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BEFORE THE FEDERAL AVIATION ADMINISTRATION

ASN 2019-WTW-4517-OE through ASN 2019-WTW-4580-OE, inclusive and ASN 2019-WTW-4585-OE through ASN 2019-WTW-4592-OE, inclusive	**Petition for Review by Backcountry Against Dumps, Donna Tisdale, and Joe "Ed" Tisdale Regarding No Hazard to Air Navigation Determinations for 72 Turbines Associated with the Campo Wind Project**

INTRODUCTION

Pursuant to 49 U.S.C. section 44718 and 14 C.F.R. section 77.39(b), we respectfully submit the following Petition for Review on behalf of Backcountry Against Dumps, Donna Tisdale, and Joe "Ed" Tisdale (collectively, "Backcountry"), objecting to and seeking review of the Federal Aviation Administration's ("FAA's") July 16, 2020 Determinations of No Hazard to Air Navigation for 72 wind turbines associated with the Campo Wind Project with Boulder Brush Facilities ("Campo Wind" or the "Project"). This Petition addresses the identical determination letters issued by the FAA for each of the Project's turbines, identified as ASN 2019-WTW-4517-OE through ASN 2019-WTW-4580-OE, inclusive, and ASN 2019-WTW-4585-OE through ASN 2019-WTW-4592-OE, inclusive.[1]

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[1] The 72 determinations relate to ASN 2019-WTW-4517-OE, ASN 2019-WTW-4518-OE, ASN 2019-WTW-4519-OE, ASN 2019-WTW-4520-OE, ASN 2019-WTW-4521-OE, ASN 2019-WTW-4522-OE, ASN 2019-WTW-4523-OE, ASN 2019-WTW-4524-OE, ASN 2019-WTW-4525-OE, ASN 2019-WTW-4526-OE, ASN 2019-WTW-4527-OE, ASN 2019-WTW-4528-OE, ASN 2019-WTW-4529-OE, ASN 2019-WTW-4530-OE, ASN 2019-WTW-4531-OE, ASN 2019-WTW-4532-OE, ASN 2019-WTW-4533-OE, ASN 2019-WTW-4534-OE, ASN 2019-WTW-4535-OE, ASN 2019-WTW-4536-OE,

Each determination letter states that the turbines will not constitute a hazard to navigation in reliance upon identical analyses and responses to comments. Yet the evidence before the FAA shows that each of the Project's wind turbines will create significant hazards to air navigation. Thus the determination letters fail to present a reasoned explanation, supported by the facts and applicable law, for the FAA's conclusions as required by law. Backcountry's January 29, 2020 comments raised several valid concerns regarding the Project's air navigation hazards that have not been appropriately resolved in the July 16, 2020 determination letters. Instead, those concerns remain unaddressed and preclude approval of this dangerous Project. For the reasons detailed below in Parts I and II, this Petition for Review should be granted to resolve these outstanding and serious safety concerns.

This Petition also addresses, in Part III, the grave deficiencies of the Bureau of Indian Affairs' Final Environmental Impact Statement for the Project. As a cooperating agency under the NEPA Guidelines, 40 C.F.R. section 1508.5, the FAA must assure that the EIS conforms to NEPA.

FULL STATEMENT OF THE AERONAUTICAL BASIS ON WHICH THE PETITION IS MADE

I. THE PROJECT SITE CURRENTLY SUPPORTS NAVIGABLE AIRSPACE

ASN 2019-WTW-4537-OE, ASN 2019-WTW-4538-OE, ASN 2019-WTW-4539-OE,
ASN 2019-WTW-4540-OE, ASN 2019-WTW-4541-OE, ASN 2019-WTW-4542-OE,
ASN 2019-WTW-4543-OE, ASN 2019-WTW-4544-OE, ASN 2019-WTW-4545-OE,
ASN 2019-WTW-4546-OE, ASN 2019-WTW-4547-OE, ASN 2019-WTW-4548-OE,
ASN 2019-WTW-4549-OE, ASN 2019-WTW-4550-OE, ASN 2019-WTW-4551-OE,
ASN 2019-WTW-4552-OE, ASN 2019-WTW-4553-OE, ASN 2019-WTW-4554-OE,
ASN 2019-WTW-4555-OE, ASN 2019-WTW-4556-OE, ASN 2019-WTW-4557-OE,
ASN 2019-WTW-4558-OE, ASN 2019-WTW-4559-OE, ASN 2019-WTW-4560-OE,
ASN 2019-WTW-4561-OE, ASN 2019-WTW-4562-OE, ASN 2019-WTW-4563-OE,
ASN 2019-WTW-4564-OE, ASN 2019-WTW-4565-OE, ASN 2019-WTW-4566-OE,
ASN 2019-WTW-4567-OE, ASN 2019-WTW-4568-OE, ASN 2019-WTW-4569-OE,
ASN 2019-WTW-4570-OE, ASN 2019-WTW-4571-OE, ASN 2019-WTW-4572-OE,
ASN 2019-WTW-4573-OE, ASN 2019-WTW-4574-OE, ASN 2019-WTW-4575-OE,
ASN 2019-WTW-4576-OE, ASN 2019-WTW-4577-OE, ASN 2019-WTW-4578-OE,
ASN 2019-WTW-4579-OE, ASN 2019-WTW-4580-OE, ASN 2019-WTW-4585-OE,
ASN 2019-WTW-4586-OE, ASN 2019-WTW-4587-OE, ASN 2019-WTW-4588-OE,
ASN 2019-WTW-4589-OE, ASN 2019-WTW-4590-OE, ASN 2019-WTW-4591-OE, and
ASN 2019-WTW-4592-OE

The Project site lies directly beneath, and the Project will directly obstruct, navigable airspace that is actively utilized for military, commercial and private flights. The site is located in the Border Zone (FAA Notice at 7) and is situated between and in proximity to numerous military bases and air stations in California vital to the nation's defense, including the Naval Base in San Diego, the Naval Air Facility in El Centro, the Naval Special Forces Training Facility in nearby Campo, and the Marine Corps Air Station in San Diego. This same airspace is also in use by the Marine Corps Air Station in Yuma, Arizona.[1] The Project site is located within an active route between these military bases and air stations, and is regularly frequented by their low flying aircraft.

Our client Donna Tisdale and her family own 267 acres on Tierra Real Road near Boulevard that share a half mile-long boundary with the Campo Reservation and the Project site on the Reservation's southeastern border along BIA Road 10. Ms. Tisdale regularly observes homeland security and military aircraft, as well as commercial and private aircraft, flying over the Project site. These aircraft often pass directly over the Project site at very low altitudes. We attach as Exhibit 2 illustrative photographs taken by Ms. Tisdale that show examples of the many low-flying aircraft she routinely observes over the Project site.[2]

II. THE PROJECT WILL IMPEDE AIRCRAFT SAFETY AND OPERATIONS

A. Low Flying Aircraft

The Project location is situated directly between several airports used by general aviation pilots flying under visual flight rules ("VFR"), including Montgomery Field, Gillespie Field, and Lindbergh Field in San Diego County, Imperial County Airport, and Yuma, in Arizona. The FAA's Determination Letters acknowledge that "the proposed wind farm would extend upwards into airspace used normally for en route VFR traffic." Determination Letters, p. 6. Indeed, flights from Montgomery or Lindbergh fields to Yuma would likely pass directly over the Project. Yet the Determination Letters state, erroneously, that "no data was available or received during the aeronautical study to indicate the wind farm would be located near a regularly and continuously used VFR en route flyway." *Id.*

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[1] Military Base List, available at: https://www.military.com/base-guide, last accessed January 8, 2020.

[2] Photographs of the airspace above the Project site taken by Donna Tisdale, attached hereto as **Exhibit 2**.

It is apparent that the Determination Letters' conclusions are not supported by, and instead conflict directly with, the evidence. The documentation in the FAA's files shows, contrary to the Determination Letters, that the Project is located directly within a regularly, and continuously, used VFR en-route flyway. The FAA's Handbook definitively states that "[a] structure would have an adverse effect upon VFR air navigation if its height is greater than 499 feet above the surface at its site, and within 2 statute miles of any regularly used VFR route." Procedures for Handling Airspace Matters, FAA Order JO 7400.2M ("Handbook") (February 28, 2019), 6-3-8(c)(1); *Town of Barnstable, Mass. v. FAA*, 659 F.3d 28, 34-35 (D.C.Cir. 2011). The Project meets both of these criteria. The wind turbines are all well over 499 feet tall, and the Project site is located within a well known and frequently used VFR route.

The Determination Letters next dismiss any hazards to firefighting and agricultural operations on the grounds that they operate below the minimum safe altitudes specified in 14 CFR part 91, "are not regular and continuous flight operations and therefore are not considered in determining the extent of adverse effect." Determination Letters, pp. 5, 6. But this fact does not mean these indisputable impacts can be ignored. It is true that 14 CFR section 137.49 permits these pilots to operate aircraft "over other than congested areas below 500 feet above the surface and closer than 500 feet to persons, vessels, vehicles, and structures, if the operations are conducted without creating a hazard to persons or property on the surface." 14 C.F.R. § 137.49. But nothing in the FAA's regulations regarding hazards (14 CFR part 77) excuses the FAA's out-of-hand dismissal of this potential hazard simply because such operations are "not considered regular and continuing." Indeed, the law is clear that the FAA must consider in its navigational study "other factors relevant to the efficient and effective use of navigable airspace" in making its determination. 49 U.S.C. § 44718 (b)(1)(A)(vii). Impacts to aerial firefighting and agricultural operations in the remote, fire prone Campo community are just the sort of "other factors" that should be considered in the FAA's analysis.

The FAA relies upon its internal policy guidance's definition of "significant volume" in order to limit its consideration of these significant adverse effects. Determination Letters, p. 6 (citing JO

7400.2L, par. 6-3-5).[3] JO 7400.2M, Policy 6-3-4 indicates that a structure would impact "regular and continuing" operations if the structure affected "one or more operations" a day. But this policy also notes that if the impacted procedure is the primary procedure, it may need to be used on average only once per week for a structure that affects it to cause a significant impact on aeronautical activities. The local Jacumba Airport, which is less than 10 nautical miles from the Project location, is primarily used for agricultural purposes and recreation including sailplanes and gliders, whose use is not subject to the minimum altitudes.[4] The Determination Letters ignore this primary use in evaluating the Project's significant impacts.

The Determination Letters also claim that aerial firefighting is beyond the scope of an aeronautical study because of "the many possible situations and unique operating characteristics." Determination Letters, p. 6. But the unique nature of aerial firefighting does not mean it should be ignored. To the contrary, because aerial firefighting is so important, the FAA should consider how the Project will create hazards to those operations. The Project itself will introduce myriad new wildfire ignition sources. High voltage wind turbines—which have a documented history of erupting in flame when their motors burn or short out or their bearings wear out—together with a high voltage substation and gen-tie line, and other electrified Project facilities will dramatically increase the risk of wildfire ignition in the area. This greatly increased risk of ignition, in turn, exponentially increases the likelihood that firefighting resources will be needed at this location in the first place.

Wind turbines and meteorological towers present a direct risk of collision with aircraft. Between 2003 and 2016 ten individuals were killed in the United States as a result of aircraft collisions with wind energy turbines and their towers.[5] This well-documented risk is multiplied in an area like the Project site

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[3] Backcountry notes that the Determination Letters rely upon JO 7400.2L, which was withdrawn in February 2019. JO 7400.2M, the applicable current verison, contains the same policies as they relate to this issue.

[4] *See, e.g.*, FAA Notice to Airmen "Frq Gld Act Drg Wkends, Pwrd Acft be Alert for Gld Tfc Launching Frm Field and Operg on and in Vcnty of Ap, Sfc to 18000 Ft MSL.," *see also* Aircraft Owners and Pilots Association webpage for Jacumba Airport: available at https://www.aopa.org/destinations/airports/L78/details; New Desert Times, Towns of Yesteryear, available at: http://newdeserttimes.com/the-towns-of-yesteryear/)

[5] Linowes, Lisa, *Wind Energy and Aviation Safety, Fatalities,* WindAction.org, April 4, 2017, attached hereto as **Exhibit 4**.

where, despite the mountainous terrain, low flying aircraft are a regular occurrence. The determination letters dismiss this concern without a word, instead focusing on the review provided by each branch of service. Determination Letters, p. 5. But these low flying aircraft are essential to effective firefighting in this wildfire-prone area. The Project will add to the risk of wildfire, and worse, impede wildfire suppression, particularly by aircraft. Therefore the FAA must consider this risk as part of its examination of the hazards this Project poses to public, including aviation, safety.

B. Radar

Radar systems may be impaired or disrupted by wind energy facilities. Radar systems are designed to filter out false information, or "clutter."[6] Where wind energy turbines create dense centers of stationary clutter, radar may be tricked into increasing the clutter threshold, effectively causing radar systems to miss other, actual obstacles that would normally appear on the radar. Exhibit 3, at 20-21; Exhibit 6, at 57.

The Determination Letters indicate that four of the Project's turbines are expected to interfere with radar quality at the San Clemente ARSR-4 radar facility, and could present clutter and target drops in the immediate area of the turbines. Determination Letters pp. 4-5. Despite this impact, the Determination Letters indicate that this will not be a navigation hazard because "this would not cause an unacceptable adverse impact on [air traffic control] or military operations in the area at this time." Determination Letters 6. But the FAA does not present any reasoning or underlying facts to support its conclusion that these radar impacts would not pose serious hazards to aviation safety.

Degradation of radar function is extremely dangerous to aircraft operations because radar is one of the main tools on which instrumented pilots rely to navigate, particularly when visibility is reduced due to rain, snow, cloud cover or darkness. Because the Project site is located in mountainous terrain where storm activity is more frequent and severe winds, including sudden up- and down-drafts associated with the steep eastern escarpment of the coast range, are more common, impaired visibility combined with degraded radar function pose particularly severe aviation hazards. Indeed, because of the area's high risk of severe winds, the east-bound (down-gradient) lanes of the adjacent Interstate 8

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[6] Novak, Andrej, *Wind Farms and Aviation*, Aviation, 2009, 13:2, 56-59, p. 57, attached hereto as **Exhibit 6**.

freeway are often unsafe for, and occasionally closed to, truck traffic. These risks cannot be ignored. Yet in dismissing the Project's degradation of radar function as inconsequential, the Determination Letters do exactly that.

C. Lighting

While the turbines and their towers are required to have lights indicating their location, those lights do not eliminate the aviation risk entirely. The turbines' blade sweep would extend 230 feet above the highest light, which would be located on the nacelle. The determination letters note that "current guidance recommends placing the obstruction lighting as high as possible on the turbine's nacelle so they are visible to pilots approaching the turbine from any direction," but they fail to address the atypically large size of these turbines. The 230-foot blade sweep is gigantic. It is equivalent to having a 20-story building rotating a fast speeds around the nacelle. A small light at the bottom of a 20 story building would give a pilot very little idea of where the top of that building would be, particularly if the building were spinning as these huge rotor blades will be. The lighting will be similarly ineffective here. Therefore this additional hazard to aviation should be recognized and addressed, rather than swept aside as insignificant.

The Determination Letters imply that the Project's turbines will not cause a hazard to navigation for pilots flying with night vision goggles. But the Determination Letters contain no requirement that the Project utilize night vision goggle-compatible lighting. Instead, the FAA's response indicates only that such lighting "is available for pilots operating under [night vision goggles] in the area of the wind farm." Determination Letters, p. 5. Other wind farms have had conditions imposed that mandate that wind turbine lighting emit infrared energy within 675–900 nanometers in order to be visible to pilots using night vision goggles. *See, e.g.* U.S. Department of the Interior, Bureau of Ocean Energy Management, 2015 Revised Environmental Assessment for Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore North Carolina, p. 4-25 available at https://www.boem.gov/sites/default/files/renewable-energy-program/State-Activities/NC/NC-EA-Camera-FONSI.pdf. Here however, neither the FAA's conditions included in its no-hazard determinations, nor the Bureau of Indian Affair's Record of Decision for the Project, impose this essential requirement. Absent such a condition here, the FAA's no-hazard determination is an abuse of discretion.

D. Turbulence

Turbulence from wind turbines can impact aeronautic operations.[7] Exhibit 3, at 31-34. "[W]ind turbines produce wakes of similar, but not identical, characteristics to aircraft" and for this reason "aircraft wake vortices can be hazardous to other aircraft." Exhibit 3, at 31. The Determination Letters dismiss the Project-caused turbulence in a single line, equating it to "severe weather phenomenon" and declaring that it is beyond the scope of the aeronautical study. Determination Letters, p. 6. But this is not a weather phenomenon. This is not unexpected turbulence caused by meteorological events. This is man-made, human-caused turbulence that can be entirely avoided is appropriate safeguards are required. Ignoring the problem rather than recognizing and addressing it is an abuse of discretion.

E. Cumulative Impacts

The FAA is also required to determine whether the Project's turbines would have a cumulatively significant adverse impact. The Determination Letters conclude that they would not have such an impact because the "Study did not disclose any significant adverse effect on existing or proposed public-use or military airports or navigational facilities, nor would the proposal affect the capacity of any known existing or planned public-use or military airport." Determination Letters, p. 7. But as shown above, each turbine will indeed have an impact on navigable airspace and the Project as a whole will significantly impact numerous resources. This failure to identify the Project's cumulative impacts is especially egregious here because there are now many wind turbine projects situated throughout this windy mountainous region, creating a maze of hazards for pilots. As with every impact discussed herein, the Project's cumulative impacts must not be ignored.

III. THE APPROVAL OF THIS PROJECT VIOLATES NEPA

A. The FEIS Unlawfully Segments the Analysis of Connected Actions

The National Environmental Policy Act ("NEPA"), 42 U.S.C. sections 4321, et seq., forbids "segmented" environmental review. 40 C.F.R. § 1508.25(a)(1). Connected actions must be considered

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[7] Mulinazzi, Thomas E., Zheng, Zhingquan Charlie, *Wind Farm Turbulence Impacts on General Aviation Airports in Kansas*, Kansas Department of Transportation, Report No. K-TRAN: KU-13-6, January 2014, attached hereto as **Exhibit 5**.

together in a single environmental impact statement. *Thomas v. Peterson*, 753 F.2d 754, 759 (9th Cir. 1985) (overruled on other grounds by *Cottonwood Environmental Law Center v. U.S. Forest Service*, 789 F.3d 1075, 1088-1092 (9th Cir. 2015)). Connected actions are those that (1) "[a]utomatically trigger" other actions, (2) "cannot or will not proceed unless other actions are taken previously or simultaneously," or (3) are "interdependent parts of a larger action and depend on the larger action for their justification." 40 C.F.R. § 1508.25(a)(1). Actions do not lose their "connected" status just because they are proposed by a different project applicant. *Alpine Lakes Protection Society v. U.S. Forest Service*, 838 F.Supp. 478, 482 (W.D. Wash. 1993).

Here, the Bureau of Indian Affairs' ("BIA's") Final Environmental Impact Statement ("FEIS") – for which the FAA is a cooperating agency – improperly segments the analysis of connected actions in at least two ways. First, the FEIS fails to analyze the impacts of the connected Torrey Wind project, instead considering it only a cumulative action. FEIS at RTC-10. The Torrey Wind project is a proposed 30-turbine126-MW wind energy generation facility that the Boulder Brush facilities would enable. The FEIS acknowledges that the Boulder Brush project and the Torrey Wind project "do propose to share a high-voltage substation and switchyard on private lands that would be used to interconnect both projects to the existing Sunrise Powerlink transmission line." FEIS at RTC-9. However, the FEIS claims that "the Torrey Wind Project is not a connected action because it would not be triggered by the Project and because the Project is not dependent on the Torrey Wind Project to proceed." FEIS at RTC-9. But it simultaneously admits that the Boulder Brush "high-voltage substation would allow for the receiving and stepping up of electric energy from 230 kV to 500 kV for the Torrey Wind Project." FEIS at B-12. Because the Torrey Wind project would not proceed as planned without the approval and construction of the Boulder Brush facilities, it is connected to the Campo Wind Project, and its impacts must be analyzed together in the same document.

Second, while the FEIS acknowledges that the Project "consists of both the Campo Wind Facilities on land within the Reservation and the Boulder Brush Facilities which are located on adjacent private lands within the Boulder Brush Boundary," it fails to fully analyze the impacts from and alternatives to the Boulder Brush transmission, substation and switchyard facilities being considered for approval by San Diego County (PDS2018-MPA-18-016). The FEIS admits that "the Boulder Brush

Facilities include an approximately 3.5-mile Off-Reservation portion of the gen-tie line, a high-voltage substation, a 500 kV switchyard and connection," as well as other components, yet it does not rectify the FEIS' failure to analyze the impacts of those components. FEIS at RTC-8. The FEIS states that "the term "Project Site" refers to the combined Campo Corridor and Boulder Brush Corridor, within which all Project facilities would be constructed and/or operated . . . [and]"Project Area" is used to describe a broader area potentially affected by the Project alternatives and is generally consistent with the Reservation Boundary and Boulder Brush Boundary," but the inclusion of these areas in the discussion does not by itself ensure that the impacts from the Boulder Brush components are actually analyzed. FEIS at RTC-8. Likewise, the FEIS still fails to consider alternatives to the Boulder Brush transmission facilities; instead, it just considers alternatives to the form, capacity and location of electrical generation. FEIS at 24-26. No new alternatives were added to the FEIS and the response to comments does not even address this omission. FEIS at 24-26, RTC-7 to RTC-9.

B. The FEIS Fails to Consider All Cumulative Projects

NEPA requires analysis of cumulative impacts. 40 C.F.R. § 1508.7. Yet the FEIS ignores numerous reasonably foreseeable projects that would contribute to the Project's cumulative impacts, including the Energia Sierra Juarez Phase II project in Mexico, the 90-MW Starlight Solar project near Boulevard and the 50-MW Tecate Solar Hybrid project also in the Boulevard area. FEIS at 140-142, N-1 to N-14. Without any supporting evidence, the FEIS baldly claims that these projects need not be considered because they are outside the specific geographic area that was considered and therefore will not create cumulative impacts. FEIS at RTC-14. But that conclusion is illogical. It ignores the fact that the artificial boundaries drawn around the geographic area that was considered are too small. Each of these projects has broad-ranging and long-reaching impacts that extend beyond the boundaries the FEIS arbitrarily selected. Their impacts include widespread effects on wildlife and its habitat, on wildfire risk, and on visual resources. The cumulative impacts analysis in Appendix N is likewise deficient because it does not even include a map of the cumulative projects, let alone their impact areas. FEIS at N-1 to N-14. The FEIS entirely fails to address it. FEIS at RTC-13 to RTC-14, RTC-174.

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C. The FEIS Fails to Evaluate a Reasonable Range of Project Alternatives

NEPA requires that an EIS "[r]igorously explore and objectively evaluate all reasonable alternatives" so that "reviewers may evaluate their comparative merits." 42 U.S.C. §4332; 40 C.F.R. § 1502.14. Alternatives should be wide-ranging and not exclude options just because they require other agency approvals. *Sierra Club v. Lynn*, 502 F.2d 43, 62 (5th Cir. 1974). Agencies may decline to study an alternative in detail on the grounds that it is "similar to alternatives actually considered, or . . . infeasible, ineffective, or inconsistent with the basic policy objectives for the management area," but only after providing a "reasoned explanation *in the EIS* for its rejection." *Northern Alaska Environmental Center v. Kempthorne*, 457 F.3d 969, 978 (9th Cir. 2006) (first quote; internal quotations and citation omitted); *Southeast Alaska Conservation Council v. Federal Highway Administration* ("*SEACC*"), 649 F.3d 1050, 1059 (9th Cir. 2011) (second quote; emphasis added). The existence of a viable but unexamined alternative renders an environmental impact statement inadequate." *Friends of Yosemite Valley v. Kempthorne*, 520 F.3d 1024, 1038 (9th Cir. 2008).

Here, the FEIS evaluates an artificially and unduly limited range of alternatives. It only evaluates two action alternatives: (1) a 252-MW capacity wind energy facility with 60 4.2-MW, 586-foot (ground to blade tip) tall wind turbines, and (2) a 202-MW capacity wind energy facility with 48 4.2-MW turbines. FEIS at 24. The FEIS eliminated from detailed consideration a mixed renewable generation (wind and solar) alternative, a minimal build-out (63-MW capacity) alternative, an off-Reservation location alternative, a reduced-capacity turbine (2.5-MW turbine) alternative, and a distributed generation alternative. FEIS at 25-26. As the FEIS acknowledges, it is required to "describe any alternative eliminated from further analysis *along with the rationale for elimination*." FEIS at RTC-12 (citing BIA NEPA Guidebook, § 8.4.6, emphasis added). But BIA failed to provide a "reasoned explanation *in the EIS* for its rejection" of those additional alternatives. *SEACC*, 649 F.3d at 1059 (emphasis added).

For example, the FEIS fails to list any "scientific [or] other sources relied upon" for its conclusion that the "distance and cost of connecting the scaled down [minimal build-out] project to the planned switchyard would be cost prohibitive and the delivered cost of energy from 15 turbines would be too expensive for a potential buyer to enter into a contract for such a scaled-down project based on current energy market conditions." 40 C.F.R. § 1502.24 (first quote); FEIS at 25 (second quote). And BIA's reference to the Draft EIS' ("DEIS'") statement that "the minimal buildout alternative would be economically infeasible because . . . the costs" would outweigh the "revenue in current market conditions . . . and would not support the purpose of economic benefit to the Tribe," is likewise devoid of any scientific or other source material to support that conclusion. FEIS at RTC-174. The FEIS cannot remedy the DEIS' failures by simply referring back to statements made in the DEIS. The FEIS must provide facts and figures to support its conclusion before eliminating a viable, and more environmentally friendly alternative.

The FEIS similarly fails to support its rationale for rejecting the reduced-capacity turbines alternative: that the "[i]mpacts to the environment would have been similar to those of the larger capacity turbines considered in Alternative 1." FEIS at 25. Rather, the FEIS again makes a circular argument: It refers back to its unsupported statement in the DEIS as support for that same unsupported statement in the FEIS. FEIS at RTC-175. But neither the DEIS nor the FEIS provides proof "that the reduced capacity turbines would not appreciably reduce impacts." FEIS at RTC-175. The fact that reduced-capacity turbines would also require the "same number of turbine pads," while relevant to certain types of impacts, is irrelevant to others. For example, noise would likely be reduced with lower-capacity turbines.[8] As would public health and safety impacts, avian impacts, and visual impacts.

D. The FEIS Failed to Take a Hard Look at the Project's Impacts

NEPA requires that agencies take a "hard look" at the environmental impacts of proposed major federal actions and provide a "full and fair discussion" of those impacts in an EIS. 40 C.F.R. § 1502.1; *National Parks and Conservation Association v. BLM*, 606 F.3d 1058, 1072-1073 (9th Cir. 2010); CEQA Guidelines § 15126.2(a) ("Direct and indirect significant effects of the project on the environment shall be clearly identified and described"); *National Parks & Conservation Association v. Babbitt*, 241 F.3d 722, 733 (9th Cir. 2001). That includes "insur[ing] the professional integrity,

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[8] *See*, *e.g.*, Walker, Bruce, George F. and David M. Hessler, Rob Rand & Paul Schomer, December 24, 2012, "A Cooperative Measurement Survey and Analysis of Low Frequency and Infrasound at the Shirley Wind Farm in Brown County, Wisconsin," Public Service Commission of Wisconsin Report #122412-1 (attached as Exhibit 1 to Backcountry's July 8, 2019 DEIS Comments) (noting that the "Navy's prediction of the nausogenic region . . . indicates a 6 dB decrease in the criterion level for a doubling of power such as from 1.25 MW to 2.5 MW).

including scientific integrity, of the discussions and analyses in environmental impact statements" by "identify[ing] any methodologies used and . . . mak[ing] explicit reference by footnote to the scientific and other sources relied upon for conclusions in the statement." 40 C.F.R. § 1502.24. Here, the FEIS failed to take a hard look at numerous Project impacts.

1. Impacts on Aviation and Aerial Firefighting

The Project's turbines and meteorological towers would create aviation hazards, including hazards to aerial firefighting as discussed above. The FEIS claims that the Project "would comply with any applicable Federal Aviation Administration (FAA) requirements to ensure that FAA, military, and emergency responders navigate the area safely." FEIS at RTC-206. But it does not examine or discuss how the Project could impact the extensive military aviation in the area, nor how it would impair aerial firefighting and other emergency response. The FEIS' reliance upon its vague and facile claims of compliance with "any applicable" FAA requirements cannot substitute for analysis of the impacts. Without more the agency cannot take the hard look that NEPA requires.

2. Impacts to Biological Resources

The FEIS significantly downplays the Project's biological impacts on numerous species. By understating these impacts, the FEIS fails to accurately inform the public and decisionmakers of the Project's environmental harm, in violation of NEPA.

a. Golden Eagles and Other Avian Species

Wind turbines kill birds.[9] The Campo Wind Project's 60 turbines will be no different. A wealth of bird species has been documented inhabiting or otherwise using the Project area, including sensitive species like golden eagles. FEIS Appendix F. The risk to golden eagles is particularly concerning because they are "currently known to be at risk of *population-level* effects from [wind turbine] collisions," and must be afforded every possible protection. July 8, 2019 Comments Exhibit 2 at 306. Yet the FEIS brushes aside the risk to golden eagles because "[e]agle use on site is infrequent and the chance for collisions is low." FEIS at 88. It also dismisses collision impacts to other migratory birds (protected under the Migratory Bird Treaty Act, 16 U.S.C. section 703 *et seq.*) because the Project would

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[9] Dwyer, J.F., M.A. Landon, and E.K. Mojica, 2018, "Impact of Renewable Energy Sources on Birds of Prey," in J.H. Sarasola *et al.* (eds.), 2018, *Birds of Prey*, Springer International Publishing AG (attached as Exhibit 2 to Backcountry's July 8, 2019 DEIS Comments).

implement a “Bird and Bat Conservation Strategy (“BBCS”)” to monitor, report and notify a Project biologist about dead or injured birds and bats. FEIS at 88; FEIS Appendix P at P-5 to P-6. But the updated BBCS fails to actually mitigate the impact of bird collisions. Yet the FEIS still dismisses the impact as less than significant with mitigation. FEIS at RTC-21. But if the impact is significant before mitigation, and the mitigation does not lessen the impact, as here, then the impact is still significant after mitigation. FEIS at 88 (admitting that “Absent mitigation, these direct impacts would be adverse” but simultaneously claiming that with mitigation, “the Project would not result in adverse effects to migratory birds”). Those conclusion are unsupported and insufficient to reasonably inform decisionmakers and the public for at least four reasons.

First, the FEIS fails to *quantify* the number of expected wind turbine collisions with golden eagles or any other bird species. It is impossible to know how significant the Project’s impacts to birds will be without a collision quantification. While BIA did complete additional avian surveys to determine the presence of species in the area, it still failed to quantify potential impacts. The significance of that failure is underscored by the FEIS’ admission that “wind turbines were considered to present a potential risk to avian species for collision.” FEIS at RTC-27. Yet, despite this clear risk and the lack of concrete information, the FEIS nonetheless claims that “there would be no additional impacts anticipated” to avian species. FEIS at RTC-27. But the FEIS cannot draw that conclusion without facts to support it. And that conclusion does not follow from the facts that *are* available. For example, because the golden eagle *population* is at risk from wind turbines and other causes, as discussed, the loss of one golden eagle could have population-level consequences. But the FEIS ignores that potentially devastating impact and erroneously declares that “there would be no adverse effects on eagles.” FEIS at 88.

Second, after-the-fact monitoring of bird collisions and removal of bird carcasses (as proposed as part of MM-BIO-4) merely documents the harm. It does nothing to mitigate, let alone prevent, the collision impacts. FEIS Appendix P at P-5 to P-6. Monitoring cannot bring birds back from the dead. The revision of MM-BIO-4 does nothing to lessen the ineffectiveness of that mitigation measure. Adding more post-mortem monitoring and notification does not stop the impact from happening in the first place. To the contrary, it just habituates the public to the growing death toll, compounding the unfolding tragedy.

Third, the FEIS fails to analyze the *landscape*-scale avoidance impacts that the Project's turbines would likely cause.[10] A recent longitudinal study of bird densities at 12 wind farms in Ireland and their paired control sites found that "densities of open-habitat species were lower at wind farms" than at the control sites "independent of distance to turbines." July 8, 2019 Comments Exhibit 3 at 7. This "suggests that for open-habitat birds, effects were operating at a landscape scale." July 8, 2019 Comments Exhibit 3 at 8. The Campo Wind Project could well have similar effects. While the bird species may be different near the Campo Wind Project site than at the study sites in Ireland, the terrain is more "open-habitat" than "forested" (the other type of habitat present at some of the Ireland study sites, and for which the authors found gradient rather than landscape effects).

Fourth, the avian surveys that were completed did not comply with Land-Based Wind and Eagle Conservation Plan Guidelines which call for a minimum of two years of surveys, across all seasons, and 20 hours of survey per turbine per year–which would total 2,400 hours for this Project. Yet here, these protocols were not met. The FEIS admits that the developer and USFWS agreed that the Land-Based Wind Energy Guidelines and the Eagle Conservation Plan Guidance were the appropriate methods to be used, and it does not deny that the surveys that were completed failed to reach 2,400 hours, across all seasons, for two years. Instead, the FEIS now claims that the "guidelines referenced . . . are not required . . . under federal law or regulation" and "the methods are flexible." FEIS at RTC-81 (first quote), RTC-92 (second quote), RTC-176. But no amount of flexibility changes the fact that the surveys do not meet the requirements that the developer and USFWS originally said were the best practice and therefore necessary. Furthermore, no eagle nest searches *at all* have been performed since 2011, and the FEIS does not provide any information on the status of eagle breeding territories in the region. Finally, even if the surveys had been performed, the survey methods cannot be evaluated because survey reports are not included in the FEIS.

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[10] Fernández-Bellon, D., M.W. Wilson, S. Irwin, and J. O'Halloran, 2018, "Effects of Development of Wind Energy and Associated Changes in Land Use on Bird Densities in Upland Areas," *Conservation Biology* 0(0):1-10 (attached as Exhibit 3 to Backcountry's July 8, 2019 DEIS Comments).

In sum, the FEIS' analysis of the Project's impacts to birds fails to reasonably inform decisionmakers and the public as NEPA requires. The biological resources impact analysis must accordingly be revised and recirculated.

b. Quino Checkerspot Butterfly

The FEIS admits that "Alternative 1 would permanently remove 242.1 acres of suitable Quino checkerspot habitat," and Alternative 2 would remove "approximately 191.58 acres of potentially occupied Quino checkerspot butterfly habitat." FEIS at 87 (first quote), 88 (second quote). But even these significant, plainly adverse impacts grievously understate the Project's effects on this special-status species, as explained below.

First, the information provided in the FEIS lacks detail and information necessary to provide the public and decisionmakers with the "hard look" that NEPA requires. The approximately one-page discussion of the Project's effects on the Quino checkerspot butterfly directs the reader to FEIS Appendix H for more information, but that Appendix does little to elucidate the issue. FEIS at 87; FEIS Appendix H at 133-136, 139-141. Rather, Appendix H makes more vague statements. For example, Appendix H confirms that "[c]onstruction activities increase the number of humans within the area, which can deter wildlife from using an area," but entirely fails to consider how that would impact Quino checkerspot butterfly survival. FEIS Appendix H at 139. Indeed, human presence in the area will increase collisions and noise, and increased construction equipment and vehicles can introduce nitrogen which could alter vegetation and the presence of Quino checkerspot host plants. Likewise, Appendix H admits that operation and maintenance activities would cause "fugitive dust from vehicles, habitat fragmentation, accidental additional clearing of adjacent habitat, chemical pollutants if used for operation-related activities, non-native invasive species, and alteration of the natural fire regime," but again fails to consider, let alone explain, how that would negatively impact Quino checkerspot survival. FEIS Appendix H at 141.

Appendix H also claims that "[a]pproximately 1,216 acres were considered potential suitable habitat within the Project Site," and that "[n]o Quino checkerspot butterfly or their host plants were observed during the 2018 focused surveys." FEIS Appendix H at 77. Yet those figures are understated in the FEIS, which claims that the 2018 surveys found only "699 acres within the Project Area were considered suitable habit." FEIS at 38. The public and decisionmakers are left wondering what impacts the Project will have on the Quino checkerspot butterfly, and unable to even determine how potential habitat was identified. The FEIS claims that it followed U.S. Fish and Wildlife Service guidelines to identify potential habitat, but it does not cite any source for those guidelines, or provide any definition for the terms used therein. BIA implores the public to just take its word that "[a]ll survey methods and protocols, species modeling and impact analysis methodologies were conducted in coordination and consultation with the USFWS to ensure adequacy and accuracy." FEIS at RTC-14. But without any guidelines to independently judge these methods and protocols, the public and decisionmakers are left in the dark. This is not the "hard look" that NEPA requires. Accordingly, the FEIS must provide more information.

Furthermore, the FEIS admits that it does not provide all the information needed to determine what impacts the Project will have, despite the additional Quino Checkerspot surveys completed in 2019. FEIS at RTC-16; FEIS Appendix H at 77. The FEIS concedes it still does not have this essential information, and it is still collecting data after publication of the FEIS: "[a]n additional set of Quino checkerspot butterfly surveys are being conducted within the Off-Reservation portion of the Project." FEIS at 87. Without this survey information, an agency cannot accurately determine the Project's impacts and how that would affect the FEIS' analysis and conclusions. And even if no surveys remained to be completed, and this admission in the FEIS is false, the analysis still fails. There were five Quino checkerspot butterflies identified in the 2019 off-reservation surveys. Therefore, the conclusion that "the Project would not adversely affect any federally listed plants or wildlife, *because none are present*," is patently incorrect. FEIS at 87 (emphasis added).

The FEIS also claims that "[b]ecause decommissioning would include restoration of the area to pre-Project conditions, it would ultimately not result in adverse effects on Quino checkerspot butterfly." FEIS at 87. But restoration to pre-Project conditions – which is not even possible – does not negate adverse effects. Yet BIA ignores this pivotal and dispositive fact, instead relying on the specious argument that "restoration of habitat is often an approach used to reduce the effects on species." FEIS at RTC-177. But another agency's use of this approach does not make it right, or effective. The FEIS acknowledges that decommissioning activities will "result in temporary direct and indirect adverse effects on Quino checkerspot butterfly," including collisions with equipment and vehicles, human disturbance, and noise impacts. FEIS at 87. Those adverse impacts are significant and cannot be ignored simply because the FEIS claims–without any supporting evidence– that the area will be restored to pre-Project conditions. Even with an updated decommissioning plan, revegetation cannot heal dead or injured Quino checkerspot butterflies. FEIS at RTC-177; FEIS Appendix P at P-3.

All of these failures are exacerbated by the importance of the project area to the Quino checkerspot butterfly. The Project falls within the La Posta/Campo Core Occurrence Complex for the Quino checkerspot butterfly, on the eastern edge of the species' range. 74 FR 28776- 28862. The U.S. Fish and Wildlife Service has concluded that preservation of these core occurrence complexes is essential for recovery and survival of the Quino checkerspot butterfly in San Diego County. *Id.* Furthermore, the La Posta/Campo and Jacumba core occurrence complex habitats are warmer and drier than the Otay Mountain Core Occurrence Complex and differ substantially in other habitat characteristics, and contribute significantly to reducing the subspecies' extinction probability. *Id.* "The eastern edge of Quino checkerspot's range supports large and robust butterfly populations, abundant and diverse larval host plants and nectar sources, and relatively low levels of development and intensive agriculture. These areas may provide climate refugia that Quino checkerspot will require under future predicted scenarios of climate change."[11] Therefore, the Project area is not only important because it is a core occurrence area, but because it is imperative to species survival with the ongoing perils of climate change.

The FEIS erroneously claims that any adverse impacts "would be reduced to less than adverse with implementation of recommended MM-BIO-1 and MM-BIO-3." FEIS at 87. And BIA does not deny that this conclusion is inaccurate. FEIS at RTC-177. Rather, BIA claims "NEPA does not require a fully developed plan that will mitigate all environmental harm before an agency can act." FEIS at RTC-177. But whether or not all environmental harm must be mitigated does not address the fact that the FEIS' conclusions do not follow from the facts. As the FEIS states, it is essential that "mitigation be discussed in sufficient detail to ensure that environmental consequences have been fully evaluated."

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[11] Preston, Kristine L., et al, 2012, "Changing distribution patterns of an endangered butterfly: Linking local extinction patterns and variable habitat relationships," *Biological Conservation* 152:280–290, 289 (attached to July 8, 2019 Comments as Exhibit 4).

FEIS at RTC-177. That informational goal cannot be met where, as here, the conclusions that the FEIS draws are incorrect. Indeed, the FEIS has not demonstrated that these significant impacts can be mitigated at all, let alone by the deficient mitigation measures that are proposed. MM-BIO-1 calls for development of a number of plans that it claims will protect biological resources in general, and the designation of a Project biologist to oversee construction efforts. FEIS Appendix P at P-1 to P-3. But the implementation of those plans, even if perfectly executed, would not reduce the Project's impacts to less than significant. The nature of the Project is such that there will be significant adverse impacts to the Quino checkerspot butterfly and no amount of avoidance, short of denying the Project, could protect this imperiled species.

MM-BIO-3, which is more specifically directed toward the Quino checkerspot butterfly, is vague and unenforceable. That measure simply defers the development of any Quino checkerspot specific mitigations until after Section 7 consultation is complete. FEIS Appendix P at P-4. The FEIS makes vague statements such as "[r]atios for habitat-based mitigation (if any) shall be determined during the Section 7 consultation process," and "mitigation shall focus on habitat preservation and creation for long-term conservation of metapopulation dynamics." FEIS Appendix P at P-4. But the FEIS does not provide any specific information on what those measures may be, what they may apply to, or how they would be implemented. Indeed, the FEIS even admits that there may not be *any* habitat-based mitigation at all. FEIS Appendix P at P-4. Without any detail, the FEIS cannot accurately conclude these unknown mitigation measures will reduce the Project's impacts. And the FEIS' failure to acknowledge this lack of information is just another example in a long line of insufficient analysis. NEPA requires more.

The FEIS' analysis of the Project's impacts to the Quino Checkerspot butterfly fails to reasonably inform decisionmakers and the public as NEPA requires. The biological resources impact analysis must accordingly be revised prior to any Project approval.

3. Noise Impacts

The FEIS continues the DEIS's failure to accurately and reasonably inform the public and decisionmakers of the Project's noise impacts, including audible noise, low-frequency sound and infrasound impacts. This is true, even as the FEIS acknowledges that the Project will have significant and unavoidable noise impacts. The FEIS's noise-impact discussion is wholly inadequate. It relies upon improper baseline data, and incomplete and flawed assumptions. For these reasons the FEIS fails to adequately disclose and discuss the significant impacts of the Project.

First, the FEIS continues to present improper baseline information. The deficiencies of the baseline assumptions contained in FEIS Appendix K-2 are detailed in the March 2020 Campo Wind Noise/Acoustical Review prepared by dBF Associates for Backcountry Against Dumps, and the December 16, 2019 Wind Turbine Infrasound and Low-Frequency Noise Survey in Boulevard, CA, both of which are incorporated by reference and attached hereto as **Exhibits 6 and 7**. In particular, the updated baseline ambient noise measurements were taken at locations that were not representative of the residences and other noise-sensitive land uses ("NSLUs") that will be impacted by the Project's turbines. Instead, the baseline measurements were taken in locations that are not consistent with normal setbacks for most residences. Exhibit 6, pp. 4-5, Item 14 (meters placed from less than 5 feet to approximately 55 feet from roadways in areas where most setbacks are normally at least 100 feet and sometimes over 500 feet from roadways), Item 15. Thus, Appendix K-2's baseline noise readings overstate the ambient noise surrounding NSLUs that will be impacted by the Project.

This inaccurate and exaggerated baseline ambient noise information taints the analysis of noise impacts in the FEIS. In areas with inaccurately high baseline noise readings, the Project's impacts are discounted as less than they otherwise would be, as the FEIS improperly underestimates the amount of change between the existing condition and the Project.

Second, the FEIS continues to present improper and incomplete information regarding the Project's impacts. Indeed, BIA does not deny many of the objective critiques raised by acoustics expert Dr. Richard Carman in his July 7, 2019 Review of Campo Wind Project and Boulder Brush Facilities DEIS Noise Analysis ("Noise Impact Review," attached as Exhibit 5 to Backcountry's July 8, 2019 DEIS Comments). Backcountry incorporates Dr. Carman's cogent criticism by reference as it remains highly relevant to the FEIS.

In particular, the FEIS continues to improperly discount the impacts of low frequency sound and infrasound on sensitive noise receptors, including residences that are within 0.25 and 0.5 miles of Project turbines. The FEIS downplays the findings reached by Salt, Alec, and James Kaltenbach, 2011, in "Infrasound from Wind Turbines Could Affect Humans," *Bulletin of Science, Technology and Society*, 31(4):296-302 (attached as Exhibit 9 to Backcountry's July 8, 2019 DEIS Comments). Salt and Kaltenbach demonstrated that human ears' outer hair cells respond to infrasound and low-frequency noise, and do so at levels as low as 60 dBG. In the Response to Comments, BIA concedes that the Project's operation will expose numerous residents to infrasound levels greater than 60 dBG. However, BIA quibbles over the practical effect of this exposure. BIA acknowledges that outer ear stimulation may occur as documented by Salt and Kaltenbach, but fails to recognize that this stimulation is evidence of harm. FEIS RTC-179.

BIA also appears to concede that the Project's 4.2 MW turbines will produce greater infrasound than the turbines examined in the Epsilon Associates, Inc's ("Epsilon's") 2009 noise impact study on which the BIA relies to claim no significant impact. FEIS RTC-179. Yet BIA continues to cite this study to discount the Project's ILFN impacts – solely because the Epsilon study showed a "generous" compliance margin. *Id.* BIA's continued reliance upon a flawed and inapplicable study to claim that the Project's infrasound and low frequency sound impacts will be minimal renders the FEIS' conclusions improper.

In sum, the FEIS' noise impact analysis fails to reasonably inform decisionmakers and the public as NEPA requires.

4. Impacts to Water Resources

The FEIS fails in many ways to accurately and reasonably inform the public and decisionmakers of the Project's impacts to water resources, including impacts to the underlying Campo/Cottonwood Creek Aquifer. Understanding the effects on the aquifer is particularly crucial to an informed understanding of the Project's impacts because the aquifer was designated as a sole source aquifer pursuant to section 1424(e) of the federal Safe Drinking Water Act on May 28, 1993, with the Environmental Protection Agency ("EPA") making the determination that "contamination of [the] aquifer would create a significant hazard to public health." 58 Fed. Reg. 31025 (May 28, 1993).

Hydrogeology expert Scott Snyder details many of the FEIS' deficiencies in his July 5, 2019 Draft EIS Review and Opinion (attached as Exhibit 10 to Backcountry's July 8, 2019 DEIS Comments) and his March 9, 2020 Final EIS Review and Opinion (attached as **Exhibit 8** hereto). His review and the critiques and recommendations therein are incorporated herein by reference. In addition to the deficiencies identified in Mr. Snyder's July 5, 2019 and March 9, 2020 reviews, the FEIS' analysis of the Project's impacts to water resources is deficient in at least two other ways.

First, the FEIS concludes that the Project would not violate water quality standards during construction and decommissioning because it would conform to the stormwater pollution prevention plan ("SWPPP"). FEIS at 71. But as BIA admits, the FEIS never specifies what best management practices would be adopted as part of the SWPPP because it has not yet even determined what those BMPs would be. FEIS at RTC-180. Instead, it merely provides a list of the stormwater control measures that "*could*" be included, without any analysis of the relative efficacy of the listed measures. FEIS at 15 (emphasis added). Indeed, the FEIS acknowledges that many of the sample BMPs "may not be appropriate" here. FEIS at RTC-180. That violates NEPA, which requires that EISs describe mitigation measures with sufficient detail to assess how well they "will serve to mitigate the potential harm" they target. *Foundation for North American Wild Sheep v. U.S. Department of Agriculture* ("*Wild Sheep*"), 681 F.2d 1172, 1181 (9th Cir. 1982) (quote); *South Fork Band Council v. U.S. Department of Interior* ("*South Fork*"), 588 F.3d 718, 727 (9th Cir. 2009). The FEIS improperly defers the creation of this mitigation measure without providing the appropriate and necessary information to inform the public and decisionmakers about the effectiveness of that mitigation. Without more information on what stormwater control measures would be adopted, and the relative efficacy of each one, BIA cannot possibly "supply a convincing statement of reasons why [the] project's impacts are insignificant." *Blue Mountains Biodiversity Project v. Blackwood*, 161 F.3d 1208, 1212 (internal quotations and citation omitted).

Second, the FEIS claims that "hazardous materials would not be allowed to enter the septic system," and that creation of a Hazardous Materials Management Plan ("HMMP") would reduce all impacts of use, storage, and disposal of hazardous materials to less than adverse. FEIS at 128, RTC-180 to RTC-181. But preparation of the HMMP is impermissibly deferred. Without information about how these materials will be properly and effectively used, stored and disposed, the public and decisionmakers cannot ensure that the area's vulnerable water resources will be protected. This is a critical omission because, as discussed above, the Project is located over a sole source aquifer, contamination of which "would create a significant hazard to public health." 58 Fed. Reg. 31025 (May 28, 1993).

The FEIS' analysis of impacts to water resources fails to reasonably inform decisionmakers and the public as NEPA requires. The water resources impact analysis must accordingly be revised.

5. Global Warming Impacts

The FEIS paints a rosy picture of the Project's global warming impacts, but it is based on an incomplete analysis. FEIS Appendix G at 29-44. The FEIS admits that it fails to calculate the Project's entire life cycle greenhouse gas ("GHG") emissions. FEIS at RTC-46 (modeling tools used "did not account for the full life-cycle of GHG emissions from construction activities"). Instead, the FEIS focuses on the GHG emissions from on-site Project construction and operation. FEIS 4.5-1 to 3. BIA claims that this failure should be overlooked because it did consider some "directly related GHG impacts." FEIS at RTC-47. But consideration of those impacts does not make up for failure to consider others.

Myriad published life cycle analyses demonstrate that wind energy projects have many more sources of GHG emissions than just on-site construction and operation. As one recent study states, "due to GHG emissions produced during equipment manufacture, transportation, on-site construction, maintenance, and decommissioning, wind and solar technologies are not GHG emission free."[12] July 8, 2019 Comments Exhibit 11 at SI36. That same study concluded, based on a "systematic review and harmonization of life cycle assessment (LCA) literature of utility-scale wind power systems," that industrial-scale wind turbines produce 11 g CO2-eq/kWh (median value, with a range of 3 g CO2-eq/kWh to 45 g CO2-eq/kWh). July 8, 2019 Comments Exhibit 11 at SI36, SI46. To fully analyze the Project's global warming impact in compliance with NEPA, BIA must conduct a life cycle assessment of the Project's GHG emissions.

BIA asserts that a life-cycle analysis would be speculative "because a turbine model has not been selected for the Project and the location of manufacturing for turbine components is unknown." FEIS at RTC-47. But uncertainty about a turbine model is irrelevant because NEPA requires a hard look at the potential impacts. Therefore, the FEIS should include analysis of what those potential impacts could be, and acknowledge any gaps in the available information. Without this information, the FEIS does not

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[12] Dolan, Stacey L. & Garvin A. Heath, 2012, "Life Cycle Greenhouse Gas Emissions of Utility-Scale Wind Power: Systematic Review and Harmonization," *Journal of Industrial Ecology*, 16(SI) (attached to July 8, 2019 Comments as Exhibit 11).

provide an accurate assessment of the potential impacts. The FEIS' assertion that these impacts would be considered in other NEPA analyses likewise fails. Because the production of wind turbines is often project-dependent, the components for the Project may not be built absent the Project, rendering their manufacturing impacts unreviewed unless they are examined as indirect impacts of the Project that require analysis in the FEIS. And even if the impacts had been analyzed in a prior NEPA document, BIA must still disclose that analysis in the FEIS here.

6. Shadow Flicker Impacts

As discussed in Backcountry's December 21, 2018 Scoping Comments on the Campo Wind Project and the July 8, 2019 DEIS comments, spinning wind turbines can produce harmful and annoying "shadow flicker." While the FEIS does significantly expand the shadow flicker analysis, it fails to properly mitigate the impacts of shadow flicker. The FEIS admits that "receptors both On- and Off-Reservations may experience nuisance-level shadow flicker effects for more than 30 hours in a given year," and on-reservation receptors may also "experience shadow flicker for more than 30 minutes in a given day." FEIS at RTC-39 (first quote), 63 (second quote). These effects exceed the guidance and recommendations adopted for shadow flicker in multiple jurisdictions and for this FEIS. FEIS at 137. Yet despite admitting that shadow flicker will exceed established thresholds, the FEIS claims that "the modern wind turbines that will be utilized for the Project will rotate well below any frequency of health concern." FEIS at RTC-38.

The FEIS asserts that Project Design Features would be implemented to minimize the impacts of shadow flicker, including "coordinat[ion] with the relevant tribe to assess shadow flicker complaints made within one year from the initial operations date of the Project by the resident of any existing" and "with the resident of any existing (existing as of the date of Record of Decision approval) Off-Reservations receptor located within a distance of 15 x Rotor Diameter (i.e. approximately 6,750 feet) of a Project turbine to assess their shadow flicker complaints made within one year from the initial operations date of the Project." FEIS at RTC-40. But this after-the-fact assessment fails to address the impact before it happens.

Furthermore, the FEIS removes what may have been a more effective mitigation measure. The DEIS stated that "'all turbine software would include programming to reduce or shut off turbines during times of shadow flicker potential.'" FEIS at RTC-39. But the FEIS removes that technology because "it was determined that this design feature would significantly impact the economic benefits of the Project to the Tribe." FEIS at RTC-39. NEPA requires a full discussion of the potential impacts of the Project, and possibilities for mitigation. The FEIS must include this possible mitigation so that the public and decisionmakers can at least weigh the benefits of its inclusion against the costs to the Tribe.

7. Visual Impacts

The Tisdales' ranch shares a half-mile border with the Reservation. Because the Project includes numerous large industrial facilities sited along the border of the Tisdales' ranch, it will significantly degrade their beautiful view of the surrounding land. **Exhibit 9** attached hereto includes two photos that depict the view of the reservation from the Tisdales' ranch. The short white fence is along the border with the Reservation, and the land on the far side will be marred by an operations and maintenance facility, temporary construction/laydown yard, and temporary batch plant.

Additionally, there will be seven large towers that loom large over the Tisdales' ranch substantially degrading their use and enjoyment of this pristine and bucolic property. Indeed, the Project Description admits that the turbine hub height will be up to 374 ft (114 m) and the rotor diameter will be up to 460 feet, with approximately 230 foot long blades. FEIS Appendix B, B-2. These turbines are exponentially larger than any other structure in the area. Indeed, the turbines are twice the 301-foot height of the Statue of Liberty, and even larger than the enormous One American Plaza building in San Diego. *See* graphic attached hereto as **Exhibit 10**. The sheer size of these turbines would completely dominate and destroy the view from the Tisdales' ranch and surrounding viewpoints, and irretrievably degrade the existing natural beauty of this rural area. Vision Scape Imagery has prepared numerous simulations showing the impact of these gigantic turbines from both the Tisdale property and other viewpoints. Those simulations are attached hereto as **Exhibit 11**.

While the FEIS admits that the Project's visual impacts will be significant and unavoidable, it still understates those impacts significantly. FEIS 120-125. Rather than accurately analyze their impact, the FEIS used smaller allegedly 'representative turbines' for visual analysis that do not accurately or fairly represent the real world impacts from the 60 to 90 separate 4.2 MW wind turbines proposed for the Campo Wind and Torrey Wind projects. The FEIS claims that mitigation measures will help minimize the impacts, but nothing can change the fact that the Project will decimate the Tisdales' view from the property where they have for decades built their lives, and where they plan to enjoy their retirement years with their children, grandchildren, and great-grandchildren.

8. Wildfire Impacts

There can be no dispute that wildfire risk in the Project area is dangerously high. This risk is exacerbated by the Project and is a risk that also threatens its operation. The FEIS acknowledges that the Project "would increase the potential for a wildfire and could impact the public and the environment by exposure to wildfire due to construction and decommissioning activities and ground disturbance with heavy construction equipment." FEIS 131, 132. Despite this admission, the FEIS fails to detail the increased risks of fire – and the increased risk to firefighting – posed by the Project's operation.

First, the FEIS fails to address the risk of wind-turbine fires that could occur during Project operation, despite several comments mentioning this operational risk. Instead of addressing the substantial risk of ignition from operation, the FEIS speculates that a non-existent Campo Fire Protection Plan that might be developed in the future to mitigate any risk. *E.g.* FEIS RTC-230.

Second, the FEIS fails to address the fact that the Project's wind turbines and meteorological towers would directly interfere with firefighting safety and effectiveness, as discussed above.

While the FEIS claims that mitigation measures "would reduce [the] adverse effects" of the Project's fire risks, these mitigation measures are wholly inadequate. FEIS 131, 132. Neither the non-existent, proposed future Campo Fire Protection Plan nor the Project's setbacks are sufficient to mitigate the increased risk of fire or the impairment to firefighting posed by the Project.

9. Socioeconomic Impacts

Ed Tisdale has lived and ranched at Morning Star Ranch for 55 years, and Donna Tisdale, a fourth generation California rancher and co-owner of Morning Star Ranch, has been there with him for 43 years. The Tisdales' home, ranch and rental property are *directly* adjacent to the Project.

The FEIS concludes that "the presence of wind turbines" is not a factor in changes in property values, and that the Project's impacts "would be insignificant." FEIS RTC-44. Yet, as discussed above, the Project will cause significant impacts on the Tisdales' property. The Project will replace the currently pristine view outside the Tisdales' home and seen through their windows with a gigantic, ugly, industrial nightmare of towering and whining wind turbines. Those turbines will dramatically increase audible and inaudible sound pressures, causing physical discomfort and annoyance for the Tisdales and others present on their property. It will replace their stunning dark night sky with its brilliant blaze of stars with annoying, incessantly blinking red lights and noisy, whirling 200-foot long turbine blades. While admitting that "environmental and physical changes may affect property values within an immediate distance of a wind project" the FEIS declines to attribute any significant to this effect, and instead dismisses these impacts as having only a speculative impact on property value. FEIS RTC-45. This conclusion completely ignores the overwhelming evidence of property value destruction before the agency.

CONCLUSION

The Project will indisputably have a significant adverse effect on aircraft safety and operation, by producing turbulence, degrading radar function, and impeding low flying aircraft, among other hazards. The Project will also pose an unacceptable risk of fatal aircraft collisions that cannot be eliminated by FAA-required lighting. This severe risk—exacerbated by the acknowledged fact that the area is frequently used by low flying military aircraft—is unacceptable. For these reasons, and because the environmental impacts of the Project are not adequately addressed as required by NEPA, the Determination Letters are an abuse of discretion and should be vacated.

Dated: August 17, 2020

Respectfully submitted,

STEPHAN C. VOLKER
Attorney for Backcountry Against Dumps, Donna
Tisdale, and Joe "Ed" Tisdale

EXHIBIT LIST

Exhibit 1:	Photographs taken by Donna Tisdale, at the Project site
Exhibit 2:	Linowes, Lisa, *Wind Energy and Aviation Safety, Fatalities,* WindAction.org, April 4, 2017
Exhibit 3:	Novak, Andrej, *Wind Farms and Aviation*, Aviation, 2009, 13:2, 56-59
Exhibit 4:	Civil Aviation Authority, *CAA Policy and Guidelines on Wind Turbines, CAP 764*, Safety and Airspace Regulation Group, 6th Ed., February 2016
Exhibit 5:	Mulinazzi, Thomas E., Zheng, Zhingquan Charlie, *Wind Farm Turbulence Impacts on General Aviation Airports in Kansas*, Kansas Department of Transportation, Report No. K-TRAN: KU-13-6, January 2014
Exhibit 6:	Steven Fiedler, INCE, dBF Associates, Campo Wind Noise/Acoustical Review (March 10, 2020)
Exhibit 7:	Steven Fiedler, INCE, dBF Associates, Wind Turbine Infrasound and Low-Frequency Noise Survey in Boulevard, CA (December 16, 2019)
Exhibit 8:	Scott Snyder, PG, Snyder Geologic, Inc., Campo Wind Final Environmental Impact Statement (EIS) with Boulder Brush Facilities Final EIS Review and Opinion (March 9, 2020)
Exhibit 9:	Photographs of Campo Reservation from Tisdales' Ranch
Exhibit 10:	Graphic depicting relative height of Project turbines
Exhibit 11:	Vision Scape Imagery turbine simulations (March 2020)

EXHIBIT
1

EXHIBIT
2

Wind Energy and Aviation Safety, Fatalities

windaction.org/posts/46562-wind-energy-and-aviation-safety-fatalities

Lisa Linowes - April 4, 2017 Safety Injury
USA

Earlier this year, a single engine plane collided with a wind turbine in Germany killing the pilot and shattering the aircraft. The appalling tragedy was reported as a rare occurrence, but few realize that in the U.S. alone at least ten people have lost their lives in fatal aviation accidents involving collisions with U.S. sited wind turbines and meteorological (MET) towers.

The table below lists these accidents, six in all.

Date	Location	Fatality	Activity	Information
Dec 15, 2003	Vansycle, OR	Yes, 2	Transport (MET)	NTSB Accident ID SEA04LA027
May 19, 2005	Ralls, TX	Yes, 1	Ag Spray (MET)	NTSB Accident ID DFW05LA126
Jan 10, 2011	Oakley, CA	Yes, 1	Ag Spray (MET)	NTSB Accident ID WPR11LA094
Aug 5, 2013	Balko, OK	Yes, 1	Ag Spray (MET)	NTSB Accident ID CEN13FA465
Apr 27, 2014	Highmore, SD	Yes, 4	Transport (Turbine)	NTSB Accident ID CEN14FA224
Aug 19, 2016	Ruthton, MN	Yes, 1	Ag Spray (MET)	NTSB Accident ID CEN16LA326 [1]

Wind and Collisions

The most widely reported incident occurred the night of April 27, 2014, just ten miles south of the airport in Highmore, South Dakota. All four passengers, including the pilot, were killed when their plane struck an operating wind turbine owned by NextEra. According to the National Transportation Safety Board (NTSB) report, the facility was not marked on the sectional charts covering the accident location.

NTSB also reported that the light on the turbine tower was not operational at the time of the accident, and the outage was not documented in a notice to airmen (NOTAM)[2]. NTSB investigators opined that “[i]f the pilot observed the lights from the surrounding wind turbines, it is possible that he perceived a break in the light string between the wind turbines as an obstacle-free zone.”

The other five incidents involved collisions with wind project meteorological (MET) towers. MET towers are erected at proposed wind energy sites for assessing wind speed and direction. The towers, made from galvanized tubing 6-8 inches in diameter and secured with guy wires, can be erected in a matter of hours and, in many cases, without notice to the local aviation community. Their rapid deployment means the navigable airspace of an area could quickly become hazardous for low-flying aircraft. Generally, the towers stand under 200-feet, thus below the threshold for requiring FAA notification, are unlit and usually devoid of any markings, so they are difficult to see.

In the three fatalities from 2003, 2005, and 2011, final NTSB reports cited the unmarked towers and the inability of the pilot to see the towers as the probable causes for the accidents. In the 2013 fatality, the MET tower was marked but sun glare impaired the pilot’s ability to avoid the tower.

NTSB Recommendations and FAA Delays

The NTSB is well aware of the hazards these towers pose. On May 15, 2013, the agency filed the following safety recommendations with the FAA related to MET tower aviation risks: [3]

- Amend 14 [CFR] Part 77 to require that all [METs] **be registered, marked, and—where feasible—lighted**.
- **Create and maintain a publicly accessible national database** for the required registration of all [METs].

The FAA delayed acting on its MET-tower safety recommendations claiming limited resources and competing priorities so it wasn’t until December 2015, [4] before updated rules for marking MET towers were released. Still, the FAA stopped short of mandating them. Eight months later (August 2016), a 6th fatality occurred when a pilot collided with an unmarked MET tower in Minnesota.

Following FAA’s delays, Congress acted by passing the “FAA Extension, Safety, and Security Act of 2016,” which mandates that towers between 50 and 200-feet having an above-ground base of 10-feet or less in diameter be marked. Specific provisions in the bill explain the types and location of towers for which the law applies. The FAA is again tasked with creating rules to implement the regulation [5] but with a deadline of July 2017.

Encroachment and Fatal Risks

Other aviation fatalities have happened involving wind turbines but without direct collisions and where blame was attributed to the pilot. One such incident occurred on February 8, 2008 when Philip Ray Edgington, an experienced American Airlines pilot, was flying his vintage Cessna 140 airplane near Grand Meadow, Minnesota, at an elevation between 300 and 600 feet above ground level (agl).

On that fatal day, Mr. Edgington came upon an array of 400-foot tall turbines, whereupon "the airplane made a 90-degree course change, which was followed by a figure-8 turn at varying altitudes between 800 and 1,500 feet agl." The NTSB reported that the craft "impacted terrain in a nose-low, left-wing-down attitude. The 300-foot-long debris path and fragmentation of the airplane were consistent with a high-speed impact."

The probable cause of the accident according to the NNTSB was "The pilot's continued visual flight into an area of known instrument meteorological conditions in an airplane not equipped for instrument flight, and his failure to maintain control of the airplane while maneuvering at low altitude."

Pilot error may be the strict legal explanation for the accident, but there should be no question the wind turbines played a role.

Wind turbines and associated MET towers are encroaching on aviation air space, and safety concerns are growing worldwide. In September 2015, Royal Air Force pilots produced a catalogue of near misses with wind farms in the United Kingdom. Recreational and light-craft pilots are also sounding the alarm. According to microlight aircraft instructor Colin MacKinnon in the UK, millions have been spent "to investigate the impact and guarantee the safety of commercial aviation" but "very little has been done for the general aviation sector which is us." The general aviation sector is the primary user of low-elevation flight space.

Recommendations:

As the Trump Administration undertakes its review of existing agency rules, we recommend the following actions be considered in order to secure the safety of our airspace for all aviators.

- FAA quickly adopt new rules governing the safe siting of wind MET towers; Mandate that rules apply immediately to all new *and* existing MET towers unless specifically exempted by law;
- Mandate full review and update of SkyVector sectional charts to ensure wind turbine installations and MET towers are correctly represented;
- Follow the NTSB recommendation to create and maintain a national database of wind-related towers with full public access;

- Institute periodic review and enforcement to ensure all FAA required turbine safety equipment including lighting is operating properly. Apply punitive fines for developers who fail to maintain all safety equipment.

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[1] We note that the NTSB preliminary report makes no mention of the met tower, only the guy wire.

[2] NOTAM: a written notification issued to pilots before a flight, advising them of circumstances relating to the state of flying.

[3] Special Investigation Report on the Safety of Agricultural Aircraft Operations NTSB/ SIR-14/01 PB2014-105983 Notation 8582 Adopted May 7, 2014 (Recommendations were also filed with the American Wind Energy Association (AWEA), Department of the Interior (DOI), U.S. Department of Agriculture (USDA), Department of Defense (DOD), 46 states, 5 territories, and the District of Columbia.)

[4] Advisory Circular U.S. Department of Transportation Federal Aviation Administration, Obstruction Marking and Lighting December 4, 2015, AC No: 70/7460-1L

[5] NAAA Newsletter: Everything You Need to Know About New Tower Marking Requirements.

EXHIBIT
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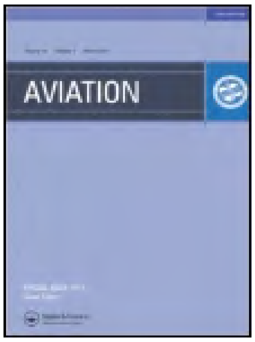

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Wind farms and aviation

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WIND FARMS AND AVIATION

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Abstract. Wind is an increasingly important source of energy for the Slovak Republic. It is exploited by the use of turbines to generate electricity. Because of their physical size, in particular their height, wind farms can have an effect on aviation. Additionally, rotating wind turbine blades may have an impact on certain aviation operations, particularly those involving radar.

Keywords: wind farm, radar theory, air traffic management, communication navigation and surveillance.

1. Introduction

There are two types of radar used for air traffic control and air defence control and surveillance: primary surveillance radar (PSR) and secondary surveillance radar (SSR).

Primary radar operates by radiating electromagnetic energy and detecting the presence and character of the echo returned from reflecting objects. Comparison of the returned signal with that transmitted yields information about the target, such as location, size, and whether it is in motion relative to the radar.

Primary radar cannot differentiate between types of objects; its energy will bounce off any reflective surface in its path. Moreover, air traffic control primary radar has no means of determining the height of an object, whereas modern air defence radars do possess this capability, using electronic beam control techniques.

For SSR, the ground station emits "interrogation" pulses of radio frequency (RF) energy via the directional beam of a rotating antenna system. When the antenna beam is pointing in the direction of an aircraft, airborne equipment, known as a transponder, transmits a reply to the interrogation. The reply is detected by the ground station and processed by a plot extractor.

The plot extractor measures the range and bearing of the aircraft and decodes the replies of the aircraft to determine the aircraft's flight level and identity (Mode C operation).

In the Slovak Republic, all aircraft flying in controlled airspace must carry a SSR transponder. Some light aircraft do not, and aircraft that do carry them may not have them switched on, in which case they will not be visible to SSR. Most ATC units are equipped with both primary and SSR, but increasingly, radar services are provided using SSR only.

From 2008 onwards, a new type of SSR called *Mode S* will begin to be introduced in SR airspace. Mode S is a development of classical SSR that overcomes many of the current limitations of the SSR system. It is proposed, subject to formal consultation, to introduce Mode S initially in 2008 with a second phase of regulatory changes in 2008. In addition, it is proposed that the requirements for the carriage and operation of transponders will be significantly extended in conjunction with the Mode S plans for 2009.

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2. Radar functions

2.1 Air traffic control (ATC)

Radar performs two functions for air traffic control:

a) airport surveillance radar allows air traffic controllers to provide air traffic services to aircraft in the vicinity of an airport. This service may include vectoring aircraft to land, providing radar service to departing aircraft, or providing service to aircraft either transiting through the area or in the airfield circuit;

b) en route (or area) radar is used to provide services to traffic in transit. This includes commercial airliners and military traffic. Area radar has a longer range than airport radar, particularly at high altitudes.

2.2 Air defence

Air defence radar is used in two ways. On the one hand, it performs a function similar to its ATC counterparts, being used by air defence controllers to provide control services to military (usually air defence) traffic. It is, however, also used to monitor all air traffic activity within the Slovak Republic and its approaches to produce a recognised air picture (RAP) with the aim of preserving the integrity of SR airspace through air policing. The RAP is produced by allocating track identities to each radar return (or "plot") of interest. A radar plot can often fade from a radar display for a period of time due to a number of factors, but the track identity will remain, indicating that the associated plot is actually still present (Lewis 2001).

2.3 Meteorological radar

Meteorological radar uses electromagnetic (EM) energy to monitor weather conditions (predominantly cloud and precipitation) at low altitudes to assist weather forecasting. Wind profiling radar is used to measure wind speed at different altitudes.

3. The nature of the impact of wind turbines

Masking

This is the main anticipated effect on air defence surveillance radar. Such radar works at high radio frequencies and therefore depends on a clear "line of sight" to the target object for successful detection. It follows that any geographical feature or structure lying between the radar and the target will cause a shadowing or masking effect; military aircraft wishing to avoid detection readily exploits indeed this phenomenon. It is possible that, depending on their size, wind turbines may cause shadowing effects. Such effects may be expected to vary, depending upon the turbine dimensions, the type of transmitting radar, and the aspect of the turbine relative to it.

The Met Office is also concerned with the effect of masking on their sensors. Met Office radar looks at a relatively narrow altitude band that is as near to the earth's surface as possible. Due to the sensitivity of the radar, wind turbines, if they are poorly sited, have the potential to significantly reduce weather radar performance (Wind … 2001).

4. Radar returns/radar clutter

Radar returns may be received from any radar-reflective surface. In certain geographical areas, or under particular meteorological conditions, radar performance may be adversely affected by unwanted returns, which may mask those of interest. Such unwanted returns are known as radar clutter. Clutter is displayed to a controller as "interference" and is primarily a problem for air defence and airport radar operators because it occurs more often at lower altitudes.

For an airport radar operator, a wind turbine or turbines in the vicinity of his airfield can present operational problems. If the turbine generates a return on his radar screen and the controller recognises it as such, he may choose to ignore it. However, such unwanted returns may obscure others that genuinely represent aircraft, thereby creating a potential hazard to flight safety. This may be of particular concern in poor weather.

A structure, which permanently paints on the radar in the same position, is preferable to one that only presents an intermittent return. This is because an intermittent return is more likely to represent a manoeuvring or unknown aircraft, obliging the controller to act accordingly. With this in mind, it is possible that aviators and radar operators could work safely with one or perhaps two turbines in the vicinity of an aerodrome. Of greater concern is the prospect of a proliferation of turbines, which could potentially saturate an airfield radar picture, making safe flying operations difficult to guarantee.

Several turbines in close proximity to each other and painting on radar could present particular difficulties for long-range air surveillance radar. A rotating wind turbine is likely to appear on a radar display intermittently (studies suggest a working figure to be one paint every six sweeps).

Multiple turbines, in proximity to each other, will present several returns during every radar sweep, causing a "twinkling" effect. As these will appear at slightly different points in space, the radar system may interpret them as being one or more moving objects and a surveillance radar will then initiate a "track" on the returns. This can confuse the system and may eventually overload it with too many tracks. Measures can be taken to mitigate this problem, and they are amplified in Section D4, but these too have their drawbacks (Knill 2002).

5. "Scattering", "refraction" and/or "false returns"

Scattering occurs when the rotating wind turbine blades reflect or refract radar waves in the atmosphere. These are then subsequently absorbed either by the source radar system or another system and can then give false information to that system. It may affect both primary and SSR radars. This effect is as yet not quantified but is certainly possible. It has, for example, been witnessed at Copenhagen Airport as a result of the Middelgrunden Offshore Wind Farm.

The possible effects are:

a) multiple, false radar returns being displayed to the radar operator: blade reflections may be displayed at the controller's console as spurious radar contacts;
b) radar returns from genuine aircraft being displayed, but in an incorrect location (range, azimuth, or both);
c) garbling or loss of SSR information.

The SSR code allocated to an aircraft may not be received correctly at the radar installation because of attenuation, scattering, or refraction effects. Moreover, it is possible that the aircraft altitude information derived from Mode C may also be lost or degraded.

6. Potential mitigating measures

6.1 Technical measures

Moving Target Indicator Processing

Objects that are moving cause a shift in the frequency of the returned EM energy to the radar receiver; this is known as Doppler shift. Moving target indicator (MTI) processing removes from the display any returned pulses that indicate no movement or are within a specified range of Doppler shift. This removes unnecessary clutter, eliminates unwanted moving targets (such as road traffic), and makes moving targets above a certain velocity more visible.

Rotating wind turbine blades can impart Doppler shift to EM energy reflecting off the blades. Depending on the MTI thresholds set in the radar processor, this may be displayed as a moving target. Changes in wind direction at the turbine, the position of the blade in its rotation, the blade pitch, and other factors may cause the amount of energy returned to the radar on different sweeps to vary. At single turbine sites, a radar return will be repeatedly displayed in the same position and MTI processing can be deployed. However, multiple-turbine sites cause a different effect and MTI processing is much more difficult. On one return, blades from one (or more) turbine(s) may paint on the radar; on the next sweep, the blades of a different turbine may paint. This can create the appearance of radar returns moving around within the area of the wind farm.

On both airport and air defence radar this can appear (depending on the type of radar and the processing thresholds in effect) as unknown aircraft manoeuvring unpredictably. On air defence radar such as those used in the Air Defence Slovak Republic, the overall system may well interpret the activity as an aircraft and automatically start tracking the activity (Wind … 2002).

Filters

It is technically possible with many types of radar to filter out returns from a given area to ensure they are not presented on operational displays. This is however at the expense of detecting actual aircraft in the area concerned. In the case of radar that has the ability to discriminate returns in height, it may be possible to filter out only the affected height band. On other radar, all returns in the given area will be lost and, in effect, no overall operational benefit is gained.

Non-Automatic Initiation

A measure that can be taken within the command and control system to mitigate the effects of spurious radar returns is to establish what is known as a non-automatic initiation (NAI) area. Within this area, the system does not perform its normal function of automatic track association and correlation. This would prevent the system attempting to correlate the returns from a large number of turbines to form what it perceives to be aircraft tracks. Instead, a human operator monitors the affected area to manually detect genuine aircraft tracks. Whilst this technique can help avoid problems both for surveillance and control of spurious tracks, it can be manpower intensive and requires operator expertise. Furthermore, it cannot help to overcome the effect of clutter on safety. Indeed, the use of clutter filters and NAIs may be operationally mutually exclusive.

6.2 Operational measures

The type of operations being conducted and the type of airspace within which a controller is operating are both relevant factors if radar clutter is being experienced.

Controlled airspace

Within controlled airspace, flight is only possible if approved by an ATC authority. Therefore, controllers should know of all aircraft within that controlled airspace. In this case, if radar clutter is experienced, whether from a wind turbine or other obstacle, the controller may assume that the return is not from an unknown aircraft and will not need to take any action. (There are exceptions to this rule that do not need to be explored here.)

Outside controlled airspace

Outside controlled airspace (in the Slovak Republic, categorised as Class G airspace), clutter and unknown radar returns present more of a problem. In such airspace, the radar returns of aircraft are the primary means on which the separation of aircraft is based. Clutter must therefore be avoided since it is the only way of ensuring separation from unknown aircraft.

What may occur is that radar clutter from a wind turbine may be interpreted as being a return from an aircraft, or the clutter may be obscuring a genuine radar return from an actual aircraft operating in the vicinity of that clutter.

There are two ways a controller can deal with this problem. The safest option is to simply avoid the area of clutter, usually by a range of 5 nautical miles. Naturally, this is not always possible. Alternatively, the controller may "limit" his radar service by informing the aircraft receiving the service that, due to being in an area of clutter, the pilot may receive late or no warning of other aircraft.

Controllers use both methods but each presents its own problem. The cumulative effects of clutter make vectoring to avoid clutter harder and harder. Controllers may be able to cope with one or two areas of clutter, but there is a difficult judgement as to how much proliferation is acceptable. Alternatively, limiting the service is often a last resort, and to admit that clutter may well be obscuring returns from genuine aircraft is a clear indication that flight safety may be compromised.

The significance of unwanted radar returns from wind turbines will depend not only on what type of airspace they are in or underneath, but also on their proximity to traffic patterns and routes. Wind turbines on an extended centreline of a runway are more likely to present a significant problem to controllers at longer ranges due to aircraft lining up for approaches and on departure. Similarly, airports have standard arrival routes (STAR) and standard instrument departure (SID) routes, which may also be considered problematic.

7. Conclusions

All radar is different (even if only due to the physical impact of operating locations) and creating a “rule of thumb” for wind farm development near all systems would require a level of generalisation that would probably make it worthless.

Therefore, in considering the effect of wind turbines on radar, developers need to focus on individual radar in the vicinity of their planned development. It is also important for developers to appreciate the nature and extent of any problem. For example, studies in air defence radar that take no account of the associated command and control systems may be of very limited value.

Both civil and military aviation communities have legitimate interests that must be protected, and they include protection against the adverse effects of wind turbines. There is scope for flexibility throughout the process of considering wind farm applications, however. The effects of wind turbines on the physical element of the air domain (as obstructions) are well understood and the procedures for handling them are relatively straightforward. Certainly, a flexible approach to the sitting of turbines can be expected to pay dividends. Developers must, however, bear in mind that there are some locations in which the presence of turbines is unlikely ever to be tolerated.

The effects of wind turbines on electronic systems and the measures that can be taken to overcome these effects are less clear-cut. The sitting of wind turbines will, potentially, affect the radar sensors belonging to both civil and military users in much the same ways, although the operational impact of these effects will probably not be the same. As further research is conducted and experience with existing (and currently approved) wind farms grow, all stakeholders will be able to determine more precisely what may be acceptable and what will not. No matter what, however, this is an area in which early dialogue with the relevant stakeholders is particularly recommended.

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VĖJO FERMA IR AVIACIJA

A. Novák

Santrauka

Vėjas yra vis didėjantis energijos šaltinis Slovakijos Respublikoje. Jis naudojamas generuoti elektrą turbinomis. Vėjo fermos pagal savo fizikinį dydį ir ypač pagal aukštį gali turėti įtakos aviacijai. Besisukančios vėjo turbinų mentės gali turėti įtakos tam tikroms aviacijos operacijoms, ypač susijusioms su radarais.

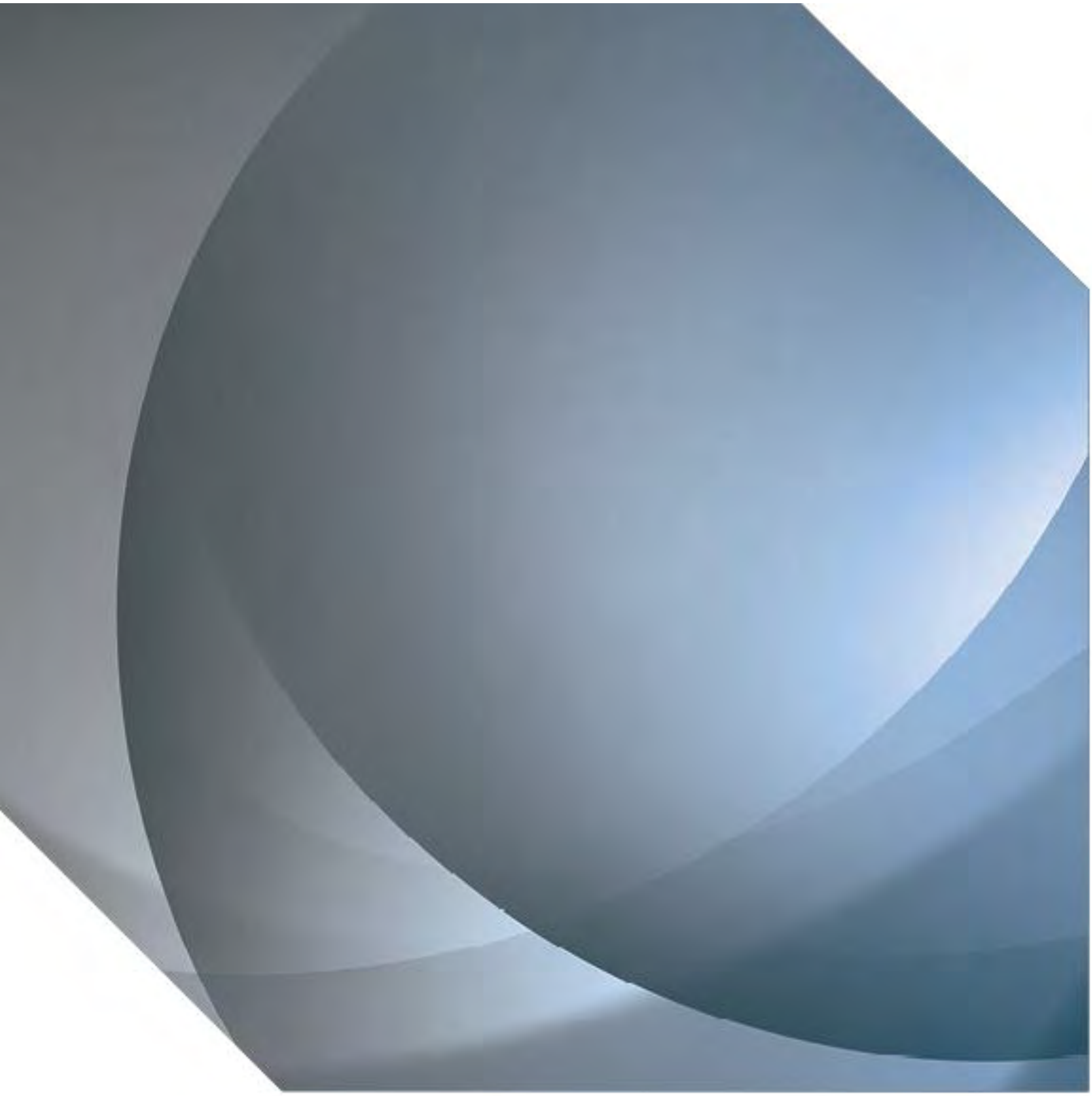
Reikšminiai žodžiai: vėjo ferma, radarų teorija, skrydžių valdymas, komunikacijos navigacija ir priežiūra.

EXHIBIT
4

Safety & Airspace Regulation Group

CAA Policy and Guidelines on Wind Turbines

CAP 764



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The latest version of this document is available in electronic format at www.caa.co.uk, where you may also register for e-mail notification of amendments.

Contents

Revision History

Issue 1 July 2006

Neither aviation nor the wind energy industry is at a steady state and both can be expected to evolve in ways that may impact the other. Combining the current drive for renewable energy and the increasing number of wind farms with the finite land resource in the UK, means that wind turbines and aviation are being required to operate closer and closer together. However, providing a suitable environment that allows the co-existence of wind turbines and aviation is extremely complicated and new or improved mitigation solutions are being developed all the time. Therefore, it is expected that this CAP will be a living document, which will be updated periodically to reflect the outcome of any further research into the interaction between wind turbine developments and aviation. It will also be revised to take account of changes in regulations, feedback from industry, and recognised best practice.

Issue 2 February 2009

The way in which Aviation Stakeholders and Wind Turbine Developers interact has matured since the initial release of CAP 764 in 2006. This revision includes updates on Government renewable energy policy and details of how all interested parties interact. Additionally, the scope of the document has been widened to include all aspects of aviation that may be affected by Wind Turbines. The appendix detailing the method for determining if a wind turbine is in line of sight of an aeronautical radar station has been simplified.

Issue 3 May 2010

This revision is published to update references to the Air Navigation Order which has been completely re-numbered and to incorporate editorial corrections.

Issue 4 July 2011

This revision follows extensive consultation amongst the aviation and renewable energy communities. Whilst remaining an aviation stakeholder-focused document, CAP 764 has been amended in an attempt to broaden its appeal to all interested wind energy parties with the intention of becoming the ‘go to’ document for aviation and wind energy stakeholders alike. It is important that this document is read in conjunction with the CAA Wind Energy web pages, which provide amplifying information, and which will enable currency and relevancy to be maintained in between the biennial revisions of CAP 764.

A re-issue to issue 4 was made in August 2011 incorporating corrections to the Glossary, Chapter 2, Pages 4, 8 and 9, Chapter 3, Pages 6 and 7.

Revisions included in Amendment 1 to Issue 4

This revision includes changes to Offshore Helicopter Operations, Consultation Zones around Offshore Helidecks, Helicopter Main Routes and Facilitation of Helicopter Support to Offshore Installations.

Issue 5 June 2013

This revision is in the new CAA format and as such paragraph numbering has been updated. In addition, previous paragraphs detailing the impact of wind turbines on aviation and specifically radar have been updated. This is supplemented by an updated overview and analysis of the various mitigation techniques available. It replaces Issue 4 completely.

Issue 6 February 2016

Issue 6 is publicised following a lengthy consultation with both external and CAA stakeholders. It simplifies radar effects paragraphs and returns the more complicated radar detail to the CAP 670. Potential Mitigation Measures were also taken directly from the CAP 670 therefore detailed explanations are removed from the CAP 764 with only a summary retained. Issue 6 also incorporates CAA Policy Statements on the 'Lighting of Wind Turbine Generators in United Kingdom Territorial Waters (22 November 2012)' and the 'Failure of Aviation Warning Lights on Offshore Wind Turbines (27 April 2012)'. CAA Policy Statement 'Lighting of En-Route Obstacles and Onshore Wind Turbines (1 April 2010)' remains extant. Appendices concerning radar assessment methodology and references are removed, the latter being comprehensively covered by hyperlinks and footnotes within the document. It should be noted that hyperlinks were verified on publication. Issue 6 has been comprehensively reviewed and updated where necessary to reflect current information and practices. It replaces Issue 5 completely.

Foreword

Introduction and background

The Department for Transport (DfT) 'Aviation Policy Framework[1], presented to Parliament in March 2013, provided a high level strategy setting out Government objectives for aviation. The aviation sector is seen as a major contributor to the economy and the Government seeks to support its growth within a framework which maintains a balance between the benefits of aviation and its costs, particularly its contribution to climate change and noise.

Whilst recognising the need for further aviation capacity in the UK in order to promote economic growth, the strategy is also based on the requirement for a balanced approach which addresses the wider impacts of aviation and the need for sustainable development.

The Government is also committed to reducing greenhouse gas emissions within the UK and, in turn, this means there is now a shift towards economically viable renewable energy sources rather than carbon fuels. The 2008 Climate Change Act established the world's first legally binding climate change target which aims to reduce the UK's greenhouse gas emissions by at least 80% (from the 1990 baseline) by 2050. In addition, Directive 2009/28/EC of the European Parliament and of the Council set the national overall target for the share of energy from renewable energy by 2020 as 15% for the UK. However, it is UK Government policy that 30% of the UK's electricity supply should come from renewable sources by 2020; the Scottish parliament has adopted a more ambitious 100% electricity demand equivalent from renewables by 2020.

It is anticipated that wind energy will provide a significant contribution to renewable energy targets. In order to harness this energy supply, both on- and offshore wind turbine developments are being constructed, which range in size from single structures to developments encompassing many hundreds of wind turbines. Moreover, the installation of Micro Wind Turbines (MWT) is becoming increasingly prevalent. The physical characteristics of wind turbines, coupled with the size and siting of the developments, can result in effects that can have a negative impact on aviation.

Both wind energy and aviation are important to UK national interests and both industries have legitimate interests that must be balanced carefully. Therefore it is important that the aviation community recognises the Government aspiration for wind turbine developments to play an increasing role in the national economy. As such, the aviation community must engage positively in the process of developing solutions to potential conflicts of interest between wind energy and aviation operations. In a similar vein, wind turbine developers

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[1] DfT Aviation Policy Framework March 2013

must understand the potential impact of developments on aviation, both at a local and a national level, and to fully engage with the aviation industry to develop suitable mitigation solutions.

Those involved in addressing wind energy and aviation issues must do so in a positive, co-operative and informed manner. Whilst the aims and interests of the respective industries must be protected, a realistic and pragmatic approach is essential for resolving any conflicts between the Government's energy, transport and defence policies.

Aim of this publication

Being a CAP, this document is aimed primarily at providing assistance to aviation stakeholders to help understand and address wind energy related issues, thereby ensuring greater consistency in the consideration of the potential impact of proposed wind turbine developments. However, it is acknowledged that other users such as Local Planning Authorities (LPAs)[2], wind energy developers and members of the general public will also refer to it.

Consequently, it is hoped that some of the issues and questions often posed by these groups have, where appropriate, also been discussed.

Scope

This document provides CAA policy and guidance on a range of issues associated with wind turbines and their effect on aviation that will need to be considered by aviation stakeholders, wind energy developers and LPAs when assessing the viability of wind turbine developments.

It is not the intention or purpose of this CAP to provide instruction on the need or means to object to wind turbine developments; this must remain the decision of individual aerodrome operators, service providers or other organisations. Furthermore, it should also be noted that within the framework of these guidelines, specific circumstances will have to be addressed on a case-by-case basis, as it is not possible or appropriate to prescribe a standard solution. This document should be read in conjunction with specific policy and/or legislative documentation as referenced in the text, as well as the CAA Windfarms web pages.

Significant effort has been spent developing a cohesive approach to wind energy across the civil and military spectrum of aviation. It is an aspiration to create a joint and integrated publication that details both civil and military aviation policy on wind turbines. However, until this is achieved, the Ministry of Defence (MoD), through Defence Infrastructure Organisation (DIO), must continue to be consulted separately on all developments that may affect their sites (both aviation and others).

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[2] The term 'LPA' throughout this document is used generically to refer to Planning Authorities within England, Scotland, Wales and Northern Ireland.

Feedback

Stakeholders are encouraged to provide feedback on their experiences with wind turbine development so that this CAP can be updated appropriately. This CAP will be reviewed biennially and, due to the lengthy process that must be followed, minor amendments cannot be made. However, interim amendments and supplementary guidance will be published through additional CAA Policy Statements or on the CAA Wind Energy web pages to maintain the currency and relevance of CAA guidance and policy.

Contact details

General enquiries concerning this publication can be addressed to windfarms@caa.co.uk. Additional contact details, including postal addresses, are provided at Appendix B.

Glossary

A list of specialised words or terms with their definitions follows:	
AAA	Airspace, ATM and Aerodromes (CAA)
ACP	Airspace Change Process
AD	Air Defence
AIP	Aeronautical Information Publication
ANO	Air Navigation Order
ANSP	Air Navigation Service Provider
AOA	Airport Operators Association
ATC	Air Traffic Control
CAA	Civil Aviation Authority
CAS	Controlled Airspace
CAP	Civil Aviation Publication
CFAR	Constant False Alarm Rate
CNS	Communications, Navigation And Surveillance
DECC	Department Of Energy And Climate Change
DfT	Department For Transport
DIO	Defence Infrastructure Organisation (Formerly Defence Estates)
DME	Distance Measuring Equipment
DTM	Digital Terrain Mapping
DVOF	Defence Vertical Obstruction File
DZ	Dropping Zone
EASA	European Aviation Safety Agency
EM	Electromagnetic
FT	Feet
GA	General Aviation

A list of specialised words or terms with their definitions follows:	
HMR	Helicopter Main Route
IFP	Instrument Flight Procedures
ILS	Instrument Landing System
JAR	Joint Aviation Requirements
KM	Kilometre(S)
LF	Low Flying
LOS	Line Of Sight
LPA	Local Planning Authority (also refers to planning authorities of devolved governments)
m	Metre(s)
MAP	Missed Approach Procedure
MATS	Manual of Air Traffic Services
MHz	Mega Hertz
MoD	Ministry of Defence
Mode S	Mode Select
MSD	Minimum Separation Distance
MW	Mega Watts
MWT	Micro Wind Turbine
NAFW	National Assembly for Wales
NAIZ	Non-Automatic Initiation Zones
Navaids	Navigation Aids
NDB	Non Directional Beacon
NERL	NATS En Route plc
NM	Nautical mile(s) (1853 m or 1.15 Statute Miles)
ODPM	Office of the Deputy Prime Minister
OLS	Obstacle Limitation Surface
PPG	Planning Policy Guidance Note

A list of specialised words or terms with their definitions follows:	
P-RNAV	Precision Area Navigation
PSR	Primary Surveillance Radar
RAM	Radar Absorbent Material
RCS	Radar Cross-Section
RF	Radio Frequency
RNAV	Area Navigation
SARG	Safety and Airspace Regulation Group (CAA)
SID	Standard Instrument Departure
SMS	Safety Management Systems
SSR	Secondary Surveillance Radar
STAR	Standard Instrument Arrival Route
TMZ	Transponder Mandatory Zones
VFR	Visual Flight Rules
VOR	VHF Omni Directional Range

Chapter 1

CAA Responsibilities

General

1.1 The CAA is responsible for safety and airspace regulation of civil aviation in the UK under the Civil Aviation Act 1982 and the Transport Act 2000. The CAA's Safety and Airspace Regulation Group (SARG) is responsible for the regulation of licensed aerodromes and Air Traffic Services (ATS) in the UK; the planning and regulation of all UK airspace, including the communications, navigation and surveillance (CNS) infrastructure, and also has the lead responsibility within the CAA for all wind turbine related issues. Within SARG, wind turbine related issues are addressed by CAA Infrastructure.

1.2 Legislative provisions affecting all development, including wind turbines, are set out for England and Wales in Town & Country Planning (Safeguarded Aerodromes, Technical Sites and Military Explosives Storage Areas) Direction 2002 (ODPM Circular 01/2003). Similar provisions are set out for Scotland in the Town & Country Planning Safeguarded Aerodromes, Technical Sites and Military Explosives Storage Areas (Scotland) Direction 2003 (Scottish Planning Circular 2/2003), and for Northern Ireland in the Planning Policy Statement 18: Renewable Energy. These provisions only apply formally to those aerodromes and technical sites that are officially safeguarded; moreover, statutory consultees are limited to the MoD, NATS En Route Ltd (NERL) and affected service providers.

1.3 At all times, responsibility for the provision of safe services lies with the ATS provider or Air Navigation Service Provider (ANSP). It should be noted that the CAA does not have regulatory powers to approve or reject planning applications.

1.4 The CAA policy on wind energy is that:

1. Wind turbine developments and aviation need to co-exist in order for the UK to achieve its binding European target to achieve a 15% renewable energy commitment by 2020, and enhance energy security, whilst meeting national and international transport policies. However, safety in the air is paramount and will not be compromised. As the independent aviation regulator, the CAA is well placed to provide clarification to both the aviation industry and the wind energy industry;
2. Due to the complex nature of aviation operations, and the impact of local environmental constraints, all instances of potential negative impact of proposed wind turbine developments on aviation operations must be considered on a case- by-case basis;

3. It is CAA policy to provide the best and most timely advice to aviation and wider wind development stakeholders through consultation, the publication of CAP 764 and its associated web pages on the CAA web site;
4. Such clarification, advice and guidance is provided through the publication of this and associated official CAA and government documents, along with the CAA Windfarms web pages.

Aerodrome and Communications Navigation and Surveillance (CNS) site safeguarding[3]

1.5 Many civil aerodromes in the UK are certificated in accordance with EU Regulation 139/2014 (Aerodromes) or licensed in accordance with the Air Navigation Order (ANO) 2009 as amended. Under either of these provisions, the CAA is responsible for being satisfied that a certificated or licensed aerodrome complies with the relevant requirements and is safe for use by civil aircraft, having regard in particular to the physical characteristics of the aerodrome and its surroundings. Aerodrome operators are required to have procedures for safeguarding, to monitor the changes in the obstacle environment, marking and lighting, and in human activities or land use on the aerodrome and in the areas around the aerodrome. In addition, a requirement is placed on the licensee to take all reasonable steps to ensure that the aerodrome and its surrounding airspace are safe at all times for use by aircraft.

1.6 'Statutory' or 'official' safeguarding is a process of obligatory consultation between an LPA and consultees and is designed to safeguard technical sites and certain aerodromes in the UK. However, the same process of consultation can take place for aerodromes and technical sites that are not given this statutory protection; this process is known as unofficial safeguarding.

1.7 Certain civil licensed aerodromes (selected by Government on the basis of their importance to the national air transport system) are officially safeguarded. All EASA certificated aerodromes are deemed to be officially safeguarded. In particular, such safeguarding ensures that the operations and development of the aerodromes are not inhibited by buildings, structures, erections or works which infringe protected surfaces, obscure runway approach lights or have the potential to impair the performance of aerodrome CNS. A similar official safeguarding system applies to certain military sites, including aerodromes,

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[3] Further information can be found in:

- England and Wales: Joint ODPM, DfT, Planning Circular 1/2003 guidance on Safeguarding, Aerodromes, Technical Sites and Military Explosives Storage Areas
- Scotland: Planning Circular 2 2003
- Graphics of safeguarded technical sites can be found at:
- http://www.nats.aero/services/information/wind-farms/self-assessment-maps/

selected on the basis of their strategic importance.

1.8 In general, aerodrome safeguarding is limited to the vicinity of the aerodrome (the definition of ‘vicinity’ will vary depending upon the activity that takes place at that aerodrome). The CAA Aerodromes Team conducts oversight audits at certified and licensed aerodromes to confirm compliance to the applicable rules.

1.9 CAP 793 (Safe Operating Procedures at Unlicensed Aerodromes) provides guidance for unlicensed aerodromes.

1.10 Where an Instrument Landing System (ILS) is used at an aerodrome, safeguarding criteria are used to protect the ILS radio signals from corruption. Technical safeguarding aspects are detailed in CAP 670 (Air Traffic Services Safety Requirements) GEN 02.

1.11 Aerodrome operators are responsible for liaising with LPAs to prevent operational airspace being infringed by new development. One significant consideration is the protection of the Obstacle Limitation Surface (OLS)[4] that should be applied for aerodrome safeguarding. The CAA may be required to explain technical matters to local or central government if a contested development proposal is referred to Ministers for decision.

1.12 The safeguarding of unlicensed aerodromes falls within the advice promulgated in the aforementioned national circulars, which, at Paragraph 13 of Annex 2 state: “Operators of licensed aerodromes which are not officially safeguarded and operators of unlicensed aerodromes and sites for other aviation activities (for example gliding or parachuting) should take steps to protect their locations from the effects of possible adverse development by establishing an agreed consultation procedure between themselves and the local planning authority or authorities. Local planning authorities are asked to respond sympathetically to requests for non-official safeguarding.”

1.13 The safeguarding of unlicensed aerodromes is therefore a matter of discussion between the operator and the LPA and the need for constructive liaison from an early stage is evident. CAP 793 provides guidance. Both official and unofficial safeguarding are discussed further in Chapter 3 of this document.

1.14 In all cases, regardless of the status of the aerodrome, any development that causes pilots to experience an increase in difficulty when using an aerodrome may lead to a loss of utility. The CAA considers that if the aerodrome operator

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[4] OLS is the hypothetical boundary which indicates the extent of a volume of airspace which should be kept free of obstacles, so far as is reasonably practicable, to facilitate the safe passage of aircraft. It is used collectively to refer to other terms which are fully defined in Chapter 4 of Annex 14 to the Chicago Convention and incorporated into UK civil aviation regulation within CAP 168. OLS comprises of: approach surface, balked landing surface, conical surface, inner approach surface, inner horizontal surface, inner transitional surface, take-off climb surface and transitional surface.

advises that the aerodrome's established amenity would be affected by a development, their advice can generally be considered as expert testimony in the context of the operation of the aerodrome. However, such comment requires robust evidence, and may be subjected to scrutiny by the CAA (or any other party with equivalent expertise), should disagreement between the aviation operator and the wind energy developer arise. Notwithstanding that the CAA has no regulatory oversight of unlicensed aerodromes it is recommended that developers and planning authorities give similar consideration to comments and evidence from the operators of unlicensed aerodromes.

1.15 It is recommended that aerodrome operators that are not officially safeguarded have agreed unofficial safeguarding maps with LPAs.

1.16 The safety of aircraft in UK airspace is often dependent on ground-based navigation and radio aids. DfT Circular 1/2003 and Scottish Circular 2/2003 provides for the safeguarding of civil technical sites currently owned by NERL and military technical sites owned by the Secretary of State for Defence.

Airspace management

1.17 SARG, as the airspace regulatory authority, is responsible for developing, approving, monitoring and enforcing policies for the safe and efficient allocation and use of UK airspace and its supporting infrastructure, taking into account the needs of all stakeholders, national security and environmental issues.

1.18 SARG is directed by the Secretary of State for Transport to act with impartiality to ensure that the interests of all airspace users (including General Aviation (GA) stakeholders) and the community at large are taken into account in respect of how UK airspace is managed. To this end, formal consultation with airspace users, service providers and other relevant bodies shall be conducted with the aim of obtaining consensus, wherever possible, before making changes in the planning or design of UK airspace arrangements. The environmental impact of proposals for change shall be taken into consideration by ensuring that consultation is conducted with the appropriate authorities, to lessen or mitigate such impact to the maximum extent possible.

1.19 The Airspace Change Process (ACP) is mandatory for the majority of airspace change requests. It is a robust process that ensures that all appropriate stakeholders are consulted; CAP 725 refers.

Approvals for equipment and service provision

1.20 In order to provide an ATS in the UK, a service provider must be granted an approval by the CAA. EC 1035/2011, EC 550/2004 and relevant sections of the ANO (2009) as amended apply.

1.21 Where service providers use a remote feed of surveillance data from a contracted source, they remain responsible for gaining the requisite approvals for the use of data as part of a surveillance service. ANSPs must have effective processes and procedures to:

1. Safeguard their service through being able to recognise when wind turbine developments may affect their service, and by participating in planning activities;
2. Be able to assess the likely effect of a wind turbine development on their service. It is not automatically the case that a wind turbine development will result in a degradation to the service. The service provider must first assess whether the planned development will technically impact upon the CNS systems used. Where it is assessed that there will be a technical impact, the service provider must then assess whether this has any operational significance (see also Chapter 2);
3. Be able to establish what reasonable measures may be put in place to mitigate the effect of a wind turbine development. At all times, a collaborative approach between the service provider and the wind turbine developer is required to ensure an appropriate (i.e. reasonable, achievable and timely) mitigation is identified.

1.22 Where a service provider has to make a change to equipment or operational procedures in order to safely accommodate a wind turbine development then the following must be addressed:

1. The service provider must perform a safety assessment on the change. The final safety assessment cannot be made until all changes have been implemented and wind turbine developments are operational;
2. As part of the safety assessment, the service provider should at least consider the issues raised in Chapter 2 of this CAP concerning the impact of wind turbines on aviation;
3. Where considering mitigations to address the impact of the wind turbine development, service providers are advised to review the issues and limitations summarised in Chapter 2. Full details are available in the CAA CAP 670;
4. All significant changes to an ATS must be notified by an ANSP to their SARG Regional Inspector who may wish to see evidence that the change has been managed safely and in accordance with the ANSPs change management processes. Where appropriate, an updated or amended Safety Case may be required;
5. ANSPs that fail to properly address the effects of a wind turbine development on a service may have the existing Certificate withdrawn by the CAA, or

variations applied to the Designation which may result in the closure of that service.

Advice to Government

1.23 In discharging its role as an independent regulator, the CAA is required to provide advice to Government as required. To this end, the CAA is proactive with appropriate Government departments in respect of wind energy related issues. The CAA is a member of the DECC (Department of Energy and Climate Change) Aviation Management Board and its sub-groups to provide expert input on aviation aspects of the Government’s renewable energy programme. Details of these groups are contained in Appendix A.

Chapter 2

Impact of wind turbines on aviation

Introduction

2.1 The development of sites for wind turbines has the potential to cause a variety of negative effects on aviation. These include (but are not limited to): physical obstructions; the generation of unwanted returns on Primary Surveillance Radar (PSR); adverse effects on the overall performance of CNS equipment; and turbulence. Whilst it is generally the larger, commercial turbines that have the greatest impact on aviation, the installation of other equipment may also affect operations. Smaller turbines, and the preliminary activities for larger turbines (such as the erection of anemometer masts on potential development sites), could have a negative impact on aviation and so require assessment. Moreover, the cumulative effects of wind turbines on aviation need to be assessed if developments proliferate in specific areas.

2.2 This chapter aims to provide a summary of the issues that aviation stakeholders should consider when assessing the impact of a proposed wind turbine development. It is not intended to be exhaustive because local circumstances may raise issues that are unique to a specific case. For this reason, the local aerodrome operator, ANSP and ATS providers may be best qualified to interpret what this impact might be; however, they must demonstrate a thorough assessment of how it will affect the safety, efficiency and flexibility of their specific operations. Robust evidence may be required: see also para 1.14.

Wind turbine effects on PSR[5]

2.3 The following section describes the various effects that wind turbines have caused on Air Traffic Control (ATC) PSRs during the trials conducted as part of many research projects around the UK and the rest of the world.

2.4 ANSPs must therefore consider the possibility that their radars be affected by each of these phenomena as a result of wind turbines within the coverage range of their surveillance systems.

2.5 In basic terms, a PSR transmits a pulse of energy that is reflected back to the radar receiver by an object that is within its Line of Sight (LOS)[6]. The amount of reflected energy picked up by the receiver will depend upon a number of factors

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[5] The following paragraphs are intended as a summary only. Full explanations and detailed technical discussion are available in the CAA CAP 670: ATS Safety Requirements at SUR 13.

[6] Note radar line of sight is different to visual line of sight.

such as the size, shape and orientation of the object[7], as well as receiver sensitivity and the weather. In general terms, the larger a wind turbine is, the more energy will be reflected and there is an increased chance of it creating false returns to radar (i.e. returns that are not aircraft). These unwanted returns are known as ‘clutter’[8]. Issues may be compounded by increasing numbers of wind turbines which could potentially cause greater areas and densities of clutter.

2.6 Providing that it remains within radar LOS, generally the closer a wind turbine is to a radar station, the greater the likelihood its reflected energy will be picked up by the radar receiver. It also follows that the taller a turbine is, the greater the distance from the radar that it will remain within radar LOS (unless the turbine is hidden by terrain). A characteristic that makes wind turbines more unpredictable is the fact that because the turbines rotate to follow the wind, the cross-sectional area presented to the radar at any given time, and therefore the RCS of the turbine, will vary depending upon wind direction. This presents challenges to generating a ‘standard’ turbine RCS for radar modelling purposes. Given that aviation safety issues are involved, a conservative approach should generally be adopted.

2.7 Typically, radar returns from a wind turbine comprise reflections from both stationary and moving elements: these provide different challenges for the radar. While the reflected radar signal from stationary elements, such as the tower, can be removed using stationary clutter filters in the radar processor, rotating wind turbine blades can impart a Doppler shift to any radar energy reflecting off the blades. Doppler shifts are used by a number of radars to differentiate between moving objects, namely aircraft, and stationary terrain with the latter being processed out and not displayed to the operator. The radar may therefore detect Doppler returns from moving wind turbine blades and display them as returns on the radar screen. Furthermore, at sites with more than one turbine, the radar may illuminate a blade or blades from one turbine on one antenna sweep, then illuminate the blades of a different turbine on the next sweep. This can create the appearance on the radar screen of returns moving about within the area of the wind farm, sometimes described as a “twinkling” appearance or “blade flash effect”. These moving returns can appear very similar to those that would be produced by a light aircraft. The appearance of multiple false targets in close proximity can trick the radar into initiating false aircraft tracks. False PSR returns can also ‘seduce’ real aircraft tracks away from their true returns as the radar attempts to update an aircraft track using the false return. This can lead to degradation of radar tracking capability.

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[7] Which together contribute to the Radar Cross Section (RCS) of the obstacle.

[8] Note that the term ‘clutter’ refers simply to unwanted false returns and can be generated by a number of means, not simply from wind turbines.

2.8 The large RCS of wind turbines and the blade flash effect can also lead to a decrease in radar sensitivity. This can result in the loss of small targets and a reduction in the maximum range at which the smallest targets can be detected. Wind turbines can also create a shadow above and beyond the wind farm so that aircraft flying within this shadow may go undetected.

Wind Turbine Effects on secondary surveillance radar (SSR)[9]

2.9 In general terms, SSRs differ from PSRs as rather than measuring the range and bearing of targets through detecting reflected radar signals, an SSR transmits an interrogation requesting a dedicated response. Upon receiving an interrogation, the aircraft then transmits a coded reply which the SSR can use to ascertain the aircraft's position as well as decode other information contained within the response.

2.10 Wind turbine effects on SSR are traditionally less than those on PSRs but can be caused due to the physical blanking and diffracting effects of the turbine towers, depending on the size of the turbines and the wind farm. These effects are typically only a consideration when the turbines are located very close to the SSR i.e. less than 10 km.

2.11 SSR energy may be reflected off the structures during both the interrogation and reply phases. In effect, the signals are bounced off the wind turbines and can therefore arrive at the intended target from a false direction. This can result in aircraft, which are in a different direction to the way the radar is looking, replying through the reflector and tricking the radar into outputting a false target in the direction where the radar is pointing, or at the obstruction.

Surveillance service impact assessment

2.12 Prediction of the effect of wind turbines on any particular radar site is a complex task depending on many factors including terrain, the weather, the maximum height of both radar and wind turbines, radar LOS, the operational range of affected radars, diffraction and antenna beam tilt.

2.13 There are a number of models that are employed to demonstrate potential impacts of wind turbine developments on radar. Such models are constantly developing and will offer some guidance as to the likelihood of wind turbines presenting a radar return; although the nature of wind turbine operations vary due to the unpredictability of different turbine types, variable turbine rotation speed and the times of operation of individual turbines. Therefore, the degree of certainty as to whether a turbine, or group of turbines, will be displayed or not in marginal ‘radar/radio LOS’ cases cannot be guaranteed. In such cases, and

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[9] The following paragraphs are intended as a summary only. Full explanations and detailed technical discussion are available in the CAA CAP 670: ATS Safety Requirements at SUR 13.

where aviation safety is a potential issue, safety consideration should always be applied in a conservative manner.

2.14 The CAA does not endorse any one specific radar modelling tool. Nor, given the multitude of factors affecting RCS, can a ‘standard’ RCS be identified for micro, medium and large wind turbines. It is strongly suggested that developers engage with the appropriate ANSP prior to commissioning a propagation assessment in order to ensure that the proposed model is suitable and is acceptable to the ANSP. Failure to do this could result in later disagreement and conflict once results are released. ANSPs are encouraged to consider publishing clear guidance as to which radar models they would consider acceptable to their requirements.

2.15 Eurocontrol has provided basic international guidelines on how to assess the effects of wind turbines on radar. It should be noted that these guidelines do not overwrite national planning jurisdictions or requirements, but are included here as a source of further potential information.

2.16 If the radar station likely to be affected by a proposed wind turbine development belongs to NATS, useful self assessment guidance is available at: http://www.nats.aero/services/information/wind-farms/self-assessment-maps/.

2.17 If the wind turbine development is likely to affect an MOD radar station; it is recommended that the MOD should be contacted at the earliest opportunity. Further guidance can be found on the MOD Windfarms Safeguarding web site

Mitigation

2.18 The following paragraphs give a summary of some of the mitigation methods that are available to help counter the effects of wind turbines, primarily on PSR and SSR related issues. More detailed explanations and analysis of mitigation techniques are contained within the CAA CAP 670: ATS Safety Requirements at SUR 13. Not all the mitigation methods will be suitable in all circumstances and more than one method may be required to mitigate risks to an acceptable level. The definition of ‘acceptable’ will have to be made on a case by case basis.

2.19 It is the responsibility of the developer to consult with the aviation stakeholder to discuss whether mitigation is possible and, if so, how it would best be implemented. It must also be noted that most mitigation methods would be subject to a standard safety assessment process by the ANSP who, in turn, would need to demonstrate that the system is safe in order to gain CAA approval (where applicable). Accordingly, where a wind turbine development is likely to impact upon the provision of an ATS, then the developer and ANSP should co-operate to mitigate such impacts wherever possible.

2.20 In determining the appropriateness of radar mitigations, stakeholders need to be aware of the potential impact of the Government’s Spectrum Release

Programme. This work stream, overseen by the Government Public Expenditure Committee (Assets) seeks to release 500MHz of spectrum from "public infrastructure" use by 2020 to boost growth in the UK economy. The CAA has been tasked to undertake a major piece of work in support of this programme. This aims to deliver a release from 2.7-2.9MHz (which is currently used by S-Band PSR) by reviewing how non-cooperative surveillance can be best delivered to meet the operational and safety requirements of ANSPs and consistent with the Future Airspace Strategy (FAS). In parallel, there is an aspiration to use this opportunity to develop a strategic approach to windfarm mitigation in how non-cooperative surveillance is deployed. This significant programme is being managed as a phased approach with GO/NO GO decision points at appropriate milestones. The CAA will be providing updates on progress via the web page listed at footnote 13, below, at suitable intervals to keep stakeholders informed.

Summary of mitigation techniques

2.21 Mitigation techniques can be categorised in to several key types. This section provides a summary of each category. More detailed explanation is available in the CAP 670: ATS Safety Requirements.

Work-rounds

2.22 Work-rounds are interim measures which would enable an ANSP to continue providing an ATS using surveillance radar, potentially under reduced operational efficiency or an increased level of risk, whilst a long-term full mitigation solution is being progressed. Work-rounds can include moving the locations of the wind turbines (where feasible), introducing sector blanking, re-routing traffic, or using SSR only.

In-fill radars

2.23 Several manufacturers are known to have developed in-fill solutions specifically designed for the purpose of wind farm mitigation on ATC radars. This either involves combining the target data from a radar that does not have line-of-sight to the wind farm or from a radar with a smaller coverage area that is situated somewhere within the wind farm or where the wind farm is within its within LOS such that the airspace above the wind farm area can be monitored using the in-fill radar, therefore a complete air situation picture can be produced by combining the two results.

Three- Dimensional radars

2.24 Traditional ATC primary radars measure only the range and bearing of the target and do not measure altitude data. They are therefore classed as two dimensional radars. Some PSRs can provide three-dimensional information and can therefore be used as in fill radars above wind farm affected areas.

High Pulse Repetition Frequency (PRF) radars

2.25 Some manufacturers have also developed radars that utilise a high transmitter PRF. This technique makes it possible to discriminate between aircraft and wind turbines by analysing their Doppler signatures and remove the turbine clutter from the display. Such radars may be used as in-fills or if sufficient range is achievable, the radar may be used as an alternative to a conventional PSR.

Spectrum filters

2.26 Some manufacturers have attempted to develop a solution that is based on modifying their existing radars by incorporating software to compare target return Doppler signatures with the aim of giving the system the ability to discriminate between turbines and aircraft.

Predictive and multi-sensor trackers

2.27 There have been proposals to employ specialist tracking systems to overcome the impact of wind turbine farms on radar. Such solutions offer the addition of plot extraction and predictive tracking to any compatible radar. Although this may not provide a complete solution to address all potential effects they may offer some potential for the radar processing system to make a semi-intelligent assessment of returns from the vicinity of a wind turbine farm in order to distinguish clutter, including that induced by turbines, from aircraft.

Transponder Mandatory Zones (TMZ) and surveillance by co-operative ground sensor

2.28 Under current UK regulations or proposals not all UK airspace will require an SSR transponder to be fitted and used by aircraft. However it is recognised that in certain circumstances and in certain areas, mandatory transponder carriage can provide significant safety benefits. The CAA has regulatory powers to create TMZs for a number of reasons, one of which may be to help mitigate wind turbine effects on a PSR. External bodies can also request TMZs; however, the Airspace Change Process (ACP) (CAP 725) must be followed. The ACP ensures that the requirement for a TMZ is fully justified and that the effect upon all airspace users is fully consulted and assessed. Proposals for a TMZ should be submitted to CAA Airspace Regulation[10]. A CAA case officer will assess the proposal and make recommendations to CAA Director SARG (formerly Director Airspace Policy) as appropriate. Consideration of the feasibility of a TMZ to mitigate a specific and identified risk should include: effect on other airspace users; the creation of ‘choke points’ within Class G airspace; whether the affected ATC system is capable of PSR blanking; and the likelihood of the CAA approving SSR-only operations.

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[10] Contact via AROps@caa.co.uk

2.29 Offshore SSR Only and TMZ. Despite offshore uncontrolled airspace being largely free of non-transponder equipped aircraft, this cannot be taken to mean that SSR only operations, or TMZs, would enjoy an easier approval process. In many instances, the ability to identify non-transponding aircraft (for example, following equipment failure) will be required to maintain safety cases.

2.30 Effect of TMZ on ATS Provision. TMZs are only viable when it is acceptable that the use of a non-co-operative surveillance technique (such as PSR) is not necessary for security reasons or for the detection of targets that are possibly undetected by SSR or other co-operative surveillance technique being used. It must be noted that, for Air Defence reasons, TMZs may not be suitable in all areas.

2.31 ANSPs may choose to provide surveillance by a suitable co-operative sensor over the wind farm area, in addition to the main PSR, as mitigation to the wind farm clutter on a surveillance display.

Risk assessment and mitigation of possible hazards introduced by wind turbines

2.32 Any new hazards should be identified and assessed to determine if mitigations are adequate to reduce risks to an acceptable level; this should be in accordance with the service provider’s Safety Management System (SMS) Risk Assessment and Mitigation process. Ultimately, failure to address such issues may result in withdrawal or variation of the article 169/ 205 Approval/Designation thereby preventing the provision of the air navigation service.

2.33 In assessing proposed developments and mitigations submitted by wind turbine developers, it is not unreasonable for an aviation stakeholder/ANSP to request sufficient technical information from the developer that would support the production of an adequate safety case. The responsibility for completing the safety case lies with the ANSP. However its completion should be a co-operative effort between the developer and the ANSP with any necessary commercial considerations subject to agreement between the two.

Aeronautical navigation aids and communication systems

2.34 A wide range of systems, including aids such as ILS, VOR/DME, and Direction Finders, together with air-ground communications facilities, could potentially be affected by wind turbine developments. Wind turbines can affect the propagation of the radiated signal from these navigation and communication facilities because of their physical characteristics, such as their situation and orientation in relation to the facility. As a result, the integrity and performance of these systems can, potentially, be degraded.

2.35 The CAA has been made aware of research that indicates the possibility of wind turbines adversely affecting the quality of radio communication between Air Traffic Controllers and aircraft under their control. Accordingly, as a work-stream under the DECC Aviation Management Board, the CAA are working in conjunction with NATS and others to test a variety of civil VHF aircraft radios and a smaller number of military UHF airborne radios against a simulated wind farm signature waveform. This research will be published in due course and in the interim, updates will be provided to the Aviation Management Board[11]. Until further information is available, issues concerning wind turbines and VHF communications should be dealt with on a case-by-case basis and reference made to the guidance contained in Section GEN-01 of CAP 670. Information regarding the technical safeguarding of aeronautical radio stations at aerodromes, including examples of the minimum dimensions for those areas that must be safeguarded, is contained in GEN-02 of CAP 670. However, aerodrome operators and ANSPs are advised to consider each proposal carefully and if necessary, seek specific technical advice.

Air Traffic Services

2.36 Where an ANSP determines that it is likely that a planned wind turbine development would result in any of the above effects on their CNS infrastructure, this may not, in itself, be sufficient reason to justify grounds for rejection of the planning application. The ANSP must determine whether the effect on the CNS infrastructure has a negative impact on the provision of the ATS. The developer should pay for an assessment of appropriate mitigating actions that could be taken by the ANSP and/or wind energy developer to deal with the negative impact. The position of an ANSP at inquiry would be significantly degraded if they had not considered all potentially appropriate mitigations. It is essential that wind energy developers form a relationship with the relevant ANSP in order to deal with the impact that their development may have, prior to making an application.

2.37 Where possible, it can be beneficial for the ANSP to record or plot real traffic patterns over a period of time using the radar system, and to use this to identify the prevalent traffic patterns. This can then be compared to the location of the proposed wind turbine development. Where appropriate and feasible, the recorded traffic data above a particular project may be released for further analysis.

2.38 When examining the effects of wind turbines on ATS, particular attention should be paid to the following:

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[11] Minutes of meetings and other information can be found on the Aviation Management Board Web Page https://www.gov.uk/government/groups/aviation-management-board-aviation-advisory-panel-and-fund-management-board

1. Departure Routes including Standard Instrument Departures;
2. Standard Instrument Arrival Routes;
3. Airspace Classification.
4. Area Navigation (RNAV) and Precision Air Navigation routes;
5. Sector Entry and Exit points;
6. Holding points (including the holding areas);
7. Missed Approach Routes;
8. Radar Vectoring Routes;
9. Final Approach Tracks;
10. Visual Reporting Points;
11. Published Instrument Flight Path for the aerodrome;
12. Potential impact on navigation aids and voice communications;
13. Future airspace and operational requirements where aerodrome growth is anticipated (Para 2.49 provides comment on future requirements).

2.39 Factors such as the type of radar service being applied and the airspace classification must also be considered when trying to assess the adverse impact of wind turbine effects.

Offshore helicopter operations

2.40 Wind energy developments (including anemometer masts) within a 9 NM radius of an offshore helicopter installation could introduce obstructions that would have an impact on the ability to safely conduct essential instrument flight procedures to such facilities in low visibility conditions. Consequently, any such restrictions have the potential to affect not only normal helicopter operations but could also threaten the integrity of offshore installation safety cases where emergency procedures are predicated on the use of helicopters to evacuate the installation.

2.41 Chapter 3 provides background information on the issues related to wind energy developments and offshore helicopter activities including Helicopter Main Routes (HMRs).

Maritime and Coastguard Agency (MCA)

2.42 The MCA's mission is to deliver safety at sea, counter pollution response and the coordination of maritime Search and Rescue (SAR) throughout the UK SAR Region and UK Pollution Control Zone. In the context of aviation, the MCA will (from early-2016) provide the SAR helicopter service for the UK.

2.43 The increasing numbers and geographical extent of offshore wind farms not only has the potential to increase the probability of a maritime SAR incident but also could constrain the MCA's ability to respond to such an incident. It is therefore strongly recommended that developers consult with the MCA at the earliest opportunity such that mitigating measures can be designed in from the outset. The following guidance has been provided by the MCA but should not be taken as being exhaustive and does not remove the recommendation to consult; further detail can be found in Maritime Guidance Note 371 and contact details for the MCA are listed at Appendix B.

2.44 The nature of SAR activity necessitates the requirement to conduct SAR within the confines of offshore wind turbine developments. Given the distance offshore of some UK windfarms, helicopters may be the only viable means of SAR. While in clear weather, searches can be conducted from above the maximum blade tip height, operations in poor weather and rescues themselves may necessitate SAR operations within a windfarm below blade tip height. As technology progresses and turbine heights increase, this issue is exacerbated. Furthermore, when faced with the prospect of long transits to a SAR area, the presence of adjacent windfarms along the transit route can provide obstacles to SAR helicopters if conditions do not permit transits to be flown above maximum blade height.

2.45 The MCA has provided the following guidance to mitigate SAR risks:

1. Turbines are positioned in straight lines with a common orientation across the whole development, creating safe lanes for SAR access.
2. Safe lanes are constructed across the width of the development rather than the length.
3. Curved or non-linear designs should be avoided.
4. High density perimeter turbines can compromise the safe lanes and should be avoided.
5. The wind farm should be fitted with lighting that is controllable from the development control room and which is NVG compatible.
6. The control room for the development should be equipped with VHF (air and maritime) communications with remote antennas in the wind farm to facilitate SAR communications.
7. Turbines should be marked with geographically logical numbering to facilitate navigation within the wind farm.
8. Substations and meteorological masts should be aligned with turbines so as not to impede SAR lanes.

9. Where possible, SAR lanes should be aligned with those of adjacent wind turbine developments or buffer zones created.

Cumulative effects

2.46 There is no doubt that, while developments with small numbers of wind turbines can have an adverse effect on aviation operations, it is the proliferation of developments, and the resulting cumulative effect, that is of far more significant concern. It may be possible to successfully mitigate the effects of a single turbine or small development; however, the combined effect of numerous individual turbines or multiple wind turbine developments can be hard, if not impossible, to mitigate. Therefore it is feasible that ANSPs may lodge objections to subsequent developments in areas where they had previously been able to accommodate proposed wind turbine developments.

2.47 The cumulative effect of geographically separated wind turbine developments may have more impact on aviation than if such developments were located in close proximity to each other. For example, individual areas of clutter separated by 5 NM could have more impact on the provision of ATS than one slightly larger area of clutter. This does not mean to suggest that large areas of clutter are always more preferable; however, this should be taken into consideration and discussed with the ANSP.

2.48 For aerodrome operators or en route service providers, there is a difficulty in protecting aviation activity from these cumulative effects, in part because planning applications are generally dealt with on a 'first come, first served' basis. All approved applications[12] must be taken into account when considering future applications. This could lead to a situation whereby viable applications are objected to on the grounds of cumulative effect even though other, potentially less viable, projects have not been completed due to the inability, for a variety of reasons, to satisfactorily resolve suspensive conditions.

2.49 The basis for an objection based on cumulative effect would be that the safety and efficiency of the aerodrome or en-route service may not be maintained or that the growth of an aerodrome or en-route service may be constrained. However, the decision concerning how firm these future plans have to be in order to be considered would be within the remit of the LPA. Nevertheless, airports are encouraged to produce 'Master Plans' indicating their future development plans. It is anticipated that these may be taken into consideration by an LPA.

2.50 It is recognised that many potential developments fail to reach maturity within the formal planning stage. Nevertheless, it is in the interests of aviation stakeholders

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[12] Including developments subject to 'suspensive conditions': where planning approval is granted subject to final agreement between an aviation stakeholder and a developer concerning an appropriate mitigation solution.

to take all developments about which they are aware into account until they have been formally notified that a proposal has been abandoned. Therefore, it is in a wind turbine developer's interest to inform all involved parties when such developments are abandoned or postponed.

Turbulence

2.51 Turbulence is caused by the wake of the turbine which extends down-wind behind the blades and the tower, from a near to a far field. The dissipation of the wake and the reduction of its intensity depend on the convection, the turbulence diffusion, the topography (obstacles, terrain etc.) and the atmospheric conditions.

2.52 There is evidence of considerable research activity on modelling and studying the wake characteristics within wind developments, using computational fluid dynamics techniques, wind tunnel tests and on site LIDAR measurements. A literature survey was recently conducted by the University of Liverpool and CAA[13] to establish the scale and the advances of current research on this front.

2.53 It is recognised that aircraft wake vortices can be hazardous to other aircraft, and that wind turbines produce wakes of similar, but not identical, characteristics to aircraft. Although there are independent bodies of knowledge for both of the above, currently, there is no known method of linking the two. Published research shows measurements at 16 rotor diameters downstream of the wind turbine indicating that turbulence effects are still noticeable[14]. Measurement work has been focused on the near wake due to technical challenges of the experimental set up, while modelling studies are capable of examining the wake turbulence further downstream[15][16]. Although models can be used to study the effects of the far wake, verification and validation processes of these models are still ongoing[17].

2.54 There are currently no Mandatory Occurrence Reports (MOR)[18] or aircraft accident reports related to wind turbines in the UK. However, the CAA has received anecdotal reports of aircraft encounters with wind turbine wakes

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[13] http://www.liv.ac.uk/flight-science/cfd/wake-encounter-aircraft/

[14] Wind Turbine Wake Analysis, L.J. Vermeer, J.N. Sorenson, A Crespo, Progress in Aerospace Sciences, 39 (2003) 467-510.

[15] Calculating the flow field in the wake of wind turbines, J.F. Ainslie, Journal of Wind Engineering and Industrial Aerodynamics, 27 (1988) 213-224.

[16] Turbulence characteristics in wind-turbine wakes, A Crespo and J Hernandez, Journal of Wind Engineering and Industrial Aerodynamics 61 (1996) 71-85.

[17] Investigation and Validation or Wind turbine Wake Models, A Duckworth and R.J. Barthelmie, Wind Engineering, 32 (2008) 459-475. Also http://www.liv.ac.uk/flight-science/cfd/wake-encounter-aircraft/

[18] CAP 382 - The Mandatory Occurrence Reporting Scheme - comment verified against CAA database up to 30 June 2015.

representing a wide variety of views as to the significance of the turbulence. Although research on wind turbine wakes has been carried out, the effects of these wakes on aircraft are not yet known. Furthermore, the CAA is not aware of any formal flight trials to investigate wake effects behind operating wind turbines. In the UK wind turbines are being proposed and built close to aerodromes (both licensed and unlicensed), including some developments on aerodrome sites, indicating an urgent need to assess the potential impact of turbulence on aircraft and in particular, to light aircraft and helicopters.

2.55 The CAA has so far investigated the effects of small wind turbine wakes on GA aircraft[19]. The results of this study show that wind turbines of rotor diameter (RD) of less than 30m should be treated like an obstacle and GA aircraft should maintain a 500ft clearance. Regarding wind turbines of larger RD than 30m; these are subject to further investigations. Until the results of these investigations are available, discussions between aerodrome managers and wind farm developers are encouraged, taking note of existing CAA safeguarding guidance. As the results of this research become available the CAA Wind Energy web pages will be updated.

2.56 Pilots of any air vehicle who firmly believe that they have encountered significant turbulence, which they believe to have been caused by a wind turbine, should consider the need to report this through the existing MOR scheme.

2.57 Until the result of further research is known, analysis of turbulence can only be undertaken on a case-by-case basis, taking into account the proximity of the development and the type of aviation activity conducted. Whilst being a consideration for all aircraft (particularly in critical stages of flight), turbulence is of particular concern to those involved in very light sport aviation such as gliding, parachuting, hang-gliding, paragliding or microlight operations as in certain circumstances turbulence could potentially cause loss of control that is impossible to recover from.

Wind turbine wake physics

2.58 Wind turbine wake is dependent on many parameters. The thrust generated by rotor, the tip velocity ratio (blade tip velocity to wind speed), wind direction and speed, turbulence level in free stream, weather condition and the geometry of wind turbine all have impacts on the characteristics of the wake. Due to all these parameters, it is difficult to scale wake results from a small to a large wind

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[19] http://www.liv.ac.uk/flight-science/cfd/wake-encounter-aircraft/

turbine. For this reason the work carried out by Liverpool University[20] is, at present, restricted to small wind turbines of less than 30m of RD.

2.59 The wake of a wind turbine can be divided into a near and a far region. The near wake is the area just downstream of the rotor up to one RD, where the effect of the rotor properties, including the blade aerodynamics and geometry determine the flow field. Near wake research is mainly focused on the wind turbine's performance and the physics of power extraction. The far wake is the region beyond the near wake, where the details of the wake are less dependent on the rotor design. The main interest in this area is the wake interference with other wind turbines (e.g. in a wind farm) or passing-by aircraft (wind turbine wake encounter). Here, flow convection and turbulent diffusion are the two main mechanisms that determine the flow field.

2.60 LIDAR field measurements on a WTN250 wind turbine at East Midlands Airport, UK, indicated that statistically, the wake velocities recovered to 90% of the free stream velocity at the downstream distance of 5 RD. It is expected that the work conducted by Liverpool University will continue with LIDAR surveys of larger wind turbines to provide reliable wake data to allow the study of the encounters using flight simulations. These results will be made public as soon as they become available.

2.61 Based on the models described in the Liverpool University Research Paper[21], schematics of the wake region for small wind turbines are given in the following figures. The figures show the zone where wake encounter has potential to cause severe impact on the encountering GA aircraft.

Figure 1: Schematic of the wind turbine wake. The effect of wake is weaker beyond 5-RD downwind for the wind turbines of diameter < 30m.

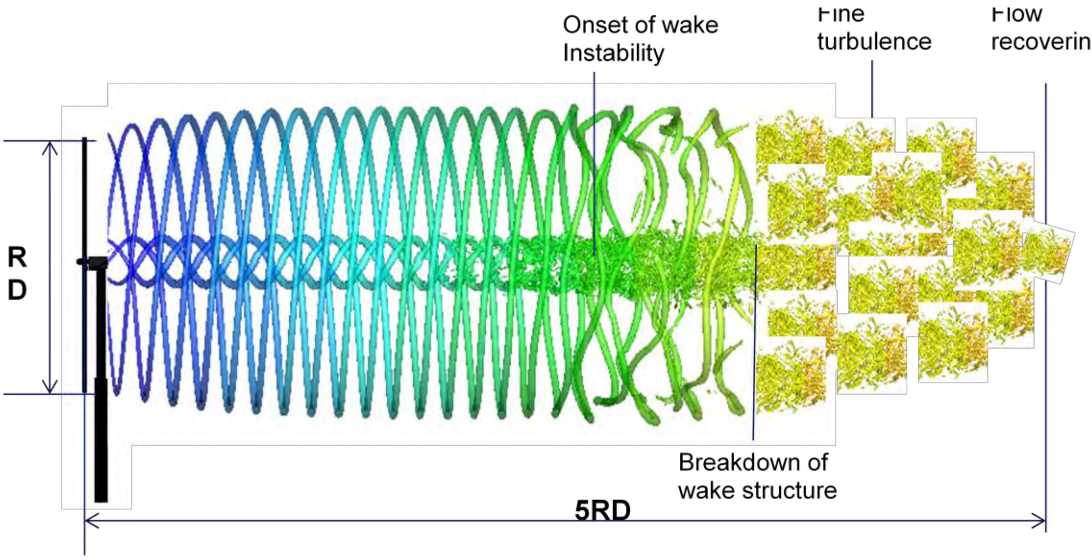

Figure 1:

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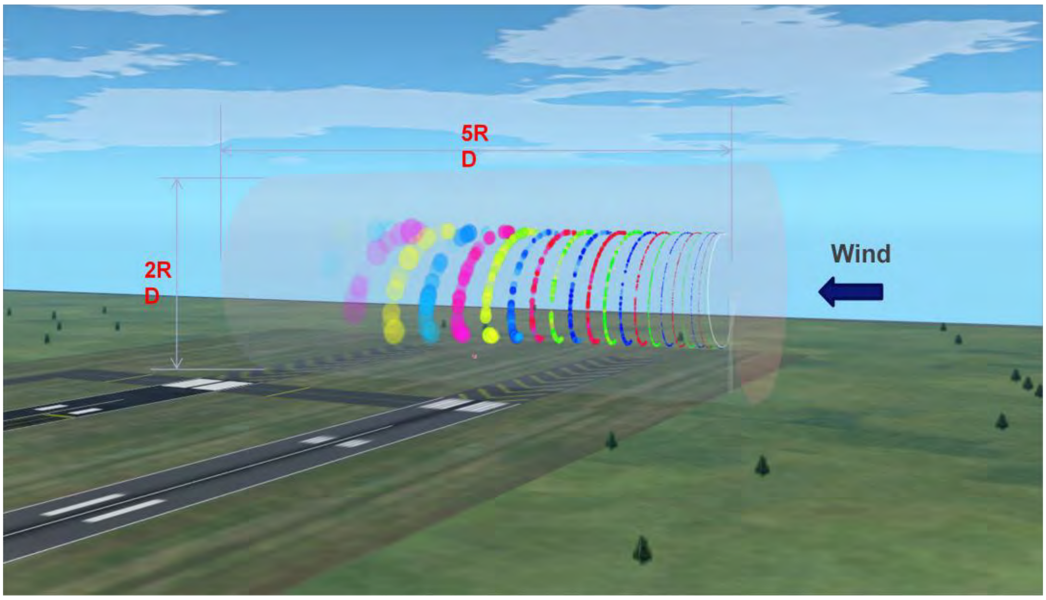
[20] http://www.liv.ac.uk/flight-science/cfd/wake-encounter-aircraft/

[21] http://www.liv.ac.uk/flight-science/cfd/wake-encounter-aircraft/

Figure 2: The cylindrical region downwind the rotor should be avoided. Its size is 5RD (downwind) by 2RD (vertical). Coloured helices indicate wake vortices and decay.



Economic issues

2.62 As a result of the role and responsibilities of the CAA and aviation stakeholders, action will be taken to maintain the high standards of safety, efficiency and flexibility. However, it is possible that aviation activity might have to be constrained as a consequence of proposed wind energy developments. Even in circumstances where a proposed development may not affect a current activity, future expansion (for example, as listed in an Aerodrome Master Plan) may be restricted were it to go ahead. This could eventually have an economic impact on the aerodrome, ANSP or activity, and this aspect should be taken into consideration when assessing the impact of any proposed wind turbine development. Therefore, it is considered entirely appropriate for an aerodrome to include an assessment of the economic impact that may arise from a proposed wind turbine development. However, it is important to note that comments made in this respect need to be unambiguous in order to allow an LPA to ensure that this important aspect is taken into account appropriately.

En-route obstructions

2.63 It is possible that an existing or proposed wind turbine development that does not infringe an aerodrome OLS may nevertheless have a potential impact upon local aviation activity. For example, a development beyond an OLS, but only marginally clear (laterally or vertically), of Controlled Airspace (CAS), might be assessed as having a potential adverse impact upon operations within Class G (uncontrolled) airspace due to the potential for the creation of ‘choke points’ where aircraft are forced into a reduced volume of available airspace

2.64 Whilst the CAA will highlight such issues away from the immediate vicinity of aerodromes, aerodrome operators/licensees should be cognisant of these issues when engaging with other parties on wind turbine associated matters. Further related comment is contained at Chapter 3 (Obstructions, Lighting and Marking).

Figure 3: Difficulties in visually acquiring anemometer masts.

2.65 Wind turbine developers should be aware that anemometer masts are often difficult for pilots to acquire visually (see Figure 3 above), and so aviation stakeholders may assess that individual masts should be considered a significant hazard to air navigation and may request (either during the planning process, or post-installation) that masts be lit and/or marked. Typically, there is no legal mandate for structures smaller than 150 m (492 ft) to be lit. Whilst the CAA would not in isolation make any case for lighting and/or marking of structures that is not required under existing regulation, the CAA would typically support related aviation stakeholder proposals to aid the visual conspicuity of anemometer masts on a case by case basis. Individual cases should not set a precedent for future requests. The MCA is likely to require that all offshore masts are lit to mitigate the risks to SAR helicopters. In addition, onshore masts have to potential to pose a risk to general aviation. To that end, the General Aviation Awareness Council (on behalf of other GA representative bodies) and a number of helicopter operators, with the in principle agreement of RenewableUK (the

UK's leading not for profit renewable energy trade association), have asked that the following request be relayed by the CAA on their behalf[22]:

"Anemometer masts and/ or their guy wires should be equipped with aids to increase their daytime visual conspicuity where a risk based proposal demonstrating specific need for such measures has been submitted by the aviation stakeholder. Noting that the deployment of any such measure can only be mandated by the relevant Planning Authority, it is acknowledged that such visual conspicuity aids should not impact upon the integrity of the structure itself, the data generated or risk to personnel these aspects are for the developer to consider/assess.

The most effective means of achieving this may be the use of orange marker buoys on the guy wires, such as those that may be fitted to overhead power cables (the use of which has some basis in international regulatory direction). However it is noted that in some locations the structural loads imposed by such markers may be unacceptable. In such cases, the goal of increasing the visual conspicuity of masts and supporting guys might be achieved by different means, which generally place little or no additional structural load on the mast/guy combination. Such means include:

1. *Painting all or part of the mast; options could include alternate contrasting stripes, such as orange and white, or a single contrasting colour (noting that it may need to contrast with terrain, or sky, or both) and/or,*
2. *Reflective bird flight deflectors of minimum 120mm diameter fitted to the guy wires at intervals, and/or*
3. *High visibility sheaths enveloping the supporting guy and/or*
4. *Ground mats, or construction such as a box, of a contrasting colour scheme to the ground at the foot of the mast.*

Whichever method is chosen it will need to satisfy all other relevant planning considerations. For example, bird deflectors may be required for bird protection reasons, and visual intrusion concerns may need to be taken into account. It is envisaged that the norm would be that one method would suffice."

It is recommended that agreement should be sought, through dialogue between the aviation stakeholder, the developer and the LPA regarding the most appropriate method of mitigation. However, should the LPA require further input regarding the general requirement for increasing the visual conspicuity of lattice masts or the specific need in any particular case, enquiries should be forwarded

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[22] This text is routinely replicated in CAA Correspondence when asked to comment on related planning applications.

to the GAAC at GAAC, Bicester Airfield, Skimmingdish Lane, Bicester, Oxon, OX26 5HA (e-mail planning@gaac.org.uk).

2.66 Where such obstacles affect operations on an aerodrome, it is the responsibility of the aerodrome operator to ensure appropriate publication in the UK Aeronautical Information Publication (AIP), and to ensure that they establish an effective working relationship with their LPA to ensure that they are consulted when appropriate.

Emergency Services Aviation Support Units (ASUs)

2.67 Since the inception of emergency aviation, there has been a dramatic rise in the number of police and air ambulance operators as well as a small number of fire brigade operations. Due to their unique operating nature, it is difficult to predict the impact of wind turbine developments on these ASUs. It is important, therefore, for emergency service ASUs to engage with all relevant LPAs within their operating area to ensure that they are consulted when planning applications are made. The CAA encourages developers and LPAs to consult with local ASUs, and would be supportive of claims to mark or light turbines that do not fall under article 219 of the ANO where a case by case assessment demonstrates there is a justifiable benefit.

2.68 Police ASUs are licensed by the CAA to operate below 500 feet Above Ground Level (AGL) in order to carry out their duties. Police helicopters will routinely follow main roads and motorways but may also transit along open land, sometimes in difficult weather conditions, during their operations and may need to land anywhere; although they will also have specifically designated landing sites. It should be noted that while some Police ASUs fly with Night Vision Goggles (NVGs), their use is not currently universal. Police Aviation in England and Wales is centrally coordinated by the National Police Air Service (NPAS) which is administered by the West Yorkshire Constabulary. Maps showing NPAS helicopter bases can be found on the NPAS Website. NPAS have recently established a single email address for windfarm consultations and advice: npas.obstructions@npas.pnn.police.uk which should be used for correspondence. The Scottish Police ASU, based in Glasgow, is not currently part of NPAS and should be contacted directly where appropriate.

Military impact

2.69 Wind turbine developments can have a detrimental effect on military operations. Military aviation operations predominantly take place in Class G airspace and can differ markedly from civil operations, particularly with respect to operational low flying, and the sensitivity of military CNS facilities. The DIO are to be consulted in all cases where a proposed wind turbine development may affect military operations. More information is available from the DIO Website.

Chapter 3

Safeguarding considerations

General considerations

3.1. There are a significant number of certificated or licensed aerodromes in the UK. In the region of one third of these, along with en-route CNS, have been designated by the Government as aerodromes to be safeguarded by statutory process, this is known as 'official safeguarding'. As part of this process, CAA certified maps of these officially safeguarded aerodromes and en route technical sites are produced and a Statutory Direction obliges associated LPAs to consult the aerodromes operators about proposed developments that fall within the boundaries specified on the maps.

3.2. Those aerodromes and CNS sites that are not safeguarded by statutory process can be unofficially safeguarded by agreeing protection measures with their LPA.

3.3. Further information about aerodrome safeguarding can be found on the Publications Section of the CAA website.

Safeguarding maps

3.4. Maps of officially safeguarded aerodromes and en route CNS technical sites are produced and submitted to LPAs. These maps denote the areas where consultation should take place with the aerodrome operator.

3.5. Other aerodromes may produce a safeguarding map and request that their LPA recognise their wish to be included in consultation for planning purposes. It is the published advice of the Government[23] that all aerodromes should take steps to protect their locations from the effects of possible adverse development by agreeing a safeguarding procedure with the LPA.

Wind turbine safeguarding maps

3.6. In order to assist the consultation process with wind turbine developers and in providing a diagrammatic illustration of the related aviation issues in discussion with LPAs, a number of aerodromes have developed specific wind turbine safeguarding maps, which graphically depict the aviation operator's assessment of the desirability and feasibility of wind turbine developments. Areas are shown where development would be either undesirable, undesirable but possible, or acceptable (albeit potentially with constraints to address cumulative effects and

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[23] The Town and Country Planning (Safeguarded Aerodromes, Technical Sites and Military Explosives Storage Areas) Direction 2002

proliferation issues). Other aerodromes have simply prepared radar consultation zone maps, given the dynamic nature of cumulative effects.

Safeguarding of technical sites

3.7. There is a statutory process to safeguard certain sites which are integral to the provision of en-route ATS. Radar and radio stations, navigation beacons and some microwave communications links are subject to such arrangements[24]. LPAs have an obligation to consult the operators of such sites as defined in official safeguarding maps. Developers may also request discussion with site operators in order to provide necessary mitigation. The International Civil Aviation Organization (ICAO) Eur Doc 015 and CAP 670 are sources of guidance to provide a basis for such discussion.

Obstructions, lighting and marking

3.8. The treatment of land-based obstacles to air navigation is covered by existing legislation. Obstacles located close to licensed aerodromes are covered under Section 47 of the Civil Aviation Act 1982. Government aerodromes are similarly covered under the Town & Country Planning Act (General Permitted Development) Order 2000. article 219 of the ANO 2009 details the requirement for the lighting of land-based tall structures located outside of the safeguarded areas of licensed and government aerodromes.

3.9. Onshore Obstacle Lighting Requirement ICAO regulations (Annex 14 Chapter 6) and article 219 of the ANO 2009 require that structures away from the immediate vicinity of an aerodrome, which have a height of 150 m (492 ft) or more AGL are:

1. Fitted with medium intensity steady red lights[25] positioned as close as possible to the top of the obstacle[26], and also equally spaced at intermediate levels, so far as practicable, between the top lights and ground level with an interval not exceeding 52 m;
2. Illuminated at night, visible in all directions and any lighting failure is rectified as soon as is reasonably practicable;

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[24] ICAO EUR DOC 015 recommends safeguarding zones for VORs.

[25] 'Medium intensity steady red light' means a light that complies with the characteristics described for a medium intensity type C light as specified in Volume 1 (Aerodrome Design and Operations) of Annex 14 (Third edition November 1999) to the Chicago Convention.

[26] In relationship to wind turbines, the requirement to fit aviation obstruction lighting 'as close as possible to the top of the obstacle' is typically translated to mean the fitting of lights on the top of the supporting structure (the nacelle) rather than the blade tips. However, any case by case study related to onshore turbines with a maximum height at or above 150m AGL may conclude that additional or amended lighting specifications are required.

3. Painted appropriately: the rotor blades, nacelle and upper 2/3 of the supporting mast of wind turbines that are deemed to be an aviation obstruction should be painted white, unless otherwise indicated by an aeronautical study.

3.10. In addition, the CAA will provide advice and recommendations regarding any extra lighting requirements for aviation obstruction purposes where, owing to the nature or location of the structure, it presents a significant hazard to air navigation. However, in general terms, structures less than 150 m (492 ft) high, which are outside the immediate vicinity of an aerodrome, are not routinely lit; unless the ‘by virtue of its nature or location’ argument is maintained. UK AIP ENR 1.1 para 5.4 'Air Navigation Obstacles' refers.

3.11. When input is sought, the CAA routinely comments to the effect that, in respect to a proposed wind turbine development, there might be a need to install aviation obstruction lighting to some or all of the associated turbines, when specific concerns have been expressed by other elements of the aviation industry; i.e. the operators. For example, if the MoD or a local aerodrome suggest and can support such a need, the CAA (sponsor of policy for aviation obstruction lighting) would wish, in generic terms, to support such a claim. However, this would only be done where it can reasonably be argued that the structure(s), by virtue of its/their location and nature, could be considered a significant navigational hazard. That said, if the claim was clearly outside credible limits (i.e. the proposed turbine(s) was/were many miles away from any aerodrome or it/they were of a height that was unlikely to affect even military low flying), the CAA would play an ‘honest-broker’ role. It is unusual for the CAA, in isolation, to make a case for aviation warning lighting unless article 219 demands such lighting.

3.12. All parties should be aware that, in any case where a wind turbine development lies (or would lie) outside any aerodrome safeguarding limits and the turbine height was less than 150 m (492 ft) (and therefore the provisions of article 219 of the ANO 2009 would not apply), the aviation industry, including the CAA, is not in a position to demand that the turbines are lit. In such cases the decision related to the fitting of aviation warning lighting rests with the relevant LPA, which will necessarily need to balance the aviation lighting requirement against other considerations (e.g. environmental). If deemed as an aviation obstruction, and thus requiring a specific marking scheme, the CAA advice on the colour of wind turbines would align with ICAO criteria.

3.13. Whilst anemometer masts are likely to remain below the threshold that requires they be lit, there may be instances where their lighting is deemed prudent.

Offshore obstacle requirements

3.14. Whilst the mandated requirement for the lighting of wind turbines generators in UK territorial waters[27] is set out at article 220 of the UK ANO (2009) as amended, additional guidance is provided below.[28]

3.15. The article requires medium intensity (2000 candela) steady red lighting mounted on the top of each nacelle and requires for some downward spillage of light. The article also allows for the CAA to permit that only turbines on the periphery of any wind farm need to be equipped with aviation warning lighting. Such lighting, where achievable, shall be spaced at longitudinal intervals not exceeding 900 metres[29]. There is no current routine requirement for offshore obstacles to be fitted with intermediate vertically spaced aviation lighting, however, given the potential increase in maximum height of the next generation of offshore wind turbines with nacelle heights potentially approaching 150m above sea level, additional lighting may be required. The CAA will consider such applications on a case by case basis.

3.16. To resolve concerns from the maritime community, work has been undertaken to develop an aviation warning lighting standard which is clearly distinguishable from maritime lighting. Where it is evident that the default aviation warning lighting standard (article 220) may generate issues for the maritime community, a developer can make a case, that is likely to receive CAA approval, for the use of a flashing red Morse Code Letter ‘W’ instead. There is, however, no intent to change the lighting intensity specifications set out in article 220; indeed those specifications remain the default aviation warning lighting requirement.

3.17. Where flashing lights are used, they are to be synchronised to flash simultaneously[30]. Where the Flashing Morse W standard is approved by the CAA and utilised, the recommendation is for a 5 second long sequence, visually synchronised across aviation and maritime lighting sequences.

3.18. Attention is drawn to the provisions that already exist within article 220 that require the reduction in lighting intensity at and below the horizontal and allow a further reduction in lighting intensity when the visibility in all directions from every wind turbine is more than 5km. All offshore wind turbine developers are expected

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[27] Taken to apply to any wind turbine generator or meteorological mast that is situated in waters within or adjacent to the United Kingdom up to the seaward limits of the territorial sea. However, the CAA will provide similar planning advice related to the lighting of wind turbines and meteorological mast beyond the limits of UK Territorial Waters.

[28] This guidance replaces CAA Policy Statements 22 November 2012 ‘Lighting of Wind Turbine Generators in United Kingdom Territorial Waters’ and 27 April 2012 ‘Failure of Aviation Warning Lights on Offshore Wind Turbines'.

[29] ICAO Annex 14 Volume 1 paragraph 6.3.14.

[30] ICAO Annex 14 Volume 1 paragraph 6.4.3.

to comply fully with the requirement aspect and to make full use of the additional allowance that exists within article 220.

3.19. In addition to the article 220 mandated lighting, there may also be lighting requirements associated with winching and SAR operations. The lighting needed to facilitate safe helicopter hoist operations to wind turbine platforms is set out in CAP 437. Information on SAR Requirements can be found in Maritime Guidance Note 371 and a summary of relevant aspects can be found in Chapter 2 of this document. It is recommended that SAR lighting requirements are agreed with the MCA at the earliest possible opportunity.

3.20. As offshore wind farms are developed, meteorological masts may be deployed to ascertain the wind resource characteristics. These masts can be in excess of 100 m tall and are extremely slender rendering them potentially inconspicuous to aviators flying over the sea, particularly when there are no other structures nearby. This is potentially hazardous, particularly during helicopter operations when it may be necessary to descend in order to avoid icing conditions. Consequently the CAA recommends that all offshore obstacles (regardless of their location within or outside of territorial waters) that are over 60 m (197 feet) above sea level should be fitted with one medium intensity steady red light positioned as close as possible to the top of the obstacle.

3.21. The CAA does not typically request specific markings for offshore obstacles. However, any aviation stakeholder that considered a particular structure to be a significant navigational hazard could make a case for it to be lit and/or marked to increase its visual conspicuity. The request (as opposed to mandate) for such lighting and/or marking would need to be negotiated with the owner of the structure or, if at the planning stage, the relevant planning authority. If asked for comment, it would be unlikely that the CAA would have any fundamental issue associated with an appropriate aviation stakeholder's case for lighting/marking of any structure that could reasonably be considered to be a significant hazard.

3.22. For military aviation purposes the MoD may suggest an additional offshore lighting requirement. Whilst it is possible that the lighting standard described above will meet the MoD needs, it is recommended that in all cases developers additionally seek related input from the DIO.

Failure of offshore lighting

3.23. Article 220 (7) of the ANO 2009 states “In the event of the failure of any light which is required by this article to be displayed by night the person in charge of a wind turbine generator must repair or replace the light as soon as reasonably practicable.” It is accepted that in the case of Offshore Obstacles there may be occasions when meteorological or sea conditions prohibit the safe transport of staff for repair tasks. In such cases International Standards and Recommended Practices require the issue of a Notice to Airmen (NOTAM).

3.24. The CAA considers the operator of an Offshore Wind Farm as an appropriate person for the request of a NOTAM relating to the lighting of their wind farm. Should the anticipated outage be greater than 36 hours then the operator shall request a NOTAM to be issued by informing the NOTAM section (operating 24 hours) of the UK Aeronautical Information Service (AIS) by telephoning +44 (0) 20 8750 3773/3774 as soon as possible. AIS will copy the details of the NOTAM to the operator and to the CAA.

3.25. The following information should be provided:

1. Name of wind farm (as already recorded in the AIP[31]).
2. Identifiers of affected lights (as listed in the AIP) or region of wind farm if fault is extensive (e.g. North east quadrant/south west quadrant/ entire or 3 NM centred on position 515151N 0010101W).
3. Expected date of reinstatement.
4. Contact telephone number.

3.26. Note that if the turbine or wind farm does not have a listing in the AIP then it will not be possible to issue a NOTAM. Typically all offshore turbines of a maximum blade tip height of 300 feet or more will be recorded within the AIP.

3.27. In order to expedite the dissemination of information during active aviation operations the wind farm operator may also consider establishing a direct communication method with aviation operators in the area. These may include:

1. Air Traffic Service Units e.g. Aberdeen Radar or Anglia Radar.
2. Local airports.
3. Local helicopter operators.

3.28. The information will be the same as in the NOTAM request, and should also include a note that a NOTAM has been requested, or if available, the NOTAM reference.

3.29. If an outage is expected to last longer than 14 days then the CAA shall also be notified directly at windfarms@caa.co.uk (normal working hours) to discuss any issues that may arise and longer term strategies.

Consultation zones around offshore helidecks

3.30. For many years, the CAA has emphasised the importance of operators and developers taking into consideration all existing and planned obstacles around offshore helicopter destinations that might impact on the safe operation of

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[31] UK Aeronautical Information Publication (www.ais.org.uk) En Route Supplement 5.4.

associated helicopter low visibility approaches in poor weather conditions. In order to help achieve a safe operating environment, a consultation zone of 9 NM radius exists around offshore helicopter destinations. This consultation zone is not a prohibition on development within a 9 NM radius of offshore operations, but a trigger for consultation with offshore helicopter operators, the operators of existing installations and exploration and development locations to determine a solution that maintains safe offshore helicopter operations alongside the proposed development. This consultation is essential in respect of established developments. However, wind energy lease holders, oil and gas developers, and petroleum licence holders are advised to discuss their development plans with each other to minimise the risks of unanticipated conflict at a later date. Topics for discussion within any such consultation should include, but are not limited to:

1. Prevailing weather conditions, including predominant wind direction;
2. Manning status of the installation;
3. Frequency of flights to the installation and predominant routes;
4. Performance limitations of offshore helicopter types utilising the helideck;
5. Established helicopter instrument and low visibility approach procedures;
6. Mandated constraints on approaches to helidecks on installations;
7. Long term access to well and subsea infrastructure;
8. Concurrent wind farm operations and oil and gas operations to well and subsea infrastructure;
9. SAR operations to the installation in the event of an emergency;
10. Location and height of potential obstacles including proposed wind turbines.

3.31. The following paragraphs provide, in layman’s terms, an explanation of the reasoning behind the need for the 9 NM consultation zone. While procedures will differ depending upon the installation, operator and aircraft type involved, the following notes are based upon Commission Regulation (EU) No 965/2012 (the European Air Operations Regulation), improved flight procedure documentation and the practical application of such requirements:

1. Basic Requirement. The 9 NM consultation zone aims to provide a volume of obstacle-free airspace within which a low visibility approach profile and, in the event of a pilot not being able to complete his approach, a missed approach can be flown safely. Such profiles must allow for an acceptable pilot workload, a controlled rate of descent, one engine inoperative performance and obstacle clearance.

2. Approach. Routinely, helicopters making manually flown radar/GPS approaches and, in the future, autopilot-coupled approaches, to offshore installations will commence the approach from not below 1500 ft Above Mean Sea Level (AMSL) or 1000 ft above obstacles, whichever the higher. As helicopters approaching offshore installations must make the final approach substantially into wind, the approach could be from any direction. The obstacle-free zone must, therefore, extend throughout 360° around the installation to prevent restrictions being placed on the direction of low visibility approaches and departures. Additionally, during the approach, all radar contacts have to be avoided by at least 1 NM which could interfere with the necessary stable approach path if manoeuvring is required. The approach sequence and descent below 1500 ft routinely commences from about 8 NM downwind of the destination installation and the final approach starts at around 5–6 NM and 1000–1500 ft. The helicopter descends to a minimum descent height (at least 200 ft by day and 300 ft at night), which is commonly achieved within 2 NM of the helideck having descended on a ‘glide path’ of between 3–4°. Thereafter, it flies level at that height towards the Missed Approach Point (MAPt). As the helicopter approaches the MAPt, a minimum of 0.75 NM from the offshore destination, the pilot must decide whether or not he has the required the necessary visual references to proceed to land or, if not, conduct a go-around following a missed approach procedure.
3. Go-Around and Missed Approach Procedure (MAP). Upon initiating a go-around, the pilot will follow a MAP whereby the helicopter is either turned away from the destination structure by up to 45° and climbs, or climbs straight ahead depending on the procedure being used. The anticipated rate of climb during the missed approach phase is based upon one engine inoperative performance criteria and could be quite shallow (1–2°). For obvious safety reasons, a go-around involving a climb from the minimum descent height needs to be conducted in an area free of obstructions as this procedure assures safe avoidance of the destination structure.
4. Departure Procedure. On departure from an offshore installation the aircraft will be climbed vertically over the deck to a height determined by its performance criteria and is committed to the take off once a nose down attitude is adopted. If during this phase an engine failure is experienced then the anticipated rate of climb will be the same as described above for the MAP; however, the climb could start from as low as 35 ft above sea level dependent on deck height. The distance to climb to a safe altitude by which either a turn can be carried out, or straight ahead, to reach separation from obstacles will be dependent on aircraft one engine inoperative performance criteria. The aircraft can be up to 10º either side of the departure heading and the radius of any turn carried out can be up to 1000 m.

3.32. In summary, obstacles within 9 NM of an offshore destination would potentially impact upon the feasibility to conduct some helicopter operations (namely, low visibility or missed approach procedures) at the associated site. Owing to the obstruction avoidance criteria, inappropriately located wind turbines could delay the descent of a helicopter on approach such that the required rate of descent (at low level) would be excessive and impair the ability of a pilot to safely descend to 200/300 ft by the appropriate point of the approach (2 NM). If the zone is compromised by an obstruction, it should be appreciated that routine low visibility flight operations to an installation may be impaired with subsequent consequences for the platform operator or drilling unit charterer. One such consequence could be that the integrity of offshore platform or drilling unit safety cases, where emergency procedures are predicated on the use of helicopters to evacuate the installation, is threatened. Additionally, helicopter operations to wind farms may impact on oil and gas operations. It is therefore essential that the installation operators, helicopter operators and other interested parties are engaged in the consultation process.

Helicopter Main Routes (HMR)

3.33. HMRs, as defined in the UK AIP, have been in use over the North Sea and in Morecambe Bay for many years. Whilst such routes have no lateral dimensions (only route centre-lines are charted) they provide a network of offshore routes utilised by civilian helicopters. Wind turbine developments could impact significantly on operations associated with HMRs: the effect will depend on the degree of proliferation, and so a small number of individual turbines should cause minimal effect. However, a large number of turbines beneath an HMR could result in significant difficulties by forcing the aircraft to fly higher in order to maintain a safe vertical separation from wind turbines. The ability of a helicopter to fly higher would be dependent upon the 0° isotherm (icing level); this might preclude the aircraft from operating on days of low cloud base if the 0º isotherm was at 2000 ft or below as the aircraft must be able to descend to a clear area below cloud and with a positive temperature to safely de-ice if necessary.

3.34. There should be no obstacles within 2 NM either side of HMRs but where planned should be consulted upon with the helicopter operators and ANSP. The 2 NM distance is based upon: operational experience; the accuracy of navigation systems; and, importantly, practicality. Such a distance (2 NM) would provide time and space for helicopter pilots to descend safely to an operating height below the icing level. For the purpose of transiting wind turbine developments under Visual Flight Rules, corridors may be established that are no less than 1 NM wide. Additionally, helicopters (like all aircraft), are required by Commission Implementing Regulation (EU) No 932/2012 (the Standardised Rules of the Air Regulation) to avoid persons, vessels, vehicles and structures by a minimum distance of 500 ft; this applies equally to the avoidance of wind turbines and any other structure.

3.35. Notwithstanding the above, low level coverage is of particular importance in the provision of full ATS to offshore helicopter operators, and ANSPs will need to give careful consideration to any proposed development that impact on the supporting PSR feed. Moreover, dependent on the level and type of service provided prior to the installation of wind turbines, it may prove necessary to maintain a buffer greater than 2 NM from HMRs in order to maintain the previous service provision by an ATS provider or ANSP. Further guidance is available from SARG.

Facilitation of helicopter support to offshore installations

3.36. In order to facilitate construction or maintenance flights within the boundaries of wind turbine developments, consideration should be given to the use of flight corridors being built into the development layout plans. Such corridors should be oriented and their width designed in consultation with the helicopter operators, given that it will be governed by the VFR performance of the aircraft in use. The layout of the turbines may also need to consider the requirements of the MCA with regards to SAR within the field.

Military requirement for Infra-Red (IR) lighting

3.37. Low flying is a vital element of military operations in areas of conflict, and a large proportion of the flying will be undertaken at night. Low flying training across the UK can take place as low as 100 ft for fast jet aircraft in Tactical Training Areas, and 250 ft in Low Flying Areas. Helicopters fly tactically down to 50 ft and routinely down to100 ft during training sorties in all areas.

3.38. The MoD have recently published Obstruction Lighting Guidance which is also available via the Aviation and Radar page on the RenewablesUK Website. The majority of night time flying by MoD aircraft is undertaken by crews equipped with NVGs; therefore IR vertical obstruction lights will be suitable in most occasions.

3.39. An application for onshore wind turbines will receive notification from DIO indicating whether IR lights will be suitable. In some cases a combination IR / red lighting will be required, for example geographical choke points or to denote the extremities of a larger wind farm.

3.40. Careful attention needs to be taken to ensure that the IR light chosen by the wind developer meets the MoD's requirements, as some IR (Light Emitting Diode) lights are not compatible with military NVGs.

3.41. Requests for clarification should be addressed to the DIO. Contact details are included in Appendix B.

Parachute drop zones

3.42. Parachutists drop from heights up to 15,000 ft AGL within a published Drop Zone (DZ), normally out to a minimum of 1.5 NM/2.8 km radius from the centre of the Parachute Landing Area (PLA).

3.43. Hazards to PLAs are categorized as:

1. Special Hazard. A hazard which could constitute a special risk to parachutists and if parachutists were to come into contact with may result in serious or fatal injury" e.g. stretches of open water, deep rivers, electricity power lines, wind turbines of a height greater than 15m to blade tip at its highest point, densely built up areas, cliffs and quarries.
2. Major Hazard. Obstacles, either natural or artificial, which because of their size may be difficult to avoid and which, if struck by a parachutist, may result in injury; i.e. large hangars, buildings, woods etc.;
3. Minor Hazard. Any object, either natural or artificial, which should be easily avoided but which if struck by a parachutist may result in injury; i.e. hedges, fences, ditches etc.).

3.44. CAP 660 (Parachuting) refers.

3.45. Wind turbines pose a special risk to parachutists and if parachutists were to come into contact with may result in serious or fatal injury; those over 15 m high are considered by the British Parachute Association (BPA) to be a Special Hazard. Wind turbines of 15 m or below are considered Major Hazards.

3.46. PLAs to be used by all designations of parachutists should provide a large open space of reasonably level ground, which can contain a circle of 250 m radius free from Major Hazards and largely free from Minor Hazards. These PLAs should be bordered on at least three sides by suitable overshoot areas, where parachutists may land if they are unable to land on the PLA: these overshoot areas should be free from Special Hazards and largely free of Major Hazards.

3.47. Wind turbines over 15 m high (50 feet) are considered a rotating special hazard and as such if located within the designated DZ would likely result in restrictions being placed upon any parachute activity within that DZ.

3.48. It is worthy of note that any obstacle over 300 ft (91.4 m) in height is no longer considered by the BPA to be just a ground obstacle to parachutists, but also an air obstacle, given that it protrudes into airspace within which parachutists (particularly in an emergency situation) may not yet have taken control of their canopies, and so could result in an aerial collision.

Very light aircraft

3.49. Due to the potential for sudden loss of lift within areas of turbulence, very light aircraft are operated away from areas of known turbulence or only in areas where turbulence is consistent and predictable (such as hill sites used by hang-gliding/paragliding clubs). Introducing a wind turbine to a location that is frequented by very light aircraft may result in that location becoming unviable or less attractive to visiting pilots if the turbine generates turbulence that may exceed the aircraft's operating limits.

Chapter 4

Wind turbine development planning process

Pre-planning and consultation

4.1. The weight of relevant knowledge accrued by wind turbine developers and ANSPs over the past decade has been substantial: issues are better understood, and proper procedures for effective consultation are in place. Developers are required to undertake their own pre- planning assessment of potential civil aviation related issues. It should also be noted that NATS, the MoD and certain airports also offer pre-planning services. Table 1 provides an overview of considerations, and the following paragraphs detail what developers will need to consider, conducting associated consultations as appropriate.

Table 1: Overview of consultation considerations

	CNS Facilities	**Obstacle Considerations**
Aerodrome *(Consultation required with aerodrome licensee/manager)*	▪ Safeguard PSR and SSR ▪ Safeguard Approach Aids ▪ Safeguard Navigation Beacons ▪ Safeguard VHF	▪ OLS ▪ Impact on procedures ▪ Need for lighting to aid night time conspicuity ▪ Anemometer masts
En Route *(Consultation required with MoD and NERL)*	▪ Safeguard PSR and SSR ▪ Safeguard Navigation Beacons ▪ Safeguard VHF	▪ >300 ft/91 m Chart and entry to AIP ▪ >150 m (492 ft) Lighting in accordance with article 219 of ANO (2009) ▪ Marking of turbine (upper 2/3 white in accordance with ICAO guidance) ▪ Potential for additional lighting requirements where turbines may be considered as a significant hazard to air users ▪ Anemometer masts ▪ Emergency Service ASUs and HEMS (including MCA in remote areas)
Offshore *(Consultation*	▪ Safeguard PSR and SSR	▪ Offshore Lighting in accordance with article 220 of ANO (2009) and CAP

	CNS Facilities	**Obstacle Considerations**
required with MoD NERL and MCA)	▪ Safeguard Navigation Beacons ▪ Safeguard VHF	764 ▪ HMR ▪ Operations around oil and gas platforms ▪ Anemometer masts ▪ Search and Rescue requirements

4.2. Aerodromes. Whilst not definitive, it should be anticipated that any wind turbine development within the following criteria[32] might have an impact upon civil aerodrome[33] - related operations:

1. Unless otherwise specified by the aerodrome or indicated on the aerodrome's published wind turbine consultation map, within 30 km of an aerodrome with a surveillance radar facility. The distance can be far greater than 30 km depending upon a number of factors including the type and coverage of the radar and the particular operation at the aerodrome;
2. Within airspace coincidental with any published Instrument Flight Procedure (IFP) to take into account the aerodrome's requirement to protect its IFPs;
3. Within 17 km of a non-radar equipped licensed[34] aerodrome with a runway of 1100 m or more;
4. Within 5 km of a non-radar equipped licensed aerodrome with a runway of less than 1100 m;
5. Within 4 km of a non-radar equipped unlicensed aerodrome with a runway of more than 800 m;
6. Within 3 km of a non-radar equipped unlicensed aerodrome with a runway of less than 800 m.

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[32] Aerodrome criteria are generically based upon the safeguarding requirements and guidance contained in Regulation EC 139 of 2014, CAP 168 and CAP 793 (both current and historical). The ranges quoted are for guidance only. If proposed developments lie marginally outside the ranges highlighted, but nevertheless in close proximity to other developments, developers are advised to consider the potential proliferation issues. The object of any pre-planning process is to identify all possible aviation concerns to the developer at an early stage and as such, the assessment should err on the side of caution.

[33] In this context the term 'aerodrome' includes any site used regularly by aircraft (including helicopters and gliders) for take-off and landing. The CAA-sponsored, NATS-produced VFR charts depict all such sites known to the CAA, although effects on uncharted aerodromes must still be considered.

[34] Licensed in accordance with Part 27 of ANO (2009) as amended.

4.3. The figures above are for initial guidance purposes only and do not represent definitive ranges beyond which all wind turbine developments will be approved or within which they will always be objected to. These ranges are intended as a prompt for further discussion between developers and aviation stakeholders in the absence of any other published criteria.

4.4. Many modern gliders have a glide ratio of at least 50:1 and the most modern gliders can exceed that, with further progress expected in future. Developments of wind turbines within 10 km of a gliding site or where the maximum height of the structure is within a 50:1 angle of a gliding site will present additional considerations beyond those associated with powered aircraft. Therefore, notwithstanding the CAA recommended distances quoted above, the British Gliding Association (BGA) requests that relevant gliding sites and the BGA are consulted where proposed developments are within 10 km of any charted glider launch site.

4.5. Aerodrome operators should address physical safeguarding issues in accordance with the guidance contained within relevant EASA documentation, CAP 168 and CAP 738 as applicable. Operators of unlicensed aerodromes should refer to CAPs 793 and 738 as applicable and are strongly advised to engage with their LPA to ensure that their activities and requirements are well understood. At the very least, unlicensed aerodromes should subscribe to their LPA’s Weekly Planning List, which will provide them with information on all planning applications – including wind turbines and anemometer masts – and therefore provide a mechanism for effective self-briefing for their associated pilots.

4.6. Non-aerodrome related activity. Developers should also consider the potential for wind turbines to impact upon known general aviation activity that are annotated on CAA-sponsored, NATS-produced VFR charts, but which are not related to a recognised or single aerodrome (for example, charted fee-fall parachute DZ and hang/ para-gliding winch launch sites). Typically, developers will need to engage direct with relevant aviation operators where a development would be within 3 km of any such site.

4.7. NATS. There may be issues related to en route CNS facilities. Accordingly, details of any proposal need to be considered by NATS. Developers need to undertake related consultation as appropriate as NATS will be consulted by the LPAs. NATS Windfarm web pages provide support.

4.8. Lighting and marking. There might be a need to install aviation warning lighting to some or all of the turbines if increased conspicuity is deemed necessary.

4.9. Charting. In terms of obstacle charting requirements in the UK, a threshold exists at 300 ft (91.4m)[35]

1. Structures with a maximum height of 300 ft (91.4m) above ground level or higher:

    a) There is an ICAO Annex 15 requirement for all obstacles (temporary or otherwise) over 300 ft (91.4m) AGL to be promulgated in the UK AIP and charted on civil aviation charts. Accordingly, any such structure is required to be notified to the Defence Geographic Centre (DGC) who provides the source of obstacle data, published in the UK AIP at ENR 5.4 no later than 10 weeks prior to construction. Information provided should include the type of structure and name of location, an accurate location of the structure(s) in WGS 84 latitude and longitude (degrees, minutes and 1/100 second), an accurate maximum height AMSL/AGL, the lighting status of the turbines and date for the completion of construction. In addition, the developer should also provide the maximum height of any construction equipment required to build the turbines. Removal of turbines is also required to be notified and expected date of removal. The DGC prefer notifications to be submitted electronically: mail to dvof@mod.uk.

    b) In order to ensure that aviation stakeholders are aware of the turbines while aviation charts are in the process of being updated, developments should also be notified through the means of a NOTAM. To arrange an associated NOTAM, a developer should contact CAA Airspace Regulation[36] (AROps@caa.co.uk / 0207 453 6599) no later than 14 days prior to the commencement of construction with the same information as required by the DGC. Of note, if the obstacle falls within an Aerodrome Traffic Zone or Military Aerodrome Traffic Zone, it is the responsibility of that aerodrome to issue the NOTAM.

2. Structures with a maximum height below 300 ft (91.4m) above ground level. In the interest of Aviation Safety, the CAA also requests that any feature/structure 70 ft (21.3m) in height, or greater, above ground level is also reported to the DGC. It should be noted that NOTAMs would not routinely be required for structures under 300 ft (91.4m) unless specifically requested by an aviation stakeholder.

4.10. Emergency ASUs. For completeness it would also be sensible to establish the related viewpoint of local emergency ASUs. This is because of the unique nature of their operations in respect of operating altitudes and potentially unusual

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[35] The effective height of a Wind Turbine is the maximum height to blade tip.

[36] Previously named Airspace Utilisation with the email address AUSOps@caa.co.uk. The AROps email address should now be used for all correspondence and NOTAM requests.

landing sites. In addition, The MCA is responsible for the provision of SAR services onshore and offshore. It is recommended that the MCA is consulted on all offshore developments and one of the factors that it will consider is the implications of a development on SAR operations (with surface craft and helicopters). Further information is available in Chapter 2.

4.11. Cumulative effect. The growth in the number of wind turbine developments (either under consideration, in planning, under construction, or operational), is significant. It is possible that the cumulative effect of a number of wind turbine developments in any particular area might potentially result in difficulties for aviation that a single development would not have generated. See also Chapter 2.

4.12. Cross-boundary. In order to delineate responsibility for the provision of flight information services to aircraft, airspace is divided up into internationally recognised Flight Information Regions (FIRs). Airspace in the UK is divided into the London and Scottish FIRs which together form the UK FIR. Coordinates for these boundaries are listed in the UK Aeronautical Information Publication Section ENR 2.1. Offshore developments have the potential to straddle these boundaries, one example being the consented East Anglia ONE development, part of which is in the Dutch FIR. Airspace outside the UK FIR is the responsibility of other European aviation authorities, whose regulations may differ from those that apply in the UK. Accordingly, wind turbine developers should contact the CAA for specific guidance in all instances where developments are likely to approach the limits of the UK FIR.

Formal planning

4.13. Regardless of whether voluntary pre-planning has been undertaken, all proposals for wind turbine developments must eventually move into a formal approval process either through the Electricity Act 1989, the Planning Act 2008, or through the Town and Country Planning Acts[37] . The process is outlined in the subsequent paragraphs, although these guidelines do not purport to be a comprehensive guide to planning procedures.

England and Wales

4.14. In England, LPAs currently handle consent applications for land-based generating stations with a capacity up to 50 MW in accordance with the polices set out in the National Planning Policy Framework (NPPF) and following the procedure set out in the Town and Country Planning Act 1990. The Planning Act 2008 sets out thresholds above which certain types of infrastructure development

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[37] Taken to include the Town and Country Planning Act 1990 and Town and Country Planning Act (Scotland) 1997.

are considered to be nationally significant. Currently, land-based electricity generating stations with a capacity over 50MW and offshore generating stations with a capacity above 100MW are classified as Nationally Significant Infrastructure Projects (NSIPs), however, it is the Government's published intention to amend legislation so that all applications for onshore wind energy developments are handled by local planning authorities[38]. Any developer wishing to construct an NSIP must first apply for a type of consent known as 'development consent'. For such projects, the Planning Inspectorate examines the application and will make a recommendation to the relevant Secretary of State, who will determine the application. In Wales, onshore applications over 50 MW and offshore applications over 100MW are currently decided by the relevant UK Secretary of State following the recommendation of the Planning Inspectorate. Applications for developments under 50 MW are dealt with by the relevant LPA under the Town and Country Planning Legislation (Wales). The Welsh Government has published planning advice on renewable energy in the form of Technical Advice Note (TAN) 8 and in the Planning (Wales) Act 2015. In addition, the UK Government has expressed the intent to devolve powers to Welsh Ministers for the consenting of energy schemes both onshore and offshore of up to 350 megawatts capacity[39].

Scotland

4.15. In Scotland, there is currently a similar division of responsibility. Applications for onshore stations of a capacity up to 50 MW are made to the relevant LPA under the Town and Country Planning Act (Scotland). Onshore developments with a capacity greater than 50 MW require consent from the Scottish Government. These applications are handled on behalf of the Scottish Ministers by the Energy Consents Unit (ECU) under Section 36 of the Electricity Act (1989). In Scotland, applications for marine energy (including offshore wind) are made to Marine Scotland.

Northern Ireland

4.16. Previously in Northern Ireland, the Planning Service (an Agency within the Department of the Environment), handled all proposals for land-based generating stations irrespective of capacity. From 1 April 2015, the responsibility for planning has been shared between 11 new councils and the Department of the Environment. Applications will be classified as either 'local', 'major' or being of 'regional significance'. Criteria for assessing the classification of developments are contained within The Planning (Development Management) Regulations (Northern Ireland) 2015. An application deemed to be of regional significance

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[38] Dept of Communities and Local Government online guidance on Renewable and Low Carbon Energy dated 18 June 15.

[39] The Queens Speech 27 May 2015 - contained within the proposed Wales Bill.

must be made to, and will be determined by, the Department of the Environment. Councils will be responsible for determining major and local development applications. In Northern Ireland, offshore wind farm proposals are the responsibility of the Department of Enterprise, Trade and Investment.

Micro wind turbines

4.17. The legislation to allow permitted development rights for householders to install MWTs on their premises came into force on 1 December 2011. Details of the order can be found in Class H and I of Part 14 in Schedule 2 of The Town and Country Planning (General Permitted Development) (England) Order 2015. The same legislation came into force in Wales on 22 May 2012. The legislation applies to both building mounted and free standing turbines that do not exceed 15 metres and 11.1 metres above the ground respectively. The Planning Portal hosts the Domestic Wind Turbine Safeguarding Land Tool, which establishes whether or not a proposed wind turbine will be located on safeguarded land. If the proposed turbine is not on safeguarded land it has successfully met one of the requirements of being eligible for permitted development. All turbines that do not meet the above requirements are currently processed in a manner relevant to all other scales of wind turbine development.

CAA involvement

4.18. Currently, the CAA can provide the following input to formal planning submissions for wind turbine developments:

1. Identification of aviation stakeholders that would potentially be affected;
2. Reviewing the aviation section of the Environmental Statement for accuracy and completeness;
3. Consideration of regulatory requirements;
4. Consideration of whether all other aviation issues known to the CAA have been taken into account (including other potential developments).

4.19. It should be noted that the CAA is currently only a statutory consultee for onshore developments in excess of 50MW and for offshore developments in excess of 100MW. Responses to other planning submissions will be made, resource permitting.

Promulgation of wind turbine developments

4.20. The need to promulgate the existence of tall structures that might constitute a significant aviation obstruction is self-evident. LPAs routinely advise the DGC of also report such information to DGC. Through the updated promulgation of a database document, the SARG Aeronautical Charts and Data section is advised of all such developments and update aviation charts accordingly. All structures (including wind turbines and anemometer masts) in excess of 300 ft in height are depicted on charts and details of each wind turbine are promulgated in the UK AIP, ENR 5.4 (CAP 32) 9.2. By exception, structures less than 300 ft high may be promulgated for civil aviation en-route purposes if their presence is deemed to be of navigational significance.

Call-ins and inquiries

Call ins

4.21. Whilst the aviation industry has no powers of veto, there is a legal obligation placed upon LPAs to give warning if they are minded to grant planning permission against advice given by a statutory safeguarding consultee (ODPM/DfT/ NAFW Circular 1/2003 and Scottish Executive Circular 2/2003 refer). This process offers an opportunity for the CAA to establish whether a solution is apparent or, if it fails to resolve the issue, to refer the matter for a decision by central Government. This procedure is always a last resort, as it is anticipated that communication and cooperation can obviate the need for it.

Inquiries

4.22. In the event that a planning application is referred to a planning inquiry, the CAA may be requested by the LPA to provide expert witness evidence. This may be by providing written statements or by attendance at the Inquiry.

Consistency, accuracy and use of consultants

4.23. When aviation stakeholders are consulted over wind turbine developments, either at the pre-planning stage or once the formal planning application process has begun, it is critical that the responses made are consistent, factually accurate and cover all relevant aspects. It should be noted that these responses may be subject to challenge and CAA is often asked to provide an impartial regulatory perspective on what has been submitted.

4.24. In submitting a wind turbine development proposal, developers will regularly employ subject matter experts in the form of consultants to prepare reports to identify potential issues and address any issues raised by aviation stakeholders. This may be in the pre-application stage or to seek to address aviation concerns following aviation objections. In addition, as part of the formal process, developers are often required to submit an Environmental Impact Assessment which will include an assessment of aviation issues and mitigations, often based on supporting reports commissioned by the developers. If asked for comment, CAA will request that LPAs pursue any assertions or statements made in respect of aviation with the appropriate aviation stakeholder, developer or consultant.

CAA provision of advice

4.25. The CAA is often approached for comment and advice concerning the validity of objections raised or the suitability of mitigations proposed. However, it is incumbent upon the developer to liaise with the appropriate aviation stakeholder to discuss – and hopefully resolve or mitigate – aviation related concerns without requiring further CAA input. However, if these discussions break down or an impasse is reached, the CAA can be asked to provide objective comment. It must be remembered that the CAA has no powers to either prevent wind turbine developments going ahead or to require that an aviation stakeholder remove their objection. Nevertheless, by involving the CAA at an appropriate stage, it is hoped that some form of agreement can be reached that prevents the need for costly Planning Inquiries that feature aviation as a key issue.

4.26. Of further note is that as the UK's independent civil aviation regulator of, the CAA will not typically provide comment on MoD objections or arguments unless such comments have been requested by the MoD. However, in circumstances where there is a mixture of civil and military objections and where it is appropriate to do so, the CAA could facilitate discussions between all the parties (including the MoD).

APPENDIX A

DECC Governance and meeting structure

A1 In addition to work to improve the processes of consultation and assessment, there is a substantial amount of other activity going on to identify, develop and implement solutions to the potential impacts that wind turbines can have on radar systems. It was recognised that it would be beneficial to draw this work together within a single plan in order to have a coordinated approach to finding solutions to the wind turbine – radar issue. Therefore, together with stakeholders in the aviation and wind development sectors, DECC and several partners jointly developed an Aviation Plan to move work forward so that wind turbine developments could be developed while, at the same time, the maintenance of national security and the continued safe operation of our aviation environment were ensured. The structure and principles of the Aviation Plan were endorsed by the Wind Energy, Defence and Civil Aviation Interests Working Group in March 2008.

A2 The overall aim of the Aviation Plan is to provide an evolving suite of generic mitigation solutions to which wind turbine developers and their aviation stakeholders can turn when discussing the best potential solutions for any particular wind proposal. The development of this suite of generic solutions is an on-going process and builds on a number of solutions that are already available to wind turbine developers.

A3 The governance of the Aviation Plan is the responsibility of an Aviation Management Board (AMB), which in turn is supported by a technical-level Aviation Advisory Panel (AAP). RenewableUK have taken on the responsibility of establishing an industry funding mechanism that will part- support, financially, the work-streams within the Plan, which is managed by the Fund Management Board. All meetings sit quarterly.

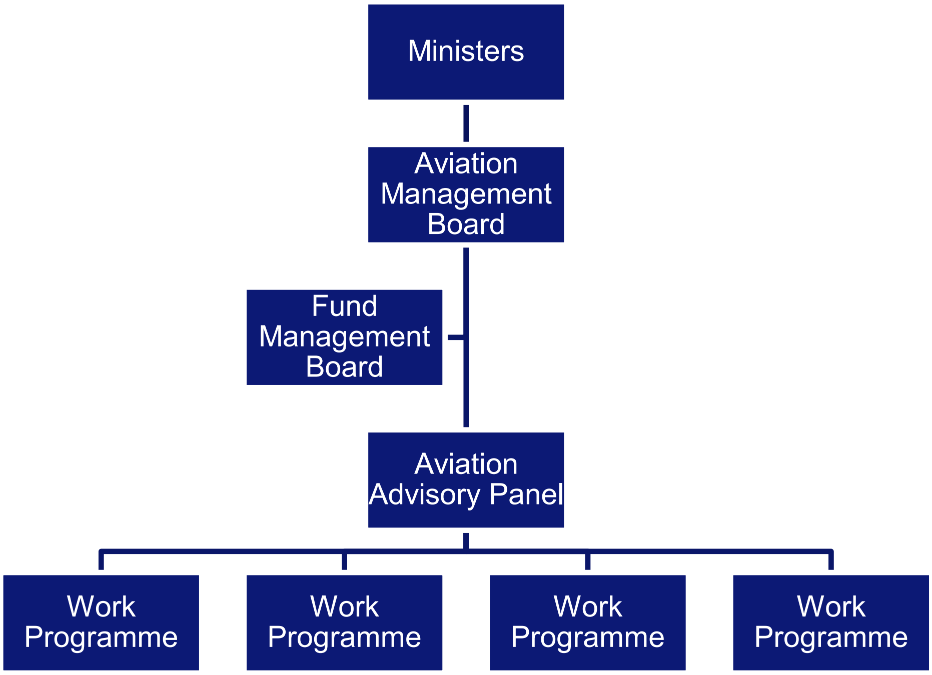

Figure A-1: AMB Governance

A4 The value of the Aviation Plan as a tool for enabling the development of mitigation solutions has been recognised by key stakeholders that have an interest in radar systems and wind turbine developments. To ensure the success of the plan, a number of these have agreed to sign off a second Memorandum of Understanding[40] to commit to the full implementation of the Aviation Plan and its approach to ensuring the timely and effective delivery of solutions to reduce the effect of wind turbines on aviation interests.

---

[40] https://www.gov.uk/government/publications/wind-turbines-and-aviation-radar-mitigation-issues-memorandum-of-understanding-2011-update

APPENDIX B

Contact Information

CAA Contacts

CAA Windfarms

Windfarms

Infrastructure

Safety and Airspace Regulation Group

CAA House

45-59 Kingsway

London

WC2B 6TE

Tel: 020 7453 6534

http://www.caa.co.uk/Safety-Initiatives-and-Resources/Safety-projects/Windfarms/Windfarms/

windfarms@caa.co.uk

CAA Aerodromes

For information on aerodrome licensing criteria, obstacle limitation surfaces and call-in procedures, contact:

Civil Aviation Authority

Aerodromes Standards Department

Safety and Airspace Regulation Group

Aviation House

Gatwick Airport South

West Sussex

RH6 0YR

CAAAerodromeStandardsDepartment@caa.co.uk

CAA Air Traffic Standards

Where a service provider has to update the safety documentation for a service as a result of a wind turbine development, then they should follow standard practice and contact their regional inspector for approval as necessary. Contact details are below:

CAA En-Route Regulation

Safety and Airspace Regulation Group Aviation House – 2W

Gatwick Airport South

West Sussex

RH6 0YR

Tel: (+44) (0)1293 573060, Fax: (+44) (0)1293 573974

ats.enquiries@caa.co.uk (mark to 'En-Route Regulation')

CAA Southern Regional Office (Gatwick)

Regional Manager ATS Safety Regulation (Southern Region)

Air Traffic Standards Division

Safety and Airspace Regulation Group

Civil Aviation Authority

Aviation House

Gatwick Airport South

West Sussex

RH6 0YR

Tel (+44) (0) 1293 573330, Fax: (+44) (0) 1293 573974

ats.southern.regional.office@caa.co.uk

CAA Northern Regional Office (Stirling)

Regional Manager ATS Safety Regulation (Northern Region)

Air Traffic Standards Division

Safety and Airspace Regulation Group

Civil Aviation Authority

First Floor, Kings Park House
Laurelhill Business Park
Stirling
Scotland
FK8 9JQ
Tel: (+44) (0) 1786 457400
ats.northern.regional.office@caa.co.uk

ATCO Training and Area Control Centres

Enquiries about ATS at Area Control Centres and air traffic controller training establishments should be addressed to:

En Route and College Regulation
Air Traffic Standards
Civil Aviation Authority
Safety and Airspace Regulation Group
Civil Aviation Authority
Aviation House
Gatwick Airport South
West Sussex
RH6 0YR
Tel: (+44) (0) 1293 573259
Fax: (+44) (0) 1293 573974

Other Contacts

The Airport Operators' Association

3 Birdcage Walk
London SW1H 9JJ
www.aoa.org.uk
Tel: (+44) (0) 20 7799 3171

General Aviation Awareness Council

RAeS House

4 Hamilton Place

London

W1J 7BQ

www.gaac.org.uk

Tel: 020 7670 4501

Fax: 020 7670 4309

British Gliding Association Limited

8 Merus Court

Meridian Business Park

Leicester

LE19 1RJ

Tel: +44 (0) 116 289 2956

Fax: +44 (0) 116 289 5025

office@gliding.co.uk

British Parachuting Association

Wharf Way

Glen Parva

Leicester

LE2 9TF

www.bpa.org.uk

Tel: +44 (0)116 278 5271

Fax: +44 (0)116 247 7662

skydive@bpa.org.uk

Defence Geographic Centre

UK DVOF & Powerlines

Air Information Section

Defence Geographic Centre

Elmwood Avenue

Feltham

Middlesex

TW13 7AH

Tel: (+44) (0) 208 818 2702

DVOF@mod.uk

Department for Environment, Food and Rural Affairs

Nobel House

17 Smith Square

London

SW1P 3JR

https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs

Department of Energy and Climate Change

Kieran Power

3 Whitehall Place

London

SW1A 2AW

Tel: 0300 068 6189

www.decc.gov.uk

kieran.power@decc.gsi.gov.uk

Department for Transport

Great Minster House

76 Marsham Street

London

SW1P 4DR

https://www.gov.uk/government/organisations/department-for-transport

Maritime and Coastguard Agency

For general enquiries:

SAR Operations Officer

HM Coastguard

Maritime and Coastguard Agency

Southampton

UK

Tel: (023) 8032 9332

Fax: (023) 8032 9488

https://www.gov.uk/government/organisations/maritime-and-coastguard-agency

Roly.McKie@mcga.gov.uk

For Maritime lighting requirements:

MCA Navigation Safety Branch,

HM Coastguard

Maritime and Coastguard Agency

Southampton

UK

Tel: (023) 8032 9523

Fax: (023) 8032 9488

National Police Air Service (England and Wales)

NPAS HQ

Head of Estates and Infrastructure

West Yorkshire Police

Laburnum Road

Wakefield

West Yorkshire

WF1 3QP

Tel: 01924 292520

npas.obstructions@npas.pnn.police.uk

http://www.npas.police.uk/

Ministry of Defence – Defence Infrastructure Organisation (formerly Defence Estates)

Kingston Road

Sutton Coldfield

West Midlands

B75 7RL

0121 311 3847

dio-safeguarding-wind@mod.uk

www.mod.uk/DIO

NATS Safeguarding

NATS Corporate and Technical Centre

4000-4200 Parkway

Whiteley

Hants

PO15 7FL

NATSSafeguarding@nats.co.uk

National Assembly for Wales

Planning Division
Cathays Park
Cardiff
CF10 3NQ
0300 0603300 or 0845 010 3300
Planning.division@wales.gsi.gov.uk
http://gov.wales/topics/planning/?lang=en

DOE Northern Ireland Planning

DOE Planning
Causeway Exchange
1-7 Bedford Street
19-25 Great Victoria Street
Belfast
BT2 7EG
www.planningni.gov.uk

Department for Communities and Local Government

Eland House
Bressenden Place
London
SW1E 5DU
https://www.gov.uk/government/organisations/department-for-communities-and-local-governmentw

Office of Gas and Electricity Markets (OFGEM)

9 Millbank

London

SW1P 3GE

70 West Regent Street

Regents Court

Glasgow

G2 2QZ

https://www.ofgem.gov.uk/

RenewableUK

Greencoat House

Francis Street

London

SW1P 1DH

http://www.renewableuk.com/

Scottish Executive

Energy Consents Unit

4th Floor

5 Atlantic Quay

150 Broomielaw

Glasgow

G2 8LU

econsentsadmin@scotland.gsi.gov.uk

http://www.energyconsents.scot/

EXHIBIT
5

Report No. K-TRAN: KU-13-6 ▪ FINAL REPORT ▪ January 2014

Wind Farm Turbulence Impacts on General Aviation Airports in Kansas

Thomas E. Mulinazzi, Ph.D., P.E., L.S.
Zhongquan Charlie Zheng, Ph.D.

The University of Kansas

A cooperative transportation research program between
Kansas Department of Transportation,
Kansas State University Transportation Center, and
The University of Kansas

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16 Abstract

Wind turbines and wind farms have become popular in the State of Kansas. Some general aviation pilots have expressed a concern about the turbulence that the spinning blades are creating. If a wind farm is built near an airport, does this affect the operations in and out of that airport? Other problems associated with wind farms are their impact on agricultural aviation and their influence on radar detection of aircraft in the vicinity of a wind farm.

This research project has three objectives:

1. Determine the amount and pattern of the turbulence from a single wind turbine.
2. Determine the amount and pattern of wind turbulence from a wind farm, both in a horizontal direction and in a vertical direction.
3. This information will result in recommendations concerning the location of wind farms and their impacts of the safe operation of airports and other aviation activities.

The results of this project support the findings in the literature search that the turbulence from a wind turbine can impact operations at a general aviation airport. Two case studies were used to illustrate the impact of turbulence from a wind turbine on a general aviation airport. This project analyzed the roll hazard and the crosswind hazard resulting from a wind farm located near a general aviation airport. The wind turbine wake model is based on a theoretical helical vortex model and the decay rate is calculated following the aircraft wake decay rate in the atmosphere.

The roll hazard analysis showed that for the Rooks County Regional Airport, the potential roll hazard index is in the high range as far out as 2.84 miles. For the Pratt Regional Airport, the roll hazard index is in the high range as far out as 1.14 miles. These numbers are based on a gust wind of 40 mph that is below the turbine brake wind speed of 55 mph. As the results show, the scenario is different according to the relative locations and orientations of the airport and the nearby wind farm. Therefore, the analysis has to be performed for each specific regional airport.

The crosswind hazard analysis for the Rooks County Regional Airport showed part of the airport in the high range even under the mild wind condition at 10 mph. The wind turbine wake increases the crosswind component to more than 12 mph which is considered high risk crosswind for small general aviation aircraft. For the Pratt Regional Airport, the crosswind hazard is relatively small under the mild wind condition (10 mph). When there is a gust of 40 mph wind, the turbine wake induced crosswind puts the majority of runway areas to high hazard areas at both of the airports.

It is recommended that additional studies should be performed to draw the proper correlation between the hazard index developed in this study and the safe operation of aircraft at low airspeeds and at low flight altitudes operating near or at a general aviation airport.

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Wind Farm Turbulence Impacts on General Aviation Airports in Kansas

Final Report

Prepared by

Thomas E. Mulinazzi, Ph.D., P.E., L.S.
Zhongquan Charlie Zheng, Ph.D.
The University of Kansas

A Report on Research Sponsored by

THE KANSAS DEPARTMENT OF TRANSPORTATION
TOPEKA, KANSAS

and

THE UNIVERSITY OF KANSAS
LAWRENCE, KANSAS

January 2014

PREFACE

The Kansas Department of Transportation's (KDOT) Kansas Transportation Research and New-Developments (K-TRAN) Research Program funded this research project. It is an ongoing, cooperative and comprehensive research program addressing transportation needs of the state of Kansas utilizing academic and research resources from KDOT, Kansas State University and the University of Kansas. Transportation professionals in KDOT and the universities jointly develop the projects included in the research program.

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DISCLAIMER

Abstract

Wind turbines and wind farms have become popular in the State of Kansas. Some general aviation pilots have expressed a concern about the turbulence that the spinning blades are creating. If a wind farm is built near an airport, does this affect the operations in and out of that airport? Other problems associated with wind farms are their impact on agricultural aviation and their influence on radar detection of aircraft in the vicinity of a wind farm.

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It is recommended that additional studies should be performed to draw the proper correlation between the hazard index developed in this study and the safe operation of aircraft at low airspeeds and at low flight altitudes operating near or at a general aviation airport.

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Chapter 1: Introduction

Wind turbines and wind farms have become popular in the State of Kansas. Figure 1.1 shows the proposed and existing wind farm projects in Kansas as of February 2013. However, some general aviation pilots have expressed a concern about the turbulence that the spinning blades are creating. If a wind farm is built near an airport, does this affect the operations in and out of that airport? Other problems associated with wind farms are their impact on agricultural aviation and their influence on radar detection of aircraft in the vicinity of a wind farm.

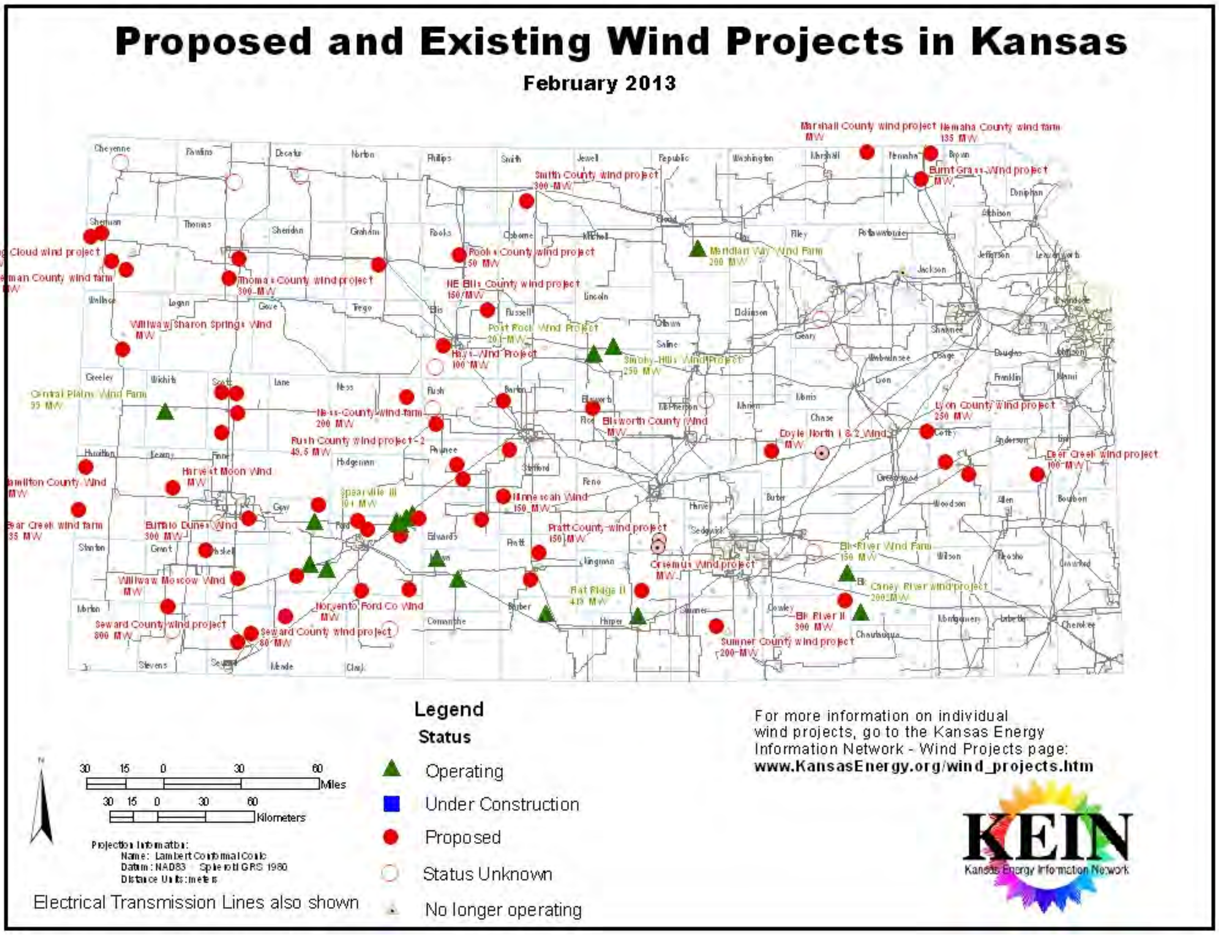


FIGURE 1.1
Proposed and Existing Wind Projects in Kansas

This research project has three objectives:

1. Determine the amount and pattern of the turbulence from a single wind turbine.

2. Determine the amount and pattern of wind turbulence from a wind farm, both in a horizontal direction and in a vertical direction.
3. This information will result in recommendations concerning the location of wind farms and their impacts of the safe operation of airports and other aviation activities.

There were five tasks in this project:

1. Determine the amount and pattern of the turbulence from a single wind turbine.
2. Determine the amount and pattern of wind turbulence from a wind farm.
3. Locate the existing and planned wind farms in the State of Kansas.
4. Locate the existing general aviation airports and their proximity to existing and proposed wind farms.
5. Write the final report

Chapter 2: Literature Search

2.1 Wind Turbine Specifications

After going through the popular wind turbine models of the top 10 wind turbine manufacturing companies in the world, the height of the wind turbine hub varied from 165ft to a maximum of 450ft. Many times the height of the hub is site specific, as it depends on the height at which the wind speed is the maximum. The rotor diameters vary from around 260ft to a maximum of 500ft, though the average diameter is around 300ft. The rated power of the wind turbines is between 8.0 MW to 0.6 MW (www.aweo.org/windmodels).

Johan Meyers (Katholieke Universiteit Leuven, Belgium) and Charles Meneveau (Johns Hopkins University) tried to find the optimal turbine spacing in a fully developed wind-farm. The researchers used the computational studies based on the Large Eddy Simulation, which allows them to predict the wind velocity at the hub height as a function of wind turbine spacing and loading factors. In this research, they used this simulation to predict the optimal spacing as a function of above parameters along with ratio of turbine costs to land surface costs. They found out that for realistic cost ratios the average optimal turbine spacing should be 15 times the diameter of the rotor as against the conventional 7 times. The above is true for large wind farms on flat terrain whose length exceeds the atmospheric boundary layer (height of approximately 1 km). The optimal spacing of wind turbines in small wind farms may depend on the location, as the turbines in the front will be operating under powerful winds compared to the one behind (Meyers and Meneveau 2012).

Ivan Mustakerov and Daniela Borissova studied the problems associated with optimal wind farm design in Bulgaria. The authors developed an optimization model for wind turbine type, number and placement based on given wind conditions and wind farm area being developed. To determine the optimization criteria they used wind farm investment cost and total power as functions of wind turbine type and number. The researchers considered two main wind directions regarding uniform and predominant wind directions for wind farm of shapes – square and rectangular. After testing a developed wind farm numerically, they observed that the different practical requirements and restrictions define the different choices. Their results also confirmed that using big size turbines is more profitable than a large number of small size turbines. The numerical tests show that the developed optimization approach can be applied to wind farm design (Mustakerov and Borissova 2009).

2.2 Wind Terminology

Start-up speed: Speed at which the rotor and blade assembly starts to rotate.

Cut-in speed: The minimum speed at which the wind turbine will generate usable power, generally between 7 and 10mph.

Rated speed: It is the minimum speed at which the wind turbine will generate its designated rated power. It is generally between 25 and 35mph for most of the turbines.

Cut-out speed: The speed at which the turbines stop generating power and shuts down, usually between 45 and 80mph (www.energybible.com 2012).

2.3 Wind Farms and Aviation

2.3.1 Turbulence Impact Assessment

EMD International A/S conducted a study on the turbulence impact from a wind farm located off shore. This study was undertaken because some sailors and recreational users off the coast of the island Hiiumaa complained about the turbulence. In this study the actual locations of the wind turbines were not considered, but a large number of turbines were selected. The turbulence was calculated to be 8m/s at a 10 m height on off shore locations. The size of the wind farm considered in this study was 636 MW, distributed on 212 units. For calculations Vestas V90-3 was used, which has a nominal power of 3 MW, a rotor diameter of 90m and a hub height of 80m. The turbulence of wind was described by turbulence intensity, which is the ratio of wind speed changes to mean wind speed. Turbulence depends on the terrain; sea surface causes little turbulence while forest area causes very high turbulence. The higher the turbulence, the longer is the distance required for dissipation. The wind turbines add wake to the wind turbulence. The wake can be recognized up to 2000m (about 6600ft) downwind side of the turbine. The wake turbulence is the largest behind the turbine and decreases further downstream. The turbulence from turbines has a short and predictable spectral size unlike the natural turbulence. They concluded that the maximum turbulence from a single turbine is at 200m and is almost negligible after 500m. The researchers concluded that the turbulence impact of the turbines is negligible beyond a few hundred meters, when compared with the turbulence on land (EMD International A/S 2010).

2.3.2 CAA Policy and Guidelines on Wind Turbines

The Civil Aviation Authority (CAA) in England is the statutory corporation which oversees and regulates all aspects of civil aviation in the United Kingdom (UK). The study focused on the issues related to the UK but lessons still can be applied here. There was also recognition in their report that both aviation and wind energy were important to natural interests and each side should cooperate to find solution to potential problems. The CAA published this document to give the aviation stakeholder a better understanding of the wind turbine related issues. In Chapter 2 of their report, they identified several impacts of wind farms on aviation. They report that Primary Surveillance Radar is adversely affected. If the wind turbine falls within the line of sight of the radar, then the radar misinterprets a wind turbine as an aircraft. Sometimes wind turbines cause a loss of sensitivity in detection of aircrafts to an extent that they are lost completely. The wind turbines form an obstruction and, thus, there is a region behind the turbine in which aircrafts are masked and cannot be detected. The receiver requires a large range to detect reflected signals from small and large aircrafts. If there is an obstacle such as a wind turbine, then it reflects a significant amount of signals and thus the receiver becomes saturated. The wind turbine also affects the Secondary Surveillance Radar even though it does not rely on the reflections from an object. The turbulence caused by the wake of the turbine extends downstream of the blades. The wake intensity depends on the size and height of turbines. It has been seen that the wind turbines create wake vortices similar to aircraft vortices, these can be hazardous to an aircraft. “Published research shows measurements at 16 rotor diameters, approximately 1500m (5000ft) downstream of the wind turbine indicating that turbulence effects are still noticeable.” The measurement of effect is very difficult even though modeling studies can predict the effects further downstream. The verification and validation processes of these models are still going on. They found that very light aircrafts such as gliders, gyroplanes, microlights, etc. are more susceptible to the wake turbulence. Thus, the CAA will analyze the turbulence of wind farms near the airports on a case-by-case basis until they observe a significant pattern (Civil Aviation Authority 2011).

2.3.3 Airport Cooperative Research Program Synthesis 28: Investigating Safety Impacts of Energy Technologies on Airports and Aviation

This synthesis study was carried out to inform airport operators, aircraft pilots, airport planners and developers, legislators and regulators responsible for aviation safety of the visual and communications interference impacts of the new energy technologies on aviation. They list that the main concerns of using wind turbines are the height of the turbines and the communication system interference. In addition, the turbulence, lighting and marking of wind turbines are also a concern. Though CFR Part 77 deals with the height, size and location of aviation obstructions, this information is advisory in nature. Wind turbines are issued "No Hazard" determination if they are not located within the airport approach areas by the Federal Aviation Administration (FAA). Similar to the CAA findings, this report also states the adverse effects of wind turbines on the primary and secondary radars. They found that the turbulence from the wind turbines creates vortices at a distance of 2-6 rotor radii (250-750ft). Thus the aircrafts flying at a height of 200-400ft above ground, i.e. at the turbine level, are in danger. To minimize the effects of wind farms they have considered some mitigation options

- Appropriate siting to avoid communication system impacts.
- Re-route air traffic.
- Use of supplemental radars wherever the main radar is receiving false signals.
- Use radar absorbent materials on the turbines (Barret and Devita 2011).

2.3.4 NationAir Aviation Insurance

The NationAir Aviation Insurance (NAAI), an insurance company in Illinois, discussed the hazards of wind turbines to the aerial applicators. They say that the tax credits, and other grants and subsidies from the government drastically increased the number of wind turbines in the mid-west region. According to the NAAI Tower Policy all the recorded aerial applicator and tower collisions have been fatal. The wind turbine has hazards like wake turbulence and shadow flicker. The researchers found out that a typical commercial wind farm has 2.5 turbines per square mile, with the exception of some states like Wisconsin, where there are 10-12 wind turbines per square mile. Turbine flickers can play visual “tricks” and lead to pilot disorientation. The specific location of wind farm can drastically impact application ability and its associated cost. The researchers also say that the MET (meteorological test towers) are very dangerous as they are below 200 feet and require no painting or marking. The NAAI has developed guidelines in order to inform the tower industry about the aerial applicators concerns, they are as follows:

- Construction Petitions should be provided to zoning authorities, landowners, applicators within a half mile from towers and regional agricultural aviation organizations.
- Towers should be avoided on prime agricultural land or locations which will inhibit spray.
- Information on whether the land will be or will not be suitable for aerial application after construction should be provided by the developers.
- The towers should be free standing without guy wires and in a linear pattern.
- Detailed field layout should be provided to those who work in the proximity after construction is completed. (NationAir Aviation Insurance 2012)

2.3.5 Other Reports

The De Kalb County, Indiana, case concerns the major safety of the MET towers set up to monitor the wind. The cost of aerial application increases with this and many operators refuse to operate within the confines of a wind farm. The farmers with land adjacent to a wind farm development are also affected. The operators charge 50% more than usual for aerial application in a wind farm zone. Potential impact on NexRad appears to be low, but one of the weather radars operating in Fort Wayne has seen impacts from towers in the Ohio counties of Paulding and Van Wert. The researcher concludes that the wind farm development will not affect aviation in all weather conditions but only in certain conditions. All the wind farm development should be studied on a case to case basis by a third party before local approvals are given. The researchers also state that the developments, which have been proven to not have any negative impacts, should not be restricted on unsubstantiated and unproven public claims. (Stump 2012)

The Fraunhofer Institute for Wind Energy and Energy System Technology (IWES) in Oldenburg, Germany developed a simulation which enables them to calculate the turbulence created by the wind farms, how they change the wind speed and how it affects the airplanes. The IWES conducted this research on behalf of BMR Windenergie, the operator of the wind farm, which has proposed a wind farm near an airfield. The researchers created a model of ground and wind profile of the area surrounding the proposed area of the wind farm. Over this model a grid was placed. The computer calculates the changes in the wind conditions and turbulence caused by the wind farms. Dr. Bernhard Stoevesandt said, "The true skill was creation of a grid: Because the points on the grid where the computer makes the individual calculations must lie exactly at the right place." Another challenge that the researcher faced was to depict the trail properly, which is the turbulence and wind conditions behind the rotor and determine its effects on aircraft. The researchers measured the trail at various individual points behind the rotor at actual wind farms in order to validate the simulations. The researchers carried out simulations for various wind directions, two different wind speeds and five different flight trajectories under which the airplanes will be influenced for varying lengths of time. The researchers found that the turbulence generated by the wind turbines is lower than the ordinary turbulence from the surrounding area. This finding can be applied to other airports to a limited extent, because of the fact that the surrounding terrain has a tremendous impact on the trail and, thus, it is very different for forested and hilly terrain compared to flat terrain (Stoevesandt 2012).

2.4 General Aviation

The FAA recommends a crosswind runway, if a runway orientation provides wind coverage less than 95% for any aircraft forecasted to use the airport on a regular basis. To calculate 95% wind coverage the crosswind should not exceed the following limits:

TABLE 2.1
Airport Reference Code for Maximum Crosswind

Airport Reference Code	Maximum Crosswind
A-I and B-I	12.10 mph
A-II and B-II	15 mph
A-III, B-III, and C-I through D-III	18.41 mph
A-IV through D-VI	23 mph

The Airport Reference Codes A-I or B-I are expected to accommodate single engine airplanes. Codes B-II or B-III refers to airports serving larger general aviation aircrafts and commuter type aircrafts. C-III is small or medium sized airports serving air carriers. And larger air carrier airports are with codes D-VI or D-V. (Federal Aviation Administration 2012)

Rate of change of wind speed and/or direction an aircraft experiences is called wind shear. There are two types of shear, namely vertical and horizontal, though generally they occur as a combination of both. Wind shear in aviation terms is defined as a sudden but sustained "variation in wind along the flight path of a pattern, intensity and duration that displaces the aircraft abruptly from its intended path so that substantial and timely control action is needed". Though wind shear is short lived it is probably the greatest hazard to aircrafts at low altitude. A substantial change in the lift generation linked with the aircraft inertia results in the displacement of the flight path. Terrain, constructed obstructions, thermals, and temperature inversions may cause wind shears. For a light aircraft, the closer to the surface a shear appears, the more dangerous it is. (Brandon 2012)

The Aircraft Owners and Pilots Association (AOPA) published two letters which state that "wind turbines have the potential to be a hazard to air navigation". "According to Greg Pecoraro, AOPA vice president of airports and state advocacy, it has become increasingly important for AOPA to educate lawmakers across the country about the effects of these systems on aviation, particularly so when the wind farms are in close proximity to airports. Aside from the obstruction itself, they can also interfere with communication and navigation, and wind patterns for all aircraft, especially gliders". Pecoraro went on to say, "If the systems (wind farms) were to be installed near arrival or departure paths of these facilities (airports), the safety of passengers and crew, as well as citizen below, would be greatly compromised" (Twombly 2009).

In an article titled, “Wind Farms Could be a Hazard to VFR Flights “ the AOPA is urging the FAA to find the 130 wind turbines proposed for the Nantucket Sound near Cotuit, Massachusetts, would pose a hazard to the many low-altitude VFR flights between the three area airports. The turbines could also disrupt local radar systems”. An AOPA Pilot Blog stated that “the National Weather Association newsletter had the statement that wind farms are showing up on NexRad radars. … They make radar returns that look a lot like a tornado vortex” (Namowitz 2012).

Another AOPA report has the title “Wind Farms Can’t Come at the Expense of Airports”. The mayor of Kentland, Indiana protected his town’s airport from a request by a local farmer to close the airport so he could build a wind turbine farm on his property” (AOPA 2010).

2.4.1 Imaginary Surfaces of Airports

To provide safe navigation of aircrafts to and from an airport, there are certain specifications to guard the airspace surrounding an airport. According to FAA, a runway protection zone should be provided at the end of a runway. It is an area on the ground beneath the approach surface, from the end of primary surface and extended to a point where the approach surface is 50ft above the primary surface. If the runway protection zone starts at any location 200ft beyond the end of the runway, then two protection zones are required, the approach protection zone and departure protection zone.

Part 77 of the Federal Aviation Regulations establishes standards to determine what would be considered as obstructions to the navigable airspace and sets requirements for notice to the FAA due to constructions and alterations; it also provides studies to explain the effects of obstructions on safe and efficient use of airspace. It is the responsibility of the airport operator to make sure that the aerial approaches to the airport are clear and protected and the land adjacent or in vicinity of the airport is restricted with measures such as zoning ordinances. Several imaginary surfaces have been established to determine whether an object is an obstruction to the airspace. These surfaces vary with the type of runway (e.g. utility, transport) and the approach planned for that runway (e.g. visual, non-precision instrument, etc.).

- Primary Surface: This surface is longitudinally centered on a runway. It extends 200ft from each end of the runway when the runway is paved; if the runway is unpaved it ends at the end of the runway. Its elevation is the same as that of the nearest point on the runway centerline.
- Horizontal Surface: This is a horizontal plane 150ft above the established airport elevation. The perimeter of this surface is constructed by swinging arcs of fixed radii from the end of the primary surfaces and the two arcs are joined by tangents.
- Conical Surface: It is a surface extending outwards and upwards from the periphery of horizontal surface at a slope of 20:1 for a horizontal distance of 4000ft.
- Approach Surface: This surface is longitudinally centered along the extended runway centerline. It extends outwards and upwards at a designated slope based on the type of approach planned or present.
- Transitional Surface: This surface extends outwards and upwards at right angles to the runway centerline and to the extended runway centerline at a slope of 7:1 from the sides of the primary surface up to horizontal surface and also from that of the approach surface. The width of the transitional surface is 5000ft from the edge of the approach surfaces.

Along with the above imaginary surfaces, existing or future objects are considered as obstructions if they are of greater height than any of following heights or obstructions:

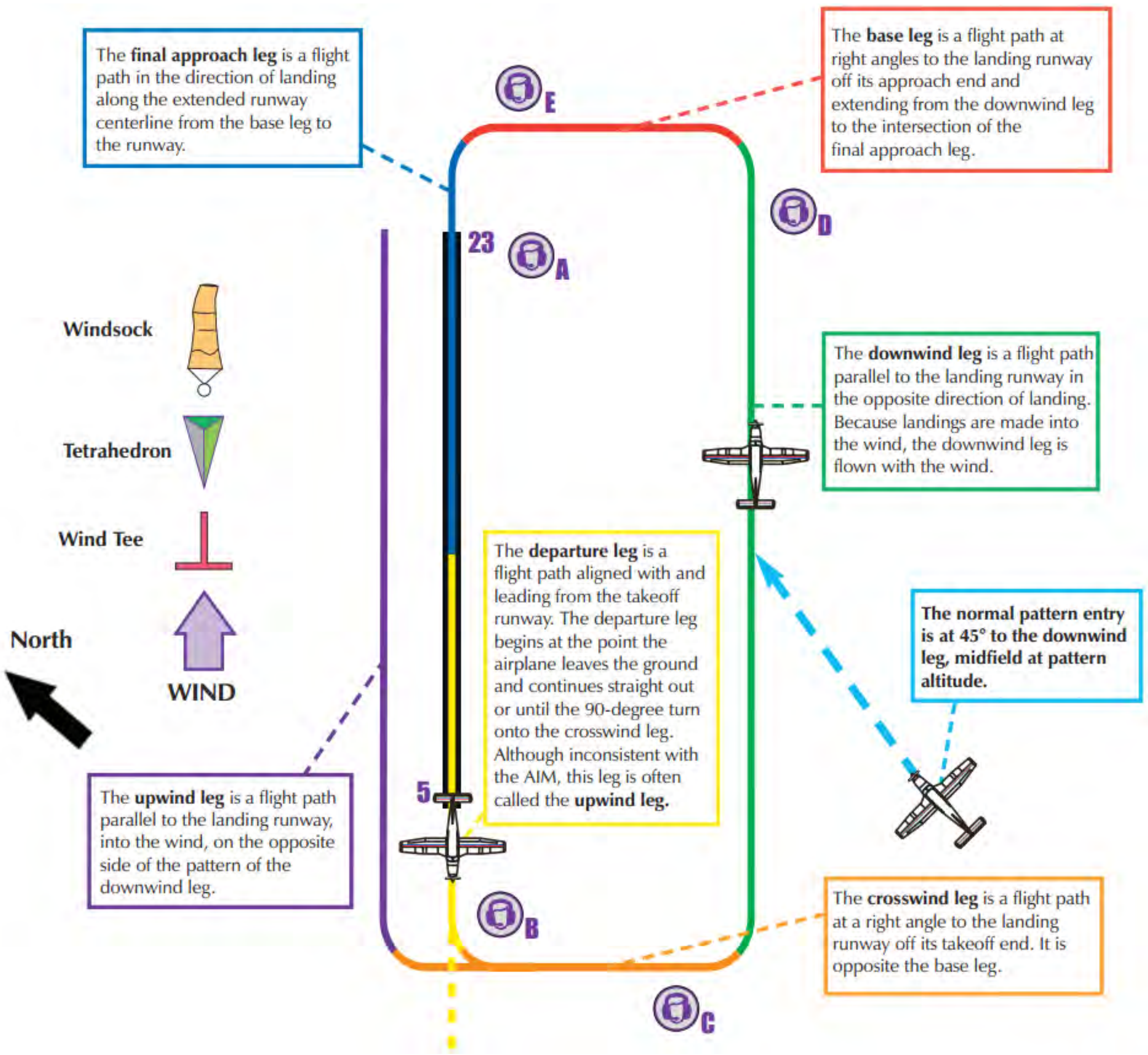
- A height of 500ft above ground level at the site of the airport.
- A height of 200ft above ground level or above the established elevation of the airport, whichever is greater, within 3 nautical miles (3.45 miles) of the ARP (airport reference point) which has a longest runway of more than 3200ft. This is increased 100 ft for every mile up to 500 ft. at 6 miles from the ARP.
- A height within a terminal obstacle clearance area, including an initial approach segment, a departure area, and a circling approach area, that would result in the vertical distance between any point on the object and an established minimum instrument flight altitude in that area less than required obstacle clearance.

- A height that would increase the minimum obstacle clearance altitude within an obstacle clearance area along with turn and termination area on a federal airway or off-airway route.
- Any of the imaginary surfaces defined earlier. (Horonjeff, et al. 2010)

2.4.2 Operations at Airports

This is a standard operation procedure for an airport:

- First scan for traffic on the base and final approach legs. Turn on the landing and anti-collision lights, taxi on the runway and align with the runway centerline and take off.
- Departure Leg: Climb the extended runway centerline beyond departure end of runway up to 1000ft. Then look left and right to check for traffic conflict.
- Crosswind Leg: After climbing to the pattern altitude (1000ft) level off and reduce power. Go on crosswind for a half mile.
- Downwind Leg: Perform all the landing configuration tasks on this leg. Select a touchdown point on runway and descent when the spot is passed. Turn to base leg so as to achieve ½ - ¾ mile final approach leg.
- Base Leg: this leg is perpendicular to the runway. Scan for conflicting traffic on this leg. Approaching the turn point and scan for conflicts again.
- Final Approach Leg: Verify all the configurations. Keep scanning for traffic. Clear both sides of the final approach leg. (Air Safety Institute n.d.)



The **final approach leg** is a flight path in the direction of landing along the extended runway centerline from the base leg to the runway.

The **base leg** is a flight path at right angles to the landing runway off its approach end and extending from the downwind leg to the intersection of the final approach leg.

The **downwind leg** is a flight path parallel to the landing runway in the opposite direction of landing. Because landings are made into the wind, the downwind leg is flown with the wind.

The **departure leg** is a flight path aligned with and leading from the takeoff runway. The departure leg begins at the point the airplane leaves the ground and continues straight out or until the 90-degree turn onto the crosswind leg. Although inconsistent with the AIM, this leg is often called the **upwind leg.**

The normal pattern entry is at 45° to the downwind leg, midfield at pattern altitude.

The **upwind leg** is a flight path parallel to the landing runway, into the wind, on the opposite side of the pattern of the downwind leg.

The **crosswind leg** is a flight path at a right angle to the landing runway off its takeoff end. It is opposite the base leg.

FIGURE 2.1
Non-Towered Airport Approach Traffic Pattern

Figure 2.1 illustrates the traffic pattern used when a pilot approaches a non-towered airport. The location of a wind farm in relationship to an airport can impact the operations of the airport in three ways:

1. The wind turbines should not intersect any of the imaginary surfaces
2. The wind turbines should not be in the path of the recommended traffic pattern
3. The turbulence caused by the wind farm could impact airport operations even though the turbines don't violate 1 and 2 above.

2.5 Wind Farms and the Environment, Health, Agriculture, and Economics

The National Research Council studied the impacts of the wind farms on the environment, aesthetics, cultural, recreational, social, and economics. The committee addressed the beneficial as well as harmful effects of wind farms. Though the committee studied the wind farms all over the US and world, their primary focus was on the wind farms located in the Mid-Atlantic Highland region. They concluded that wind farms had an adverse effect on ecology; birds and bat fatalities occurred due to collisions. They also observed that the new monopole turbines may have less fatalities compared to the older, lattice style turbines. They also observed that the bat fatalities were much higher compared to birds. They observed that the wind turbines had a great impact on the aesthetics of the area and this resulted in strong negative reactions. They suggest that the tools, which are available to study the project visibility and appearance as well as the landscape characteristics, should be used. Wind farms may have an impact on the recreational, sacred and archeological sites as well, as natural scenery is part of recreation and, in the case of historic or sacred sites, their appreciation can be affected. The researchers do not have clarity to evaluate such situations and solve them. The noise from the rotor and flickering of the light due to the blades can cause irritation to the people living there. The noise can be monitored using various measurement techniques and the flickering of light has not been identified even as a mild annoyance, while in Europe it has been noted as a cause of concern. The wind turbine cause electromagnetic interference and has a potential to cause interference to television broadcasts. (National Research Council 2007)

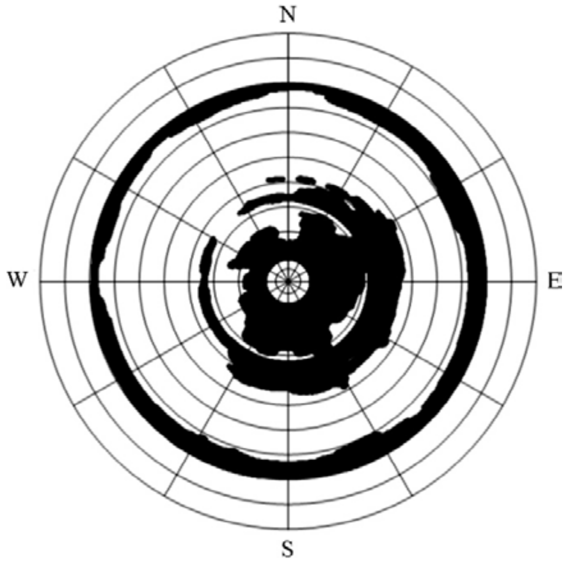
Jay Calleja, Manager of Communications for National Agricultural Aviation Association, discusses the effects of wind energy on farming. The author states that when wind turbines are erected on the farm, aerial application becomes difficult. This is not only limited to the farm in which the turbines are installed, but the neighboring farms can also be affected. If the aerial aviators decide to apply on areas in or around wind turbines they will charge more. Apart from the fact that aerial application cannot be done, there is a deeper problem that exists and that being what the damage from the construction and maintenance does to the farm drainage systems. Although the wind companies do not say that they won't repair the damage, the amount of money that the wind companies are obligated to pay may not match the amount that is required to fix the farm drainage system. The author also gives many examples of how farmers have been affected even though they did not have wind turbines on their farms. Finally, the author concludes that the aerial applicators should educate farmers about the overall effect that wind turbine construction can have on farmlands and the ability to maximize production. (Calleja 2010)

Howard Graham studied the political and social controversy surrounding the proposed wind farm in the Flint Hills region, Kansas. The author states that even though most people of Kansas will back a wind farm project due to various reasons: they trust environmental groups, back local and state government and mistrust energy companies. Yet, in the case of Flint Hills, the Tallgrass Ranchers and Protect the Flint Hills and many environmental organizations urged the local and state authorities to ban wind turbines in Wabaunsee County, Kansas. This was done mainly based on the reason that the wind turbines will alter the social, cultural and aesthetics of the hills. All the new structures in the county require a permit. In this county "the establishment of land uses except agricultural and single-family uses" requires a conditional use. Also, the county limits the industrial structures to a maximum height of 45 feet along major roads and highways. So, the county law prohibits the industrial scale turbines in two ways: the height is more than the maximum and they cannot be erected on agricultural land as they are not permitted as a conditional use. The people residing in Flint Hills felt that erecting wind turbines was like driving a knife in their hearts. Thus, the county enacted a moratorium period of 2002-2013, during which the "County Zoning Administration shall not accept nor process applications for conditional use permits in connection with wind turbine electric generating project" till the moratorium was repealed or expired. (Graham 2008)

Michael C. Slattery, Eric Lantz and Becky L. Johnson estimates the economic impact of a 1398MW wind power development in four counties of west Texas using Job and Economics Development Impacts model. Impacts of projects are estimated at a local level (within 100 miles of the wind farm) as well as the state level. The researchers observed that during the four year construction phase almost 4100 full time equivalent jobs were created and out of these 58% were accounted for by the turbine and supply chain industry. The researchers found that, assuming 4 years of construction and a 20 year life of the wind farm, the total lifetime economic activity in the state will amount to $1.8 billion, or $1.3 million per MW of installed capacity. The total economic activity at local level over the 20 year life cycle was substantial at $ 730 million, or $0.52 million per MW of installed capacity. The researchers conclude that, with this kind of impact observed from the wind industry and the potential to increase impacts by manufacturing equipment instate and developing trained wind industry labor, Texas appears to be well equipped to have increasing impacts from wind farm development. (Slattery, Lantz and Johnson 2011)

Johannes Pohl, Gundula Hubner, and Anja Mohs studied the stress effects of aircraft obstruction markings of wind turbines. The researchers state that along with the visual impact on the landscape, the stress effect of the aircraft markings is an emerging topic for resistance. As the height of the turbines increases, the number of markings increases as well. The researchers used environmental and stress methodologies to analyze the stress impact. The researchers sent out a questionnaire to 420 residents with a direct sight of 13 wind farms. They found that no substantial annoyance was caused by the obstruction markings. They also observed that the residents exposed to xenon lights reported intense and multifaceted stress compared to those exposed to LED lights. Also, the xenon lights negatively affected the general acceptance of wind farms. The residents also report more annoyance towards non-synchronized lights compared to synchronized conditions under certain weather conditions. Thus, the authors recommend that, to increase the social acceptance of wind farms, xenon lights should be banned, synchronized lights should be used and light intensity should be adjusted. (Pohl, Hubner and Mohs 2012)

Giuseppe Carbone and Luciano Afferrante defined the setback distance and/or buffer zones to reduce the risk of damage or injury from rotor failure. Currently, the distances are based as a "Rule of Thumb" based on the height of the tower and are often overestimated. The researchers combined a 3D dynamic model of detached blade fragment with a rigorous probabilistic approach. Their results show that there are large portions which are safe, even though they are located within the maximum range of the detached blade. Figure 2.2 below shows the safe and unsafe zones around a wind turbine (Carbone and Afferrante 2013).



The external circle has a radius of 200 m and the radial distance between the two contiguous circles is 20 m. White areas are the safe regions.

FIGURE 2.2
Map of Impact Risk per Unit Area for a Detached Blade

Loren D. Knopper and Christopher A. Ollson reviewed the literature on the health effects of wind turbines and compared the peer-reviewed and popular literature. They searched for literature from the Thomas Reuters Web of Knowledge and Google. They concluded that the peer-reviewed differed from the popular literature in some ways. The reviewers found that the peer-reviewed studies the turbine annoyance was attributed to turbine noise, but were, in fact, strongly related to visual impact, attitude towards turbines and noise. The peer-reviewed articles only report health effects due to environmental stress that lead to annoyed/stressed state and does not demonstrate a link between physiological health effects of the people living close to the turbines and noise they emit. While on the other hand, they observed in popular literature that the health effects are related to the distances from the turbines. In conclusion, they observed that both type of studies had a common conclusion that being that the noise from turbine leads to annoyance to some people. They concluded that the change in the environment cause health effects and not the turbine specific variables like audible noise (Knopper and Ollson 2011).

2.6 Conclusion of the Literature Search

There is a need for more detailed information on the impact of the turbulence resulting from wind farms on a general aviation airport. The wind turbulence from a single wind turbine was simulated in the project and the methodology is presented in the next chapter of this report.

Chapter 3: Wind Turbine Wake Hazard Analysis

The potential hazard caused by wind turbine vortex wakes can be viewed as two different types: the induced roll hazard on the aircraft and the gusty crosswind from the vortex. Therefore, the wind turbine wake hazard is analyzed based on two criteria: *the roll hazard criterion and the crosswind hazard criterion*.

In the following analysis, we investigated two cases, the Rooks County Regional Airport and the Pratt Regional Airport. In each case, the potential roll and crosswind hazard range caused by the proposed nearby wind farm were studied.

The case study conditions are assumed as (www.aweo.org/windmodels):

- Wind turbine center height: h = 400 ft
- Turbine blade diameter: D = 300 ft
- Typical GA airplane wing span: L = 30 ft
- Atmospheric wind speed range: v = 10mph-40mph

3.1 Simulation of the Roll Hazard Caused by Wind Turbine Wake Helical Vortex

Under the situation of the highest wind speed V = 40 mph (58.67 ft/s), the circulation of the wind turbine wake helical vortex is $\Gamma = 5006.3$ (ft^2/s), which is calculated based on the model in Appendix A. Using this circulation value, a single turbine wake helical vortex was simulated. Figure 3.1 shows the simulated turbine wake helical vortex. The mathematical model is presented in Appendix B. The color represents the velocity magnitude.

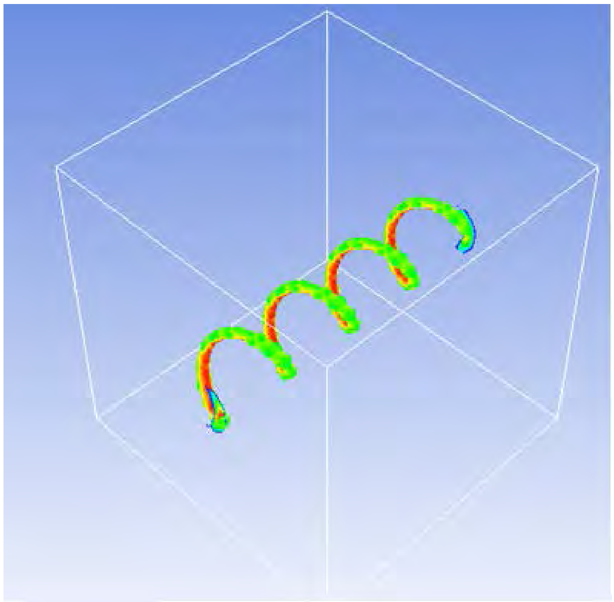


FIGURE 3.1
Wind Turbine Helical Vortex Model Used in the Case Analysis (with Color Representing the Velocity Magnitude)

Using the velocity field, the rolling moment coefficient acting on an airplane could be calculated (Appendix C). The hazard index range for the wind turbine induced rolling moment coefficient was defined as:

- Above an induced rolling moment coefficient of 0.28: high hazard
- Between 0.1 to 0.28: medium hazard
- And below 0.1: low hazard.

Please refer to the Appendix D to see how to determine these values.

3.2 The Rooks County Case

Figure 3.2 shows the aerial image and a sketch of the Rooks County Regional Airport. Runway 18-36 is the only existing runway in the center of the airport.

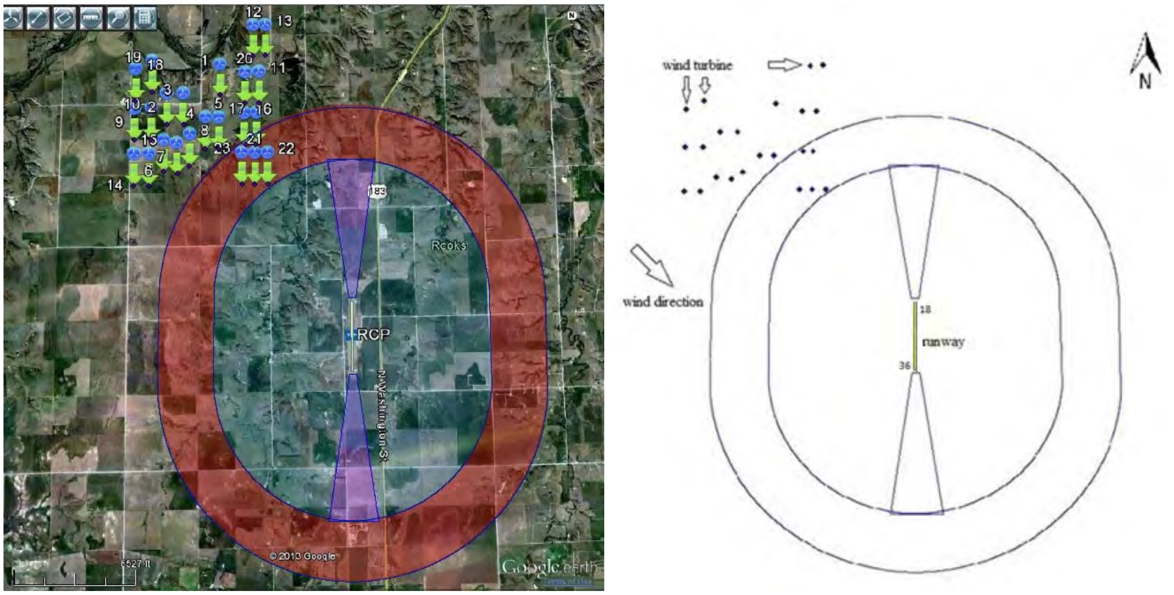


FIGURE 3.2
Rooks County Regional Airport and Wind Farm with a Scenario of a Northwest Wind

3.2.1 The Roll Hazard Analysis

Based on this decay distribution in Appendix E, the induced rolling momentum coefficient due to the wind turbine wake on the encountering aircraft, and the hazard index near the runway, can be calculated. The contours for Runway 18-36 under the 40 mph (which is assumed to be the highest possible safe wind speed under which wind turbines can operate) wind speed condition are shown in Figure 3.3. The rhombus area in Figure 3.3a is a cross section of the area where the helical vortex exists (between two red lines) and the area near the runway from south to north (between the two green lines). Figure 3.3b shows the exact rolling moment value in the area and Figure 3.3b shows the hazard index. As Figure 3.3b shows, the area around the runway is within the high hazard region (determined in 3.1).

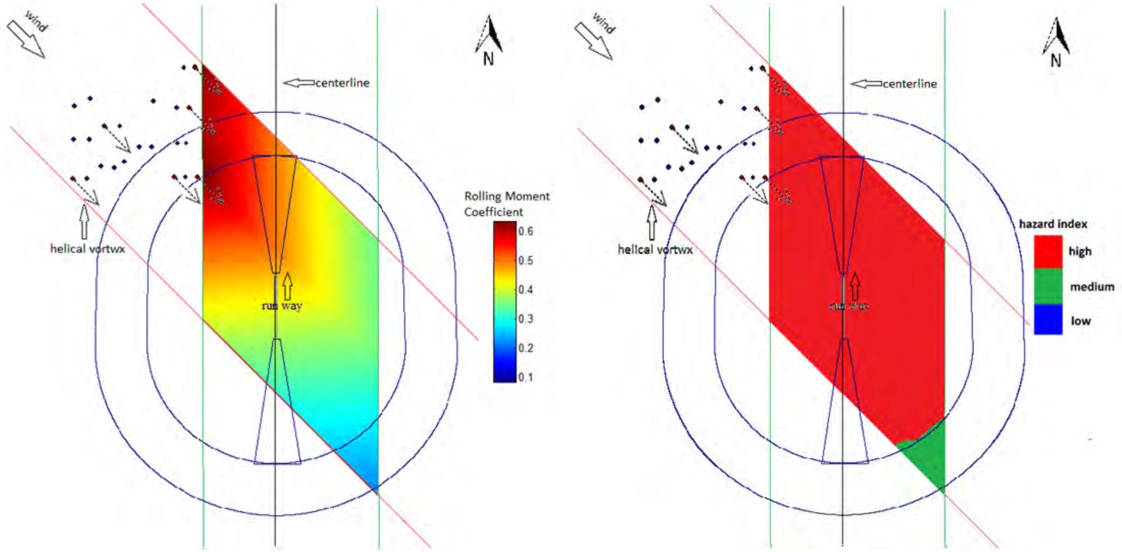


FIGURE 3.3
(a) Rolling Moment Coefficient and (b) Hazard Index around the Rooks County Regional Airport

Figure 3.4 is a plot of the end of Runway 18 and its approach surface from the airport layout plan drawing provided by the Kansas Department of Transportation. There are two approach surfaces: one is 20:1 approach surface and the other is 34:1 approach surface.

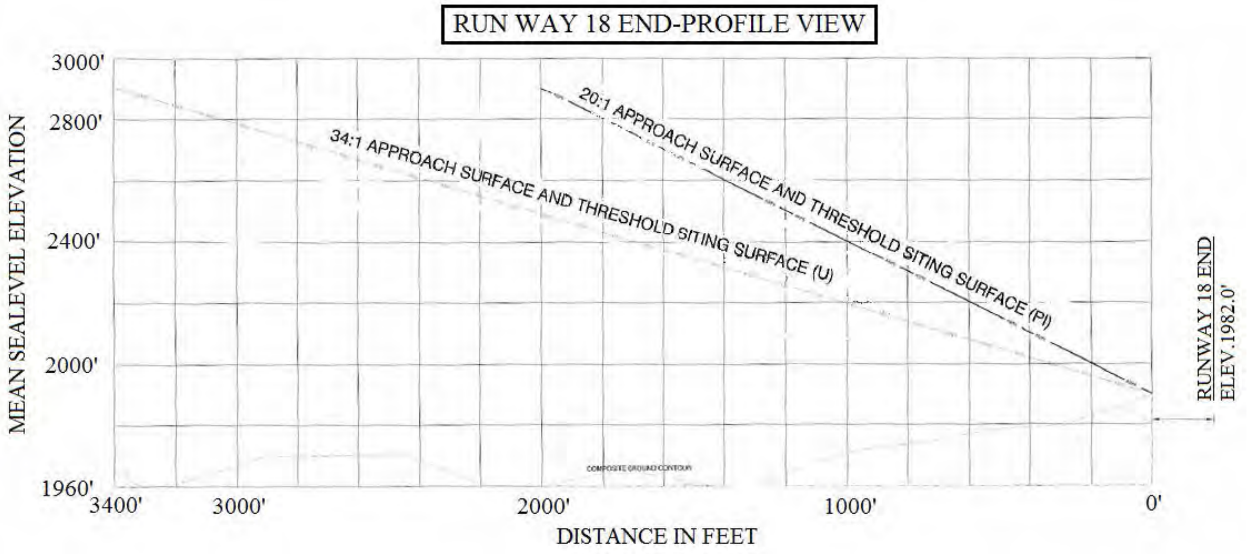


FIGURE 3.4
Approach Surface of Runway 18 in the Airport Layout Plan Drawing

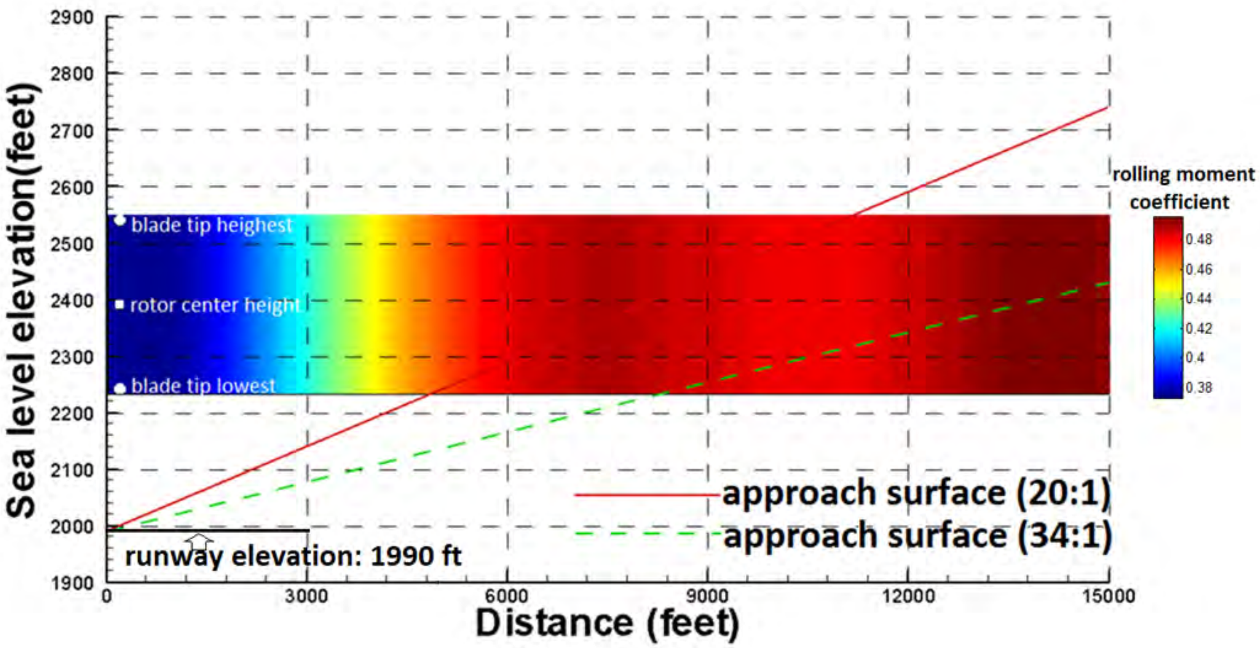


FIGURE 3.5
Rolling Moment Distribution along the Approach Aurface of Runway 18 (All in the High Hazard Index Range)

The approach surface portion in the above plot is about 100 ft. Since the turbine tower center is 400-foot high, we extended the plot following the trend and put the contours of the rolling moment coefficient in Figure 3.5 for the elevation between 2240 ft (the lowest blade tip elevation) and 2540 ft (the highest blade tip elevation). The rolling moment coefficient along this runway and the extended trend up to 15000 ft distance is always in the high hazard range. But for the approach surfaces, only within the height between two tips the airplane will experience the high hazard.

3.2.2 The Crosswind Hazard Analysis

Under the situation of the highest wind speed v = 40 mph (58.67 ft/s), the circulation of the wind turbine wake helical vortex is Γ = 5006.3 (ft^2/s). Using this circulation value, we simulated a single turbine wake helical vortex, as Figure 3.1 shows. In aviation, a crosswind is the component of wind that is blowing across the runway making landings and take-offs more difficult. Because the helical vortex can also enhance the crosswind, we need to assess the crosswind hazard in the area around the runway.

Figure 3.6 shows the aerial image and a sketch of the Rooks County Regional Airport. The wind direction is northwest. So as a component of it, the crosswind direction to Runway 18-36 is from west to east.

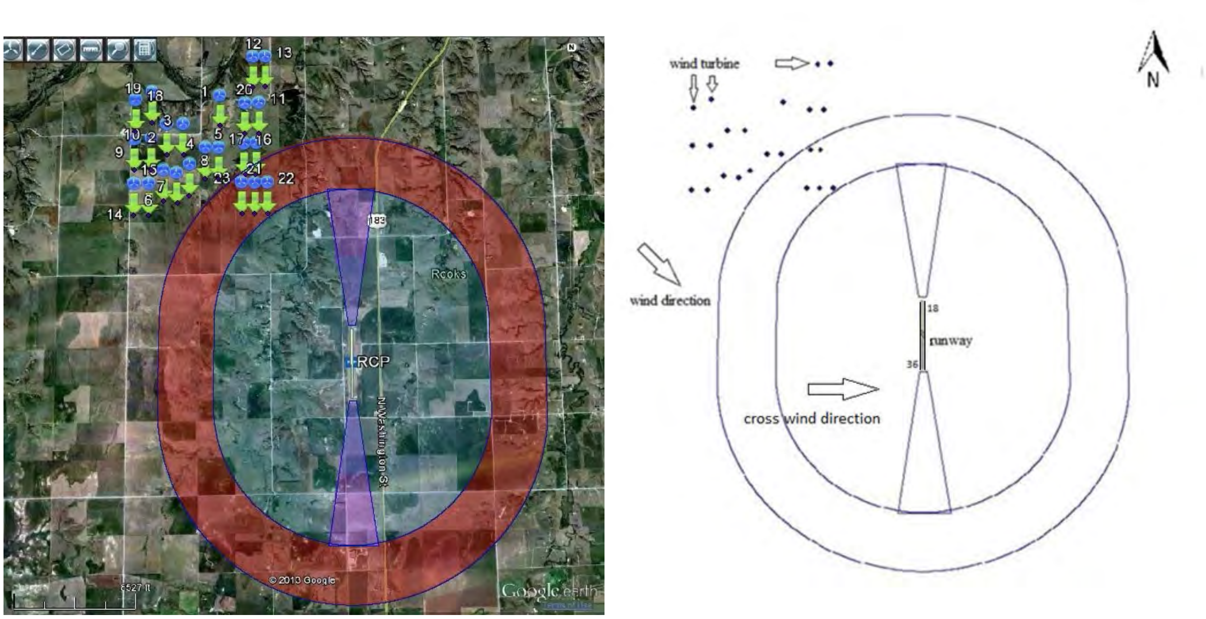
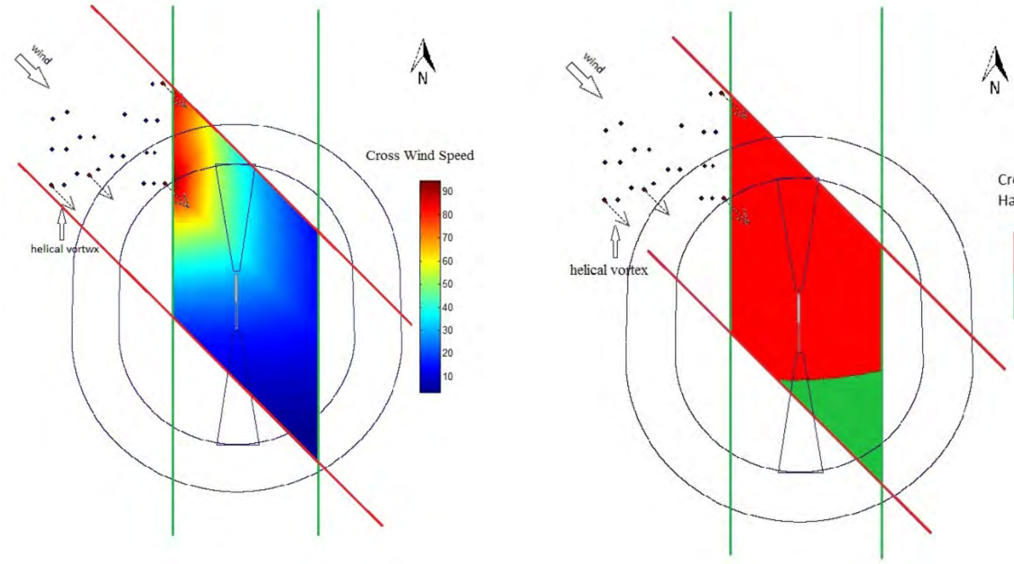


FIGURE 3.6
Wind Farm with a Northwest Wind

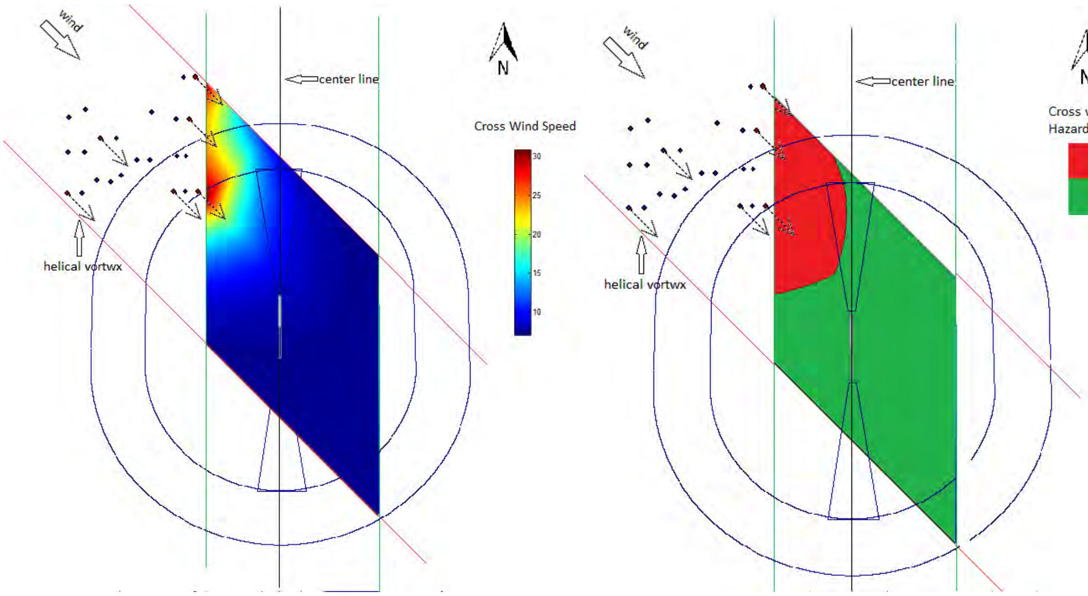
Based on the same decay distribution in Appendix E, the crosswind speed and the hazard index near the runway can be calculated (see Appendix F).

If there is a 40 mph gust, we only consider the crosswind induced by the helical vortex due to a gust-driven wind turbine wake. Any component of 40 mph gust itself is not included in the crosswind here. The contours for Runway 18-36 under the 40 mph (58.68 ft/s) gust wake are shown in Figures 3.7a and 3.7b. The rhombus area is a cross section of the area where the helical vortex exists (between the two red lines) and the area near the runway from south to north (between the two green lines). If we consider the crosswind above 12.1 mph (17.7 ft/s) as a high hazard, as shown in Table 2.1 from the literature, and below 12.1 as a low hazard, Figure 3.7b shows that a major portion of the runway is in the high hazard region.

The contours for Runway 18-36 under the 10 mph (14.67 ft/s) continuous wind speed condition, which is a mild wind condition, are shown in Figures 3.7c and 3.7d. Assuming that the 10 mph wind blows constantly, we calculated the summation of the crosswind induced by helical vortex and generated by the 10 mph wind itself. Figure 3.7d shows that a partial area around the runway is within the high hazard region.



(a) Turbine wake induced crosswind under 40 mph gust (b) Hazard index under 40 mph gust



(c) Crosswind speed under 10 mph wind (d) Hazard index under 10 mph wind

FIGURE 3.7
Crosswind Speed and Hazard around the Rooks County Regional Airport

3.3 The Pratt Regional Airport Case

Figure 3.8 shows the aerial image and a sketch map of the Pratt Regional Airport. Runway 17-35 is the only open runway.

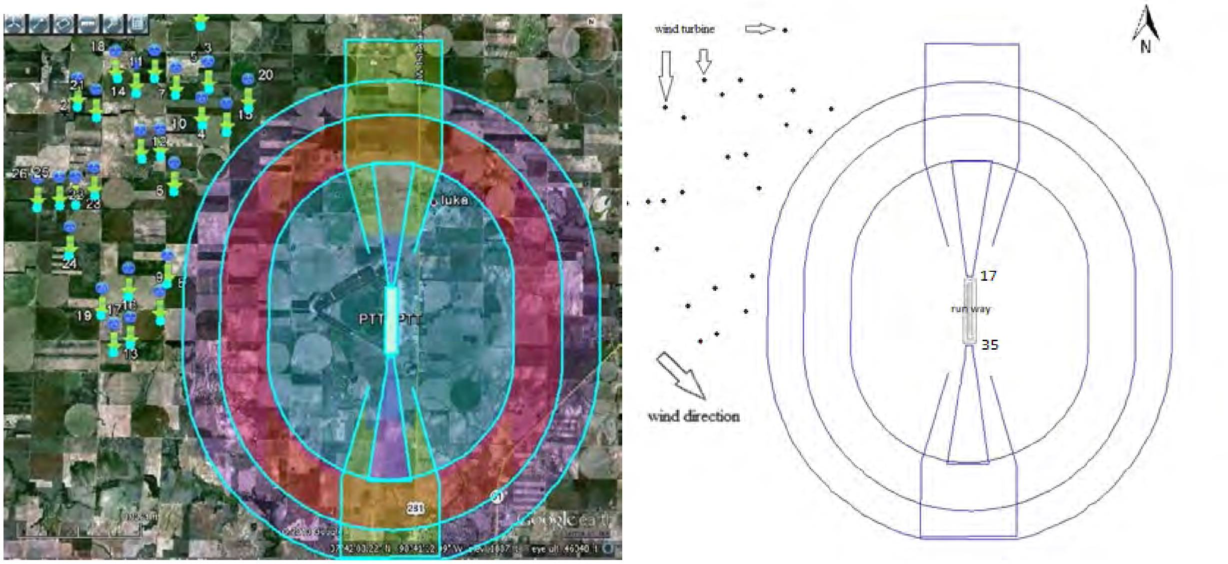


FIGURE 3.8
Pratt Regional Airport and Wind Farm with a Scenario of a Northwest Wind

3.3.1 The Roll Hazard Analysis

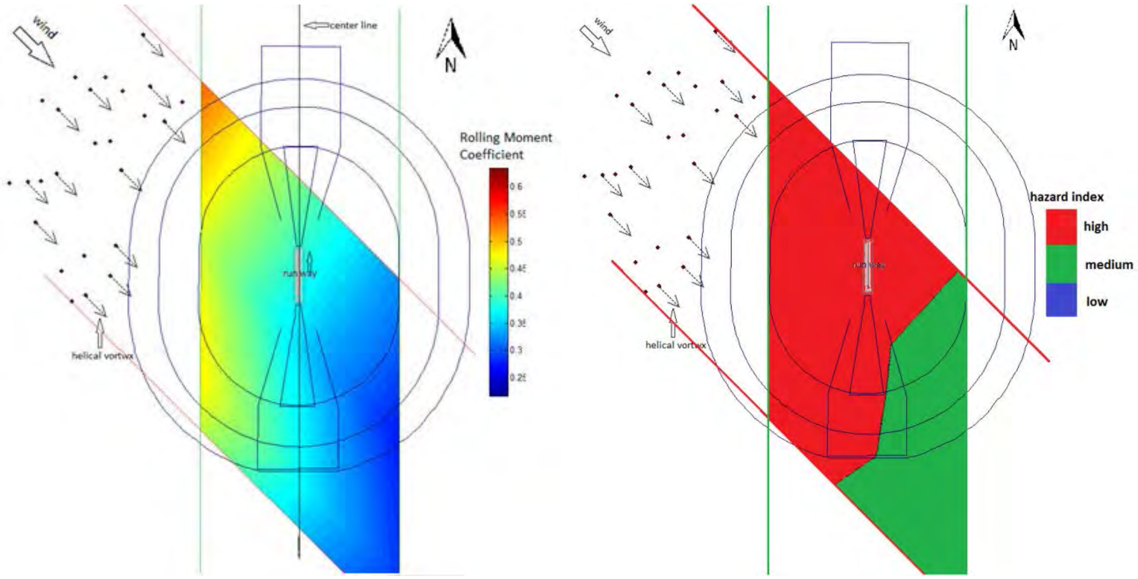


FIGURE 3.9
(a) Rolling Moment Coefficient and (b) Hazard Index around the Pratt Regional Airport

Based on this decay distribution in Appendix E, the rolling momentum coefficient can be calculated, and then the hazard index near the runway is determined. The contours for Runway 17-35 under the 40 mph wind speed condition are shown in Figure 3.9. Figure 3.9a shows the exact rolling moment value in the area, and Figure 3.9b shows the hazard index. As Figure 3.9b shows, the area around the runway is within the high hazard region.

Figure 3.10 is a plot of the end of Runway 17 and its approach surface from the airport layout plan drawing provided by KDOT. The approach surface is a 34:1 approach surface.

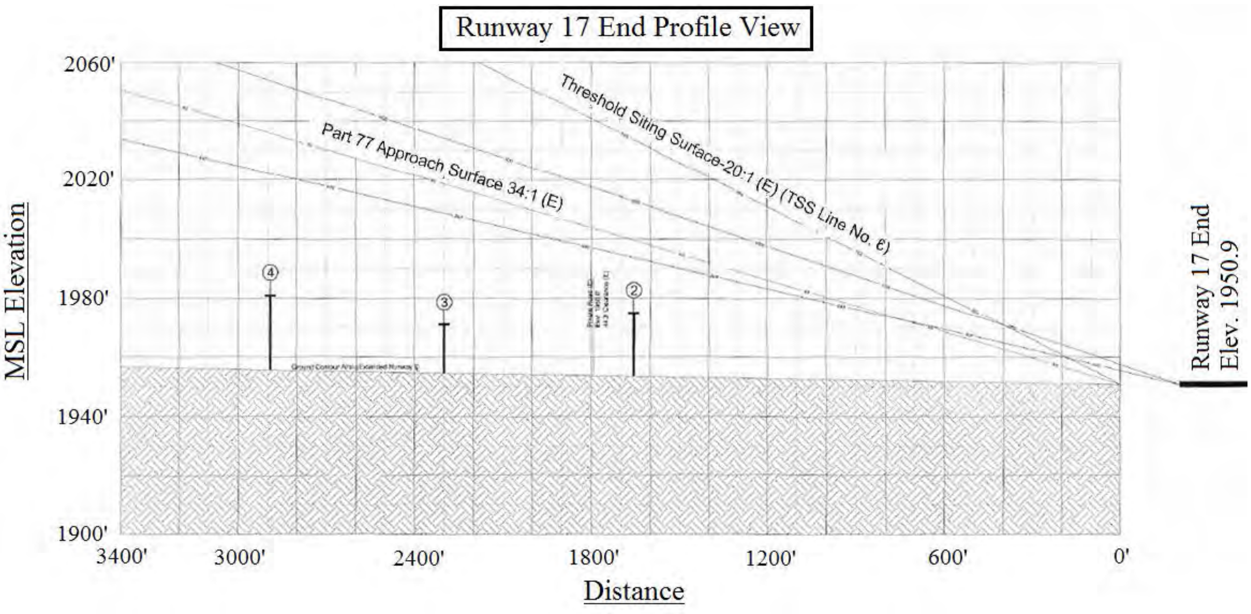


FIGURE 3.10
Approach Surface of Runway 17 in the Airport Layout Plan Drawing

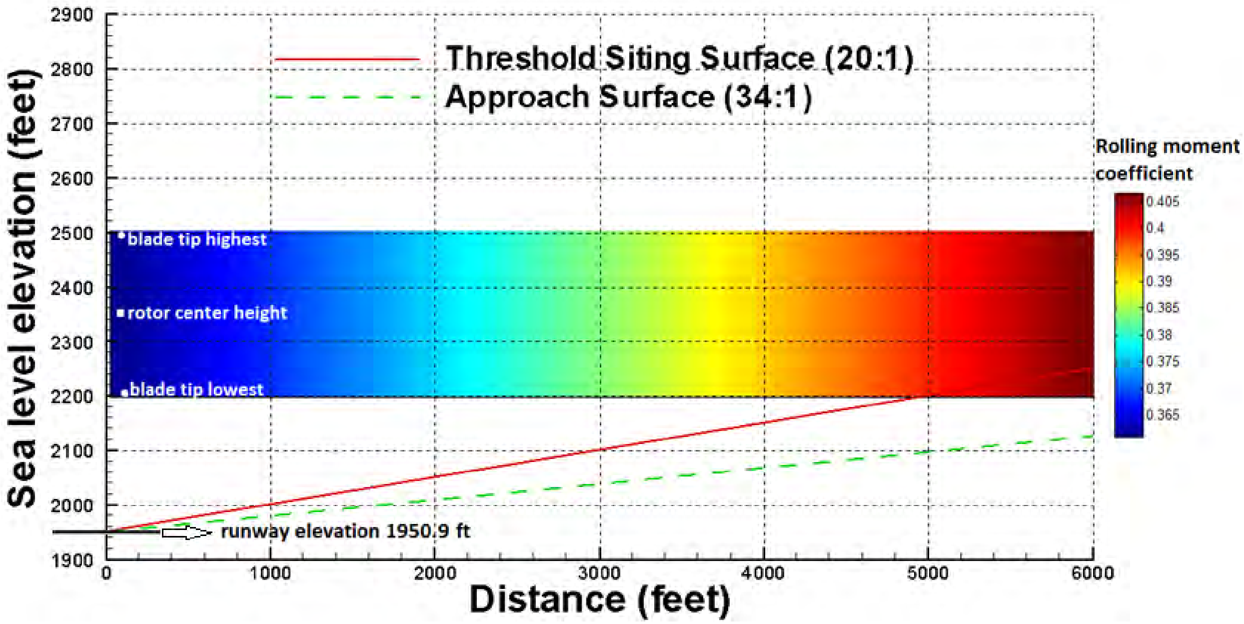


FIGURE 3.11
Rolling Moment Distribution along the Approach Surface of Runway 18 (All in the High Hazard Index Range)

We also extended the plot following the trend of the approaching surface and threshold siting surface and put the contours of rolling moment coefficient in Figure 3.11 for the elevation between 2200 ft and 2500 ft. The rolling moment coefficient along this runway and the extended trend up to 6000 ft (the limitation of the hazard area) distance is always in the high hazard range. The very end of the threshold site surface will experience the high hazard.

3.3.2 The Crosswind Hazard Analysis

Because the helical vortex can also enhance the crosswind acting on an airplane, we need to assess the crosswind hazard in the area around the runway in Pratt Regional Airport as well. Figure 3.12 shows the aerial image and a sketch map of Pratt Regional Airport. The crosswind direction to Runway 17-35 is from west to east.

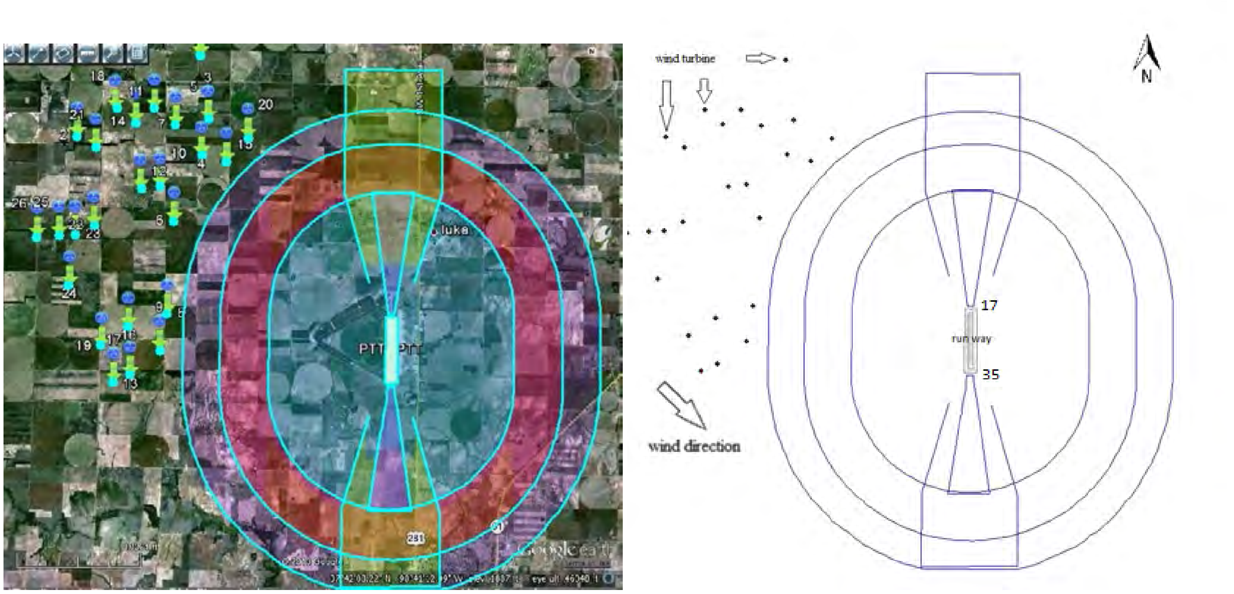
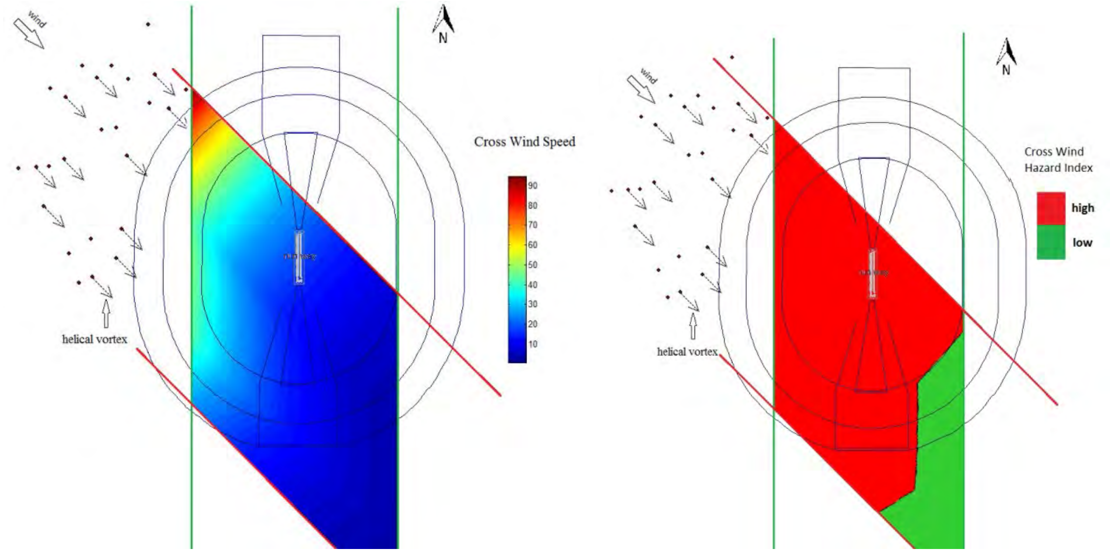


FIGURE 3.12
Pratt Regional Airport and Wind Farm with a Scenario of a Northwest Wind

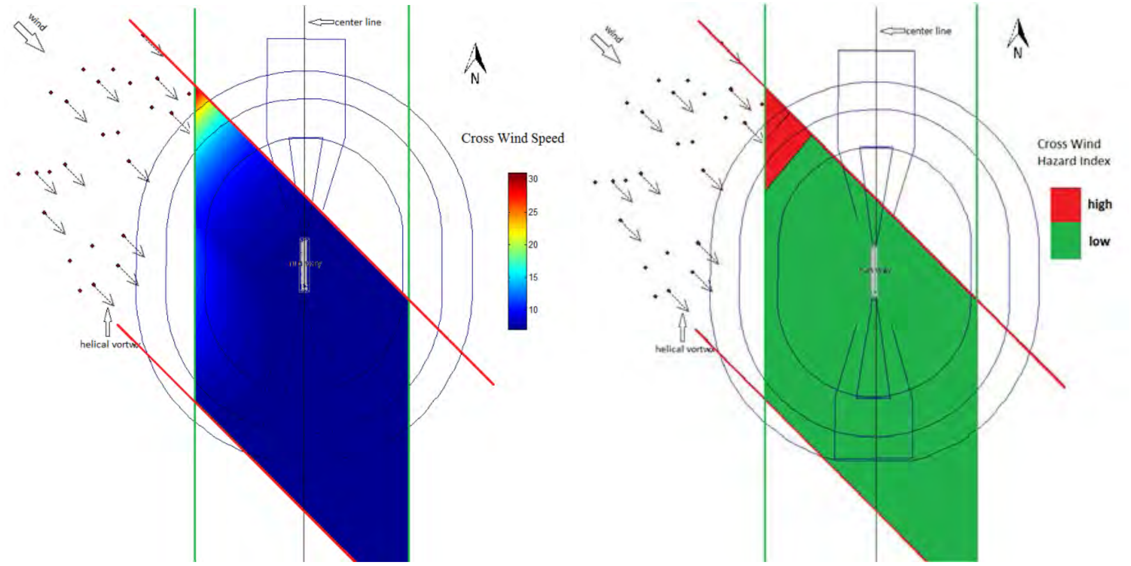
Based on the same decay distribution in Appendix E, the crosswind speed and the hazard index near the runway can be calculated (see Appendix F).

Again, the case was analyzed in two scenarios: one is the 40 mph gust, and the other is the 10 mph continuous wind. The contours of the crosswind and the corresponding hazard for the 17-35 runway under the 40 mph (58.68 ft/s) wind speed condition are shown in Figures 3.13a and 3.13b. The rhombus colorful area is a cross section of the area where the helical vortex exists (between the two red lines) and the area near the runway from south to north (between the two green lines). If we consider the crosswind above 12.1 mph (17.7 ft/s) as a high hazard, as shown in Table 2.1 from the literature, and below 12.1 as a low hazard, Figure 3.13b shows that the runway is in the high hazard region.

The contours for Runway 17-35 under the 10 mph (14.67 ft/s) continuous wind speed condition, which is a mild wind condition, are shown in Figures 3.7c and 3.7d. Figure 3.13d shows that only a very small area around the runway near the wind turbines is within the high hazard region.



(a) Turbine wake induced crosswind under 40 mph gust (b) Hazard index under 40 mph gust



(c) Crosswind speed under 10 mph wind (d) Hazard index under 10 mph wind

FIGURE 3.13
Crosswind Speed and Hazard around the Pratt Regional Airport

Chapter 4: Conclusions and Recommendations

The literature review shows that wind farms may have an adverse impact on general aviation, in general, and more specifically with aircraft operating at or near an airport. The impacts of wind turbines on aviation include physical penetration of airspace, communication systems interferences and rotor blade-induced turbulence.

The results of this project support the findings in the literature search that the turbulence from a wind turbine can impact operations at a general aviation airport. Two case studies were used to illustrate the impact of turbulence from a wind turbine on a general aviation airport. This project analyzed the roll hazard and the crosswind hazard resulting from a wind farm located near a general aviation airport. The wind turbine wake model is based on a theoretical helical vortex model and the decay rate is calculated following the aircraft wake decay rate in the atmosphere.

The roll hazard analysis showed that for the Rooks County Regional Airport, the potential roll hazard index is in the high range as far out as 2.84 miles. For the Pratt Regional Airport, the roll hazard index is in the high range as far out as 1.14 miles. These numbers are based on a gust wind of 40 mph that is below the turbine brake wind speed of 55 mph. As the results show, the scenario is different according to the relative locations and orientations of the airport and the nearby wind farm. Therefore, the analysis has to be performed for each specific regional airport.

The crosswind hazard analysis for the Rooks County Regional Airport showed part of the airport in the high range even under the mild wind condition at 10 mph. The wind turbine wake increases the crosswind component to more than 12 mph which is considered high risk crosswind for small general aviation aircraft. For the Pratt Regional Airport, the crosswind hazard is relatively small under the mild wind condition (10 mph). When there is a gust of 40 mph wind, the turbine wake induced crosswind puts the majority of runway areas to high hazard areas at both of the airports.

It is recommended that additional studies should be performed to draw the proper correlation between the hazard index developed in this study and the safe operation of aircraft at low airspeeds and at low flight altitudes operating near or at a general aviation airport.

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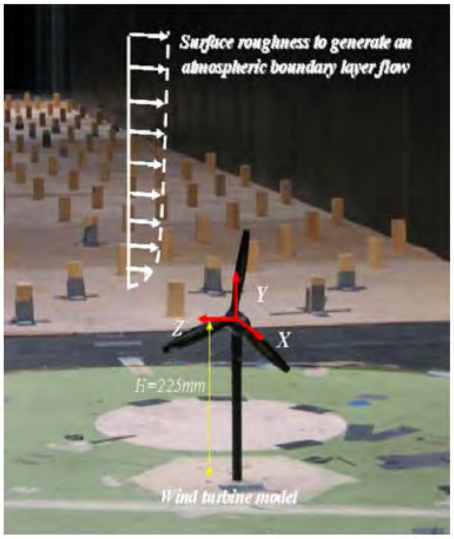
www.aweo.org/windmodels

Appendix A: Wind Turbine Wake Vortex Circulation

The experimental study referenced in this report was conducted in an aerodynamic/atmospheric boundary layer (AABL) wind tunnel located at Iowa State University as shown in Figure A.1 (Yang et al. 2012). This experiment was to simulate a radius of 45 m wind turbine using a 1:350 scale down small turbine. During the experiments, the wind speed at the hub height was set to be 4.0 m/s (i.e., U_0=4.0 m/s). The corresponding chord Reynolds number (i.e., based on the averaged chord length of the rotor blades and the wind speed at hub height) would be about 6,000, which is significantly lower than those of real wind turbines. The chord Reynolds number would have significant effects on the characteristics of wind turbine performance. However, the fundamental behavior of the helical tip vortices and turbulent wake flow structures at the downstream of wind turbines would be almost independent to the chord Reynolds number. The wind turbines with similar tip-speed-ratio (TSR) would produce similar near wake characteristics such as helical shape, rotation and tip vortices.



(Source: Yang, et al. 2012)

FIGURE A.1
Model of a Turbine in a Wind Tunnel Experiment

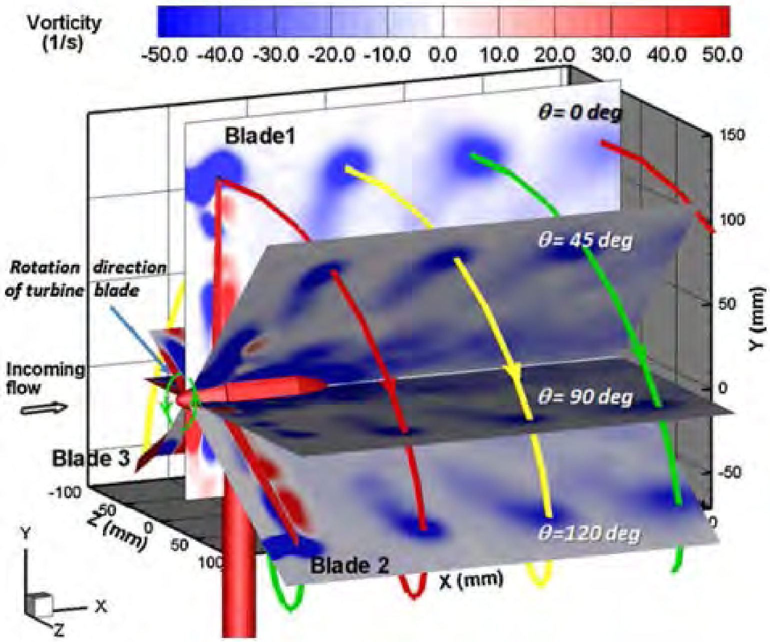
It is therefore reasonable using the data in Yang at el. (2012) to scale up the rotation based on the incoming wind speed and the dimension of the large wind turbine.

In that paper, V_0 = 4 m/s and the rotor diameter is 0.254 m and the vorticity and velocity result is shown in Figure A.2. Using the maximum of the velocity value and the area of vortex the circulation can be calculated:

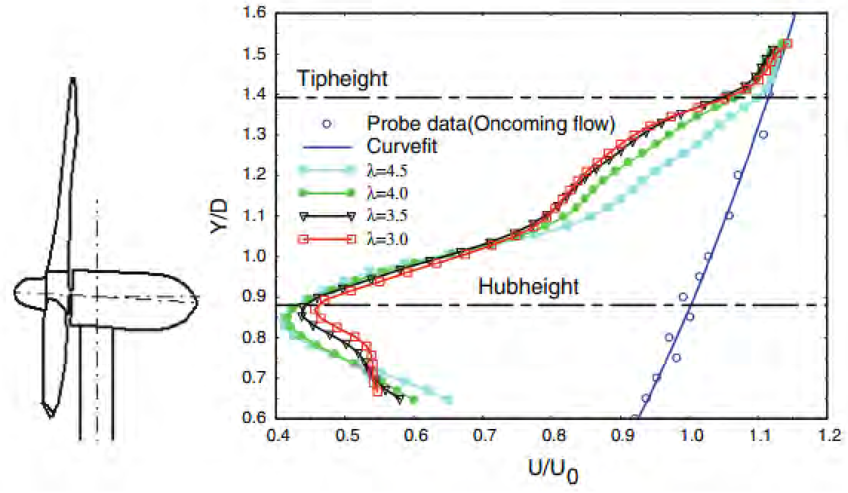
$$\Gamma = 2\pi \mathrm{rv} = 2\pi \times 0.01\mathrm{m} \times (4(\mathrm{m/s}) * 1.15) = 0.289\ \mathrm{m^2/s}$$

We thus can calculate the circulation in our case as:

$$\Gamma = 0.289(\frac{\mathrm{m^2}}{\mathrm{s}}) \times \left(\frac{17.88(\frac{\mathrm{m}}{\mathrm{s}})}{4\left(\frac{\mathrm{m}}{\mathrm{s}}\right)}\right) \times \left(\frac{91.44\mathrm{m}}{0.254\mathrm{m}}\right) = 465.1\frac{\mathrm{m^2}}{\mathrm{s}} = 5006.3\frac{ft^2}{s}$$



(a) Vorticity result



(b) Velocity result

(Source: Yang et al. 2012)

FIGURE A.2
Vorticity and Velocity Distribution

Appendix B: Helical Vortex Model for Wind Turbine Vortex Wake

Wind turbine wakes are modeled by helical vortices (Hardin 1982). In a Cartesian coordinate, when the radius is less than the helical radius ($r < R_{helical}$):

$$u_r = \frac{\Gamma_{helical} R_{helical}}{\pi k^2} S_2$$

$$u_\phi = \frac{\Gamma_{helical} R_{helical}}{r \pi k} S_1$$

$$w = \frac{\Gamma_{helical}}{2\pi k} - \frac{\Gamma_{helical} R_{helical}}{\pi k^2} S_1$$

where $\Gamma_{helical}$ is the circulation of the vortex filament, $R_{helical}$ is the radius of the helical vortex, and:

$$S_1(r,\phi) = \sum_{m=1}^{\infty} m K'_m \left(\frac{R_{helical} m}{k} \right) I_m \left(\frac{rm}{k} \right) \cos(m\psi)$$

$$S_2(r,\phi) = \sum_{m=1}^{\infty} m K'_m \left(\frac{R_{helical} m}{k} \right) I'_m \left(\frac{rm}{k} \right) \sin(m\psi)$$

$$\psi = \phi - z / k$$

where K'_m and I_m are modified Bessel functions of the *m*th order.

When the radius is greater than the helical radius ($r > R_{helical}$):

$$u_r = \frac{\Gamma_{helical} R_{helical}}{\pi k^2} S_4$$

$$u_\phi = \frac{\Gamma_{helical}}{2\pi r} + \frac{\Gamma_{helical} R_{helical}}{r \pi k} S_3$$

$$w = -\frac{\Gamma_{helical} R_{helical}}{\pi k^2} S_3$$

where:

$$S_3(r,\phi) = \sum_{m=1}^{\infty} m K_m \left(\frac{rm}{k} \right) I'_m \left(\frac{R_{helical} m}{k} \right) \cos(m\psi)$$

$$S_4(r,\phi) = \sum_{m=1}^{\infty} m K'_m \left(\frac{rm}{k} \right) I'_m \left(\frac{R_{helical} m}{k} \right) \sin(m\psi)$$

Appendix C: Rolling Moment Coefficient Calculation

Since we have the wind turbine wake velocity field from the helical vortex model, we can calculate the induced rolling moment coefficient on an aircraft that flies through the wake (Zheng and Xu 2008). Considering the aircraft with a wing span of $2s_F$ and flying speed W_F, we have, for the lift force acting on a spanwise element section dx_F:

$$\boldsymbol{\rho W_F \Gamma_F(x_F) dx_F = \frac{1}{2}\rho {W_F}^2 C_{LF}(x_F)\, dx_F \cdot c_F(x_F)} \qquad \textbf{Equation C.1}$$

where Γ_F is the circulation, C_{LF} is the lift coefficient, and $c_F(x_F)$ is the chord length of the aircraft at x_F. Assuming that $\partial C_{LF}/\partial\alpha$ is approximately constant in the range of angle of attack α, we have:

$$\boldsymbol{\Gamma_F(x_F) = \frac{\frac{1}{2} W_F \Delta\alpha \cdot \partial C_{LF}}{\partial\alpha}\ c_F(x_F)} \qquad \textbf{Equation C.2}$$

Since

$$\boldsymbol{\Delta\alpha \approx \frac{\nu}{W_F}} \qquad \textbf{Equation C.3}$$

where ν is the vertical velocity component at the location of the wing (produced by the wake vortex system). We have

$$\boldsymbol{\Gamma_F(x_F) = \frac{1}{2}\upsilon(x_F)\frac{\partial C_{LF}}{\partial\alpha}\ c_F(x_F)} \qquad \textbf{Equation C.4}$$

The rolling moment on the wing can then be expressed by:

$$M_{RF} = \int_{-s_F}^{s_F} \rho W_F \Gamma_F(x_F) x_F dx_F = \frac{1}{2}\rho W_F \frac{\partial C_{LF}}{\partial \alpha} \int_{-s_F}^{s_F} v(x_F)\, c_F(x_F)\, x_F dx_F$$

Equation C.5

And the rolling moment coefficient is:

$$C_{RF} = \frac{M_{RF}}{\frac{1}{2}\rho {W_F}^2 S_F \cdot 2s_F} = \frac{\partial C_{LF}}{\partial \alpha} \cdot \frac{1}{2S_F \cdot 2s_F} \int_{-s_F}^{s_F} v(x_F)\, c_F(x_F) x_F dx_F$$

Equation C.6

where S_F is the plan form area and is defined as

$$S_F = 2 s_F \bar{c}_F$$

Equation C.7

with $\bar{c}_F$ equal to the average chord length of the wing.

Using a Fourier series, we define

$$\Gamma_F(\theta) = 4 s_F W_F [\frac{P_0}{2} + \sum_1^N (P_0 cos 2n\theta + Q_n sin 2n\theta)]$$

Equation C.8

where θ is used to replace the spanwise coordinate of the airplane wing x_F, defined as:

$$cos\theta = -x_F/s_F. \ -1 \leq x_F/s_F \leq 1 \ for \ 0 \leq \theta \leq \pi$$

Equation C.9

Then from the first part of Equation C.6, the rolling moment coefficient can be expressed as

$$C_{RF} = \frac{4{s_F}^2}{S_F} \int_0^{\pi} [\frac{P_0}{2} + \sum_1^N (P_n cos 2n\theta + Q_n sin 2n\theta)]\,(-cos\,\theta)(-sin\theta) d\theta$$

$$= \pi/4\ (AR)_F Q_1$$

Equation C.10

where $(\mathrm{AR})_F$ is the aspect ratio of the wing. Now with Equations C.4 and C.8, we have

$$\frac{\boldsymbol{v(x_F)}}{\boldsymbol{W_F}} = \frac{\mathbf{2\Gamma_F(x_F)}}{\boldsymbol{W_F}\frac{\partial \mathrm{C_{LF}}}{\partial \alpha}\, \boldsymbol{c_F(x_F)}} = \frac{\mathbf{4}\,\boldsymbol{(AR)_F}}{\frac{\partial \mathrm{C_{LF}}}{\partial \alpha}\frac{\boldsymbol{c_F}^{(6)}}{\boldsymbol{\bar{c}_F}}}\left[\frac{\boldsymbol{P_0}}{\mathbf{2}} + \sum_{\mathbf{1}}^{\boldsymbol{N}}(\boldsymbol{P_n cos2n\theta} + \boldsymbol{Q_n sin2n\theta})\right]$$

$$= \left[\frac{\boldsymbol{A_0}}{\mathbf{2}} + \sum_{\mathbf{1}}^{\boldsymbol{N}}(\boldsymbol{A_n cos2n\theta} + \boldsymbol{B_n sin2n\theta})\right]\frac{\boldsymbol{\bar{c}_F}}{\boldsymbol{c_F(\theta)}}$$

Equation C.11

for

$$\boldsymbol{A_n} = \frac{\mathbf{4}\,\boldsymbol{(AR)_F}}{\frac{\partial \mathrm{C_{LF}}}{\partial \alpha}}\boldsymbol{P_n}$$

Equation C.12

and

$$\boldsymbol{B_n} = \frac{\mathbf{4}\,\boldsymbol{(AR)_F}}{\frac{\partial \mathrm{C_{LF}}}{\partial \alpha}}\boldsymbol{Q_n}$$

Equation C.13

Hence, with Equation C.10

$$\boldsymbol{C_{RF}} = \frac{\boldsymbol{\pi}}{\mathbf{16}}\frac{\partial \mathrm{C_{LF}}}{\partial \alpha}\boldsymbol{B_1}$$

Equation C.14

From Equation C.11 we can see that

$$\frac{\boldsymbol{A_0}}{\mathbf{2}} + \sum_{\mathbf{1}}^{\boldsymbol{N}}(\boldsymbol{A_n cos2n\theta} + \boldsymbol{B_n sin2n\theta}) = \frac{\boldsymbol{v(\theta)}\,\boldsymbol{c_F(\theta)}}{\boldsymbol{W_F\bar{c}_F}}$$

Equation C.15

That is, if we perform a Fourier series expansion on $\frac{v(\theta)\, c_F(\theta)}{W_F \bar{c}_F}$, only the first coefficient of the sine series of that series is needed to calculate the rolling moment coefficient.

If we let

$$\boldsymbol{F(\theta) = \frac{v(\theta)\, c_F(\theta)}{W_F \bar{c}_F}} \qquad \textbf{Equation C.16}$$

then

$$\boldsymbol{C_{RF} = \frac{\pi}{16} \frac{\partial C_{LF}}{\partial \alpha} \frac{\pi}{2} \int_0^{\pi} F(\theta) \sin(2\theta) d\theta} \qquad \textbf{Equation C.17}$$

where C_{LF} is the lift coefficient, α is the angle of attack. In our case, $\frac{\partial C_{LF}}{\partial \alpha}$ equals to 0.075/degree, 4.2972 /rad. In addition, θ can be determined by x_F, the position of each section, and s_F the length of the wing. $\cos(\theta) = -\frac{x_F}{s_F}$

where $v(\theta)$ is the vertical velocity, $c_F(\theta)$ is the chord length, $\overline{c_F}$ is the average chord length, W_F is the flying speed, for our case, its 80 m/s. And

$$\frac{c_F(\theta)}{\overline{c_F}} = \frac{20}{13}(1 - 0.7\,|\frac{x_F}{s_F}|) = \frac{20}{13}(1 - 0.7\,|\cos(\theta)|) \qquad \textbf{Equation C.18}$$

Appendix D: Roll Hazard Index

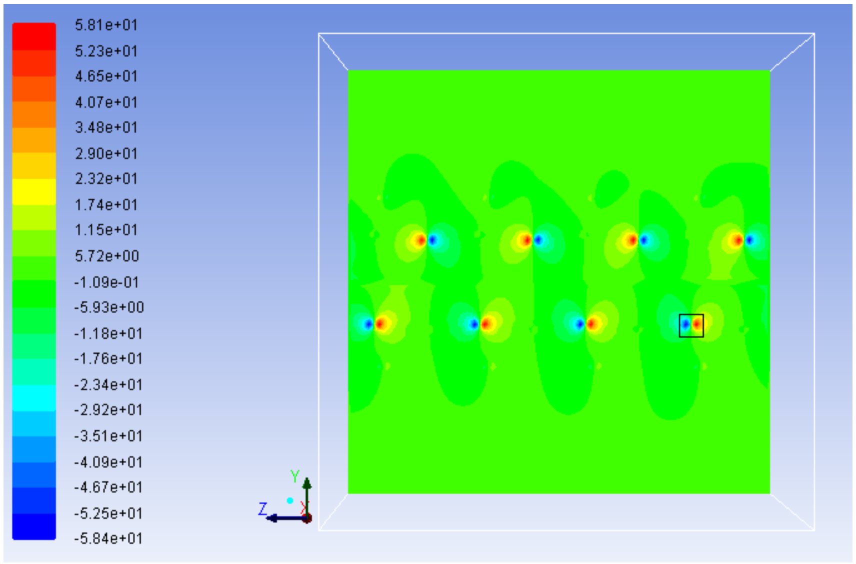


FIGURE D.1
Y-Direction Velocity on the Center X-Z Cutting Plane

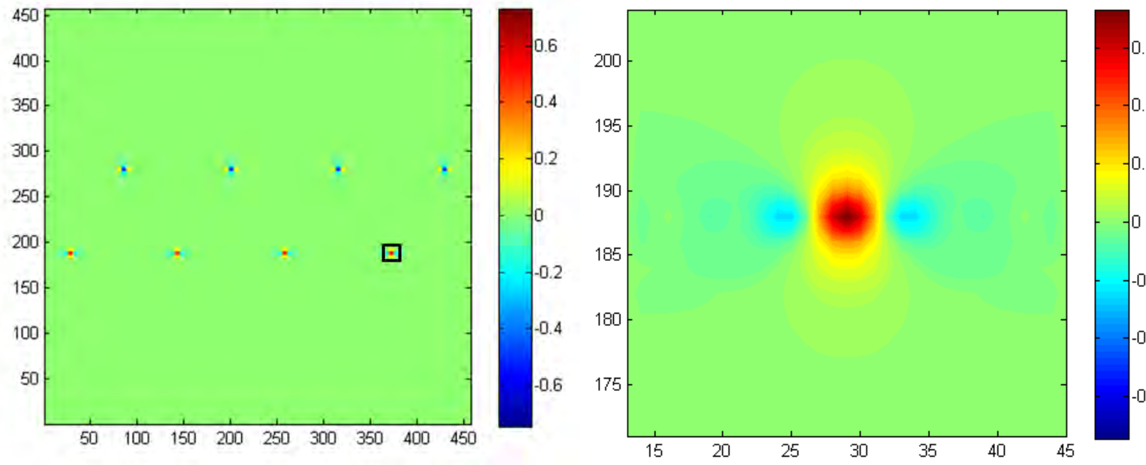


FIGURE D.2
(a) The Rolling Momentum Coefficient in the Domain and (b) in the Zoom-In Domain

In order to evaluate the roll hazard caused by the wind turbine wake, the induced rolling moment coefficient on a wake-penetrating aircraft is calculated based on the vertical component velocity distribution. Figure D.1 shows the y-direction velocity on a cutting plane. With the y-direction velocity, we can calculate the rolling moment coefficient using the relations developed in Appendix C. Figure D.2a is the resultant rolling momentum coefficient acting on a 30-ft wingspan airplane when it is passing through the turbine wake region. The highest rolling momentum coefficient occurs at the center of the helical vortex core, which can be seen in Figure D.2b in a zoom-in region.

The relative magnitude between the operable rolling moment and the rolling moment induced by the wind turbine wake is used in this study to determine the hazard index.

The rolling moment coefficient that the airplane is able to operate is modeled by this formula:

$$C_R = 2C_{l\delta_A}\delta_A;$$

For a normal airplane

$$0 < C_{l\delta_A} < 0.4$$

$$0 < \delta_A < 20°$$

So at the maximum:

$$C_R = 2C_{l\delta_A}\delta_A = 2 \times 0.4 \times \frac{20}{180} \times \pi = 0.28$$

Appendix E: Rolling Moment Coefficient Decay with Distance

The local circulation Γ_i can be calculated by the initial circulation Γ_0 and vortex span b_0 after time *t* (Zheng et al. 2009):

$$\frac{\Gamma_\mathrm{i}}{\Gamma_0} = \exp(-C\frac{t\Gamma_0}{2\pi {b_0}^2 {T_c}^*}) \qquad \text{Equation E.1}$$

where C is a constant of 0.45, and ${T_c}^*$ is determined by the following calculation:

$$\varepsilon^* = \frac{2\pi b_0}{\Gamma_0}(\varepsilon b_0)^{1/3} \qquad \text{Equation E.2}$$

For a high turbulence case at the turbulent intensity 10%, ε is 0.01 in our case, which indicates that ε^* has a high value and the eddy-dissipation rate in the entire range can be approximately related by this formula:

$$\varepsilon^*({T_c}^*)^{4/3} = 0.7475 \qquad \text{Equation E.3}$$

So

$${T_c}^* = (\frac{0.7475}{\varepsilon^*})^{3/4} = (\frac{0.7475\Gamma_0}{2\pi b_0(\varepsilon b_0)^{1/3}})^{3/4} \qquad \text{Equation E.4}$$

$$\frac{\Gamma_\mathrm{i}}{\Gamma_0} = \exp\left(-C\frac{t\Gamma_0}{2\pi {b_0}^2\left(\frac{0.7475\Gamma_0}{2\pi b_0(\varepsilon b_0)^{\frac{1}{3}}}\right)^{\frac{3}{4}}}\right) = \exp\left(\frac{-Ct(\varepsilon\Gamma_0)^{1/4}}{0.956(\pi)^{1/4}b_0}\right) \qquad \text{Equation E.5}$$

At distance S with the wind speed V_0

$$t = \frac{S}{V_0} \qquad \text{Equation E.6}$$

$$\frac{\Gamma_i}{\Gamma_0} = \exp\left(\frac{-CS(\varepsilon\Gamma_0)^{0.25}}{1.2727 V_0 b_0}\right) \qquad \text{Equation E.7}$$

For the 18-36 runway of Rooks County Regional Airport under the northwest wind situation, the maximum induced rolling moment coefficient on the 30-ft wingspan GA aircraft caused by a wind turbine is 0.65, when the wake is close to the wind turbine. The induced rolling moment coefficient decays with distance due to atmospheric turbulence, as shown in Figure E.1. At lower wind speeds, the induced rolling moment coefficient becomes lower, and when the distance from the wind turbine increases, the coefficient value becomes lower.

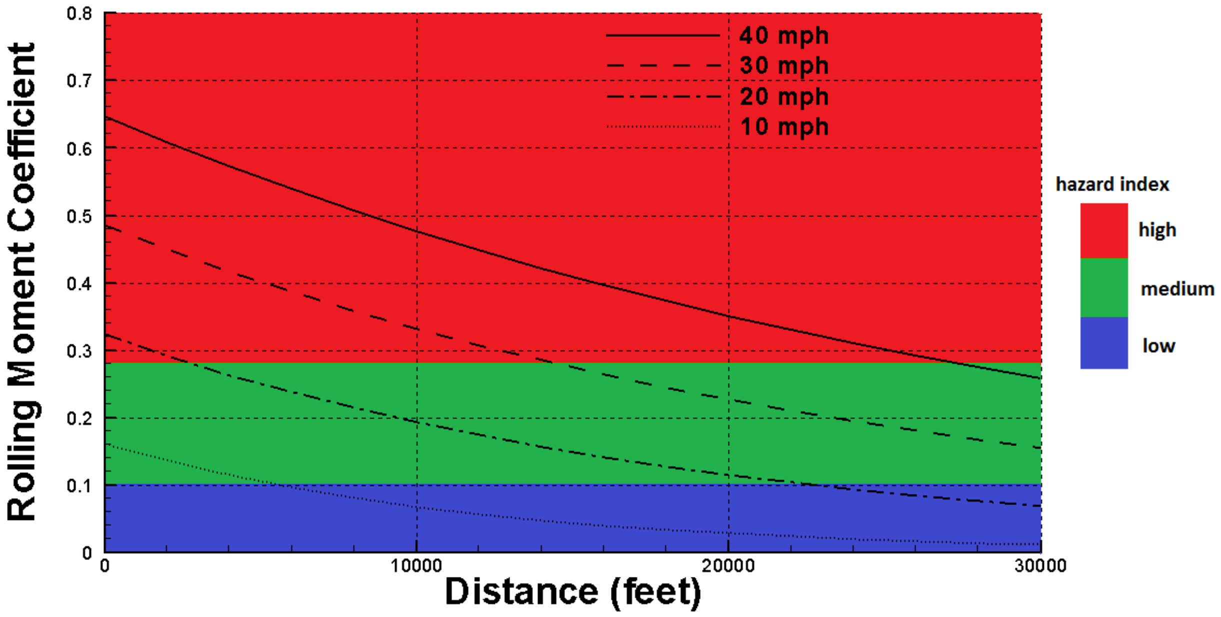


FIGURE E.1
Rolling Moment Coefficient Decay with Distance

For the 17-35 runway of Pratt Regional Airport under the northwest wind situation, the maximum induced rolling moment coefficient on the 30-ft wingspan GA aircraft caused by a wind turbine is 0.65, when the wake is close to the wind turbine. The induced rolling moment coefficient decays with distance due to atmospheric turbulence, as shown in Figure E.2. At lower wind speeds, the induced rolling moment coefficient becomes lower, and when the distance from the wind turbine increases, the coefficient value becomes lower.

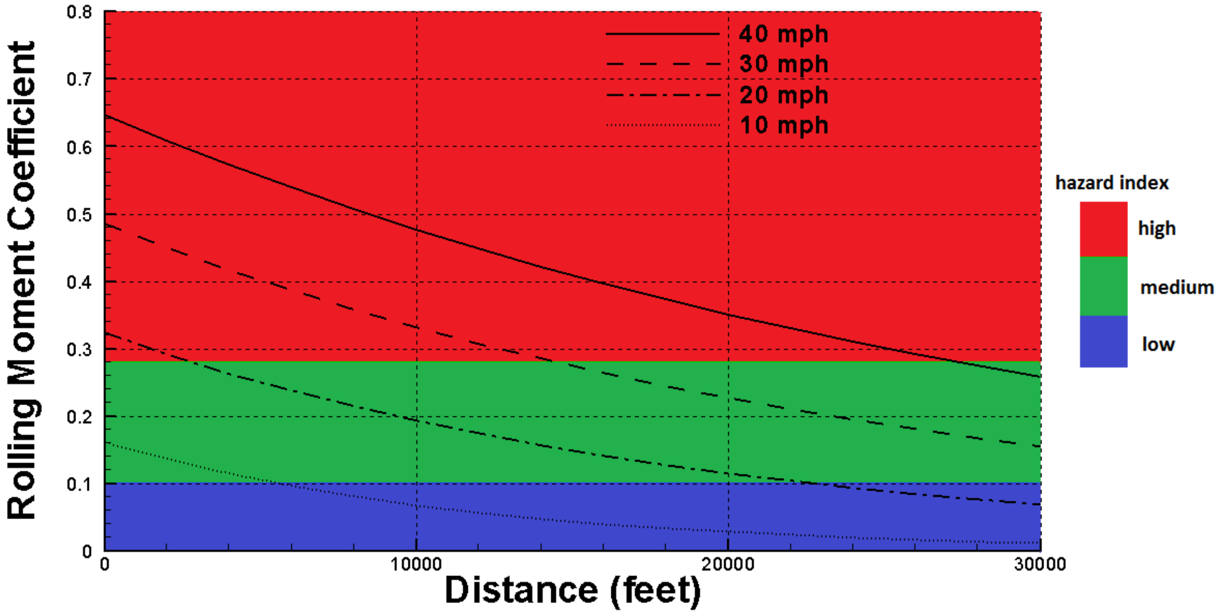


FIGURE E.2
Rolling Moment Coefficient Decay with Distance

Appendix F: Crosswind from Wind Turbine Wake on an Airplane

Figure F.1 shows the 45 degree direction velocity which is vertical to the aircraft body on a cutting plane parallel to the ground shown in Figure F.2. The maximum velocity from the turbine wake is 95.25 mph (139.7 ft/s).

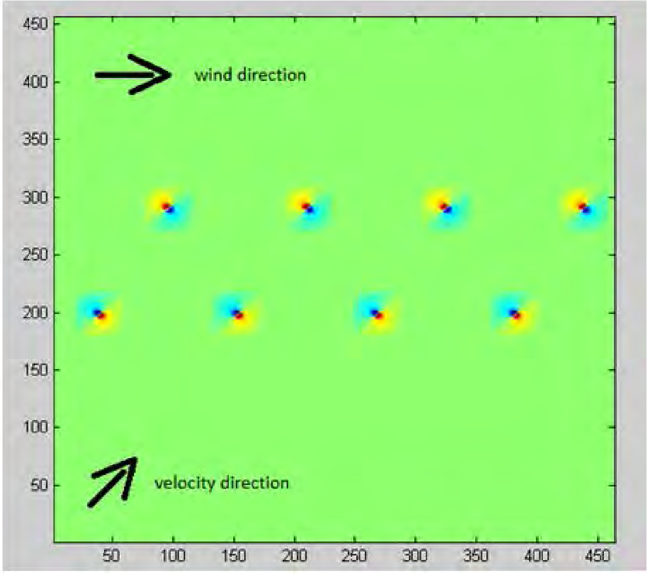


FIGURE F.1
45 Degree Direction Velocity Value from the Wind Turbine Wake on a Cutting Plane

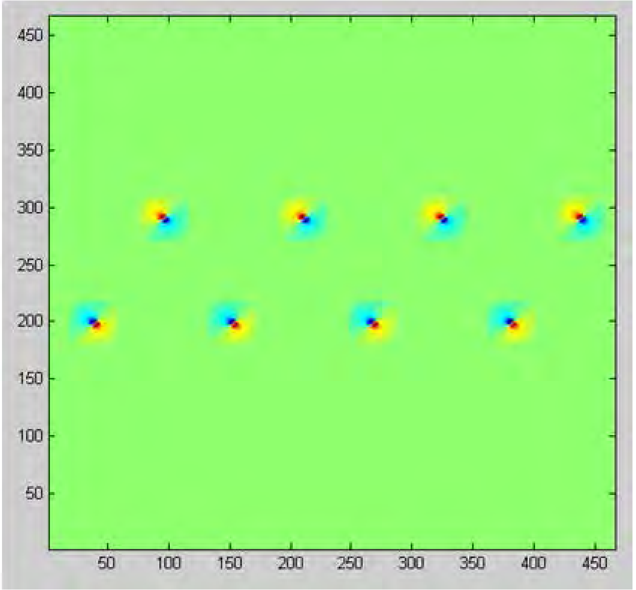


FIGURE F.2
45 Degree Direction Velocity Value Added by the Background Velocity

The value of background wind component on crosswind direction is the wind speed 40 mph multiplied by cosine 45 degree equal to 28.28 m ph ($40\, mph \times \frac{\sqrt{2}}{2} = 28.28\, mph = 41.48\, ft/s$). If we add this value to the velocity field in Figure F.1, it is what Figure F.2 shows. The maximum velocity is 123.53 mph (181.18 ft/s)

TABLE F.1
Possible Maximum Crosswind Velocity in the Wind Turbine Wake in Different Background Wind Speeds

Wind speed (mph)	40	30	20	10
Cross wind component (mph)	28.28	21.21	14.14	7.07
Max vortex induced cross wind (mph)	95.25	71.44	47.63	23.81
Max crosswind velocity (mph)	123.53	92.65	61.77	30.88

The limit, as shown in Table 2.1 in the literature, is 10.5 knot which is 12.1 mph (17.7 ft/s). Table F.1 lists the maximum crosswind velocity in different background wind speeds. If the wind is larger than 20 mph, the wind component at cross direction is already over the 12 mph limit. So we consider the 10 mph wind speed as an example to see the hazard in the airport.

K-TRAN

KANSAS TRANSPORTATION RESEARCH
AND
NEW-DEVELOPMENT PROGRAM

Kansas
Department of Transportation

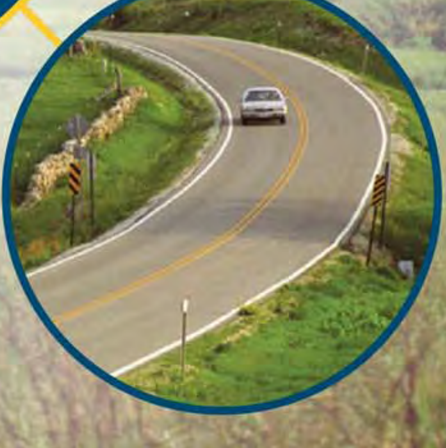


EXHIBIT
6

dBF
Associates, Inc.

3129 Tiger Run Court, Suite 202
Carlsbad, CA 92010
619-609-0712

March 10, 2020

Donna Tisdale
Backcountry Against Dumps, Inc.
P.O. Box 1275
Boulevard, CA 91905

Re: Campo Wind Project
Noise / Acoustical Review

Ms. Tisdale:

dBF Associates, Inc. was retained by Backcountry Against Dumps, Inc. to review the following documents:

- Final Environmental Impact Statement for the Campo Wind Project with Boulder Brush Facilities. Dudek. January 2020.
- Draft Acoustical Analysis Report for the Campo Wind Project with Boulder Brush Facilities. Dudek. May 2019.
- Campo Wind Project with Boulder Brush Facilities – EIS Noise Response to Comments Addendum Memo. 17 October 2019.

In its current form, the Acoustical Analysis Report and Final Environmental Impact Statement underpredict project noise levels at NSLUs and underreport the severity and extent of project noise impacts.

Our comments are presented below.

1. In 1-95 Response, Dudek defends using incorrect data and cites another sound level specification but does not provide the requested data or the data for the other source. Dudek implies that the data is privileged; however, an analysis based on information not publicly available is inherently flawed. This response is unsatisfactory.

2. In 1-96 Response, Dudek states that San Diego County Ordinance 10262 “merely indicates that the applicable County threshold per 36.404 would be reduced by 5 dB if this effect exists while a large wind turbine is operating. However, for informational purposes, evaluating the manufacturer’s sound power data for GE 2.X-127 operation at hub-height wind speed of 10 m/s at

1/3-OBCF detail indicates that conditions for pure tone as defined by the County do not occur."

Ordinance 10262 ordains, in Section 14, that Section 6952(f)(3) of the Zoning Code is amended to consider pure tone in establishing noise limits.

Dudek cites the 1/3-OBCF (one-third octave band center frequency) detail as evidence that no pure tones exist; however, this information was not provided for review. This response is incorrect and unsatisfactory.

3. In 1-97 Response, Dudek does not dispute that the Piccolo ANSI Type 2 sound level meters were inappropriate for ambient sound level measurements in the Project area. By virtue of conducting a new baseline outdoor SPL survey of existing conditions with ANSI Type 1 sound level meters, it is implied that Dudek understands that they were inappropriate. However, due to certain circumstances, Dudek continued to use the previous data as the basis of the analysis in some locations. This response is unsatisfactory.

4. In 1-98 Response, Dudek states that the "factory-provided 35- × 25-millimeter windscreen for the 1/2-inch microphone … was appropriate for the measurements." No evidence was given to support this statement. Note that these physical measurements refer to the overall dimensions (approximately 0.98 inches in width × 1.37 inches in height); this corresponds to a windscreen material thickness of approximately ¼ inch around the surface of the microphone. In common practice, acoustical measurements in standard wind conditions utilize 3-inch diameter windscreens, which provide over 1 inch of material thickness. In high-wind environments, 7-inch diameter windscreens are often used.

   In addition, Dudek's "new baseline outdoor ambient sound level survey included Larson-Davis 'environmental shrouds' (i.e., 12-inch-long, 4-inch-diameter windscreens with bird-spikes)", which implies that Dudek understood the previous windscreens were inadequate. This response is incomplete and unsatisfactory.

5. In 1-99 Response, Dudek states that the monitoring locations were "meant to be representative of areas on and around the Project Site." As described further in this comment letter, these locations were in fact not representative of noise-sensitive areas near the proposed Project. This response is unsatisfactory.

6. In 1-100 Response, Dudek states that "differences in the CadnaA-to-Excel models were no more than a +/−2 dB difference at matched locations." This response is unsatisfactory, as it does not address any of the concerns raised

in the comment: that Project noise levels that are higher than predicted by 3 dB would result in impacts during several more conditions than reported in the AAR and that the AAR should use multiple CadnaA models rather than spreadsheets, or the AAR should provide the spreadsheets as an appendix.

7. In 1-101 Response, Dudek states that "The average variance between integral hub height wind speeds (e.g., 4 m/s to 5 m/s) for one-third octave bands differs from the overall dBA variance by less than 1 dB. On this basis, Dudek believes its presentation of wind turbine operational noise levels at different integral hub-height wind speeds is accurate."

   This response acknowledges that Dudek is in possession of one-third octave band data for various integral hub height wind speeds. The level of additional effort to use the accurate data, relative to the scope of this Project, is insignificant. This response is unsatisfactory.

8. In 1-102 Response, Dudek indicates that the reader is to "correlate an indicated impact prediction" and "surmise" impacts rather than being presented with a report, in unambiguous terms, of how often impacts would occur. This response is unsatisfactory.

9. In 1-103 Response, Dudek states that "The locations of specific On-Reservation NSLUs are not publicly available information."

   Locations of most or all on-reservation residences and any other NSLU should be readily available from tribal documentation. Alternatively, most on-reservation structures are clearly identifiable on publicly available aerial photography maps. In addition, the representative locations used to evaluate impacts do not indicate or approximate the number of represented NSLUs. The AAR should identify the quantity and locations of On-Reservation NSLUs. Omission of this information potentially under-represents the extent of potential impacts. This response is unsatisfactory.

10. In 1-107 Response, Dudek states "In general, any sound level meter handling that may have occurred near the start and/or end of a measurement period would have been very brief, and thus would make a very small (perhaps negligible) acoustic contribution to the presented hourly metrics from which averaging or log-averaging techniques were used to calculate other metrics such as Ldn values."

    Several of the measurements included starting and ending periods that reported markedly higher sound levels than the adjacent periods. These periods should not have been included in the calculations, as they incorrectly overstate the ambient noise levels by a not-negligible amount, which in turn underreports Project noise impacts. This response is incorrect and unsatisfactory.

11. In 1-108 Response, 1-109 Response, 1-110 Response, Dudek states that "for these identified instances of reported value discrepanc[ies] …, measurement and/or data-reporting tolerances associated with the SoftdB Piccolo sound level meters are likely explanations." This response confirms that the meter selection was inappropriate.

12. In 1-114 Response, Dudek addresses the "Mod LAeq" issue, but does not address the measurement location issue. Placing a sound level meter very close to a major thoroughfare overstates the ambient noise environment experienced by dozens of residences in the area. This, in turn, underestimates Project noise impacts.

13. The EIS Noise Response to Comments Addendum Memo (Memo) contains extensive updates, corrections, and clarifications to information presented in the Acoustical Analysis Report (AAR). These should have been incorporated into a subsequent AAR. The May 2019 AAR supporting the Draft Environmental Statement (DEIS) has not been updated for the Final Environmental Statement (FEIS).

14. GPS coordinates of ambient noise level measurements were included in the Memo; however, site photographs were not included.

    At several locations, the microphone positions were not representative of ambient noise levels near NSLUs.

    a. At LT-1, the meter was placed approximately 50 feet from BIA Route 10, one of the two primary on-reservation roadways used by residents and border patrol agents. Homes in this area are generally over 500 feet from roadways.
    b. At LT-2, the meter was placed less than 25 feet from a long driveway road, and approximately 130 feet from a rail line.
    c. At LT-3, the meter was placed less than 10 feet from BIA Route 15, one of the two primary on-reservation roadways used by residents and border patrol agents. Homes in this area are over 200 feet from roadways, and often over 500 feet away.
    d. At LT-6, the meter was placed less than 15 feet from Miller Valley Road, the sole access road for at least nine homes. Homes in this area are generally over 250 feet from roadways.
    e. At LT-7, the meter was placed approximately 55 feet from the centerline of Old Highway 80, a 55-mph major thoroughfare in the area.

There are several NSLUs in the area at a similar distance from this roadway, but many more are much further.

- f. At LT-8, the meter was placed less than 15 feet from Tusil Road (BIA Route 12). Homes in this area are generally more than 100 feet from roadways.
- g. At LT-11, the meter was placed approximately 55 feet from BIA Route 10 (Church Road), one of the two primary on-reservation roadways used by residents and border patrol agents. Homes in this area are generally over 250 feet from roadways, and often over 500 feet away.
- h. At LT-12, the meter was placed approximately 25 feet from Manzanita Road. Homes in this area are generally over 500 feet from roadways.
- i. At LT-13, the meter was placed less than 5 feet from Tierra Del Sol Road, a roadway utilized by several residents and border patrol agents. Homes in this area are generally over 100 feet from roadways.

These microphone placements overstate the ambient noise environment and consequently underreport project noise impacts. These measurements should be repeated at locations acoustically equivalent to NSLUs, and sufficiently removed from known transportation noise sources.

15. Some measurement positions are not appropriate for use as impact evaluation locations.

- a. There is at least one home near LT-3 that is markedly closer to the proposed turbines than the measurement position.
- b. There are at least six homes or other structures near LT-4 that are markedly closer to the proposed turbines than the measurement position.
- c. There are at least four homes near LT-6 that are markedly closer to the proposed turbines than the measurement position.
- d. There are dozens of homes near LT-7 that are markedly closer to the proposed turbines than the measurement position. In particular, there are approximately six homes north of Hi Pass Road, on off-reservation land, that are poorly represented by LT-7. Further, there is a large congregation of NSLUs in the Live Oak Springs area; this is not properly evaluated.
- e. There are at least two homes near LT-8 that are markedly closer to the proposed turbines than the measurement position.
- f. There are at least eleven homes near LT-11 that are markedly closer to the proposed turbines than the measurement position.

The AAR should evaluate the project noise levels at the closest potential NSLU(s).

This concludes our review. Should you have any questions regarding the information provided, please contact me at (619) 609-0712 ×102.

Steven Fiedler, INCE
Principal

EXHIBIT
7

dBF
Associates, Inc.

3129 Tiger Run Court, Suite 202
Carlsbad, CA 92010
619-609-0712

December 16, 2019

Backcountry Against Dumps, Inc.
% Donna Tisdale
P.O. Box 1275
Boulevard, CA 91905

Re: Wind Turbine Infrasound and Low-Frequency Noise Survey in Boulevard, CA

Ms. Tisdale:

At your request, dBF Associates, Inc. (dBFA) conducted an acoustical survey to document infrasound and low-frequency noise (ILFN) generated by the existing wind turbines (WTs) in the Boulevard area of unincorporated San Diego County, California.

There are currently two wind farms in the Boulevard area: Kumeyaay with (25) 2-megawatt WTs and Tule with (57) 2.3-megawatt WTs. To the east is the Ocotillo wind farm with (112) 2.3-megawatt WTs. To the southeast in Mexico is the Energia Sierra Juarez (ESJ) wind farm with (47) 3.3-megawatt WTs.

Noise recordings obtained on Friday, August 16, 2019 conclusively document the presence of ILFN, at homes up to approximately 6 miles away, generated by the WTs at the Kumeyaay and Tule facilities.

During the noise recordings, amplitude modulated (AM) noise was observed in the field. Analysis of the noise recordings also indicates excessive AM noise generated by the existing WTs.

MEASUREMENT LOCATIONS

Outdoor and indoor noise recordings were made at three residences in the Boulevard area, during daytime, evening, and nighttime periods of the day. Refer to Table 1 for details.

Table 1. Measurement Locations

Residence	Address	Location	Distance to Closest WT	Measurement Start Times
Tisdale	1250 Tierra Real Lane	32.622245, -116.348327	5.7 miles (Kumeyaay)	12:12 PM 6:58 PM 10:23 PM
Morrison	2920 Ribbonwood Road	32.709943, -116.297129	1.46 miles (Tule)	1:40 PM 8:14 PM 11:16 PM
Guy	2975 Ribbonwood Road	32.718458, -116.290017	4,430 feet (Tule)	2:44 PM 9:25 PM 11:58 PM

NOISE RECORDING METHODOLOGY

All noise recordings were made with Brüel and Kjær (B&K) type-4193 ½-inch pressure field microphones, which are specifically designed for infrasound and low frequency (below 40 cycles per second [Hz]) measurements, and provide a linear response from 0.07 Hz to 20,000 Hz. A B&K type-UC-0211 adapter was used to couple the microphones to a B&K type-2639 preamplifier, providing a linear frequency response down to 0.1 Hz for the microphone / adaptor / preamplifier system. All recordings were calibrated with B&K type-4230 calibrators, which are checked and adjusted every 6 months with a B&K type-4220 pistonphone in the Wilson Ihrig laboratory in Emeryville, California. The Wilson Ihrig pistonphone itself is calibrated annually with a signal traceable to the National Institute of Standards and Technology.

Inside each residence, a microphone was mounted on a tripod at 4.5 feet above the floor, in the middle of the living room or a bedroom; the microphone was oriented vertically and covered with a 3-inch diameter wind screen.

A second microphone was set up outside of each residence. In some cases, a third microphone was set up in another location outside of the residence. Following International Electrotechnical Commission (IEC) Standard 61400-11, the outside microphone was rested horizontally (i.e., flush mounted) on a ½-inch-thick plywood “ground board” that is 1 meter in diameter. The microphone was oriented in the direction of the nearest visible wind turbine and the ground board was placed in a flat location between the residence and the wind turbines.

Also following IEC 61400-11, wind effects on the outdoor microphone were reduced using both a hemispherical 7-inch-diameter primary windscreen placed directly over the microphone, and a hemispherical 20-inch-diameter secondary windscreen placed over the primary windscreen and mounted on the ground board. The microphone and primary windscreen were placed under the center of the secondary windscreen.

The primary windscreen was cut from a spherical, ACO-Pacific foam windscreen with a density of 80 pores per inch (ppi). The secondary windscreen was constructed by WIA using a wire frame covered with ½ inch open wire mesh. A one-inch-thick layer of open cell foam with a density of 30 ppi was attached to the wire mesh.

Both microphones used at the residences were powered by B&K type-2804 power supplies. Indoor and outdoor noise signals were recorded simultaneously to allow for correlation of indoor and outdoor sound levels during subsequent analysis.

All noise samples were recorded with a RION DA21 digital recorder, which provides a linear frequency response (i.e., ±0.1% or less) to a lower frequency limit of essentially 0.1 Hz when used in the "AC mode" (which was used). Twenty-minute (nominal) noise recordings were made at each location. All measurement data reported herein are based on analyses conducted in the Wilson Ihrig laboratory.

Noise Measurements in Presence of Wind

Some atmospheric pressure fluctuations are oscillatory in nature, whereas others are not. An example of a non-oscillatory pressure fluctuation is a change in barometric pressure – a change that occurs over a much longer time scale (e.g., hours) than the fluctuations being measured in this study. Wind and, in particular, gusts of wind cause another form of non-oscillatory pressure fluctuation, though it occurs on a much shorter time scale (e.g., a fraction of a second). Local wind can cause a pressure change affecting the human ear similar to the pressure change that occurs in an airplane as it ascends or descends during takeoff and landing, but this pressure change is not sound.

Sound, in contrast to non-oscillatory fluctuations, consists of regular oscillatory pressure fluctuations in the air due to traveling waves. Sound waves can propagate over long distances depending on many factors. In the case of noise generated by machinery, the pressure fluctuations can be highly periodic in nature (i.e., regular oscillations). Sound that is characterized by discrete frequencies is referred to as being tonal. Although wind can generate sound due to turbulence around objects (e.g., trees, buildings), this sound is generally random in nature, lacks periodicity and is usually not in the infrasound range of frequencies.

However, the sound measurements we were interested in for this study (i.e., periodic wind turbine-generated ILFN) can be greatly impacted by non-oscillatory pressure fluctuations and extraneous noise caused by, for example, wind turbulence due to steady wind and particularly during gusts. The microphones used in these measurements are highly sensitive instruments, with pressure sensor diaphragms that will respond to any rapid enough pressure change in the air regardless of the cause. To minimize spurious (i.e. unrelated to the noise source being measured) noise and “pseudo sound” artifacts caused by wind gusts and other pressure fluctuations not associated with the wind turbine-generated noise itself, we employed special procedures. The main sources of spurious noise and the procedures we used to minimize its impact are discussed more fully below.

Noise Artifacts due to Turbulence at the Microphone

The most commonly-encountered source of noise artifacts in outdoor noise measurements is the turbulence caused by wind blowing over the microphone. To minimize this effect of wind when conducting environmental noise measurements outdoors, it is standard practice to use a windscreen, the size of which is usually selected based on the magnitude of the wind encountered. The higher the wind speed, generally the larger the windscreen required to minimize noise artifacts caused by air turbulence at the microphone.

The windscreen used must be porous enough so as not to significantly diminish the pressure fluctuations associated with the noise being measured, which is to say that the windscreen must be acoustically transparent. As indicated above, the measurements reported herein followed procedures on windscreen design and usage as recommended by IEC 64100-11 to ensure accurate measurements.

Noise Artifacts due to Air Gusts

There is another – and more problematic – source of wind-based noise artifacts. This one is caused by non-oscillatory pressure fluctuations associated with wind gusts as well as the pressure associated with the air flow in a steady wind. Air gusts can have an effect on a microphone signal in two ways. Outdoors, the microphone diaphragm will respond to the direct change in pressure associated with air flow; whereas indoors, the microphone will respond to the indirect change in pressure associated with wind and particularly gusts of wind that pressurize the interior of the building. These wind effects induce noise artifacts that appear in the electrical signal generated by the microphone that is in the ILFN frequency range. This pseudo noise can, in turn, affect the spectral analysis of the recorded data. This form of pseudo noise (i.e., pressure changes due to air flow) is not substantially reduced by the use of a windscreen or even multiple windscreens regardless of their size.

As discussed more fully in the Method of Analysis of Recorded Data section below, the sound recordings in this study were analyzed using a fast Fourier transform (FFT) technique to resolve low frequency and infrasound data. The primary range of interest in these measurements was in frequencies between 0.1 and 40 Hz. An FFT analysis produces a constant bandwidth (B). A 400-line FFT was used in the analysis, which means the bandwidth was B = 0.1 Hz. This allows resolution of frequency components to fractions of one Hz. When using a very narrow bandwidth (e.g., 0.1 Hz), the time required for filtering is long in order to obtain adequate frequency resolution. The FFT analysis time T required for a specific bandwidth B is given by: T = 1/B. For a 0.1 Hz bandwidth, the time required is 10 seconds. At this time scale, the effects of air pressure changes due to air movement tend to linger in the filtering process as discussed in the Method of Analysis of Recorded Data section below.

To reduce the wind gust-induced noise artifacts that manifest in the data with such long filtering times, both physical means during recording and analytical post-recording methods can be employed to minimize this spurious noise. The most effective pre-measurement technique is to dig a hole in the ground and put the microphone into it. If two pits and microphones are used, then a cross-spectral analysis is also possible. In this study, however, it was impractical and, in some cases, impossible to dig microphone pits at the measurement locations. We thus relied on post-measurement analytical methods to filter out the pseudo noise as much as possible.

Each of the two most effective analytical techniques takes advantage of the fact that wind turbines and other large rotating machinery with blades (e.g., building ventilation fans and helicopters) produce very regular, oscillatory pressure fluctuations that are highly deterministic, whereas pressure changes due to air movement associated with local wind gusts are essentially random in nature. The sound produced by wind turbines is tonal in nature, meaning that it has a spectrum with discrete frequencies that, in this case, are interrelated (i.e., harmonics of the blade passage frequency). This difference between the random wind noise and the wind turbine noise provides a means to minimize the latter in the signal processing of the recorded data. It has been posited that it is the tonal nature of wind turbine infrasound that may have some influence on residents in the vicinity of large wind turbines.

The noise artifacts associated with pressure changes at the microphone due to local wind gusts can be minimized in two ways when analyzing the recorded signal. The first technique is to average the noise measurements over a longer time period. This tends to reduce the effect of pseudo noise associated with random air pressure transients during wind gusts, but does not affect the very regular, periodic pressure fluctuations generated by wind turbines.

When averaging over time is not sufficient, a second technique can be used to further minimize the effect of random pressure fluctuations associated with local wind. This second technique uses “coherent output power,” a cross-spectral process. Both time averaging and coherent output power are discussed below under the method of analysis of recorded data.

WIND TURBINE OPERATION DURING MEASUREMENTS

The blade passage frequency (BPF) is the rate at which a WT blade passes in front of its tower. The formula for BPF is:

BPF = (Turbine rpm / 60 seconds per minute) × Number of blades

Associated with the BPF are harmonics, which are integer multiples of the BPF. In this study, we typically observed up to five discrete harmonics in the measurement data. The majority of the WTs at Kumeyaay and Tule were observed to be operating during the recordings. The BPFs observed for Kumeyaay Wind and Tule Wind were 0.84 Hz and 0.71 Hz, respectively.

METEOROLOGICAL DATA

Weather Underground is a source for local weather data including wind speed and direction, temperature, precipitation, and atmospheric pressure. The closest weather monitoring station to Boulevard is approximately 12 miles away in Campo. Weather Underground data are archived by MesoWest from which we obtained meteorological data for the period of noise recordings. Average wind speeds ranged from 4 mph to a high of 18 mph. Daytime and evening wind was predominately from the west-southwest, southwest, or south-southwest; nighttime wind was from the north-northeast.

METHOD OF ANALYSIS OF RECORDED DATA

The recordings were subsequently analyzed in the Wilson Ihrig laboratory with a Larson Davis type-2900 2-channel FFT analyzer. Each recorded sample was first viewed in digital strip chart format to visually locate periods of lower local wind gusts to minimize low- frequency wind pressure transient effects on the data. The FFT analyzer was set for 40-Hz bandwidth, with 400-lines, resulting in 0.1-Hz resolution. Linear averaging was used. A Hanning window was used during a one- to two-minute, low-wind period to obtain an “energy average” with maximum sampling overlap. The results were stored for each sample, including autospectra, coherence, and coherent output power for both channels of data at the residential locations (i.e., indoors and outdoors). Autospectra were also obtained for the reference locations.

Autospectra and Coherent Output Power

One of the strengths of the indoor-outdoor sampling procedure is that it made possible the use of what is called the “coherent output power” to minimize the effect of the low-frequency wind pressure transients caused by local wind gusts.

Coherent output power is based on use of the coherence between two signals to weight the spectra of one of the signals based on coherent frequency components common to the two simultaneously recorded signals. Where, as here, the wind turbine-generated noise remains at fairly consistent frequencies over the recording periods, the effects on the recorded signal of the essentially random, non-oscillatory pressure fluctuations caused by wind gusts should be reduced using this analysis procedure. The result is sometimes referred to as the coherent output spectrum.

Sound Level Corrections Due to Use of Ground Board

Placing an outdoor microphone on a ground board, as was done in this study, results in higher sound pressure levels (up to 3 dB greater) for frequencies in the range of 50 to 20,000 Hz when compared to those measured at 4.5 to 5.5 feet above the ground, a standard height used to make environmental noise measurements as indicated in ANSI S12.9-2013/Part 3. Consequently, corrections to the sound level data at frequencies greater than 50 Hz obtained using a ground board would be required.

However, for frequencies less than 50 Hz, the sound pressure level at the ground surface is essentially the same as that at a height of 5 feet. This is because a microphone on a tripod 5 feet above the ground is at a height less than one-fourth the wavelength of the sound at this frequency and there is little difference at frequencies less than 50 Hz between the sound field at ground level and the sound field at 5 feet above the ground.

Because the data presented herein are in the ILFN range with frequencies less than 40 Hz, no corrections to the sound level data are necessary, even though the measurements were made with a ground board. Similarly, because AM describes relative differences in sound level, no corrections are necessary.

ILFN Data

There are four wind turbine facilities with a combined total of 241 WTs within 11 miles of the residences at which recordings were made. Each of the current WT facilities has an array of WTs made by a different manufacturer or installed with a different WT model. Consequently, the WTs at each facility have different rotational speeds. It was not practical to simultaneously observe all the WTs at the four facilities, and the rotational speeds of individual WTs vary from one another and change over time depending on local wind conditions. Furthermore, the WTs at Kumeyaay Wind and Tule Wind operate at rotational speeds that are not too dissimilar (i.e., about 16 and 14 rpm, respectively). These factors make linkage of ILFN at certain frequencies with a specific wind turbine facility somewhat challenging.

It is clear from the discussion above that well-defined spectral peaks at frequencies less than 10 Hz are generally mechanically-generated infrasound, and at frequencies less 5 Hz the infrasound is obviously generated by WTs. Note that in general for large, industrial wind turbines the highest operational speed is 20 rpm, which corresponds to a BPF of 1.0 Hz for a turbine with three blades.

Consequently, peaks below 1.0 Hz are clearly BPFs of various WTs, and peaks that are multiples of a BPF between the frequencies of 1.0 Hz and 10 Hz are consequently harmonics of BPF, although harmonics that appear in the spectral data are typically limited to about 5 Hz.

The coherent output power spectra measured inside residences are shown in the attached plots. It is apparent from the data plots that there are reoccurring spectral peaks at specific frequencies less than 5 Hz. Not all the peaks occur for all the residences, due to differences in distance, orientation of WT blade to the residence, possible shielding by intervening terrain, atmospheric conditions; however, where they are present, they are present regardless of time of day or location, which is a clear indication of infrasound generated by WTs.

Table 2 lists the highest measured indoor sound pressure levels, and the frequency of those peak sound pressure levels.

Table 2. Measured Sound Levels

Residence	Measurement Period	Highest Sound Pressure Level; Dominant Frequency	Rotor Rotational Component
Tisdale	Daytime Evening Nighttime	44 dB at 0.88 Hz 49 dB at 2.54 Hz 47 dB at 1.66 Hz	Kumeyaay BPF Kumeyaay 2nd Harmonic Kumeyaay 1st Harmonic
Morrison	Daytime Evening Nighttime	52 dB at 0.59 Hz 48 dB at 0.78 Hz 57 dB at 1.66 Hz	Ocotillo BPF Tule BPF Kumeyaay 1st Harmonic
Guy	Daytime Evening Nighttime	64 dB at 0.88 Hz 60 dB at 1.47 Hz 63 dB at 2.54 Hz	Kumeyaay BPF Tule 1st Harmonic Kumeyaay 2nd Harmonic

AMPLITUDE MODULATION

Several area residents have commented on what they characterize as a “whooshing” sound from WTs. This sound was pronounced at the Guy residence, the closest measurement to the Tule WTs. An analysis of the Guy residence recordings clearly indicates amplitude modulation (AM). AM is the fluctuation of sound, in this case air flow turbulence noise generated at the WT blades’ trailing edge, modulated (changing sound level) at the frequency of the BPF.

A sample of recorded noise from the Guy residence was analyzed, as shown in the attached plot. At 250 Hz, the AM ranges from 3 to 10 dB, with the typical variation from 5 to 6 dBA.

CONCLUSIONS

It is clear from the measured noise data that there is significant wind turbine-generated ILFN and AM from the Kumeyaay and Tule Wind facilities affecting homes up to approximately 6 miles away. This conclusion is coherent with the conclusions of the 2014 and 2019 Wilson Ihrig studies.

Sincerely,

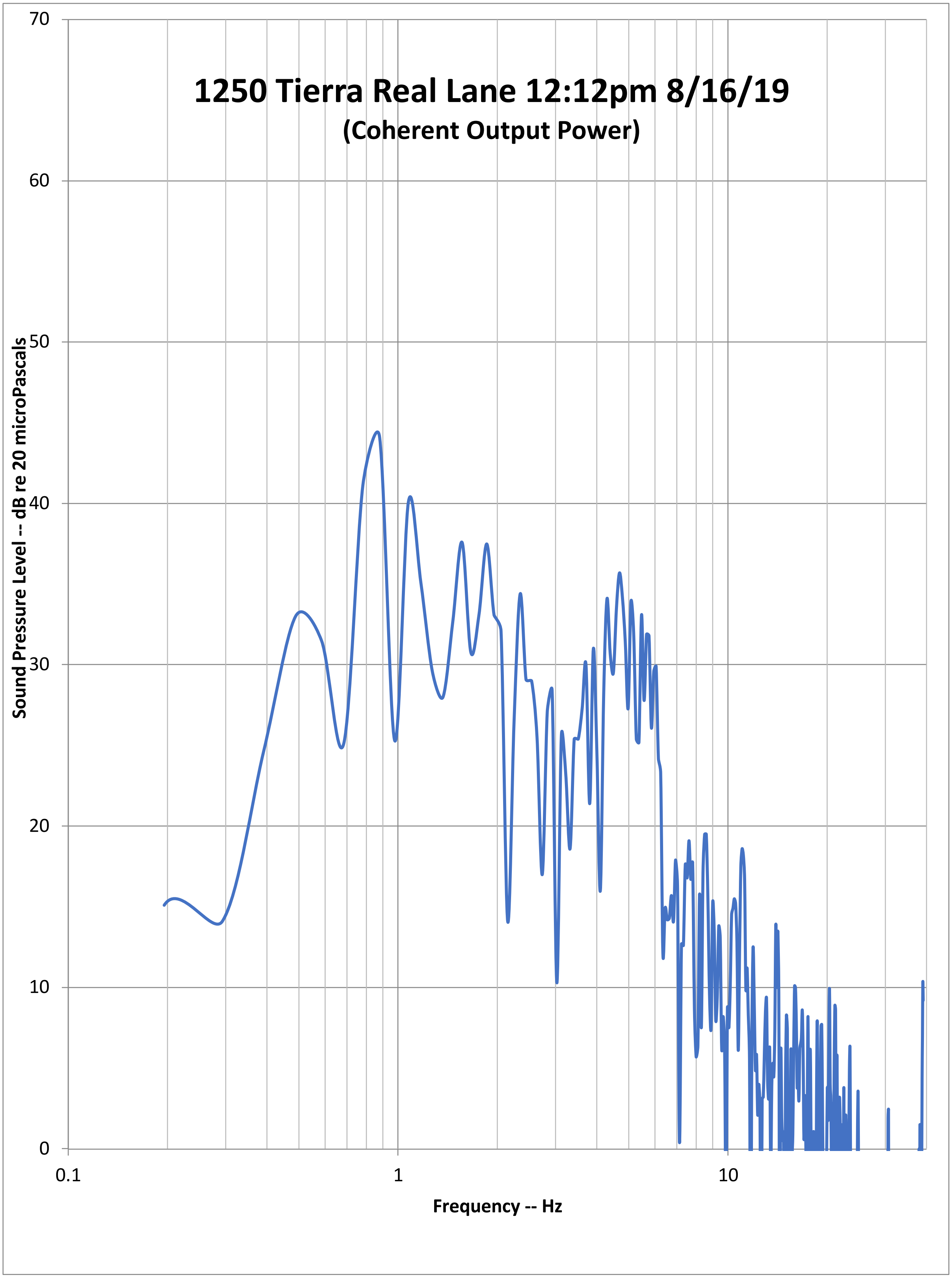
dBF ASSOCIATES, INC.

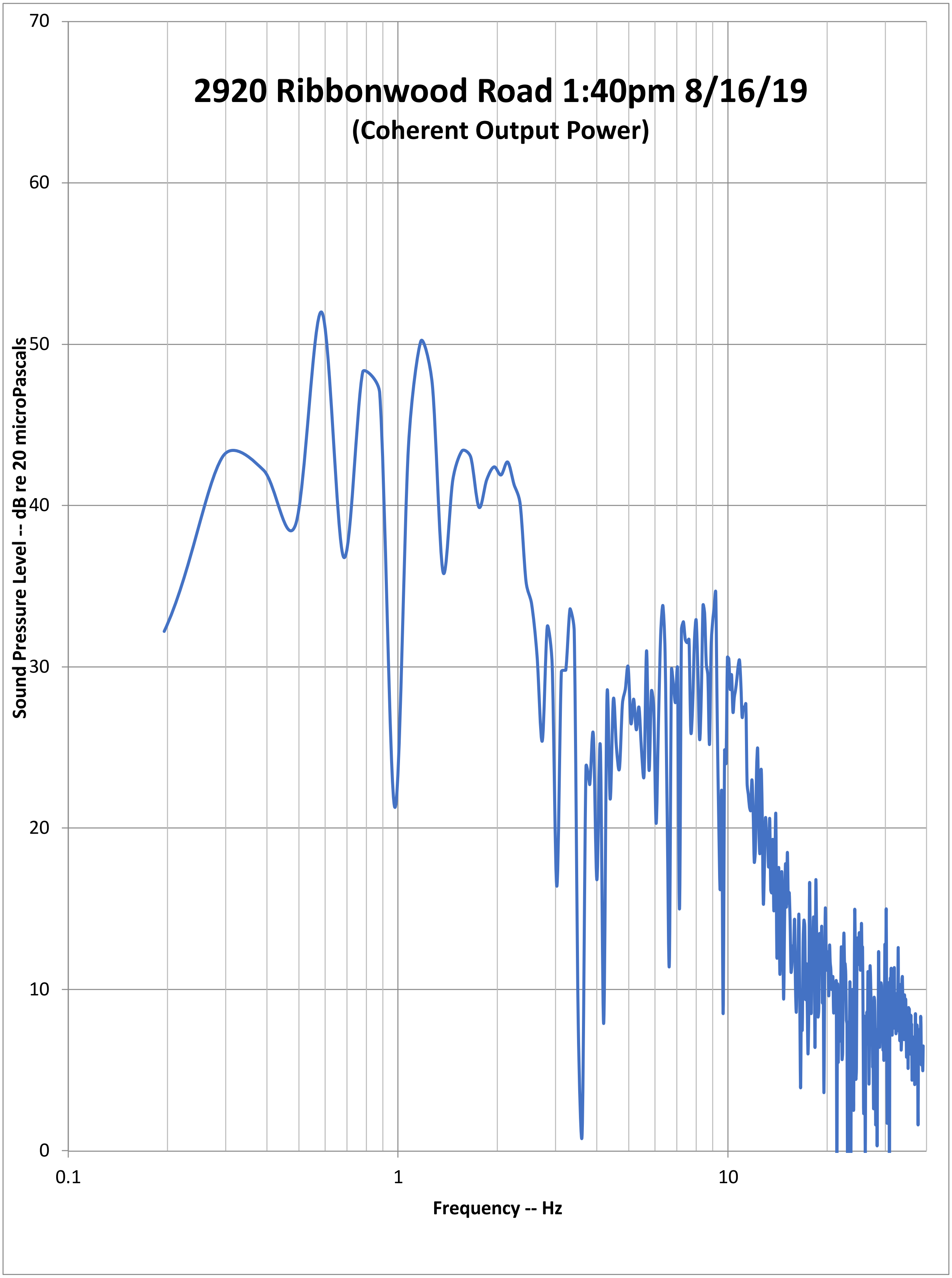
Steven Fiedler, INCE
Principal

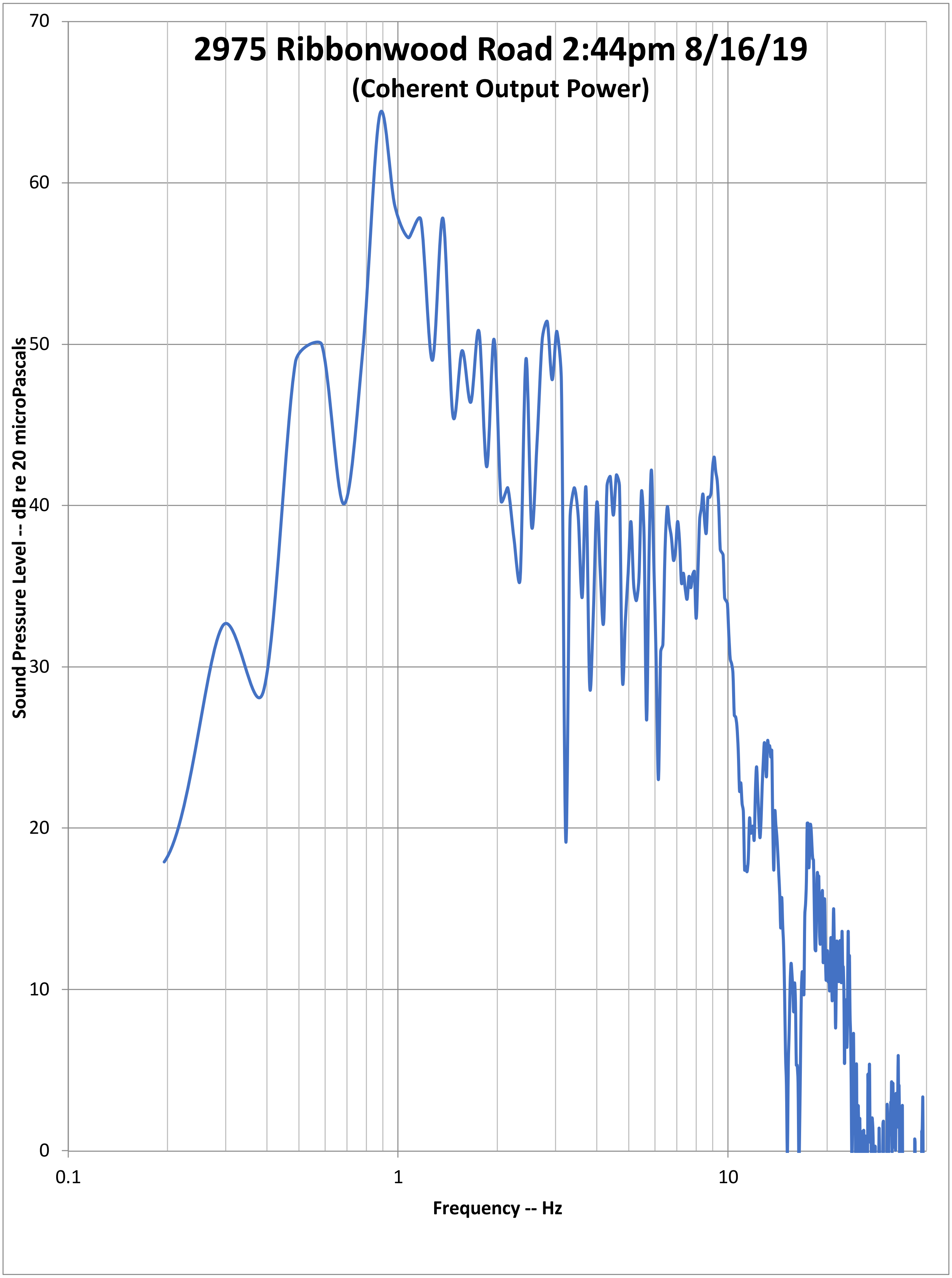
References:

Wilson Ihrig. 2014. Kumeyaay and Octotillo Wind Turbine Facilities Noise Measurements. February 28.

Wilson Ihrig. 2019. Results of Ambient Noise Measurements of the Existing Kumeyaay Wind and Tule Wind Facilities in the Area of Boulevard and Jacumba Hot Springs Pertaining to the Proposed Torrey and Campo Wind Turbine Facilities. March 18.

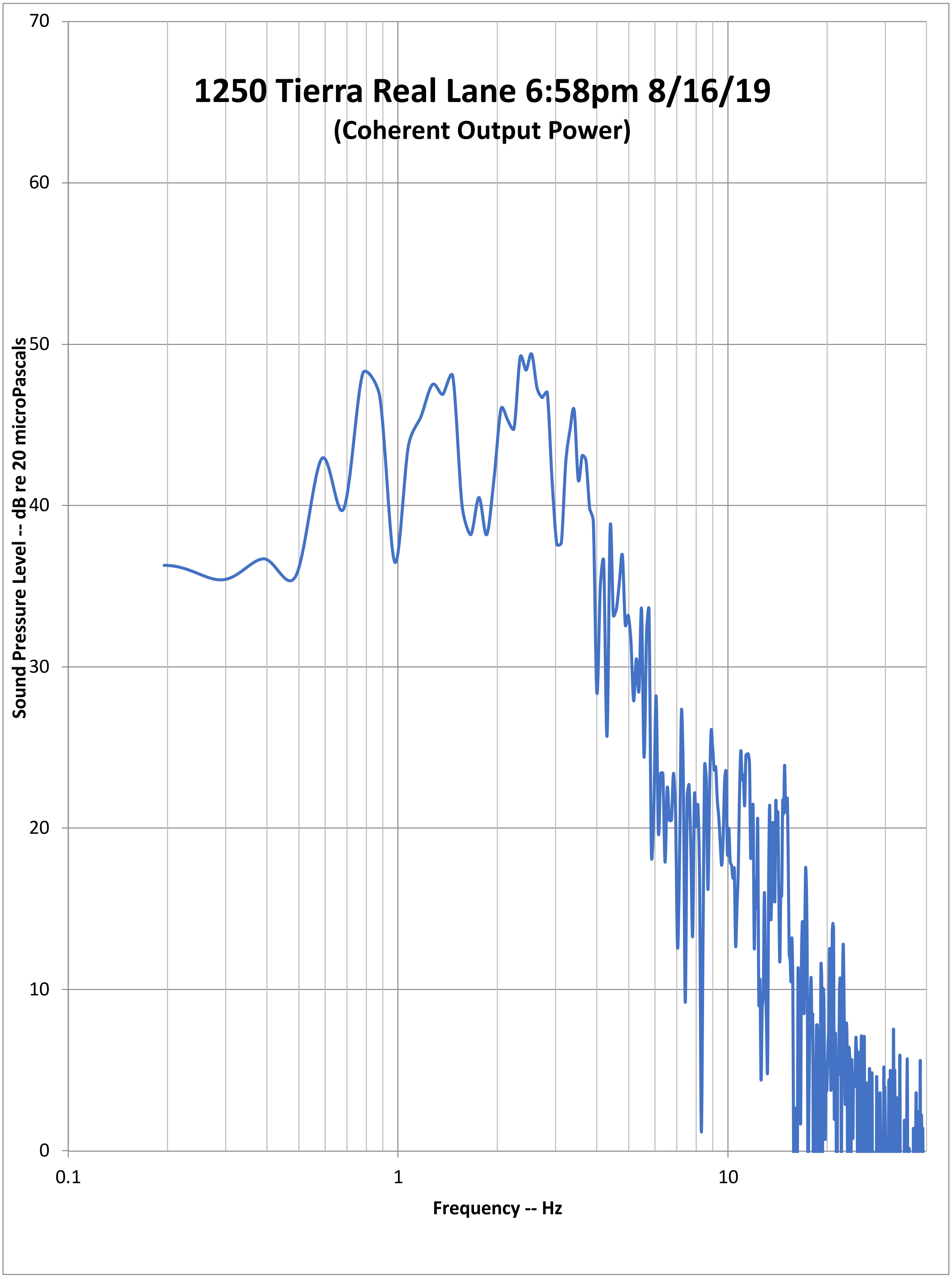

1250 Tierra Real Lane 12:12pm 8/16/19
(Coherent Output Power)
Sound Pressure Level -- dB re 20 microPascals
70
60
50
40
30
20
10
0
0.1
1
10
Frequency -- Hz


2920 Ribbonwood Road 1:40pm 8/16/19
(Coherent Output Power)
Sound Pressure Level -- dB re 20 microPascals
70
60
50
40
30
20
10
0
0.1
1
10
Frequency -- Hz

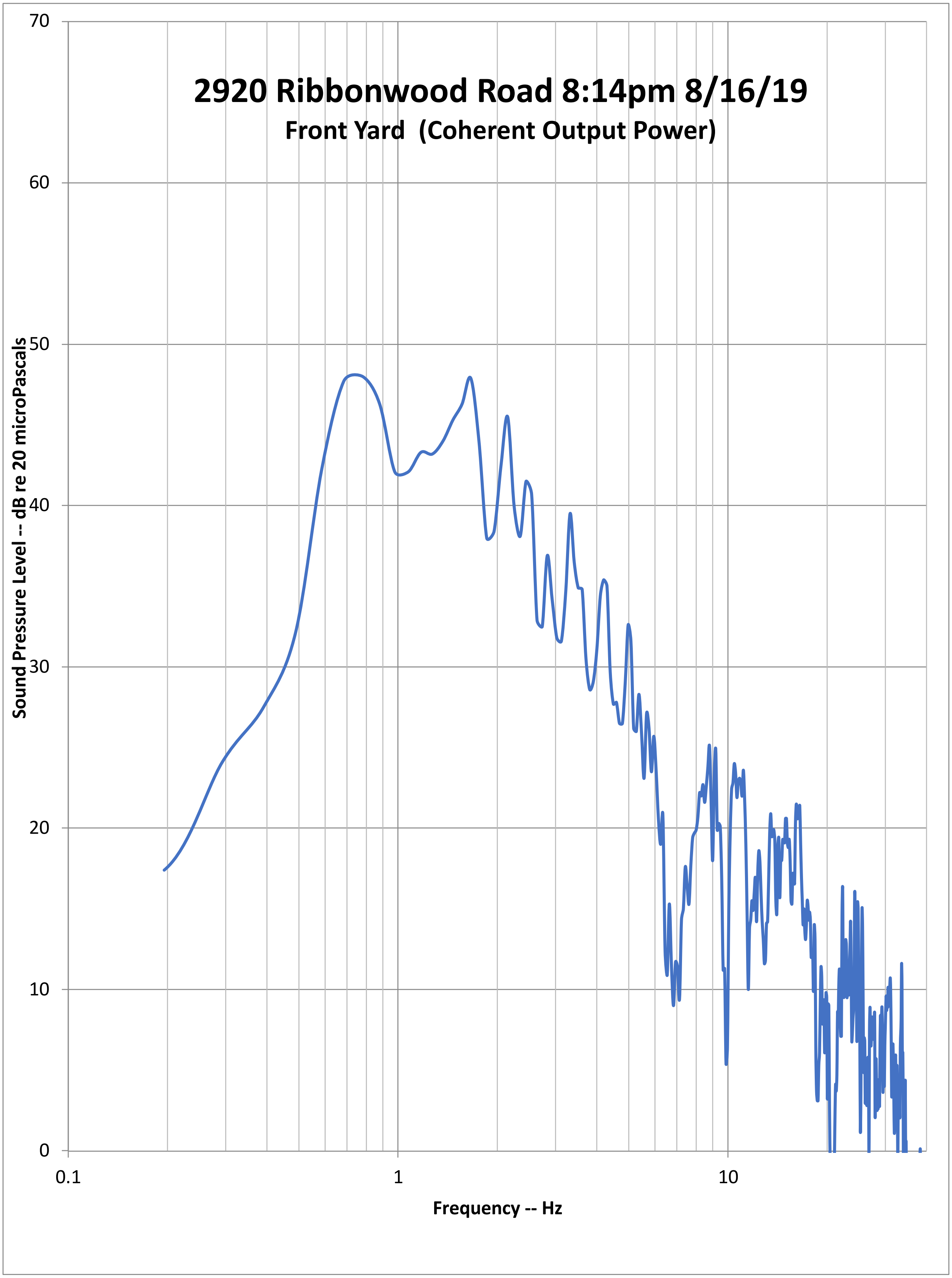


2975 Ribbonwood Road 2:44pm 8/16/19

(Coherent Output Power)

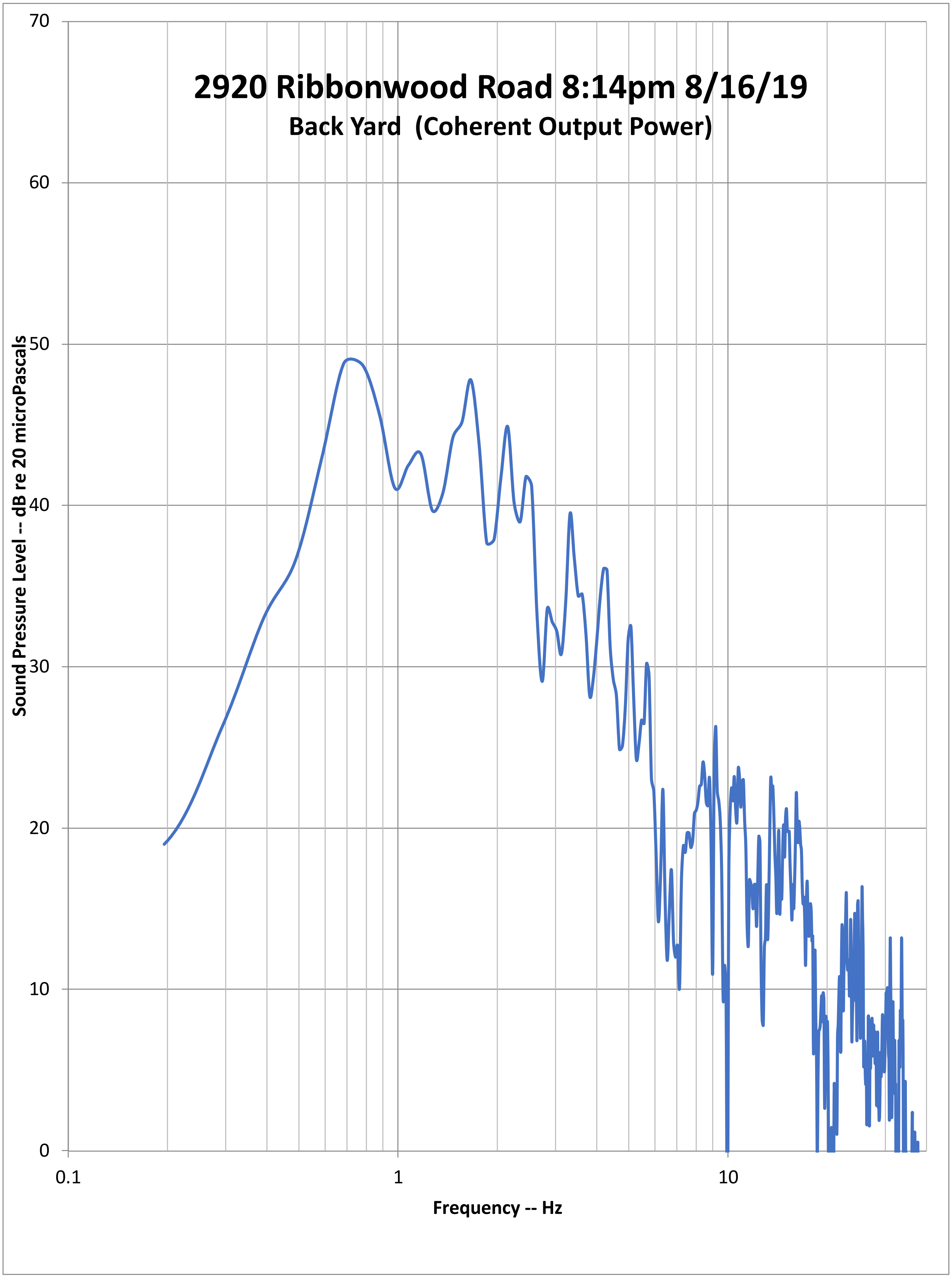


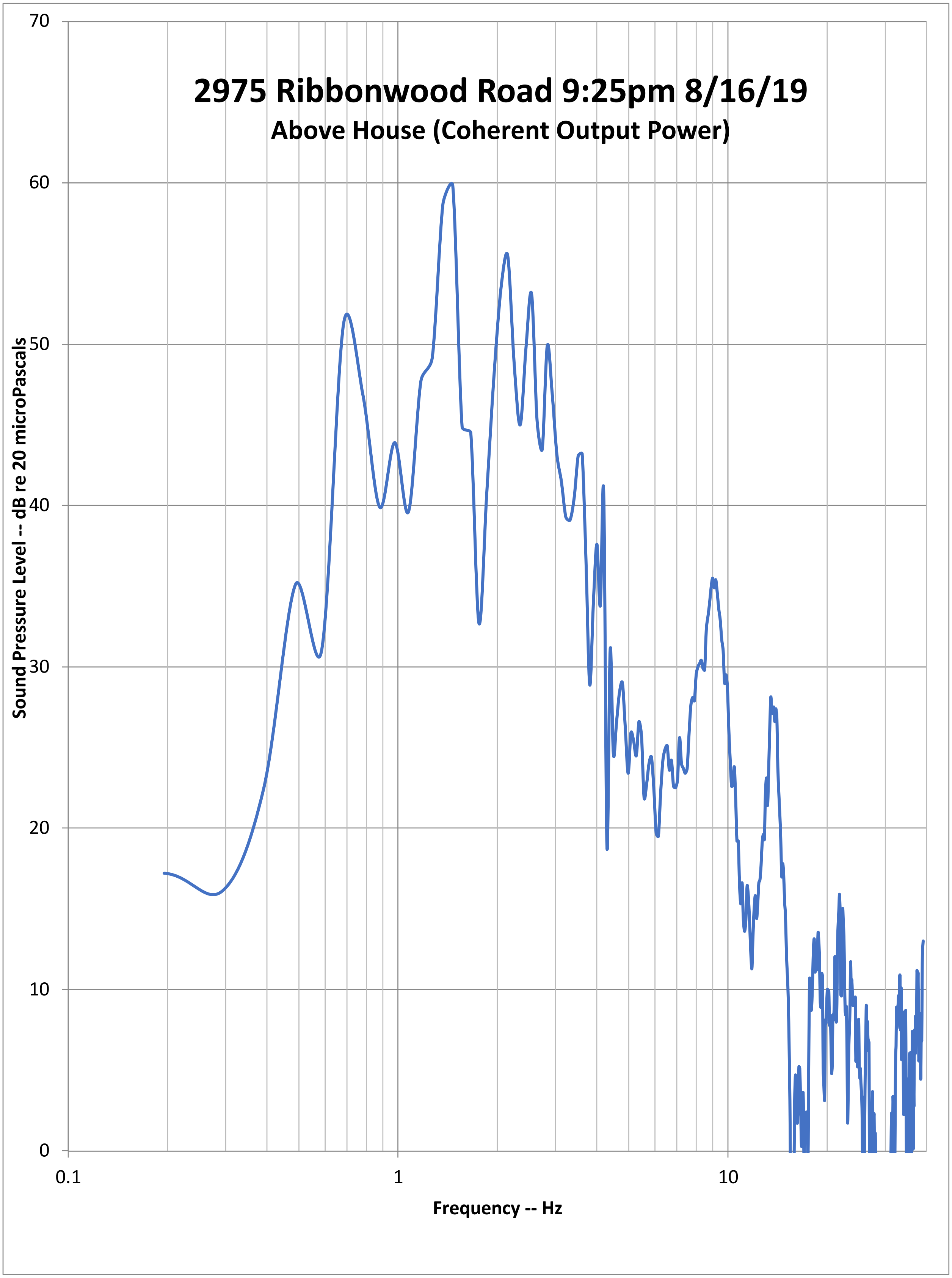
1250 Tierra Real Lane 6:58pm 8/16/19
(Coherent Output Power)
Sound Pressure Level -- dB re 20 microPascals
70
60
50
40
30
20
10
0
0.1
1
10
Frequency -- Hz

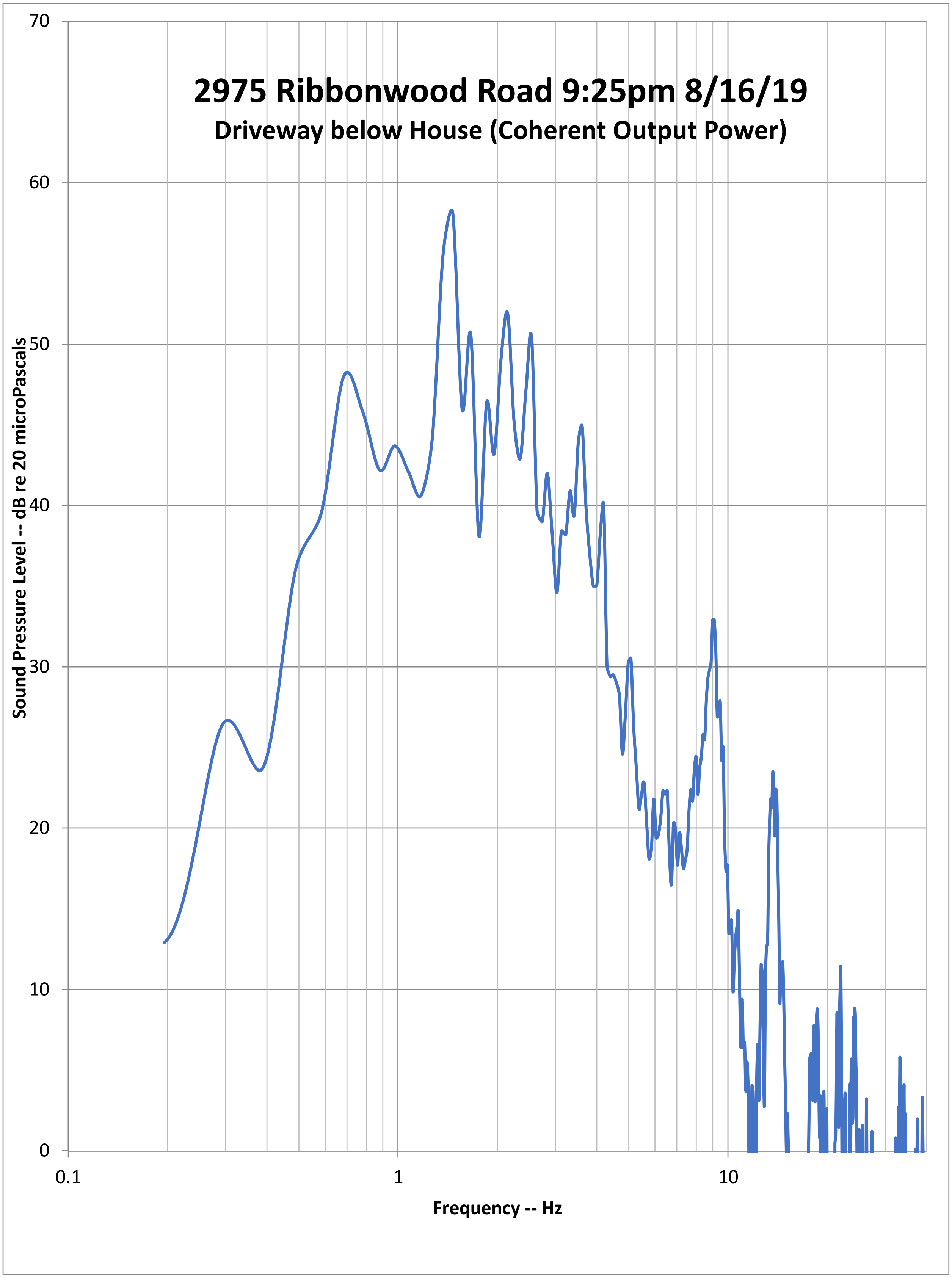


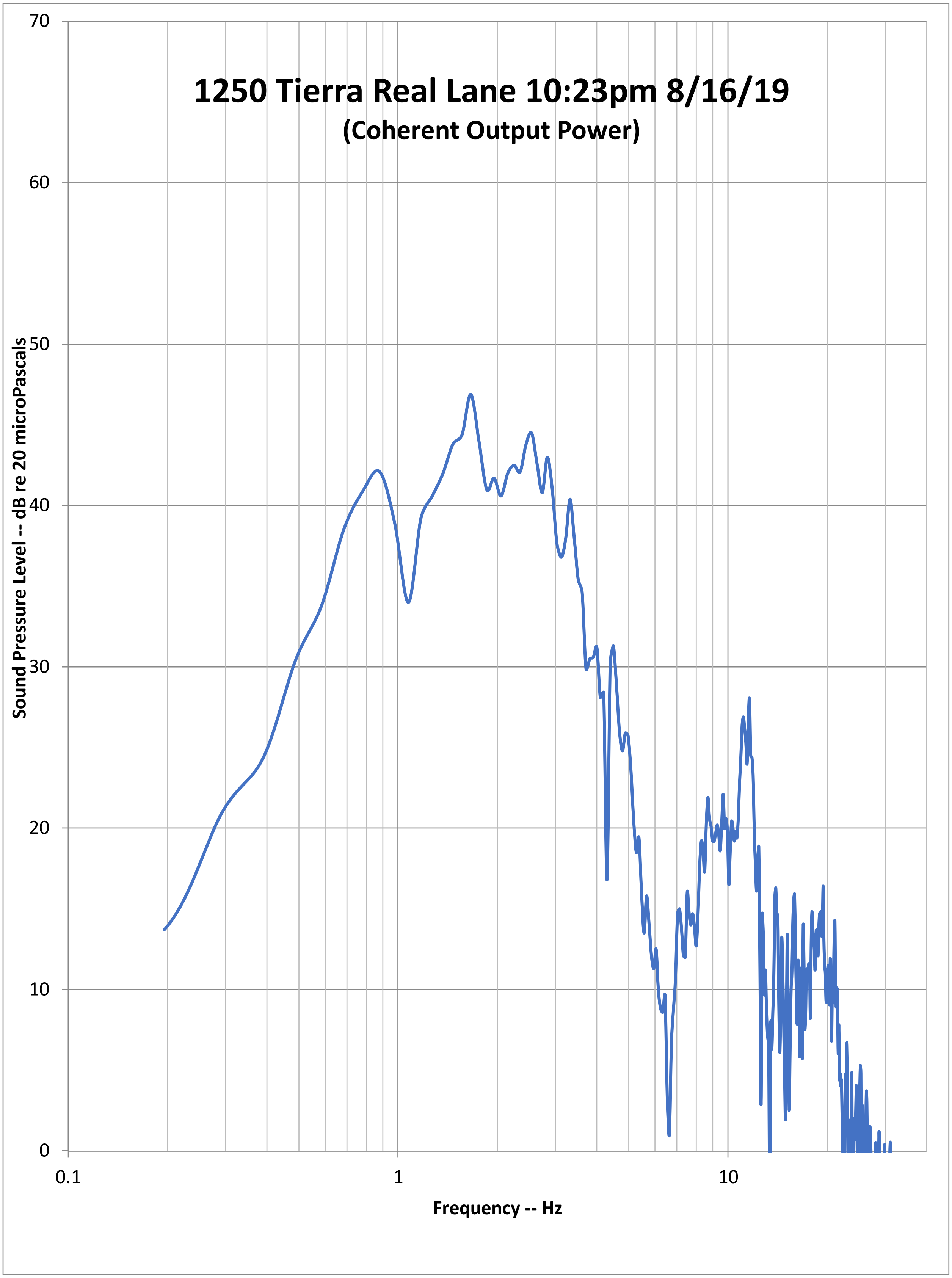
2920 Ribbonwood Road 8:14pm 8/16/19

Front Yard (Coherent Output Power)


2920 Ribbonwood Road 8:14pm 8/16/19
Back Yard (Coherent Output Power)
Sound Pressure Level -- dB re 20 microPascals
Frequency -- Hz
70
60
50
40
30
20
10
0
0.1
1
10


2975 Ribbonwood Road 9:25pm 8/16/19
Above House (Coherent Output Power)
Sound Pressure Level -- dB re 20 microPascals
70
60
50
40
30
20
10
0
0.1
1
10
Frequency -- Hz


2975 Ribbonwood Road 9:25pm 8/16/19
Driveway below House (Coherent Output Power)
Sound Pressure Level -- dB re 20 microPascals
70
60
50
40
30
20
10
0
0.1
1
10
Frequency -- Hz


1250 Tierra Real Lane 10:23pm 8/16/19
(Coherent Output Power)
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Frequency -- Hz
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10
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0.1
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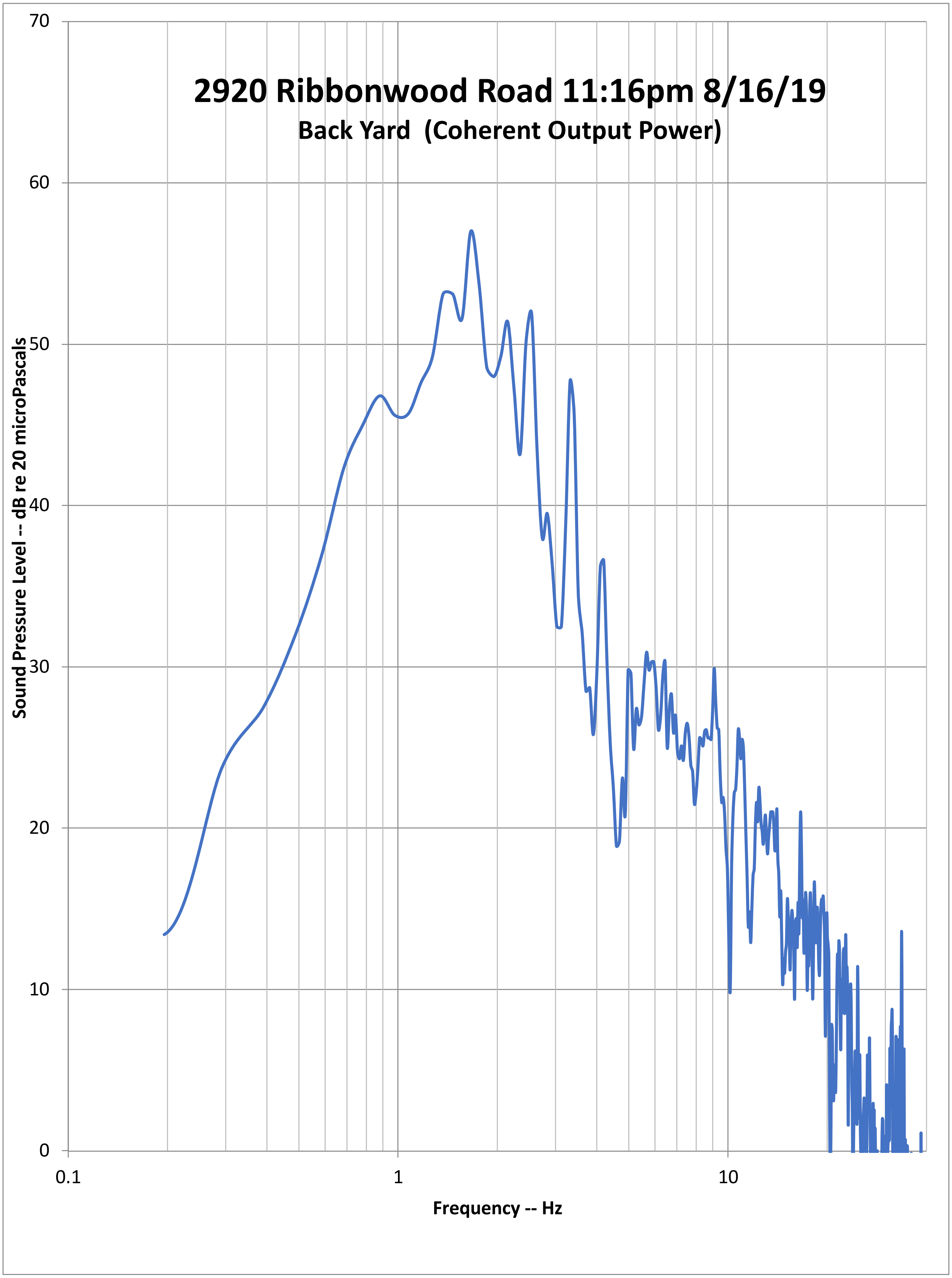
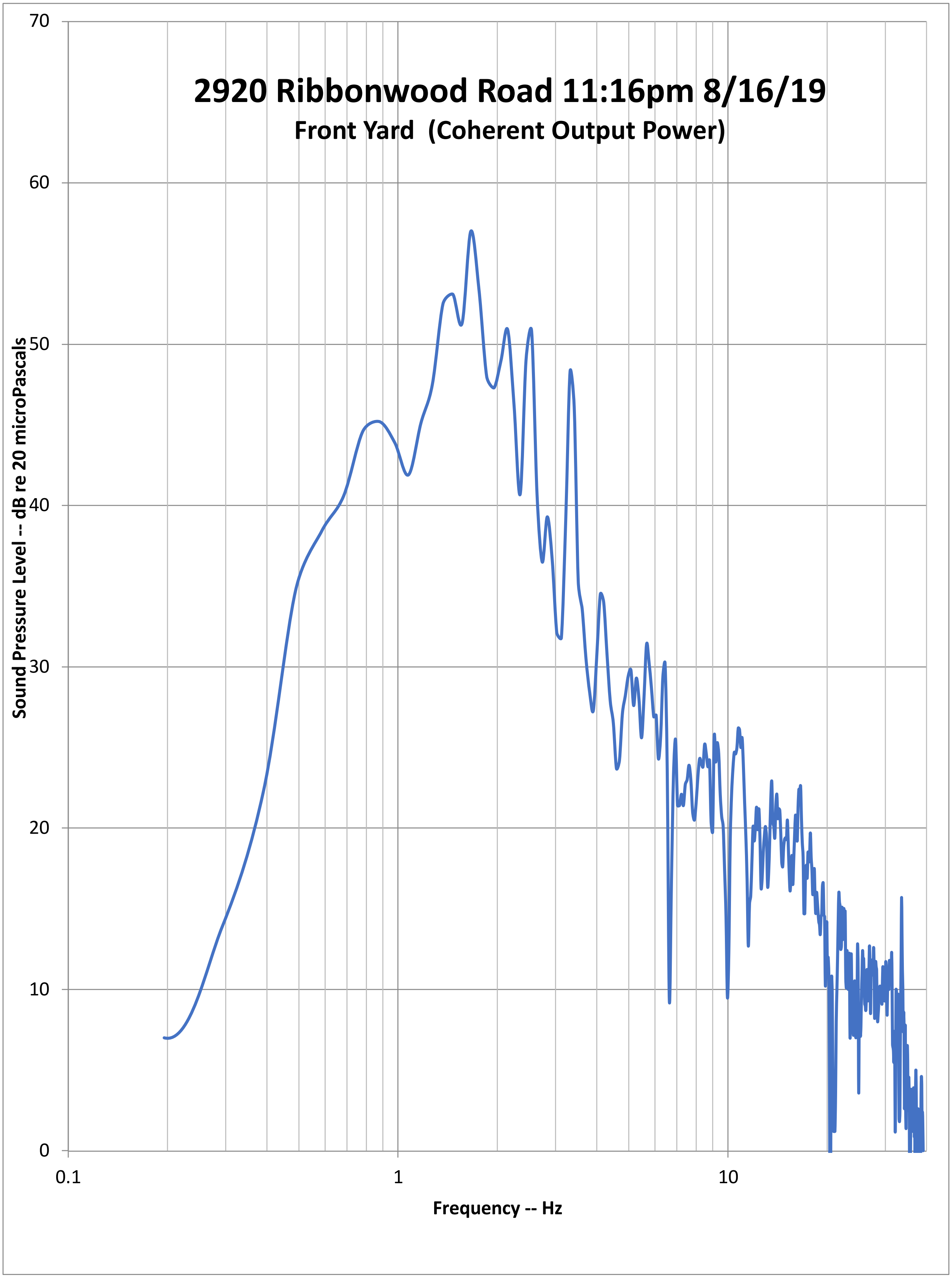
10



2920 Ribbonwood Road 11:16pm 8/16/19

Back Yard (Coherent Output Power)


2920 Ribbonwood Road 11:16pm 8/16/19
Front Yard (Coherent Output Power)
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60
50
40
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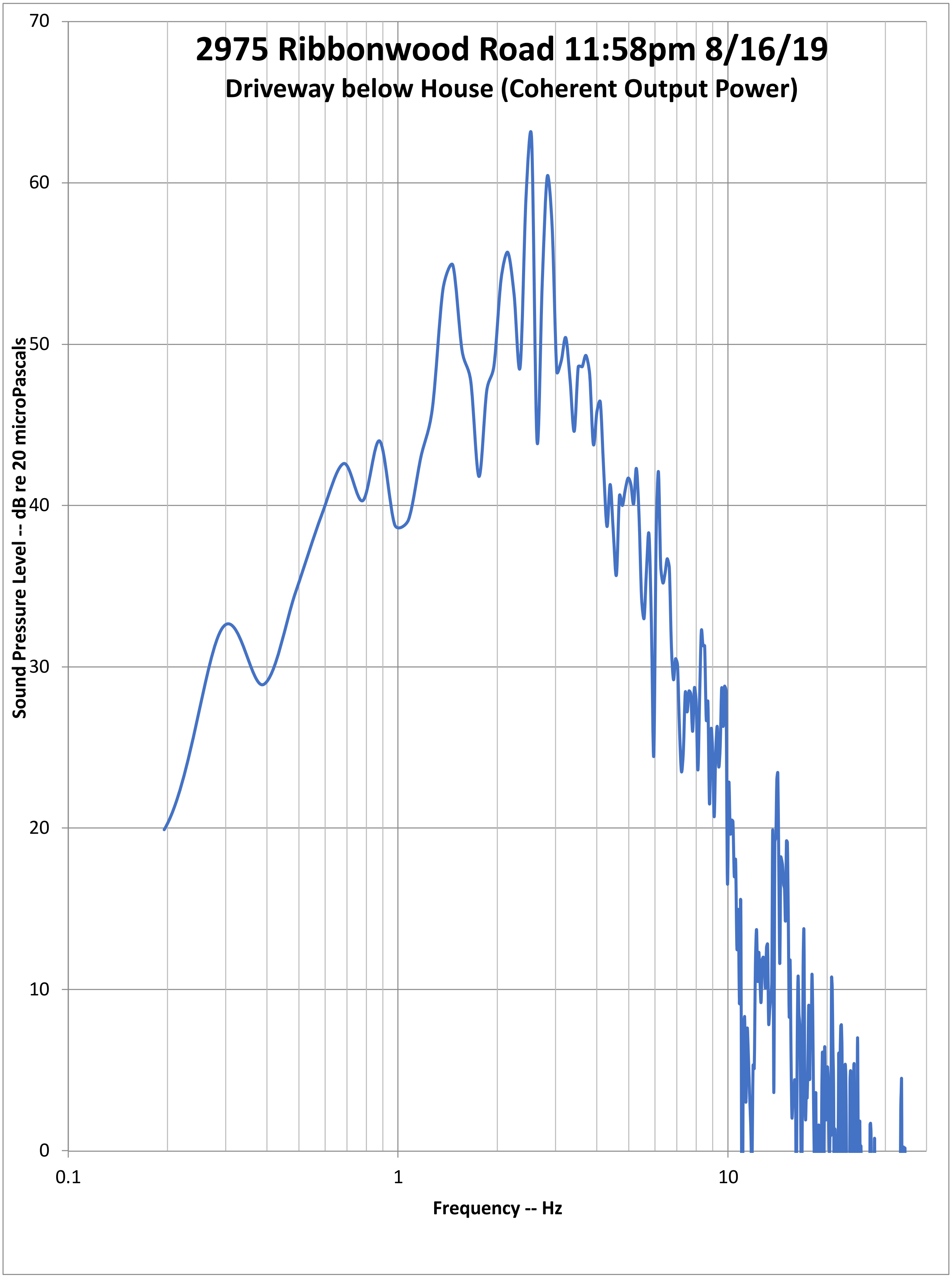
20
10
0
0.1
1
10
Frequency -- Hz


2975 Ribbonwood Road 11:58pm 8/16/19
Driveway below House (Coherent Output Power)
Sound Pressure Level -- dB re 20 microPascals
Frequency -- Hz
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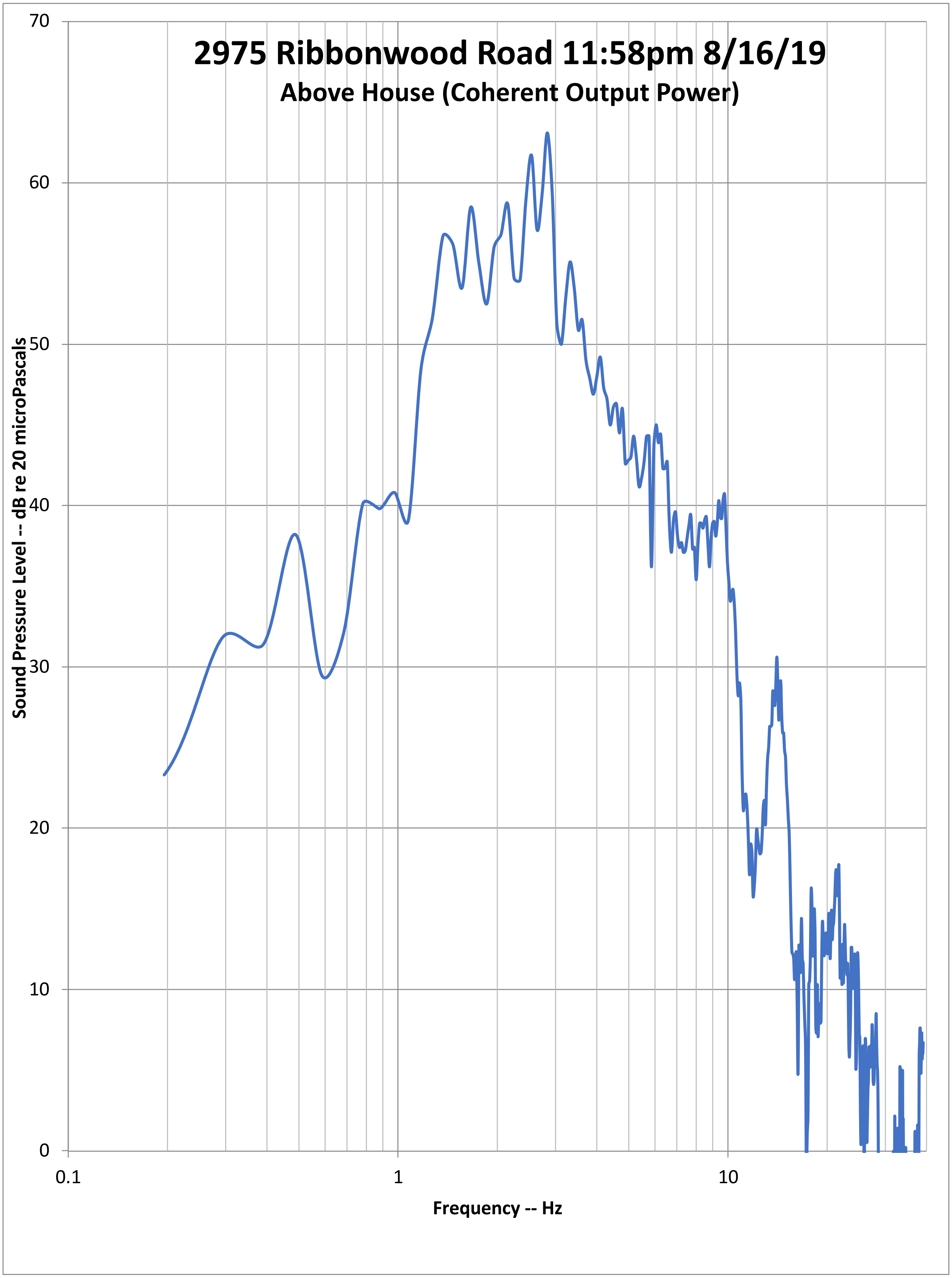
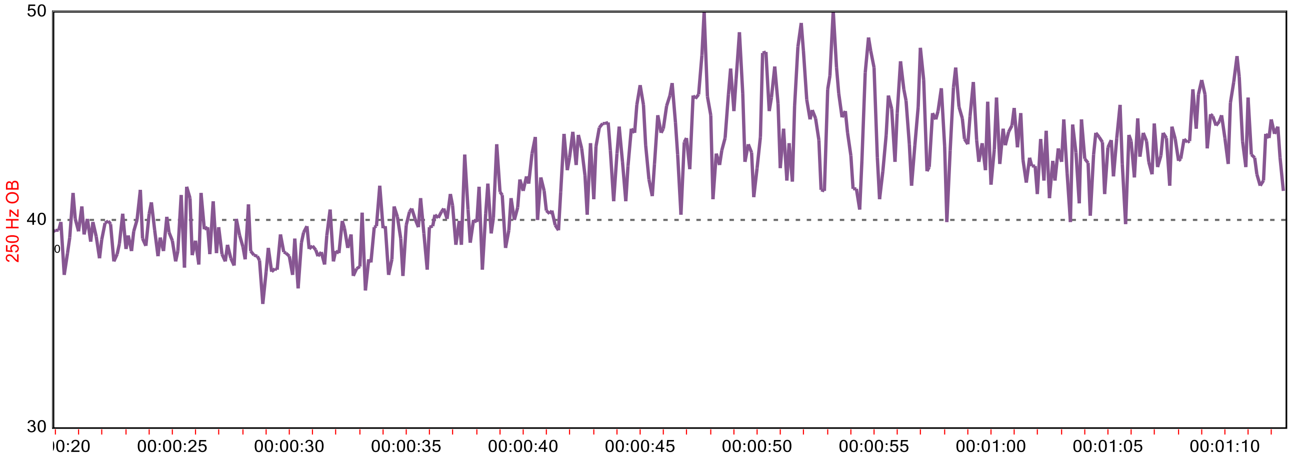
30
20
10
0
0.1
1
10



2975 Ribbonwood Road 11:58pm 8/16/19

Above House (Coherent Output Power)



Wind Turbine Amplitude Modulation at Guy Residence 11:58pm 8/16/19

EXHIBIT
8

SNYDERGEOLOGIC

March 9, 2020
Project No. 0023.004

Backcountry Against Dumps
c/o Donna Tisdale
PO Box 1275
Boulevard, CA 91905-0375

Subject: Campo Wind Final Environmental Impact Statement (EIS) with Boulder Brush Facilities
Final EIS Review and Opinion

Dear Ms. Tisdale,

We are pleased to present this report to Backcountry Against Dumps that provides an independent, technical review of relevant groundwater portions of the Campo Wind Final EIS, prepared by Dudek, for the Campo Wind Project with Boulder Brush Facilities (project). Scott Snyder is a California Professional Geologist and Certified Hydrogeologist with 25 years of experience in hydrogeology, nineteen of which have been in San Diego County.

In summary of the information presented in this report, it seems clear that when presented with valid technical and scientific arguments in our original comment letter dated July 5, 2019, the project proponent ignored the arguments and provided responses that are inadequate, broadly dismissive, and without technical merit. They have relied on data that are not site-specific and made liberal assumptions, and have not conducted further evaluation of the well field and its pumping effects on nearby residential wells.

PURPOSE

The purpose of this report is to provide comments to the responses provided by Dudek on the comments we prepared for the Groundwater Resource Evaluation (GRE) Report, Appendix F of the Final EIS.

DOCUMENTS REVIEWED

We reviewed the following documents found on the Bureau of Indian Affairs website for Campo Wind (www.campowind.com):

- Final EIS Section 1 – Introduction
- Final EIS Section 2 – Project Description and Alternatives

- Final EIS Section 3.2 – Affected Environment and Areas Not Further Discussed, Water Resources
- Final EIS Section 4.2 – Environmental Consequences, Water Resources
- Final EIS Appendix B – Project Description Details
- Final EIS Appendix C – Regulatory Settings
- Final EIS Appendix D – Environmental Resources Section Tables and Graphs
- Final EIS Appendix E – EIS Figures
- Final EIS Appendix F – Groundwater Resource Evaluation (GRE)
- Final EIS Appendix P – Mitigation Measures
- Final EIS Appendix T – Responses to Public Comments

SUMMARY OF ANALYSIS

Based on our review of the above documents the following is a summary of our findings:

- The original GRE appears to have been prepared using estimates and assumptions of groundwater conditions based on no field work of any kind or actual testing of the on-reservation production well field.
- The GRE prepared by Dudek for the Final EIS is unchanged from the version in the Draft EIS. The technical comments by the County of San Diego and the technical community resulted in no reevaluation of the calculations in the reports or in the assumptions and estimates made, and no field work was conducted.
- The County of San Diego noted that their significance criterion for off-site well drawdown was violated based on the calculations by Dudek.
- Liberal estimates of aquifer parameters and misleading assumptions of actual planned withdrawal activities underestimate potential impacts to off-reservation wells.
- Depth to groundwater in the reservation production wells during the 2013 ECO Substation project was presented incorrectly, discussing only transducer drawdown data (110 feet) that did not present the largest decline in water levels, which were up to 202 feet based on manual readings.
- A clear presentation of calculations used to estimate off-reservation well drawdown has still not been presented.

- Reduction in storage calculations presented in the GRE assume a water use of 0.5 acre feet per year (AFY) per residence, a figure that is assumed for the average San Diego County residence. The residential properties in this area are far larger than average for San Diego County; thus, the assumed consumptive use should be far greater than 0.5 AFY. Consumptive use should be area-specific, not based on an average that is clearly not justified for this area.

- The only mitigation measure for water resources (PDF-HYD-1) is inadequate as a protective measure for off-reservation wells. It relies on monitoring on-reservation wells only, using a monitoring network that has not been evaluated for adequacy (e.g., monitoring well locations, well logs, proximity to production wells, total well depth). Likewise, since the details of the production wells are not known (e.g., location of wells, total depth of wells, well logs, water bearing fracture intervals), it is impossible to determine if the monitoring wells would be adequate to monitor the effects of production well pumping. Researching, compiling, and presenting these data would be the first step in evaluating whether this measure, combined with off-reservation well monitoring, would be adequate to protect the groundwater resources for both on- and off-reservation well users. Actual well tests of the reservation well field, with on- and off-reservation monitoring, must also be conducted prior to any approval to proceed with the Project.

- A Supplemental Environmental Impact Statement is necessary to correct the errors and omissions in the FEIS.

RESPONSE TO COMMENTS

<u>E-13 Response:</u> In Comment E-13, the County of San Diego stated that:

> “While the groundwater impacts analysis notes that drawdown at the nearest offsite wells was estimated at up to 31 feet, the investigation concludes that long-term depletion of groundwater storage is not anticipated and environmental impacts would be minimal. However, based on County Guidelines, <u>a decrease in water level of 20 feet or more in offsite wells would be considered a significant impact</u>, even if it is only for a year. The investigation <u>inaccurately concludes</u> that Project impacts on offsite wells is within the County’s thresholds and that environmental impacts would be minimal.”

In Dudek’s report, they stated that while the County CEQA Guidelines do not apply to this project, they would use them to evaluate the potential impact to groundwater resources. Upon a detailed analysis of the report, Dudek appears to ignore the County thresholds they claim to have applied to the results of their investigation (County comment above) and appear to use liberal assumptions in calculating the effects of groundwater pumping to <u>estimate</u> anticipated drawdown off the reservation since <u>no well tests were performed for this project</u>. Those calculations resulted in the appearance of no significant impact by presenting that drawdown in the nearest off-site well would be 19 feet (the threshold is 20 feet). Using a more realistic drawdown scenario, we calculated a drawdown of nearly 26 feet in the nearest off-reservation well after 5 years.

J-107 Response: The response by Dudek to this comment, that if all 295 users used groundwater at 22.4 AFY (to which they have a right) they would deplete the aquifer in 6 months, highlights the concern for this project. In fact, there are many more wells than 295 in the area as many users have more than one well on their property, and many wells were drilled before drilling permits were required. Dudek notes that the average residence in San Diego County uses 0.5 AFY and that the 22.4 AFY use by residences is not substantiated by actual conditions. In fact, the 0.5 AFY for these remote residences that are totally groundwater dependent, some with large acreage, is not realistic, and Dudek does not know what the actual usage is by residences. Dudek's use of 0.5 AFY is likewise unsubstantiated by actual conditions. In the absence of data confirming actual groundwater usage by residences, a more conservative groundwater usage figure should be used in the calculations.

J-111 Response: Dudek acknowledges that the well depths in the production well field are unknown.

- This is a basic data point that should be known for any hydrogeologic investigation so that potential impacts to wells in the area can be better understood and a well-defined monitoring well network can be designed. The greater the well depth, the more likely the well is to encounter water-bearing fractures that, if pumped, could impact other nearby wells.
- Secondly, the monitoring well network and pumping well network is not provided in the report; therefore, the adequacy of the monitoring plan cannot be evaluated. If proposed monitoring wells are not as deep as the production wells, drawdown impacts will not be able to be adequately monitored. The information regarding well depths should be researched or measured and the information should be shared for a proper evaluation.
- Thirdly, due to the heterogeneity of groundwater flow in fractured rock aquifers, impacts to off-reservation wells may not be adequately detected through a use of on-reservation monitoring wells in a fractured rock groundwater system. Production wells on the reservation may not be connected by fractures to the on-reservation monitoring network (or the on-reservation monitoring wells may not be as deep as the production wells) to detect groundwater level declines. At the same time, the production wells may be connected by fractures to the off-reservation wells. Therefore, when drawdown occurs at the production wells, the drawdown of water levels in the bedrock aquifer may not be detected by the on-reservation monitoring wells even though off-reservation wells may be experiencing water level declines.
- Lastly, off-reservation impacts to wells through on-reservation pumping are not indirect impacts, they are direct impacts. They are caused by the pumping of reservation wells for the project and occur at the same time and place (the only distinguishing feature regarding place is a property boundary). Drawdown of off-reservation wells is directly caused by pumping wells on-reservation.

<u>J-114 Response:</u> The pumping rate was not previously provided in the Dudek report; however, in the response it is presented that the pumping rate was estimated (still not provided) using the total groundwater extraction volume <u>amortized</u> over 5 years. This method of developing a pumping rate is extremely deceptive. Essentially, it averages the 173 AF withdrawal in the first year over the 5-year construction period. It is irresponsible to calculate groundwater conditions during the first year based on an extraction of 34.6 AF when the actual extraction will be five times that amount in the first year. A well test should be conducted using the maximum flow rate anticipated and both on- and off- reservation wells should be monitored. Despite the improper amortizing of groundwater extraction over 5 years, after year 1 the nearest off-site well was calculated to have a drawdown of 31 feet, which exceeds the significance threshold. After 5 years, the drawdown would be as high as 19 feet. Considering the actual usage of groundwater in year 1 will be five times the rate used in the calculation, and liberal assumptions were made for transmissivity and storativity, if proper calculations were made using actual anticipated year 1 pumping rates and more conservative values for transmissivity and storativity, the drawdown impacts would be much greater. A drawdown of 31 feet is a significant impact and will be far greater than that during pumping in year 1. As stated previously, there is no explanation provided as to why Dudek assumed a storativity of 0.001 in Table 4-2 when Table 4-1 provides a specific yield of 0.0005 and the storativities from the Boulevard Border Patrol wells in Table 4-2 are 0.00048 to 0.00074. While the 0.001 value falls within averages for San Diego County, it is an order of magnitude higher (less conservative) than that provided by the County of San Diego and from wells in the area that have been tested. It appears that values are being chosen to provide a specific outcome rather than being conservative and protective of nearby residential wells.

<u>J-116 Response:</u> The comment to which Dudek has provided a response was that they had presented in their report that “transducer measurements …indicated groundwater level declines in the wells of up to 110 feet when pumps were on.” This implies that groundwater levels in the wells during pumping did not exceed 110 feet of drawdown. However, this does not present all of the data collected for the wells during the pumping period. Their response to our comment that manual readings actually showed that water levels declined in the four pumping wells between 145 and 202 feet, was that they were only referring to the transducer levels. The response by Dudek ignores that fact that they presented only the transducer data and did not discuss the manual readings, as if somehow the manual readings were insignificant. Simply because the transducers were not installed to an adequate depth (or lowered when water levels dropped below their set depth), is not a reason to ignore the manual readings that showed 32 to 83% more drawdown than the transducers. The maximum drawdown of the wells during pumping is what is important, not the method by which the data were collected. Dudek’s response missed the point of the comment and the importance of the manual data readings.

<u>J-118 Response:</u> In the response, Dudek claimed that they used historical pumping data from the 312-acre well field and estimates of aquifer properties from the local fractured rock aquifer to evaluate groundwater impacts. This is only partially correct. Nowhere in the Dudek report are any of the groundwater pumping data from the reservation used to estimate groundwater impacts to nearby users; those data (and only a part of it) were presented to show that while

drawdown occurred during pumping, the wells recovered. This is not a scientific analysis of the hydrogeology of the area, it is simply presenting data with no analysis or comparison to what is proposed for this project. Secondly, Dudek claims to have used "estimates of aquifer properties" to evaluate drawdown impacts. The calculations to which Dudek refers, identified a drawdown of 31 feet at an off-site well in year 1 of pumping (the significance threshold is 20 feet) and a drawdown of 19 feet after year 5. To achieve this, they used a calculation in which they simply selected a higher storativity than that calculated from actual well tests in the area (and higher than the estimate presented in their own Table 4-1 from County of San Diego guidance). The calculations also amortized the entire withdrawal of 173 AF groundwater in Project Year 1 over the entire 5-year construction period. Without these incorrect and liberal assumptions, the calculated drawdown at off-site wells would be much greater and would clearly exceed County of San Diego significance thresholds.

DUDEK GROUNDWATER RESOURCES EVALUATION

The Draft Groundwater Resources Evaluation report prepared by Dudek is unchanged in the Final EIS from the May 2019 report prepared for the Draft EIS. No comments received from the local community, scientific community, nor the County of San Diego Groundwater Geologist resulted in any further evaluation of the groundwater conditions and conclusions drawn in the report. Based on our review of their responses to our comments, significant data gaps still remain, some of which require field testing of the production wells with monitoring of both on- and off-reservation wells.

MITIGATION MEASURE PDF-HYD-1

Mitigation measure (MM) PDF-HYD-1 is the only mitigation measure proposed to protect the groundwater resources and it is limited to protecting the resources for the reservation only. It provides no protections for the off-site residential communities that rely on groundwater as their sole source of water, and is insufficient. The MM states that a "groundwater level drawdown threshold *should* be established to ensure that declines in groundwater levels in On-Reservation wells remain at less than 20 feet resultant from On-Reservation pumping for Project construction." However, there has been no testing of the wells on the reservation to develop aquifer parameters to establish such a threshold, nor will monitoring of on-reservation wells guarantee that off-reservation wells will be protected in a fractured rock groundwater system.

This mitigation measure is totally inadequate given the heterogeneity of groundwater flow in fractured well systems and provides for no off-reservation monitoring of any wells used by local residents. Groundwater flow in hard rock is limited to fractures in the bedrock in groundwater systems such as the project area. The fracture flow results in wells being connected hydraulically that may be located thousands of feet apart and across topographic divides, wells that in alluvial aquifers would not otherwise be connected. The on-reservation wells that may be monitored may not be hydraulically connected to production wells through a fracture network while off-reservation wells may be connected by fracture systems to the production well. There is no method to predict which wells will not be affected by groundwater pumping in a fractured system without conducting one or more well tests to simulate actual project conditions.

At a minimum, this MM needs a defined drawdown level at which pumping ceases that must be verified through aquifer testing and monitoring of nearby, off-reservation wells. In addition, the MM must include monitoring of off-reservation wells. Because no field testing was conducted to determine the effect of groundwater pumping and no off-reservation monitoring is proposed, monitoring of on-reservation wells will not adequately protect off-reservation wells during pumping of production wells on the reservation. It is also our understanding that some tribal residences may rely on spring water, which is even more vulnerable to groundwater withdrawals than wells. Without proper protections in place, these users could also face the loss of use of their groundwater resource.

The following section provides more detail with respect to data gaps that still need to be addressed.

SIGNIFICANT DATA GAPS NOT OR INADEQUATELY ADDRESSED IN RESPONSES

There are still several significant data gaps that should be addressed, or re-analysis of data that should occur, to better analyze the impact on groundwater supplies from the proposed project.

- The identification and location of wells is not provided on any map anywhere in the EIS document, nor are the well details provided (e.g., total depth, geologic conditions, yield). There is no information regarding the safe pumping capacity for any of the wells that would be used for water production. Constant rate pumping tests with a minimum 72-hour duration should be conducted on any of the water supply wells that are proposed to supply water to the project. These tests will determine the safe yield for each well and will allow monitoring of water levels in nearby residential wells for potential impacts.

- The soil moisture balance calculations (Section 4.1.1) and groundwater in storage (Section 4.1.2 and a San Diego County significant impact criterion) should be recalculated using average rainfall data rather than rainfall data from the one weather station that is the furthest of all five stations from the well field and is 1,000 feet lower in elevation. The rainfall amount should be calculated either by averaging all five stations (14.9 inches), or by omitting the highest and lowest rainfall amount stations and averaging the three remaining rainfall stations (15.6 inches).

  Groundwater in storage calculations (related to the 50% reduction in storage analysis significance criterion) should be reanalyzed using the maximum permitted groundwater use per residence/private well of 22.4 AFY or a more conservative usage rate than 0.5 AFY.

- The second of the two significant impact tests, according to County of San Diego Guidelines, is that residual drawdown in off-site wells after 5 years must not exceed 20 feet.

The nearest well to the well field is reported to be 4,500 feet. Therefore, the drawdown in this well was estimated in order to evaluate the County criterion.

The discharge rate (Q) is still not presented in the Dudek report or in the responses to comments. However, Dudek claims that the 173 AFY to be pumped in year 1 was amortized over the 5-year construction period. This grossly underestimates the pumping rate in year 1 and therefore the calculations also grossly underestimate the projected drawdown in nearby, off-reservations wells.

For the Tierra Del Sol (TDS) well scenario in Table 4-2 of the Dudek GRE, an estimate of Storativity (S) was presented as 0.001 since S could not be calculated for the TDS project, which resulted in a residual drawdown of 19 feet after 5 years, one foot below the criterion of 20 feet. The arbitrary nature of the storativity value selection must be re-evaluated. Given that the transmissivity for the TDS well was 75 percent lower than the transmissivities for the Border Patrol wells, it seems appropriate to select a storativity value that is also proportionately lower than the Border Patrol wells (i.e., 0.00012 to 0.00019). However, we calculated the 5-year drawdown under the TDS well scenario at the nearest off-site well using the two storativity values from the Border Patrol wells (0.00074 and 0.00048) and the resulting drawdown values were 21.89 and 26.25 feet, respectively. Using the storage value used by Dudek in their own calculation of groundwater in storage in the basin (0.0005), the drawdown after 5 years at the nearest off-site well under the TDS well scenario is 25.84 feet, which violates the County's significance guideline of 20 feet.

No discussion was presented as to the comparability of the well tests conducted at TDS, or Border Patrol wells 2 and 3 to the wells at the southern well field on the reservation. No details regarding well depths, well diameters, geologic conditions, or pumping rates for the three off-site well tests versus the on-site well production during the SDG&E ECO Substation project were given. Therefore, it is impossible to know if the calculations provided in Section 4.2 accurately reflect the conditions that would result from actual pumping tests of the production wells at the southern well field.

- The effects of pumping on the basin and on water levels in nearby residential wells use estimates of aquifer parameters from unacceptable proxies to actual groundwater pumping tests. It is our opinion that the standard of care is not being met by using estimates of storativity and using transmissivities from other wells in other locations many miles from the project site to evaluate if there will be unacceptable off-site impacts. When these estimates were used, the result was within 5% of the acceptable limit. This is an unacceptable margin for error given the broad assumptions that are being made. Our recalculations indicated the 20-foot drawdown limit would be exceeded.
- No groundwater protections were proposed as part of this project because the GRE stated there would be no groundwater impact. Given the data provided and assumptions made in this report, it is premature to make such a statement. Until actual groundwater

investigations can be undertaken and more conservative assumptions can be made with regard to groundwater in storage and off-site impacts, it should be assumed that the project will have negative, unacceptable, and avoidable impacts. Along with the investigation and re-analysis of data, groundwater protections including well extraction rate caps and intensive off-site well monitoring should be included in any approval for the project, if it were to move forward. These protections would be necessary to ensure that nearby private well owners would continue to have sufficient groundwater resources to meet their consumptive needs, as the aquifer is their only resource for a water supply.

These changes and additional analyses will provide substantially more protection for the groundwater-dependent communities in the area of the project. Some of the changes and reanalysis will also further clarify the use of groundwater during the project.

Respectfully submitted,
SNYDER GEOLOGIC, INC.

Scott Snyder

Scott Snyder PG 7356, CHG 748, QSD/P 445
Principal Hydrogeologist

REGISTERED GEOLOGIST
W. SCOTT SNYDER
No. 748
CERTIFIED HYDROGEOLOGIST
Exp. 09/20
STATE OF CALIFORNIA

EXHIBIT
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EXHIBIT

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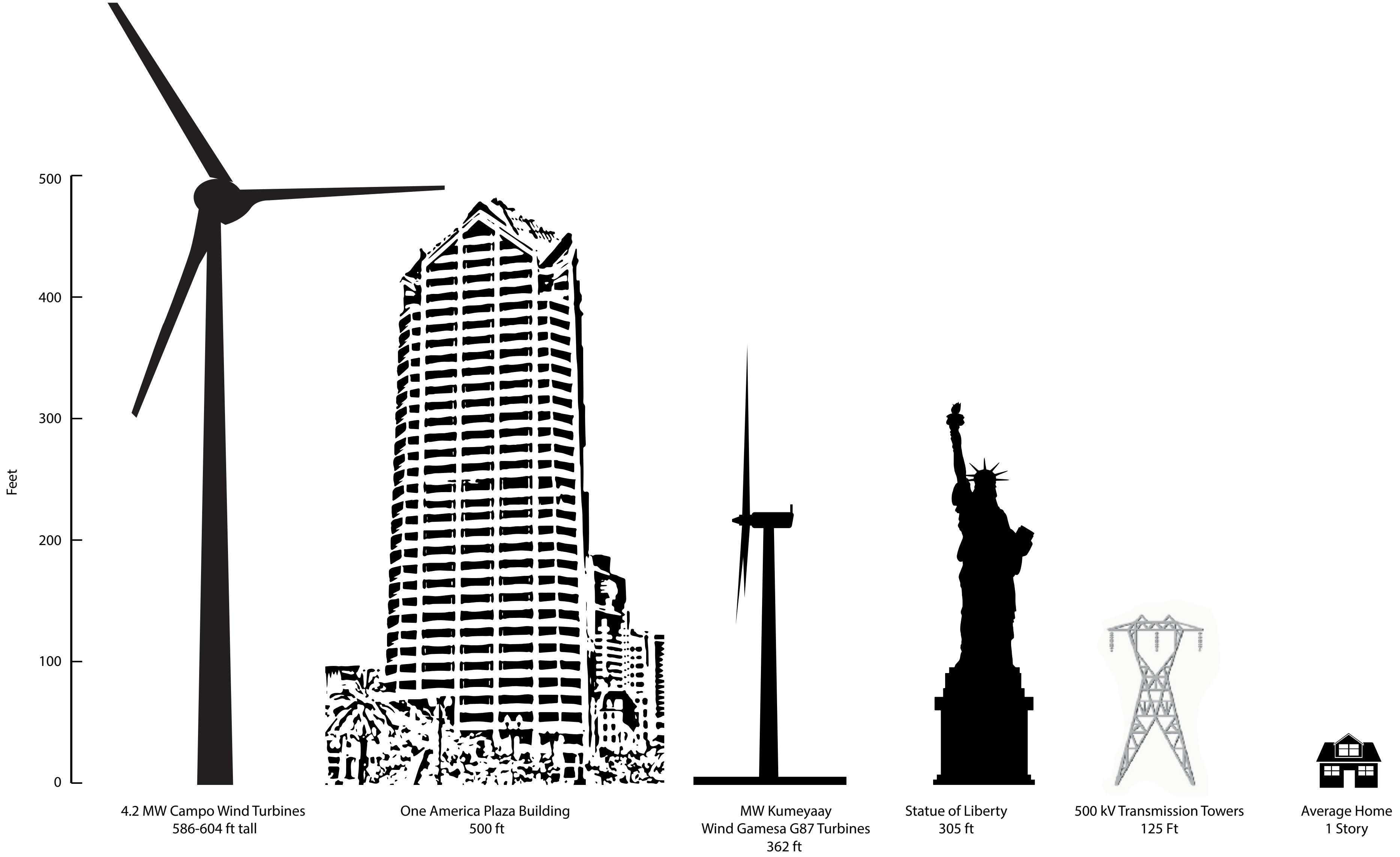
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400
300
200
100
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Feet
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586-604 ft tall
One America Plaza Building
500 ft
MW Kumeyaay
Wind Gamesa G87 Turbines
362 ft
Statue of Liberty
305 ft
500 kV Transmission Towers
125 Ft
Average Home
1 Story

EXHIBIT
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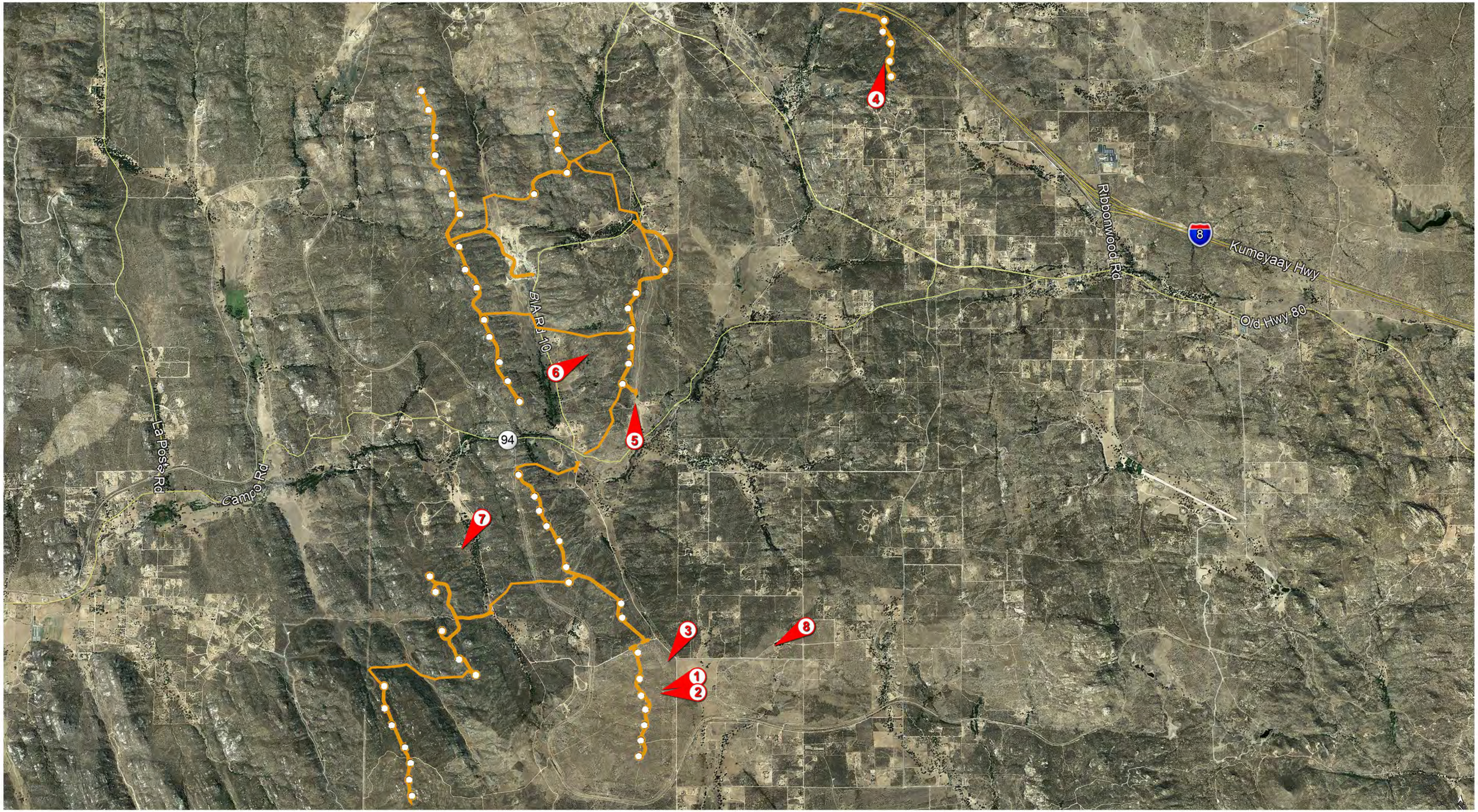

TERRA-GEN'S CAMPO WIND

Key Map

VisionScape IMAGERY
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Existing View

Proposed View

TERRA-GEN'S CAMPO WIND

View 1

Tisdale's Morning Star Ranch

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Existing View

Proposed View

TERRA-GEN'S CAMPO WIND

View 2

Tisdale's Rental Property

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Existing View

Proposed View

TERRA-GEN'S CAMPO WIND

View 3

Fordyce Home

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Existing View

Proposed View

TERRA-GEN'S CAMPO WIND

View 4A

DeGroot Property

VisionScape IMAGERY
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Existing View

Proposed View

TERRA-GEN'S CAMPO WIND

View 4B

DeGroot Property

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Existing View

Proposed View

TERRA-GEN'S CAMPO WIND

View 5

Campo Tribal Members' Homes - Kumeyaay Road

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Existing View

Proposed View

TERRA-GEN'S CAMPO WIND

View 6

Southern Indian Health Center- Church Road

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Existing View

Proposed View

TERRA-GEN'S CAMPO WIND

View 7

Campo Tribal Member's Home -BIA 15

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Existing View

Proposed View

TERRA-GEN'S CAMPO WIND

View 8

Tisdale's Vacant 50 Acre Parcel - Homesite

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