10(a)(1)(A) Permit Application Study Plan - Kings Point & North Fork Ridge Wind Projects

Activity-based Informed Curtailment Study

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February 2, 2021

1.0 Introduction

Wind energy development impacts bat populations, and installed wind power capacity is expected to increase to 9,000 megawatts (MW) by 2030 in the southeastern United States which includes the majority of states within the range of the federally endangered gray bat (*Myotis grisescens*) (AWWI 2018). The impact of wind energy development on gray bat populations is unknown because only one commercial-scale wind energy facility exists within the southeastern range of the gray bat (Buffalo Mountain Wind [BMW]). Carcass monitoring between 2000–2005 at BMW, which is 16 miles from a colony of 5,000 gray bats, did not document fatality of gray bats (Fiedler 2004, Fiedler et al. 2007, Nicholson et al. 2005). As wind power development expands within the gray bat range, more studies in a wider range of habitats are needed to understand the impacts of wind power development on gray bats and to develop effective measures to reduce those impacts.

Operational curtailment is the only measure with widespread and consistent effectiveness to reduce bat fatalities (Arnett et al. 2016), and has been used to reduce or avoid risk for other *Myotis* species including the Endangered Species Act-listed (ESA-listed) Indiana bat (*Myotis sodalis*). To date, most curtailment programs prevent turbine operation below a single cut-in speed selected based on regulatory precedent or policy as opposed to site-specific data and are often termed blanket curtailment because they apply the same cut-in speed to all turbines over a broad season. By contrast, smart curtailment is a promising alternative that uses site-specific data on bat activity to tailor cut-in wind speeds and additional parameters such as wind speed to varying levels of risk. Stantec has developed an approach to smart curtailment, known as Activity Based Informed Curtailment (ABIC), that uses acoustic bat data recorded at nacelle height to determine conditions associated with risk, allowing curtailment to be focused on these high-risk conditions.

ABIC relies on the metric of exposed bat activity, defined as the subset of bat passes occurring when turbine rotors are spinning, as a quantitative indicator of risk. Unlike total bat activity, which has been a poor predictor of fatality risk based on comparisons of pre-construction and post-construction survey results (Solick et al. 2020), exposed bat activity was correlated positively with fatality risk on multiple temporal scales based on monitoring at two wind farms in West Virginia (Peterson 2020; Peterson et al. *in review*). Curtailment works because bats are at risk only when turbine blades are rotating, and by extension, acoustic activity indicates risk only if it occurs when turbines are operating. By simulating exposure associated with various curtailment alternatives, ABIC provides a quantitative method to design a smart curtailment strategy based on site-specific data that achieves targeted reductions in exposure for minimal energy loss. The resulting ABIC strategy depends on how bat activity is distributed, and the amount of risk reduction associated with a particular project.

Stantec has used ABIC to optimize curtailment strategies at multiple commercial wind farms in the northeast and has successfully designed ABIC strategies. This study will provide an opportunity to test the assumptions underlying ABIC at two commercial wind projects within the range of the gray bat, laying an empirical foundation for minimizing risk to gray bats while allowing for additional generation of renewable energy. As outlined below, ABIC strategies rely on the same concept as blanket curtailment, which has consistently been shown to reduce fatality.

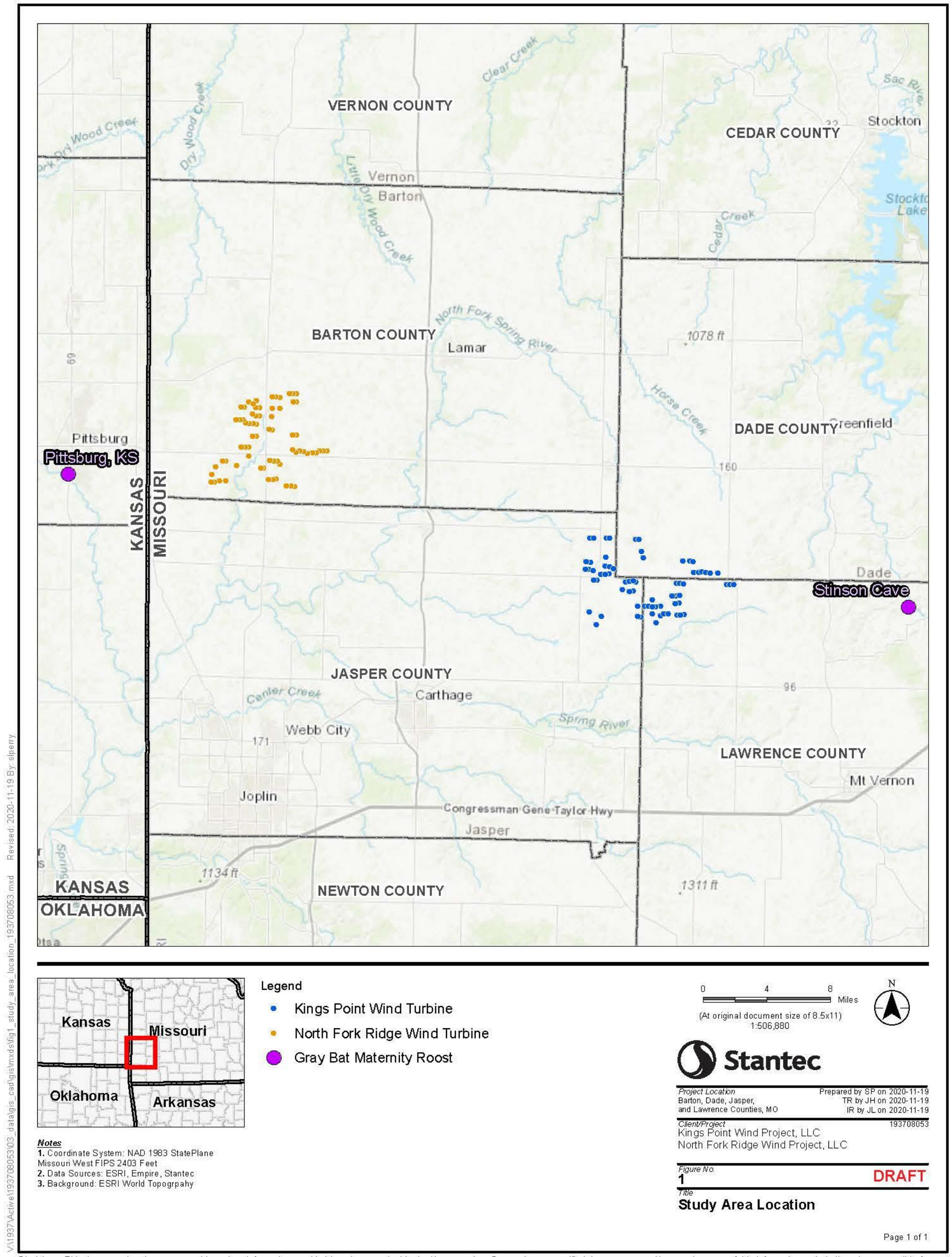
1.1 Research Objectives

The goal of this study is to evaluate and understand gray bat fatality rates at wind facilities to develop and test an optimal curtailment strategy for reducing impacts. This will aid in the recovery of the gray bat by providing a basis of understanding for gray bat and wind energy interactions. To achieve this goal, our study has 4 objectives:

- Objective 1: Quantify turbine-related fatality rates for gray bats
- Objective 2: Quantify relationship between exposed bat activity and fatality
- Objective 3: Quantify effectiveness of blanket curtailment for reducing gray bat fatality
- Objective 4: Demonstrate use of nacelle-based acoustic and weather data to optimize curtailment and evaluate its effectiveness at reducing gray bat fatality

1.2 Study Area

The Empire District – Liberty Utilities Central (the Applicant) is developing the Kings Point Wind Project (KP) and the North Fork Ridge Wind Project (NFR) within the Missouri counties of Barton, Dade, Jasper, and Lawrence. KP is located approximately 4.8 km (3.0 mi) south of Golden City, Missouri. NFR is approximately 4.8 km (3.0 mi) east/southeast of Mindenmines, Missouri. Both sites are 149.4 MW (approximately 300 MW total) and include 69 turbines each (138 total turbines) – collectively referred to as the Study Area. For a map of the Study Area, see Figure 1. The general landscape within the Study Area is primarily hay/pasture and cultivated crop including soybeans, corn, and wheat. Stantec determined potential bat habitat resources through analysis of 2017 aerial imagery. KP contained 2,592 acres of wooded area and 140 acres of open water (Stantec 2020a). For NFR, 3,010 acres were wooded and 330 acres were open water (Stantec 2020b).



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Gray bats were captured at KP and acoustically confirmed at NFR (Stantec 2018a and 2018b). Gray bats captured at KP used a maternity roost with a summer population of ~9,000 bats located approximately 17.9 kilometers (km; 11.1 mi) from its eastern-most wind turbine (Stantec 2018a and 2019a). There is a small (~2,000 individuals) maternity roost 14.2 km (8.8 mi) from NFRs western-most turbine. Pre-construction studies at both sites have determined that the only ESA-listed bat species at risk of impact is the gray bat (Stantec 2018a and 2018b). Onsite acoustic monitors recorded gray bats occurring in potential rotor swept zones of turbines within both sites (Stantec 2019b and 2020c).

Gray bats have been shown to fly at higher wind speeds than what is typically observed for other *Myotis* spp., and therefore higher cut-in wind speeds may be necessary to avoid or reduce risk to acceptable levels. As a result, cost of curtailment in terms of energy loss could be substantially higher, especially when using blanket curtailment. We propose investigating ABIC as a method to avoid and reduce impacts to gray bats while minimizing associated energy loss. This study will test the utility of biologically-driven predictive models to design curtailment scenarios based on wind speed, temperature, and time of year. Prospective wind development throughout the species' range will have a tested model for operational strategies to limit potential impacts on the population.

1.3 Turbine Specifications

Each facility will include (12) Vestas 2.0 MW and (57) Vestas 2.2 MW wind turbine generators (WTGs). For both WTG models, the turbines are designed to begin generating energy (i.e., cut-in) at wind speeds of 3.0 meters per second (m/s; 6.7 miles per hour). The turbine specifications are shown in Table 1-1.

Table 1-1. Turbine Specifications for Study Area Sites

Vestas WTG	Number per Site	Rotor Hub Height (meters [m] above ground level [agl])	Blade Diameter Length (m)	Rotor Swept Area (m^2)	Rotor Blade Tip Height (m agl)	
					Max	*Min*
2.0	12	120	110	9,509	175.1	65.1
2.2	57	122	120	11,326.9	182	62

2.0 Overview of Study Design

To address our objectives while simultaneously reducing risk to gray bats, the first two years of the study will compare effectiveness of a blanket curtailment strategy with a 5.0 m/s cut-in speed and an operational control. We will use a combination of nacelle-height acoustic bat monitoring and standardized carcass monitoring to evaluate effectiveness of the blanket curtailment strategy and gather the data necessary to design an ABIC alternative. The remaining two field seasons will evaluate the effectiveness of the ABIC alternative in comparison to blanket 5.0 m/s curtailment and operational control.

The overall goal of this study is to demonstrate that curtailment can be optimized using data collected by wind facility operators to strategically reduce exposure of targeted species while simultaneously enabling energy loss to be reduced. Our study will also demonstrate how acoustic data collected at nacelle-height can provide a reliable and sensitive metric to design and evaluate curtailment programs. In so doing, our framework includes a built-in validation procedure using consistent methods and metrics and relieves the need to rely solely on carcass monitoring, which fails to address the relationship between fatality risk and conditions at a temporal scale sufficient to design and adaptively manage curtailment with precision. These results will encourage broader consideration and implementation of strategic curtailment within the wind industry to enable continued expansion of this important source of renewable energy generation while simultaneously protecting the viability of vulnerable bat species.

3.0 Methods

The methods required to address the study objectives include assigning treatments for turbine operations, acoustic data collection, carcass monitoring, and development of curtailment scenarios. Details of these methods are provided in the sections below.

3.1 Turbine Operations

Turbines will be divided equally among two-three operational treatments (varies by Phase) during each monitoring year, with treatments reassigned for each year but not rotated within years. Operational treatments will be assigned using spatially balanced design (Robertson et al. 2017) such that treatments are distributed throughout both sites and so that each treatment includes a proportional representation of different turbine sizes (i.e., the [12] 2.0 MW turbines at both sites will be divided evenly among the treatments). During the first two years (Phase 1), treatments will include control (feathering below normal cut-in of 3.0 m/s), and blanket curtailment below 5.0 m/s. For years 3 and 4 (Phase 2), each facility will be divided into three treatments and an ABIC smart curtailment strategy will be implemented as one of the treatments. The control and 5.0 m/s treatments will remain the same but will be implemented at fewer turbines to accommodate for the third treatment (Table 3-1). Treatments will operate from April 1 – October 31, sunset to sunrise at or above 10 degrees Celsius (°C)

Table 3-1. Treatment Groups for Study Site Turbines

Year	Treatment Descriptions
1-2 Phase 1	Control (3.0 m/s) at ~50% (35) of turbines Blanket (5.0 m/s) at ~50% (34) of turbines
3-4 Phase 2	Control (3.0 m/s) at 33% (23) of turbines Blanket (5.0 m/s) at 33% (23) of turbines ABIC Strategy at 33% (23) of turbines

Parameters for the ABIC treatment will be dictated based on acoustic data collected during the Phase 1 of the survey to target a reduction in gray bat acoustic exposure similar to the 5.0 m/s blanket treatment. Parameters of the ABIC alternative will be tailored by site based on onsite data and designed within specific constraints imposed by turbine manufacturers, warranties, permitting requirements, or other factors such as supervisory control and data acquisition (SCADA) control algorithms. Turbine functionality will be evaluated quarterly in both Phases to verify correct implementation of curtailment strategies.

Turbine operation and weather data (e.g. turbine rotations per minute [rpm], ambient air temperature, wind speed at nacelle height) will be recorded for each turbine at 10-minute intervals and used to estimate potential energy generation, energy loss due to curtailment, and to determine conditions under which bats are active at nacelle height. Turbine rpm data will also be used to calculate the proportion of acoustic bat activity exposed to turbine operation (e.g., occurring when turbine rpm exceeds 1).

3.2 Acoustic Bat Monitoring and Analysis

3.2.1 Acoustic Data collection

Acoustic bat detectors will be deployed on the nacelles of 15 turbines at each site in March and taken down in November, providing a potential of 6,420 detector nights per year. Based on preconstruction bat passage data from 55 m agl microphones on meteorological (met) towers, we expect up to 21,000 bat passes (all species) each year. Turbines to be monitored acoustically will be selected from the subset of turbines with full search plots, using a spatially balanced method, to adequately encompass the full extent of each site and so that detectors are assigned approximately evenly to turbines in each operational treatment. Stantec will program detectors to operate from 1/2 hour before sunset until 1/2 hour after sunrise every night throughout the survey period.

Detectors will collect full spectrum acoustic data using an omnidirectional ultrasonic microphone (e.g., Wildlife Acoustics SM4BAT FS with an SMM-U1 microphone). Detectors and microphones will be oriented to record bat activity at the downwind side of the turbine nacelle with the microphones pointed away from the turbine rotor to minimize wind noise. The detector and microphone are weather resistant and do not require weatherproofing though the microphone will be oriented horizontally or slightly downward to limit potential damage due to precipitation. Supporting equipment will be housed in weatherproof enclosures suitable for mounting on top of nacelles. Each detector will be powered by external batteries charged by solar panels. Microphones will be grounded to the tower when possible to limit the effects of electrostatic damage.

Detectors will be equipped with memory cards up to 512 GB capacity (per detector), enabling long-term autonomous operation, although we will attempt to check all bat detectors at least once during each field season to offload data and replace malfunctioning system components, as necessary. Detectors and support equipment will be self-contained and will not be connected to the power supply or communications network of site turbines. After each survey period, Stantec will inspect detectors and associated hardware to perform a post-season microphone sensitivity test for each detector. Only data collected from properly functioning detectors and microphones will be used for analysis.

3.2.2 Acoustic Data Analysis

Data from detectors will be reviewed and processed using Wildlife Acoustics Kaleidoscope Pro at the end of each field season. Acoustic data will be screened through the analysis software to eliminate files containing noise (e.g., static or wind) and to auto-assign regional-specific species identification. A Stantec biologist with experience in visual acoustic bat identification will manually review all files passed through the software to verify bat passes (a minimum of 2 echolocation pulses) and gray bat identifications. In cases where passes cannot be reliably identified to species (e.g., passes that share characteristics of multiple species), passes will be assigned to species groups. Acoustic survey results will be compiled per site.

3.3 Carcass Monitoring Protocols

Standardized carcass monitoring will occur during each year of the study, although a higher level of effort will occur during Phase 1. During the first year, cleared plot searches will occur at ~35% (24 turbines) of the turbines at both sites, split between the treatment groups. Vegetation in cleared plots will be kept below 12.7 centimeters (5 inches). Of the turbines with full plots, 4 (2 per treatment) will have cleared plots extending out to a radius of 100 m from the turbine (“large full plots”). The 4 large full plots will increase detection probability for the first year of monitoring and allow for site-specific calculation of carcass density weighted proportions (DWP). The remaining full plots will be cleared to 60 m (“regular full plots”), which is expected to encompass 80% of where fatalities are found away from a turbine (U.S. Fish and Wildlife Service [USFWS] 2016). The remaining 45 turbines will be searched using a road and pad protocol out to a radius of 100 m from the base (“RP plots”). Searches will be conducted semi-weekly (2x per week) from April 1 to October 31 at all turbines.

In the second year of carcass monitoring the 4 large full plots will be replaced with regular full plots. Regular full plot sizes will be adjusted to be the lesser of either 60 m or the distance containing an estimated ≥80% of carcasses (based on results of the DWP calculations from the large full plots). Road and pad searches for year two will be consistent with those of year one. The search interval will remain 2x per week in year two. For Phase 2, carcass monitoring will remain consistent with the second year of Phase 1. Carcass searches will follow standard procedures as outlined below.

3.3.1 Permits and Wildlife Handling Procedures

Carcass searches will be conducted by trained personnel experienced in conducting fatality search methods, including proper handling and reporting of carcasses. Searchers will be able to accurately identify bat species likely to be found in the sites.

Any suspected gray bat or other ESA-listed bats discovered during fatality searches will be identified by a qualified USFWS-approved bat expert or sent to a USFWS-recommended genetic testing facility to verify the species for positive identification. The USFWS will be notified of the fatality within 48 hours.

Necessary wildlife salvage/collection permits will be obtained from the Missouri Department of Conservation and the USFWS to facilitate legal transport of injured animals and/or carcasses. If an injured bat is found, the animal will be sent to a local wildlife rehabilitator.

Bat carcasses found will be labeled with a unique number, individually bagged, and retained in a secure freezer at each site Operations and Maintenance (O&M) building. A copy of the original data sheet will accompany every carcass. Carcasses may be used in future searcher efficiency and carcass removal trials; however, house mice (*Mus musculus*) purchased through a commercial source may be used as a surrogate.

For all carcasses found, data recorded will include:

- Date and time;
- Initial species identification;
- Sex, age, and reproductive condition (when possible);
- Global Positioning System location;
- Distance and bearing to turbine;
- Substrate/ground cover condition(s);
- Condition (intact, scavenged);
- Notes on presumed cause of death; and
- Wind speeds and direction and general weather conditions for nights preceding search.

A digital photograph of a carcass will be taken before the carcass is handled and removed. As previously mentioned, all bat carcasses will be labeled with a unique identifier, bagged, and stored frozen as needed for future studies (with a copy of the original data sheet) at the site O&M building.

Bat carcasses found in non-search areas or outside standardized search periods will be coded as “incidental finds” and documented in a similar fashion to those found during standard searches. Operations personnel will be informed of the timing of standardized searches and will be trained on the collision event reporting protocol. Any carcasses found by operations personnel will also be considered incidental finds. Incidental finds will be included in survey summary totals but will not be included in the mortality estimates because the lack of standardized search effort and search area, as well as the lack of searcher efficiency and carcass removal trials. These limitations prohibit calculations to account for bias and extrapolate incidental carcasses found to estimated fatalities.

3.3.2 Searcher Efficiency and Carcass Removal Trials

Searcher efficiency (SE) and carcass removal (CR) trials will be used to estimate the number of bat fatalities that may be overlooked or removed by scavengers. Each monitoring period will include SE and CR trials in addition to the standardized carcass searches. All searchers will be tested, and the Applicant will make efforts for searcher consistency. Trials will be conducted during each season, defined as: spring (April 1 – May 31), summer (June 1 – August 31), and fall (September 1 – October 31) using either carcasses previously collected or a suitable surrogate carcass (e.g., house mice). The SE and CR rates are incorporated into the mortality estimator to provide a more accurate amount of take of gray bats for the sites. Species mortality estimators are highly sensitive to these factors (Huso et al. 2018).

These period trials attempt to capture seasonal changes in weather, scavenger abundance, searcher experience, etc. Trials will be limited to the maximum extent possible to avoid attracting scavengers to the sites. No more than two trial carcasses will be placed at each turbine. Every trial carcass will be discretely marked prior to placement and the date, species, turbine number, distance and direction from turbine will be recorded. Trials must be blind to provide accurate results. Carcasses will be left in place and the CR trial will begin and continue for 30 days. To the extent practicable, carcass condition will be monitored and recorded on the following days after placement: 1, 2, 3, 4, 5, 6, 7, 10, 14, 20, and 30, or until no longer detectable.

3.3.3 Bat Fatality Estimates

Results of the standardized fatality monitoring including carcass information, survey effort data, search area information, and results of bias trials will be processed using a common and accepted fatality estimator (e.g., GenEst [Dalthorp et al. 2018]). Fatality estimates will be calculated separately for subsets of turbines in each operational treatment and will incorporate site-specific results of SE and CR trials, the total number of carcasses found per turbine per treatment, search interval, and a density-weighted area correction factor (Huso 2010). Fatality estimates will be calculated for a common time period between the two sites to improve inter-site comparability. Bat fatality data will also be tabulated per turbine and per search interval for comparison with acoustic exposure at various scales. Given sufficient sample size we anticipate performing most analyses based on gray bat fatality rates. However, in the absence of sufficient sample sizes we will calculate fatality estimates for all bats. Should no gray bat carcasses be found, we will estimate the fatality rate that could have occurred given zero detections using the evidence of absence (EoA). Based on plausible assumptions of searcher efficiency (95% for roads and pads, 70% for cleared plots) and carcass persistence (3.5 days with removals following a Weibull distribution) and proportions of bat carcasses falling within searchable areas (23% for roads and pads, 80% for 60 m cleared plots and 99% for 100 m cleared plots) we estimate that the monitoring program would have an annual detection probability (“g-value”) of at least 0.2. Accordingly, this protocol would be highly likely to detect gray bat fatalities should fatality rates equal those assumed by the USFWS.

3.4 Curtailment Evaluations and Design

3.4.1 Turbine Operation Analysis

We will categorize 10-minute periods as meeting or not meeting the corresponding curtailment parameters specific to each treatment/turbine and use the 10-minute rpm to determine whether turbines were effectively curtailed (rpm < 1) when conditions were met. These evaluations will be compared against SCADA output or other event logs (where available) tracking periods where curtailment was triggered. Accordingly, we will generate an independent assessment of how closely turbine performance aligned with the parameters of an operational treatment. In other words, this analysis will compare actual turbine operation to how turbines should have performed under each curtailment strategy. This metric (defined as the proportion of 10-minute periods in which curtailment conditions were met and the turbine rpm was less than 1) will provide a quantitative indication of how effectively curtailment was implemented and will be used to fine-tune curtailment programs. This analysis will also provide the basis of comparing the actual amount of curtailment for each treatment and quantifying differences among the treatments.

3.4.2 Comparing Acoustic Exposure and Fatality Risk

Given adequate sample sizes, all analyses will be performed on gray bat data specifically. However, in the absence of sufficient sample sizes of carcasses or acoustic data, all bat activity and fatality rates will be used as a surrogate.

Timestamps of acoustic bat passes will be rounded to the nearest 10-minute interval and aligned with wind speed, temperature, and turbine rpm data recorded by the corresponding turbine in the same interval. We may use temperature data from onsite permanent met towers and/or apply correction factors to the nacelle-based measurements if advised to do so by operations staff. Using these data, Stantec will calculate for each turbine the proportion and number of bat passes exposed to turbine operation per sampled 10-minute period and summarize exposure per treatment as a mean among turbines and as an aggregate, pooling data among turbines. The difference in exposed bat activity between control and blanket curtailments, calculated after the first two field seasons, will establish the risk reduction per treatment and will be compared to corresponding reductions in fatality estimates.

We will evaluate the relationship between exposed bat activity and fatality at three scales including fatality rates estimated per operational treatment, carcass totals per turbine, and whether carcasses were found during individual turbine searches. At the site and treatment scale, we will compare fatality estimates per treatment to the number of exposed bat passes per 10-minute period, aggregating data among turbines within each treatment. For comparison, we will also test the relationship between total bat activity and bat fatality using similar methods. We will also compare the reduction in estimated bat fatality and the reduction in measured exposure of bat activity per treatment relative to the operational control. As above, we will compare models with and without site to evaluate whether the relationship between exposed activity and fatality varied among sites.

To compare fatality patterns and acoustic data at a finer spatial scale, we will compare the total number of bat carcasses found per turbine as a function of bat activity measured per turbine. Because the number of searches and search area affect the number of carcasses, we will include survey effort and search area as offsets or continuous variables in the model structure. Individual turbine searches represent bat fatality on a finer temporal as well as spatial scale. Because most turbine searches result in discovery of 1 or fewer bat carcasses, we will use logistic regression (generalized linear model assuming a binomial distribution) to test whether the amount of bat activity recorded during intervals between turbine searches explained variation in the binary probability of finding or not finding a fresh bat carcass during the subsequent turbine search. As for the treatment level, we will again run separate models for all bat activity and the subset of activity exposed to turbine operation and evaluate the significance of site for the per turbine and per search interval tests.

3.4.3 Curtailment Simulations and Optimization

After each year of the study, Stantec will load acoustic, wind speed, temperature, and rpm data from both sites into an interactive data visualizer built in the R software environment using R package *shiny* (Chang et al. 2020). See Figure 3-1 for a representation of the interactive data visualizer. This viewer enables the user to set parameters of a customized curtailment treatment such as cut-in speed and temperature threshold on a monthly basis and simulate the associated energy loss (MW hour/turbine/year and reduction in exposure of bat activity [%]).

After the second year of the study, Stantec will design an ABIC strategy for both sites that targets an equivalent level of risk reduction as achieved by the 5.0 m/s blanket strategy. This strategy will still rely on cut-in speed curtailment, but will presumably have different cut-in speeds assigned on a monthly basis, may include additional parameters such as temperature, and may have different start and end dates for curtailment, with the goal being to achieve equivalent risk reduction with less energy loss than the 5.0 m/s strategy. Stantec will work with operations staff for both sites to ensure the plausibility of smart curtailment strategies. This approach represents a manual optimization based on patterns of bat activity and fatality documented on site during the first two years of monitoring.

Stantec will use the data visualization tool to predict the proportion of exposed bat activity for control operation, blanket curtailment at 5.0 m/s, and the ABIC alternative for both sites based on results of the first and second year of monitoring. Predictions will be based on aggregated data from all available turbines. We will predict energy loss and exposure reduction by summing the potential energy generation and acoustic bat activity during intervals in which curtailment will be in place and comparing these to un-curtailed operation. We will use an empirical power curve derived from on-site data and/or a manufacturer's power curve to estimate lost energy potential.

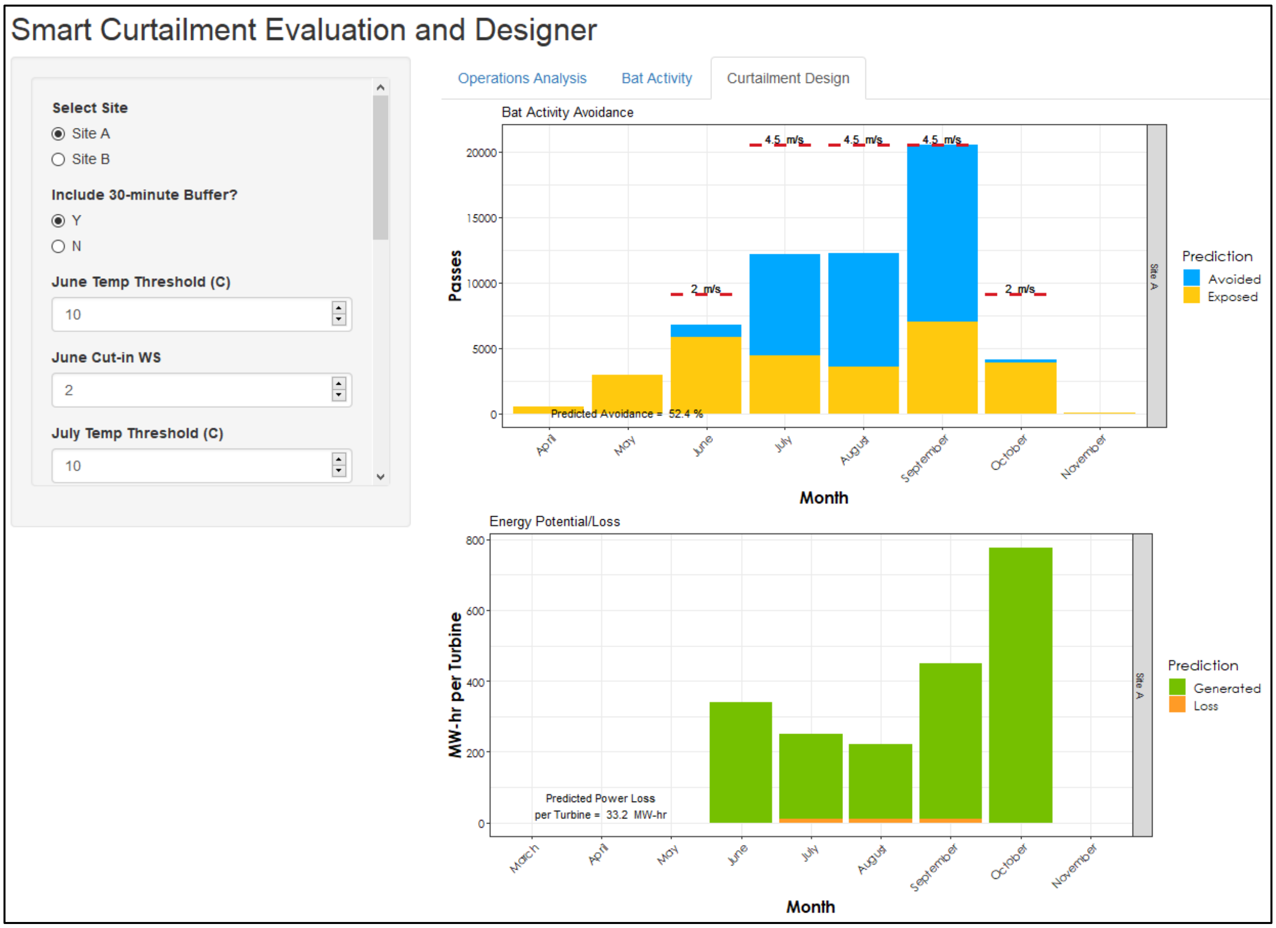

Figure 3-1. Screenshot of simulated data visualization tool used to predict monthly reductions in acoustic exposure and energy loss for ABIC alternatives.

3.4.4 ABIC and Blanket Curtailment Evaluation

The ABIC strategy will be implemented alongside the 5.0 m/s blanket strategy and operational control during Phase 2 at both sites, and continued acoustic monitoring and carcass monitoring will be used to calculate measured reductions in exposed activity, empirical fatality estimates, and energy loss per treatment. By comparing these results against predictions, we will explicitly test the predictions and evaluate how successfully each curtailment treatment prevented turbine operation during periods with bat activity. After the second year, the results of Phase 1 of monitoring will be aggregated within and among sites to account for project-specific interactions. Results will be analyzed to evaluate relationships between exposed bat activity and fatality and measure consistency of seasonal activity trends and the relationship between bat activity and conditions. Aggregation of annual data will occur again after the final year of data collection to demonstrate long-term consistency and predictability.

To compare effectiveness of blanket curtailment and ABIC strategies at reducing bat fatality, Stantec will analyze carcass counts per turbine by treatment group using statistical tests for central tendency (e.g., ANOVA with alpha 0.05). We will also compare exposed bat activity among treatments using general linear models (e.g., ANOVA) to determine whether exposure differed significantly among treatments at both sites, treating each turbine as an independent sample and including site and year as categorical factors. By design, the ABIC strategy should result in equivalent reductions in fatality and exposed bat activity as the 5.0 m/s blanket strategy compared to the control strategy.

3.5 Reporting and Timeline

The study will begin in early spring 2021 and will continue through late fall 2024. Throughout this period, Stantec will produce written updates to the USFWS on a quarterly basis and will prepare an interim technical report at the end of each field season, as outlined in Table 3-2. Interim technical reports will include detailed descriptions of survey methods and results and will include results of statistical tests with all data available at the end of each monitoring period. At the conclusion of the study, Stantec will prepare a comprehensive technical report summarizing the methods and results of the study, including supporting tables, figures, and statistical analyses. The intention will be for this study to lead to one or more technical manuscripts suitable for submission to peer-reviewed journals for publication.

3.6 Conservation and Protection Measures

The results of this study will be used, in part, to inform a Habitat Conservation Plan that minimizes and mitigates impacts to gray bats due to facility operations. The Applicant is developing a dedicated mitigation property to protect the future of the gray bat within the Study Area. The Applicant purchased the Buffalo Quarry in 2019 because the property is occupied by a large gray bat maternity colony and will make a suitable conservation bank. The purchase of the mine by the Applicant prohibits the opportunity of reopening this limestone quarry and potentially jeopardizing the gray bat colony.

Buffalo Quarry has been on the radar of the Service and Missouri Department of Conservation since 2013 due to the large population of gray bats. The site provides substantial conservation benefits to the local population of gray bats in Dallas County, Missouri and will continue to provide those benefits in perpetuity. In addition, the North American gray bat population will substantially benefit from the protection of this maternity colony, which will provide valuable maternity habitat, genetic diversity, and connectivity for continuing the persistence of the species.

The estimated population using Buffalo Quarry classifies it as a Priority 1 maternity colony for gray bats, which is a colony that includes greater than 10,000 bats. Annual gray bat maternity colony emergence counts will verify the number of credits that are available annually. Unlike mitigation provided by protection of a hibernaculum, almost 100% of the bats exiting the roost are expected to be reproductive adult females. During the two emergence counts performed in June and July 2019, the number of gray bats exiting the Buffalo Quarry mine were between 14,000 – 17,549 individuals.

The Applicant is working with the Service to develop a conservation banking instrument and a Habitat Mitigation Plan to protect the endangered bats at the Buffalo Quarry site. When finalized, the conservation bank will be used as part of a Habitat Conservation Plan to offset impacts associated with future operations at the facility. The conservation banking instrument will be under development during the time of this study and the maternity colony is currently under the protection of the Applicant.

Table 3-2 Study schedule, work breakdown structure, and milestones.

Phase	Timeframe	Milestones	Tasks	Turbine Treatments / Site	Post-construction Carcass Monitoring / Site
Phase 1 Planning	Quarter (Q) 1 2021	• Written work scope for both sites • Equipment selection and deployment design	Select Turbines for Treatments		

Phase 1
Year 1 Field Surveys
	Q2 2021	Quarterly field update	Initiate:
			• Acoustic monitoring
			• Carcass monitoring
			• Operational data monitoring
				(1) 5.0 m/s - 35 turbines
				(2) 3.0 m/s - 34 turbines (Control)
				
				Treatments will operate from April 1 – October 31, sunset to sunrise, during temperatures $\geq$10°C
					• 35% Full cleared plots (24 turbines)
					  • Full plots split between treatments
					  • 10 plots per treatment (20 per site) cleared and searched to 60 m radius
					  • 2 plots per treatment (4 per site) cleared and searched to 100 m radius
					• 65% Roads and pads searched to 100m from turbine (45 turbines)
					• Twice weekly search interval
					• Seasonal carcass and searcher efficiency trials

	Q3 2021	Quarterly field update	• Acoustic, carcass, and operational/weather data collection • Mid-season detector check		
	Q4 2021	Quarterly field update	• Acoustic, carcass, and operation/weather data collection • Demobilize acoustic equipment and offload data • Acoustic data analysis, year 1		
Phase 1 Year 1 Analysis/Reporting	Q1 2022	• Year 1 interim report deliverable • Revisions (if necessary) to work scope for Year 2 monitoring	Acoustic data QA/QC, statistical analysis, reporting		

Phase	Timeframe	Milestones	Tasks	Turbine Treatments / Site	Post-construction Carcass Monitoring / Site

Phase 1
Year 2 Field Surveys
	Q2 2022	Quarterly field update	Initiate:
			• Acoustic monitoring
			• Carcass monitoring
			• Operational data monitoring
				(1) 5.0 m/s - 35 turbines
				(2) 3.0 m/s - 34 turbines (Control)
				
				Treatments will operate from April 1 – October 31, sunset to sunrise, during temperatures ≥10°C
					• 35% Full cleared plots (24 turbines)
					  • Full plots split between treatments
					  • All plots per treatment cleared and searched to lesser of 60m or containing an estimated 80% of carcasses
					• 65% Roads and pads searched to 100m from turbine (45 turbines)
					• Twice weekly search interval
					• Seasonal carcass and searcher efficiency trials

	Q3 2022	Quarterly field update	• Acoustic, carcass, and operational/weather data collection • Mid-season detector check		
	Q4 2022	Quarterly field update	• Acoustic, carcass, and operation/weather data collection • Demobilize acoustic equipment and offload data • Acoustic data analysis, year 2		
Phase 1 Year 2 Analysis/Reporting	Q1 2023	• Year 2 interim report deliverable • Revisions (if necessary) to work scope for Year 3 monitoring	• Acoustic data QA/QC, statistical analysis, reporting • Smart curtailment design		

Phase	Timeframe	Milestones	Tasks	Turbine Treatments / Site	Post-construction Carcass Monitoring / Site

Phase 2
Year 3 and 4 Field Surveys
	Q2	Quarterly field update	Initiate:
			• Acoustic monitoring
			• Carcass monitoring
			• Operational data monitoring
				(1) ABIC - 23 turbines
				(2) 5.0 m/s - 23 turbines
				(3) 3.0 m/s - 23 turbines (Control)
				
				Treatments will operate from April 1 – October 31, sunset to sunrise, during temperatures $\geq$10°C
					• 35% Full cleared plots (24 turbines)
					  ◦ Full plots split between treatments
					  ◦ All plots per treatment cleared and searched to lesser of 60m or containing an estimated 80% of carcasses
					• 65% Roads and pads searched to 100m from turbine (45 turbines)
					• Twice weekly search interval
					• Seasonal carcass and searcher efficiency trials

	Q3	Quarterly field update	• Acoustic, carcass, and operational/weather data collection • Mid-season detector check		
	Q4	Quarterly field update	• Acoustic, carcass, and operation/weather data collection • Demobilize acoustic equipment and offload data • Acoustic data analysis for each year		
Phase 2 Year 3 and 4 Analysis/Reporting	Q1	• Year 3 interim report deliverable • Revisions (if necessary) to work scope for subsequent year monitoring	Acoustic data QA/QC, statistical analysis, reporting		
Year 5 Post Study	Q1 2025	Final report deliverable	Comprehensive summation of all years		

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