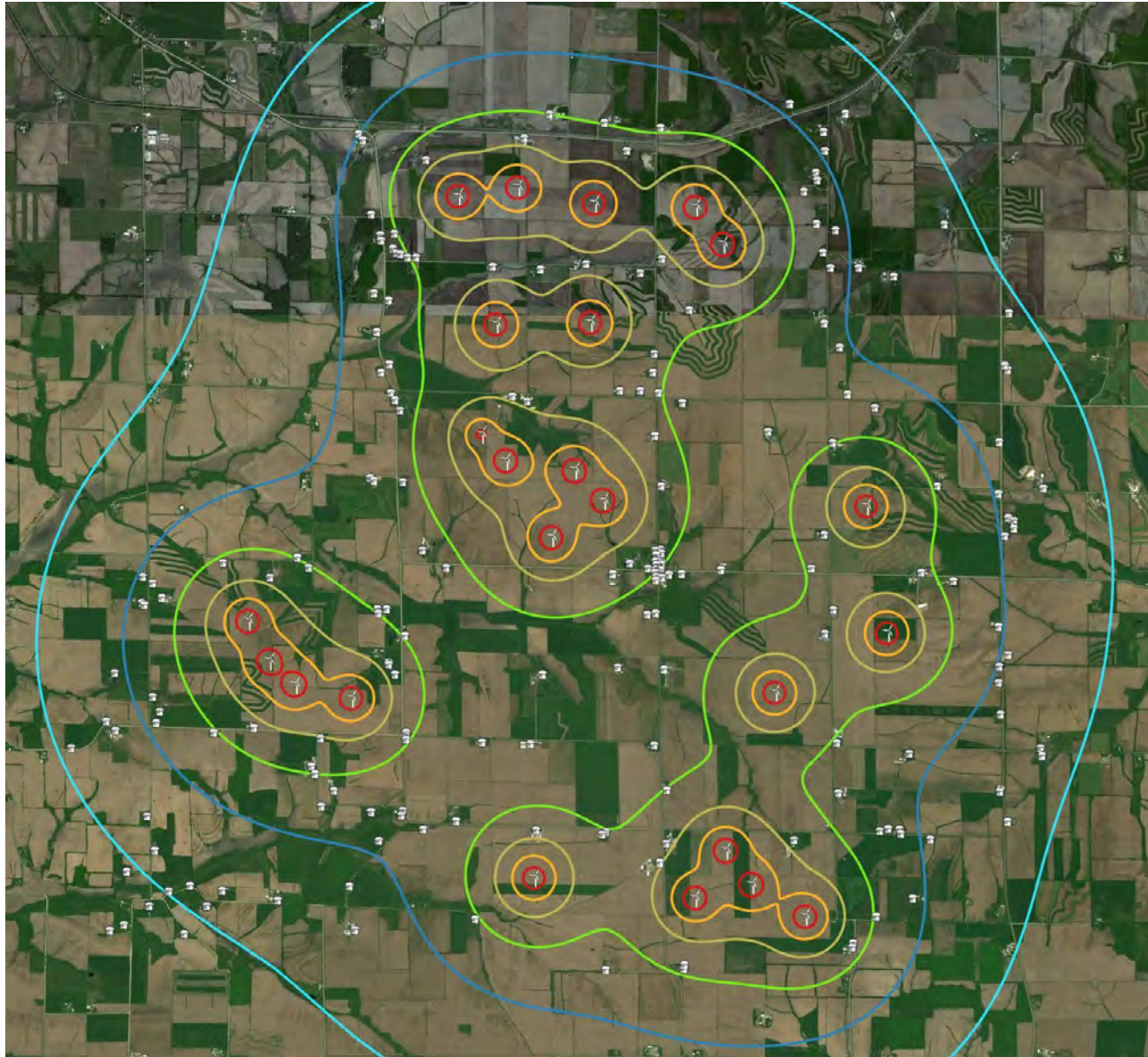
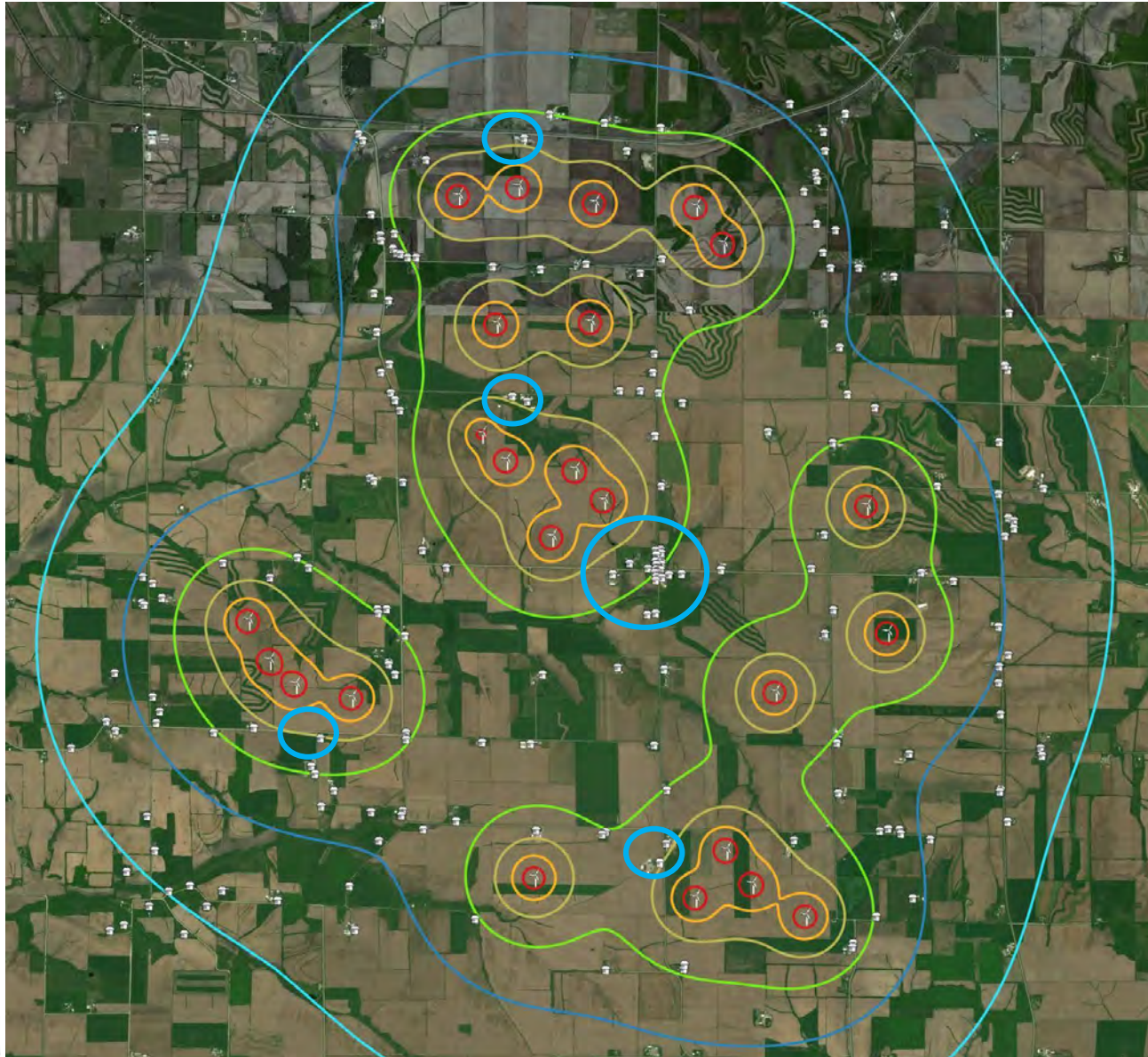


Figure 7.1 Measured Project Sound Level Compared to Threshold of Hearing

Wind Turbine Noise – Sugar River Project



Wind Turbine Noise – Sugar River Project



Wind Turbine Noise – Modeling Accuracy



- Hankard Environmental recently reviewed our noise measurement data at 28 locations on eight projects across U.S.
- Determined loudest one-hour regularly occurring turbine-only noise level.
- Compared these to predicted levels using the same modeling methodology employed on the proposed project.
- On average the model predicts perfectly.
- Occasional under-predictions of 1 dBA, as well as many over-predictions.
- LFN levels generally less than 60 dB.
- Infrasound not measured. International studies consistently show levels significantly less than human hearing threshold.

Wind Turbine Noise – Conclusions

- Sugar River Wind Project will be designed to a maximum level of 45 dBA at non-participating residences.
- This level complies with State of Wisconsin requirements, as well as EPA and WHO standards, is in line with Health Canada results, and at the lower end of the range that projects across the U.S. have been and continue to be permitted and operated.
- Actual turbine noise levels are less than predicted “loudest-hour” levels a majority of the time.
- When producing full emissions, noise from turbines is often masked by noise from the wind blowing through vegetation.
- Turbines not a source of significant LFN, turbine LFN levels meet stringent standards, and turbine LFN levels not linked to health effects.
- Turbines not a significant source of infrasound, levels are well below hearing thresholds, and no demonstrated evidence of health impacts.