Appendix E-3

Attachments

Attachments

Attachment	Document	Description
Attachment 1	Summary of Micro Siting	Summarizes micro-siting recommendations and efforts at Sand Hill Project on a site-by-site, layout-by-layout basis. Update and clarifies Exhibit 1 to Sand Hill Micrositing Alternative Summary published with DSEIR.
Attachment 2	sPower Responses to California Office of the Attorney General: Smallwood and Estep Sand Hill Micro Siting Recommendations and Sand Hill Response: Pre-Micro Sited Layout Alternative (Proposed Layout 5)	Corrects document submitted by Attorney General to TAC on 19 September 2019 and as Exhibit A to Attorney General's comments on DSEIR. Provides key information not included in Attorney General document.
Attachment 3	Micro Siting Overview Tables	Offers two high-level overviews of micrositing outcomes at Sand Hill project.
Attachment 4	Siting and Wake-Related Constraints at Sand Hill	Provides additional information regarding setbacks and wake effect, which constrained micro-siting efforts at Sand Hill project.
Attachment 5	Old Generation Turbines at Sand Hill Project Site	Provides information regarding old generation turbines at project site requested by commenters.
Attachment 6	Figures: Old-Generation Turbine Overlays	Depicts locations of old-generation turbines at project site in comparison to proposed project layouts.
Attachment 7	Cumulative Fatality Rates	Estimates avian and bat cumulative fatalities.
Attachment 8	Figure: Bat Foraging and Roosting Habitat and Pre-Construction Survey Areas	Depicts bat foraging and roosting habitat, as well as recommended locations for preconstruction surveys, at project site.
Attachment 9	Bird and Bat Conservation Strategy for the Sand Hill Wind Repowering Project	Provides the combined equivalents of an Avian Protection Plan and a Bat Protection Plan, that would have been required after approval of the conditional use permit, and which were not expected to have been prepared in advance of such approval.

Attachment 1

Summary of Micro Siting

Key:
Followed full recommendation of Smallwood and Neher (2018) and/or Estep (2019)
Followed partial, modified, or secondary recommendation of Smallwood and Neher (2018) and/or Estep (2019)
Unable to follow expert recommendation

Turbine	Used in Micro-sited Layout Alternative?	Original Nameplate MW	Final Nameplate MW	Smallwood SRC-Style Hazard Rating	Smallwood Fuzzy Logic Rating	Smallwood Micro-siting Recommendation	Layout 4: Does Turbine Follow Smallwood Recommendation?	Estep Relative Risk Rating	Estep micro-siting Recommendation	Layout 5: Does Turbine Follow Estep Recommendation?	Has Risk Been Reduced?
SH01-1,2,3	No	GE 3.8	-	8.5	1	Maybe move ENE 60 m.	Yes. Moved 80m (260 ft) east to site 01-4. Modified Smallwood recommendation to avoid turbine blocking the Microwave Path WQQE305/WQQD503.	Low-Mod	Use modified site 01-4, which is slightly lower risk than this site.	Not using this site.	
SH01-4	No	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Low-Mod	Move at least 60 feet north, which moves turbine further from the upward slope to the south, centers it better within the broad valley, and moves it further from rock piles and overhead powerlines.	Yes. Moved 60 feet north in Layout 5.	
SH01-5	Yes	GE 3.8	GE 2.8					Low		Yes. Moved to this site in Layout 5 based on Estep recommendation.	Yes - sPower followed the micro-siting recommendation for this site. In addition, blade height above ground increased, and RSA and MWs reduced.
SH02-1,2,3, 4, 5	Yes	GE 2.3	GE 2.8	6	1	None. No concern with this site.	Using this site.	Low	Use this site.	Using this site.	Yes - sPower followed the micro-siting recommendation for this site. In addition, blade height above ground increased.
SH03-1, 2, 3, 4	No	GE 2.3	GE 2.8	6	1	None. No better options locally.	N/A	Low-Mod	Move approximately 105 feet south, further from the swale to the east to slightly reduce collision risk.	Yes. Moved 105 feet south.	
SH03-5	Yes	GE 2.3	GE 2.8					Low-Mod		Yes. Moved to this site in Layout 5 based on Estep recommendation.	Yes - sPower followed the micro-siting recommendation for this site. In addition, blade height above ground increased.
SH04-1,2,3	No	GE 2.3	-	10	3	Recommends avoiding this site.	Yes. Moved 80 m (260 ft) SW to move farther from ravine (farthest move possible due to wake) to Site 04-4. Move puts Turbine 4-4 only 2.2 RD from Turbine 5-4, thereby increasing wake-related losses.	High	None.	Not using this site.	

SH04-4, 5	Yes	GE 2.3	GE 2.8				Yes. Moved to this site (farther from ravine and closer to top of hill) in Layout 4 to avoid site Smallwood recommended avoiding.	High	Move approximately 225 feet due south of Site 04-4 to the top of the hill, and further off of northwest-facing slope edge.	No. Could not move further south due to wake effect. The suggested move would further increase wake and WSM losses by decreasing the separation between Turbines 4 and 5 from 2.2 RD to 1.6 RD. Turbine size slightly increased because smaller turbines required at other locations to meet setbacks and/or to reduce golden eagle risk.	Yes -sPower followed a modified Smallwood recommendation by moving this turbine away from site 4-1, 2, 3. Turbine blade height above ground also increased, a factor that tends to decrease mortality risk
SH05-1,2,3	No	GE 3.8	-	6	1	Shift SW to hill peak.	Yes. Moved 62 m (205 ft) SW to hill peak to Site 05-4.	Low-Mod	None.	Not using this site.	
SH05-4	No	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Low-Mod	Move approximately 80 feet northeast to keep the turbine further from the edge of slope.	Yes. Moved 53 feet east to back away from steep slope. Also reduced turbine size. Could not move north due to wake effect. Turbine 5-4 is approximately 2.2 RD from Turbine 4-4. The suggested move would further increase wake-related losses by decreasing the separation between Turbines 4 and 5 to 2.05 RD.	
SH05-5	Yes.	GE 3.8	GE 2.8					Low-Mod		Yes. Moved to this site in Layout 5 based on modified Estep recommendation.	Yes - sPower followed the micro siting recommendation for this site by moving to the Layout 4 location in response to Smallwood's recommendation, and further refining the final location by following a partial Estep recommendation. In addition, blade height above ground increased, and RSA and MWs reduced.
SH06-1,2,3,4,5	Yes	GE 3.8	GE 2.8	7	3	None. This site likely safest site on ridge.	Using this site.	Mod	No relocation recommended.	Using this site.	Yes - sPower followed the micro siting recommendation for this location. In addition, blade height above ground increased, and RSA and MWs reduced.
SH07-1,2,3	No	GE 3.8	-	6.5	1	Move to N ridge crest.	Yes. Moved 12 m (40 ft) N (farthest move possible due to wake) to Site 07-4.	Mod	None.	Not using this site.	
SH07-4,5	Yes	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Mod	Move approximately 200 feet northwest to the top of hill/ridge.	No. Could not move further due to wake effect. Suggested move would further increase wake and WSM losses by decreasing turbine separation between Turbines 06 and 07 from 2.0 RD to 1.6 RD.	Yes - sPower followed a partial micro siting recommendation by moving this site closer to the ridge crest in Layouts 4 and 5. In addition, blade height above ground increased, and RSA and MWs reduced.
SH08-1,2,3	No	GE 3.8	-	8	3	None. This site likely safest local option.	N/A	Low	Move 50 feet north to center on ridge top.	No. Unable to move this turbine north due to public road setback constraints. The county requires that turbines are sited a minimum of 1.25x TTH +- 1% TTH per 10ft above or below affected right-of-way. The recommended move would conflict with this requirement.	
SH08-4,5	Yes	GE 3.8	GE 2.8					Low	None. Use modified site 08-1.	Using this site.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH09-1,2,3,4,5	Yes	GE 3.8	GE 2.3	7	1	Shift west and uphill.	No. Turbine cannot be relocated west and uphill due to wake. Turbine 09 is 1.7 RD from Turbine 08. Suggested move would also affect Turbine 08 by placing Turbine 09 upstream of Turbine 08.	Mod	Move approximately 280 feet northwest to top of hill.	No. Suggested move would further increase wake-related losses by placing Turbine 9 in front of Turbine 8 more frequently, increasing losses at Turbine 8 to approximately 85%.	Yes - turbine could not be moved, but turbine blade height above ground increased, and RSA and MWs reduced.
SH10-1,2,3,4,5	Yes	GE 2.3	GE 2.8	7.5	1	None. Uncertain about likely impacts here.	Using this site.	Low-Mod	Use this site.	Using this site.	Yes - sPower followed the micro siting recommendation for this site. In addition, blade height above ground increased.

SH11-1,2,3,4,5	Yes	GE 3.8	GE 2.8	4	4	None. This site safest place in area.	Using this site.	Mod	Use this site.	Using this site.	Yes - sPower followed the micro siting recommendation for this site. In addition, blade height above ground increased, and RSA and MWs reduced.
SH12-1	No	GE 3.8	-	7	2	Move 25 m west.	Yes. Moved 25 m (82 ft) W, to site 12-4 in Layout 4.	Low	Use site 12-4.	Not using this site.	
SH12-2	No	GE 3.8	-	6	1	None. This site safest place in area.	N/A.	Low-Mod	Use site 12-4.	Not using this site.	
SH12-3	No	GE 3.8	-	6	1	None. This site safest place in area.	N/A	Low-Mod	Use site 12-4.	Not using this site.	
SH12-4	No	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Low	Use this site.	Yes. Following site visit, moved additional 37 feet south. Estep confirmed this location as safe as 12-4, and is also recommended site.	
SH12-5	Yes.	GE 3.8	GE 2.8					Low		Yes. Moved to this site in Layout 5, which Estep confirmed is as safe as 12-4, and is also recommended site.	Yes - sPower followed the micro siting recommendation for this location. In addition, blade height above ground increased, and RSA and MWs reduced.
SH13-1	No	GE 3.8	-	7	1	Move east to ridge crest.	Yes. Moved 30 m (100 ft) E to ridge crest to site 13-4.	High	Use modified site 13-4.	Not using this site	
SH13-2	No	GE 3.8	-	8	3	Use modified site 13 or 13-2.	N/A.	High	Use modified site 13-4.	Not using this site.	
SH13-3	No	GE 3.8	-	8.5	3	Move east to peak of hill.	Layout 4 does not use this site because site 13 microsited to reduce risk.	High	As alternative, move this turbine 400 ft NE to top of hill, but access problems would result.	Not using this site.	
SH13-4	No	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	High	Move 50 feet to top of hill.	Yes. Moved 50 feet to top of hill.	
SH13-5	Yes.	GE 3.8	GE 2.8					Mod-High		Yes. Moved to this site in Layout 5 in response to Estep recommendation.	Yes - sPower followed the micro siting recommendation for this location. In addition, turbine blade height above ground increased, and RSA and MWs reduced.
SH14-1,4	No	GE 3.8	GE 2.8	7.5	3	Use site 14-2.	No. Using site 14-2 would place Turbine 14 downstream of Turbines 13 and 15, further increasing wake losses. Sites 14-2 and 14-3 would also require lengthier access roads.	High	Move 130 feet north along ridge.	Yes. Moved 130 feet north, farther from the shoulder on the south. Although move likely to negatively impact wake, prioritized this move due to relatively high risk designation.	
SH14-2	No	GE 3.8	-	6.5	2	None.	No. Using this site would place Turbine 14 downstream of Turbines 13 and 15, further increasing wake losses. Sites 14-2 and 14-3 would also require lengthier access roads.	Low-Mod	Use this site.	No. Using this site would place Turbine 14 downstream of Turbines 13 and 15, further increasing wake losses. Sites 14-2 and 14-3 would also require lengthier access roads.	
SH14-3	No	GE 3.8	-	7	3	Use site 14-2.	No. Using site 14-2 would place Turbine 14 downstream of Turbines 13 and 15, further increasing wake losses. Sites 14-2 and 14-3 would also require lengthier access roads.	Mod	None.	Not using this site. This site has similar issues to site 14-2. Although turbines would be spaced farther apart, Turbine 14-3 would be downwind of Turbines 13 and 15 more frequently, further increasing wake losses.	
SH14-5	Yes.	GE 3.8	GE 2.8					Mod-High		Yes. Moved to this site in Layout 5 following the Estep recommendation for the Layout 4 site. Although move likely to negatively impact wake, prioritized this move due to relatively high risk designation.	Yes - sPower relocated this turbine per Estep's secondary recommendation. In addition, blade height above ground increased, and RSA and MWs reduced.
SH15-1,4	No.	GE 3.8	GE 2.8	6	2 (3)	Shift north 25 m.	No. Turbine could not be moved due to wake. Move would place Turbine 15 downstream of Turbines 14 and 16, increasing wake losses. Sites 15-2 and 15-3 also would require lengthier access roads.	High	Move 140 feet northwest to top of ridge.	Yes. Moved 140 feet northwest to top of ridge. Although move likely to negatively impact wake, prioritized this move due to high risk designation. Turbine 15 is now 2.0 RD from Turbine 14 and 2.9 RD from Turbine 16.	
SH15-2	No	GE 3.8	-	6.5	1	Use site 15-1.	Yes. Using site 15-1	Mod	Move 200 feet northwest to top of ridge.	Not using this site. Using this site would place turbine downstream of Turbines 14 and 16, further increasing wake losses.	

SH15-3	No	GE 3.8	-	6.5	2 (4)	Use site 15-1.	Yes. Using site 15-1	Mod	Move 450 feet northwest to top of hill. This is recommended site.	Not using this site, due to wake effect. Using this site would place this turbine downwind of Turbines 14 and 16 more frequently, further increasing wake losses.	
SH15-5	Yes.	GE 3.8	GE 2.8					Mod-High		Yes. Moved to this site in Layout 5 following the Estep recommendation for the Layout 4 site. Although move likely to negatively impact wake, prioritized this move due to high risk designation.	Yes - sPower relocated this turbine pursuant to Estep's secondary suggestion. In addition, blade height above ground increased, and RSA and MWs reduced.
SH16-1,4	No	GE 3.8	GE 2.8	7	3	Avoid leaving berm.	Yes. Using this site in Layout 4 because Smallwood recommends avoiding Layout 2 and 3 sites.	High	Move 90 feet east-southeast to top of hill.	Yes. Moved 90 feet east-southeast to top of hill. Although move likely to negatively impact wake, prioritized this move due to high risk designation. Turbine 16 is now 2.0 RD from nearest turbine.	
SH16-2	No	GE 3.8	-	7	2	Recommends avoiding this site.	N/A	High	Move 120 feet east-southeast to top of ridge. This is the recommended site.	Not using this site, due to wake effect. Estep's suggested relocation site would place Turbine 16 directly downwind of Turbines 15 and 17 more frequently, increasing wake losses.	
SH16-3	No	GE 3.8	-	8.5	1	Recommends avoiding this site	N/A	High	Limted opportunities to relocate. Would need to move at least 500-600 feet east-southeast.	Not using this site.	
SH16-5	Yes.	GE 3.8	GE 2.8					Mod-High		Yes. Moved to this site in Layout 5 following the Estep recommendation for the Layout 4 site. Although move likely to negatively impact wake, prioritized this move due to high risk designation.	Yes - sPower followed the micro siting recommendation for this location. In addition, turbine blade height above ground increased, and RSA and MWs reduced.
SH17-1,4,5	Yes	GE 3.8	GE 2.8	6	3	Move north to ridge crest	No. Turbine cannot be moved north to ridge crest due to wake. Using this site in Layout 4 because less risk than 17-2. Move would place Turbine 17 within 1.5 RD of Turbine 16.	Mod	Move 230 feet north to top of hill.	No. Could not move due to wake effect. Move would place Turbine 17 within 1.5 RD of Turbine 16.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH17-2	No	GE 3.8	-	8	1	None. Recommends avoiding this site	N/A.	Mod-High	None.	Not using this site.	
SH17-3	No	GE 3.8	-	7.5	1	Move north to ridge crest	N/A. Layout 4 uses Site 17-1.	Mod	Move 250 feet west-northwest to top of hill.	Not using this site. Using this site would place this turbine downwind of Turbines 16 and 18 more frequently, further increasing wake losses.	
SH18-1,4	No	GE 3.8	GE 2.8	7	3	This site best option on this ridge	Yes. Using this site in Layout 4 because less risk than 18-2 and 18-3.	High	Move 290 feet northeast to top of ridge.	Yes. Moved 290 feet northeast to top of ridge.	
SH18-2	No	GE 3.8	-	7	3 (4)	Use site 18-1	Yes.	Mod-High	Move 100 feet northeast.	Not using this site due to wake effect. This site would place Turbine 18 downwind of Turbines 17 and 19 more frequently, further increasing wake losses. It would also cause increased waking of Turbine 24 as it moves directly upstream closer to Turbine 24.	
SH18-3	No	GE 3.8	-	7	2 (4)	Use site 18-1	Yes.	Mod-High	None. May be safest site.	Not using this site due to wake effect. This site would be downwind of Turbines 17 and 19 more frequently, further increasing wake losses. In addition, this site would increase wake losses on Turbine 24 as the site is closer to Turbine 24 and directly upstream.	
SH18-5	Yes.	GE 3.8	GE 2.8					Mod-High		Yes. Moved to this site in Layout 5 following the Estep recommendation for the Layout 4 site.	Yes - sPower followed the micro siting recommendation for this location. In addition, turbine blade height above ground increased, and RSA and MWs reduced.
SH19-1,4, 5	Yes	GE 3.8	GE 2.3	6	4	Use this site (see below). Speculates that site might be safer 30 m south	Yes. Using this site. Cannot move turbine 30m south due to wake, as move would reduce the separation between Turbine 19 and 20 from 2.1 to 1.9 RD, further increasing wake-related losses.	Mod-High	None.	Using this site.	Yes - sPower followed the micro siting recommendation for this site by using Smallwood's preferred site. In addition, turbine blade height above ground increased, and RSA and MWs reduced.

SH19-2	No	GE 3.8	-	6	4	Use either site 19-1 or 19-3	Yes. Using site 19-1.	Mod	None.	Not using this site due to wake effect. This site creates similar issues as site 18-2.	
SH19-3	No	GE 3.8	-	5	2	None. This site safest local option except for burrowing owls.	N/A. Cannot use this site in Layout 4 due to wake effect.	Low-Mod	Move 200 feet south to top of hill.	No. Not using this site due to wake effect and additional ground disturbance that would have been required. Using this site would increase wake losses on Turbine 24, as the site is closer to Turbine 24 and directly upstream. Using this site would also increase wake losses on Turbine 25.	
SH20-1,4	No	GE 3.8	GE 2.8	8	3 (4)	Move N to crest	No. Turbine cannot be moved north to crest due to wake. Using this site in Layout 4 because less risk than 20-2 and 20-3.	Low-Mod	Move 80 feet north-northeast to highest point on ridge. This is the recommended location.	Yes. Moved 80 feet north-northeast to highest point on ridge.	
SH20-2	No	GE 3.8	-	9.5	1	None. Recommends avoiding this site.	Yes. Avoided this site.	Mod	Move 170 feet northwest to ridge top.	Not using this site.	
SH20-3	No	GE 3.8	-	8	3	None.	N/A.	Mod	None.	Not using this site.	
SH20-5	Yes.	GE 3.8	GE 2.8					Low		Yes. Moved to this site in Layout 5 following Estep's recommendation for the Layout 4 site.	Yes - sPower followed the micro siting recommendation for this site. In addition, blade height above ground increased, and RSA and MWs reduced.
SH21-1	No	GE 3.8	-	8	2	None. Recommends avoiding this site.	Yes. Moved 150 m NE, closer to 21-2 (farthest move possible due to wake), to site 21-4. This site is more compatible with SH22-4, as no turbine is being placed upstream of another. See below.	High	Move northwest 360 feet to top of hill.	Not using this site.	
SH21-2	No	GE 3.8	-	6	1	None. This site safest place in area.	N/A. Cannot use this site in Layout 4 due to wake effect. Using this site would reduce the separation between SH21 and SH22 from 2.4 RD to 1.8 RD, increasing wake-related losses.	Mod	Probably lowest risk site.	Not using this site, due to wake effect. Using this site would reduce the separation between SH21 and SH22 from 2.4 RD to 1.8 RD, increasing wake-related losses.	
SH21-3	No	GE 3.8	-	6	1	Use site 21-2.	N/A.	Mod-High	None.	Not using this site due to wake effect, as SH21-3 is directly upstream of SH26.	
SH21-4, 5	Yes	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on modified Smallwood recommendation.	High	None.	Using this site.	Yes - sPower partially implemented the micro siting recommendation by moving away from the Layout 1 site. In addition, blade height above ground increased, and RSA and MWs reduced.
SH22-1	No	GE 3.8	-	8.5	2	Move N away from canyon edge or use 22-2.	N/A. Layout 4 uses modified site 22-2.	Mod-High	As alternative, move 200 feet away from east-facing slope, but this would require substantial earth-moving	Not using this site.	
SH22-2	No	GE 3.8	-	7.5	2	Move N away from edge of deep ravine.	Yes. Site 22-2 has been relocated 25 m northwest away from edge of ravine, to site 22-4.	Mod-High	None.	Not using this site.	
SH22-3	No	GE 3.8	-	7.5	4	Use modified site 22-2.	N/A.	Mod-High	None.	Not using this site.	
SH22-4,5	Yes	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Mod	This is the recommended site.	Using this site.	Yes - sPower followed the micro-siting recommendation for this site. In addition, blade height above ground increased, and RSA and MWs reduced.
SH23-1,2,3,4,5	Yes	GE 2.3	GE 2.8	8	2 (3)	None. No safer local option.	Using this site.	Mod-High	Move 100 feet south to top of hill.	No. Could not move due to setback requirements. Turbine 23 just meets the county of Alameda required setback to parcels without an approved wind energy CUP of 1.25x the total tip height +- 1% TTH per 10ft above or below affected parcel. The recommended move would conflict with this requirement.	No - constrained by setback requirements, but blade height above ground increased.

SH24-1,2,3,4	No	GE 3.8	GE 2.8	6	2	None. No safer local option.	N/A	Low	Move at least 150 feet southwest closer to top of hill.	Yes. Moved 150 feet southwest closer to top of hill.	
SH24-5	Yes.	GE 3.8	GE 2.8					Low		Yes. Moved to this site in Layout 5 following Estep's recommendation for the Layout 4 site.	Yes - sPower followed the micro siting recommendation for this site. In addition, blade height above ground increased, and RSA and MWs reduced.
SH25-1,2,3,4,5	Yes	GE 3.8	GE 2.8	9	3	None. Recommends avoiding this site.	Using this site.	Mod-High	No recommendation.	N/A	Yes - turbine blade height increased, and RSA and MWs reduced.
SH26-1,2,3	No	GE 3.8	-	8	1	Move SW to crest or south to higher ground.	Yes. Moved 50 m SW to higher ground, to site 26-4.	Mod	Use modified site 26-4.	Not using this site.	
SH26-4	No	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Low-Mod	Use this site.	Following site visit, moved additional 33 feet south. Estep confirmed this location as safe as 26-4, and is also recommended site.	
SH26-5	Yes.	GE 3.8	GE 2.8					Low-Mod		Moved to this site in Layout 5 following a site visit. Estep confirmed this location as safe as 26-4, and is also recommended site.	Yes - sPower followed the micro siting recommendation for this site. In addition, blade height above ground increased, and RSA and MWs reduced.
SH27-1,2,3,4,5	Yes	GE 3.8	GE 2.8	8	-	Move north to hill peak.	No. The turbine could not be moved north because Turbine 27 is just south of the Bethany Reservoir and Alameda county requires a minimum setback to recreational areas of 1x TTH +- 1% TTH per 10ft above or below affected property. The recommended move would conflict with this requirement.	High	Move 200 feet south to top of hill, or 275 feet north to top of hill.	No. Could not move this turbine north due to setback requirements, and unable to move it south due to wake effect. Specifically, moving the turbine south as recommended would further reduce separation between Turbines 27 and 28 from 2.2 RD to 1.8 RD, increasing wake-related losses. The turbine could not be moved north because Turbine 27 is just south of the Bethany Reservoir and Alameda county requires a minimum setback to recreational areas of 1x TTH +- 1% TTH per 10ft above or below affected property. The recommended move would conflict with this requirement.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH28-1,2,3	No	GE 3.8	-	8	-	Move north to hill peak.	No. Cannot be moved due to wake.	High	Use modified site 28-4.	Not using this site.	
SH28-4,5	Yes	GE 3.8	GE 2.8					High	Move 150 feet toward top of hill.	No. Could not be moved due to wake effect. Suggested move would further reduce separation between Turbines 28 and 27 from 2.2 RD to 1.7 RD, increasing wake-related losses.	Yes-turbine blade height above ground increased, and RSA and MWs reduced.
SH29-1,2,3	No	GE 3.8	-	8	-	Move east to high ground.	Yes. Moved 60 m E to higher ground, to site 29-4.	High	Use modified site 29-4.	Not using this site.	
SH29-4	No.	GE 3.8	GE 2.3				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Mod-High	Move 140 feet east-northeast across road, where site would be considered low risk.	Yes. Moved 165 feet southeast, away from the edge of the swale. Original Estep recommendation could not be made because of setback requirements. Turbine 29 is just south of a parcel with no wind energy CUP. The county of Alameda requires that turbines are sited 1.25x TTH +- 1% TTH per 10ft above or below affected parcel. There is a steep drop off down to a fossil fuel plant at the boundary of the neighboring parcel. Turbine 29 was sited slightly farther south than would otherwise be necessary as a result. Estep confirmed that the modified location is only low-to-moderate risk.	

SH29-5	Yes	GE 3.8	GE 2.3					Low-Mod	Moved to this site in Layout 5 based on modified Estep recommendation.	Yes. Moved to this site in Layout 5 following a modified Estep recommendation for the Layout 4 site.	Yes -sPower followed the micro-siting recommendation for this site, relocating the turbine per Smallwood and further refining its location per a modified Estep recommendation. In addition, blade height above ground increased, and RSA and MWs reduced.
SH30-1,2,3,4	No	GE 3.8	GE 2.8	6	-	No better local options.	Yes, uses this site.	High	No initial recommendation.	Moved slightly based on field visit, and in order to accommodate site 29-4 move. Estep confirmed that new location a slight improvement.	
SH30-5	Yes	GE 3.8	GE 2.8				Yes, uses this site.	High		Moved slightly to this location based on field visit, and in order to accommodate site 29-4 move. Estep confirmed that new location a slight improvement.	Yes - sPower followed the micro siting recommendation for this site. In addition, blade height above ground increased, and RSA and MWs reduced.
SH31-1,2,3	No	GE 3.8	-	4	-	Avoid berm by moving west.	Yes. Moved 25 m W/SW to site 31-4.	Low	Use site 31-4.	Not using this site	
SH31-4,5	Yes	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Low	Use this site.	Using this site.	Yes - sPower followed the micro siting recommendation for this site. In addition, blade height above ground increased, and RSA and MWs reduced.
SH32-1,2,3,4,5	Yes	GE 3.8	GE 2.3	3	-	None. This site safest place in area.	Using this site.	Low	Use this site.	Using this site.	Yes - sPower followed the micro siting recommendation for this site. In addition, blade height above ground increased, and RSA and MWs reduced.
SH33-1,2,3,4,5	Yes	GE 3.8	GE 2.8	4	-	None. This site safest place in area.	Using this site.	Low	Use this site.	Using this site.	Yes - sPower followed the micro siting recommendation for this site. In addition, blade height above ground increased, and RSA and MWs reduced.
SH34-1,2,3,4,5	Yes	GE 3.8	GE 2.8	8	-	None. Recommends avoiding this site.	Using this site.	High	Move 350 feet east-southeast to hilltop.	No. Could not move due to setback. Turbine 34 is west of a parcel with no wind energy CUP. The county of Alameda requires that turbines are sited 1.25x TTH +- 1% TTH per 10ft above or below affected parcel. Turbine 34 is just outside this setback, therefore, the recommended move would conflict with this requirement.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH35-1,2,3,4,5	Yes	GE 3.8	GE 2.8	5	-	None. This site safest place in area.	Using this site.	Low	Use this site.	Using this site.	Yes - sPower followed the micro siting recommendation for this site. In addition, blade height above ground increased, and RSA and MWs reduced.
SH36-1,2,3,4,5	Yes	GE 3.8	GE 2.8	7	3	Move NNW away from canyon edge.	No. Cannot move due to wake. Suggested move would reduce the separation between SH36 and SH35 from 2.4 RD to 2.1 RD, further increasing already-high wake-related losses.	Mod	Move 200 feet northwest up slope.	No. Could not move due to wake effect. Suggested move would reduce the separation between SH36 and SH35 from 2.4 RD to 2.1 RD, further increasing already-high wake-related losses.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.

SH37-1,2,3,4,5	Yes	GE 3.8	GE 2.3	8	4	Move west to higher ground.	No. sPower was unable to move this turbine west due to transmission line setback constraints. The county requires that turbines are sited a minimum of 1x TTH +- 1% TTH per 10ft above or below affected conductor line at ground level. The recommended move would conflict with this requirement.	High	Move 140 feet south-southwest onto flat ground, or 300 feet west across access road.	No. sPower was unable to move this turbine west due to transmission line setback constraints. The county requires that turbines are sited a minimum of 1x TTH +- 1% TTH per 10ft above or below affected conductor line at ground level. The recommended move would conflict with this requirement. This turbine could not be moved S-SW due to wake. The suggested move would reduce the separation between Turbines 37 and 38 from 2.1 RD to 1.7 RD, further increasing wake-related losses.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH38-1,2,3,4,5	Yes	GE 3.8	GE 2.8	6	2	None. Safest place in area.	Using this site.	Low	Use this site.	Using this site.	Yes - sPower followed the micro siting recommendation for this site. In addition, blade height above ground increased, and RSA and MWs reduced.
SH39-1,2,3,4,5	Yes	GE 3.8	GE 2.8	6	2	None. Safest place in area.	Using this site.	Low	Use this site.	Using this site.	Yes - sPower followed the micro siting recommendation for this site. In addition, blade height above ground increased, and RSA and MWs reduced.
SH40-1,2,3	No	GE 3.8	-	7	1	None. No local option to recommend.	N/A	Mod	None.	Not using this site.	
SH40-4,5	Yes	GE 3.8	GE 2.8					Mod	Move northwest 275 feet where slope levels off.	No. Could not be moved due to wake effect. Suggested move would reduce separation between Turbines 40 and 39 from 2.1 RD to 1.5 RD, further increasing wake-related losses.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.

Attachment 2

sPower Responses to California Office of the Attorney General: Smallwood and Estep Sand Hill Micro Siting Recommendations and Sand Hill Response: Pre-Micro Sited Layout Alternative (Proposed Layout 5)

sPower has prepared the following responses to the Attorney General's micro siting comments on the Draft Subsequent Environmental Impact Report for the Sand Hill Wind Repowering Project, submitted to Alameda County on October 4, 2019. Except for footnotes, the column titled "Errors and Omissions in AG Summary," the "Very High Risk Turbine Sites" and "Turbine Sites Omitted from AG Summary" sections, and formatting inconsistencies, this document is a copy of the document entitled "Sand Hill Micro Siting Recommendations vs. Proposed Layout 5," as presented by Deputy Attorney General Tara Mueller to the TAC on 19 September 2019, as modified in Exhibit A to the Attorney General's comments submitted to the County on 4 October 2019. In addition, sPower has added highlighting for clarity. Cells highlighted in purple represent sites where the Layout 5 turbine follows the recommendation of Smallwood (2018) and/or Estep (2019). Cells highlighted in blue represent sites where the Layout 5 turbine follows a partial, modified or secondary recommendation from Estep and/or Smallwood.

As the corrected summary table indicates, sPower put considerable effort into careful micro siting, going above and beyond the County's PEIR by consulting two independent experts and incurring significant losses in production capacity to reduce collision risks. In doing so, sPower followed an expert recommendation and/or reduced turbine size at 98% of the Sand Hill project's proposed turbines. In sum, proposed Layout 5:

- Follows an expert recommendation for siting 24 turbines.
- Uses a partial, modified, or secondary expert recommendation to move an additional 5 turbines to safer locations.
- Reduces the turbine size for 10 locations[1] where sPower could not follow micro siting recommendations due to siting constraints such as County setbacks.

Green: expert recommended site to use or avoid
Red: Sand Hill proposed siting that differs from expert recommendations
Purple: Sand Hill proposed siting that complies with expert recommendations

Very High Risk Turbine Sites

Turbine Site No.	Micro Siting Rec.	Sand Hill Prop. Layout 5	Errors and Omissions in AG Summary
None	None	None	No turbine sites designated very high risk.

[1] Only one turbine out of 40 could not be modified due to siting constraints and increased in size in Layout 5.

High to Moderate-High Risk Turbine Sites[1]

Turbine Site No.[2]	Micro Siting Rec.[3]	Sand Hill Prop. Layout 5	Errors and Omissions in AG Summary
Site No. 4			
4A [High] (Lay. 1-3)	Reloc 225 ft south to top of hill	Not using this site	**AG misreads micro siting report.** Estep made no micrositing recommendation for this turbine site.
4B [High] (Layout 4)	Reloc 225 ft south to top of hill **[Smallwood rec avoiding this site]**	Turbine moved unspecified number of feet and increased in size from 2.3 MW to 2.8 MW	**AG misreads micro siting report and omits key information.** sPower followed a modified Smallwood recommendation by moving this turbine away from site 4-1, 2, 3. Smallwood did not recommend avoiding this site (4-4). Instead, Smallwood recommended avoiding Site 4-1, 2, 3, which sPower did (see preceding row) by relocating Turbine 4 80m (260 feet) SW in Layouts 4 and 5. This brought Turbine 4 within 2.2 rotor diameters ("RD") of Turbine 5, thereby increasing wake-related losses.[4]

[1]sPower note: the below relative risk designations noted by the AG appear to be exclusively by Jim Estep. As Estep explained in his report, these are *relative* risk designations and should not be taken out of context: "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." (Emphasis in original). Note that *no* site received a "very high" relative risk designation.

[2] sPower note: these relative risk designations noted by the AG appear to be by Estep exclusively. Additionally, where a turbine was moved in Layout 5, these relative risk designations may not apply to the final site location.

[3] sPower note: these recommendations noted by the AG appear to be by Estep unless expressly noted otherwise.

[4] sPower note: As wind passes through a wind turbine, it is both slowed down and disturbed, leaving behind a wake of slower-moving, more turbulent air.

Turbine Site No.[2]	**Micro Siting Rec.**[3]	**Sand Hill Prop. Layout 5**	**Errors and Omissions in AG Summary**
			Turbine size slightly increased because smaller turbines required at other locations to meet setbacks and/or to reduce golden eagle risk. Blade height above ground also increased, a factor that tends to decrease mortality risk. The turbine could not be moved 225 feet further south because it would have reduced separation between SH04 and SH05 from 2.2 rotor diameters to 1.6 rotor diameters.
Site No. 13			
13A [High] (Layout I)	Eliminate site	Not using this site	
13B [High] (Layout 2)	Eliminate site	Not using this site	
13C [High] (Layout 3)	Reloc. 400 ft NE to top of hill [2nd alt]	Not using this site	**AG misreads micro siting report and omits key information.** Estep did not describe the modified Site 13-3 location as the "2nd alt." Instead, Estep suggested the modified Site 13-3 location as "another alternative location for Turbine 13," but noted that access problems would result from using this site.
13D [High] (Layout 4)	Reloc. 50 ft to top of hill [1st rec alt]	Turbine moved per Estep and reduced in size from 3.8 MW to 2.8 MW	**AG misreads micro siting report and omits key information.** sPower followed the micro siting recommendation for this location. Estep

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Industry standards call for spacing turbines at least 10 rotor diameters (RD) apart front-to-back, and at least 3 RD shoulder-to-shoulder in order to avoid production losses (from slower moving air) and turbine damage (from turbulent air). Where these spacings cannot be achieved, turbines must be shut down during certain wind conditions, further diminishing productivity. In Layout 5, sPower spaced many turbines closer than 3 RD, despite incurring resulting production losses.

Turbine Site No.[2]	Micro Siting Rec.[3]	Sand Hill Prop. Layout 5	Errors and Omissions in AG Summary
			did not describe the modified site 13-4 location as a "1st rec alt," which would suggest that this site and the modified 13-3 site were equally preferred. To the contrary, Estep stated that moving the turbine 50 feet to the top of the hill "is the recommended location." sPower followed this recommendation. Estep confirmed that the micro-sited location is a relatively moderate-high risk site.
Site No. 16			
16A [High] (Lay. 1, 4)	Reloc. upslope 90 ft E-SE [Slight reduc./still a very risky site]	Turbine moved per Estep and reduced in size from 3.8 MW to 2.8 MW	**AG misreads micro siting report and omits key information.** sPower followed the micro siting recommendation for this location. Estep did not state that the modified 16-1, 4 site was "still a very risky site." Estep stated that "[p]otential risk can be slightly reduced at Site 16A by moving the turbine upslope to the top of the hill about 90 feet east-southeast . . . The site would still be on the edge of a deep ravine, a *potentially* risky site." (Emphasis added). The Layout 4 site was classified as relatively lower risk than 16-2 or 16-3 by Smallwood, and is the only Turbine 16 site Smallwood did not recommend avoiding. sPower additionally moved the turbine as recommended by Estep even though it is likely to increase wake

Turbine Site No.[2]	Micro Siting Rec.[3]	Sand Hill Prop. Layout 5	Errors and Omissions in AG Summary
			effects, as Turbine 16 is now only 2 RD from Turbine 17. Estep confirmed that the micro-sited location is a relatively moderate-high risk site.
16B [High] (Layout 2)	Reloc. upslope 120 ft E-SE **[Recom. Loc.]**	**Cannot use** site due to wake effect	**AG omits key information.** Smallwood recommended avoiding site 16-2. As such, it is not a "[Recom. Loc.]" Estep acknowledged that this relocation would only reduce potential risks "somewhat." Estep's suggested relocation site would place Turbine 16 directly downwind of Turbines 15 and 17 more frequently, increasing wake losses.
16C [High] (Layout 3)	Reloc. 500-600 feet E-SE to next ridge	Not using this site	**AG omits key information.** Smallwood recommended avoiding site 16-3. This should be reflected in the second column.
Site No. 18			
18A [High] (Lay. 1, 4)	Reloc. 290 ft NE to top of ridge [Only slight reduc. and may result in addl. risk]	Turbine moved per Estep and size reduced from 3.8 MW to 2.8 MW	**AG misreads micro siting report and omits key information.** Smallwood stated that this site (18-1,4) is the "[b]est option on this ridge." sPower further relocated this turbine per Estep's refinements. sPower therefore followed the micro siting recommendation for this location.

Turbine Site No.[2]	Micro Siting Rec.[3]	Sand Hill Prop. Layout 5	Errors and Omissions in AG Summary
			The columns to the left also misstate Estep's report. For this site, Estep stated that "placement of the turbine pad in [the modified location] may create a notch in the ridgeline, which would also create risk; however, it would be a somewhat safer location that the current site." Estep concluded that "[R]elocating the turbine to the ridgetop, while still at least a moderately risky location, is an improvement from its current location." sPower followed these recommendations in Layout 5.Estep confirmed that the micro-sited location is a relatively moderate-high risk site.
18B [Mod-High] (Lay. 2)	Reloc. l00 ft NE along ridgetop [Only slight reduc. and may result in addl. risk. **Recom. Loc.]**	**Not using** this site due to wake effect	**AG misreads micro siting report.** Estep did *not* select this site as the "recommended location." To the contrary, Estep did not select a recommended location for Turbine 18. As noted above, however, Estep did recommend relocating Site 18-1,4, which sPower did. Smallwood recommended using site 18-1, 4. In addition, this site would place Turbine 18 downwind of Turbines 17 and 19 more frequently, further increasing wake losses. It would also cause increased

Turbine Site No.[2]	Micro Siting Rec.[3]	Sand Hill Prop. Layout 5	Errors and Omissions in AG Summary
			waking of Turbine 24 as it moves directly upstream closer to Turbine 24.
18C [Mod-High] (Lay. 3)	No suitable reloc. site	Not using this site	**AG omits key information.** sPower is not using this site due to wake effect. This site would be downwind of Turbines 17 and 19 more frequently, further increasing wake losses. In addition, this site would increase wake losses on Turbine 24 as the site is closer to Turbine 24 and directly upstream.
Site No. 21			
21A [High] (Layout 1)	Reloc. 360 ft NW to top of hill	Not using this site	
21B [Mod] (Layout 2)	No suitable reloc site/lowest risk site of 4 **[Recom. Loc]**	**Not using** this site due to wake effect	
21C [Mod-High] (Lay. 3)	No suitable reloc. site	Not using this site	
21D [High] (Layout4)	**No suitable reloc. site**	Turbine size reduced from 3.8 MW to 2.8 MW	**AG omits key information.** sPower partially implemented the micro siting recommendation. Because Smallwood and Estep recommended using site 21-2 (i.e., 21B), sPower moved turbine 21-1 approx. 150m closer to site 21-2 in Layouts 4 and 5. This was as close to site 21-2 as Turbine 21 could be moved due to wake constraints imposed by Turbine 22, which was relocated per Smallwood's recommendation and is Estep's recommended site. Specifically, using

Turbine Site No.[2]	Micro Siting Rec.[3]	Sand Hill Prop. Layout 5	**Errors and Omissions in AG Summary**
			site 21-2 would further reduce the separation between Turbines 21 and 22 from 2.4 RD to 1.8 RD, increasing wake-related losses.
Site No. 27			
27A [High] (All Lay.)	Reloc. 200 ft S to top of hill [Alt: move 275 ft N to top of diff hill]	**Could not move** S due to setback reqmts and **could not move** N due to wake effect. Turbine size reduced from 3.8MW to 2.8 MW.	sPower was unable to move this turbine north due to setback requirements, and unable to move it south due to wake effect. Specifically, moving the turbine south as recommended would further reduce separation between Turbines 27 and 28 from 2.2 RD to 1.8 RD, increasing wake-related losses. The turbine could not be moved north because Turbine 27 is just south of the Bethany Reservoir and Alameda county requires a minimum setback to recreational areas of 1x TTH +- 1% TTH per 10ft above or below affected property. The recommended move would conflict with this requirement.
Site No. 28			
28A [High] (Lay. 1-3)	Reloc. 150 ft NW to top of hill	Not using this site	
28B [High] (Lay. 4)	Reloc. 150 NW to top of hill **[Recom. Loc.]**	**Could not move** due to wake effect. Turbine size reduced from 3.8 MW to 2.8 MW	Suggested move would further reduce separation between Turbines 28 and 27 from 2.2 RD to 1.7 RD, increasing wake-related losses.
Site No. 30			
30A [High] (Lay. 1-4)	**No suitable reloc. site**	Moved slightly based field visit. Estep conf slightly better loc. Turbine size reduced from 3.8 MW to	**AG's summary misleading and omits key information** sPower followed the micro siting

Turbine Site No.[2]	Micro Siting Rec.[3]	Sand Hill Prop. Layout 5	Errors and Omissions in AG Summary
		2.8 MW.	recommendation for this site. Text should not be highlighted in red in AG's summary. Estep did not initially give a recommendation for this site. Smallwood found that there were no safer local options, and did not rate this site as high risk. sPower nevertheless found a way to reduce risk by moving the turbine.
Site No. 34			
34A [High] (All Lay.)	Reloc. 350 ft E-SE to top of hill **[Smallwood rec avoiding site]**	**Could not move** due to setback reqmts. Turbine size reduced from 3.8 MW to 2.8 MW.	Turbine 34 is west of a parcel with no wind energy CUP. The county of Alameda requires that turbines are sited 1.25x TTH +- 1% TTH per 10ft above or below affected parcel. Turbine 34 is just outside this setback, therefore, the recommended move would conflict with this requirement.
Site No. 37			
37A [High] (All Lay.)	Reloc. 140 ft S-SW from swale to flat ground or 300 ft W towards road	**Could not move** due to wake effect. Turbine size reduced from 3.8 MW to 2.3 MW	sPower was unable to move this turbine west due to transmission line setback constraints. The county requires that turbines are sited a minimum of 1x TTH +- 1% TTH per 10ft above or below affected conductor line at ground level. The recommended move would conflict with this requirement. This turbine could not be moved S-SW due to wake. The suggested move would reduce the separation between Turbines 37 and 38 from 2.1 RD to 1.7 RD, further increasing wake-related losses.

Moderate to Moderate-High Risk Turbine Sites[5]

Turbine Site No.[6]	**Micro Siting Rec.**[7]	**Sand Hill Prop. Layout 5**	**Errors and Omissions in AG Summary**
Site No. 14			
14A [High] (Lay. l, 4)	Reloc 130 ft N on ridge [Does not reduce risk from slope accelerated winds]	Turbine moved per Estep and reduced in size from 3.8 MW to 2.8 MW	**AG omits key information.** sPower relocated this turbine per Estep's secondary recommendation. Although likely to negatively impact wake, sPower prioritized this move in Layout 5 due to the Layout 4 site's relatively high risk designation. Estep confirmed that the micro-sited location is a relatively moderate-high risk site.
14B [Low-Mod] (Lay. 2)	**Recom. Loc.**	**Cannot use** site due to wake effect	Using this site would place Turbine 14 downstream of Turbines 13 and 15, further increasing wake losses. Sites 14-2 and 14-3 would also require lengthier access roads.
14C [Mod] (Layout 3)	No recom	Not using this site	This site has similar issues to site 14-2. Although turbines would be spaced farther apart, Turbine 14-3 would be downwind of Turbines 13 and 15 more frequently, further increasing wake losses.
Site No. 15			
15A [High] (Lay. l, 4)	Reloc 140 ft NW to top of ridge [Does not reduce risk from slope accelerated winds]	Turbine moved per Estep and reduced in size from 3.8 MW to 2.8 MW	**AG misreads micro siting report and omits key information.** sPower relocated this turbine pursuant to

[5] sPower note: the below relative risk designations appear to be exclusively by Jim Estep. See note 2, above.
[6] sPower note: where turbine was moved in Layout 5, these relative risk designations may not apply to final site location.
[7] sPower note: these recommendations appear to be by Estep unless expressly noted otherwise.

Turbine Site No.[6]	Micro Siting Rec.[7]	Sand Hill Prop. Layout 5	**Errors and Omissions in AG Summary**
			Estep's secondary suggestion.[8] Estep did not state that relocating the site 15-1, 4 turbine per his recommendation would "not reduce risk from slope accelerated winds." To the contrary, Estep opined that "[a]lthough still subject to slope-accelerated winds, risk at Site 15A may be reduced by moving the turbine upslope about 140 feet northwest to the top of the ridge. This is consistent with Smallwood and Neher (2018)." Although likely to negatively impact wake, sPower prioritized this move in Layout 5 due to the Layout 4 site's high risk designation. Estep confirmed that the micro-sited location is a relatively moderate-high risk site.
15B [Mod] (Layout 2)	Reloc. 200 ft NW to top of ridge	Not using this site	Using this site would place turbine downstream of Turbines 14 and 16, further increasing wake losses.
l5C [Mod] (Layout 3)	Reloc. 450 ft NW to top of hill **[Recom. Loc.]**	**Cannot use** this site due to wake effect	**AG misreads micro siting report and omits key information** This was not Smallwood's recommended site. Smallwood recommended using site 15-1, which sPower did (and then modified further pursuant to Estep).

[8] Smallwood (2018) states both that the Layout 1, 4 site should be moved 25m north and that the Layout 1, 4 site should be used. Erring on the side of caution, sPower classifies this site as following a partial or secondary micro siting recommendation.

Turbine Site No.[6]	Micro Siting Rec.[7]	Sand Hill Prop. Layout 5	Errors and Omissions in AG Summary
			Using this site would place this turbine downwind of Turbines 14 and 16 more frequently, further increasing wake losses.
Site No. 17			
17A [Mod] (Lay. 1, 4)	Reloc 230 ft N to top of ridge **[Recom. Loc.]**	**Could not move** turbine due to wake effect; turbine size reduced from 3.8 to 2.8 MW	Could not move due to wake effect. Move would place Turbine 17 within 1.5 RD of Turbine 16.
17B [Mod High] (Lay. 2)	No suitable reloc. site	Not using this site	**AG omits key information.** sPower avoided this site, which Smallwood recommended avoiding and Estep designated as the highest risk of the Site 17 locations.
17C [Mod] (Layout 3)	Reloc. 250 ft W-NW upslope	Not using this site	Using this site would place this turbine downwind of Turbines 16 and 18 more frequently, further increasing wake losses.
Site No. 19			
19A [Mod-High] (Lay. 1, 4)	No suitable reloc. site	Turbine size reduced from 3.8 MW to 2.3 MW	**AG omits key information.** Smallwood did not state no suitable relocation site; rather, he recommended using either this site or site 19-3, and noted burrowing owl concerns at site 19-3. sPower therefore followed the micro siting recommendation for this site.
19B [Mod] (Layout 2)	No suitable reloc. site	Not using this site	
19C [Low-Mod] (Lay. 3)	Reloc. 200 ft S to top of hill [**Recom. Loc.**]	**Not using** this site due to wake effect and addl ground disturbance	**AG omits key information** Smallwood noted burrowing owl concerns at this site, and therefore also recommended site 19-1, 4, which sPower

Turbine Site No.[6]	Micro Siting Rec.[7]	Sand Hill Prop. Layout 5	Errors and Omissions in AG Summary
			used in Layout 5 instead of this site. In addition, using this site would increase wake losses on Turbine 24, as the site is closer to Turbine 24 and directly upstream. Using this site would also increase wake losses on Turbine 25.
Site No. 22			
22A [Mod-High] (Lay. 1)	Reloc. 200 ft away from east slope	Not using this site	**AG omits key information.** As noted below, Estep recommended this relocation as an alternative, but noted that it would require substantial earth moving.
22B [Mod-High] (Lay. 2)	No suitable reloc. site	Not using this site	**AG omits key information.** Smallwood recommended moving this site away from the edge of a ravine. sPower relocated this turbine 25 m northwest away from edge of ravine, to site 22-4, in Layout 4.
22C [Mod-High] (Lay. 3)	No suitable reloc. site	Not using this site	
22D [Mod] (Layout 4)	No suitable reloc. site/safest loc [**Recom Loc.**]	Turbine size reduced from 3.8 MW to 2.8 MW	**AG misreads micro siting report and omits key information.** sPower followed the micro siting recommendation for this location. Relocated to this site per Smallwood recommendation. Estep did not state that there were "no suitable reloc[ation] site[s]" for this turbine. Instead, Estep stated that "Site

Turbine Site No.[6]	Micro Siting Rec.[7]	Sand Hill Prop. Layout 5	Errors and Omissions in AG Summary
			22D is probably the safest of the four alternative sites because it is on flat terrain, further from the deep ravine on the south, and closer to an existing access road. It is the recommended location for Turbine 22, which is generally consistent with Smallwood and Neher (2018) (Figure A-22). Alternatively, Site 22A could also be relocated northward about 200 feet away from the east-facing slope, but would require substantial earth-moving to access the site."
Site No. 23			
23A [Mod-High] (All Lay.)	Reloc. 100 ft S to top of hill	**Could not move** turbine due to setback requirements/size increased from 2.3 MW to 2.8 MW	**AG omits key information.** Although turbine size increased, turbine blade height from ground also increased. Turbine 23 just meets the county of Alameda required setback to parcels without an approved wind energy CUP of 1.25x the total tip height +- 1% TTH per 10ft above or below affected parcel. The recommended move would conflict with this requirement.
Site No. 25			
25A [Mod-High] (All Lay.)	No suitable reloc. site **[Smallwood rec avoiding site]**	Turbine size reduced from 3.8 MW to 2.8 MW	
Site No. 29			
29A [High] (Lay 1-3)	No suitable reloc. site	Not using this site	**AG misreads micro siting report and omits key information.**

Turbine Site No.[6]	Micro Siting Rec.[7]	Sand Hill Prop. Layout 5	Errors and Omissions in AG Summary
			Smallwood recommended moving this site east to higher ground. sPower followed this recommendation when setting the Layout 4 site.
29B [Mod] (Lay 4)	Reloc. 140 ft E-NE across rd [**Recom. Loc.**]	Turbine moved 165 ft SE away from edge of swale [**Note**: orig. Estep rec could not be done due to setback reqmts. Estep confirmed this loc is low to mod risk. Reduced turbine size from 3.8 MW to 2.3 MW.]	**AG omits key information.** sPower followed the micro siting recommendation for this location. Relocated to Layout 4 site per Smallwood recommendation. Further relocated turbine in response to Estep recommendation. Estep confirmed that the micro-sited location is a relatively low-moderate risk site.

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Turbine Sites Omitted from AG Summary

The Attorney General micro siting table omits the following turbine sites:

Turbine Site No.	Micro Siting Rec.	Sand Hill Prop. Layout 5	Additional Notes
Site No. 1			
1A [Low-Mod] (Lay. 1-3)	Smallwood: maybe move ENE 60 m. Estep: Use modified site 1-4	Not using this site in Layout 5. Followed Smallwood recommendation by relocating turbine ENE 60 m in Layout 4, and further refined location per Estep in Layout 5.	
1B [Low-Mod] (Lay. 4)	Estep: Move at least 60 feet north	Turbine moved per Estep and reduced in size from 3.8 MW to 2.8 MW.	sPower followed the micro siting recommendation for this location. Estep confirmed that the micro-sited location is a relatively low risk site.
Site No. 2			
2A [Low] (Lays. 1-4)	Smallwood: no concerns with this site Estep: Recommended location	Using this site.	sPower followed the micro siting recommendation for this location.
Site No. 3			
3A [Low-Mod] (Lays. 1-4)	Smallwood: no better options locally Estep: Move approx. 105 ft. south.	Moved 105 ft. south per Estep.	sPower followed the micro siting recommendation for this location.
Site No. 5			
5A [Low-Mod] (Lays. 1-3)	Smallwood: Shift SW to hill peak	Not using this site in Layout 5. Followed Smallwood recommendation by relocating turbine in Layout 4, and further refined location per Estep in Layout 5.	
5B [Low-Mod] (Lay. 4)	Estep: Move approx.. 80 ft. NE.	Moved 53 ft. E and reduced turbine size from 3.8 MW to 2.8	sPower followed the micro siting recommendation for this site by moving to the Layout 4 location in response to

Turbine Site No.	Micro Siting Rec.	Sand Hill Prop. Layout 5	Additional Notes
		MW. Could not move north due to wake effect.	Smallwood's recommendation, and further refining the final location by following a partial Estep recommendation. Wake-related losses are already high at the Layout 5 site for Turbine 5 (15.6% wake effect losses, and WSM losses of 3%).[9] Moving turbine N per Estep suggestion would further increase wake-related losses by decreasing the separation between Turbines 4 and 5 to 2.05 RD.
Site No. 6			
6A [Mod] (Lays. 1-4)	Smallwood: This site likely safest site on ridge. Estep: Recommended location.	Used this site, and reduced turbine size from 3.8 MW to 2.8 MW.	sPower followed the micro siting recommendation for this location.
Site No. 7			
7A [Mod] (Lays. 1-3)	Smallwood: Move N. to ridge crest Estep: None	Moved 40 ft. N in Layouts 4 and 5, the furthest move possible due to wake.	
7B [Mod] (Lay. 4)	Estep: Move approx.. 200 ft. NW	Moved to this site in Layout 4 in response to Smallwood, but could not move 200 ft further NW due to wake. Reduced turbine size from 3.8 MW to 2.8 MW.	sPower followed a partial micro siting recommendation by moving this site closer to the ridge crest in Layouts 4 and 5. Suggested additional move 200 ft NW would further increase wake and WSM losses by decreasing turbine separation between SH06 and SH07 from 2.0 RD to

[9] Wind sector management (WSM) is the practice of shutting down turbines during certain wind conditions to avoid excessive damage from wake-related turbulence.

Turbine Site No.	Micro Siting Rec.	Sand Hill Prop. Layout 5	Additional Notes
			1.6 RD.
Site No. 8			
8A [Low] (Lays. 1-3)	Smallwood: This site likely safest local option Estep: Move 50 ft. N. Recommended location.	Not using this site. Could not move north due to setback requirements.	sPower was unable to move this turbine north due to public road setback constraints. The county requires that turbines are sited a minimum of 1.25x TTH +- 1% TTH per 10ft above or below affected right-of-way. The recommended move would conflict with this requirement.
8B [Low] (Lay 4)	Estep: Use modified Site 08-1-3.	Using this site. Reduced turbine size from 3.8 MW to 2.8 MW.	
Site No. 9			
9A [Mod] (Lays. 1-4)	Smallwood: Shift west and uphill Estep: Move approx.. 280 ft. NW to top of hill	Could not move due to wake effect. Reduced turbine size from 3.8 MW to 2.8 MW.	Suggested move would further increase wake-related losses by placing Turbine 9 in front of Turbine 8 more frequently, increasing losses at Turbine 8 to approximately 85%.
Site No. 10			
10A [Low-Mod] (Lays. 1-4)	Estep: Recommended location.	Using this site. Increased turbine size from 2.3 MW to 2.8 MW.	sPower followed the micro siting recommendation for this location.
Site No. 11			
11A [Mod] (Lays. 1-4)	Smallwood: This site safest place in area Estep: Recommended location.	Using this site. Reduced turbine size from 3.8 to 2.8 MW.	sPower followed the micro siting recommendation for this location.
Site No. 12			
12A [Low] (Lay. 1)	Smallwood: Move 25m west. Estep: Use site 12-4	Not using this site. Moved 25m west, to site 12-4 per Smallwood.	
12B [Low-Mod] (Lay. 2)	Smallwood: This site sagest place in area. Estep: Use site 12-4.	Not using this site.	

Turbine Site No.	Micro Siting Rec.	Sand Hill Prop. Layout 5	Additional Notes
12C [Low-Mod] (Lay. 3)	Smallwood: This site safest place in area. Estep: Use site 12-4.	Not using this site.	
12D [Low] (Lay. 4)	Estep: Recommended location.	Following site visit, moved additional 37 feet south. Estep confirmed this location is as safe as 12-4, and is also recommended site. Reduced turbine size from 3.8 MW to 2.8 MW.	sPower followed the micro siting recommendation for this location.
Site No. 20			
20A [Low-mod] (Lays. 1, 4)	Smallwood: Move N. to crest. Estep: Move 80ft. NNE. This is the recommended location.	Moved 80 ft. NNE. Reduced turbine size from 3.8 MW to 2.8 MW.	sPower followed the micro siting recommendation for this location. Estep confirmed that the micro-sited location is a relatively low risk site.
20B [Mod] (Lay. 2)	Smallwood: avoid this site Estep: Move 170ft NW	Not using this site.	
20C [Mod] (Lay. 3)	None	Not using this site.	
Site No. 24			
24A [Low] (Lays. 1-4)	Estep: Move at least 150ft. SW.	Moved 150ft. SW. Reduced turbine size from 3.8 MW to 2.8 MW.	sPower followed the micro siting recommendation for this location.
Site No. 26			
26A [Mod] (Lays. 1-3)	Smallwood: Move SW to crest or S to higher ground. Estep: Use site 26-4 or modified site 26-4.	Not using this site. Moved 50m SW to higher ground in Layout 4, per Smallwood. Further refined in Layout 5, which Estep confirmed is	

Turbine Site No.	Micro Siting Rec.	Sand Hill Prop. Layout 5	Additional Notes
		recommended site.	
26B [Low-mod] (Lay. 4)	Estep: Use site 26-4 or modified site 26-4.	Following site visit, moved additional 33 feet south. Estep confirmed this location as safe as 26-4, and is also recommended site. Reduced turbine size from 3.8 MW to 2.8 MW.	sPower followed the micro siting recommendation for this location.
Site No. 31			
31A [Low] (Lays. 1-3)	Smallwood: avoid berm by moving west. Estep: Use site 31-4.	Not using this site. Moved Turbine 31 25m W/SW in Layout 4, per Smallwood.	
31B [Low] (Lay. 4).	Estep: Recommended location.	Using this site. Reduced turbine size from 3.8 MW to 2.8 MW.	sPower followed the micro siting recommendation for this location.
Site No. 32			
32A [Low] (Lays. 1-4).	Smallwood: This site safest place in area. Estep: Recommended location	Using this site. Reduced turbine size from 3.8 MW to 2.8 MW.	sPower followed the micro siting recommendation for this location.
Site No. 33			
33A [Low] (Lays. 1-4)	Smallwood: This site safest place in area. Estep: Recommended location.	Using this site. Reduced turbine size from 3.8 MW to 2.8 MW.	sPower followed the micro siting recommendation for this location.
Site No. 35			
35A [Low] (Lays. 1-4)	Smallwood: This site safest place in area. Estep: Recommended location.	Using this site. Reduced turbine size from 3.8 MW to 2.8 MW.	sPower followed the micro siting recommendation for this location.
Site No. 36			
36A [Mod] (Lays. 1-4)	Smallwood: Move NNW away from canyon edge. Estep: Move 200ft. NW.	Unable to move due to wake. Reduced turbine size from 3.8 MW to 2.8 MW.	Wake and WSM losses at this site are already high at 12.1% and 7%, respectively. Suggested move would reduce the separation between Turbines

Turbine Site No.	Micro Siting Rec.	Sand Hill Prop. Layout 5	Additional Notes
			36 and 35 from 2.4 RD to 2.1 RD, further increasing wake-related losses.
Site No. 38			
38A [Low] (Lays. 1-4)	Smallwood: Safest place in area. Estep: Recommended location.	Using this site. Reduced turbine size from 3.8 MW to 2.8 MW.	sPower followed the micro siting recommendation for this location.
Site No. 39			
39A [Low] (Lays. 1-4)	Smallwood: Safest place in area. Estep: Recommended location.	Using this site. Reduced turbine size from 3.8 MW to 2.8 MW.	sPower followed the micro siting recommendation for this location.
Site No. 40			
40A [Mod] (Lays. 1-3)	None		
40B [Mod] (Lay. 4)	Estep: Move 275ft. NW.	Unable to move due to wake effect. Reduced turbine size from 3.8 MW to 2.8 MW.	Suggested move would reduce separation between Turbines 40 and 39 from 2.1 RD to 1.5 RD, further increasing wake-related losses.

Attachment 3

Micro Siting Summary: Relative Risk vs. Outcomes

Estep Relative Risk Designation	Estep Relative Risk Pre Micro Siting[1]	Expert recommendation followed	Partial or secondary recommendation followed	Unable to follow recommendation	Estep Relative Risk Post Micro Siting[2]
Very High	N/A	N/A	N/A	N/A	N/A
High	13[3]	5[4]	4[5]	4[6]	7[7]
Moderate-High	5[8]	2[9]	N/A	3[10]	8[11]
Moderate	8[12]	4[13]	1[14]	3[15]	8[16]
Low-Moderate	5[17]	5[18]	N/A	N/A	5[19]
Low	9[20]	8[21]	N/A	1[22]	12[23]
Total	**40**	**24**	**5**	**11**	**40**

[1] Based on the highest relative risk designation for each turbine provided by Estep (2019).

[2] Based on Estep's relative risk designation for Layout 5, the Pre-Micro-sited Smaller Turbine Alternative Layout.

[3] Sites 4; 13; 14; 15; 16; 18; 21; 27; 28; 29; 30; 34; 37.

[4] Sites 13; 16; 18; 29; 30.

[5] Sites 4, 14; 15; 21.

[6] Sites 27; 28; 34; 37.

[7] Sites 4, 21, 27, 28, 30, 34, 37.

[8] Sites 17; 19; 22; 23; 25.

[9] Sites 19; 22.

[10] Sites 17; 23; 25. With respect to site 17, note that Estep and Smallwood recommended moving the Layout 1, 4 site. sPower could not make those moves due to wake effect, and therefore used the unmodified Layout 1, 4 site, which Estep designated as moderate relative risk. Nevertheless, sPower avoided the Layout 2 site, which Estep classified as relatively moderate-high risk and Smallwood recommended avoiding altogether.

[11] Sites 13; 14; 15; 16; 18; 19; 23; 25.

[12] Sites 6; 7; 9; 11; 20; 26; 36; 40.

[13] Sites 6; 11; 20; 26.

[14] Site 7.

[15] Sites 9; 36; 40.

[16] Sites 6; 7; 9; 11; 17; 22; 36; 40.

[17] Sites 1; 3; 5; 10; 12.

[18] Sites 1; 3; 5; 10; 12.

[19] Sites 3; 5; 10; 26; 29.

[20] Sites 2; 8; 24; 31; 32; 33; 35; 38; 39.

[21] Sites 2; 24; 31; 32; 33; 35; 38; 39.

[22] Site 8.

[23] Sites 1; 2; 5; 8; 12; 20; 24; 31; 32; 33; 35; 38; 39.

Summary of Micro Siting Outcomes

Result	Turbines	Total number of turbines
Followed full recommendation of Smallwood and/or Estep	1, 2, 3, 5, 6, 10, 11, 12, 13, 16, 18, 19, 20, 22, 24, 26, 29, 30, 31, 32, 33, 35, 38, 39	24
• Followed full expert recommendation by moving turbine	1, 3, 5, 12, 13, 16[24], 18, 20, 24, 26, 29, 31	12
o Followed full expert recommendation by moving turbine, and reduced size	1, 5, 12, 13, 16, 18, 20, 24, 26, 29, 31	11
o Followed full expert recommendation by moving turbine, but increased size	3	1
• Followed full expert recommendation by leaving turbine as is	2, 6, 11, 10, 19, 22, 30[25], 32, 33, 35, 38, 39	12
o Followed full expert recommendation by leaving turbine as is, and reduced size	6, 11, 19, 22, 30, 32, 33, 35, 38, 39	10
o Followed full expert recommendation by leaving turbine as is, and increased size	2, 10	2
Followed partial, modified, or secondary recommendation of Smallwood and/or Estep	4, 7, 14, 15[26], 21	5
• Followed partial, modified, or secondary expert recommendation by moving turbine	4, 7, 14, 15, 21	5
o Followed partial, modified, or secondary expert recommendation by moving turbine, and reduced size	7, 14, 15, 21	4
o Followed partial, modified, or secondary expert recommendation by moving turbine, and increased size	4	1
• Followed partial, modified, or secondary expert recommendation by leaving turbine as is		0
Unable to follow expert recommendation due to siting or wake-related constraints	8, 9, 17, 23, 25, 27, 28, 34, 36, 37, 40	11
• Unable to follow expert recommendation due to siting or wake-related constraints. Turbine size reduced.	8, 9, 17, 25, 27, 28, 34, 36, 37, 40	10
• Unable to follow expert recommendation due to siting or wake-related constraints. Turbine size increased.	23	1

[24] Site 16-1,4 was Smallwood's recommended site because it was the only Turbine 16 location that Smallwood did not recommend avoiding. sPower further modified site 16-1,4 by moving it per Estep's secondary recommendation.

[25] Estep did not initially give a recommendation for this site. Smallwood recommended the Layout 1-4 location, by stating that there were no safer local options not assigning this site a high risk designation. sPower found a way to further reduce risk by moving the turbine following a site visit.

[26] Smallwood recommended moving the Layout 1 site 25m north, which sPower could not do due to wake. However, Smallwood's recommendations for the Layout 2 and 3 sites were to "use site 15." Erring on the side of caution, this site is classified as following a partial Estep recommendation, as opposed to the full Smallwood recommendation.

Attachment 4

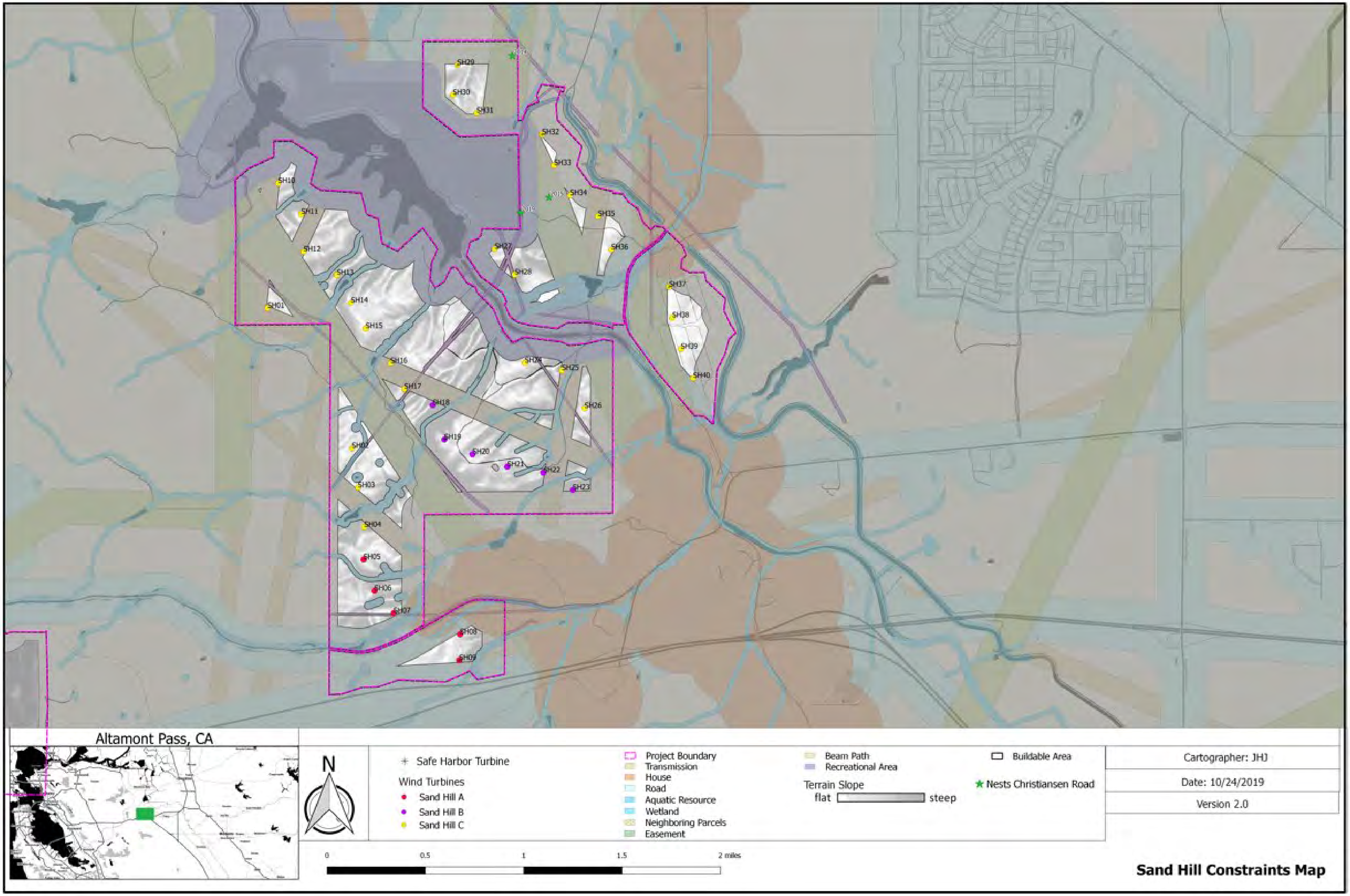
Siting and Wake-Related Constraints at Sand Hill

sPower commissioned two project-specific micro-siting reports for the Sand Hill project: Smallwood and Neher (2018) and Estep (2019). sPower attempted to comply with the recommendations set forth in those reports, and in most cases did (see Attachments 1-3). However, micro-siting recommendations are made without regard for technical or legal feasibility. As a consequence, neither report considered setback requirements or technical constraints relating to wake interference. As shown in Attachments 1-2, in each instance where sPower could not follow the full micro-siting recommendation of Smallwood and Neher (2018) and/or Estep (2019), these constraints prevented it from doing so. sPower provides additional detail regarding these constraints here.

<u>Setbacks</u>

Setback requirements severely limit the area in which sPower can site turbines within the Sand Hill project site. These include setbacks from transmission lines, residences, roads, wetlands, easements, microwave beams, and the Bethany Reservoir State Recreation Area. For example, Alameda County requires that turbines be located no closer than 1.25x total tip height (TTH) from public roads, plus or minus 1% of TTH per 10 feet above or below the affected right-of-way or parcel. (Draft SEIR; 2-25 – 2-27). The same setback generally applies to parcels without approved wind energy CUPs. (*Id*.) Similarly, the County prohibits siting wind turbines closer than 1x TTH from recreational areas and transmission lines, plus or minus 1% TTH per 10 feet above or below the affected parcel. (*Id*.). As shown in **Figure 1**, the result is a highly constrained map where turbines may only be placed in the remaining white areas that are not shaded with slope constraints.

Figure 1: Sand Hill Constraints Map



Wake Effect

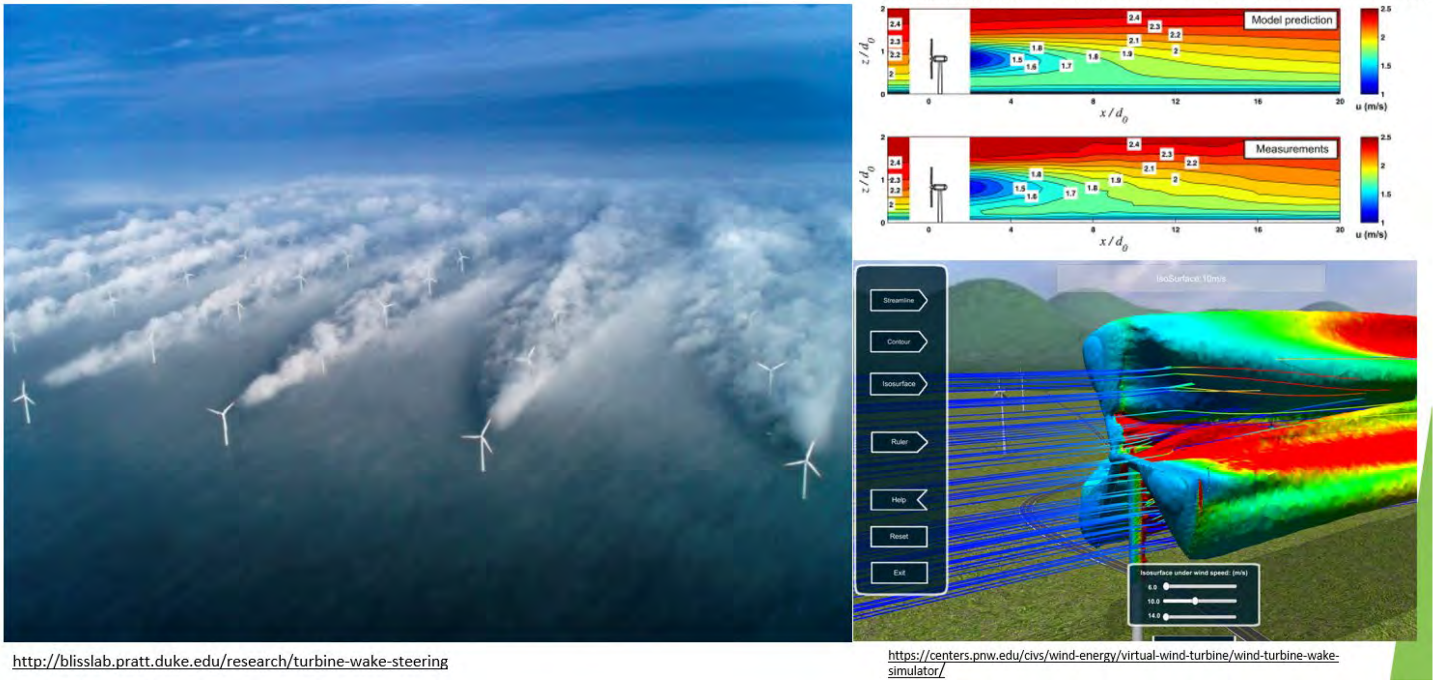
Wind turbines both slow down and disturb the air that passes through them, leaving behind a wake. **Figure 2** provides visual depictions of this effect. Wake effect poses two problems to wind farms.

The first problem is simple energy loss. Wind turbines produce electricity by extracting kinetic energy from the air. The amount of kinetic energy in the air is a function of air mass and wind speed. Because energy is conserved, when a wind turbine extracts energy from the air it also reduces wind speed. Because wind speeds are slower within the wake a turbine leaves behind, the air there contains less kinetic energy for downstream turbines to harvest. Fortunately, wake dissipates as distance from the wind turbine increases, as surrounding wind brings the air within the wake back up to speed. The relationship between wake and distance is depicted in **Figure 3**. Air typically moves faster higher off the ground, such that fast-moving air above a wind turbine helps quickly dissipate the wake it leaves behind. In the APWRA, however, cold air coming from the ocean causes an uncommon phenomenon called negative shear (or inversion) wherein wind speed *decreases* above the tops of wind turbines. The practical result is that turbines in the APWRA need more room to avoid large wake losses. As a result, while the industry standard calls for turbines to be spaced at least 10 rotor diameters (RD) apart when oriented upstream-downstream, turbines in the APWRA require greater spacing to avoid wake-related production losses.

The second problem is turbine damage. As wind passes through a turbine's blades and begins to mix with surrounding air, it becomes turbulent. Wind turbines cannot effectively convert turbulent air into electricity; instead, turbulent wind shakes turbines back and forth, causing damage and increased wear. The wake within three rotor diameters of a turbine contains the most turbulence, and is particularly damaging to neighboring units—so much so that turbine manufacturers typically will not warranty turbines subjected to it. Wind in the APWRA largely comes from the same direction, allowing turbines to be sited closer shoulder-to-shoulder than back-to-front. But when the wind inevitably does change direction, it can cause significant turbulence-related damage. To avoid this damage, industry standards call for turbines to be spaced roughly 3.0 RD apart shoulder-to-shoulder; turbines that cannot achieve this spacing must be shut down in certain wind conditions, a practice known as "wind sector management," or WSM. Thus, WSM trades added turbine life for decreased energy production. In Layout 5, which forms the basis of the Micro-sited Alternative, sPower spaced many turbines closer than 3.0 RD, despite incurring resulting production losses. However, sPower could not site turbines closer than 2.0 RD without incurring unacceptable wake-related losses.

Figure 2: Wake Effect

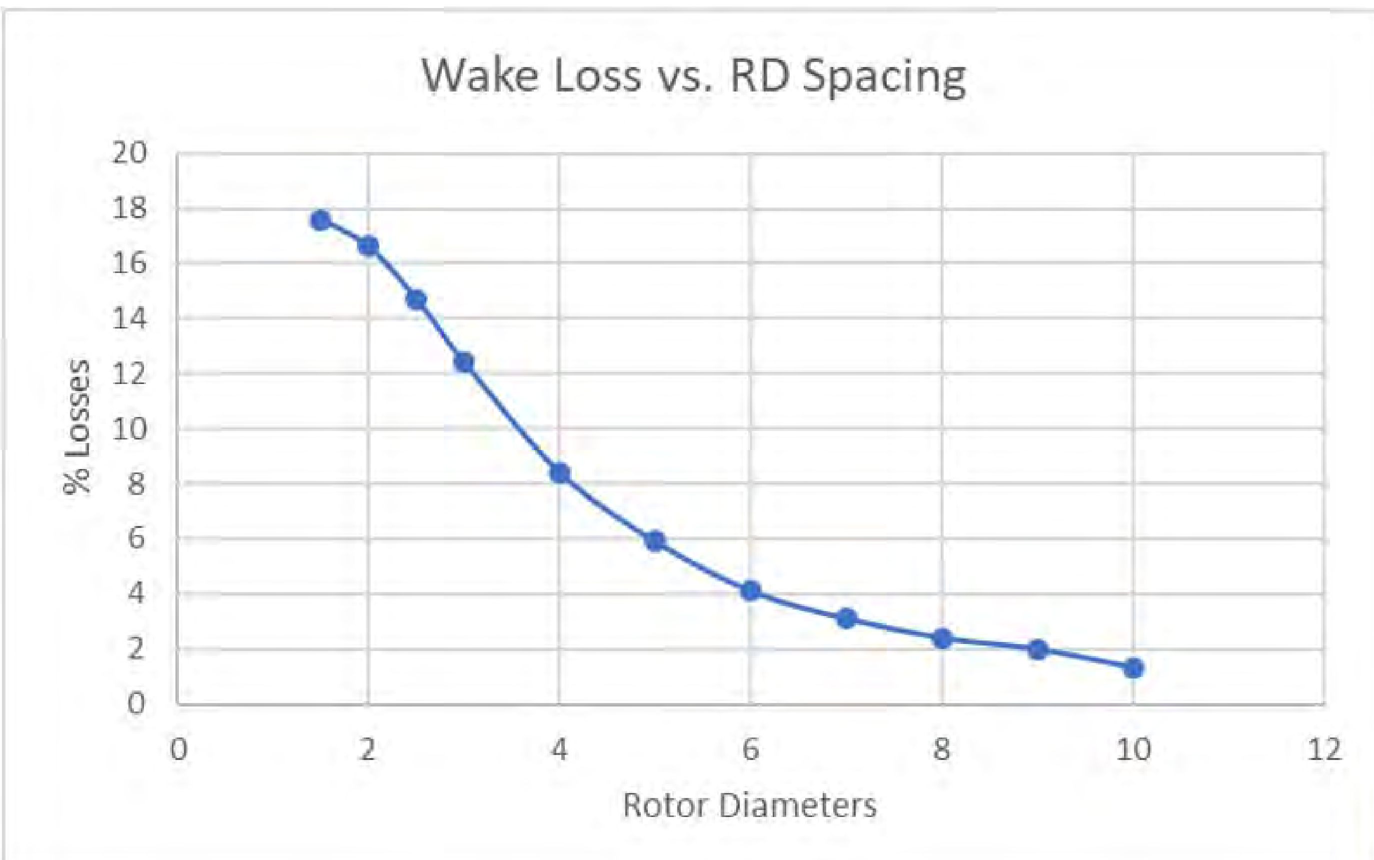
https://www.sciencedirect.com/science/article/abs/pii/S0960148114000317



http://blisslab.pratt.duke.edu/research/turbine-wake-steering

https://centers.pnw.edu/civs/wind-energy/virtual-wind-turbine/wind-turbine-wake-simulator/

Figure 3: Wake Loss vs. Turbine Spacing



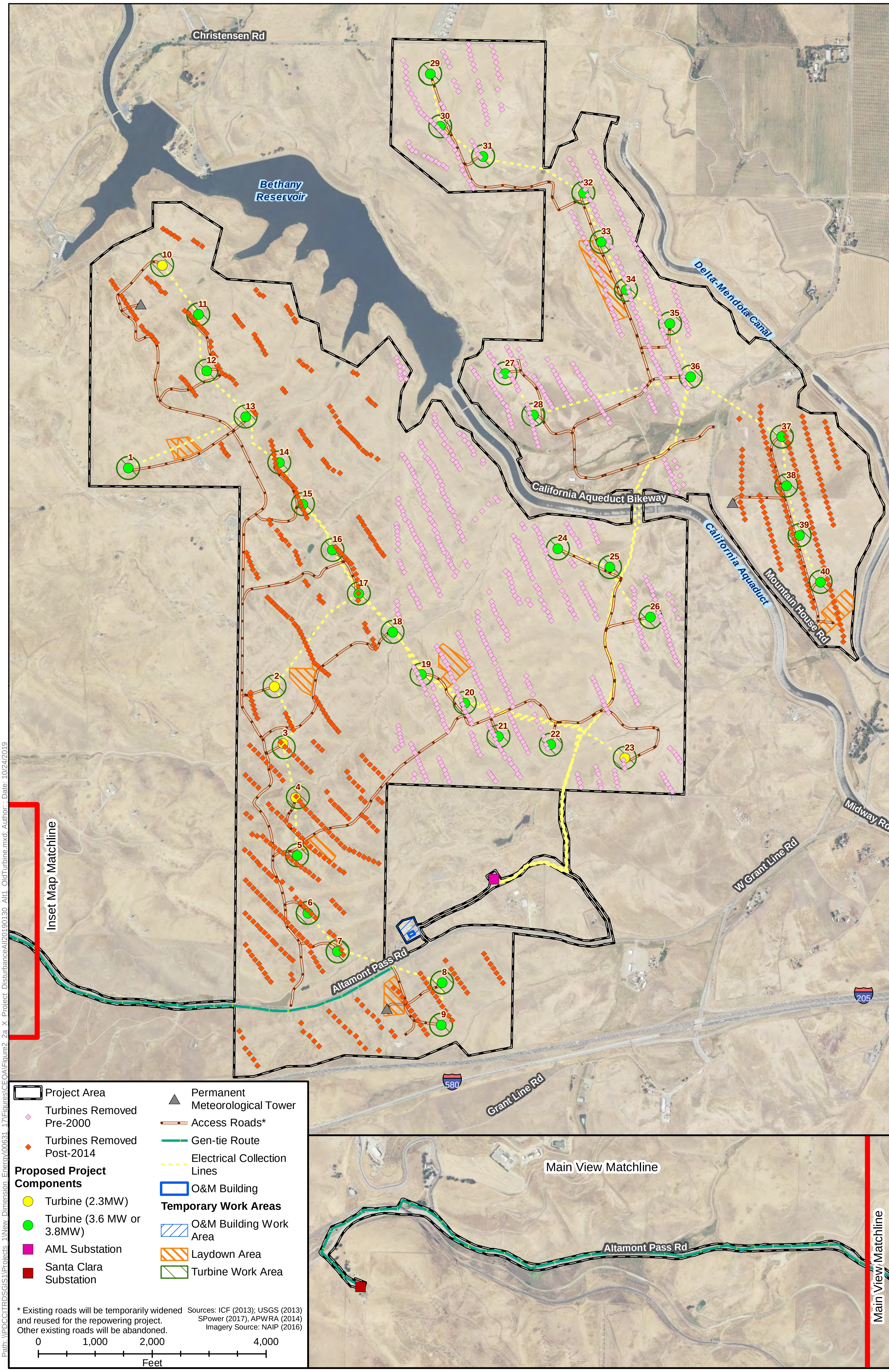
Source: sPower (2019)

Attachment 5

Old Generation Turbines at Sand Hill Project Site

Owner/Operator	Turbine Model	Tower Type	Tower Height (m)	Turbine Height (m)	Rotor Diameter (m)	Rotor-Swept Area (m2)	Turbine Rated Capacity (kW)	Turbine Removal
AES SeaWest	Enertech	Lattice	18.3	25.9	13.4	141.3	40	Post-PEIR
AES SeaWest	Micon	Tubular	24.4	32.3	15.8	197.3	65	Post-PEIR
AES SeaWest	Polenko	Tubular	24.4	33.5	18	254	100	Post-PEIR
AES SeaWest	Windmatic	Lattice	18.3	25.6	14.6	168.1	65	Post-PEIR
Altamont Winds	Kenetech 56-100	Lattice	18.3-42.7	27.7-52.1	18	254	100	Post-PEIR
Unknown	Fayette	Unknown	12.2-24.4	Unknown	Unknown	Unknown	95	Pre-PEIR
Unknown	Fayette	Unknown	24.4	Unknown	Unknown	Unknown	400	Pre-PEIR

Attachment 6



Path: \\PDCCITRDSGIS1\Projects_1\New_Dimension_Energy\00631_17\Figures\CEQA\Figure2_2a_X_Project_DisturbanceAll20190130_Alt1_OldTurbine.mxd; Author: ; Date: 10/24/2019

Figure 2-2a
Sand Hill Wind Repowering Project Layout 1

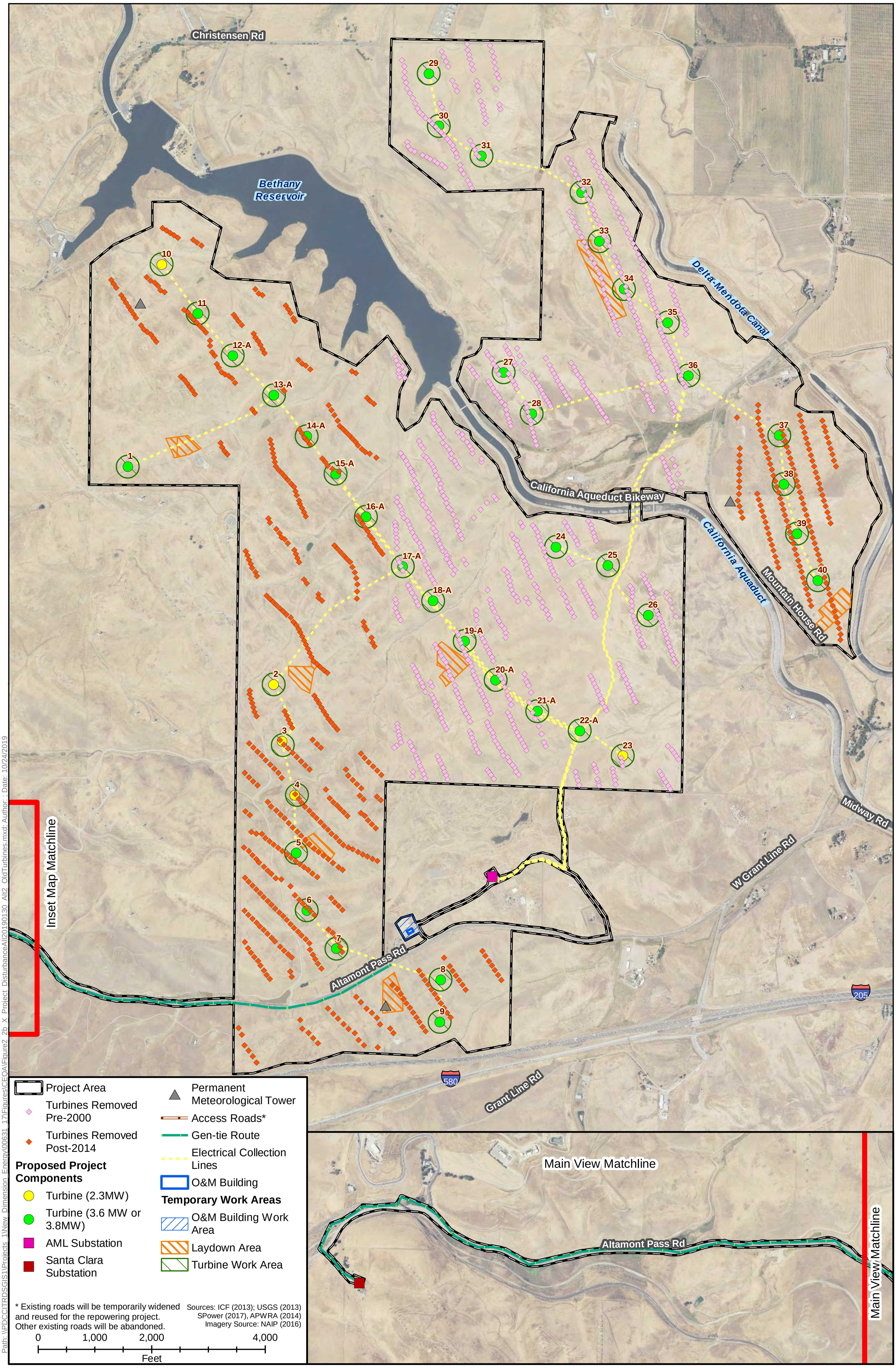


Figure 2-2b
Sand Hill Wind Repowering Project Layout 2

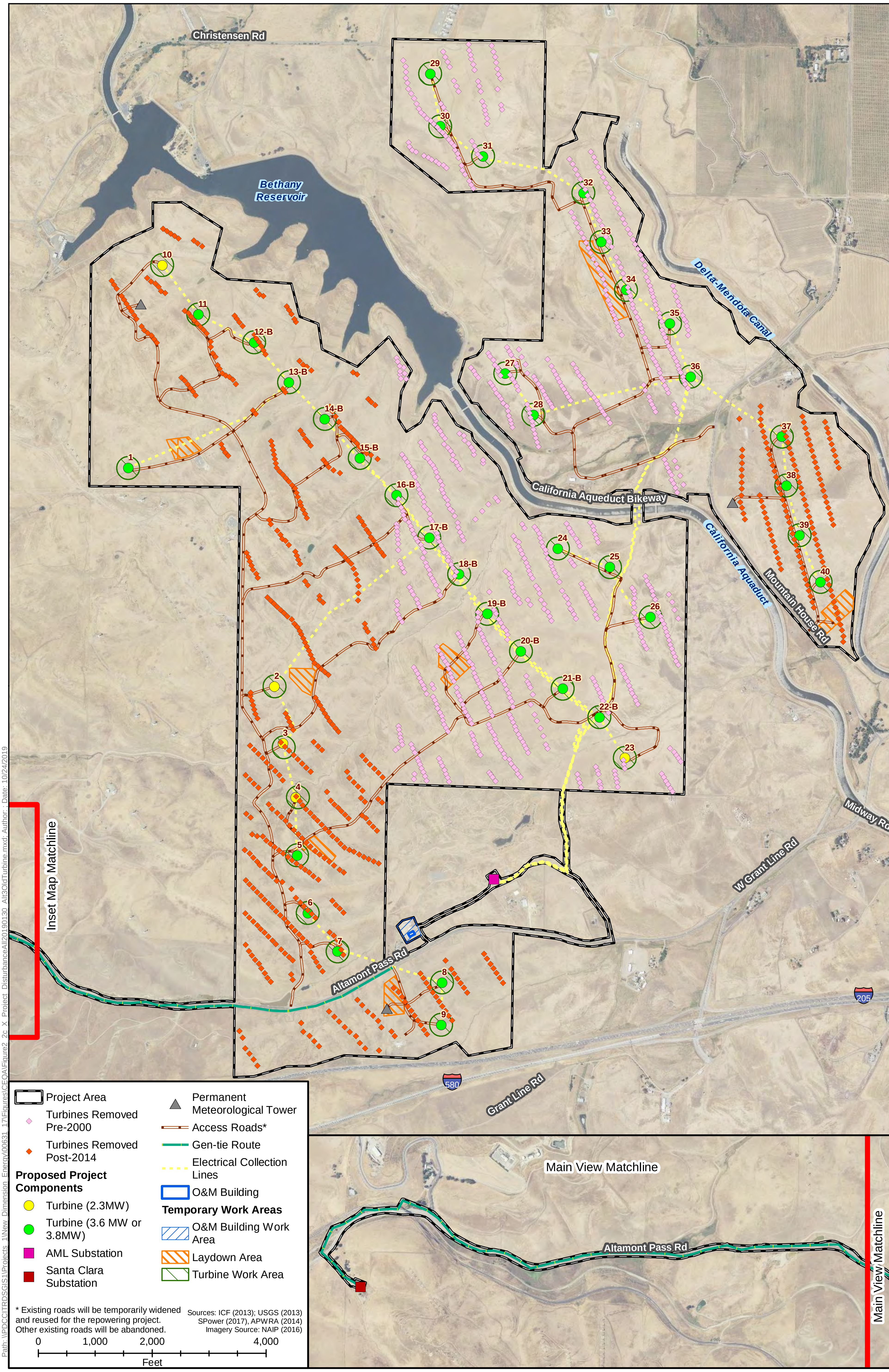


Figure 2-2c
Sand Hill Wind Repowering Project Layout 3

Attachment 7

Cumulative Fatality Rates and Population Level Effects

	Montezuma Hills Wind Resource Area (MHWRA) [1]		Altamont Pass Wind Resource Area (APWRA) [2]			Population Estimates[3, 4]			Percent of Population Affected		
	Fatality rate[5]	Average annual fatalities	Fatality rate[5]	Average annual fatalities	Total Fatalities (both WRA's)	California	BCR 32	LAP[7]	California	BCR 32	LAP
American kestrel	0.15	153.3	0.18	107.2	260.5	200,000	110,000	NA	0.13%	0.24%	NA
Burrowing owl	0	0.0	0.23	136.9	136.9	190,000	9,700	NA	0.07%	1.41%	NA
Golden eagle	0.01	10.2	0.06	35.7	45.9	NA	718	840	NA	6.40%	5.47%
Red-tailed hawk	0.11	112.4	0.3	178.6	291.0	230,000	150,000	NA	0.13%	0.19%	NA

[1] Monitoring results from Montezuma Hills (1,022 MW total) summarized from Appendix C to the Montezuma II Wind Project EIR (Solano County Department of Resource Management 2011). Fatality rate presented is the average of adjusted rates from the High Winds, Shiloh I, Shiloh II, and Solano projects.

[2] Altamont Pass Wind Resource Area includes all operational, plannned, and foreseeable projects in Alameda and Contra Costa Counties. Buena Vista (38MW), Vasco (78MW), Summit (54 MW), Patterson Pass (19.8MW), Golden Hills (85.9MW), Golden Hills North (46 MW), Diablo (20.5MW), Sand Hill (144.5MW), Rooney Ranch (25.1MW), totaling 586.6MW of installed capacity.

[3] Except where noted, all population estimates are from the Partners in Flight Population Estimate Database. (Partners in Flight. 2019. Population Estimates Database, version 3.0. Available at http://pif.birdconservancy.org/PopEstimates. Accessed on 12/11/19.)

[4] Population estimate for golden eagles in BCR 32 from USFWS 2016. As noted in the DSEIR, this estimate is likely lower than the actual number of birds in BCR 32 based on

[5] Fatality rates are provided on an adjusted per-MW basis.

[6] Average Fatality rate presented is the average of the adjusted fatality rates from Diablo Winds, Buena Vista, Golden Hills, and Vasco Winds as outlined in Table 3.4-4 of the DSEIR.

[7] USFWS (2016) estimated the population for BCR 32. The DSEIR, page 3.4-13 describes additional information USGS has collected on the eagle population within the Diablo Range and provides an estimated number of birds within the local area population.

Cumulative Fatality Rates

	Montezuma Hills Wind Resource Area (MHWRA) [1]		Altamont Pass Wind Resource Area (APWRA) [2]		
	Fatality rate[3]	Average annual fatalities	Fatality rate[3, 4]	Average annual fatalities	Total Fatalities (both WRA's)
All bats	2.58	2637	4.421	2632	5269

[1] Monitoring results from Montezuma Hills (1,022 MW total) summarized from Appendix C to the Montezuma II Wind Project EIR (Solano County Department of Resource Management 2011). Fatality rate presented is the average of adjusted rates from the High Winds, Shiloh I, Shiloh II, and Solano projects.

[2] Altamont Pass Wind Resource Area includes all operational, plannned, and foreseeable projects in Alameda and Contra Costa County totaling 586.6MW of installed capacity.

[3] Fatality rates are provided on an adjusted per-MW basis.

[4] Average Fatality rate presented is the average of the adjusted fatality rates from Golden Hills (5.635 bats/MW/year) and Vasco Winds (3.207 bats/MW/year).

Attachment 8

Memorandum

Date:	December 5, 2019
To:	Korina Cassidy, sPower
From:	Brad Norton and Brad Schafer
Re:	**Sand Hill Wind Repowering Project – Summary of Bat Foraging and Roosting Habitat and Project Considerations for Siting and Construction**

Introduction

The purpose of this memorandum is to describe bat foraging and roosting habitat in the vicinity of the project area and the variables that will need to be considered regarding bats during siting and construction. The draft Subsequent Environmental Impact Report (DSEIR) for the project identifies multiple mitigation measures that will need to be implemented for the project. These measures include:

- PEIR Mitigation Measure BIO-12a: Conduct bat roost surveys
- PEIR Mitigation Measure BIO-12b: Avoid disturbing or removing bat roosts
- PEIR Mitigation Measure BIO-14a: Site and select turbines to minimize potential mortality of bats
- 2019 Updated PEIR Mitigation Measure BIO-14b: Implement postconstruction bat fatality monitoring program for all repowering projects
- PEIR Mitigation Measure BIO-14c: Prepare and publish annual monitoring reports on the findings of bat use of the project area and fatality monitoring results
- PEIR Mitigation Measure BIO-14d: Develop and implement a bat adaptive management plan
    - Adaptive Management Measure-7: Seasonal Turbine Cut-in Speed Increase
    - Adaptive Management Measure-8: Emerging Technology as Mitigation
- PEIR Mitigation Measure BIO-14e: Compensate for expenses incurred by rehabilitating injured bats

This memorandum includes information to support BIO-12a, BIO-12b and BIO-14a. The DSEIR includes more information on the operational mitigation measures and ICF and sPower will prepare additional information, as required, to implement operational measures.

Methods

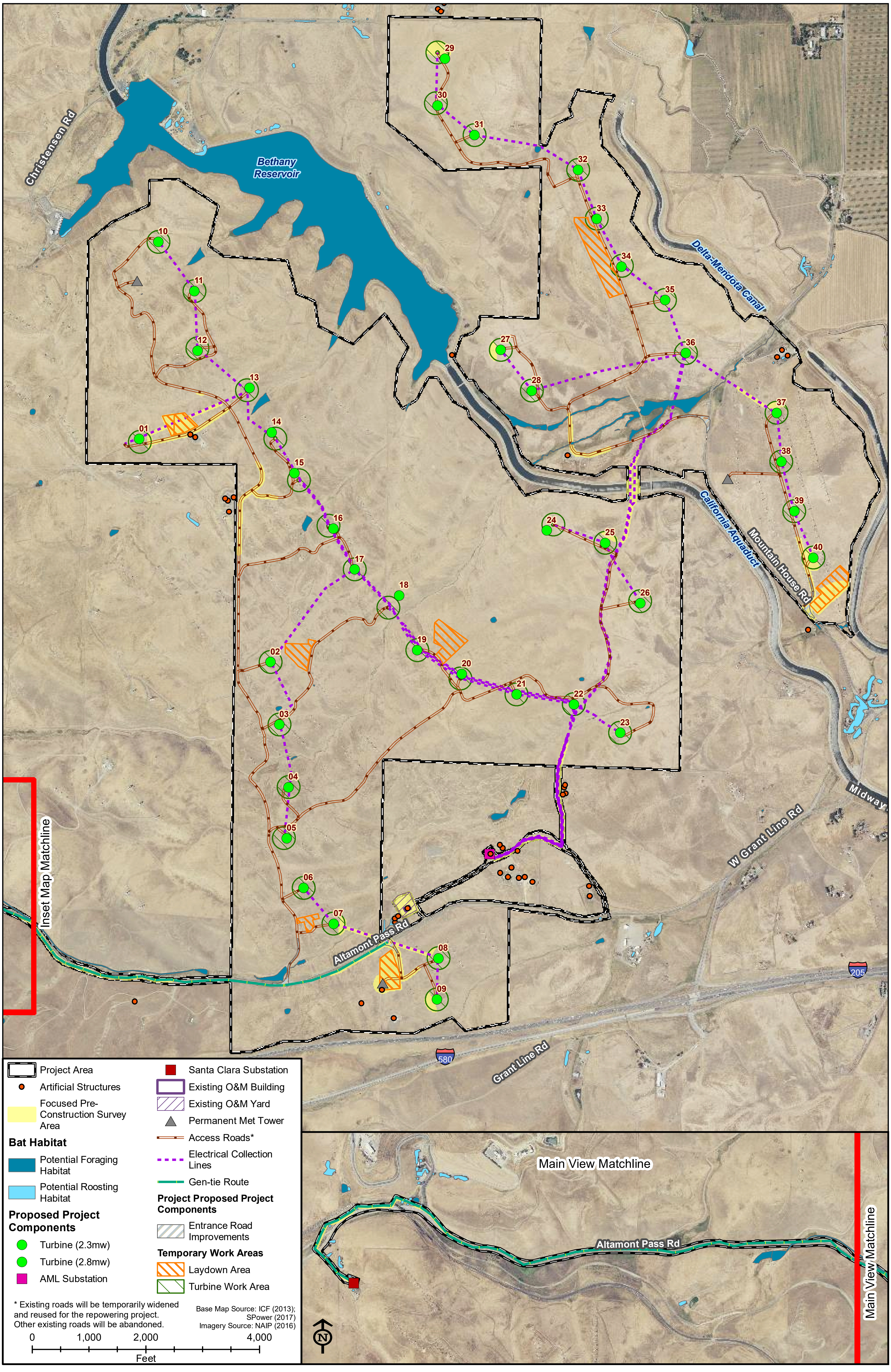
ICF conducted multiple biological resource surveys of the project area in 2017, 2018, and 2019. These surveys provided information to support the identification of wetland and other potential bat habitat on-site and along the collection line alignment. Using this information ICF's GIS staff attributed trees as potential roosting habitat and wetlands (i.e., perennial wetland drainages, ponds and Bethany Reservoir) as potential foraging habitat. ICF also digitized artificial structures within 750 feet of disturbance areas. ICF then used GIS to identify disturbance areas within 750 feet of roosting habitat (the distance identified in mitigation measures BIO-12a and BIO-12b), including artificial structures. ICF explored using general land-cover data to develop habitat maps, but the land-cover data was coarser than the site-specific survey data.

Findings and Discussion

Figure 1 illustrates roosting and foraging habitat, artificial structures, and the areas where pre-construction surveys are needed. No rock-outcrops or caves suitable for bat use were identified on site. There are 33 trees/tree groups that could provide roosting habitat in the vicinity of the project. 11 are on-site and 22 are located off-site, many of which are near the proposed collection lines. There is approximately 15.4 acres of foraging habitat on-site. The roosting and foraging habitat is somewhat difficult to identify on the figure because of the scale and small, localized patches of habitat that are on-site and nearby (except for Bethany Reservoir). There are nine artificial structures on-site and approximately two dozen near the project area; these structures provide varying suitability with respect to hosting bats and providing roosting habitat. Pre-construction survey areas are also illustrated on the figure and are located near roosting habitat. It should be noted that the figure illustrates the areas most likely to support significant insect populations and therefore areas which would provide the best foraging habitat for bats. However, the figure is a simplification of all foraging habitat, as insects, and hence foraging, would occur across the project area.

Conclusion

Overall, there is a limited amount of roosting and foraging habitat in the project area compared to the amount of the total project area. sPower will conduct targeted pre-construction roost surveys in the areas identified, implementing PEIR Mitigation Measure BIO-12a and BIO-12b, to ensure impacts are avoided and minimized for roosting bats.



ICF

Figure 3
Sand Hill Wind Repowering Project

Attachment 9

DRAFT

BIRD AND BAT CONSERVATION STRATEGY FOR THE SAND HILL WIND REPOWERING PROJECT

PREPARED FOR:

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Acronyms and Abbreviations

APP	Avian Protection Plan
APWRA	Altamont Pass Wind Resource Area
AWPPS	Avian Wildlife Protection Program and Schedule
BBCS	Bird and Bat Conservation Strategy
BCC	Birds of Conservation Concern
BCR	Bird Conservation Region
BO	biological opinion
CDFW	California Department of Fish and Wildlife
CEC	California Energy Commission
CEC Guidelines	*California Guidelines for Reducing Impacts to Birds and Bats from Windplant Development*
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
CM	conservation measure
CNDDB	California Natural Diversity Database
County	Alameda County
DFG	California Department of Fish and Game
ECP	Eagle Conservation Plan
ESA	Endangered Species Act
FR	Federal Register
HCP	habitat conservation plan
M Opinion	*M-37050—The Migratory Bird Treaty Act Does Not Prohibit Incidental Take*
MBTA	Migratory Bird Treaty Act
MW	megawatts
PEIR	*Altamont Pass Wind Resource Area Repowering Program Environmental Impact Report*
proposed project	Sand Hill Wind Repowering Project
Sand Hill	Sand Hill Wind, LLC
SEIR	Subsequent EIR
sPower	Sustainable Power Group
SRC	Scientific Review Committee
TAC	Technical Advisory Committee
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
WEG	*Land-Based Wind Energy Guidelines*

Chapter 1
Introduction (Tier 1)

1.1 Purpose of the Bird and Bat Conservation Strategy

Sand Hill Wind, LLC (Sand Hill) is proposing the Sand Hill Wind Repowering Project (proposed project) in the Altamont Pass Wind Resource Area (APWRA) (Figure 1-1). Sand Hill would decommission and remove approximately 671 old generation wind turbines and install up to 40 new wind turbines (Figures 1-2a through 1-2c).

Sand Hill has prepared this Bird and Bat Conservation Strategy (BBCS) to ensure that feasible avoidance and minimization measures are implemented into project design and operation; that the project remains in compliance with federal, state, and local requirements; and that mitigation for impacts that cannot be avoided or minimized be addressed through an appropriate program of compensatory mitigation and adaptive management. Many of the practices that have been adopted by the wind power industry are described in U.S. Fish and Wildlife Service's (USFWS's) *Land-Based Wind Energy Guidelines* (WEGs, U.S. Fish and Wildlife Service 2012) and are incorporated in this BBCS. This BBCS is organized according to the tiered approach recommended in the WEGs.[1]

This document has also been prepared to support and be consistent with Alameda County's (County's) expected requirements for the proposed project under the *Altamont Pass Wind Resource Area Repowering Program Environmental Impact Report* (PEIR; Alameda Community Development Agency 2014), as well as expected requirements under a Subsequent EIR (SEIR), currently in preparation for the proposed project by Alameda County. PEIR Mitigation Measure BIO-11a requires preparation of a project-specific Avian Protection Plan (APP) that includes following components.

- Information and methods used to site turbines to minimize collision risk.
- Documentation that appropriate turbine designs are being used.
- Documentation that avian-safe practices are being implemented on project infrastructure.
- Methods used to discourage prey for raptors.
- A detailed description of the postconstruction avian fatality monitoring methods to be used.
- Methods used to compensate for the loss of raptors.

Lastly, golden eagles, due to their regulatory status and population trends, have become a species of particular concern in the context of wind projects. Because several facets of golden eagle behavior and biology bring eagles into potential conflict with wind energy production, USFWS has additional guidance for the preparation of Eagle Conservation Plans (ECPs; U.S. Fish and Wildlife Service 2013). Sand Hill has prepared a separate but complementary ECP that specifically focuses on eagles, whereas this BBCS more generally addresses avian and bat species. Sand Hill submitted the ECP and an eagle permit request to the USFWS in early 2018.

[1] Tier 1 of the WEG is a preliminary site evaluation, which consists of a landscape-scale screening of possible project sites. Because Sand Hill is a repowering project for an existing site, Tier 1 does not apply.

1.2 Overview of Repowering Projects in the APWRA

There have been as many as 5,400 wind turbines installed in the APWRA within Alameda and Contra Costa Counties (ICF International 2016). At the end of their operating lives, many of these turbines have been removed as part of other projects to reduce avian mortality. In 2013 there were approximately 3,337 wind turbines operating with an aggregate rated capacity totaling about 462 megawatts (MW), distributed over 37,000 acres (150 square kilometers). Although some old-generation turbines are still present in the APWRA, they are no longer operational and will be removed in the near future. Table 1-1 describes approved (operational or not yet operational) and foreseeable repowering projects in the APWRA. As of July 2019, there were five operational projects within the APWRA, together generating 268.6 MW. Projects totaling 592 MW (including Sand Hill) have been approved or are reasonably foreseeable in the APWRA in the future.

Table 1-1. Approved and Foreseeable Projects in the APWRA (Alameda and Contra Costa Counties)

Project Name	Owner or Operator	Number of Turbines/Rated Capacity per Turbine	Status	Type of CEQA Document Prepared or Anticipated to be Prepared	Total MW
Approved Projects					
Diablo Winds	Glidepath	31/0.66 MW	Approved/operational	1998 EIR	20.5
Buena Vista	Pattern	38/1.0 MW	Approved/operational	EIR	38.0
Vasco Winds	NextEra	34/2.3 MW	Approved/operational	EIR	78.2
Patterson Pass	EDF (now Centauri)	8/2.4–3.3 MW	Approved/not yet operational	PEIR	19.8
Golden Hills	NextEra	48/1.79 MW	Approved/operational	Approved/PEIR	85.9
Golden Hills North	NextEra	20/2.3 MW	Approved/operational	PEIR–Tiered	46.0
Summit Wind	AWI (now Castlelake)	27/TBD	Approved/not yet operational	PEIR–Tiered	54.0
Rooney Ranch	sPower	7/2.3–3.8 MW	Approved/not yet operational	PEIR–Tiered	25.1
Subtotal					**367.5**
Foreseeable Projects					
Sand Hill	sPower	40/2.3–4.0 MW	Pending	SEIR	144.5
Mulqueeney Ranch	Brookfield	80/TBD	Foreseeable	PEIR–Tiered	80
Total					**592**

1.3 Proposed Project

Sand Hill is proposing this project on 15 privately owned parcels in the APWRA. The proposed project would entail installation of up to 40 new wind turbines with generating capacities between 2.3 and 4.0 MW, totaling a maximum of 144.5 MW (Table 1-2). Three conceptual alternative layouts have been proposed; they are substantially similar, mainly varying with the location of 11 turbines in the center of the project area, south and west of Bethany Reservoir, and their relative distance from the primary access road for the project. The final layout would be selected on the basis of site constraints (e.g., avian siting considerations), data obtained from meteorological monitoring of the wind resources, and turbine availability. Each of these factors would be considered when micro-siting turbines, with the final layout reflecting one or some combination of the alternative layouts. Some new roads would be necessary, although existing roads would be used where possible and some may be temporarily widened. The proposed project would also require collection lines and a gen-tie line connecting the project to two substations.

The proposed project is currently undergoing review and consideration by Alameda County, tiered from the PEIR under a SEIR.

Table 1-2. Proposed Sand Hill Turbine Specifications[a]

Turbine Characteristic	Turbine Model		
	General Electric 2.3-116	General Electric 3.6-137	General Electric 3.8-130
Rotor type	3-blade/horizontal axis	3-blade/horizontal axis	3-blade/horizontal axis
Blade length	56.9 m (187 ft)	67.2 m (220 ft)	63.7 m (209 ft)
Rotor diameter	116 m (381 ft)	137 m (449 ft)	130 m (427 ft)
Rotor-swept area	10,568 m^2 (113,753 ft^2)	14,741 m^2 (158,671 ft^2)	13,273 m^2 (142,869 ft^2)
Rotational speed	Variable: 5.0–14.9 rpm	Variable: 6.3–13.6 rpm	Variable: 6.95–12.1 rpm
Tower type	Tubular	Tubular	Tubular
Tower (hub) height	80 m (308 ft)	81.5 m (267 ft)	85 m (279 ft)
Rotor height (from ground to lowest tip of blade)[b]	22 m (72.2 ft)	13.0 m (42.7 ft)	20 m (65.6 ft)
Total height (from ground to top of blade)	138 m (453 ft)	150 m (492 ft)	150 m (492 ft)

[a] Depending on availability at the time of construction, turbines of up to 4.0 MW may be used for the proposed project. Turbine dimensions would not exceed those shown in the table, and the project capacity would not exceed 144.5 MW.

[b] Depending on the type of turbine and tower height used for the proposed project, total height would be up to but would not exceed 152 m (499 ft).

1.4 Regulatory Setting

A number of state and federal laws protect birds and their young, and several laws protect selected wildlife species of conservation concern. Additionally, state and federal agencies have drafted guidance to address impacts on birds and bats from wind energy projects.

1.4.1 Federal Regulations and Guidance

Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) (16 United States Code [USC] 703–712) enacts the provisions of treaties between the United States, Great Britain, Mexico, Japan, and the Soviet Union and authorizes the U.S. Secretary of the Interior to protect and regulate the taking of migratory birds. It protects migratory birds, their occupied nests, and their eggs (16 USC 703; 50 Code of Federal Regulations [CFR] 21; 50 CFR 10). Most actions that result in *take*—defined as hunting, pursuing, wounding, killing, possessing, or transporting any migratory bird, nest, egg, or part thereof—are prohibited under the MBTA. Examples of permitted actions that do not violate the MBTA are the possession of a hunting license to pursue specific gamebirds, legitimate research activities, display in zoological gardens, bird-banding, and other similar activities. USFWS is responsible for overseeing compliance with the MBTA.

On December 22, 2017, the U.S. Department of Interior Office of the Solicitor issued a memorandum: *M-37050—The Migratory Bird Treaty Act Does Not Prohibit Incidental Take* (M Opinion). The M Opinion withdrew and replaced Solicitor's Opinion *M-37041—Incidental Take Prohibited Under the Migratory Bird Treaty Act*, issued January 10, 2017. The M Opinion concludes that "the MBTA's prohibitions on pursuing, hunting, taking, capturing, killing, or attempting to do the same only criminalize affirmative actions that have as their purpose the taking or killing of migratory birds, their nests, or their eggs." USFWS issued guidance on the M Opinion on April 11, 2018, to clarify what constitutes prohibited take and what actions must be taken when conducting lawful intentional take. The guidance interprets the M Opinion to mean that the MBTA's prohibitions on take apply when the purpose of an action is to take migratory birds, their eggs, or their nests. The take of birds, eggs, or nests that results from an activity—the purpose of which is not to take birds, eggs, or nests—is not prohibited by the MBTA.

Federal Endangered Species Act

USFWS has jurisdiction over species listed as threatened or endangered under Section 9 of the federal Endangered Species Act (ESA). The ESA protects listed species from *take*—i.e., to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct." For any project involving a federal agency in which a listed species could be affected, the federal agency must consult with USFWS in accordance with Section 7 of ESA. USFWS issues a biological opinion (BO) and, if the project does not jeopardize the continued existence of the listed species, issues an incidental take permit. When no federal context is present, proponents of a project affecting a listed species must consult with USFWS and apply for an incidental take permit under Section 10 of the ESA. Section 10 requires an applicant to submit a habitat conservation plan that specifies project impacts and mitigation measures.

Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act (Eagle Act; 16 USC 668), signed into law in 1940 and expanded in 1962 to include golden eagle, prohibits take and disturbance of individuals and nests. *Take* under the Eagle Act includes any actions to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, destroy, molest, and disturb eagles. *Disturb* is further defined in 50 CFR 22.3 as:

> to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available (1) injury to an eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior.

Prior to 2009, permits for purposeful take of birds or body parts were limited to scientific (50 CFR 22.21), religious (50 CFR 22.22), or falconry (50 CFR 22.24) pursuits; eagles causing serious injury to livestock or other wildlife (50 CFR 22.23); and golden eagle nests that interfered with resource development or recovery operations (50 CFR 22.21–25). In 2009, USFWS issued the 2009 Final Rule on new permit regulations that allows take "for the protection of…other interests in any particular locality" and where the take is "associated with and not the purpose of an otherwise lawful activity" (74 Federal Register [FR] 46836–46879). The 2009 Final Rule authorized programmatic take (take that is recurring and not in a specific, identifiable timeframe or location) of eagles only if avoidance measures have been implemented to the maximum extent achievable such that take was no longer avoidable.

In 2016, USFWS issued revisions to the Final Rule pertaining to incidental take and take of eagle nests, changing the programmatic take standard to a new standard authorizing "incidental take" if all "practicable" measures to reduce impacts on eagles are implemented. An eagle incidental take permit under the 2016 Revisions to the Final Rule (50 CFR 22) is available for activities that may disturb or otherwise take eagles on an ongoing basis, such as operational activities.

The eagle incidental take permit under the 2009 Final Rule was valid up to 5 years. In 2012, USFWS proposed to extend the maximum term for eagle incidental take permits from 5 to 30 years (77 FR 22267–22278). In 2013, USFWS issued a Final Rule to extend the maximum term for eagle incidental take permits to 30 years, subject to a recurring 5-year review process throughout the life of the permit. Although this rule was challenged in 2015, the final regulations under the 2016 Revisions to the Final Rule also include a maximum permit term of 30 years, subject to a recurring 5-year review process throughout the life of the permit (81 FR 91494–91554).

Land-Based Wind Energy Guidelines

The WEGs were developed by USFWS in collaboration with the Wind Turbine Guidelines Advisory Committee to replace interim voluntary guidance prepared in 2003. The guidelines discuss various risks to species of concern from wind energy projects and provide guidance for assessing potential adverse effects on species of concern and their habitats. Species of concern include migratory birds; bats; bald and golden eagles and other birds of prey; prairie and sage grouse; and listed, proposed, or candidate species.

The WEGs are structured in tiers.

- Tier 1—Preliminary site evaluation (landscape-scale screening of possible project sites).
- Tier 2—Site characterization (broad characterization of one or more potential project sites).
- Tier 3—Field studies to document site-specific wildlife and habitat and predict project impacts.
- Tier 4—Post-construction studies to estimate impacts.
- Tier 5—Other post-construction studies and research.

During the pre-construction tiers (Tiers 1, 2, and 3), developers work to identify, avoid, and minimize risks to species of concern. During post-construction tiers (Tiers 4 and 5), developers assess whether actions taken in earlier tiers to avoid and minimize impacts are successfully achieving the goals and, when necessary, take additional steps to compensate for impacts. Each tier builds upon the previous tier(s) by refining and building upon issues previously raised and efforts undertaken. The stages of the ECP guidance follow these tiers closely.

The tiered approach allows developers to evaluate and make decisions at each stage. Developers can either abandon or proceed with project development, or they can collect additional information if required. If sufficient data are available for a specific tier, the following outcomes are possible.

1. The project proceeds to the next tier in the development process without additional data collection.
2. The project proceeds to the next tier in the development process with additional data collection.
3. An action or combination of actions, such as project modification, mitigation, or specific post-construction monitoring, is indicated.
4. The project site is abandoned because the risk is considered unacceptable.

If sufficient data are not available for a tier, more intensive study is conducted in the subsequent tier until sufficient data are available to make a decision to modify the project, proceed with the project, or abandon the project. Following the WEGs is voluntary, but USFWS will consider a developer's adherence to the WEGs if take of birds occurs.

1.4.2 State Regulations and Guidelines

California Endangered Species Act

California implemented the California Endangered Species Act (CESA) in 1984. The act prohibits the take of endangered and threatened species, but habitat destruction is not included in the state's definition of take. Under CESA, *take* is defined as an activity that would directly or indirectly kill an individual of a species, but the definition does not include harm or harassment. The California Department of Fish and Wildlife (CDFW) administers CESA and authorizes take through either Section 2080.1 (for species listed under ESA and CESA) or Section 2081 agreements (except for species designated as fully protected).

California Fish and Game Code

Fully Protected Species

Various sections of the California Fish and Game Code provide for the protection of fully protected species. Section 5050 lists fully protected amphibians and reptiles, Section 3515 lists fully protected fish, Section 3511 lists fully protected birds, and Section 4700 lists fully protected mammals. The California Fish and Game Code defines *take* as "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." Except for take related to scientific research, all take of fully protected species is prohibited unless authorized pursuant to an approved natural community conservation plan under Section 2835.

Sections 3503 and 3503.5 (Protection of Birds and Raptors)

Section 3503 of the California Fish and Game Code prohibits the killing of birds and/or the destruction of bird nests. Section 3503.5 prohibits the killing of raptor species and/or the destruction of raptor nests.

California Environmental Quality Act

The California Environmental Quality Act (CEQA) is the regulatory framework by which California public agencies identify and mitigate significant environmental impacts on the environment. Although threatened and endangered species are protected by specific federal and state laws, the State CEQA Guidelines Section 15380(b) provides that a species not listed under ESA or CESA may be considered rare or endangered if it can be shown that the species meets specific criteria. These criteria have been modeled after the definitions of ESA and sections of the California Fish and Game Code discussing rare and endangered wildlife.

During the CEQA review process, environmental impacts are assessed and their significance determined on the basis of established thresholds of significance. Thresholds are established using guidance from CEQA, particularly Appendix G of the State CEQA guidelines and CEQA Section 15065 (Mandatory Findings of Significance). CEQA guidance is then refined or defined based on further direction from the lead agency.

For the purposes of CEQA, a biological resource impact is considered significant (before considering offsetting mitigation measures) if the lead agency determines that project implementation would result in one or more of the following conditions.

- Substantial adverse effects, either directly or through habitat modifications, on any species identified as being a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by CDFW or USFWS.
    - A substantial adverse effect on a special-status wildlife species is typically defined as one that would result in at least one of the following conditions.
        - Reducing the known distribution of a species.
        - Reducing the local or regional population of a species.
        - Increasing predation of a species leading to population reduction.
        - Reducing habitat availability sufficient to affect potential reproduction.
        - Reducing habitat availability sufficiently to constrain the distribution of a species and not allow for natural changes in distributional patterns over time.
- Substantial interference with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impedance of the use of native wildlife nursery sites.
    - Substantial impedance of resident wildlife movement is typically defined as obstructions that prevent or limit wildlife access to key habitats, such as water sources or foraging habitats, or obstructions that prohibit access through key movement corridors considered important for wildlife to meet needs for food, water, reproduction, and local dispersal.
    - Substantial interference with migratory wildlife movement is typically defined as obstructions that prevent or limit regional wildlife movement through the project area to

meet requirements for migration, dispersal, and gene flow that exceed the defined baseline condition.

Consistent with CEQA Section 15065 (Mandatory Findings of Significance), a biological resource impact is considered significant if the project has the potential to create at least one of the following effects.

- Substantially degrading the quality of the environment.
- Substantially reducing the habitat of a fish or wildlife species.
- Causing a fish or wildlife population to drop below self-sustaining levels.
- Threatening to eliminate a plant or animal community.
- Substantially reducing the number or restricting the range of an endangered, rare, or threatened species.

California Energy Commission Guidelines

Published by the California Energy Commission (CEC) and the California Department of Fish and Game (2007), the *California Guidelines for Reducing Impacts to Birds and Bats from Windplant Development* (CEC Guidelines) outline the generally accepted procedures for the permitting and study of wind energy developments in the state. The CEC Guidelines are intended to provide a strategy to reduce impacts on birds and bats from new wind energy developments or repowering of existing wind energy projects in California. The CEC Guidelines include recommendations for screening proposed sites; study design; impact assessment; and development of avoidance, minimization, and mitigation measures. Although following the CEC Guidelines is voluntary, for the most part they represent the current state of knowledge on wind–wildlife interactions and are generally accepted by industry and agencies as one of the best available resources and frameworks for assessing potential impacts on birds and bats from wind energy projects in California. The CEC Guidelines describe four project categories used to determine recommended levels of pre-project study, reproduced below.

> **Category 1—Project Sites with Available Wind-Wildlife Data.** Some proposed projects have the advantage of an existing foundation of data on bird and bat use and potential impacts from nearby similar projects. For these Category 1 projects, a reduced study effort may be appropriate. Projects potentially falling into Category 1 might include infill development, repowering projects, and those near existing wind facilities for which there is little uncertainty as to the level of impacts. Consultation with the lead agency, USFWS, DFG [now CDFW], biologists with specific expertise, and other appropriate stakeholders (such as a conservation organization representative) is recommended when considering whether a project qualifies as Category 1. Factors to consider in determining whether or not data from an adjacent facility would allow a project to be classified as Category 1 include:
>
> - Whether the field data were collected using a credible sampling design
> - Where the data were collected in relation to the proposed site
> - Whether the existing data reflect comparable turbine type, layout, and habitat
> - Suitability for migratory species, physical features, and winds
> - Whether the data are scientifically defensible and still relevant
>
> Category 1 projects may not need a full year of pre-permitting studies to answer questions about potential collision risk because of the availability of existing data. Caution is warranted in

extrapolating existing data to unstudied nearby sites. Slight topographical or habitat variations can make substantial differences in bird and bat site use and potential impacts. In addition, technological changes, including use of large turbines, variations in turbine design or layout, increased operating times, and use of different lighting, may require new or additional data gathering.

Category 2—Project Sites with Little Existing Information and No Indicators Of High Wildlife Impacts. Projects in Category 2 have no obvious "red flags" that emerge from the preliminary site assessment (for example, "red flags" might be known occurrences of special-status species or high levels of fatalities at nearby wind facilities) and no substantial body of information from nearby projects that could provide information for an impact assessment. Pre-permitting surveys should last a minimum of one year to document how birds and bats use a site during spring, summer, fall, and winter.

Category 3—Project Sites with High or Uncertain Potential for Wildlife Impacts. Projects with high levels of bird and/or bat use or considerable uncertainty regarding bird and bat use or risk will need more study than Category 2 projects to help understand and formulate ways to reduce the number of fatalities. Characteristics of a site that might put a proposed project in Category 3 are:

- Known avian migration stopover destinations such as water bodies within or immediately adjacent to the project
- Special-status species occurring on or adjacent to a proposed site
- High concentrations of wintering and/or breeding raptors
- Sites near or contiguous to wind projects that have experienced high bird or bat fatalities that cannot be avoided or minimized

Pre-permitting studies in excess of one year may be necessary for Category 3 projects when baseline information is lacking and when considerable annual and seasonal variation in bird and bat populations is suspected or when there is potential for declining or vulnerable species to occur at the site.

Category 4—Project Sites Inappropriate for Wind Development. Wind development should not be considered on land protected by local, state, or federal government as: designated wilderness areas, national parks or monuments, state parks, regional parks, and wildlife or nature preserves. Sites for which existing data indicate unacceptable risk of bird or bat fatalities might also be appropriately classified as Category 4, particularly if no feasible avoidance or mitigation measures are available to reduce impacts.

Based on the survey and monitoring work that has been conducted in the APWRA and discussions with USFWS, Sand Hill considers the proposed project site a Category 1 site.

1.5 Corporate Policy

Sustainable Power Group (sPower), the parent company to Sand Hill, is committed to partnering with key stakeholders to execute high-quality renewable energy. sPower is working to provide clean energy at affordable prices, while serving the greater need of the community to create jobs and contain the damaging impact of carbon and greenhouse-gas emissions for the future. sPower is committed to implementing feasible measures to avoid and minimize avian and bat mortality associated with construction and operation of its wind energy projects.

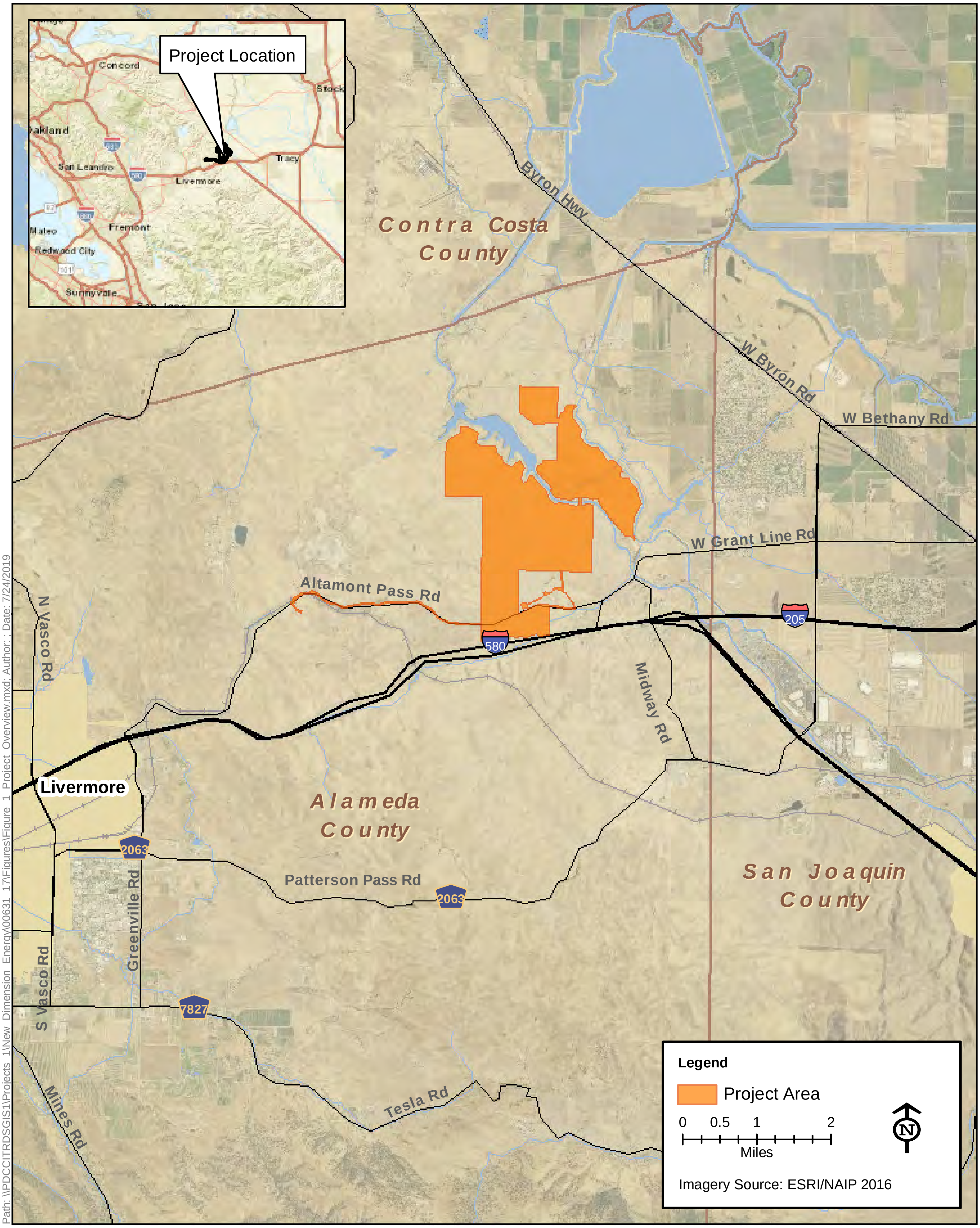

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Figure 1-1
Project Location

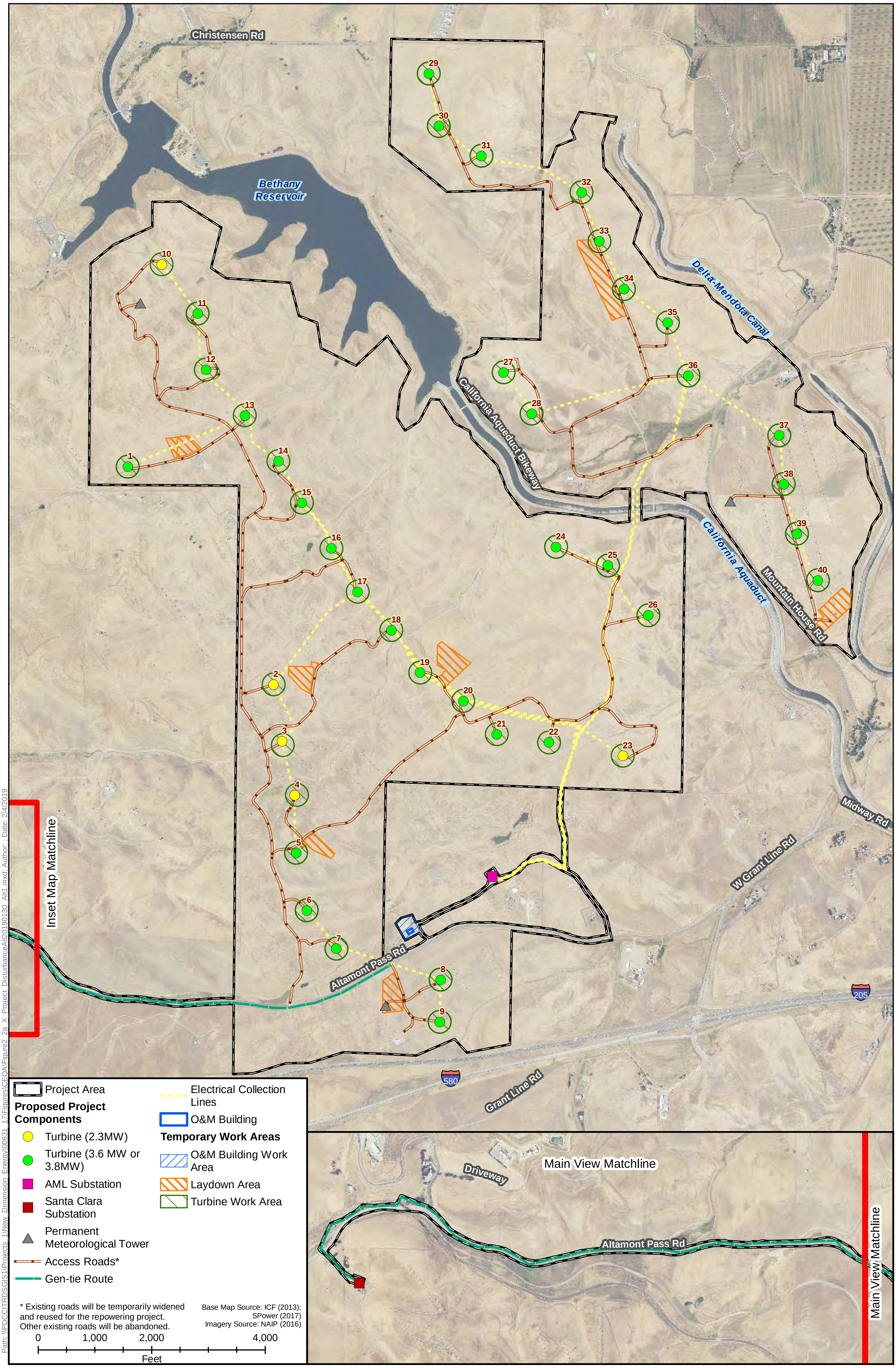

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Figure 1-2a
Sand Hill Wind Repowering Project Layout 1

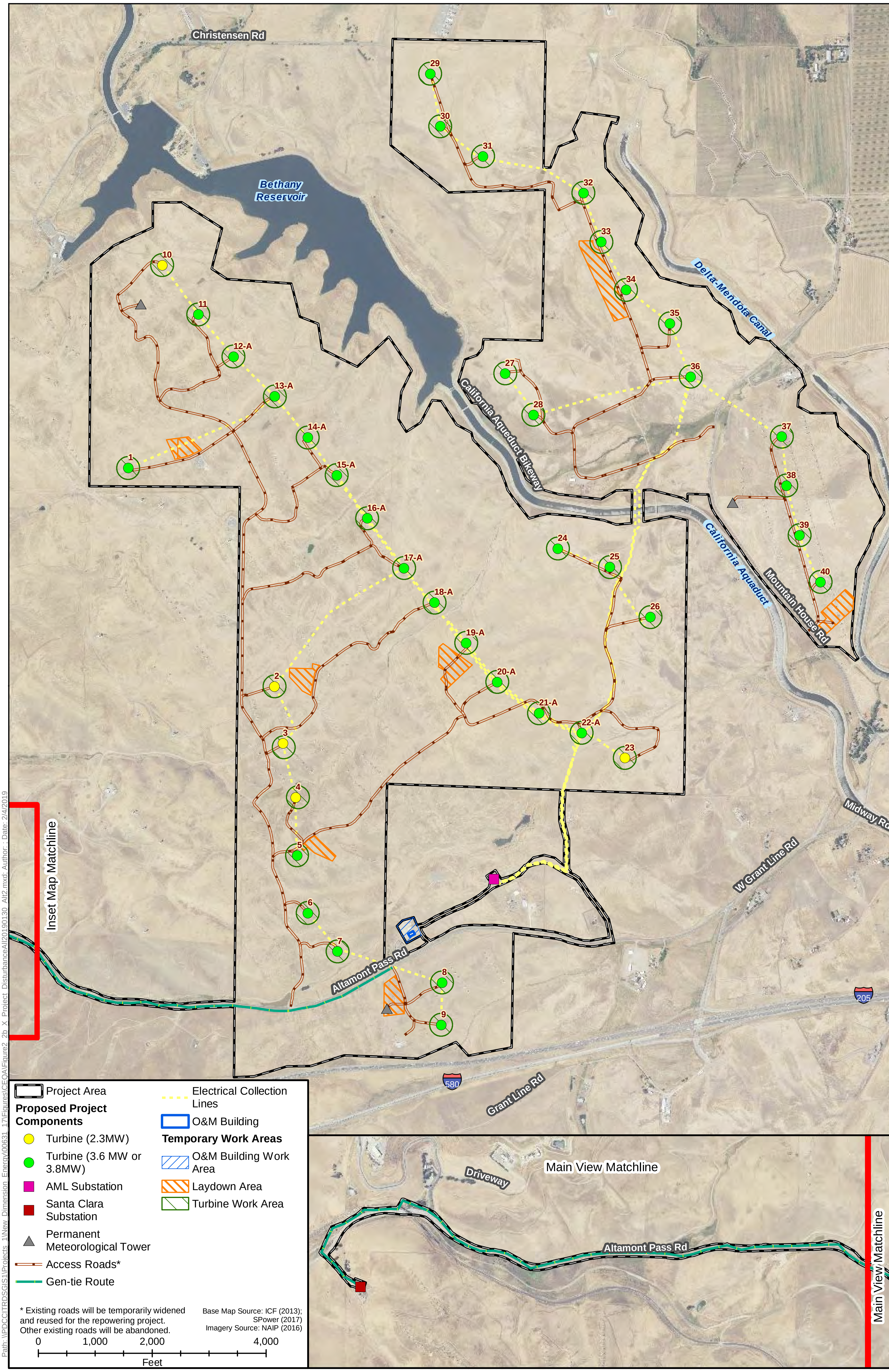

Figure 1-2b
Sand Hill Wind Repowering Project Layout 2

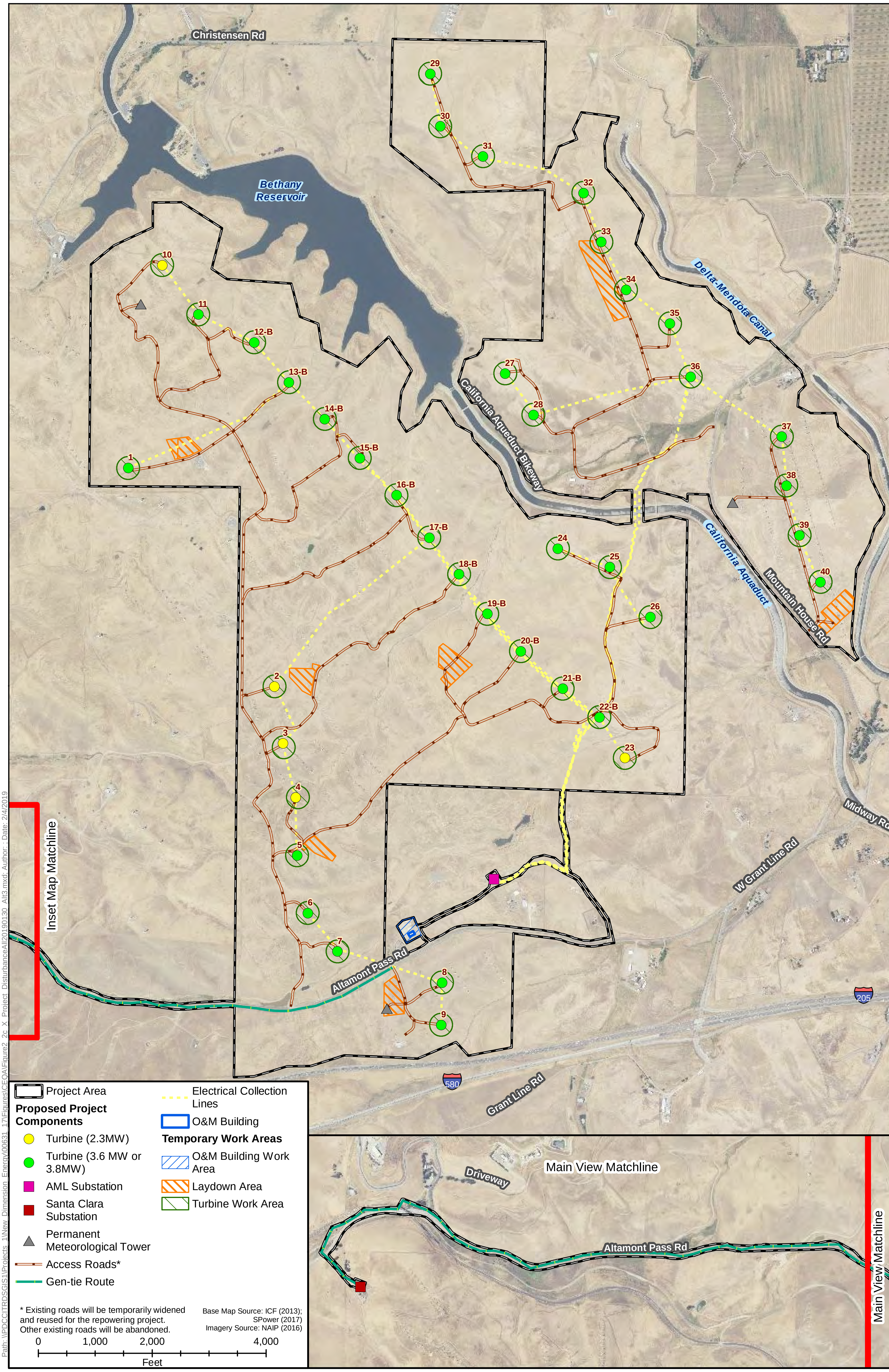

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Figure 1-2c
Sand Hill Wind Repowering Project Layout 3

Chapter 2
Site Characterization and Surveys (Tiers 2 and 3)

2.1 Project Area and Vicinity

The APWRA is in the Diablo Range of central California, approximately 56 miles (90 kilometers) east of San Francisco. The approximately 2,700-acre project area—most of which was developed with old-generation wind turbines in the Alameda County portion of the APWRA—comprises 15 parcels north of Interstate 580 (Figure 1-1). Land use in the project area and the surrounding APWRA consists largely of cattle-grazed land supporting operating wind turbines and ancillary facilities. Other major anthropogenic features of the region are the wind turbines and ancillary facilities, an extensive grid of high-voltage power transmission lines, substations, microwave towers, a landfill site, Interstate 580, railroads, ranch houses, clusters of rural residential homes on Dyer and Midway Roads, Bethany Reservoir, and South Bay Pumping Plant.

Generally characterized by rolling foothills of annual grassland, the region is mostly treeless and steeper on the west and gradually flatter on the east where it slopes toward the floor of the Central Valley. Elevations in the area range from approximately 600 to 1,200 feet above sea level. The area is predominantly used for cattle grazing. Winters are mild with moderate rainfall, but summers are very dry and hot. Winter wind speeds average 9–15 miles per hour (15–25 kilometers per hour). The spring and summer high wind period is when 70–80% of the wind turbine power is generated in the APWRA (Smallwood and Thelander 2004).

The APWRA supports a broad diversity of resident, migratory, and wintering bird species that regularly move through the wind turbine area (Orloff and Flannery 1992). In particular, diurnal raptors (eagles and hawks) use the prevailing winds and updrafts for soaring and gliding during daily movement, foraging, and migration. Birds passing through the rotor plane of operating wind turbines are at risk of being injured or killed. Multiple studies of avian fatality in the APWRA show that substantial numbers of golden eagles, red-tailed hawks, American kestrels, burrowing owls, barn owls, and a diverse mix of non-raptor species are killed each year in turbine-related incidents (Howell and DiDonato 1991; Orloff and Flannery 1992; Smallwood and Thelander 2004). Many of these species are protected by both federal and state wildlife legislation.

2.2 Bird and Bat Use

2.2.1 Avian Surveys in the Altamont Pass Wind Resource Area

The project area and surrounding APWRA have been studied intensively for avian use and fatalities. The numbers of birds killed annually in the APWRA in turbine-related incidents led to substantial controversy, which in September 2005 resulted in the Alameda County Board of Supervisors attaching extensive conditions of approval to use permits for the continued operation of wind power projects. Aimed at achieving major reductions in avian fatalities, these conditions included the formation of an Avian Wildlife Protection Program and Schedule (AWPPS) and the formation of a

Scientific Review Committee (SRC) and a Monitoring Team. The AWPPS consisted of several measures and management actions, such as the strategic removal of turbines, strategic turbine shutdowns, and other actions aimed at reducing turbine-related avian fatalities. The SRC provided expertise on research and monitoring related to wind energy production and avian behavior and safety. The SRC advised Alameda County and the power companies on actions to reduce turbine-related avian fatalities including the identification of hazardous turbines for removal or relocation and recommendations for the timing and duration of turbine shutdowns. In 2007, the AWPPS was modified by a settlement agreement to end litigation against Alameda County that had been initiated by environmental groups. This agreement included a goal to reduce turbine-related fatalities for four focal species (American kestrel, burrowing owl, golden eagle, and red-tailed hawk) by 50% from an estimate of annual raptor fatalities generated from data collected during the period 1998–2003. The primary goal of the avian fatality monitoring program, which ran continuously from October 1, 2005, through September 30, 2014, was to assess progress toward achieving the 50% reduction target.

Between 2005 and 2014 , 12,304 surveys throughout the APWRA were conducted focusing primarily on the four focal species (ICF International 2016). Avian use surveys for American kestrel, burrowing owl, golden eagle, and red-tailed hawk were first implemented by the Monitoring Team at the Diablo Winds operating group in April 2005 and were expanded to the entire APWRA in December 2005. The number of observation points has ranged from 92 in the 2006 bird year (October 1, 2006 through September 30, 2007) to 47 in the 2012 bird year. From 2005 to 2013, there were several changes in the bird survey methodology (number of observation points, survey time, search radius, species observation recorded) (ICF International 2016). Beginning in 2013, information was recorded on all species present, rather than just diurnal raptors. In addition to APWRA-wide bird use surveys conducted by the Monitoring Team, bird use surveys have been conducted at the Buena Vista and Vasco winds repowering projects.

2.2.2 Resident and Migratory Birds

The APWRA supports a broad diversity of resident, migratory, and wintering bird species that regularly move through the wind turbine area (Orloff and Flannery 1992). A total of 87 avian species were detected during APWRA use surveys across all years (ICF International 2016). However, relative abundance for APWRA non-focal species could only be evaluated for 2013 because that was the only year in which use by all species was consistently recorded. Various gulls (California, western, and ring-billed), common raven, red-tailed hawk, and blackbirds (Brewer's, tricolored, and red-winged) were the most abundant species in the APWRA in the 2013 monitoring year. Fourteen species of raptor (including owls and turkey vulture) were detected in 2013, with the four focal species and turkey vulture being the most common. Red-tailed hawks were five times more abundant than American kestrels, the second most abundant raptor species in the 2013 monitoring year (ICF International 2016). Appendix A lists all resident and migratory bird species documented in the APWRA.

For this BBCS, estimated mortality rates were calculated for the APWRA settlement focal species and the Bird Conservation Region (BCR) 32 Birds of Conservation Concern (BCC) (U.S. Fish and Wildlife Service 2008) that have been documented in the APWRA (Table 2-1). Review of the list of BCC species that were determined likely to be subject to turbine-related fatality indicated that, of the 46 BCC species in BCR 32 (Appendix B), 8 of these species have been documented in the APWRA. Of these, 7 of the species have been documented in postconstruction monitoring as turbine-related fatalities (Table 2-1). Although red-tailed hawk and American kestrel are not BCC species, they were also considered "species of local interest" for the purposes of this analysis because they are APWRA settlement focal species.

Table 2-1. Birds of Conservation Concern and Bird Species of Interest That Have Been Documented in the APWRA

Species	Status[a]	Live Observation in the APWRA	Nest within 10 Miles of Project Site	Documented Fatality in the APWRA
Red-tailed hawk[b]	–	Yes	Yes	Yes
Bald eagle	BCC	Yes	No	No
Golden eagle	FP	Yes	Yes	Yes
Long-billed curlew	BCC	Yes	No	No
Burrowing owl	BCC, SSC	Yes	Yes	Yes
Peregrine falcon	FP, BCC	Yes	Unknown	Yes
American kestrel[b]	–	Yes	None documented, but likely	Yes
Loggerhead shrike	BCC, SSC	Yes	Yes	Yes
Yellow-billed magpie	BCC	Yes	Unknown	No
Yellow warbler	BCC	Yes	Unknown	Yes
Tricolored blackbird	BCC, SSC	Yes	Likely	Yes

Sources: Insignia Environmental 2012; Brown et. al 2016; ICF International 2016.

[a] FP = state fully protected; BCC = Bird of Conservation Concern; SSC = California species of special concern.

[b] Red-tailed hawk and American kestrel are not BCCs but are considered "species of local interest" for the purpose of this analysis because they were identified as focal species in the 2007 Settlement Agreement.

2.2.3 Resident and Migratory Bats

The APWRA supports habitat types suitable for maternity, foraging, and migration for special-status and common bats. Several of these species are susceptible to direct mortality through collision or other interactions with wind turbines. Five bat species have been documented as fatalities in the APWRA: little brown bat, California myotis, western red bat, hoary bat, and Mexican free-tailed bat (Insignia Environmental 2012; ICF International 2016). Hoary bats and Mexican free-tailed bats have made up the majority of documented fatalities; western red bat, another migratory species and a California species of special concern, has sustained the third highest number of documented fatalities.

Other than fatality records, occurrence data for bat species in the APWRA are limited, and expectations of presence are generally based on known ranges and habitat associations. However, preliminary analysis of preconstruction and postconstruction acoustic survey data from the recently repowered Vasco Winds facility in the Contra Costa County portion of the APWRA documents the presence of four additional species (big brown bat, silver-haired bat, canyon bat, and Yuma myotis). Acoustic surveys indicated bat activity in all three seasons in which surveys were conducted, with a spike in activity in the fall (Pandion Systems 2010; Szewczak 2013). Mexican free-tailed bat (47% of detections) and hoary bat (40% of detections) accounted for the majority of the acoustic detections (Pandion Systems 2010). Additional postconstruction acoustic surveys were conducted during the fall migratory season (August to December) at Vasco Winds. Mexican free-tailed bat was the most common species detected, accounting for 84% of all detections (Szewczak 2013).

Dense woodlands and crevices in large rock outcrops at Vasco Caves Regional Preserve (approximately 4 miles from the northern boundary of the project area), Brushy Peak Regional Preserve (approximately 2.5 miles from the project area), and other pockets of trees could provide roosting habitat for tree-roosting bat species, including hoary, western red, and silver-haired bats. However, the project area itself is largely grassland, and rock outcrops are relatively small; consequently, little roosting habitat is likely present within the project area.

Maternity colonies of Yuma myotis and pallid bat, both nonmigratory species, occur within 23 miles of the APWRA (Johnston et al. 2010). Yuma myotis is a riparian obligate that specializes on gleaning aquatic emergent insects and is not expected to forage in the project area because of the paucity of appropriate habitat. Pallid bats typically glean insects off the ground in open grasslands and are expected to occasionally forage in the project area. Although ample foraging habitat for pallid bat occurs within the APWRA, this species is not expected to be at risk because it rarely forages or commutes more than a few yards above ground level (Szewczak 2013).

A pallid bat roost site is reported in the California Natural Diversity Database (CNDDB) (California Department of Fish and Wildlife 2018) in a mine approximately 12 miles southeast of the project area. Multiple scattered Townsend's big-eared bats were also identified at this site, suggesting that males and a nursery colony could potentially be nearby. A Townsend's big-eared bat roost is also reported at Dos Mesas wine cave, 3.5 miles south of Livermore and approximately 9 miles southwest of the project area. This was presumed to be a maternity roost (California Department of Fish and Wildlife 2018).

Chapter 3
Risk Assessment (Tier 3)

Operation of wind plants can cause fatalities of birds through collision with turbine blades and of bats through collision and barotrauma (sudden changes in air pressure created by blade movement). Extensive studies have been conducted in the APWRA; data from those studies have been used to develop mortality projections for this project.

The National Wind Coordinating Committee—an organization funded by the U.S. Department of Energy's Wind and Water Technologies Program and composed of representatives from utilities, wind developers, environmental organizations, states, federal agencies, and consumer advocacy groups (among others)—published a paper in 2001 that summarized existing mortality studies and compared avian mortality from wind plants with other sources of avian mortality (Erickson et al. 2001). The paper concluded that current levels of mortality caused by wind plants do not appear to be causing significant population impacts on avian species, with the possible exception of golden eagle impacts at the APWRA.

The project area and surrounding APWRA have been studied intensively for avian use and fatalities. Accordingly, the project is a CEC Guidelines Category 1 project, defined as projects for which there is existing information sufficient to predict the project's potential impacts with a reasonable degree of accuracy. Multiple years of defensible, empirical mortality data are available for wind facilities in the APWRA, including several recent repowering projects.

The PEIR (Alameda County Community Development Agency 2014) summarized existing mortality data available in the Altamont. Recently, ICF (2019) prepared an avian and bat assessment for the Sand Hill Wind Repowering Project that summarizes existing and recent mortality monitoring data within the APWRA and provides estimates of potential avian and bat impacts. Information on risk and potential mortality rates are summarized briefly here.

3.1.1 Avian Species

Mortality estimates for avian species at the project were developed by compiling the postconstruction mortality rates documented at four repowered facilities in the APWRA. Because the studies were conducted under varying conditions, timeframes, and protocols, the estimates for the project were developed using a broad analytic brush to encompass the full range of potential analytic variability.

To normalize the data across wind projects based on facility size and energy output, this assessment was conducted using adjusted mortality estimates (developed by applying searcher efficiency and carcass removal factors to documented fatalities) from four studies: a 5-year mortality study at the Diablo Winds site (ICF International 2016), a 3-year study at the Buena Vista Wind Farm site (Insignia Environmental 2012), a 3-year study at the Vasco Winds site (Brown et al. 2016), and a 2-year study at the Golden Hills site (H.T. Harvey & Associates 2018a, 2018b). The data were standardized on the basis of fatalities/MW/year to adjust for the differences in turbine capacities between the proposed project and the studies used to calculate mortality estimates. Average rates and weighted average rates were calculated based on the duration of postconstruction fatality monitoring. Estimates for the proposed project were calculated by multiplying the number of MW (N = 144.5) by fatalities/MW/year.

The estimated annual mortality rates (adjusted using scavenger removal and searcher efficiency correction factors) for repowering projects in the APWRA are provided per MW for the four repowering studies (Table 3-1). The mortality rates for the four studies were used to estimate the range of estimated annual fatalities for the proposed project (Table 3-2).

Table 3-1. Annual Adjusted Mortality Rates for Nonrepowered and Repowered APWRA Turbines

		Repowered			
Species/Group	Nonrepowered[a]	Diablo Winds[b]	Buena Vista[c]	Vasco Winds[d]	Golden Hills[e]
American kestrel	0.59 (0.5902)	0.09	0.15	**0.28 (-0.02)**	**0.17**
Barn owl	0.24 (0.2145)	0.02	0.00	**0.02 (-0.01)**	**0.06**
Burrowing owl	0.78 (0.7754)	0.84	–	**0.06 (+0.01)**	**0.58**
Golden eagle	0.08 (0.0807)	0.01	0.04	**0.06 (+0.03)**	**0.13–0.15[g]**
Loggerhead shrike	0.19 (0.1879)	0.00	–	–	**0.07**
Prairie falcon	0.02 (0.0201)	–	0.00	**0.01 (+0.01)**	**0.01**
Red-tailed hawk	0.44 (0.4391)	0.20	0.10	**0.21 (-0.04)**	**0.64**
Tricolored blackbird[f]	–	–	–	**0.02 (+0.02)**	**0.02**
White-tailed kite[f]	–	–	–	–	**0.02**
Swainson's hawk	0.00 (0.0014)	–	–	–	–
All raptors	2.43 (2.4313)	1.21	0.31	**0.64 (0.00)**	**1.74**
All native non-raptors	4.50 (4.5046)	2.51	1.01	**2.04 (+0.05)**	**5.38**

Notes:

Mortality rates reflect annual fatalities per MW. "–" denotes that no fatalities were detected. "0.00" signifies that, although fatalities were detected, the rate is lower than two significant digits.

Information in bold text is changed or new mortality rates available since the PEIR was prepared. Information in bold parentheses is the change in the mortality rate since the PEIR.

[a] Average of 2005–2011 bird years (as reported in Table 3.4-10 of the PEIR). The numbers in parenthesis are the estimates out to four significant digits that were used to calculate baseline mortality rates in the PEIR.

[b] Average of 2005–2009 bird years (as reported in Table 3.4-10 of the PEIR).

[c] Average of 3 years (2007–2009) (as reported in Table 3.4-10 of the PEIR).

[d] Average of 3 years as reported in Brown et al. 2016. Numbers in parentheses represent the change since the numbers reported in Table 3.4-10 of the PEIR.

[e] Average of 2 years as reported in H. T. Harvey & Associates (2018a, 2018b).

[f] Tricolored blackbird was not reported in this table in the PEIR but has been added because of its recent listing under CESA and reported fatalities at Vasco Winds and Golden Hills. Similarly, white-tailed kite was not reported in this table in the PEIR but has been added because of its fully protected status.

[g] As noted in H. T. Harvey & Associates (2018a), the estimates of golden eagle mortality rates varied between 0.07 and 0.13 bird/MW/year for the first year of monitoring, depending on the estimation method used. The authors noted that the more appropriate mortality rate estimate may be 0.09 bird/MW/year because of searcher efficiency and carcass persistence considerations. Consequently, the range of mortality rates reported for Golden Hills (as averaged over 2 years) is presented here for golden eagle.

Table 3-2. Range of Estimated Annual Fatalities at the Sand Hill Wind Repowering Project

	Total Estimated Annual Fatalities for the Sand Hill Wind Repowering Project[a]			
Species/Group	Low	High	Average[b]	Weighted Average[c]
American kestrel	13	41	25	23
Barn owl	0	9	4	3
Burrowing owl	0	121	54	62
Golden eagle	2	22	8	6
Loggerhead shrike	0	10	3	2
Prairie falcon	0	1	1	1
Red-tailed hawk	15	93	42	36
Tricolored blackbird	0	3	1	1
White-tailed kite	0	3	1	<1
Swainson’s hawk	0	0	0	0
All raptors	45	251	141	138
All native non-raptors	146	777	395	361

Notes:

[a] All estimates based on an existing and proposed capacity of 144.5 MW for the Sand Hill Repowering Project area.

[b] Average number of fatalities from four repowering projects: Diablo Winds, Buena Vista, Vasco Winds, and Golden Hills.

[c] The weighted average is calculated by considering each year of fatality monitoring for each wind energy facility in the calculations. For example, the Vasco Winds project completed 3 years of fatality monitoring, and each is year is considered in the calculated estimates. Using this method, projects with more monitoring years are given more “weight” compared to projects with fewer monitoring years.

3.1.2 Bat Species

As of the preparation of the PEIR, five species of bats have been documented as fatalities in the APWRA: little brown bat, California myotis, western red bat, hoary bat, and Mexican free-tailed bat. Since the PEIR, additional monitoring results from Vasco Winds and Golden Hills have detected two additional bat species: big brown bat and silver-haired bat (Table 3-3, updated from Table 3.4-6 in the PEIR—one unadjusted fatality for each species).

Estimates of bat mortality rates from several sources were used to provide a range of bat fatality estimates that could result from repowering. The primary source, Vasco Winds, was supplemented with bat mortality rate estimates from the two other repowering projects in the APWRA—Diablo Winds and Buena Vista—both of which used turbines smaller than those used in current and future repowering projects. Bat mortality rates from the nearby Montezuma Hills Wind Resource Area were also used because this is the nearest area (other than Vasco Winds) where fourth-generation turbines are in operation. The resultant range of possible mortality rates was compared to the baseline estimates of total fatalities for the two project areas and the program area from the PEIR.

Extrapolating from existing fatality data and from trends observed at other wind energy facilities where fourth-generation turbines are in operation, it appears likely that fatalities would occur predominantly in the late summer to mid-fall migration period; that fatalities would consist mostly of migratory bats, particularly Mexican free-tailed bat and hoary bat; that fatalities would occur sporadically at other times of year; and that fatalities of one or more other species would occur in smaller numbers. As shown in Table 3-4 (updated from Table 3.4-15 in the PEIR), annual estimated bat fatalities in the proposed project area are anticipated to increase from the current estimate of 38 (under baseline) to 463–566 fatalities.

Table 3-3. Raw Bat Fatalities by Species Detected in Standardized Searches at Various APWRA Monitoring Projects

Species	2005–2007	2008–2010	2012–2015	2017–2018
APWRA Monitoring[a]				
Hoary bat	3	2		
Mexican free-tailed bat	2	2		
Western red bat	2	1		
Little brown bat	0	2		
Unidentified bat	3	4		
Total bats	10	11		
Buena Vista[b]				
Hoary bat		9		
Mexican free-tailed bat		3		
California myotis		1		
Total bats		13		
Vasco Winds[c]				
Hoary bat			24	
Mexican free-tailed bat			29	
Western red bat			2	
California myotis			1	
Total bats			56	
Golden Hills[d]				
Hoary bat				106
Mexican free-tailed bat				155
Western red bat				5
Big brown bat				1
California myotis				1
Silver-haired bat				1
Unidentified bat				2
Total bats				271

Sources: APWRA: ICF International 2013:3-3; Buena Vista: Insignia Environmental 2012:47-8; Vasco Winds: Brown et al. 2016; Golden Hills: H. T. Harvey & Associates 2018a, 2018b.

Note: Fatalities are shown for years for which monitoring data are available. Years have been aggregated by 3-year monitoring period except for the Golden Hills project, which currently has 2 years of data available.

[a] Variable: up to 417 MW installed, turbine heights of 60–164 feet.

[b] 38 MW installed, turbine heights of 147–196 feet. Monitoring results from February 2008 to January 2011.

[c] 78 MW installed, turbine heights of 430 feet. Monitoring results from May 2012 to May 2015.

[d] 85.92 MW installed, turbine heights of 427 feet. Monitoring results from September 2016 to September 2018.

Table 3-4. Estimated Range of Annual Bat Fatalities

Study Area	Capacity (MW)	Baseline Fatalities[a]	Predicted Fatalities[b]
Existing program area	329	87	–
Program Alternative 1	417	110	**1,337–1,635 (700–1,635)**
Program Alternative 2	450	118	**1,443–1,764 (756–1,764)**
Golden Hills[c]	85.9	23	**284–347 (148–347)**
Patterson Pass[d]	19.8	5	**64–78 (33–78)**
Sand Hill	144.5	38	**463–566**

Note: Information in bold text is changed or new predicted number of fatalities based on information available since the PEIR was prepared. Information in parentheses is the predicted fatalities indicated in the PEIR.

[a] Estimate of total baseline fatalities are based on the Smallwood and Karas (2009) mortality rate of 0.263 fatality/MW/year derived from 2005–2007 monitoring at the APWRA.

[b] Estimate of total predicted fatalities are based on corrected mortality rates from the Vasco Winds repowering project (Brown et al. 2016) (3.207 fatalities/MW/year) and from the multiyear average rates from the Shiloh I project in the Montezuma Hills WRA (3.92 fatalities/MW/year).

[c] Golden Hills was identified in the PEIR as up to 88.4 MW, but 85.9 MW were ultimately constructed.

[d] The Patterson Pass project was authorized but has not been constructed.

Chapter 4
Avoidance, Minimization, and Mitigation Measures (Tiers 4 and 5)

Sand Hill has adopted an array of conservation measures (CMs) as part of its permitting and environmental compliance processes for the project. The PEIR prepared by Alameda County (Alameda County Community Development Agency 2014) specified a number of mitigation measures that would address avian and bat fatalities; this BBCS's conservation approach builds on these and other commitments developed through the environmental compliance process. These CMs are summarized below by category: design, construction, operations, monitoring, and mitigation.

4.1 Design Measures

CM-1: Site turbines to minimize risk of mortality for birds and bats

Sand Hill retained qualified avian biologists to conduct micro-siting studies. The first study was completed by Smallwood and Neher (2018) (Appendix C) and utilized computer-based collision hazard models and site-specific observations to identify potentially risky locations. The Smallwood and Neher models considered "lessons learned" from other micro-siting efforts and produced suggested modifications to the project design to reduce risk to avian species. Sand Hill used this information to refine the three proposed layouts into a single layout (referred to by Sand Hill as *Layout 4*). Following the first study, Sand Hill retained another qualified avian biologist, Jim Estep, to refine the layout further by providing more specific relocation recommendations (Estep Environmental Consulting 2019) (Appendix C). Sand Hill considered each specific siting recommendation and other factors such as turbine models in preparing a micro-sited turbine layout alternative (Appendix D).

CM-2: Use turbine designs that reduce avian impacts

Sand Hill selected a turbine design based on turbine height, color, configuration, and other features that have been shown or assumed to reduce the collision risk for avian species. The selected turbine design limits perching opportunities and includes a tubular tower with internal ladders; external catwalks, railings, or ladders will not be used. This turbine design also limits nesting and roosting opportunities. Openings on turbines will be covered to prevent cavity-nesting species from nesting in the turbines. Lighting will be installed on the fewest number of turbines allowed by Federal Aviation Administration regulations, and all pilot warning lights will fire synchronously.

CM-3: Incorporate avian-safe practices into the design of project infrastructure

Most of the proposed project's electrical system will be underground—a practice that poses no risk to birds and bats. Where underground lines rise aboveground near the substation, Sand Hill will incorporate avian-safe design characteristics into overhead power lines. These include following avian-safe practices as outlined in *Suggested Practices for Avian Protection on Power Lines* (Avian Power Line Interaction Committee 2012): using insulated jumper wires; covering exposed terminals at the substation (e.g., pot heads, lightning arresters, transformer bushings) by employing separation or insulating materials; using nonconductive materials on riser poles; and spacing energized conductors a safe distance apart.

CM-4: Retrofit existing infrastructure to minimize risk to raptors

Any existing power lines in the project area that are owned by Sand Hill and that are associated with electrocution of an eagle or other raptor will be retrofitted within 30 days to make them raptor-safe according to Avian Power Line Interaction Committee guidelines. All other existing structures to remain in the project area during repowering will be retrofitted, as feasible, according to specifications of CM-3 prior to repowered turbine operation.

CM-5: Discourage prey for raptors

Sand Hill will apply the following measures when designing and siting turbine-related infrastructure. These measures are intended to minimize opportunities for fossorial mammals to become established and thereby create a prey base that could become an attractant for raptors.

- Boulders (rocks more than 12 inches in diameter) excavated during project construction may be placed in aboveground piles in the project area so long as they are more than 500 meters (1,640 feet) from any turbine. Existing rock piles created during construction of first- and second-generation turbines will also be moved at least 500 meters (1,640 feet) from turbines.
- Gravel will be placed around each tower foundation to discourage small mammals from burrowing near turbines.

4.2 Construction Measures

CM-6: Avoid impacts on special-status nesting birds during construction

Where suitable habitat is present for raptors within 1 mile, for golden eagles within 2 miles, and for tree/shrub- and ground-nesting migratory birds (non-raptors) within 50 feet of proposed work areas, measures will be implemented to ensure that the project does not have a significant impact on nesting special-status and non–special-status birds.

CM-7: Implement measures to avoid impacts on western burrowing owl during construction

Where suitable habitat for western burrowing owl is in or within 500 feet of proposed work areas, the following measures will be implemented to avoid or minimize potential adverse impacts on burrowing owls.

- To the maximum extent feasible (e.g., where the construction footprint can be modified), construction activities within 500 feet of active burrowing owl burrows will be avoided during the nesting season (February 1–August 31).
- A qualified biologist will conduct preconstruction take avoidance surveys for burrowing owl no less than 14 days prior to and within 24 hours of initiating ground-disturbing activities. The survey area will encompass the work area and a 500-foot buffer around this area.
- If an active burrow is identified near a proposed work area and work cannot be conducted outside the nesting season (February 1–August 31), a no-activity zone will be established by a

qualified biologist in coordination with CDFW. The no-activity zone will be large enough to avoid nest abandonment and will extend a minimum of 250 feet around the burrow.

- If burrowing owls are present at the site during the nonbreeding season (September 1–January 31), a qualified biologist will establish a no-activity zone that extends a minimum of 150 feet around the burrow.
- If the designated no-activity zone for either breeding or nonbreeding burrowing owls cannot be established, a wildlife biologist experienced in burrowing owl behavior will evaluate site-specific conditions and, in coordination with CDFW, recommend a smaller buffer (if possible) or other measure that still minimizes disturbance of the owls (while allowing reproductive success during the breeding season). The site-specific buffer (or other measure) will consider the type and extent of the proposed activity occurring near the occupied burrow, the duration and timing of the activity, the sensitivity and habituation of the owls, and the dissimilarity of the proposed activity to background activities.
- If burrowing owls are present in the direct disturbance area and cannot be avoided during the nonbreeding season (generally September 1 through January 31), passive relocation techniques (e.g., installing one-way doors at burrow entrances) may be used. Passive relocation will be accomplished by installing one-way doors (e.g., modified dryer vents or other CDFW-approved method), which will be left in place for a minimum of 1 week and monitored daily to ensure that the owls have left the burrow. Excavation of the burrow will be conducted using hand tools. During excavation of the burrow, a section of flexible plastic pipe (at least 3 inches in diameter) will be inserted into the burrow tunnel to maintain an escape route for any animals that may be inside the burrow.
- Avoid destruction of unoccupied burrows outside the work area and place visible markers near burrows to ensure that they are not collapsed.
- Conduct ongoing surveillance of the project site for burrowing owls during project activities. If additional owls are observed using burrows within 500 feet of construction, the onsite biological monitor will determine, in coordination with CDFW, if the owl(s) are or would be affected by construction activities and if additional exclusion zones are required.

CM-8: Conduct preconstruction surveys for habitat for special-status wildlife species

A qualified biologist will conduct field surveys within decommissioning and repowering work areas and their immediate surroundings to determine the presence of habitat for special-status wildlife species. Sand Hill will submit a report documenting the survey results to Alameda County for review prior to conducting any repowering activities. The report will include the location and description of all proposed work areas, the location and description of all suitable habitat for special-status wildlife species, and the location and description of other sensitive habitats (e.g., vernal pools, wetlands, riparian areas). Disturbance of tree-, shrub-, and ground-nesting birds is prohibited under the MBTA. If any such active nests are detected, protective buffers will be established in consultation with CDFW and USFWS until the nests are no longer active.

CM-9: Provide training for construction and project personnel

A qualified biologist will conduct preconstruction education sessions at the project site prior to and during construction. Specific information will focus on the distribution, general behavior, and ecology of special-status species that could occur in the project area; the protection afforded to such species by the MBTA, Eagle Act, ESA, and CESA; the procedures for reporting contacts with listed and proposed species; and the importance of following all the conservation measures. The education sessions will include discussion and overview of the general constraints associated with biological resources in the project area and the timing and processes required for project implementation. Employees and contractors will be informed that they are not authorized to handle or otherwise move special-status species that they may encounter.

4.3 Operation Measures

CM-10: Train project personnel involved in operations and maintenance

Sand Hill will apply the following measures for operations and maintenance project personnel.

- Sand Hill will provide environmental awareness training to all personnel working onsite during project operation.
- Rodenticide will not be utilized by Sand Hill on the project site to avoid the risk of raptors scavenging the remains of poisoned animals.
- Operations and maintenance staff will conduct informal monitoring for avian and bat fatalities within the project area.
- Any dead avian or bat species within the project area will be reported to USFWS.

4.4 Monitoring Measures

CM-11: Implement postconstruction avian fatality monitoring

Qualified biologists will conduct annual bird and bat fatality monitoring surveys to validate the risk assessment and to document actual fatalities associated with wind turbines. These studies will be conducted in accordance with standardized guidelines as set forth in the WEGs (2012) and as outlined in the PEIR. Annual postconstruction monitoring will be conducted for 3 years beginning on the commercial operation date (COD) of the project. If the results of the first 3 years indicate that baseline fatality rates are exceeded, monitoring will be extended until the average annual fatality rate has dropped below baseline fatality rates for 2 years, and to assess the effectiveness of adaptive management measures (see Chapter 5 of this plan). An additional 2 years of monitoring will commence on the 10th anniversary of the COD.

A full monitoring protocol, considering the most recent information and monitoring methods available, will be prepared and submitted to Alameda County and the Technical Advisory Committee (TAC), following approval of the project. The monitoring protocol will have the following overall specifications:

- Bird and bat fatality surveys covering a 105-meter radius search area for each turbine.
- Turbine searches at 7-day and 28-day intervals.
  - 13 turbines searched in years 1 and 2, and 14 turbines searched in year 3, at a 7-day interval (non-overlapping between years so that all 40 turbines are subject to a 7-day interval once during the study).

  - 27 turbines searched in years 1 and 2, and 26 turbines searched in year 3, at a 28-day interval.
- Use of scent-detection dogs for 7-day search intervals and humans for 28-day search intervals.
- Use of integrated carcass detectability bias trials (i.e., the "Big D" approach).

Results will be used by Sand Hill, Alameda County, and the TAC to determine the effectiveness of mitigation measures, and to determine which, if any, turbines produce disproportionately high levels of mortality. The TAC will advise the County on requiring implementation of adaptive management if the results of the first 3 years indicate that baseline fatality rates are exceeded. Sand Hill will prepare an annual report documenting the results of each year's monitoring efforts. The reports will be submitted to Alameda County within 90 days after the end of each monitoring year, unless additional time has been approved by the County. Raw monitoring data will also be submitted annually to Alameda County during monitoring periods. Sand Hill will report any discovered injured or dead golden eagles for the life of the project.

4.5 Mitigation

4.5.1 Background

The PEIR outlines conservation requirements under Mitigation Measure BIO-11h that are intended to compensate for impacts on raptors and other avian species (including golden eagles). The PEIR outlines several conservation measures that are considered acceptable approaches to compensation for impacts on raptors and notes that "….as time proceeds, a more comprehensive approach to mitigation will be adopted to benefit a broader suite of species than might benefit from more species-specific measures." Conservation measures deemed acceptable in the PEIR include:

- Retrofitting high-risk electrical infrastructure.
- Measures outlined in an approved ECP and BBCS.
- Contribution to raptor conservation efforts.
- Contribution to regional conservation of raptor habitat.
- Other conservation measures identified in the future.

The PEIR further notes that "Project proponents will use the avian conservation strategy to craft an appropriate strategy using a balanced mix of the options… as well as considering new options suggested by the growing body of knowledge during the course of the project lifespan, as supported by a Resource Equivalency Analysis or similar type of compensation assessment acceptable to the County that demonstrates the efficacy of proposed mitigation for impacts on raptors." Other requirements noted in the PEIR include consideration of whether the mitigation plan includes a landscape-scale approach such that the conservation efforts achieve the greatest possible benefits.

With this information as a background, Sand Hill considered each of the conservation options and has designed the following conservation measures that will be implemented for the project to benefit affected raptors, while also meeting expected requirements under an eagle take permit.[2]

4.5.2 Conservation Measures

CM-12: Conservation of habitat for raptors and other avian species and bat species

Sand Hill will conserve habitat to help offset the permanent and temporary effects of the project on bats, raptors, and other avian species. Sand Hill will provide 263 acres of suitable lands in perpetuity based on the acres of habitat that will be temporarily and permanently disturbed by the project. Preserved lands will support habitat (nesting, breeding, roosting, or foraging) for the raptor species primarily affected (red-tailed hawk, American kestrel, burrowing owl, and golden eagle), as well as supporting habitat for other migratory birds and bats affected by operation of the project. By providing the mitigation so early in the project, the mitigation will also provide a temporal benefit for 35 years of operation. Sand Hill will select and conserve lands using the following approach:

- Lands will be preserved and managed for the benefit of the species affected (as provided through a long-term management plan and endowment). This approach will ensure the efficacy of the mitigation, and for the continued benefit of affected raptors.
- Lands will be selected within eastern Alameda County. This approach will ensure the lands are similar to those within the project area, supporting a similar suite of avian and bat species and habitat values.

Lands will be connected to open space that is not planned for intensive land use, residential or commercial development, or to another preserve that is conserved in perpetuity. This approach will ensure that an ecological connection and larger area is present (than could be achieved by the mitigation alone), thereby satisfying the County's preference for a "landscape-scale" approach to mitigation in order to maximize the benefits of that mitigation.

CM-13: Contribute to efforts benefitting eagles and other raptors

In addition to the conservation of habitat for raptors and other birds and bats under CM-12, Sand Hill will also contribute to additional efforts for the benefit of eagles and other raptors in an amount equal to $14,500/MW of installed capacity.[3] The funds will be used to support any of the following efforts that USFWS accepts as mitigation for the Sand Hill eagle take permit.

- **Retrofit of high-risk power poles (i.e., power poles known or suspected to electrocute and kill eagles)**. The goal of this strategy is to eliminate hazards for golden eagles. However, because the poles are also dangerous for red-tailed hawk and other large raptors (which constitute the largest non-eagle group to suffer electrocution on power lines [Avian Power Line Interaction Committee 2006]), retrofitting these poles can benefit these species as well.

[2] As of September 2019, this permit application is currently under review.

[3] The mitigation contribution is based on the per MW amount ($10,500/MW) established under the 2010 Settlement Agreement between NextEra Energy Resources and the California Attorney General, adjusted for inflation. The adjustment for inflation assumes the original contribution amount of $10,500, with contributions for Sand Hill expected in 2021 (representing 11 years of inflation adjustment) and assuming an average rate of inflation of 3%.

- **Efforts that contribute to the regional management of eagle and raptor habitat (e.g., studies that further the understanding of local avian populations).**
- **Efforts that support the additional conservation of lands for the benefit of eagles and other raptors.**
- **Efforts that support the reduction of rodenticide use in wildlands, which can have negative effects on raptor populations**. Such efforts will support the County's goal of implementing "other conservation measures identified in the future" and which may have benefits in the reduction of eagle and other raptor fatalities.

4.5.3 Conclusions

The mitigation for unavoidable impacts on birds and bats described herein is consistent with approaches previously accepted by the County for other projects within the APWRA (with financial contributions adjusted for inflation). Additionally, the mitigation approach supports the County's preferences for a "landscape-scale approach" to mitigation, mitigation that supports requirements of an associated eagle take permit, and the use of other CMs (i.e., CMs not identified in the PEIR) that can reduce eagle and other raptor fatalities.

Chapter 5
Adaptive Management Framework

To ensure that impacts on birds and bats are minimized, conservation efforts must include an adaptive management strategy that can adjust to monitoring results as well as new technologies and new research.

The first step in the adaptive management process is validating the risk assessment developed prior to project implementation. Should actual fatalities exceed the risk assessment's estimates, adaptive management measures will be implemented. Within 2 months of receiving such monitoring results, Sand Hill will propose an adaptive management plan informed by those results and the best available science (e.g., new technology and new research) to adjust operations and/or mitigation to bring impacts below baseline. Sand Hill will consider specific adaptive management needs as appropriate—e.g., if only one threshold is exceeded, such as golden eagle fatalities, the plan will target that species. As set forth in other agreements in the APWRA, Sand Hill may also focus adaptive management measures on specific turbines if they are shown to cause a significantly disproportionate number of fatalities.

The plan will follow a stepped approach. Once an adaptive measure or measures are implemented, the results will be monitored for success or failure for 1 year, and additional adaptive measures will be added as necessary, followed by another year of monitoring, until the success criteria are achieved (i.e., estimated fatalities are below the baseline).

Prior to implementation, the adaptive management plan will be reviewed by the TAC, revised by Sand Hill as necessary, and approved by the County. When reviewing the plan and suggesting measures, the TAC will take into account current research and the most effective impact reduction strategies. The adaptive management plan will be implemented within 2 months of approval by the County.

This chapter describes an adaptive management framework to be followed if fatality rates exceed biological triggers. This framework is based on that set forth in the PEIR, but any specific adaptive management plan proposed by Sand Hill will be adjusted to consider current monitoring data as well as the best science available at the time.

5.1.1 Avian Species

Adaptive Management Design

PEIR Mitigation Measure BIO-11i outlines a framework for an adaptive management program to be implemented if the fatality rates for any focal species or species group exceed preconstruction baseline fatality estimates. As described in Mitigation Measure BIO-11i, the plans should follow a stepped approach (actions are implemented, success is evaluated, changes are made if necessary, and results are further evaluated and changed until success criteria are achieved). The PEIR also notes that adaptive management design should use the best measures available when the plan is prepared, in consideration of specific management needs. Lastly, the PEIR notes that adaptive management may focus on individual or multiple turbines (e.g., if specific turbines are shown to represent a disproportionate number of fatalities compared to other turbines).

Recent work by the National Renewable Energy Laboratory (NREL; Sinclair and DeGeorge 2016) outlines a framework for testing the efficacy of avian and bat impact reduction measures, which is relevant to the implementation of adaptive management for the proposed project. The framework focuses on methods to ensure that impact reduction strategies are conducted and monitored in ways that are sufficiently rigorous and comparable. The framework focuses on a clear articulation of the research question to be answered (e.g., will a particular operational change result in a desired outcome with a sufficient statistical basis to be credible), the appropriate scale of the study (spatial and temporal scales), the inclusion of controls, and replication of treatments.

Sand Hill considered currently available information, the types of adaptive management measures outlined in the PEIR, the NREL framework, and other feasible adaptive management measures in order to design specific adaptive management actions that would be implemented for the proposed project. A review of recent monitoring reports from the APWRA (e.g., H.T. Harvey & Associates 2018a and 2018b) indicates that a substantial number of the total fatalities (actual observed fatalities) occurred between October and December. Thus, the research question was posed as whether or not a reduction in operational hours (the amount of time turbines are spinning and presenting risks to birds) during the fall months could reduce fatalities to at or below baseline levels. A stepwise approach was designed (Table 5-1) to implement a particular reduction in operational hours, monitor for the treatment effect, and implement additional operational reduction steps if sufficient fatality reductions are not achieved. A final step, implementing an experimental and different strategy, was included in case fatality reductions from operational changes alone could not be achieved.

Adaptive Management Measures

If fatality monitoring described in PEIR Mitigation Measure BIO-11g results in an estimate that exceeds the preconstruction baseline fatality estimates (i.e., estimates at the nonrepowered turbines as described in the PEIR and updated by the SEIR) for any focal species or species group identified in PEIR (specifically: individual focal species, all focal species, all raptors, all non-raptors, all birds combined), the adaptive management measures described below will be implemented (Table 5-1).

Fatality monitoring will be conducted following implementation of each adaptive management measure to verify that it has been successful (Table 5-1). The results of fatality monitoring will be used to determine if a threshold is triggered.

Table 5-1. Summary of Adaptive Management to be Implemented using a Stepwise Approach

Step	Threshold or Trigger	Adaptive Management Measure (AMM)
Step 0	Mortality rates below baseline during any 12-month monitoring period	Report fatalities as they occur, including cause or risk factor if determined.
Step 1	Mortality rates above baseline within any 12-month monitoring period	**AMM-1 Seasonal Curtailment (50% of daylight hours October–December).** Sand Hill will implement seasonal curtailment by increasing cut-in speed (i.e., the wind speed at which turbines begin to spin). If data indicate that there are measured or perceived high-risk turbine(s) causing a disproportionate impact, AMM-1 would be applied only to those turbine(s); otherwise, AMM-1 would be applied to all turbines. Data from the APWRA indicate that avian use is highest during the fall or winter months, generally October–December, and thus AMM-1 would focus on this period. Under AMM-1, from October through December, Sand Hill would increase the cut-in speed of turbines to a speed of 3.7 m/s during daylight hours. This increase would reduce the daylight operational hours of the turbines, and therefore the risk to birds, such that the turbines would not be operating during 50% of daylight hours from October through December. Implementation of AMM-1 would occur for a period of 1 year. A monitoring plan will be developed and implemented during that period to test the efficacy of the measures being implemented. The monitoring plan will include up to 4 days of field monitoring per month, either distributed throughout the month or concentrated to consecutive days, depending on the goals and objectives of the monitoring plan.
Step 2	AMM-1 does not reduce mortality rates below baseline within a 12-month monitoring period	**AMM-2 Seasonal Curtailment (75% of daylight hours October–December)**. If implementation of AMM-1 is unsuccessful in reducing fatalities to at or below baseline levels, Sand Hill will implement additional seasonal curtailment from October through December. If data indicate that there are measured or perceived high-risk turbine(s) causing a disproportionate impact, AMM-2 would be applied only to those turbine(s); otherwise, AMM-2 would be applied to all turbines. Under AMM-2, from October through December, Sand Hill would increase the cut-in speed of turbines to a speed of 6.9 m/s during daylight hours. This increase would reduce the daylight operational hours of the turbines, and therefore the risk to birds, such that the turbines would not be operating during 75% of daylight hours from October through December. Implementation of AMM-2 will occur for a period of 1 year. A monitoring plan will be developed and implemented during that period to test the efficacy of the measures being implemented. The monitoring plan will include up to 4 days of field monitoring per month, either distributed throughout the month or concentrated to consecutive days, depending on the goals and objectives of the monitoring plan.

Step	Threshold or Trigger	Adaptive Management Measure (AMM)
Step 3	AMM-2 does not reduce mortality rates below baseline within a 12-month monitoring period	**AMM-3 Annual Curtailment.** AMM-3 will only be implemented if there is no apparent seasonal pattern of avian fatalities. If implementation of AMM-2 is unsuccessful in reducing take to at or below baseline levels, Sand Hill will implement an annual increased cut-in speed. If data indicate that there are measured or perceived high-risk turbine(s) causing a disproportionate impact, AMM-3 would be applied only to those turbine(s); otherwise, AMM-3 would be applied to all turbines. Under AMM-3, Sand Hill would increase the cut-in speed of turbines to a speed of 5.3 m/s during daylight hours for 12 months. This increase would reduce the daylight operational hours of the turbines, and therefore the risk to birds, such that the turbines would not be operating during 40% of daylight hours annually. Implementation of AMM-3 will occur for a period of 1 year. A monitoring plan will be developed and implemented during that period to test the efficacy of the measures being implemented. The monitoring plan will include up to 4 days of field monitoring per month, either distributed throughout the month or concentrated to consecutive days, depending on the goals and objectives of the monitoring plan.
Step 4	AMM-2 or AMM-3 does not reduce mortality rates below baseline within a 12-month monitoring period	**AMM-4 Sensory Deterrence Measures.** If implementation of previous AMMs is unsuccessful in reducing take to at or below baseline levels, Sand Hill will implement sensory deterrence measures (visual and/or auditory) with the goal of reducing bird use and bird interaction with wind turbines onsite. As noted in a recent NREL workshop (Sinclair and DeGeorge 2016), a better understanding of the sensory biology of birds, and additional research, is needed to establish effective deterrence methods. Under this adaptive management measure, Sand Hill will consult with experts on bird biology and physiology and will design and implement a USFWS-approved sensory deterrence plan onsite using visual and/or auditory methods to build on this important research and reduce bird use and bird interaction with wind turbines onsite. Implementation of the deterrence measures will occur over a period of 1 year. A monitoring plan will be developed and implemented during that period to test the efficacy of the measures being implemented. The monitoring plan will include up to 4 days of field monitoring per month, either distributed throughout the month or concentrated to consecutive days, depending on the specifics of the deterrence measures being evaluated.

Abbreviations:
m/s = meters per second; NREL = National Renewable Energy Laboratory.

5.1.2 Bat Species

Adaptive Management Design

PEIR Mitigation Measure BIO-14d outlines a framework for development of an adaptive management plan to be implemented if the fatality rates for bats exceeds fatality estimates identified in the PEIR. As outlined in Mitigation Measure BIO-14d, a project-specific adaptive management plan must be developed and used to adjust operation and mitigation to incorporate new technology and research results, when sufficient evidence exists to support new approaches. The PEIR notes that this plan should be reviewed by the TAC, and modification of specific measures identified in the PEIR can take current research, site specific data, and the most effective strategies into account. Two adaptive management methods were suggested in the PEIR, seasonal turbine cut-in speed increase, and use of emerging technology as mitigation.

The extent to which fatality rates for bats may exceed established PEIR thresholds is unknown. Recent monitoring results from the nearby Golden Hills project (H.T. Harvey & Associates 2018a, 2019b) indicate fatalities of bats may be higher than expected; however, the use of new monitoring methods (i.e., scent-detection dogs) confounds the comparison with previous monitoring results. In the event that an adaptive management plan is needed, Sand Hill considered currently available information, the types of adaptive management measures outlined in the PEIR, the NREL framework, and other feasible adaptive management measures in order to design specific adaptive management actions that would be implemented for bats at the Sand Hill project.

A review of the most recent monitoring report from the nearby Golden Hills project (H.T. Harvey & Associates 2018b) continues to indicate that a substantial number of the total fatalities (actual observed fatalities) for bats occur during the fall migration period between August and October. Additionally, Arnett et. al. (2013) continues to be the best available evidence that cut-in speed increases offer the most promising and immediately available approach to reducing bat fatalities at fourth-generation wind turbines. Thus, the research question was posed as whether or not an increase in cut-in speed during the fall months could reduce fatalities to at or below baseline levels. An approach was designed to implement cut-in speed changes, monitor for the treatment effect, and implement additional cut-in speed changes if sufficient fatality reductions are not achieved. A final step, implementing an experimental and different strategy, was included in case fatality reductions from operational changes alone could not be achieved.

Adaptive Management Measures

If postconstruction fatality monitoring described in PEIR Mitigation Measure BIO-14b results in a point estimate for the bat fatality rate that exceeds the 3.207 fatalities/MW/year threshold[4] by a statistically significant amount, then the adaptive management measures below will be implemented.

- Increase cut-in speed to 5.0 m/s from sunset to sunrise during peak migration season (generally August–October). If this is ineffective, increase turbine cut-in speed by annual increments of 0.5 m/s until target fatality reductions are achieved.
- Sand Hill may refine site-specific migration start dates on the basis of preconstruction and postconstruction acoustic surveys and ongoing review of dates of fatality occurrences for migratory bats in the APWRA.
- Sand Hill may request a shorter season of required cut-in speed increases with substantial evidence that similar levels of mortality reduction could be achieved. Should resource agencies and the TAC find there is sufficient support for a shorter period (as short as 8 weeks), evidence in support of this shorter period will be documented for the public record and the shorter period may be implemented.
- Sand Hill may request shorter nightly periods of cut-in speed increases with substantial evidence from defensible onsite, long-term postconstruction acoustic surveys indicating

[4] As noted in Brown et. al. (2016), the average bat fatality rate at the Vasco Winds project was 3.207 bats/MW/year, representing a correction from the rate reference in the PEIR.

predictable nightly timeframes when target species appear not to be active. Target species are here defined as migratory bats or any other species appearing repeatedly in the fatality records.

- Sand Hill may request exceptions to cut-in speed increases for particular weather events or wind patterns if substantial evidence is available from onsite acoustic or other monitoring to support such exceptions (i.e., all available literature and onsite surveys indicate that bat activity ceases during specific weather events or other predictable conditions).
- In the absence of defensible site-specific data, mandatory cut-in speed increases will commence on August 1 and continue through October 31 and will be in effect from sunset to sunrise.

Fatality monitoring required by PEIR Mitigation Measure BIO-14b would be conducted to verify that it has been successful.

Chapter 6
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Appendix A
List of Avian Species Observed in the Altamont Pass Wind Resource Area

Appendix A. List of Avian Species Observed in the Altamont Pass Wind Resource Area

Common Name	Scientific Name
American kestrel	*Falco sparverius*
Burrowing owl	*Athene cunicularia*
Golden eagle	*Aquila chrysaetos*
Red-tailed hawk	*Buteo jamaicensis*
Turkey vulture	*Cathartes aura*
Osprey	*Pandion haliaetus*
White-tailed kite	*Elanus leucurus*
Bald eagle	*Haliaeetus leucocephalus*
Northern harrier	*Circus cyaneus*
Sharp-shinned hawk	*Accipiter striatus*
Cooper's hawk	*Accipiter cooperii*
Red-shouldered hawk	*Buteo lineatus*
Swainson's hawk	*Buteo swainsoni*
Ferruginous hawk	*Buteo regalis*
Rough-legged hawk	*Buteo lagopus*
Barn owl	*Tyto alba*
Great-horned owl	*Bubo virginianus*
Merlin	*Falco columbarius*
Peregrine falcon	*Falco peregrinus*
Prairie falcon	*Falco mexicanus*
Canada goose	*Branta Canadensis*
Gadwall	*Anas strepera*
American wigeon	*Mareca Americana*
Mallard	*Anas platyrhynchos*
Greater scaup	*Aythya marila*
Bufflehead	*Bucephala albeola*
Common goldeneye	*Bucephala clangula*
Barrow's goldeneye	*Bucephala islandica*
Common merganser	*Mergus merganser*
Clark's grebe	*Aechmophorus clarkia*
American white pelican	*Pelecanus erythrorhynchos*
Double-crested cormorant	*Phalacrocorax auritus*
Great blue heron	*Ardea Herodias*
Great egret	*Ardea alba*
American coot	*Fulica Americana*

Common Name	Scientific Name
Killdeer	*Charadrius vociferous*
Black-necked stilt	*Himantopus mexicanus*
American avocet	*Recurvirostra Americana*
Greater yellowlegs	*Tringa melanoleuca*
Lesser yellowlegs	*Tringa flavipes*
Long-billed curlew	*Numenius americanus*
Ring-billed gull	*Larus delawarensis*
Western gull	*Larus occidentalis*
California gull	*Larus californicus*
Rock pigeon	*Columba livia*
Mourning dove	*Zenaida macroura*
Greater roadrunner	*Geococcyx californianus*
White-throated swift	*Aeronautes saxatalis*
Ruby-throated hummingbird	*Archilochus colubris*
Anna’s hummingbird	*Calypte anna*
Black phoebe	*Sayornis nigricans*
Say’s phoebe	*Sayornis saya*
Western kingbird	*Tyrannus verticalis*
Loggerhead shrike	*Lanius ludovicianus*
Yellow-billed magpie	*Pica nuttalli*
American crow	*Corvus brachyrhynchos*
Common raven	*Corvus corax*
Horned lark	*Eremophila alpestris*
Cliff swallow	*Petrochelidon pyrrhonota*
Barn swallow	*Hirundo rustica*
Tree swallow	*Tachycineta bicolor*
Rock wren	*Salpinctes obsoletus*
Western bluebird	*Sialia Mexicana*
Mountain bluebird	*Sialia currucoides*
Northern mockingbird	*Mimus polyglottos*
European starling	*Sturnus vulgaris*
Western tanager	*Piranga ludoviciana*
American pipit	*Anthus rubescens*
Black throated gray warbler	*Dendroica nigrescens*
Yellow-rumped warbler	*Dendroica coronate*
Townsend's warbler	*Dendroica townsendi*
Yellow warbler	*Dendroica petechial*
Ruby-crowned kinglet	*Regulus calendula*
Northern flicker	*Colaptes auratus*
Vesper sparrow	*Pooecetes gramineus*
Lark sparrow	*Chondestes grammacus*
Savannah sparrow	*Passerculus sandwichensis*
Lincoln’s sparrow	*Melospiza lincolnii*

Common Name	Scientific Name
Golden-crowned sparrow	*Zonotrichia atricapilla*
White-crowned sparrow	*Zonotrichia leucophrys*
Black-headed grosbeak	*Pheucticus melanocephalus*
Red-winged blackbird	*Agelaius phoeniceus*
Tricolored blackbird	*Agelaius tricolor*
Western meadowlark	*Sturnella neglecta*
Brewer's blackbird	*Euphagus cyanocephalus*
Lesser goldfinch	*Carduelis psaltria*
House finch	*Carpodacus mexicanus*

Source: Insignia 2012, ICF International 2016, Brown et. al 2016.

Appendix B
Bird Conservation Region 32 Birds of Conservation Concern

Appendix B. Bird Conservation Region 32 Birds of Conservation Concern

Black-footed albatross (nb)
Pink-footed shearwater (nb)
Black-vented shearwater (nb)
Ashy storm-petrel
Bald eagle (b)
Peregrine falcon (b)
Yellow rail (nb)
Black rail
Snowy plover (c)
Mountain plover (nb)
Black oystercatcher
Whimbrel (nb)
Long-billed curlew (nb)
Marbled godwit (nb)
Red knot (*roselaari* ssp.) (nb)
Short-billed dowitcher (nb)
Gull-billed tern
Black skimmer
Xantus's murrelet (a)
Cassin's auklet
Yellow-billed cuckoo (w. US DPS) (a)
Flammulated owl
Burrowing owl
Spotted owl (*occidentalis* ssp.) (c)
Black swift
Costa's hummingbird
Allen's hummingbird
Lewis's woodpecker
Nuttall's woodpecker
White-headed woodpecker
Loggerhead shrike
Island scrub-jay
Yellow-billed magpie
Oak titmouse
Cactus wren
LeConte's thrasher
Yellow warbler (*brewsteri* ssp.)
Common yellowthroat (*sinuosa* ssp.)
Spotted towhee (*clementae* ssp.)
Black-chinned sparrow
Song sparrow (*graminea* ssp.)
Song sparrow (*maxillaris* ssp.)
Song sparrow (*pusillula* ssp.)
Song sparrow (*samuelis* ssp.)
Tricolored blackbird
Lawrence's goldfinch

Appendix C

Micro-Siting Studies

SITING WIND TURBINES TO MINIMIZE RAPTOR COLLISIONS AT SAND HILL REPOWERING PROJECT, ALTAMONT PASS WIND RESOURCE AREA

K. Shawn Smallwood and Lee Neher

10 August 2018

EXECUTIVE SUMMARY

Map-based collision hazard models were prepared as a set of tools to help guide the careful siting of proposed new wind turbines as part of the repowering effort at Sand Hill in the eastern Alameda County portion of the Altamont Pass Wind Resource Area (APWRA). Similar collision hazard models were prepared for the Tres Vaqueros and Vasco Winds repowering projects in Contra Costa County and for the Patterson Pass, Golden Hills, Golden Hills North, Summit Winds repowering projects in Alameda County, as well as for an earlier version of the Sand Hill repowering project. After three years of fatality monitoring following construction, it was found that the repowering of Vasco Winds reduced fatalities of raptors as well as all birds as a group. Our newest set of models for Sand Hill benefit from the lessons learned at Vasco Winds, as well as from many additional data collected through 2015 and the emergence of dependent variables and predictor variables that we believe result in superior collision hazard models. The new models were derived from an additional four years of fatality monitoring data, including monitoring with much shorter fatality search intervals at repowered, modern wind turbines as well as at some old-generation wind turbines. And like the models developed for Sand Hill and Golden Hills North, the golden eagle collision hazard model was partly derived from GPS/GSM telemetry data transmitted by golden eagles (*Aquila chrysaetos*) flying within the APWRA.

Our collision hazard model for golden eagle was derived from 121,259 GPS/GSM telemetry positions within the APWRA, from thousands of behavior records made during visual scans across many stations in the APWRA 2012 through 2015, and from fatality rates at monitored wind turbines from 1998 through 2015. Our collision hazard models for red-tailed hawk (*Buteo jamaicensis*) and American kestrel (*Falco sparverius*) were derived from thousands of behavior records and from estimates of fatality rates at wind turbines. Our collision hazard model for burrowing owl (*Athene cunicularia*) was derived from estimates of fatality rates at wind turbines and what we learned about the distribution of burrowing owls in the APWRA after 5 years of monitoring of nest and refuge burrows among 46 randomly located sampling plots.

Based on the data used to generate the models, our models performed very well at predicting increasing fatality rates with increasing hazard class. Our model predictions were usually, but not always, consistent with Smallwood's on-site assessments of collision hazard at each proposed wind turbine site. With short-distance relocations of some turbines, we believe that 24 of the proposed turbine sites will be relatively safe for raptors, so long as grading for turbine pads avoids leaving cut slopes or berms in the prevailing upwind direction from the turbines. We predict 14 of the proposed sites would be considerably more hazardous to raptors due to existing terrain conditions at those sites. If wind turbines in this project can be located well outside of ridge saddles, ravines, canyons and breaks in slope, and if grading for turbine pads can be minimized, then we predict fatality rates will lessen for golden eagles, red-tailed hawks, American kestrels, and burrowing owls relative to the same capacity of old-generation wind turbines being replaced. Given the airspace that will be opened up to safe flight traffic, we believe the golden eagle and red-tailed hawk fatality rates will lessen relative to the old turbines. American kestrel fatalities will likely lessen due to the elimination of the many small wind turbines that not only caused collision fatalities but also entrapped kestrels in hollow tubes of the lattice towers and within the turbine machinery. Burrowing owl fatalities also should lessen, but the high concentration of burrowing owls in the project area will mean that fatality reductions will not be as great at this project site as compared to other repowering projects in the APWRA. Based on our experience with the repowering of Buena Vista, Vasco Winds and Golden Hills, the fatality rates of bats might increase over those experienced at the old-generation wind turbines formerly operating at Sand Hill. In our micro-siting assessment and recommendations, we offer no assessment of macro-siting or project size.

INTRODUCTION

S-Power plans to install up to 33 wind turbines as part of its Sand Hill repowering project in the Alameda County portion of the Altamont Pass Wind Resource Area ("APWRA"), California. Careful siting of wind turbines is one of the principal measures available to minimize raptor fatalities caused by collisions with the turbines (Smallwood and Thelander 2004, Smallwood and Karas 2009, Smallwood and Neher 20010a,b, Smallwood et al. 2017). Project-level siting is referred to as macro-siting and within-project siting as micro-siting. The objective of micro-siting is to carefully site new wind turbines to minimize the frequencies at which raptors of various species encounter the wind turbines while flying, but most especially while performing specific types of flight behaviors, such as golden eagles chasing or fleeing other birds or flying low across ridge-like topographic features, or red-tailed hawks or American kestrels hovering or kiting in deflected updrafts. In this study we developed simple Fuzzy Logic (FL) models

(Tanaka 1997) of raptor activity quantified from behavior data collected across the APWRA between 13 November 2012 and 29 October 2015, and at behavior studies performed at Rooney Ranch and Sand Hill sites between 30 April 2012 and 5 March 2015 and Patterson Pass between 15 October 2013 and 24 September 2014. The behaviors used in the modeling effort were derived from the results of Smallwood et al. (2009b), and an example application of the FL modeling approach can be seen in Smallwood et al. (2009a, 2017).

The Fuzzy Logic approach is a rule-based system useful with noisy, zero-dominated data sets. It is often applied to events occurring within classes that are assumed to have graduated rather than sharp boundaries (Tanaka 1997). The rules consist of assigning likelihood values of an event occurring, which in the case of this study would be the likelihood of a bird performing a specific behavior within a cell of an analytical grid laid over the project area. Likelihood values can range 0 to 1 for each predictor variable, depending on how far a value of the predictor variable differs from the mean where the event has been recorded. The magnitude of each deviation from the mean is assessed by the analyst based on error levels, data distribution, and the analyst's knowledge of the system. In our case, the events were of birds flying over terrain characterized by suites of slope conditions, or of fatalities at wind turbines associated with specific slope conditions.

Our study goal was to accurately predict the locations where golden eagles, red-tailed hawks, American kestrels and burrowing owls are most likely to perform flight behaviors putting these species at greater risk of collision with wind turbines, so that new wind turbines can be sited to avoid these locations to the degree reasonably feasible. Achieving this goal depended on our understanding of how these species use terrain and wind, and how they perceive and react to wind turbines. It also depended on understanding patterns of fatality rates in the APWRA, so we also developed fatality rate models for golden eagle, red-tailed hawk, American kestrel, and burrowing owl. Our model results were interpreted in tandem with Smallwood's familiarity with conditions associated with proposed wind turbine locations. By carefully siting the wind turbines to minimize collision risk, the Sand Hill project should prove safer to raptors than the wind turbines being replaced, so long as grading for turbine pads avoids leaving cut slopes or berms in the prevailing wind direction from the turbines. The Sand Hill micro-siting also benefits from what was learned at the Vasco Winds repowering project, which was micro-sited using a similar approach and monitored for collision fatalities for three years (Brown et al. 2013, 2014, 2016). Additional experience was gained at the post-repowered Golden Hills, Buena Vista, and Diablo Winds projects.

Our map-based models are intended to help guide micro-siting; they do not bear on macro-siting. The models are only as predictive as our understanding of wind turbine collisions and our ability to measure terrain features bearing on collision risk. Although research and monitoring efforts in the APWRA have set the pace worldwide (Orloff and Flannery 1992, Smallwood and Thelander 2008, Smallwood et al. 2009b,c, Brown et al. 2016, ICF International 2016, Smallwood 2016a,b, 2017a,b, Smallwood and Neher 2017a), there remains considerable uncertainty over collision mechanisms. Certain behavior patterns correlate with collision fatality rates (Smallwood et al. 2009b, 2016a,b), but correlations are often confounded by the unmeasured, unobserved factors. And whereas we know that collision risk is influenced by interactions between landscape and wind, wind turbine micro-siting cannot be guided by anything more detailed than measurable terrain features and prevailing wind directions. Assuming that the prevailing wind directions are primarily from the southwest and secondarily from the northwest, and assuming that the avian behavior and fatality data reflect these prevailing wind directions, we weighted terrain features for collision risk based on whether wind turbines would be sited on or atop these features. However, when the wind shifts directions to the northeast or from the southeast, as examples, then the birds shift their activity patterns and collision risks also change. There is no way for us to micro-site wind turbines to minimize risk posed by all wind directions.

As another example of the limitations of our models, we examined the locations of golden eagle model prediction failures – sites of existing or past wind turbine sites where collision risk was predicted lowest but where fatality rates were relatively high. A pattern that quickly emerged from these sites was their occurrence on steeply declining ridge features, which is a terrain condition that we have not measured and could not incorporate into a model. We measured slope (elevation change relative to distance change) within analytical grid cells and across entire slope faces from valley bottom to ridge crest, but we did not measure slope along ridge features because this measurement did not occur to us until examining the model prediction failures. Of course, any remaining model prediction failures would likely lead us to additional as-yet-unmeasured terrain features. Our models express our current understanding and ability to measure collision factors, and should be interpreted in combination with expert opinion.

Assumptions and limitations aside, we feel that this iteration of collision hazard models in the APWRA qualifies as our best and most predictive, especially after revising our burrowing owl fatality model (reported herein). It is important to remember that the models are most effectively used as foils against expert judgement. It is also important to remember that all wind turbine locations pose collision risk to volant wildlife. Our aim is to avoid terrain settings that pose disproportionately greater collision risk to four focal species, including golden eagle, red-tailed hawk, American kestrel and burrowing owl. Attempting to optimize micro-siting to minimize impacts to these focal species could increase the risk for other bird species (Smallwood and Neher 2017b), and possibly for bats. It is also important to understand that our modeling approach is based on the assumption that wind turbines would not be installed on relatively low-lying terrain. Past research in the APWRA revealed terrain features, including low-lying areas, as more hazardous to raptors. General micro-siting guidelines were generated (Alameda County SRC 2007, 2010, Smallwood and Estep 2010), validated (Smallwood 2010a,b) and later incorporated into Alameda County's Programmatic Environmental Impact Report prepared for wind energy repowering. Our models will often predict low collision risk in low-lying areas only because we targeted our models to the higher terrain typically sought by wind companies in the APWRA.

In most cases we recommend siting the new wind turbines as far as reasonably feasible from hazard classes 3 and 4, but we also recommend considering expert input on micro-siting to account for factors not considered in the models. As a general rule, we recommend not siting wind turbines in relatively low terrain, or in ridge saddles, breaks in slope or on terrain located east (prevailing downwind) of major ridge saddles or breaks in slope. Herein are recommended changes to the initial wind turbine layout based on model predictions, expert judgment applied to on-site inspections, and fatality histories accumulated from fatality monitoring at old-generation wind turbines nearest the proposed installation sites. Two caveats are necessary for the Sand Hill portion of the project. One is that burrowing owls in the APWRA have been most numerous on the Sand Hill area, and fatality rates have been high there. Any wind turbines installed at Sand Hill will carry considerable collision risk for burrowing owls regardless of micro-siting efforts. Second, the layout extended into an area we previously did not regard as part of the APWRA, and therefore we had not prepared terrain measurements or model extensions into that area. To assess collision risk of wind turbines proposed outside our modeling area, we relied solely on the expert judgement of Smallwood upon his site visits.

We further note that we had prepared collision hazard models for a previously planned, but abandoned, repowering project at Sand Hill (Smallwood and Neher 2016). That project was planned by a different company than the project considered herein.

METHODS

On-site Assessments

One of us (Smallwood) visited the proposed repowering project area to assess the collision hazard associated with proposed wind turbine sites. Smallwood visited the sites proposed in the initial layout in December 2017. He rated collision hazard on a scale of 0 to 10 using criteria adopted by the Alameda County Scientific Review Committee in 2007/2008 and 2010 (Alameda County SRC 2007, 2010), but modified in two ways. One modification was not lumping all ratings less than 7 into the same hazard level. Another was not considering turbine operability, which varied greatly among old-generation turbines but not among proposed wind turbine sites.

Predictive Models

Multiple types of data were needed to develop collision hazard models. For developing collision hazard models of golden eagle, red-tailed hawk, and American kestrel, flight behavior data were collected and then related to terrain. For golden eagles, we also made use of GPS/GSM telemetry data collected from 18 golden eagles fitted with transmitters and flying over portions of the Altamont Pass Wind Resource Area (Bell and Nowell 2015, Smallwood et al. 2017a). For all four raptor species, we estimated fatality rates among individual wind turbines monitored throughout the APWRA and over various time periods since 1998. And of course the terrain needed to be measured, and this was done using imagery, digital elevation models, and geoprocessing steps to bring objectivity to decisions about where a slope transitions from trending towards concavity to trending towards convexity, as an example. All of these data and the steps used to integrate them are covered in the following paragraphs. We begin with the biological survey data before describing the development of our digital elevation model (DEM) and terrain measurements, but we present the methods used for processing the GPS/GSM telemetry data until after the section on terrain measurements because we relied on our terrain measurements to screen the telemetry data for inclusion in the analysis.

Behavior data

Culminating 14 years of behavior surveys and utilization surveys in the APWRA (Smallwood et al. 2004, 2005, 2009b,c; Smallwood 2013), a new methodology was developed for behavior monitoring to benefit the development of wind turbine collision hazard models (Smallwood 2016a,b). The earlier behavior surveys recorded avian behaviors that were unmapped (Smallwood and Thelander 2004, 2005; Smallwood et al. 2009b), so no spatial analysis was possible. The mapping of bird locations emerged in 2002 and continued through 2007 (Smallwood and Thelander 2005, Smallwood et al. 2009c) and 2011 (ICF International 2011), but the 2002 approach was integrated with utilization surveys that were focused primarily on counting birds to estimate relative abundance. For most observers this mixing of objectives impinged on both objectives – on both the counting of birds and the mapping of their behavior patterns. On-the-minute mapping of bird locations and behaviors yielded only crude spatial patterns for only a few site-repetitive behaviors such as perching, kiting and hovering. After comparing use rates to fatality rates and seeing no significant spatial or inter-annual relationships between the two rates, it was decided to focus more on the behavior patterns to predict collision hazards. New methods were formulated to map flight behaviors.

We gathered behavior data from 15 observation stations at Sand Hill, 9 stations in Patterson Pass, and 36 stations across the rest of the APWRA, the latter of which were funded by NextEra as mitigation for the Vasco Winds repowering project (Figure 1). Of the 36 stations funded by NextEra as mitigation, 21 were selected from those that had been ranked from 1st through 30th in order of the number of first observations per hour per km^3 of visible airspace out to the maximum survey radius at each station during use surveys performed by the Alameda County Avian Monitor from 2005 through 2009. To these 21 stations we added another 15 to Vasco Caves Regional Preserve, Northern Territories, Vasco Winds Energy Project, and the Buena Vista Wind Energy Project in Contra Costa County, where the Alameda County Avian Monitor had little coverage. The 15 stations at Sand Hill were optimized to observe how golden eagles and other raptors behave in the airspace around Ogin's before-after, control-impact (BACI) experimental treatment plots designed to test the avian safety of a new wind turbine model that was ultimately not installed.

Behavior sessions at Sand Hill lasted 30 minutes each, and elsewhere they lasted 1 hour each, including on some stations located on Sand Hill. Between 30 April 2012 and 5 March 2015 there were 2,002 surveys completed for 1,001 hours (126,084 birds tracked). The maximum survey radius depended on the printed map image extent and how far the observer felt comfortable estimating the bird's spatial location and height above ground. Map extents rarely permitted survey distances of >300 m. One of us (Smallwood) recorded all of the behavior data within Patterson Pass, and additional behavior data were collected at NextEra mitigation sites by Smallwood, Erika Walther, Elizabeth Leyvas, Skye Standish, Brian Karas, and Harvey Wilson.

The 9 Patterson Pass stations were surveyed 167 times (167 hours) from 15 October 2013 to 24 September 2014 (5,712 birds tracked). The 36 NextEra mitigation stations were surveyed 928 times (928 hours) from 13 November 2012 through 29 October 2015 (27,552 birds tracked). Between all three studies, 2,096 hours of behavior surveys (159,348 birds tracked) provided the data used for developing collision hazard models reported herein.

Each bird was recorded onto image-based maps of the survey area as point features connected by vector lines depicting the bird's flight path (Figures 2-5). Height above ground, behavior, and time into the session was recorded into Tascam digital voice recorders fitted with windjammers designed to reduce noise buffeting by high winds. Point features were recorded as often as the observer could record attribute data into the voice recorder. One objective of the behavior sessions was to obtain high quality flight paths and summaries of flight behaviors of individual birds using the surveyed airspace, and it was notably not to count birds, although it was likely that just as many raptors were recorded as would have been counted based on the use survey protocols.

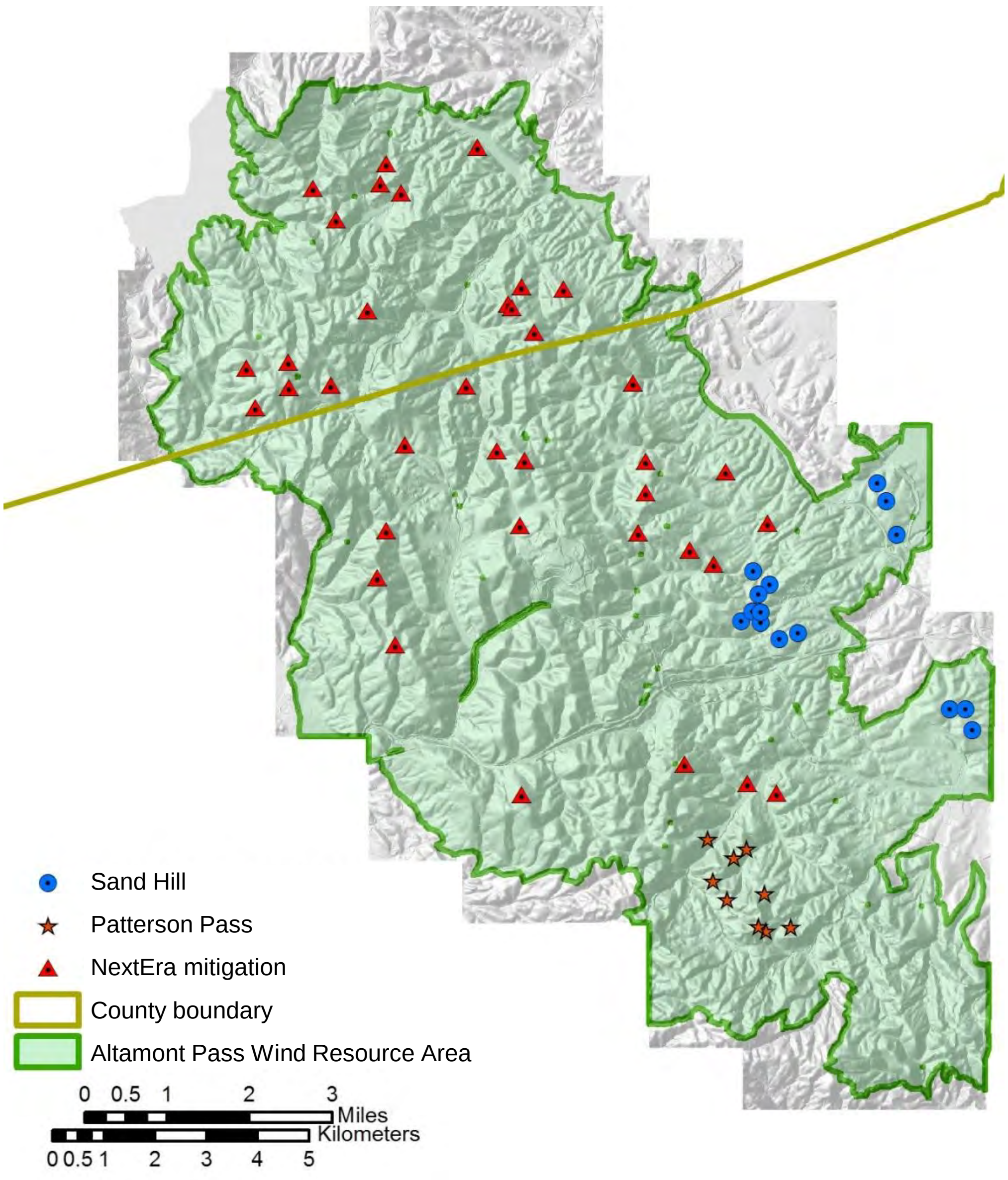

***Figure 1**. Locations of behavior observation stations used for 30 min and 60 min visual scans to track individual birds and record behaviors and flight heights along the way.*

Another objective of the behavior surveys was to learn how birds interact with wind turbines when they approached the wind turbines. Special attention was given to the bird's flight whenever it flew within 50 m of a wind turbine and, in the opinion of the observer, faced the possibility of colliding with the wind turbine. During this time, the bird's approach angle to the turbine was recorded, as well as any changes in flight direction, flight height, behavior, interactions with other birds, and the wind turbine's operating status. Whenever special attention was directed to such flights, the flight observation was termed an "event," or a wind turbine interaction event.

At the start of each behavior session, the observer identified which wind turbines in the survey area were operating, as well as temperature, wind direction, average and maximum wind speed, and percentage cloud cover. Behavior data were transcribed to electronic spreadsheets within 24 hours of collection. Mapped bird location points and line features representing the bird's flight path were then digitized into the GIS.

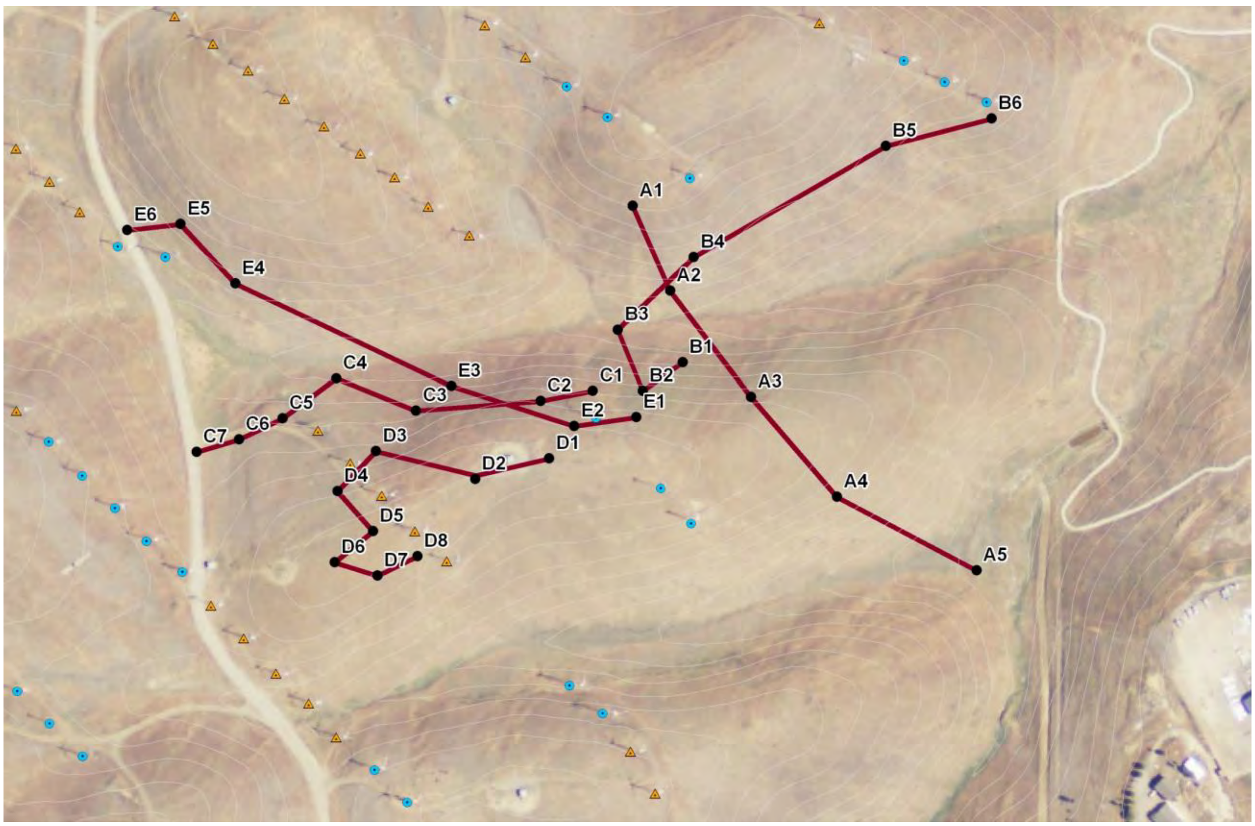

Figure 2. *Example of how birds were tracked visually during behavior surveys. Flight attributes were recorded at points, which were later connected by line segments representing a flight path. In this case 5 flight paths were recorded, A through E, and at each number associated with a point we also recorded behavior, height above ground, social group size and, when appropriate, wind turbine events. For example, D4 would likely have involved a wind turbine event*.

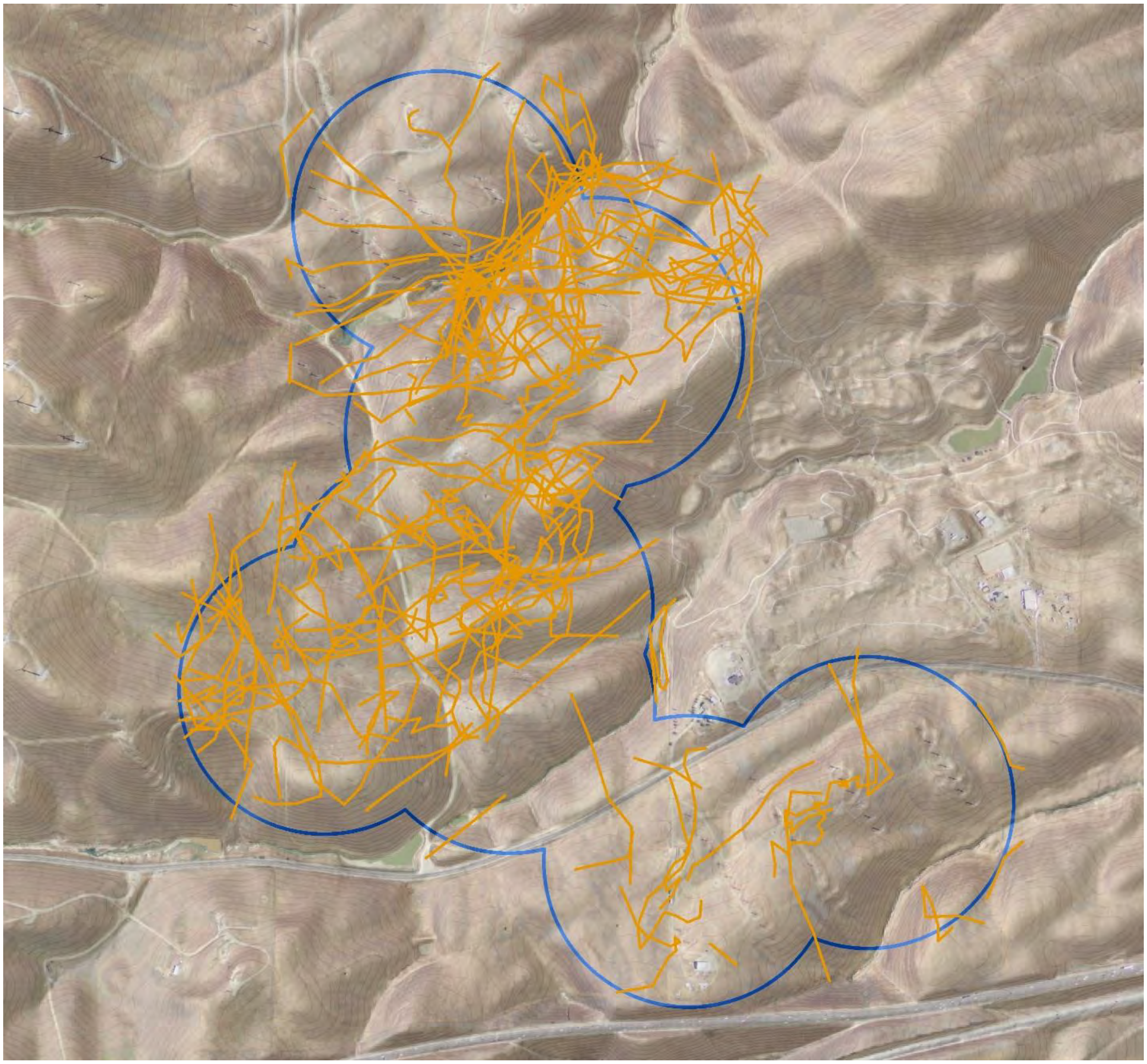

***Figure 3**. Golden eagle flight paths recorded during 3 years of visual scans for behavior patterns within a portion of the Sand Hill project area, 2012-2015*.

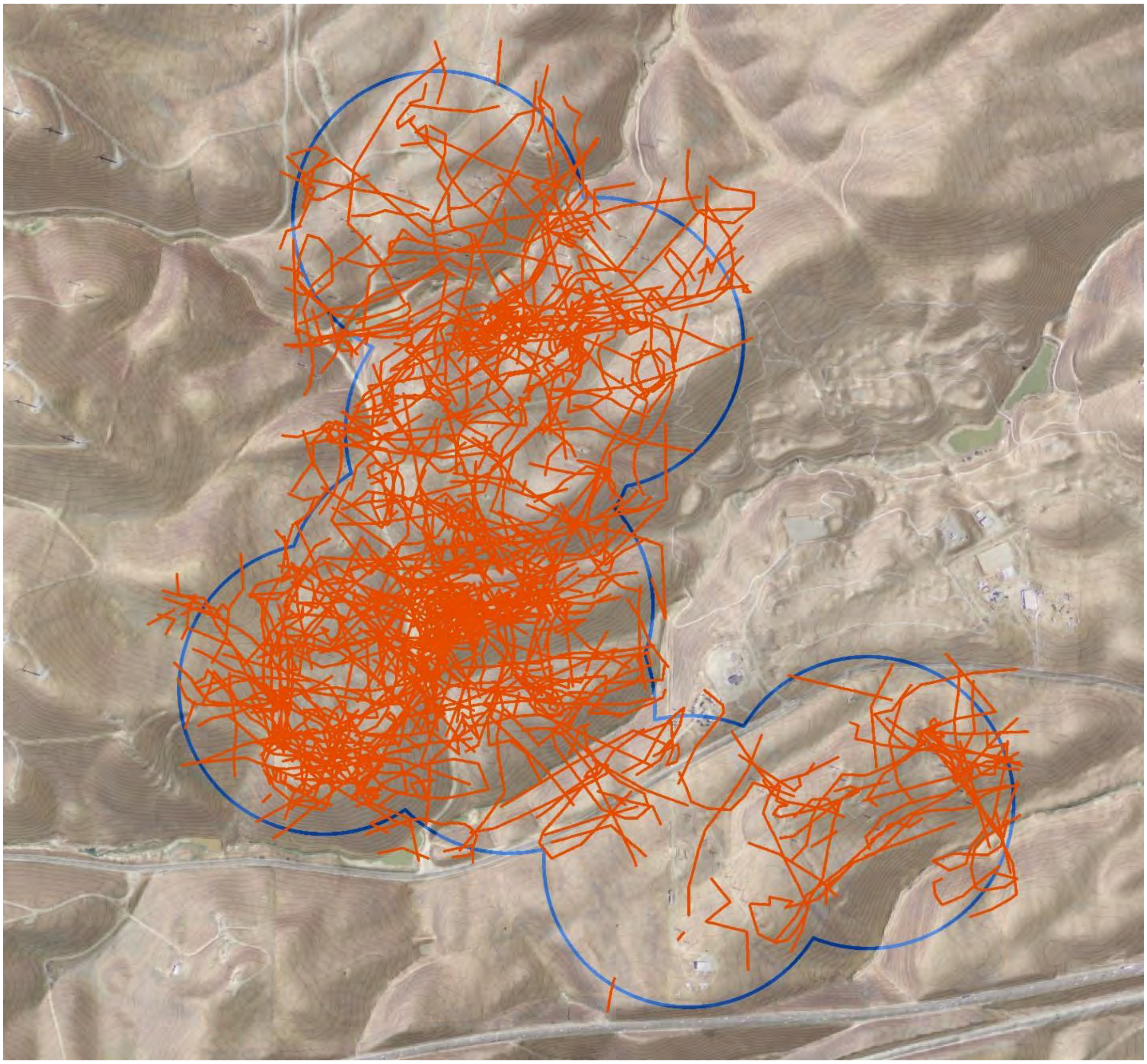

Figure 4. *Red-tailed hawk flight paths recorded during 3 years of visual scans for behavior patterns within a portion of the Sand Hill project area, 2012-2015.*

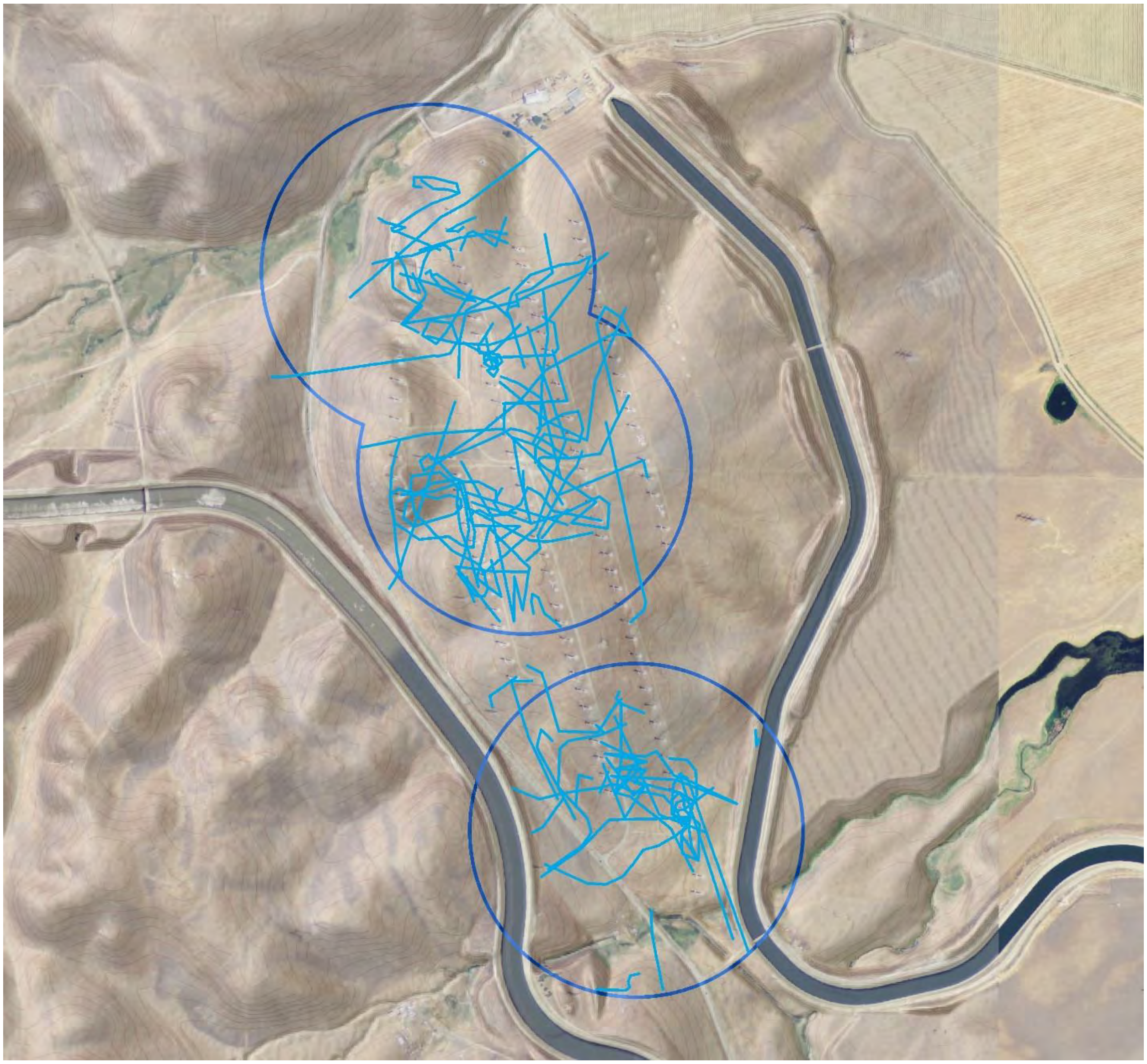

Figure 5. *American kestrel flight paths recorded during 3 years of visual scans for behavior patterns within a portion of the Sand Hill project area, 2012-2015.*

Burrowing owl burrows

Burrowing owl burrows (Figure 6) were mapped in sampling plots throughout the APWRA using a Trimble GeoXT GPS, both during the nesting season (Smallwood et al. 2013) and throughout the year in 2011 (Figure 7). Additional burrow mapping efforts were made in follow-up visits during breeding seasons of 2012-2015. Most of the burrows that were mapped were nest burrows, but refuge burrows were also included in the data pool. No satellite burrows (alternate nest burrows) were used in the analysis because satellite burrows are merely nearby extensions of nest burrows. The burrow location data were used to develop a predictive model of burrowing owl burrow sites, but for the micro-siting effort herein we discontinued using this model for anything other than gaining a better understanding of how burrowing owls distribute themselves across the APWRA.

***Figure 6**. Example of a burrowing owl nest burrow, including an adult (top) and chicks.*

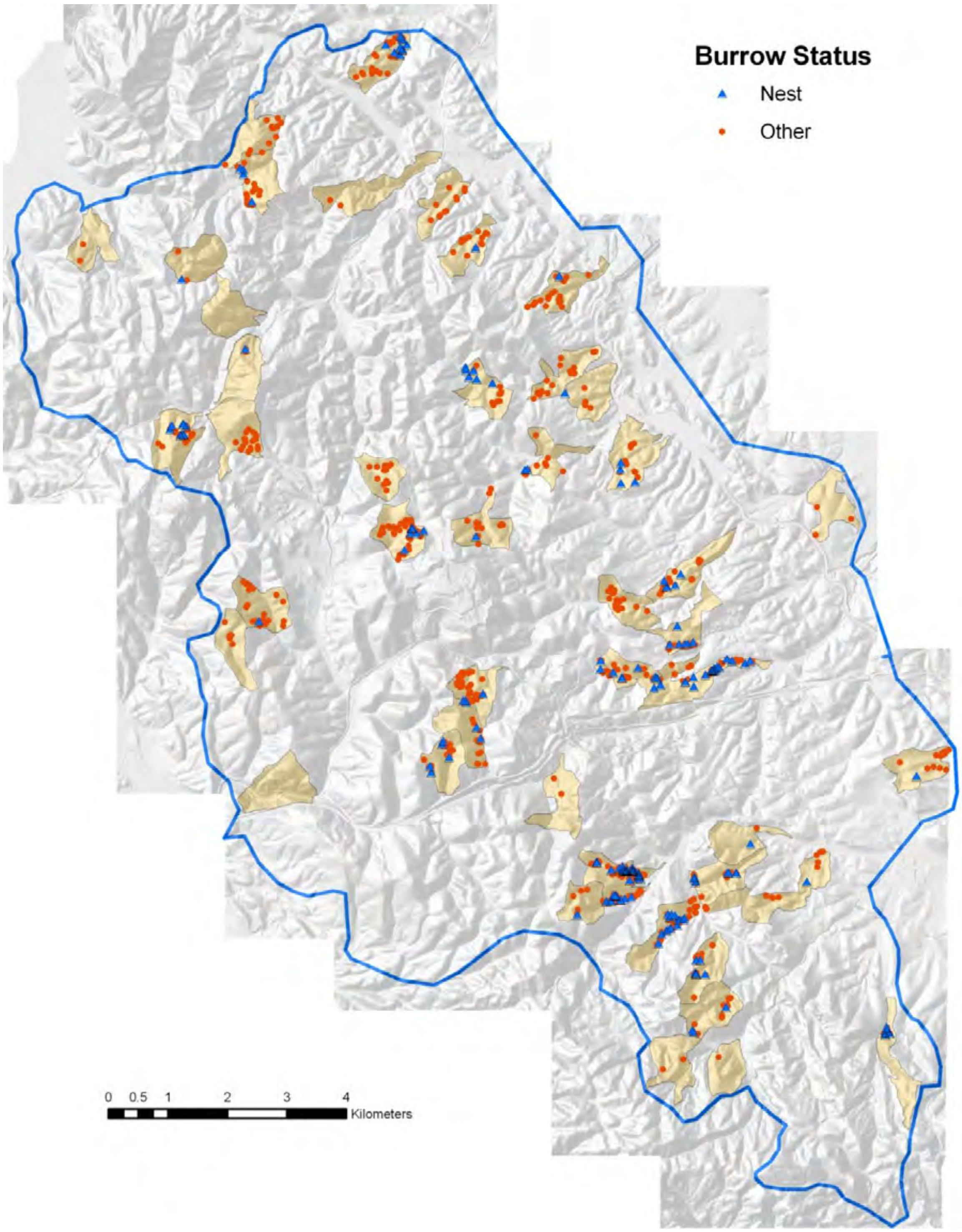

***Figure 7**. Burrowing owl sampling plots (tan color) and 2011 nest and refuge burrow locations (as examples) within the Altamont Pass Wind Resource Area (blue polygon).*

Fatality rates

We estimated annual fatality rates at all old generation wind turbines that were searched at least one year between the years 1998 through 2011 in the APWRA. We also estimated annual fatality rates at modern wind turbines monitored 2012-2015 in the Vasco Winds project (Brown et al. 2016), 2008-2011 in the Buena Vista project (Insignia Environmental 2011), and 2005-2010 in the Diablo Winds project (ICF International 2016). All fatality rates at old-generation turbines were adjusted for search detection and carcass persistence rates that were averaged among wind projects where trials were performed in similar grassland environments as compared to the APWRA (see Smallwood 2013). Fatality rates were also adjusted for variation in the maximum search radius around wind turbines (Smallwood 2013). Finally, we adjusted fatality rates for monitoring duration to account for a potential bias warned about in Smallwood and Thelander (2004:App. A). This bias is actually two biases in one, and it applies more to comparing fatality rates among individual wind turbines than it does to wind projects. The adjustments are shown in Figure 8.

Going to the first portion of the bias, as the number of fatalities is averaged into more years of survey effort, the resulting ratio of fatalities to years will decrease inversely with increasing number of years at turbines where fatalities were found. This decrease is caused simply by a relatively constant numerator (number of fatalities) being divided by a constantly changing denominator (years). If an eagle fatality is found at a wind turbine monitored over one year, the fatality rate would be 1 eagle death per year, but if this turbine is monitored over 10 years and no more eagle fatalities are found, then the fatality rate would be 0.1 eagle deaths per year. At a wind turbine monitored over 10 years, the measured rate should be regarded as reasonably reliable. But a fatality rate of 1 eagle per year measured at a wind turbine monitored only over 1 year should be regard as much less reliable because it remains unknown whether additional eagle fatalities would be found at that turbine had it been monitored over more years. Monitored over 10 years, this turbine might yield a fatality rate of 1 or more eagle deaths per year or only 0.1 eagle deaths per year, an uncertainty range of 10-fold or greater.

Going to the second portion of the bias, some fatality rates will represent false zeros where wind turbines were monitored for only one or a few years and no fatalities were found. Assuming a golden eagle fatality rate of 0.1 deaths per MW per year and assuming for this example that fatality risk is equal among 100-KW wind turbines in a project area, then the monitoring duration sufficient to register a single golden eagle fatality at the average wind turbine would be 100 years. A reasonable assumption would be that false zeroes are common for golden eagle fatality rate estimates in the APWRA. This bias, or both biases together, was partially corrected by fitting an inverse function to the data, and then multiplying the ratio of observed to predicted values by the predicted value at 10 years of monitoring (Figure 8). In other words, all fatality rates at individual wind turbines were adjusted to a common 10-year period of monitoring, even if they had been monitored only one year, 4 years, or 10 years, etc. (We note that the fatality rate metric in this case excluded the turbine's rated capacity, MW.) Our adjustment reduces the magnitude of mathematical artefact caused by high fatality rates at wind turbines monitored briefly, but it does not adjust for false zeroes at wind turbines monitored briefly.

Fatality rates adjusted for duration of monitoring were related to terrain measurements and terrain features to identify associations useful for developing predictive collision hazard models. The terrain features and terrain measurements used were those associated with the wind turbines where fatality rates had been recorded (Figure 9).

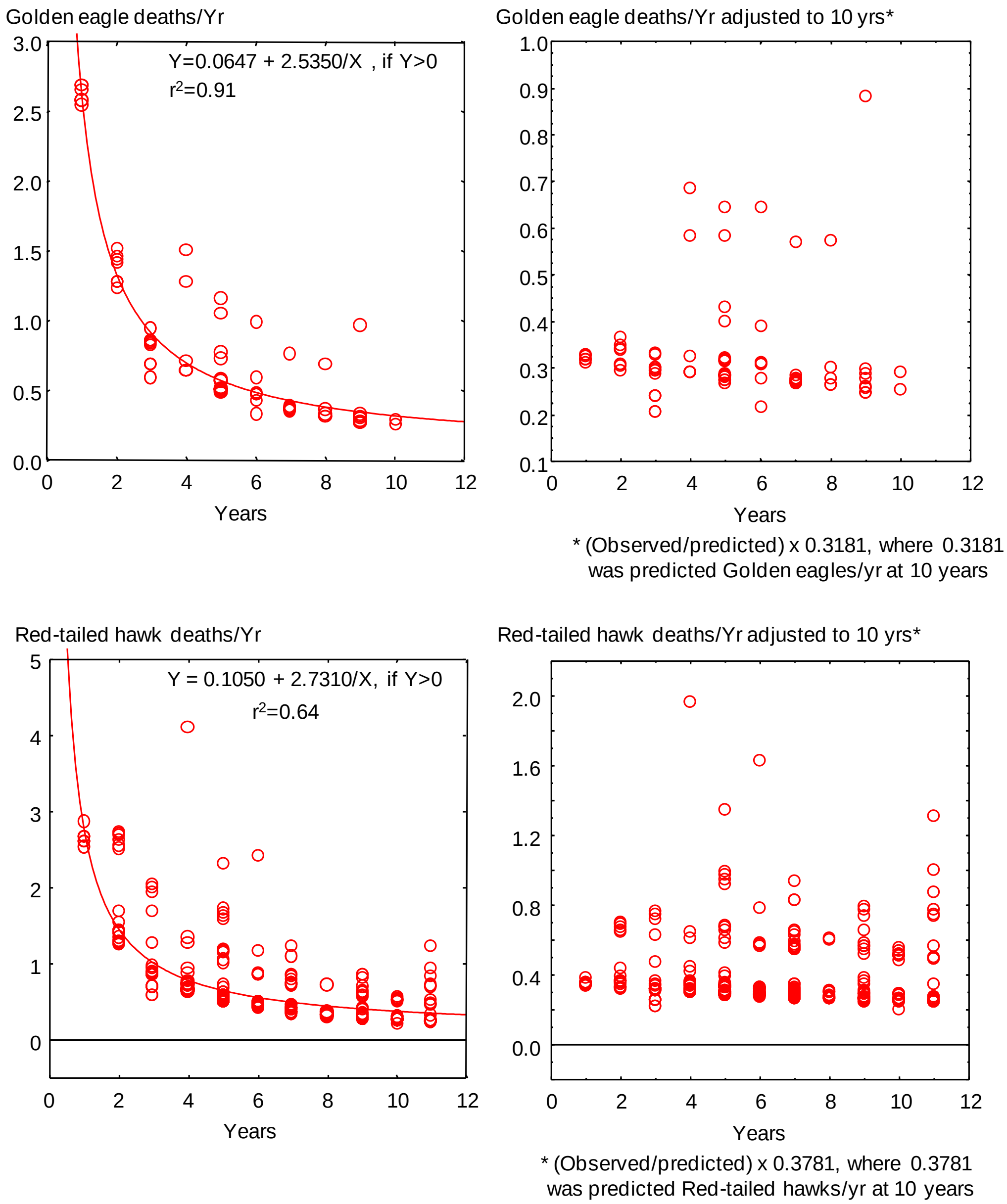

Figure 8a. *Mean annual fatalities/year at turbines where fatalities were found declined inversely with the number of years used in the denominator for golden eagle and red-tailed hawk (left graphs), so fitting inverse functions to the data removed the effect of number of years on the metric (right graphs).*

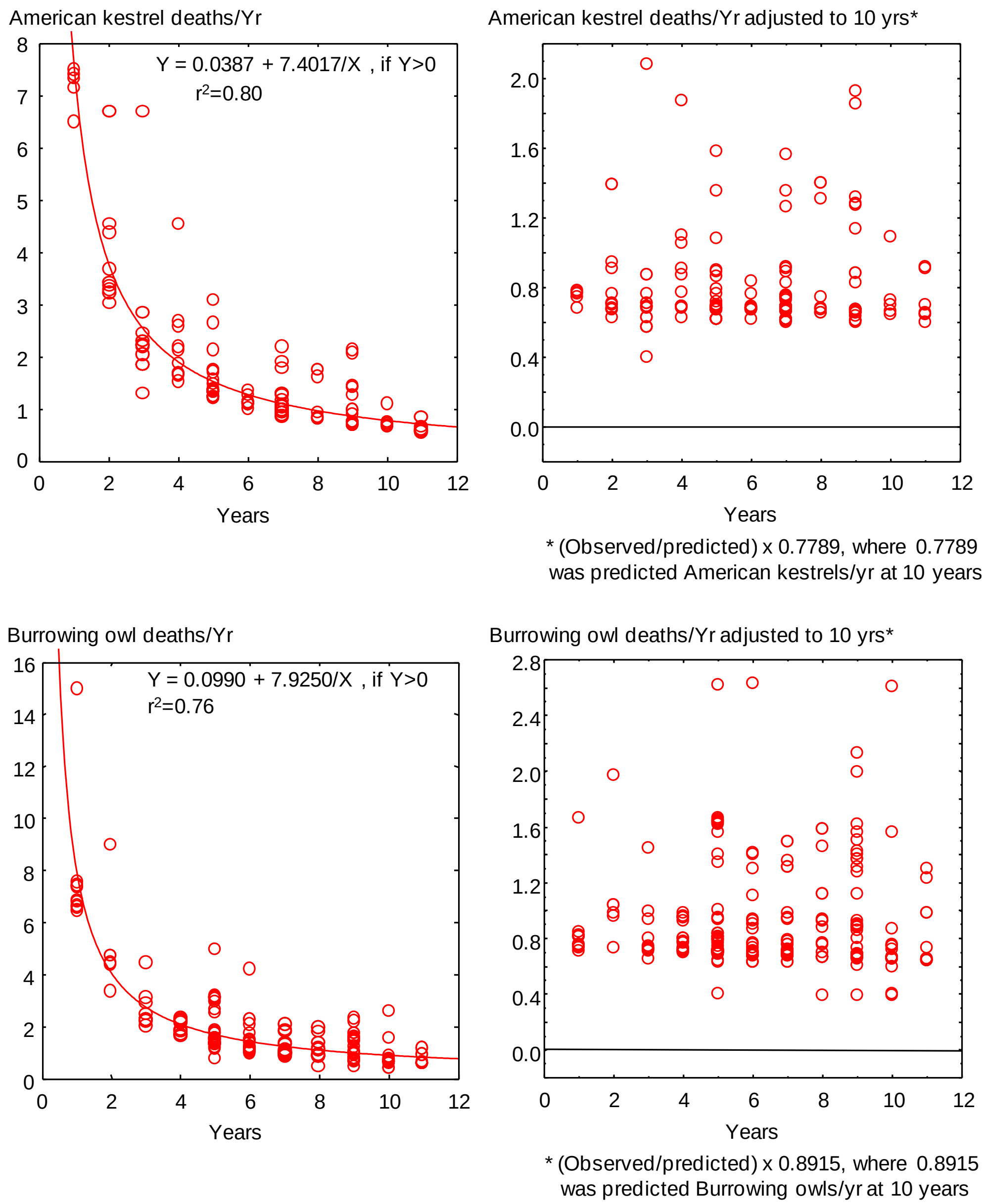

Figure 8b. *Mean annual fatalities/year at turbines where fatalities were found declined inversely with the number of years used in the denominator for American kestrel and burrowing owl (left graphs), so fitting inverse functions to the data removed the effect of number of years on the metric (right graphs).*

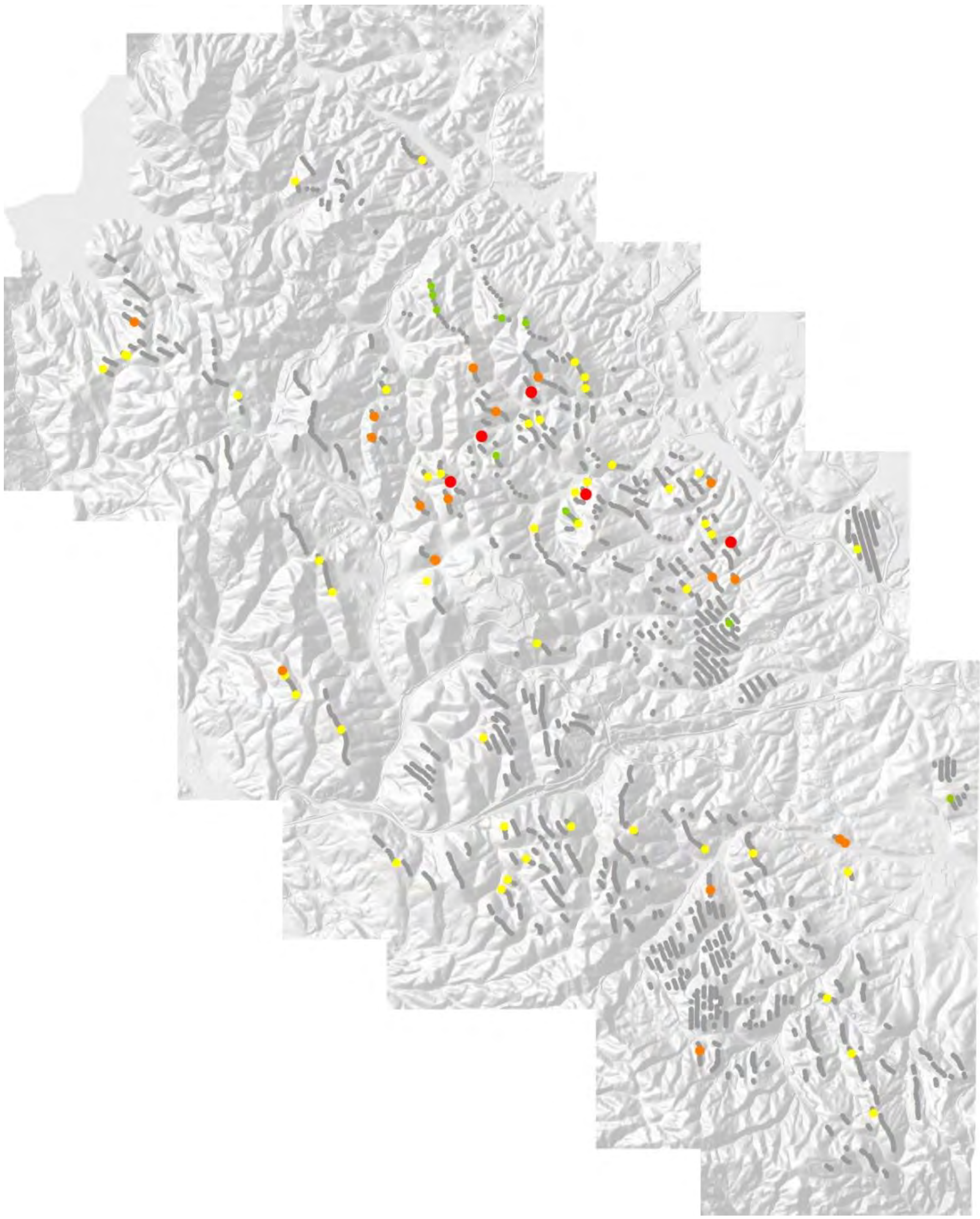

Figure 9. *Golden eagle fatality rates at Altamont Pass wind turbines, 1998 through 2010, adjusted for the duration of monitoring where gray circles represent monitored wind turbines where eagle fatalities were not found and colored circles represent adjusted fatality rates from lowest (yellow) to highest (red).*

Digital Elevation Model

Two separate digital elevation model (DEM) grids were utilized for this project. The geoprocessing tasks were performed using a 10 foot cell size DEM created by combining DEMs obtained from Contra Costa and Alameda Counties. These data sets were produced using LIDAR data and ARC TIN software by Mapcon Mapping Inc. during 2007-2008. The border of the APWRA was used as a mask to produce the APWRA DEM composed of 25,440,000 10x10-foot cells. This DEM was then converted to a cell centroid point feature class and each point assigned a unique membership number.

All derived parameters were calculated for the entire APWRA DEM and attributed into the cell centroid point feature class. An aggregated 792-m buffer served as our mask (limit) for analyzing previously collected bird data against the DEM parameters. The 792-m radius was converted to a 2,600 foot radius and an additional 200 feet was added to buffer modeling data for geoprocessing and to ensure that all bird observations would be covered.

The statistical analyses within the APWRA were limited (masked) to data within the areas searched for raptors within the behavior study areas, for burrowing owl burrows within the burrowing owl sampling plots, and for fatality rates among the wind turbines that were monitored at least one year (and the grid cells on which the turbines were located). The resulting analytical grids within the behavior survey areas were composed of a 7,548,578 (30%) subset of the 10x10-foot centroid point feature class serving as the study area for the behavior surveys, and a 393,555 subset serving as the study area for the behavior surveys restricted to 10-m buffered ridge-like features. These analytical grids were used to develop and test predictive models.

The same geoprocessing steps were used to characterize terrain attributes as reported in Smallwood and Neher (2010a,b) and in Smallwood et al. (2017). We used the Curvature function in the Spatial Analysis extension of ArcGIS 10.2 to calculate the curvature of a surface at each cell centroid. A positive curvature indicated the cell surface was upwardly convex, a negative curvature indicated the cell surface was upwardly concave, and zero indicated the cell surface was flat. Curvature data (-51 to 38) were classified using Natural Breaks (Jenks) with 3 classes of curvature – convex, concave and mid-range. Break values were visually adjusted to minimize the size of the mid-range class. A series of geoprocessing steps was used, called 'expand,' 'shrink,' and 'region group,' as well as 'majority filter tools' to enhance the primary slope curvature trend of a location. The result was a surface almost exclusively defined as either convex or concave (expressed as 1 or 0, respectively, for the variable *Curve*, and 2 and 1 respectively, for the variable *RidgeValley*, which will appear in the models below). Convex surface areas consisted primarily of ridge crests and peaks, hereafter referred to as ridges, and concave surface areas consisted primarily of valleys, ravines, ridge saddles and basins, hereafter referred to as valleys.

Line features representing the estimated average centers of ridge crests and valley bottoms were derived from the following steps. ESRI's Flow direction function was used to create a flow direction from each cell to its steepest down-slope neighbor, and then the Flow accumulation function was used to create a grid of accumulated flow through each cell by accumulating the weight of all cells flowing into each down-slope cell. A valley started where 50 upslope cells had contributed to it in the Flow accumulation function, and a ridge started where 55 cells contributed to it. We applied flow direction and flow accumulation functions to ridges by multiplying the DEM by -2 to reverse the flow. Line features representing ridges and valley bottoms were derived from ESRI's gridline and thin functions, which feed a line through the centers of the cells composing the valley or ridge. Thinning put the line through the centers of groups of cells ≥40 in the case of valleys. Lines representing ridges and valleys were also clipped to identify the major valleys and major ridges, or the topographic features dominating the local skyline and local drainage systems (Figure 10).

We used the two-foot slope analysis grid to create polygons with relatively gentle slope. We used a Standard Deviation classification to identify areas with < 7.4 % slope. These areas were then converted to polygons and intersected with the ridge/valley lines to determine polygons associated with either ridge or valley descriptions. The borders of these polygons were converted to lines and combined with the ridge/valley line datasets, respectively, and polygons in valley features were termed *valley polygons* and polygons on ridge tops were termed *ridge polygons*.

Horizontal distances (m) were then measured between each DEM grid cell and the nearest valley bottom boundary (in the valley line combined data set) and the nearest ridge top boundary or ridgeline (in the ridgeline combined data set), referred to as *distance to valley* and *distance to ridge*, respectively. These distances were measured from the DEM grid cell to the closest grid cell of a valley bottom or ridgeline, respectively, not including vertical differences in position. The *total slope distance* was the sum of *distance to valley* and *distance to ridge*, and expressed the size of the slope. The DEM grid cell's position in the slope was also expressed as the ratio of *distance to valley* and *distance to ridge*, referred to as the *distance ratio*. This expression of the grid cell's position on the slope removed the size of the slope as a factor. The same measurements were made to major valleys and major ridges.

The vertical differences between each DEM grid cell and the nearest valley bottom boundary and nearest ridge top boundary or ridgeline were referred to as *elevation difference*, and this measure also expressed the size of the slope. In addition to the trend in slope grade at each DEM grid cell, the *gross slope* was measured as the ratio of *elevation difference* and *total slope distance*. The DEM grid cell's position on the slope was also expressed as the ratio of the elevation differences between the grid cell and the nearest valley and between the grid cell and the nearest ridge, referred to as *elevation ratio*. Additionally, the grid cell's position on the slope was measured as the average of the percentage distance and the percentage elevation to the ridge top. This mean percentage was named *percent up slope*, and provided a more robust expression of the grid cell's position on the slope (Figure 11). The same measurements were made to major valleys and major ridges, leading to the variable we named *percent up major terrain slope*. Thus, on a small hill adjacent to a major hill in the area, a grid cell could be 90% under *percent up slope* and only 30% under *percent up major terrain slope*.

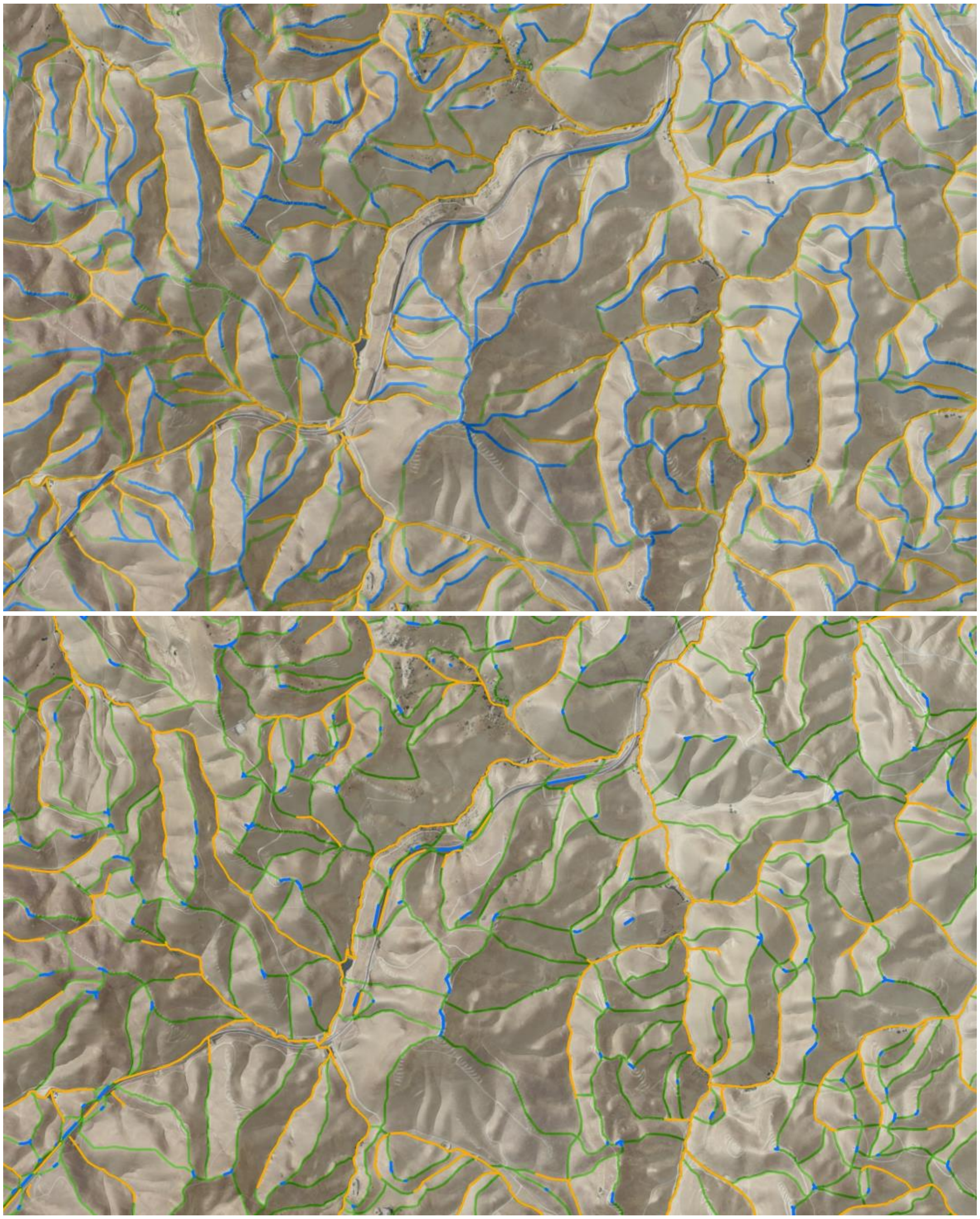

Figure 10. *Valley bottoms (gold) and ridge crests (blue) for all terrain (top) and major terrain (bottom) features*.

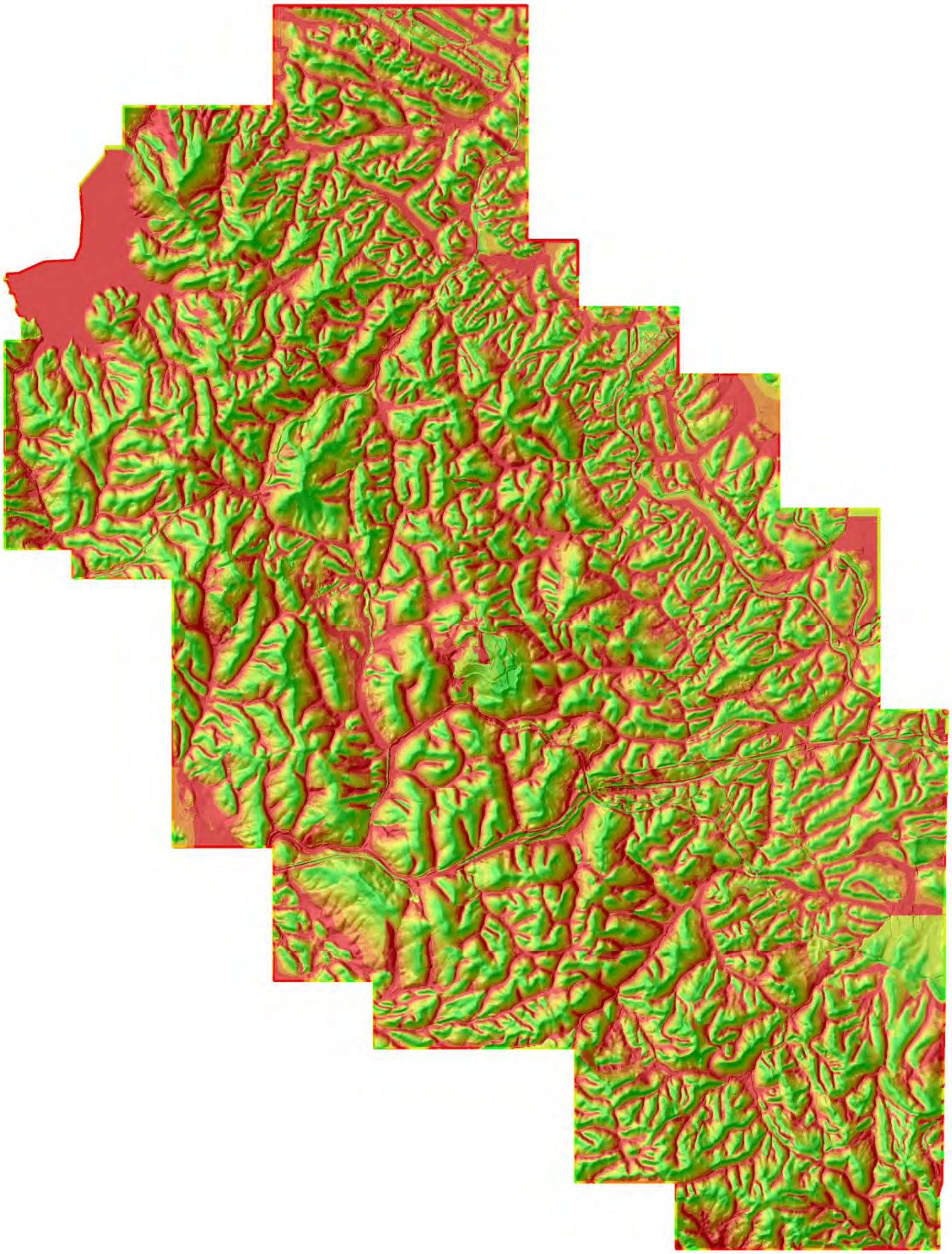

***Figure 11**. Percent up slope across the Altamont Pass Wind Resource Area was derived from multiple terrain measurements to express a grid cell's position on the slope regardless of the size of the slope, where red was at the valley bottoms and dark green at the ridge crests*.

Percent up slope did not distinguish a grid cell's position between slopes on large hills versus medium or small-sized hills, so the local topographic influence of the feature where each cell was located was expressed by the variable *hill size*, which was the elevation difference between the nearest valley bottom polygon and nearest prominent ridge top polygon. *Major hill size* was the elevation difference between the nearest major valley bottom and nearest major ridge top.

Breaks in slope were characterized with the ratio of *slope to gross slope*, and the ratio *gross slope to major gross slope* was also calculated. Additional ratios included *local to major hill size*, *local to major ridge elevation*, and *local to major valley elevation*.

Each DEM grid cell was classified by *aspect* according to whether it faced north, northeast, east, southeast, south, southwest, west, northwest, or if it was on flat terrain. Each grid cell was also categorized as to whether its center on the landscape was windward, leeward or perpendicular to the prevailing southwest and northwest wind directions as recorded during the behavior observation sessions.

The study area was divided into smaller polygons of land with like aspect, creating a predictor variable termed *Subwatershed Orientation*. Existing sub-watershed polygons already had been created between ridgelines and valley bottom lines. These watershed polygons were further divided by reviewing the existing 2-foot hypsography (contour) data and then dividing them into orientation polygons where the overall orientation of the contours changed. An orientation line feature layer was digitized with a line for each new polygon following the best observed orientation of that polygon's contours. Python scripts attributed the new line with its compass orientation, e.g., N, NNE, NE. These lines were non-directional, so a compass value could be either the returned value or the direction 180 degrees opposite. These same scripts calculated a perpendicular compass direction to the returned orientation line direction. The perpendicular orientation direction had two possible values, differing by 180 degrees based on which side of the ridge the line described. A reference point within each orientation polygon was georeferenced by scripts to a generalized aspect grid of the study area. The scripts determined the correct perpendicular orientation and calculated the compass direction of the orientation polygon.

Using similar steps, a predictor variable termed *Ridge Orientation* was created. Ridgelines were buffered by 10 feet and the resulting ridgeline polygons classified by orientation: north to south, north-northwest to south-southeast, northwest to southeast, west-northwest to east-southeast, west to east, west-southwest to east-northeast, southwest to northeast, and south-southwest to north-northeast. Flight paths crossing ridgelines were related to these Ridge Orientation polygons in use and availability analysis.

We represented *ridgeline slope* as the difference between maximum and minimum elevation of grid cells within buffered ridgelines (as above) divided by the total length of the ridgeline polygon. We were hoping to characterize the slope of individual ridge features, but our ridgeline polygons often spanned multiple ridge features, often from one side of a hill across the top to the other side. Whereas we obtained a crude representation of change in elevation along ridge features, we did not measure the slope of individual ridge features.

We also derived a variable named *ridge context*, which was categorized ridge features by their elevation difference and distance from *major ridges* (see Figure 10). We subtracted the elevation of local ridges from the elevation of major ridges and we plotted the elevation differences against the distances between the local and major ridges. After fitting a regression line to the plot to isolate the data above the trend line, we rated *ridge context* as 1 for local ridges at least 790 m from major ridges, 2 for local ridges between 440 and 790 m distant and at least 40 m lower than major ridges, 3 for local ridges between 250 and 440 m distant and at least 26 m lower than major ridges, 4 for local ridges between 170 and 250 m distant and at least 18 m lower than major ridges, 5 for local ridges between 100 and 170 m distant and at least 10 m lower than major ridges, 6 for local ridges between 25 and 45 m distant and at least 4 m lower than major ridges or for local ridges between 45 and 75 m distant and at least 6 m lower than major ridges or for local ridges between 75 and 100 m distant and at least 8 m lower than major ridges. We related adjusted fatality rates to these categories of *ridge context* to identify disproportionate fatality rates.

Steps to identify saddles, notches, and benches

Because a large amount of evidence links disproportionate numbers of raptor fatalities to wind turbines located on aspects of the landscape that are lower than immediately surrounding terrain or that represent sudden changes in elevation (Figure 12), a special effort was directed toward identifying ridge saddles, notches in ridges, and benches of slopes. Benches of slopes are where ridge features emerge from hill slopes that extend above the emerging ridge. These types of locations are where winds often compress by the landscape to create stronger force, and where raptors typically cross hilly terrain or spend more time to forage for prey. Compared to surrounding terrain, these types of features are often relatively flatter or shallower in slope and sometimes include lower elevations (e.g., saddles). Geoprocessing steps were used to provide some objectively to the identification of these features, but judgment was also required because conditions varied widely in how such features were formed and situated (Figure 12).

The same procedures were used as used in the ridge/valley selection. The two foot slope analysis grid was used to create polygons with a relatively gentle slope. A Standard Deviation classification was used to identify areas with < 7.4 % slope. These areas were then converted to polygons. Those polygons not associated with ridge or valley polygons were examined manually. Where these polygons were visually associated with saddle and or step features, they were identified as *hazard sites* representing saddles, notches, or benches. Maps depicting contours of the variable *percent up slope* were also examined, because these contours readily revealed sudden breaks in slope typical of saddles, notches, and benches, which were then also represented with polygons.

Figure 12. *We delineated polygons where ridge saddles present opportunities for flying birds to conserve energy by flying through the relatively lower portions of ridge structures (yellow arrows denote popular flight routes).*

GPS/GSM Telemetry

Doug Bell (2015) caught 18 golden eagles using baited traps since 18 December 2012. To each eagle he affixed 70 g GPS/GSM units manufactured by Cellular Tracking Technologies, LLC (CTT; http://celltracktech.com/) via backpack harness. CTT units measure 100 mm x 40 mm x 23 mm and run on solar powered batteries during daylight hours (Figure 13). All units recorded positions at 15 min intervals, and a subset recorded positions at 30 sec intervals during 3 days of every month. Actual times between position intervals varied, but were supposed to average 15 min or 30 sec. CTT Transmitters download data to cell towers daily during prescribed 1 hour windows, but if a transmitter is beyond cell tower coverage, it will store location data until it returns to an area with cell coverage. Eagle location data were down-loaded from the CTT website, and were password protected.

Figure 13. *A golden eagle fitted with a GPS/GSM telemetry unit as seen during a visual scan survey to record behavior patterns*.

GPS/GSM telemetry positions were collected from all telemetered golden eagles intersecting the boundary of the APWRA from the inception of telemetry monitoring through November 2015. Lines representing flight paths were derived by connecting sequential positions, so each line was associated with a distance and time interval summed among all line segments, where a line segment was the line connecting two sequential positions. New flight lines were initiated each day, as well as when time intervals between sequential positions exceeded 60 sec in the case of data collected at 30 sec intervals and 1,020 sec in the case of data collected at 15 min (900 sec) intervals. We also subsampled 15 min interval data from 30 sec data was when the accumulated time among sequential positions surpassed 900 sec. We included the subsampled 15 min data with the 15 min interval data.

To assess error in the GPS/GSM telemetry units, we placed the units on the ground for long periods next to a Trimble GeoXT GPS with sub-meter accuracy. We also mounted telemetry units in the back of Smallwood's truck (1.2 m above ground) and next to a Trimble GeoXT unit while driving throughout the APWRA on various dates from 22 October 2014 through 10 September 2015. Our visual examination of the GPS/GSM data indicated high lateral position accuracy relative to the Trimble GeoXT unit. However, we noticed high vertical error and a large vertical bias in the GPS/GSM data when examining simple statistics and histograms. Whereas the Trimble GeoXT unit generated positions that averaged about a meter above the 10-

foot DEM surface – where the average was supposed to be – the GPS/GSM data averaged 9 m below the 10-foot DEM surface. We therefore adjusted upward the vertical positions of the telemetered golden eagles by 9 m. We also generated a cumulative distribution curve of the vertical error in the truck-mounted telemetry data, and found that 95% of the recorded positions were within 27 m of their true positions above the 10-foot DEM surface (Figure 14). We therefore used 27 m as a threshold value for determining whether flight lines of golden eagles were above ground. Flight lines were assigned to the following height domains above our 10-foot DEM: **0 (ground)** was <0 m above the DEM surface, **1 (near ground)** = 0 to 27 m above the DEM, **2 (medium)** was >27 m and <200 m above the DEM, and **3 (high)** was >=200 m above the DEM.

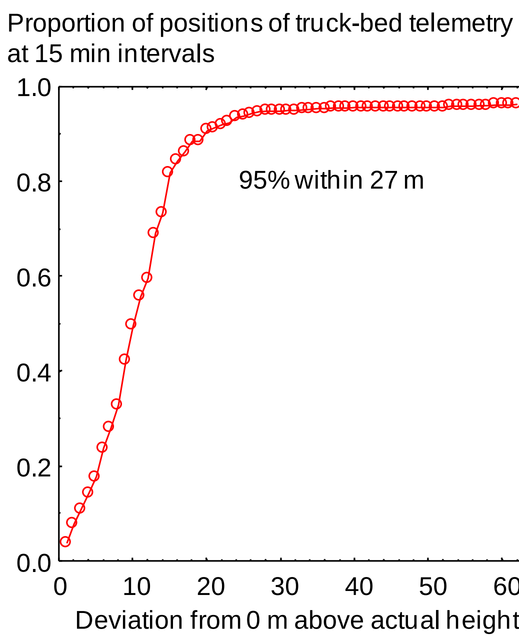

Figure 14. *Cumulative distribution of vertical error measured from 767 GPS/GSM telemetry positions between two units mounted in the back of Smallwood's truck at 1.2 m above ground while driving throughout the APWRA on various dates from 22 October 2014 through 10 September 2015.*

Examining data from GPS/GSM transmitters that we maintained at known locations (not affixed to eagles), we averaged false flight speeds caused by position scatter as 0.3 m/s (1.08 km/hr) for 30 second interval data, and 0.007 m/s (0.026 km/hr) for 15 min interval data. However, relying on speed alone was often insufficient for determining whether an eagle was flying because hovering or kiting golden eagles could have remained in the same locations over 30 sec intervals, and flying golden eagles could have returned to the same positions after flying out and back to another location or in a circle (these behaviors have been seen during visual surveys many times).

Whether an eagle was flying was determined as **possible (0)** if the flight line averaged slower than the speed of position scatter and ≤0 m above the DEM and intersected 1 subwatershed polygon, or it averaged slower than the speed of position scatter and <200 m above the DEM and intersected 1 subwatershed polygon. Whether an eagle was flying was determined as **probable (1)** it the flight line averaged faster than position scatter and ≤27 m above the DEM and intersected ≥2 subwatershed polygons, or it averaged ≥3 km/hr and 0-27 m above the DEM and intersected ≥1 subwatershed polygon, or it averaged ≥1.08 km/hr and 27-200 m above the DEM and intersected ≥1 subwatershed polygon. Whether an eagle was flying was determined as **certain (2)** if the flight line averaged ≥2.5 km/hr or ≥100 m above the 10-foot DEM and intersected ≥4 subwatershed polygons, or it averaged ≥27 m above the DEM and intersected ≥3subwatershed polygons, or it averaged ≥2.3 km/hr and ≥27 m above the DEM and intersected ≥1subwatershed polygon. To prevent flight lines used in our association analysis from being falsely generated from position scatter around perched birds, we included lines determined to have been within height domains 1 or 2 and determined to have been certainly flying (2).

Associations between bird behaviors and terrain attributes

The location of each raptor was characterized by aspect, slope, rate of change in slope, direction of change in slope, and elevation. These variables were also used to generate raster layers of the study area, one raster expressing the aspect of the corresponding slope (hereafter referred to as *aspect*), and the other expressing whether the landscape feature was tending toward convex versus concave orientation (expressed in a variable named *curve*). These features were defined using geoprocessing.

Fuzzy logic (FL) modeling (Tanaka 1997) was used to predict the likelihood each grid cell would be used by golden eagle, red-tailed hawk, American kestrel, and burrowing owl. FL likelihood surfaces were first created by each selected predictor variable. The mean, standard deviation, and standard error were calculated for each predictor variable among the grid cells where each targeted bird species was observed during standard observation sessions. These statistics formed the basis from which FL membership was assigned to grid cells. Depending on the pattern in the data, FL membership was assigned values of 1 whenever the value of the predictor variable was within a certain prescribed distance in value from the mean, oftentimes within 1 SD, but sometimes within 1 or 2 SE. FL membership values of 1 expressed confidence that grid cells with the corresponding value range for the predictor variable are likely to be visited by the target species. FL membership values of 0 were assigned to grid cells that were far from the mean value, usually defined by prescribed distances from the mean such as >2 SD from the mean. FL membership values of 0 expressed confidence that grid cells with the corresponding value range for the predictor variable are unlikely to be visited by the target species. All other grid cells were assigned FL membership values according to the following formulae, assuming that the likelihood of occurrence of each species will grade gradually rather than abruptly across grid cells that vary in value of the predictor variable (Y):

$$0.5 \text{ x } (1 - \cos(\pi \text{ x } (Y - V_c) \div (V_f - V_c))) \text{ below the mean}$$
$$0.5 \text{ x } (1 + \cos(\pi \text{ x } (Y - V_c) \div (V_f - V_c))) \text{ above the mean,}$$

where V_c represented the variance term (SD or SE) closer to the mean and V_f represented the variance term farther from the mean.

FL likelihood values were then summed across predictor variables contributing to a species-specific model. In earlier efforts to develop FL models for golden eagle, red-tailed hawk, American kestrel and burrowing owl in other parts of the APWRA, natural breaks were used to divide the summed values into 4 classes, but the percentages of study area composing these classes remained fairly consistent despite use of natural breaks. Therefore, this time the class divides were established at 63.5%, 83.5%, and 95.5% when natural breaks were not evident; otherwise, we used natural breaks. Class 1, including FL likelihood values <63.5% (i.e., 63.5% of the study area), represented the suite of grid cells including fewer bird observations other than expected. Class 2, including FL likelihood values between 63.5% and 83.5% (i.e., 20% of the study area), represented the suite of grid cells including about equal or slightly greater than equal bird observations other than expected. Class 3, including FL likelihood values between 83.5% and 95.5% (i.e., 12% of the study area), represented the suite of grid cells including more bird observations other than expected. And class 4, including the upper 4.5% of FL likelihood values, represented the suite of grid cells including substantially more bird observations other than expected.

The performance of each model was assessed by the magnitude of the ratio of the observed number to the expected number of observations representing a dependent variable and occurring within the suite of conditions specified by each FL surface class. Dependent variables included fatality rates (except for American kestrel), flights <180 m above ground, flights across ridge features and <180 m above ground (Figure 15), social interactions while flying (Figure 16), wind turbine interaction events (Figures 17 and 18), and hovering or kiting or surfing behaviors (Figure 19). FL surface models were later projected across wind project areas.

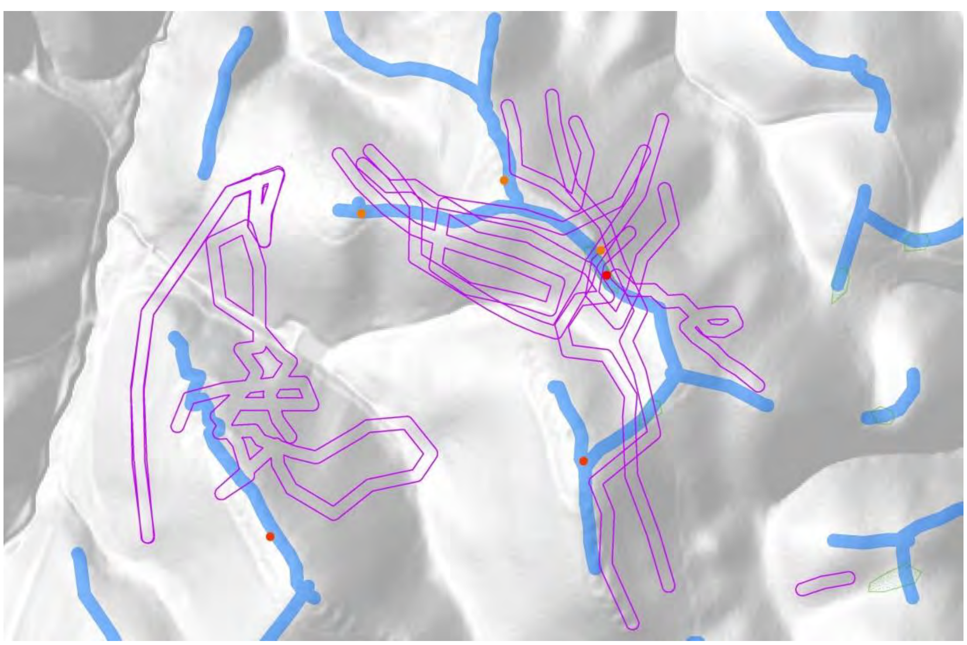

***Figure 15**. Example of how golden eagle ridge crossings were quantified. WE buffered flights within 180 m of the ground by 10 m (purple polygons) and their overlap with 10-m buffered ridge crests (blue polygons) were counted for each ridge orientation: N-S, NNE-SSW, NE-SW,*

ENE-WSW, E-W, ESE-WNW, SE-NW, and SSE-NNW. Colored circles depict golden eagle fatality rates adjusted for monitoring duration, were red was the highest fatality rates.

Figure 16*. Social or competitive interactions between flying birds served as a dependent variable for collision hazard modeling, so associations were sought between interacting birds and terrain measurements and terrain features.*

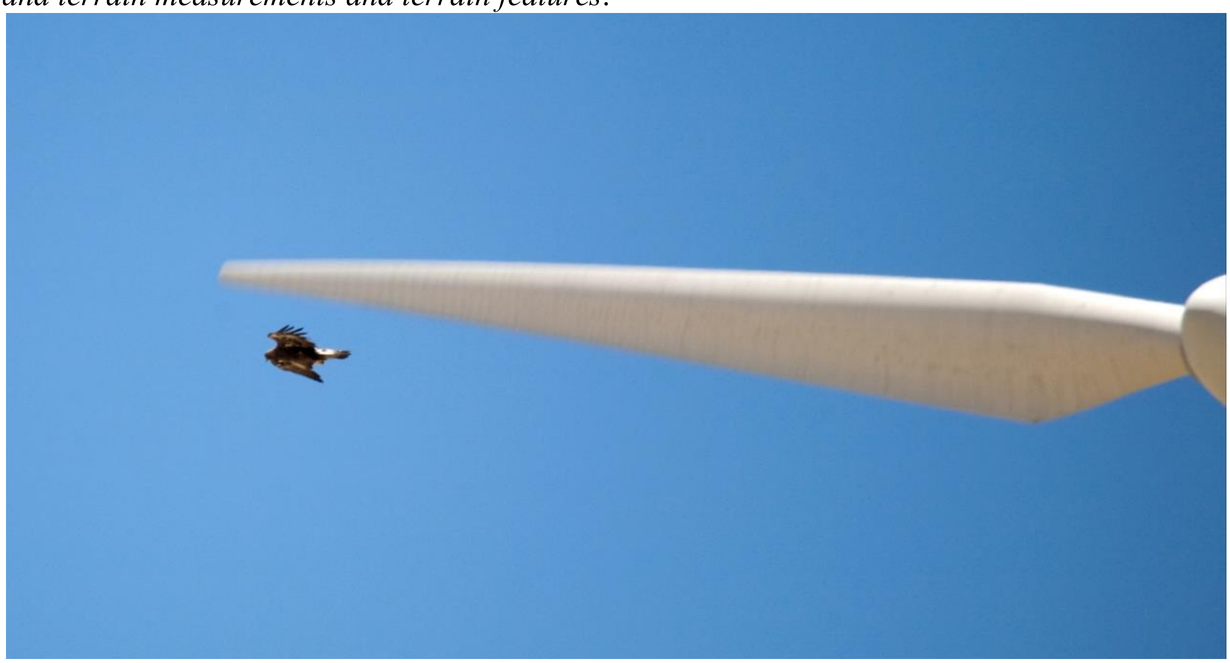

Figure 17*. Wind turbine events of birds adjudged by observers to have flown dangerously close to wind turbine blades were recorded and used for collision hazard modeling, so associations were sought between wind turbine events and terrain measurements and terrain features. In this case a golden eagle narrowly avoided a collision with a moving wind turbine blade.*

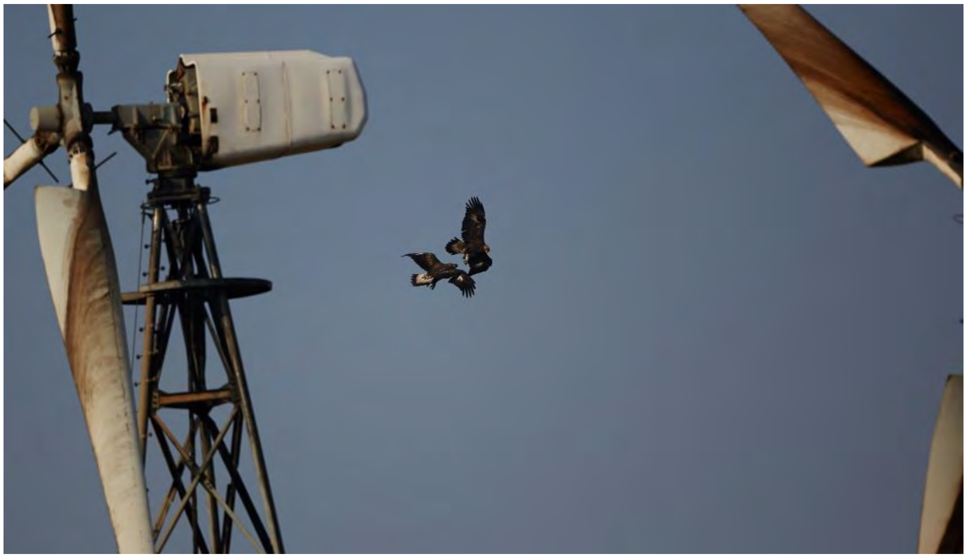

***Figure 18**. Example of a social interaction between flying golden eagles that also happen to be near wind turbines. Where and under what conditions these combined social interactions and wind turbine events occur can assist with predicting collision hazard, but many hours of directed behavior surveys are needed to accumulate a sufficient number of these events to reliably associate them with environmental and terrain factors*.

***Figure 19**. Red-tailed hawks kiting near the top of a slope. Red-tailed hawks, American kestrels and burrowing owls (at night) often perform this behavior just upwind of wind turbines. It is a known dangerous behavior, having preceded multiple eye-witness accounts of birds drifting with the wind or being pushed back by wind into operating wind turbine rotors. The behavior is also dangerous because kiting or hovering birds often break off from these behaviors to glide quickly with the wind before turning back into the wind to repeat the behaviors over another portion of the slope, but the glide with the wind often places them in sudden jeopardy of colliding with turbine blades*.

Burrowing owl model

Because burrowing owls tend to nest low on the slope, it would be rare for a predictive model of burrowing owl burrow locations to correspond with terrain where burrowing owls are killed by wind turbines. Therefore, we developed a burrowing owl fatality model. Previous attempts to develop reasonably predictive burrowing owl fatality models were frustrating. This time we examined earlier model predictions to learn where errors were accumulating. We discovered patterns that related to the size of the local terrain, with patterns of fatalities in shallower low-elevation terrain differing from those of larger high-elevation terrain (low and high elevation relative to the elevation range of the APWRA). Therefore, we divided the APWRA into four terrain regions based on ranges of analytical grid cell values representing *Valley elevation*, or elevation of the nearest valley bottom grid cell. Ranges of terrain size were Low (≤87 m), Mid-low (87-165 m), Mid-high (165-360 m), and High (>360 m). Candidate predictor variables were then related to fatality rates at monitored wind turbines within each terrain size category separately.

RESULTS

GPS/GSM Telemetry of Golden Eagles

All 18 of the golden eagles fitted with GPS/GSM telemetry units intersected the APWRA at some point during the study (Figure 20). Two of the eagles barely overlapped the APWRA with 3 positions each, so they did not contribute anything to the analysis. Another two eagles recorded only 15 and 16 positions within the APWRA, so they, too, contributed little if anything to the analysis. The other 14 eagles contributed hundreds or thousands of positions within the APWRA.

Our examination of associations between eagle positions and terrain variables indicated no difference between eagles tracked at 30 sec intervals and those tracked at 15 min intervals. Therefore, we combined the data from the two position intervals for quantifying associations with terrain variables. We found high variation in terrain associations between gender and age classes of eagles, but none of this variation appeared meaningful. However, we noticed strong differences in terrain associations between the 3 eagles that collided with wind turbines versus those that have not yet collided with wind turbines. Therefore, we relied mostly on terrain associations of the 3 eagles that collided with wind turbines to develop a collision hazard model.

After combining data sets based on 30 sec and 15 min intervals, golden eagle telemetry positions adjusted for vertical bias and intersecting the APWRA numbered 17,025 (14%) at or below ground (of course, these birds were not truly below ground, but recorded below ground due to position errors), 79,757 (66%) near ground, 18,396 (15%) within the hazardous height zone of 27 m to 200 m above ground, and 6,079 (5%) high above ground. Of the golden eagle positions intersecting the APWRA, 1.39% were possibly of flying eagles, 12.88% were probably of flying eagles, and 85.73% were certainly of flying eagles.

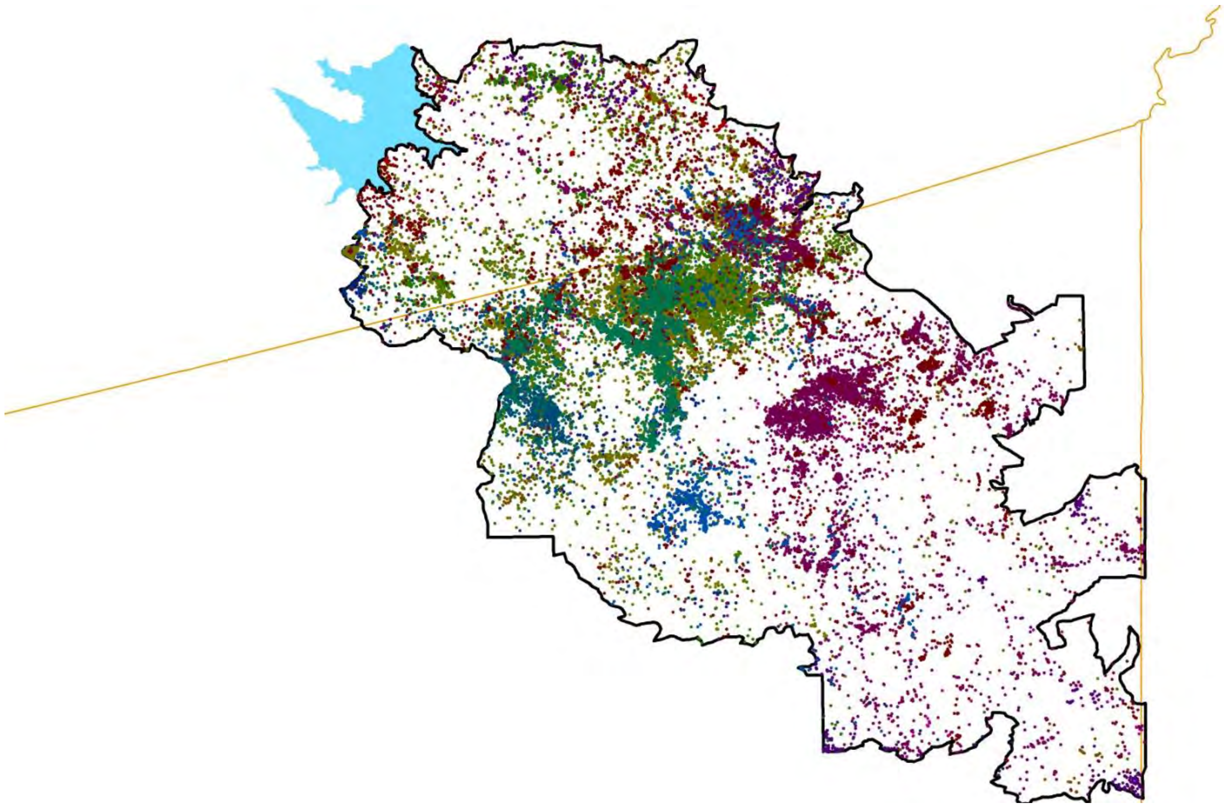

***Figure 20**. GPS/GSM telemetry positions of golden eagles (each color represents a different eagle) within the boundary of the Altamont Pass Wind Resource Area, December 2012 through September 2015. Orange lines represent County boundaries, and the blue polygon at the upper left is Los Vaqueros Reservoir. As a cautionary note, the numbers and densities of telemetry positions represent those of tracked eagles and not of all the eagles that otherwise could have used the APWRA; in other words, the densities of positions do not represent densities of eagle activity in the APWRA.*

Visual Surveys

Behavior surveys performed at Sand Hill through 5 April 2015 numbered 2,002 30-min surveys and across the rest of the APWRA through 29 October 2015 numbered 1,095 1-hr surveys elsewhere in the APWRA for a combined 2,096 hours. APWRA-wide observation rates were 0.6115 golden eagles/hour, 1.3597 red-tailed hawks/hour, and 0.4054 American kestrels/hour. We recorded wind turbine interaction events, including 86 golden eagle events, 156 red-tailed hawk events, and 98 American kestrel events.

Hazard Models

The FL models of golden eagle were composed of 7 predictor variables based on telemetry data (Table 1), 3 predictor variables based on behavior data (Table 2), and 9 predictor variables based on fatality rates (Table 3). The FL models of red-tailed hawk were composed of 3 predictor variables based on behavior data (Table 4), and 6 predictor variables based on fatality rates (Table 5). The FL models of American kestrel were composed of 5 predictor variables based on behavior data (Table 6), and 7 predictor variables based on fatality rates (Table 7). The FL models of burrowing owl were composed of 2 predictor variables based on burrow location data (Table 8), and 5 predictor variables based on fatality rates and conditional to size categories of terrain (Table 9). How the models were weighted and combined for each species is summarized in Table 10.

Telemetered golden eagles were recorded flying disproportionately over the upper portions of slopes, even more so for the colliders (Figure 21). Colliders were also disproportionately recorded flying higher up the slopes of major terrain features, as well as over ridges oriented east to west and east-southeast to west-northwest and over slopes facing north-northwest, south-southwest and south (Figure 22). Colliders were disproportionately recorded flying farther from the major valley bottoms and over steeper-than-average slopes.

Golden eagle flights and wind turbine interactions occurred disproportionately over ridges oriented generally west-east. Associations were also strong with subwatershed slopes facing westerly directions, especially west and northwest. Golden eagles flew and interacted with wind turbines disproportionately at 91% to 100% up the slope (Figure 23).

Red-tailed hawks hovered and kited disproportionately over slopes oriented north-northeast, west, and northwest. Red-tailed hawks hovered and kited disproportionately over ground that was between 85% and 100% to the top of the slope (Figure 24). Red-tailed hawk kiting and hovering was broader across major terrain features, with peak activity ranging between 53% and 83% to the top of the feature (Figure 24).

American kestrels flew most disproportionately over slopes oriented west and southwest, ranging mostly between three-quarters to the peak of the slope and midway to just below the peaks of major terrain features. American kestrel wind turbine interaction events were observed disproportionately on relatively small hills.

Burrowing owl burrows were located disproportionately between 5% and 30% of the way up south-facing slopes (Figure 25). Burrowing owl fatality rates were disproportionately higher at low to moderate elevations and between 35% and 42% of the way up the slopes of major terrain features and in hazard sites (Figure 25).

Based on the data used to develop the models, the models performed well (Figure 26). Of course, it should be remembered that model performance tends to be higher when validation is based on the data underlying the models.

Map-based collision hazard models were used to recommend shifts in the initially proposed wind turbine layout at Sand Hill (Figures 27-46). The models for golden eagle, red-tailed hawk and American kestrel were combined from other models as described in the Methods section and Table 10, and the burrowing owl model was based solely on fatality data. Addresses with letters indicate alternative sites under consideration with respect to the address number, so 15, 15-A and 15-B are three sites from which one wind turbine might be installed.

Table 1. *Golden eagle fuzzy logic membership functions of DEM grid cells based on GPS telemetry positions primarily of 3 study birds that collided with wind turbines.*

Value of variable Y for *i*th grid cell (type of event)	**Membership function of grid cell (Values >1 include weightings)**
Ridge orientation	
Y = W-E	3
Y = WNW-ESE	2
Y = NW-SE,	1
Y = Other orientation	0
Subwatershed orientation	
Y = S, SSW, NNW	2
Y = N, NE, SW, WNW	1
Y = Other orientation	0
Percent up slope	
$85.70 < Y \leq 100$	1
$71.56 \leq Y \leq 85.70$	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y - 71.56) / (85.70 - 71.56)))$
$Y < 71.56$	0
Percent up major terrain slope	
$59.0 < Y \leq 98.0$	1
$39.5 \leq Y \leq 59.0$	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y - 39.5) / (59.0 - 39.5)))$
$98.0 < Y \leq 100.0$	$0.5 \times (1 + \mathrm{COS}(\pi \times (Y - 98.0) / (100.0 - 98.0)))$
$Y < 39.5$	0
Distance to major valley	
$168.81 < Y \leq 538.34$	1
$117.25 \leq Y \leq 168.81$	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y - 117.25) / (168.81 - 117.25)))$
$538.34 < Y < 684.44$	$0.5 \times (1 + \mathrm{COS}(\pi \times (Y - 538.34) / (684.44 - 538.34)))$
$Y < 117.25$ or $Y > 684.44$	0
Gross slope	
$19.56 < Y \leq 33.10$	1
$15.04 \leq Y \leq 19.56$	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y - 15.04) / (19.56 - 15.04)))$
$33.10 < Y < 42.13$	$0.5 \times (1 + \mathrm{COS}(\pi \times (Y - 33.10) / (42.13 - 33.10)))$
$Y < 15.04$ or $Y > 42.13$	0
Hazard site	
Y = Within polygon	1
Y = Outside polygon	0

Table 2. *Golden eagle fuzzy logic membership functions of DEM grid cells based on flights involving ridge crossings, interactions with other birds, and wind turbine interaction events.*

Value of variable Y for *i*th grid cell (type of event)	**Membership function of grid cell (Values >1 include weightings)**
Ridge orientation (ridge crossings, social interactions, turbine events, behavior)	
Y = W-E	2
Y = N-S, NE-SW, WNW-ESE, NNW-SSE	1
Y = Other orientation	0
Subwatershed orientation (social interactions, turbine events, behavior)	
Y = WSW, W, NW	3
Y = SSE, WNW, SSW, NNW	2
Y = N, NNE, NE, SW	1
Y = Other orientation	0
Percent up slope (turbine events, social interactions)	
$91 < Y \leq 100$	1
$15 \leq Y \leq 91$	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y - 15) / (91 - 15)))$
$Y < 15$	0

Table 3. *Golden eagle fuzzy logic membership functions of DEM grid cells based on fatality rates at wind turbine locations.*

Value of variable Y for *i*th grid cell (type of event)	Membership function of grid cell (Values >1 include weightings)
Ridge orientation	
Y = WNW-ESE	2
Y = WSW-ENE, W-E	1
Slope orientation (for percent upslope <90)	
Y = WNW	3
Y = WSW, NW	2
Y = SSW, SW	1
Ridge context (relative to major ridges)	
Y = 2 (low & far), 6 (low & very near)	2
Y = 5 (low & near)	1
Ridge elevation	
$207.70 < Y \leq 251.48$	1
$69.09 \leq Y \leq 207.70$	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y - 69.09) / (207.70 - 69.09)))$
$251.48 < Y \leq 360.91$	$0.5 \times (1 + \mathrm{COS}(\pi \times (Y - 251.48) / (360.91 - 251.48)))$
$Y < 69.09$ or $Y > 360.91$	0
Hill size (for percent upslope <90)	
$66.76 < Y < 75.24$	1
$49.80 \leq Y \leq 66.76$	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y - 49.80) / (66.76 - 49.80)))$
$75.24 < Y \leq 92.20$	$0.5 \times (1 + \mathrm{COS}(\pi \times (Y - 75.24) / (92.20 - 75.24)))$
$Y < 49.80$ or $Y > 92.20$	0
Ridgeline slope	
$Y > 10$	1
$Y \leq 10$	0
Percent upslope	
$30.65 < Y \leq 51.35$	1
$15.13 \leq Y \leq 30.65$	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y - 15.13) / (30.65 - 15.13)))$
$51.35 < Y \leq 66.87$	$0.5 \times (1 + \mathrm{COS}(\pi \times (Y - 51.35) / (66.87 - 51.35)))$
$Y < 15.13$ or $Y > 66.87$	0
Percent up major terrain slope	
$15.29 < Y \leq 36.71$	1
$9.30 \leq Y \leq 15.29$	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y - 9.30) / (15.29 - 9.30)))$
$36.71 < Y < 42.07$	$0.5 \times (1 + \mathrm{COS}(\pi \times (Y - 36.71) / (42.07 - 36.71)))$
$Y < 9.30$ or $Y > 42.07$	0
Hazard site	
Y = Within polygon	1
Y = Outside polygon	0

Table 4. *Red-tailed hawk fuzzy logic membership functions of DEM grid cells based on flights involving ridge crossings, interactions with other birds, behavior, and wind turbine interaction events.*

Value of variable Y for *i*th grid cell (type of event)	**Membership function of grid cell (Values >1 include weightings)**
Subwatershed orientation (ridge crossings, social interactions, turbine events, hovering/kiting)	
Y = NNE, W, NW	3
Y = SW, N	2
Y = WSW, WNW, NNW	1
Y = Other orientation	0
Percent up slope (hovering/kiting)	
$85.43 < Y \leq 100$	1
$43.84 \leq Y \leq 85.43$	$0.5 \times (1 - \text{COS}(\pi \times (Y - 43.84) / (85.43 - 43.84)))$
$Y < 43.84$	0
Percent up major terrain slope (hovering/kiting)	
$52.98 < Y \leq 82.66$	1
$29.24 \leq Y \leq 52.98$	$0.5 \times (1 - \text{COS}(\pi \times (Y - 29.24) / (52.98 - 29.24)))$
$82.66 < Y \leq 100$	$0.5 \times (1 + \text{COS}(\pi \times (Y - 82.66) / (100 - 82.66)))$
$Y < 29.24$	0

Table 5. *Red-tailed hawk fuzzy logic membership functions of DEM grid cells based on fatality rates at wind turbine locations.*

Value of variable Y for *i*th grid cell (type of event)	**Membership function of grid cell (Values >1 include weightings)**
Ridge orientation	
Y = N-S, NW-SE, WNW-ESE, W-E, WSW-ENE	1
Y = NNW-SSE, SW-NE, SSW-NNE	0
Subwatershed orientation (percent upslope <90)	
Y = SSW, NW	1.5
Y = SW, WNW, NNW	1
Ridge context (relative to major ridges)	
Y = 6 (low & very near)	1
Ridge elevation	
$195.68 < Y \le 222.32$	1
$80.24 \le Y \le 195.68$	$0.5 \times (1 - \cos(\pi \times (Y - 80.24) / (195.68 - 80.24)))$
$222.32 < Y \le 320$	$0.5 \times (1 + \cos(\pi \times (Y - 222.32) / (320 - 222.32)))$
$Y < 80.24$ or $Y > 320$	0
Percent up major terrain slope	
$22.18 < Y \le 27.82$	1
$13.71 \le Y \le 22.18$	$0.5 \times (1 - \cos(\pi \times (Y - 13.71) / (22.18 - 13.71)))$
$27.82 < Y < 36.29$	$0.5 \times (1 + \cos(\pi \times (Y - 27.82) / (36.29 - 27.82)))$
$Y < 13.71$ or $Y > 36.29$	0
Hazard site	
Y = Within polygon	1
Y = Outside polygon	0

Table 6. *American kestrel fuzzy logic membership functions of DEM grid cells based on flights involving ridge crossings, interactions with other birds, behavior, and wind turbine interaction events.*

Value of variable Y for *i*th grid cell (type of event)	**Membership function of grid cell (Values >1 include weightings)**
Subwatershed orientation (ridge crossings, social interactions, turbine events, hovering/kiting)	
Y = SE, SSW, SW, W, NNW	3
Y = WSW, NW	2
Y = N, NNE, SSE, S	1
Y = Other orientation	0
Percent up slope (hovering/kiting)	
$85.43 < Y \leq 100$	1
$43.84 \leq Y \leq 85.43$	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y – 43.84) / (85.43 – 43.84)))$
$Y < 43.84$	0
Percent up major terrain slope (hovering/kiting)	
$66.36 < Y \leq 92.55$	1
$40.15 \leq Y \leq 66.36$	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y – 40.15) / (66.36 – 40.15)))$
$92.55 < Y \leq 100$	$0.5 \times (1 + \mathrm{COS}(\pi \times (Y – 92.55) / (100 – 92.55)))$
$Y < 40.15$	
Hill size (turbine events)	
$20.73 < Y \leq 25.03$	1
$9.98 \leq Y \leq 20.73$	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y – 9.98) / (20.73 – 9.98)))$
$25.03 < Y \leq 44.38$	$0.5 \times (1 + \mathrm{COS}(\pi \times (Y – 25.03) / (44.38 – 25.03)))$
$Y < 9.98$ or $Y > 44.38$	0
Hazard site	
Y = Within polygon	1
Y = Outside polygon	0

Table 7. *American kestrel fuzzy logic membership functions of DEM grid cells based on fatality rates at wind turbine locations.*

Value of variable Y for *i*th grid cell (type of event)	Membership function of grid cell (Values >1 include weightings)
Subwatershed orientation	
Y = NNE, SW	2
Y = SE, SSW	1
Y = Other orientation	0
Ridge orientation	
Y = WSW-ENE	2
Y = NW-SE, NNW-SSE	1
Ridge context (relative to major ridges)	
Y = 4 (low & close), 5 (low & near)	1
Valley elevation (percent upslope < 90)	
66.75 < Y < 91.25 or 135.88 < Y < 148.12	1
54.50 ≤ Y ≤ 66.75 or 129.75 ≤ Y ≤ 135.88	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y – 54.50) / (66.75 – 54.50)))$ $0.5 \times (1 - \mathrm{COS}(\pi \times (Y – 129.75) / (135.88– 129.75)))$
91.25 < Y ≤ 103.5 or 148.12 < Y < 154.25	$0.5 \times (1 + \mathrm{COS}(\pi \times (Y – 91.25) / (103.5 – 91.25)))$ $0.5 \times (1 + \mathrm{COS}(\pi \times (Y –148.12) / (154.25 – 148.12)))$
54.5 < Y > 154.25	0
Slope to gross slope ratio (percent upslope < 90)	
0.79 < Y ≤ 1.20	1
0.69 ≤ Y ≤ 0.79	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y – 0.69) / (0.79 – 0.69)))$
1.20 < Y ≤ 1.31	$0.5 \times (1 + \mathrm{COS}(\pi \times (Y – 1.2) / (1.31 – 1.2)))$
Y < 0.69 or Y > 1.31	0
Distance to major ridge (percent upslope ≥90)	
155 < Y ≤ 195	1
75 ≤ Y ≤ 155	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y – 75) / (155 – 75)))$
195 < Y ≤ 275	$0.5 \times (1 + \mathrm{COS}(\pi \times (Y – 195) / (275 – 195)))$
Y < 75 or Y > 275	0
Hazard site	
Y = Within polygon	1
Y = Outside polygon	0

Table 8. *Burrowing owl fuzzy logic membership functions of DEM grid cells for burrow sites.*

Value of variable Y for *i*th grid cell (type of event)	Membership function of grid cell (Values >1 include weightings)
Subwatershed orientation	
Y = S	2.5
Y = ESE, SE, SSE	1.5
Y = ENE, E	1
Y = Other orientation	0
Percent up slope	
$5.56 < Y \leq 20.83$	1
$0.47 \leq Y \leq 5.56$	$0.5 \times (1 - \mathrm{COS}(\pi \times (Y - 0.47) / (5.56 - 0.47)))$
$20.83 \leq Y \leq 51.37$	$0.5 \times (1 + \mathrm{COS}(\pi \times (Y - 20.83) / (51.37 - 20.83)))$
$Y < 0.47$ or $Y > 51.37$	0

Table 9. *Burrowing owl fuzzy logic membership functions of DEM grid cells based on fatality rates at wind turbine locations.*

Value of variable Y for *i*th grid cell (type of event)	Membership function of grid cell (Values >1 include weightings)
Low: Valley elevation ≤ 87 m	
Ridge orientation	
Y = N-S, NNE-SSW, NE-SW, ENE-WSW, W-E, NNW-SSE	1
Y = SNW-ESE, NW-SE, or not on ridge	2
Mid-low: 87 m < Valley elevation ≤ 165 m	
Not on Ridge: Slope orientation	
Y = SSW, SW, WSW, W	0
Y = WNW, NW, NNW, E	1
Y = N, NNE, NE. ENE, SE	2
Ridge orientation	
Y = WNW-ESE, NW-SE, NNW-SSE	0
Y = NNE-SSW, NE-SW, ENE-WSW, W-E	1
Y = N-S	2
Percent up slope	$Y = (3.153-0.0242 \times \mathrm{Slope})/3.153$
Mid-high: 165 m < Valley elevation ≤ 360 m	
Ridge orientation	
Y = On ridge	1
Y = Not on ridge	2
Slope	$Y = (0.27 + 0.02 \times \mathrm{Slope})/0.76503$
High: Valley elevation > 360 m	
Ridge orientation	
Y = N-S	1
Y = NNE-SSW or not on ridge	2
Slope	
$Y > 6.5$	1
Hill size	
$15 \leq Y \leq 30$	1

Table 10. *Fuzzy logic models developed for Sand Hill, where Low, Mid-low, Mid-high, and High VE represent nearest Valley elevation ranges of ≤87 m, 87-165 m, 165-360 m, and >360 m, respectively.*

Dependent variable	Model	Max score possible
Golden eagle telemetry	Distance to major valley + 2×Percent up slope + 2× Percent up major terrain slope + Gross slope + 2×Subwatershed orientation + 3×Ridge orientation + 10×Hazard site	29
Golden eagle flights	Ridge orientation + 2×Subwatershed orientation + 2×Percent up slope +	10
Golden eagle fatalities	10×Hazard site + Ridge orientation + 2×Subwatershed orientation + 2×Ridge context + Ridge elevation + 2×Hill size + Ridgeline slope + Percent upslope + Major terrain upslope	28
Golden eagle combined	((Telemetry score/29)×2 + Behavior score/10 + (Fatality score/28)×3)/6	1
Red-tailed hawk kiting	2×(Percent up slope + Percent up major terrain slope) + Subwatershed orientation	7
Red-tailed hawk fatalities	6×Hazard site + Ridge orientation + 3×Subwatershed orientation + Ridge context + Ridge elevation + Percent up major terrain slope	14.5
Red-tailed hawk combined	((Behavior score/7) + (Fatality score/14.5))/2	1
American kestrel kiting	7×Hazard site + Ridge orientation + 3×Subwatershed orientation + 3×Percent up slope + Percent up major terrain slope + Hill size	21
American kestrel fatalities	8×Hazard site + 2×Ridge orientation + 2×Subwatershed orientation + 2×Ridge context + Valley elevation + Slope to grosslope ratio + Major ridge distance	21
American kestrel combined	((Behavior score/21)×3 + (Fatality score/21))/4	1
Burrowing owl fatalities	4×Hazard site + Ridge orientation $_{\text{Low VE}}$ + ((Ridge orientation $_{\text{Mid-low VE}}$ or Slope orientation not on ridge $_{\text{Mid-low VE}}$) + 3×Percent up slope $_{\text{Mid-low VE}}$)×3 + (Ridge orientation $_{\text{Mid-high VE}}$ × Slope $_{\text{Mid-high VE}}$)×2 + (Ridge orientation $_{\text{High VE}}$ + Slope $_{\text{High VE}}$ + Hill size $_{\text{High VE}}$)	31

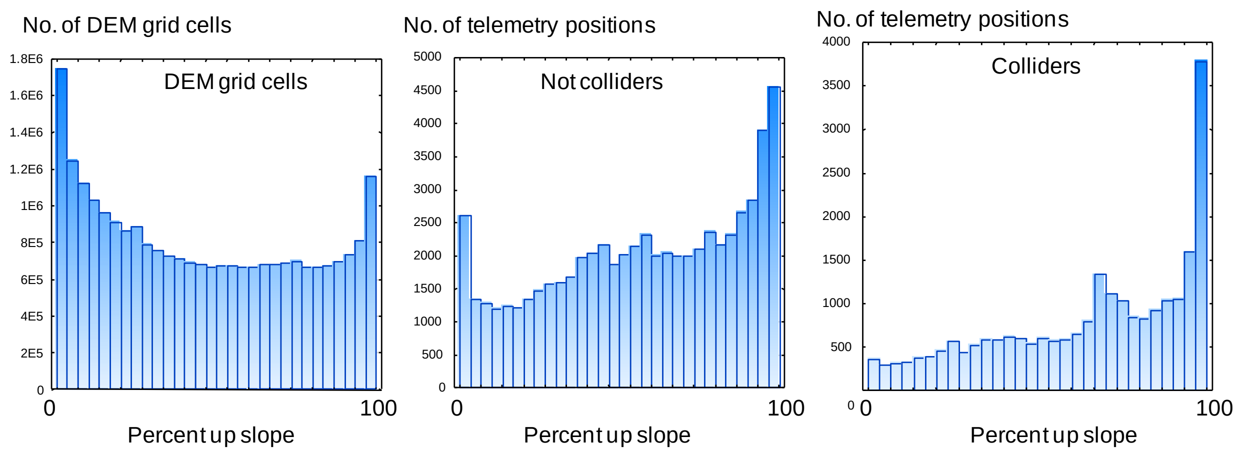

Figure 21. The distributions of telemetered eagle positions were shifted up the slopes (middle and right graphs) compared to the distribution of DEM grid cells in the APWRA (left graph).

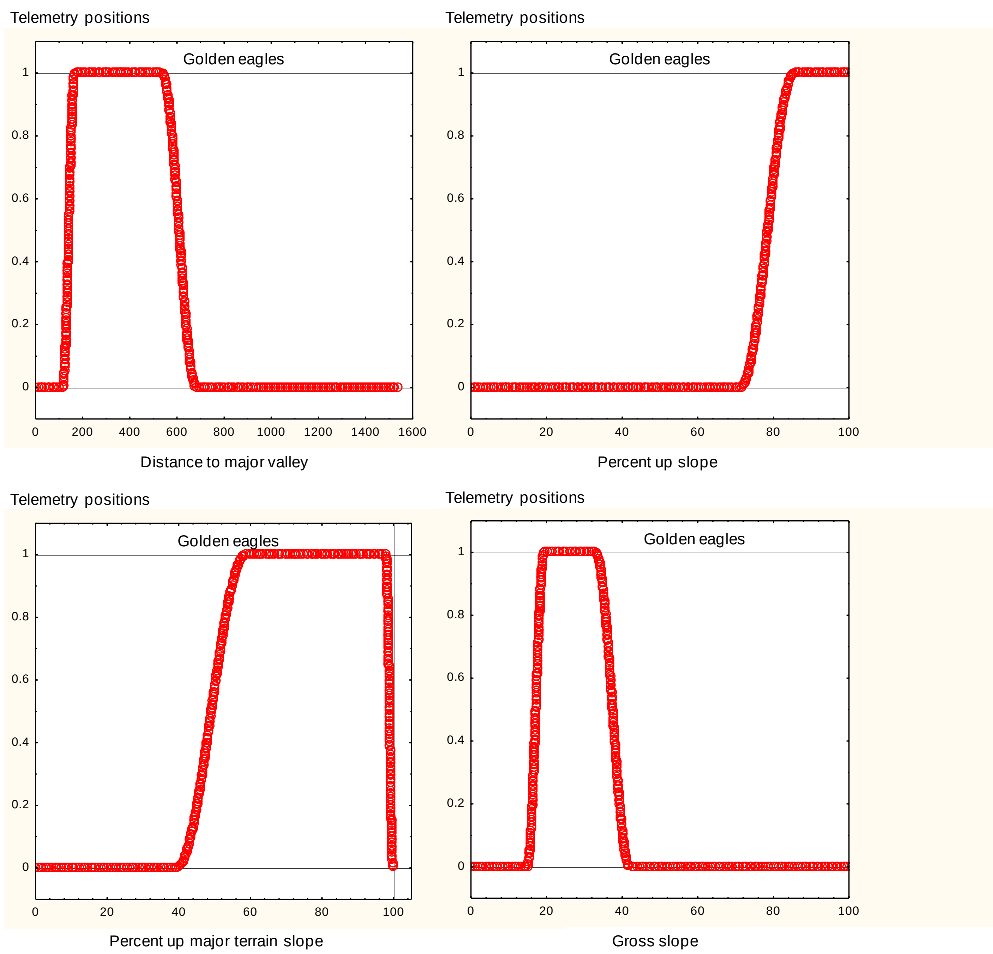

Figure 22. *Examples of grid cell membership values in respective fuzzy logic sets for telemetry positions related to four predictor variables.*

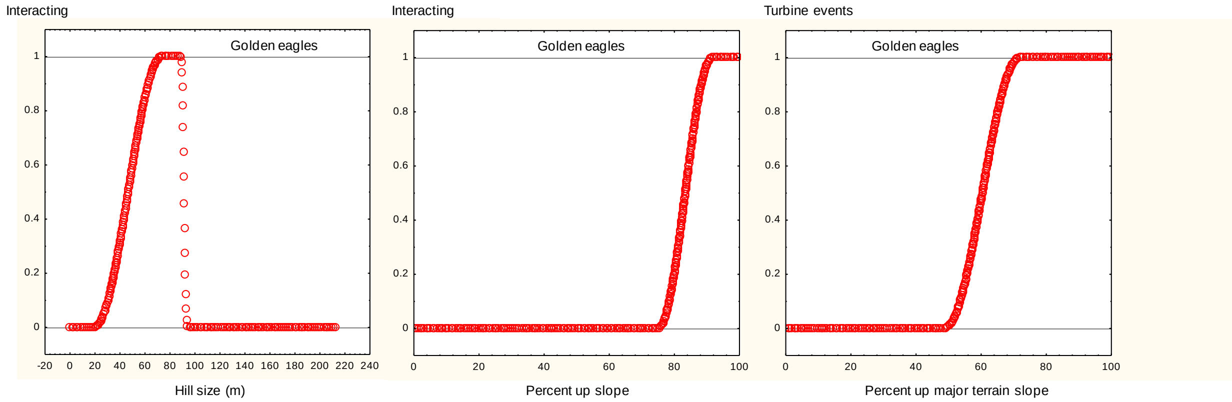

Figure 23. *Examples of grid cell membership values in respective fuzzy logic sets for three predictor variables, including of golden eagle interactions with other birds (left and middle) and wind turbine events (right).*

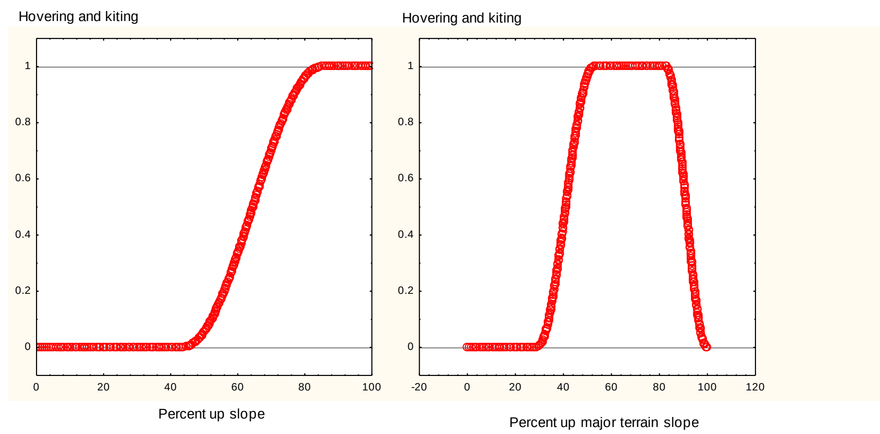

Figure 24. *Examples of grid cell membership values of red-tailed hawk hovering and kiting in respective fuzzy logic sets for percent upslope (left) and percent upslope of major terrain (right).*

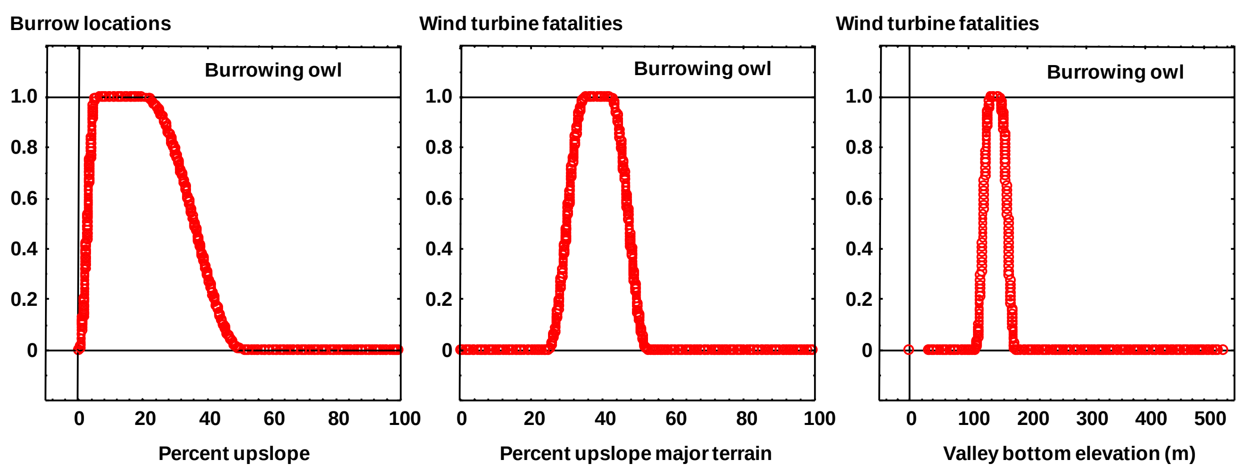

Figure 25. *Examples of grid cell membership values in respective fuzzy logic sets for three predictor variables, including of burrowing owl burrow locations (left) and burrowing owl fatalities at wind turbines (middle and right) in the study area.*

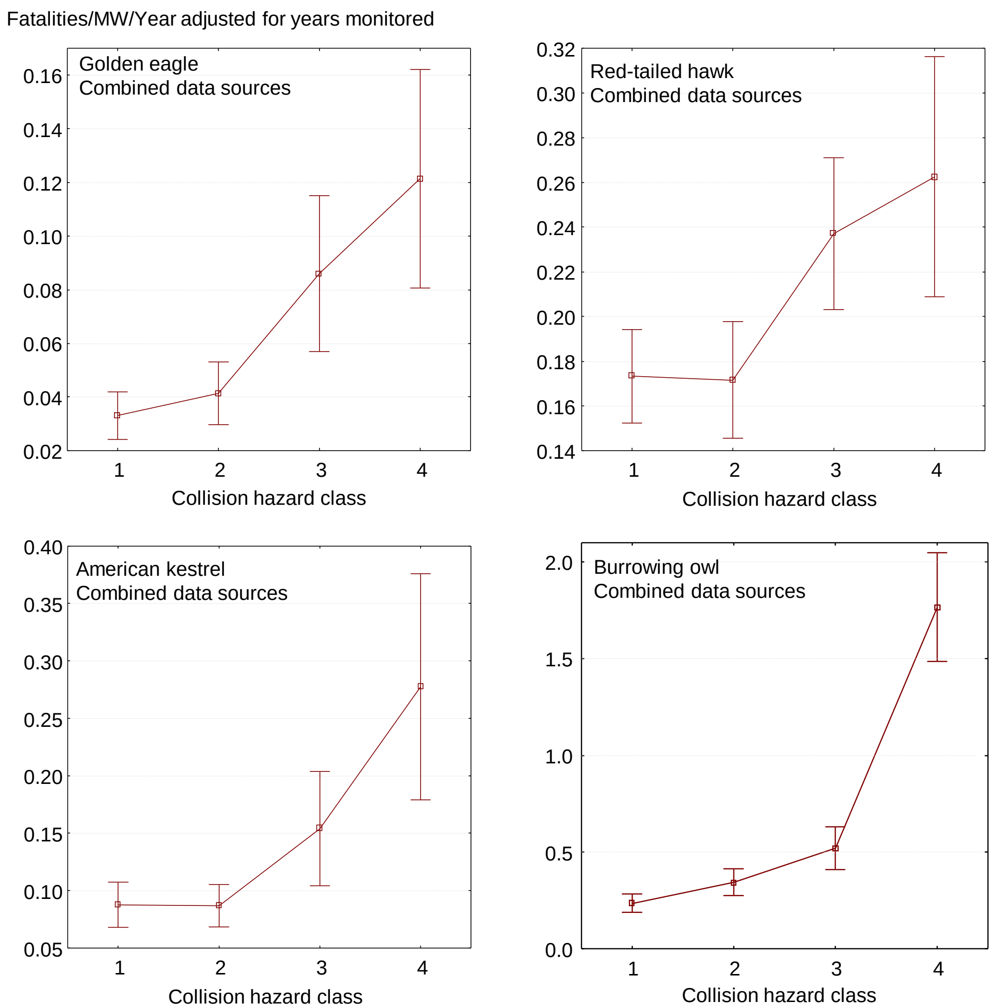

Figure 26. *Performance of collision hazard models based on data used to generate the models.*

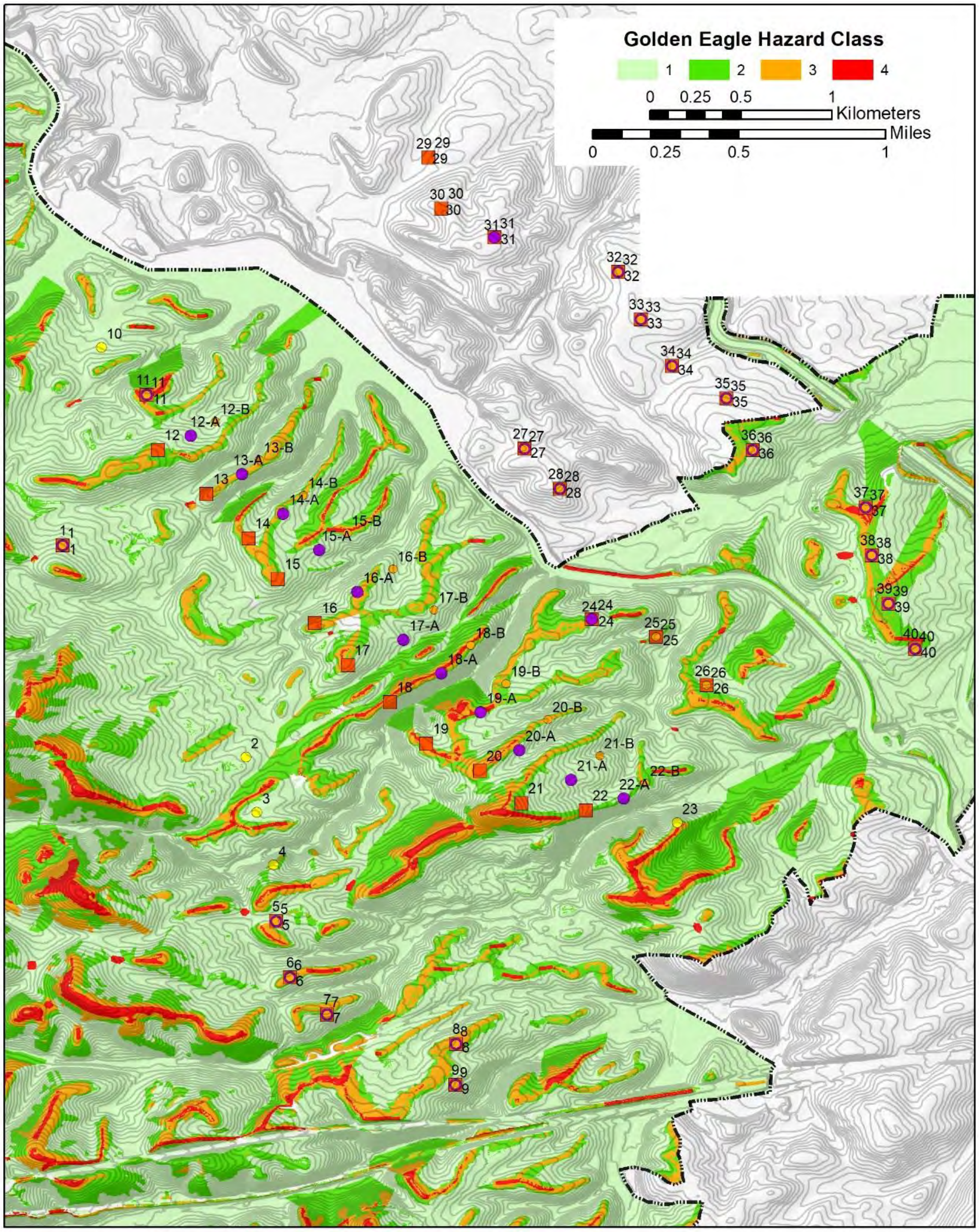

***Figure 27.** Fuzzy Logic likelihood surface classes of golden eagle telemetry, flight behavior and fatality locations across the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

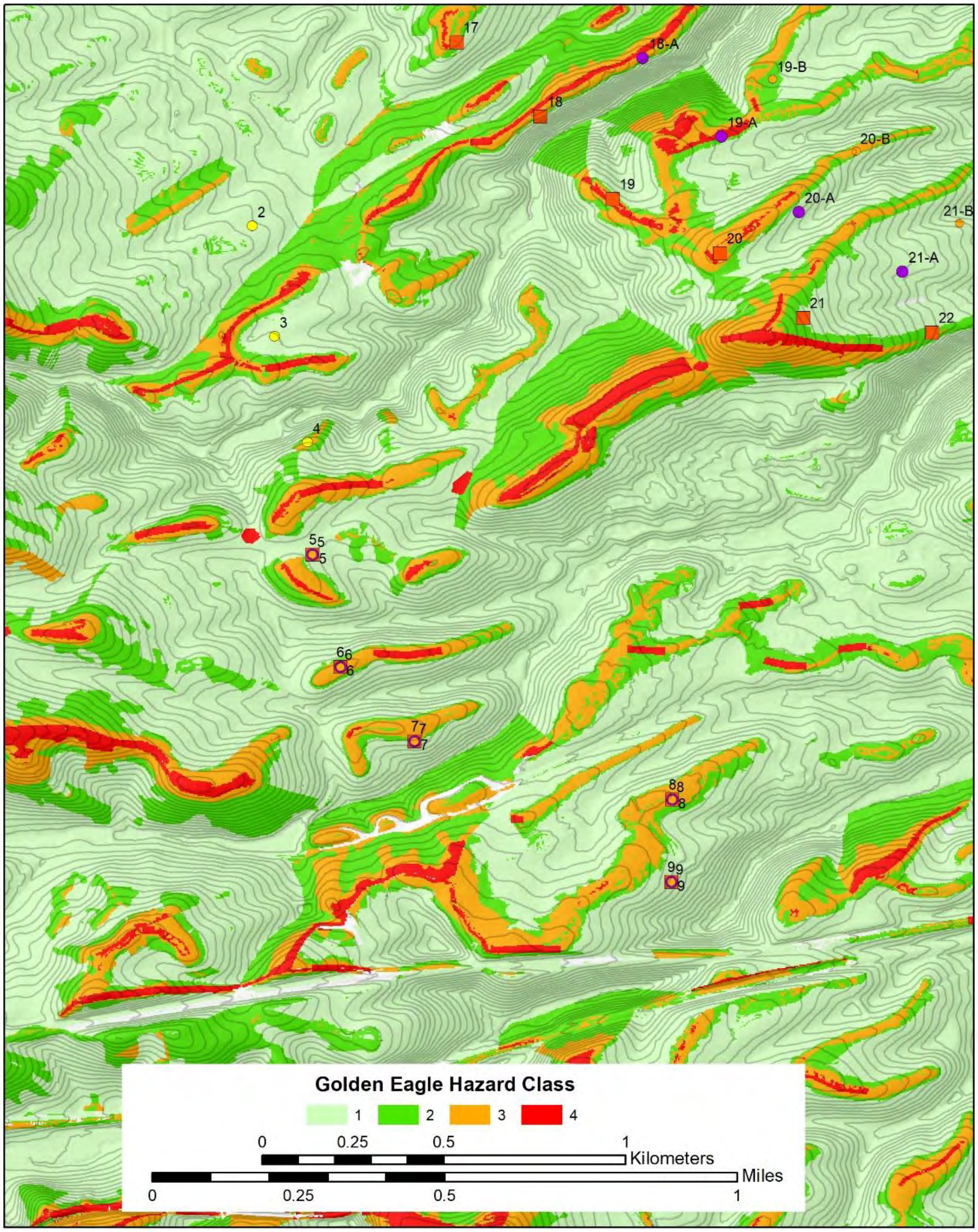

Figure 28. *Fuzzy Logic likelihood surface classes of golden eagle telemetry, flight behavior and fatality locations across the southwest portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

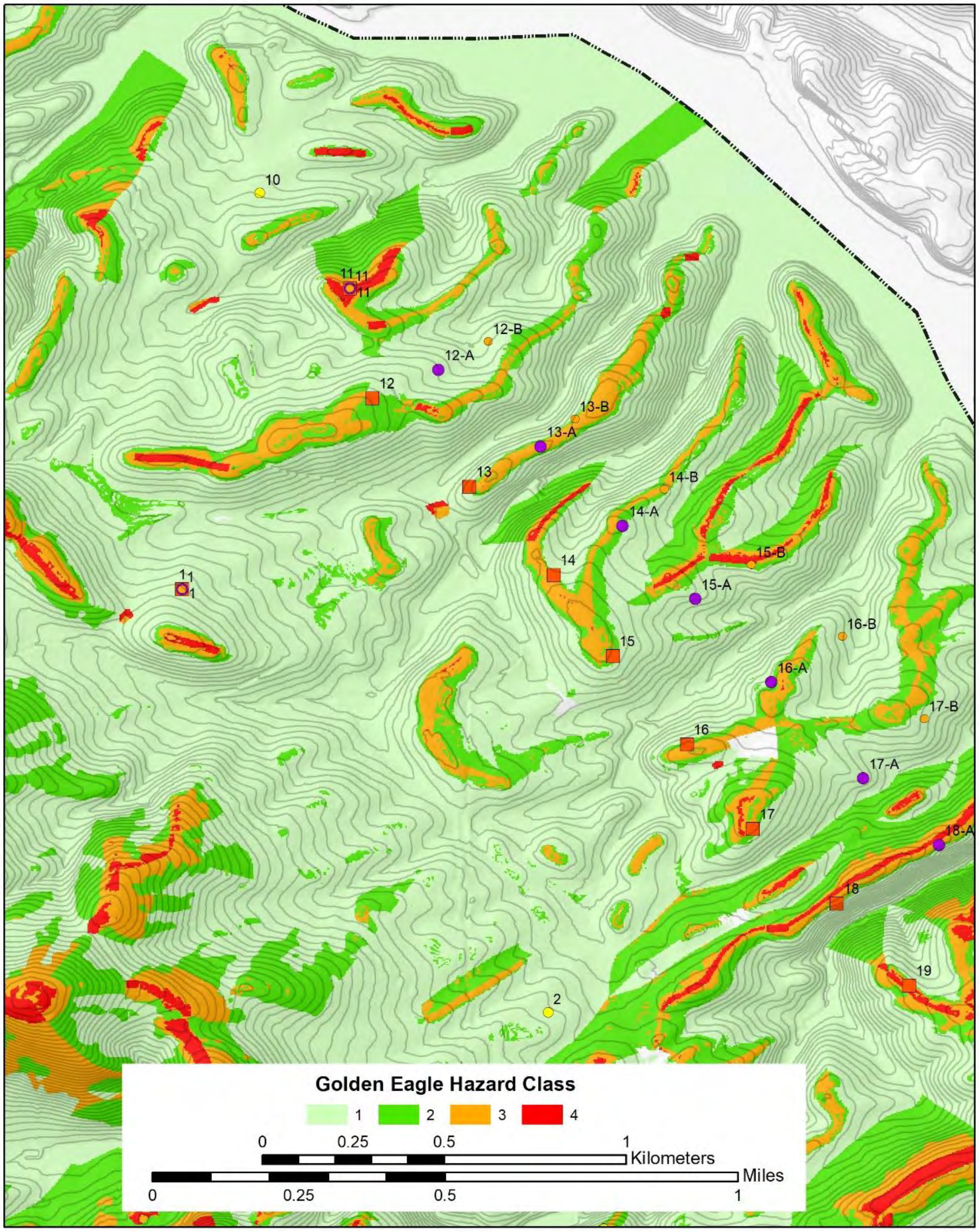

Figure 29. *Fuzzy Logic likelihood surface classes of golden eagle telemetry, flight behavior and fatality locations across the northcentral portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

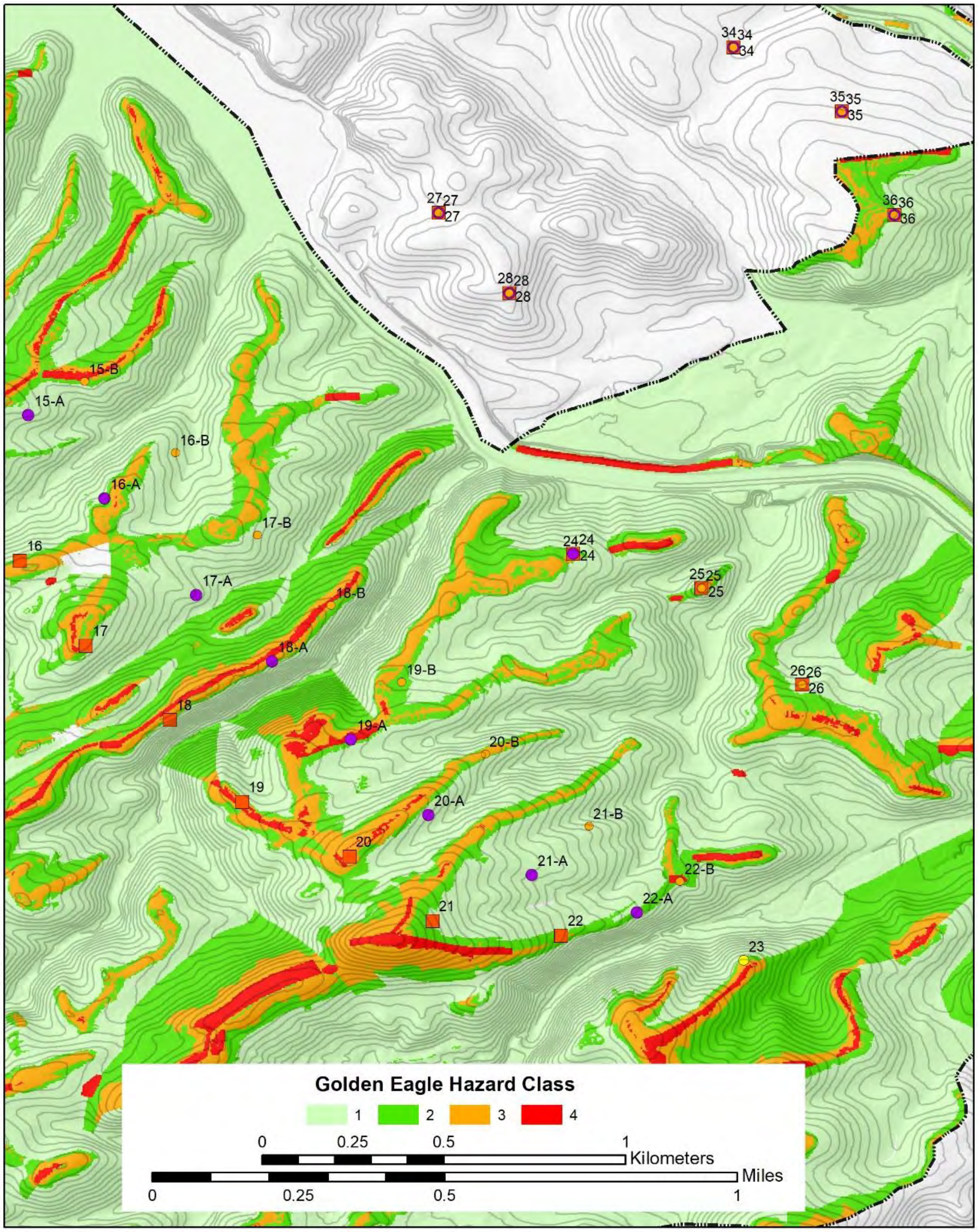

Figure 30. *Fuzzy Logic likelihood surface classes of golden eagle telemetry, flight behavior and fatality locations across the central portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

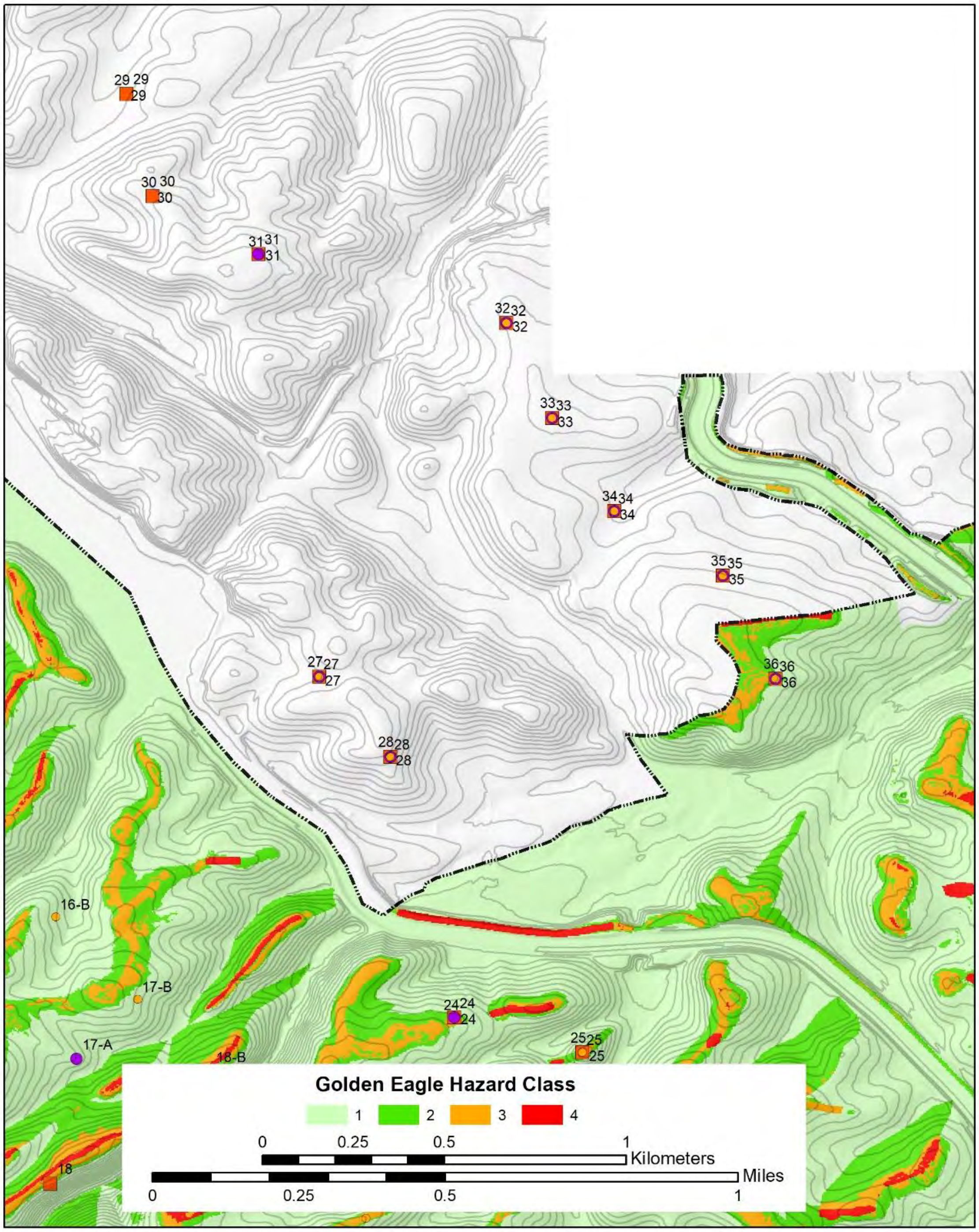

Figure 31. *Fuzzy Logic likelihood surface classes of golden eagle telemetry, flight behavior and fatality locations across the northeastern portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

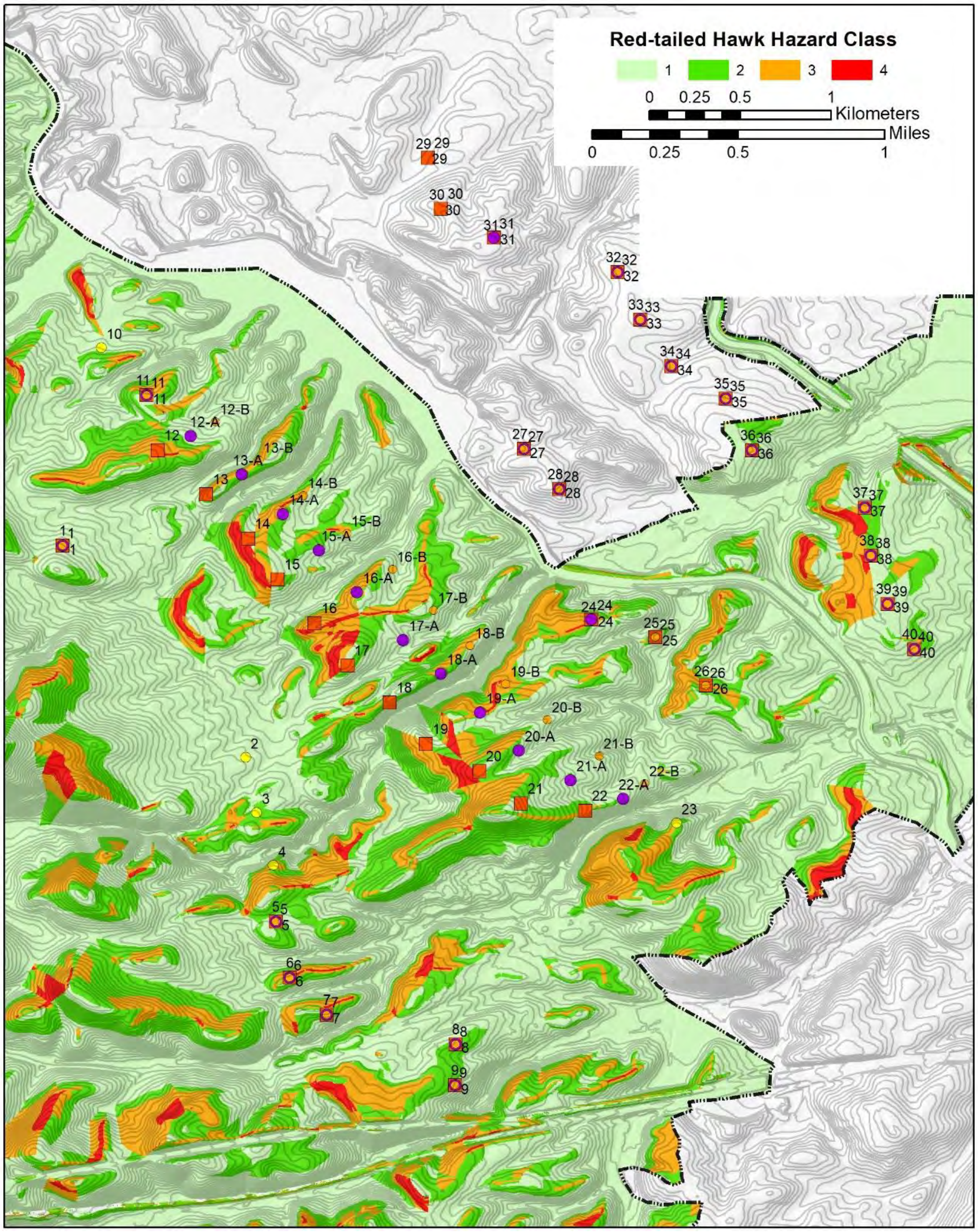

Figure 32. *Fuzzy Logic likelihood surface classes of red-tailed hawk flight behavior and fatality locations across the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

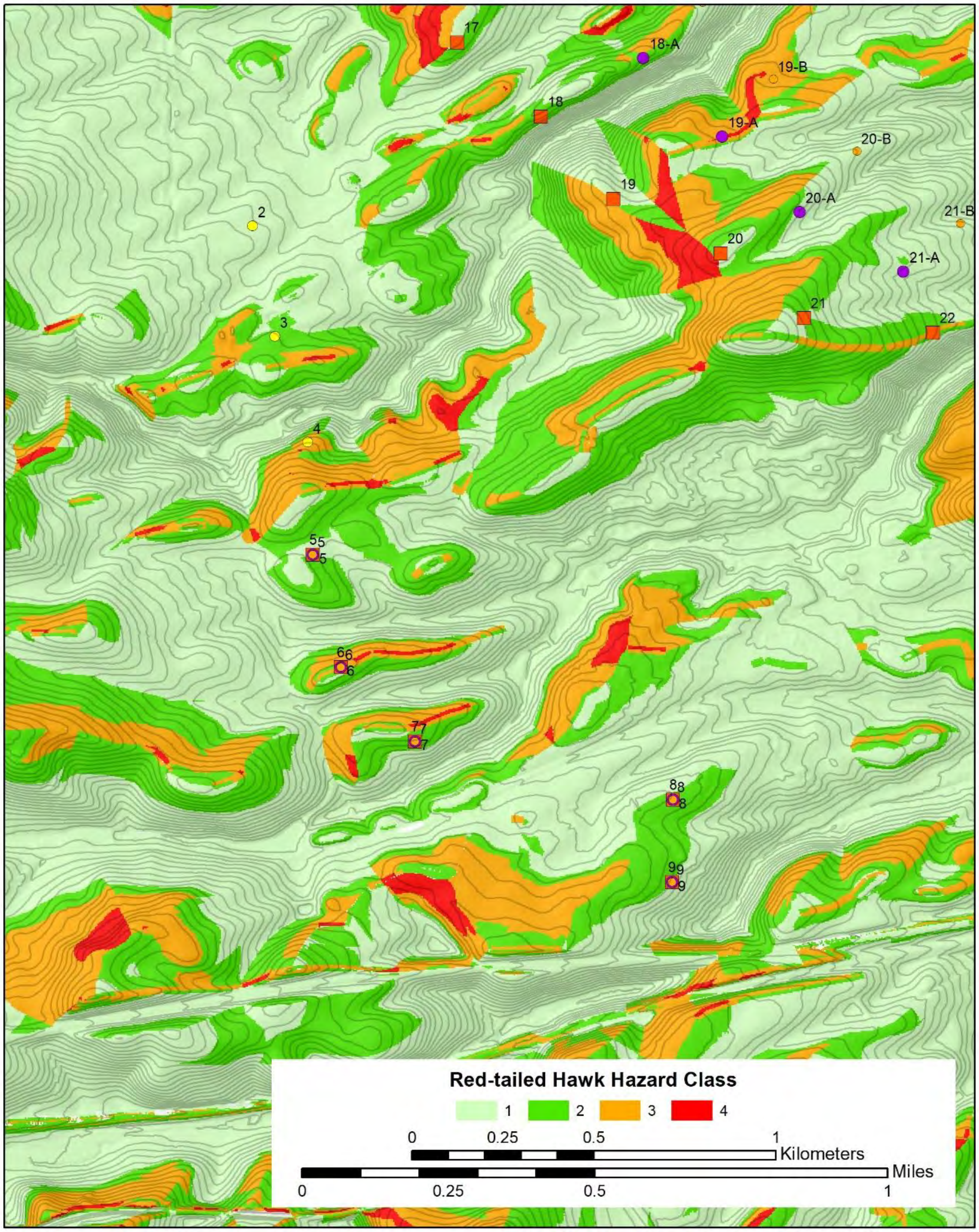

Figure 33. *Fuzzy Logic likelihood surface classes of red-tailed hawk flight behavior and fatality locations across the southwest portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

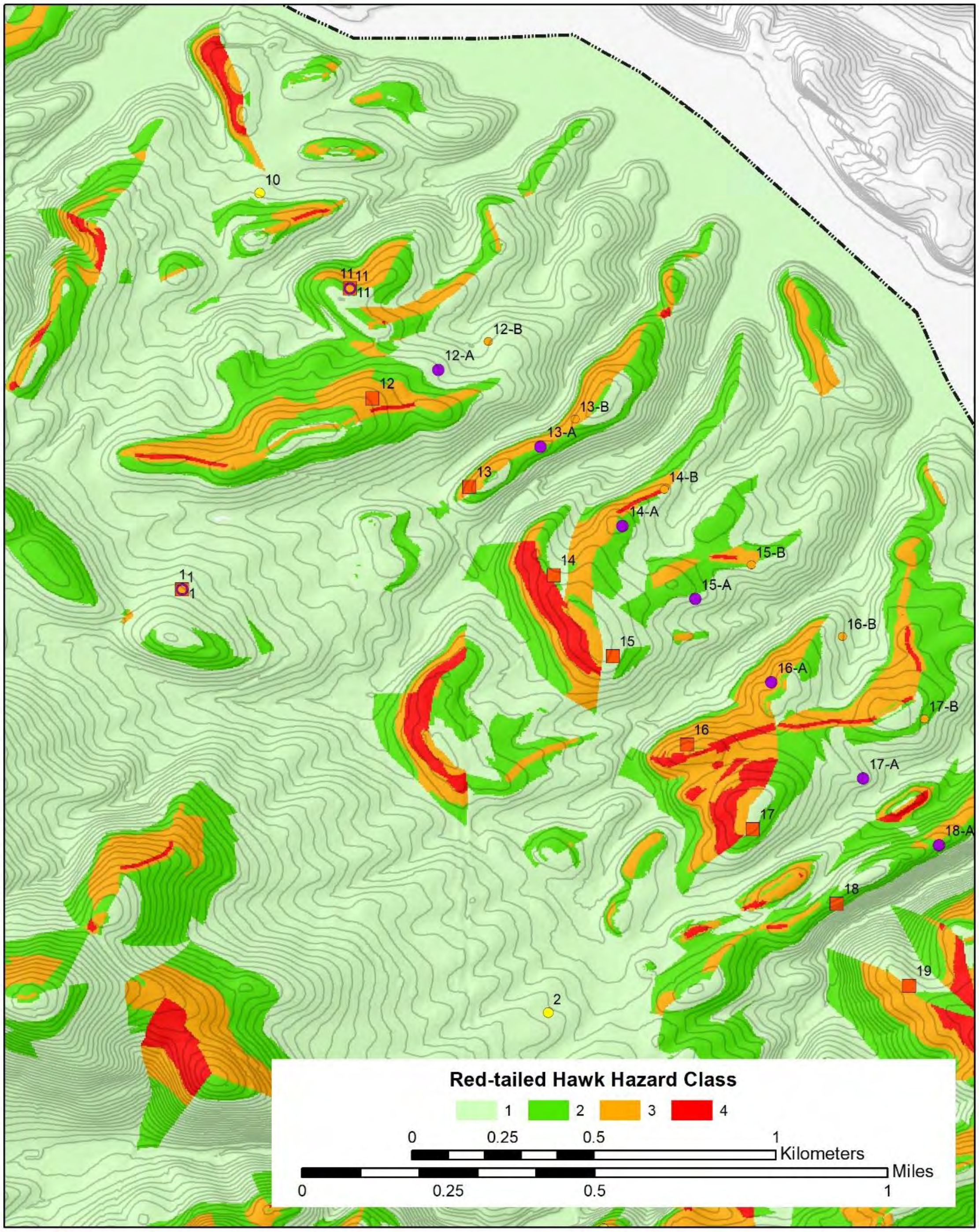

Figure 34. *Fuzzy Logic likelihood surface classes of red-tailed hawk flight behavior and fatality locations across the northcentral portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

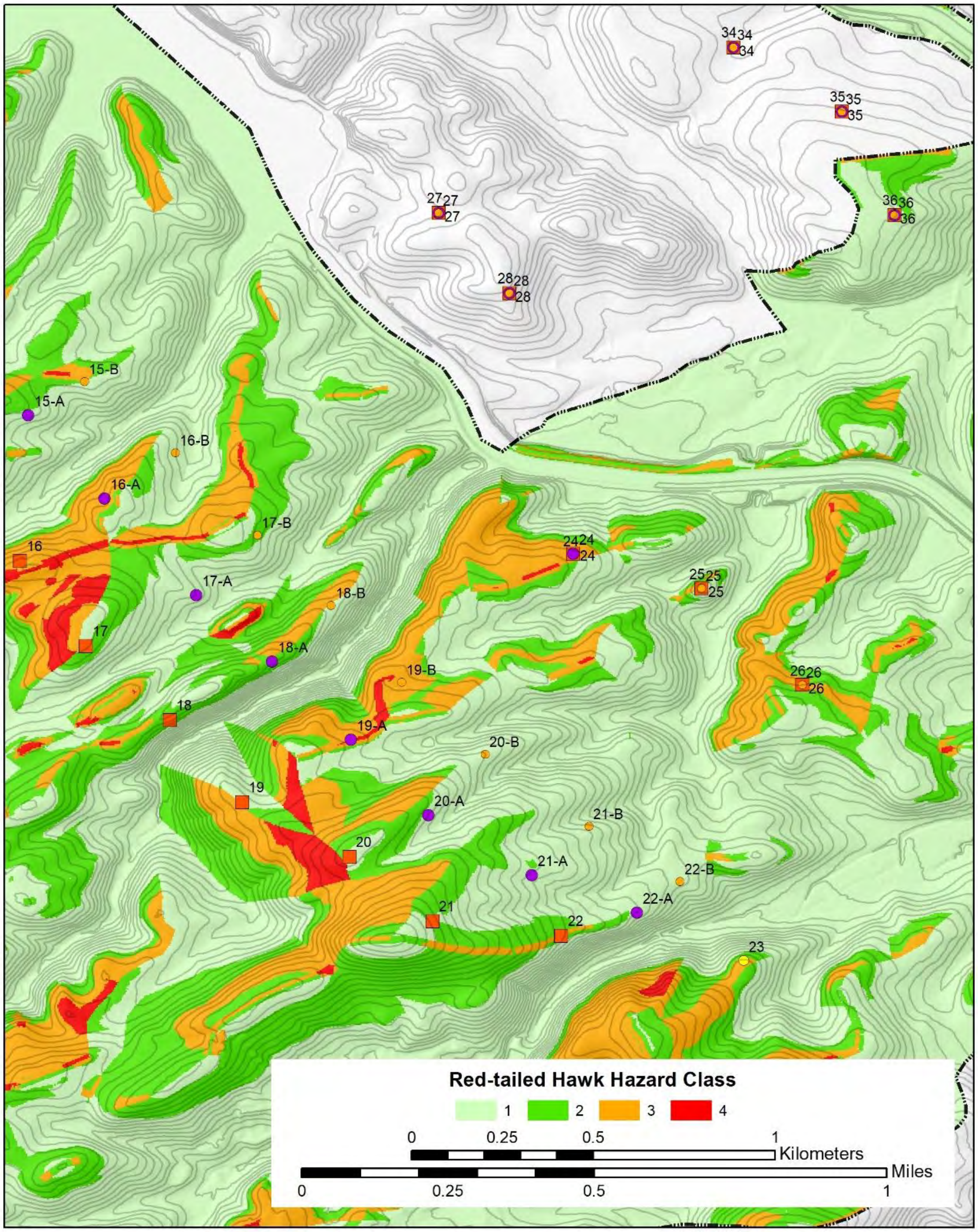

Figure 35. *Fuzzy Logic likelihood surface classes of red-tailed hawk flight behavior and fatality locations across the central portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

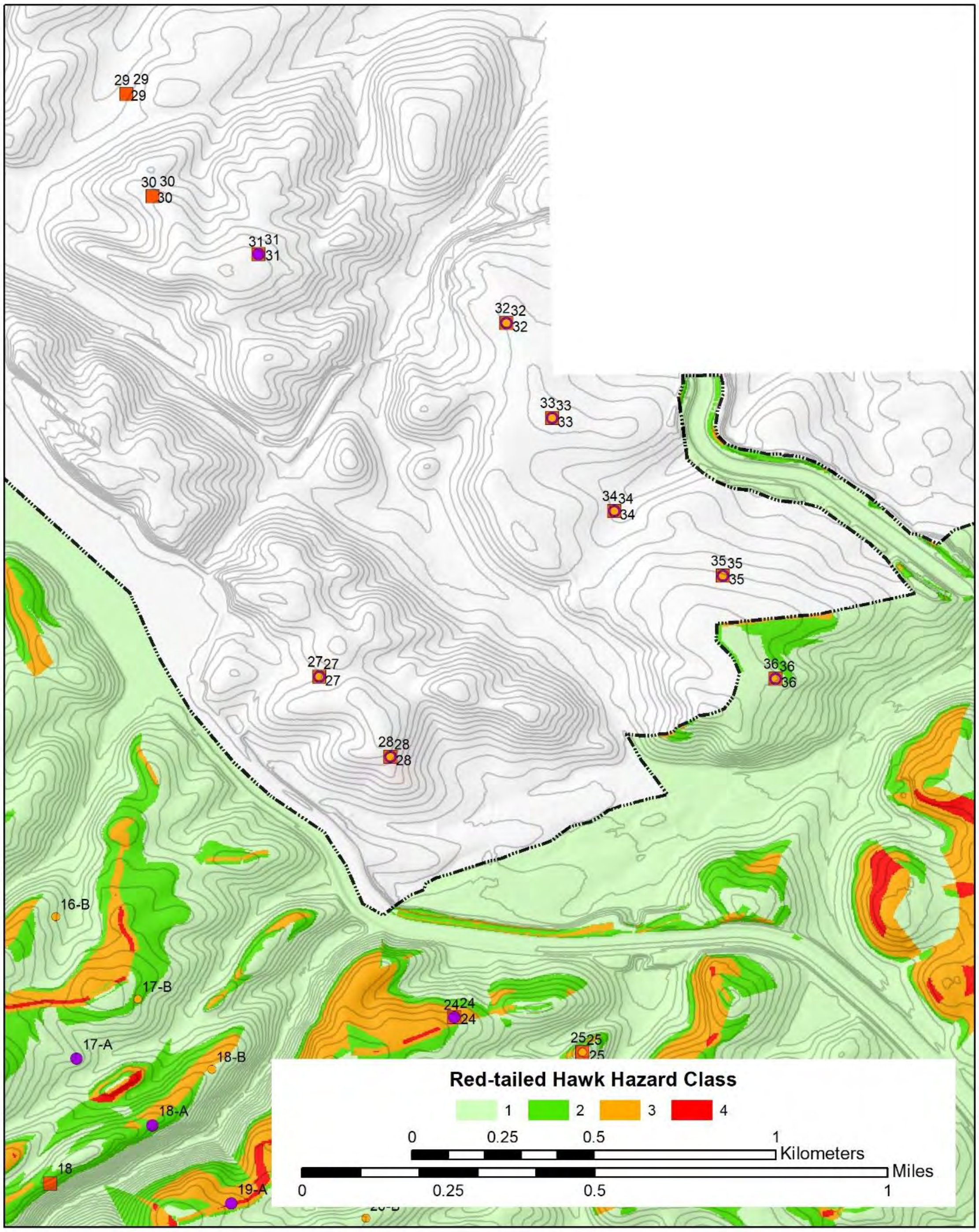

Figure 36. *Fuzzy Logic likelihood surface classes of red-tailed hawk flight behavior and fatality locations across the northeastern portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

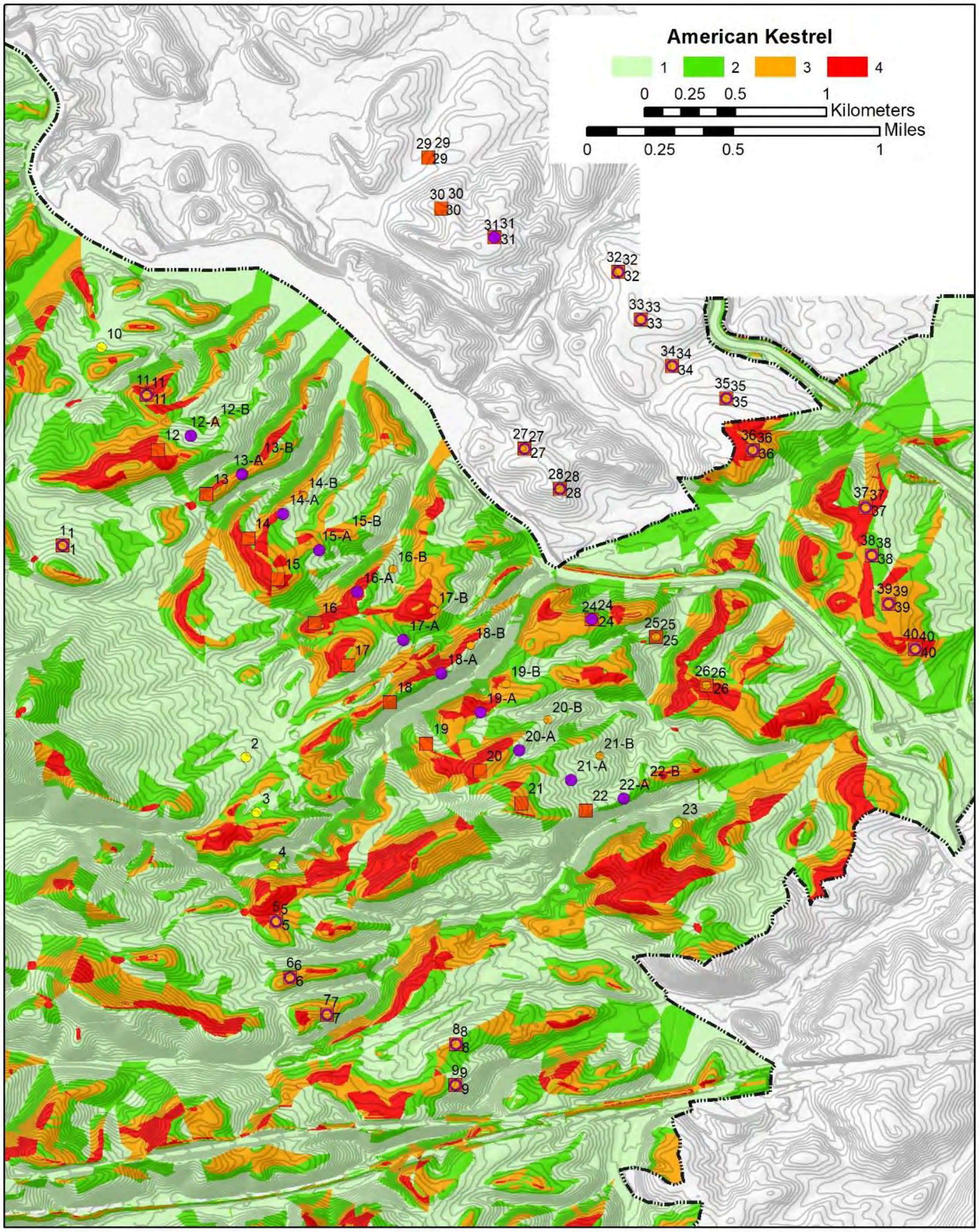

Figure 37. *Fuzzy Logic likelihood surface classes of American kestrel flight behavior and fatality locations across the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

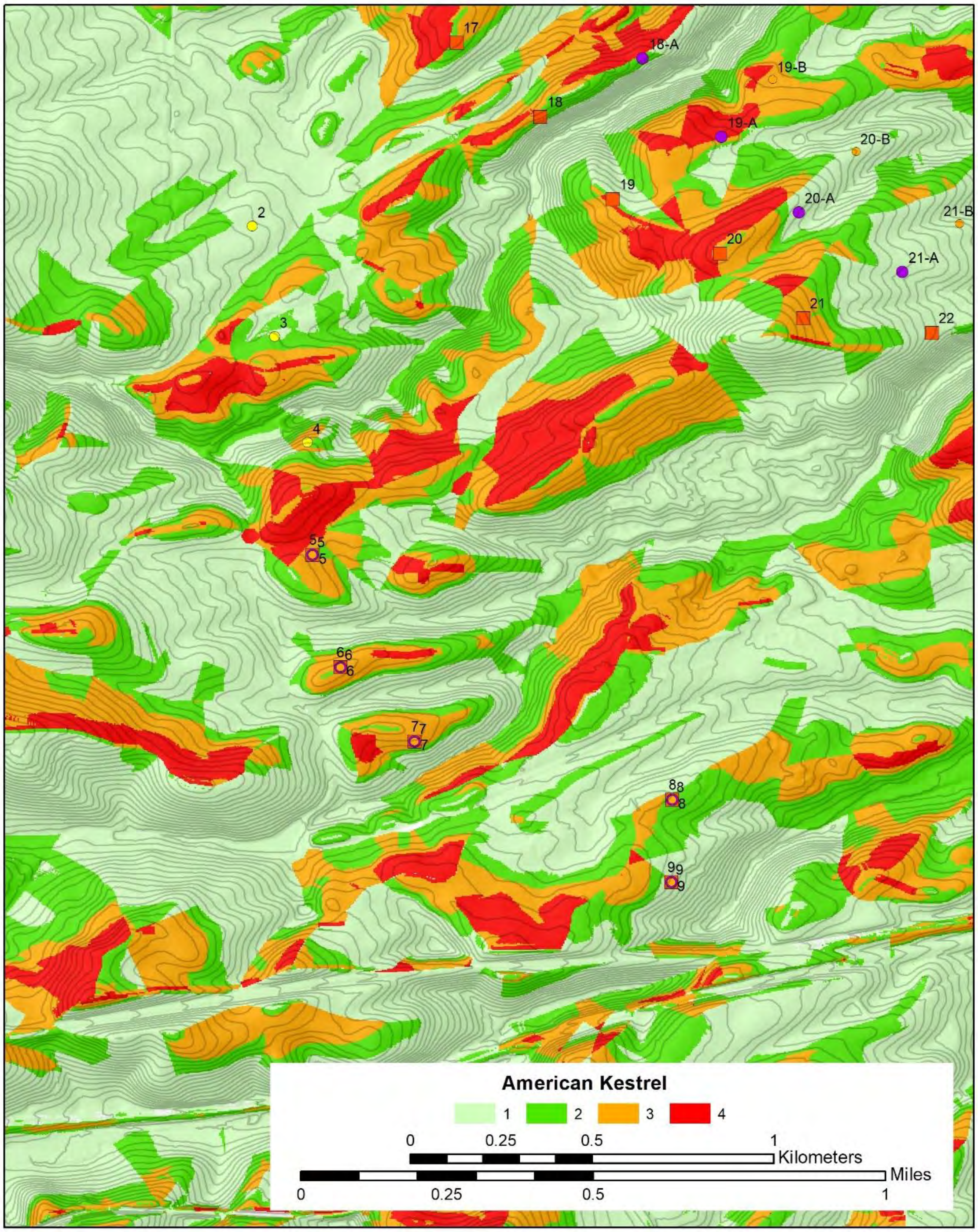

Figure 38. *Fuzzy Logic likelihood surface classes of American kestrel flight behavior and fatality locations across the southwest portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

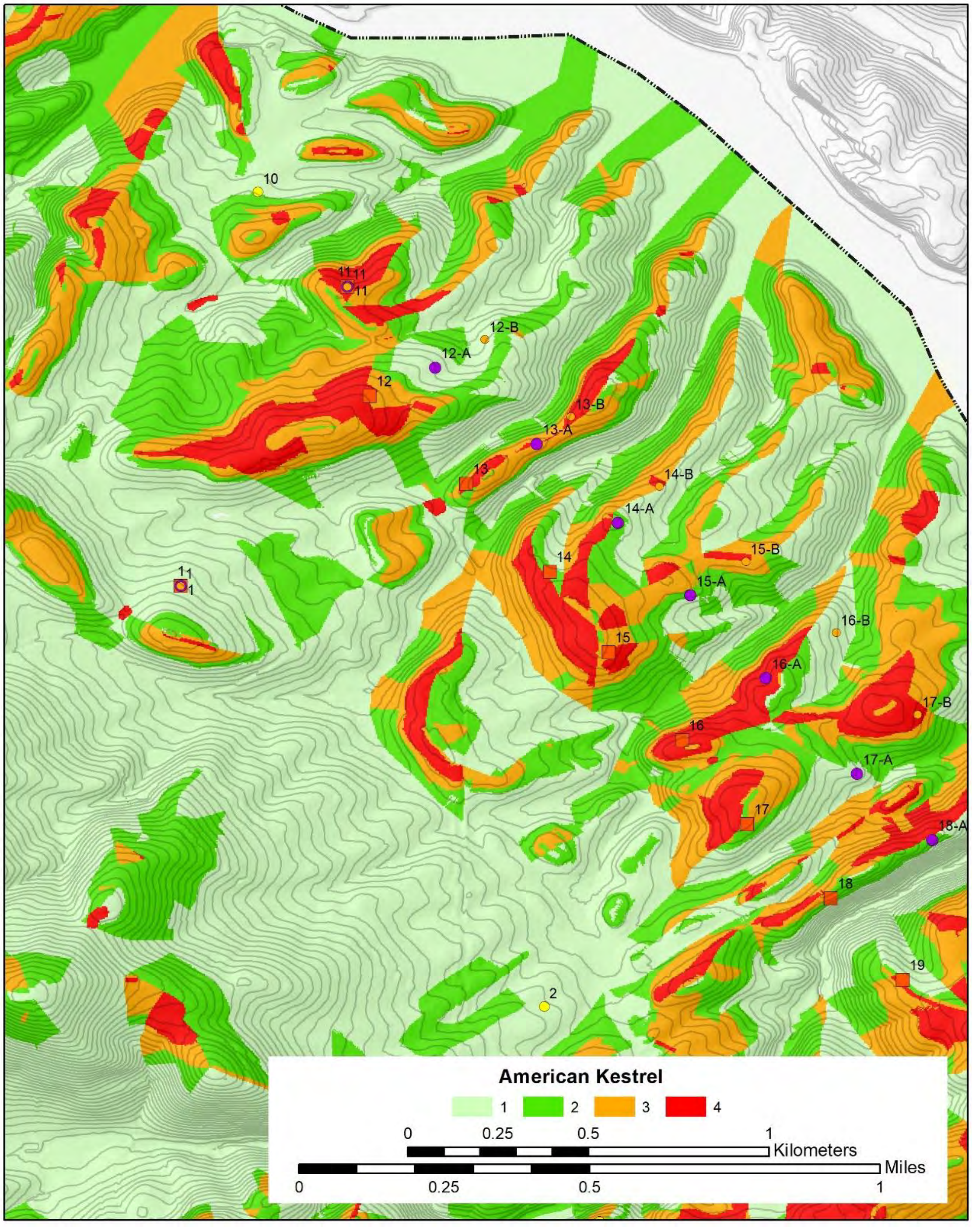

Figure 39. *Fuzzy Logic likelihood surface classes of American kestrel flight behavior and fatality locations across the northcentral portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

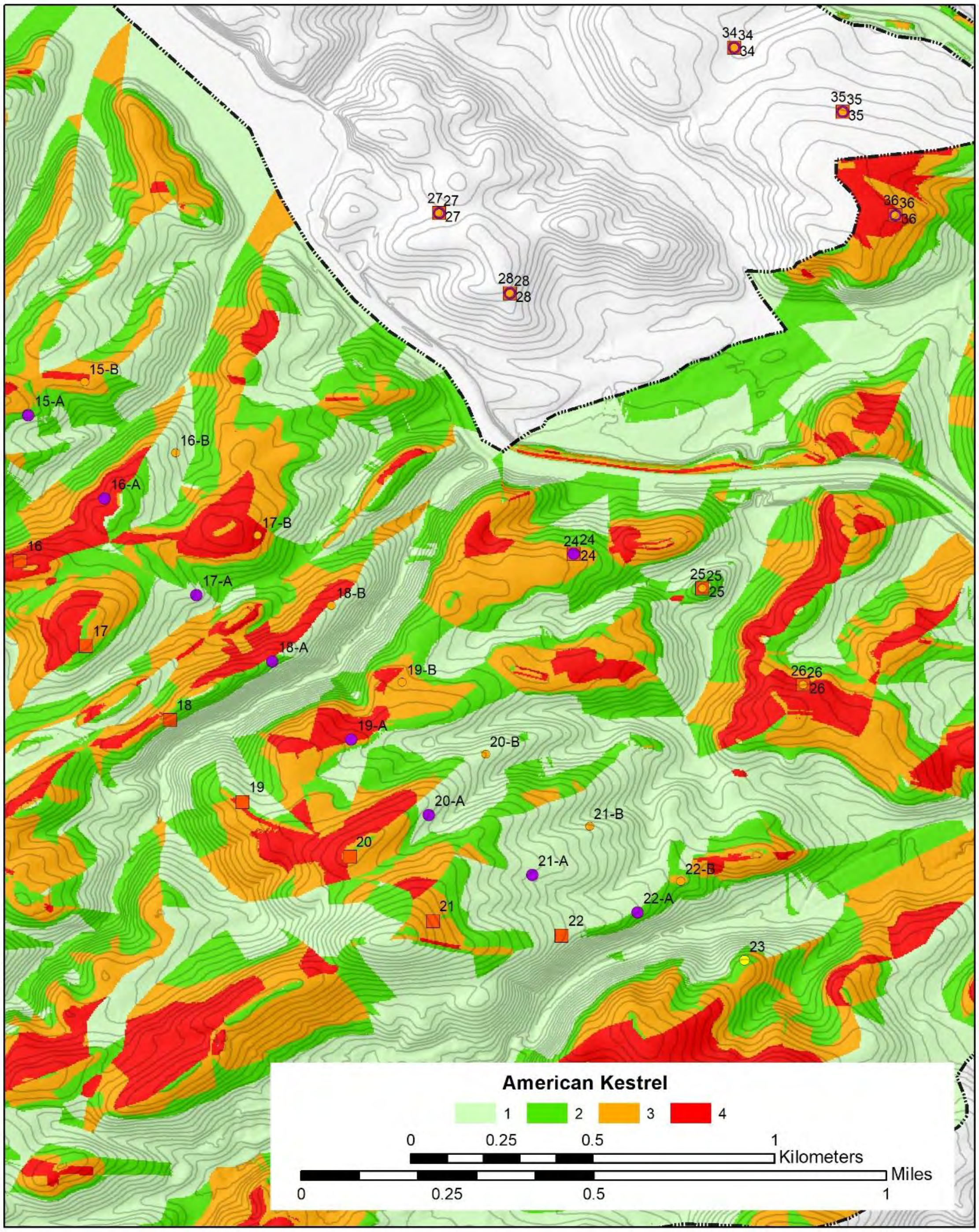

Figure 40. *Fuzzy Logic likelihood surface classes of American kestrel flight behavior and fatality locations across the central portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

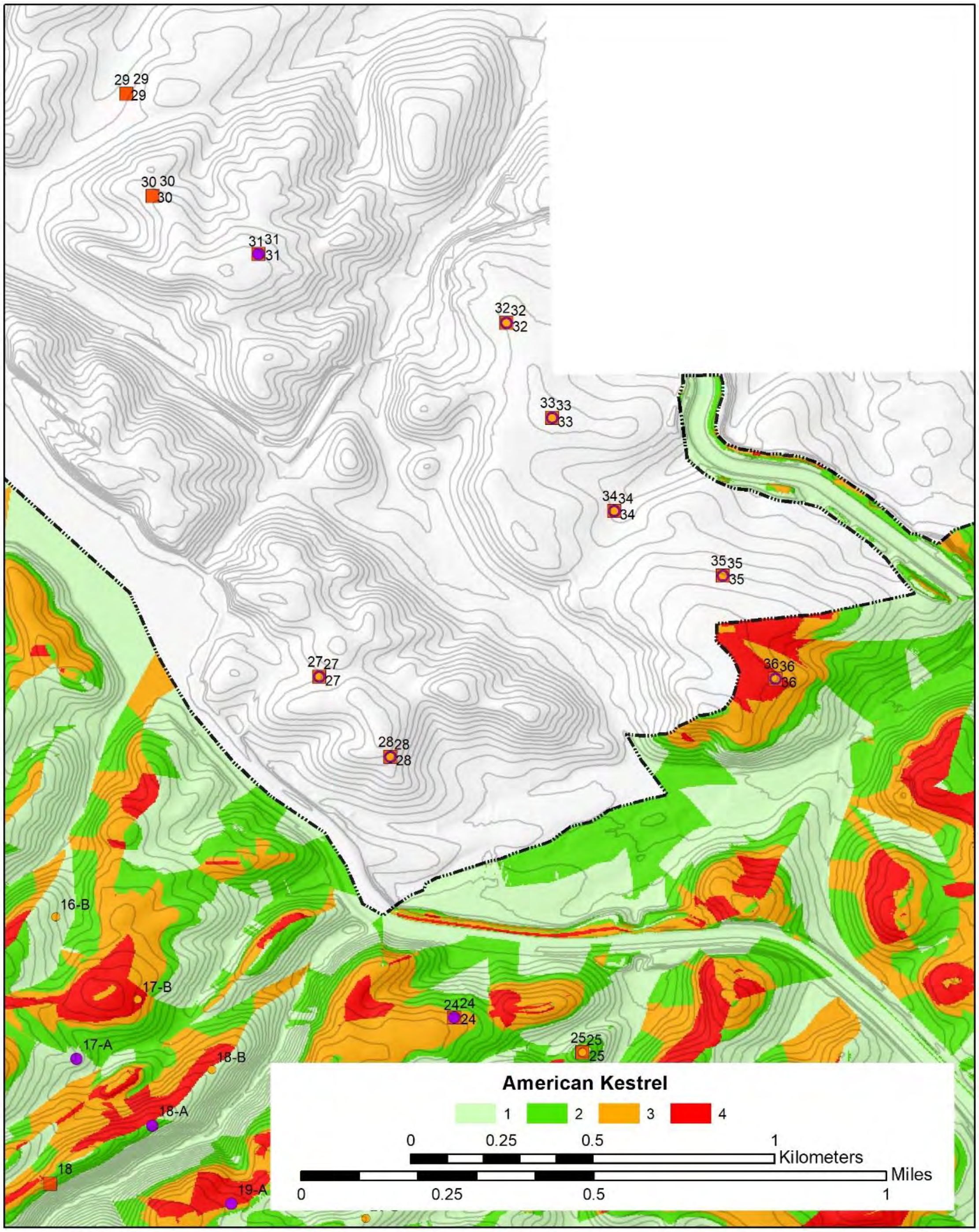

Figure 41. *Fuzzy Logic likelihood surface classes of American kestrel flight behavior and fatality locations across the northeastern portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

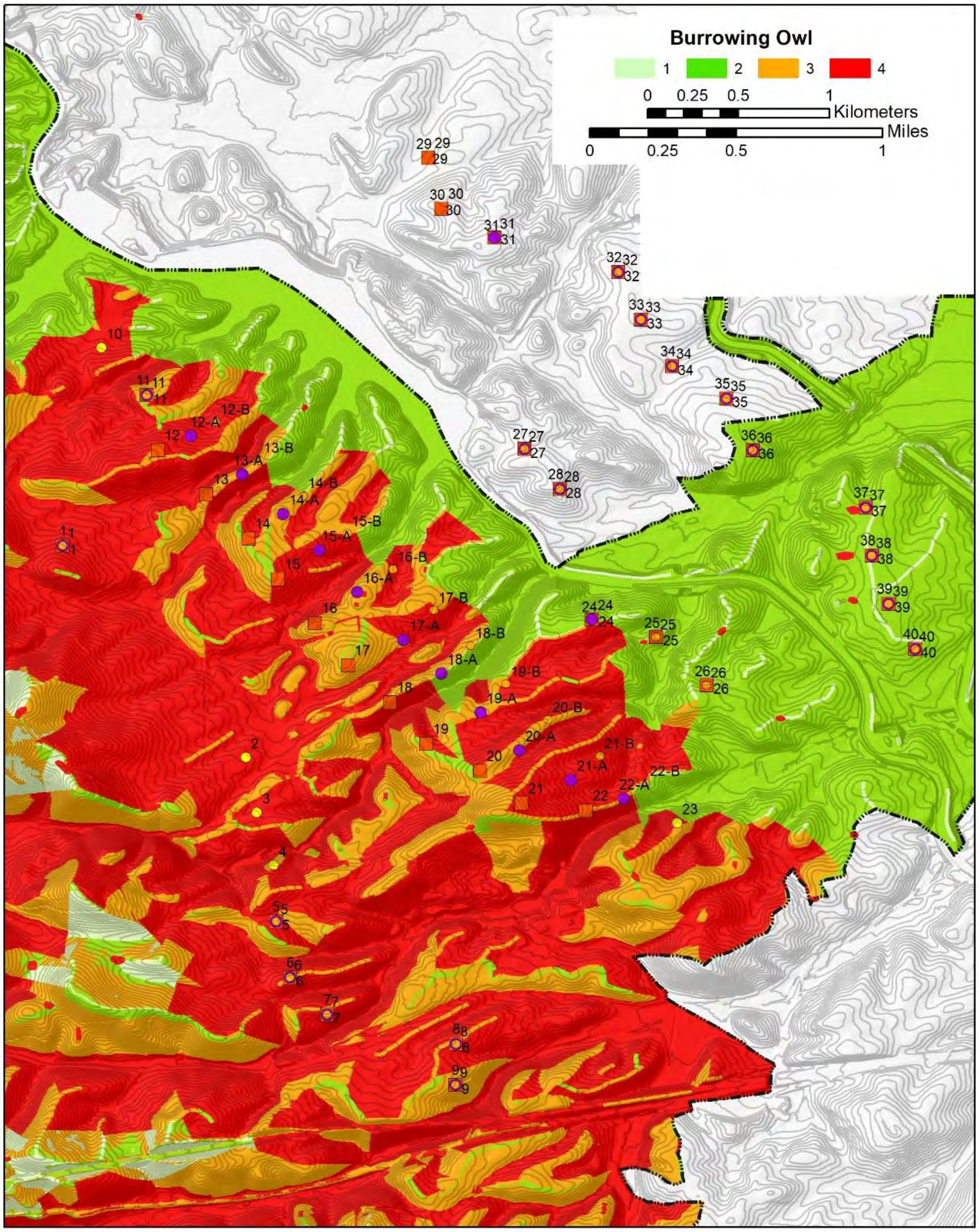

Figure 42. *Fuzzy Logic likelihood surface classes of burrowing owl fatality locations across the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

Figure 43. *Fuzzy Logic likelihood surface classes of burrowing owl fatality locations across the northcentral portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

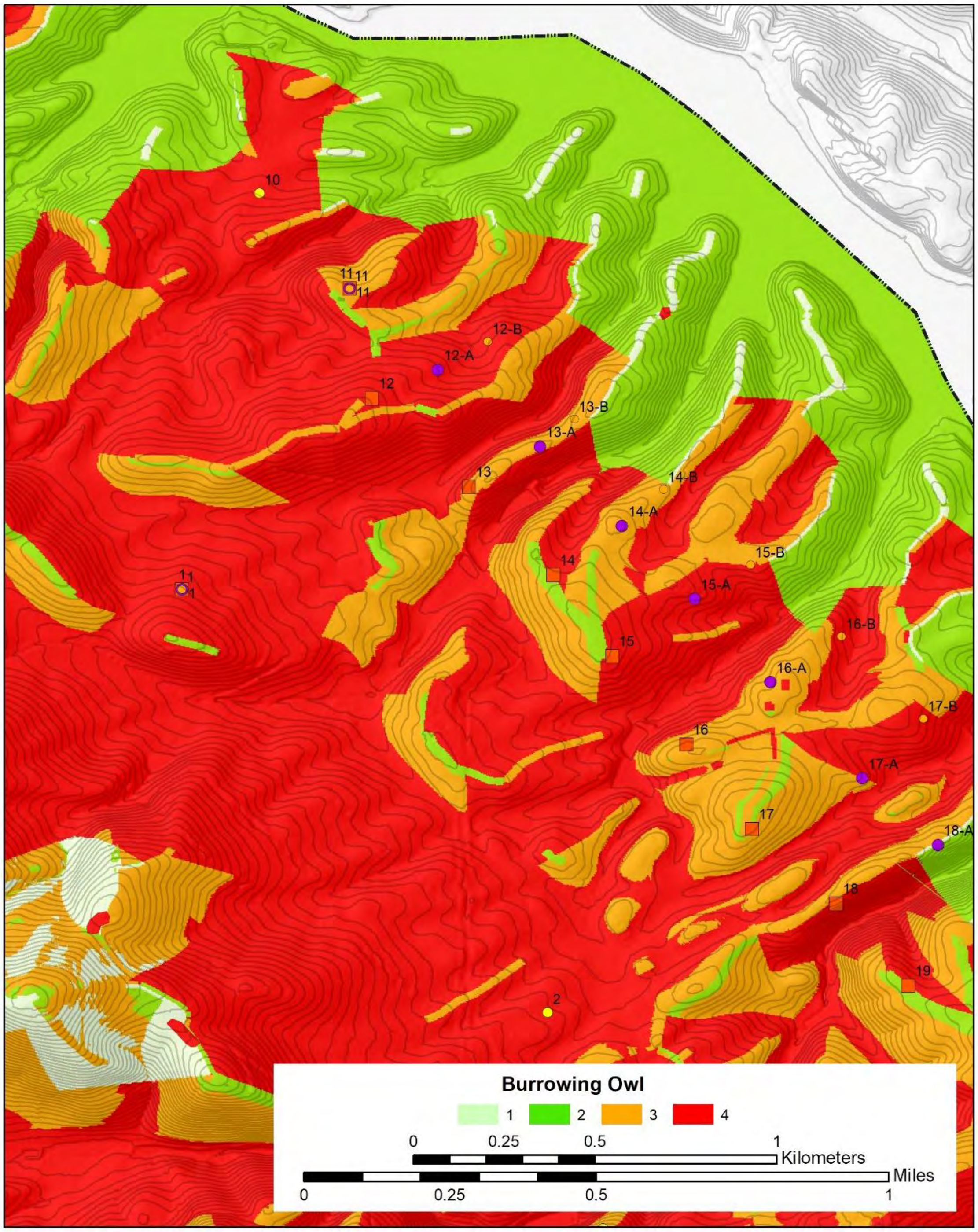

Figure 44. *Fuzzy Logic likelihood surface classes of burrowing owl fatality locations across the central portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

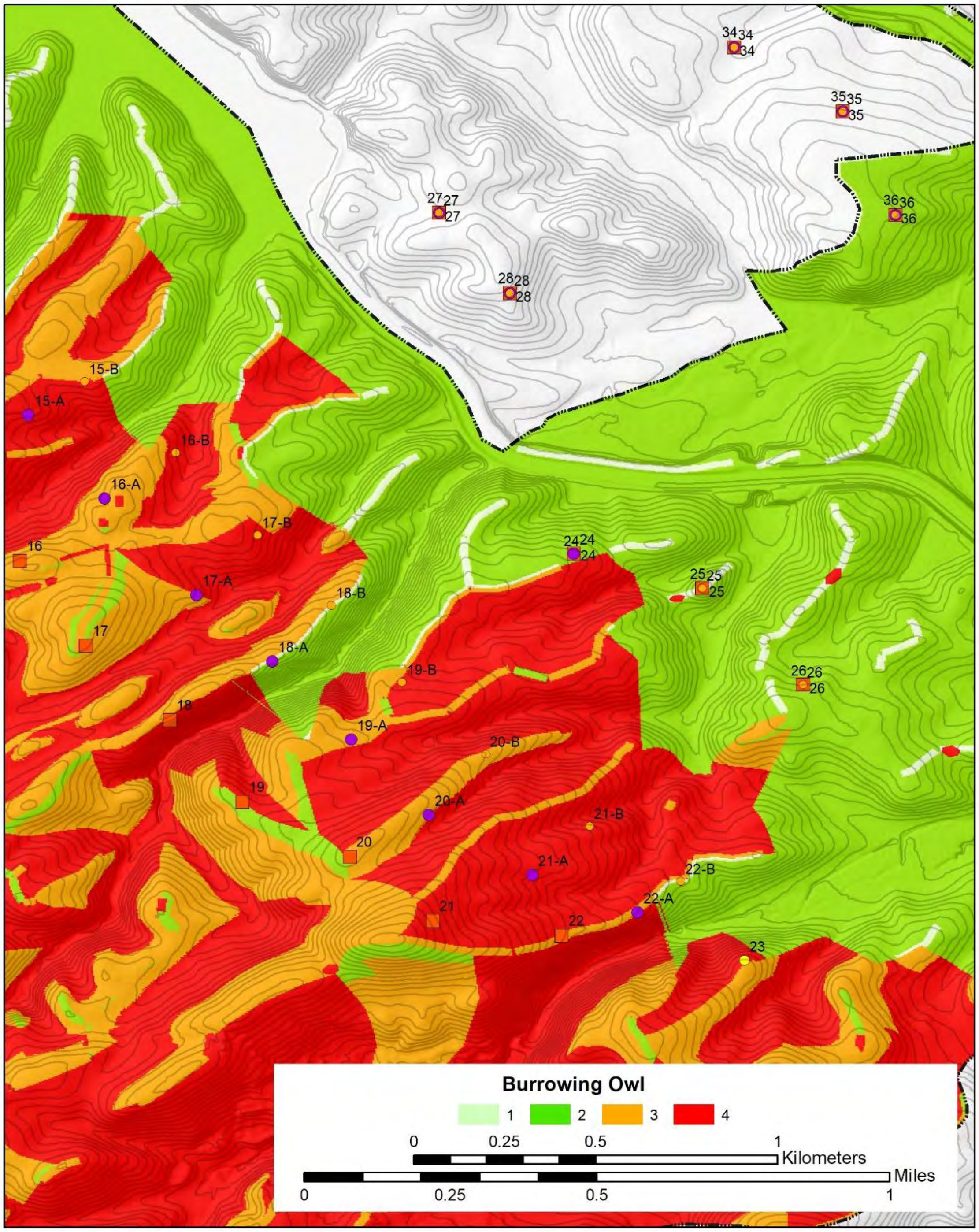

Figure 45. *Fuzzy Logic likelihood surface classes of burrowing owl fatality locations across the northeastern portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

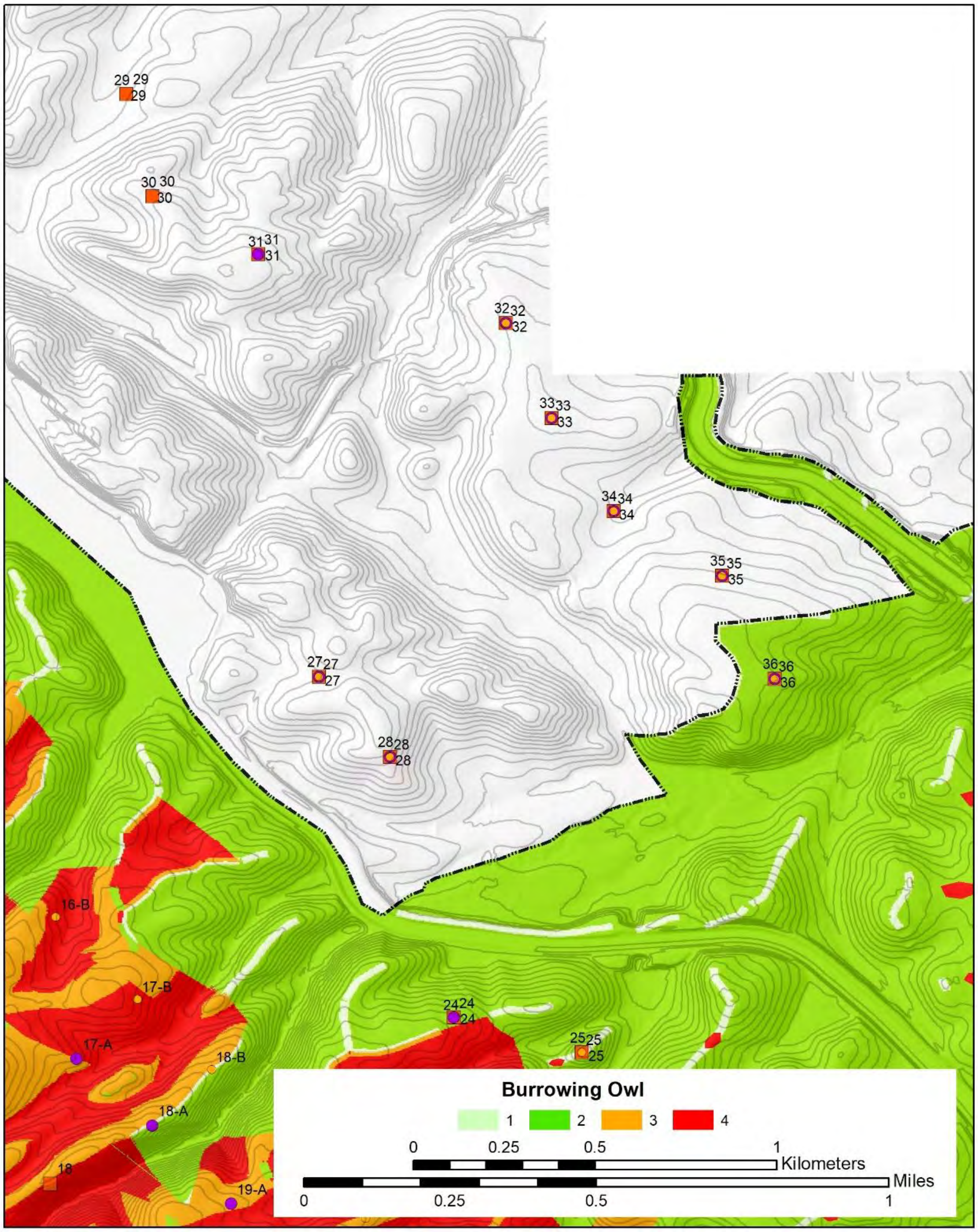

Figure 46. *Fuzzy Logic likelihood surface classes of burrowing owl fatality locations across the northeastern portion of the Sand Hill project area, Altamont Pass Wind Resources Area, California, where red corresponds with the highest likelihood of golden eagle collision, orange corresponds with the second highest likelihood, yellow corresponds with the third highest likelihood, and dark green corresponds with the least likelihood.*

DISCUSSION

We produced simple map-based collision hazard models of golden eagle telemetry positions, ridge crossing flights, wind turbine events, and wind turbine fatalities, as well as of red-tailed hawk and American kestrel flight behaviors and fatalities in the Altamont Pass Wind Resource Area. We also produced a simple collision hazard model of burrowing owls based on fatalities at wind turbines and further informed by burrow locations. We extended these models to the Sand Hill project area for which we had developed a DEM and terrain measurements. Most of these areas also included stations where flight behavior data were collected and sampling plots where burrowing owl burrow data were collected for developing the collision hazard models. Micro-siting according to these models and expert opinion should generally achieve the levels of fatality reductions observed at the repowered Vasco Winds project, although it is likely that fatality reductions will not be as great for burrowing owl. After three years of operations at Vasco Winds, and compared to the old-generation wind project that preceded it, Brown et al. (2016) estimated fatality rate reductions of 75% to 82% for golden eagle, 34% to 47% for red-tailed hawk, and 48% to 57% for American kestrel, and 45% to 59% for burrowing owl.

Table 11 summarizes the coincidences of proposed wind turbine locations with Smallwood's SRC-style hazard rating made upon site inspections, predicted fuzzy logic collision hazard classes, and fatality monitoring histories for golden eagle, red-tailed hawk, American kestrel and burrowing owl. Proposed turbine sites where Smallwood made SRC-style hazard ratings of 8 or greater should be reconsidered, and Table 12 should be consulted for recommended relocations. Ratings of 6.5 to 7.5 were worrying to Smallwood, but sufficient uncertainty remains that relocations are not always warranted. Some terrain settings posed collision hazard risks that were difficult to predict or outside our experience, such as turbine sites on very narrow east-west ridge structures such as sites 20B or 18 to 18-B. Another example of an uncertain site was site 10, where several valley-like structures come together in low terrain. Site 25 – a small hill surrounded by larger hill and ridge structures – will not be predicted as particularly hazardous by our models, but based on all that we have experienced in the APWRA, we judged it to be high risk. Golden eagles approaching site 25 will be at altitudes established by the surrounding higher-elevation terrain, thereby putting them at rotor-height when encountering site 25. Table 12 also warns of many situations where in our experience the grading for turbine pads will likely leave berms or cut slopes located between the tower base and the prevailing upwind direction. Golden eagles or other birds approaching the turbine from the prevailing wind direction will need to clear the ground just upwind of the turbine, putting the bird into the rotor. Such berms or cut slopes shorten the effective height above ground of the low reach of the turbine blades – from the bird's perspective, an 8-m berm might shorten the low reach of the blades from 28 m to 20 m, thereby lessening the room to negotiate the blade sweeps.

Map-based collision hazard maps need to be interpreted carefully, meaning the hazards of specific terrain and wind situations – ridge saddles, apices of southwest and northwest-facing concave slopes, and breaks in slope – should always trump model predictions. The turbine sites causing us the greatest concern at Sand Hill include 4, 16-A, 16-B, 17-A, 20-A, 21, 25, and 34 (Table 12). In Table 12 we also recommend using particular alternative sites over others, and we recommend numerous relocations to avoid hazardous situations.

At some sites we know from experience that golden eagle traffic has been intense, or that social interactions are common. At these locations we are inclined to rely more on experience in the field than on model predictions. As examples, we know that golden eagles often fly through a certain canyon, exiting east toward proposed Sand Hill sites 3 and 4. As these eagles exist east they are moving fast as they glide downhill through the canyon with the wind, so when they reach the area of sites 3 and 4 they might have less time to negotiate the turbines, especially in cloudy conditions. In another example, Sand Hill site 1 is located east of a ridge saddle often used by eagles to cross the ridge structure west of site 1. Our models were unable to predict collision hazard posed by some associations between terrain features affecting flight patterns at coarse resolutions, such as flight trajectories set by canyons, long ravines or nearby ridge saddles used as crossing points.

As earlier discussed, the effects of grading for turbine access roads and tower pads also need to be considered, because they are not anticipated in the collision hazard models. Changes in the shape of the hills due to grading can transform the location to a more hazardous situation than was assessed herein. It would be safer to avoid enhancing ridge saddles or breaks in slope due to grading. It would also be safer to not leave earthen berms upwind of turbine towers, because doing so decreases the effective vertical space between the low reach of turbine blades and the ground that birds need to clear.

Whereas we focused on four target raptor species, Sand Hill could have adverse impacts on bats and small birds. We developed no collision hazard maps for bats or small birds. Recent research has revealed that modern wind turbines in the AWPRA take many small birds and bats (Brown et al. 2016, Smallwood 2017c, Smallwood et al. 2017 unpublished data). Bats might be attracted to modern wind turbines, thereby increasing collision risk (Smallwood 2016b).

We also found cause to support many of the proposed wind turbine locations from a micro-siting perspective. As much as we worry about every proposed location due to the inherent risk to birds and bats, our working philosophy is that once the project capacity has been decided upon, the wind turbines to meet that capacity must go someplace. We make our recommendations on micro-siting based on the wind company's proposed capacity, and nothing more. Proposed turbine sites that we believe pose the least collision risk, including as recommended for slight relocations in Table 12, were sites 2, 3, 5, 6, 7, 11, 12-A, 12-B, 14-A, 15, 16, 17, 18, 19-B, 21-A, 24, 30, 32, 33, 35, 38, 39.

Grading for pads in complex terrain has created unsafe situations for golden eagles and other raptors by leaving berms or cut slopes in the prevailing upwind direction (Smallwood 2018, attached). We recommend avoiding pad excavations that create or enhance ridge saddles or breaks in slope, because eagles use them for passage, they alter winds at the interface between the cut slope and natural slope, and eagles approaching a rotor just above grade-level will have less room to maneuver when crossing into the airspace between the pad and rotor.

Table 11. *Micro-siting recommendations directed to Sand Hill wind turbine layout, where GOEA = golden eagle, RTHA = red-tailed hawk, AMKE = American kestrel, and BUOW = burrowing owl. Additional acronyms are BNOW = barn owl, GHOW = great-horned owl, and TUVU = turkey vulture. Birds represent species other than raptors. Values in parentheses represented hazard classes very close to the proposed turbine site. 'Yrs' represented the number of years of monitoring.*

Site	SRC hazard rating	Predicted hazard class				Nearest old turbines	SRC ratings old turbines	Collision history
		GOEA	RTHA	AMKE	BUOW			
1	8.5	1	1	1	4	Far away		No history available
2	6	1	1	1	4	Far away		No history available
3	6	1	2	2	4	VK-16, VK-17	7, 7.5	1 BUOW, 1 GHOW, 9 birds – 10 yrs
4	10	3	3	3	3	M-1, M-2	8.5, 7.5	2 RTHA, 2 BUOW, 6 birds – 10 yrs
5	6	1	1	3	4	K-11	<7	1 bird – 10 yrs
6	7	3	3	3	3 (4)	J-10, J-9	--, --	4 birds – 8 yrs
7	6.5	1	2	3	4	F-5, F-4	<7, <7	1 BUOW, 5 birds – 9 yrs
8	8	3	2	2	3	PO-27, PO-28	<7, <7	1 RTHA, 1 BUOW, 38 birds – 9 yrs
9	7	1	2	1	3	WM-24	--	1 TUVU, 1 bird – 6 yrs
10	7.5	1	1	1 (2)	4	Far away		No history available
11	4	4	2 (3)	4	3	6363, 6364	<7, <7	2 birds – 6 yrs
12	7	2	3	4	4	6375	7	3 birds – 6 yrs
12A	6	1	1	1	4	6375	7	3 birds – 6 yrs
12B	6	1	1	1	4	6357	7	7 birds – 5 yrs
13	7	1	3	4	3	6393, 6394	7, 7	1 GOEA, 1 RTHA, 8 birds – 3.5 yrs
13A	8	3	2 (3)	3	3	6392	<7	No birds – 0 yrs
13B	8.5	3	3	4	3	6392	<7	No birds – 0 yrs
14	7.5	3	2 (4)	2 (4)	4	6441-6443	8, 7, 7	1 GOEA, 1 Buteo, 3 birds – 3.5 yrs
14A	6.5	2	2	2	3	6427, 6428	--, --	1 RTHA, 2 birds – 1 yr
14B	7	3	4	4	3	6410, 6411	<7, <7	No birds – 0 yrs
15	6	2 (3)	1	3(4)	4	6453, 6452	<7, --	3 birds – 3.5 yrs
15A	6.5	1	1	2	4	6434	<7	No birds – 0 yrs
15B	6.5	2 (4)	3	4	4	6422, 6421	<7, <7	No birds – 0 yrs
16	7	3	3	4	3	6489, 6490	<7, 7.5	1 RTHA, 1 AMKE, 4 birds – 3.5 yrs

Site	SRC hazard rating	Predicted hazard class				Nearest old turbines	SRC ratings old turbines	Collision history
		GOEA	RTHA	AMKE	BUOW			
16A	7	2	3	4	3	6477-6479	7.5, <7, <7	2 GOEA, 5 RTHA, 1 Buteo, 1 Raptor, 1 GHOW, 1 TUVU, 17 birds – 7.5 yrs
16B	8.5	1	1	1	4	Far away		No history available
17	6	3	1	2 (3/4)	3	6498	<7	1 BUOW, 3 birds – 3.5 yrs
17A	8	1	1	1	3 (4)	Far away		No history available
17B	7.5	1	2	4	4	Far away		No history available
18	7	3	2	2 (3)	3 (4)	Far away		No history available
18A	7	3 (4)	2	2	3	Far away		No history available
18B	7	2 (4)	1 (3)	1 (4)	3	Far away		No history available
19	6	4	1 (3)	2 (4)	2 (4)	Far away		No history available
19A	6	4	4	4	3	Far away		No history available
19B	5	2	3	3	4	Far away		No history available
20	8	3 (4)	1	3 (4)	3	Far away		No history available
20A	9.5	1	1	1	3 (4)	Far away		No history available
20B	8	3	1	1	3 (4)	Far away		No history available
21	8	2	1	3	4	Far away		No history available
21A	6	1	1	1	4	Far away		No history available
21B	6	1	1	1	4	Far away		No history available
22	8.5	2	3	1	3 (4)	Far away		No history available
22A	7.5	2	1	2	3 (4)	Far away		No history available
22B	7.5	4	1	3	3 (4)	Far away		No history available
23	8	2 (3)	3	2	4	Far away		No history available
24	6	2	3	3	2	Far away		No history available
25	9	3	3	2	2	Far away		No history available
26	8	1	3	4	2	Far away		No history available
27	8	--	--	--	--	Far away		No history available
28	8	--	--	--	--	Far away		No history available
29	8	--	--	--	--	Far away		No history available
30	6	--	--	--	--	Far away		No history available

Site	SRC hazard rating	Predicted hazard class				Nearest old turbines	SRC ratings old turbines	Collision history
		GOEA	RTHA	AMKE	BUOW			
31	4	--	--	--	--	Far away		No history available
32	3	--	--	--	--	Far away		No history available
33	4	--	--	--	--	Far away		No history available
34	8	--	--	--	--	Far away		No history available
35	5	--	--	--	--	Far away		No history available
36	7	3	1	4	2	Far away		No history available
37	8	4	3	4	4	CD-13	<7	1 BUOW, 13 birds – 11 yrs
38	6	2	2	2	2	CC-2	<7	1 bird – 11 yrs
39	6	2	1	3	2	AC-8, AC-9	<7, <7	1 RTHA, 1 bird – 8.5 yrs
40	7	1	1	3 (4)	2	AD-13, AD-14	<7, <7	15 birds – 11 yrs

Table 12. *Micro-siting recommendations directed to Sand Hill wind turbine layout, where GOEA = golden eagle, RTHA = red-tailed hawk, AMKE = American kestrel, and BUOW = burrowing owl, and E =east, W = west, and so on.*

Site	**Concern**	**Suggested move/Recommendation**
1	Near Vestas & near upwind saddle	Maybe move ENE 60 m
2	None	None
3	East of major E-W canyon, so likely more flight traffic here	No better options locally
4	In ravine on steep slope; documented RTHA hazard site	We recommend avoiding this site
5	None	Shift SW to hill peak
6	E-W ridge	Likely safest site on ridge
7	Low on slope of E-W ravine	Move to N ridge crest
8	E-W ridge; record of many bird collisions, but mostly rock pigeons	Likely safest local option
9	Low on slope	Shift west and uphill
10	Low spot where shallow valleys meet; model predictions safe except for BUOW	Uncertain about likely impacts here
11	Conflicts with model prediction	Safest place in area
12	Near N-S saddle	move 25 m west
12A	None	Safest place in area
12B	None	Safest place in area
13	Low terrain; documented eagle fatality	Move east to ridge crest
13A	Shallow saddle on E-W ridge; no monitoring history	Use modified site 13 or 13B
13B	Shallow saddle on E-W ridge; no monitoring history	Move east to peak of hill
14	West edge of E-W concave slope; documented eagle fatality	Use site 14A
14A	E-W ridge	Probably safest site on this ridge
14B	Low along E-W ridge	Use site 14A
15	Next to model-predicted class 3 hazard level and long ravine	Shift north 25 m
15A	On concave slope	Use site 15
15B	E-W ridge close to golden eagle hazard class 4	Use site 15
16	E-W ridge; edge of deep ravine	Avoid leaving berm
16A	Side of deep ravine; documented 2 golden eagle & 5 RTHA fatalities	We recommend avoiding this site
16B	Side of ravine; too low on slope	We recommend avoiding this site
17	Edge of ravine	Move north to ridge crest

Site	Concern	Suggested move/Recommendation
17A	Shallow saddle	We recommend avoiding this site
17B	Edge of ravine; low on slope	Move north to ridge crest
18	Long E-W ridge	Best option on this ridge
18A	Long E-W ridge	Use site 18
18B	Long E-W ridge	Use site 18
19	Conflicts with model prediction	Might be safer 30 m south
19A	Conflicts with model prediction	Use either site 19 or 19B
19B	W side of long E-W concave slope	Safest local option except for burrowing owls
20	Near saddle/bench; Conflicts with model prediction	move N to crest
20A	Ravine	We recommend avoiding this site
20B	Very narrow E-W ridge	Relatively unsafe for eagles
21	Below & downwind of ridge crest	We recommend avoiding this site
21A	None	Safest place in area
21B	In small ravine	Use site 21A
22	Edge of canyon	Move N away from canyon edge or use 22A
22A	Edge of deep ravine	Move N away from edge of deep ravine
22B	Declining E-W ridge next to canyon; conflicts with model prediction	Use modified site 22A
23	E-W ridge into deep canyon	No safer local option
24	E-W ridge	No safer local option
25	On knoll lower than surrounding ridges; surrounded by valleys	No solution here; We recommend avoiding this site
26	In shallow trough/saddle	Move SW to crest or south to higher ground
27	No model; In saddle (also on pipeline)	Move north to hill peak
28	No model; Break in slope near saddle (also on pipeline)	Move north to hill peak
29	No model; Low near valley	Move east to high ground
30	No model; Trough to E; edge of deep ravine to S	No better local options
31	No model; Pad grading will leave upwind berm	Avoid berm by moving west
32	None but no model	Safest place in area
33	None but no model	Safest place in area
34	No model; Saddle with concave slopes to NE, SW – crossover point	We recommend avoiding this site

Site	Concern	Suggested move/Recommendation
35	None but no model	Safest place in area
36	Edge of canyon	Move NNW away from canyon edge
37	Complex saddle; known crossing point; conflicts with model prediction	Move west to higher ground
38	None	Safest place in area
39	None	Safest place in area
40	Known crossing point on descending ridge	No local option to recommend

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

March 2019

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ICF

and

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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).

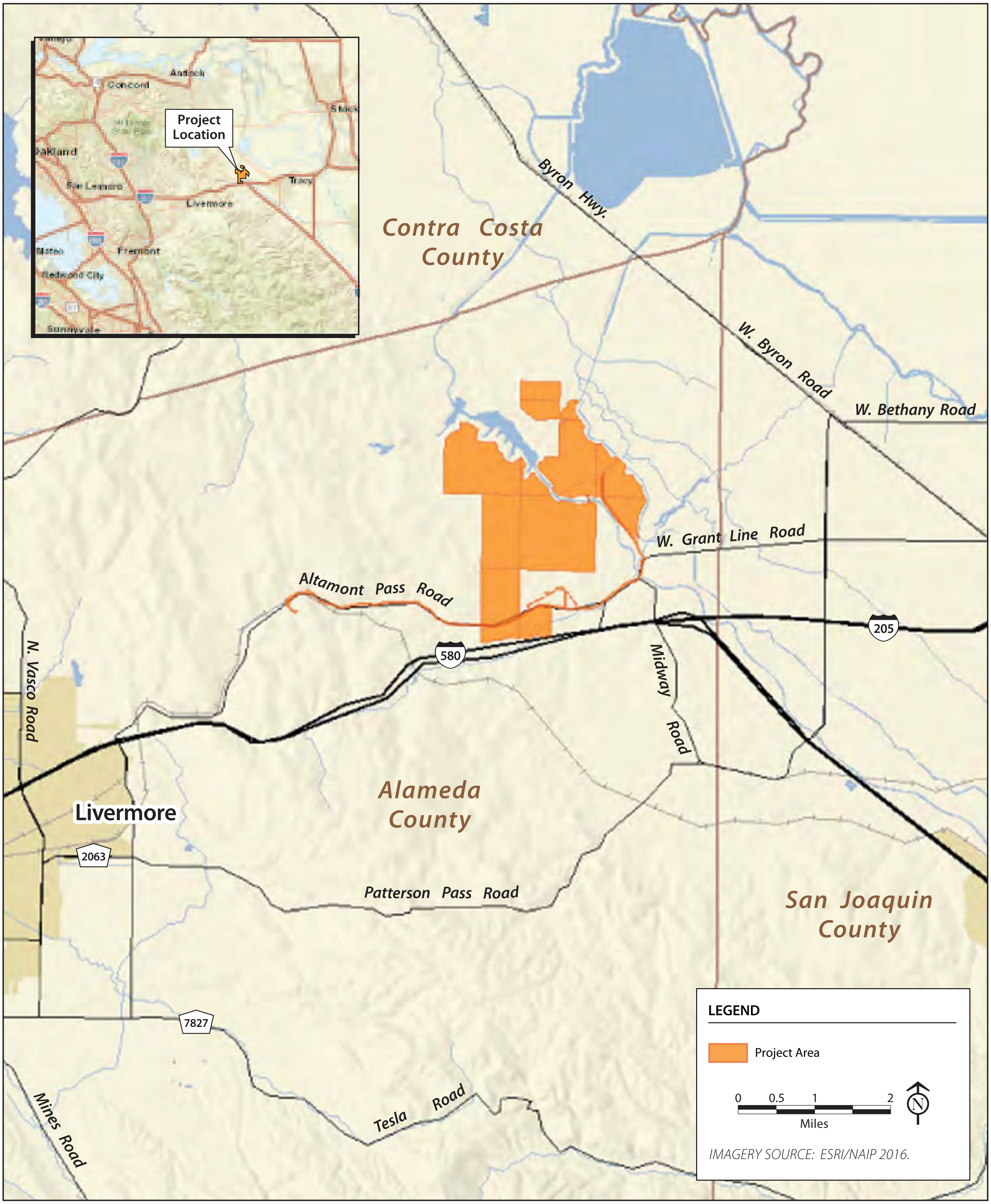
Repowering the APWRA

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.

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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.

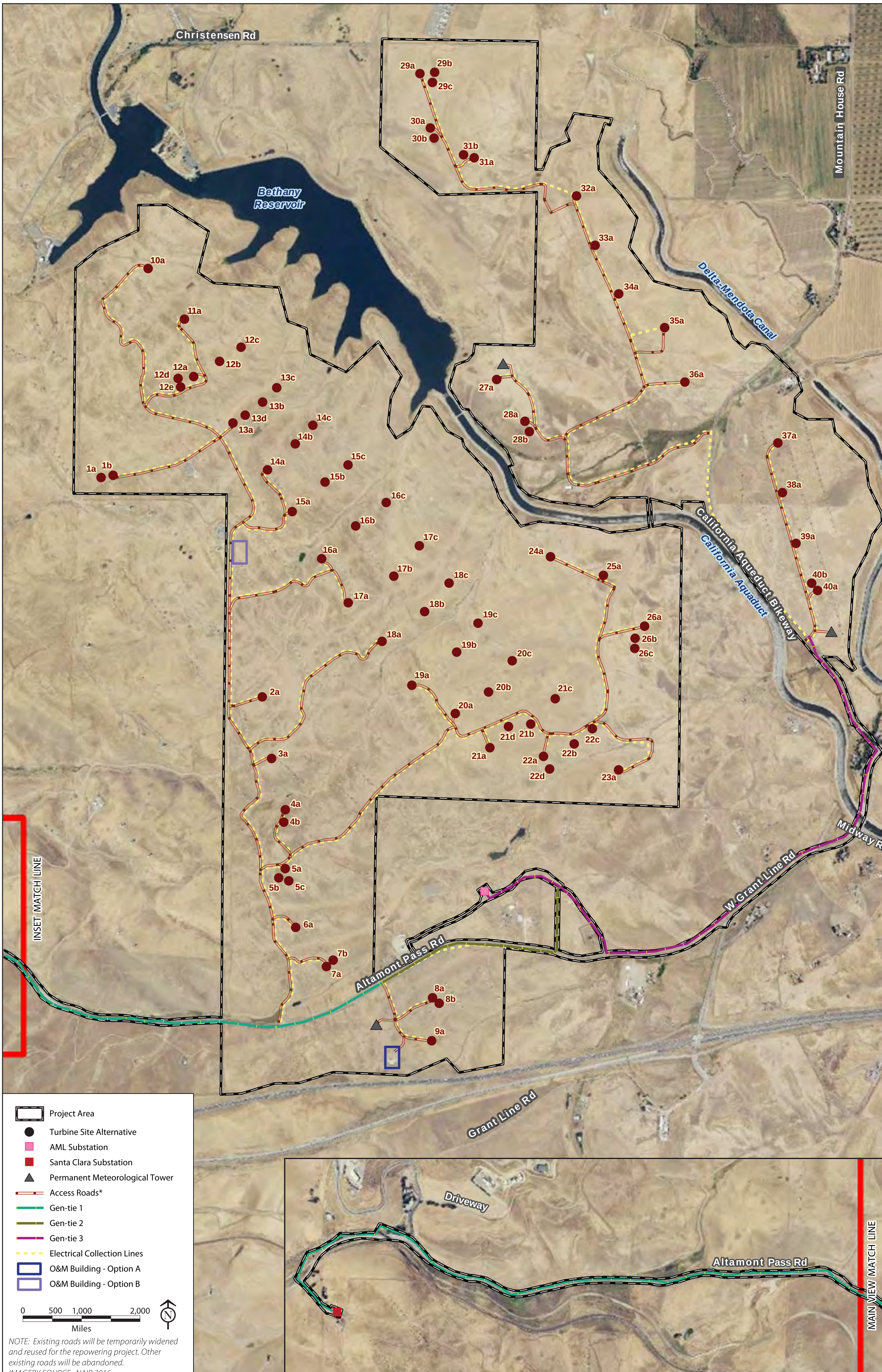
To ensure compliance with BIO-11b and to address the recommendations of the TAC, the Sand Hill Project has undertaken additional site review to micro-site each of their proposed turbine locations. A collision hazard model was initially used to evaluate proposed locations and recommend relocation sites 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.



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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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Sand Hill Wind Repowering Project

Appendix A-1. Assessment of Turbines 1 through 10

March 2019

Turbine 1

Turbine 1 has two alternative locations: Site 1A (the location for layouts 1, 2, and 3); and Site 1B (the location for layout 4). Site 1A is approximately 150 feet east of Site 1B (Figure A-1).

Topographical Description

Both sites are located near the western end of a broad, open, shallow east-west valley that gently slopes (<5%) down toward the east. The ascending westward slope is somewhat steeper, leading to a saddle between two hills about 600 feet southwest of Site 1A (Plate 1). There is a shallow swale approximately 200 feet north and a somewhat steeper upward slope (10%) within approximately 200 feet south of both sites (Plate 2). Otherwise the topography at both sites is relatively flat and open with little topographical relief relative to the surrounding area.

Topographical features that may influence raptor movement are primarily the ascending slopes to the south and west, the ravine/swale to the north, and particularly the saddle southwest (typically upwind) of both sites.

Proximity to Other Potential Risk Factors

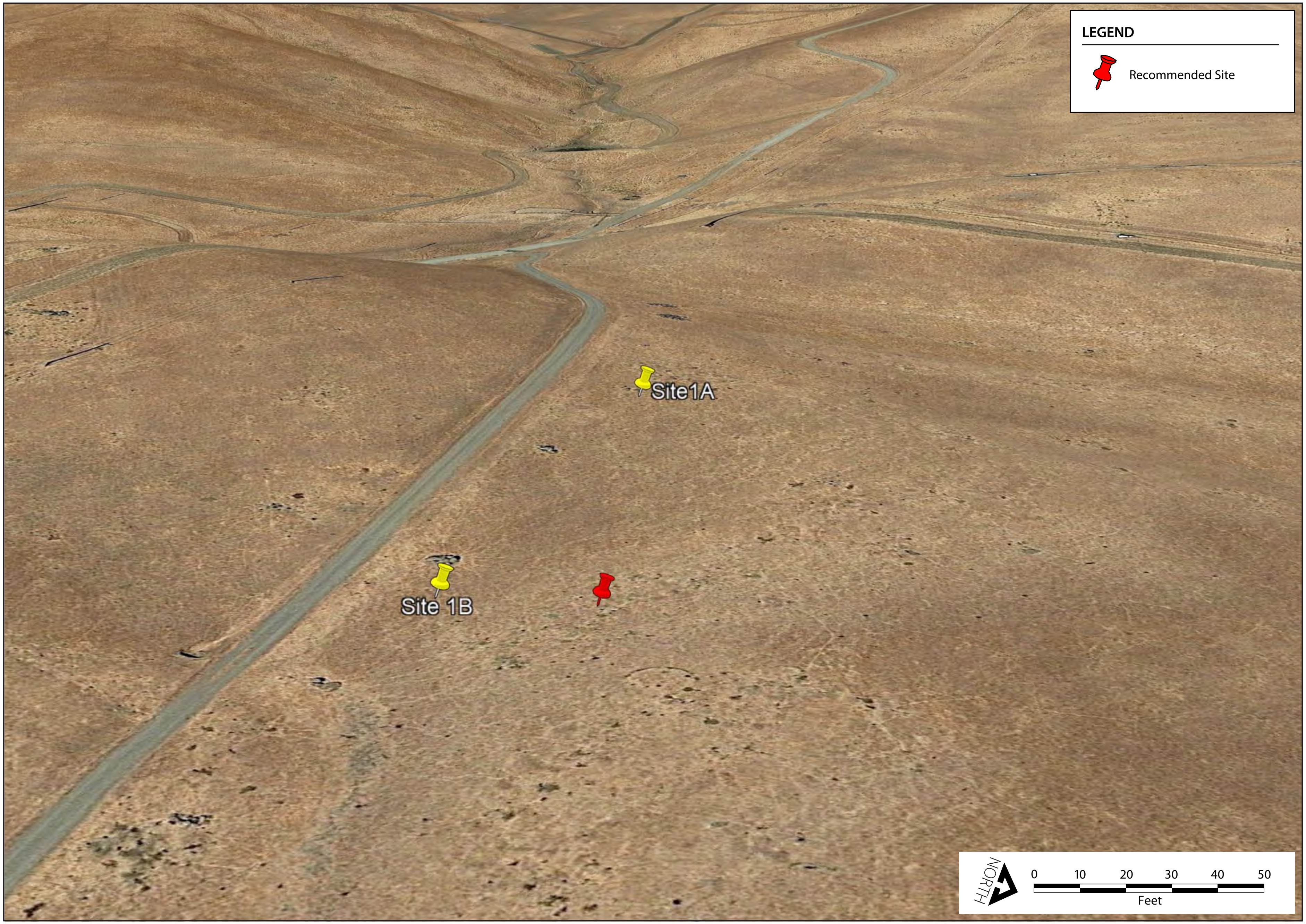
There are two small rockpiles within approximately 50 feet of both sites and two large rockpiles within 250-feet of Site 1A, and a small rock pile within 30 feet of Site 1B. There is an overhead powerline within 300 feet and several old-generation turbines on the neighboring property and a transmission line within 600 feet of both sites. There is also substantial ground squirrel activity in the immediate vicinity of both sites. With existing road access and relatively flat terrain, turbine pad construction and road improvements in this area are not expected to substantially alter the local topography and influence raptor use or behavior.

Relative Risk and Determination

Risk is considered relatively low to moderate at both sites due mainly to the open and fairly flat terrain in the immediate vicinity of the sites; however, Site 1B is a slight improvement due to its more eastward location away from the upslope and saddle to the southwest. Raptor movement is likely somewhat influenced by the topography to the north, south, and west, and particularly through the saddle to the southwest. But both sites may be sufficiently distant from these features to have a substantial increase in risk. Given the extent of ground squirrel activity, the area likely receives substantial raptor foraging use, which also increases overall risk. However, foraging movement in this area is unpredictable due to the low-profile terrain.

Recommendation

Further reduce risk by moving the site at least 60 feet north of Site 1B (37.767137/121.619948). This moves it further from the upward slope to the south, centers it better within the broad



3/28/2019

SOURCE: *Google Earth 2018.*

Figure A-1
Location of Alternative Sites for Turbine 1 at the Sand Hill Wind Project

valley, and moves it further from rock piles and overhead powerlines. At this location, there are no topographical features in the immediate vicinity that would influence raptor movement. This recommendation is generally consistent with Smallwood and Neher (2018).

Plate 1. Looking southwest from Site 1A. Note the proximity to the shallow saddle on the right, rock piles, ground squirrel activity, and overhead power lines.

Plate 2. Looking east from Site 1B. Better than Site 1A, but improved by moving an additional 60 feet north (left).

Turbine 2

Turbine 2 has only one location (Site 2A) for the four layouts (Figure A-2).

Topographical Description

Located within relatively flat terrain – Site 2A is near the top of a low plateau (Plate 3). In this area, between 8 and 10 feet separate the high elevation from the low elevation. The site is on a very gentle (<5% west-southwest ascending slope). This area is characterized by a series of low plateaus separated by shallow swales, one of which is approximately 300 feet south of Site 2A.

Proximity to Other Potential Risk Factors

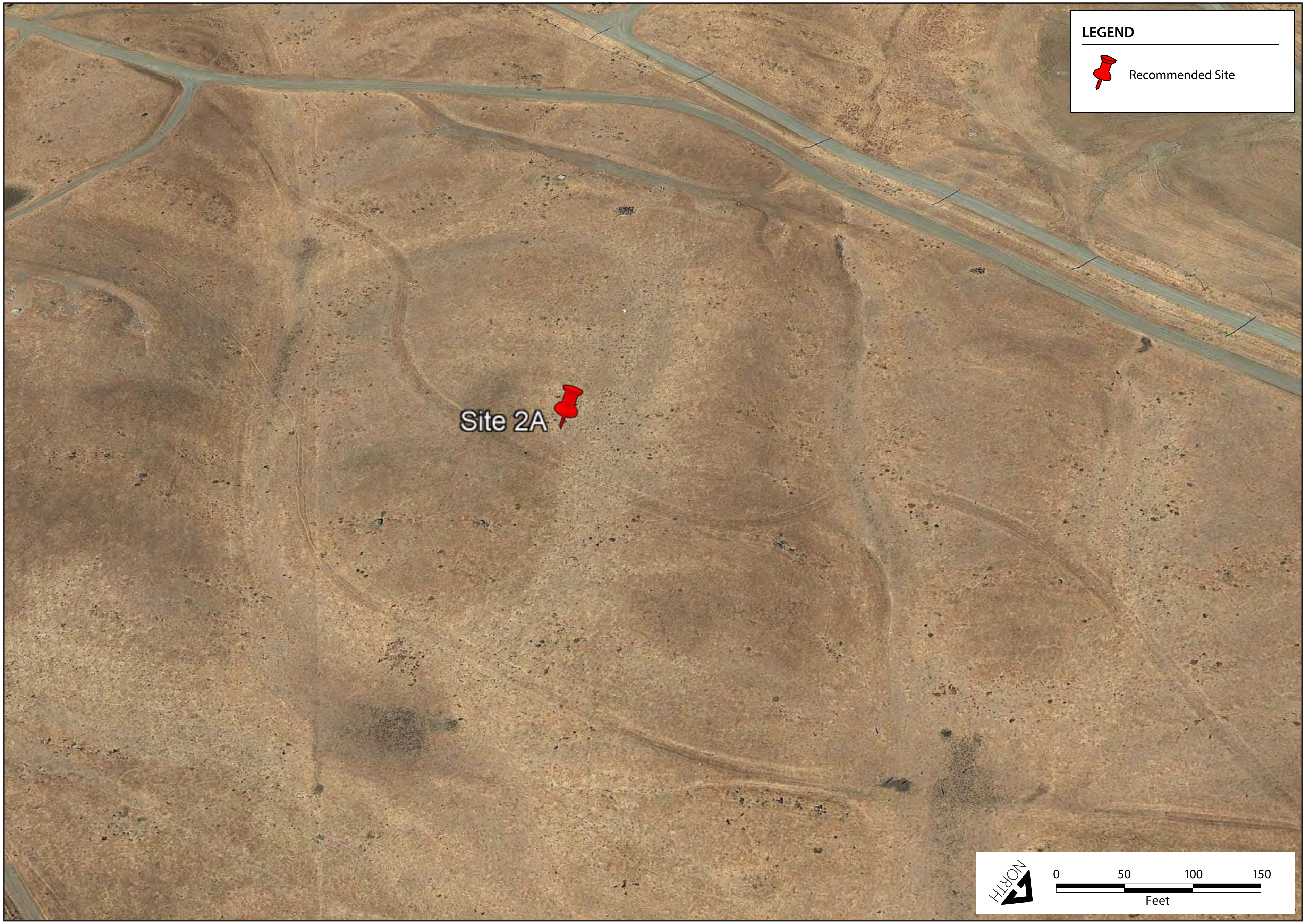
The nearest rockpile is approximately 500 feet from Site 2A. The nearest overhead powerline is approximately 550 feet away. There are no other topographical features or risk factors in the immediate vicinity. Additional road construction will be required to access this site; however, because of the relatively low topographical relief, road and turbine pad construction is not expected to substantially alter the local topography or influence raptor use or behavior.

Relative Risk and Determination

Site 2A is considered a relatively low-risk site due to the low topographical relief. Raptor movement in this area is associated less with topographical features compared to areas with greater complexity, and thus specific flight patterns are less predictable.

Recommendation

Site 2A is the recommended site. There is no recommendation for relocation. This is generally consistent with Smallwood and Neher (2018).



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SOURCE: Google Earth 2018.

Figure A-2
Location of Alternative Sites for Turbine 2 at the Sand Hill Wind Project

Plate 3. Looking northeast toward Site 2A.

Turbine 3

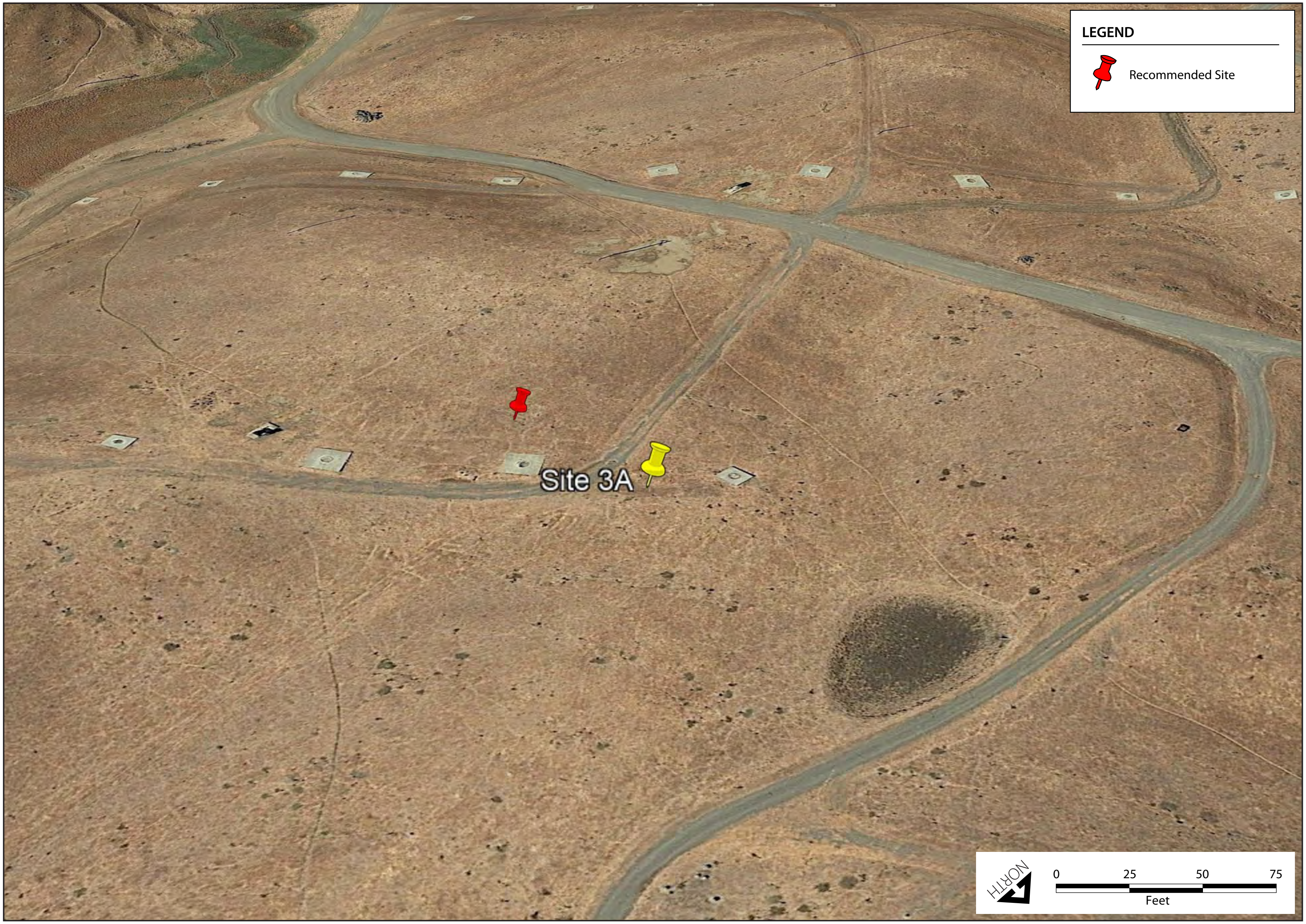
Turbine 3 has only one location (Site 3A) for the four layouts (Figure A-3).

Topographical Description

Site 3A is located along an old-generation turbine string on relatively flat terrain with little topographical relief compared with the surrounding landscape. The ground slopes upward slightly to the southwest with a minor dip to the north-northwest, and a dip to the east. The most significant topographical feature is a swale extending eastward from approximately 200 feet east of Site 3A and dropping down into a larger swale/ravine (Plate 4). There is also a deep ravine 600-800 feet south and southeast of the site.

Proximity to Other Potential Risk Factors

There is a decommissioned meteorological tower approximately 300 feet west and a dry stock pond 100 feet north of the site. An overhead powerline also occurs within 250 feet west and south of the site; however, it would be removed. There is also substantial ground squirrel activity in the immediate area. With existing road access and relatively flat terrain, turbine pad construction and road improvements in this area are not expected to substantially alter the local topography and influence raptor use or behavior.



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SOURCE: Google Earth 2018.

Figure A-3
Location of Alternative Sites for Turbine 3 at the Sand Hill Wind Project

Relative Risk and Determination

This site is considered a relatively low- to moderate-risk site due to the low topographical relief. However, although Site 3A is set back approximately 200 feet from the top of the swale just east of the site, this feature may influence raptor movement and because Site 3A is at the top of this swale, it may pose some risk to raptors flying up through this feature.

Recommendation

Although the risk is not considered high in its current location, relocating Site 3A approximately 105 feet south (37.753410/121.611207) along the old turbine string and further from the swale to the east may slightly reduce collision risk. This is generally consistent with Smallwood and Neher (2018); however, they did not recommend relocation.

Plate 4. Looking east from Site 3A. Note the saddle at the top of the swale in the foreground. The site may be sufficiently distant from this dip to influence potential risk, but a slight movement of the site to the southeast may slightly reduce risk.

Turbine 4

Turbine 4 has two alternative locations: Site 4A (the location for layouts 1, 2, and 3); and Site 4B (the location for layout 4). Site 4A is approximately 275 feet north-northeast of Site 4B (Figure A-4).

Topographical Description

Site 4A is on a steep (25%) northwest-facing slope shoulder at the end of an old-generation turbine string. It descends steeply into a deep ravine on the northwest with a more gradual slope into the same ravine on the northeast. The slope ascends southward toward the top of the hill (Plate 5). Site 4B is 258 feet south of Site 4A on the same northwest-facing slope, but it is approximately 40 vertical feet higher on a northwest-facing slope shoulder. The slope descends sharply to the northwest and ascends southward toward the top of the hill (Plate 6).

Proximity to Other Potential Risk Factors

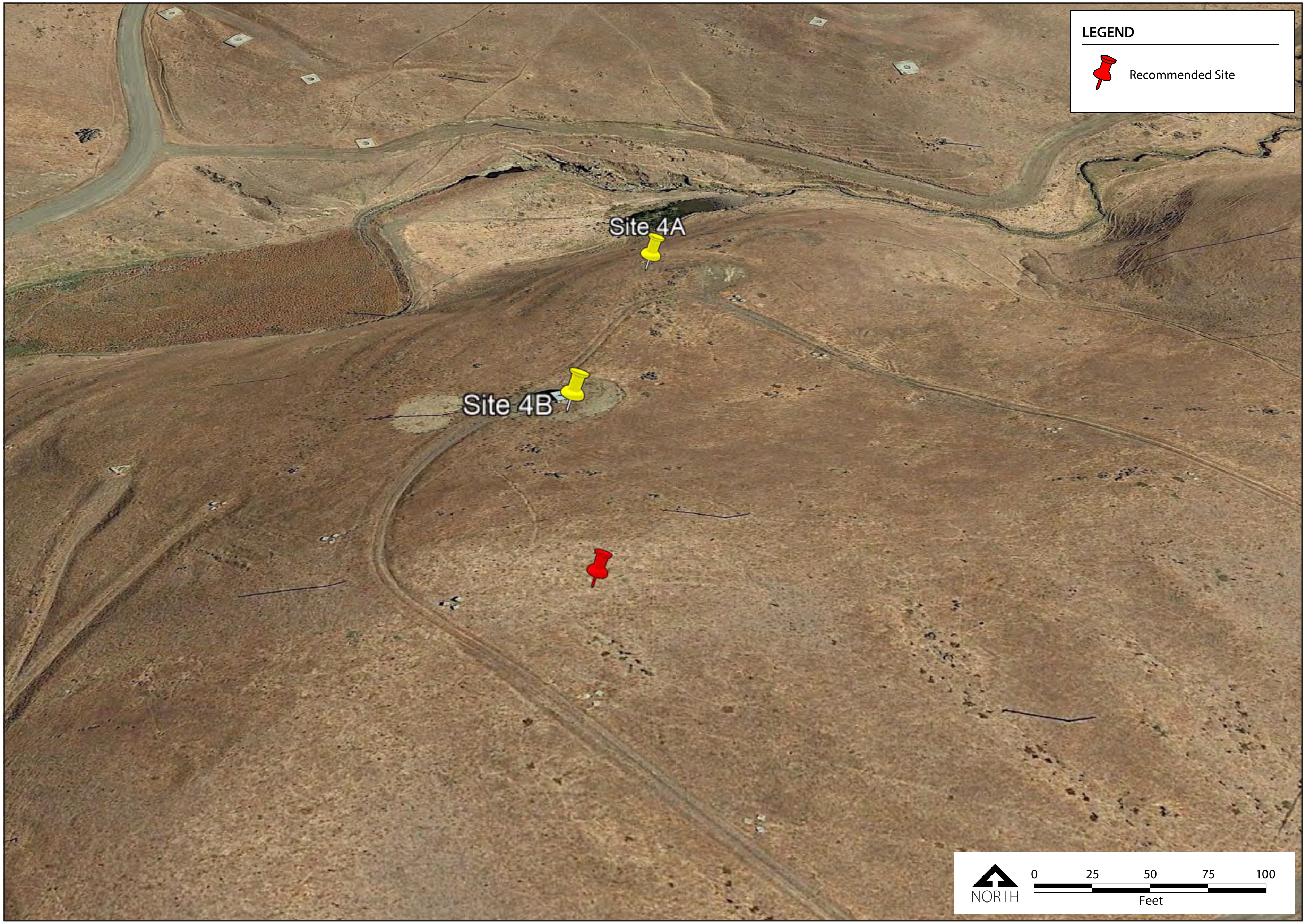
There is a stock pond about 230-feet north of Site 4A and 470-feet north of Site 4B. There is also a decommissioned meteorological tower about 300 feet west and overhead distribution lines within 100-feet of both sites, which would be removed as part of the project. There are also several rock piles within 60-70 feet of both sites.

Relative Risk and Determination

Both Sites 4A and 4B are considered relatively high-risk sites due their location on a steep slope bench and above a steep northwest-facing slope. Steep slopes and benches on steep slopes are generally considered high risk areas due to their influence on raptor movement and behavior, particularly golden eagles and American kestrels. Road construction to access either of these sites and turbine pad construction will further increase risk by creating larger slope benches and berms. Although both are considered high-risk sites, Site 4B may be slightly less risky than Site 4A, which is further downslope and would require additional access road construction along the slope compared with Site 4A. Although prevailing winds in the APWRA are most often from the southwest, northwest winds are also common. The northwest-facing slope has potential for slope-accelerated winds and a turbine on the edge of the slope is a potential risk to raptors, particularly red-tailed hawks, that hunt in these conditions by hovering and kiting.

Recommendation

As a general rule to reduce potential raptor fatalities, siting locations on steep slopes should be relocated to the ridge or hill top above the slope. To reduce risk, Turbine 4 should be relocated approximately 225 feet due south of Site 4B to the top of the hill (37.749771/121.610541). This also moves the site further off of the northwest-facing slope edge. Smallwood and Neher (2018) note the high-risk conditions at these sites but do not make a recommendation for relocation.



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SOURCE: Google Earth 2018.

Figure A-4
Location of Alternative Sites for Turbine 4 at the Sand Hill Wind Project

Plate 5. Looking upslope from Site 4A.

Plate 6. Looking upslope to the west from Site 4B toward the recommended relocation site.

Turbine 5

Turbine 5 has three alternative locations: Site 5A (the location for layouts 1, 2, and 3); Site 5B (the location for layout 4); and Site 5C (the proposed alternative to the recommended location as per the February 4-5 site visit by sPower engineers). Site 5A is approximately 210 feet northeast of Site 5B and Site 5C is approximately 50 feet east of Site 5B (Figure A-5).

Topographical Description

The topography in this area is gently rolling with only moderate relief. Site 5A is located within a shallow north-south swale near its northern terminus. There is a gradual ascending slope to the north and west, and a slight descending slope to the east and south (Plate 7). Site 5B is slightly upslope from Site 5A, on level ground and at the top of a west-facing steeper descending slope. Site 5C is similar to Site 5B but is 50 feet further back from the west-facing slope (Plate 8).

Proximity to Other Potential Risk Factors

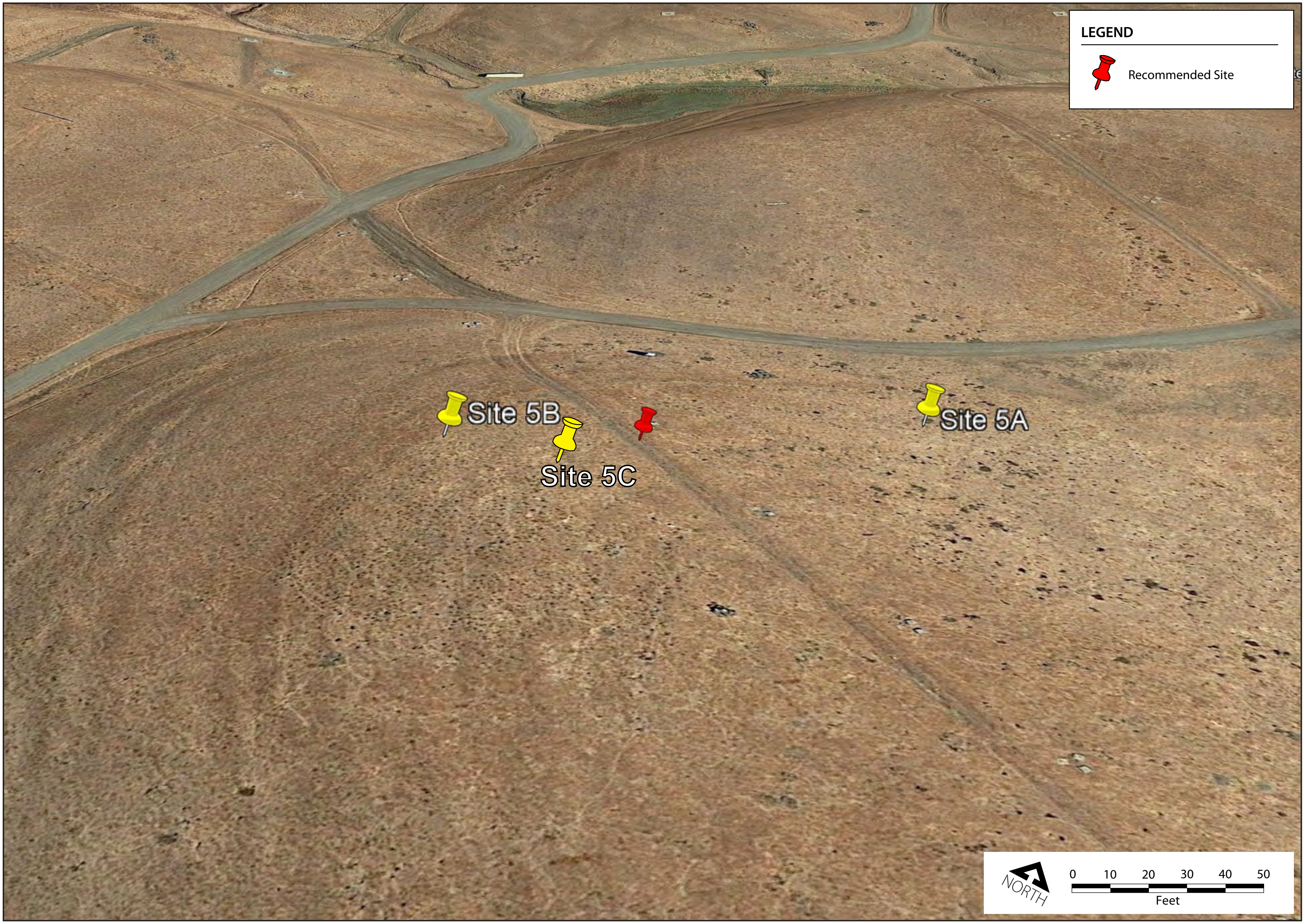
There is one rock pile within 80 feet of Site 5A and 160 feet of Site 5B. There are above-ground distribution lines approximately 450 feet northeast of Site 5A and approximately 600 feet west of Site 5B. There is also substantial ground squirrel activity in the area. With the moderate topographical relief and close proximity to existing access roads, road and turbine pad construction at these sites is not expected to substantially alter local topography and raptor use or movements.

Relative Risk and Determination

Site 5A is relatively low- to moderate-risk due to its location within and near a shallow swale. However, the topographical relief is not extreme around the site, and although raptor movement may be influenced by the swale, it is likely not significant, particularly given the size the turbine. Site 5B relocates the site outside and above the swale onto higher and more even ground, which would generally be considered a somewhat less risky site compared with Site 5A. However, the location is also near the edge of a relatively steep southwest-facing slope (Figure A-5). This is a location where slope-accelerated winds from the southwest may encourage kiting by raptors, particularly red-tailed hawks, and increase the potential for collision as birds hunt along this slope. As a result, this site is also considered low-to moderate-risk. Site 5C is similar to Site 5B and is also considered low- to moderate-risk, but considered slightly less risky because it is further away from the west-facing slope.

Recommendation

Move Site 5B about 80 feet northeast near the existing access road to keep the turbine further from the edge of the southwest-facing slope while still on the higher ground slightly above Site 5A (37.748025/121.610605). This is consistent with Smallwood and Neher (2018).



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SOURCE: Google Earth 2018.

Figure A-5
Location of Alternative Sites for Turbine 5 at the Sand Hill Wind Project

Plate 7. Site 5A, looking southeast

Plate 8. Site 5B, looking southwest above the southwest-facing slope. The recommendation is to move the site northeast to increase the distance from this slope and possible slope-accelerated winds.

Turbine 6

Turbine 6 has only one location (Site 6A) for the four layouts (Figure A-6).

Topographical Description

Site 6A is located near the west end of an east-west-oriented ridge. The ridge apex is fairly narrow and relatively level, although descending slightly along the ridge. Site 6A is located at the highest point on the west end. The ridge slopes down to deep ravines on the north, south, and west. The site is near the edge of the west-facing slope (Plate 9).

Proximity to Other Potential Risk Factors

There is one large rock pile within 100 feet of the site and an overhead powerline with 220 feet, which would be removed as part of the project. There is also substantial ground squirrel and pocket gopher activity in this area.

Relative Risk and Determination

Site 6A is considered a moderate risk site due primarily to the narrow ridge top. The west face is fairly narrow and therefore less subject to slope-accelerated winds from the west and southwest compared with Turbine Site 5B. However, due to the narrow ridge apex, the turbine rotors will extend out over the slopes and may pose some moderate level of risk for raptors funneling through the deep ravines on the north and south. Construction of the turbine pad and an access road up the steep slope to the site will alter the topographical conditions somewhat, but because Site 6A is on the highest point on the ridge, corresponding potential changes in raptor movement may not further increase risk at this site. The exception would be if a large bench would need to be constructed to accommodate the turbine pad, and the turbine pad ends up lower than the ridge to the east. This would effectively create a large slope bench, which raptors may use to cross the ridge slope and thereby increase risk.

Recommendation

There are limited opportunities to reduce risk at this site. Site 6A is probably the most appropriate location on the ridge. This is consistent with Smallwood and Neher (2018). However, to avoid creating a slope bench at the end of the ridge, the turbine pad should not be constructed below the elevation of the ridge.

1/03/2019

SOURCE: Google Earth 2018.

Figure A-6
Location of Alternative Sites for Turbine 6 at the Sand Hill Wind Project

Plate 9. Looking west-southwest from Site 6A.

Turbine 7

Turbine 7 has two alternative locations: Site 7A (the location for layouts 1, 2, and 3); and Site 7B (the location for layout 4). Site 7A is approximately 40 feet south of Site 7B (Figure A-7).

Topographical Description

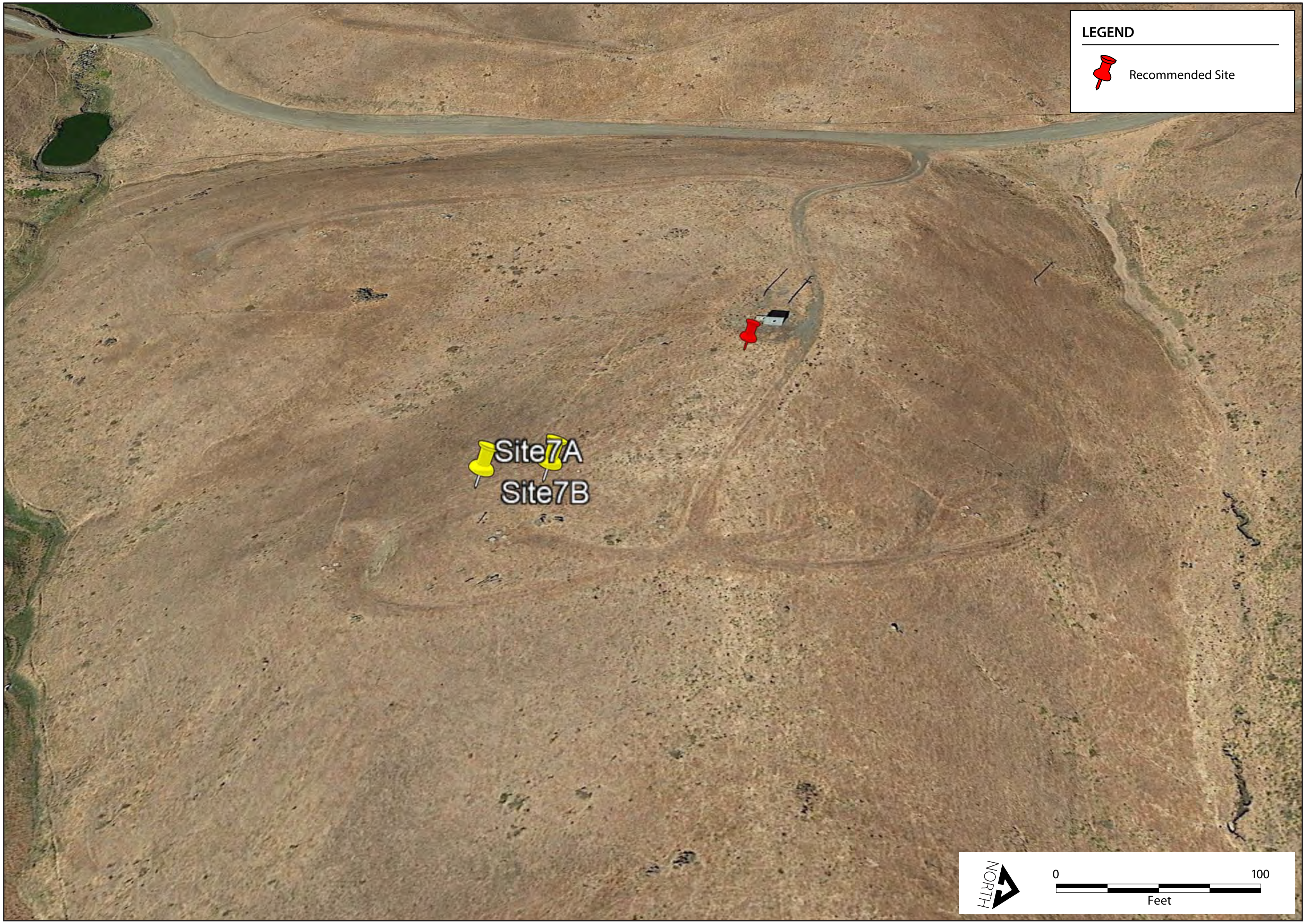
Both Sites 7A and 7B are located on a southeast-facing slope along an east-west-oriented ridge. Both sites are downslope from the ridge top with Site 7A located approximately 40-feet further downslope than Site 7B. The ridge top is narrow and relatively even although descending gradually toward the east. Steep slopes extend down from the narrow apex on the north and south into deep ravines (Plates 10 and 11).

Proximity to Other Potential Risk Factors

There is an overhead powerline within 270 feet, which would be removed by the project.

Relative Risk and Determination

Site 7B is a slight improvement over Site 7A; however, both sides are along the slope of the ridge and are considered moderate-risk. As with all slope locations, construction of the turbine



1/03/2019

SOURCE: Google Earth 2018.

Figure A-7
Location of Alternative Sites for Turbine 7 at the Sand Hill Wind Project

pad will result in a slope bench, which increases risk. Road construction to access these sites may also create a berm along the slope, also increasing risk.

Recommendation

Risk can be reduced by relocating 7B approximately 200 feet northwest to the top of the hill/ridge (37.743994/121.608436). The topography at this location has less influence on raptor movement compared to the slope positions of Sites 7A and 7B. The construction of the turbine pad and access road will also have less influence on potential risk. This is consistent with Smallwood and Neher (2018).

Plate 10. Looking southwest toward Site 7A

Plate 11. Looking southwest toward Site 7B.

Turbine 8

Turbine 8 has two alternative locations: Site 8A (the location for layouts 1, 2, and 3); and Site 8B (the location for layout 4). Site 8A is 15 feet northwest of Site 8B (Figure A-8).

Topographical Description

Both sites are within 15 feet of each other and have the same topographical characteristics. Both are along a fairly broad ridge top, but on the slightly-sloped (<5%) south edge of the ridge top (Plate 12). The east-west-oriented ridge is long and with a fairly broad and flat ridge top that descends gradually to the north and south. The ridge has a slight downward slope to the east, but otherwise is relatively flat and without dips, notches, or saddles.

Proximity to Other Potential Risk Factors

A decommissioned meteorological tower is within 150 feet, but would be removed.

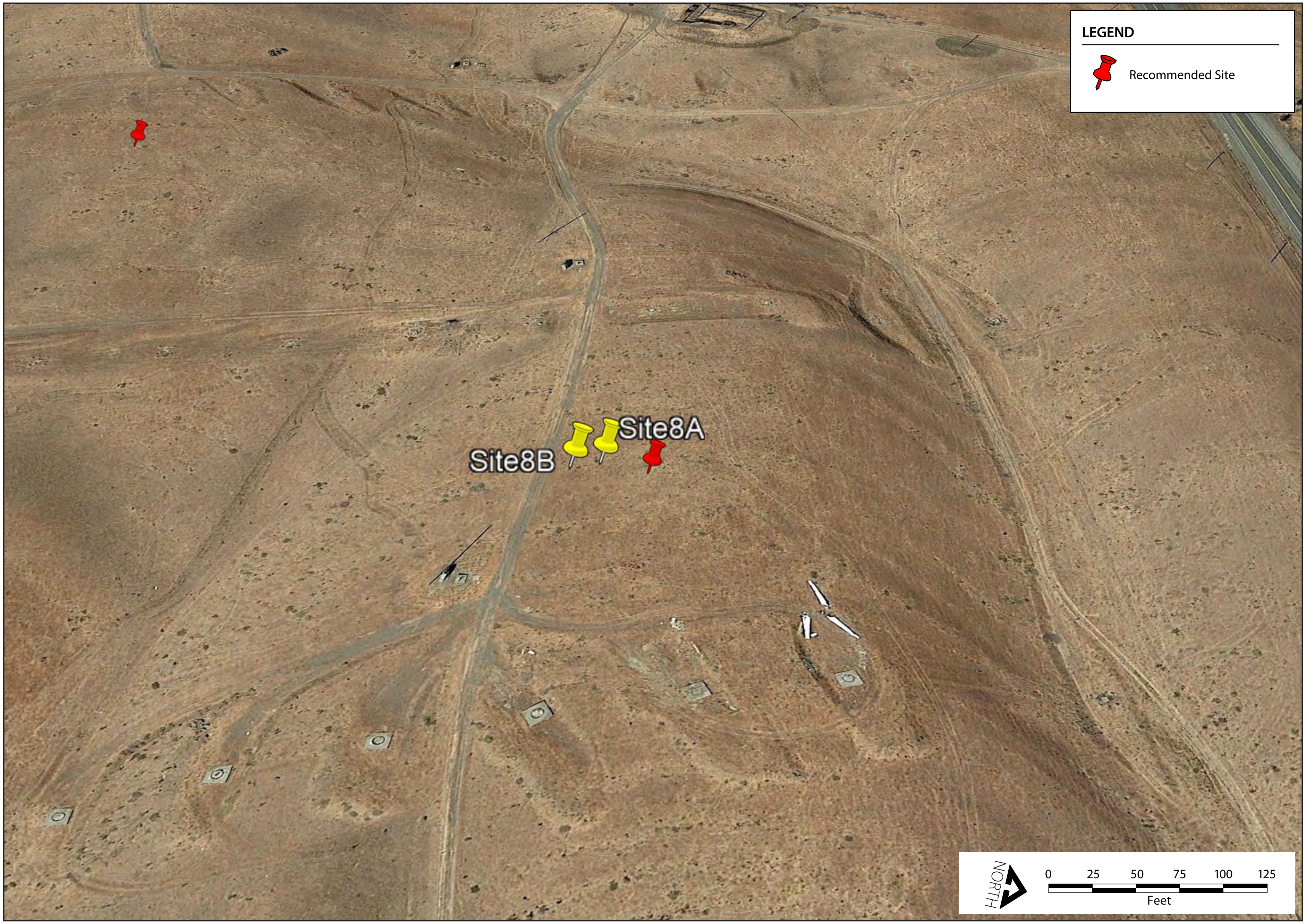
Relative Risk and Determination

Sites 8A and 8B are considered to have relatively low-risk due to their location along the ridge top and located in flat terrain. This is generally consistent with Smallwood and Neher (2018). There are no topographical features in the immediate area that would influence predictable raptor movements. Because of the generally flat topography, access road and turbine pad construction would also not substantially influence raptor use and behavior.

Recommendation

The recommended location is an additional 50 feet north (37.742348/121.601410) of Site 8A to better center it on the ridge top and further from the south-facing slope.

Plate 12. Looking west from Sites 8A and 8B



1/03/2019

SOURCE: Google Earth 2018.

Figure A-8
Location of Alternative Sites for Turbine 8 at the Sand Hill Wind Project

Turbine 9

Turbine 9 has only one location (Site 9A) for the four layouts (Figure A-9).

Topographical Description

Site 9A is midway down a south-facing 8% slope toward a deep ravine (Plate 13). There are a series of slope shoulders approximately 120 feet east and 260-feet west of the site resulting from recently removed old generation turbines. To the north and northwest, the slope increases to the top of the hill, which is fairly broad, open, and relatively flat with few topographical features.

Proximity to Other Potential Risk Factors

None in the immediate vicinity.

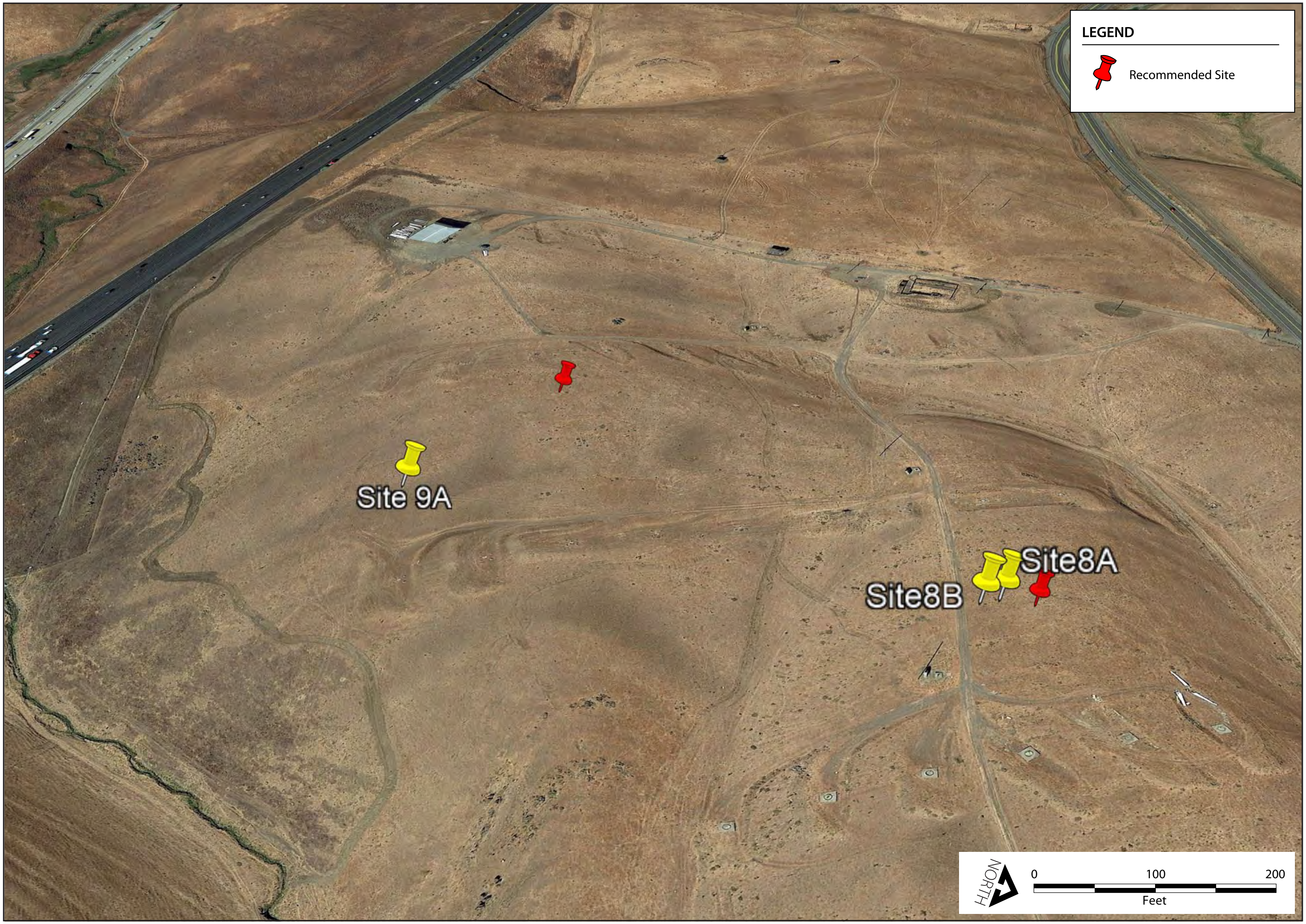
Relative Risk and Determination

Although the south-facing slope is relatively gentle and consistent across most of the south face of the hill (with the exception of the slope shoulders from the early-generation turbine sites), Site 9A is considered a moderate risk site. Raptor flight and movement patterns may be influenced by the slope and the presence of the slope shoulders. Construction of an access road and the turbine pad at this location would also create a bench in the slope and a berm along the road edge, further increasing potential risk at this location.

Recommendation

To reduce risk, relocate Site 9A approximately 280 feet upslope to the northwest to the top of the hill (37.740440/121.602393). This moves the turbine off of the slope and away from the slope shoulders. This is generally consistent with Smallwood and Neher (2018).

Plate 13. Looking east from Site 9A.



1/03/2019

SOURCE: Google Earth 2018.

Figure A-9
Location of Alternative Sites for Turbine 9 at the Sand Hill Wind Project

Turbine 10

Turbine 10 has only one location (Site 10A) for the four layouts (Figure A-10).

Topographical Description

Site 10A is on fairly level ground in a broad, shallow valley. Shallow swales converge here from the west, east, and north, where the ground slopes gently downward. The site is also near the base of a slight ascending slope to the southeast, south, and southwest. The overall landscape in the area is relatively low-profile rolling hills (Plate 14).

Proximity to Other Potential Risk Factors

The site is within approximately 1,000 feet of inlets of Bethany Reservoir to the east and west. A transmission line runs northwest to southeast about 1,100 feet to the west. There is a rock pile within 350 feet and a stock pond within 680 feet of Site 10A. There is also substantial ground squirrel activity in the area.

Relative Risk and Determination

Although Site 10A is located within a low, broad swale and at the base of a long, gradual slope, it is a considered a relatively low-moderate risk site. The breadth and low profile of the site does not confine and has minimal influence on raptor movement, and allows for high visibility. Road and turbine pad construction would not substantially alter topography and influence raptor use and movement in this generally low-profile terrain.

Recommendation

Relocating the site about 300 feet south moves the turbine out of the low plain, but closer to a deep ravine to the south. So, Site 10A is the recommended site. No relocation is recommended. This is generally consistent with Smallwood and Neher (2018).

1/03/2019

SOURCE: Google Earth 2018.

Figure A-10
Location of Alternative Sites for Turbine 10 at the Sand Hill Wind Project

Plate 14. Looking northeast from Site 10A.

Sand Hill Wind Repowering Project

Appendix A-2. Assessment of Turbines 11 through 20

March 2019

Turbine 11

Turbine 11 has only one location (Site 11A) for the four layouts (Figure A-11).

Topographical Description

Site 11A is near the top of a small southeastward-sloping ridge. It is also on the edge of a steep, broad swale that extends from a stock pond downslope to the north in the adjacent ravine to the top of the ridge, creating a broad saddle on the north side of the ridge (Plate 15). The site is also set back about 200 feet eastward from a steep broad west-southwest-facing ridge.

Proximity to Other Potential Risk Factors

A stock pond is approximately 500-feet north of the site.

Relative Risk and Determination

Although Site 11A is located near the top of the ridge, the proximity to the saddle/swale on the north side of the ridge and the west-facing slope of the ridge results in moderate-risk to raptors whose flight patterns are influenced by these topographic features. Raptors, particularly golden eagles, may use the low, broad swale as a flight corridor, and the west-facing slope creates potential slope-accelerated winds where raptors, particularly red-tailed hawks, may kite and hover as they hunt above the slope. However, the Site 11A location may be sufficiently distant (200 feet at the slope break) from the west-facing slope.

Recommendation

Any local relocation would place the turbine either more in alignment with the swale/saddle or closer to the west-facing slope. So, the current location of Site 11A is the recommended site. This is generally consistent with Smallwood and Neher (2018).

Plate 15. Looking north from Site 11A.

1/05/2019

SOURCE: Google Earth 2018.

Figure A-11
Location of Alternative Sites for Turbine 11 at the Sand Hill Wind Project

Turbine 12

Turbine 12 has five alternative locations, 12A (Layout 1), 12B (layout 2), 12C (layout 3), 12D (layout 4), and 12E (an additional proposed alternative as per the February 4-5 site visit by sPower engineers) (Figure A-12).

Topographical Description

Overall, the topography in the vicinity of Turbine 12 is relatively low-relief rolling hills.

Site 12A is on relatively flat ground, sloping down slightly to the northeast and east, and slightly up to the southwest. There are no significant topographic features in the immediate vicinity that would influence raptor flight patterns.

Site 12B is on a small shoulder on a gentle southeast-facing slope. The slope gradually increases to the west toward the top of the low ridge. There is a dip at the top of the slope. Northward after reaching the top of the southeast-facing slope, the terrain drops down into a deep swale.

Site 12C is along an old generation turbine string near the top of a low ridge. The slope continues upward to the southeast until reaching the apex at a gravel road before dropping off into a ravine to the southeast. The old turbine pads create small benches cut into the north and northwest-facing slope.

Site 12D is 110 feet southwest of Site 12A. It's near the top of a gradual north-facing slope. The terrain continues to ascend toward the southwest and descend toward the north and east. There are no significant topographic features in the immediate vicinity that would influence raptor flight patterns (Plate 16).

Site 12E is 37 feet south of Site 12D with similar topographic conditions.

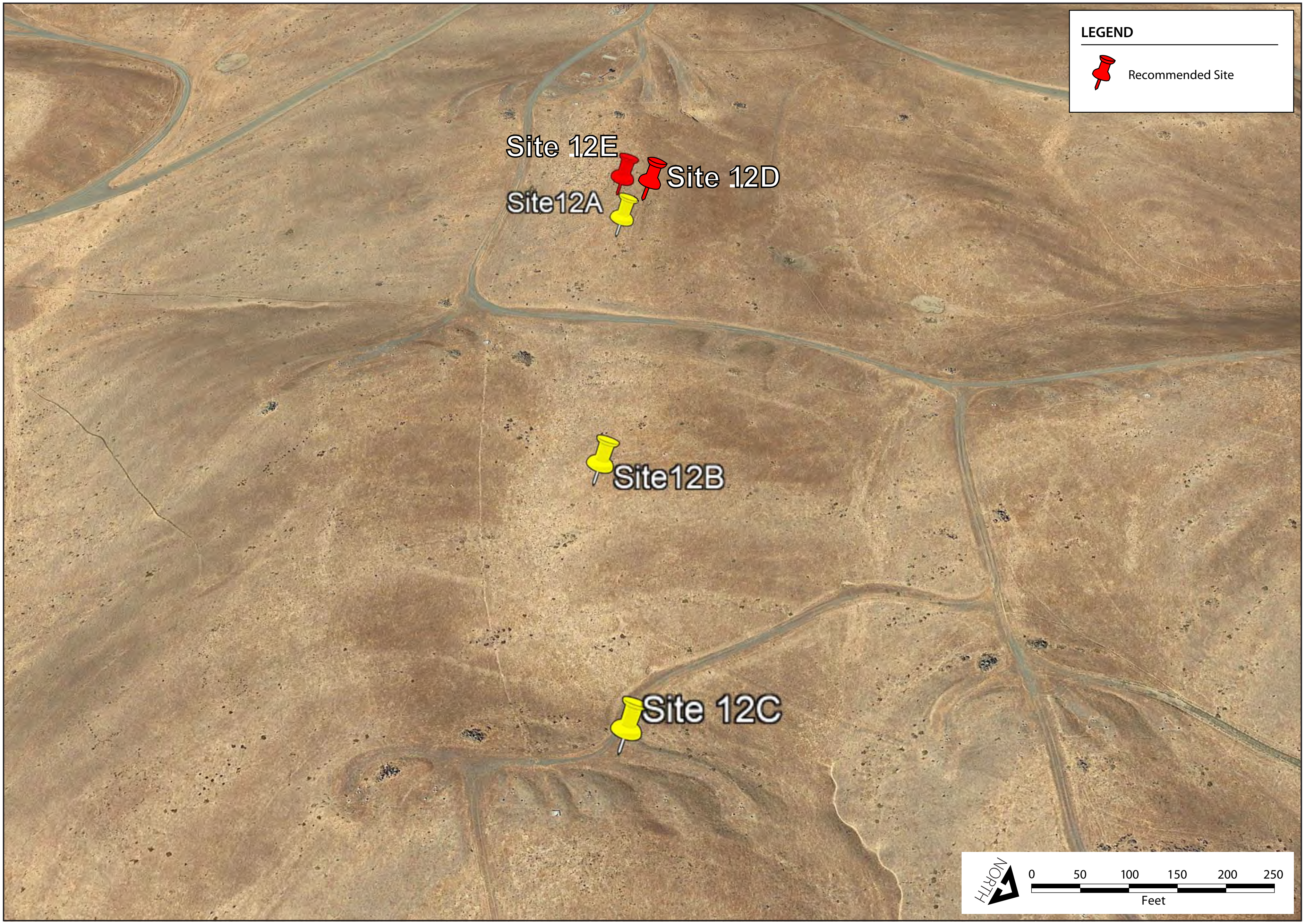
Proximity to Other Potential Risk Factors

A transmission line is 600-700 feet west of Sites 12A and 12D. The is a large rock pile within 130 feet of Site 12C.

Relative Risk and Determination

All four of the Turbine 12 sites are relatively low- to moderate-risk sites. Each is on a gentle slope and because of the generally low topographical relief in the area, there are few significant topographic features that influence raptors movements.

Site 12A is considered a relatively low-risk site due to the generally flat topography and lack of other risk factors. Site 12B is considered low-to-moderate risk due to slope conditions. Site



4/2/2019

SOURCE: Google Earth 2018.

Figure A-12
Location of Alternative Sites for Turbine 12 at the Sand Hill Wind Project

12C is considered a low-to moderate risk due to location on a small slope bench. Sites 12D and 12E are considered low risk sites due to relatively flat terrain with no significant topographical features in the immediate area that would influence raptor flight patterns. Because of the generally low topographical profile, each would be highly visible from all directions. Access road and turbine pad construction would not substantially alter topography or raptor use or movement at any of these sites.

Recommendation

Sites 12D and 12E are similar and are probably the safest of the five locations. Either of these is the recommended site. This is consistent with Smallwood and Neher (2018). Risk could be further reduced by moving the site 280 feet to the southwest to the top of the hill. However, this places the turbine within 300 feet of the transmission line.

Plate 16. Looking southeast from Site 12D, the recommended location for Turbine 12.

Turbine 13

Turbine 13 has four alternative locations, 13A (Layout 1), 13B (layout 2), 13C (layout 3) and 13D (layout 4) (Figure A-13).

Topographical Description

All four alternative sites are along a narrow northeast-southwest-oriented ridge with steep (25%) drop-offs to the northwest and southeast (Figure A-13). The flatter portion of the ridge top ranges from about 30 to 45 feet-wide along the length of the ridge.

Site 13A is on relatively steep (20%) west-facing slope at the far west end of the narrow ridge (Plate 17). The site is 172 feet down the westward-ascending ridge from the ridge top.

Site 13B is on a particularly narrow portion of the ridge top between two shallow saddles along the ridgeline (Plate 18).

Site 13C is in a dip at the site of an old-generation turbine. Eastward, the ridge is ascending, so Site 13C is in a low spot on the ridge line at the base of a slope (Plate 19).

Site 13D is about 90 feet upslope to the east of Site 13A and about 90 feet from the top of the ridge just downslope from the site of an old-generation turbine (Plate 20).

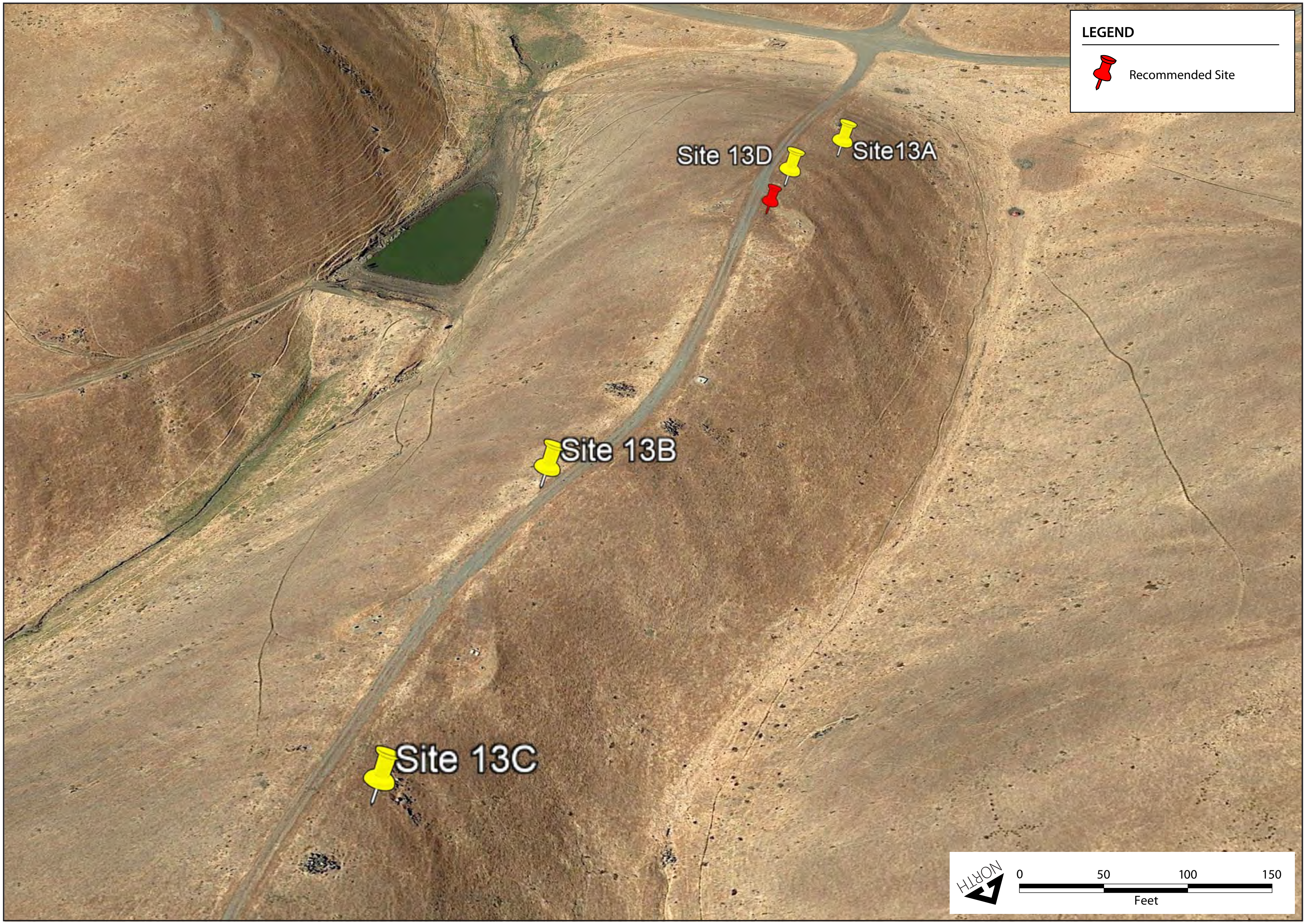
Proximity to Other Potential Risk Factors

There is a large rock pile within 80 feet of Site 13A and two rock piles within 120 feet of Site 13B. There is also a large stock pond downslope in the ravine approximately 250 feet southeast of Sites 13A and 13D.

Relative Risk and Determination

Because of its narrowness, construction at any of the Turbine 13 alternatives along the ridge will likely require the creation of a large bench, which may create a significant notch in the ridgeline, and potentially result in a high-risk topographical feature at the location of the turbine. Also, significant road construction will be required to access this ridge and construct the turbine, which will modify the topographic conditions along the ridge and potentially result in high risk topographical features not currently present.

The slopes on both sides of this ridge provide ideal contour hunting opportunities for golden eagles. The relative narrowness of the slope means that the turbine will be in close proximity to the edge of the ridge slope.



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SOURCE: Google Earth 2018.

Figure A-13
Location of Alternative Sites for Turbine 13 at the Sand Hill Wind Project

Recommendation

Alternatives for reducing risk potential are limited for Turbine 13 due mainly to the narrowness of the ridgetop. Site 13D is preferable to Site 13A because it moves the site further up on the slope. However, Site 13D should be moved an additional 50 feet to the top of the hill at the location of the old generation turbine site (37.769669/121.613260). This is the recommended location (Figure A-13). Another alternative location for Turbine 13 is approximately 400 feet northeast of site 13C to the top of the hill (37.771870/121.610223). This is also the site of an old generation turbine. This location relocates the turbine off of the narrowest portion of the ridgeline onto a slightly broader, flatter site. However, if this site were used, access should be from the existing road that crosses the ridge to the northeast to avoid the significant earth-moving that would be required if the ridge road from the southwest were used. These recommendations are generally consistent with Smallwood and Neher (2018).

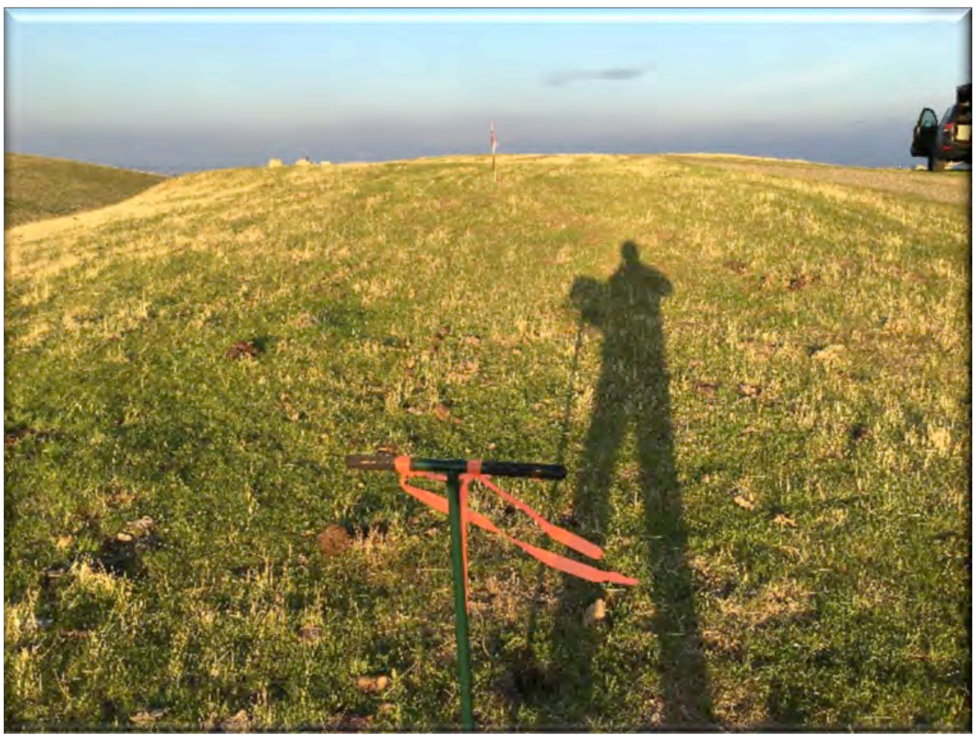


Plate 17. Looking east upslope from Site 13A toward Site 13D. The site is 172 feet downslope from the top of the ridge.

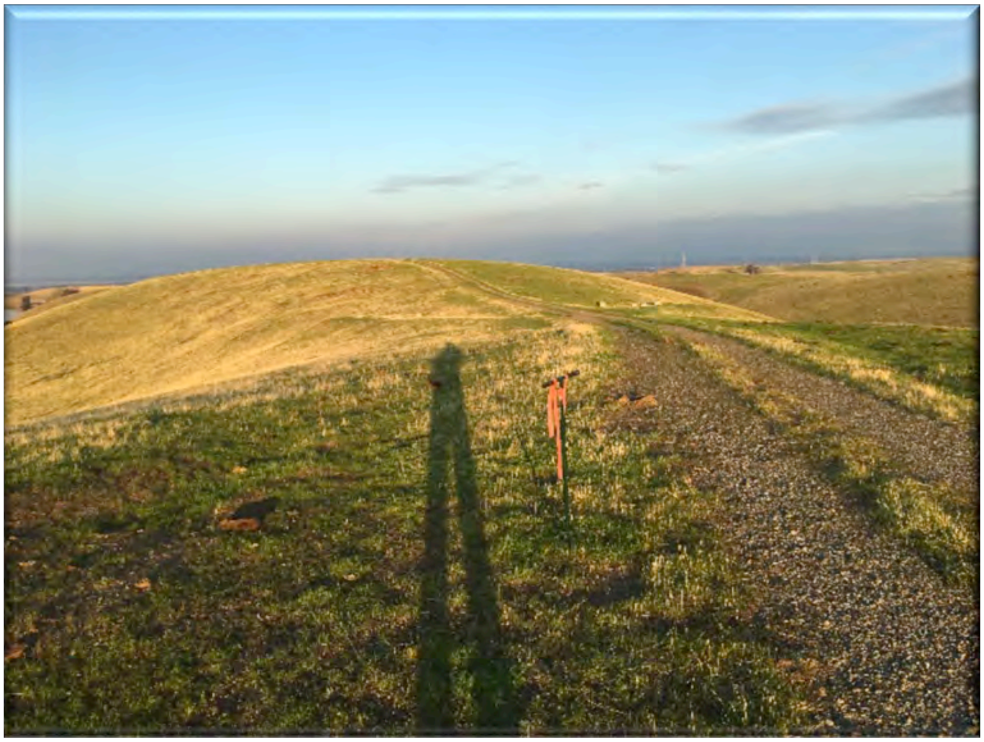


Plate 18. Looking east along the narrow ridge at Site 13B. Note the narrow ridge and the shallow saddle just east of the site.

Plate 19. Looking west from Site 13C. Note the bench below the ridge.

Plate 20. Looking east from Site 13D. About 80 feet east would put the turbine on top of the ridge.

Turbine 14

Turbine 14 has three alternative locations, 14A (Layout 1 and Layout 4), 14B (layout 2), and 14C (layout 3) (Figure A-14).

Topographical Description

Site 14A is at the far southwest end of a northeast-southwest-oriented ridge intersected by several fairly deep lateral (northwest-southeast-oriented swales) (Plate 21). As a result, several smaller northwest-southeast-oriented ridges occur, with Site 14A located on the western-most of these near the top of a broad west- to southwest-facing slope. The site is along an old-generation turbine string. The west-southwest-facing slope is fairly steep (20%) and with its northwest-southeast extent (>1,200 feet-wide), creates a significant location for slope-accelerated winds. Topography is relatively flat to the north with an ascending slope to the south along the old-generation turbine string. From a northwest-southeast orientation, the site is on a shoulder of the south-facing ascending slope. Eastward the slope descends into a broad swale.

1/05/2019

SOURCE: Google Earth 2018.

Figure A-14
Location of Alternative Sites for Turbine 14 at the Sand Hill Wind Project

Site 14B is located on a hill top along an old-generation turbine string (Plate 22). Its approximately 650 feet east-northeast of Site 14A along the next small northwest-southeast-oriented lateral ridge, across the broad swale east of Site 14A. The topography slopes steeply (25%) northward into a ravine, and descends (15%) to the west into the swale separating it from Site 14A, eastward (15%), and southward (10%).

Site 14C is approximately 450 feet northeast of Site 14B near the top of the northeast-southwest-oriented ridgeline (Plate 23). The ridge top is relatively narrow at this location. The site itself is fairly flat with a slight (5%) ascending slope southwestward – down the ridgeline – but with only about 40 feet of flat ridgetop before dropping steeply to the north (20%) into a deep ravine, and to the south (15%) into a deep swale.

Proximity to Other Potential Risk Factors

There is a stock pond approximately 600 feet of all three sites. There is a rock pile about 120 feet west of Site 14B. There are 3 large rock piles within 150 to 200 feet of Site 14C.

Relative Risk and Determination

Site 14A is a relatively high-risk location due its proximity to the west-southwest-facing slope, which has potential for slope-accelerated winds where raptors, particularly red-tailed hawks, will hunt by kiting or hovering in the wind and creating opportunities for birds to backup or turn back toward the turbine rotors while changing position.

Site 14B is a low- to moderate-risk site. It's on a fairly broad hilltop along on old-generation turbine string with good road access.
Site 14C is a moderate-risk site due to the narrowness of the ridge, which may require substantial earth-moving to create a pad, and possibility of creating a notch in the ridgeline from the installation of the turbine pad.

All three sites have existing road access, but in each case, roads will need substantial improvements. Improving the road at Site 14A would create a larger berm along the west-facing slope and potentially increase risk. Road construction to access Sites 14B and 14C would result in less alteration of the local topography and are less likely to increase risk.

Recommendation

A less-risk alternative for Site 14A is to relocate the turbine about 130 feet northward along the ridge (37.767506/121.611658). This moves it further from the shoulder on the south, although it does not reduce the risk caused by slope-accelerated winds. The recommended site for Turbine 14 is Site 14B. This location moves the turbine away from the high-risk wind conditions at Site 14A and is on a relatively flat and broad ridge/hilltop (Figure A-14). This is consistent with Smallwood and Neher (2018).

Plate 21. Looking northeast along the ridge from Site 14A.

Plate 22. Looking southward from Site 14B.

Plate 23. Looking northeast along ridge from Site 14C.

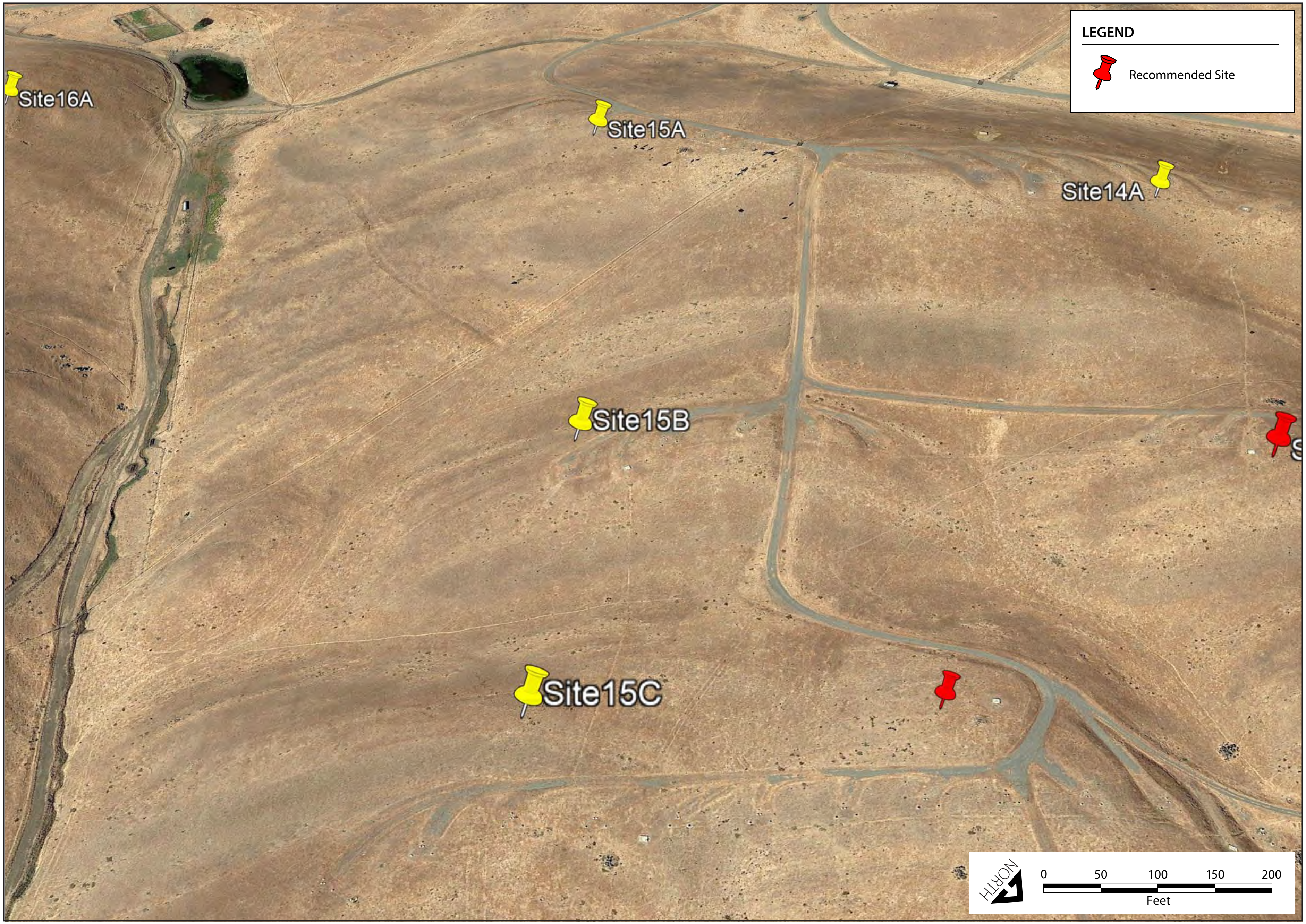
Turbine 15

Turbine 15 has three alternative locations, 15A (Layout 1 and Layout 4), 15B (layout 2), and 15C (layout 3) (Figure A-15).

Topographical Description

Site 15A is near the top of a hill on relatively flat terrain (Plate 24). There is a 5% ascending slope to the top of the hill, approximately 140 feet northward. The terrain slopes steeply (20%) downward to the west at the south end of the broad west-facing slope. As a result, this site may also be subject to slope-accelerated winds from the west and southwest, but perhaps not to the extent of Site 14A. There is also a fairly steep (15%) descending slope toward the south into a deep ravine and a gentle descending slope to the east into a swale. At the top of the hill, the terrain is relatively flat and broad to the north-northwest for about 450 feet.

Site 15B is located along a small, fairly low-profile northwest-southeast-oriented transverse ridge at the southeast end of an old-generation turbine string (Figure A-15). There is an ascending slope to the north toward the top of the hill/ridge and slightly downward to the south. The slopes descend more steeply into swales to the east (15%) and west (20%). The site is on a small slope bench created during the installation of the old-generation turbines (Plate 25).



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SOURCE: *Google Earth 2018.*

Figure A-15
Location of Alternative Sites for Turbine 15 at the Sand Hill Wind Project

Site 15C is on relatively flat terrain extending nearly 300 feet to the northwest before an ascending slope to the top of the hill and for about 150 feet to the northeast before dropping into a swale (Plate 26). The site slopes down to the south into a deep ravine, and to the west into a swale that separates Site 5C from Site 5B.

Proximity to Other Potential Risk Factors

There is an overhead powerline approximately 300 feet west of Site 15A (which would be removed by the project) and a transmission line approximately 1,000 feet. There is also a rock pile about 130 feet north of Site 15A, and a rock pile within 200 feet of Site 15C.

Relative Risk and Determination

Site 15A is considered a high-risk due to the proximity of the west-facing slope. Sites 15B and 15C are considered to have to moderate risk. There are no extreme topographical features associated with the immediate vicinity of either site; however, both are on a broad mid-slope bench below the ridgetop to the north and above a deep ravine to the south. This may create some risk for birds using this south-facing slope for movement or contour hunting. Also, installing a turbine at the Site 15B or 15C locations would create a larger bench along the south-facing slope, potentially increasing risk.

Recommendation

Although still subject to slope-accelerated winds, risk at Site 15A may be reduced by moving the turbine upslope about 140 feet northwest to the top of the ridge (37.764653/121.612303). This moves the site off of the slope and further from the deep ravine on the south. This is consistent with Smallwood and Neher (2018).

Risk at Site 15B would be reduced by moving the turbine upslope 200 feet to the northwest (37.767039/121.608761) to the top of the ridge. This would relocate the turbine off of the south-facing slope to the top of the ridge and closer to the existing road, minimizing road construction and changes to the slope contour from both turbine and new roads.

Risk at Site 15C would be minimized by moving the turbine upslope about 450 feet to the northwest to the top of the hill (37.768344/121.607787). This site is at the top of the hill, has the greatest amount flat ground, and is closer to the existing road (Plate 27). This is the recommended site for Turbine 15 (Figure A-15).

Plate 24. Looking east along ridge from Site 15A. Note proximity to deep ravine to south (right).

Plate 25. Looking north-northwest upslope from Site 15B.

Plate 26. Looking east from Site 15C.

Plate 27. Recommended relocation site for Turbine 15. North and slightly upslope from Site 15C, and further from the deep ravine to the south.

Turbine 16

Turbine 16 has three alternative locations, 16A (Layout 1 and Layout 4), 16B (layout 2), and 16C (layout 3) (Figure A-16).

Topographical Description

Site 16A is on a bench of a northwest-facing slope below the top of a hill at the end of an old-generation turbine string. The hill top is the western end of a northeast-southwest-oriented ridge with deep transverse swales that create a rolling topography (Figure A-16). The top of the slope is approximately 100 feet east-southeast of the site. The steep slope (30%) descends immediately to the north into a deep ravine (Plate 28). The terrain also slopes downward toward the west and upward toward the top of the hill.

Site 16B is approximately 800 feet northeast of Site 16A along the northeast-southwest-oriented ridge. The site is within a swale along the northwest-facing slope, which ascends to the south and east (Plate 29). Site 16C is on the east-facing slope of a large north-south-oriented swale with ascending slopes to the east and west (Plate 30).

Proximity to Other Potential Risk Factors

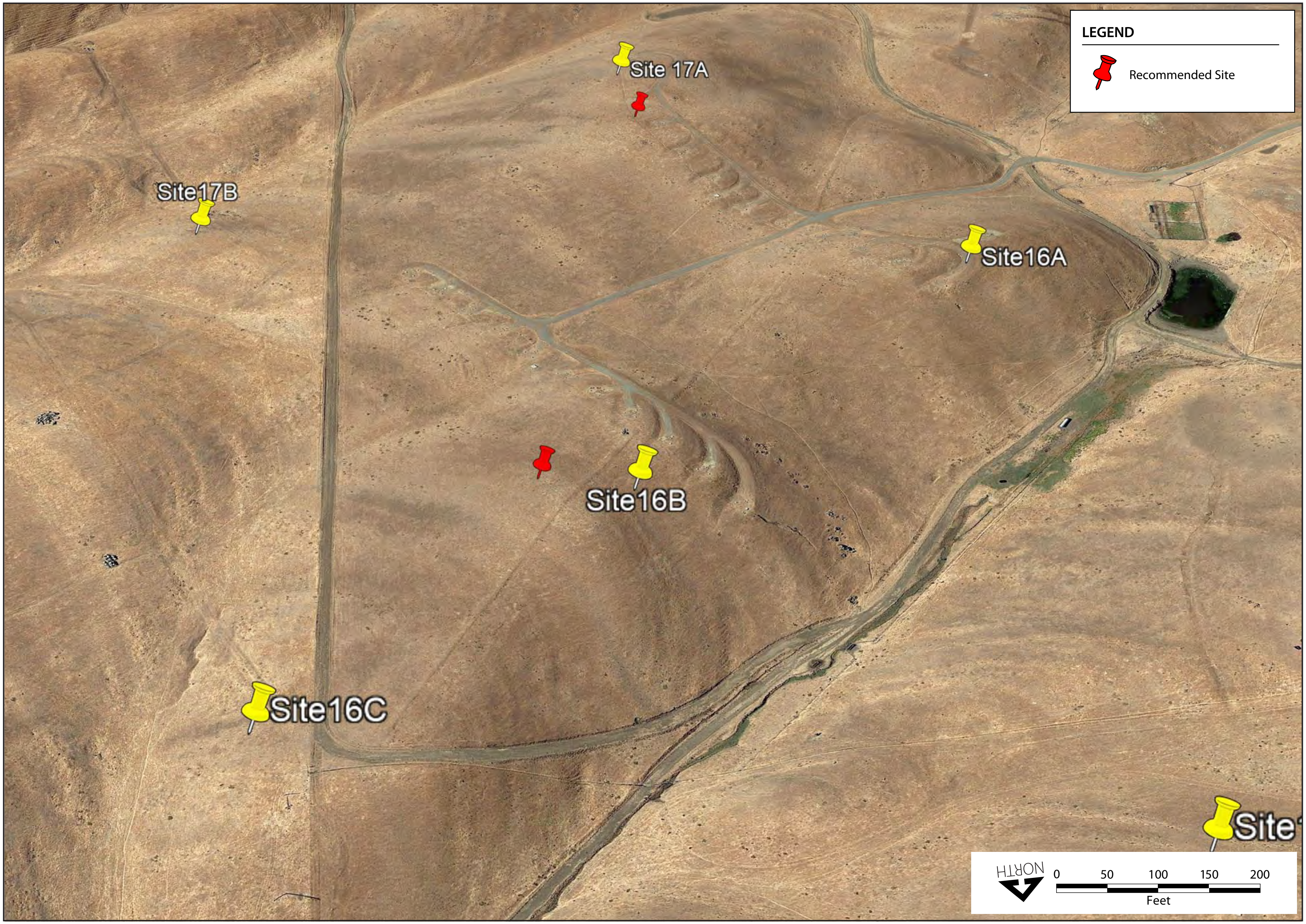
There is a stock pond approximately 300 feet downslope to the west of Site 16A. Site 16B is within 120 to 250 feet of numerous rock piles. Site 16C is within 120 feet of overhead power lines (that would be removed) and within 60 feet of a fence line.

Relative Risk and Determination

Sites 16A, 16B, and 16C are all considered high risk sites. Site 16A is considered high-risk due to its location on a bench of a steep slope. Site 16B is considered high-risk due to its location within a swale that creates a dip in the northwest-facing slope. Site 16C is considered high risk due to its location within a deep swale. These are topographic features that influence raptor movement and behavior and can contribute to collision risk.

Recommendation

Potential risk can be slightly reduced at Site 16A by moving the turbine upslope to the top of the hill about 90 feet east-southeast (37.762922/121.608068). The site would still be on the edge of a deep ravine, a potentially risky site. Potential risk can be reduced somewhat at Site 16B by moving the turbine upslope to the top of the ridge about 120 feet east-southeast (37.764529/121.605827). This is the recommended location for Turbine 16 (Figure A-16). At this location, the turbine is on a relatively flat ridge top (Plate 31), although still in close proximity to a deep ravine. Opportunities to reduce risk at Site 16C are limited and would require moving the turbine at least 500 to 600 feet east-southeast to the next ridgeline.



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SOURCE: Google Earth 2018.

Figure A-16
Location of Alternative Sites for Turbine 16 at the Sand Hill Wind Project

Plate 28. Looking northeast along ridge from Site 16A. The site is downslope above a deep ravine.

Plate 29. Looking upslope to the southeast from Site 16B.

Plate 30. Looking south along the east-facing slope of the large swale at Site 16C.

Plate 31. Looking eastward from recommended location southeast of Site 16B.

Turbine 17

Turbine 17 has three alternative locations, 17A (Layout 1 and Layout 4), 17B (layout 2), and 17C (layout 3) (Figure A-17).

Topographical Description

Sites 17A, B, and C are along a northeast-southwest-oriented ridge with several deep, lateral swales across the ridge creating a rolling east-west topography (Figure A-17). Site 17A is at the upper edge of a south-facing slope along the south end of an old-generation turbine string (Plate 32). The south-facing descending slope is fairly steep (15%), leading down to a deep swale on the south and continues upward north of Site 17A, although less steep, for about 230 feet before the top of the ridge. The ridge top is relatively flat to the north and south, but drops down steeply to the west and more gently to the east. There are no extreme topographical features at this immediate location; however, the west-facing slope could generate slope-accelerated winds from the west and southwest, creating a potential hazard. The site is near the top of a hill that descends down in all directions. The hill top is fairly broad.

Site 17B is midway on a southeast-facing slope (7%) at the top of an east-west swale that turns northward just below the site (Plate 33). The ground slopes up to the north where there is a small swale, then an upslope to the west. Site 17C is midway up a southeast-facing slope (10%) about 250 feet from the top of the hill. The site is above a deep east-west-oriented swale (Plate 34). There are no extreme topographical features in the immediate vicinity.

Proximity to Other Potential Risk Factors

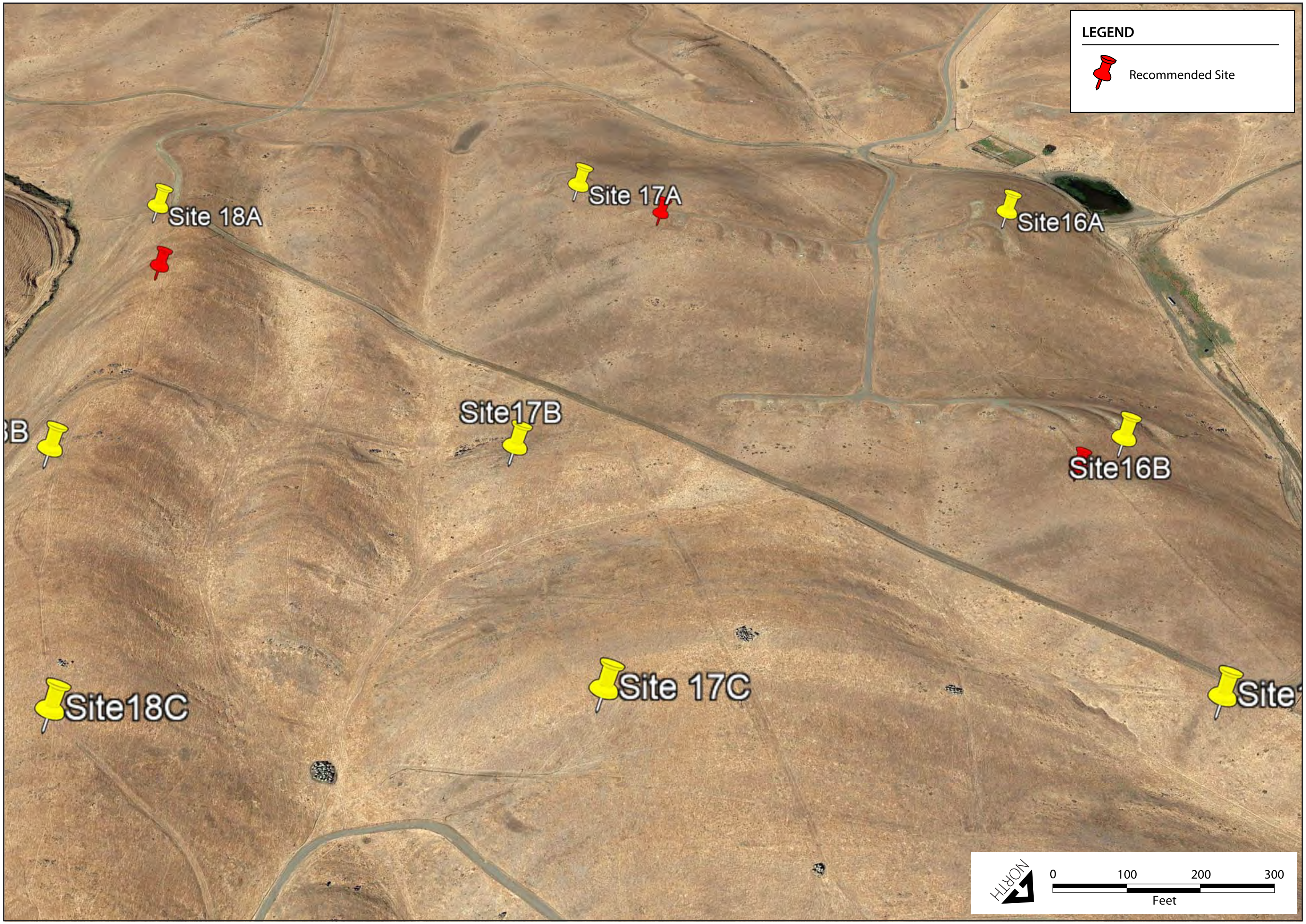
There is a rock pile within 100 feet and a fence line within 200 feet of Site 17B.

Relative Risk and Determination

Site 17A is considered a moderate risk site due to its location on a slope above a deep swale and near a southwest-facing slope with potential for slope-accelerated winds. Site 17B is a moderate- to high-risk site due to its location on a slope and at the top end of a long swale. Site 17C is considered a moderate-risk site. Although it's on a slope, the slope is broad and only moderately steep with no other relevant topographic features in the immediate vicinity. Construction of the turbine pad and access road at each of these sites would create slope benches and berms and would further increase risk.

Recommendation

Risk can be reduced at Site 17A by moving the turbine approximately 230 feet north to the top of the ridge/hill (37.761537/121.606710) (Plate 35) (Figure A-17). This is the recommended location and is generally consistent with Smallwood and Neher (2018). There are no suitable



1/05/2019

SOURCE: Google Earth 2018.

Figure A-17
Location of Alternative Sites for Turbine 17 at the Sand Hill Wind Project

opportunities to reduce risk for Site 17B without substantial relocation distance. Risk can be reduced at Site 17C by moving the turbine upslope about 250 feet west-northwest (37.763914/121.603422). This will put the turbine at the top of the hill and off of the slope.

Plate 32. Looking east from Site 17A. The top of the hill is upslope to the left of the photo.

Plate 33. Looking east from Site 17B.

Plate 34. Looking east from Site 17C.

Plate 35. Looking north from recommended relocation site for Site 17A

Turbine 18

Turbine 18 has three alternative locations, 18A (Layout 1 and Layout 4), 18B (layout 2), and 18C (layout 3) (Figure A-18).

Topographical Description

The four alternative sites for Turbine 18 are along the same narrow northeast-southwest ridge (Figure A-18). The ridge has a gradual northeastward descending slope.

Site 18A is the westernmost of the three and near the west end of the ridge. The turbine is sited down the steep south-facing slope, which continues into a deep canyon (Plate 36). The ridgeline drops westward to a lower bench. A road crosses the ridge about 40 feet west of Site 18A creating a small shoulder in the west slope. To the north, the ridge slopes down more gradually.

Site 18B is near the top of the narrow ridge (although slightly downslope to the south) about 1,000 feet northeast of Site 18A. A relatively flat site, the ridge descends gradually to the northeast. The site is within a slight dip in the ridgeline with a somewhat steeper ascending slope southwestward. The narrow ridge slopes steeply to the south and more gradually to the north (Plate 37).

Site 18C is near the northeastern end of the ridge (Figure A-18). Topographical considerations at this site are similar to Site 18B. The site itself is relatively flat (3% slope) and fairly level for about 100 feet eastward toward the east-facing descending slope (Plate 38). But like Site 18B, the ridgeline ascends gradually to the southwest. The ridge top is slightly broader here than at Site 18B, but also steeply slopes to the south, east, and more gradually to the north.

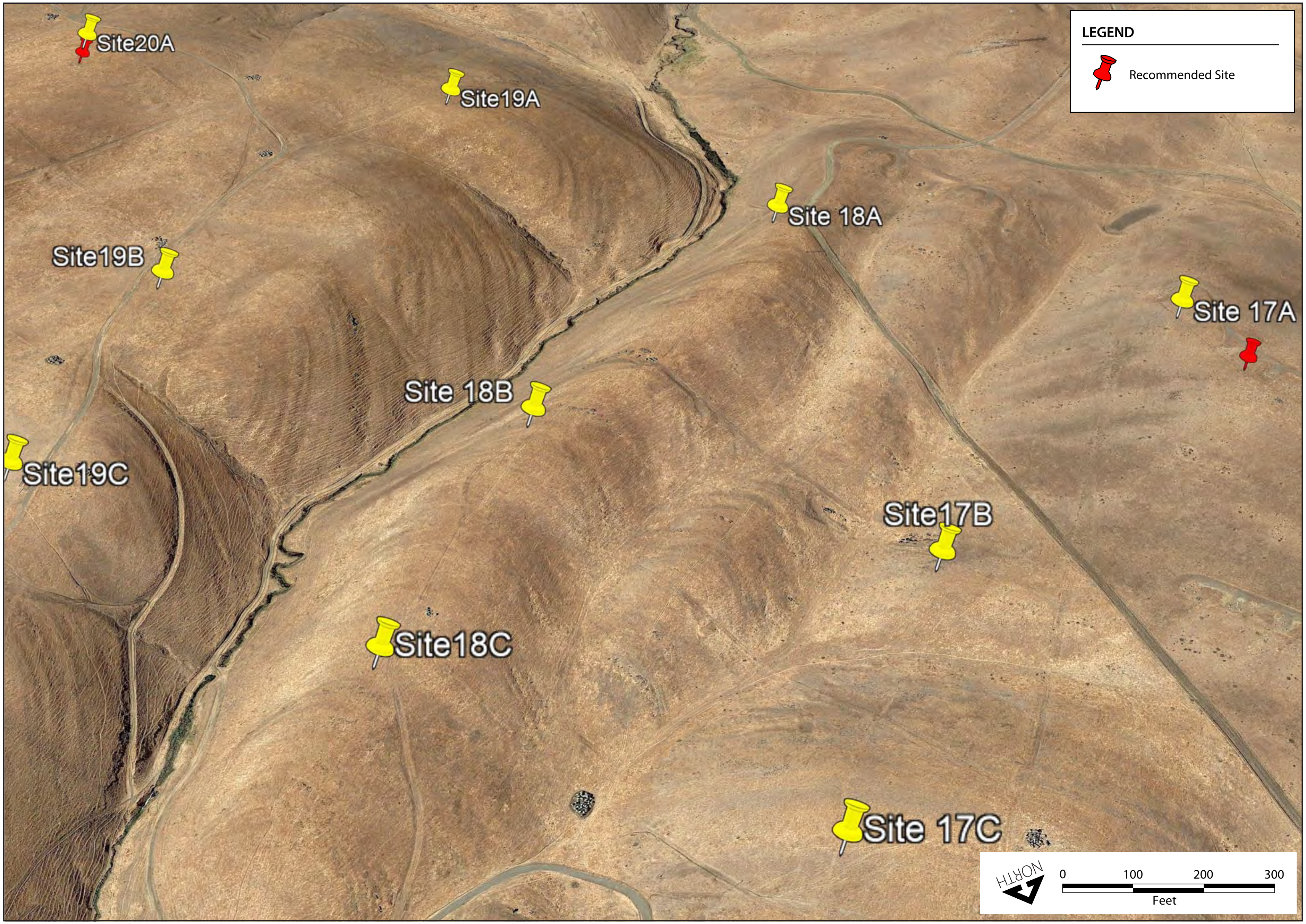
Proximity to Other Potential Risk Factors

There is an overhead power line about 40 feet from Site 18A (which would be removed) and a fence line within about 30 feet of the site. There is a rock pile within about 100 feet of Site 18B.

Relative Risk and Determination

Site 18A is considered a high-risk site due to its location along the south-facing slope of the ridge and just above (east of) a lower bench of the ridge.

Site 18B is considered a moderate-high risk site due to its location along a narrow ridge with steep slopes. Although the top of the ridge is less risky than the slopes, the close proximity to the steep slopes – particularly given the size of the turbines – poses some risk. Also, because the narrowness of the ridge, construction of a turbine pad in this location may create a notch in the ridgeline, further increasing risk at this location. Road construction will also require significant



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SOURCE: Google Earth 2018.

Figure A-18
Location of Alternative Sites for Turbine 18 at the Sand Hill Wind Project

modification of a portion of the slope, and given the narrowness of the ridgeline, may also result in increased risk at this location.

Site 18C is also considered a moderate-high risk site due the issues described above for Site 18B. It's also a bench on a descending ridge slope and may be used as a cross-over point for raptors. However, because the ridgetop is somewhat broader at this site and because road access would require less modification of the ridge topography (an existing road is approximately 500 feet from the site with a spur road directly to the site), it is considered slightly less risky than Site 18B.

Recommendation

Risk can be reduced slightly at Site 18A by moving the turbine upslope approximately 290 feet to the northeast (37.759722/121.604003). This would move the site to the top of the ridge and off of the slope. However, because of the narrowness of the ridgetop, placement of the turbine pad in this location may create a notch in the ridgeline, which would also create risk; however, it would be a somewhat safer location that the current site.

Risk can be reduced slightly at Site 18B by moving the turbine about 100 feet northeast along the ridge top. However, because the site is on a gradually descending ridge line, constructing a turbine pad in this location may result in additional risk by creating a shelf along the narrow, descending ridge.

There are limited opportunities for reducing risk at Site 18C. Although the site for the turbine pad is somewhat larger and flatter than Sites 18A and 18B, its position near the end of a descending ridge where deep ravines converge create risky conditions, and any local relocation would likely increase risk.

Even with local movements, these sites are likely to remain moderate to high risk sites due to the narrow ridge and the close proximity to a deep ravine. Road construction along this narrow ridge or upslope to access the ridge top would increase potential risk at all sites by creating berms along the slope or ridgeline.

There is some conflict with these recommendations with Smallwood and Neher (2018). They suggest that Site 18A is the safest location; however, they do not recommend moving the site upslope. They also include no recommendations for Sites 18B or 18C. At its currently downslope location above a deep canyon, Site 18A is considered high-risk due to potential interaction with raptors using the slope contours for hunting or movement. However, relocating the turbine to the ridgetop, while still at least a moderately risky location, is an improvement from its current location.

Plate 36. Looking east from Site 18A.

Plate 37. Looking east along the gradually descending ridge from Site 18B.

Plate 38. Looking east from Site 18C.

Turbine 19

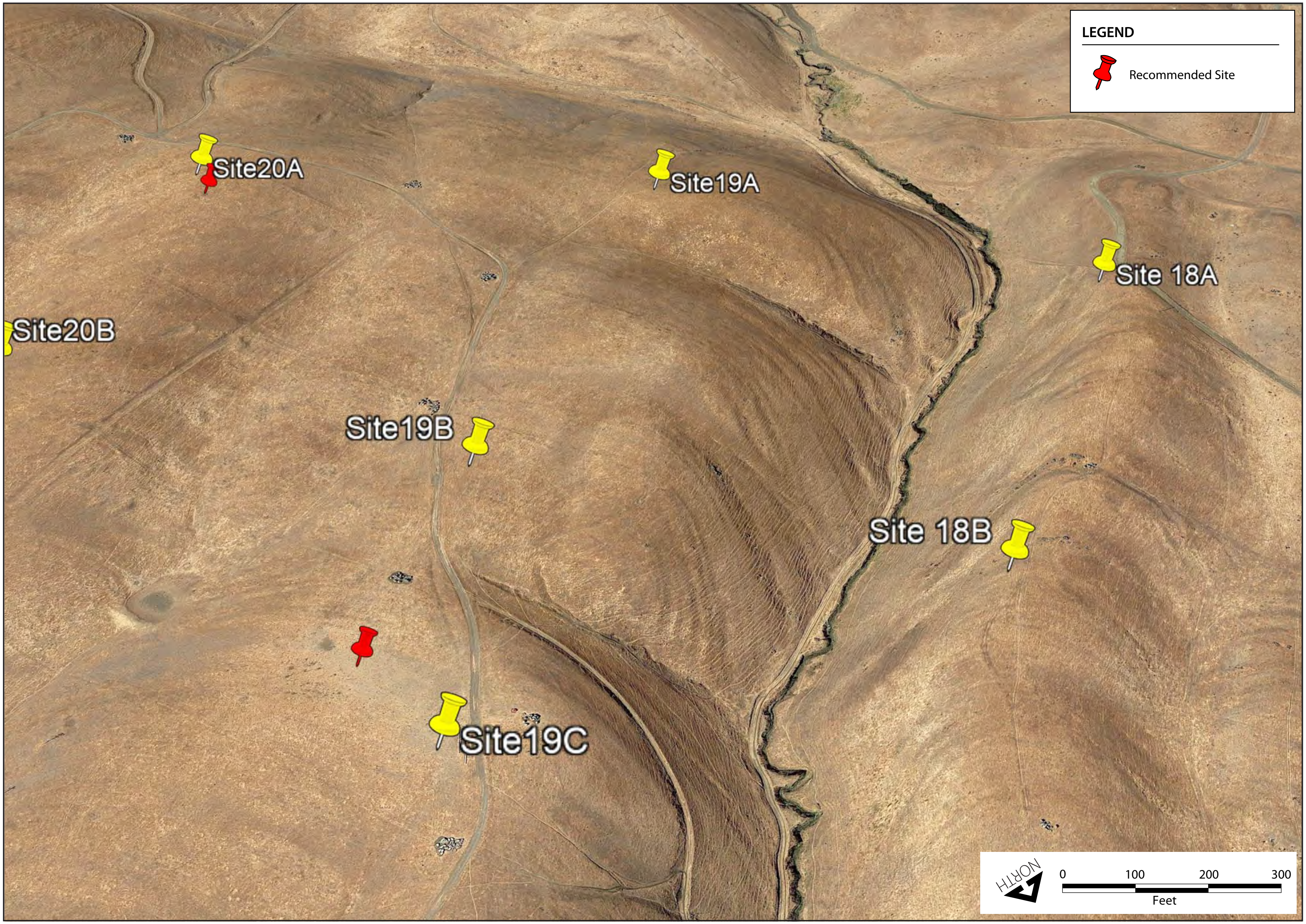
Turbine 19 has three alternative locations, 19A (Layout 1 and Layout 4), 19B (layout 2), and 19C (layout 3) (Figure A-19).

Topographical Description

Site 19A is in a relatively flat location, but near the top of steep west-facing slope that is subject to slope-accelerated winds. To the east is a broad swale that descends northward into a deep ravine. To the south, there is a shallow dip in the west-facing ridge, then the terrain slopes slightly upward before descending into another swale (Plate 39).

Site 19B is at a relatively flat location but is at the base of an east-facing slope and near the top of a deep swale to the north that descends into a deep ravine (Plate 40).

Site 19C is also in a relatively flat location but near the base of a 15% ascending slope to the southwest. The site is also near the top of a swale that extends eastward (Plate 41).



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SOURCE: Google Earth 2018.

Figure A-19
Location of Alternative Sites for Turbine 19 at the Sand Hill Wind Project

Proximity to Other Potential Risk Factors

There is an overhead powerline near Site 19A (that would be removed). There are two debris piles within 100 feet of the Site 19B and a debris pile within 100 feet of Site 19C.

Relative Risk and Determination

Site 19A is considered a moderate to high risk site due to its proximity to the west-facing slope and the potential for slope-accelerated winds. Site 19B is considered a moderate risk site due to its location at the top of a long, extended swale that may function as a flight corridor for raptors. Site 19C is considered a low- to moderate risk site due to relatively flat topography but in close proximity to the top of a swale and the base of an upward slope.

Recommendation

There are limited opportunities to reduce risk at Sites 19A and B. Risk may be reduced at Site 19C by moving the turbine south for approximately 200 feet toward the top of the hill and away from the top of the east-west swale (37.759488/121.598865) (Plate 42) (Figure A-19). This is generally consistent with Smallwood and Neher (2018); however, they did not recommend relocating the turbine.

Plate 39. Looking south from Site 19A (next to vehicle). The site is on the edge of a broad west-facing slope (right).

Plate 40. Looking east from Site 19B. The site is near a ridge saddle at the top of a swale.

Plate 41. Looking east-northeast from Site 19C. Note the shallow swale to the east.

Plate 42. Looking east from recommended relocation site for Site 19C.

Turbine 20

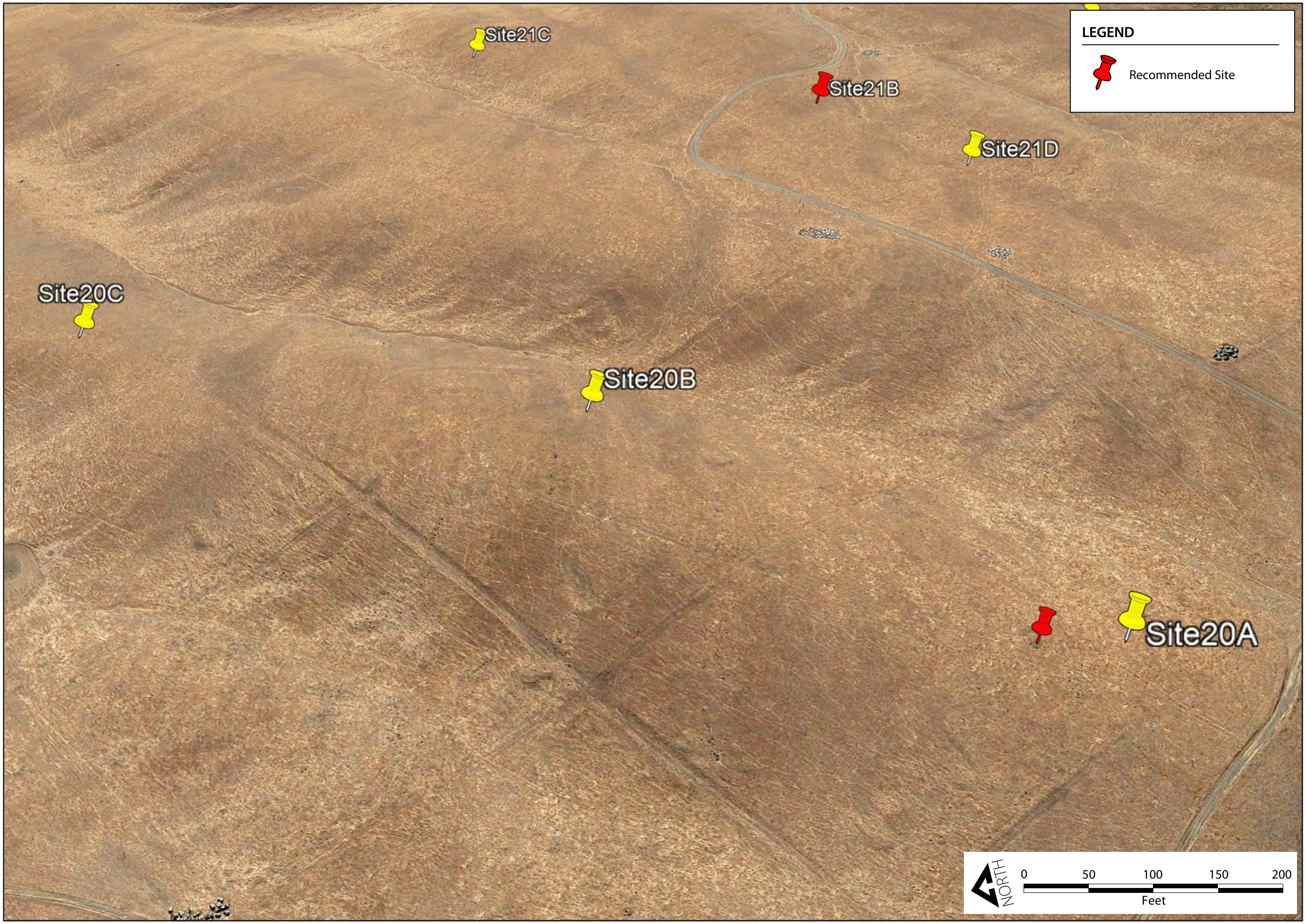
Turbine 20 has three alternative locations, 20A (Layout 1 and Layout 4), 20B (layout 2), and 20C (layout 3) (Figure A-20).

Topographical Description

The three alternative locations for Turbine 20 are all along a relatively low-profile, broad northeast-southwest ridge (Figure A-20).

Site 20A is near the southwestern end of the northeast-southwest ridge. The site itself is fairly flat but is on a very gradual west- and south-facing slope just below the top of the ridge/hill to the northeast and just upslope and northeast of a saddle at the top of the west-facing ridge below. There are broad swales to the north and south. To the west, the slope gradually descends to the road on the west and then rapidly beyond the road to the bottom of the west-facing ridge slope (Plate 43).

Site 20B is along the south-facing slope of the ridge about 670 feet northeast of Site 20A (Figure A-20). The slope ascends for about 470 feet to the ridge top and descends into a deep swale (Plate 44).



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SOURCE: Google Earth 2018.

Figure A-20
Location of Alternative Sites for Turbine 20 at the Sand Hill Wind Project

Site 20C is on the top of the northeastern end of the ridge (Figure A-20). The site itself is relatively flat, but the ridge slope gradually descends eastward (Plate 45). The north and south slopes descend into deep swales, which converge about 900 feet east of the site.

Proximity to Other Potential Risk Factors

There is a debris pile within 220 feet of Site 20A and a stock pond downslope approximately 370 feet northwest of Site 20C.

Relative Risk and Determination

Site 20A is a relatively low- to moderate-risk site. The site is on a very gradual slope, which ascends northward to the top of the ridge/hill. The site is also near a shallow saddle along the west-facing slope. This slope may also be subject to slope-accelerated winds; however, site 20A may be sufficiently distant from the edge of the slope to be considered a hazard to raptors using these winds to hunt. Beyond the shallow saddle to the south, the terrain ascends to a higher hill on the south. But otherwise, the surrounding terrain is relatively low-profile. Road and turbine pad construction at this location would not alter the terrain sufficient to substantially affect raptor use or movement through the area.

Site 20B is a moderate-risk site due to its location on the slope above a deep swale and on a gradually descending ridge slope. Also, road construction into the site would require substantial earth moving and possible changes to the slope configuration.

Site 20C is considered a moderate-risk site due to its location on the descending ridge slope and the extent of earth-moving required for road access to the site. Construction of the turbine pad at this location would also create a bench in the gradually descending slope and increase potential risk.

Recommendation

Risk can be reduced at Site 20A by moving the turbine 80 feet to the north-northeast (37.755965/121.600147). This moves the turbine to the highest point on the ridge where there is a broad, flat area within 200 feet of an existing road. It also moves the turbine further from the west-facing slope. This is the recommended location for Turbine 20 and is generally consistent with Smallwood and Neher (2018) (Figure A-20).

Risk can be reduced at Site 20B by moving the turbine upslope to the north approximately 170 feet northwest to the ridge top (37.756896/121.598853). However, this would still keep the turbine on the descending ridge slope.

There are limited opportunities to reduce risk at Site 20C.

Plate 43. Looking south from Site 20A.

Plate 44. Looking upslope to the west from Site 20B.

Plate 45. Looking downslope eastward toward Site 20C.

Sand Hill Wind Repowering Project

Appendix A-3. Assessment of Turbines 21 through 30

March 2019

Turbine 21

Turbine 21 has four alternative locations, 21A (Layout 1), 21B (Layout 2), 21C (Layout 3), and 21D (Layout 4) (Figure A-21).

Topographical Description

Site 21A is located on a steep (20%) east-southeast-facing slope below a high rounded hill. The terrain descends steeply on the east, south, and north, and continues ascending to the west toward the top of the hill. The site is near the top of a shallow swale extending from the east (Plate 46).

Site 21B is on relatively flat ground approximately 800 feet east-northeast of Site 21A. It's on a broad bench of a gradually declining eastward slope. There are swales to the north and south of the site. To the east, the ground remains even, but gradually slopes downward (Plate 47).

Site 21C is on a north-facing slope of an east-west ravine that intersects with a north-south ravine approximately 400 feet eastward (Plate 48). It's on a gradually descending eastward slope and downslope of Sites 21A, B, and D.

Site 21D is between Sites 21A and 21B. It's downslope of the road to the north and the hill to the west. The slope also descends eastward. The site is in a low spot situated between higher slopes to the north and west (Plate 49).

Proximity to Other Potential Risk Factors

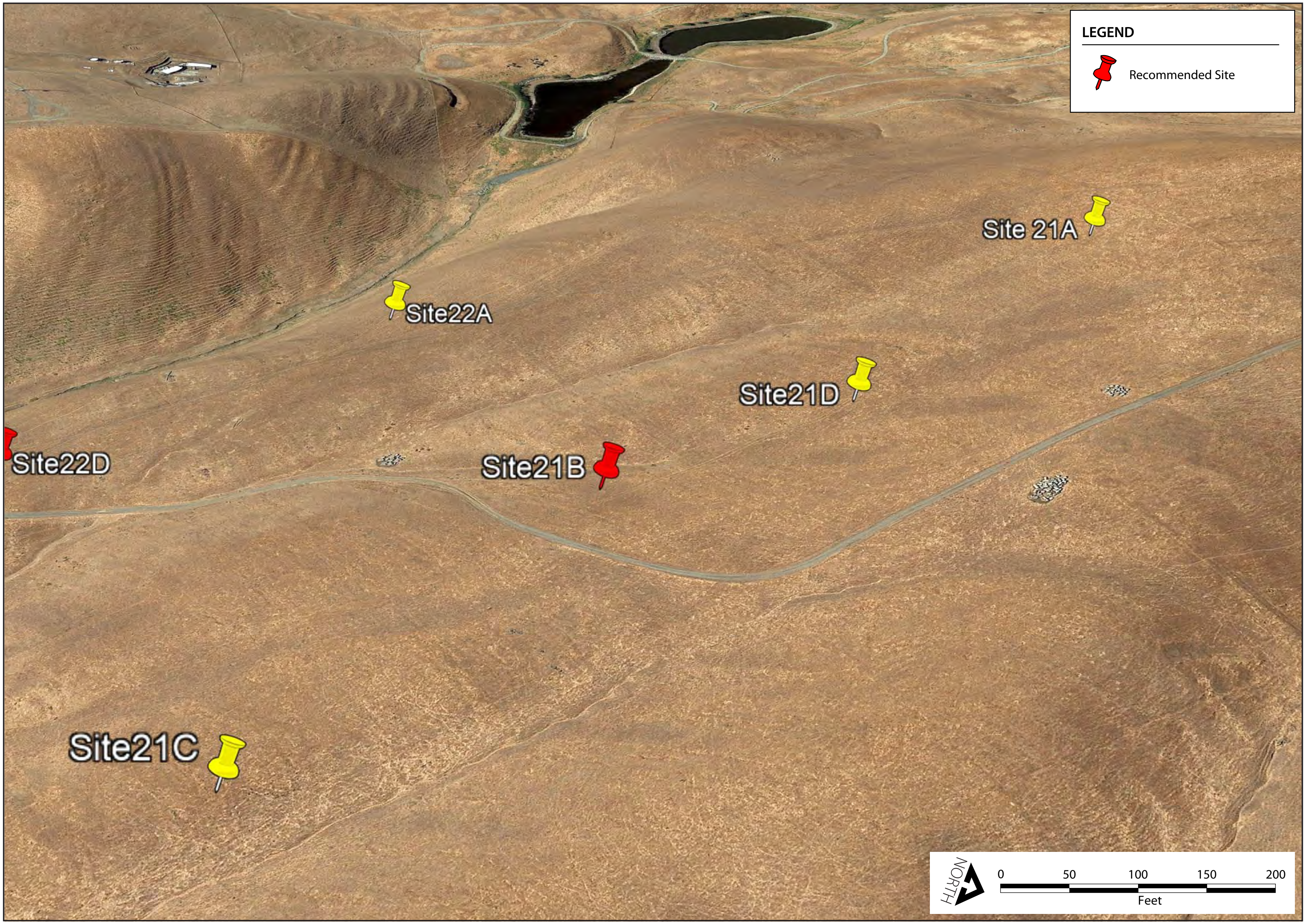
There is a debris pile within 280 feet of Sites 21B and D.

Relative Risk- Determination

Each of these sites are considered moderate to high risk. The topography in this area is less defined by ridges and basins and includes low hills and swales generally increasing in elevation westward. Raptor use of the area is also probably less predictable based on topographical features compared with other areas in the vicinity. However, even in this area, steep slopes and close proximity to swales and other drainage features are considered riskier sites. Each of the sites is on or at the base of a slope.

Site 21A is considered a high-risk site due to its position on a steep slope below the top of a hill. Road and turbine pad construction at this location would create a large bench and berm on the slope, which may influence raptor movement through the site and potentially increase risk.

Although on relatively flat terrain, Site 21B is considered a moderate-risk site because it is in a low area relative to the surrounding hills, particularly to the south and west. However, at this



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SOURCE: Google Earth 2018.

Figure A-21
Location of Alternative Sites for Turbine 21 at the Sand Hill Wind Project

location turbine pad and road construction would not substantially alter the local topography sufficient to influence raptor movement.

Site 21C is considered a moderate-to high-risk site because it's on a slope above a ravine and is also subject to increase risk from road and turbine pad construction.

Site 21D is considered a high-risk site due to its location at the base of slopes to the north and west. Risk may be particularly problematic from raptors flying around the hill from the west and across the low ridge from the north.

Recommendation

There are limited opportunities to reduce risk for any of the Turbine 21 alternatives. Of the four, Site 21B may be the lowest risk due to the distance from slopes and the relatively flat ground. But relocating this site to reduce risk is also problematic. Therefore, although it is considered a moderate-risk site, Site 21B is the recommended location for Turbine 21 (Figure A-21). This is generally consistent with Smallwood and Neher (2018).

Alternatively, risk at Site 21A could be reduced by moving it northwest about 360 feet (37.753741/121.599336). This moves the site off of the slope and onto the top of the hill.

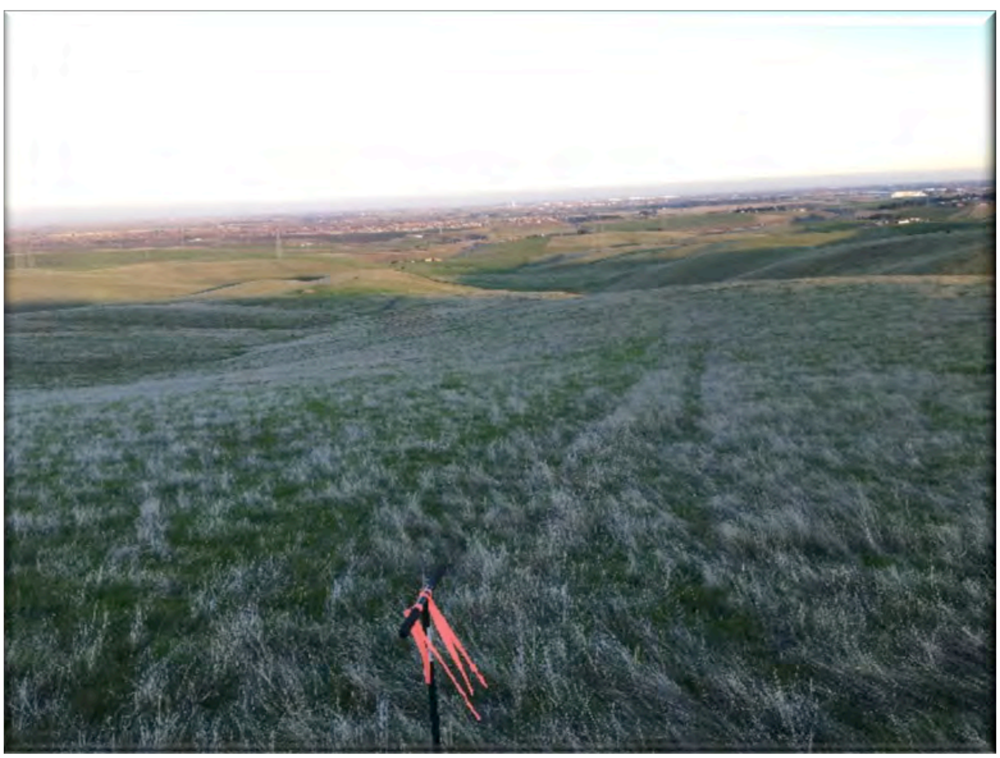


Plate 46. Looking east (downslope) from Site 21A.

Plate 47. Looking southeast from Site 21B.

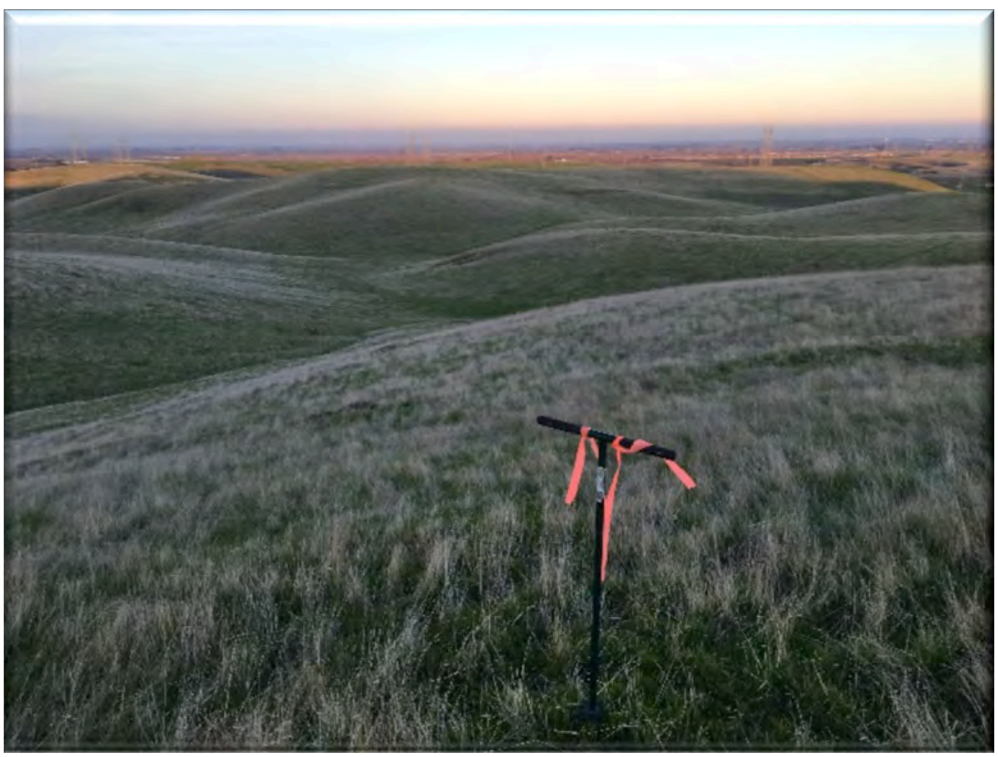


Plate 48. Looking east from Site 21C.

Plate 49. Looking north from Site 21D. The site is at the base of the slope to the north, and at the base of a larger slope to the west.

Turbine 22

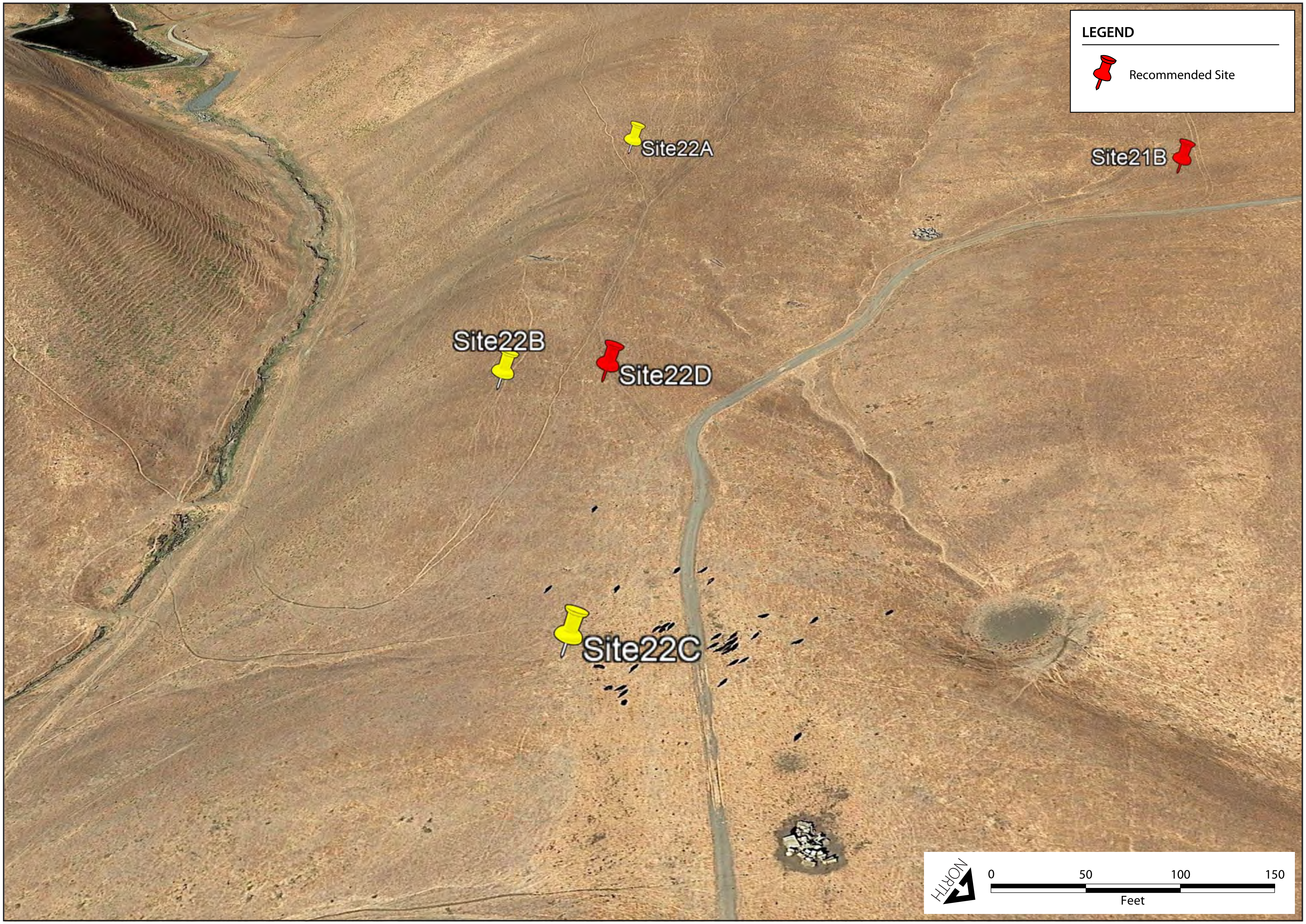
Turbine 22 has four alternative locations, 22A (Layout 1), 22B (Layout 2), 22C (Layout 3), and 22D (Layout 4) (Figure A-22).

Topographical Description

All four sites are along a northeast-southwest-oriented ridge with a gradually northeastward descending ridge slope, on a gradual southeast-facing slope above a deep ravine. In general, the area is characterized by relatively low-profile topography and low-elevation rolling hills.

Site 22A is the westernmost of the four, located on the upper edge of a steep south-facing slope along the northeast-southwest-oriented ridge (Figure A-22). The ridge slope ascends to the west (Plate 50) but is relatively flat toward the east – although the ridge slope trends downward toward the east. The site is flat toward the north for about 200 feet before dropping into a swale.

Site 22B is on relatively flat ground (Plate 51), but near the descending southeastern slope into the deep ravine and more gently toward the northeast into a swale. The ridgeline ascends toward the southwest. To the east, the ground is fairly level for several hundred feet along the ridge but is generally trending downward along the ridgeline.



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SOURCE: Google Earth 2018.

Figure A-22
Location of Alternative Sites for Turbine 22 at the Sand Hill Wind Project

Site 22C is also on relatively flat ridge top although trending up slightly to the southwest along the ridgeline (Plate 52). It's the easternmost of the four alternative sites, and is on a portion of the ridge that levels out after a gradual downward slope toward the east. The site is on a wide bench (approximately 600 feet) below the steeper sloped portion of the ridge. It's also on a broader, flatter part of the ridge, sloping to the south into the deep ravine and to the north into the shallower swale. Approximately 225 feet east of the site is a transverse swale across the ridge creating a dip in the ridgeline.

Site 22D is 90 feet northwest of and slightly upslope of Site 22B (Plate 53). The conditions are generally the same except Site 22D is further away from the edge of the south-facing slope.

Proximity to Other Potential Risk Factors

There is a debris pile approximately 200 feet from Site 22C.

Relative Risk and Determination

There are two primary issues that contribute to potential risk at the Turbine 22 sites: the downward trend of the southwest-northeast slope of the ridge and the proximity of the south-facing slope overlooking a deep ravine. For these reasons, Sites 22A, B, and C are considered relatively moderate-high-risk sites. Site 22A would be subject to addition road construction and the turbine pad at this location could create a notch along the ridge line. Site 22D is somewhat improved due to its position further away from the south-facing slope and closer proximity to existing road access.

Recommendation

Site 22D is probably the safest of the four alternative sites because it is on flat terrain, further from the deep ravine on the south, and closer to an existing access road. It is the recommended location for Turbine 22, which is generally consistent with Smallwood and Neher (2018) (Figure A-22). Alternatively, Site 22A could also be relocated northward about 200 feet away from the east-facing slope, but would require substantial earth-moving to access the site.

Plate 50. Looking west from Site 22A. Note the steep drop-off to the south.

Plate 51. Looking northwest from site 22B.

Plate 52. Looking northeast from Site 22C.

Plate 53. Looking northeast from Site 22D.

Turbine 23

Turbine 23 has only one location (23A) for the four layouts (Figure A-23). A second location was initially noted, but it is within 10 feet of Site 23A, so they are considered here as the same site.

Topographical Description

Site 23A is near the highest point on a northeast-southwest oriented ridge. The site is slightly downslope on the northeast-facing slope (Plate 54). There are steep slopes (30%) descending on all sides of the hill leading to a deep ravine on the northwest, a deep swale on the south, and to a saddle on the lower part of the ridge to the west (Figure A-23).

Proximity to Other Potential Risk Factors

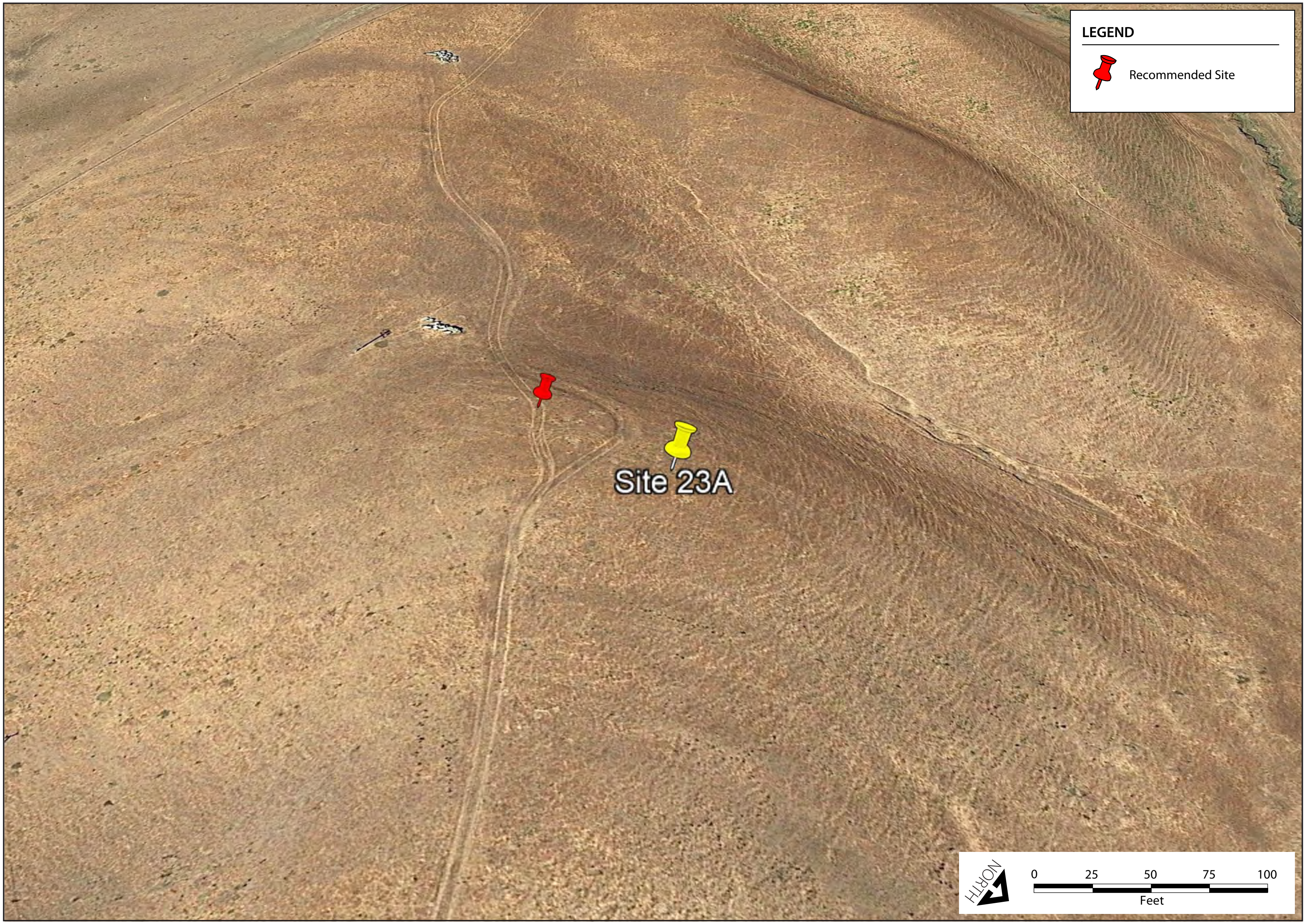
There is an overhead power line within 100 feet (which would be removed) and a debris pile within 100 feet.

Relative Risk and Determination

There is likely significant raptor movement through the ravine and swale on the north and south sides of Site 23A. The site is probably high enough on the slope to avoid most contour hunting, but because it is on the slope, it still represents some risk to raptors moving through and hunting along these slopes. Because the site is on a relatively steep slope, it is considered a moderate- to high-risk site.

Recommendation

Risk can be reduced at Site 23A by moving the turbine upslope to the top of the hill approximately 100 feet south (37.752922/121.590500) (Plate 55) (Figure A-23). This will move turbine off of the slope and onto a relatively broad hill top. This assessment is generally consistent with Smallwood and Neher (2018); however, they do not recommend relocation of Site 23A.



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SOURCE: Google Earth 2018.

Figure A-23
Location of Alternative Sites for Turbine 23 at the Sand Hill Wind Project

Plate 54. Looking northwest from Site 23A.

Plate 55. Looking south from Site 23A toward the top of the hill (at vehicle) and the recommended location.

Turbine 24

Turbine 24 has only one location (Site 24A) for the four layouts (Figure A-24). A second location was initially noted, but it is within 10 feet of Site 24A, so they are considered here as the same site.

Topographical Description

Site 24A is near the east end of a small low-profile east-west-oriented ridge with a gradual eastward-descending ridge slope. The general topography in the general area is low-profile without extreme topographical features. Site 24A is on a relatively flat hill top, although slightly downslope on the east-facing slope. To the east, the slope descends toward the California Aqueduct (Plate 56), to the south into a deep swale, and to the north into a ravine. To the west and southwest, the land is fairly level for at least 1,000 feet, although trending gradually upward along the ridge.

Proximity to Other Potential Risk Factors

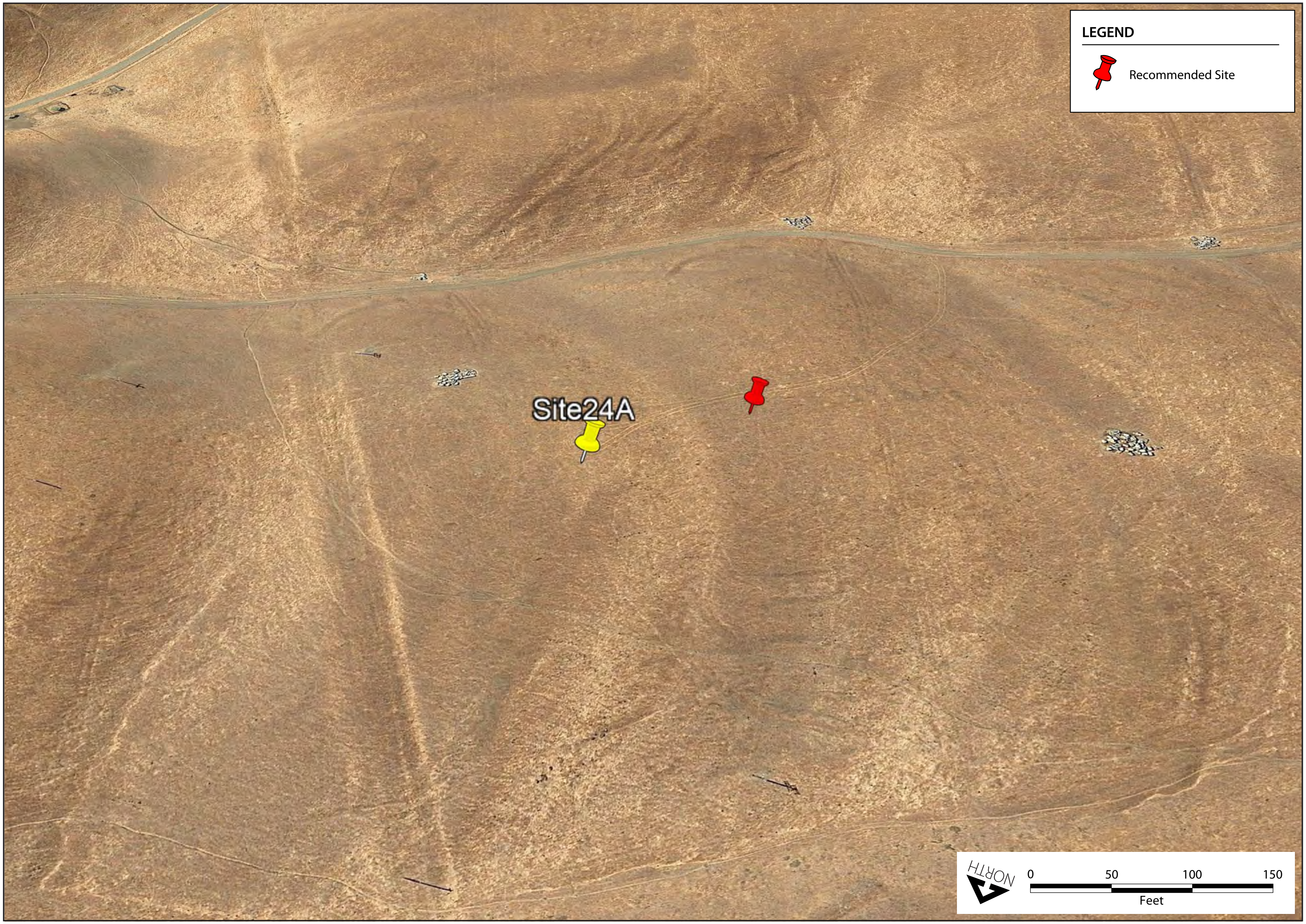
There is a debris pile with 200 feet of the site.

Relative Risk-Determination

Site 24A is considered a low-risk site due to the lack of steep slopes, the broad and generally flat top of the low-profile ridge, and the lack of other risky topographic features.

Recommendation

To further reduce risk, move the turbine at least 150 feet southwest closer to the top of hill (37.762950/121.595078) (Plate 57).



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SOURCE: Google Earth 2018.

Figure A-24
Location of Alternative Sites for Turbine 24 at the Sand Hill Wind Project

Plate 56. Looking northeast from Site 24A.

Plate 57. Looking northeast from recommended location for Turbine 24 at top of hill. Site 24A is near the person standing in the background.

Turbine 25

Turbine 25 has only one location (Site 25A) for the four layouts (Figure A-25). A second location was initially selected, but it is within 10 feet of Site 25A, so they are considered here as the same site.

Topographical Description

Site 25 is on the top of a small hill within an area of relatively low-profile hilly topography. The site slopes down all around the hill top leading to deep swales on the north and south and converging toward the east. The hill also slopes to the west into a north-south swale before rising up westward toward another low-profile ridge (Plate 58). The hill is isolated from more extensive ridges to the north, south, and west, and is lower in elevation than much of the surrounding hill tops (Plate 59).

Proximity to Other Potential Risk Factors

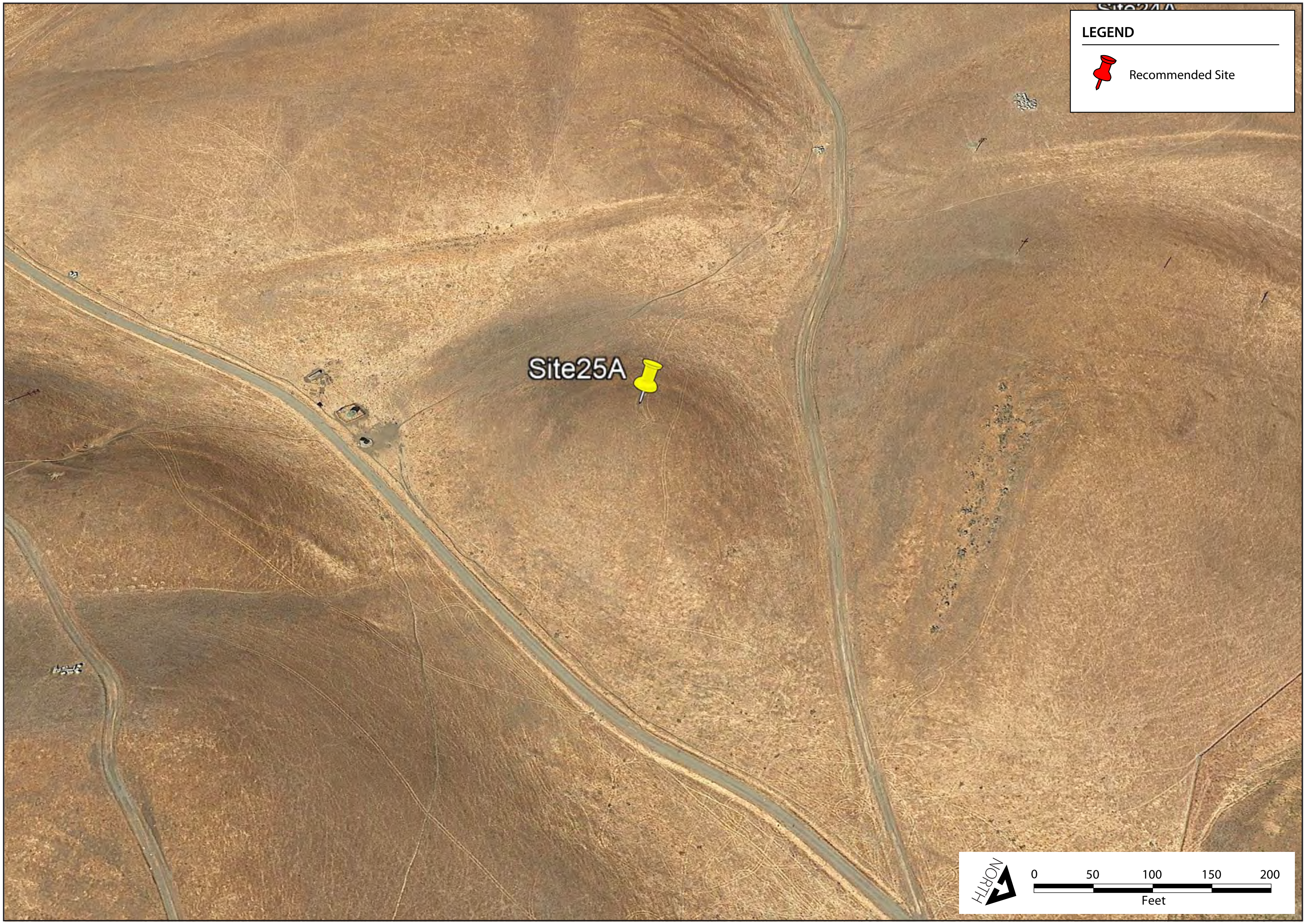
None.

Relative Risk and Determination

Site 25A is considered a moderate-to high-risk site due to the small size of the hill, its isolation from nearby ridges, and its low elevation relative to surrounding hills. Also, the hill is small and will require significant earth moving to accommodate a turbine pad. Along with creating road access to the top of the small hill, this will alter the topography of the site and may alter bird movement through it. Although the turbine is at the top of the hill, the turbine rotors would extend over the swales to the north and south, creating a possible hazard for birds moving through them.

Recommendation

There are no alternative locations in the immediate vicinity that would reduce the potential risk at Turbine 25, and thus there is no recommendation.



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SOURCE: Google Earth 2018.

Figure A-25
Location of Alternative Sites for Turbine 25 at the Sand Hill Wind Project

Plate 58. Looking northeast from Site 25A.

Plate 59. Looking west from Site 25A.

Turbine 26

Turbine 26 has three alternative locations: Site 26A (the location for layouts 1, 2, and 3); Site 26B (the location for layout 4), and Site 26C (an additional proposed alternative as per the February 4-5 site visit by sPower engineers) (Figure A-26).

Topographical Description

All sites are located in a relatively low-profile hilly terrain. Site 26A is on a northeast-facing slope above a swale to the northeast that leads up to a hill/ridge top to the southwest. The terrain descends to the north and south into broad swales and toward the east where the swales converge. The general area is fairly low-profile hilly terrain with no extreme topographic features in the immediate area (Plate 60).

Site 26B is approximately 200 feet southwest of Site 26A at the highest point on the broad and low-profile hill/ridge. From the hilltop, the terrain descends in all directions with a particularly steep slope to the west where there is a broad west- and southwest-facing slope (Plate 61).

Site 26C is 33 feet south of Site 26B with similar topographic conditions.

Proximity to Other Potential Risk Factors

There is a debris pile within 60 feet of Sites 26B and 26C and a transmission line corridor within 600 to 700 feet of all sites.

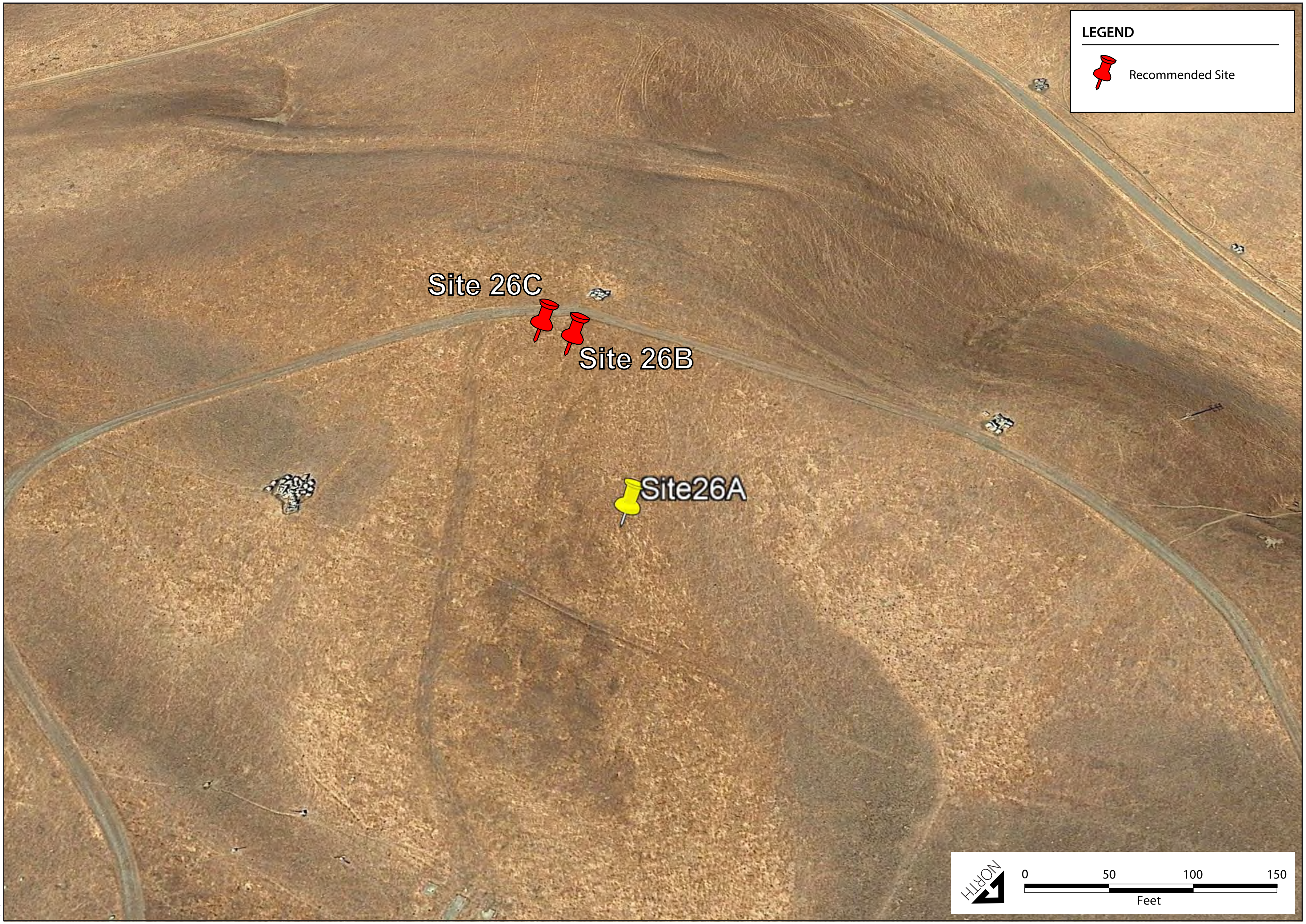
Relative Risk and Determination

Site 26A is considered to have moderate risk due to its location on a slope above a swale and below the hill/ridge top. Because of the low-profile terrain, road and turbine pad construction at this site would not substantially alter the local topography and increase risk.

Sites 26B and 26C are considered low to moderate-risk sites because they are on the top of the hill/ridge. However, the west-facing slope to the west of these sites may contribute to slope-accelerated winds that attract hunting raptors. But the sites may be sufficiently distant from the edge of the west-facing slope (approximately 130 feet). Both Sites 26B and 26C are near an existing access road on relatively flat terrain. Road improvements and turbine pad construction at this location would not substantially alter the topography of the site and would have little influence on raptor use or flight patterns.

Recommendation

Sites 26B and 26C are similar risk and are the recommended sites for Turbine 26. This is generally consistent with Smallwood and Neher (2018).



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SOURCE: Google Earth 2018.

Figure A-26
Location of Alternative Sites for Turbine 26 at the Sand Hill Wind Project

Plate 60. Looking east from Site 26A.

Plate 61. Looking southwest from Site 26B.

Turbine 27

Turbine 27 has only one location (Site 27A) for the four layouts (Figure A-27). A second location was initially noted, but it is within 10 feet of Site 27A, so they are considered here as the same site.

Topographical Description

Site 27A is located within an east-west-oriented swale descending from a saddle in the ridge just to the east. The terrain slopes up steeply to the east, north, and south. The swale continues west following a road (Plate 62). The is at an elevational low point surrounded by higher terrain to the north, east, and south.

Proximity to Other Potential Risk Factors

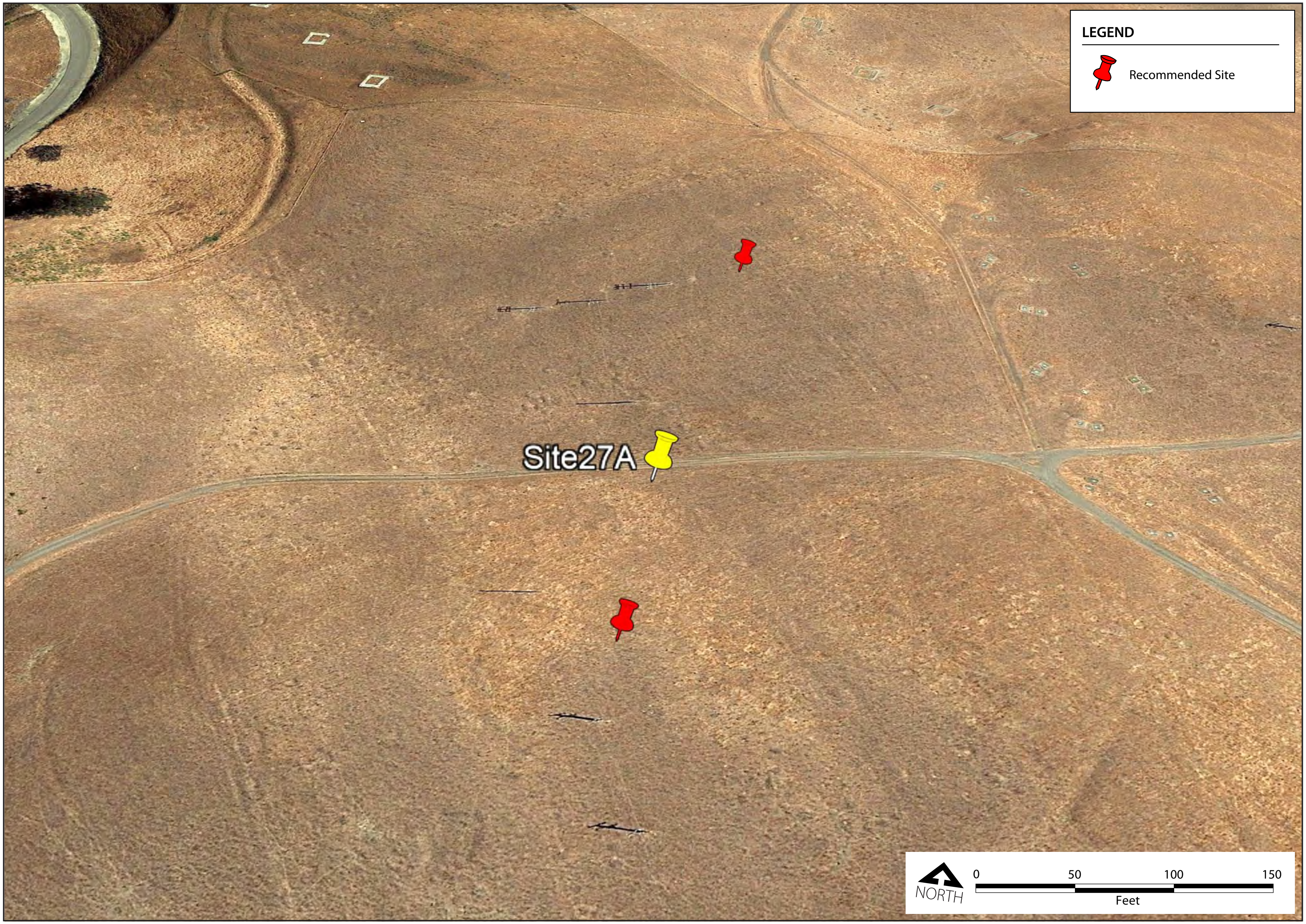
There is an overhead powerline within 60 feet, a group of eucalyptus trees within 700 feet, and the edge of Bethany Reservoir within 800 feet of the site.

Relative Risk and Determination

Site 27A is considered a high-risk site because it is located below a saddle and within a swale surrounding on three sides by upward sloping terrain. Raptors moving through the saddle would be at risk.

Recommendation

To reduce risk at Site 27A, move the turbine upslope approximately 200 feet south to the top of the hill (37.771110/121.597990) (Plate 63), or north approximately 275 feet to the hill top north of the site (37.772408/121.597877). This relocates the turbine out of the swale, off of the slope, and onto an adjacent hill top. This is generally consistent with Smallwood and Neher (2018).



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SOURCE: Google Earth 2018.

Figure A-27
Location of Alternative Sites for Turbine 27 at the Sand Hill Wind Project

Plate 62. Looking southwest from Site 27A toward the saddle.

Plate 63. Looking north toward Site 27A (at vehicle) (note the location within the swale) from hilltop to south (recommended relocation site); and toward the alternate relocation site on the hilltop north of Site 27A.

Turbine 28

Turbine 28 has two locations for the four layouts, Site 28A (Layouts 1, 2, and 3) and Site 28B (Layout 4) (Figure A-28). However, because they are only 45 feet from each other and both are on the same steep slope, the conditions at these sites are similar.

Topographical Description

Both sites are on a steep (25%) east-facing slope overlooking a broad valley to the east and southeast (Plate 64). Site 28B is approximately 145 feet from the top of the hill to the northwest. Site 28A is about 45 feet further down the hill slope to the east. The hill slopes up sharply to the northwest toward the hill top (Plate 65). There are no significant features on the hill slope. From the top of the hill, the topography slopes down southward to a lower bench before dropping into the valley. On the west and northwest sides of the hill, the land drops steeply toward the California Aqueduct.

Proximity to Other Potential Risk Factors

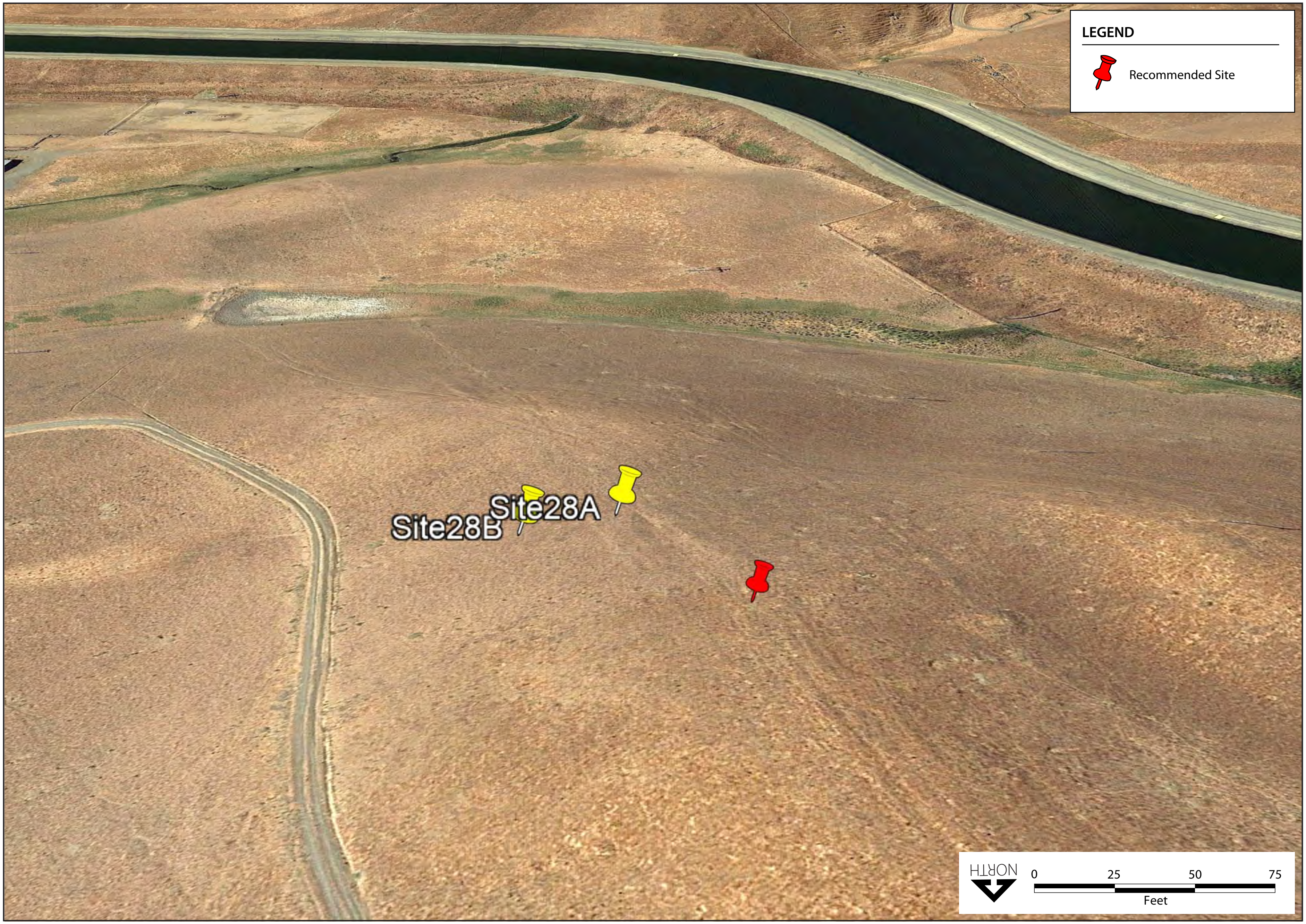
Site 28B is approximately 280 feet from an overhead powerline (which would be removed).

Relative Risk and Determination

Sites 28A and B are considered relatively high-risk sites due to their location on the steep hillslope. Either site would require the construction of a bench along the slope to accommodate the tower pad. Along with road construction to the site, this would require substantial earth moving and the alteration of the slope, which could influence raptor use of the site and create additional risk.

Recommendation

To reduce risk at Sites 28A and B, move the turbine upslope to the northwest from Site 28B approximately 150 feet toward the top of the hill (37.770050/121.596461). This will relocate the turbine off of the slope and on the top of the hill and is generally consistent with Smallwood and Neher (2018).



1/07/2019

SOURCE: Google Earth 2018.

Figure A-28
Location of Alternative Sites for Turbine 28 at the Sand Hill Wind Project

Plate 64. Looking east from Site 28B. Site 28A is just downslope from the stake.

Plate 65. Looking upslope to the northwest from Site 28B, toward the recommended site on the hilltop.

Turbine 29

Turbine 29 has three locations for the four layouts, Site 29A (Layouts 1, 2, and 3), Site 29B (Layout 4), and Site 29C (the proposed alternative to the recommended location as per the February 4-5 site visit by sPower engineers). Site 29B is approximately 200 feet east of Site 29A and Site 29C is approximately 170 feet southeast of Site 29B (Figure A-29).

Topographical Description

Each site is situated in an area of relatively low-profile hilly topography.

Site 29A is located in a broad, deep swale at the base of a west-facing slope (Plate 66). The swale extends toward the south and southwest. It intersects with a second northwest-southeast swale creating a small valley. The site sits at the base of the west-facing slope, which ascends approximately 200 feet east toward the top of the swale.

Site 29B is about 200 feet east and upslope of Site 29A. It's near the top of the swale (Plate 67) on the west side of the access road. To the west, the terrain descends down into the small valley toward Site 29A; to the south is a shallow east-west-oriented swale; and to the east-northeast, the land is fairly flat for at least 500 feet before descending in a very gradual slope.

Site 29C is on the north edge of the east-west swale about 270 feet southwest of Site 29B. The terrain gently ascends south of the swale, and is generally flat to the east-northeast.

Proximity to Other Potential Risk Factors

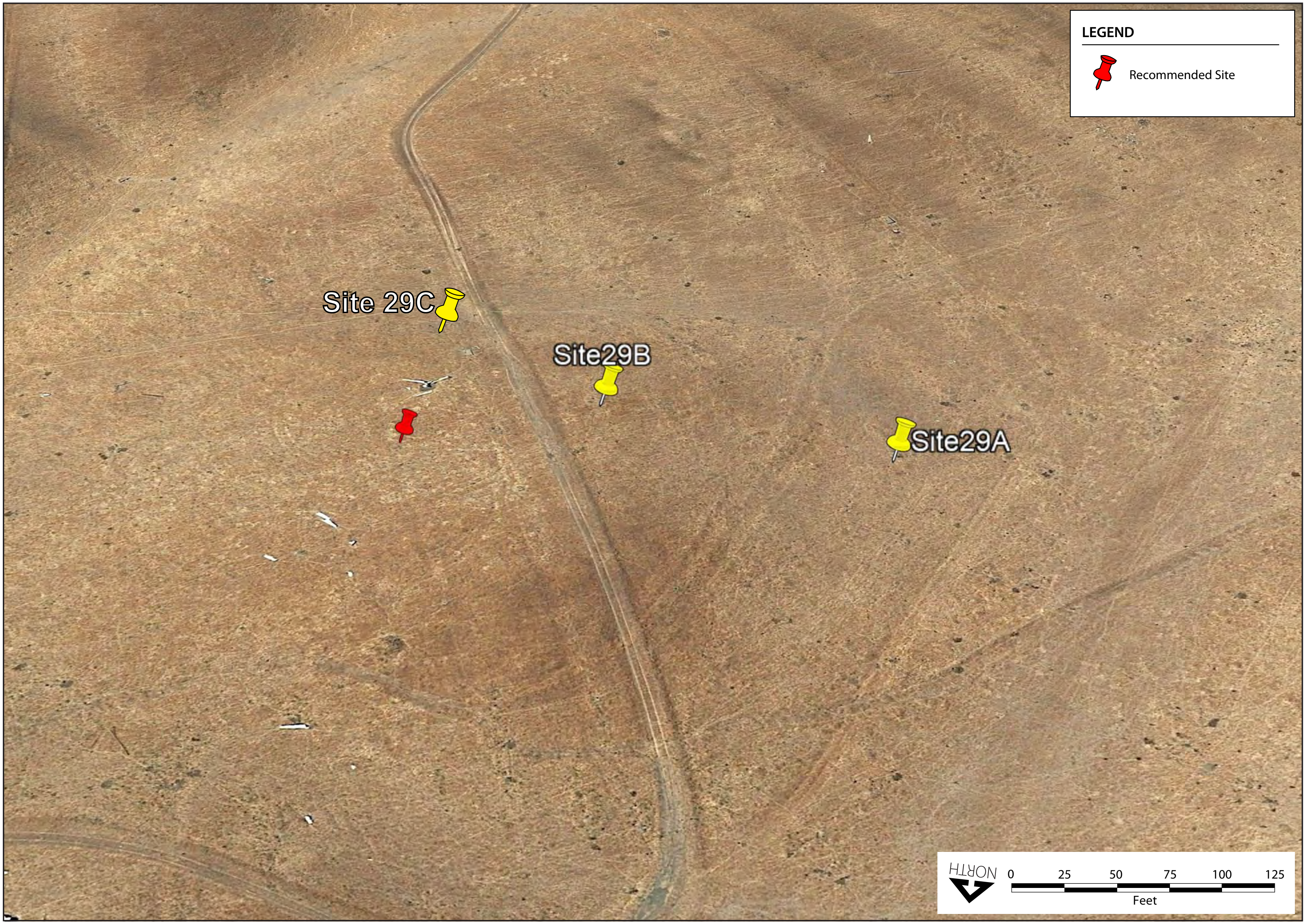
Site 29A is approximately 1,000 feet from a group of eucalyptus trees. There is a power plant with utility poles and a transmission line within 500 feet of Site 29B.

Relative Risk and Determination

Site 29A is considered a relatively high-risk site due to its location within the broad swale and at the base of a steep slope.

Site 29B is considered moderate-risk because it is near the top of the slope. Although an improvement over Site 29A, it is located on the upper edge of the slope, a potentially risky location for raptors flying into and out of the swale and for contour hunters. Also, placement of a turbine pad at this location could create a notch along the top of the slope above the swale and potentially result in additional risk.

Site 29C is considered a low-to-moderate-risk site due to its location along the edge of the shallow swale but otherwise adjacent to open, flat terrain. Because the site is near an existing



SOURCE: Google Earth 2018.

Figure A-29
Location of Alternative Sites for Turbine 29 at the Sand Hill Wind Project

access road and on generally flat terrain, road and turbine pad construction would not alter the local topography or influence bird use or movement through the area.

Recommendation

To reduce risk, move the turbine east-northeast 140 feet across the road (37.786169/121.601622) from Site 29B. This relocates the turbine to flat ground away from the edge of the swale and other topographical features. This relocated site would be considered low risk. This is generally consistent with Smallwood and Neher (2018).

Plate 66. Looking upslope to the east from Site 29A. Site 29B is upslope near the vehicle.

Plate 67. Looking northeast from Site 29B. Moving the turbine an additional 100 feet east across the road onto the flat, open ground and away from the edge of the slope would reduce risk.

Turbine 30

Turbine 30 has two locations for the four layouts, Site 30A (Layouts 1,2,3, and 4) and Site 30B (the proposed alternative to the recommended location as per the February 4-5 site visit by sPower engineers) (Figure A-30). An additional location was initially selected, but because its within 10 feet of Site 30A, they are considered the same site.

Topographical Description

Site 30A is midway up a fairly steep (17%) north-facing slope. The ascending slope extends along the north-south-oriented ridge about 700 feet to the east and descends to northward about 900 feet. There are deep swales west and east of the site (Plates 68, 69, and 70).

Site 30B is approximately 46 feet southeast of Site 30A along the same north-south-oriented ridge. Conditions at this site are nearly identical to Site 30A, although the north-south slope is slightly less steep at this location.

4/4/2019

SOURCE: Google Earth 2018.

Figure A-30
Location of Alternative Sites for Turbine 30at the Sand Hill Wind Project

Proximity to Other Potential Risk Factors

There are overhead powerlines within about 100 feet (which would be removed).

Relative Risk and Determination

Site 30A is considered a relatively high-risk site due to its position on the north-facing slope, and the proximity of deep swales to the east and west. Site 30B is considered marginally less risky due to its location on the slope, but is still considered a high-risk site.

Recommendation

There are no suitable options for relocating Site 30 locally to significantly reduce risk without moving the site a substantial distance, and thus there is no recommendation for Turbine 30.

Plate 68. Looking east-northeast from Site 30A.

Plate 69. Looking upslope to the south from Site 30A.

Plate 70. Looking northwest from Site 30A.

Sand Hill Wind Repowering Project

Appendix A-4. Assessment of Turbines 31 through 40

March 2019

Turbine 31

Turbine 31 has two locations for the four layouts, Site 31A (Layouts 1, 2, and 3) and Site 31B (Layout 4). Site 31B is approximately 75 feet southwest of Site 31A (Figure A-31).

Topographical Description

Sites 31A and 31B are both on relatively low-profile hilly terrain. Both are on a relatively flat and broad, low-profile ridge/hilltop (Plate 71).

Proximity to Other Potential Risk Factors

There is an overhead powerline within 100 to 200 feet (which would be removed) and a transmission line corridor within 450 feet.

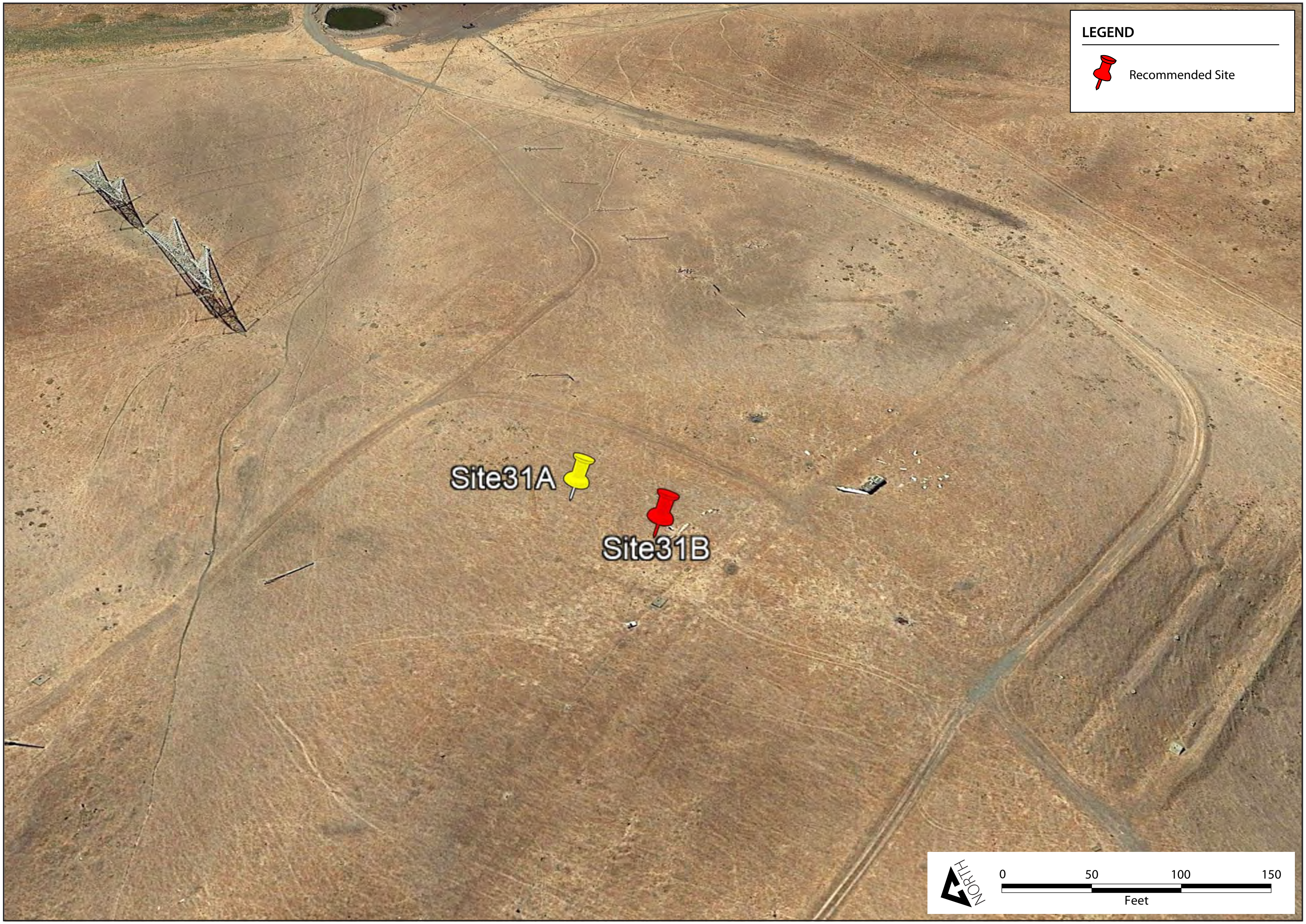
Relative Risk and Determination

Both sites are considered low-risk. There are no topographic features in the immediate vicinity that would influence predictable raptor movement. Site 31A is closer to the east-facing slope and thus is considered somewhat slightly riskier. Placement of the turbine pad at this location could slightly change the configuration of the slope edge, but not sufficient to influence raptor movement. Access road construction would also not affect raptor use or movements.

Recommendation

Site 31B is the recommended site because it is more centrally located on the flat, broad hilltop. No relocation is recommended. This is generally consistent with Smallwood and Neher (2018).

Plate 71. Looking south from Site 31B



1/07/2019

SOURCE: Google Earth 2018.

Figure A-31
Location of Alternative Sites for Turbine 31 at the Sand Hill Wind Project

Turbine 32

Turbine 32 has only one location (Site 32A) for the four layouts (Figure A-32). A second location was initially noted, but because they are within 8 feet of each other, they are considered here as the same site.

Topographical Description

Site 32A is on a flat, broad northwest-southeast-oriented ridge top/plateau with no features in the immediate area that would influence raptor flight patterns (Plate 72).

Proximity to Other Potential Risk Factors

There is an overhead powerline within 50 feet (which will be removed) and a fence line within 6 feet of the site.

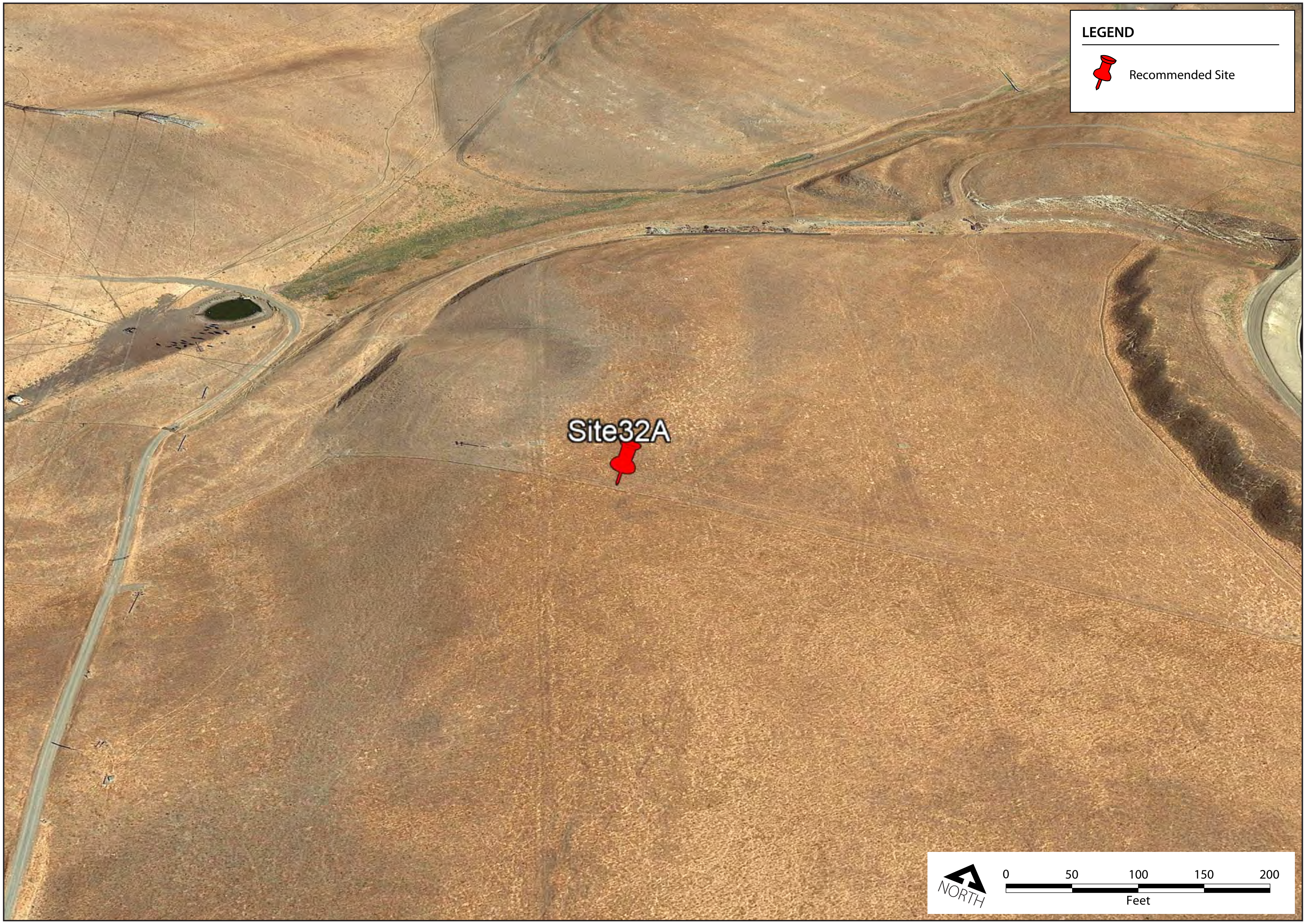
Relative Risk and Determination

Site 32A is considered a low risk site due to the flat terrain and lack of topographical features in the immediate area that would influence raptor use or flight patterns. Access road and turbine pad construction would also not affect raptor use or movements.

Recommendation

Site 32A is the recommended site. There are no recommendations for relocation. This is generally consistent with Smallwood and Neher (2018).

Plate 72. Looking north-northeast from Site 32A.



1/07/2019

SOURCE: Google Earth 2018.

Figure A-32
Location of Alternative Sites for Turbine 32 at the Sand Hill Wind Project

Turbine 33

Turbine 33 has only one location (Site 33A) for the four layouts (Figure A-33).

Topographical Description

Site 33A is on a broad, flat, ridge top/plateau with no topographic features in the vicinity that would influence raptor use (Plate 73).

Proximity to Other Potential Risk Factors

There is a transmission line approximately 550 feet west.

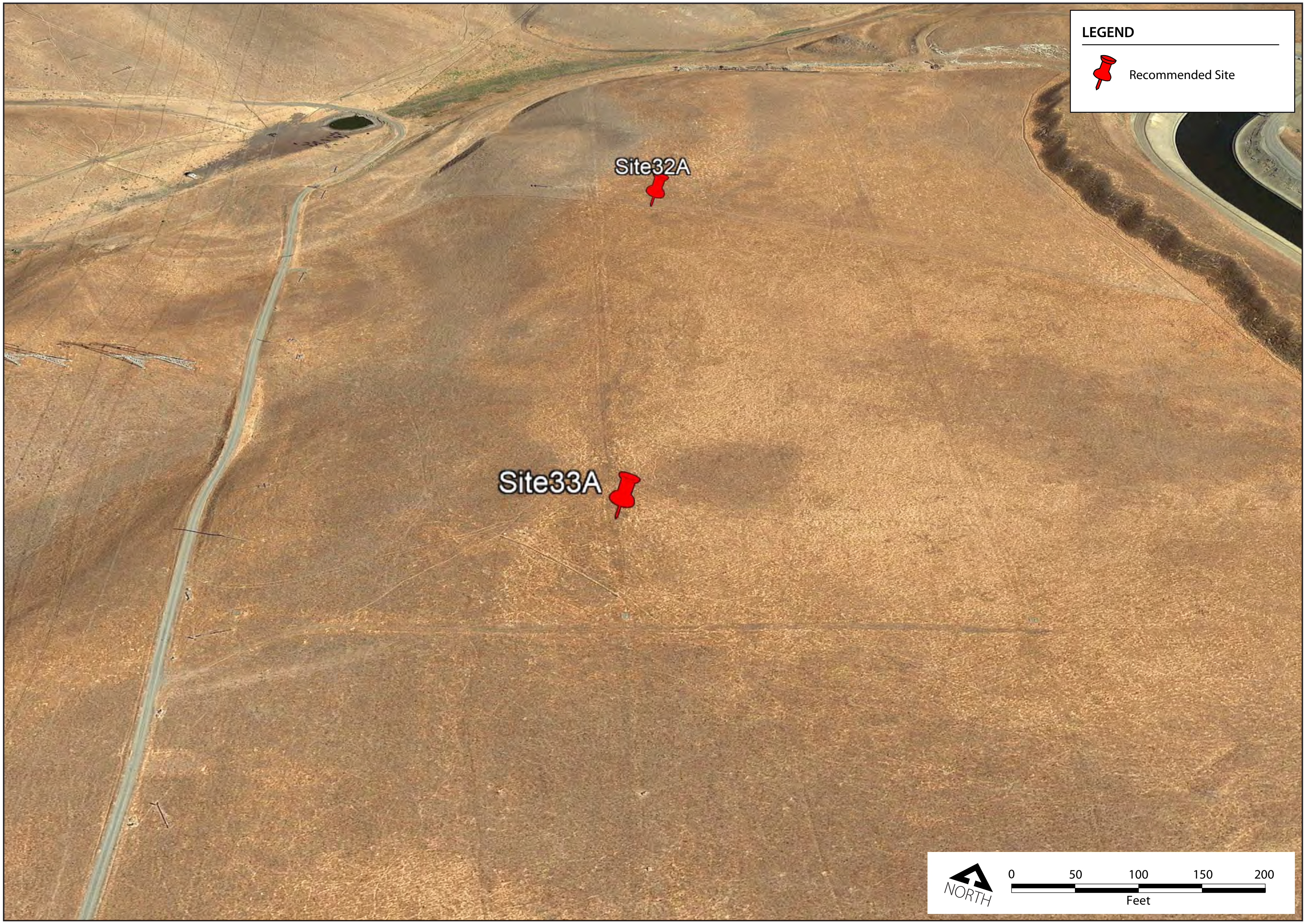
Relative Risk and Determination

Site 33A is considered a low risk site due to the flat terrain and lack of topographical features that would influence raptor use or flight patterns. Access road and turbine pad construction would also not affect raptor use or movements.

Recommendation

Site 33A is the recommended site. There are no recommendations for relocation. This is generally consistent with Smallwood and Neher (2018).

Plate 73. Looking east from Site 33A.



1/07/2019

SOURCE: Google Earth 2018.

Figure A-33
Location of Alternative Sites for Turbine 33 at the Sand Hill Wind Project

Turbine 34

Turbine 34 has only one location (Site 34A) for the four layouts (Figure A-34). A second location was initially noted, but it is within 10 feet of Site 34A, so they are considered here as the same site.

Topographical Description

Site 34A is within and at the lowest point is an east-west-oriented swale leading up toward a saddle on the east. Elevation increases in all directions surrounding the site (Plates 74 and 75).

Proximity to Other Potential Risk Factors

A transmission line is 580 feet from Site 34A.

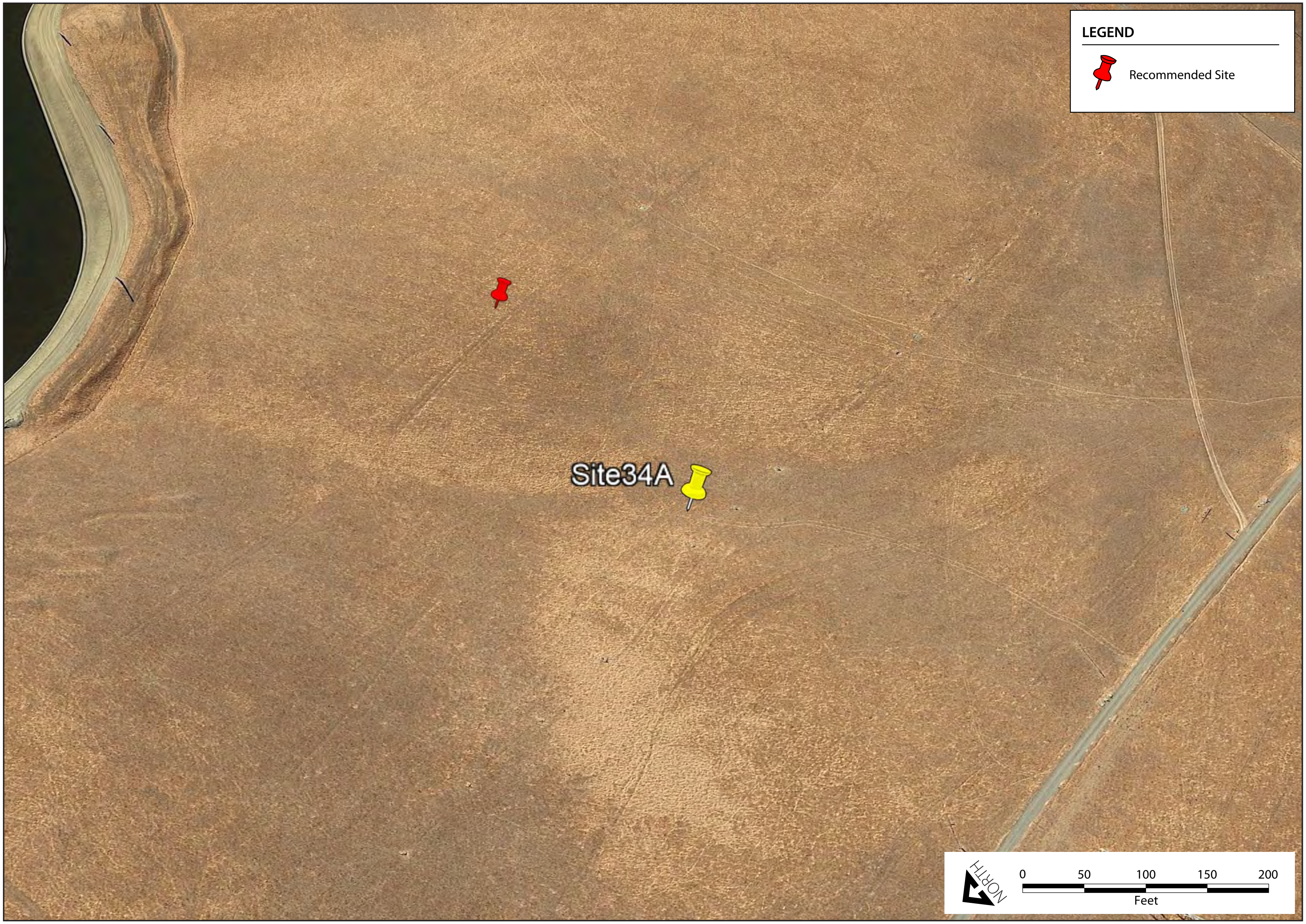
Relative Risk and Determination

Site 34A is considered a high-risk site due to its position within the swale and at the base of upward slopes on all sides.

Recommendation

Risk can be reduced at Site 34A by relocating the site upslope to the east-southeast approximately 350 feet (37.775806/121.589371) to the hilltop. This will move the site out of the swale and onto the hill/ridge top, where there is otherwise flat, open terrain (Plate 76). Although the risk determination is consistent with Smallwood and Neher (2018), they did not recommend a relocation alternative.

Plate 74. Looking east through the swale from Site 34A.



1/07/2019

SOURCE: Google Earth 2018.

Figure A-34
Location of Alternative Sites for Turbine 34 at the Sand Hill Wind Project

Plate 75. Looking west, upslope from Site 34A.

Plate 76. Looking northwest from recommended relocation site for Site 34A outside and south of the swale

Turbine 35

Turbine 35 has only one location (Site 35A) for the four layouts (Figure A-35). A second location was initially noted, but it is within 10 feet of Site 35A, so they are considered here as the same site.

Topographical Description

Site 35A is on a broad, flat ridge top that slopes gently (5%) eastward (Plate 77). There are no other topographic features in the immediate vicinity of the site.

Proximity to Other Potential Risk Factors

None.

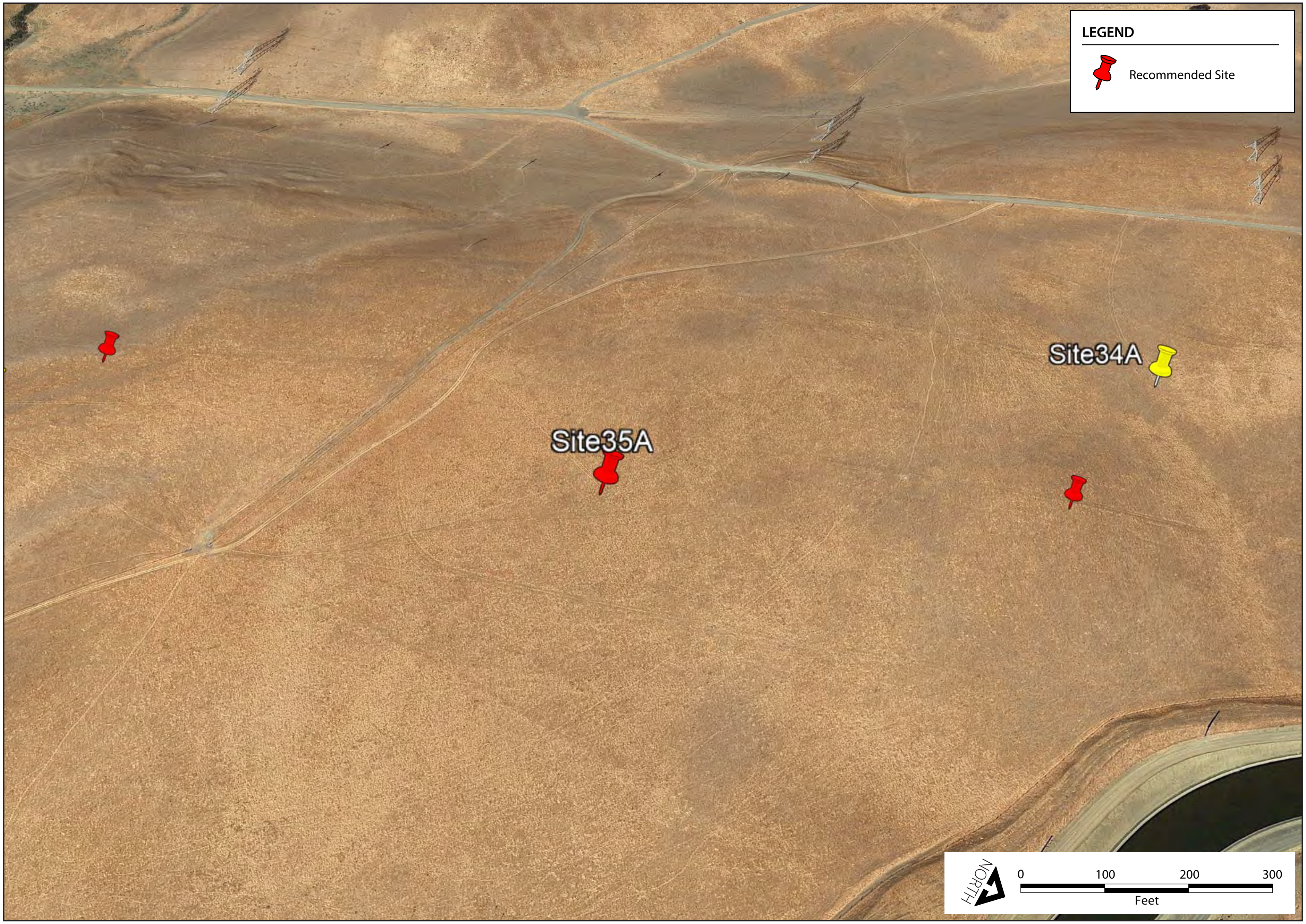
Relative Risk and Determination

Site 35A is considered a relatively low-risk site due to the flat terrain with no other topographic features that will influence or that can be used to clearly predict raptor movement through the site. Access road and turbine pad construction would also not affect raptor use or movements.

Recommendation

Site 35A is the recommended site. There are no recommendations for relocation. This is generally consistent with Smallwood and Neher (2018).

Plate 77. Looking east from Site 35A.



1/07/2019

SOURCE: Google Earth 2018.

Figure A-35
Location of Alternative Sites for Turbine 35 at the Sand Hill Wind Project

Turbine 36.

Turbine 36 has only one location (Site 36A) for the four layouts (Figure A-36). A second location was initially noted, but it is within 10 feet of Site 36A, so they are considered here as the same site.

Topographical Description

Site 36A is at the south end of the broad and flat north-south-oriented ridge/plateau above Mountain House Road. The southeast-facing slope descends gradually (10%) south and east into a deep ravine (Plate 78). The slope ascends to the northwest where it evens out onto the flat plateau (Plate 79).

Proximity to Other Potential Risk Factors

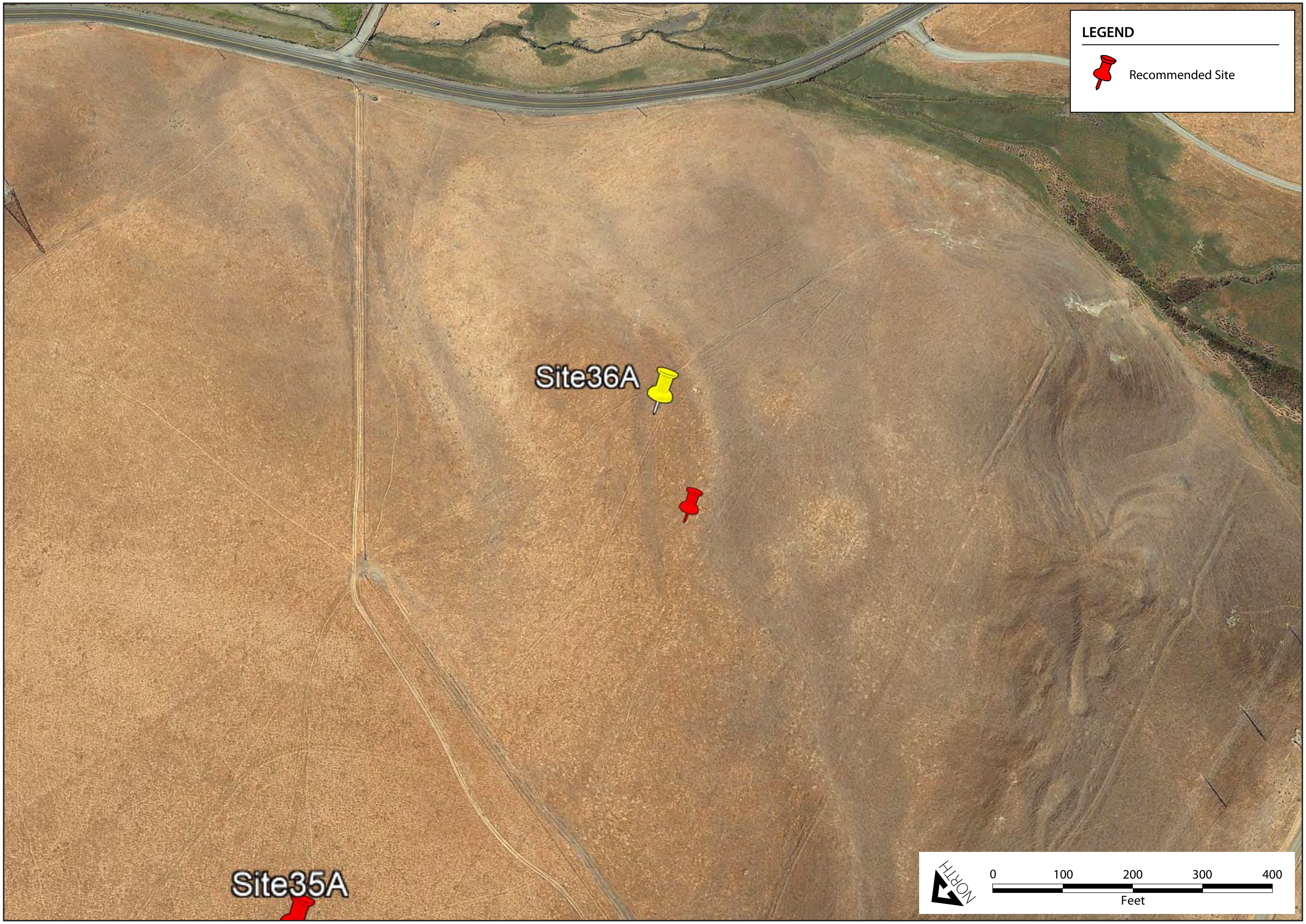
None.

Relative Risk and Determination

Site 36A is considered a moderate-risk site due to its location on the south-east-facing slope. The site is close to the steeper portion of the south-facing slope, which could pose some risk to birds using the hill contour for movement or foraging. Road and turbine pad construction could also potentially create a shallow bench and berm and could influence raptor movement along the slope.

Recommendation

Risk could be reduced by moving the site at least 200 feet upslope to the northwest (37.771814/121.587380). This would move the site further away from the edge of the south-facing slope. This is generally consistent with Smallwood and Neher (2018).



1/07/2019

SOURCE: Google Earth 2018.

Figure A-36
Location of Alternative Sites for Turbine 36 at the Sand Hill Wind Project

Plate 78. Looking southeast from Site 36A, just upslope from steeper drop-off to south and east.

Plate 79. Looking northwest from Site 36A.   Recommended location is just up slope from this site. Note that the slope at this location is not extreme, but the turbine pad would create a shallow bench in close proximity to the steeper slope just south of this location.

Turbine 37

Turbine 37 has only one location (Site 37A) for the four layouts (Figure A-37). A second location was initially noted, but it is within 10 feet of Site 37A, so they are considered here as the same site.

Topographical Description

Site 37A is located at the far north end of a mostly flat plateau with a gradual downward eastern slope on the eastern edge of the APWRA. The site is at the top of a deep north-south swale creating a saddle along the ridge top of the plateau (Plate 80). The surrounding area is generally flat and featureless.

Proximity to Other Potential Risk Factors

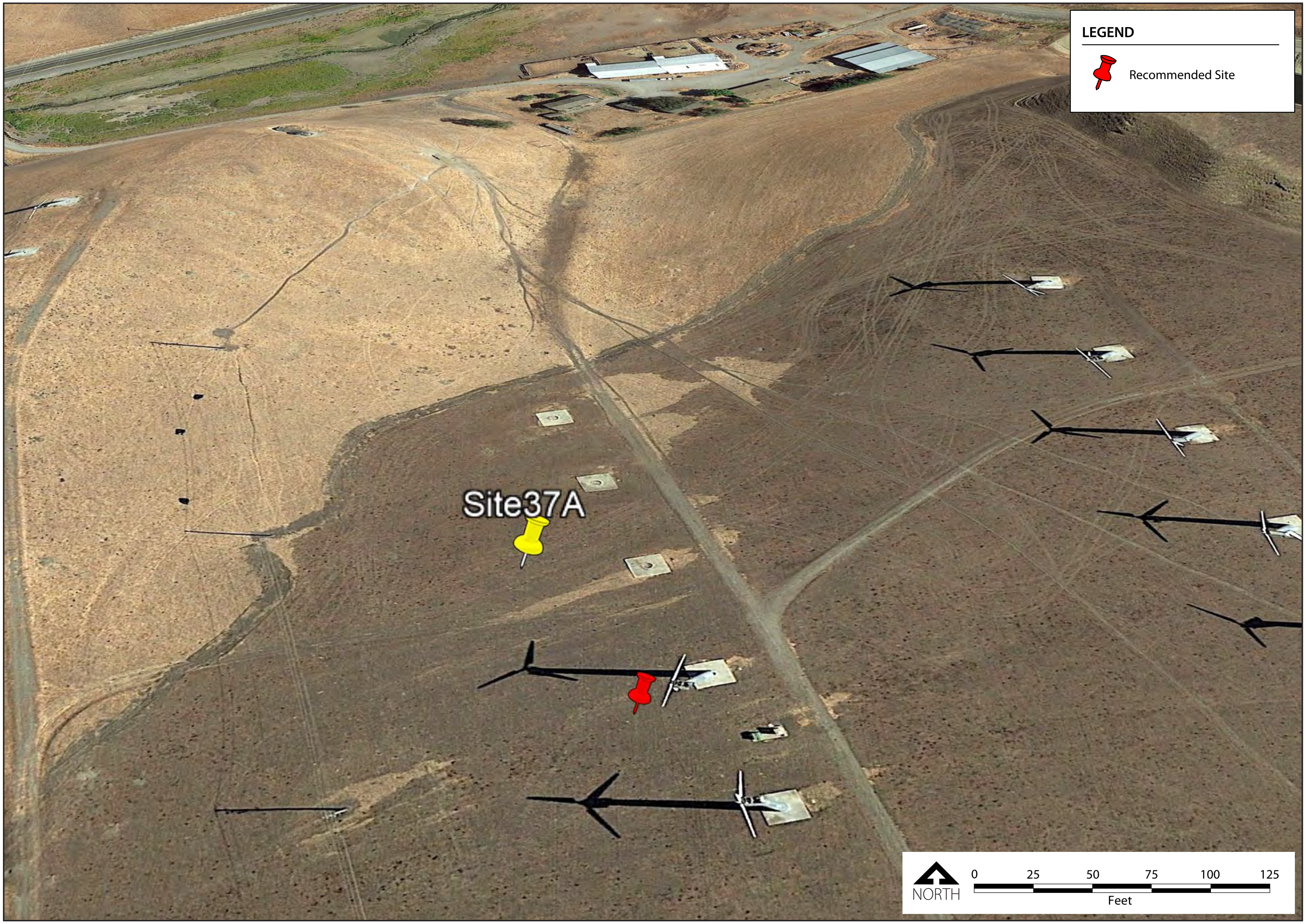
There is a decommissioned meteorological tower with approximately 200 feet and an overhead powerline within 120 feet (both which would be removed), and a transmission line within 540 feet of Site 37A.

Relative Risk and Determination

Because Site 37A is at the top of a deep swale in line of the ridge saddle, it is considered a high-risk site. Raptors moving up through the swale and the saddle will encounter the turbine, which will have rotors that extend across the breadth of the swale/saddle.

Recommendation

To reduce risk at Site 37A, move the turbine 140 feet south-southwest (37.768403/121.580945) (Plate 81). This will move the turbine away from the top of the deep swale and onto flat ground. Alternatively, move the site west about 300 feet toward the existing access road. However, this would place the turbine within 240 feet of a transmission line. This is generally consistent with Smallwood and Neher (2018).



1/07/2019

SOURCE: Google Earth 2018.

Figure A-37
Location of Alternative Sites for Turbine 37 at the Sand Hill Wind Project

Plate 80. Looking north from Site 37A toward the saddle/swale.

Plate 81. Looking northwest from recommended site. Site 37A is located where the person in the background is standing at the top of the swale.

Turbine 38

Turbine 38 has only one location (Site 38A) for the four layouts (Figure A-38). A second location was initially noted, but it is within 10 feet of Site 38A, so they are considered here as the same site.

Topographical Description

Site 38A is located on a mostly flat plateau with a gradual downward eastern slope on the eastern edge of the APWRA (Plate 82). There is a shallow north-south swale about 200 feet west of the site, but otherwise no topographical features in the immediate vicinity.

Proximity to Other Potential Risk Factors

There is an overhead powerline within 30 feet (which would be removed), a transmission line within 540 feet, and a fence line within 200 feet of Site 38A.

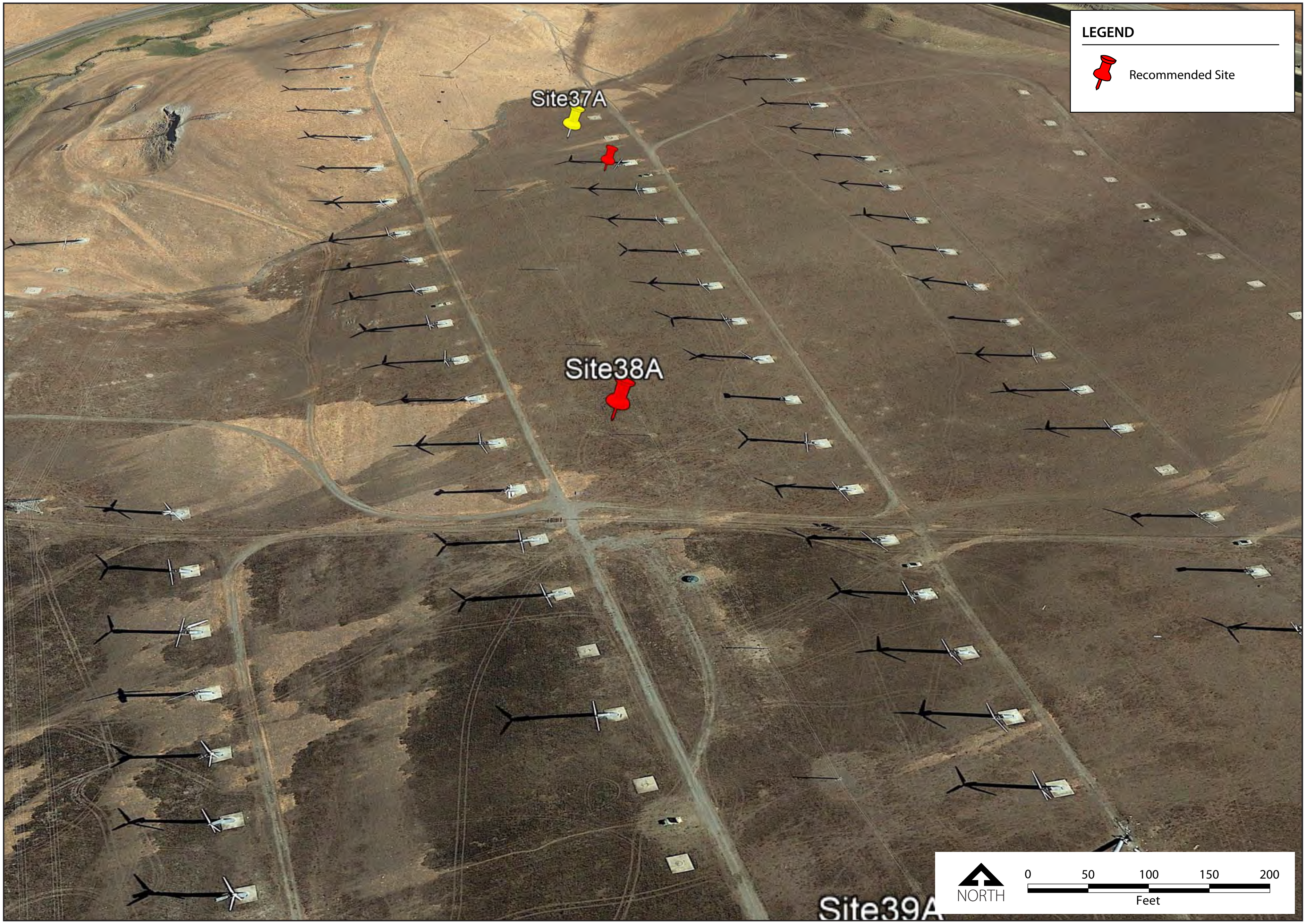
Relative Risk and Determination

Site 38A is considered a low-risk site. There are no features in the immediate vicinity that would influence predictable raptor movements. Access road and turbine pad construction would also not affect raptor use or movements.

Recommendation

Site 38A is the recommended site. There is no recommendation for relocation. This is generally consistent with Smallwood and Neher (2018).

Plate 82. Looking east from Site 38A.



1/07/2019

SOURCE: Google Earth 2018.

Figure A-38
Location of Alternative Sites for Turbine 38 at the Sand Hill Wind Project

Turbine 39

Turbine 39 has only one location (Site 39A) for the four layouts (Figure A-39).

Topographical Description

Site 39A is located on a mostly flat plateau with a gradual downward eastern slope on the eastern edge of the APWRA (Plate 83). There are no significant topographical features in the immediate vicinity.

Proximity to Other Potential Risk Factors

There is a distribution line within 30 feet (which would be removed) and a transmission line within 540 feet.

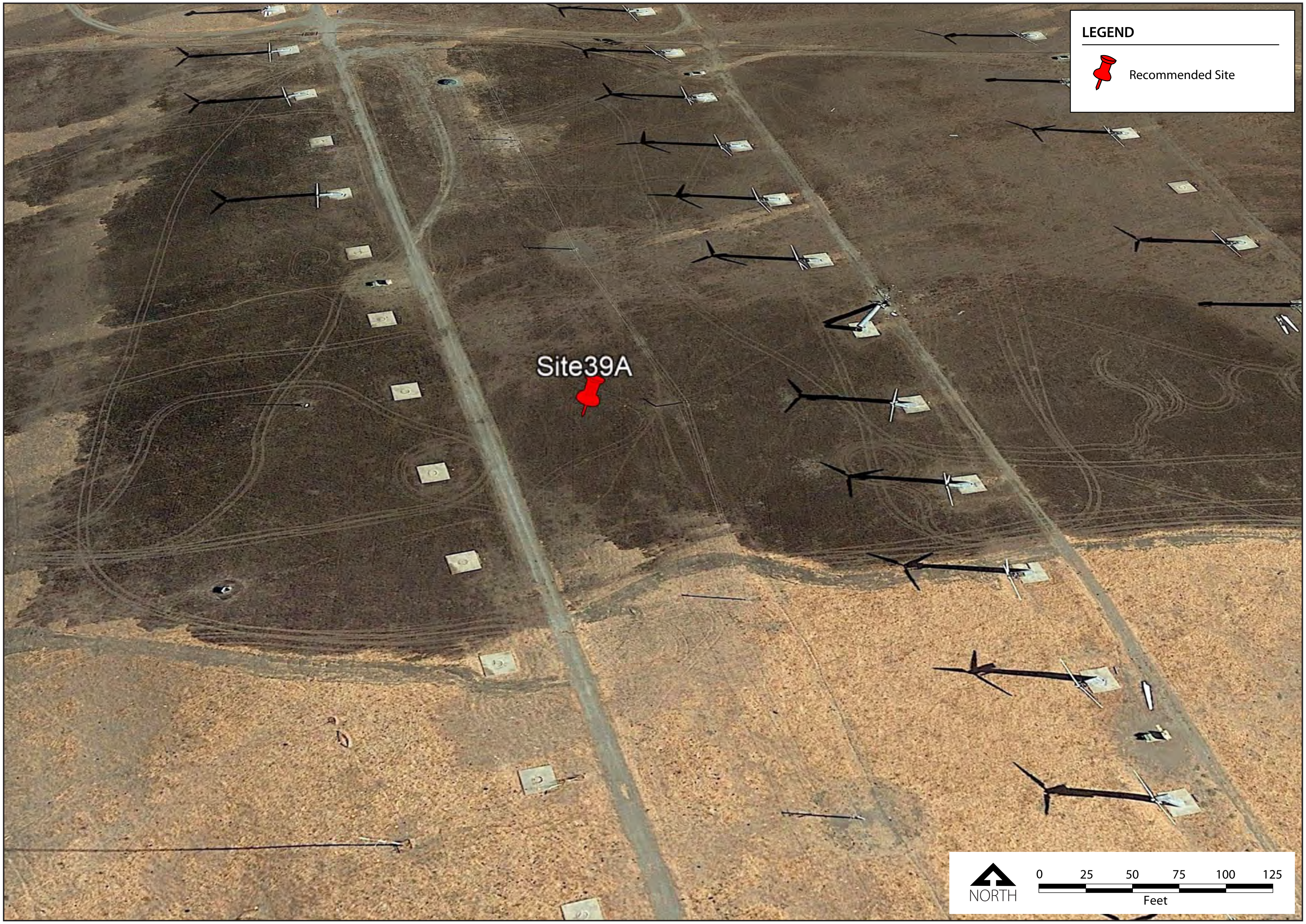
Relative Risk and Determination

Site 39A is considered a low-risk site. There are no features in the immediate vicinity that would influence predictable raptor movements. Access road and turbine pad construction would also not affect raptor use or movements.

Recommendation

Site 39A is the recommended site. There is no recommendation for relocation. This is generally consistent with Smallwood and Neher (2018).

Plate 83. Looking north from Site 39A.



1/07/2019

SOURCE: Google Earth 2018.

Figure A-39
Location of Alternative Sites for Turbine 39 at the Sand Hill Wind Project

Turbine 40

Turbine 40 has two alternative locations, Site 40A (the location for layouts 1, 2, and 3); and Site 40B (the location for layout 4) (Figure A-40). However, these sites are only 34 feet from each other on similar terrain, and so are addressed together.

Topographical Description

Sites 40A and B are on a gradual (12%) south-southeast-facing slope at the south end of a long, otherwise flat plateau (Plates 84 and 85). The site is just downslope from a slope break, descending gradually for an additional 1,200 feet before reaching a small drainage at the far southern end of the plateau feature, and ascending gradually to the north-northwest about 250 feet before levelling. From east to west, the plateau extends for about 700 feet before descending. There are no other significant topographical features in the immediate area.

Proximity to Other Potential Risk Factors

There is an overhead powerline within 30 feet (which would be removed) and a transmission line corridor within 700 feet of the site.

Relative Risk and Determination

Because they are below the ridge top, descending slopes along ridges – even on broad plateaus, are often used by raptors as crossing points to access one side of a ridge to the other. Road and turbine pad construction at these locations would also create a shallow bench on the slope. Because Sites 40A and B are on a descending slope of the plateau – even within an otherwise low-profile topographical landscape, the sites are considered moderate risk.

Recommendation

Risk can be reduced somewhat by relocating the turbine northwestward of Site 40B for approximately 275 feet where the slope begins to level off (37.762312/121.579552). This is generally consistent with Smallwood and Neher (2018); however, they do not recommend relocation to reduce potential risk.

1/07/2019

SOURCE: Google Earth 2018.

Figure A-40
Location of Alternative Sites for Turbine 40 at the Sand Hill Wind Project

Plate 84. Looking south along the gradually descending slope from Site 40A.

Plate 85. Looking upslope to north from Site 40A toward Site 40B, about 34 feet upslope.

Appendix D
Micro-Sited Smaller Turbine Layout Alternative

Micro-sited Smaller Turbine Layout Alternative

Overview

The Micro-sited Smaller Turbine Layout alternative results from Sand Hill Wind, LLC's ("Sand Hill") efforts to minimize adverse impacts to birds and bats to the extent possible given unavoidable Project constraints (*e.g.*, mandatory setbacks, turbine availability, and the need to maintain commercial viability).

The Micro-sited Smaller Turbine Layout alternative is driven by the recommendations of two sequential, Project-specific micro-siting reports: Smallwood and Neher (2018), and Estep (2019). These studies analyzed the proposed Project's expected avian impacts on a turbine-by-turbine level—taking into account factors ranging from current understandings of raptor behavior to the effects of expected grading at the Project—and suggested revised turbine locations to minimize raptor collision risks. Incorporating the results of these studies to the extent possible, the Micro-sited Smaller Turbine Layout alternative relocates roughly half of the proposed Project's turbines, as indicated in the attached Sand Hill Turbine Tracking Spreadsheet ("Turbine Spreadsheet").[1] This alternative further employs the results of these micro-siting reports to reduce the rotor-swept area ("RSA") and increase the minimum blade-to-ground distance of 35 of the proposed Project's 40 turbines, with the intent to reduce overall risk to birds and bats.

In all, the Micro-sited Smaller Turbine Layout alternative relocates 19 of the proposed Project's 40 turbines,[2] reduces overall Project capacity by 24% from 144.5 MW to 109.5 MW, reduces rotor-swept area by 13%, from 568,775 m^2 to 496,220 m^2, and raises the average clearance of turbine blades by 75%, from 14.1 m to 24.7 m above the ground. (*Id.*) As a result of these changes, the Micro-sited Smaller Turbine Layout alternative is expected to substantially reduce bird and bat mortality compared to the proposed Project.

Initial Micro-siting: Smallwood and Neher (2018) and Layout 4

Smallwood and Neher's approach to micro-siting relies heavily on computer-based collision hazard models. Previously, they had prepared such models for the Tres Vaqueros, Vasco Winds, Patterson Pass, Golden Hills, Golden Hills North, and Summit Winds repowering projects. (Smallwood and Neher (2018) at 1). After analyzing additional data collected since the creation of these earlier models and incorporating lessons learned from other projects (including three years of fatality monitoring following construction of Vasco Winds), Smallwood and Neher developed updated models specific to the Project. (*Id.*)

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[1] The Turbine Spreadsheet, attached hereto as **Exhibit 1,** provides detail on each turbine site, including risk levels assigned and relocation recommendations made by Smallwood and Neher (2018) and Estep (2019), and actions taken in response thereto. Images depicting the locations of relocated Project turbines, in both pre-micro-siting layouts (Layouts 1-3) and post-micro-siting layouts (Layouts 4-5), are attached as **Exhibit 2**.

[2] Three additional turbines were moved for reasons other than to reduce bird and bat collision risks. Turbine 8 was moved to further distance it from a nearby road. The location for Turbine 28 was revised to accommodate a pipeline easement. And Turbine 40 was relocated in response to a setback requirement.

Smallwood and Neher's models for the Project were designed to predict and map collision hazards for golden eagle, red-tailed hawk, American kestrel, and burrowing owl. (*Id*. at 2, 5, 31). Their models incorporated three primary variables: (1) flight behavior data (including data from surveys made during more than 2,000 hours of site visits across the APWRA and the Project site, and, in the case of golden eagles, GPS/GSM telemetry positions tracking actual golden eagle flight patterns at the Project location); (2) fatality rates at monitored wind turbines; and (3) the topographic landscape using a digital elevation model. (*Id.* at 2-3, 5, 18-19, 32).

Smallwood and Neher (2018) also drew from site visits in which Smallwood rated collision hazards at Proposed Project turbine sites using modified SRC criteria. (*Id*. at 5). This allowed Smallwood and Neher (2018) to address site-specific risks not captured in their hazard models. For example, even though the computer hazard models did not consider the effects of grading for turbine access roads or tower pads, Smallwood and Neher (2018) were able to analyze risks associated with grading at specific turbine locations. (*Id.* at 71, 72).

Smallwood and Neher (2018) then compared proposed turbine locations set forth in the three pre-micro-siting Proposed Project layouts (Layouts 1, 2, and 3) to (a) Smallwood's SRC-style hazard ratings; (b) predicted computer-generated collision hazards; and (c) fatality monitoring histories for golden eagle, red-tailed hawk, American kestrel, and burrowing owl. (*Id.* at 71, 73-75). Finally, Smallwood and Neher (2018) made turbine-by-turbine micro-siting recommendations based on this analysis, including recommendations expressly responding to risks associated with grading. (*Id.* at 72, 76-78) Smallwood and Neher (2018) concluded that, with micro-siting, the Project would be expected to reduce fatalities of raptors and birds as a group compared to the pre-repowering baseline, although bat fatalities may increase despite micro-siting efforts. (*Id.* at 1, 2, 71).

In response to Smallwood and Neher (2018), Sand Hill compiled a fourth turbine layout—Layout 4—that incorporated that study's micro-siting recommendations to the extent possible. (Turbine Spreadsheet).

Subsequent Micro-siting: Estep (2019) and Layout 5

Although Layout 4 was expected to reduce the Project's avian collision risks, room for additional refinement remained. As Smallwood and Neher (2018) acknowledged, "map-based collision hazard maps need to be interpreted carefully, meaning the hazards of specific terrain and wind situations . . . should always trump model predictions." (Smallwood and Neher (2018) at 71). Sand Hill therefore commissioned a second Project-specific micro-siting report: Estep (2019). The Estep report was designed to refine Smallwood and Neher (2018) by reexamining each proposed turbine location in Layouts 1-4, and providing more specific relocation recommendations. (Estep (2019) at 3).

While Smallwood and Neher (2018) represents an important contribution to understanding collision risk in the APWRA generally, Estep (2019) takes a more Project-centered approach that focuses on the results of site visits and on SRC turbine siting guidelines (SRC 2010) to produce more accurate micro-siting recommendations at the Project level. (Estep (2019) at 6-7). Estep (2019) considered a number of potential risk factors when evaluating each proposed turbine location. (*Id.* at 7-9). These included not only existing topographical features such as slopes, ridges, and swales, but expected changes to those features resulting from grading at the proposed Project. Thus, Estep (2019) performed "an assessment of . . . the most likely road access, the need to construct new roads, and the extent of road improvements necessary to accommodate the new larger turbines." (*Id*. at 8). Similarly, Estep (2019) assessed "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." (*Id*.).

After visiting and evaluating each proposed turbine site, Estep (2019) assigned each location a relative potential risk designation: very high risk, high risk, moderate-high risk, moderate risk, moderate-low risk, or low risk. (*Id.* at 8).[3] No proposed turbine site earned a "very high risk" designation. Estep (2019) then made a micro-siting recommendation for each site, including a determination of whether an alternative location would reduce potential mortality. (*Id.* at 8-9). Estep (2019) made these recommendations exclusively on the basis of potential reduction of raptor collision risk, and did not consider other constraints, such as setback requirements. (*Id.* at 9).

In response to the Estep micro-siting report, Sand Hill prepared a fifth and final turbine layout, Layout 5, which became the Micro-sited Smaller Turbine Layout alternative. In this alternative, Sand Hill was able to follow many of the micro-siting recommendations made by Smallwood and Neher (2018) and Estep (2019), thereby reducing expected collision risk. In certain instances, however, unavoidable Project constraints such as County setback requirements prevented Sand Hill from relocating turbines in accordance with these reports. In these events, Sand Hill attempted to reduce risk in other ways, including by continuing to work with Estep to find suitable alternative turbine locations, and, in almost all instances, by reducing turbine sizes (and therefore decreasing rotor-swept area and increasing blade heights above ground-level).

For example, Layouts 1-3 (the non-micro-sited layouts) would have used 35 3.8 MW turbines, and five 2.3 MW turbines. The Micro-sited Smaller Turbine Layout alternative, by contrast, uses 35 2.8 MW turbines, and five 2.3 MW turbines. As the following table indicates, the result is not just a smaller rotor-swept area, but also greater distance between the ground and turbine blades.

Turbine Model	Capacity (MW)	Tower Height (m)	Rotor-Swept Area (m^2)	Height of blades from ground (m)
GE 3.8-137	3.8	81.5	14,741	13
GE 2.8-127	2.8	88.6	12,668	25
GE 2.3-116	2.3	80	10,568	22

In many cases, Sand Hill was able to use a combination of Smallwood and Neher (2018), Estep (2019), and ongoing consultation with Estep to move turbines from relatively moderate- or high-risk sites to locations expected to reduce collision threats. The following examples are illustrative:

- **Turbine 29**. Both Smallwood and Neher (2018) and Estep (2019) concluded that Turbine 29 as proposed in Layouts 1-3 would pose a considerable collision risk to raptors, with Estep designating it a relatively high-risk site. (Smallwood and Neher (2018) at 74-75; Estep (2019), Appendix A-3). Smallwood and Neher (2018) recommended moving the turbine east toward

[3] Estep (2019) notes that its relative risk designations are based on current understandings of conditions that lead to raptor-turbine interactions, and that as a result may lead to higher collision rates. (Estep (2019) at 8). That report further cautions that its relative risk designations "do not otherwise indicate that a site *will* have more or less collision events than another, only that . . . the *potential for* more or less collision events is assumed." (*Id*. at 8-9).

higher ground. (Smallwood and Neher (2018) at 77). Sand Hill did so in Layout 4, and Estep (2019) confirmed that the new site would reduce risk to moderate-to-high levels. (Estep (2019), Appendix A-3). Estep noted, however, that "placement of a turbine pad at this location could create a notch along the top of the slope above the swale and potentially result in additional risk," and recommended further moving Turbine 29-4. (*Id*.). Although setback requirements prevented Sand Hill from accommodating this recommendation, Sand Hill proposed another alternative location for Turbine 29 following additional site visits; Estep confirmed that this location—used in the Micro-sited Smaller Turbine Layout alternative—would reduce expected collision risks to a low-to-moderate level. (*Id*.). In addition, Turbine 29 is reduced from 3.8 MW (rotor-swept area of 14,741 m^2 with blades 13 m from the ground) to 2.3 MW (rotor swept area of 10,568m^2 with blades 22m from the ground), which is expected to further reduce collision risks for birds and bats by reducing rotor-swept area by 28% and increasing blade height from the ground by 69%.

- **Turbine 20**. In Layouts 2 and 3, Turbine 20 presented what Estep (2019) predicted would be a moderate collision risk, owing in part to the expected effects of grading for road access to those sites. (Estep (2019), Appendix A-2). Smallwood and Neher (2018) recommended siting Turbine 20 on the crest of a hill near the location proposed in Layout 1. (Smallwood and Neher (2018) at 77). However, because this would have resulted in two or more turbines being placed so closely together that wake interference would render them commercially infeasible, Sand Hill was unable to so relocate Turbine 20 in Layout 4. (Turbine Spreadsheet). Estep (2019) concluded that the Layout 1 site would pose a low to moderate risk, and did not anticipate special risks due to grading. (Estep (2019), Appendix A-2). Estep further concluded that this risk could be further mitigated by moving Turbine 20 approximately 80 feet. (*Id*.). In the Micro-sited Smaller Turbine Layout alternative, Sand Hill located Turbine 20 in accordance with the Estep (2019) recommendation. (Turbine Spreadsheet). In addition, it reduced the size of Turbine 20 by over 26%, from 3.8 MW to 2.8 MW. (*Id.*) This cut Turbine 20's rotor-swept area by approximately 14%, from 14,741 m^2 to 12,668 m^2, and raised its blades approximately 92% higher off the ground (from 13m to 25 m), thereby further lessening risk to birds and bats.

In many instances, micro-siting recommendations would have resulted in diminished turbine production due to wake effect. Because Sand Hill could not sustain unlimited output losses due to wake effect, it prioritized high-risk sites in the Micro-sited Smaller Turbine Layout alternative. For example:

- **Turbines 14, 15, and 16**. Estep (2019) designated Turbines 14, 15, and 16 as proposed in certain previous layouts as relatively high-risk sites. For each turbine, Estep (2019) provided a relocation recommendation that would result in wake-effect losses. (Estep (2019), Appendix A-2). Prioritizing changes at these relatively high-risk sites, the Micro-sited Smaller Turbine Layout alternative follows Estep's recommendations for each site despite wake effect losses. (Turbine Spreadsheet). In addition, this alternative reduces the size of Turbines 14, 15, and 16 from 3.8 MW to 2.8 MW (resulting at each turbine in a 26% MW reduction, a 14% RSA reduction from 14,741 m^2 to 12,668 m^2 and blades raised approximately 92% higher off the ground from 13m to 25 m). The Micro-sited Smaller Turbine Layout alternative also avoids grading-related risks that Estep (2019) flagged for certain non-micro-sited locations of Turbine 15. (Estep (2019), Appendix A-2).

- **Turbine 36**. Estep (2019) recommended moving Turbine 36 approximately 200 feet. (Estep (2019), Appendix A-4). The resulting wake-effect loss would be similar to that sustained by relocating Turbine 14. However, because Turbine 36 is only a moderate-risk site (and one for which neither Estep (2019) nor Smallwood and Neher (2018) noted any grading-related concerns), the Micro-sited Smaller Turbine Layout does not relocate Turbine 36, but instead reduces its size by over 26% from 3.8 MW to 2.8 MW (resulting in a 14% RSA reduction from 14,741 m^2 to 12,668 m^2 and blades raised approximately 92% higher off the ground from 13m to 25 m).

At other sites, Sand Hill used micro-siting to make already relatively low-risk turbines even safer. The following examples are illustrative:

- **Turbine 1**. Smallwood and Neher (2018) recommended moving Turbine 1 approximately 197 feet from its proposed location in Layouts 1-3. (Smallwood and Neher (2018) at 76). Sand Hill was largely able to accommodate this relocation, as reflected in Layout 4. (Turbine Spreadsheet). Although neither Estep (2019) nor Smallwood and Neher (2018) noted concerns with respect to grading at either location, Estep (2019) found the Layout 4 site to be a slight improvement that presented a low-to-moderate collision risk. (Estep (2019), Appendix A-1). Estep (2019) then recommended placing Turbine 1 approximately 60 feet north of the Layout 4 site, which would further distance Turbine 1 from an upward slope, better center it within a broad valley, and move it further from rock piles and overhead powerlines. (*Id*.). Sand Hill was able to move Turbine 1 60 feet north. (Turbine Spreadsheet). Additionally, the Micro-sited Smaller Turbine Layout alternative further minimizes risk by reducing the size of Turbine 1 from 3.8 MW to 2.8 MW, resulting in 26% MW reduction, a 14% RSA reduction from 14,741 m^2 to 12,668 m^2 and blades raised approximately 92% higher off the ground from 13m to 25 m. (Turbine Spreadsheet).
- **Turbine 12**. Prior to micro-siting, Turbine 12 would have been situated in areas designated by Estep (2019) as either low or low-to-moderate risk. (Estep (2019), Appendix A-2). Neither Estep (2019) nor Smallwood and Neher (2018) noted concerns with respect to grading at any proposed Turbine 12 location. Sand Hill re-sited Turbine 12 based on Smallwood and Neher's recommendations, and Estep (2019) confirmed the new site to be the safest local alternative. (Turbine Spreadsheet; Estep (2019), Appendix A-2). Following an additional site visit, Sand Hill proposed moving Turbine 12 an additional 37 feet south; Estep confirmed that this was an equally safe location, and a recommended site. (Estep (2019), Appendix A-2). In addition, Sand Hill also further minimized risk by reducing the size of Turbine 12 from 3.8 MW to 2.8 MW, resulting in 26% MW reduction, a 14% RSA reduction from 14,741 m^2 to 12,668 m^2 and blades raised approximately 92% higher off the ground from 13m to 25 m. (Turbine Spreadsheet).

In some instances, although Estep (2019) or Smallwood and Neher (2018) suggested relocating a turbine, relocation proved infeasible. To compensate, Sand Hill attempted to reduce expected collision threats to birds and bats through other means, primarily by reducing turbine sizes. The following examples are illustrative.

- **Turbine 9.** Estep (2019) gave the Turbine 9 location a "moderate" relative risk designation. (Estep (2019), Appendix A-1). Both Estep (2019) and Smallwood and Neher (2018) recommended that Turbine 9 be moved closer to the top of a nearby hill. (Smallwood and

Neher (2018) at 76; Estep (2019), Appendix A-1). However, it was not possible to relocate Turbine 9 because it would have resulted in infeasibly high wake effect interference with Turbine 8. Instead, the Micro-Sited Smaller Turbine Layout alternative reduces the size of Turbine 9 by nearly 40% (3.8 MW to 2.3 MW). (Turbine Spreadsheet). This results in an approximately 28% reduction in RSA (from 14,741 m^2 to 10,568 m^2) and rotor blades that are more than 69% higher off the ground (from 13 m above the ground to 22 m).

- **Turbine 27.** Although neither noted any grading concerns, both Estep (2019) and Smallwood and Neher (2018) made relocation recommendations for Turbine 27, which Estep classified as posing a relatively high collision risk. (Smallwood and Neher (2018) at 78; Estep (2019), Appendix A-3). However, mandatory setbacks prohibited Sand Hill from relocating Turbine 27. (Turbine Spreadsheet). Instead, the Micro-sited Smaller Turbine Layout alternative cuts the size of Turbine 27 more than 26%, from 3.8 MW to 2.8 MW (thereby reducing RSA by 14% from 14,741 m^2 to 12,668 m^2 and increasing blade distance from the ground by 92% from 13 m to 25 m). (Turbine Spreadsheet).
- **Turbine 37**. While not finding concerns related to grading, both Estep (2019) and Smallwood and Neher (2018) classified Turbine 37 as relatively high risk, and recommended relocation. (Smallwood and Neher (2018) at 75, 78; Estep (2019), Appendix A-4). However, relocating Turbine 37 would have resulted in unacceptably high wake effect, rendering these recommendations infeasible. (Turbine Spreadsheet). In order to reduce risk at Turbine 37, the Micro-sited Smaller Turbine Layout alternative instead reduces the size of Turbine 37 by nearly 40% (3.8 MW to 2.3 MW), resulting in a 28% reduction of RSA from 14,741 m^2 to 10,568 m^2 and an increase in blade distance from ground by 69% from 13 m to 22 m). (*Id*.).

Similarly, there were a number of turbine sites in Layouts 1-3 for which neither Smallwood and Neher (2018) nor Estep (2019) were able to identify a nearby relocation site that would reduce raptor collision risks. Here too, Sand Hill attempted to reduce collision potential at higher-risk locations by reducing turbine sizes. For example, Estep (2019) designated Turbine 6 as moderate risk, and neither Estep nor Smallwood and Neher (2018) proposed a better alternative site. (Smallwood and Neher (2018) at 76; Estep (2019), Appendix A-1). The Micro-sited Smaller Turbine Layout alternative nevertheless reduces the size of Turbine 6 from 3.8 MW to 2.8 MW, a more than 26% capacity reduction that reduces rotor-swept area by 14% from 14,741 m^2 to 12,668 m^2, and raises the turbine's minimum blade elevation by 92% from 13 meters to 25 meters.

In order for the Project to meet its primary objectives of satisfying Power Purchase Agreements obtained for the Project by siting up to 40, fourth-generation turbines and maintaining commercial viability, its capacity can be no less than 109.5 MW. Turbine-size reductions in the Micro-sited Smaller Turbine Layout alternative therefore decrease the overall capacity of the Project to the maximum extent feasible, from 144.5 MW to 109.5 MW.

In total, the Micro-sited Smaller Turbine Layout alternative relocates 19 of the proposed Project's 40 turbines, reduces overall Project capacity by 24% from 144.5 MW to 109.5 MW, reduces rotor-swept area by 13%, from 568,775 m^2 to 496,220 m^2, and raises the average clearance of turbine blades by 75%, from 14.1 m to 24.7 m above the ground. Each of these steps is expected to reduce bird and bat mortality based on input obtained from the Smallwood and Neher (2018) and Estep (2019) micro-siting studies prepared for the Project.

EXHIBIT 1

Turbine	Used in Micro-sited Smaller Turbine Layout Alternative?	Original Nameplate MW	Final Nameplate MW	Smallwood SRC-Style Hazard Rating	Smallwood Fuzzy Logic Rating	Smallwood Micro-siting Recommendation	Layout 4: Turbine Relocated in Response to Smallwood?	Estep Relative Risk Rating	Estep micro-siting Recommendation	Layout 5: Turbine Relocated in Response to Estep?	Has Risk Been Reduced?
SH01-1,2,3	No	GE 3.8	-	8.5	1	Maybe move ENE 60 m.	Yes. Moved 80m (260 ft) east to site 01-4. Modified Smallwood recommendation to avoid beam path issue.	Low-Mod	Use modified site 01-4, which is slightly lower risk than this site.	Not using this site.	Yes - site removed.
SH01-4	Yes, modified	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Low-Mod	Move at least 60 feet north, which moves turbine further from the upward slope to the south, centers it better within the broad valley, and moves it further from rock piles and overhead powerlines.	Yes. Moved 60 feet north in Layout 5.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH02-1,2,3, 4	Yes	GE 2.3	GE 2.8	6	1	None. No concern with this site.	N/A	Low	Use this site.	Using this site.	Recommended, low-risk site, and blade height above ground increased.
SH03-1, 2, 3, 4	Yes, modified	GE 2.3	GE 2.8	6	1	None. No better options locally.	N/A	Low-Mod	Move approximately 105 feet south, further from the swale to the east to slightly reduce collision risk.	Yes. Moved 105 feet south.	Yes - turbine moved and blade height above ground increased.
SH04-1,2,3	No	GE 2.3	-	10	3	None. Recommends avoiding this site.	Yes. Moved 80 m (260 ft) SW to move farther from ravine (farthest move possible due to wake) to Site 04-4.	High	None.	Not using this site.	Yes - site removed.
SH04-4	Yes	GE 2.3	GE 2.8				Yes. Moved to this site in Layout 4 to move farther from ravine and closer to top of hill.	High	Move approximately 225 feet due south of Site 04-4 to the top of the hill, and further off of northwest-facing slope edge.	No. Could not move further south due to wake effect. Turbine size slightly increased because smaller turbines required at other locations for setbacks and/or to reduce golden eagle risk.	Yes - turbine moved and blade height above ground increased.
SH05-1,2,3	No	GE 3.8	-	6	1	Shift SW to hill peak.	Yes. Moved 62 m (205 ft) SW to hill peak to Site 05-4.	Low-Mod	None.	Not using this site.	Yes - site removed.
SH05-4	Yes, modified	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Low-Mod	Move approximately 80 feet northeast to keep the turbine further from the edge of slope.	Yes. Moved 53 feet east to back away from steep slope. Could not move north due to wake effect. Also reduced turbine size.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH06-1,2,3,4	Yes	GE 3.8	GE 2.8	7	3	None. This site likely safest site on ridge.	N/A	Mod	No relocation recommended.	Using this site.	Yes - site recommended, turbine blade height above ground increased, and RSA and MWs reduced.
SH07-1,2,3	No	GE 3.8	-	6.5	1	Move to N ridge crest.	Yes. Moved 12 m (40 ft) N (farthest move possible due to wake) to Site 07-4.	Mod	None.	Not using this site.	Yes - site removed.
SH07-4	Yes	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Mod	Move approximately 200 feet northwest to the top of hill/ridge.	No. Could not move further due to wake effect.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH08-1,2,3	No	GE 3.8	-	8	3	None. This site likely safest local option.	N/A	Low	Move 50 feet north to center on ridge top.	Not using this site. Could not move north due to proximity of road.	Yes - site removed.
SH08-4	Yes	GE 3.8	GE 2.8					Low	None. Use modified site 08-1.	Using this site.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH09-1,2,3,4	Yes	GE 3.8	GE 2.3	7	1	Shift west and uphill.	No. Turbine cannot be relocated west and uphill due to wake.	Mod	Move approximately 280 feet northwest to top of hill.	No. Could not move due to wake effect.	Yes - turbine could not be moved, but turbine blade height above ground increased, and RSA and MWs reduced.
SH10-1,2,3,4	Yes	GE 2.3	GE 2.8	7.5	1	None. Uncertain about likely impacts here.	N/A	Low-Mod	Use this site.	Using this site.	Recommended, low-mod risk site, and blade height above ground increased.
SH11-1,2,3,4	Yes	GE 3.8	GE 2.8	4	4	None. This site safest place in area.	N/A	Mod	Use this site.	Using this site.	Yes - site recommended, turbine blade height above ground increased, and RSA and MWs reduced.
SH12-1	No	GE 3.8	-	7	2	Move 25 m west.	Yes. Moved 25 m (82 ft) W, to site 12-4.	Low	Use site 12-4.	Not using this site.	Yes - site removed.
SH12-2	No	GE 3.8	-	6	1	None. This site safest place in area.	N/A.	Low-Mod	Use site 12-4.	Not using this site.	Yes - site removed.
SH12-3	No	GE 3.8	-	6	1	None. This site safest place in area.	N/A	Low-Mod	Use site 12-4.	Not using this site.	Yes - site removed.
SH12-4	Yes, modified	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Low	Use this site.	Following site visit, moved additional 37 feet south. Estep confirmed this location as safe as 12-4, and is also recommended site.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH13-1	No	GE 3.8	-	7	1	Move east to ridge crest.	Yes. Moved 30 m (100 ft) E to ridge crest to site 13-4.	High	Use modified site 13-4.	Not using this site	Yes - site removed.
SH13-2	No	GE 3.8	-	8	3	Use modified site 13 or 13-2.	N/A.	High	Use modified site 13-4.	Not using this site.	Yes - site removed.
SH13-3	No	GE 3.8	-	8.5	3	Move east to peak of hill.	No. Layout 4 does not use this site because site 13 micrometed to reduce risk.	High	As alternative, move this turbine 400 ft NE to top of hill.	Not using this site.	Yes - site removed.
SH13-4	Yes, modified	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	High	Move 50 feet to top of hill.	Yes. Moved 50 feet to top of hill.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.

SH14-1,4	Yes, modified	GE 3.8	GE 2.8	7.5	3	Use site 14-2.	No. Cannot use site 14-2 in Layout 4 due to wake effect.	High	Move 130 feet north along ridge.	Yes. Moved 130 feet north, farther from the shoulder on the south. Although move likely to negatively impact wake, prioritized this move due to high risk designation.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH14-2	No	GE 3.8	-	6.5	2	None.	N/A. Cannot use this site in Layout 4 due to wake effect.	Low-Mod	Use this site.	Unable to use this site due to wake effect.	Yes - site removed.
SH14-3	No	GE 3.8	-	7	3	Use site 14-2.	N/A	Mod	None.	Not using this site.	Yes - site removed.
SH15-1,4	Yes, modified	GE 3.8	GE 2.8	6	2 (3)	Shift north 25 m.	No. Turbine could not be moved due to wake.	High	Move 140 feet northwest to top of ridge.	Yes. Moved 140 feet northwest to top of ridge. Although move likely to negatively impact wake, prioritized this move due to high risk designation.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH15-2	No	GE 3.8	-	6.5	1	Use site 15-1.	N/A	Mod	Move 200 feet northwest to top of ridge.	Not using this site.	Yes - site removed.
SH15-3	No	GE 3.8	-	6.5	2 (4)	Use site 15-1.	N/A	Mod	Move 450 feet northwest to top of hill. This is recommended site.	Not using this site, due to wake effect.	Yes - site removed.
SH16-1,4	Yes, modified	GE 3.8	GE 2.8	7	3	None.	N/A. Using this site in Layout 4 because less risk than 16-2 and 16-3.	High	Move 90 feet east-southeast to top of hill.	Yes. Moved 90 feet east-southeast to top of hill. Although move likely to negatively impact wake, prioritized this move due to high risk designation.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH16-2	No	GE 3.8	-	7	2	None. Recommends avoiding this site.	N/A	High	Move 120 feet east-southeast to top of ridge. This is the recommended site.	Not using this site, due to wake effect.	Yes - site removed.
SH16-3	No	GE 3.8	-	8.5	1	None. Recommends avoiding this site	N/A	High	Limted opportunities to relocate. Would need to move at least 500-600 feet east-southeast.	Not using this site.	Yes - site removed.
SH17-1,4	Yes	GE 3.8	GE 2.8	6	3	Move north to ridge crest	No. Turbine cannot be moved north to ridge crest due to wake. Using this site in Layout 4 because less risk than 17-2.	Mod	Move 230 feet north to top of hill.	No. Could not move due to wake effect.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH17-2	No	GE 3.8	-	8	1	None. Recommends avoiding this site	N/A.	Mod-High	None.	Not using this site.	Yes - site removed.
SH17-3	No	GE 3.8	-	7.5	1	Move north to ridge crest	N/A. Layout 4 uses Site 17-1.	Mod	Move 250 feet west-northwest to top of hill.	Not using this site.	Yes - site removed.
SH18-1,4	Yes, modified	GE 3.8	GE 2.8	7	3	None. This site best option on this ridge	N/A. Using this site in Layout 4 because less risk than 18-2 and 18-3.	High	Move 290 feet northeast to top of ridge.	Yes. Moved 290 feet northeast to top of ridge.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH18-2	No	GE 3.8	-	7	3 (4)	Use site 18-1	N/A	Mod-High	Move 100 feet northeast.	Not using this site due to wake effect.	Yes - site removed.
SH18-3	No	GE 3.8	-	7	2 (4)	Use site 18-1	N/A	Mod-High	None. May be safest site.	Not using this site due to wake effect.	Yes - site removed.
SH19-1,4	Yes	GE 3.8	GE 2.3	6	4	Might be safer 30 m south	No. Cannot move turbine 30m south due to wake.	Mod-High	None.	Using this site.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH19-2	No	GE 3.8	-	6	4	Use either site 19-1 or 19-3	N/A. Using site 19-1 in Layout 4 because safer than site 19-2.	Mod	None.	Not using this site due to wake effect.	Yes - site removed.
SH19-3	No	GE 3.8	-	5	2	None. This site safest local option except for burrowing owls.	N/A. Cannot use this site in Layout 4 due to wake effect.	Low-Mod	Move 200 feet south to top of hill.	No. Not using this site, due to wake effect and additional ground disturbance that would have been required.	Yes - site removed.
SH20-1,4	Yes, modified	GE 3.8	GE 2.8	8	3 (4)	Move N to crest	No. Turbine cannot be moved north to crest due to wake. Using this site in Layout 4 because less risk than 20-2 and 20-3.	Low-Mod	Move 80 feet north-northeast to highest point on ridge. This is the recommended location.	Yes. Moved 80 feet north-northeast to highest point on ridge.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH20-2	No	GE 3.8	-	9.5	1	None. Recommends avoiding this site.	N/A.	Mod	Move 170 feet northwest to ridge top.	Not using this site.	Yes - site removed.
SH20-3	No	GE 3.8	-	8	3	None.	N/A.	Mod	None.	Not using this site.	Yes - site removed.
SH21-1	No	GE 3.8	-	8	2	None. Recommends avoiding this site.	Yes. Moved 150 m E, closer to 21-2 (farthest move possible due to wake), to site 21-4.	High	Move northwest 360 feet to top of hill.	Not using this site.	Yes - site removed.
SH21-2	No	GE 3.8	-	6	1	None. This site safest place in area.	N/A. Cannot use this site in Layout 4 due to wake effect.	Mod	Probably lowest risk site.	Not using this site, due to wake effect.	Yes - site removed.
SH21-3	No	GE 3.8	-	6	1	Use site 21-2.	N/A.	Mod-High	None.	Not using this site.	Yes - site removed.
SH21-4	Yes	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	High	None.	Using this site.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH22-1	No	GE 3.8	-	8.5	2	Move N away from canyon edge or use 22-2.	N/A. Layout 4 uses modified site 22-2.	Mod-High	As alternative, move 200 feet away from east-facing slope.	Not using this site.	Yes - site removed.
SH22-2	No	GE 3.8	-	7.5	2	Move N away from edge of deep ravine.	Yes. Site 22-2 has been relocated 25 m northwest away from edge of ravine, to site 22-4.	Mod-High	None.	Not using this site.	Yes - site removed.
SH22-3	No	GE 3.8	-	7.5	4	Use modified site 22-2.	N/A.	Mod-High	None.	Not using this site.	Yes - site removed.

SH22-4	Yes	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Mod	This is the recommended site.	Using this site.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH23-1,2,3,4	Yes	GE 2.3	GE 2.8	8	2 (3)	None. No safer local option.	N/A	Mod-High	Move 100 feet south to top of hill.	No. Could not move due to setback requirements.	No - constrained by setback requirements, but blade height above ground increased.
SH24-1,2,3,4	Yes, modified	GE 3.8	GE 2.8	6	2	None. No safer local option.	N/A	Low	Move at least 150 feet southwest closer to top of hill.	Yes. Moved 150 feet southwest closer to top of hill.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH25-1,2,3,4	Yes	GE 3.8	GE 2.8	9	3	None. Recommends avoiding this site.	N/A	Mod-High	No recommendation.	N/A	Yes - turbine blade height increased, and RSA and MWs reduced.
SH26-1,2,3	No	GE 3.8	-	8	1	Move SW to crest or south to higher ground.	Yes. Moved 50 m SW to higher ground, to site 26-4.	Mod	Use modified site 26-4.	Not using this site.	Yes - site removed.
SH26-4	Yes, modified	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Low-Mod	Use this site.	Following site visit, moved additional 33 feet south. Estep confirmed this location as safe as 26-4, and is also recommended site.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH27-1,2,3,4	Yes	GE 3.8	GE 2.8	8	-	Move north to hill peak.	No. Unable to move north due to setback requirements.	High	Move 200 feet south to top of hill, or 275 feet north to top of hill.	No. Could not move north due to setback requirements. Could not move south due to wake effect.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH28-1,2,3	No	GE 3.8	-	8	-	Move north to hill peak.	No. Cannot be moved due to wake.	High	Use modified site 28-4.	Not using this site.	Yes - site removed.
SH28-4	Yes	GE 3.8	GE 2.8					High	Move 150 feet toward top of hill.	No. Could not be moved due to wake effect.	Yes-turbine blade height above ground increased, and RSA and MWs reduced.
SH29-1,2,3	No	GE 3.8	-	8	-	Move east to high ground.	Yes. Moved 60 m E to higher ground, to site 29-4.	High	Use modified site 29-4.	Not using this site.	Yes - site removed.
SH29-4	Yes, modified	GE 3.8	GE 2.3				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Mod-High	Move 140 feet east-northeast across road, where site would be considered low risk.	Yes. Moved 165 feet southeast, away from the edge of the swale. Original Estep recommendation could not be made because of setback requirementss. Estep confirmed that this location is only low-to-moderate risk.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH30-1,2,3,4	Yes, modified	GE 3.8	GE 2.8	6	-	None. No better local options.	N/A	High	No recommendation.	Moved slightly based on field visit, and in order to accommodate site 29-4 move. Estep confirmed that new location a slight improvement.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH31-1,2,3	No	GE 3.8	-	4	-	Avoid berm by moving west.	Yes. Moved 25 m W/SW to site 31-4.	Low	Use site 31-4.	Not using this site	Yes - site removed.
SH31-4	Yes	GE 3.8	GE 2.8				Yes. Moved to this site in Layout 4 based on Smallwood recommendation.	Low	Use this site.	Using this site.	Yes - turbine moved, blade height above ground increased, and RSA and MWs reduced.
SH32-1,2,3,4	Yes	GE 3.8	GE 2.3	3	-	None. This site safest place in area.	N/A	Low	Use this site.	Using this site.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH33-1,2,3,4	Yes	GE 3.8	GE 2.8	4	-	None. This site safest place in area.	N/A	Low	Use this site.	Using this site.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH34-1,2,3,4	Yes	GE 3.8	GE 2.8	8	-	None. Recommends avoiding this site.	N/A	High	Move 350 feet east-southeast to hilltop.	No. Could not move due to setback.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH35-1,2,3,4	Yes	GE 3.8	GE 2.8	5	-	None. This site safest place in area.	N/A	Low	Use this site.	Using this site.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH36-1,2,3,4	Yes	GE 3.8	GE 2.8	7	3	Move NNW away from canyon edge.	No. Cannot move due to wake.	Mod	Move 200 feet northwest up slope.	No. Could not move due to wake effect.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH37-1,2,3,4	Yes	GE 3.8	GE 2.3	8	4	Move west to higher ground.	No. Unable to move west due to wake.	High	Move 140 feet south-southwest onto flat ground, or 300 feet west across access road.	No. Could not move due to wake effect.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH38-1,2,3,4	Yes	GE 3.8	GE 2.8	6	2	None. Safest place in area.	N/A	Low	Use this site.	Using this site.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH39-1,2,3,4	Yes	GE 3.8	GE 2.8	6	2	None. Safest place in area.	N/A	Low	Use this site.	Using this site.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.
SH40-1,2,3	No	GE 3.8	-	7	1	None. No local option to recommend.	N/A	Mod	None.	Not using this site.	Yes - site removed.
SH40-4	Yes	GE 3.8	GE 2.8					Mod	Move northwest 275 feet where slope levels off.	No. Could not be moved due to wake effect.	Yes - turbine blade height above ground increased, and RSA and MWs reduced.

EXHIBIT 2

Figure 1: SH01-1,2,3 is representative of Layouts 1-3. SH01-4 was relocated 80 m E in response to Smallwood's recommendation and a beam path constraint. SH01-5 was relocated 60 ft N in response to Estep's recommendation and is the Micro-sited Smaller Turbine Layout (Layout 5).

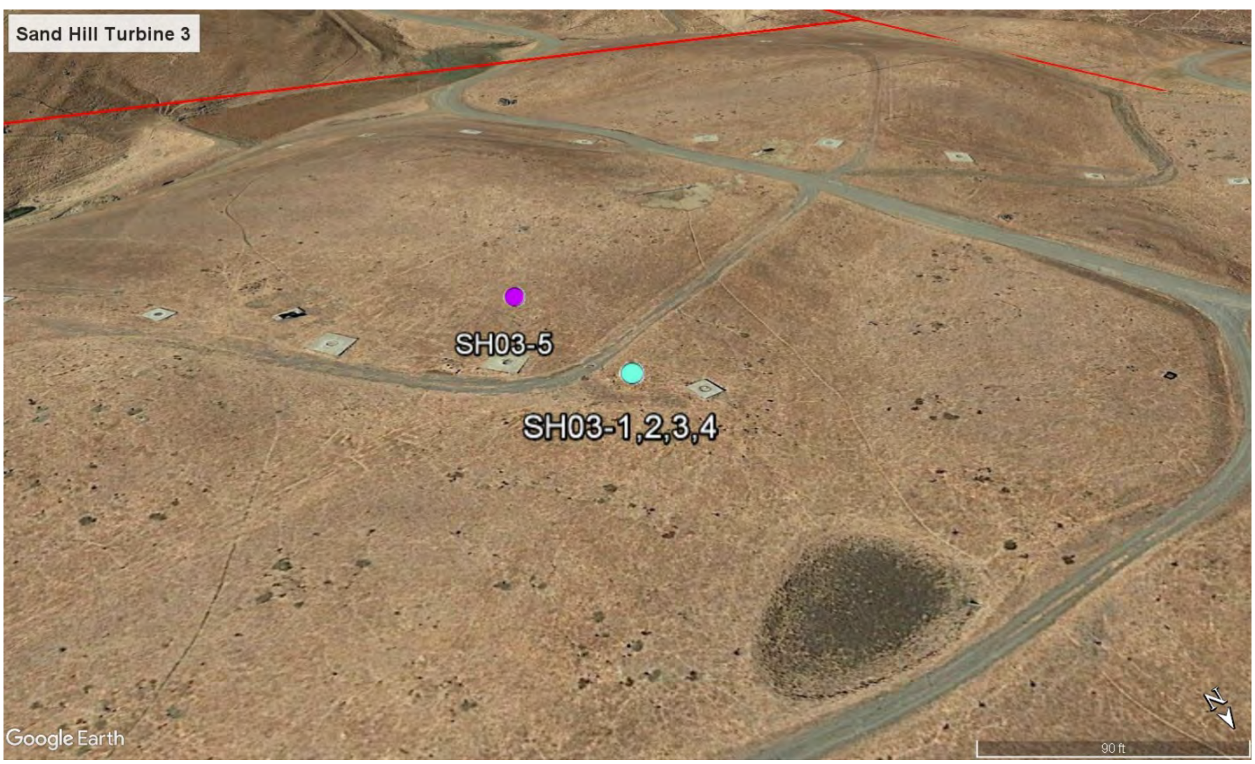

Figure 2: SH03-1,2,3,4 is representative of Layouts 1-4. SH03-5 was relocated 105 ft S in response to Estep's recommendation and is the Micro-sited Smaller Turbine Layout (Layout 5).

Figure 3: SH04-1,2,3 is representative of Layouts 1-3. SH-04-4,5 was relocated 80 m SW away from the ravine and closer to the top of the hill and is the Micro-sited Smaller Turbine Layout (Layout 5).

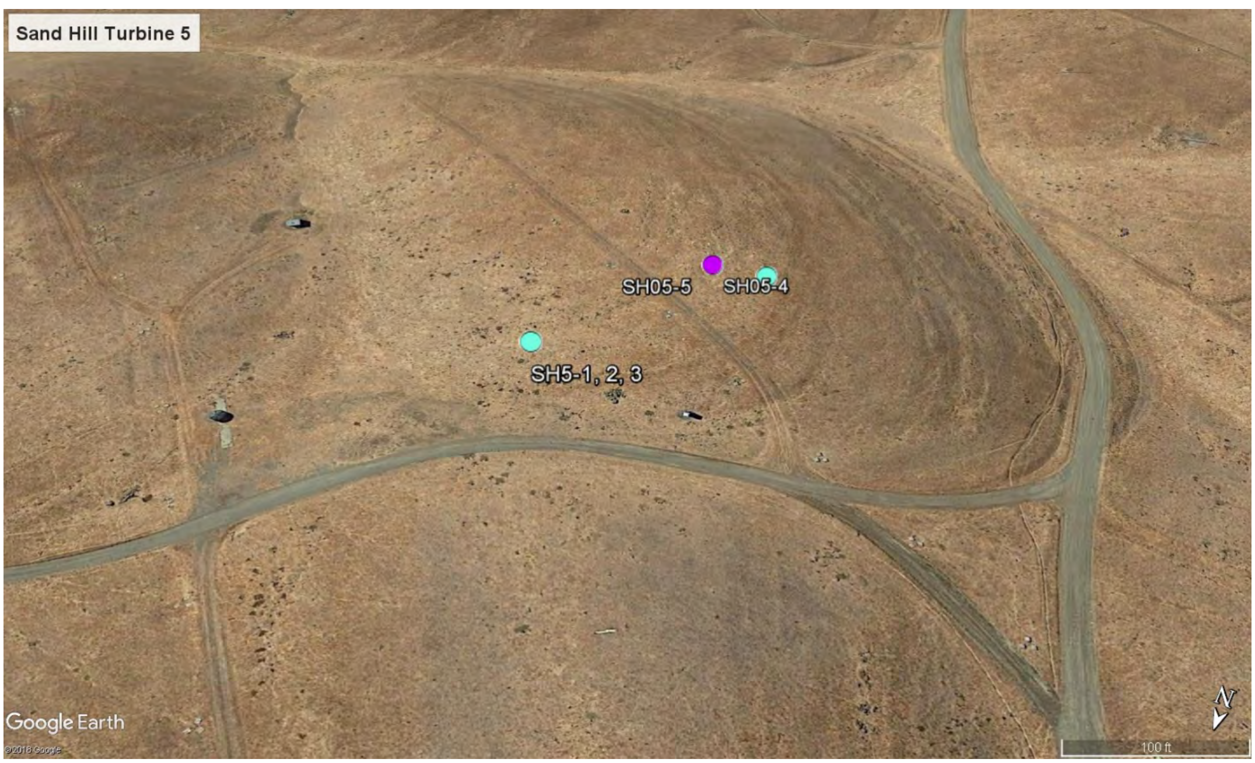

Figure 4: SH05-1,2,3 is representative of Layouts 1-3. SH05-4 was relocated 62 m SW in response to Smallwood's recommendation. SH05-5 was relocated 53 ft E in response to Estep's recommendation and is the Micro-sited Smaller Turbine Layout (Layout 5).

Figure 5: SH07-1,2,3 is representative of Layouts 1-3. SH07-4,5 was relocated 12 m N in response to Smallwood's recommendation and is the Micro-sited Smaller Turbine Layout (Layout 5).

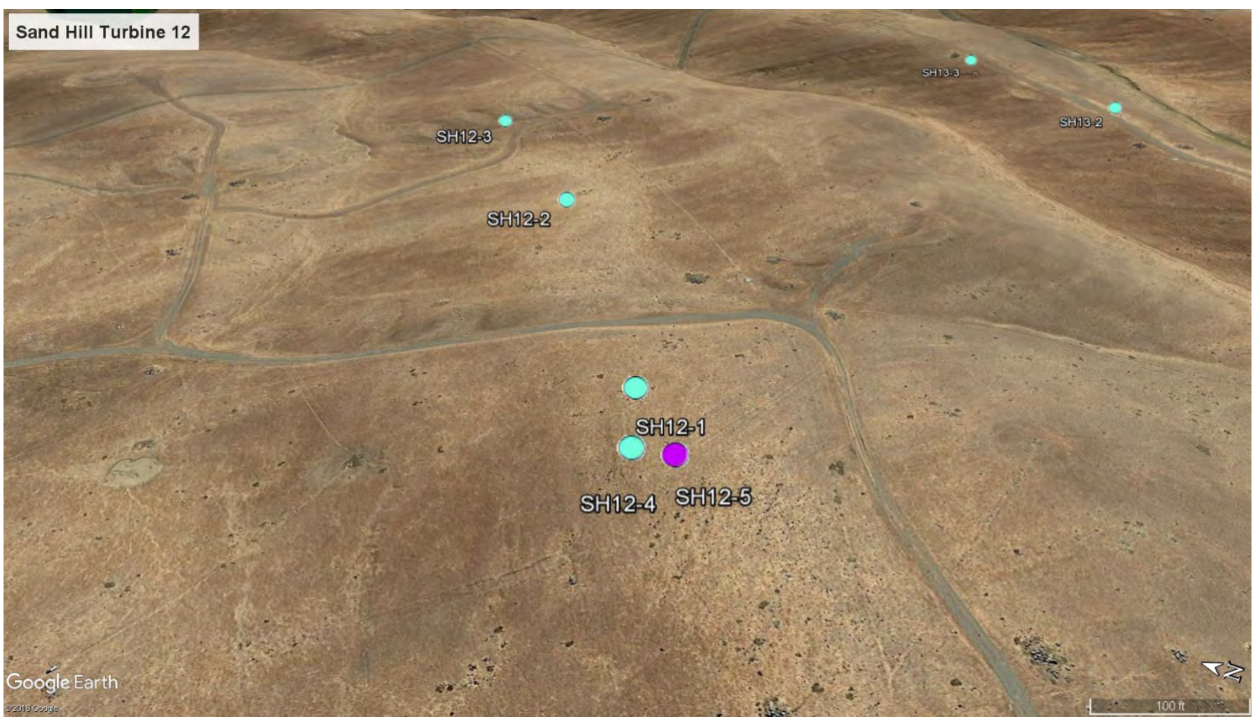

Figure 6: SH12-1,-2,-3 are representative of Layouts 1-3. SH12-4 was relocated 25 m W in response to Smallwood's recommendation. SH12-5 was relocated 37 ft S following a site visit and is the Micro-sited Smaller Turbine Layout (Layout 5).

Figure 7: SH13-1,-2,-3 are representative of Layouts 1-3. SH13-4 was relocated 30 m E in response to Smallwood's recommendation. SH13-5 was moved 50 ft NW to top of hill in response to Estep's recommendation and is the Micro-sited Smaller Turbine Layout (Layout 5).

Figure 8: SH14-1,4,-2,-3 are representative of Layouts 1-4. SH14-5 was relocated 130 ft N away from southern shoulder in response to Estep's recommendation and is the Micro-sited Smaller Turbine Layout (Layout 5).

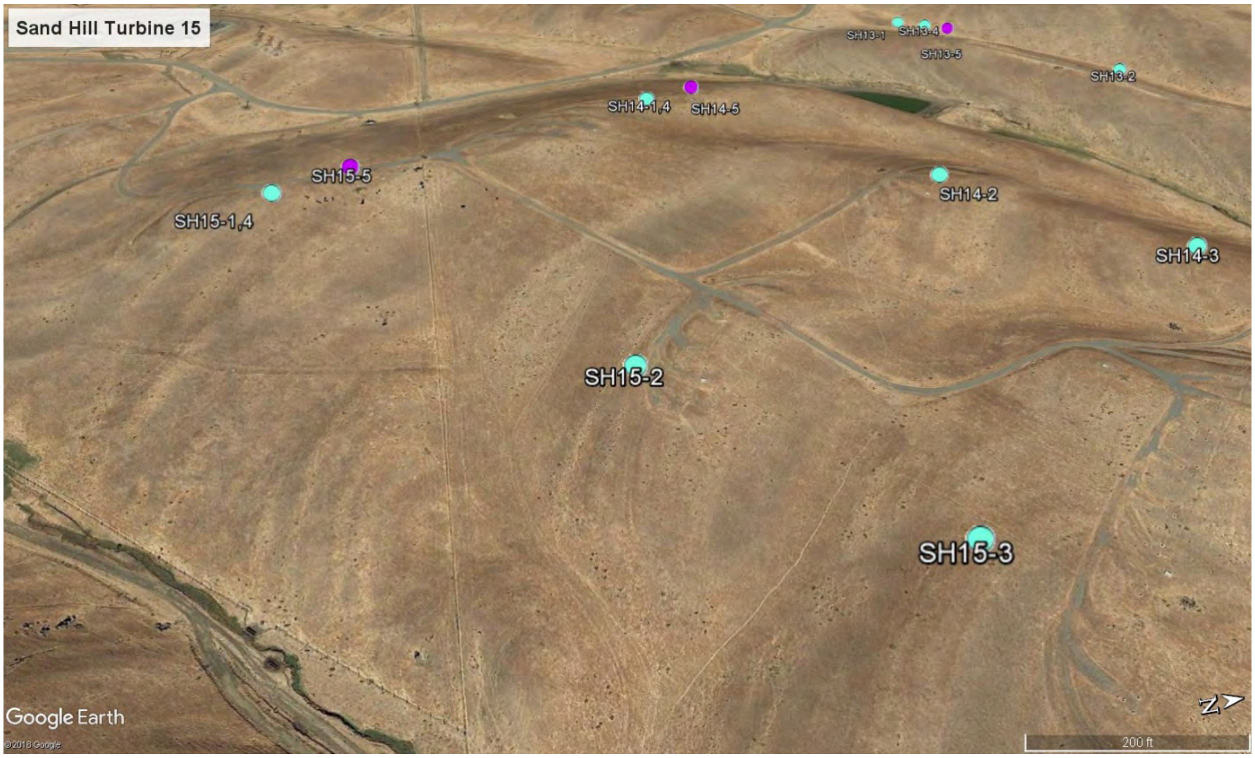

Figure 9: SH15-1,4,-2,-3 are representative of Layouts 1-4. SH15-5 was relocated 140 ft NW in response to Estep's recommendation and is the Micro-sited Smaller Turbine Layout (Layout 5).

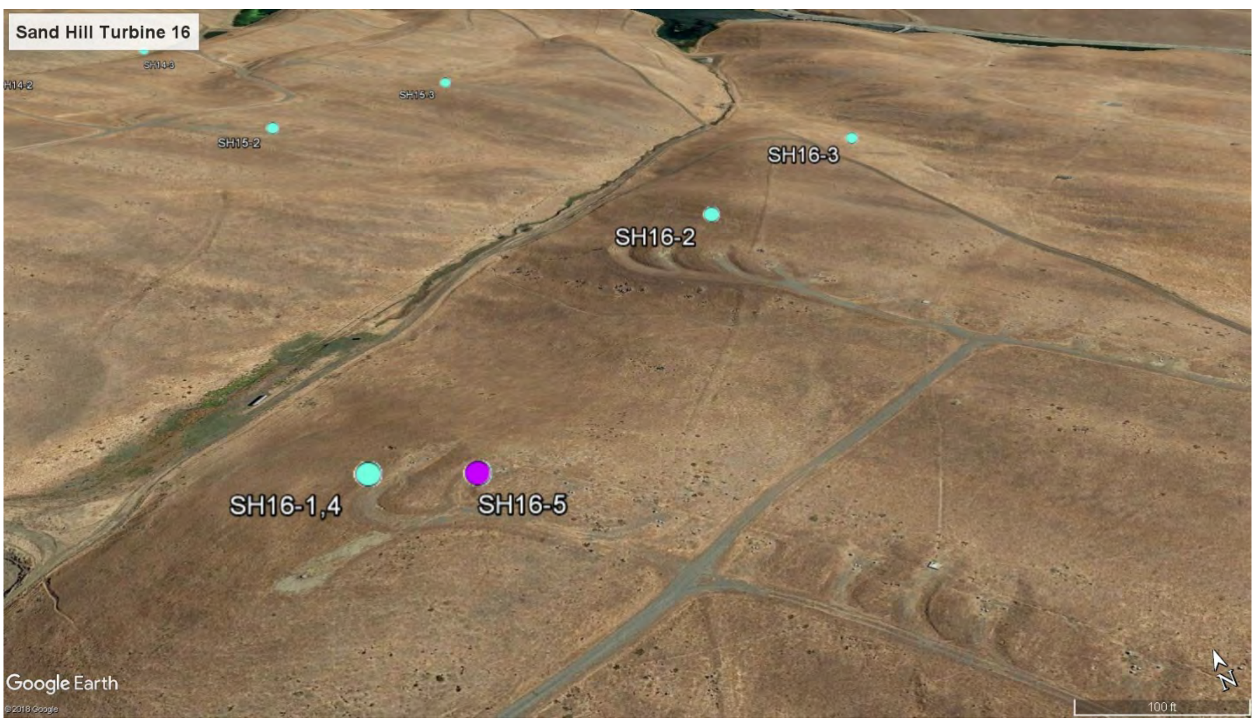

Figure 10: SH16-1,4,-2,-3 are representative of Layouts 1-4. SH16-5 was relocated 90 ft E/SE to top of hill in response to Estep's recommendation and is the Micro-sited Smaller Turbine Layout (Layout 5).

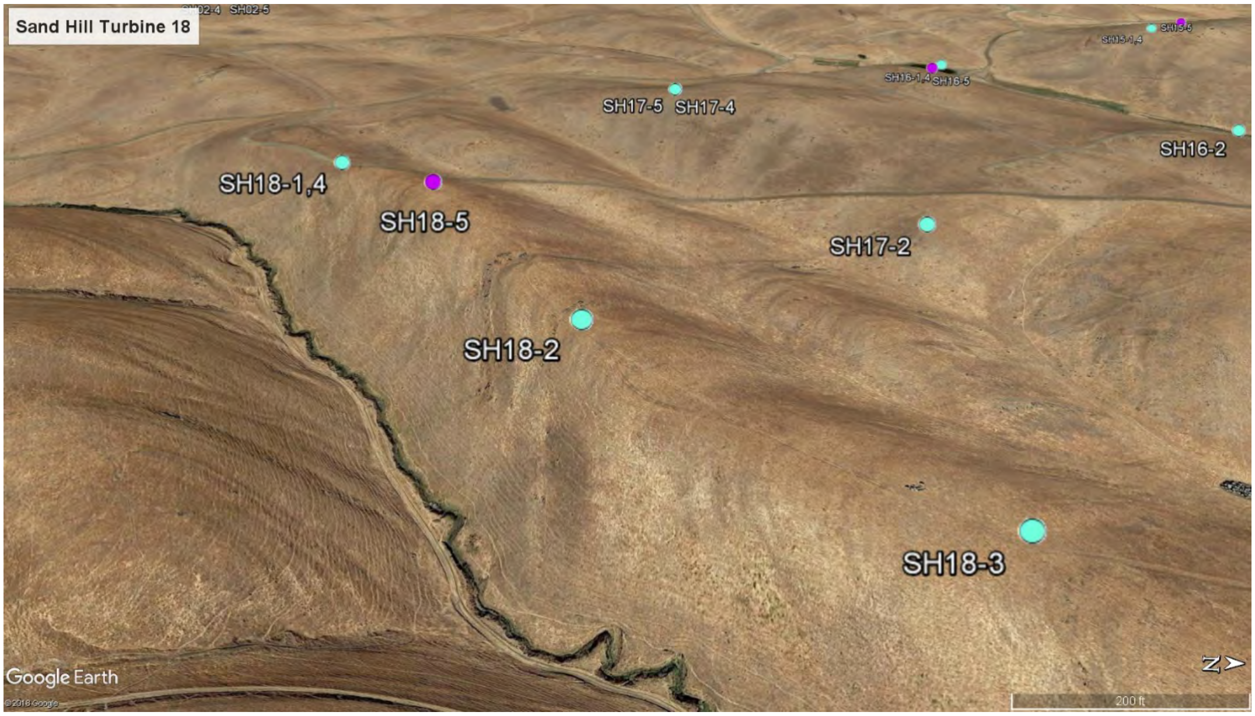

Figure 11: SH18-1,4,-2,-3 are representative of Layouts 1-4. SH18-5 was relocated 290 ft NE in response to Estep's recommendation and is the Micro-sited Smaller Turbine Layout (Layout 5).

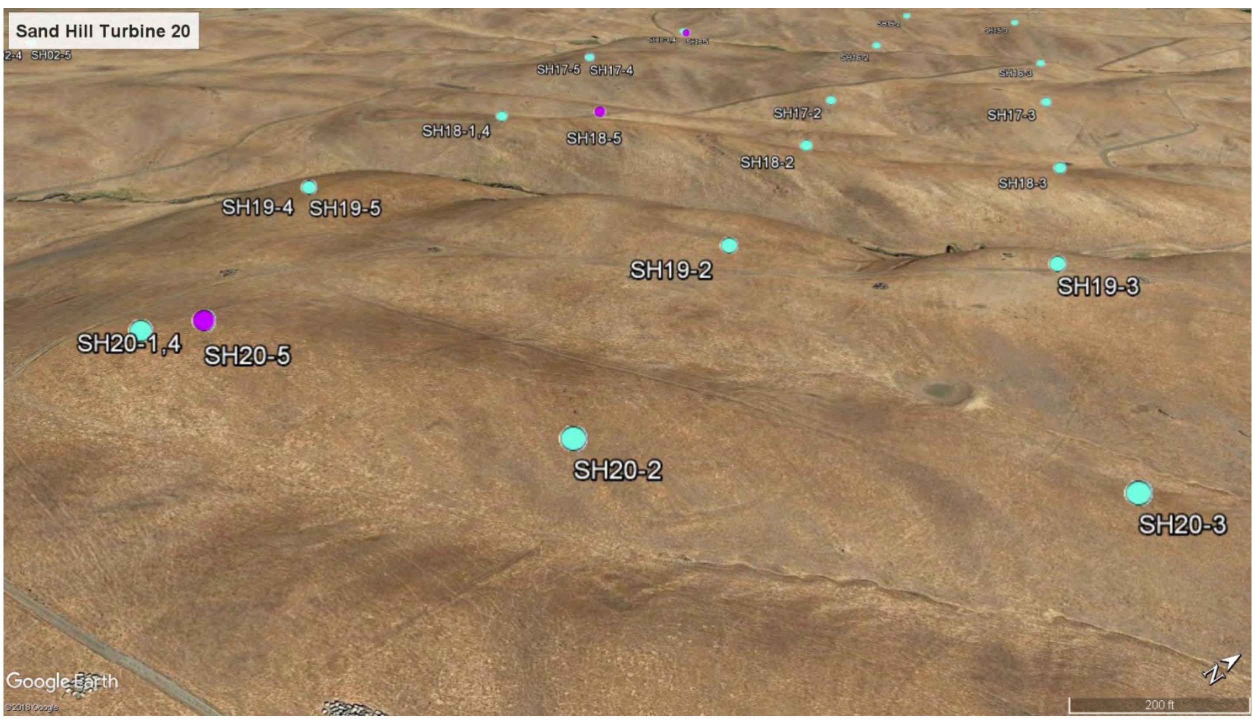

Figure 12: SH20-1,4,-2,-3 are representative of Layouts 1-4. SH20-5 was relocated 80 ft N/NE to highest point on the ridge in response to Estep's micro-siting recommendation and is the Micro-sited Smaller Turbine Layout (Layout 5).

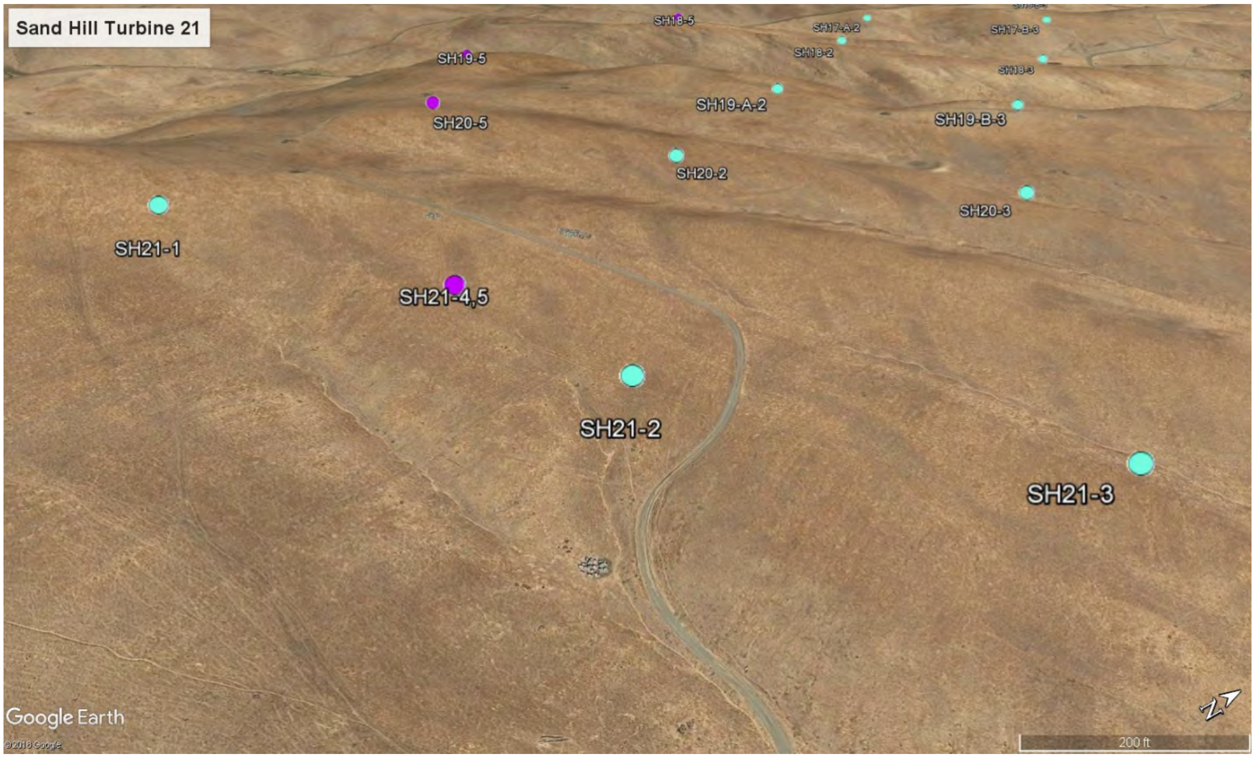

Figure 13: SH21-1,-2,-3 are representative of Layouts 1-3. SH21-4,5 was relocated 150 m E in response to Smallwood's recommendation and is the Micro-sited Smaller Turbine Layout (Layout 5).

Figure 14: SH22-1,2,3 are representative of Layouts 1-3. SH22-4,5 was relocated 25 m NW from edge of ravine in response to Smallwood's recommendation and is the Micro-sited Smaller Turbine Layout (Layout 5).

Figure 15: SH24-1,2,3,4 is representative of Layouts 1-4. SH24-5 was relocated 150 ft SW toward the hilltop in response to Estep's recommendation and is the Micro-sited Smaller Turbine Layout (Layout 5).

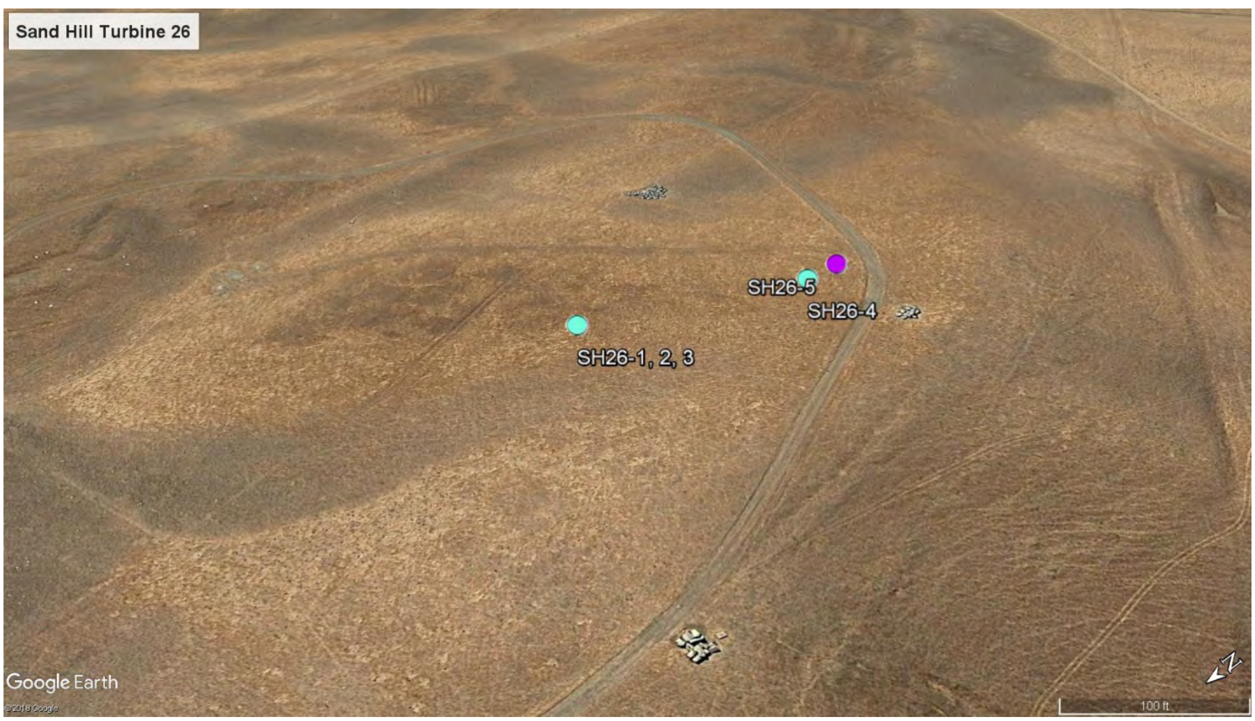

Figure 16: SH26-1,2,3 is representative of Layouts 1-3. SH26-4 was relocated 50 m SW upslope in response to Smallwood's recommendation. SH26-5 was moved an additional 33 ft S following a site visit and is the Micro-sited Smaller Turbine Layout (Layout 5).

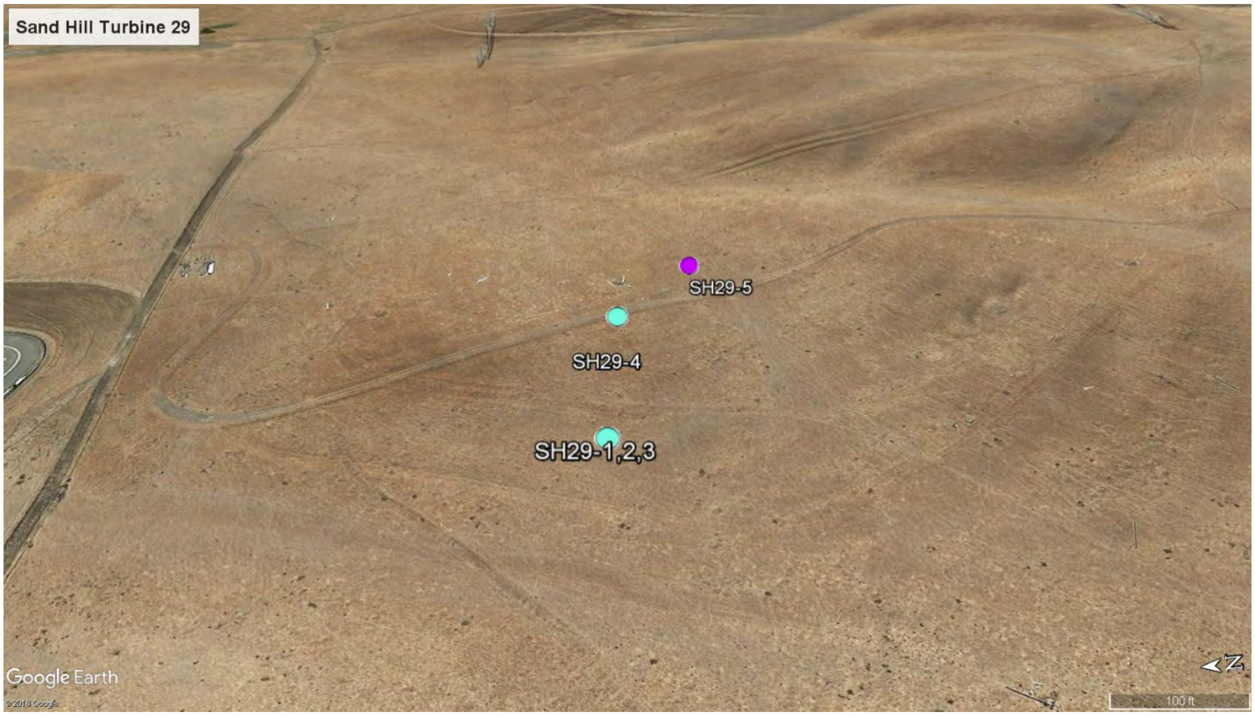

Figure 17: SH29-1,2,3 is representative of Layouts 1-3. SH29-4 was relocated 60 m E in response to Smallwood's recommendation. SH29-5 was relocated an additional 165 ft SE from the edge of the swale following a site visit and is the Micro-sited Smaller Turbine Layout (Layout 5).

Figure 18: SH30-1,2,3,4 is representative of Layouts 1-4. SH30-5 was moved slightly following a site visit and is the Micro-sited Smaller Turbine Layout (Layout 5).

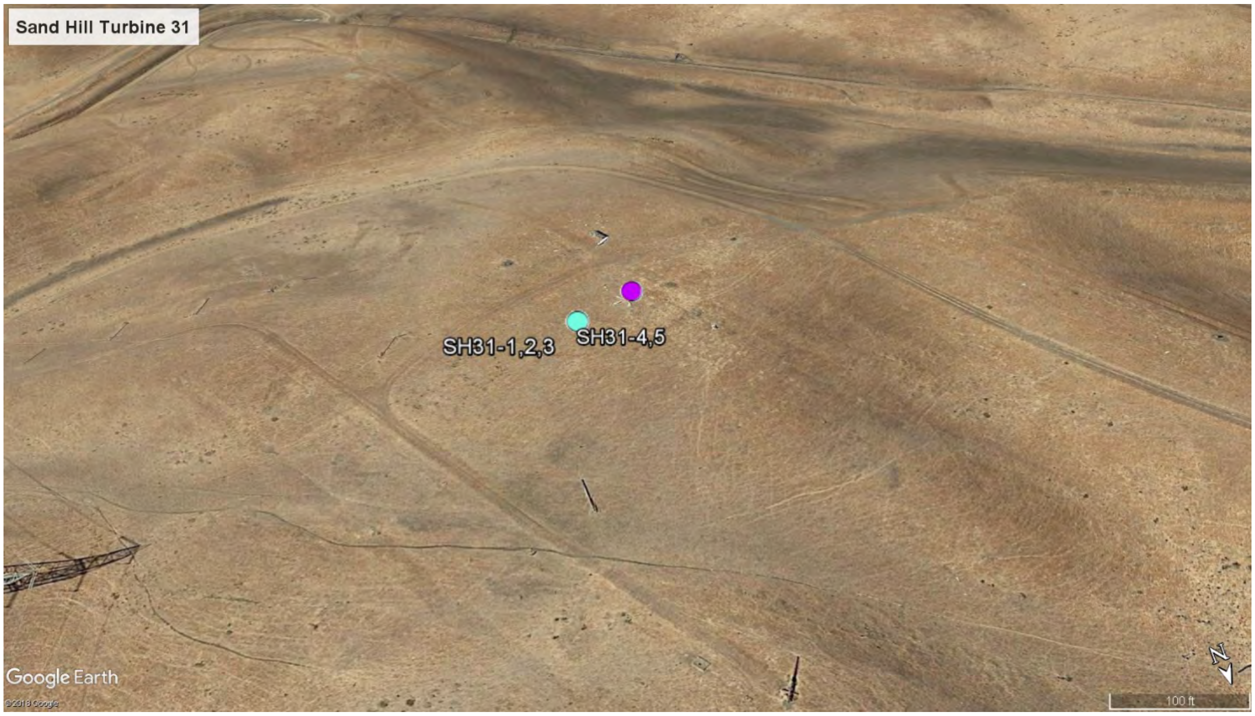

Figure 19: SH31-1,2,3 is representative of Layouts 1-3. SH31-4,5 was relocated 25 m W/SW in response to Smallwood's recommendation and is the Micro-sited Smaller Turbine Layout (Layout 5).