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Masking of Sage-grouse Display Calls by Noise from Wind Turbines

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Summary

Locations with promising wind energy potential in the western United States (U.S.) and Canada are often collocated within or in close proximity to either current or historic greater sage-grouse habitat. The sage-grouse is a lek species, which means that during the spring breeding season, males and females gather at specific locations where the males display and breeding takes place. Sage-grouse populations have historically been in decline over much of the species' range due to a variety of factors, while wind energy development has been increasing; therefore, identifying how these two potentially conflicting interests can coexist may be of interest to both environmental conservation and the wind energy industry. To start the discussion, an acoustic screening level analysis was conducted to evaluate the potential for sage-grouse breeding display calls to be masked by sounds from utility-scale wind turbine generators (WTGs). Preliminary conclusions are that noise from WTGs located at linear distances up to 400 meters of active sage-grouse leks could potentially mask the lower frequencies (125 Hz and below) of their breeding display calls. More study is required to identify any candidate mitigation measures and determining adequate setback distances to help minimize the potential for adverse noise impacts from active leks in areas that are also suitable for future wind energy development.

1. Introduction

Noise from WTGs has the potential to mask sage-grouse breeding display calls. Analyses were conducted to ascertain how noise from WTGs might mask sage-grouse display calls. The analyses sought to answer the following questions:

1. To what extent could operating WTG noise mask sage--grouse breeding display calls?
2. Does natural sound from wind interacting with the environment interfere with sage-grouse breeding calls?
3. What is the frequency (Hz) range ofsage-grouse breeding calls and at what distances are these frequencies present when considering -site-specific terrain and other factors such as environmental effects foliage and ground attenuation rates?
4. Male sage-grouse display calls typically occur from approximately 1 hour before sunrise to about 3 hours after sunrise. Do WTGs generally operate during this early morning time period in the sage-grouse habitats selected for this study.

WTG spectral noise data from various manufacturers were evaluated to ascertain their potential for masking sage-grouse breeding calls. Selected WTG types were modelled using the Organization for International Standardization (ISO) standard *ISO 9613-2 Part 1: Calculation of the absorption of sound by the atmosphere, 1993* and *Part 2: General method of calculation (ISO 9613-2:1996).* The calculation methodology assesses the sound propagation based on the octave band center frequency range from 31.5 Hz to 8000 Hz.

The purpose of this paper was to estimate potential masking effects and associated time and seasonal dependencies. Hourly wind patterns were analyzed at selected United States National Interagency Fire Center (NIFC) Remote Automated Weather Stations (RAWS) in areas near wind energy development with sage-grouse habitat. This paper investigates the probability of WTGs operating during the period of time when sage-grouse display calls occur as well as masking from wind-related noise and the WTGs themselves.

2. Experimental design

To answer the four questions introduced in Section 1.0 the following experimental analyses were conducted.

2.1 Masking Effects of WTG Noise and Sage-grouse Breeding Display Calls Information on the frequency range of sage-grouse breeding display calls was obtained from research conducted by Jessica L. Blickley and Gail L. Patricelli at the University of California-Davis, Department of Evolution and Ecology (Blickley et al. 2012). Sage-grouse calls are highly directional and each measurement presented in Blickley's analysis had been obtained in from 30 to 90 degrees in the direction of the call at approximately 15 feet (4.5 meters). Blickley and Patricelli indicate that the sage-grouse vocal display is composed of three major note types: a series of low-frequency "coo" notes, two broadband "pops", and a frequency-modulated "whistle". Further characterization of these note types, including spectral data, may be found in their work. Using ISO 9613-2, spectral data from these measurements were used to model the sound attenuation rate of the sage-grouse calls and to identify at what point the sage-grouse calls would be expected to blend in with the assumed rural background sound level (see Section 2.2).

A similar methodology was employed to model WTG noise for using ISO 9613-2 using spectral data derived from WTG types that are commonly in use in the U.S. and Canada. Spectral data from the selected WTGs were obtained from public records for wind energy projects in the U.S. and Canada via a simple internet search and are used in this paper only if such data were found in a public domain document (i.e., from wind energy project documentation published on the web). The author understands that although the WTG spectral data used in these analyses is part of public domain documents, WTG manufacturers typically consider these data proprietary. Therefore WTGs are not referred to by manufacturer name; rather they are referred to generically as WTG-1, WTG-2, and WTG-3.

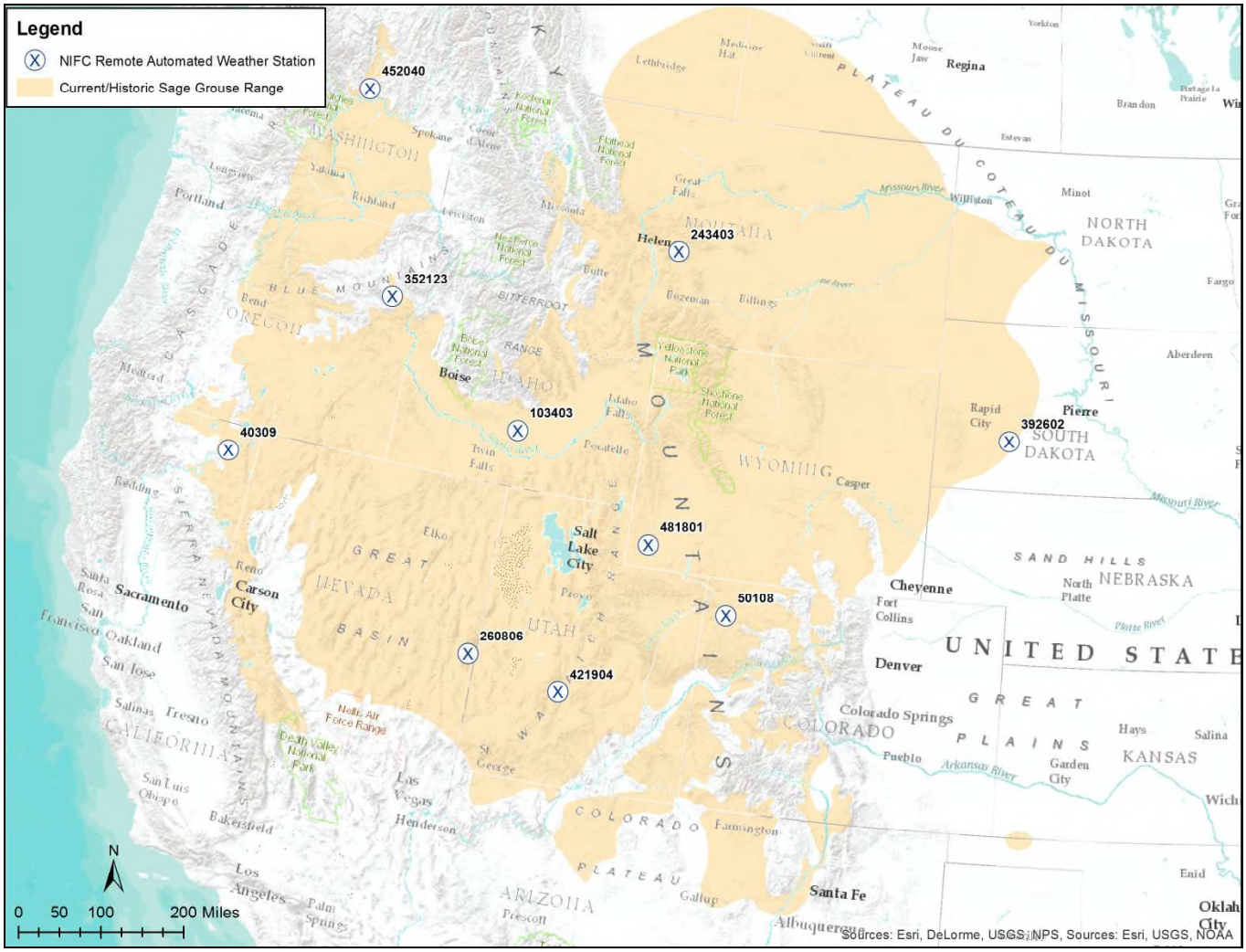
The WTG acoustic modelling analyses were conducted assuming flat terrain and a highly reflective ground absorption factor of 0.0. Meteorological parameters were set at a temperature of 10 degrees Celsius and relative humidity of 70%. WTGs and sage-grouse breeding display calls were modelled as spectral omnidirectional sound sources. Representative WTG source emission levels were modelled at a hub-height of 100 meters (328 feet) above ground and sage-grouse breeding display calls were modelled at a height of 0.6 meters (2 feet) above ground. For the purpose of this analysis sage-grouse were the receptors of interest; therefore, they were also modelled at of 0.6 meters (2 feet) above ground. The likelihood of masking was determined by comparing the modelling results of each WTG with the sage-grouse display calls. Octave band frequency sound levels were compared to evaluate whether the levels associated with WTG operation would be greater than those produced by sage-grouse display calls at a lek.

2.2 Natural Sound of Wind Interacting with the Environment and Sage-grouse Breeding Display Calls Masking of both WTG noise and sage-grouse breeding display calls could result from wind interacting with vegetation and terrain in close proximity to wind energy development. The amount of masking at any location is highly variable and site-specific but general conclusions are drawn from guidance used on transportation projects in the U.S. (FTA 2012).

2.3 Distances of Masking from WTG Noise according to Frequency Range of Sage-grouse Breeding Calls Modelling conducted as described in Section 2.1 was used to identify the distance at which WTG noise might mask sage-grouse breeding display calls. Analysis of WTG noise attenuation was conducted at distances of 75 meters (246 feet), 400 meters (1,312 feet), and 1,500 meters (4,921 feet) from a representative WTG. Additionally, the distance at which sagesage-grouse display calls is expected to be masked by assumed rural ambient sound levels was estimated by modelling attenuation from sage-grouse display calls with distance. Sage-grouse breeding display calls were modelled at the same set receptor distances used for modelling WTG noise.

2.4 RAWS Meteorological Data Review of WTG Operational Wind Speeds during the Sage-grouse Breeding Season Hourly meteorological data from May 1, 2012 to May 1, 2013 were obtained from NIFC RAWS locations (NIFC 2013) that are located in close proximity to wind energy development or in areas where sage-grouse habitat and good wind energy potential coexist. Sage-grouse breed annually in the spring, which for the purposes of this analysis has been designated as occurring from May 1, 2012 to June 20, 2012 and March 20, 2013 to May 1, 2013. Additionally, according to research conducted by several scientists, including Blickley and Patricelli (Blickley et al. 2012), sage-grouse make breeding display calls from 1 hour prior to sunrise to 3 hours after sunrise during the spring. Meteorological data were refined to analyze operational wind speeds only during this time period in order to ascertain the potential occurrence of masking effects coinciding with breeding display calls. Meteorological stations were selected from the following U.S. states: California, Colorado, Idaho, Montana, Nevada, Oregon, South Dakota, Utah, Washington, and Wyoming. Figure 2-1 is a map showing the selected RAWS stations as well as current/historic sage-grouse habitat for the U.S.

Figure 2-1 Selected RAWS and Sage-grouse Habitat



3.0 Preliminary Results

The results of the analyses described in Section 2.0 are summarized in the subsections that follow.

3.1 Masking Effects of WTG Noise and Sage-grouse Breeding Display Calls Results

Sage-grouse breeding display calls have unique frequency components that were compared to sound spectra data from three industrial-sized WTG types referred to as WTG-1, WTG-2, and WTG-3. While somewhat variable depending on WTG type, generally the results show that the main frequency range where masking likely occurs is at 125 Hz and lower . Additionally, some masking of the display calls may occur at 2000 Hz for WTG-2; however, this would only be expected in close proximity, within 75 meters (246 feet) from the WTG. Nevertheless, the primary component of WTG noise that could mask sage-grouse display calls would appear to occur in the lower frequencies. Section 3.3 includes charts with modelling results for each WTG.

3.2 Natural Sound of Wind Interacting with the Environment and Sage-grouse Breeding Display Calls Results Masking of both WTG noise and sage-grouse breeding display calls is likely to result from natural sounds such as wind, rain, insects, and wildlife as well as from other non-wind energy anthropogenic sound sources such as roadways, railroads, and aircraft over-flights. Masking effects of these kinds are highly variable and location dependent. The scope of this analysis did not permit a more extensive study of natural and non-wind energy anthropogenic sound sources located in proximity to wind energy projects and sage-grouse leks. Nevertheless, it has been demonstrated for many wind energy projects that when wind speeds increase so do ambient sound levels in a given area. Generally this is a result of wind interacting with vegetation, terrain, or structures in the vicinity of a wind energy project. The degree to which masking effects of this type are apparent at a given location would need to be verified via a baseline sound survey. A baseline sound survey could also be used to ascertain the level of masking associated with natural and other anthropogenic existing sound sources in that area.

Since this analysis did not include a baseline sound survey, a rural ambient level was assumed based on guidance documents often referenced in noise impact studies in the United States. Specifically, according to the Federal Transit Authority's High-Speed Ground Transportation Noise and Vibration Impact Assessment (FTA 2012) guidance document, rural settings with the lowest population densities (i.e., 1 to 99 people per square mile) typically are exposed to ambient sound levels ranging from an equivalent sound level (L_{eq}) of 25 dBA at night to 35 dBA L_{eq} during the day. Since breeding display calls usually occur during daytime hours, 35 dBA L_{eq} has been assumed as the rural baseline sound level for comparative purposes.

Table 3-1 lists the results of sage-grouse display call attenuation with distance. The "coo" and "whistle" components of the display call are at or below the assumed rural background (i.e., 35 dBA L_{eq}) at 200 meters (656 feet) from the receptor and the "pop" components are at or below the assumed rural background at 1,312 feet (400 meters) or less.

Table 3-1 Sage-grouse Display Call Attenuation with Distance

Display Call	Assumed Rural Background dBA L_{eq}*	4.5 meters (15 feet) dBA**	75 meters (246 feet) dBA	200 meters (656 feet) dBA	400 meters (1312 feet) dBA	1500 meters (4921 feet) dBA
Coo2	35	84	40	32	26	12
Coo3	35	87	43	35	29	15
Pop1	35	92	47	39	33	19
Pop2	35	93	49	41	35	22
Whistle Trough	35	82	38	30	23	9
Whistle Peak	35	79	34	26	20	5

Sources: *FTA (2012,) **Blickley et al .(2012) converted from dBL to dBA

3.3 Distances of Masking from WTG Noise according to Frequency Range of Sage-grouse Breeding Calls Modelling, as described in Section 2.1, was conducted to identify the distance at which WTG noise might mask sages-grouse breeding display calls. Figures 3-1 to 3-3 display the results of the WTG modelled at distances ranging from 75 meters (246 feet) to 1500, meters (4,921 feet) compared to the sound of sage-grouse display calls at a lek (i.e., 15 feet or 4.5 meters). Generally sound from each of the WTG types analyzed would cease to mask lek breeding display calls when WTGs are located 400 meters (1,312 feet) or greater from active leks. Acoustic modelling for WTG-2 demonstrates that masking effects would cease at a distance of approximately 200 meters (656 feet).

Figure 3-1 WTG-1 Masking Compared to Sage-grouse Display Calls

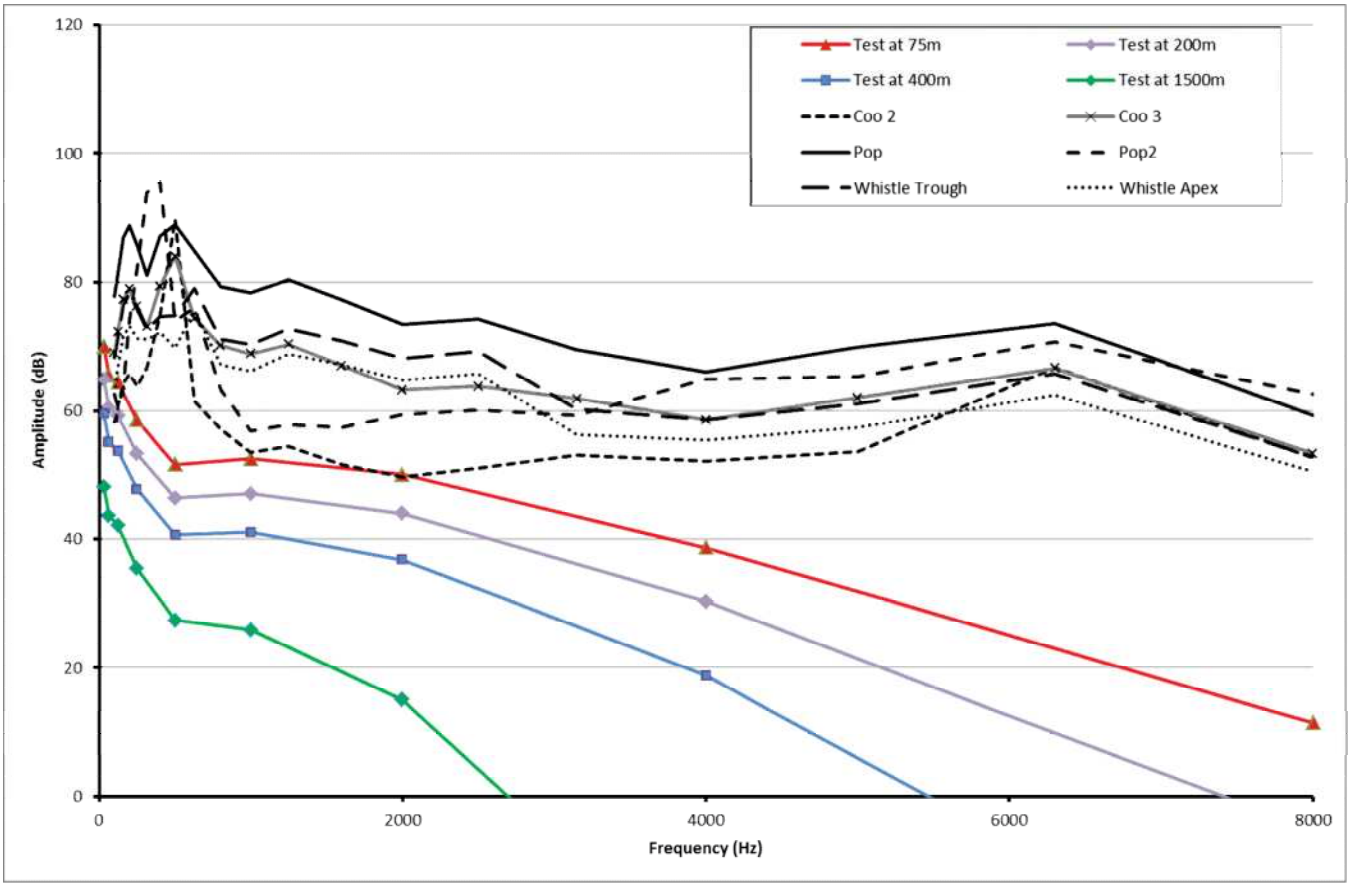


Figure 3-2 WTG-2 Masking Compared to Sage-grouse Display Calls

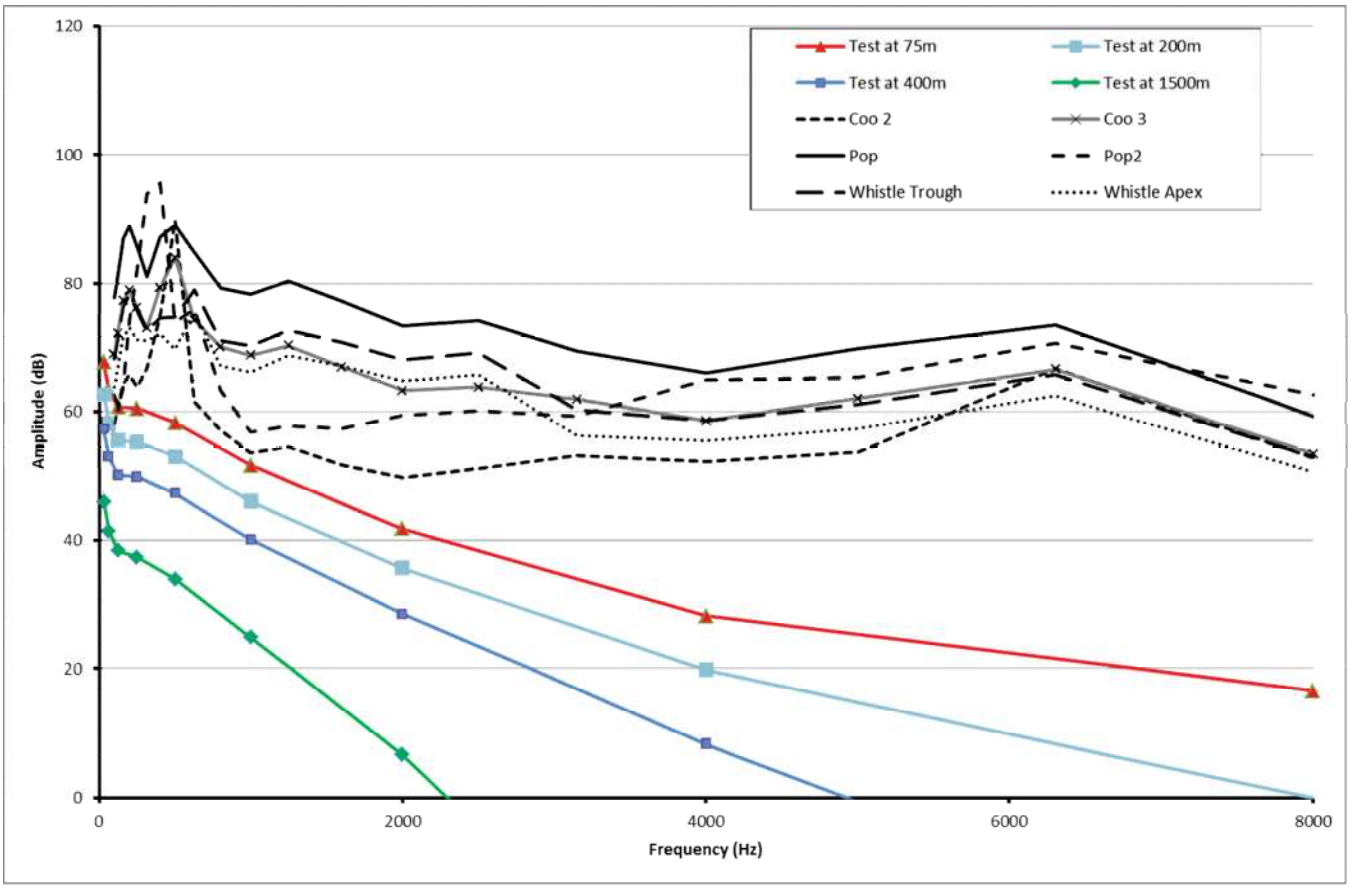
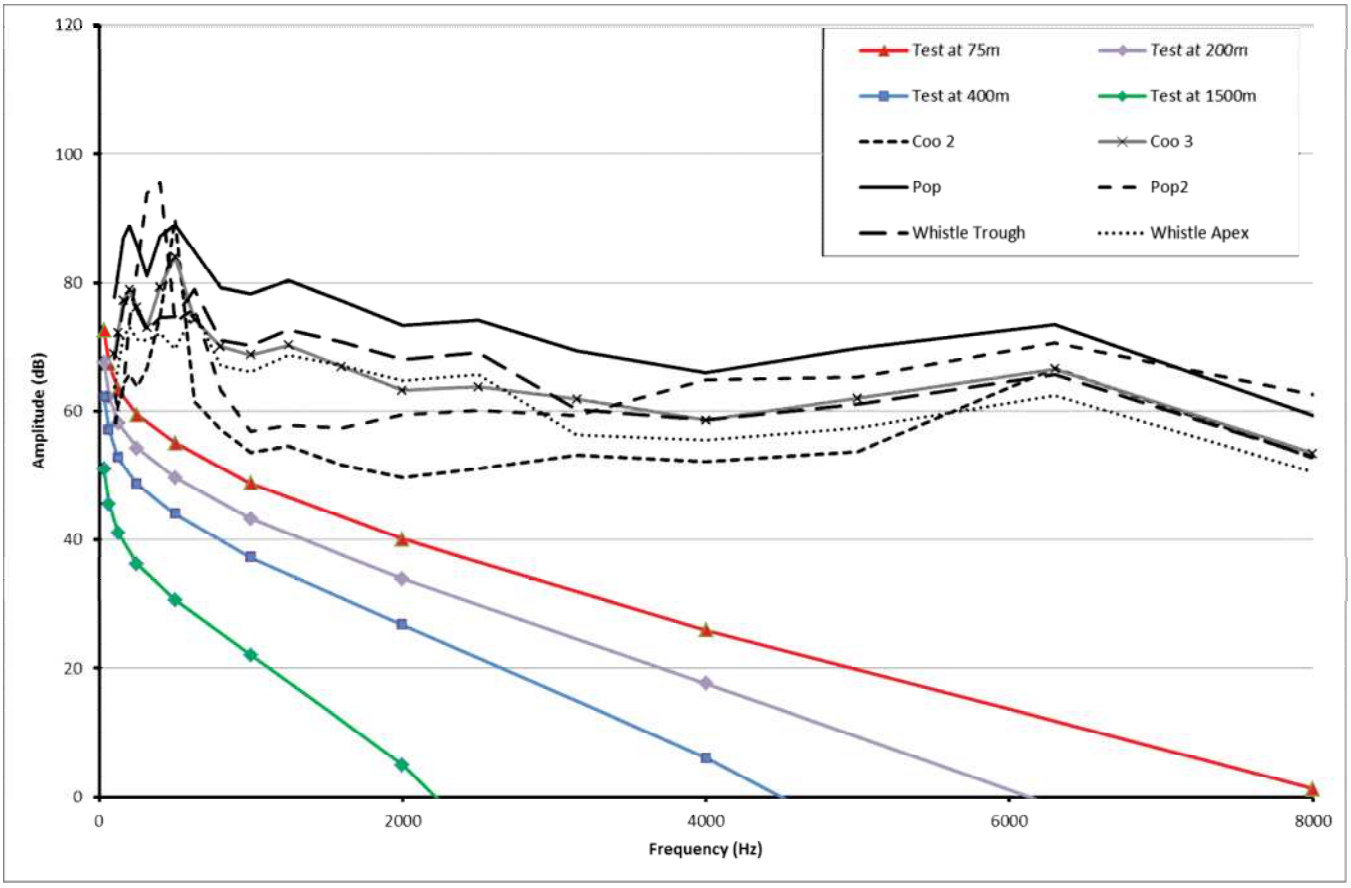


Figure 3-3 WTG-3 Masking Compared to Sage-grouse Display Calls



3.4 RAWS Meteorological Data Review of WTG Operational Wind Speeds during Sage-grouse Breeding Season Results Hourly meteorological data from May 1, 2012 to May 1,-2013 during sages-grouse breeding display call periods (i.e., in the spring) and from 1 hour before sunrise to 3 hours after sunrise were analyzed to determine if WTGs are likely to operate during those times. Results show that wind speeds are of sufficient strength to operate WTGs during sages-grouse breeding display call time periods. It should be noted that results from the selected RAWS, while located in close proximity to wind energy development/potential, would vary considerably compared to wind energy development -site-specific meteorological stations. Site-specific data would be expected to provide a higher level of accuracy and reliability. The data analyzed was only used for screening purposes to determine if there is potential for WTGs to operate during the display call time periods. In addition, more extensive analysis of historical meteorological data may be recommended to confirm whether the trends presented would be consistent over a longer period of time. Table 3-2 presents the percentage of time during sage-grouse breeding display call time periods where WTGs would be operational for each of the RAWS stations analyzed.

Table 3-2 Sage-grouse Display Call Attenuation with Distance

State	RAWS ID	Percentage of Breeding Period	
		WTG Operational	WTG not Operational
California	**40309**	48%	52%
Colorado	**50108**	67%	33%
Idaho	**103403**	64%	36%
Montana	**243403**	48%	52%
Nevada	**260806**	21%	79%
Oregon	**352123**	54%	46%
South Dakota	**392602**	90%	10%
Utah	**421904**	50%	50%
Washington	**452040**	65%	35%
Wyoming	**481801**	51%	49%

4.0 Preliminary Conclusions and Next Steps

It has been stated that sound from WTGs has the potential to mask sage-grouse display calls if WTGs are located in close proximity to active leks. The degree to which masking of sage-grouse display calls would occur as a result of WTG noise is dependent on the distance between a WTG to a lek, what other masking effects may be present due to natural sounds (i.e., wind, animals, insects, weather, etc.), and masking effects from other non-wind energy related anthropogenic sound sources (i.e., railroad, roadway, aviation, industry). Preliminary screening level results indicate that if WTG are sited at distances 400 meters (1,312 feet) or greater from active leks, sage-grouse display calls are highly unlikely to be masked by operational sound of WTGs. However, depending on the WTG type, this distance may vary.

Sage-grouse display calls blend in with an assumed background sound level of 35 dBA L_{eq} at varying distances depending on the call component. Generally the “coo” and “whistle” components would be at or below 35 dBA L_{eq} at 200 meters (656 feet) or less from the displaying bird. The “pop” components would be at or below 35 dBA L_{eq} at 400 meters (1,312 feet).

Taking these two findings into account, for wind energy projects that are planned within 400 meters (1,312 feet) from active leks additional analyses may be helpful to determine potential breeding display call masking effects. Note that existing sound levels near wind energy projects are highly variable; therefore, if an active lek is found in proximity to proposed wind energy development, a baseline sound survey may help to ascertain the level with which masking of display calls may already occur. It is unknown whether or not existing wind energy projects are located within 400 meters (1,312) feet of active sage-grouse leks; however, if there are such projects acoustic monitoring and observations of the lek during breeding season could help to clarify how WTG noise effects breeding patterns.

Furthermore, monitoring of sage-grouse breeding display call sound spectra data at frequencies in lower than 100 Hz may help to describe how lower frequency components of WTGs noise spectral content may overlap with that of sage-grouse display calls. Additional monitoring of sage-grouse display calls and analysis would be needed to establish this relationship.

This analysis looked at a single WTG in isolation on flat terrain with ground conditions that are highly reflective thereby resulting in highly conservative results. This is not necessarily a “real world” application of WTG noise. For example, modelling for WTG-3 with highly absorptive ground conditions demonstrates that sage-grouse breeding display calls show potential masking effects at distances less than 200 meters (656 feet), In general, it has been found that mixed’, i.e. a combination of hard and porous, corresponding to a ground absorption coefficient of 0.5 is appropriate for rural farming country in the sense that predicted sound levels agree very well with measurements of turbine-only sound levels over a variety of wind speeds. This would imply masking somewhere in the range of 200 to 400 m from an isolated turbine while operating under the worst case full rotational speeds. More complex terrain and/or additional WTGs as part of a larger array would result in different received sound levels at leks. Moreover, sage-grouse display calls were modelled in a similar fashion over highly reflective flat terrain, which may overestimate the distance with which sounds from display calls travel. Refined and more detailed modelling on a project-by-project basis taking into account variation in terrain including vegetation coverage would help to describe how sound from both WTG and sage-grouse display calls attenuate with distance.

Additionally, this analysis uses ISO 9613-2 for sound propagation calculations which is consistent with recommendations by the American Wind Energy Association for WTG sound propagation calculations. However, this is merely one approach to modelling sound propagation.

Nevertheless, as wind energy development continues on public and private land where sage-grouse habitat co-exists, the need for establishing setback distances from active leks may be of use to wind energy developers particularly with addressing potential concerns related to sage-grouse communication during active breeding season.

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