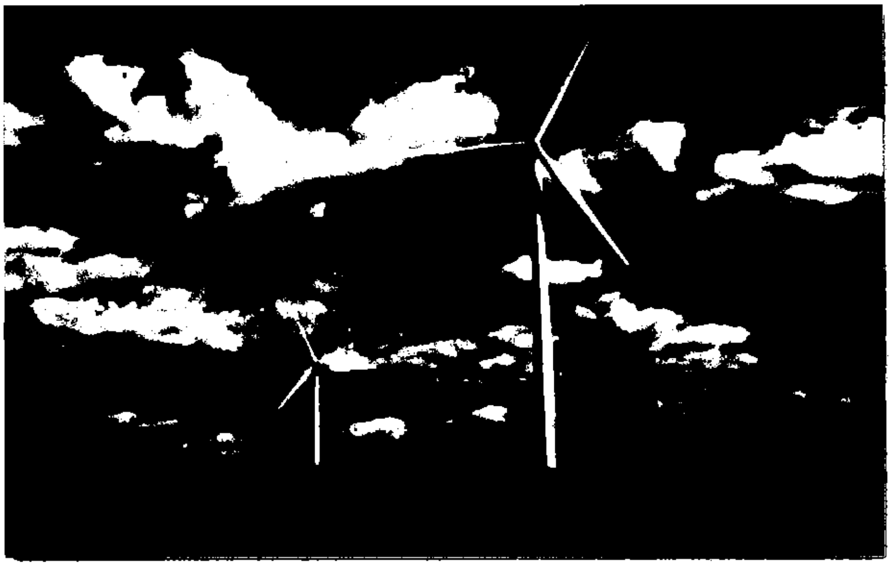
Study Plan for Post-construction Fatality Monitoring and Bat Acoustic Monitoring for the Colebrook Wind Resource Area, Litchfield County, Connecticut



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WEST Inc.

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1.0 INTRODUCTION

BNE Energy Inc (BNE) is proposing to develop the Colebrook North Wind Resource Area (CSWRA) in northeastern Litchfield County, Connecticut. The project is located at Winsted-Norfolk Road (Route 44) at the intersection of Rock Hall Road in Colebrook, CT and is comprised of three 1.6 megawatt (MW) GE wind turbines at 80 meter (m) hub heights and 82.5 m diameter rotor blades. (see Figure 1). BNE contracted Western EcoSystems Technology, Inc. (WEST) to develop protocols to estimate the impacts of the project on birds and bats. WEST has developed this protocol, based on experience studying the impacts of operational wind turbines on wildlife at projects located throughout the US and within the region (e.g. Chatfield et al 2010, Derby et al 2010, Erickson et al 2007, Gruver et al 2008, Tidhar et al 2010, Tidhar et al 2011, Young et al 2009), consistent with federal recommendations and draft guidance documents (USFWS 2011a and 2011c), and industry standards (Strickland et al 2011). Connecticut does not currently have guidelines for studying the impacts of wind energy projects on wildlife. However, the following study plan includes methods and metrics recommended by states with current guidelines, and also falls within the range of sampling intensity and study duration requested by states which have such guidelines (USFWS 2011b).

1.1 Objectives and Study Components

The objectives of the post-construction monitoring study would include:

1. To estimate the level of bird and bat mortality attributable to collisions with wind turbines on an annual basis at the site in comparison to other wind-energy facilities;
2. To provide a general understanding of the factors associated with the timing, extent, species composition, distribution, and location of the fatalities found; and
3. To examine the relationship between bat activity and bat fatalities observed at the project.

The post-construction monitoring study would be conducted over a three year period at the CSWRA, with all turbines included in the fatality monitoring study (see 1-4 below). The study would commence the first April following completion of all construction and reclamation activities. The study would include the following components:

1. Standardized carcass searches of turbines;
2. Searcher efficiency trials to determine the percentage of carcasses found by searchers;
3. Carcass removal trials to estimate the length of time that a carcass remained in the field for possible detection;
4. Adjusted fatality estimates for birds and bats based on the results of searcher efficiency trials and carcass removal trials to estimate bird and bat mortality within the facility; and
5. Acoustic bat surveys to determine the relationship between bat activity data and bat fatalities.

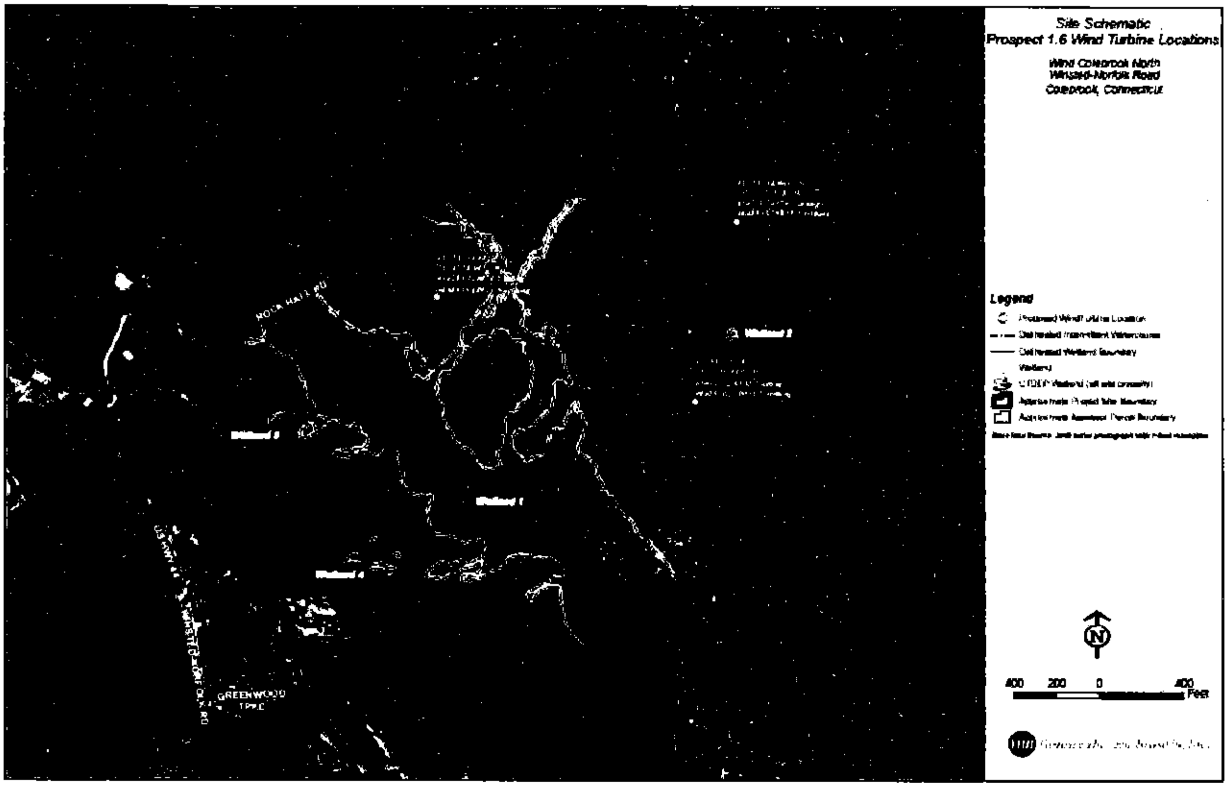

Figure 1. Map of the Colebrook North Wind project.

2.0 METHODS

2.1 Fatality Monitoring Study

Methods presented herein are currently assumed to be those most appropriate for the CSWRA, however, it is possible that advances in field or statistical methods may occur prior to initiation of the fatality monitoring study and that protocols would be recommended by WEST to be updated or modified prior to initiation of field studies.

2.1.1 Standardized Carcass Searches

Standardized carcass searches will be conducted on 100 % of Colebrook North turbines (three) at a weekly search interval between April 15 – October 31, and over a three year period. This will result in approximately 81 at Colebrook North turbine carcass searches over each annual 27 week study period. Based on observed carcass removal rates documented during fatality monitoring completed at the Lempster Wind Project located in Sullivan County, New Hampshire (Tidhar et al 2010 and 2011) and other regional wind projects, large variation in the probability of carcasses persisting between daily and weekly searches is not anticipated for the CSWRA. Therefore, it is assumed that weekly search intervals would result in robust estimates of bird and bat fatalities resulting from operation of the turbines. Carcass removal rates will be monitored throughout the study, and adjustments to search intervals may be necessary if carcasses are removed at a quicker rate than expected.

The size of search plots will be up to 123 m x 123 m around each turbine. The length of each side of the search plot is approximately 1.5 times the rotor blade length (82.5 m). Based on BNE design, areas cleared for turbine construction within the largely forested project areas will generally be smaller than 123 m x 123 m in order to minimize environmental impacts. However, the majority of bird, and particularly bat, carcasses located during fatality monitoring projects are located within close proximity to turbines (Strickland et al 2011, Tidhar et al 2010, Tidhar et al 2011). Consistent with other similar studies (e.g. Tidhar 2010, Strickland et al 2011), forest and shrublands will be excluded from search plots.

Casualties found during the study could be found either: 1) by searchers during scheduled searches; 2) by searchers outside of search plots or within search plots outside of scheduled searches; or 3) by facility personnel or others on site for other purposes, such as turbine maintenance. Search plots will be mowed on a regular basis in order to maximize the potential for searchers to detect carcasses, if vegetation growth is determined by the lead biologist to be impeding detection of carcasses. This vegetation management regime will be completed at search plots only after weekly carcass searches will be completed in order to minimize the potential for carcass destruction during mowing operations. All casualties found within a search plot during or outside of a scheduled search will be included in the overall fatality estimates. Casualties found within search plots outside of scheduled surveys will be included with the assumption that they would have been found during the next scheduled survey. Casualties found within outside of search plots or outside of the study period will be documented but not included in final fatality estimates.

All casualties found will be recorded using the methods described below. Cause of death will be determined, if possible, based on field inspection; however, due to the difficulty associated with obtaining accurate estimates of natural or reference mortality (Johnson et al. 2000), the assumption will be made that all casualties found are attributable to turbine collision or barotraumas (Baerwald et al 2008). This assumption likely leads to an over-estimation for bird and bat fatalities attributable to the facility.

Field technicians will be trained in proper search techniques prior to conducting the carcass searches. All casualties found, will be given a unique ID number, bagged, and frozen for future reference and possible genetic analysis. The following data will be collected: species, sex and age (when possible), date and time collected, Global Positioning System (GPS) coordinates, condition (see definitions below), and any comments that indicate possible cause of death. Photographs of the casualties will be taken *in situ,* in relation to the search turbine and other associated facilities (e.g., transmission lines or met tower). A copy of the data sheet for each carcass will be maintained, bagged, and frozen with the carcass at all times. Live birds and bats will be processed in the same manner as fatalities with the same data collected.

The condition of each carcass found will be recorded as:

a. *Intact* - a carcass that is completely intact, is not badly decomposed, and shows no sign of being scavenged;
b. *Scavenged* - a carcass that shows signs of being scavenged, a portion(s) of a carcass in one location (e.g., wings, skeletal remains, portion of a carcass, etc.), or a carcass that has been heavily infested by insects; or
c. *Feather spot* - ten or more feathers or two or more primary feathers in one location.

Casualties observed within search areas but outside of the standard search period, will be coded as incidental discoveries and will be documented in a similar fashion as those found during standard searches. Casualties observed in non-search areas (e.g., near a turbine not included in the search area), outside of the study period (during setup or decommissioning of the study), or found by maintenance personnel and others not conducting formal searches will be similarly documented but not included in calculations of fatality estimates (see Section 2.1.4).

2.1.2 Searcher Efficiency Trials

The objective of the searcher efficiency trials will be to estimate the percentage of casualties found by searchers. Searcher efficiency estimates will be made for all birds, small birds, large birds, and bats. Estimates of searcher efficiency are used to adjust the total number of casualties found by correcting for detection bias.

Searcher efficiency trials will be conducted within search plots throughout the study period. Trials will be considered blind, such that searchers will not know when they are being conducted or the location of the trial carcasses. Carcasses used will be non-native/non-protected or commercially available species such as house sparrows (*Passer domesticus*) or two-week old

Coturnix quail (*Coturnix coturnix*) for small birds and rock pigeons (*Columba livia*) or mallards (*Anas platyrhynchos*) for large birds. Non-Myotis bats found during the study will be used in addition to commercially available mice, which will be used as bat surrogates if insufficient quantities of bats are available for use in trials. Carcasses will be discreetly marked so that they may be identified as a trial carcass when found. Trial carcasses will be placed at random locations within search plots prior to scheduled carcass searches. Carcasses will be dropped from waist height and allowed to land in a natural manner to simulate a fall from collision with a turbine.

The number and location of the searcher efficiency carcasses found during the standardized carcass searches will be recorded. The number of carcasses available for detection during each trial will be determined immediately after the trial by the person responsible for distributing the carcasses. A carcass missed by the searcher but retrieved by the person conducting the trial, will be determined to be available but undetected. A carcass missed by the searcher and not subsequently found by the person conducting the trial will be determined to be unavailable.

The type and amount of ground cover under each selected turbine will be recorded periodically. Searcher efficiency estimates will be calculated based on the varying degrees of search difficulty for each carcass, as defined by ground cover types or visibility classes. Groundcover types/visibility classes will be defined as:

- *Easy* - e.g. >90% bare ground; sparse ground cover <6 inches tall;
- *Moderate* - e.g. >25% bare ground, ground cover <6 inches tall and mostly sparse);
- *Difficult* - e.g. <25% bare ground, < 25% ground cover is >12 inches tall;
- *Not searched* - Areas within the 115 m x 115 m plot that were not searched for safety reasons (e.g., steep rocky berms), vegetation that could not be mowed or managed to allow for efficient searching to take place (e.g., thick shrubs or forest patches), or waterbodies.

2.1.3 Carcass Removal Trials

The objective of carcass removal trials will be to estimate the length of time a carcass remains in the study area and is available for detection. Carcass removal estimates will be used to adjust the total number of carcasses found by correcting for removal bias.

Trials will be conducted throughout the study period to include varying weather, climatic conditions, and scavenger densities. Carcasses may become unavailable due to removal by scavengers or by other means. The species used in carcass removal trials will be similar to those used in searcher efficiency trials. Trial carcasses will be randomly placed within 123 m of turbines by dropping the carcass from waist height and allowing it to land in a natural manner to simulate a fall from collision with a turbine. Trial carcasses will be discreetly marked, for recognition by searchers and other personnel, and left in place until the end of the trial or at the time it is removed by scavengers. Carcasses will be checked daily for the first five days and then approximately every two days through Day 14, and every seventh day thereafter for a maximum of 28 days. The schedule may vary depending on weather and coordination with the other survey work. At the end of each trial any remains of the carcass will be removed.

2.1.4 Statistical Analysis

2.1.4.1 Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) measures will be implemented at all stages of the study, including in the field, during data entry and analysis, and during report writing. Following field surveys, observers will be responsible for inspecting data forms for completeness, accuracy, and legibility. A sample of records from an electronic database will be compared to the raw data forms and any errors detected will be corrected. Irregular codes or data suspected as questionable will be discussed with the observer and/or project manager. Errors, omissions, or problems identified in later stages of analysis will be traced back to the raw data forms, and appropriate changes in all steps made.

2.1.4.2 Data Compilation and Storage

A Microsoft® ACCESS database will be developed to store, organize, and retrieve data. Data will be keyed into the electronic database using a pre-defined format to facilitate subsequent QA/QC and data analysis. All data forms, field notebooks, and electronic data files will be retained for reference.

2.1.4.3 Statistical Methods for Fatality Estimates

Statistical methods for calculating bird and bat fatalities resulting from operation of wind turbines are evolving (Strickland et al 2011). Fatality estimates and 90% confidence intervals will be calculated for five categories: 1) all birds, 2) small birds, 3) large birds, 4) raptors, and 5) bats.

Estimates of facility-related fatalities will be based on:

1. Number of bird and bat casualties found during standardized carcasses searches during the annualized study period;
2. Searcher efficiency expressed as the proportion of trial carcasses found by searchers during searcher efficiency trials; and
3. Non-removal rates expressed as the average probability a carcass is expected to remain in the study area and be available for detection by the searchers during carcass removal trials.

2.1.4.3.1 Definition of Variables

The following variables are used in the equations below:

c_i the number of carcasses detected at plot i for the study period of interest (e.g., one monitoring year), for which the cause of death is either unknown or is attributed to the facility

n	the number of search plots
k	the number of turbines searched (including the turbines centered within each search plot)
$\bar{c}$	the average number of carcasses observed per turbine per monitoring period
s	the number of carcasses used in removal trials
s_c	the number of carcasses in removal trials that remain in the study area after 30 days
se	standard error (square of the sample variance of the mean)
t_i	the time (in days) a carcass remains in the study area before it is removed, as determined by the removal trials
$\bar{t}$	the average time (in days) a carcass remains in the study area before it is removed, as determined by the removal trials
d	the total number of carcasses placed in searcher efficiency trials
p	the estimated proportion of detectable carcasses found by searchers, as determined by the searcher efficiency trials
I	the average interval between standardized carcass searches, in days
A	proportion of the search area of a turbine actually searched
$\hat{\pi}$	the estimated probability that a carcass is both available to be found during a search and is found, as determined by the removal trials and the searcher efficiency trials
m	the estimated annual average number of fatalities per turbine per year, adjusted for removal and searcher efficiency bias

2.1.4.3.2 Observed Number of Carcasses

The average number of carcasses detected per turbine is:

$$\bar{c} = \frac{\sum_{i=1}^{k} c_i}{k}$$

where c_i is the number of carcasses detected at turbine i for the period of study, and k is the number of turbines searched.

2.1.4.3.3 Estimation of Searcher Efficiency

Searcher efficiency is expressed as p, the estimated proportion of trial carcasses found by searchers. The variance of the estimate, v(p), is calculated by the formula:

$$v(p) = \frac{p(1-p)}{d}$$

where d is the total number of carcasses placed. Carcass detection rates were estimated by visibility class, carcass size (birds only), and season. Data will be pooled across seasons if detection rates are not significantly different between seasons.

2.1.4.3.4 Estimation of Carcass Removal

Estimates of carcass removal are used to adjust carcass counts for removal bias. The length of time a carcass remains in the study area before it is removed is denoted as t_i. Mean carcass removal time is expressed as $\bar{t}$, the average length of time carcasses remain in the study area before it was removed:

$$\bar{t} = \frac{\sum_{i=1}^{s} t_i}{s}$$

where s is the number of carcasses used in the removal trials. Consideration will be made for modifying the estimator if there were a significant number of trial carcasses that remained at the end of the 28-day trial period. Mean carcass removal time will be calculated for each carcass size class (birds only) and season. Data will be pooled across seasons if removal rates are not significantly different between seasons.

2.1.4.3.5 Estimation of the Total Number of Facility-Related Fatalities

Assuming an equal sampling effort among turbines and seasons, equal observer detection and scavenging rates among seasons, the total number of facility-related fatalities (M) is calculated by dividing the observed fatality rate divided by $\hat{\pi}$, an estimate of the probability a casualty is not removed by a scavenger (or other means), and is detected:

$$M = \frac{N * \bar{c}}{\hat{\pi}}$$

where N is the total number of turbines in the wind farm and $\hat{\pi}$ is an estimate of the average probability of the carcass being available at a search (i.e., function of carcass removal) and detected (i.e., function of searcher efficiency).

Annual fatality estimates will be calculated for all birds combined, small birds, large birds, raptors, and bats. The final reported estimates of m and associated standard errors and 90% confidence intervals will be calculated using bootstrapping (Manly 1997). Bootstrapping is a computer simulation technique that is useful for calculating point estimates, variances, and confidence intervals for complicated test statistics. For each iteration of the bootstrap, the turbines and associated mortality data, searcher efficiency trial birds and associated data, and the scavenging removal trial birds and associated data are sampled with replacement. Estimates of $\bar{c}$, $\bar{t}$, p, and m are calculated for each 5,000 bootstrap samples. The final estimates of $\bar{c}$, $\bar{t}$, p, and m, and associated bootstrap percentile confidence intervals, are calculated from the 5,000 bootstrap estimates. Annual fatality estimates will be presented per turbine, per MW, and per rotor-swept area (RSA) equivalent to provide comparable results to other regional or national monitoring studies.

2.2 Acoustic Bat Surveys

Bat activity within the CSWRA will be monitored concurrently with the fatality monitoring study over a three year period between April 15 to October 31. Surveys will be completed using using Anabat™ SD-1 bat detectors (Titley Scientific™, Australia), which were used during pre-construction surveys (Tidhar and Gruver 2011).

Up to four Anabat™ detectors will be placed inside plastic weather-tight containers with an opening in the side through which the microphone extended at ground height. If possible, detectors would be placed a nacelle height, however, it is not currently known whether restrictions in turbine warranty or other manufacturer constraints may permit such a deployment. Microphones will be encased in poly-vinyl chloride (PVC) tubing that curve skyward at 45 degrees. To minimize potential for water damage due to rain, holes are drilled in the PVC. Detectors protected in this manner have been found to detect similar numbers and quality of bat calls as detectors exposed to the environment (Britzke et al. 2010). Ground-based containers are raised approximately one m off the ground to minimize echo interference from vegetation.

Anabat™ detectors record bat echolocation calls with a broadband microphone. Calls are recorded to a compact high-capacity flash memory card and data are subsequently transferred onto a computer for analysis. The echolocation sounds are then translated into frequencies audible to humans by dividing the frequencies by a predetermined ratio. A division ratio of 16 will be used for this study. Bat detectors also detect other ultrasonic sounds, such as those sounds made by insects, raindrops hitting vegetation; to reduce interference from these sources a sensitivity level of six was used. The detection range of Anabat™ units depends on factors such as call characteristics, microphone sensitivity, habitat, the orientation of the bat, and atmospheric conditions (Limpens and McCracken 2004), but is generally less than 30 m (98 ft) due to the effects of atmospheric absorption of echolocation pulses (Fenton 1991). To ensure similar detection ranges among detectors, microphone sensitivities will be calibrated using a BatChirp ultrasonic emitter (Tony Messina, Las Vegas, Nevada) as described in Larson and Hayes (2000). All units will be programmed to turn on each night approximately 30 minutes before sunset and turn off approximately 30 minutes after sunrise.

2.2.1 Statistical Analysis

The units of bat activity used for analysis are the number of bat passes per detector night (Hayes 1997). A bat pass is defined as a continuous series of two or more call notes produced by an individual bat with no pauses between call notes of more than one second (White and Gehrt 2001, Gannon et al. 2003). The terms bat pass and bat call are often used interchangeably. The number of bat passes will be determined by downloading the data files to a computer and tallying the number of echolocation passes recorded. Data files will be analyzed using Analook W v3.5r (2008, Chris Corben) and Analook DOS v4.9j (2004, Chris Corben) software. The Analook software displays bat calls (and extraneous noise) as a series of pixels on a time over frequency display. Analook provides a framework to build filters that constrain the values of certain call parameters. Pixels that fall outside the specified range of the filter parameters are ignored (e.g. pixels not following a smooth line, pixels below or above a specified frequency, etc.). A series of filters developed by WEST will be used to quickly and effectively separate out files that contained only noise, and to sort remaining files containing bat calls into frequency groups. Filtered files will be visually examined by an analyst to ensure accuracy. The total number of bat calls will then be corrected for effort by dividing the number of calls by the number of detector nights. One detector collecting data for one night is a detector-night. Data determined to be noise and calls that do not meet the pre-specified criteria to be termed a pass will be removed from further analysis. Bat activity is defined as the total number of bat passes per detector-night, and is used as an index representing bat use within CSWRA. Bat pass data represent levels of bat activity rather than the numbers of individuals present because individuals cannot be differentiated by their calls.

Anabat™ units have limited capabilities for identifying the bat species utilizing an area. Some bat species produce a call that has a very distinctive sonogram (shape on a frequency-time graph); however, there is much overlap between some species. For this reason, a conservative approach to species identification will be used. Calls will be sorted into two groups, based on their minimum frequency, that correspond roughly to species groups of interest. Most species of *Myotis* bats echolocate at frequencies above 40 kHz, species such as the eastern red bat (*Lasiurus borealis*) typically have echolocation calls that fall between 30-40 kHz, and species such as big brown (*Eptesicus fuscus*), silver-haired (*Lasionycteris noctivagans*), and hoary bat (*Lasiurus cinereus*), have echolocation calls that ≤25 kHz. Calls will be classified as high-frequency (HF; >30 kHz) or low-frequency (LF; <30 kHz). A list of species expected to occur in the study area was compiled from range maps (Table 1; Harvey et al. 1999, and CDEP 1999). Based on range maps, all species with the potential to occur at the CSWRA have been found as casualties at wind-energy facilities.

Table 1. Bat species with the potential to occur within the CSWRA. Data from Harvey et al. (1999) and the Connecticut Department of Environmental Protection (CDEP 1999).

Common Name	Scientific Name
High-Frequency (> 40 kHz)	
northern long-eared bat[2]	*Myotis septentrionalis*
Indiana bat[2]	*Myotis sodalis*
tri-colored bat[2]	*Perimyotis subflavus*
Mid-Frequency (30-40 kHz)	
eastern red bat[1,2]	*Lasiurus borealis*
little brown bat[2]	*Myotis lucifugus*
Low-Frequency (< 30 kHz)	
big brown bat[2]	*Eptesicus fuscus*
silver-haired bat[1,2]	*Lasionycteris noctivagans*
hoary bat[1,2]	*Lasiurus cinereus*

[1]long-distance migrant; [2]species known to have been killed at wind energy facilities

The study period will be divided into two seasons: Spring (April 15–July 15) and Fall (July 16–October 31). In addition, bat activity will be calculated for a so-called Fall Migration Period (July

30–October 14). This standardized period represents the time between dissolution of maternity colonies and onset of the swarming and hibernation seasons. During this period bats begin moving toward wintering areas and many species of bats initiate mating behaviors (Cryan 2008). This period of increased landscape-scale movement and mating behavior is often associated with increased levels of bat fatalities at operating wind-energy facilities (Arnett et al. 2008). The activity rate recorded during the Fall Migration Period serves as an index compiled by WERT for comparison with activity data from other wind energy facilities where similar, publically available, information has been collected.

The period of highest bat activity within CSWRA will be estimated by taking the maximum average bat activity rate for any consecutive seven day period, not restricted to a particular starting date. If two or more consecutive seven day periods have this maximum rate, the start date and end date for peak activity will be determined to be the start date of the first seven day period through the end date of the last seven day period.

2.3 Relationships between Bat Activity and Bat Fatalities

Associations between bat activity and fresh bat fatalities will be investigated using Pearson's correlation and multiple regression (Kutner et al. 2005). Since the data being evaluated are count data, a Poisson regression model will be adopted. Fresh bat casualties are defined as those carcasses estimated to have been killed within 24 hours of the time of detection. If low numbers of fresh bat casualties are detected during each annual study period, then data may be pooled from both years for the final third year report.

3.0 DISPOSITION OF DATA

Three annual reports will be prepared within 60-days of completion of annual study periods with the first report due one year after the commencement of operations. The annual reports will be filed with the Connecticut Siting Council and the Department of Energy and Environmental Protection. All necessary state and federal salvage permits would be acquired prior to commencement of fieldwork and permit reporting requirements would be met.

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