Appendix E
Alta East Golden Eagle Fatality Predictions
Western Ecosystems Technology, Inc.
Technical Memorandum

NATURAL RESOURCES ◆ SCIENTIFIC SOLUTIONS

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TECHNICAL MEMORANDUM

Golden Eagle Fatality Predictions and Resource Equivalency Analyses for the Proposed Alta East Wind Resource Area Kern County, California

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Submitted by:

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Introduction

From May 11, 2009 through June 1, 2011 Western EcoSystems Technology, Inc. (WEST) conducted baseline avian studies at the proposed Alta East Wind Resource Area (AEWRA) in Kern County, California. These surveys were designed to document avian use patterns, identify potential risk issues, and assist with siting turbines to minimize impacts to avian resources. Because use of the AEWRA and adjacent areas by golden eagles (*Aquila chrysaetos*) was documented, and golden eagle nests were located in the surrounding landscape WEST, was contracted to provide golden eagle fatality predictions using the current USFWS Bayesian Collision Risk Model (USFWS 2013) based on the two years of site-specific baseline avian use data collected at AEWRA. In addition, a resource equivalency analysis was performed to evaluate the number of power pole retrofits required to offset the estimated eagle fatalities due to the operation of the Alta East Wind Project.

Collision risk modeling attempts to estimate the number of annual golden eagle fatalities that might be expected at a proposed wind-energy facility from flight activity recorded during on site avian use surveys. Assuming that eagle mortality is proportional to pre-construction eagle activity a Bayesian correction factor has been established by the USFWS based on pre- and post-construction surveys conducted at four wind energy facilities. Bayesian analyses incorporate a prior belief (or best guess) about model parameters as supporting evidence in determining a posterior distribution of eagle exposure and mortality. In order to obtain an estimate of golden eagle fatalities at AEWRA using the USFWS methodology, the following information was used: 1) the level of golden eagle use observed during baseline avian use studies at AEWRA; 2) the quantity and rotor radius of the turbines proposed for use at AEWRA; and 3) the prior Bayesian collision correction factor as recommended by the USFWS (2013).

Site-Specific Avian Use Surveys

This golden eagle risk assessment is based on golden eagle observations collected from fixed point surveys of 800-m radius plots over two years. Surveys at each point consisted of 30-minute surveys, in which all eagle use was recorded. Eagles observed at any distance were recorded; however, only those observed within the 800-m radius plots are used in estimates of mean use and Bayesian fatality modeling.

Six points were selected across representative habitats and topography of the study area while providing relatively even visual coverage of the area proposed for development. Due to changes to land access and changes to the project boundary, points 2, 4, 5, and 6 were relocated for the second year of surveys to more accurately assess the area currently planned for wind turbine installation (Figure 1).

A total 285.5 hours of fixed-point surveys were conducted from May 11, 2009 through May 6, 2010 and from July 10, 2010 through June 1, 2011. Surveys were conducted approximately once per week during daylight hours, with varying start times approximately covering all daylight hours.

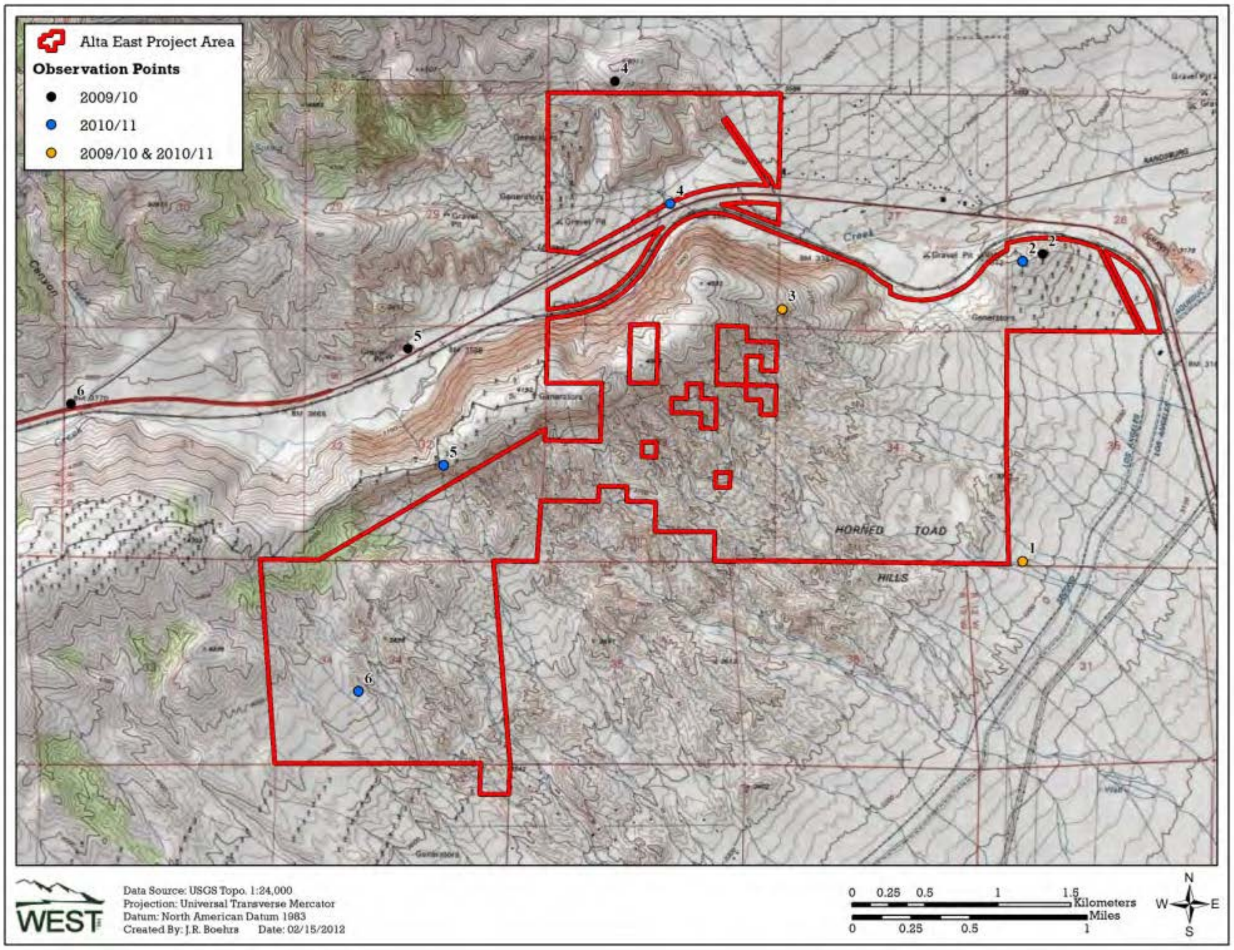

Figure 1. Locations of fixed-point bird use survey stations during 2009 through 2011 surveys conducted at Alta East Wind Resource Area

Exposure Rate Calculations

Exposure rate (λ), as defined by the USFWS (2013), is the expected number of flight minutes below 200 m per daylight hour across the surveyed area (km^2). A total of 17 golden eagle observations were recorded within fixed-point plots during 571 30-minute surveys for a total of 285.5 hours (Table 1). A $Gamma(\alpha = 0.97, \beta = 2.76)$ prior distribution with mean (0.352) and standard deviation (0.357) was recommended by the USFWS. A posterior distribution of golden eagle use at AEWRA was estimated as $Gamma$ distributions with parameters equal to the sum of the prior α and β with total flight minutes below 200 m and effort (hours of surveys x km^2 of area surveyed). This resulted in a posterior distribution for an exposure rate at AEWRA; G*amma*(17.97,576.79); mean 0.0312 eagle flight minutes observed per hour of survey in a single square km respectively (Table 1). Since total minutes in flight was not recorded for observations made during point-count surveys, one minute of flight was assigned to each eagle observation. This assumption is consistent with the current USFWS Eagle Conservation Plan Guidance Technical Appendices which state that most observations will likely equal one eagle-minute (USFWS 2013).

Table 1. Estimated Exposure Rate (λ) from golden eagle observations made during point-count surveys at Alta East Wind Resource Area during 2009 through 2011 studies.

Variable	Nordex N117/103 RD
1) Recorded Flight Minutes below 200	17
2) Number of Surveys	571
3) Length of Surveys	0.5
4) Survey Hours	285.5
5) Survey Radius (meters)	800
6) Eagle Flight Minutes (α: Line 1 + 0.97)	17.97
7) Effort (β; survey hours x sq km of area surveyed + 2.76)	576.7918
8) Mean Exposure Rate (Line 6 / Line 7)	0.0312

Expansion Factor

A facility-specific expansion factor is multiplied by the eagle exposure rate $\left(\frac{\text{eagle flight minutes}}{\text{hour}\cdot\text{km}^2}\right)$ to estimate the potential annual eagle-wind turbine interactions (minutes of flight within the turbine hazardous area). The expansion factor scales the exposure rate to daylight hours (τ) within a year across the total hazardous areas (δ_i) surrounding all proposed turbines (n_t; USFWS 2013).

$$\varepsilon = \tau \sum_{i=1}^{n_t} \delta_i$$

The USFWS has defined the turbine hazardous area (δ_i) as the rotor-swept area around each turbine or proposed turbine location (km^2; USFWS 2013). Expansion factors (ε) were calculated based on two proposed turbine layouts. The two layouts proposed consist of 51 and 106 turbine locations each using Nordex N117 - 2.4 MW with a rotor radius of 58.5 m, or alternatively a 103 RD with a rotor radius of 51.5 m (Table 2).

Table 2. Expansion Factor (ε) for the proposed turbine layout at the Alta East Wind Resource Area.

	51 Turbines		106 Turbines	
Variable	N117	103 RD	N117	103 RD
9) Hours per Year	4383	4383	4383	4383
10) Rotor Radius (meters)	58.5	51.5	58.5	51.5
11) Turbine Hazardous Area (pi × radius of turbine in km^2)	0.0108	0.0083	0.0108	0.0083
12) Number of Turbines	51	51	106	106
13) Expansion Factor (Line 9 x Line 11 x Line 12)	2403.274	1862.542	4995.040	3871.165

Collision Correction Factor

The collision correction factor (collision probability; C) was defined as the probability of a golden eagle colliding with a turbine given each minute of golden eagle flight in the turbine hazardous area. The prior distribution for collision probability was developed by the USFWS using the four previous fatality studies reported in Whitfield (2009). A weighted mean of the estimated flight minutes within the turbine hazardous area versus recorded collision events at those facilities was used to determine a $Beta(2.31, 396.69)$ prior distribution for collision probability with mean and standard deviation of 0.0058 and 0.0038 eagle fatalities per minute of flight in the turbine hazardous area, respectively (Table 3). No site specific information regarding collision probability is used at the time of pre-construction permitting. As post-construction monitoring is completed at AEWRA a posterior, site specific, estimate of collision probability can be estimated.

Table 3. Collision correction factor (*C*).

Variable	Value
14) Prior Fatalities	2.31
15) Prior exposure events not resulting in fatality	396.69
16) Prior mean collision correction factor (Line 14/(Line 14 + Line 15))	0.0058

Fatality Estimation

The USFWS Bayesian collision risk model assumes that higher site-specific eagle flight activity will correspond to higher annual eagle mortality once the wind energy facility is operational. Under this assumption, predictions of annual eagle mortality (F) were modeled as the pre-construction measure of eagle exposure (λ) within areas of potential eagle-wind turbine interactions (ε) multiplied by a collision correction factor(C):

$$F = \varepsilon \lambda C$$

Credible intervals (i.e., a Bayesian confidence interval) were calculated using a simulation of 1,000,000 Monte Carlo draws from the posterior distribution of eagle exposure (λ) and the collision probability distribution (C; Manly 1991). The product of each of these draws with the exposure area corresponding to Nordex 117 and 103 RD turbine models was used to estimate the distribution of possible fatality at AEWRA. The upper 80th percentile of this distribution has been recommended by the USWFS as the estimated take for a proposed project (USFWS 2013).

For the 51 turbine layout the predicted number of golden eagle fatalities per year using the USFWS Bayesian Collision Risk Model was 0.434 (upper 80th credible interval limit = 0.641) when modeling Nordex 117 and 0.336 (upper 80th credible interval limit = 0.496) for the 103 RD. For the 106 turbine layout, the predicted number of golden eagle fatalities per year using the USFWS Bayesian Collision Risk Model was 0.901 (upper 80th credible interval limit = 1.331) when modeling Nordex 117 and 0.698 (upper 80th credible interval limit = 1.031) for the 103 RD (Table 4).

Table 4. Eagle fatalities per year (F).

	51 Turbines		106 Turbines	
Variable	**N117**	**103 RD**	**N117**	**103 RD**
Estimated Annual Eagle Fatalities (Line 8 x Line 13 x Line 16)	0.4335	0.3359	0.9010	0.6982
Upper 80th Credible Interval Limit	0.6406	0.4956	1.3311	1.0306

Resource Equivalency Analysis

A resource equivalency analysis was performed to evaluate the number of power pole retrofits required to offset the estimated eagle fatalities due to the operation of the Alta East Wind Project. Based on proposed 51 turbine layout of the 103 RD to be used at the Alta East project site, the estimated golden eagle take was 0.3359 eagles per year, with an upper 80% credible interval limit of 0.4956 eagles per year (Table 4).

Using these take values, an eagle resource equivalency analysis was performed using the REA spreadsheet models provided by USFWS. The calculations assumed a 5-year permitted take, and power pole retrofits to be maintained for 10 years. Based on these assumptions, the total debt owed for the length of the 5-year permit was 21.21 bird-years in present value for the estimated mean annual rate, and 31.29 bird-years in present value (PV) for the upper 80% credible interval limit (Table 5).

Table 5. Debit summary: Total debit with foregone reproduction.

Lost Bird-Years: 1-Year Permitted Take of Golden Eagle		
Source of Bird-Years	**Estimated Mean Annual PV Bird-Years**	**80% Credible Interval PV Bird-Years**
Direct Loss:	2.03	2.99
Indirect Loss—1st Gen	1.60	2.36
Indirect Loss—2nd Gen	0.87	1.29
Subtotal Indirect Loss:	2.47	3.64
Total Debit (Direct+Indirect):	**4.50**	**6.63**
Total Debit: 5-year Permitted Take of Golden Eagle		
Year	**PV Bird-Years**	**PV Bird-Years**
2014	4.50	6.63
2015	4.37	6.44
2016	4.24	6.25
2017	4.11	6.07
2018	3.99	5.89
Total PV Bird-Years	**21.21**	**31.29**

Credits were also calculated using the USFWS REA spreadsheet models. According to this model, the total relative productivity of a retrofitted power pole over the 10-year maintenance cycle was 0.423 bird-years in present value (Table 6).

Table 6. Credit summary: Relative productivity.

Retrofitting Lethal Electric Poles for Avoided Loss of Golden Eagles	
Source of Bird-Years	**PV Bird-Years**
Avoided Direct Loss:	0.02
Avoided Indirect Loss—1st Gen	*0.02*
Avoided Indirect Loss—2nd Gen	*0.01*
Avoided Indirect Loss:	0.03
Total Credit (Direct + Indirect):	**0.05**
Relative Productivity With Foregone Reproduction	
Year	**PV Bird-Years/pole**
2014	0.048
2015	0.047
2016	0.045
2017	0.044
2018	0.043
2019	0.042
2020	0.040
2021	0.039
2022	0.038
2023	0.037
Total PV Bird-Years	**0.423**

Note: Assumes 10 years of avoided loss per retrofitted pole.

Once total debits and credits were calculated, total mitigation owed was also found using the USFWS REA spreadsheets. The total debit was divided by the total credit from one power pole retrofit to get the total number of poles to be retrofit to achieve no net loss of golden eagles. Based on the estimated mean annual rate, approximately 51 power poles would need to be retrofitted and maintained for 10 years to achieve no net loss of golden eagles for the 5-year permit cycle (Table 7). When the upper 80% credible interval limit was used, this number increased to approximately 74 power poles to be retrofitted.

Table 7. Mitigation owed with foregone reproduction.

Credit Owed for a 5-Year Permitted Take of Golden Eagle (assuming 10 years of avoided loss from retrofitted poles)			
	Estimated Mean Annual	**80% CI**	
Total Debit	21.21	31.29	PV bird-years
÷ Relative Productivity of Lethal Electric Pole Retrofitting	0.42	0.42	Avoided loss of PV bird-years/pole
= Credit owed	**50.09**	**73.91**	**Poles to be retrofitted to achieve no net loss of golden eagle**

Based on information from some utilities, effectiveness of retrofits are believed to last longer than the 10 years assumed in this model. Therefore, the credit owed in Table 7 would be conservative (too high) for retrofitted poles that last longer than 10 years. For example, if the retrofits are believed to last 30 years, or are kept or maintained for 30 years, the number of poles to be retrofitted would be 22 (estimated mean) to 33 (upper 80% credible interval limit) poles.

References

Manly, B.F.J. 1991. Randomization and Monte Carlo Methods in Biology. Chapman and Hall, London, United Kingdom.

US Fish and Wildlife Service (USFWS). 2013. Eagle Conservation Plan Guidance. Module 1 - Land-Based Wind Energy. Version 2. Division of Migratory Bird Management, USFWS. April 2013. Available online at: http://www.fws.gov/migratorybirds/Eagle_Conservation_Plan_Guidance-Module%201.pdf

Whitfield, DP. 2009. Collision Avoidance of Golden Eagles at Wind Farms under the 'Band' Collision Risk Model. Report from Natural Research to Scottish Natural Heritage. Natural Research Ltd, Banchory.