Assessment of Proposed Wind Turbine Sites to Minimize Raptor Collisions at the Sand Hill Wind Repowering Project in the Altamont Pass Wind Resource Area

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Executive Summary

The Sand Hill Wind Repowering Project (Sand Hill Project) is part of a regional wind turbine repowering effort in the Altamont Pass Wind Resource Area (APWRA) coordinated by Alameda County through the framework provided under the 2014 *Altamont Pass Wind Resource Area Repowering Final Program Environmental Impact Report* (PEIR). One of the mitigation measures required of repowering projects under the PEIR is Mitigation Measure BIO-11b: Site Turbines to Minimize Potential Mortality of Birds. To comply with BIO-11b, sPower, the applicant for the Sand Hill Project, following decommissioning and removal of the original old-generation turbines, has undertaken a turbine site assessment for the purpose of selecting a turbine layout for its new-generation turbines that reduces potential raptor mortality to the extent feasible.

The Sand Hill Project proposes 40 new turbines to replace 671 old-generation turbines and associated infrastructure. A total of 81 site locations were examined in order to determine the relative potential for collision risk of raptors among alternative site locations for each of the 40 turbines. Using topographic features and other potential risk factors, each site was assigned a risk rating. The rating was based on rationale that included the presence/absence of risky topographical features and other potential risk factors, wind patterns, and their relationship to raptor movement and behavior. Recommendations were made for each of the 40 turbines based on the relative risk of each alternative, including the recommended relocation of the alternative sites to further reduce potential collision mortality. Recommended locations are based entirely on raptor collision reduction and do not include other possible constraints, such as construction feasibility or wake effects from neighboring turbines.

Introduction

sPower is proposing to repower a wind energy project along the eastern edge of the Altamont Pass Wind Resource Area (APWRA). The Sand Hill Wind Repowering Project (Sand Hill Project) will repower an estimated 671 existing or previously existing wind turbine sites with up to 40 new turbines with a maximum production capacity of 144.5 megawatts (MW), using turbines rated between 2.3 and 4.0 MW per turbine, on fifteen nearly contiguous parcels extending over approximately 2,600 acres (Figure 1).

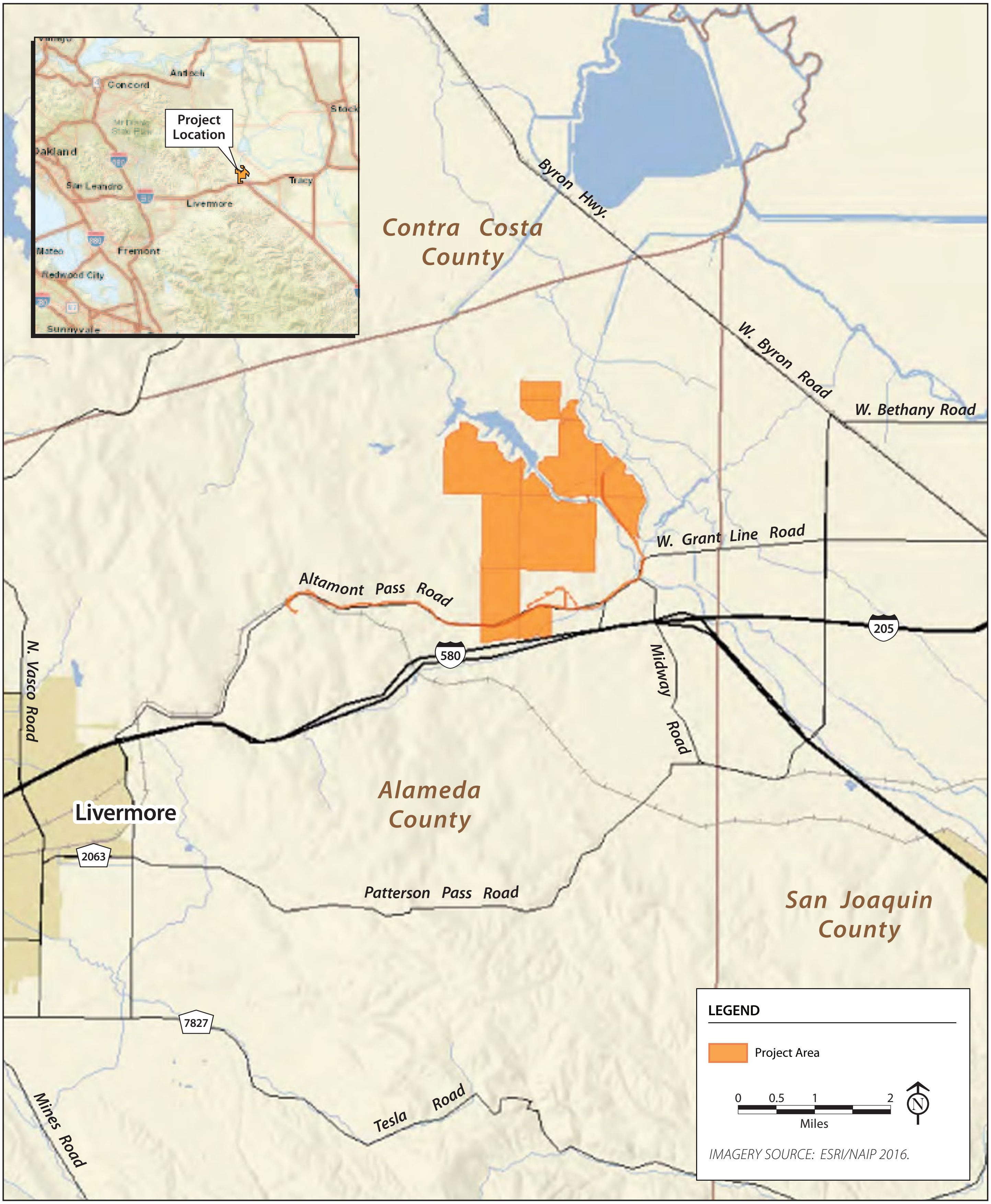
Repowering the APWRA

Wind energy development in the APWRA, an approximately 50,000□acre area extending across the northeastern hills of Alameda County and a small portion of Contra Costa County, began in the early 1980s with the counties issuing Conditional Use Permits (CUPs) for privately-owned wind facilities. Installed primarily on open rangeland, a generally compatible land use, by the mid-1990s there were more than 7,200 operating wind turbines in the APWRA. Most of these facilities consisted of densely-spaced small turbines (referred to hereafter as old-generation turbines) situated along rows (turbine strings) that usually corresponded with ridgelines or other topographical features that maximized energy production via the typical prevailing wind patterns in the APWRA.

By the late-1980s, evidence of avian mortality resulting from collision with wind turbines began to surface (Estep 1989, Howell and Didonato 1991, Orloff and Flannery 1992) resulting in ongoing coordination between energy companies, the counties, and state and federal resource agencies to explore the extent and magnitude of the issue, and facilitating a variety of research projects in an attempt to determine causal relationships (Tucker 1996, Orloff and Flannery 1996, Howell 1997, Kerlinger and Curry 1999, McIssaac 2000, Hodos et al. 2000). The primary avian focus was on raptor species, particularly golden eagles (*Aquila chrysaetos*) and red-tailed hawks (*Buteo jamaicensis*), the two species that, from results of monitoring, appeared to be among the most susceptible to collision mortality.

As monitoring and research efforts continued to expand but failed to provide meaningful results in terms of mortality reduction, wind turbine technology continued to advance. By the late 1990s, operators began to explore the potential for removing their old-generation turbines and replacing them with newer, higher capacity turbine models. New-generation turbines had substantially higher per turbine energy generation capacity, but were also significantly larger than their predecessors. They also required much more space between them, and thus with conversion to new-generation turbines, dense turbine strings, wind-walls, and other old-generation configurations would become obsolete, and fewer individual turbines would be required on the landscape in order to meet the permitted capacity.

The larger, new-generation turbines also seemed to be more compatible with the increasing body of data that suggested certain structural and operational characteristics of turbines contributed to



SOURCE: ICF 2018.

Figure 1
Location of the Sand Hill Wind Repowering Project

mortality (Orloff and Flannery 1996). The increased distance from rotors to the ground, the tubular towers lacking perch sites, the slower rpms and more visible rotation of the rotors, undergrounding of power lines, and other factors were considered positive developments that could potentially reduce fatality rates. While continued investigation has not been entirely conclusive regarding the benefits of some of these structural and operational factors, perhaps the most anticipated change was the density and configuration of turbines on the landscape. Careful siting of new-generation turbines that included an assessment of avian collision potential, was and continues to be considered the most effective means of reducing fatality rates of targeted raptor species (Alameda County 1998, Smallwood 2006, ICF 2014).

In the mid-1990s, Alameda and Contra Costa Counties began the process of developing a repowering program for a portion of the APWRA, culminating in the 1998 Alameda County Repowering EIR (Alameda County 1998), which included a Biological Resources Management Plan that included turbine siting recommendations to reduce avian mortality. However, as CUPs for projects initially permitted in the 1980s were nearing their end date, their renewal became the source of additional controversy ultimately resulting in a settlement agreement that, among other things, required a new programmatic EIR that addressed all future repowering in the APWRA.

In November 2014, the Alameda County Community Development Agency certified the *Altamont Pass Wind Resource Area Repowering Final Program Environmental Impact Report* (PEIR). The PEIR includes a detailed account of the history and legal activities culminating in preparation of the PEIR, and provides a framework for consideration of subsequent projects to remove the old generation turbines and related infrastructure and repower with new-generation turbines, provided they are consistent with the PEIR and would be developed to be consistent with the County's goals, objectives, and conditions.

The Sand Hill Project is planned within the framework of the PEIR. In 2018, an Environmental Analysis (ICF 2018) was prepared specifically to address the Sand Hill Project to validate the proposed project's conformance with the analysis and mitigation presented in the PEIR, and to ensure that the project is in compliance with the requirements of the California Environmental Quality Act (CEQA).

Purpose

With the approval of the PEIR, the County included several Conditions of Approval for the subsequent CUPs, including the formation of a technical advisory committee (TAC) to oversee implementation of specific mitigation measures in the EIR. Among these is BIO-11b*: Site Turbines to Minimize Potential Mortality of Birds*. As a result of ongoing coordination with the TAC, the micro-siting of wind turbine locations is being integrated into the turbine layouts of repowering projects in the APWRA, along with other physical and operational constraints, in order to further reduce the potential for raptor collisions.

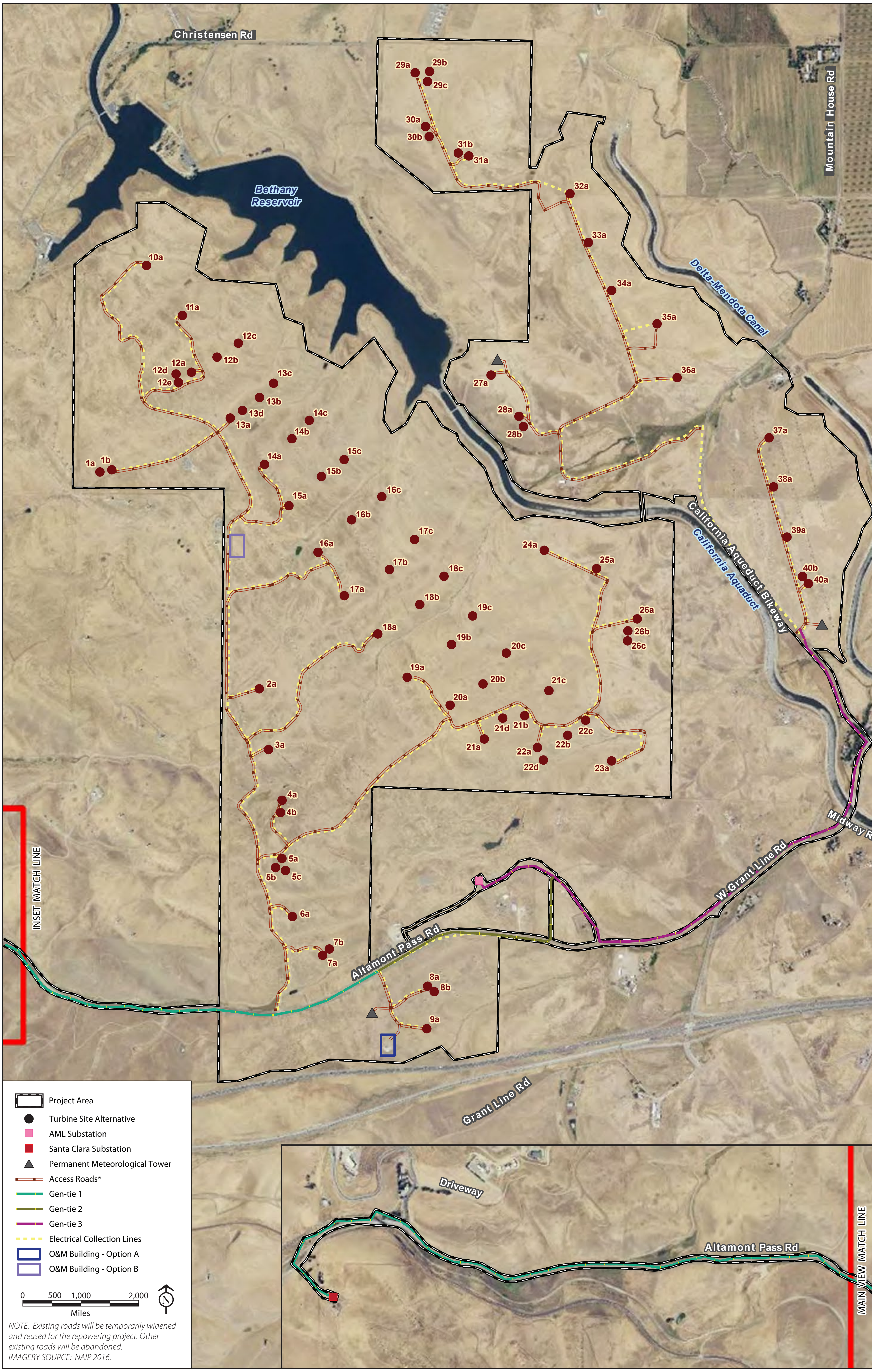
To ensure compliance with BIO-11b and to address the recommendations of the TAC, the Sand Hill Project has undertaken additional site review to micro-site each of their proposed turbine locations. A collision hazard model was initially used to evaluate proposed locations and recommend relocation sites as necessary (Smallwood and Neher 2018). However, due to concerns regarding the effectiveness of the model and the lack of clear rationale in the results and recommendations, sPower decided to conduct an additional siting assessment of the proposed project. The purpose of this report is to reexamine each of the proposed alternative turbine locations, provide a clearer and more rationalized baseline for recommendations, and use the Smallwood and Neher (2018) micro-siting model results to verify or, if appropriate, modify the results of this assessment.

Project Location

The Sand Hill Project area is located at the far eastern edge of the APWRA north of Interstate 580 along both the north and south sides of Altamont Pass Road, both the east and west sides of Mountain House Road north of West Grant Line Road, and on both sides of Bethany Reservoir and the California Aqueduct, west of the Delta-Mendota Canal (Figure 1).

Project Description

The Sand Hill Project includes removal of 671 old-generation turbines and related infrastructure, and the installation of up to 40 new wind turbines with generation capacities between 2.3 and 4.0 MW. Three conceptual alternative layouts were initially proposed, each using up to 40 wind turbines. The layouts were substantially similar, mainly varying according to the location of 11 turbines in the center of the project, south and west of Bethany Reservoir and their relative distance from the primary access road for the project. Turbine site locations were initially selected on the basis of meteorological monitoring of wind resources, wake effects, construction feasibility, and biological site constraints. Following the application of the Smallwood and Neher (2018) collision hazard model, a fourth conceptual alternative layout was proposed that incorporated some of their recommendations to reduce potential raptor mortality. Following the initial field assessment conducted for this report, a subsequent site visit was conducted by sPower engineers to review recommended turbine locations, which resulted in adding 5 additional alternatives. As a result, each of the 40 proposed turbines has between 1 and 5 alternative sites for a total of 81 potential turbine site locations (Figure 2). The final layout for up to 40 project turbines will be selected on the basis of site feasibility and constraints (including avian mortality considerations) and turbine availability. Existing roads would be used where possible, and temporary widening and some new roads would be necessary. The project would require the reconductoring/installation of generation-tie (gen-tie) lines connecting the project to two substations.



BASE MAP SOURCE: ICF 2013, sPower 2017.

Figure 2
Turbine Site Alternatives for the Sand Hill Wind Repowering Project

Approaches to Site Evaluation to Reduce Avian Mortality in the APWRA

Although structural and operational changes that result from the repowering of wind turbine facilities, and land management procedures that influence prey populations and distribution can potentially contribute to mortality reduction, probably most effective means of mortality reduction is through the careful siting of turbines at the onset of project design. The siting of wind turbines to reduce avian mortality, particularly raptor mortality, is thought to be primarily a function of topography and proximity to certain topographical features or other risk factors (e.g., high prey density) (Howell and Noone 1992; Orloff and Flannery 1992, 1996; Alameda County Community Development Agency 1997; Kerlinger and Curry 1999; Strickland et al. 2000, Thelander and Rugge 2001, Smallwood and Thelander 2004, Alameda County Scientific Review Committee 2010). This is particularly important in the APWRA, an area that supports abundant raptor nesting and wintering raptor populations and complex topography.

In general, these and other studies suggest that turbines sited along the edges of steep slopes, on downslope benches, within depressions such as swales, saddles, and notches, or along descending ridge slopes following a slope break, may contribute to increased raptor mortality. Flight patterns of many birds, particularly hunting raptors, use topographical features and corresponding wind patterns that help to conserve energy or aid in prey capture (Kerlinger and Curry 1999, Smallwood and Thelander 2004). Some raptors, including golden eagles, often fly along slope contours and rapidly cross over ridges or fly across slope benches where they may encounter wind turbines. Other species, particularly red-tailed hawks and American kestrels (*Falco sparverius*), often use slope-accelerated winds to hover or kite while hunting, requiring them to back up or rapidly turn and re-position along the ridgeline above the slope. Raptors also often use deep saddles or notches in ridges or descending slopes following a slope break to cross ridges. Using information about bird behavior and topography/wind patterns (and integration with other possible risk factors), it is possible to establish a general risk assessment approach to turbine siting. Recognition and avoidance of high-risk conditions could therefore potentially reduce raptor collisions with wind turbines within a wind energy project.

SRC Siting Guidelines and High-Risk Turbine Ranking Procedures

Using information initially described in earlier studies in the APWRA and the nearby Montezuma Hills Wind Resource Area (Howell and Noone 1992, Kerlinger and Curry 1999), the Alameda County Scientific Review Committee (SRC) developed a method to assign a numeric relative risk category to old-generation turbines in the APWRA (Smallwood and Estep 2010). The objective was to identify high risk turbines (HRTs) or turbine sites for removal or relocation for purposes of reducing the potential for collision-related mortality of raptors. The variables used in the assignment of a risk category included topographic and wind conditions and corresponding knowledge of raptor flight behavior, reported raptor fatalities, and to a lesser extent other risk factors such as proximity to perches, rock piles, and areas of high ground squirrel density.

The development of the hazard rating procedures then led to the development by the SRC of guidelines for siting wind turbines recommended for relocation (SRC 2010). The guidelines included examples of preferred and discouraged site conditions. Although initially developed as procedures for relocation of old generation turbines, elements of the guidelines that are related to topographical conditions are also applicable to turbine siting of new wind energy developments to reduce the potential for collision-related mortality of raptors.

Guidance elements (slightly modified to remove references to existing old-generation turbines) in the SRC guidelines that are related to topographic conditions and are applicable to the Sand Hill Project include:

Preferred Relocation Sites or Settings

- Hill peaks, ridge crests, and relatively even terrain

- Slopes that are leeward to one or two prevailing wind directions or that are set back from slopes facing prevailing wind directions

Discouraged Relocation Sites or Settings

- Saddles of ridges or saddles between ridges, and especially where saddles form the apex of ravines that face a prevailing wind direction or especially where these types of slope conditions occur in combination with nearby electric distribution lines or other tall structures;

- On benches of hill slopes or ridges, or just at the base of shoulders of hills, i.e., in locations of sudden elevation changes, where a raptor more often decides to fly while contouring around the slope;

- On or immediately adjacent to steep slopes;

- Next to artificial rock piles or natural rock formations;

- Next to streams or ponds;

- Next to transmission towers, electric distribution poles, or litter control fences;

- Where slope-accelerated winds would likely position a raptor at the height domain of the rotor plain of functional turbines, including where lips in the slope can locally accelerate winds used by hovering or kiting American kestrels;

Collision Hazard Model

A more recent effort has been undertaken in the APWRA to further refine the assessment and decision-making process for turbine siting (e.g., micro-siting) to reduce raptor collision potential through the application of a collision hazard model (Smallwood and Neher 2010a, 2010b, 2016, 2015, 2018). Smallwood and Neher (2018) incorporate three primary variables into their collision hazard model for the Sand Hill Project: fatality monitoring data, flight behavior data, and the topographic landscape using a digital elevation model (DEM) they developed for a large portion of the APWRA. By providing more precise information using field observation data (supplemented with some telemetry data for golden eagles) on bird flight patterns, a highly detailed DEM, and existing data on raptor collision-related fatalities within the project area, their objective was to provide greater certainty and more precise recommendations with regard to turbine siting. However, a review of Smallwood and Neher (2018), particularly the results and recommendations, suggest substantial uncertainty with regard to meeting this objective through application of the model. Although the continued refinement and development of the collision hazard model may be an important contribution to understanding collision risk in the APWRA and to aid in the micro-siting of turbines to reduce collision mortality, there are limitations in the current application of the model that potentially reduce its effectiveness and may restrict its utility.

The model is an interesting and data-rich attempt to characterize the relationship between site conditions and bird behavior for purposes of predicting and minimizing risk of collision events. The general approach makes sense, the model attributes are appropriate, and the outcomes may be reasonably accurate in the larger sense of identifying high risk sites. But it is unclear how the specificity of the model outcomes corresponds to higher certainty with regard to a potential reduction in fatalities of target species. This is particularly evident in the use of avian flight and behavior data, which is largely based on presumably inexact observational field mapping and its association with landforms – in contrast to the specificity of the digital elevation model. Also, attempting to precisely describe high risk conditions through a standardized modeling procedure may not be well-supported given the complexity and uncertainty of bird movements and continued lack of supporting data with regard to specific causes of collision events – particularly with new-generation turbines. Although certainly valid in a general sense, it’s unclear how the model outcomes result in small changes to turbine siting that would not be otherwise apparent during a field assessment.

The model also relies in part on fatality data that were collected primarily at old generation turbines. The purpose of the model is to identify high risk sites in order to minimize collision risk. Using past fatality data is appropriate insofar as those data may be associated with physical conditions that may contribute to fatalities and that are important in risk assessment. But there is no risk if there is no turbine; and similarly, if the turbine is substantially different in the repowered landscape, this should also influence risk and call into question the validity of using fatality data collected from old-generation turbines in the collision hazard model. What may be regarded as a high-risk site for old generation turbines may be less risky in a repowered landscape with fewer, larger turbines and with the vastly different structural and operational aspects between old- and new-generation turbines. Conversely, the repowered landscape in the APWRA may introduce new risks not yet fully explored through avian behavior and mortality monitoring studies.

Although the collision hazard model approach seems to include the necessary model attributes, to date there have been few opportunities to test its effectiveness. The model has been applied mainly to repowered projects in the APWRA where the entire turbine landscape has changed from old to new generation turbines. Variable success in reducing mortality has been reported at these projects (H.T. Harvey 2018), and reported reductions (Smallwood and Neher 2017) may have been largely a result of this change in the turbine landscape and not necessarily attributable to model-based micro-siting. To date, there is little evidence that would confirm the effectiveness of micro-siting of turbines in a repowered landscape due to application of the model.

Micro-siting and Bats

Many bat species are also susceptible to collision with wind turbines. Although there are data that indicate operational modifications (Arnett et al. 2010) and avoidance of bat roosts (e.g., caves, trees), habitats known to support greater concentrations of bats (e.g., riparian corridors, wetlands), or physical objects that attract large concentrations of insects (e.g., lights) (Johnston et al. 2013), may reduce potential bat mortality, there is little information that would suggest micro-siting of turbines in an otherwise monotypic landscape, even one with complex topography like the APWRA, would influence potential bat mortality. As a result, minimizing potential bat mortality has not been a focus of micro-siting efforts in the APWRA.

Methods

Using the approach described in the SRC turbine siting guidelines (SRC 2010), each of the 81 alternative turbine site locations were examined and each site was assigned a relative risk determination. This approach focuses primarily on topographic and wind conditions and proximity to other risk factors, and how these conditions influence raptor movement and behavior that may correspond with collision events.

Field Methods

I visited 76 of the alternative site locations (prior to the latest field assessment by sPower engineers, which resulted in 5 additional alternative locations) with sPower's Construction Director, Mike Goodwin, on December 10, 11, 12, and 13, 2018. Sites were accessed using existing roads originally constructed to access the previous old-generation turbine strings. Where roads were not available, I walked to the site. Each site was evaluated with regard to its specific location and the surrounding topographic and wind conditions that could influence raptor movements. Field data collected include:

- Percent Slope (using a hand-held slope meter)
- Position on Slope (ascending and descending distances)
- Slope face characteristics relative to prevailing winds
- Proximity to ridge or hill top
- Position on ridges and ridge slope characteristics
- Presence of or proximity to saddles, notches, and dips
- Presence of or proximity to swales, ravines, and canyons
- Presence of or proximity to slope breaks, slope shoulders, and slope benches
- Presence of other topographical features such as converging swales or ravines, convergence of descending ridges
- Visual assessment of ground squirrel activity
- Proximity to rock and debris piles
- Proximity to overhead distribution lines, transmission lines, meteorological towers, and fence lines
- Using onsite information from Mike Goodwin, a general assessment of the degree of difficulty for construction, the most likely road access, the need to construct new roads, and the extent of road improvements necessary to accommodate the new larger turbines.
- Assessment of the extent of disturbance to construct a new turbine pad and how this might alter the configuration of ridges or slopes (e.g., create berms or notches along ridgelines or create new benches on slopes) that would result in additional risk.

Data were recorded on a standardized field form and mapped on aerial photographs. GPS coordinates were taken to confirm field locations for sites that were not previously staked and a series of representative photographs taken of each site.

Assessment Methods

Each alternative site was plotted on Google Earth Pro (2018) to examine the overall relationship to the topographical landscape, and to verify topographical characteristics and recorded distances from the field survey. Each site was carefully examined to determine the presence of conditions that are thought to contribute to potential collision risk. A rating system was used to assign relative risk designations to each site. These include Very High Risk, High Risk, Moderate-High Risk, Moderate Risk, Moderate-Low Risk, and Low Risk. These generally correspond to the relative numerical relationships used in the SRC hazard rating system. The assignment of risk designations was based on the presence or absence of the risk factors noted above; however, it's important to note that these are relative designations based on an interpretation of conditions as well as the presence/absence of risk factors. They are based on our current understanding of conditions that lead to turbines and raptors interacting at the same location in space, and that as a result may contribute to higher rates of collision events. They do not otherwise indicate that a site *will* have more or less collision events than another, only that based on these factors, the *potential for* more or less collision events is assumed.

Each site was further examined for possibility of local relocation of the turbine site that would reduce potential mortality. A more suitable local location (in the immediate vicinity of the turbine site) was noted, if available. This determination was made solely on the potential reduction of raptor collisions and did not address other possible constraints, such as construction feasibility or wake effects (proximity of neighboring turbines). Finally, a recommended site was selected among the alternatives for each of the 40 proposed turbines. The recommended site would either be the original location of the selected turbine site or a new recommended alternative site selected to reduce potential mortality.
sPower engineers toured the project site on February 4 and 5, 2019 to conduct a feasibility review of the recommended relocation sites. During this review, they added five additional alternative turbine locations bringing the total number of alternative locations to 81. Assessment of these additional sites was limited to information recorded from the previous December 2018 surveys, and a desktop review using field maps and Google Earth Pro (2018).

Results

Physiographic and Land Use Characteristics

The Sand Hill Project area is located on the easternmost edge of the Diablo Range along the western edge of the Central Valley. The area is characterized by relatively low-profile foothills along primarily northeast-southwest-oriented ridges with a gradual northeastward descending slope and separated by low, narrow ravines and valleys (Plates 1 through 5). Elevation ranges between 146 and 582 feet above mean sea level. Predominate wind direction, particularly during the spring and summer months, is from the southwest between 230 and 250 degrees. The landscape is nearly all open grazed annual grassland devoid of trees or shrubs, even at the lower elevations along narrow stream corridors. There are stock ponds in several locations at the lower elevations and rock piles scattered throughout the area, created using rocks excavated during road and pad construction from the original wind facility.

Although all old-generation turbines had been removed at the time of the site assessment, concrete footings and foundations remain, along with several decommissioned meteorological towers and above-ground power lines that would be removed as part of the proposed project (Plates 6 and 7). Throughout much of the eastern half of the project area, there are large debris piles that resemble rock piles. They include parts of old-generation turbines that were placed during the decommissioning and removal activities of the previous project. There are also dirt and gravel roads throughout the project area, most of which were constructed to access the previous project. They have been maintained and will be used and expanded, in order to access new turbine sites and to accommodate the vehicles used to deliver and construct the new project turbines.

Plate 1. Typical low-profile rolling hills in the Sand Hill Project area.

Plate 2. Example of deep ravine separating complex ridges with intersecting swales in the Sand Hill Project area.

Plate 3. Looking north across three ridge complexes separated by deep ravines.

Plate 4. Looking east toward converging swales separating gradually northeastward- descending ridges.

Plate 5. Looking east along deep ravine between two northeast-southwest-oriented ridges.

Plate 6. Example of concrete footings remaining following removal of decommissioned old-generation turbine string.

Plate 7. Example of decommissioned above-ground distribution lines that would be removed as part of the project.

Turbine Site Assessment

Appendices A-1 through A-4 provide the detailed assessments of each of the 81 alternative turbine locations along with aerial figures depicting the topographical landscape and representative photographs of each site. Table 1 summarizes the relative risk determination for each alternative site and the recommended location for each of the 40 proposed turbines.

Of the 40 proposed turbines, 15 recommended locations corresponded with one of the alternative sites; 22 recommended locations involved a local movement between 50 and 450 feet from one of the alternative sites in order to reduce potential collision hazard; and no recommendation was made for 3 turbines due to the lack of potential local relocation sites to reduce risk.

Recommendations that differed from all proposed alternative locations focused primarily on moving turbines off of slopes, out of swales and ravines, and away from saddles and notches along ridges; and onto hill or ridge tops and generally flat terrain away from other risky topography including proximity to slope-accelerated winds and areas where the construction of turbine pads or roads would not substantially alter the local topography.

The risk determination and recommendations for most of the sites appeared to be generally consistent with those of Smallwood and Neher (2018), although their report lacked clear rationale or a clear relationship between the model results and determinations, particularly given the complexity of the model, and less specificity with regard to relocation recommendations compared with the approached used here.

Table 1. Risk Determination and Recommendations of 81 alternative locations for 40 Proposed Turbines at the Sand Hill Wind Turbine Repowering Project.

Turbine	Site	Layout	Lat-Long Location	Determination	Recommended Location
1	1A	1,2,3	37.766881 -121.620838	Low-Moderate	Move 60 feet north of 1B to 37.767137/121.619948
	1B	4	37.766987 -121.619905	Low-Moderate	
2	2A	1,2,3,4	37.756428 -121.611791	Low	2A
3	3A	1,2,3,4	37.753700 -121.611241	Low-Moderate	Move 105 feet S of 3A to 37.753410/121.611207
4	4A	1,2,3	37.751085 -121.610427	High	Move 225 feet south of 4B to 37.749771/121.610541
	4B	4	37.750390 -121.610606	High	
5	5A	1,2,3	37.748299 -121.610298	Low-Moderate	Move 80 feet NE of 5B to 37.748025/121.610605
	5B	4	37.747924 -121.610848	Low-Moderate	
	5C	*	37.747920 -121.610671	Low-Moderate	
6	6A	1,2,3,4	37.745524 -121.609612	Moderate	6A
7	7A	1,2,3	37.743691 -121.607773	Moderate	Move 200 feet north of 7B to 37.743994/121.608436
	7B	4	37.743809 -121.607766	Moderate	
8	8A	1,2,3	37.742245 -121.601399	Low	Move 50 feet north of 8A to 37.742348/121.601410
	8B	4	37.742196 -121.601355	Low	
9	9A	1,2,3,4	37.740209 -121.601426	Moderate	Move 280 feet NW of 9A to 37.740440/121.602393
10	10A	1,2,3,4	37.776682 -121.618918	Low-Moderate	10A
11	11A	1,2,3,4	37.774322 -121.616691	Moderate	11A
12	12A	1	37.771611 -121.616140	Low	12D or 12E
	12B	2	37.772313 -121.614515	Low-Moderate	
	12C	3	37.773011 -121.613275	Low-Moderate	
	12D	4	37.771552 -121.616471	Low	
	12E	*	37.771449 -121.616462	Low	
13	13A	1	37.769420 -121.613740	High	Move 50 feet NE of 13D to 37.769669/121.613260 or Move 400 feet NE of 13C to 37.771870/121.610223
	13B	2	37.770418 -121.611984	High	
	13C	3	37.771102 -121.611131	High	
	13D	4	37.769552 -121.613419	High	
14	14A	1,4	37.767233 -121.611658	High	14B
	14B	2	37.768456 -121.609954	Low-moderate	
	14C	3	37.769354 -121.608927	Moderate	
15	15A	1,4	37.765233 -121.610196	High	Move 450 feet NW of 14C to 37.768344/121.607787
	15B	2	37.766651 -121.608160	Moderate	
	15C	3	37.767490 -121.606771	Moderate	
16	16A	1,4	37.763048 -121.608364	High	Move 120 feet E-SE of 16B to 37.764529/121.605827
	16B	2	37.764591 -121.606280	High	
	16C	3	37.765724 -121.604522	High	
17	17A	1,4	37.760956 -121.606735	Moderate	Move 230 N of 17A to 37.761537/121.606710, or 250 feet N of 17C at 37.763914/121.603422
	17B	2	37.762212 -121.604009	Moderate-High	
	17C	3	37.763690 -121.602494	Moderate	
18	18A	1,4	37.759120 -121.604658	High	None
	18B	2	37.760568 -121.602133	Moderate-High	
	18C	3	37.761947 -121.600665	Moderate-High	

Turbine	Site	Layout	Lat-Long Location	Determination	Recommended Location
19	19A	1,4	37.757089 -121.602868	Moderate-High	Move 200 feet S of 19C to 37.759462/121.598870
	19B	2	37.758634 -121.600183	Moderate	
	19C	3	37.760052 -121.598919	Low-Moderate	
20	20A	1,4	37.755741 -121.600214	Low-Moderate	Move 80 feet NW of 20A to 37.755965/121.600147
	20B	2	37.756773 -121.598265	Moderate	
	20C	3	37.758270 -121.596852	Moderate	
21	21A	1	37.754149 -121.598156	High	21B or move 360 feet NW of 21A to 37.753741/121.599336
	21B	2	37.755291 -121.595705	Moderate	
	21C	3	37.756491 -121.594286	Moderate-High	
	21D	4	37.755007 -121.596789	High	
22	22A	1	37.753786 -121.594973	Moderate-High	22D
	22B	2	37.754368 -121.593100	Moderate-High	
	22C	3	37.755130 -121.592030	Moderate-High	
	22D	4	37.754559 -121.593301	Moderate	
23	23A	1,2,3,4	37.753183 -121.590455	Moderate-High	Move 100 feet S of 23A to 37.752922/121.590500
24	24A	1,2,3,5	37.763237 -121.594670	Low	Move 100 feet SW of 24A to 37.762950/121.595078
25	25A	1,2,3,4	37.762378 -121.591503	Moderate-High	None
26	26A	1,2,3	37.759991 -121.589009	Moderate	26B or 26C
	26B	4	37.759577 -121.589335	Low-Moderate	
	26C	*	37.759482 -121.589318	Low-Moderate	
27	27A	1,2,3,4	37.771656 -121.598003	High	Move 200 S to 37.771110/121.597990, or 275 feet N to 37.772408/121.597877
28	28A	1,2,3	37.769676 -121.596252	High	Move 150 NW of 28B to 37.770050/121.596461
	28B	4	37.769695 -121.596083	High	
29	29A	1,2,3	37.786059 -121.602772	High	Move 140 feet NE of 29B to 37.786169/121.601622
	29B	4	37.785991 -121.602065	Moderate	
	29C	*	37.785710 -121.601608	Low-Moderate	
30	30A	1,2,3,4	37.783533 -121.602121	High	None
	30B	*	37.783425 -121.602033	High	
31	31A	1,2,3	37.782111 -121.599506	Low	31B
	31B	4	37.782025 -121.599753	Low	
32	32A	1,2,3,4	37.780399 -121.593379	Low	32A
33	33A	1,2,3,4	37.778052 -121.592254	Low	33A
34	34A	1,2,3,4	37.775752 -121.590717	High	Move 350 feet E of 34A to 37.7758061/121.589371
35	35A	1,2,3,4	37.774158 -121.588029	Low	35A
36	36A	1,2,3,4	37.771605 -121.586734	Moderate	Move 200 feet NW of 36A to 37.771814/121.587380
37	37A	1,2,3,4	37.768762 -121.581157	High	Move 140 feet SW of 37A to 37.768403/121.580945
38	38A	1,2,3,4	37.766406 -121.580839	Low	38A

Turbine	Site	Layout	Lat-Long Location	Determination	Recommended Location
39	39A	1,2,3,4	37.764017 -121.580010	Low	39A
40	40A	1,2,3	37.761775 -121.578702	Moderate	Move 275 feet NW of 40B to 37.762312/121.579552
	40B	4	37.761784 -121.578822	Moderate	

*alternative to recommended site from February 4 - 5 site visit.

Conclusion

It's important to note that raptor collisions with wind turbines remain a rare event, and thus assessing predictability or assigning cause continues to be problematic. Where wind turbines share the same air space as birds in flight, collision incidents will likely always occur at some level despite our best mitigating efforts; and because the precise causal relationships that contribute to collision incidents remains uncertain, it remains possible that raptor collisions with wind turbines could in fact be more related to unpredictable behaviors that deviate from observed patterns. However, data derived from mortality monitoring surveys and field observation of flight patterns and behavior reveal possible relationships related to topography, wind patterns, land use, prey availability, and other structures on the landscape. These relationships can then be used to develop assessment approaches to aid in siting of turbines for purposes of reducing potential mortality. But the extent to which these approaches are effective remains unclear based on monitoring results of repowered projects in the APWRA. To date, there has been no way to reasonably differentiate the potential benefits of micro-siting new-generation turbines from the possibility that any reported changes in collision-related mortality are instead a function of the change from an old-generation to a new-generation turbine landscape. Identifying and avoiding high risk locations and relocating turbines to further minimize potential mortality based on current knowledge is certainly valid, but the effectiveness of these approaches may only be determined through ongoing monitoring of repowered projects.

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Appendix A-1. Assessment of Sand Hill Turbines 1 through 10

Included as separate document

Appendix A-2. Assessment of Sand Hill Turbines 11 through 20

Included as separate document

Appendix A-3. Assessment of Sand Hill Turbines 21 through 30

Included as separate document

Appendix A-4. Assessment of Sand Hill Turbines 31 through 40

Included as separate document