TECHNICAL MEMORANDUM

In-Air Noise Evaluation – South Fork Wind Farm and South Export Cable

PREPARED FOR:	Deepwater Wind South Fork, LLC (DWSF)
COPY TO:	File
PREPARED BY:	Mark Bastasch, P.E., Jacobs
DATE:	March 21, 2019
PROJECT NUMBER:	689538
REVISION NO.:	03
APPROVED BY:	Jeff Nield, Jacobs

DWSF asked CH2M (now, Jacobs) to evaluate selected project-related activities resulting in impact-producing factors for in-air (or airborne) noise and its potential for causing adverse impacts on wildlife and people. Based on the project descriptions provided by DWSF describing the construction, operation and maintenance (O&M), and decommissioning of the South Fork Wind Farm (SFWF) and South Fork Export Cable (SFEC), CH2M identified those offshore project activities that will result in in-air noise. The scope of this evaluation included project activities for the SFWF and the offshore segments of the SFEC. Noise-producing activities associated with the construction and operations of the proposed SFEC and SFEC Onshore are the subject of a separate study completed by VHB (2018). Additionally, project-related underwater sounds were evaluated in a separate study by Denes et. al. (2018).

This technical memorandum provides the results of a literature review and desktop sound analysis conducted to help define a few in-air sounds from construction and decommissioning and O&M activities of the SFWF and offshore portions of the SFEC sea-to-shore transition. It puts into context the anticipated sound levels and their potential to impact certain receptors. For instance, expected offshore in-air sounds will be to too far away from receptors (people) other than shipboard project construction workers or the infrequent visitor to the construction area. Also, many of the anticipated construction sounds in or near East Hampton are considered within the range of typical construction sounds. Therefore, the potential for in-air sound impacts are expected to be low, resulting in negligible to minor impacts, as discussed in Section 4 of the SFWF and SFEC Construction and Operations Plan (COP).

Sources of Airborne Noises: SFWF and SFEC

Noises expected to be transmitted through the atmosphere, above the surface of the water, at levels potentially impactful to wildlife and people were assessed. The activities included in this assessment are helicopter use, impact pile driving, vibratory pile driving, and wind turbine operations. Other construction noises are the subject of separate noise evaluations also included in Appendix J of the COP.

To begin the assessment, it is useful to discuss the difference between a sound pressure level (or noise level) and a sound power level. A sound power level (commonly abbreviated as PWL or Lw) is analogous to the wattage of a light bulb; it is a measure of the acoustical energy emitted by the source and is, therefore, independent of distance. A sound pressure level (commonly abbreviated as SPL or Lp) is analogous to the brightness or intensity of light experienced at a specific distance from a source and is measured directly at the Vashon Ferry Terminal (WSDOT, 2010) found that sound levels predicted with a sound level meter.

Sound power level data are used in acoustic models to predict sound pressure levels. This is because sound power levels consider the size of the acoustical source and account for the total acoustical energy emitted by the source. For example, the sound pressure level 15 feet (4.6 meters [m]) from a small radio and a large orchestra may be the same, but the sound power level of the orchestra will be much larger because it emits sound over a larger area. Similarly, 2-horsepower (hp) and 2,000-hp pumps can both achieve 85 A-weighted decibels (dBA) at 3 feet (1 m; a common specification), but the 2,000-hp pump will have a significantly larger sound power level. Consequently, the noise from the 2,000-hp pump will travel farther. A sound power level can be determined from a sound pressure level if the distance from and dimensions of the source are known. Sound power levels always will be greater than sound pressure levels, and sound power levels should never be compared to sound pressure levels.

Aircraft Noise: Helicopters

Helicopters may be used to a limited extent for emergency transport between the SFWF and onshore landing locations. While flying offshore, helicopters generally maintain altitudes above 700 feet (213.4 m). However, when traveling between wind turbine generators (WTGs), helicopters may fly at a height between 200 and 500 feet (61 and 152.4 m). The helicopter flight path generally will avoid flying directly over residences. Increased helicopter activity could result in increased noise at the offshore helipad or along flight paths to the SFWF. The audibility and duration of noise associated with the helicopter is greater in air than underwater. Figure 1 compares noise from helicopters to those of other common sources (Helicopter Association International, 2017). The infrequent use of helicopters and distances offshore of the predominant helicopter flight path make it unlikely that helicopter noise will adversely impact onshore or offshore receptors, except for personnel located near the helipads used by the project.

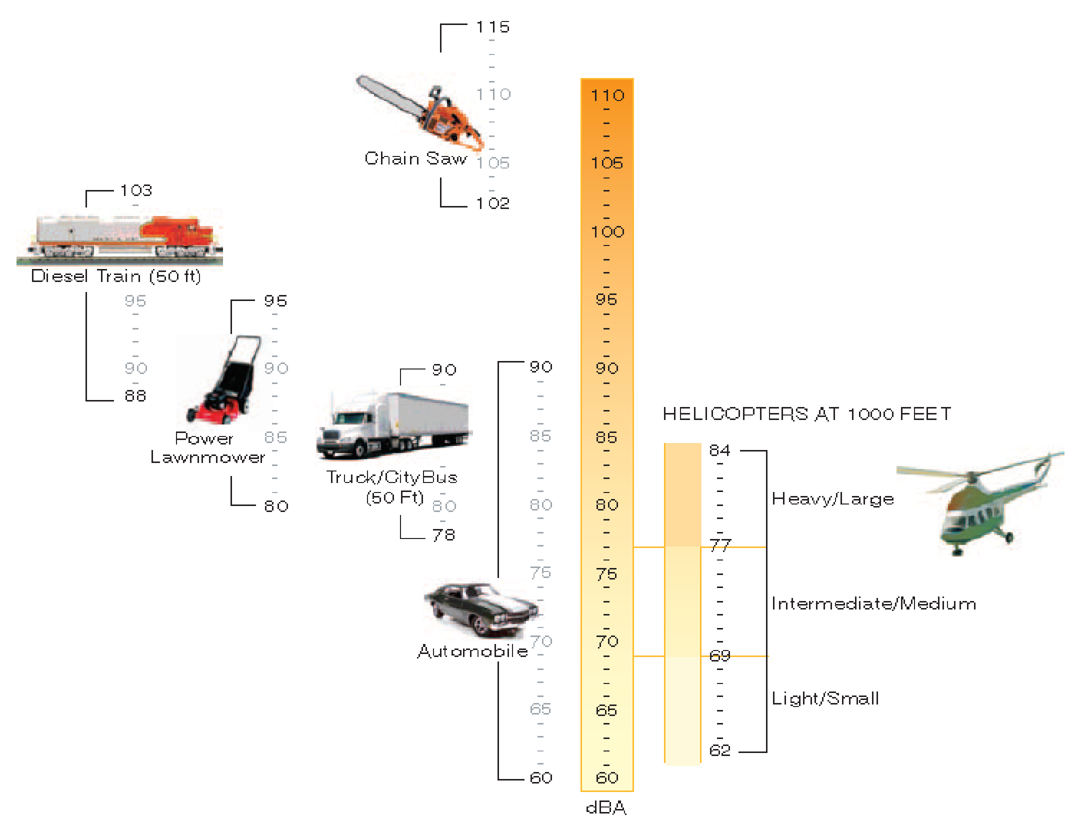

Figure 1. Helicopter Noise Comparison (Helicopter Association International, 2017)

Pile Driving Noises

The Roadway Construction Noise Model (RCNM) created by the Federal Highway Administration (FHWA, 2006) was used to evaluate airborne noise associated with offshore pile driving for SFWF foundation installation and SFEC cofferdam installation. The RCNM provides measured were not exceeded; therefore, this analysis will rely on the RCNM.

The RCNM provides maximum A-weighted (Lmax) sound pressure levels at a reference distance of 50 feet (15.2 m) for various equipment, including impact and vibratory pile drivers. The RCNM value for impact and vibratory pile-driving equipment is the same, 101 dBA. The RCNM identifies an acoustical utilization or usage factor of 20 percent for both pile driver types (FHWA, 2006). The acoustical usage factor is the fraction of time that the equipment generates noise at the maximum level. The average (Leq) sound level at a receptor is calculated by accounting for the reduction in sound level with distance (that is, geometric divergence). At great distances, additional attenuation (for example, ground effects and atmospheric attenuation) can also be significant.

The predicted sound level from each piece of equipment is determined by the following formula for geometric spreading:

*Reference Noise Level – 20*log(Distance to Receptor/50) + 10*log(Usage Factor %/100)*

Thus, for a vibratory pile driver with a reference noise level of 101 dBA and a usage factor of 20 percent, the contribution of each pile driver is determined by the following formula:

*101 dBA – 20*log(Distance to Receptor/50) + 10*log(20/100)*

Table 1 summarizes the predicted average airborne sound level from impact and vibratory pile driving at various distances considering the usage and distance losses.

Table 1. Predicted Average Airborne Sound Level from Vibratory Pile Driving

Distance (feet)	Sound Level (dBA)
50	94
100	88
200	82
300	78
400	76
500	74
600	72
700	71
800	70
900	69
1,000	68
1,200	66
1,400	65

Table 1. Predicted Average Airborne Sound Level from Vibratory Pile Driving

Distance (feet)	Sound Level (dBA)
1,600	64
1,800	63
2,000	62
2,200	61
2,400	60

Construction is a dynamic activity, so the sound levels may vary for a variety of reasons; instantaneous levels will be higher than average levels. The total level from multiple pieces of equipment operating simultaneously is determined by decibel addition of each individual piece's contribution. It is important to note that decibel addition is not the same as arithmetic addition; rather, it is logarithmic (for example, 50 dBA + 50 dBA = 53 dBA). Table 2 presents the required adjustments to sound levels according to the number of sources under consideration.

Table 2. Adjustment to Sound Levels According to the Number of Sources

Number of Sources	dBA Adjustment
1	0
2	3.0
3	4.8
4	6.0
5	7.0
6	7.8
7	8.5
8	9.0
9	.5
10	10.0
20	13.0
40	16.0

Airborne pile driving noise associated with the SFWF pile driving is not expected to impact receptors on land or nearshore because of the distance between the SFWF and the nearest shoreline (that is, approximately 19 miles [29 kilometers {km}] from Block Island, 23 miles [37 km] from Martha's Vineyard, and 34 miles [55 km] from Montauk). While long-distance airborne propagation of sound over water can be a complex process, downwind propagation under a variety of atmospheric and sea conditions were not predicted to exceed approximately 40 dBA at a distance of 6.2 miles (10 km) (Renterghem et al., 2014).

Receptors on the water near the pile-driving activity will hear sound at varying sound levels, depending on distance to the activity and the level of background noise (that is, wind-induced noise, surface wave action, boat engine noise). Some variability is inevitable given the dynamic nature of the construction activities and averaging periods, as well as varying atmospheric and sea conditions. The distances presented in Table 1 are generally within approximately 5 to 10 dBA of the levels predicted by Renterghem et al. (2014); therefore, they are considered applicable to the SFWF pile-driving scenario.

SFEC Offshore Cofferdam Installation

Vibratory hammer pile drivers will be used to install steel sheet piles for the offshore cofferdam to facilitate the SFEC sea-to-shore transition. Typically, the vibratory hammer is clamped to the pile and requires motors to generate vibrations in the range of 2 to 25 hertz (Hz). The vibrations allow the pile to advance into the ground. The primary sources of noise associated with vibratory driving are the engine and motor, and radiated noise from the vibrating pile. The noise from a vibratory driver is considered a continuous or nonimpulsive noise.

A Washington State Department of Transportation evaluation of vibratory pile driving at the Vashon Ferry Terminal (WSDOT, 2010) found that the RCNM sound levels were not exceeded; therefore, this analysis will rely on the RCNM database, and the pile driving analysis conducted for SFWF and presented in Table 1. The sheet pile cofferdam installation and removal is not anticipated to use more than one pile-driving rig, therefore the average onshore sound levels at 2,100 feet (640 m) are anticipated to be approximately 62 dBA. Some variability is inevitable given the dynamic nature of the construction activities, averaging periods, as well as varying atmospheric and sea conditions.

For comparison, typical noise levels generated by construction equipment provided in the Federal Highway Administration (FHWA) *Roadway Construction Noise Model User's Guide* (FHWA, 2006) are provided in Table 3. Table 3 summarizes the average (L_{eq}) noise level at various distinct distances.

Table 3. Typical Construction Equipment Noise Levels

Equipment Description	Acoustical Usage Factor (%)	Specified L_{max} at 50 feet (dBA)	Calculated L_{eq} at 100 feet (dBA)	Calculated L_{eq} at 500 feet (dBA)	Calculated L_{eq} at 1,000 feet (dBA)	Calculated L_{eq} at 2,000 feet (dBA)
All Other Equipment > 5 hp	50	85	76	62	56	50
Auger Drill Rig	20	85	72	58	52	46
Backhoe	40	80	70	56	50	44
Crane	16	85	71	57	51	45
Dump Truck	40	84	74	60	54	48
Grader	40	85	75	61	55	49
Pickup Truck	40	55	45	31	25	19
Tractor	40	84	74	60	54	48

Source*:* FHWA, 2006

L_{eq} = equivalent sound pressure level

Equation to calculate L_{max} at 1,000, 2,000, and 4,000 feet is as follows:

$$L_{eq}(h) = L_{max} + 10*\log(A.U.F.) – 20*\log(D/Do)$$

Where:

L_{max} = Maximum noise emission level of equipment based on work cycle at D/Do (decibel).

A.U.F. = Acoustical usage factor, which accounts for the estimated percent time that equipment is in use over the period of interest (1 hour).

D = Distance from the equipment to the receptor (feet).

Table 3. Typical Construction Equipment Noise Levels

Equipment Description	Acoustical Usage Factor (%)	Specified L_{max} at 50 feet (dBA)	Calculated L_{eq} at 100 feet (dBA)	Calculated L_{eq} at 500 feet (dBA)	Calculated L_{eq} at 1,000 feet (dBA)	Calculated L_{eq} at 2,000 feet (dBA)

Do = Reference distance (generally, 50 feet) at which the L_{max} was measured for the equipment of interest (feet).

> = greater than

The loudest typical construction equipment generally emits noise in the range of 80 to 85 dBA at 50 feet, with usage factors of 40 to 50 percent. Noise perceived by any specific receptor is dominated by the closest and loudest equipment, which will vary over time. If vibratory hammering occurs simultaneously with other construction activities, it is likely that the continuous noise will not be heard on the shoreline. If it is the only construction activity over any span of time, the sound will be affected by the distance from shore and by ambient noises, such as wind, waves, and vehicle traffic.

Wind Turbine Generator Operational Noise

Standard acoustical engineering methods were used to estimate the airborne sound levels from SFWF WTG operations. The sound power levels representing the standard performance of the wind turbines are assigned based on International Electrotechnical Commission (IEC) 61400-11 (2012) data supplied by the manufacturer. Using these sound power levels as a basis, the model calculates the sound pressure level that will occur after losses from distance and air absorption are considered. The modeling performed for this analysis was based on a sound power level of 118 dBA, which is subject to refinement once the final turbine selection is made.

The sound propagation factors used in the acoustical model have been adopted from International Organization for Standardization (ISO) 9613-2, *Acoustics—Attenuation of sound during propagation outdoors*, Part 2: General method of calculation (1996). This method is based on an omnidirectional downwind condition. That is, the sound prediction algorithms assume every point at which sound level is calculated is downwind of all noise-emitting equipment simultaneously. The prediction assumes each receiver or prediction point is a "black hole," and the wind is blowing from each turbine and into this black hole. While this is physically impossible, the ISO 9613-2 model has been widely and successfully used to develop acoustical models for wind energy and other facilities.

The modeling has been conducted using a hard ground condition, where hard ground represents water, and soft or fully absorptive represents plowed earth. Atmospheric absorption for conditions of 50 degrees Fahrenheit (50°F; 10 degrees Celsius [°C]) and 70 percent relative humidity (conditions that favor propagation) was computed in accordance with ISO 9613-1, *Acoustics—Sound attenuation during propagation outdoors, Part 1: Calculation of the absorption of sound by the atmosphere* (ISO, 1993).

The predicted results are subject to both negative and positive variance, the level of which depends on many factors, including timescale, metric, and methods of evaluation. Long distance sound propagation over water is a complex phenomenon influenced by both atmospheric and sea conditions. At large distances and under some conditions, the propagation may shift from the spherical spreading (6 dB reduction per doubling of distance) considered in ISO 9613-2 to cylindrical spreading (3 dB reduction per doubling of distance). However, given the distances between dwellings and the SFWF (that is, approximately 18 miles [29 km] from Block Island, 23 miles [37 km] from Martha's Vineyard, and 34 miles [55 km] from Montauk), factors, such as scattering from atmospheric turbulence, as well as atmospheric absorption, are substantial.

The expected WTG sound level is not anticipated to exceed 35 dBA at any area of concern. These results represent the cumulative sound level of all turbines operating simultaneously at their maximum rated sound power level. Impacts from this noise on offshore receptors will be negligible to minor and highly subjective based upon the individualized nature of if and how the sound is perceived (that is, pleasant, annoying).

References

Denes., S.L., D.G. Zeddies, and M.M. Weirathmueller. 2018. Turbine Foundation and Cable Installation at South Fork Wind Farm: Underwater Acoustic Modeling of Construction Noise. Document 01605, Version 1.0. Technical report by JASCO Applied Sciences for Jacobs Engineering Group Inc.

Federal Highway Administration (FHWA). 2006. *Roadway Construction Noise Model User's Guide*.

Helicopter Association International. 2017. *Fly Neighboring Guide*. 3rd Ed. Accessed March 21, 2018. https://www.rotor.org/Operations/FlyNeighborly/FlyNeighborlyGuide.aspx.

International Electrotechnical Commission (IEC). 2012. "Part 11: Acoustic Noise Measurement Techniques." *IEC 61400-11 Ed. 3.0, Wind Turbine Generator Systems*. Geneva: International Electrotechnical Commission.

International Organization for Standardization (ISO). 1993. *ISO 9613-1, Acoustics—Sound attenuation during propagation outdoors, Part 1: Calculation of the absorption of sound by the atmosphere*.

International Organization for Standardization (ISO). 1996. *ISO 9613-2, Acoustics—Attenuation of sound during propagation outdoors Part 2: General method of calculation*.

Renterghem, T. Van, D. Botteldooren, and L. Dekoninck. 2014. "Airborne sound propagation over sea during offshore wind farm piling." *The Journal of the Acoustical Society of America.* 135, 599. Accessed March 8, 2018. https://asa.scitation.org/doi/10.1121/1.4861244.

VHB, 2018. South Fork Export Cable and Substation Construction Sound Report. Prepared for Deepwater Wind South Fork, LLC. May 2018.

Washington State Department of Transportation (WSDOT). 2010. *Vashon Ferry Terminal Test Pile Project – Vibratory Pile Monitoring Technical Memorandum*. Accessed on May 29, 2018. https://www.wsdot.wa.gov/environment/environmental-technical/environmental-disciplines/air-quality-noise-energy/noise .