Appendix H: Noise and Vibration Resource Report

For Programmatic Environmental Impact Statement on Utility-Scale Onshore Wind Energy Facilities in Washington State

By

Environmental Science Associates

For the

Shorelands and Environmental Assistance Program

Washington State Department of Ecology

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DEPARTMENT OF ECOLOGY
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Acronyms and Abbreviations List

BESS	battery energy storage system
dB	decibel
dBA	A-weighted decibel
EDNA	Environmental Designation for Noise Abatement
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
gen-tie line	generation-tie transmission line
Hz	hertz
in/sec	inches per second
kV	kilovolt
lb	pound
L_{dn}	average A-weighted noise level during a 24-hour day
L_{eq}	equivalent-continuous sound level
L_{max}	maximum, instantaneous noise level
LNTE	low noise trailing edge
MRI	magnetic resonance imaging
MW	megawatt
PEIS	Programmatic Environmental Impact Statement
PPV	peak particle velocity
RCNM	Roadway Construction Noise Model
RMS	root mean square
VdB	decibel notation
WAC	Washington Administrative Code

Executive Summary

This resource report describes the noise and vibration conditions in the study area. It also describes the regulatory context, outlines methods for assessing potential noise and vibration impacts from types of onshore wind energy facilities, presents current noise levels in the study area, and identifies sensitive receptors for noise and vibration. It also assesses the potential impacts of the alternatives and actions that could avoid or reduce impacts. This technical memorandum focuses on the noise and vibration impacts on people and the vibration impacts on structures. Potential impacts of noise and vibration on terrestrial and aquatic species and habitats are described in the *Biological Resources Report* (Anchor QEA 2024a).

Findings for noise and vibration impacts described in this resource report are summarized below.

Through compliance with laws, permits, and with implementation of actions that could avoid and reduce impacts, most construction, operation, and decommissioning activities would likely result in **less than significant impacts** on noise and vibration.

Potentially significant adverse impacts related to noise would occur if:

- Construction or decommissioning activities occur within 2,500 feet of noise-sensitive receptors in a quiet rural area
- During operations, wind turbines for small to medium facilities are closer than 1,000 feet from a noise-sensitive land use or closer than 3,000 feet from a noise-sensitive land use in a quiet rural area, or turbines for large facilities are sited closer than 2,400 feet from a noise-sensitive land use or closer than 5,000 feet from a noise-sensitive receptor in a quiet rural area
- During operations, substations for small to medium facilities are closer than 110 feet from a noise-sensitive land use or closer than 350 feet from a noise-sensitive land use in quiet rural areas, or substations for large facilities are closer than 650 feet from a noise-sensitive receptor or 2,000 feet from a noise-sensitive receptor in quiet rural areas
- A facility with a battery energy storage system of certain design and consolidated configuration is closer than 1.5 miles from noise-sensitive land uses

Potentially significant adverse impacts related to vibration would occur if:

- Pile driving during construction and decommissioning activities occur closer than 350 feet from residential land uses or in close proximity to modern or historic structures
- Blasting is conducted within 2,000 feet of historic structures

No significant and unavoidable adverse impacts related to noise and vibration would occur.

Crosswalk with Noise and Vibration Resource Report for Utility-Scale Solar Energy

Two Programmatic Environmental Impact Statements (PEISs) are being released at the same time, one for utility-scale solar energy facilities and one for utility-scale onshore wind energy facilities. This crosswalk identifies the areas with substantial differences between the noise and vibration resource reports for each PEIS.

Utility-Scale Solar Energy PEIS	Utility-Scale Onshore Wind Energy PEIS (this document)
• Differences in the types of facility noise- and vibration-generating activities • Some differences in actions to avoid and reduce impacts	• Differences in the types of facility noise- and vibration-generating activities • Larger distance at which potential impacts from facilities could occur • Some differences in actions to avoid and reduce impacts

1 Introduction

This resource report describes potential noise and vibration environments within the study area and assesses probable impacts associated with types of facilities (alternatives), including a No Action Alternative. Chapter 2 of the State Environmental Policy Act Programmatic Environmental Impact Statement (PEIS) provides a description of the types of facilities evaluated (alternatives).

1.1 Resource description

1.1.1 Fundamentals of noise

Noise is generally defined as unwanted sound. Sound, traveling in the form of waves from a source, exerts a sound pressure level that is measured in decibels (dB). The dB scale is a logarithmic scale that describes the physical intensity of the pressure vibrations that make up any sound, with 0 dB corresponding roughly to the threshold of human hearing and 120 to 140 dB corresponding to the threshold of pain.

Sound pressure fluctuations can be measured in units of hertz (Hz), which correspond to the frequency of a particular sound. Typically, sound does not consist of a single frequency, but rather a broad band of frequencies varying in levels of magnitude spanning 20 to 20,000 Hz.

The typical human ear is not equally sensitive to all frequencies of the audible sound spectrum. As a consequence, when assessing potential noise impacts, sound is measured using an electronic filter that de-emphasizes the frequencies below 1,000 Hz and above 5,000 Hz in a manner corresponding to the human ear's decreased sensitivity to extremely low and extremely high frequencies. This method of frequency weighting is referred to as A-weighting and is expressed in units of A-weighted decibels (dBA). Some representative noise sources and their corresponding A-weighted noise levels are shown in Figure 1. All noise levels presented in this technical memorandum are A-weighted unless otherwise stated.

Some land uses are considered more sensitive to noise than others due to the amount of noise exposure and the types of activities typically involved. Residences, motels and hotels, schools, libraries, churches, hospitals, nursing homes, and auditoriums generally are more sensitive to noise than are commercial and industrial land uses. Section 3.2 provides more detail on noise-sensitive receptors.

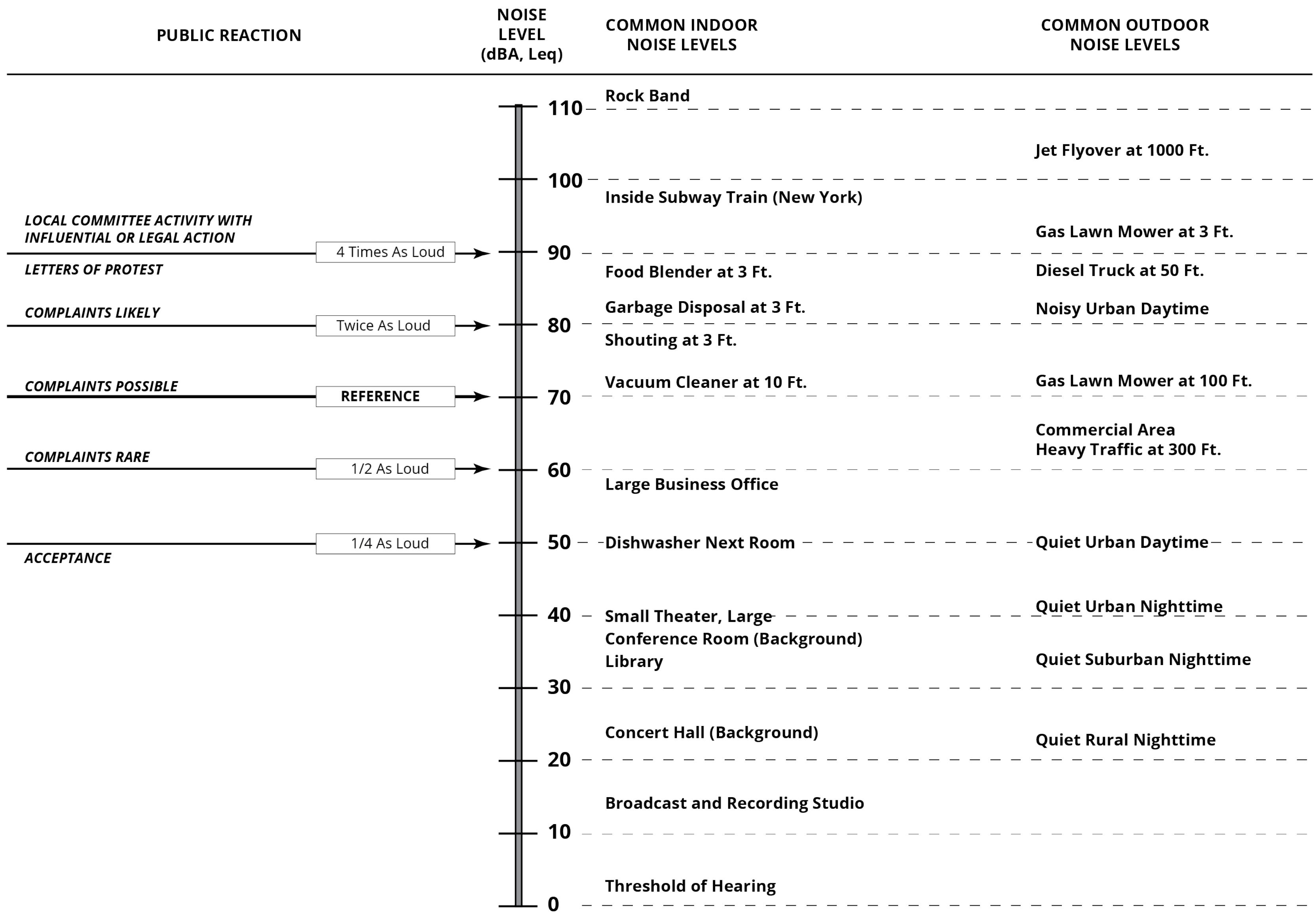

Figure 1. Common range of noise levels

Data source: Caltrans 2013; and modification by ESA

1.1.2 Fundamentals of vibration

The generally accepted source document for assessment of vibration impacts is the Federal Transit Administration's (FTA's) Transit Noise and Vibration Impact Assessment (FTA 2018). It is unusual for vibration from sources such as trucks to be perceptible, even in locations close to major roads. Some common sources of human-induced groundborne vibration are trains; loaded haul trucks on rough roads; and construction activities, such as blasting, pile driving, and operation of heavy earth-moving equipment. Vibrations from naturally occurring phenomena, such as earthquakes, are addressed in the *Earth Resource Report* (Anchor QEA 2024b).

Several different methods are used to quantify vibration. The peak particle velocity (PPV) is defined as the maximum instantaneous peak of the vibration signal. The PPV is most frequently used to describe vibration impacts on buildings. The root mean square (RMS) amplitude is most frequently used to describe the effect of vibration on the human body. The RMS amplitude is defined as the average of the squared amplitude of the signal. Decibel notation (VdB) is commonly used to measure RMS. Typically, groundborne vibration generated by man-made activities attenuates rapidly with distance from the source of the vibration.

The effects of groundborne vibration include movement of building floors, rattling of windows, shaking of items on shelves or hanging on walls, and rumbling sounds. In extreme cases, vibration can damage buildings. Building damage is not a factor for most projects, with the occasional exception of blasting and pile driving during construction. The FTA measure of the threshold of architectural damage for historic structures[1] is 0.12 inch/second (in/sec) PPV (FTA 2018).

In residential areas, the background vibration velocity level is usually around 50 VdB (approximately 0.0013 in/sec PPV). This level is well below the vibration velocity level threshold of perception for humans, which is approximately 65 VdB. A vibration velocity level of 75 VdB is considered to be the approximate dividing line between barely perceptible and distinctly perceptible levels for many people (FTA 2018). Annoyance from vibration often occurs when the vibration levels exceed the threshold of perception by only a small margin. A vibration level that causes annoyance would be well below the damage threshold for modern buildings.

Sensitive receptors for vibration include structures that may be damaged by vibration, residential uses during nighttime hours, and vibration-sensitive equipment, such as magnetic resonance imaging (MRI) machines. Section 3.2 provides more detail on vibration-sensitive receptors.

[1] FTA applies this criterion for buildings extremely susceptible to vibration damage.

1.2 Regulatory context

Potentially applicable federal, state, and local laws and regulations are listed in Table 1, which will contribute to the evaluation of potential noise and vibration impacts.

Table 1. Applicable laws, plans, and policies

Regulation, statute, guideline	Description
Federal	
Noise Control Act of 1972 (42 *United States Code* 4910)	Protects the health and welfare of U.S. citizens from the growing risk of noise pollution, primarily from transportation vehicles, machinery, and other commerce products. Increases coordination between federal researchers and noise-control activities; establishes noise emissions standards; and presents noise emissions and reduction information to the public.
Federal Transit Administration Construction Noise Impact Criteria for General Assessment; Transit Noise and Vibration Impact Assessment Manual (FTA 2018)	This document provides procedures and guidance for analyzing the level of noise and vibration, assessing the resulting impacts, and determining possible mitigation for most federally funded transit projects.
State	
Washington State Noise Control Act of 1974 (Chapter 70.107 Revised Code of Washington)	This act establishes maximum environmental noise levels. The regulations (Chapter 173-60 Washington Administrative Code) apply to a variety of land uses, activities, and facilities, including general construction activities and maintenance facilities. Exemptions include electrical substations, mobile noise sources, vehicles traveling in public right-of-way, and safety warning devices, such as bells. Many cities and counties in Washington have adopted the state provisions.
Local	
County and City Municipal Codes	Based on the scale of the study area, it is infeasible to review the county and municipal code of each local government within the scale of the Programmatic Environmental Impact Statement. However, it is noted that many counties and cities in Washington defer to the Washington Administrative Code regulations.

2 Methodology

2.1 Study area

The study area for noise and vibration includes the overall wind geographic study area (Figure 2). The programmatic study area for assessment of noise and vibration impacts associated with site characterization, construction, operation, and decommissioning of the potential utility-scale onshore wind energy facilities includes consideration of potential sensitive human receptor locations surrounding onshore wind facility sites and along access roads associated with truck hauling of materials and supplies.

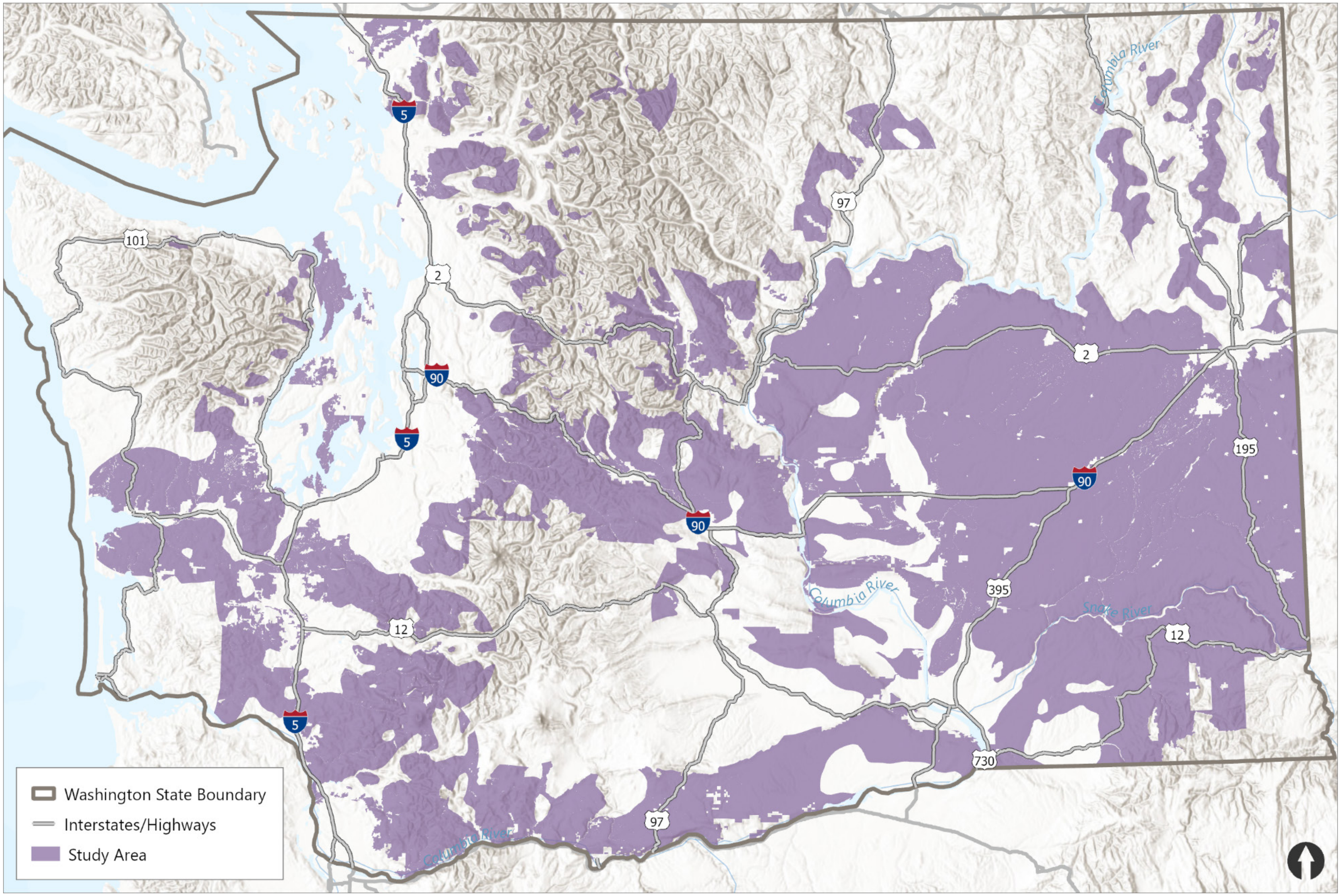

Figure 2. Onshore Wind Energy Facilities PEIS – geographic scope of study

2.2 Technical approach

The approach for assessing construction-related noise impacts utilizes the General Assessment methodology of the FTA's Noise and Vibration Impact Assessment Manual (FTA 2018). Based on an equipment list commonly used for construction of wind facilities, a tabular range of construction noise was generated with respect to distance from the outermost equipment for a typical construction site. The Federal Highway Administration's (FHWA's) Roadway Construction Noise Model (RCNM) was used to calculate noise levels at certain distances for comparison to FTA's published construction noise criteria (FHWA 2006). A separate analysis was provided for conditions where blasting or pile driving would be a necessary method of construction. This analysis can also be applied to linear construction work for generation-tie transmission lines (gen-tie lines).

Similarly, the approach for construction-related vibration impact assessment used a tabular estimate of vibration generation with distance from specific construction equipment known to generate vibration. Reference vibration levels published by FTA were used to develop impact distances to modern structures of standard construction, as well as to historic structures.

For operational impacts from utility-scale wind energy facilities, reference noise levels from sources associated with these facilities were researched from existing project-level analysis (proxy projects) that included three-dimensional noise modeling of noise generation. Using the existing analysis from proxy projects that fall within the scale of the facilities considered for the PEIS, a conservative estimate of noise generation with distance was developed for distances at which potential impacts of operational noise may occur from the extent of an onshore wind energy facility footprint.

2.3 Impact assessment

The impact analysis for noise and vibration considered the following:

- Site characterization activities of utility-scale onshore wind energy development would result in noise and vibration associated with construction of meteorological towers and soil coring.
- Construction and ultimate decommissioning of onshore wind energy facilities will result in noise and vibration associated with construction-related activities typically employed for such facilities. These would include operation of off-road equipment, pile driving for wind turbine foundations, the potential on-site operation of a concrete batch plant, and operation of haul trucks to bring in equipment and materials and remove soil or demolition debris. Blasting, if required, would also generate noise and vibration impacts.
- Construction for gen-tie lines for facilities could include noise and vibration from off-road equipment along alignments for power poles and line stringing, cut and cover trenching, and potentially sheet pile installation for jack-and-bore pits, where necessary.
- Operational noise sources may include intermittent noise from substation operations, battery storage liquid cooling units, battery storage inverters, potential corona noise

from overhead connector and gen-tie lines during wet weather conditions, and intermittent noise from operations and maintenance activities of employees during daytime hours.

Of particular note, operational noise associated with wind farms would include noise generated by wind turbines 24 hours a day, which would include the noise-sensitive nighttime hours for which more stringent noise standards apply under the Washington Administrative Code (WAC) Chapter 173-60. Wind turbines also generate a component of low-frequency infrasonic noise, which is not necessarily captured by metrics in terms of A-weighted decibels.

Site characterization, construction, and decommissioning related noise impacts were evaluated for likely conflicts with local ordinances or potential exposure of noise-sensitive land uses in excess of the FTA criteria. Additionally, in recognition that existing noise levels are commonly quiet in rural areas where siting of energy facilities would likely occur, an increase of 10 dBA over ambient was applied to the assessment, which corresponds to a perceived doubling loudness for temporary construction activities (FHWA 2017). Chapter 173-60 WAC exempts sounds originating from blasting and from temporary construction sites as a result of construction activity between the hours of 7:00 a.m. and 10:00 p.m.

Operational noise impacts were evaluated for likely conflicts with local ordinances or potential to exceed the maximum permissible environmental noise levels specific to land use as codified in Chapter 173-60 WAC. For residential uses, an Environmental Designation for Noise Abatement (EDNA) of 50 dBA would apply during nighttime hours. Additionally, in recognition that existing noise levels are commonly quiet in rural areas where siting of energy facilities would likely occur, an increase of 5 dBA over ambient is applied, which corresponds to a readily perceptible increase in noise for permanent operations (FHWA 2017).

Construction vibration impacts were evaluated for the potential to expose nearby land uses and structures to PPV levels that would meet or exceed FTA criteria of 0.5 in/sec for modern structures or 0.12 in/sec for historic structures.

3 Technical Analysis and Results

3.1 Overview

This section describes the potentially significant adverse noise and vibration impacts that might occur for a given utility-scale onshore wind facility analyzed in the PEIS. The extent of the impact area would depend on the size and design of the specific facility and the relative quiet (low ambient noise levels) of a given location. This section also evaluates actions that could avoid, minimize, or reduce the identified impacts, and potential unavoidable significant adverse impacts.

3.2 Affected environment

3.2.1 Ambient noise levels

The affected environment represents the conditions before any construction begins. Given the substantial geographic extent of the onshore wind study area, the affected environment, in terms of existing ambient noise levels, would vary considerably based on the specific facility siting conditions. Noise levels continuously vary with location and time. In general, noise levels are high around major transportation corridors (highways and railways), airports, industrial facilities, and construction activities. To characterize noise levels associated with general community activities over the study area, countywide background L_{dn}[2] (i.e., average A-weighted noise level during a 24-hour day) levels may be estimated based on population density. More densely populated counties, such as King County and Pierce County, have generalized background L_{dn} values of between 45 and 55 dBA, while more remote, sparsely populated counties, such as Columbia County, have background L_{dn} values of less than 35 dBA (BLM 2024). These are geographically averaged estimates, and localized values, particularly in urban areas, can be as high as 70 L_{dn} adjacent to freeways.

Utility-scale onshore wind energy facilities would often likely be located in rural areas with low population density. These areas are expected to have low ambient sound levels, given the lack of industrial and commercial sound sources. Noise may be sporadically elevated in localized areas due to roadway noise or periods of human activity. The existing acoustic environment in these areas could include existing wind turbines; motor vehicle traffic; mobile farming equipment; farming activities, such as plowing and irrigation; all-terrain vehicles; local roadways; periodic aircraft flyovers; and natural sounds. Rural areas can be exposed to natural

[2] The L_{dn} metric is the energy average of the A-weighted sound levels occurring during a 24-hour period, with a 10 dB penalty added to sound levels between 10 p.m. and 7 a.m. It is commonly used for land use compatibility assessment.

wind noise that can generate noise levels of up to 85 dBA at high windspeeds. Sound levels in non-industrial and rural areas are typically quieter during the night than during the daytime.

Sound propagating through the air is affected by air temperature, humidity, wind and temperature gradients, vicinity and type of ground surface, obstacles, and terrain features. Natural terrain features, such as hills, and constructed features, such as buildings and walls, can significantly alter noise levels. Rural areas can commonly possess a range of topographical features that can serve to reduce the propagation of noise.

It is uncommon for trees and vegetation to result in a noticeable reduction in noise. A vegetative strip must be very dense and wide for there to be any meaningful shielding effect. However, a heavily vegetated ground surface may increase ground absorption of noise, which can increase attenuation over distance.

3.2.2 Noise-sensitive receptors

Some land uses are considered more sensitive to noise than others due to the amount of noise exposure (in terms of both exposure duration and insulation from noise) and the types of activities typically involved. Residences, motels and hotels, schools, libraries, churches, hospitals, nursing homes, and auditoriums generally are more sensitive to noise than are commercial and industrial land uses. Recreational uses are also sensitive to noises; refer to the *Recreation Resource Report* (Anchor QEA 2024c) for an analysis of noise impacts on recreationists.

Sensitive wildlife and habitats, including the habitat of rare, threatened, or endangered species, can also be impacted by noise. For noise impacts on wildlife, including airborne noise effects on terrestrial wildlife and waterborne noise effects on fish and marine mammals, please refer to the *Biological Resources Report*.

3.2.3 Vibration-sensitive land uses and structures

Sensitive receptors for vibration include structures (especially older masonry structures), people (particularly residential uses during nighttime hours), and vibration-sensitive equipment (such as recording studios or MRI). There are separate criteria for evaluating the potential for structural damage depending on whether the structure is considered to be of modern construction versus older historic structures that are more sensitive to vibration.

3.3 Potentially required permits

With the exception of unique circumstances, there would be no specific permit requirements related to noise or vibration. If blasting were needed for construction, then a blasting permit would be required. Permits are typically administered by the city or county in which the work is conducted. Blasting with explosives requires a Washington State explosives license to abate potential hazards, including noise and vibration.

Additionally, local jurisdictions may require a permit or variance to conduct nighttime construction work.

3.4 Small to medium utility-scale facilities of 10 MW to 250 MW (Alternative 1)

3.4.1 Impacts from construction

3.4.1.1 Construction noise

Construction of a small to medium utility-scale facility (Alternative 1) would generate noise from multiple sources, including the following:

- Off-road equipment used for site preparation and construction
- Blasting
- On-road truck trips to bring materials to work sites, including sand, fly ash, and cement to a concrete batch plant
- Noise generated by rock processing at a concrete batch plant

Off-road equipment noise for site preparation and construction

An example inventory of equipment needed to construct a small to medium onshore wind facility (EFSEC 2022) is provided in Table 2. The table summarizes equipment that may be used and estimates of noise levels at a reference distance of 50 feet, as well as at 100, 1,000, and 2,500 feet from each piece of equipment, as well as from the combined contribution of all equipment. The combined noise levels in Table 2 include construction blasting, which is further addressed in the next section.

In addition to the equipment listed in Table 2, generators may be used for temporary power over the turbine commissioning period. Commissioning includes the testing and startup of the wind turbines after they are installed but before they begin normal operations. Generators for construction are estimated to generate a noise level of 78 dBA, equivalent-continuous sound level (L_{eq}) at 50 feet, which could be further reduced with an acoustical enclosure.

Table 2. Maximum and modeled equivalent noise levels from construction equipment associated with onshore wind facility construction

Equipment	L_{max} equipment sound level at 50 feet (dBA)[1]	Usage factor (%)[2]	Equipment sound level (L_{eq}) at 50 feet (dBA)	Equipment sound level (L_{eq}) at 100 feet (dBA)	Equipment sound level (L_{eq}) at 1,000 feet (dBA)	Equipment sound level (L_{eq}) at 2,500 feet (dBA)
Crane	85	16	77	71	51	43
Forklift	83	40	79	73	53	45
Backhoe	78	40	74	68	48	40
Grader	85	40	81	75	55	38

Equipment	L_{max} equipment sound level at 50 feet (dBA)[1]	Usage factor (%)[2]	Equipment sound level (L_{eq}) at 50 feet (dBA)	Equipment sound level (L_{eq}) at 100 feet (dBA)	Equipment sound level (L_{eq}) at 1,000 feet (dBA)	Equipment sound level (L_{eq}) at 2,500 feet (dBA)
Man Lift	75	20	68	62	42	47
Dozer	82	40	78	72	52	44
Loader	79	40	75	69	49	41
Scissor Lift	75	20	68	62	42	34
Truck	77	40	73	67	47	39
Welder	74	40	70	64	44	36
Compressor	78	40	74	68	48	40
Concrete Batch Plant	83	15	75	69	49	41
Pile Driver	101	20	94	88	68	60
Blasting	94	1	74	68	48	40
Combined	NA	NA	95	89	69	61

Source: FHWA 2006

Notes:

1. These are maximum field-measured values at 50 feet as reported from multiple samples. Where sufficient data are unavailable, the reference noise level is a manufacturer-specified level.
2. The usage factor is the percentage of time during operation that a piece of construction equipment is operating at full power.

As shown in Table 2, FTA's daytime criterion of 90 dBA would be exceeded if pile-driving activities were conducted within 85 feet of noise-sensitive receptors. For an onshore wind facility located in a rural environment, this would be an unlikely scenario.

However, in recognition that existing noise levels are commonly low in rural areas where siting of energy facilities would likely occur, potentially 35 to 40 dBA or lower, a prolonged noise contribution of 45 to 50 dBA could also result in a noise impact at noise-sensitive receptors located closer than 2,500 feet, particularly during nighttime hours. The extent of a construction noise impact would depend on the existing ambient noise level at any given receptor.

As shown in Table 2, at a distance of 2,500 feet, all construction activities except pile driving, forklifts, and manlifts would be below 45 to 50 dBA, as well as the composite noise level, which conservatively assumes simultaneous operation of all equipment. If required for turbine foundations, pile driving may only exceed noise criterion during construction of a small number of turbine locations and, hence, may not constitute a prolonged noise increase at a distance of 2,500 feet.

Blasting noise

Blasting may be needed for construction of facilities (e.g., wind turbine foundations) and may occur depending on subsurface conditions. Noise from blasting activities was estimated using reference noise levels from RCNM and assuming one blast per hour; the associated noise levels are presented in Table 2. Blasting mats are usually used to control noise. Blasting would typically be a part of site preparation and, therefore, not occur simultaneously with pile driving or other construction building activities. As shown in Table 2, noise generated by blasting is similar in magnitude to that of other construction activities, based on the reference noise levels for RCNM. The combined noise levels in Table 2 include construction blasting. Vibration impacts from blasting are addressed in Section 3.4.1.2.

Noise from on-road trucks

Noise from trucks bringing materials from off-site locations to a facility construction site and exporting excavated materials from the facility site would potentially increase noise levels along roadways used to access a given onshore wind facility. Generally, these truck trips would be distributed throughout the day and, except in cases where substantial volumes of material would be hauled, the increase in noise levels would not be sufficient to result in a noticeable increase in traffic noise.

Concrete batch plant noise

Noise from a concrete batch plant during facility construction was estimated using reference noise levels from RCNM, and the associated noise levels are presented in Table 2. Concrete batch plants may be used to provide material for construction of foundations and would occur simultaneously with pile driving or other construction activities. As shown in Table 2, noise generated by batch plant operations is similar in magnitude to that of other construction activities, based on the reference noise levels for RCNM. The combined noise levels in Table 2 include operation of a batch plant.

Construction noise impact summary

Heavy equipment use would vary during the site preparation and construction phases for facilities. Site characterization activities would include noise generation during soil coring and the construction of meteorological towers. Typically, noise levels are highest during site preparation when land clearing, grading, and road construction would occur.

Most local jurisdictions and the noise standards in Chapter 173-60 WAC exempt temporary construction site noise between the hours of 7:00 a.m. and 10:00 p.m. Outside of these times, construction activities would be required to meet noise limits. In addition, construction activities would be temporary and of short duration.

Potential construction noise impacts would depend on the activities, terrain, vegetation, and local weather conditions, as well as distance to the nearest sensitive receptors. Through compliance with laws, permits, and with implementation of actions that could avoid and reduce impacts, most construction, operation, and decommissioning activities would likely result in **less than significant impacts** from noise. If construction activities occur within 2,500 feet of noise-sensitive receptors in quiet rural areas, this would result in a **potentially significant adverse impact**.

3.4.1.2 Construction vibration

Construction may involve blasting and the use of equipment, such as impact pile drivers and vibratory rollers, that can generate substantial vibration.

Vibration impacts and human annoyance

Vibration impact criteria related to human disturbance published by FTA are established in terms of the VdB metric. Vibration levels from various construction activities known to generate vibration were estimated in Table 3 using reference vibration levels published by FTA (2018) and attenuating that vibration at a range of distances encompassing impact criteria. Bold cells in Table 3 indicate the distances at which vibration levels would exceed the applicable FTA criterion. As seen from the table, vibration from pile driving would exceed the applicable FTA criterion at distances closer than 350 feet, while vibration from vibratory rollers would exceed FTA criterion at distances closer than 50 feet. All other construction equipment could be 25 feet or closer without exceeding FTA criteria. Therefore, vibration from specific construction activities occurring at distances closer than 350 feet from residential land uses could be a potential impact with respect to human annoyance.

Table 3. Predicted vibration levels (VdB) from construction activities at distance

Equipment/ activity	Predicted VdB					
	At 25 feet (Reference)	At 50 feet	At 100 feet	At 200 feet	At 350 feet	FTA Criteria for Residential Uses (Human Response)
Jack Hammer	79	70	61	52	45	80
Loaded Trucks	**86**	77	68	59	52	80
Large Bulldozer	**87**	78	69	60	53	80
Caisson Drilling	**87**	78	69	60	53	80
Vibratory Roller	**94**	**85**	76	66	60	80
Impact Pile Driver	**104**	**65**	**86**	**77**	70	72[a]

Source: FTA 2018

Notes:

Shaded cells indicate exceedance of the applicable FTA criterion.

a. Residential criterion for frequent events applies to pile driving.

Vibration impacts and structural damage

Construction-related vibration also has the potential to result in architectural damage to nearby structures. For historic structures, including buildings that are structurally weakened, a continuous vibration limit of 0.12 in/sec PPV is the standard applied to minimize the potential for structural or cosmetic damage (e.g., minor cracking in plastered walls). A continuous vibration limit of 0.50 in/sec PPV is applied to minimize the potential for cosmetic damage at buildings of modern construction.

Table 4 presents the analysis of vibration from typical construction activities with distances to structures. In Table 4, distances at which vibration levels would exceed the criterion for conventional structures are indicated with a superscript "a." Distances at which the criterion would be exceeded for historic structures or structurally weakened buildings are marked with a superscript "b." As shown in Table 4, cosmetic damage could result from pile driving closer than 30 feet to a conventionally constructed building, or closer than 80 feet to a historic building. Given the distances at which most off-site structures and sensitive receptors are assumed to be located from potential utility-scale facilities and with appropriate control measures and monitoring programs in place and as required by permits, temporary construction-related vibration effects for the construction of small to medium utility-scale onshore wind energy facilities would be less than significant.

Table 4. Vibration levels (PPV) for construction activity

Equipment	Estimated PPV (inches per second)			
	At 25 feet	At 30 feet	At 40 feet	At 80 feet
Jackhammer	0.035	0.027	0.01710	0.00610
Loaded Trucks	0.076	0.058	0.038	0.013
Caisson Drilling	0.089	0.068	0.044	0.016
Large Bulldozer	0.089	0.068	0.044	0.016
Vibratory Roller	0.20[b]	0.160[b]	0.104	0.037
Impact Pile Driver	0.65[a]	0.494[b]	0.321[b]	0.113

Source: FTA 2018
Notes:

a. Indicates distances where vibration levels would exceed the criterion for conventional structures.
b. Indicates the distances at which the criterion for historic structure or buildings that are documented to be structurally weakened would be exceeded.

Vibration generated by blasting

Blasting may occur as part of site preparation activities, depending on subsurface conditions. When blasting occurs at greater distances from sensitive structures, the primary concern is the potential for cosmetic damage. Cosmetic damage can occur as a result of groundborne vibration or acoustic overpressures. Vibration levels that may be generated by blasting events were calculated using methods established by the former U.S. Bureau of Mines (USDI 2000) and are presented in Table 5. Calculated ground vibration levels are summarized in Table 5 for a variety of charge weights and distances. Receptors located farther from blasting activities would experience lower vibration levels.

Table 5. Ground vibration levels generated by blasting

Distance (feet)	Blasting level (in/sec PPV) for various explosive charge weights per delay[1] (lbs)		
	175 lbs	350 lbs	700 lbs
2,000	0.098	0.170	0.296
3,000	0.051	0.089	0.155
4,000	0.032	0.056	0.098

Note:

1. The maximum quantity of explosive charge detonated on one interval (delay) within a blast.

As shown in Table 5, blasting, using a charge weight of 700 lbs/delay[3] within 2,000 feet of sensitive structures could generate groundborne vibration levels as high as 0.296 in/sec PPV, which would be below the 0.5 in/sec PPV threshold for modern structures, but would exceed the 0.12 in/sec PPV threshold for historic structures. Consequently, use of charge weights in excess of approximately 250 pounds per delay could result in vibration impacts if historic structures are located within 2,000 feet**.**

Construction vibration impact summary

Potential construction vibration impacts would depend on the equipment, methods, and distance to sensitive receptors or structures. Through compliance with laws, permits, and with implementation of actions that could avoid and reduce impacts, most construction and decommissioning activities would likely result in **less than significant impacts** related to vibration.

Vibration from specific construction activities occurring at distances closer than 350 feet from residential land uses, or in close proximity to conventional or historic structures, would be a **potentially significant adverse impact** with respect to human annoyance or building damage. If some types of blasting are conducted within 2,000 feet of historic structures, it would result in a **potentially significant adverse impact.**

3.4.2 Impacts from operation

Operation activities would not be expected to generate vibration.

Wind turbine noise

Noise impacts from turbines will vary based on the type of model, configuration of towers, wind environment, distance to nearest sensitive receptors, and presence of intervening structures or geographic features. The major noise sources for small to medium facilities that could be operated under Alternative 1 are wind turbines and substations. Generally, these sources are likely to operate 24-hours a day and hence would generate noise during the more noise-sensitive nighttime hours. While there are different operational cycles whereby some

[3] The maximum quantity of explosive charge detonated on one interval (delay) within a blast.

equipment will be operating while other equipment will be cycling on and off, given the programmatic approach of this analysis, all sources are conservatively assumed to operate at all times.

For the small to medium facilities, a project-level noise assessment for a proxy project was used to estimate the noise generation potential. Project-level analysis for onshore wind energy facilities generally requires modeling with a three-dimensional noise propagation program, such as CadnaA, that develops noise contours around facilities to determine the spatial extent of noise levels from turbines and transformers. The proxy project analysis used for the small to medium facilities was for a proposed 216-megawatt (MW) wind facility with up to 72 turbines rated from 3 to 7.5 MW each (Fountain Wind in Shasta County, California).

Noise modeling developed for the proxy project shows that while turbines may be clumped into groups of three or more on a given project footprint, the 50 dBA, L_{eq} noise contour consistently extends approximately 1,000 feet from each turbine (I&R 2019).

In Washington state, the maximum permissible environmental noise levels specific to land use are codified in Chapter 173-60 WAC. For residential uses, an EDNA of 50 dBA would apply during nighttime hours.

Additionally, in recognition that existing ambient noise levels are commonly quiet in rural areas where siting of energy facilities would likely occur, an increase of 5 dBA over ambient conditions could also result in a noise impact at noise-sensitive receptors located in such an area. An increase of 5 dBA corresponds to a readily perceptible increase in noise for permanent operations (FHWA 2017). As discussed in Section 3.2.1, remote, sparsely populated counties, such as Columbia County, can have background L_{dn} values of 35 dBA or lower (BLM 2024). In such rural areas, an increase of 5 dBA over ambient noise could result when turbines generate a noise level of 40 dBA at such a receptor. Based on two-dimensional geometric spreading equations, it is estimated that this noise increase would have the potential to occur within approximately 3,000 feet of the nearest turbine.

Substation noise

An on-site collector substation and switching station (substation) would increase the voltage of the electricity from the collection system's rated voltage to match the voltage of the existing or proposed power transmission line.

A typical substation transformer is estimated to generate a noise level of 72 dBA at a distance of 6 feet during full load with fans and pumps running (I&R 2019). With two transformers running simultaneously, the noise level would be 3 dBA higher. Equipment-generated noise levels drop off at a rate of about 6 dBA per doubling of the distance between the source and receptor. Shielding by buildings or terrain can provide an additional 5 to 10 dBA or more noise reduction at distant receptors. At a distance of 110 feet, noise would be attenuated to below the 50 dBA EDNA that would apply during nighttime hours.

Similarly, at a distance of 350 feet, noise would be attenuated to below 40 dBA, which is the working assumption for a 5 dBA increase over ambient conditions in a rural area.

Corona noise

Onshore wind facilities would require overhead gen-tie lines ranging from 69 kilovolts (kV) to 345 kV to match the voltage of existing transmission lines. Collector lines would range from 34.5 kV to 230 kV. Higher-voltage overhead lines of 100 kV or more may be used if the distance to the electrical substation is long. The localized electric field near an energized conductor can be sufficiently concentrated to produce a small electric discharge, which can ionize air close to the conductors. This effect is called corona and is associated with all energized electric power lines. Corona can produce small amounts of sound. Corona noise is typically characterized as a hissing or crackling sound, which may be accompanied by a 120-Hz hum. Slight irregularities or water droplets on the conductor and/or insulator surface accentuate the electric field strength near the conductor surface, making corona discharge and the associated audible noise more likely. Therefore, audible noise levels from gen-tie lines are generally higher during wet weather.

Computer modeling software developed by the Bonneville Power Administration (BPA 1977) indicates that, during wet weather conditions, audible noise levels of up to 46 dBA can occur within the gen-tie right-of-way corridor for a 230-kV line. The study assumed an 80-foot-wide right-of-way, and the gen-tie right-of-way for onshore wind facilities is assumed to be wider than this. The 34.5-kV lines would likely be inaudible outside the right-of-way assumed for onshore wind facilities. Noise from lower voltage lines and/or during dry conditions would be lower. Such a noise level would be below the 50 dBA EDNA applicable to residential uses within the State of Washington.

Operational noise impact summary

Through compliance with laws, permits, and with implementation of actions that could avoid and reduce impacts, most operations activities would likely result in **less than significant impacts** related to noise and vibration.

Wind turbines located closer than 1,000 feet from a noise-sensitive land use, or closer than 3,000 feet from noise-sensitive land uses within a quiet rural setting, could have a **potentially significant adverse impact**. Facility substations located closer than 110 feet from a noise-sensitive land use or closer than 350 feet from a noise-sensitive land use located in a rural area would also have a **potentially significant adverse impact.**

3.4.3 Impacts from decommissioning

For the purposes of this analysis, it is assumed that facility decommissioning or repowering of wind facilities would result in similar noise levels and vibration as construction, with the exception of pile driving and blasting activities, which would not occur for decommissioning. Therefore, noise impacts from decommissioning activities would be similar or less than those described for construction and would range from **less than significant impact** to **potentially significant adverse impact** depending on the distance from sensitive receptors.

3.4.4 Actions to avoid and reduce impacts

Because this a programmatic environmental review of utility-scale onshore wind facilities, site-specific mitigation actions would be developed during project-specific reviews and permitting for each facility proposed in the future. Potential actions that could avoid or reduce impacts from construction, operation, or decommissioning of facilities are outlined below.

Recommended siting distances identified in this programmatic analysis are based on proxy projects and unspecified existing noise conditions and locations of sensitive receptors. Each individual facility would need to conduct facility- and site-specific modeling to determine the applicable distances necessary to avoid a significant noise or vibration impact.

3.4.4.1 Siting and design considerations

Careful site selection and layout for a utility-scale onshore wind facility represents the best tool available to reduce the potential for noise and vibration impacts. For the potentially significant adverse noise and vibration impacts identified previously, the following site selection considerations could be used to reduce these potential impacts to a less than significant level.

Construction and decommissioning noise

As discussed above, FTA's daytime noise criterion for construction would likely not be exceeded if the construction footprint was located more than 100 feet from noise-sensitive receptors. For facility construction in quiet rural areas, a distance of at least 2,500 feet to noise-sensitive receptors should be provided. Provision of a buffer distance from noise-sensitive receptors would reduce the need for additional mitigation measures.

Operational noise

As discussed above, siting of wind turbines closer than 1,000 feet from a noise-sensitive land use would have the potential for a significant adverse impact with respect to the State of Washington nighttime EDNA of 50 dBA for residential uses, and facility-specific modeling would be required to substantiate the need for mitigation. Consequently, siting of utility-scale wind turbines 1,000 feet or farther from the closest noise-sensitive land use could preclude a significant adverse operational impact.

For facilities in quiet rural areas, a turbine distance of at least 3,000 feet from noise-sensitive receptors should be provided for siting the closest turbines.

Construction vibration

Siting utility-scale wind facilities such that the construction zone would be at least 80 feet from the closest structure would avoid a significant adverse construction-related vibration impact.

3.4.4.2 Permits, plans, and best management practices

The only permit, plan, or best management practice related to noise or vibration associated with construction of a utility-scale onshore wind facility would be a blasting permit, if blasting were needed for site preparation. Blasting with explosives requires a Washington State explosives license to abate potential hazards, including noise and vibration.

3.4.4.3 Additional mitigation measures

Construction noise

If the construction area of a proposed utility-scale onshore wind facility is closer than 2,500 feet from a noise-sensitive receptor, then a Construction Noise Management Plan should be developed and implemented to minimize localized noise increases from prolonged construction activity. Elements of the Construction Noise Management Plan include the following:

- Install cast-in-place concrete piles, as feasible. Noise from auger drilling is 17 dBA less than an impact pile driver.
- Vibrate piles into place and install shrouds around the pile-driving hammer where feasible.
- Site immobile construction equipment (e.g., compressors and generators) and permanent sound-generating facilities away from nearby residences and other sensitive receptors.
- Incorporate low-noise systems (e.g., for pumps, generators, compressors, and fans) and select equipment with low noise emissions and/or without prominent discrete tones, as indicated by the manufacturer.
- Use noise-reduction measures, such as siting noise sources to take advantage of existing topography and distances and constructing engineered sound barriers and/or berms to reduce potential noise impacts at the locations of nearby sensitive receptors.
- Establish a noise complaint resolution process and hotline to address any noise complaints received.
- Enclose noisy equipment when located near sensitive receptors.
- Notify nearby residents in advance of noisy activities, such as blasting or pile driving, before and during the construction period.
- Post warning signs at high-noise areas and implement a hearing protection program for work areas with noise in excess of 85 dBA.
- Maintain tools and equipment in good operating order according to manufacturers' specifications.
- Schedule construction activity during normal working hours on weekdays to reduce noise impacts.
- Limit possible evening shift work to low-noise activities, such as welding, wire pulling, and other similar activities.
- Equip any internal combustion engine used for any purpose on the job or related to the job with a properly operating muffler that is free from rust, holes, and leaks.
- For construction devices that use internal combustion engines, ensure the engine's housing doors are kept closed and install noise-insulating material mounted on the engine housing consistent with manufacturers' guidelines, if possible.
- Limit noise-producing signals, such as horns, whistles, or alarms, to safety warning purposes only.
- Locate construction vehicle routes at the most distant point feasible from noise-sensitive receptors.

- Ensure all heavy trucks are properly maintained and equipped with noise-control (e.g., muffler) devices, in accordance with manufacturers' specifications, at each work site during facility construction, decommissioning, and site reclamation to minimize heavy truck traffic noise effects on sensitive receptors.
- Limit construction operations located within 2,500 feet of residences to daytime hours.
- Prohibit nighttime (10 p.m. to 7 a.m.) blasting.

Operational noise
Because of the height of wind turbines, acoustical barriers do not represent a feasible mitigation strategy for reducing potential noise impacts.

Equipment selection could reduce operational noise impacts. Some turbines are designed to operate in noise-reduced operation mode. Manufacturer-provided options include the use of low noise trailing edge (LNTE) technology and noise-reduced operation modes. LNTE consists of the addition of plastic or metal sawtooth serrations that can be affixed to the blade's rear edge to reduce blade trailing edge noise. Application of noise-reduced operation modes limits the rotational speed of the turbines to reduce their sound emissions. However, available data on the potential degree of noise reduction would depend on manufacturer design and are not specified for this programmatic analysis. The need for manufacturer-provided options to reduce noise levels would not be required over an entire wind farm but only to the extent needed to address impacts to affected noise-sensitive receptors.

Construction vibration
Blast vibrations are a function of several variables besides distance, primarily the weight of explosives per delay. This variable can be controlled by the blasting contractor to ensure that blasting activities do not result in either structural damage or human annoyance. The Oregon Department of Transportation estimates that if a structure is 1,320 feet away (1/4 of a mile) and the PPV at that receptor is limited to 0.5 in/sec to avoid structural damage, then the maximum weight of explosives that can be detonated is approximately 2,300 pounds per delay period (ODOT 2000). Therefore, blasting contractors should calculate and maintain the weight of explosives necessary to ensure that vibrations from blasting do not exceed a performance standard of 0.5 PPV in/sec for conventional construction and 0.12 PPV in/sec for historic structures.

If the construction area of a proposed utility-scale onshore wind facility is closer than 80 feet from an existing structure, a Construction Vibration Management Plan should be developed and implemented to reduce the potential for building damage. Measures and controls should be identified based on facility-specific design and may include, but are not limited to, the following:

- Use nonvibratory excavator-mounted compaction wheels and small, smooth drum rollers for final compaction of asphalt base and asphalt concrete. If needed to meet compaction requirements, use smaller vibratory rollers to minimize vibration levels during repaving activities to meet vibration standards.
- Implement buffers and use specific types of equipment to minimize vibration impacts during construction at nearby receptors.

- Implement a vibration, crack, and line and grade monitoring program for identified historic buildings located within 80 feet of construction activities, in coordination with a geotechnical engineer and qualified architectural historian.

3.4.5 Unavoidable significant adverse impacts

Through compliance with laws, permits, and with implementation of actions to avoid and mitigate significant impacts, small to medium utility-scale wind facilities would have **no significant and unavoidable adverse impacts** from noise from construction, operation, or decommissioning.

3.5 Large utility-scale facilities of 751 MW to 1,500 MW (Alternative 2)

3.5.1 Impacts from construction

Site characterization and construction of a large utility-scale onshore wind facility would include the same equipment and activities generating construction noise and vibration as those analyzed for small to medium utility-scale facilities, but likely across a larger facility footprint and over a greater construction period. Noise and vibration from multiple sources, including off-road equipment, blasting, vendor and haul truck trips, and a concrete batch plant, could all increase noise levels at receptors in the vicinity of the construction area footprint. Construction equipment and methods for large facilities would be the same as those for small to medium facilities. Therefore, construction noise and vibration impacts would be the same as those identified for small to medium facilities and would range from **less than significant impact** to **potentially significant adverse impact** depending on the distance from sensitive receptors.

3.5.2 Impacts from operation

Larger facilities would likely require a larger, and potentially louder, substation transformer. For the large-scale facilities, a project-level noise assessment for a proxy project was used to estimate the noise generation potential. The proxy project analysis used for the large facility was for a proposed 1,150-MW wind facility with 244 turbines rated from 2.8 to 5.5 MW each (Horse Heaven in Benton County, Washington).

Noise modeling for the proxy project was developed for operation of the turbines, as well as for the contributions from substations. The contours show that turbines are the predominant source of noise (EFSEC 2022).

Wind turbine noise

While turbines may be clumped into groups of three or more on a given project footprint, the 55 dBA, L_{eq} noise contour consistently extends approximately 1,260 feet from each turbine (EFSEC 2022).

For residential uses, an EDNA of 50 dBA would apply during nighttime hours. Based on two-dimensional geometric spreading equations, it is estimated that this noise level would occur at approximately 2,400 feet. Therefore, siting of wind turbines closer than 2,400 feet from a noise-sensitive land use could have a **potentially significant adverse impact**.

Additionally, in recognition that existing ambient noise levels are commonly quiet in rural areas where siting of energy facilities would likely occur, an increase of 5 dBA over ambient would correspond to a readily perceptible increase in noise for permanent operations (FHWA 2017). In quiet rural areas, an increase of 5 dBA over ambient noise could potentially result when turbines generate a noise level of 40 dBA at a receptor. Based on two-dimensional geometric spreading equations, this increase is estimated to have potential to occur within approximately 5,000 feet from the turbines. Consequently, siting of wind turbines closer than 5,000 feet from a noise-sensitive land use in a quiet rural area would have a **potentially significant adverse impact**.

Substation Noise

Modeling from the proxy project, in which the substations are surrounded by wind turbines, indicates that the contributions of substation noise would be negligible in the presence of wind turbine operations for large facilities (EFSEC 2022). Substation noise modeling for another proxy project indicated that the 40 dBA noise contour extends approximately 2,000 feet from substations (BLM and Tetra Tech 2011). Based on 2D geometric spreading equations, it is estimated that the 50 dBA contour would occur at 650 feet. Consequently, siting of substations for large facilities closer than 650 feet from a noise-sensitive receptor or 2,000 feet from a noise-sensitive land use in a quiet rural area would have a **potentially significant adverse impact.**

Corona noise

Analysis of corona noise for overhead lines of 34.5 kV is included in Section 3.4.2 and would be the same for large facilities. Noise estimates would be negligible (EFSEC 2022) and would result in a **less than significant impact**.

3.5.3 Impacts from decommissioning

Decommissioning or repowering noise and vibration impacts for large facilities would be the same as those identified in Section 3.4.3 and would range from **less than significant impact** to **potentially significant adverse impact** depending on the distance from sensitive receptors.

3.5.4 Actions to avoid and reduce impacts

Available means of reducing noise and vibration-related impacts for large facilities are the same as those identified in Section 3.4.4.

3.5.5 Unavoidable significant adverse impacts

Through compliance with laws, permits, and with implementation of actions to avoid and mitigate significant impacts, large utility-scale wind facilities would have **no significant and unavoidable adverse impacts** from noise from construction, operation, or decommissioning.

3.6 Wind facility and co-located battery energy storage system (Alternative 3)

3.6.1 Impacts from construction

Site characterization and construction of a utility-scale onshore wind facility and a co-located battery energy storage system (BESS) would generate the same construction noise levels and vibrations as those analyzed for small to medium facilities and large facilities, with the minor addition of construction of the BESS using the same construction equipment and methods. Therefore, construction noise and vibration impacts for wind energy facilities and co-located BESSs would be the same as those identified for small to medium and large facilities and would range from **less than significant impact** to **potentially significant adverse impact** depending on the distance from sensitive receptors.

3.6.2 Impacts from operation

The major noise sources for wind facilities and co-located BESSs are wind turbines and substations.

Noise from a BESS would be generated by battery storage liquid cooling units, as well as inverters specific to the BESS. BESSs would not be expected to generate operational vibration. In general, these sources would likely operate 24-hours a day and, hence, would generate noise during the more noise-sensitive nighttime hours.

For the utility-scale wind facilities with co-located BESSs, a project-level noise assessment for a proxy project—the 470-MW Wautoma Solar Energy Project in Benton County, Washington—was used to estimate the noise generation potential. Large-scale consolidated direct current-coupled BESSs generate higher noise levels when concentrated in a single area. Such systems can result in a noise level of approximately 65 dBA at a distance of one-half mile (2,600 feet) as compared to approximately 700 feet from each of a single distributed unit (Tetra Tech 2022). The analysis for another proxy project—the 1,150-MW Horse Heaven Wind Farm Project in Benton County, Washington—indicates that three consolidated BESS facilities, one in each solar array area, generate noise levels below 65 dBA within 1,000 feet (Tetra Tech 2022), substantially less than the consolidated BESS for Wautoma. These proxy project analyses indicate that there is a wide range of variability in predicted noise levels based on BESS design and configuration, particularly when comparing distributed and consolidated BESS. The potential exists for some consolidated BESS operations to exceed the Chapter 173-60 WAC EDNA of 50 dBA at distances ranging up to 1.5 miles from consolidated BESS equipment, depending on the design layout of the BESS.

The addition of BESSs could change the operational noise impacts identified for small to medium facilities and large facilities, and the operational noise impact would range from **less than significant impact** to **potentially significant adverse impact** depending on the design and layout of the BESS and distance of sensitive receptors from the facility.

Noise contours for the proxy project indicate that while turbines may be clumped into groups of three or more on a given project footprint, the 55 dBA, L_{eq} noise contour consistently extends approximately 1,260 feet from each turbine (EFSEC 2022).

In Washington state, maximum permissible environmental noise levels specific to land use are codified in Chapter 173-60 WAC. For residential uses, an EDNA of 50 dBA would apply during nighttime hours. Based on two-dimensional geometric spreading equations, it is estimated that this noise level would occur at approximately 2,400 feet. Therefore, siting of wind turbines closer than 2,400 feet from a noise-sensitive land use could have a **potentially significant adverse impact**.

Additionally, in recognition that existing ambient noise levels are commonly quiet in rural areas where siting of energy facilities would likely occur, an increase of 5 dBA over ambient would correspond to a readily perceptible increase in noise for permanent operations (FHWA 2017). As discussed in Section 3.2.1, remote, sparsely populated counties, such as Columbia County, can have background L_{dn} values of 35 dBA or lower (BLM 2024). In such rural areas, an increase of 5 dBA over ambient noise could potentially result when turbines generate a noise level of 40 dBA at such a receptor. Using two-dimensional geometric spreading equations, this increase is estimated to have potential to occur within approximately 5,000 feet from the turbines or substations. Consequently, siting of wind turbines closer than 5,000 feet from a noise-sensitive land use within a quiet rural setting could have a **potentially significant adverse impact**.

Corona noise

Analysis of corona noise for overhead lines of 34.5 kV is included in Section 3.4.2 and would be the same for facilities with co-located BESS. Noise estimates would be negligible (EFSEC 2022) and result in a **less than significant impact**.

Vibration

The BESS would not be expected to generate operational vibration.

3.6.3 Impacts from decommissioning

Decommissioning or repowering noise and vibration impacts for wind facilities with co-located BESSs would be the same as those identified for small to medium facilities and large facilities and would range from **less than significant impact** to **potentially significant adverse impact** depending on the distance from sensitive receptors.

3.6.4 Actions to avoid and reduce impacts

Available means of reducing noise and vibration-related impacts for wind energy facilities with co-located BESSs are the same as those identified in Section 3.4.4, including additional mitigation measures. Additionally, noise generated by BESSs may need to be controlled to maintain operational noise exposure to within the noise standards of Chapter 173-60 WAC. Additional potential actions that could avoid or reduce impacts are outlined below.

3.6.4.1 Siting and design considerations

- Include acoustical enclosures or barriers for BESS containers to reduce potential operational noise impacts.
- Utilize a dispersed or distributed layout of BESSs.

3.6.5 Unavoidable significant adverse impacts

Through compliance with laws, permits, and with implementation of actions to avoid and mitigate significant impacts, utility-scale wind facilities with co-located BESSs would have **no significant and unavoidable adverse impacts** from noise from construction, operation, or decommissioning.

3.7 Wind facility combined with agricultural land use (Alternative 4)

3.7.1 Impacts from construction

A utility-scale onshore wind facility combined with agricultural use may be located on land that already had existing agricultural uses or the facility could add a new agricultural use where the facility is located. Site characterization and construction would generate the same construction noise and vibration levels as those analyzed for small to medium facilities and large facilities without combined agriculture land use. Therefore, construction noise and vibration impacts for facilities combined with agricultural use would be the same as those identified for small to medium and large facilities and would range from **less than significant impact** to **potentially significant adverse impact** depending on the distance from sensitive receptors.

3.7.2 Impacts from operation

For a facility that includes agricultural land uses, any existing agricultural lands would be maintained, or new agricultural use could be co-located with the utility-scale wind facility, including rangeland or farmland. Activities at these facilities may include maintenance of existing or addition of new infrastructure, roads, fences, gates, and operation of farming machinery. If the agricultural uses exist prior to facility construction, any noise contribution from these existing activities would reduce the increase over ambient that is assumed to occur (as analyzed in Sections 3.4.2 and 3.5.2). If a new agricultural use is also introduced as part of this alternative, it would result in seasonal operations of farm equipment (tractors, tillers, and reapers) that would generate noise levels similar to those identified in Table 2. While mobile equipment operations of agricultural equipment under this alternative could represent a new additional noise source, the seasonality of such operations and temporary duration of any additional noise generation would be a **less than significant** noise contribution. Overall operational noise impact would range from **less than significant impact** to a **potentially significant adverse impact** depending on the distance of the receptor from the facility

3.7.3 Impacts from decommissioning

Decommissioning or repowering noise and vibration impacts for a facility that includes agricultural land uses would be the same as those identified for small to medium and large facilities and would range from **less than significant impact** to **potentially significant adverse impact** depending on the distance from sensitive receptors.

3.7.4 Actions to avoid and reduce impacts

Available means of reducing noise and vibration-related impacts for a facility that includes agricultural land uses are the same as those identified in Section 3.4.4.

3.7.5 Unavoidable significant adverse impacts

Through compliance with laws, permits, and with implementation of actions to avoid and mitigate significant impacts, utility-scale wind facilities with agricultural uses would have **no significant and unavoidable adverse impacts** from noise from construction, operation, or decommissioning.

3.8 No Action Alternative

Under the No Action Alternative, the city, county, and state agencies would continue to conduct environmental review and permitting for utility-scale wind energy development under existing state and local laws on a project-by-project basis. The potential impacts from facilities developed under the No Action Alternative would be similar to the impacts for the types of facilities described previously for construction, operations, and decommissioning, depending on facility size and design, and would range from **less than significant impacts** to **potentially significant adverse impacts.**

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