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February 22, 2019

Dr. Brandon Storm, Ph.D.
Senior Meteorologist
Tradewind Energy, Inc.
Via email at BStorm@tradewindenergy.com

Subject: Sound Level Analysis Review
Proposed Aurora Wind Project – Williams County, North Dakota

Dear Dr. Storm:

Epsilon Associates, Inc. (Epsilon) has reviewed the sound level modeling analysis conducted by Tradewind Energy, Inc. (Tradewind) for the proposed Aurora Wind Project (Project) to be located in Williams County, North Dakota. The Aurora Wind Project consists of 130 proposed wind turbine locations with five (5) wind turbine scenarios being considered.

Sound level modeling was conducted for the proposed wind energy facility using WindPRO and was summarized in a report provided by Tradewind. Epsilon reviewed the sound modeling report which included figures and the model output in order to determine whether the methodology used to calculate project sound levels is consistent with the modeling methodology used by Epsilon for wind energy facilities and is consistent with an analysis specific to North Dakota.

Summary

The methods described in the report to predict sound pressure levels from wind energy facilities are generally consistent with Epsilon's sound modeling practices. Sound modeling for the Project adheres to the ISO 9613-2 international standard for sound propagation (Acoustics – Attenuation of sound during propagation outdoors – Part 2: General Method of Calculation) and uses a ground absorption factor of G = 0.5 (mixed ground). The manufacturer's sound power level documents were not provided, however, the sound power levels presented in the WindPRO sound reports are similar to those Epsilon has encountered for other wind turbines. A

+2dB k-factor has been added to the sound levels, which is also consistent with Epsilon's modeling approach.

Although the modeling details presented in the report are conservative and aligned with Epsilon's modeling methods, there are several aspects of the modeling and regulatory evaluation which require further explanation. Specific comments on those items are found below.

Terrain

Terrain can have a significant impact on sound levels, therefore it is important to include terrain for all outdoor acoustic modeling. There is no mention of terrain in the Tradewind report. However, based upon the Z-values shown in the WindPRO output, Epsilon assumes that terrain was used for sound modeling. This has been confirmed through personal communication with Tradewind.

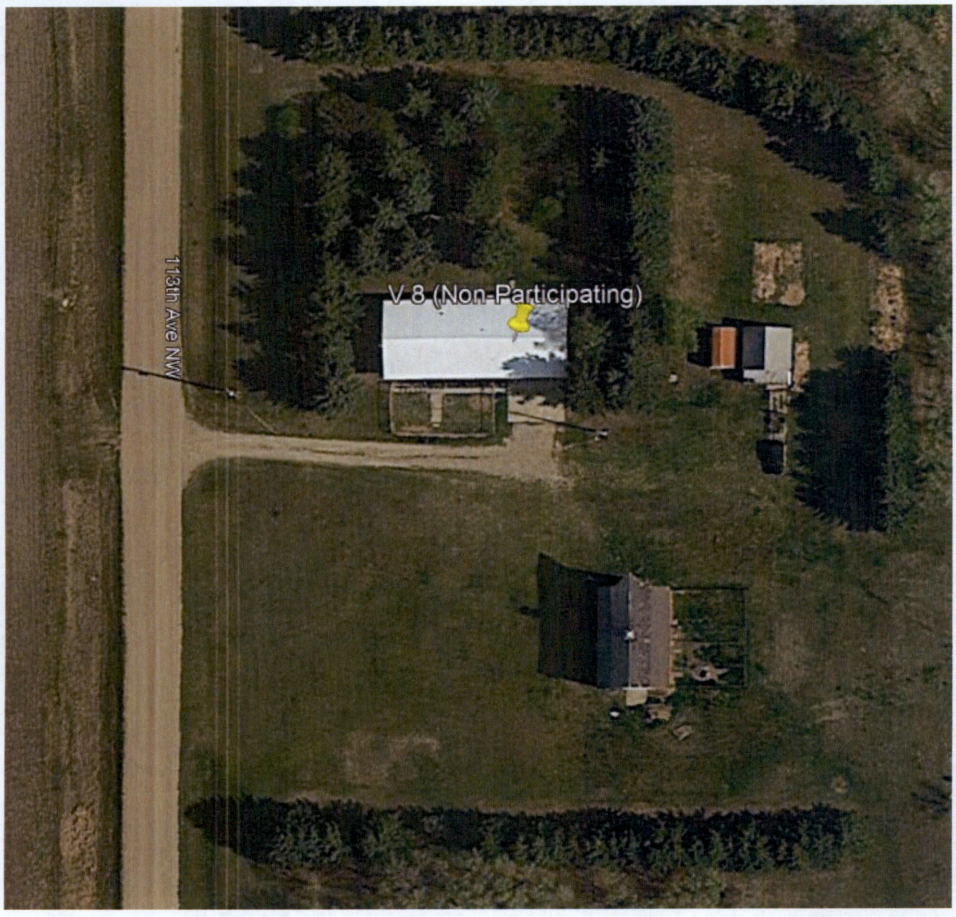
Receptors

Although in the Sound Analysis section of the report it states that the Commission has a wind turbine sound level limit of 50 dBA within 100 feet of an inhabited residence or community building, only center points of structures have been modeled. A detailed review of all receptor locations was not conducted, but Google Earth imagery for one receptor point (labeled as "V 8") is shown on the following page. Of the structures shown, the modeled location is likely a home although "Street View" was not available for this location to confirm this assumption.

Due to the modeling receptor location, sound levels within 100 feet of inhabited residences in the direction of the wind closest wind turbine would likely be slightly higher than what is presented in the WindPRO output. Although discrete points 100 feet from the homes were not modeled, compliance with respect to 50 dBA at this distance was evaluated by Tradewind. Table 2 of the Sound Analysis presents the distance from the receptor (assumed approximate center point of the home) to 50 dBA for the worst-case scenario (GE 2.5-127). The minimum distance presented is 253 feet. This distance (in meters) is directly output by WindPRO as shown in the provided outputs labeled as "Distance to noise demand". 253 feet (77 meters) is greater than the distance from the center point of the home to the façade of the home plus 100 feet; therefore, this location is in compliance with the sound level limit. Although this approach differs from Epsilon's typical approach for evaluating

this type of limit, the modeling analysis demonstrates compliance with the 50 dBA limit 100 feet from an inhabited residence for all turbine models presented.

Screenshot from Google Earth of Receptor V 8:



Meteorological Conditions

In the Main Result pages of the WindPRO generated output, a Meteorological coefficient (C0) is equal to 0.0 dB. It is unclear what temperature and humidity the model uses to calculate sound levels. Epsilon's standard assumptions are a relative humidity of 70% and a temperature of 10°C (50°F) in order to minimize the atmospheric attenuation in the 500 Hz and 1 kHz octave bands where the human ear is most sensitive. The use of 70% and 10°C (50°F) in this analysis has been confirmed through personal communication with Tradewind.

Wind Turbine Sound Power Levels

In the Main Result pages for the Gamesa SG132-3.465 in the Noise data column, the "Loudest Octave + 2dB" is indicated to be a sound power level of 106.1+2, however in the LwA,ref column, the total sound power level is listed as 108.0 dBA. It is unclear why this value is not 108.1 dBA; all other scenarios are accurate to the tenth of a decibel. This difference in the sound power level would result in an insignificant change to the receptors. In addition, this scenario results in modeled sound levels significantly less than other wind turbine scenarios modeled for this Project and would have no impact on this wind turbine model being compliant with the requirements.

Wind Turbine Hub Heights

The statement is made in the Tradewind report that the shortest hub height for a given wind turbine model was utilized to present worst-case sound results. Although this is true for the closest receptors, more distant receptors may have slightly higher modeled sound levels under a higher hub height. The approach selected by Tradewind does not negatively impact the sound level compliance evaluation for this Project as the approach results in higher sound levels at closer receptors which are the critical receptors for evaluating compliance.

Substation

A substation is not identified in the Sound Analysis. Based on personal communication with Tradewind a substation is a component of this Project. Tradewind has indicated that the substation will be beyond one mile from the closest inhabited residence. Therefore, the sound levels associated with transformer(s) at the substation will not result in an exceedance of the 50 dBA limit at inhabited residences.

Local Regulations

A discussion of county regulations is not presented in the report. Based on personal communication with Tradewind there are no applicable county or township wind energy regulations with respect to sound.

Conclusions

Epsilon has completed a review of the sound level modeling analysis conducted by Tradewind for the proposed Aurora Wind Project. The details of the modeling used

to predict sound pressure levels in the Project area as presented in the report are generally consistent with Epsilon's methodology. Although the analysis does not include discrete receptors 100 feet from inhabited structures, the limit at this distance is evaluated and demonstrates compliance. Items not clearly identified in the submitted report have been addressed through follow-up communication with Tradewind as identified in this letter and documented in the attached Exhibit A.

Based on the review of the sound level analysis conducted and my experience in this field of study, I conclude to a reasonable degree of scientific certainty that the Tradewind Sound Analysis can be relied upon for evaluating compliance with the North Dakota State Regulations with respect to sound from wind energy conversion facilities.

Sincerely,

EPSILON ASSOCIATES, INC.

Richard Lampeter

Richard Lampeter, INCE
Associate

Attachment: Exhibit A - Tradewind letter to Epsilon dated February 21, 2019

EXHIBIT A

tradewind energy

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Lenexa, Kansas 66219
P: 913.888.9463
tradewindenergy.com

February 21, 2019

Richard Lampeter, INCE
Associate
Epsilon Associates, Inc.
Via email at rlampeter@epsilonassociates.com

Subject: Confirming sound modeling assumptions and information

Dear Mr. Lampeter,

This communication is to confirm assumptions and modeling techniques Tradewind Energy applied in the Aurora Wind Project ("Project") sound analysis, as well as provide other requested information.

Terrain within WindPRO was represented in the sound analysis by ten foot height contour lines created from a ten meter digital elevation model.

The atmospheric absorption within WindPRO used reflects those applicable to a 10ºC and relative humidity of 70%.

With respect to the planned Project substation, the substation will be located more than one mile from any existing occupied residences or community buildings.

There are no county or township regulations regarding sound from wind energy facilities.

If you need any further information, please let me know.

Sincerely,

/s/ Brandon Storm

Brandon Storm
Senior Meteorologist
Tradewind Energy

EDUCATION

B.S., Environmental Science, Lyndon State College, 2001

PROFESSIONAL SUMMARY

Mr. Lampeter has more than 15 years of experience in conducting community sound level impact assessments. His areas of expertise include the measurement of ambient sound levels, modeling sound levels from proposed developments, evaluation of conceptual mitigation, and compliance sound level measurements. Mr. Lampeter has conducted impact assessments for power generating facilities, commercial developments, industrial facilities, and transfer stations. Richard's understanding of acoustical standards and modeling software has allowed him to provide accurate and reliable modeling results to developers and communities.

Since 2004, Mr. Lampeter has been involved in approximately 90 wind energy projects. In addition to performing numerous sound level impact assessments for wind energy facilities, Mr. Lampeter has conducted shadow flicker analyses for approximately 50 wind energy projects across the United States. Mr. Lampeter frequently presents key aspects of analyses to boards and committees and has provided sworn expert testimony.

Mr. Lampeter utilizes his diverse skill set as he serves in a variety of rolls on projects, ranging from project manager, to modeler, to field scientist. Richard is adept at using Larson Davis, Norsonic, RION, and CEL sound level meters and various modeling software packages including, Cadna/A and WindPRO.

Mr. Lampeter also has experience in air quality modeling and meteorological monitoring. Richard has used a variety of air dispersion models including CAL3QHCR, AERMOD, and CALPUFF and has displayed expertise in working with HOBO and NovaLynx portable weather stations.

Mr. Lampeter has co-authored several papers ranging in topics from wind energy to metal shredders, one of which appeared in a peer-reviewed journal. Mr. Lampeter has been a speaker at CanWEA's annual conference on the topic of low frequency noise from wind turbines and presented shadow flicker guidance and a regulatory update in a New England Wind Energy Education Project webinar.

PROFESSIONAL EXPERIENCE

Noise Impact Assessment – Power Projects – Renewable Energy

- *NextEra Energy Resources – Tuscola Wind II, Tuscola County, MI.* Project Manager for pre- and post-construction sound level impact assessments for a 100 megawatt (MW) wind energy facility composed of 59 GE wind turbines. Modeling was performed in order to demonstrate compliance with the sound level limits in each community. During multiple public hearings,

Mr. Lampeter responded to questions and comments. Following construction, operational sound levels were measured in each of the four townships per ordinance requirements.

- *Boreal Renewable Energy Development – Christopher House Wind Turbine Generator Project, Worcester, MA.* Project Manager for a sound level impact assessment prepared for a wind turbine feasibility study. Measured ambient background sound levels and modeled wind turbine sound levels under two scenarios. Impacts were compared to the local zoning ordinance and the Massachusetts Department of Environmental Protection (MassDEP) Noise Policy.

- *Palmer Renewable Energy Project, Springfield, MA.* Predicted future sound levels from a proposed 38 MW renewable biomass energy plant using the Cadna/A software package. Impacts were compared to state and local regulations with the results presented in the Environmental Notification Form.

- *NextEra Energy Resources – Pheasant Run Wind Energy Center, Huron County, MI.* Project Manager for a post-construction sound level compliance evaluation for a wind power generation facility composed of 88 wind turbines and an electrical substation. Sound levels were measured and evaluated at 15 residential locations. Following the submittal of a comprehensive report, results were presented to the Huron County Planning Commission.

- *Zotos International, Inc. – Two Wind Turbine Project, Geneva, NY.* Conducted a sound level impact assessment for two proposed wind turbines at the existing Zotos International facility. Calculated future sound levels using the Cadna/A noise calculation software. Prepared a comprehensive report comparing modeled sound levels to local regulations and relevant criteria. Presented the sound level assessment to the City of Geneva Planning Board.

- *FPL Energy (now NextEra Energy Resources) – Horse Hollow Wind Energy Center, Taylor County, TX.* Assisted in the development and execution of multiple sound level measurement programs for the 735 MW wind farm which at the time of its in-service date it was the world's largest wind farm. Analyzed sound level data in conjunction with power output data provided by NextEra Energy Resources and assisted in the preparation for legal proceedings.

- *Iberdrola Renewables – Groton Wind, Groton, NH.* Assisted in the collection of pre-construction ambient sound levels for a proposed 48 MW wind energy facility. Conducted post-construction sound level measurement programs in order to address the requirements of the State of New Hampshire Site Evaluation Committee Order and the Certificate of Site and Facility with Conditions for the Groton Wind Project. Analyzed the data collected for the evaluation of applicable limits.

- *NextEra Energy Resources – Lake Benton II Wind Project, Pipestone County, MN.* Project Manager for a sound level assessment for a repower project in Minnesota. The assessment consisted of an ambient measurement program and sound level modeling of the proposed wind turbines and existing wind turbines in the vicinity of the project. The findings were presented in a comprehensive report.

- *Heritage Sustainable Energy – Big Turtle Wind Farm Phase 2, Huron County, MI.* Project Manager for a pre- and post-construction sound level assessment for a wind energy facility to consisting of 14 Gamesa wind turbines. Sound levels were evaluated with respect to limits in the Huron County Wind Energy Facility Overlay Zoning Ordinance. Presented the results of the post-construction compliance evaluation to the Huron County Planning Commission.

- *Confidential Project, OK.* Project Manager for a sound level impact analysis. Developed and executed sound level measurement program in response to complaints made by a resident living adjacent to the wind farm. Data were compared to a generally accepted guideline and presented in a letter report.

- *NextEra Energy Resources – Golden West Wind Energy Center, El Paso County, CO.* Project Manager for a post-construction sound level evaluation of 249.4 MW wind power generation facility composed of 145 GE wind turbines. Collected attended and unattended sound level and meteorological data during two measurement programs. Presented the findings of the study to the Board of County Commissioners.

- *NextEra Energy Resources – Eight Point Wind Energy Center, Steuben County, NY.* Assisted in the sound level modeling for the pre-construction impact assessment required as part of the NY State Article 10 process. Sounds levels were modeled using Cadna/A and incorporated CONCAWE meteorology.

- *NextEra Energy Resources – Lee/DeKalb Wind Energy Center, Lee and DeKalb Counties, IL.* Developed and executed a post-construction sound level measurement program for a 217.5 MW wind farm consisting of 145 GE 1.5xle wind turbines. Over 5,000 hours were collected over a 5-week period at 16 locations. The results of this program found that sound levels due to the wind turbines under worst-case conditions were at or below the Illinois Pollution Control Board noise limits.

- *FPL – St. Lucie Wind Turbine Generation Project, St. Lucie County, FL.* Assisted in the development and execution of an extensive sound level measurement and modeling program for a proposed wind farm in St. Lucie County, FL. Collected ambient sound level data and meteorological data. Calculated the sound levels resulting from the operation of the wind turbines using the WindPRO modeling software. Six wind turbines were proposed to be constructed along a beach in Florida.

- *Boreal Renewable Energy Development – Nauset Regional High School Wind Turbine Generator Project, Eastham, MA.* Conducted a sound level impact assessment for a wind turbine feasibility study. Prepared a comprehensive letter report comparing modeled sound levels to the MassDEP Noise Policy.

- *NextEra Energy Resources – Tuscola Bay Wind Energy Center, Tuscola, Bay, & Saginaw Counties, MI.* Managed a sound level impact assessment project for a proposed 120 MW wind power generation facility composed of 75 wind turbines. Modeling was performed in order to demonstrate compliance with the sound level limits in each community. During multiple public hearings, Mr. Lampeter responded to questions and comments. Following construction, operational sound levels were measured as required by the township's ordinance.

- *NextEra Energy Resources - Waymart Wind Farm, Waymart, PA.* Executed multiple post-construction sound level measurement programs around the 65 MW wind turbine facility. Analyzed pre- and post-construction sound level data. Summarized data in succinct letter reports.

- *Iberdrola Renewables – Wild Meadows, Alexandria & Danbury, NH.* Measured ambient sound levels for a proposed 75.9 MW wind energy facility. Sound levels were measured at eight locations representative of nearby residences in various directions from the proposed wind turbines.

- *NextEra Energy Resources – Pegasus Wind Energy Center, Tuscola County, MI.* Project Manager for a pre-construction acoustic study for a 62 wind turbine project. Both ambient sound level measurements and sound level modeling were components of the project. Presented analysis findings and responded to questions and comments during multiple public hearings.

- *John Deere Wind Energy – Michigan Wind 1 Wind Farm, Huron County, MI.* Measured and analyzed post-construction sound level data collected to assess compliance with the Huron County noise ordinance and address complaints. The wind farm is a 69 MW project consisting of 46 GE 1.5sle wind turbines. Sound levels were measured at 14 different locations over a 20-day period. Over 4,000 hours of data were collected and analyzed for this program.

- *Heritage Sustainable Energy – Big Turtle Wind Farm, Huron County, MI.* Project Manager for a sound level compliance evaluation for an existing 20 MW wind energy facility composed of 10 Gamesa wind turbines. Measured sound levels were evaluated with respect to limits in the Huron County Wind Energy Facility Overlay Zoning Ordinance.

- Project Manager for a pre-construction acoustic study for a 62 wind turbine project. Both ambient sound level measurements and sound level modeling were components of the project. Presented analysis findings and responded to questions and comments during multiple public hearings.

- *Confidential Project, IA.* Project Manager for a sound level impact assessment for a wind farm in Iowa. Predicted future sound levels due to the operation of the wind turbines in areas surrounding the wind farm. Data were presented in tabular format and overlaid onto aerial photography.

- *NextEra Energy Resources – Osborn Wind Energy Center, MO.* Provided expert opinions regarding proposed amendments to the Clinton County Zoning Ordinance with respect to sound from a Wind Energy Conversion System. Provided sworn testimony under direct and cross examination at a Clinton County Planning & Zoning Commission hearing.

Noise Impact Assessment – Power Projects

- *Medical Area Total Energy Plant (MATEP), Boston, MA.* Managed multiple sound level measurement programs for the plant following the installation of two combustion turbines, gas compressors, and cooling towers. These programs included background sound level measurements, compliance operational sound level measurements, and evaluations of noise mitigation. The results of these measurement programs have been summarized in reports submitted to Veolia Energy and regulatory agencies. Assisted in the sound level modeling of a proposed 14.4 MW combustion turbine with a Heat Recovery Steam Generator. Collected sound level data for various rooftop equipment. Conducted post-construction sound level measurements for the evaluation of the MassDEP Noise Policy.

- *Lean Flame, Watervliet Arsenal, NY.* Project Manager for a sound level impact assessment for a proposed GE Frame 5 gas turbine on land leased from the Watervliet Arsenal. Developed and executed an ambient sound level measurement program. Calculated sound levels at various locations surrounding the site using modeling software. Presented the analysis in a comprehensive report.

- *Hollingsworth & Vose, Inc. Combined Heat & Power Project, West Groton, MA.* Conducted a sound level impact assessment for the proposed CHP. Sound levels were modeled using the Cadna/A noise calculation software. Evaluated multiple project designs. Presented the analysis to the local planning board.

- *National Grid – East Main Street Substation, Westborough, MA.* Managed a sound level impact assessment for the proposed expansion of a substation. The expansion included the installation of a 115/13.8 kV transformer. Predicted future sound levels were compared to existing sound levels for evaluation with the MassDEP Noise Policy. Presented the analysis in a concise report.

- *St. Joseph's Hospital Combined Heat & Power Project, Syracuse, NY.* Measured existing sound levels and conducted a modeling analysis for a project including a Solar Turbines Mercury 50 gas turbine with an electrical output of 4.5 MW and a Heat Recovery Steam Generator capable of producing 45,000 lbs. of steam. Sound levels were evaluated both in the community and in a patient room above the project. Summarized the results of the post-construction sound level measurement program in a concise letter report.

- *Advanced Power, Brockton Power Project, Brockton, MA.* Performed acoustical modeling for the 350 MW power generating facility using a noise prediction software package. Completed a Best Available Noise Control Technology (BANCT) Analysis which evaluated various noise control options. Assisted in the preparation for the Energy Facilities Siting Board (EFSB) hearings.

- *Braintree Electric Light Department – Thomas A. Watson Generating Station, Braintree, MA.* Measured sound levels at various locations for a proposed 116 MW natural gas and oil-fired simple cycle electric power generation facility. Assisted in the acoustical modeling, including several rounds of mitigation analyses. Team member for compliance sound level measurement programs.

- *Milford Power Company, Milford, CT.* Executed an ambient sound level measurement program over a three-day period for a combined cycle electric generating facility proposed in southern Connecticut. Participated in an additional sound level measurement program while construction was under way to collect sound level data during periods of steam venting.

- *Union College Combined Heat & Power Project, Schenectady, NY.* Conducted an analysis of the sound associated with the operation of a proposed gas-turbine based CHP plant for Bette & Cringe, LLC. The proposed plant will include a gas turbine generator package with an expected nominal gross power output of 1,804 kW. The NY DEC guidance document's 6 dBA increase over ambient limit was used as a guideline in evaluating noise impacts from the project.

- *Franklin Energy Center, Franklin, MA.* Conducted an ambient sound level measurement program around the Garelick Farms facility in Franklin to establish background sound levels before the construction of the cogeneration plant at the facility. Following construction of the plant, post-construction sound level measurements were taken. Drafted a sound level measurement letter report presenting the results of the program with respect to the Massachusetts Noise Policy.

- *FPL Energy - Jamaica Bay Peaking Facility, Far Rockaway, NY.* Participated in a sound level measurement program. Short-term and continuous measurements were made at the nearest residences.

- *Billerica Energy, Billerica, MA.* Assisted in the acoustical modeling using Cadna/A for a 480 MW simple cycle turbine facility. Modeled impacts under various scenarios and analyzed noise impacts at multiple locations.

- *Weaver's Cove Energy, Fall River, MA.* Assisted in the development and implementation of an extensive sound measurement program. Over a three-day period continuous and/or short-term measurements were taken at seven locations around the proposed liquefied natural gas (LNG) terminal. Obtained permission from local residences to install temporary noise equipment. Collected and organized the sound data for this project. Participated in an additional sound level measurement program to collect background sound level data in four communities which were in the vicinity of the proposed offshore berth.

- *Clifton Street Substation, Marblehead, MA.* Participated in multiple sound level measurement programs. Conducted a baseline noise measurement survey around the existing substation. Conducted a second survey after the existing transformer was replaced to assess compliance with permit conditions. Prepared a letter report summarizing the results.

Noise Impact Assessment – Quarries / Sand & Gravel / Asphalt

- *Aggregate Industries, Peabody, MA.* Project Manager for sound level measurement programs developed as part of the Special Permit requirements for the quarry and asphalt plant. Gathered data before and after mitigation measures were implemented, analyzed potential impacts due to a proposed relocation of equipment, and presented results at a Peabody Board of Health Meeting.

- *McCullough Crushing, Calais, VT.* Collected reference sound level data at an operating sand and gravel pit. Modeled future sound levels due to sand and gravel extraction and processing using Cadna/A. Prepared a comprehensive report evaluating potential community noise impacts.

- *Dalrymple Gravel & Contracting Co., Inc., Erwin, NY.* Measured reference sound levels for an off-road haul truck and associated hopper-loading activities at the existing Scudder Sand and Gravel Pit.

- *Massachusetts Broken Stone Company, Berlin, MA.* Executed a sound measurement program for an existing asphalt company. Measured sound levels during operational and background conditions. Prepared a letter report summarizing the results.

- *Ambrose Brothers Inc., Sandwich, NH.* Executed two sound level programs at a sand and gravel excavation site. The first program involved measuring sound levels at the house of a concerned neighbor with a portable crusher at its original location. The second program involved measuring sound levels at the same residence with the crusher at a new location. Prepared letter reports for each of the measurement programs.

Noise Impact Assessment – Industrial

- *General Electric Company, Hudson River PCBs Superfund Site, Hudson River, NY.* Assisted in the Phase 1 RAM through the routine collection of sound level data in the community surrounding the dredging activity and processing facility. Collected reference sound level data of noise sources for the project.

- *Cianbro Corporation – Metal Fabrication Plant, Georgetown, MA.* Conducted an operational sound level measurement program around the existing facility during which sound levels were continuously measured at a property line and sound levels associated with individual operations/equipment were measured at a reference distance. Summarized the program and identified mitigation options in a letter report.

- *Berwick Iron and Metal Recycling, Berwick, ME.* Modeled a proposed metal shredder at an existing metal recycling facility using Cadna/A and proposed mitigation to minimize sound level impacts to the community. Participated in a post-construction sound level measurement program to assess compliance with respect to local sound level limits.

- *Former Coal Tar Processing Facility, Island End River, Everett, MA.* Participated in multiple sound measurement programs at a former industrial facility. Measured sound levels under existing conditions before and after a pilot study. Measured sound levels at nine locations during a pilot program to generate information about the relationships between dredging operations and their effects on area sound levels. Took individual reference measurements for each of the various types of equipment operated during the pilot study. Collected sound level data during periods of pile driving activity during the sheet pile wall installation phase of the project.

- *Excel Recycling, Freetown MA.* Conducted attended sound level measurements and detailed sound level modeling to evaluate potential mitigation options for an existing metal shredding and processing facility.

- *FedEx Distribution Facility, Billerica, MA.* Conducted a third-party review of a noise study for a proposed distribution facility. The review was performed for BETA Group who was hired by the Town of Billerica. Presented findings at a Billerica Board of Health meeting.

Noise Impact Assessment – Transfer Stations / Landfills

- *Casella Waste Systems, Inc. - Juniper Ridge Landfill, Old Town, ME.* Conducted a sound level impact assessment for the proposed expansion of the existing Juniper Ridge Landfill. The analysis included mobile noise sources associated with the management of solid waste and a new stationary source, the proposed landfill gas to energy facility. Modeled sound levels were evaluated against both state and local regulations.

- *Holliston Solid Waste Transfer Station, Holliston, MA.* Participated in a sound level measurement program at a solid waste transfer station in Massachusetts. Coordinated with the transfer station and with local residences on the placement of noise equipment. Weekday and weekend measurements (short-term and continuous) were taken at up to six locations around the facility. Participated in additional sound level measurement programs following the enclosure of the C&D facility to evaluate various mitigation options.

- *Hardwick Landfill, Hardwick, MA.* Conducted multiple sound level measurement programs around an existing landfill. Sound levels were measured to evaluate the effectiveness of backup alarm mitigation and to compare levels with and without a gas flare operating. Presented the results of the measurement programs in concise letter reports.

- *Resource Recovery of Cape Cod Inc., Sandwich, MA.* Participated in a group effort in conducting two consecutive 12-hour ambient sound level measurements and one 5-hour ambient sound level measurement at multiple locations for a construction & demolition transfer station in Cape Cod. The study was conducted to establish background sound levels around the facility.

Noise Impact Assessment – Institutional

- *Town Hall Renovation, Orleans, MA.* Project Manager for a sound level impact analysis for the renovation of a town hall. Measured existing sound levels at several locations and calculated future sound levels from the proposed mechanical equipment at multiple evaluation points. Following construction and the installation of the new equipment, additional measurements were collected to compare current operational sound levels to background sound levels. All findings were summarized in concise letter reports.

- *Institute of Contemporary Art, Boston, MA.* Conducted a sound level measurement program at the future site of the ICA to determine the maximum noise impacts from airplanes taking off from Logan Airport. Coordinated with the Massport Noise Abatement Office to ensure that the

desired runway was being used. Gathered detailed information characterizing the noise environment of the site.

- *Phillips Academy, Andover, MA.* Measured sound levels with and without the compressor system operating at the new ice hockey facility. Prepared a letter report comparing the results to the Massachusetts Noise Policy.

- *Harvard University, Boston, MA.* Conducted an ambient sound level measurement program. Sound levels were measured around the proposed Northwest Laboratory.

- *Northeastern University, Boston, MA.* Conducted an ambient sound level measurement program. The college was interested in constructing an additional building on campus and was concerned about the noise issues related to the project.

Noise Impact Assessment – Commercial / Residential

- *Stop & Shop Supermarkets.* Executed ambient sound level programs at numerous supermarket locations in New England. Gathered reference sound level data for mechanical equipment at an existing store. Analyzed the potential for impacts at residences due to the addition of mechanical equipment using the Cadna/A noise prediction software.

- *Washington Village Project, Boston, MA.* Evaluated predicted sound levels for the proposed redevelopment of an approximately 4.89-acre site in the South Boston neighborhood. The redevelopment will include eight new residential buildings with most containing ground floor retail, as well as new streets, plazas, and green spaces. Results of the analysis were presented in an Expanded Project Notification Form (PNF).

- *110 Broad Street Project, Boston, MA.* Conducted a sound level modeling analysis for the redevelopment of 7,680 square foot site. The project includes the restoration of the historic Bulfinch Building at 102 Broad Street and the construction of a new residential building with ground floor commercial/café space at 110-112 Broad Street. The predicted sound levels were evaluated with respect to the City of Boston noise standards with the results presented in an Expanded PNF.

- *55 India Street Project, Boston, MA.* Modeled and evaluated sound levels for mechanical equipment associated with a proposed 67,000 square foot building with ground floor commercial space and 44 residential units above. Results were presented in the Expanded PNF.

- *Parcel 1 Project, Boston, MA.* Analyzed sound level impacts from the mechanical equipment associated with the proposed residential/commercial development located in Boston's historic Bulfinch Triangle. Modeling was performed using Cadna/A with the results presented in the Expanded PNF.

- *Big Y Supermarket, Northampton, MA.* Measured sound levels during normal operations at the supermarket and gathered background sound levels without the supermarket operating.

- *Crosby's Market, Hamilton, MA.* Measured sound levels around the existing market at the nearest residences in response to concerns by neighbors over the renovation and expansion of the market.

- *Condominiums, Marblehead, MA.* Measured sound levels during the operation of condenser units located at a condominium. Prepared a letter report comparing the results to the town noise ordinance.

- *Banquet Hall, Whately, MA.* Conducted a sound level analysis for a proposed seasonal banquet hall. The noise source of concern was music being played during functions at the hall. Prepared a letter report comparing the modeling results to the MassDEP Noise Policy.

Noise Impact Assessment – Additional Projects

- *Chestnut Ridge Rod and Gun Club, Dover, NY.* Project Manager for a sound level impact analysis at an existing rod and gun club. Devised and executed a sound level measurement program. Developed mitigation strategies and calculated potential future noise impacts. Summarized all findings in a comprehensive letter report.

- *Storrow Drive Tunnel Reconstruction Project, Boston, MA.* Collected sound level data at various points along Storrow Drive. Presented the noise impact analysis during an Advisory Committee Meeting.

- *TMR Preserve, Dover, NY.* Conducted two sound level programs at a proposed sporting club. Took ambient measurements to document existing conditions in the area. Future conditions were simulated as individuals discharged several types of firearms at various shooting locations in the preserve. Compared measurements taken during these conditions to the existing conditions along with state and local noise regulations.

Shadow Flicker

- *Iberdrola Renewables – Desert Wind, Perquimans and Pasquotank Counties, NC.* Managed a shadow flicker impact assessment for a proposed wind power generation facility to be located in North Carolina. Shadow flicker from the 150 Gamesa G97 2.0 MW wind turbines was calculated. Separate reports were prepared for each county. Gave sworn testimony to the Board of Commissioners in each county.

- *NextEra Energy Resources – Tuscola Bay Wind Energy Center, Tuscola, Bay, & Saginaw Counties, MI.* Project Manager for a shadow flicker analysis for a proposed 120 MW wind power generation facility composed of 75 wind turbines. The expected duration of shadow flicker was calculated at sensitive receptors in the vicinity of the project. Responded to questions and comments at multiple public hearings.

- *Confidential Project, MA.* Calculated the duration of shadow flicker from a proposed wind turbine to be located in Massachusetts using the WindPRO shadow module.

- *State of Connecticut Siting Council, CT.* Contributor to the Epsilon project team providing professional consulting services for renewable energy projects to the Siting Council in CT. Examined analyses conducted, including shadow flicker, for a proposed wind energy project in CT. Reviewed submittals provided by the council and submitted comments.

- *State of New Hampshire, Concord, NH.* Conducted an independent review of the shadow flicker analysis for the proposed 24 MW Lempster Mountain Wind Power Project in Lempster, NH. Calculated the duration of shadow flicker using WindPRO software and compared the results to the developer's analysis.

- *Pioneer Green Energy – Great Bay Wind I, Somerset County, MD.* Calculated the expected annual duration of shadow flicker from a 25-wind turbine project. Multiple layouts and wind turbine types were evaluated for the project. Reductions in shadow flicker due to vegetation were calculated for individual residences. A scaling factor due to curtailments was incorporated into the analysis. The results were presented in a stand-alone report.

- *NextEra Energy Resources – Golden West Wind Energy Center, El Paso County, CO.* Project Manager for a shadow flicker modeling analysis of an operating 249.4 MW wind power generation facility composed of 145 GE wind turbines. Presented the findings of the study to the Board of County Commissioners.

- *NextEra Energy Resources – Lake Benton II Wind Project, Pipestone County, MN.* Project Manager for a shadow flicker modeling analysis for a repower project in Minnesota. Shadow flicker modeling was conducted for 44 proposed wind turbines and four alternates.

- *NextEra Energy Resources – Eight Point Wind Energy Center, Steuben County, NY.* Conducted the shadow flicker analysis for the proposed wind energy project required as part of the NY State Article 10 process. The shadow flicker analysis was performed to determine the location and duration of shadow flicker resulting from the proposed 31 GE wind turbines.

- *NextEra Energy Resources – Pegasus Wind Energy Center, Tuscola County, MI.* Project Manager for a pre-construction shadow flicker modeling study for a 62 wind turbine project. Provided recommendations for layout adjustments to reduce shadow flicker. Presented analysis findings and responded to questions and comments during multiple public hearings.

- *Eolian Renewable Energy – Antrim Wind, Antrim, NH.* Conducted a shadow flicker analysis for a proposed 28.8 MW wind power generation facility to be composed of nine (9) Siemens SWT-3.2-113 3.2 MW wind turbines. There were no federal, state, or local regulations limiting the amount of shadow flicker resulting from the operation of the proposed wind turbines for this Project. However, the predicted shadow flicker at occupied buildings in the vicinity of the project were put into context by comparing the annual duration of shadow flicker to a value of 30 hours per year.

- *Heritage Sustainable Energy – Big Turtle Wind Farm Phase 2, Huron County, MI.* Project Manager for a shadow flicker analysis for a proposed wind energy facility. Shadow flicker resulting from the operation of 15 Gamesa wind turbines was calculated at discrete modeling

points and isolines were generated from a grid encompassing the area surrounding the wind turbines.

- *NextEra Energy Resources – Tuscola Wind II, Tuscola County, MI.* Project Manager for a shadow flicker analysis for a proposed 100 MW wind power generation facility composed of 59 wind turbines. Results were presented in reports for each of the four townships which would have a wind turbine. Responded to questions and comments at multiple public hearings.

- *Iberdrola Renewables – Blue Creek Wind Farm, Van Wert and Paulding Counties, OH.* Project Manager for a shadow flicker analysis for a proposed wind farm in Ohio consisting of Gamesa G90 2.0 MW wind turbines. Results were presented in a comprehensive report which was submitted to the Ohio Power Siting Board.

- *First Wind - Weaver Wind, Hancock County, ME.* Sub-consultant to Normandeau Associates for a wind energy project consisting of approximately 15 wind turbines. Shadow flicker modeling was conducted for two options with the results compared to local regulations. The results of the analyses were presented at an Open House for the project.

- *NextEra Energy Resources – Montezuma Wind Farm, Solano County, CA.* Performed an analysis to estimate the hours per year of shadow flicker in the area surrounding the proposed wind farm. Impacts were presented visually as isolines overlaid onto an aerial image which was included in a concise letter report summarizing the results.

- *FPL – St. Lucie Wind Turbine Generation Project, St. Lucie County, FL.* Evaluated the potential for shadow flicker impacts at the nearest residences resulting from the operation of six wind turbines proposed as part of this project. Presented the results in a clear and concise report.

- *NextEra Energy Resources – Osborn Wind Energy Center, MO.* Provided expert opinions regarding proposed amendments to the Clinton County Zoning Ordinance with respect to shadow flicker from a Wind Energy Conversion System. Provided sworn testimony under direct and cross examination at a Clinton County Planning & Zoning Commission hearing.

Air Quality Modeling

- *Besicorp Empire Development Company, Rensselaer, NY.* Worked on modeling predicting $PM_{2.5}$ concentrations from truck and rail traffic associated with a newsprint facility and a cogeneration facility using CAL3QHCR. Produced graphics showing the estimated concentrations in the nearby area.

- *Alcoa Eastalco Works, Frederick, MD.* Assisted in the modeling of an existing aluminum facility. Worked closely with project managers in developing strategies to accurately address the numerous sources throughout the facility. Assisted in the running of CALMET, CALPUFF, and CALPOST. Developed various graphics to illustrate to the client the results of the modeling.

- *Storrow Drive Tunnel Reconstruction Project, Boston, MA.* Assisted in a microscale analysis using EPA MOBILE6 and CAL3QHC. Analyzed various reconfiguration scenarios. Presented the mesoscale and microscale analyses during an Advisory Committee Meeting.

- *Bangor-Hydro Electric Company, Bangor, ME.* Assisted in the renewal process for existing air permits for the Medway, Eastport, and Bar Harbor facilities of the Bangor-Hydro Electric Company. Utilized Satellite i-Steps for generating annual air emission statements.

- *JAMALCO, Jamaica.* Assisted with the modeling analysis for the Clarendon Alumina Works in Jamaica. ISCST3 was used to model various operating scenarios. Prepared graphics illustrating pollutant concentrations around the facility.

- *FPL Energy.* Assisted in AERMOD, CALMET, and CALPUFF modeling for a project in Virginia. Gathered and processed data for the project. Helped to create many of the model runs used in the analysis. Created several figures used in the report.

- *Columbus Center, Boston, MA.* Assisted in the microscale analysis of seven intersections around a proposed development over the Massachusetts Turnpike. Used ISC-Prime to estimate impacts from point sources and volume sources from proposed buildings and tunnels. Used CAL3QHCR to estimate impacts from mobile sources. These models were used to evaluate each of the four building alternatives. Provided graphics for the project.

Air Quality Monitoring

- *Massachusetts Broken Stone Company, Berlin, MA.* Participated in an air quality monitoring program for an existing asphalt plant. Assisted in the installation of a meteorological tower. Made routine trips to the facility to maintain and download data from the H_2S monitor.

- *Former Coal Tar Processing Facility, Island End River, Everett, MA.* Participated in an air quality monitoring program for a former industrial facility. Gathered data before and after a pilot study to document existing conditions. Used various types of sampling equipment including SUMMA Canisters and PUF samplers to collect samples during the pilot study.

Meteorological Monitoring

- *Wheelabrator Millbury Municipal Waste Combustor Facility, Millbury, MA.* Routinely collected data from a meteorological tower at a municipal waste facility. Assisted in the maintenance and calibration of the equipment. Provided quarterly reports.

PUBLICATIONS

- "Low frequency sound and infrasound from wind turbines." Noise Control Engineering Journal, Institute of Noise Control Engineering, Volume 59, Number 2, March-April 2011. O'Neal, R.D., Hellweg, Jr., R.D. and R. M. Lampeter.

- "Sound Defense for a Wind Turbine Farm." North American Windpower, Zackin Publications, Volume 4, Number 4, May 2007. O'Neal, R.D., and R.M. Lampeter.

CONFERENCE PAPERS

- "Evaluating and controlling noise from a metal shredder system." INTER-NOISE 2012, New York City, NY, August 19-22, 2012. O'Neal, R.D., Lampeter, R.M., Emil, C.B. and B.A. Gallant.
- "Low frequency sound and infrasound from wind turbines – a status update." NOISE-CON 2010, Baltimore, MD, April 19-21, 2010. O'Neal, R.D., Hellweg, Jr., R.D. and R. M. Lampeter.
- "Nuisance noise and the defense of a wind farm." INTER-NOISE 2009, Ottawa, Canada, August 23-26, 2009. O'Neal, R.D., and R.M. Lampeter.

PRESENTATIONS

- "Sound Levels and the Evolving Regulatory Landscape." AWEA WINDPOWER 2016 Poster Presentation, May 23-26, 2016.
- "How to Address Post-Construction Sound Level Measurement Requirements." AWEA WINDPOWER 2015 Poster Presentation, May 18-21, 2015.
- "Evaluating Shadow Flicker in the Current Regulatory Environment." Massachusetts Wind Working Group, October 30, 2013.
- "Shadow Flicker Regulations and Guidance: New England and Beyond." New England Wind Energy Education Project Webinar, February 10, 2011
- "Low Frequency Sound and Infrasound from Wind Turbines." CanWEA 2010, Montreal, Canada, November 1-3, 2010. O'Neal, R.D., Hellweg, Jr., R.D. and R. M. Lampeter.

PROFESSIONAL ORGANIZATIONS

Institute of Noise Control Engineering (INCE)

PREVIOUS EMPLOYERS

NYC Department of Environmental Protection, June - August 2000.
Meyer Strong and Jones Engineers, P.C., May – August 1999.